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Building the Lunar Economy

How a sustained presence on the Moon could transform life, industry, and infrastructure on Earth and beyond

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INTRODUCTION

LETTER FROM THE AUTHORS

Our team tracks emerging technologies and markets for a living—the ones that feel speculative today but may reshape industries tomorrow. About a year ago, we started noticing the conversation around the Moon was changing.

For decades, the Moon was framed as a story of flags and footprints: a demonstration of technological capability and national ambition. A worthy pursuit, but not a serious market. That seemed to be the end of the story, but what we've learned since suggests otherwise.

Governments are now aligning policy, funding, and mission planning around something far more permanent: a sustained presence on and around the Moon. Commercial companies are now building the systems that could make it possible, and for the first time, we started hearing a word rarely associated with the Moon: *investable*.

Over the past year, we spoke with founders, engineers, investors, economists, and government leaders to understand what is actually being built and which opportunities are likeliest to matter.

We've done this for emerging technology before—it's at the heart of publications like Deloitte's annual *Tech Trends* report—but what distinguished this research was the degree of convergence we found. Energy, communications, transportation, construction, and computing aren't advancing as isolated capabilities; they are beginning to interconnect into something that looks like the foundations of a new economic and industrial system. That conviction led us to put our own stake in the ground: Deloitte's Silent Shield™ cyber detection system is now part of NASA's Moon Base II initiative, one of our earliest direct investments in lunar infrastructure.

This report maps the expansive lunar system we see forming: the forces driving it, the infrastructure required to sustain a long-term presence, and the market opportunities that could develop around it. It is early in the lunar economy's development, but our analysis projects the total economic value of the lunar economy through 2050 could be US$566 billion under an accelerated growth scenario.

The broad, societal benefits a lunar economy could create—such as those related to innovation, scientific advancement, and human inspiration associated with exploration—are estimated at an additional US$541 billion, suggesting that the economic significance of a lunar program may extend beyond mere observable market transactions.

However, you do not need to believe the lunar economy can become a multibillion-dollar market to find this worth understanding. Decisions being made today about funding, infrastructure, and standards could shape outcomes beyond the space sector itself.

We wrote this for anyone trying to make sense of the moment: investors evaluating the space sector, policymakers shaping its direction, executives in adjacent industries watching the market develop, and the engineers and founders doing the building. We hope it provides a foundation for sharper questions, better decisions, and a clearer view of what is unfolding 384,400 kilometers away.[1]

For thousands of years, humanity has looked up at the Moon and wondered about what might be possible beyond our world. Today, we have the opportunity to look at it differently: not only as something to inspire us, but as a place where a new chapter of human progress could begin.

Ad lunam!

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Some of our greatest insights came from speaking with leaders across the industry. We'd like to thank the following individuals for their time:

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ABOUT THE REPORT

Geographic Scope

This report and our economic analysis draw primarily on US policy, programs, and commercial activity, given the US represents the largest share of current public and private space investment and maintains extensive openly documented lunar efforts.[2] But the lunar economy is global by nature. The barrier to entry has dropped far enough that companies and space agencies worldwide are now participating in ways that weren't possible a decade ago, and the opportunities described here extend well beyond any single national program.

Report Structure

To illustrate how the lunar economy might unfold, we structured this report in two main parts, as shown on the next page in our **Lunar Economy Architecture** framework.

What it Takes maps the infrastructure required to operate on the Moon: transportation; energy and power; communications and navigation; surface mobility; construction; and life support. These are some of the systems being built right now, largely backed by government funding, that determine what is physically possible on the lunar surface.

What it Makes explores the possibilities that infrastructure might create once it exists: national security capabilities; lunar data & services; new resources and materials; in-space production; innovation and scientific discovery; and human inspiration. These are the returns that flow back to Earth and beyond.

Building a lunar economy requires significant investment in capabilities whose full value may not be realized for decades. To connect today's investments with tomorrow's possibilities, our economic analysis estimates the potential value of both the infrastructure required to enable lunar activity and the economic value that could emerge from it through 2050.

LUNAR ECONOMY ARCHITECTURE

WHAT IT TAKES

The infrastructure required for a sustained lunar presence

Transportation
Getting to and from the lunar surface

Energy & Power
Generating, storing, and distributing energy

Communications & Navigation
Connecting operators and assets across cislunar space

Surface Mobility
Moving people, robots, and materials across the surface

Construction
Building physical infrastructure and goods on the Moon

Life Support
Keeping astronauts safe and healthy

WHAT IT MAKES

The possibilities the lunar economy could create

National Security

Lunar Data & Services

New Resources & Materials

In-Space Production

Innovation & Scientific Discovery

Human Inspiration

WHY THE MOON, WHY NOW?

A new space race is taking shape

The most consequential territory in the next decade may not be on Earth.

Many governments and private companies are converging on the Moon, each for their own reasons. Science. Security. Commerce. National prestige. The promise of valuable resources. The fear of being left behind.

What was once a niche corner of the space industry is becoming one of the fastest-moving frontiers, and the momentum is building quickly.

In late 2025, a White House executive order elevated the Moon to a national strategic priority.[3] Artemis IV is scheduled to return astronauts to the surface in 2028, marking the first crewed lunar landing in more than fifty years.[4] NASA Administrator Jared Isaacman is calling for monthly lunar lander missions starting in 2027 and a permanent moon base powered by a nuclear fission reactor by 2030.[5]

China is also rapidly expanding its lunar program, building on successful far-side landings and sample return missions while developing the International Lunar Research Station (ILRS) with partner nations.[6] Japan, India, South Korea, and the European Space Agency (ESA) all have their own missions in development.[7]

Commercial priorities are shifting as well. In February 2026, SpaceX announced it would prioritize building a “self-growing city on the Moon,” a notable departure from the Mars-first mission the company held for two decades.[8] Four months later, the company completed what became one of the largest initial public offerings (IPOs) in history, with its S-1 filing highlighting lunar manufacturing, surface energy production, and space-based AI compute among its future business lines.[9]

In total, more than 400 lunar missions are planned over the next two decades.[10]

So why is all of this happening right now?

The scientific case for the Moon has existed for decades. It is the closest laboratory for studying planetary formation and testing the technologies that may eventually be needed for deep-space exploration. Every dollar spent on lunar infrastructure is also an investment toward reaching Mars and beyond, but science alone could never sustain this level of political will or capital.[11]

The confirmation of water ice at the lunar poles in the late 2000s changed the calculus.[12] For decades, sustained lunar operations had largely been viewed as prohibitively expensive due to the need to transport nearly everything from Earth. However, the discovery of water ice raised a new possibility: lunar water could eventually support fuel production, life support, and long-duration operations, making a permanent presence far more plausible than previously thought.[13]

At the same time, access to space is becoming cheaper.[14] Reusable rockets, commercial launch providers, rideshare programs, and new procurement models are lowering barriers that have historically limited participation to superpower governments and a small number of major aerospace contractors.

These same forces helped transform low Earth orbit (LEO) from a largely government-led domain into a thriving commercial market. Across the broader space economy, commercial activity now accounts for 78% of the more than US$613 billion generated annually.[15] Many of the conditions that enabled that growth are now taking shape around the Moon.

With the barriers to entry falling and the promise of valuable resources growing, the strategic significance of the Moon has intensified. Governments now see cislunar space, the broader Earth-Moon region, as a strategic domain—a place where early presence determines who sets the standards, who controls coveted locations, and who secures the resources.[16]

These motivations reinforce one another. Scientific missions justify infrastructure. Infrastructure enables commercial activity. Commercial activity creates assets. Assets create security interests.

This has created an ecosystem that looks nothing like the Apollo era. What was once the domain of governments and a handful of aerospace contractors now includes venture-backed startups, investors, defense firms, and some of the world's largest companies all seeking a role in the emerging lunar economy.

Although still in its earliest stages, the upside potential could be massive. Our analysis at Deloitte estimates that emerging lunar markets could generate US$566 billion in cumulative potential economic value through 2050 in an accelerated growth scenario. The model analyzes two dimensions of market activity: the infrastructure required to operate on and around the Moon, and the downstream markets those capabilities could ultimately enable. Figure 1 summarizes the results across both scenarios, and the Appendix showcases details for the economic model methodology and assumptions.

Yet a thriving lunar economy is not inevitable. Significant engineering hurdles remain, development timelines are long, and the commercial viability is still uncertain. The pace of progress will likely depend on the combination of technological advances, geopolitical developments, regulatory clarity, and sustained investment; but if even just part of the planned infrastructure is built, the effects could extend well beyond the Moon itself.

The debate is no longer whether humanity is going back to the Moon. It is what happens once we stay.

The answer depends first on what can be built. **Part I: What it Takes** explores the systems, engineering, and infrastructure that may shape what is physically feasible on the lunar surface. **Part II: What it Makes** looks at how those capabilities could create economic, strategic, and societal value. Together, these sections frame the economic analysis presented in this report and discussed in greater detail in the Appendix.

As you move through the chapters ahead, we hope you keep one idea in mind: the developments described in this report are part of a story much larger than the Moon itself. The missions, technologies, and markets explored in these pages are early building blocks of a future that could reshape industries, influence economies, and help define the next chapter of human progress.

> ***“We’re witnessing the most exciting moment in space history. The combination of capital, technology, and commercial momentum entering the market today exceeds anything we’ve seen before.”***
>
> **- Jack “2fish” Fischer, Retired US Astronaut and Chief Integration Officer of Intuitive Machines[17]**

Figure 1

THE VALUE OF THE LUNAR ECONOMY THROUGH 2050

The estimated value of the lunar economy could reach between $343 B (conservative growth) and $566 B (accelerated growth) from 2026–2050

	CONSERVATIVE GROWTH SCENARIO *Base scenario assuming steady-state growth rates*	ACCELERATED GROWTH SCENARIO *High-growth scenario enabled by breakthrough technologies*
PART I **WHAT IT TAKES:** The infrastructure required for a sustained lunar presence		
Transportation	$150.0 B	$205.7 B
Energy & Power	$31.8 B	$44.3 B
Communications & Navigation	$7.4 B	$9.1 B
Surface Mobility	$12.3 B	$13.3 B
Construction	$5.1 B	$6.4 B
Life Support	$2.4 B	$3.5 B
PART II **WHAT IT MAKES**: The possibilities the lunar economy could create		
National Security	$11.9 B	$31.4 B
Lunar Data & Services	$1.4 B	$31.7 B
New Resources & Materials	$59.2 B	$114.5 B
In-Space Production	$61.3 B	$105.9 B
TOTAL VALUE OF LUNAR ECONOMY 2026–2050*	**$342.8 B**	**$565.7 B**

**Data reflects cumulative values from 2026–2050, discounted at 7% in real terms, in USD*

Source: Deloitte analysis (2026)

PART I

WHAT IT TAKES

The infrastructure required for a sustained lunar presence

WHAT IT TAKES

The infrastructure required for a sustained lunar presence

Building a sustained presence on the Moon requires far more than just reaching it. It requires infrastructure. On Earth, infrastructure is so deeply embedded in daily life that it often goes unnoticed: the power grid behind every light switch, the roads under every delivery truck, the wireless signal that lets a factory floor coordinate in real time. As AJ Gemer, co-founder and CTO of Lunar Outpost, put it: “Here on Earth, we take things like GPS and cellular communications for granted. On the Moon, you have to bring all that with you.”[18]

When Apollo 11 landed in the Sea of Tranquility in 1969, the site was chosen for ease and safety: a flat, sunlit plain near the lunar equator with a clear line of sight back to Earth.[19] The astronauts brought everything they needed and departed days later.

Today’s lunar ambitions extend beyond short-duration exploration. A sustained human presence on the Moon would require infrastructure to support living, working, and operating there over extended periods.

The challenge is that the resources and natural advantages that could help sustain that presence are concentrated in one of the Moon’s most difficult environments: the lunar South Pole.[20]

The lunar South Pole is a landscape of jagged ridgelines and deep craters, where some regions have not seen daylight in billions of years. Inside those permanently shadowed regions (PSRs), scientists believe significant deposits of water ice have accumulated over time.[21] On the Moon, water is more than something astronauts drink—it could determine where humans live, build, and refuel. Water can be split into hydrogen and oxygen to produce rocket fuel and breathable air, reducing the need to transport critical supplies from Earth.[22] Meanwhile, some elevated peaks and crater rims near these PSRs receive sunlight nearly year-round, offering some of the most promising locations on the Moon for solar power.[23]

It is arguably the most strategically important region beyond Earth: fuel, power, and the ability to sustain life—the basic inputs of any economy—concentrated in one place.

Since the first successful landing near the lunar South Pole by India in 2023, the region has become the focal point of global lunar activity.[24] Nearly half of all planned Moon landings now target the lunar South Pole, and by 2028, nearly every major mission on the books is headed there, including the first crewed landing since Apollo.[25] Both planned permanent lunar bases—NASA’s Artemis Base Camp and China’s International Lunar Research Station—are also slated for the region.[26] The rare combination of accessible water ice, ridgelines with near-continuous sunlight, and suitable landing terrain may exist in only a handful of locations, placing the world's major lunar programs in competition for the same real estate.

To fully realize the potential of resources at the lunar South Pole, foundational systems and infrastructure will likely be needed. Building that foundation requires significant upfront investment, and today governments remain the primary source of that capital. Globally, government space spending reached US$137 billion in 2025 and is projected to rise sharply.[27] NASA's permanent Moon Base alone is expected to cost roughly US$20 billion, while the US government is funding roughly US$7 billion a year in public-private collaboration to develop the systems required to operate on the Moon.[28]

Regardless of how the broader lunar economy develops, this infrastructure buildout may represent one of the earliest major economic opportunities in the cislunar market.

The rest of this chapter explores that market across six infrastructure systems: transportation, energy and power, communications and navigation, surface mobility, construction, and life support. Together, these six systems could help enable future lunar activity and, according to Deloitte's economic analysis, may represent a potential present value opportunity of US$282 billion through 2050 in an accelerated growth scenario.

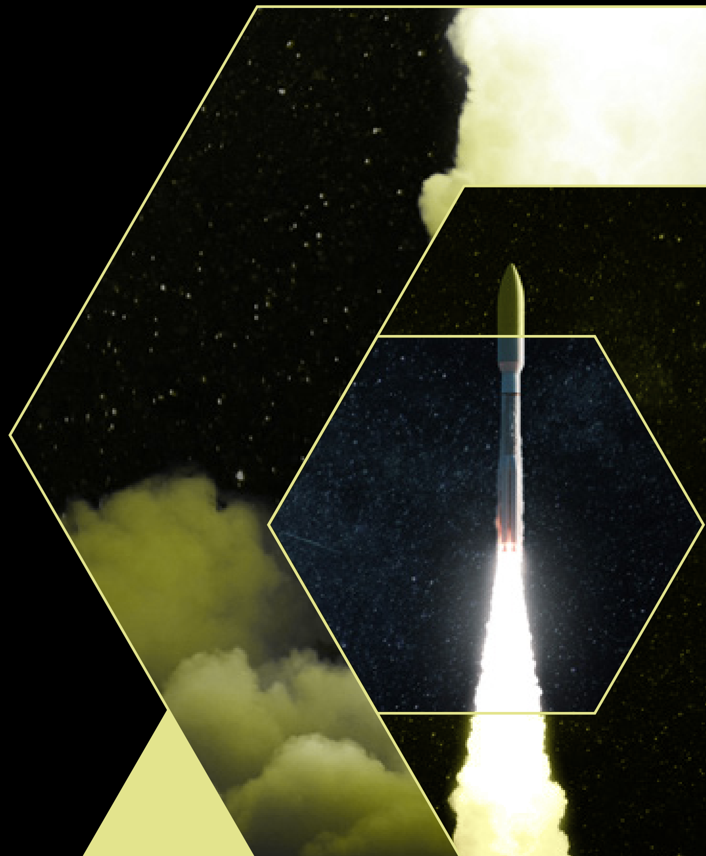
TRANSPORTATION

Getting to and from the lunar surface

Getting to the Moon was once a problem only a government superpower could solve. Now, NASA is buying the ride—not simply to reach the Moon, but to help create a commercial transportation market.

"The model has shifted from government-owned resources to more of a service-based procurement with NASA as the buyer," Mike Lewis of Voyager explained.[29]

Through the Commercial Lunar Payload Services (CLPS) program, NASA has awarded up to US$2.6 billion in contracts to private companies to deliver cargo, technology demonstrations, and scientific instruments to the lunar surface.[30] By acting as an early anchor customer instead of building and owning the transportation system itself, NASA is following the same playbook that helped catalyze today's commercial LEO transportation market,



creating demand for services that can eventually support government and private customers alike.

The strategy is already beginning to gain traction. In 2024, Intuitive Machines became the first private company to achieve a soft landing on the Moon.[31] In 2025, Firefly Aerospace followed with Blue Ghost, achieving the first fully successful commercial lunar landing.[32]

Commercial providers are now moving beyond demonstration missions toward supporting sustained lunar operations. One early example is Moon Base I, which is expected to be the first privately funded lunar lander mission in history, using Blue Origin's Blue Moon Mark 1 Endurance lander to deliver early lunar infrastructure to the lunar South Pole.[33]

As commercial lunar transportation matures, the range of customers who can reach the Moon widens with it. The United Arab Emirates, for example, is using Firefly's commercial transportation services to deliver its Rashid rover, demonstrating how countries and organizations could access the lunar surface without building their own transportation systems.[34] Making that process easier has become a business opportunity in its own right: ispace plans to offer a lunar access integration service as early as 2030, packaging transportation and mission integration into a single offering.[35]

The expanding market for lunar transportation is also reaching beyond traditional space companies. As just one example, Intuitive Machines collaborated with Columbia Sportswear to adapt thermal management technologies, originally developed for outdoor apparel, to help protect its lunar lander from the extreme temperatures of space and the Moon.[36]

The commercial transportation model appears to be gaining traction, but developing a system capable of serving multiple missions and customers would still require overcoming significant engineering challenges.

During the Apollo era, a single vehicle carried the crew from Earth to lunar orbit and back, with Apollo's lander built for two people and a three-day stay.[37] A sustained lunar presence would require greater capacity, which may exceed what a single launch architecture can support.

Artemis splits that job across multiple spacecraft and multiple companies. Starting with Artemis IV in 2028, the current plan is for a crew to launch aboard NASA's Space Launch System (SLS), travel to lunar orbit aboard Orion, and then transfer to a separately launched commercial lander for the journey to the surface.[38] Before that can happen, the current architecture calls for the lander to be fueled in orbit through a series of propellant transfers. SpaceX and Blue Origin are both developing crewed landers, and NASA plans to test docking with at least one as part of the Artemis III mission in 2027.[39]

The scale of what can reach the surface is also changing. SpaceX has invested more than US$15 billion in Starship, and its newest variant is designed to carry up to 100 metric tons to orbit, with future versions targeting significantly more.[40] Transportation is increasingly about moving people, cargo, and infrastructure at a cadence that can support permanent operations on the lunar surface.

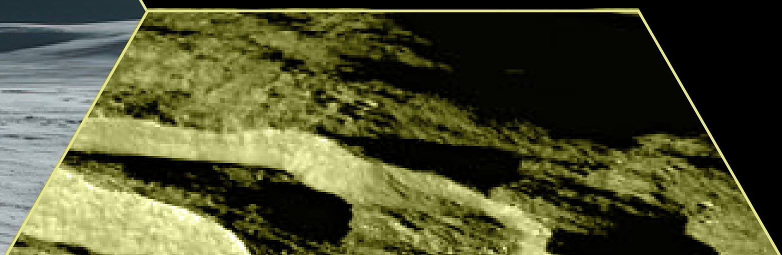
Getting to the lunar surface is no small feat, but mission success ultimately depends on sticking the landing. Landing once is difficult enough, but developing a transportation system capable of returning to the same location repeatedly presents an even greater engineering challenge.

The lunar surface is covered in regolith: a layer of jagged, abrasive soil made of crushed rock, dust, and glass.[41] In one-sixth gravity and no atmosphere, a landing rocket sends this regolith flying at velocities up to 2,000 meters per second.[42] During Apollo 12, ejecta damaged nearby equipment more than 150 meters from the landing site, posing a serious concern for astronauts and assets on the surface.[43]

A solution is landing pads: hardened surfaces built from the regolith itself, surrounded by berms that contain or deflect debris. As DARPA's Commercial Lunar Economy Field Guide writes, "neglecting landing pads would be like asking a Boeing 767 to land on a beach instead of a runway every time."[44] Companies like Redwire, Ethos, and ICON are developing the tools to build them. Kari Abromitis, formerly of Redwire, explains: "Redwire's construction tools will enable launch and landing in the same location without causing a big crater and a bunch of destruction."[45] A lunar base ultimately requires this: repeatability, high mission cadence, and assets close enough together to function as infrastructure.

Our economic analysis suggests that the lunar transportation market may ultimately become the single largest segment of the early lunar economy, potentially generating economic value of US$206 billion—which accounts for an estimated 36% of total value under the accelerated growth scenario through 2050. It is worth noting that, when looking exclusively at the six "What it Takes" infrastructure systems in the accelerated growth scenario, lunar transportation accounts for an estimated 72% of value—highlighting just how central transportation is to the overall foundational lunar ecosystem.

However, a successful landing is just the beginning. Sustaining operations on the lunar surface requires reliable power, and many areas go without sunlight for extended periods of time.



ENERGY & POWER

Generating, storing, and distributing energy

On Earth, infrastructure is built on the assumption that power is always available. Imagine designing a car if you could never refuel, or a city where every building had to generate and store its own energy. That is the Moon today. Fix the energy problem and what follows is a structural shift in what can be built and how far it can go.

Today, every asset on the lunar surface carries its own energy supply, and most of it depends on the Sun. At first, that works: solar arrays charge, instruments run, data flows back to Earth. Then, the Sun sets, darkness blankets the surface, and temperatures plunge below -133 degrees Celsius as the lunar night begins.[46] It lasts fourteen Earth days, and for most missions, when the power runs out, the mission is over.

Lunar power discussions commonly reference three approaches: solar energy, radioisotope systems, and fission surface power. Solar and radioisotope systems are more established and available today, while fission surface power remains an option planned for future missions.

Generating power on the Moon presents several challenges. One difficulty is that lunar dust can adhere to exposed surfaces, which may ultimately affect the performance of solar panels and thermal control systems. Another is that in the lunar environment, power systems rely on dedicated thermal management hardware, which typically increases mass and cost to every mission.[47]

In the emerging lunar economy, energy development follows what Zeno Power CEO Tyler Bernstein describes as a simple progression:

> ***“First, we need to survive the night. Then we need to operate through the night. Then we need to thrive during the night.”***
>
> **- Tyler Bernstein, Co-Founder and CEO of Zeno Power[48]**

Surviving means, at minimum, keeping equipment alive through those two weeks of darkness. “If we can keep them alive through the lunar night,” Volta’s COO Paul Damphousse explains, “if nothing more, just to hibernate and come out the other side and use their standard solar arrays to generate power again, we’ve just doubled their ROI.”[49] Operating means sustaining power through the night: sensors pinging, rovers moving, navigation nodes activating. Thriving means scaling to industrial levels: around 100 kilowatts for initial operations, and hundreds of kilowatts to megawatts for sustained human presence.[50]

Each source serves a different point on that progression.

SOLAR POWER

Solar power is among the most established energy options and is often viewed as an important part of early lunar surface infrastructure. However, the lunar South Pole presents additional challenges, as local sunlight conditions may require vertical or otherwise specialized solar panel configurations.

Through NASA’s Vertical Solar Array Technology (VSAT) program, Astrobotic (now Voyager Lunar Systems), Honeybee

Robotics, and Lockheed Martin developed prototype arrays on masts up to 20 meters tall to capture near-continuous sunlight at polar sites.[51] Astrobotic's design is mounted on a mobile rover base that can reposition to track the Sun or relocate to higher-illumination sites, targeting an operational power grid at the lunar South Pole by 2028.[52] They are also working with Honda to integrate a regenerative fuel cell system that stores solar energy as hydrogen during the day and converts it back to electricity during the night.[53]

The raw materials for solar panels—silicon and aluminum oxide—are abundant in lunar regolith, raising the long-term possibility of manufacturing them on-site.[54] But solar has hard limits: it cannot generate power during the lunar night, and it offers little help in the permanently shadowed craters where many of the most promising water ice deposits are located.

RADIOISOTOPE POWER

Radioisotope power systems are essentially nuclear batteries: compact units that convert heat from radioactive decay into continuous electricity and thermal energy. Nuclear energy in space is hardly new. Similar systems have powered everything from NASA's Voyager spacecraft to Mars rovers, delivering reliable energy where solar power is impractical.[55] They carry their own fuel and need no sunlight, which makes them one of the few sources that work anywhere on the Moon, including inside permanently shadowed craters.

At low tens to hundreds of watts, they are not grid-scale, but they could serve as trickle chargers for nighttime operations, and their excess heat could keep nearby equipment warm through the darkness.[56] "China has maintained a continuous presence on the Moon since 2019 with its Chang'e program, powered by radioisotopes to keep its assets alive through the lunar night," Zeno Power's Bernstein notes.[57] But existing systems are expensive, costing roughly US$250 million per unit.[58] Zeno Power plans to change that by delivering the first commercially-built nuclear batteries as early as 2027 at a fraction of that cost.[59]

FISSION SURFACE POWER

Fission surface power is a compact nuclear reactor designed to generate continuous electricity on the lunar surface. It works by splitting atoms to produce heat, which is converted into electricity.[60] Its ability to provide sustained, high-output electricity independent of the Sun may make it well-suited for industrial operations on the Moon. "Solar gets you started. Nuclear gets you to scale," says Joe Pawelski, co-founder and CTO of CisLunar Industries.[61]

In January 2026, NASA and the Department of Energy committed to deploying a fission surface power system on the Moon by 2030 to provide continuous, reliable power regardless of location or lighting.[62] NASA has since raised its target from the original 40-kilowatt reactor concepts to at least 100 kilowatts of electrical power, enough to support lunar habitats and large-scale resource processing.[63] Russia and China have also announced plans to jointly deploy a lunar reactor in the 2030s.[64]

The promise carries real obstacles. Nuclear systems are expensive and technically complex, and they raise regulatory and geopolitical questions as nations debate how reactors should be deployed and governed on the lunar surface.[65]

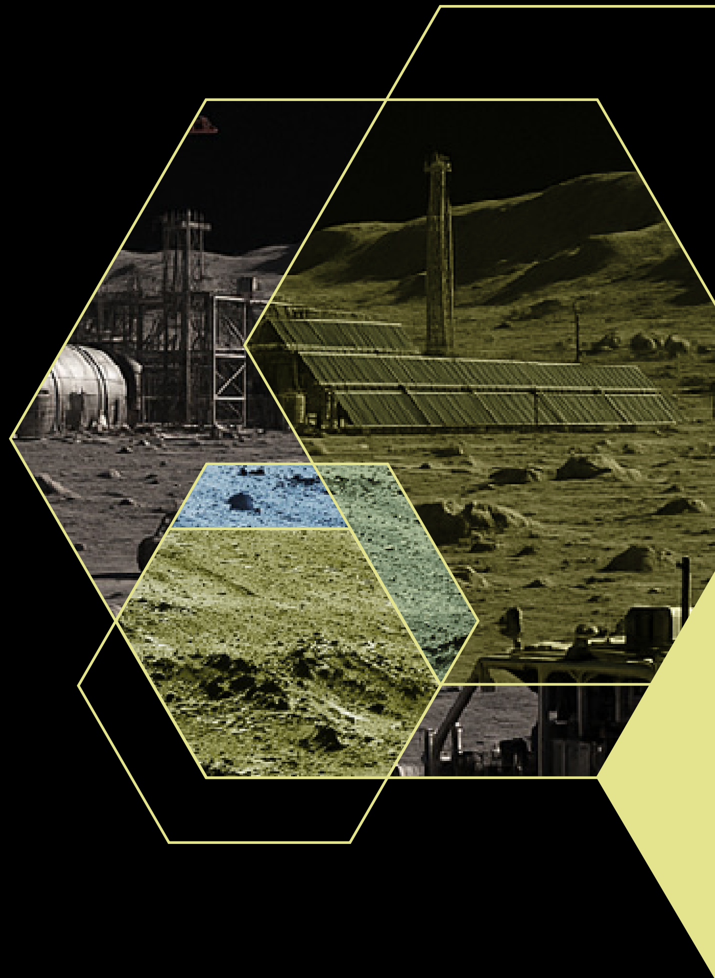
Producing energy is one thing but getting it where it needs to go is another. The places that need power often lie far from where it's easiest to generate, and wired connections only serve fixed installations. Volta Space Technologies is working to tackle this issue by building an orbital constellation called LightGrid that beams solar energy from satellites directly to surface receivers anywhere on the Moon, regardless of the day-night cycle.[66]

In what Volta's Damphousse calls the "prospecting phase," as NASA evaluates candidate sites for a permanent base, that flexibility is essential: "You never know where the final site is until you hit it, and putting the energy source down first is putting the cart before the horse."[67] The business model mirrors a terrestrial utility: standardized receivers small enough to fit on a rover, provided free with a two-year power purchase agreement, with a long-term vision of delivering sufficient continuous power to sustain operations through the lunar night and beyond.[68]

Over time, these sources could link into lunar microgrids: networks of power hubs distributing energy across kilometers of terrain. No single source may be sufficient on its own. The answer, as Zeno Power's Bernstein puts it, is "all of the above."[69]

> ***"It is likely that the first utility you will be able to buy and sell on the Moon will be power."***
>
> **- Robert P. Mueller, Senior Technologist and Principal Investigator at NASA**[70]

Power is only one component of a functioning lunar system—assets must also coordinate, exchange data, and operate in sync. Enabling that capability on the Moon depends on communications and networking infrastructure that is still taking shape.



COMMUNICATIONS & NAVIGATION

Connecting operators and assets across cislunar space

When you travel to a new country, you do not pack a cell tower in your luggage. You land, turn on your phone, and within seconds you know the local time, can see your location, pull up directions, message a friend, or search for a restaurant.

On the Moon, none of that infrastructure exists. There are no cell networks to exchange information, no Global Positioning System (GPS) satellites to determine location, and even something as simple as asking "what time is it?" becomes extraordinarily complex. Astronauts, rovers, habitats, and instruments must exchange information, know where they are, and remain synchronized while operating hundreds of thousands of kilometers from Earth. Without reliable communications and positioning, navigation and timing (PNT), nothing else in the lunar economy can function.

These capabilities can be viewed in three layers: local surface networks connecting astronauts, rovers, and equipment (surface-to-surface communication); relay networks supporting communication between the Moon and Earth (surface-to-Earth communication); and PNT services that enable coordinated operations. Across all three are the shared standards and governance frameworks that support interoperability.

Although discussed separately below, it is worth noting that communications and PNT capabilities may in many cases be delivered through the same underlying infrastructure.

SURFACE-TO-SURFACE COMMUNICATION

On the lunar surface, operations will likely increasingly depend on exchanging voice, video, telemetry, and commands across large distances. The solutions that have worked for lunar missions to date, including Ultra High Frequency (UHF) and Very High Frequency (VHF) radios, were designed to support voice communications for a small number of assets operating in close proximity.[71]

As Modul8's Dr. Thierry Klein puts it: "A UHF/VHF radio transmits small amounts of data at kilobits per second, akin to data rates of 2G phones."[72] Artemis and the Moon Base may require orders of magnitude more capacity over an area spanning hundreds of square miles, with astronauts streaming high-definition video, rovers traversing long distances, and interconnected mission systems all requiring reliable, low-latency communications simultaneously.

To meet those demands, Modul8, Nokia's Space Communication Solutions venture built from Nokia Bell Labs technology, is adapting terrestrial cellular networks for the Moon.[73] The company has reengineered a cellular network into a highly compact form factor Dr. Klein describes as "a single unit roughly the size of a small notebook"—modular, fully redundant, and designed to operate reliably without human intervention.[74] That autonomy is essential: "On Earth, if something goes wrong with the network, you could send a technician in a truck to fix it. On the Moon, you cannot. It's not an astronaut's job to be a telecom technician, so these networks have to be completely autonomous (self-healing, self-configuring, and self-optimizing) from the moment you turn them on."[75]

In March 2025, Nokia's Lunar Surface Communications System flew to the Moon aboard Intuitive Machines' IM-2 mission and became the first cellular network ever operated on another celestial body.[76] For Artemis, the Modul8 team is working with Axiom Space to integrate cellular technology directly into the next-generation spacesuits, allowing astronauts, rovers, and instruments to share a common local network for the first time.[77]

SURFACE-TO-EARTH COMMUNICATION

Surface networks solve local connectivity, but information generated on the Moon still needs to find its way home. That presents three distinct challenges.

Coverage: At the lunar South Pole, Earth is often hidden below the horizon, restricting direct-to-Earth communication to between 17% and 43% of the time depending on location.[78] Without additional infrastructure, missions are likely confined to the narrow set of landing sites where lighting conditions, terrain, water ice, and Earth visibility align, representing just 0.6% of the lunar South Pole surface area.[79]

Relay satellites in lunar orbit can help overcome that constraint, maintaining continuous coverage regardless of where Earth sits on the horizon. Rather than transmitting directly to Earth, surface assets can send data to orbiting relays, which then forward it home. NASA selected Intuitive Machines to design and operate a lunar relay constellation, providing communications services on a pay-per-use basis to government and commercial customers alike.[80] Europe is pursuing a similar approach through ESA's Moonlight program, which aims to provide communications, navigation, and timing services as shared infrastructure for future lunar missions.[81]

Ground capacity: Once data is transmitted back to Earth, there needs to be someone listening on the other end. For decades, nearly all lunar communications have flowed through NASA's Deep Space Network (DSN), a global system of large radio antennas originally built for deep space exploration that is increasingly oversubscribed as mission volume and data demand grows.[82] However, commercial providers are beginning to expand capacity to meet growing demand. A recent example is Intuitive Machines' acquisition of Goonhilly Earth Station, which extends commercial ground infrastructure for lunar and cislunar missions and diversifies an architecture that has historically relied on NASA-owned assets.[83]

Bandwidth: Even with sufficient coverage and ground capacity, radio frequency (RF) communications may face bandwidth limits. As the number of rovers, landers, instruments, and crewed activities increases on the lunar surface, data demand may begin to outpace the capacity of radio-based networks. Astrolab founder and CEO Jaret Matthews, whose rovers may depend on that connectivity, describes bandwidth as "the ultimate choke point," adding that "until you see optical comm solutions deployed on the Moon, progress will be somewhat limited by the bandwidth available."[84]

Laser-based optical communications can carry far more data than radio, and Artemis II offered an early proof of concept. The mission's laser communications system transmitted high-definition video at 260 megabits per second, orders of magnitude beyond what radio links from the Moon have historically achieved.[85]

Dr. Klein sees a path to scaling it further:

> ***"Eventually, we will have gigabits per second of data connectivity on the lunar surface. If you want to bring that home, you need big pipes. Optical communication will provide the necessary bandwidth to effectively connect the Moon to Earth. We believe that we can achieve 100-gigabit-per-second links to the Moon within this decade."***
>
> **- Dr. Thierry E. Klein, Co-Founder of Modul8 and Head of Bell Labs Research at Nokia**[86]

Communications networks facilitate the flow of information, but it is PNT infrastructure that enables assets to determine their location, synchronize their activities, and navigate safely.

POSITIONING, NAVIGATION AND TIMING

On Earth, GPS and other satellite-based positioning and timing services support everything from driving directions to financial transactions. On the Moon, positioning and navigation are more complex: there is no GPS constellation overhead, no magnetic field to orient a compass, and lighting at the lunar South Pole can make visual orientation unreliable. "You're going to get lost very easily on the Moon," says NASA senior technologist Robert P. Mueller.[87] The consequences go well beyond disorientation. Precision landing, autonomous mobility, resource prospecting, and coordinated operations all depend on accurate positioning and tightly synchronized time.

Positioning and navigation: The same relay constellations being developed for communications are designed to serve double duty, broadcasting the positioning signals that may give the Moon its first equivalent of GPS.[88] As Fischer, former NASA astronaut now a senior executive involved in constellation development at Intuitive Machines explains: "Once we have a robust PNT signal in cislunar space, all I have to do is ask the network where I am, and it tells me. The emergence of reliable shared positioning services will dramatically reduce the cost and complexity of every lunar mission that follows."[89]

Timing: Positioning signals need a common time reference. GPS works because its satellites are synchronized to Coordinated Universal Time (UTC), a global reference maintained by atomic clocks. Because time passes at a slightly different rate on the Moon due to its lower gravity, lunar systems cannot simply rely on Earth's time standard. To address this, Open Lunar Foundation is working to establish Lunar Coordinated Time, a new reference that any mission can synchronize to regardless of which constellation it uses.[90]

STANDARDS AND GOVERNANCE

Establishing a common time reference is one example of a broader challenge facing the lunar economy: creating accepted standards so that communications and navigation infrastructure developed by different organizations can operate as part of a shared system.

International frameworks governing lunar spectrum remain underdeveloped despite growing demand. As of January 2024, the International Telecommunication Union (ITU) had received more than 50 lunar spectrum filings from nine countries, with commercial operators accounting for the majority of filings.[91] This is one of several reasons why lunar communications spectrum is expected to be a key topic of discussion at the ITU's World Radiocommunication Conference in Shanghai in 2027.[92]

Beyond spectrum allocation, communications and PNT systems would need to be able to exchange information across networks built by different providers.

NASA's LunaNet framework establishes common standards so that any mission's hardware can plug into the same network, regardless of who built it.[93] China is developing a parallel system with its own standards and rules of access, raising the risk of fragmented and potentially incompatible lunar infrastructure.[94] The result, as Mehak Sarang of Open Lunar describes it, is investing in "two types of GPS and two types of communications infrastructure, because we can't trust each other."[95]

Together, these efforts may indicate a shift from mission-specific systems toward a shared infrastructure model, in which new entrants could leverage existing services rather than developing bespoke systems for each mission.

Establishing a sustained presence on the Moon involves more than reaching the surface, generating power, and maintaining connectivity. It also depends on the ability to move and operate beyond the initial landing site.

SURFACE MOBILITY

Moving people, robots, and materials across the surface

The Moon has a last-mile problem. Once cargo lands, it still has to get to where it's needed, traversing unprepared terrain that degrades mechanical systems, through a region where craters plunge more than three times the depth of the Grand Canyon, and with a signal delay that makes real-time remote control from Earth impractical.[96] DARPA has estimated that a single rover making round trips could require more than 130 journeys and thousands of hours just to unload one large lander's cargo.[97] At scale, mobility on the Moon may require vehicles that can navigate autonomously, withstand the dust, and operate for years without maintenance.

The first generation of commercial lunar mobility systems is already taking shape. By the end of 2026, Astrolab's FLIP rover is scheduled to travel to the lunar South Pole aboard Voyager Lunar Systems' Griffin lander as part of NASA's Moon Base II mission, helping mature mobility systems for future surface operations.[98] The rover will also host Hewlett Packard Enterprise's lunar edge computing platform, giving Astrolab and its payload customers shared access to onboard AI and data processing services that reduce reliance on Earth-based computing.[99]

The next step is crew-capable mobility. In May 2026, NASA awarded Lunar Terrain Vehicle (LTV) contracts to Lunar Outpost (US$220 million) and Astrolab (US$219 million) to build autonomous rovers that can operate with or without astronauts on board, with delivery to the lunar surface planned by 2028.[100] Much like CLPS, the program is intended to help establish commercial mobility capabilities that can eventually support a broader range of lunar customers and activities.

This shift is also drawing in traditional automotive OEMs. Toyota is developing a crew-capable Lunar Cruiser with the Japan Aerospace Exploration Agency (JAXA) while also supporting ispace's next-generation commercial rover, applying decades of automotive engineering experience to both government and commercial lunar mobility programs.[101] Hyundai Motor Group has also entered the market, developing an autonomous lunar rover with Korean aerospace research institutes as part of a broader effort to extend its mobility capabilities beyond Earth.[102]

But companies are already designing what comes next: industrial lunar vehicles built for construction, logistics, and infrastructure development. Lunar Outpost's Eagle rover offers an early glimpse into this future. Its robotic arm can connect power systems, deploy solar arrays, and support construction tasks.[103] The company's CTO, AJ Gemer, envisions "hundreds, eventually thousands, of these vehicles all over the lunar surface," serving as the pickup trucks of a working lunar economy.[104]

As lunar activity expands, the Moon is likely to require a broader transportation network: cargo haulers for moving regolith between processing sites, pressurized crew vehicles for long-distance traverses, and surface hoppers for reaching terrain that may be too steep for wheeled vehicles.

At the far end of this trajectory, mobility even begins to resemble terrestrial infrastructure. One example is DARPA's selection of Northrop Grumman to develop a lunar railroad concept that could one day connect outposts, mines, and research facilities across the surface.[105]

But before fleets, hoppers, or railways, the Moon may need something far more basic: paved roads. Compacted or sintered surfaces between key sites may be among the earliest pieces of infrastructure built on the Moon.

BUILDING CYBER RESILIENCE IN CISLUNAR SPACE

As lunar infrastructure becomes more connected, autonomous, and commercially valuable, cybersecurity may become an increasingly important enabling element of the cislunar economy. A sustained lunar presence would likely depend on power, mobility, communications, construction, and landing systems working together, often in environments where delays, disruptions, or intrusion could have broader operational effects.

Deloitte is investing in that resilience layer through Silent Shield™, an out-of-band cyber intrusion detection system built to identify anomalies and alert mission operators in near real time. Silent Shield™ is being extended to Astrolab's lunar rover, planned for delivery to the lunar surface in support of Moon Base II in 2026, helping test how cyber resilience can protect the infrastructure on which future lunar operations may depend.

CONSTRUCTION

Building physical infrastructure and goods on the Moon

If lunar activity expands beyond isolated missions, construction on the surface becomes increasingly important. Every kilogram delivered to the Moon arrives at enormous cost and, once there, faces an unforgiving environment. Early construction efforts are likely to be guided by a simple imperative: protect what you have. Initial measures could include landing pads, berms, and shielding around high-value assets that may be difficult or costly to replace. “Really, it’s about protecting investments,” says Abromitis, who focused on space infrastructure at Redwire.[106]

The good news is that the Moon’s surface contains nearly everything needed to do it. Lunar regolith is rich in silicon, iron, aluminum, titanium, and oxygen—the raw materials for concrete, steel, and glass.[107] Processing these local materials into usable infrastructure is known as in-situ resource utilization, or ISRU—a concept built around using what is already available rather than launching everything from Earth.[108] As Pawelski of CisLunar Industries puts it, “At a certain point, it becomes less expensive to produce something at the source than to ship it in.”[109]

Approaches for processing regolith range from laser sintering, which uses concentrated energy to fuse regolith into hardened surfaces, to microwave systems producing what researchers have started calling “Moon bricks.”[110]

Companies are already translating these methods into flight-ready systems. Redwire’s suite is designed to grade, compact, and fuse regolith into solid material. Intended to mount on any lander, rover, or robotic arm, it’s among the first construction systems approaching flight demonstration.[111]

ICON, known for its advanced 3D printing technology for homebuilding on Earth, is also developing autonomous lunar construction through its Olympus platform, which uses Laser VMX (Vitreous Multi-material Transformation) to convert lunar regolith into landing pads, roads, and habitats.[112] Backed by a US$57.2 million NASA award, the company is advancing technologies for in-situ lunar infrastructure and has already tested 3D-printed pad structures with built-in exhaust channels designed to contain dust during launch and landing—a critical feature for repeated lunar missions.[113]

Construction technology extends beyond the hardware itself. NASA is leveraging Caterpillar’s simulation technology to develop the In-Situ Pilot Excavator (IPEx), a robotic excavator designed to support future lunar infrastructure projects.[114] The technology may allow engineers to model lunar soil conditions and test excavation concepts before deploying equipment to the surface.

But much of this infrastructure carries a second, less obvious significance. International agreements such as the 1967 Outer Space Treaty and the more recent Artemis Accords provide a legal framework for lunar activities, but ambiguity in that framework creates debate about who can control what on the Moon.[115]

As activity accelerates around a small number of strategically valuable locations, these questions are becoming increasingly important. Economist Jim Zukin notes that while international law bars national appropriation of the Moon, "It appears to not bar ownership of what you place on it. Landing pads, spaceports, moon bases, data centers, power grids, hotels—all can be owned, leased, even tokenized."[116] For governments and companies alike, building first may be as much about strategic positioning as about physical infrastructure.

But the question is, who actually does this work? Robots or humans? The economic case for robots is clear. As Zukin puts it, "When you put people into the mix, you dramatically increase your budgets. However, human judgment is essential from day one as operations grow more complex, so the best case is a hybrid of the two."[117] Where the line between robot and human ownership falls shapes the cost, the timeline, and the pace at which a lunar economy can develop.

Robots can do much of the early work, but a permanent presence ultimately requires humans. And keeping people alive changes mission requirements entirely.

LIFE SUPPORT

Keeping people safe and healthy

Robots don't need to breathe. They don't need pressurized shelter, food, or clean water. Humans do, bringing an entirely different set of infrastructure needs.

Sustaining human activity on the Moon would depend on addressing challenges across multiple levels, from the suits used during surface operations to the habitats, life-support systems, and medical infrastructure that support crews inside. These systems would need to operate reliably in a challenging lunar environment.

Radiation exposure remains one of the largest unresolved biological threats. "There's no magnetic field on the Moon to protect it from a solar storm," says Dr. Jonathan Cirtain, CEO and President, Axiom Space.[118] A single solar event can deliver dangerous radiation doses with little warning, and there is no proven solution yet for long-duration protection on the surface.[119] Until one exists, every crewed mission carries a risk that cannot be fully mitigated.

The spacesuit alone is one of the most complex pieces of equipment astronauts rely on—a wearable life support system responsible for pressure, thermal regulation, communications, and radiation protection. Axiom Space was awarded its first US$228 million NASA contract in 2022 to develop the next-generation spacesuit, the Axiom Extravehicular Mobility Unit (AxEMU), for Artemis lunar missions.[120]

Axiom did not build the suit alone. Its outer layer was co-designed not by a defense contractor, but by Prada, drawing on decades of experience in advanced textiles and materials engineering.[121] Oakley, known for precision optics in extreme environments, developed the gold-coated visor, designed to maintain visual clarity as conditions swing from total darkness to unfiltered solar exposure.[122]

> ***"We don't have to develop these things on our own. As we expand into space, we want to take the best of the best with us."***
>
> **- Dr. Jonathan Cirtain, CEO and President, Axiom Space[123]**

The spacesuit is only the beginning. On the Moon, even the basics of survival become complex engineering challenges. Every liter of water and every breath of oxygen needs to be either recycled continuously or produced locally for a crew to survive without constant resupply. These Environmental Control and Life Support Systems (ECLSS) have been tested on the International Space Station, where they currently recover up to 98% of water but only about 50% of oxygen from CO_2.[124]

Improving the rate of consumables recovery is the central technical challenge, and Dr. Cirtain describes ECLSS as "the lowest technical readiness level component" of the whole architecture.[125] Until these systems advance, most consumables will need to be launched from Earth at costs that can reach hundreds of thousands of dollars per kilogram.

Beyond the habitats, medical care remains largely unsolved. Space medicine today focuses on astronaut selection, pre-flight preparation, on-orbit monitoring, and post-flight recovery, not on performing surgery on another world. The logistics alone are daunting—pharmacy, blood banking, and diagnostic equipment consume far more space than the operating room itself.

"Sparky" Matthews M.D., first Surgeon General (Acting) of the US Space Force, frames three requirements when it comes to space medicine: the ability to treat the patient on the lunar surface, to evacuate rapidly if needed, and to transport them back to Earth.[126] Emerging technologies like 3D bioprinting, which could one day produce blood cells and medications on demand, may begin to change that calculus. "That would be a sea change," Dr. Matthews says. "That would change everything in medicine, both in space and on Earth."[127]

Infrastructure is only the first chapter of the story, as its real significance lies in the industries, markets, and opportunities it could enable. Part II explores a sample of these opportunities in detail.

PART II

WHAT IT MAKES

The possibilities the lunar economy could create

WHAT IT MAKES

The possibilities the lunar economy could create

In preparing this report, we set out to answer a simple—but not simplistic—question: what value does a sustained presence on the Moon create?

Governments have several established motivations for returning to the Moon, including science, national security, strategic positioning, and long-duration space capabilities. A sustained lunar economy, however, would likely require demand beyond government programs alone. The longer-term opportunity will depend in part on whether the infrastructure being developed today can support value beyond individual government missions.

Across dozens of interviews with operators, investors, engineers, and policymakers, the answers to our central question varied wildly. Some pointed to propellant, others to resources, data, or tourism. Even among the most experienced voices in the field, few could point to a single outcome with certainty.

If there was one point of consensus, it was that the uncertainty itself is part of the story.

History shows that when governments invest in foundational infrastructure, entirely new markets often follow. GPS was built for military navigation but has since contributed more than US$1.4 trillion to the US economy alone, enabling industries from precision agriculture to financial trading.[128] The lunar economy may be following the same pattern, but it faces a sequencing problem. As Evan Jensen, formerly of ICON, put it: "You wouldn't open a barbershop in the middle of the desert—no customers, no roads, no adjacent businesses."[129] Many of the opportunities discussed throughout this section only become possible once the underlying infrastructure exists.

What follows is a sample of the strategic, economic, scientific, and broader opportunities that could emerge from a sustained presence on the Moon. Some may become significant, while others may not materialize. Although there's no way yet to know exactly where the greatest value may emerge, these are among the opportunities currently attracting investment, talent, and interest in lunar activity.

The opportunities explored in this section are ordered from the most immediate and tangible to the most speculative and long-term. Some are already shaping investment and policy decisions, while others depend on capabilities and markets that have yet to fully emerge.

Together, they illustrate some of the ways a sustained lunar presence could create value in the decades ahead.

NATIONAL SECURITY

The ultimate high ground

The most immediate demand signal for lunar infrastructure may come from national security and intelligence organizations, which already spend heavily in space.

Cislunar space encompasses a volume over 1,000 times that of geosynchronous orbit, yet no current capability can meaningfully monitor it.[130] Sensors designed to track objects in low Earth and geostationary orbit lose effectiveness at lunar distances, creating a growing blind spot as activity beyond Earth orbit accelerates.[131]

The Department of War is already beginning to respond. In April 2026, the US Space Force stood up a Cislunar Coordination Office, led by Dr. Jaime Stearns, to determine how the service should operate beyond traditional Earth orbit.[132]

> ***"Where US interests go, it's imperative that national security follow. If we want to protect those interests, we need to learn how to operate in cislunar space."***
>
> **- Dr. Jaime Stearns, Director, DAF Cislunar Coordination Office[133]**

Dedicated cislunar hardware is already in development. The Air Force Research Laboratory is developing Oracle Prime, the first satellite designed for sustained operations at the L1 Lagrange point between Earth and the Moon, with delivery expected in 2028.[134] The experimental satellite will likely attempt to detect and track objects where no persistent monitoring exists today, an early step toward space situational awareness (SSA) in a region that has already seen a significant increase in activity in the last five years and is only expected to increase.

The US Space Force does not currently have official cislunar operations or acquisition programs, but it is actively evaluating how cislunar requirements should fit into the broader national security enterprise. One potential path is folding lunar capabilities directly into existing offices and operational functions, making cislunar part of the same USSF programs that already handle Earth orbit.[135]

Space defense is already a large and rapidly growing market. The US Space Force's proposed budget for FY27 is US$71.1 billion,

a 124% increase from FY26, reflecting the growing strategic importance of space across national security missions.[136]

While not focused on cislunar operations, initiatives such as Golden Dome, the US administration's effort to build a layered missile defense architecture capable of detecting and intercepting threats from orbit, are driving significant investment into space-based capabilities. The US$3.2 billion in Golden Dome interceptor contracts awarded to date span traditional primes alongside emerging space companies, several of which are simultaneously developing commercial cislunar capabilities.[137]

The overlap is not incidental. Much of the infrastructure the military is funding for operations in Earth orbit, including sensing, communications, power systems, and autonomous operations, may also be required for a sustained lunar presence as previously described in **Part I: What it Takes** of this report.

Companies like Turion Space reflect this overlap, developing sensing and imaging capabilities that aim to help address near-term national security and intelligence needs while laying the foundation for navigation, resource mapping, and site selection across the emerging cislunar economy. As Ryan Westerdahl, Founder and CEO of Turion Space, noted, "On Earth, every major economic domain depends on visibility. Cislunar space will be no different."[138]

This pattern has played out before. Earth observation began as a government-funded national security capability before evolving into a commercial market that now underpins industries across the global economy ranging from agriculture and logistics to insurance, finance, disaster response, and climate monitoring. According to a Deloitte and World Economic Forum analysis, it is projected to unlock US$3.8 trillion in cumulative global GDP growth by 2030.[139] The value of Earth observation today reflects decades of sustained national security investment that enabled commercial innovation. Cislunar infrastructure may follow a similar development model, with defense investment funding the initial infrastructure and capabilities before broader commercial markets emerge around them.

In fact, our Deloitte analysis estimates that national security activity in the lunar economy could potentially generate US$31 billion in economic value through 2050 under the accelerated growth scenario.

While national security may help justify the first wave of investment, long-term sustainability may require a broader set of customers and markets. That raises the next question: what commercial value could a permanent presence on the Moon create?

LUNAR DATA & SERVICES

Signals from the surface

One of the largest markets created by the commercialization of LEO was data. Today, satellite data services represent a roughly US$12 billion market, while enabling far larger industries that rely on geospatial intelligence to optimize operations, manage risk, and make real-time decisions.[140] Lunar data is still in its infancy, but some of the earliest signs of a similar market are already beginning to emerge.

In 2025, NASA paid US$10 million for 120 gigabytes of data from Firefly Aerospace's Blue Ghost Mission 1, including HD imagery of a lunar sunset, communication and propulsion performance data, and scientific data beyond the original scope.[141] High-definition imagery and video from the surface might also carry additional commercial value for entertainment, documentaries, gaming, and licensing, as demonstrated by the widespread global attention surrounding Artemis II imagery.

Terrestrial industries could have their own reasons to buy. The Moon offers a unique environment for understanding how materials, equipment, and systems perform under extreme conditions, including vacuum, abrasive dust, radiation exposure, and dramatic temperature swings. Data on durability, thermal management, dust interaction, and long-term system performance could have applications for companies developing advanced materials, industrial equipment, and other technologies designed for demanding operating environments. Research institutions and governments represent additional potential buyers for surface, subsurface, and geospatial datasets.

These data markets are still nascent and developing, but they share a trait that most lunar commercial customers lack: the buyer doesn't need the rest of the lunar economy to exist first. AJ Gemer, CTO of Lunar Outpost, sees these data products as both a revenue stream and a recruitment tool: "Once people can see the Moon in high definition, they can more easily imagine their own business case for operating there."[142]

The challenge is that the industry hasn't figured out how to sell what it collects. Lander companies are sitting on gigabytes of mission data with no clear path to market. As Mehak Sarang of Open Lunar described it, without visibility, "nobody knows what anybody else has collected, and nobody knows the true value of that data until there are people who are making it valuable."[143] Open Lunar is trying to change that by convincing operators to simply publish what datasets they have—a first step toward matching supply with demand in a market that hasn't organized itself yet.[144] Startup Potomac Database Systems is approaching the problem from the other direction, building a business around deploying low-cost missions specifically to collect novel lunar datasets.[145]

Volta's Damphousse offers a useful reminder: "Look at the history of the commercial space economy. The biggest chunk has always been the ones and zeros that fly through the medium—communications, weather data, intelligence and reconnaissance, imagery, and tracking."[146] If the lunar economy follows the same pattern, data products could account for a meaningful share of the lunar economy.

NEW RESOURCES & MATERIALS

Tapping into the lunar landscape

The Moon may look barren, but not everyone sees it that way. The lunar surface contains a range of potentially valuable resources, including water ice, titanium- and aluminum-rich minerals, rare earth elements, trace platinum group metals, and helium-3.[147]

Among these, helium-3 has emerged as a closely watched opportunity due to its potential applications in quantum computing, national security, and nuclear fusion, while lunar water ice could be split into oxygen and hydrogen to produce rocket fuel. Together, these resources illustrate how lunar materials could support markets both on Earth and throughout cislunar space, which could represent an estimated US$115 billion in value through 2050 under the accelerated growth scenario in Deloitte's economic analysis.

HELIUM-3

Helium-3 is a rare isotope with an unusual set of properties that make it valuable across several industries at once. It enables cooling to just above absolute zero, far colder than any known natural environment, which makes it indispensable to superconducting quantum computers.[148] It is also exceptionally good at signaling the presence of neutrons, making it useful in sensors that, for example, could screen cargo at borders for hidden nuclear materials.[149] And it could one day fuel a cleaner form of nuclear fusion, a nearly neutron-free reaction that could allow direct conversion of fusion energy into electricity, reducing some of the engineering challenges that plague conventional fusion approaches.[150]

The problem is supply. On Earth, helium-3 is produced in small quantities as a byproduct of nuclear reactors which is tightly controlled and fundamentally limited.[151] "We can't even meet today's demand, let alone what quantum computing, fusion, and national

security will require in the future," said Indra Hornsby, co-founder and COO of Interlune, a company developing technology to harvest helium-3 from lunar regolith.[152]

The Moon offers a different picture. Without a global magnetic field to deflect the solar wind, its surface has accumulated helium-3 over billions of years, embedded in the regolith in quantities that far exceed anything available on Earth.[153] In 2022, Chinese researchers confirmed its presence and measured its concentration and extraction parameters in lunar samples returned by the Chang'e-5 mission.[154]

Since 2015, US law has recognized the right of private companies to extract and sell space resources, a position reflected by a 2020 executive order and supported by the Artemis Accords framework.[155] Several companies are now racing to be among the first to extract and sell lunar resources.

Interlune, for example, has signed more than US$500 million in offtake agreements as of March 2026, including a deal with Bluefors, a leading manufacturer of ultra-low-temperature refrigeration systems used in quantum computing.[156] At current prices, often cited around US$20 million per kilogram, the economics are compelling, at least on paper.[157] Other players include Black Moon Energy, whose founders built their careers in the oil and gas industry and are now bringing that experience to the lunar surface.[158] The company is collaborating with NASA's Jet Propulsion Laboratory (JPL) and Caltech on its Fusion 1 mission to survey and delineate a production zone for commercial-scale extraction in the mid-2030s.[159]

The challenge is that helium-3's most promising markets are still emerging. Quantum computing and national security applications are creating early commercial demand that is expected to grow substantially over the next decade, with the quantum computing market projected to reach between US$43 billion and US$71 billion by 2035.[160] Nuclear fusion could create a much larger source of demand, but its commercial timeline remains uncertain, and many near-term reactor designs do

not require helium-3 at all.[161] As a result, the commercial viability of lunar helium-3 extraction depends not only on the ability to harvest the resource, but on how rapidly these downstream markets mature.

LUNAR PROPELLANT

Space travel has a fuel problem, and it's baked into the physics. The challenge is known as the rocket equation: the farther you want to go, the more fuel you need—but carrying more fuel means carrying more weight, which demands still more fuel.[162] The math compounds exponentially. It is the reason a kilogram of rocket fuel could cost about a dollar on Earth, roughly US$4,000 in low Earth orbit, and US$36,000 on the lunar surface if shipped from home.[163]

Lunar propellant flips this equation. Water ice or oxygen bound in lunar soil can be processed into liquid oxygen and liquid hydrogen, the same propellants used by most rockets.[164]

"Water ice is the oil of the Moon," says economist Jim Zukin.[165] If unlocked at scale, it could do for space what gas stations did for the road: reduce the cost of existing trips, and make entirely new ones possible, creating a network linking every station, city, and state with fuel and a delivery infrastructure.

In geostationary orbit, spacecraft worth roughly US$100 billion were retired over the past decade simply because they ran out of propellant, which is why companies like Orbit Fab are already building infrastructure to extend satellite lifespans through on-orbit refueling.[166] Lunar-produced fuel could eventually feed into systems like these. But the bigger promise of lunar propellant lies beyond Earth orbit. It potentially opens the door to missions that current economics might rule out, such as Mars transport, sustained in-space logistics, and the long-envisioned prospect of asteroid mining.

A single platinum-rich asteroid is estimated to hold US$25–50 billion in precious metals, but the cost of launching equipment and propellant from Earth remains a major barrier to large-scale commercial extraction.[167] Lunar fuel could improve that calculus. The cheaper the propellant, the more missions become viable, which generates more demand: a self-reinforcing flywheel.

The bull case for lunar propellant has no shortage of skeptics. AstroForge co-founder and CEO Matt Gialich maintains that "there is simply no market for in-space propellant today, despite the technology's theoretical validity."[168] In addition to supply-side challenges, the near-term demand for fuel runs almost entirely through NASA, exposing the business to budget politics and program shifts. Meanwhile, SpaceX's Starship, the highest capacity cislunar vehicle in development, relies on orbital refueling from Earth-launched tankers.[169] And if launch costs continue to fall and refueling architecture scales as planned, it could undercut the case for lunar production before it ever reaches scale.[170]

But as Voyager Technologies' Mike Lewis pointed out, the real comparison isn't price: "That's a pound less that we don't have to bring. It's also physically a pound that we couldn't have before."[171] Every kilogram of propellant sourced locally frees up launch capacity for higher-value cargo, from scientific equipment to the materials and infrastructure needed to expand a sustained lunar presence.

Either way, between the physics and the flywheel lies a construction project of enormous scale. Extraction systems, processing plants, cryogenic storage, power generation, and transportation infrastructure all have to be built and operated in one of the harshest environments imaginable. No funded program currently integrates commercial-scale production, and Zukin, while bullish on the long-term case, places the credible timeline for commercial production in the 2030–2035 timeframe—a horizon that has limited venture capital and kept much of the institutional capital on the sidelines, even as the technical case has strengthened.[172]

Before any of that can happen, there is a more basic uncertainty. Orbital missions have confirmed water ice at the lunar poles, but important questions remain about how concentrated it is, how deep it lies, and how difficult it may be to extract.[173] NASA's VIPER rover, slated for a mission to the lunar South Pole in 2027, is designed to begin answering those questions.[174] Until then, many business cases for lunar propellant rest on geological assumptions that have not yet been proven.

IN-SPACE PRODUCTION

A new frontier for manufacturing

Not all lunar resources need to return home. As activity in orbit and on the Moon expands, some of the most compelling markets may emerge from using lunar resources to support activity already taking place in space. Space-based compute offers one example of how the Moon's unique environment and available resources could create new possibilities for manufacturing beyond Earth.

SPACE-BASED COMPUTE

Until recently, the idea of putting data centers in space was on the margins, but now, some of the largest technology companies in the world are actively pursuing it. Google announced Project Suncatcher, an initiative to deploy satellite clusters for compute in orbit; NVIDIA has unveiled hardware purpose-built for space; and Starcloud has trained the first machine learning model in orbit.[175] In January 2026, SpaceX requested permission from the FCC to launch 1 million space-based data-center satellites.[176]

The shift has been remarkably fast, driven by a problem that terrestrial infrastructure is struggling to solve. Compute demand is outpacing the infrastructure needed to support it, pushing the industry to look beyond Earth.[177] As Dr. Philip T. Metzger, planetary physicist and co-founder of NASA's Swamp Works lab, put it: "The emergence of AI and the potential for it to grow without an upper limit on demand will inevitably cause it to be pushed off the planet."[178]

Orbital data centers offer a potential path around some of the biggest constraints facing terrestrial AI infrastructure. Satellites can access near-continuous solar energy and reject heat through radiative cooling, reducing dependence on Earth-based power and cooling infrastructure.[179] But the more compelling advantage may be speed. Nearly half of planned US data centers are delayed or canceled as grid capacity, cooling water, land availability, permitting timelines, and community opposition become growing constraints.[180] In a market where compute demand continues to outpace available supply, bringing capacity online years faster may matter more than cost differences alone.[181]

The challenge is scale. Orbital data centers require vast amounts of supporting infrastructure, including solar arrays, radiators, structural frameworks, and radiation protection.[182] While early systems can be launched from Earth, a mature orbital compute economy would require moving enormous quantities of material into space. Delivering that mass from Earth would require a dramatic increase in launch activity, eventually creating atmospheric damage. Dr. Metzger's conclusion: "We're going to have to manufacture the hardware in space using local resources."[183]

If orbital infrastructure may need to eventually be manufactured in space, the Moon may be a logical place to start. Its shallow gravity well and potential resource base could make it a plausible location for producing the structural mass that a future orbital compute economy might require. SpaceX's S-1 prospectus hints at where this could lead, describing a future of "terawatt-scale annual AI compute growth" and envisioning lunar manufacturing facilities capable of producing and launching satellites directly from the Moon.[184]

Over the longer term, the compute itself may begin moving outward as well. As lunar operations scale, Earth-Moon latency may likely make real-time inference from Earth and orbital data centers impractical, suggesting an eventual need for compute hosted on the lunar surface itself. Organizations like NASA's JPL envision lunar data centers one day powering the autonomy stacks needed to drive advanced robotics on the Moon.[185] Meanwhile, companies such as Lonestar Data Holdings are actively developing lunar data centers, positioning the Moon as a uniquely secure location for resilient data storage, disaster recovery, and critical digital infrastructure.[186]

Among emerging cislunar industries, compute has the potential to become a meaningful demand driver for adjacent markets. Power generation, transportation, manufacturing, communications, and propellant could find potential customers in a space-based compute industry that has only recently begun to attract serious attention. Global AI infrastructure investment could total roughly US$7.6 trillion between 2026 and 2031, suggesting that even if only a small share of that investment shifts beyond Earth, it could create meaningful opportunities across the lunar economy.[187] As Dr. Metzger put it, "If AI goes to space, it drags everything else up with it."[188]

MARKETS IN THE MAKING

A sustained lunar presence could unlock entirely new commercial markets, many of which remain early-stage and dependent on infrastructure still being built.

LUNAR DATA & SERVICES

Lunar imagery, scientific data, and mission insights delivered as commercial products and services.

HELIUM-3

A rare isotope found in lunar regolith, with potential applications in fusion energy, quantum computing, and national security.

LUNAR PROPELLANT

Rocket fuel produced from lunar water ice, enabling more efficient transportation throughout cislunar space and beyond.

SPACE-BASED COMPUTE

Cislunar computing infrastructure built to expand AI capacity beyond terrestrial constraints.

It is still too early to know which, if any, of these opportunities could emerge as meaningful markets, or when they might reach commercial viability. As Brendan Rosseau, co-author of *Space to Grow*, a Harvard Business School study of the emerging space economy, notes: "Some surprising companies and use cases can really be valuable, so we shouldn't be total skeptics. But companies who say they're going to generate commercial demand really quickly—that should raise a red flag."[189]

The opportunities visible today may not be the ones that matter most a decade from now, but they offer an important window into where the market is beginning to take shape.

At the same time, market estimates tell only part of the story. Some longer-term outcomes of a sustained lunar presence may be reflected not only in economic value, but also in innovation, scientific discovery, and inspiration—which based on methodology outlined in the Appendix, could potentially contribute US$541 billion in additional value beyond the market transactions of the lunar economy.

INNOVATION & SCIENTIFIC DISCOVERY

Moonshots that pay dividends on Earth

A near-term return from lunar investment may be its potential to help solve challenges on Earth. Building and operating on the Moon requires overcoming significant engineering challenges, and technologies developed for those conditions may also find applications closer to home.

Construction technologies developed for lunar landing pads, roads, and habitats, such as ICON's Project Olympus, could advance automated construction and additive manufacturing techniques on Earth, particularly in remote environments where transporting building materials is difficult or expensive.[190] Cellular networks being developed to function on the lunar surface, where there are no towers, no fiber, and no line of sight, are stress-testing connectivity solutions for the most constrained environments on Earth.[191]

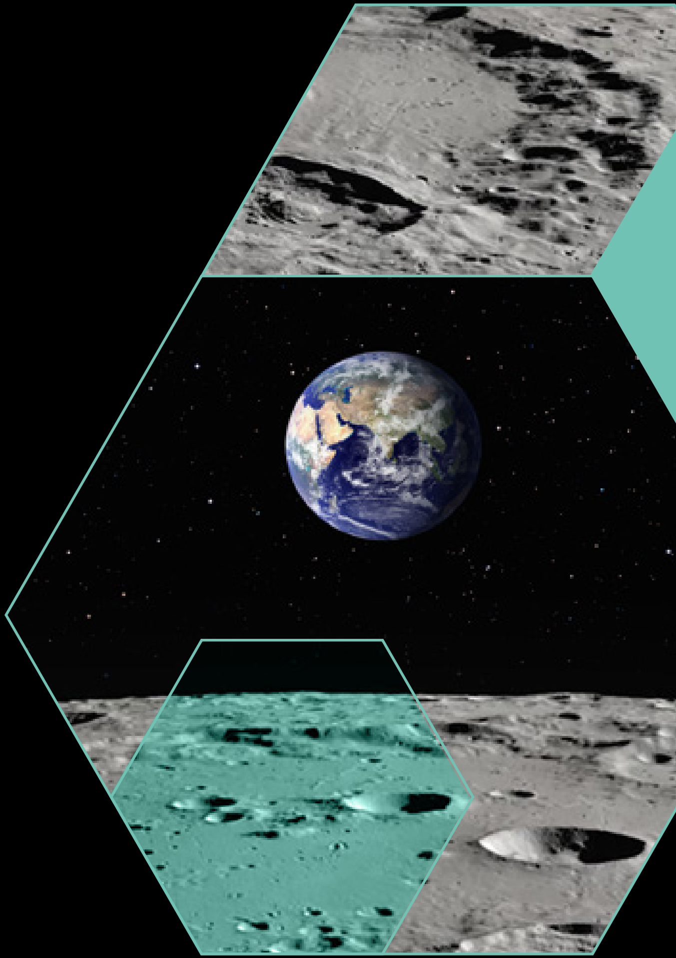
The commercial value of these capabilities is already becoming apparent. Meta recently signed an agreement with Overview Energy for up to 1 GW of future space-based solar capacity, using satellites to beam energy to existing solar farms so data centers can access power after dark.[192]

Dr. Sparky Matthews treats this innovation spillover as a given:

> ***"We will find terrestrial applications for anything that we do in space. If we don't, it's a failure of imagination on our part."***
>
> **- Walter "Sparky" Matthews M.D., First Surgeon General (Acting) of the United States Space Force[193]**

His team at Baylor is already 3D printing surgical instruments from simulated lunar regolith and scrap metal—technology that could one day allow medical supplies to be manufactured on-site in remote regions rather than shipped from thousands of kilometers away.[194]

While many of the commercial markets may take decades to mature, the innovations required to build them could create value well before a sustained lunar economy takes shape.



HUMAN INSPIRATION

Going beyond the balance sheet

Of the opportunities discussed in this report, none may be as important as what space exploration does for the collective human psyche.

The Moon occupies a unique place in human consciousness. It is the one celestial body every person on Earth can look up and see. Intuitive Machines' Fischer captures that sentiment simply: "the Moon connects with our hearts." It resonates on a level that precedes any economic argument.[195]

That resonance has tangible effects. Apollo produced a generation of engineers, scientists, and operators whose contributions extended far beyond aerospace. The early signs suggest Artemis is doing the same. Just one month after the Artemis II lunar flyby, registrations at Space Camp, a program that counts NASA Administrator Jared Isaacman and astronaut Christina Koch among its alumni, had doubled.[196]

This helps explain why private ventures such as GRU Space report accepting million-dollar deposits from customers hoping to stay at a lunar hotel in the coming decades.[197] Whether such projects succeed is almost beside the point. The willingness to spend extraordinary sums for the chance to visit the Moon illustrates the power it continues to hold over the human imagination.

When astronauts return to the surface in 2028, it will likely be the first Moon landing that billions of people can watch live, in real time, in high definition. Robert P. Mueller of NASA estimates that "for every person who works in space, ten or twenty more are inspired by it, drawn into STEM fields and the broader innovation economy."[198] A generation that grows up taking a lunar presence for granted may find uses for it we can't even begin to fathom just yet.

CONCLUSION

We began this report with a question about commercial markets. We came away with a different one: what happens when infrastructure beyond Earth becomes permanent?

The Moon has existed for four and a half billion years.[199] For nearly all of that time, it has been unreachable. Now, for the first time, it is becoming a place where humanity might live, work, and build beyond Earth.

We are at the beginning of that story, and today, much of the focus is on building the infrastructure that could make a sustained human presence on the Moon possible. Governments are funding launch systems, power networks, communications architecture, and construction capabilities that may shape what is feasible on the lunar surface.

What is yet to be mapped, however, is what that infrastructure makes possible once it exists. The commercial opportunities explored in this report are the ones visible today. Some may prove out. Others not yet known may ultimately matter more. New infrastructure tends to invite uses its builders never anticipated, and if that pattern holds, the lunar economy could develop in ways that are difficult to predict from here.

This is precisely why our economic analysis considers two scenarios: an estimated cumulative economic value through 2050 of US$343 billion under a conservative growth scenario and US$566 billion under an accelerated growth scenario.

How these scenarios develop may depend on whether commercial activity can remain viable beyond government funding cycles, and on which companies, industries, and nations participate early as the underlying architecture continues to take shape.

The stakes look different depending on where you sit.

For governments
The infrastructure being funded today is setting the standards and norms that may govern lunar activity for decades. The countries that build first may likely shape the rules.

For space companies
The ones gaining traction are designing for multiple customers, building interoperable systems, and operating on commercial timelines. A competitive advantage in this market is compatibility.

For industries beyond space
A thriving lunar economy is unlikely to be built by the space sector alone. It will likely draw on capabilities from across the broader economy, including advanced manufacturing, logistics, robotics, communications, energy, and materials. Some of the companies that contribute to the lunar economy may never even think of themselves as space companies, though they may be playing a

critical role. For many organizations, the opportunity may begin with supplying technologies and components, licensing intellectual property, forming strategic ecosystem alliances, or adapting existing products and services for the lunar economy.

For everyone else

The technologies developed for the Moon may reshape industries on Earth, creating new innovations that inspire humanity to dream bigger. When actual moonshots become routine, how could our collective perspective on what's possible not change?

Fifty years ago, we went to the Moon to prove we could. Now, we're going with the goal of staying.

We don't know what new possibilities may unfold in the next 50 years to come, but that might very well be the most exciting part.

As Neil Armstrong said in his 1969 address to the US Congress: "Who knows what mysteries will be solved in our lifetime, and what new riddles will become the challenge of the new generations?"[200]

For the first time in more than half a century, we now have the opportunity to find out.

ACKNOWLEDGMENTS

Our insights can help you navigate the emerging space and lunar economy.
If you're looking for fresh ideas to address your business challenges, let's talk.

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SPECIAL THANKS

Our deepest gratitude to the colleagues and friends who made this possible.

Georgia Parris for being at the heart of this report from the very beginning. Your leadership, organization, and tireless effort brought every detail together. There is no version of this work without you.

Conor Lepore and Rishi Pania for driving the research and shaping the story at every turn. You brought the rigor, curiosity, and perspective that made this report what it is.

Leila Bouhussein, Mark Osis, Sejal Rai, Ariel Spektor, and Bella Stash for bringing the broader NExT perspective to this work. You challenged our thinking, brought energy when the path felt unclear, and helped us see the lunar economy through a wider lens.

Charlie Hudson, Liesda Marsdon, Pradeep Philip, Morgan Richards, Kai Song, and Preston Tsamassiros for taking on one of the hardest questions in this report: how to size an economy that barely exists yet. You brought rigor and defensibility to an uncertain market and helped turn a speculative opportunity into a grounded economic story.

Makarand Kukade, Paulina Limaselle, Heidi Morrow, and Katie Tran for turning a complex, speculative story into something clear, beautiful, and engaging. Your design skills shaped how this report feels and brought the lunar economy to life on the page.

Diane Ashley, Christina Canavan, Jerry Cook, Sarah Horn, Mike Kuchler, and Carey Miller for pushing us to think more deeply, more carefully, and more honestly about the space industry. You challenged assumptions, surfaced nuance, and kept this report grounded in real experience.

Mike Brinker, Scott Buchholz, Teddy Clamp, Joey Couture, Kyle Engle, Michael Gretczko, Bifford Lyons, Logan Marcus, Joe Mariani, James Planeaux, and Adam Routh for lending your experience, perspective, and thoughtful feedback as this work took shape. You helped us pressure-test the ideas and strengthen the story.

Kashima Atwood, Heidi Boyer, Colleen Bullett, Gabriela Camacho, Lindsay Flanagan, Jennifer Gladstone, Tracey Parry, Melanie Pelouze, Chandni Shah, and Sarah Taillon for helping us think beyond the report itself to the story it could tell and the audience it could reach. Your insight helped shape how this work is shared and elevated it at every step.

Caroline Brown, Ed Burns, Ben Hebbe, Bri Henley, and Kelly Raskovich for your unwavering support and collaboration along the way. Your help behind the scenes made this possible.

APPENDIX

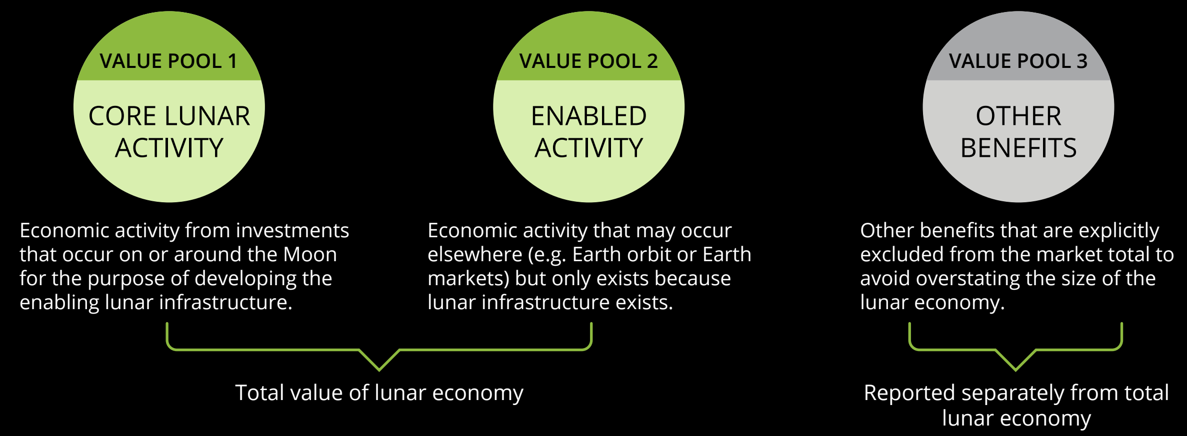
ECONOMIC ANALYSIS

The previous sections of this report explored what it will likely take to establish a sustained presence on the Moon and the opportunities that such a presence could unlock. The next question is economic: how large could the lunar economy become, and where might that value come from?

Projecting the value of an economy that does not yet exist requires more than estimating the cost of missions or the value of individual industries. It requires understanding how infrastructure, technology, policy, and commercial adoption interact over time.

To do so, the analysis is structured around the same framework used throughout this report. The first value pool, the core lunar activity, quantifies the infrastructure and operations described in Part I: What it Takes. The second, enabled activity, quantifies the downstream economic value explored in Part II: What it Makes.

Figure 1: The framework of the lunar economy size evaluation



Source: Deloitte analysis (2026)

Together, these two value pools provide a framework for understanding both the investment required to build a sustained lunar presence and the value that presence could ultimately create. In addition, a third value pool captures the broader benefits of lunar exploration including human inspiration, the value people place on research with an unknown payoff, and the innovation spillovers that are likely to materialize from the technological leaps required to unlock the lunar frontier.

ANALYTICAL FRAMEWORK

Value Pool 1: Core Lunar Activity

The six lunar sectors discussed below each include a range of underlying activities that may help enable broader lunar economic activity, as outlined in **Table 1**. While these activities are not intended to be an exhaustive list of everything that may be needed to develop foundational lunar infrastructure, they illustrate several potential drivers of value.

The calculation for each activity is illustrated by the following equation. Under this approach, annual economic activity is estimated based on the projected unit price for a given year and the estimated quantity required.

$$Activity_{(i,t)} = (Unit\ price_{i} * Unit\ price\ profile_{(i,t)}) * Quantity\ profile_{(i,t)}$$

Table 1: Core lunar sectors and their constituent parts

Sector	Definition	Underlying activity
Transportation	Movement of cargo and crew across the Earth–orbit–Moon system, including launches, landers, and cislunar transfer.	• Payload delivery • Support launches • Insurance • Crewed mission, Earth return, and recovery • Cislunar transit, staging, and coordination
Energy and power	Generation, storage, and distribution of energy such as solar, nuclear, and grid infrastructure.	• Power generation • Power distribution • Batteries and storage
Communications and navigation	Communications and positioning systems linking the lunar surface, orbit, and Earth.	• Surface network infrastructure • Orbital relay and navigation constellation • Earth-based ground stations and mission operations
Surface mobility	Surface transport of crew, equipment, and materials by rovers.	• Rover construction • Fleet operations • Maintenance and servicing
Construction	Building fixed infrastructure on the lunar surface, including pads and roads.	• Site preparation and landing pads • Fixed surface infrastructure
Life support	Systems and consumables required to sustain human life, including habitats, food and water, recycling systems, and clothing (e.g., extravehicular activity (EVA) spacesuit).	• Surface habitats • Environmental control and life support systems • EVA suits and systems

Source: Deloitte analysis (2026)

For each sector, i represents the underlying activity and t the relevant year. Quantity for each activity is based on a projection of an underlying driver sourced from the literature and published plans for lunar surface habitation. Specifically:

- **Transportation** is driven by the number of lunar missions and payload mass delivered to the lunar surface
- **Energy and power** is driven by the megawatts (MW) of electricity required to sustain lunar surface operations
- **Communications and navigation** is driven by the number of satellites and communication nodes in operation
- **Surface mobility** is driven by the number of vehicles supporting surface activity
- **Construction** is driven by the volume of fixed surface infrastructure
- **Life support** is driven by the number of person-days on the lunar surface

The initial unit price for each activity was estimated using a range of inputs, including published literature, consultation with subject matter specialists, and selected terrestrial proxies where relevant. The model further assumes that efficiency gains may occur over the modeled period, which are reflected as declines in unit price. These efficiency assumptions are based on:

- **Published estimates** such as the projected decline in per kilogram (kg) transport costs associated with improved rocket reusability and economies of scale
- **Learning rates** that reduce unit costs as cumulative activity increases and knowledge builds. For example, the unit cost per kilowatt-hour (kWh) of installed battery capacity falls by 10% each time total installed capacity doubles. The rates were selected based on reasonable proxies from aerospace, power, and infrastructure research.

Value Pool 2: Enabled Economic Activity

The estimates included in Value Pool 2 relate to commercial activities that can be realized once the core lunar infrastructure has been established. In other words, Value Pool 1 unlocks the activity that is included within Value Pool 2.

This approach is intended to reflect the uncertainty associated with several use cases while recognizing their potential economic significance if realized.

To avoid overstating estimated contributions, and to account for differences across use cases, the analysis applies three distinct methodologies depending on whether an activity displaces existing activity, supports an emerging market, or remains speculative in nature.

Classifying the value pool in this way reflects the relative maturity of the underlying technologies and the different ways value may be realized. The resulting estimates are then translated based on how that value could manifest within existing economic systems.

Approach 1: Replacement

An activity is assigned to the **replacement calculation** where the lunar use case is expected to replace, or compete directly with, existing terrestrial or space-based activity. These use cases involve established incumbent markets for which a counterfactual can be reasonably observed.

The calculation methodology for these markets is illustrated by the equation below and is driven by the share of lunar-produced activity assumed to displace existing market activity. For example, over time, lunar-supplied helium-3 may compete with terrestrially supplied helium-3 in existing applications such as neutron detection, cryogenics, and scientific instrumentation.

$$\textit{Activity}_{(i,t)} = (\textit{Replacement share}_{(i,t)} * \textit{Addressable market volume}_{(i,t)}) * \textit{Lunar unit price}_{(i,t)}$$

Approach 2: Nascent

For an activity to be categorized as **nascent,** it is assumed to operate in markets that do not yet exist at scale but are believed to have credible demand drivers and early adoption signals, meaning demand is identifiable but immature, often being contemporarily government-led and highly dependent on enabling lunar infrastructure.

The calculation methodology for these markets is represented by the equation below and is driven by market volumes and growth rates applicable to the relevant market. For example, the in-space propellant refueling market is indicatively sized based on in-space activity and existing growth rates in the orbital refueling market, which is used as a proxy for lunar activity.

$$\textit{Activity}_{(i,t)} = (\textit{Theoretical market volume}_{i} * \textit{Growth rate}) * \textit{Lunar unit price}_{(i,t)}$$

Approach 3: Speculative

An activity is classified as **speculative** where its commercial use case is long-term in nature or depends on markets that are not yet well defined, such that feasibility remains uncertain. These activities often depend on unresolved technology pathways, lack near-term commercial demand, and are characterized by significant uncertainty in timing and scale over the modeled period. At the same time, they may represent substantial long-term economic potential if realized.

The calculation methodology for these markets is illustrated by the equation below and is probability-weighted to reflect the likelihood that particular markets and technologies emerge within the modeled timeframe. The purpose of these scenarios is not to predict a single outcome, but to illustrate a range of economic futures that could emerge as the lunar economy develops. For example, nuclear fusion may emerge as an early commercial market in the 2030s; however, neither its development nor the use of helium-3 as a fuel source is certain.

$$Activity_{(i,t)} = (Theoretical\ market\ volume_i * Growth\ rate_i) * Lunar\ unit\ price_{(i,t)} * Probability_i$$

Table 2 applies these three approaches to the enabled activities included in the analysis. It summarizes each activity, the broader category to which it belongs, and the calculation approach used to estimate its potential economic contribution.

Table 2: Enabled lunar activities

Category	Activity	Definition	Calculation approach
National security	National security and space situational awareness	Cislunar monitoring and defense-related analytics services built on lunar communications infrastructure.	Replacement
Lunar data and services	Lunar and cislunar data products	Information generated by lunar/cislunar activity sold as products such as prospecting data, lunar imagery, scientific datasets, and space situational awareness.	Nascent
New resources and materials	Helium-3	Supply existing terrestrial helium-3 markets including neutron detection, cryogenics, and scientific instrumentation.	Replacement
	Nuclear fusion fuel	Helium-3 is a candidate fuel for aneutronic fusion.	Speculative
	Quantum computing cooling	Helium-3 is the working fluid in dilution refrigerators.	Speculative
	In-space propellant refueling	Propellant produced from lunar regolith or polar ice (liquid oxygen (LOX), hydrogen, methane) and consumed in space rather than launched from Earth.	Nascent
In-space production	Lunar manufacturing for off-Earth data centers	Producing data center components (excluding GPUs) from lunar regolith. Key components include solar panels and data center satellite bodies.	Speculative
	Manufacturing advanced materials and isotopes	Production in lunar or cislunar facilities that benefits from a vacuum, microgravity, or unique cooling environment.	Speculative

Source: Deloitte analysis (2026)

Value Pool 3: Other Benefits

Finally, Value Pool 3 is included to capture selected broader benefits associated with lunar activity. Although these benefits are not additive to the final estimate, they are included to provide context for the potential value associated with lunar exploration.

The estimates in this value pool are not intended to measure upstream or downstream lunar markets directly. Rather, they reflect broader benefits that may emerge through scientific, technological, and exploratory activity associated with lunar exploration.

Three categories of benefit have been incorporated into this framework:

1. **Economic spillovers:** Space exploration and related research can generate broader economic spillovers by pushing research and development into technically demanding environments. Historically, advances associated with space activity have contributed to scientific, engineering, and commercial developments with applications beyond the space sector.

2. **Global pride and inspiration:** As with the first lunar landing, space travel and exploration may contribute to global pride and public inspiration by demonstrating advances in human capability and scientific achievement.

3. **Transformative unknown benefits:** Some benefits associated with space exploration are difficult to quantify in advance and may not be fully captured in this study. These may include additional scientific, technological, or societal benefits that emerge over time.

These benefits are reported separately from the lunar market-based estimates, so the broader potential benefits are captured without overstating the size of the directly measurable lunar economy.

RESULTS OVERVIEW

This analysis considered two scenarios for lunar economic activity: a conservative growth scenario with measured assumptions on the trajectory of commercial activity that could be realized, and an accelerated growth scenario where commercial markets expand more rapidly. The inclusion of an accelerated growth scenario reflects the underlying contingencies, and ultimately the significant upside that could be realized if certain foundational technologies commercialize.

Estimated headline results are expressed as net present values (NPV) in 2026 US dollars using a 7% discount rate, a standard approach for long-horizon infrastructure investments under uncertainty.

The analysis suggests that the lunar economy may generate between US$343 billion and

Table 3: Other benefits enabled by lunar exploration and commercialization

Activity	Definition	Key driver
Global pride and inspiration	The estimated welfare associated with inspiring individuals to take pride in their nation and the world.	The estimated welfare associated with inspiring individuals, proxied by short-term excess stock market returns observed around events of national or cultural significance.
Economic spillovers	The impact of research and development on economy-wide productivity.	The return on investment from research and development spending, measured through gross domestic product (GDP) uplift.
Transformative unknown benefits	The value of the research and development on knowledge exploration with unclear use cases.	The individual willingness to pay for research without known use cases or payoffs.

Source: Deloitte analysis (2026)

US$566 billion in present value through 2050, depending on the pace of technological and commercial development. While near-term activity is expected to center on enabling infrastructure, a significant share of longer-term value may depend on the industries and markets that this infrastructure supports. Under the conservative growth scenario, annual enabled activity could reach US$102 billion by 2050, relative to an estimated US$46 billion in annual output for core lunar activity.

Conservative Growth Scenario

Core Lunar Activity

Under the conservative growth scenario, core lunar activity has a present value of US$209 billion through 2050, with total economic activity potential reaching US$46 billion annually by that year.

The lunar economy modeled in 2050 looks substantially different from the one emerging today. By mid-century, the conservative growth scenario projects approximately 350 lunar-related launches per year, driven by the growing network of cargo deliveries, refueling operations, crew transport, and supporting infrastructure required to maintain a permanent presence. Commercial missions outnumber government missions by a factor of three. Astronauts can remain on the surface for up to 50 days at a time. The power generation, storage, and distribution network services 600 megawatts of demand, and two parallel communications and navigation satellite constellations are in operation, each comprising 25 satellites, providing full coverage of the lunar surface.

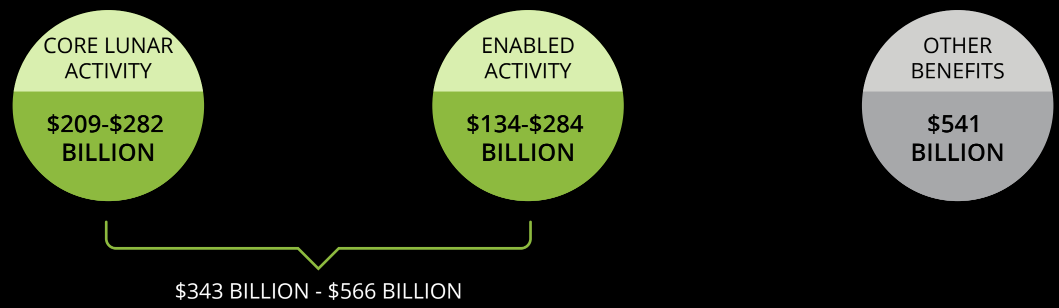
In this case, transportation accounts for approximately US$150 billion, or 72% of total core lunar activity through 2050. The remaining value is distributed across energy and power, communications and navigation, surface mobility, construction, and life support. Each is essential to the functioning of the broader system, and their growth trajectories are closely linked to the transportation infrastructure that enables them.

Enabled Economic Activity

The second value pool captures the economic activity that lunar infrastructure may enable. Under the conservative growth scenario, enabled activity is estimated to have a present value of US$134 billion through 2050, with annual activity reaching US$102 billion by that year.

Two features of this value pool are notable. First, enabled activity ramps up later than core infrastructure spending, reflecting the fact that downstream value from lunar operations can emerge only once the underlying systems are in place. Second, enabled activity ultimately becomes larger in annual terms. By 2050, annual enabled activity is estimated to reach US$102 billion, compared with US$46 billion generated by core lunar activity. This indicates that a

Figure 2: Estimated value of the lunar economy by value pool



Source: Deloitte analysis (2026)

substantial share of the lunar economy's long-term value may arise from the industries and services that lunar infrastructure supports, rather than from the infrastructure itself.

The enabled activity value pool consists of six potential markets: national security, lunar data and services, helium-3, lunar propellant, orbital compute, and in-space manufacturing. For each market, the analysis estimates potential economic value through 2050 and adjusts that estimate based on the likelihood that the underlying technology, demand, and business model mature within the modeled timeframe.

These markets vary considerably in maturity and certainty. Some are beginning to emerge, while others depend on technological and commercial developments that have yet to occur. The conservative growth scenario reflects a scenario in which these markets develop gradually and at different scales. But there is another possibility: that one or more of these opportunities expand far more rapidly than expected, creating new sources of demand that pull the broader lunar economy forward.

Accelerated Growth Scenario

The accelerated growth scenario does not simply assume faster growth. Instead, it assumes that one or more production frontiers fundamentally alter what is economically possible on and around the Moon. Rather than extending current trajectories, this scenario explores how breakthroughs in energy, computing, manufacturing, resource extraction, or national security demand could create entirely new categories of economic activity. The production frontier shifts we model are outlined in **Table 4**.

Table 4: Production frontiers modeled in the accelerated growth scenario

Category	Activity	Calculation approach
National security	National security and space situational awareness	Increase in the security-to-space-economy ratio to capture the additional incentive to protect commercial assets that grow in the accelerated growth scenario.
Lunar data and services	Lunar and cislunar data products	The development of a new lunar-based data market that grows analogously to the existing near-Earth observation market.
New resources and materials	Helium-3	Existing helium-3 markets expand as additional availability of the resource makes it more feasible to utilize use cases such as neutron detection at a greater diversity of sites.
	Nuclear fusion fuel	If fusion reaches commercial viability and helium-3 becomes a preferred fuel source, lunar resource extraction could expand dramatically beyond the demand modeled in the conservative growth scenario.
	Quantum computing cooling	If quantum technology adoption accelerates from medium-term semiconductor industry growth rates to rates approaching Moore's law after 2030, the likelihood of a viable lunar helium-3 market for quantum computing cooling would increase within the modeled period.
	In-space propellant refueling	Increase in the share of lunar-supplied propellant into the existing orbital market spurred by the need to ramp up production of Mars missions post-2036.
In-space production	Lunar manufacturing for off-Earth data centers	If space-based data centers become economically viable, demand for transportation, manufacturing, energy, and supporting infrastructure could accelerate significantly. Orbital compute is among the few potential markets large enough to pull the broader lunar economy forward.
	Manufacturing advanced materials and isotopes	Increase in probability that relevant technology materializes within the modeled period.

Source: Deloitte analysis (2026)

The uplift in lunar commercial activity affects the core lunar activity value pool by bringing forward and expanding the development of core lunar infrastructure. As emerging commercial applications become more likely to materialize and achieve greater scale, demand for transport, power, mobility, life support, and construction infrastructure increases. This leads to:

- Increasing mass and frequency **transported** between the lunar surface, orbit, and Earth, which brings forward the commercial transportation activities
- More frequent cargo return missions to transport larger volumes of **resources** extracted from the lunar environment
- Additional people and time spent on the lunar surface, driving up the demand for **life support** activities and infrastructure
- Increased utilization of surface **mobility** supporting extraction and processing sites
- Earlier and expanded surface **power** and **construction** infrastructure for habitation and commercial production
- Increase in the number and quality of satellites, surface nodes, and other infrastructure for **communications and navigation**.

In effect, the change is not the creation of new infrastructure sectors but a shift toward a larger, more heavily utilized and more industrialized lunar economy.

Under this scenario, the total present value of the lunar economy through 2050 could reach US$566 billion, with enabled activity accounting for a larger share of the total than in the conservative growth scenario. The difference between the two scenarios highlights the sensitivity of the lunar economy's trajectory to a relatively small number of high-impact developments. While the precise scale of the opportunity remains uncertain, both scenarios suggest that the economic value of the lunar economy may extend beyond the infrastructure required to establish it. The emergence and timing of downstream markets may therefore play a significant role in shaping the overall scale of the lunar economy.

Other Benefits

Broad benefits associated with the development of the lunar economy may include innovation, scientific advancement, and human inspiration associated with exploration. Together, these elements are estimated at US$541 billion, suggesting that the economic significance of a lunar program may extend beyond observable market transactions. A substantial portion of this value may arise through capability building, knowledge accumulation, and the potential for future applications that cannot yet be clearly identified or quantified. Given the high degree of uncertainty associated with these benefits, the same estimate is applied in both the conservative growth scenario and the accelerated growth scenario.

Limitations

The estimates presented in this analysis should be interpreted as indicative rather than definitive, reflecting the difficulty of sizing an economy that does not yet exist. Several limitations are particularly important.

First, the analysis draws on currently available information, published mission plans, and interviews with subject matter specialists. Because the most detailed publicly articulated lunar plans are those of the United States and its commercial market participants, the modeled inputs, unit prices, mission cadences, and infrastructure assumptions broadly reflect a US-centric view of lunar development. While the modeling is intended to represent global activity, the estimates may understate activity driven by other national programs or capture that activity imperfectly.

Second, the enabled activity and other-benefits value pools depend on multiple unresolved technology pathways. Several of the largest potential markets, including nuclear fusion, quantum computing, and lunar manufacturing, rely on scientific and engineering developments that have not yet occurred, and whose timing and feasibility remain uncertain. The probability-weighting approach is intended to reflect this uncertainty, but the underlying probabilities are themselves judgment-based estimates rather than observed outcomes. As a result, relatively small changes in these assumptions can materially affect the results, as reflected in the difference between the conservative growth scenario and accelerated growth scenario.

Third, much of the value identified in this analysis materializes toward the end of the modeled period. The value is likely to continue to grow beyond the modeled period as the lunar ecosystem and commercial use cases scale. For example, while nuclear fusion is estimated to comprise 0.8% of global electricity demand in 2050, the International Atomic Energy Agency projects it could climb to 27% by 2100.[201]

Fourth, unit prices, efficiency gains, and learning rates are informed by terrestrial proxies drawn from aerospace, power, and infrastructure research. Although these proxies provide a reasonable analytical basis, the lunar operating environment differs materially from terrestrial precedent, and actual cost trajectories may diverge from those observed in comparable industries on Earth.

Finally, the other-benefits value pool—comprising human inspiration, innovation spillovers, and the value of future applications that are not yet known or well defined—is subject to an especially high degree of uncertainty. These benefits are estimated using indirect proxies and are reported separately from the market-based estimates because they cannot be measured with the same degree of confidence. They should therefore be understood as illustrative of scale rather than precise valuations.

Taken together, these limitations reinforce the central framing of the analysis: the objective is not to predict a single outcome, but to illustrate a range of plausible economic futures associated with a sustained lunar presence.

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