



+SPACE TECH

The invisible tapestry of space technologies accelerating commerce, innovation, and exploration

THE “OPERATING SYSTEM” FOR OUR PLANET:

Welcome to +Space TECH

Welcome to *+Space Tech*, the next eBook from KPMG built for leaders who recognize that space-enabled technology is no longer optional infrastructure, but a strategic lever shaping cost, resilience, growth, and risk across industries.

Most organizations experience space through outcomes, not orbits. It shows up when a weather alert protects revenue, when a logistics network reroutes before disruption hits, when an insurer prices climate risk with confidence, or when real-time intelligence sharpens operational decisions. Those everyday moments are powered by something bigger than any single satellite or launch: a rapidly maturing, largely invisible operating system for our planet—a technology stack that turns access to space into data, data into intelligence, and intelligence into real-world advantage.

This eBook is the natural evolution of *+Space*. The original idea was intentionally expansive: Space is no longer a distant frontier—it is becoming a pervasive economic domain that will reshape industries. *+Space Tech* takes the next step. It translates that vision into a framework you can use—one that helps executives, boards, and technology leaders move from curiosity to decisions: where to invest, how to partner, what to govern, and how to scale responsibly.

A simple idea:

The space economy behaves like a tech stack

The modern space economy can be understood the same way we understand digital platforms on Earth. Hardware enables networks. Networks enable intelligence. Intelligence enables applications. And once applications become essential, the whole system becomes infrastructure.

+Space Tech is designed as four interconnected layers, recognizing that meaningful impact emerges from their integrated orchestration rather than isolated performance.



THE HARDWARE

Layer 1 — Space Access and Infrastructure

This is the physical foundation: launch systems, satellites, and orbital platforms; today's stations; and tomorrow's commercial outposts. It is the layer that makes the rest possible by putting capability where it can operate in orbit and beyond.

THE NETWORK

Layer 2 — Space Data and Connectivity

Once the hardware exists, it becomes an information utility: communications, Earth observation, and positioning/navigation/timing signals that deliver connectivity, visibility, and synchronization across the global economy. This is where space stops being a destination and becomes a service.

THE BRAIN

Layer 3 — Enabling Technologies

This is the intelligence layer: artificial intelligence (AI), edge computing, quantum sensing, advanced materials, autonomy, and the architectures that make the stack faster, more resilient, and more scalable. Layer 3 is where space systems become increasingly software-defined, capable of adapting, prioritizing, and acting with less human intervention.

THE APP STORE

Layer 4 — Downstream Applications

This is where value becomes tangible. It's the farmer optimizing irrigation, the logistics operator tracking movement in near-real time, the bank depending on precise timing, the insurer validating catastrophe exposure, and public agencies strengthening disaster response. Layer 4 is where the space stack becomes "just how the world works."

Why this matters now:

A converging ecosystem across Earth and orbit



The change we are seeing is more fundamental than “more satellites” or “better launch economics.” The real shift is the emergence of a space ecosystem defined by the convergence of capital, industrial manufacturing, digital infrastructure, and advanced technologies across commercial, civil, and defense domains. This ecosystem spans Earth and orbit, linking terrestrial industries with space-based capabilities in ways that are reshaping how value is created, scaled, and secured.

Commercial innovation is driving scale, cadence, and cost curves turning capabilities once reserved for national programs into services enterprises can adopt. Civil missions are advancing science, standards, and global datasets

that underpin climate resilience and societal value. Defense requirements are accelerating the demand for resilience, redundancy, cybersecurity rigor, and operational tempo. Increasingly, these domains are not separate lanes, they are interdependent, often sharing suppliers, architectures, and operating models. The *result is a compounding flywheel*: access enables data; data enables intelligence; intelligence enables outcomes; outcomes justify investment; investment accelerates the next wave of capability.

For leaders, the implication is direct: the question is no longer whether space will matter to your organization. The question is how you will engage, where you will differentiate, what you will rely on, what you must govern, and how you will build resilience in a world where space-enabled services become as foundational as cloud and cyber.

HOW TO USE THIS EBOOK

We wrote *+Space Tech* to be practical. As you move through the layers, consider three lenses:

- 1. Value creation:** Where can space-enabled capabilities expand revenue, reduce cost, or improve performance?
- 2. Resilience and risk:** Where do dependencies form—connectivity, timing, data access, supply chain, cyber—and how do you manage them?
- 3. Ecosystem advantage:** What should you build, buy, or partner for—across commercial, civil, and defense networks—so you can scale responsibly and win sustainably?

We’re glad you’re here. Let’s explore the operating system that is quietly reshaping the world—and how you can turn it into strategic advantage.

Jonathon Gill
Global Sector Lead, Aerospace
& Industrial Markets, KPMG UK

Brian Miske
Americas Space Lead
National Ignition Leader, KPMG US



We are living through the industrial revolution of space, a transformation unfolding quietly above us. Space infrastructure, satellite constellations, and AI-driven platforms are becoming the invisible backbone of industries, governments, and societies. Autonomous satellites process vast streams of data in orbit, quantum sensors measure with unprecedented precision, and AI-driven platforms turn data into actionable insight. The impact on Earth is already tangible: global defense and security, smarter agriculture, resilient financial systems, connected cities, rapid disaster response, and secure critical services. The scale is staggering: the global space economy is projected to grow from \$630 billion to \$1.8 trillion by 2035. For organizations seeking resilience, insight, and strategic advantage, understanding and acting on this invisible infrastructure is no longer optional, it's essential."

—Rob Desborough, General Partner, Seraphim Space

The big idea

What if the most profound transformation of this decade isn't visible at all?

It's forming as an invisible mesh of technologies—a lattice of space infrastructure, data streams, and intelligent systems—quietly becoming the backbone of global innovation.

Most organizations remain grounded and focused on incremental optimization, while a new class of leaders is using space enabled data, experimentation, and foresight to accelerate decisions and strengthen resilience. This is not about astronauts. It is about assured data, rapid learning cycles, and strategic advantage. The future is already being tested in orbit.

At KPMG LLP, we help enterprises apply space technologies to core business outcomes: regulatory confidence, risk management, operational reach, and revenue growth. We treat space as enterprise infrastructure—an enabler of assurance, interoperability, and faster, more confident decisions across sectors.

+Space Tech outlines four interconnected layers—**Space Access and Infrastructure, Space Data and Connectivity, Enabling Technologies, and Downstream Applications**. Together, these layers form a cohesive digital stack that enterprises can activate to improve interoperability, reconfigure operating models, and respond faster to disruption. Space is no longer a destination—it is an enterprise platform for growth, resilience, and sustained advantage.

LAYER 1

Space Access and Infrastructure

Launchers, satellites, and orbital platforms



Introduction summary

78%

of space economy
growth is driven by
the commercial sector

Layer 1—Space Access and Infrastructure—encompassing launchers, satellites, and orbital platforms—forms the invisible backbone of the global space economy, quietly transforming how industries innovate, communicate, and operate. As the foundational utility for all subsequent space value layers, Layer 1 enables humanity to transcend Earth’s gravity, persistently operate in orbit, and return safely. The dramatic collapse in launch costs—from \$65,000 per kilogram in the Space Shuttle era to approximately \$1,500 per kilogram with Falcon 9, and soon below \$100 per kilogram with

heavy-lift vehicles—has catalyzed a surge in orbital capacity and downstream applications. This shift is not only about astronauts or exploration but also about building resilient, scalable infrastructure that supports global connectivity, real-time data, and strategic experimentation for terrestrial industries. The commercial sector now drives nearly 78 percent of space economy growth, with record launches and the rapid deployment of mega-constellations like Starlink, fundamentally altering telecommunications, logistics, and Earth intelligence.

As humanity looks to expand into cislunar and deep-space economies, Layer 1 solves critical terrestrial and orbital challenges by enabling routine, affordable access to orbit, supporting global communications, and unlocking new markets for research, manufacturing, and services. Reusable rockets and mass-produced small spacecraft (smallsats) have shifted space logistics from rare events to routine operations, making it possible to envision persistent infrastructure not only in low-Earth orbit (LEO) but also across lunar and deep-space domains. Orbital platforms—commercial stations

and hosted payloads—are emerging as multitenant “real estate” for microgravity research and development (R&D) and manufacturing, paving the way for industrial parks in space. These capabilities underpin the next wave of economic growth, resilience, and competitive differentiation, positioning space as a strategic platform for terrestrial industries and future off-world expansion.



The increasing commoditization of access to space is driving a tremendous acceleration in innovation, building certainty in markets and making growth predictable. It is providing the foundations for a genuine inflection point in technology.”

— Neil Rae, Space Lead, KPMG UK

Problems to solve for the next five years

Despite these advances, Layer 1 is expanding faster than the global governance, manufacturing, and safety systems built to manage it. To realize the full opportunities of the space economy over the next five years, several challenges must be addressed: launch cadence and range availability constraints, supply-chain bottlenecks for critical components, manufacturing and integration capacity, spectrum and regulatory bottlenecks, orbital debris and traffic management, and the

need for robust reliability and mission assurance. Addressing these issues will require coordinated action across industry, government, and academia to ensure that space infrastructure remains safe, scalable, and interoperable as humanity pushes toward cislunar and deep-space frontiers. The following sections will explore these challenges in detail and outline actionable strategies for executives and boards to position their organizations for success in the evolving space economy.

Executive summary

Layer 1 is the physical backbone and economic bedrock of the global space economy—the rockets that provide access to orbit, the satellites that carry sensors and communications payloads, and the orbital platforms that host astronauts and microgravity R&D. This layer is the foundational utility upon which all subsequent value layers are constructed, encompassing the hardware, systems, and logistical networks that enable humanity to transcend Earth’s gravity, operate persistently in orbit, and return safely. Without the physical capability to transport mass to orbit and sustain it there, the downstream benefits brought on by the space economy cannot exist.

Layer 1 supports a record-sized and rapidly growing global space economy, which recorded \$626 billion in 2025.²⁰ And it’s currently undergoing a structural transformation of historical significance, driven principally by a collapse in access costs creating a surge in orbital capacity and downstream applications. The commercial sector has emerged as the dominant engine of this expansion, accounting for approximately 78 percent

of the total growth.² The launch sector—the “shipping” industry of space—generated \$9.3 billion in revenue in 2024, representing a robust 30 percent increase over the previous year.¹ This financial growth is underpinned by an unprecedented operational cadence: In 2025 alone, launch providers conducted 329 orbital launches, with commercially procured missions accounting for 230 of them.⁸

\$626 BILLION
Global space economy recorded in 2025

\$9.3 BILLION
Launch sector revenue in 2024

329
Orbital launches in 2025

78%

of total growth comes from the commercial sector

30%

growth year over year comes from the launch sector

230
Commercially procured missions

For the non-space-executive, the strategic relevance of Layer 1 lies in its rapid transition from a scarcity model to an abundance model. Historical launch costs, which hovered around \$65,000 per kilogram during the Space Shuttle era, have plummeted to approximately \$1,500 per kilogram with the operational maturity of the Falcon 9, and are projected to fall below \$100 per kilogram with the imminent introduction of heavy-lift vehicles like Starship.³ This dramatic cost compression has catalyzed the deployment of mega-constellations such as Starlink, which now boasts over 6,750 active satellites, fundamentally altering the telecommunications landscape and enabling ubiquitous global connectivity.⁴ Orbital infrastructure is also commercializing as private space stations compete to replace the International Space Station (ISS). Axiom Space is sending up ISS-attached modules with a path to an independent four-module station by 2030.



A new generation of multiuser spaceports is emerging beyond traditional launch ranges. These sites—often in countries with minimal local launch activity—add pad capacity to the global launch market and offer new geographic advantages, alternative regulatory pathways, and earlier access for vehicle developers facing constraints at established ranges.”

—Joe Noble, Defence & Space, KPMG Australia



Layer 1 in plain English

What it is and why it matters

To navigate the modern space economy, one must first demystify the physical infrastructure that makes it possible.

For the executive accustomed to terrestrial supply chains, Layer 1 can be best understood through the analogy of global logistics: It consists of the ports (launch sites), cargo ships (launch vehicles), shipping containers (satellite buses), and factories and warehouses (orbital platforms) of the space domain. Just as global trade relies on the physical movement of goods across oceans, the space economy relies on the physical movement of mass against the pull of gravity.

Launch vehicles

A launch vehicle is, in functional terms, a ship designed to carry a payload (cargo) from the Earth’s surface into orbit. For much of the space age, this rocket “ship” was prohibitively expensive, single-use, and infrequent. Imagine a logistics model where a Boeing 747 flies from New York to London once, delivers its packages, and is then deliberately crashed into the Atlantic Ocean. The cost of shipping a single letter under such a model would be astronomical. This was the economic status quo of the space industry for nearly half a century. The fundamental shift defining the current era of Layer 1 is the transition toward reusability pioneered by SpaceX beginning in 2015. The introduction of rockets that

can launch, land, refuel, and fly again has radically altered the cost curve of space access, transforming it from a barrier to entry into a competitive enabler. SpaceX’s reusable Falcon 9 rocket can place approximately 22.8 metric tons in LEO, enabling frequent, predictable access and lower average cost per kilogram as cadence rises.^{5,6} As of 2025, SpaceX now launches approximately every other day. In November 2025, Blue Origin became the second orbital launch provider to succeed in landing a first stage booster. Multiple more reusable rockets are expected to enter the market in the coming years, further accelerating launch rates and lowering costs.

Satellites

Think of a satellite as a delivery van (the bus: power, propulsion, thermal) carrying specialized equipment (the payload: cameras, communications, navigation) designed for a mission. The industry has trended towards smaller, standardized, modular buses that shorten integration time and lower cost by reusing flight-proven subsystems. Architectures describe how many satellites you deploy, where and how they talk—e.g., proliferated LEO constellations with hundreds or thousands of smallsats trading individual capacity for network redundancy, latency, and revisit rates.³

Orbital platforms

Beyond single spacecraft, commercial stations and hosted-payload platforms are emerging as multitenant “real estate” in orbit—hosting research, manufacturing, and services, with the National Aeronautics and Space Administration (NASA) advancing commercial station development and Axiom modules that will attach to the ISS before free-flying.^{11,12}

Why Layer 1 matters. No satellites, no data. No platforms, no on-orbit services. No launch, no access. Every downstream benefit—broadband anywhere, real-time agriculture and energy monitoring, logistics visibility, secure communications—begins with reliable, affordable, and scalable access and assets in orbit.^{1,2}

The problems Layer 1 solves (and the value it creates)

Global access to space enables new markets

Reusable, high-cadence launch created surplus capacity that moves enterprises from “rare events” to “routine logistics.” New markets become economically viable as launch costs decline. A 2023 European Space Agency study suggested space-based solar power could become feasible at \$1,100/kg.

Global communications and Earth intelligence expand markets and unlock competitive advantages

Connectivity: LEO constellations and carrier partnerships are enabling broadband and direct-to-cell services, forming the transport for Layer 2 data products and Layer 4 applications in aviation, maritime, logistics, and Internet of Things (IoT).

Logistics/shipping: Sentinel-6B altimetry will feed near-real-time marine forecasts and extend a 30-year sea-level record to help safeguard vessels, crews, and cargo.

Agriculture and infrastructure: NASA-ISRO Synthetic Aperture Radar will scan nearly all land and ice surfaces twice every 12 days, aiding monitoring and disaster preparation.

Orbital stations enable previously impossible experiments and potential to create out of this world products

NASA’s commercial LEO destinations program and Axiom’s ISS modules signal a move to multitenant orbital platforms for research, manufacturing, and hosting—opening new logistics and microgravity markets.^{11,12} Astroscale is advancing life extension and refueling (including the first-ever refueling of a US Space Force asset) and will inspect two large debris objects on ISSA-J1, slated for a 2027 PSLV launch.



The most important infrastructure of the next decade isn’t built on land—it’s built above it. Space is quietly becoming the new backbone of global digital capability.”

—Amanda Price, Head of High Growth Ventures, KPMG Australia

What's new— and why this layer is different now

Layer 1 has shifted from bespoke, low-cadence hardware to scalable, service-like infrastructure. Heavy-lift reusable launch is coming online, proliferated LEO meshes are being fielded, smallsats are moving to serial production, modular hosting platforms are emerging, commercial stations are entering assembly, and civil-commercial-defense programs now share architectures and procurement paths.

Reuse at scale

Reusable first stages and standardized integration flows have made high-frequency launch normal; Falcon 9's 22.8-ton LEO capacity and Block 5 reusability underpin sustained cadence and rideshare economics:^{5, 6}

Blue Origin's New Glenn adds reusable heavy-lift capacity and China and others for more reusability and more rockets of more sizes.

This new lower-cost, higher-cadence, multiprovider ecosystem now supports faster product cycles and more optionality of launch schedules.

4,526
satellites
launched in 2025

3,193.9
tons of payload sent
to orbit in 2025

Small-satellite mass production replacing bespoke builds, enabling constellations

Industrialization of buses and payloads compresses lead times and brings unit costs down; the 4,526 satellites launched in 2025.⁸ Constellations built from mass-produced smallsats now dominate the manifest, enabling rapid iteration and resilient networks (more nodes, more paths).

Hosted payloads and modularity create "plug and play" orbit.

Hosted payloads and modularity providing path for commercial stations and in-orbit manufacturing

NASA has adjusted commercial LEO destination (CLD) milestones and funding (e.g., Orbital Reef total to \$172 million; Starlab to \$217.5 million) to mature life-support subsystems and docking upgrades—evidence of real progress toward commercial, multitenant platforms at scale.¹²

Microgravity manufacturing and space-based compute become multitenant services with commercial pricing.

The challenges that must be solved next

Layer 1 is expanding faster than the global governance, manufacturing, and safety systems built to manage it.

Launch cadence versus demand. Record activity—329 orbital launches in 2025 (199 of them US-licensed)—creates scheduling and range-availability constraints, especially for time-sensitive missions and unique orbits.^{6, 7} Heavy-lift capacity is tightening even as demand rises.

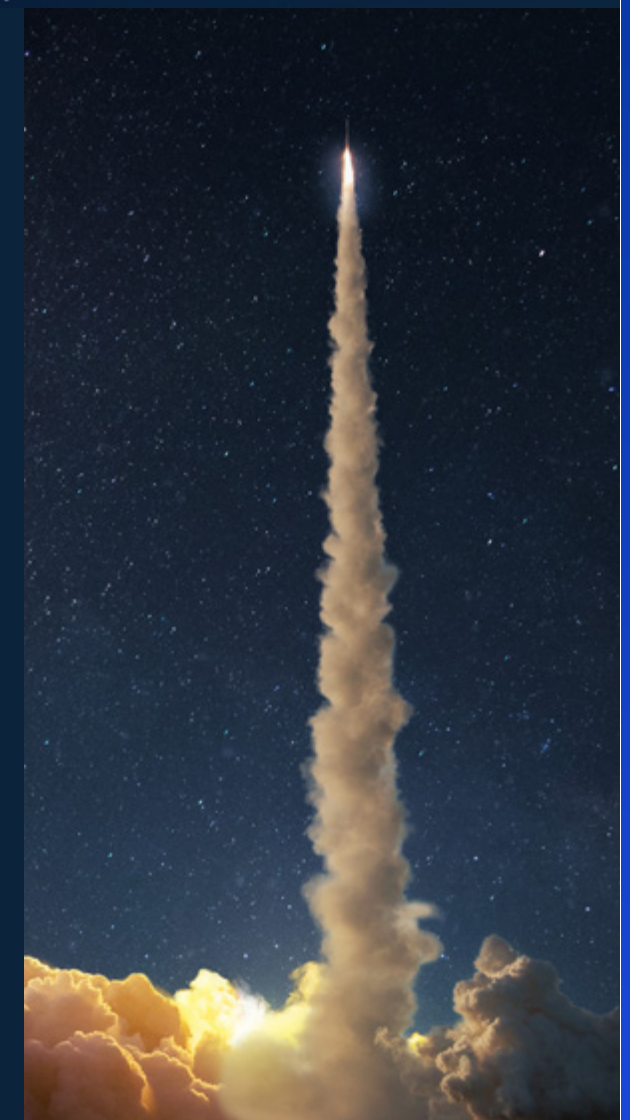
Supply-chain constraints. Avionics, reaction wheels, optical terminals, and rare components can become bottlenecks as constellations compress timelines; firms must dual-source and standardize interfaces (trend evidenced by the rapid scaling of satellites launched to 4,5256 payloads in 2025).⁸

Manufacturing and integration capacity. High-rate builds require automotive-style quality and statistical process control; integration slots, test chambers, and ground segment build-outs can gate deployment (a practical constraint as US spaceports climbed to 14 active by January 2025).⁷

Spectrum and regulatory bottlenecks. Interference risks and coordination costs grow with constellation density. The US National Spectrum Strategy is piloting co-equal sharing frameworks (e.g., Lower 37 GHz) to balance federal and nonfederal users—an important step for satcom scaling.¹⁹

Orbital debris and traffic management. With approximately 40,000 tracked objects and approximately 11,000 active payloads, collision-avoidance and end-of-life planning are mandatory; new Federal Communications Commission (FCC) five-year deorbit rules for LEO satellites tighten disposal timelines.^{9, 12}

Reliability, safety, mission assurance. As launch and constellation cycles compress, qualification and verification must keep pace. Defense-grade networks like Space Development Agency (SDA) Tranche-1 show how optical links, redundant paths, and operations centers harden the architecture.¹⁵



The opportunity map 2026–2035

NOW
NEAR
NEXT

1–2 years

LAUNCH SERVICES PROCUREMENT

Lock in multilaunch options and secondary payload opportunities; leverage US capacity proven by 199 licensed orbital launches in 2025 and 14 active spaceports to de-risk timelines.⁷

SATELLITE PLATFORMS AND DATA PARTNERSHIPS

Pilot Earth observation/remote sensing and direct-to-device backhaul; track Amazon Leo's 2026 production launches to diversify beyond a single provider.

HOSTED-PAYLOAD EXPERIMENTS

Use modular buses and rideshare missions to validate sensing or communications payloads quickly; align with emerging commercial station timelines for on-orbit R&D.^{16, 17}



NOW
NEAR
NEXT

3-5 years

ORBITAL SERVICING AND INSPECTION

Prepare for on-orbit inspection and limited servicing in proliferated constellations; coordinate debris-mitigation compliance per the FCC's five-year deorbit rule.¹²

IN-SPACE ASSEMBLY PILOTS

Piggyback on defense and civil programs maturing optical crosslinks and standardized docking to trial modular assembly workflows.^{15,17}

COMMERCIAL STATION ENGAGEMENTS

Target microgravity R&D, manufacturing demos, and platform tenancy aligned to Axiom and CLD milestones.^{16, 17}



NOW
NEAR
NEXT

5-10 years

DEBRIS REMOVAL AND TRAFFIC SERVICES

As tracked objects approach and exceed today's approximately 40,000, demand grows for software transactional memory (STM) software, conjunction alerts, and active debris removal.⁹

IN-SPACE MANUFACTURING AT SCALE

Pharmaceutical crystallization, fiber, semiconductors—commercial stations provide the “industrial park” in LEO.¹⁷

PLATFORM ECOSYSTEMS

Stations and tug services and hosted payloads culminate in multicustomer, multiservice marketplaces—space as infrastructure, not project.^{16, 17}

How Layer 1 creates value

for CFOs, CTOs, CIOs, CHROs, and boards

Layer 1 choices—launch access, satellite platforms, and orbital stations—now directly influence enterprise modernization, resilience, and returns.



CFO

Key performance indicators (KPIs):

Cost-per-acquisition for data (per GB or pixel), \$/kg to orbit equivalents from contracts, uptime/latency service-level agreements, and asset-turnover on orbital investments.

Value pools: Reducing terrestrial backhaul costs via LEO, de-risking critical operations with space redundancy, and monetizing proprietary sensing.

Capital considerations: Multiyear launch blocks lower price volatility; align with providers scaling cadence (e.g., US licensed launches and spaceport availability).²

Risk-adjusted returns: Treat spectrum and debris compliance as gating risks; the FCC five-year rule is now a hard constraint for LEO projects.¹²

CTO/CIO:

Infrastructure and data strategy:

Architect a cloud–edge–space stack; integrate proliferated LEO for low-latency, high-availability paths; roadmap direct-to-device pilots as Amazon Leo and others light up.¹⁸

Integration with information technology/operational technology (IT/OT): Build standard application programming interfaces to orbital data; plan for frequent refresh cycles as smallsats iterate quickly (see 2025 satellite volumes).⁸

Vendor landscape: Balance single-provider simplicity against resilience and bargaining power; consider dual-constellation strategies.

CEO

Strategic differentiation: Use Layer 1 to harden supply chains (global visibility), unlock greenfield markets (remote connectivity), and create dual-use offerings aligned to defense/civil convergence (e.g., SDA-style transport/tracking patterns).¹⁵

Ecosystem strategy: Co-invest with platform providers (stations, hosted payloads) to secure capacity and influence roadmaps.^{16,17}

CHRO

Capabilities: Space systems product management, radio frequency (RF) and optical networking, orbital mechanics basics, and STM/space law; create learning and development pathways and recruit from aerospace and telecom programs.

Org design: Embed a “space project management office” across network, data, and compliance.

Board

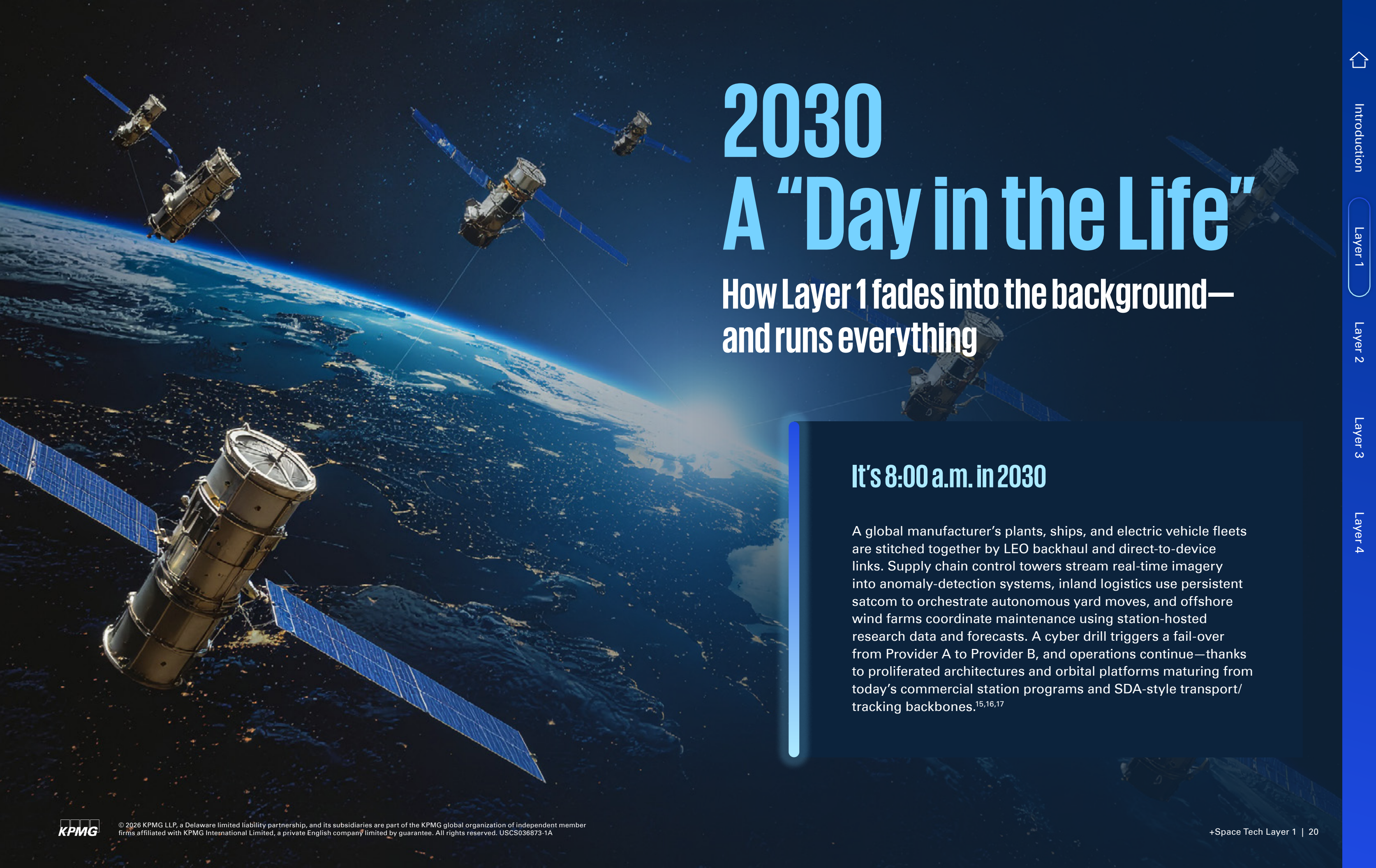
Governance priorities: Debris/spectrum compliance, third-party launch risks, cyber for space assets, and geopolitical exposure.

Oversight: Require scenario plans that assume temporary loss of one constellation and regulatory changes to sharing frameworks (e.g., Lower 37 GHz pilots).¹²



Space access today is about more than rockets; it’s about creating the persistent, digital infrastructure in the sky that powers modern industry. Satellite constellations, launch networks, and orbital platforms form the backbone of connectivity and data delivery, enabling everything from real-time Earth observation to GNSS timing that supports nearly every industry, including finance, transport, energy, and critical services. For enterprises, engaging with this infrastructure isn’t just strategic, it’s the foundation for resilience, operational efficiency, and the ability to innovate at a global scale.”

—Seraphim Space



2030 A “Day in the Life”

How Layer 1 fades into the background—
and runs everything

It’s 8:00 a.m. in 2030

A global manufacturer’s plants, ships, and electric vehicle fleets are stitched together by LEO backhaul and direct-to-device links. Supply chain control towers stream real-time imagery into anomaly-detection systems, inland logistics use persistent satcom to orchestrate autonomous yard moves, and offshore wind farms coordinate maintenance using station-hosted research data and forecasts. A cyber drill triggers a fail-over from Provider A to Provider B, and operations continue—thanks to proliferated architectures and orbital platforms maturing from today’s commercial station programs and SDA-style transport/tracking backbones.^{15,16,17}



Executive checklist

What to do Monday morning



Immediate steps

Map critical operations to satellite coverage and latency requirements; identify single-points-of-failure and alternatives (dual-constellation, terrestrial).

Secure multilaunch options or rideshares for 2026–2028; treat spaceport and range as capacity constraints in planning.



Partnership and vendor considerations

Engage commercial station providers and hosted-payload platforms for R&D and microgravity pilots.

Track Amazon Leo's production launches and alternatives for direct-to-device or backhaul redundancy.



Diagnostic questions

What KPIs (uptime, latency, revisit, \$/GB) tie Layer 1 services to profit and loss outcomes?

Which workloads (backup connectivity, remote operations, video analytics) move to space-augmented networks in 12–24 months?



Data, talent, and capability requirements

Hire or upskill in RF/optical networking, orbital operations, and spectrum policy; assign a compliance lead for debris and spectrum sharing pilots (e.g., Lower 37 GHz initiatives).



Integration priorities

Stand up a space integration runbook (ground stations, cloud routing, data contracts); sync with IT/OT and cybersecurity.

Build a debris and disposal compliance plan aligned to the FCC five-year rule and emerging STM practices.



LAYER 2

Space Data and Connectivity

Earth observation and communications

Introduction summary

Layer 2—Space Data and Connectivity—is rapidly transforming the invisible backbone of global innovation, turning orbital infrastructure into streams of signal and insight that power terrestrial and orbital economies. This layer encompasses satellite communications (SATCOM); Earth observation (EO); and positioning, navigation, and timing/global navigation satellite systems (PNT/GNSS), collectively underpinning everything from global logistics and financial markets to precision agriculture, disaster response, and autonomous systems. As humanity looks to

expand into cislunar and deep-space economies, Layer 2 solves critical challenges by providing resilient connectivity for remote operations, real-time sensing for climate and infrastructure monitoring, and precise timing for synchronizing networks and markets. The proliferation of mega-constellations—such as more than 9,900 Starlink satellites³²—and the rise of direct-to-device services are closing digital divides, enabling business continuity in disaster zones, and supporting new markets in regions previously unreachable by terrestrial networks.

Orbital sensing and data services are equally transformative, delivering near-real-time views of Earth’s surface, enabling climate resilience, supply chain visibility, and risk management at unprecedented scale. EO programs like Landsat have generated tens of billions of dollars in annual economic value, while commercial synthetic aperture radar (SAR) and hyperspectral constellations are unlocking new insights for agriculture, insurance, and national security. As enterprises and governments prepare for lunar and deep space expansion, Layer 2’s capabilities will be essential for maintaining operational awareness,

supporting autonomous systems, and integrating off-world assets into terrestrial digital infrastructure. In this new era, space data is no longer a niche specialty—it is a mainstream input to enterprise analytics, resilience planning, and strategic growth.



Our ability to observe the planet at high resolution to rapidly communicate from anywhere is becoming fundamentally real. This will drive new business models and ways of working.”

—Neil Rae, Space Lead, KPMG UK

TRANSITION: Problems to solve for the next five years

To fully realize the opportunities of Layer 2 over the next five years, several critical challenges must be addressed. Spectrum and regulatory constraints threaten to limit the growth of satellite communications and remote sensing, while usability barriers—such as complex data formats and limited interoperability—hinder the integration of space-derived data into daily workflows. The expanding cyber-physical attack surface, driven by increased reliance on satellite connectivity and GNSS, raises new risks for operational resilience and continuity. As economies become

more dependent on precise timing and navigation, backup PNT and robust cybersecurity will be essential. Addressing these challenges will require coordinated action across industry, government, and academia to ensure that space data and connectivity remain secure, accessible, and interoperable as humanity pushes toward cislunar and deep-space frontiers. The following sections will explore these issues in detail and outline actionable strategies for executives and boards to position their organizations for success in the evolving space economy.

Executive summary

Layer 2 is where space turns into *signal and insight* rather than metal and fuel. It covers the data and connectivity streams that flow from orbit to Earth—SATCOM, EO imagery, and PNT/GNSS. Together, these capabilities underpin everything from global logistics, financial markets, and precision agriculture to disaster response and autonomous systems.

The global SATCOM market alone is estimated at about \$98.7 billion in 2024, with projections of more than \$260 billion by 2034 at roughly 10 percent compound annual growth.¹ The EO market is sized at \$5.1 billion in 2024, expected to reach around \$7.2 billion by 2030.² The satellite data services segment, which turns raw imagery and signals into usable analytics, is estimated at \$5.25 billion in 2024, with

forecasts to exceed \$12 billion by 2032.³ Meanwhile, the PNT/GNSS market that provides precise timing and location is already massive—about \$301 billion in 2024, with projections of more than \$703 billion by 2032.⁴

Rapid growth in orbital assets is fueling this layer. The Union of Concerned Scientists counted 7,560 operating

satellites as of May 2023,⁵ and follow-on analyses put active spacecraft at more than 100,000 by 2030^{3,3}, with further growth through 2024 driven largely by communications and EO constellations.⁶ One provider—Starlink—reports over 7,800 satellites in orbit, offering resilient broadband that stays online even when terrestrial cables are cut.⁷

EO market size expected to reach around \$7.2 billion by 2030

\$5.1 B → **\$7.2 B**
2024 2030

The satellite data services segment is forecast to exceed \$12 billion by 2032

\$5.25 B → **\$12 B**
2024 2032



are estimated to be in orbit by 2030



Layer 2 converts that infrastructure into economic and strategic value

Connectivity for remote operations, maritime and aviation, and critical infrastructure

Sensing for climate, land use, supply chains, insurance, and national security

Timing for financial trading, grid synchronization, and telecommunications networks.

For executives and boards, the strategic implications are clear:



01 Space data becomes a mainstream input to enterprise analytics, not a niche specialty.



02 Connectivity gaps shrink, enabling digital programs in markets that were previously unreachable.



03 Operational resilience increasingly depends on space-based redundancy for networks and situational awareness.



04 Regulation and geopolitics will shape who gets access to what data, how fast, and under which conditions.



05 The winners treat Layer 2 as an extension of their cloud and data strategy, not a separate “space project.”



Data alone isn't enough; its value comes from speed, reach, and usability. Space-based data and connectivity act as the digital nervous system for industries and governments, powering smarter supply chains, climate-risk assessment, disaster response, security operations, and financial markets. Organizations that can integrate and act on this information fastest gain a critical advantage, while those that lag risk blind spots and lost opportunities. Space data isn't optional; it's becoming essential infrastructure for decision-making at every scale."

—Seraphim Space



Layer 2 in plain English

What it is and why it matters



Across recent conflicts, GNSS interference has emerged as an early and persistent form of disruption. Governments and industries that depend on precise timing and navigation—yet have not planned for sustained widespread outages—are increasingly exposed in today's security environment.”

—Joe Noble, Defence & Space,
KPMG Australia

Satellite communications

SATCOM is the space-based cousin of fiber and cellular networks—an orbital telecommunications layer. Satellites relay internet, voice, video, and secure data between ground stations, ships, aircraft, and remote sites. Industry analyses value the satellite communications market at roughly \$98.7 billion in 2024, with projections to more than \$260 billion by 2034.¹ Starlink alone reports more than 9,900 satellites serving millions of customers,³² using low-Earth-orbit

(LEO) orbits to reduce latency and provide redundancy when terrestrial networks fail.⁷

Governments are moving aggressively, too. The European Union’s Infrastructure for Resilience, Interconnectivity, and Security by Satellite (IRIS²) constellation is a planned 290-satellite system backed by about €10 billion, aiming to provide secure connectivity for governments and commercial users by 2030.^{12,13}



estimated global SATCOM market in 2024



IRIS constellation backed by €10 billion

Earth observation/remote sensing

EO satellites are essentially orbiting cameras and sensors. They measure light (optical), heat (infrared), radar reflections (SAR), and other signals to track what’s happening on the planet’s surface and in the atmosphere. The global EO market—which includes imagery, analytics, and value-added services—is estimated to be around \$5 billion–\$7 billion in 2024, depending on definition and scope.^{2,8}

Landsat, a long-running US program, shows how this data turns into economic value. In 2023, users accessed 65.6 million Landsat “scene equivalents,” and the total annual economic value of Landsat imagery was estimated at \$25.6 billion—a jump from about \$3.5 billion in 2017.^{9,10} The program now supports four decades of consistent land-cover data across the US, enabling everything from crop monitoring to urban planning.¹¹

Positioning, navigation, and timing

PNT services—GNSS like GPS, Galileo, BeiDou, and GLONASS—are the timekeeper and map for modern economies. A recent industry report valued the GNSS market at about \$301 billion in 2024, with an expected rise to \$703 billion by 2032, driven by automotive, smartphones, precision agriculture, and industrial applications.⁴ These services provide precise time stamps for financial trades, synchronize power grids and telecom networks, and guide everything from container ships to drones.



Earth observation has moved well beyond experimental pilots and into production workflows across multiple sectors. What stands out across enterprise deployments is not just the diversity of use cases, but the way EO data is increasingly embedded directly into core operational systems—supporting real-time monitoring, regulatory compliance, asset optimization, and risk management at scale.”

—David Pessah, Ignition Discovery Leader, KPMG US

Why Layer 2 is foundational

Put simply: **Layer 1 puts objects in orbit; Layer 2 turns them into an information utility.** Without EO, SATCOM, and PNT, enterprises lose:

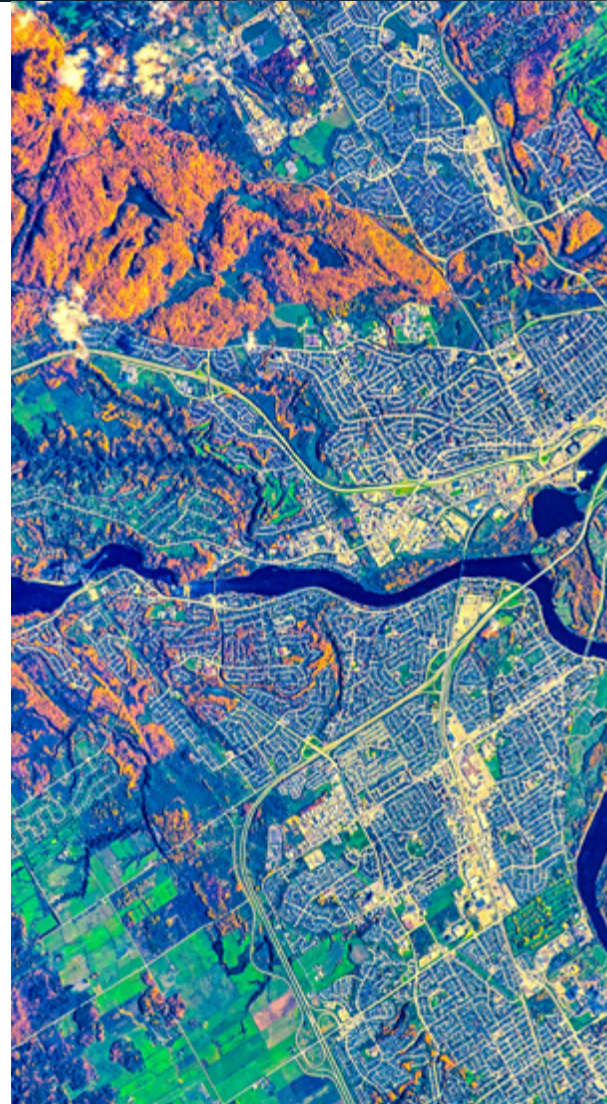
- Global visibility into operations and risk
- The ability to run cloud services and analytics in remote or contested regions
- The timing backbone that keeps financial markets, grids, and networks synchronized.

Layer 2 is therefore a **core digital infrastructure**, on par with cloud, undersea cables, and terrestrial networks—not a science project.

The problems Layer 2 solves (and the value it creates)

Connectivity gaps and digital inclusion

In telecom, Layer 2 is closing the “last-mile” gap. India’s SATCOM market, for example, is valued at about \$2.3 billion today, with expectations of nearly tenfold growth over three years as operators serve rural and remote regions.¹⁸ LEO constellations offer backhaul for mobile networks, direct broadband to underserved communities, and resilient links after disasters. A new wave of direct-to-device services aims to connect standard smartphones directly to satellites as a fallback or complement to terrestrial networks. AST SpaceMobile’s BlueWalker-3 test satellite has demonstrated 4G and 5G broadband from space to regular phones, achieving download speeds above 10 Mbps in tests.^{19,20} Lynk Global has received Federal Communications Commission approval to offer satellite direct-to-device services in areas like Guam and the Northern Mariana Islands, building on an earlier license for commercial satellite-to-phone operations.^{21,22}



Supply chain, logistics, and infrastructure

SAR and optical constellations provide near-real-time views of ports, rail yards, pipelines, and roads, even at night or through clouds. ICEYE, for example, operates a fleet of 62 SAR satellites³⁴ and will provide SAR data to the North Atlantic Treaty Organization’s (NATO) Situation Centre to enhance situational awareness and decision-making.^{15,16} The same capabilities can monitor container buildup at ports, track rail congestion, and detect infrastructure damage after storms.

Climate, land use, and environmental monitoring

EO underpins modern climate and land-management strategies. The Landsat program alone delivered \$25.6 billion in estimated economic value in 2023, reflecting its widespread use in agriculture, water management, environmental regulation, and disaster response.^{9,10} Annual land-cover databases now provide nearly 40 years of consistent land-change records across the continental US, enabling better modeling of floods, fires, and urbanization.¹¹

Commercial imagery is growing quickly as well: The satellite imaging market was about \$4.2 billion in 2023, with forecasts of double-digit growth as governments and insurers rely on imagery for disaster management.¹⁴

What's new— and why this layer is different now

Several shifts make Layer 2 qualitatively different from even five years ago.

Massive constellations and persistent coverage

SpaceX has launched nearly 11,400 Starlink satellites since 2019 and have more than 9,900 Starlinks currently operational as of March 2026.³² This density enables near-continuous global coverage and rapid fail-over.



More capable EO constellations

New entrants like Pixxel are deploying hyperspectral imaging constellations; Pixxel's first three satellites, launched in early 2025, support use cases across agriculture, mining, and environmental monitoring, with estimates that hyperspectral EO could reach \$500 million–\$1 billion in annual market value by 2029.²⁵

Hyperspectral EO could reach
\$500M–\$1B
and annual market value by 2029

Explosive growth in data services and downstream analytics

The satellite data services market is projected to grow from \$5.25 billion in 2024 to more than \$12 billion by 2032, with double-digit compound annual growth rate as organizations pay for “insight-as-a-service” rather than raw pixels.³ A separate analysis projects data services will reach \$62.3 billion by 2034 from about \$11.5 billion in 2024, underscoring how quickly downstream analytics are expanding.²⁴

Data services projected to reach
\$62.3 B
by 2034 from \$11.5 billion in 2024

The challenges that must be solved next



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Spectrum and regulatory constraints

In the United States, National Oceanic and Atmospheric Administration (NOAA) licenses private remote sensing systems under a detailed regulatory regime aimed at balancing innovation with national security.²⁸ Recent reforms have lifted many restrictive conditions from high-end (Tier 3) licenses, signaling a more permissive stance—but also more attention to debris and data-sharing obligations.^{29, 30} For SATCOM and device-to-device (D2D), spectrum sharing between satellites and terrestrial mobile networks remains a contested issue, with regulators scrutinizing interference and coexistence.

Ease of using space-derived data

For end users, the true value of EO data depends on how easily it can be accessed, understood, and integrated into daily workflows. Despite rapid advances in satellite imaging and analytics, usability remains a key challenge. Many organizations still face barriers such as complex data formats, limited interoperability with existing business systems, and a lack of intuitive tools for visualization and analysis.

Cybersecurity and resilience

As more operations depend on satellite connectivity and PNT, cyber-physical attack surfaces expand. GNSS spoofing, jamming, and cyberattacks on ground infrastructure could have outsized effects on logistics, grids, and finance. The same redundancy that makes Starlink resilient—thousands of satellites and distributed gateways—also means organizations must integrate space assets into their cyber and continuity planning.⁷

PNT reliance and vulnerability. With GNSS markets exceeding \$300 billion and forecast to more than double by 2032, economies are becoming more dependent on precise timing and navigation.⁴ This increases the importance of backup PNT and space-based alternatives for resilience.



The opportunity map 2026–2035

NOW
NEAR
NEXT

1-2 years

DATA SUBSCRIPTIONS AND APPLICATION PROGRAMMING INTERFACES (APIS)

Buy access to EO and SAR data—e.g., Landsat, commercial optical, and providers like ICEYE—to enhance risk; environmental, social, and governance (ESG); and operational dashboards.^{9,15,16}

CONNECT REMOTE OPERATIONS

Use LEO broadband (Starlink, emerging Amazon Leo, regional providers) for mines, offshore platforms, and rural facilities, particularly in markets like India where SATCOM demand is booming.^{7,18}

PNT RISK ASSESSMENT

Benchmark your dependence on GNSS timing and navigation; plans should reflect a GNSS ecosystem of more than \$300 billion that is powerful but vulnerable.⁴



NOW
NEAR
NEXT

3–5 years

VERTICAL ARTIFICIAL INTELLIGENCE PRODUCTS BUILT ON EO

Leverage fast-growing satellite data markets—projected to more than double by the early 2030s—to build sector-specific risk scores (crop yield indices, flood-risk curves, maritime risk scores).^{3,24}

D2D FOR BUSINESS CONTINUITY

Pilot direct-to-device satellite services as backup connectivity for workforces in rural regions or during disasters, using early-mover services from AST SpaceMobile and Lynk.^{19,21,22}

SOVEREIGN AND PARTNER CONSTELLATIONS

Explore partnerships with regional programs like IRIS² for secure connectivity and data-sovereignty guarantees, especially in Europe and adjacent markets.^{12,13}



NOW
NEAR
NEXT

5–10 years

ALWAYS-ON OPERATIONAL TWINS

Combine EO, SAR, GNSS, and in-situ sensors to maintain continuously updated “digital twins” of supply chains, assets, and ecosystems—supported by a data-services market that could reach tens of billions of dollars annually.^{3,24}

NEW FINANCIAL AND INSURANCE PRODUCTS

Use historical EO archives and GNSS-tagged event logs to price risk more accurately—building parametric insurance, climate-linked securities, and performance-based contracts around observed outcomes (e.g., rainfall, crop vigor, flood extent).

INTEGRATED CONNECTIVITY STRATEGIES

Treat LEO, medium Earth orbit, geosynchronous orbit, terrestrial 5G, and fiber as parts of a single enterprise network design, rather than separate projects, leveraging maturing regional constellations and competitive dynamics.



How Layer 2 creates value

for CFOs, CTOs/CIOs, CEOs, CHROs, and boards



CFO

Key performance indicators (KPIs): Cost per GB of connectivity, cost per “insight” (e.g., per EO-derived metric), avoided loss from climate events, and revenue lift from new data-driven products.

Value pools:

- Lower network total cost of ownership in remote operations by blending LEO with terrestrial backhaul.
- Reduced disaster losses through earlier warnings and faster response, enabled by EO markets sized at \$5 billion–\$7 billion today and growings.^{2,8}

Capital view: Data subscriptions and APIs are often operating expenses, not capital expenses, which can accelerate adoption but requires robust vendor-risk management—especially where governments can restrict access, as seen in Ukraine imagery suspensions.¹⁷

CEO

Strategic differentiation:

- Use EO-derived metrics and GNSS-enabled telemetry to offer better-priced, more transparent services (e.g., insured logistics, climate-resilient agriculture).
- Build or acquire data-driven ventures that package satellite data into vertical solutions; EO investment patterns show downstream application companies attracting the majority of new funding.³¹

CTO/CIO:

Infrastructure and data strategy:

Position Layer 2 as an extension of your cloud and edge stack, not a separate system; EO and SATCOM providers increasingly offer data via cloud marketplaces and standard APIs, aligned with the satellite-data services market’s projected more than 2x growth by the early 2030s.^{3,24}

Integration with information technology/operational technology:

Integrate satellite feeds into existing observability tools, geographic information system (GIS) platforms, and Internet of Things systems; SAR and optical data from providers like ICEYE and Landsat can plug directly into asset-monitoring and risk dashboards.^{9,15}

Vendor landscape: Balance single-provider simplicity against resilience and bargaining power; consider dual-constellation strategies.

Geopolitical and resilience implications:

- Diversify providers across jurisdictions (US, Europe, Asia) to mitigate export controls or access suspensions.
- Engage with sovereign constellations like IRIS² for strategic autonomy in key markets.^{12,13}

Capabilities required:

- Geospatial analytics, remote sensing science, radio frequency engineering, and cloud data engineering.
- Policy literacy around spectrum, remote sensing regulations, and data protection.

Learning and development priorities:

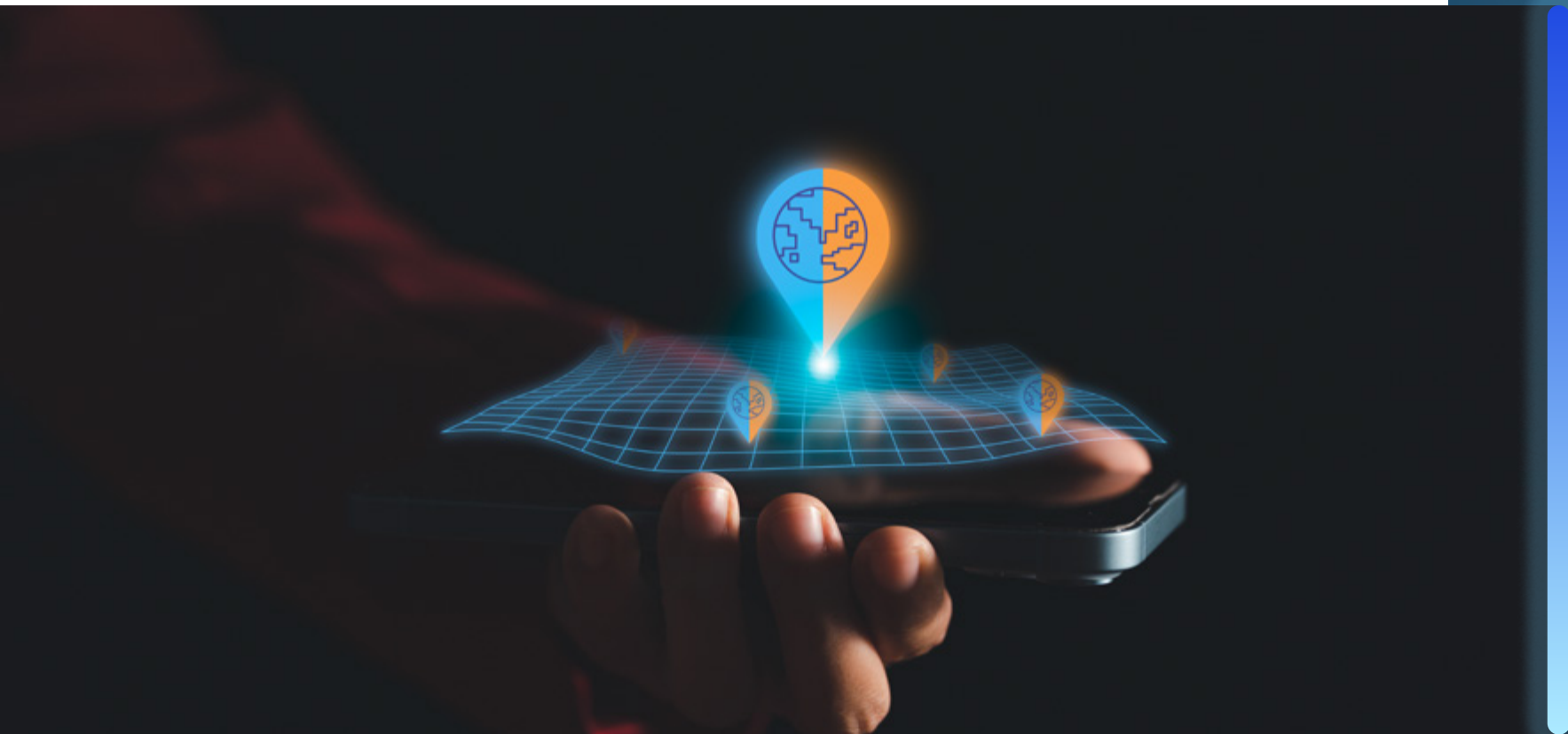
Upskill existing analytics, network, and cyber teams on EO and SATCOM basics; recruit selectively from aerospace, defense, and geospatial sectors.

Governance priorities:

- Oversight of data-governance and privacy policies for high-resolution imagery and movement data.
- Assessment of PNT and connectivity dependencies, given GNSS market scale and related vulnerabilities.⁴

Risk and foresight:

- Scenario planning for loss or restriction of specific constellations or regions.
- Oversight of participation in space-data ecosystems with military or dual-use implications (e.g., NATO, national security customers).^{16, 26}



As the US Space Force (USSF) continues to scale its size and acquisition/operational capabilities, space data and connectivity become crucial for a decisive warfighting advantage. What was once invisible orbital infrastructure, now delivers continuous streams of signal and insight that underpin joint military operations and national security. From resilient SATCOM and real-time Earth observation to precision timing that synchronizes battle networks, this strategic layer empowers the USSF to equip its Guardians and joint and allied partners with the situational awareness, connectivity, and rapid response capabilities.”

—Stephen Ponce, US Space Force Lead, KPMG US

2030

A “Day in the Life”

Space data as invisible infrastructure

It's 6:30 a.m. in 2030

A global food and energy company's operations center brings up its daily “planetary dashboard”:

- EO feeds show overnight changes in soil moisture and vegetation across millions of hectares, fusing open Landsat-style archives with commercial hyperspectral data from constellations like Pixxel.^{9,25}
- SAR imagery from providers such as ICEYE tracks flood extent and port congestion, feeding risk scores into shipping and insurance decisions.^{15,16}
- LEO SATCOM and regional constellations like IRIS² ensure every site—offshore platforms, rural grain silos, and microgrids—has resilient connectivity, even though storms knocked out several terrestrial backhaul links overnight.^{7,12}
- GNSS feeds anchor everything in time and space, synchronizing energy trading systems and the company's internal stablecoins to submillisecond precision.⁴

Executives rarely say “space” during the morning meeting. They talk about fill rates, risk scores, service-level adherence, and emissions intensity. Layer 2 has faded into the background—yet it quietly powers the dashboards, alerts, and automations running the enterprise.

Executive checklist

What to do Monday morning



Immediate steps

Map dependence on space data. Inventory where EO, SATCOM, and GNSS already sit in your workflows (network resilience, fleet tracking, risk analytics).

Get a baseline “space data bill.” Quantify current and potential spend on satellite data and connectivity relative to avoided losses and new revenue.



Partnership and vendor considerations

Diversify across jurisdictions and constellations (e.g., US, European, and regional providers) to mitigate policy risk and enhance resilience.^{12,13,18}

For strategic sectors, explore multiyear agreements for dedicated capacity (as seen in Planet’s \$230 million Asia-Pacific deal) to lock in service levels and influence constellation design.²⁶



Diagnostic questions

Where do we suffer from blind spots—regions, assets, or risks we cannot see in near-real time?

How much of our critical infrastructure would fail or degrade if we lost GNSS or a major satellite broadband provider?^{4,7}



Data, talent, and capability requirements

Add remote sensing and GNSS expertise to analytics and network-engineering teams.

Establish an internal Space Data Working Group spanning CIO, COO, risk, and ESG to set priorities, governance, and early pilots across business units.



Integration priorities

Connect at least one EO/SAR provider and one SATCOM provider into your cloud environment via APIs or marketplaces within the next 12–18 months.^{3,15}

Ask network and cyber teams to treat satellites and ground segments as first-class assets in incident-response and continuity plans.



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LAYER 3

Enabling Technologies

AI, edge computing, quantum, and beyond

Introduction summary

Layer 3—Enabling Technologies—is where the space economy evolves from “metal in orbit” to a software-defined, self-optimizing system. This layer encompasses artificial intelligence (AI), edge computing, quantum sensing, advanced materials, and automation architectures, transforming space infrastructure and data into intelligent, responsive networks. As humanity looks to expand into cislunar and deep-space economies, Layer 3 solves critical challenges both terrestrially and orbitally: onboard AI and edge computing enable satellites and platforms to autonomously process vast data

streams, triage events, and deliver actionable insights in real time, reducing latency and bandwidth constraints. Quantum sensors and advanced materials unlock new capabilities in navigation, climate monitoring, and reusable spacecraft, while automation architectures lower operational costs and enhance resilience. These technologies are already being deployed to support autonomous guidance, rapid disaster response, and secure communications, laying the groundwork for persistent infrastructure and intelligent operations across Earth, lunar, and deep-space domains.

By integrating these enabling technologies, Layer 3 addresses the growing complexity and scale of space operations, making it possible to manage fleets of satellites, optimize resource use, and deliver high-value services to terrestrial industries. AI-driven automation and edge processing shift the paradigm from human-intensive operations to exception-based management, while quantum sensing and new materials extend mission lifetimes and improve precision in harsh environments. As orbital platforms become more intelligent and interconnected, enterprises gain faster situational

awareness, improved risk management, and the ability to support autonomous systems and digital twins for infrastructure, logistics, and resource exploration. In the decades to come, Layer 3 will be essential for realizing the full potential of cislunar and deep-space economies, enabling seamless integration of space assets into terrestrial digital infrastructure and unlocking new frontiers for innovation and growth.





The intersection of digital innovations such as AI, edge computing, and quantum with space-based capabilities will help us to manage the sheer volume of Earth observation data and communications capacity that is now available.”

—Neil Rae, Space Lead, KPMG UK

TRANSITION: Problems to solve for the next five years

To fully realize the opportunities of Layer 3 over the next five years, several critical challenges must be addressed. Compute in harsh space environments remains a barrier, as radiation-hardened processors lag behind commercial chips, limiting the deployment of advanced AI models and edge platforms. Model robustness and verification are essential for trusted autonomy, requiring new approaches to training, validation, and safety in novel orbital conditions. The ecosystem of satellite edge-computing platforms is fragmented, with standardization and orchestration still emerging. Scaling quantum technologies demands breakthroughs in miniaturization, cost, and mass production, while advanced

materials require extensive qualification to ensure reliability and manage lifecycle costs. As satellites become software-defined and AI-rich, cybersecurity and supply-chain risks expand, necessitating robust governance and resilience strategies. Addressing these challenges will require coordinated action across industry, government, and academia to ensure that enabling technologies remain secure, scalable, and interoperable as humanity pushes toward cislunar and deep-space frontiers. The following sections will explore these issues in detail and outline actionable strategies for executives and boards to position their organizations for success in the evolving space economy.

Executive summary

Layer 3 is where the space economy stops being “metal in orbit” and starts behaving like a software-defined, self-optimizing system. It covers the enabling technologies—AI, edge computing, quantum sensing, advanced materials, and automation architectures—that make Layers 1 (infrastructure) and 2 (data and connectivity) dramatically more capable.

Across agencies and industry, AI and machine learning (ML) are now being deployed onboard spacecraft to deliver low-latency predictions, perform autonomous guidance and navigation, and triage massive data streams before they ever reach the ground.^{1, 2, 3} New architectures for onboard AI processing in satellite communications are emerging to reduce human intervention and operational cost.⁴ In parallel, satellite edge computing has moved from concept to necessity: the global satellite edge-computing market was about \$1.1 billion–\$1.5 billion in 2024, with forecasts to \$6 billion–\$11 billion by 2033,

implying annual growth rates well above 20 percent.^{5, 6, 7} Quantum technologies are moving from lab to orbit. The National Aeronautics and Space Administration’s (NASA) Quantum Gravity Gradiometer Pathfinder will fly a compact quantum sensor using ultra-cold atoms to map Earth’s gravity field with sensitivities up to an order of magnitude better than classical instruments.^{8, 9} A broader quantum sensors market is projected to grow to about \$1.9 billion by 2046, with navigation, remote

sensing, and timing as key applications.¹⁰ Advanced materials, particularly new thermal protection system (TPS) composites, are enabling reusable spacecraft and higher-temperature operations. NASA’s TPS program has developed multiple reusable tile and composite systems,¹³ and a recent Oak Ridge National Laboratory–Sierra Space collaboration produced a carbon-fiber/silicon-carbide (C/SiC) TPS designed for repeated atmospheric re-entry.¹⁴

global satellite edge-computing
market forecast

\$1.1–\$1.5

billion in 2024



\$6–\$11

billion by 2033

The broader quantum
sensors market is
projected to reach

\$1.9

BILLION IN 2046

For executives, Layer 3 changes the conversation from “Can we get data from space?” (Layer 2) to “How smart, secure, and responsive can our entire space–ground system be?” It affects:

- **CFOs:** Cost curves for operations and maintenance, AI-driven automation of ground segments, and new high-margin data products
- **CTOs/CIOs:** Integration of orbital edge nodes into enterprise cloud/edge architectures
- **CEOs and boards:** Strategic differentiation, sovereign capability, and resilience in a world where AI, quantum, and orbital compute converge.



We often think of AI as software, but this is the year it becomes truly physical. In space, we’re embedding intelligence directly into the hardware. This transforms our satellite infrastructure from a passive data collector into an active, physical backbone for the global economy, making decisions and delivering insights right at the source.

—Brian Higgins, Americas and US Sector Leader, Industrial Manufacturing, KPMG US

Layer 3 in plain English

What it is and why it matters

Think of Layers 1 and 2 as hard-coded infrastructure and data feeds. Layer 3 is the “intelligence layer” that:

- Makes satellites act more like autonomous robots than passive hardware
- Processes data in orbit instead of shipping everything back to Earth
- Uses quantum effects to measure gravity, time, and fields with extreme precision
- Uses new materials to make vehicles reusable, lighter, and more durable.

AI and onboard autonomy

NASA describes onboard AI as crucial for low-latency predictions and autonomous behavior in remote sensing and guidance/navigation, constrained by the limited compute power and radiation environment in space.¹ Scientific reviews of AI for satellite operations show growing use of ML for tasks like anomaly detection, mission planning, and resource optimization—shifting from scripted modes to trusted autonomous operations.³

In business terms, this means:

- Fewer routine human interventions in operations centers
- Faster response to events (e.g., a satellite automatically retargets wildfires)
- Lower operating expenditures as automation scales across fleets.

Quantum sensing and communications

Quantum sensors use quantum phenomena—like the wavelike behavior of ultra-cold atoms—to measure gravity, acceleration, magnetic fields, and time far more precisely than classical instruments.^{9,10} NASA’s planned mission will fly a compact quantum gravity gradiometer (approximately 0.25 m³, approximately 125 kg) using clouds of ultra-cold rubidium atoms to map gravitational anomalies and potentially offer up to 10x sensitivity improvement over existing space instruments.⁸

For executives, quantum sensing means better climate, resource, and navigation data—not a science fair trick.

Edge computing in orbit

“Edge computing” simply means processing data near where it is generated instead of sending it all back to a central cloud.⁷ For satellites, that means running algorithms onboard to compress, classify, and interpret data in real time. On-orbit edge-computing nodes reduce latency, cut bandwidth usage, and improve data security by keeping sensitive information in space.^{5,8}

Market research estimates the satellite edge-computing market was around \$800 million–\$1.1 billion in 2024, with projections to \$6 billion–\$7 billion by 2033, growing at approximately 19 percent–28 percent compound annual growth rate (CAGR).^{5,6,7}

Advanced materials

Reusable spacecraft and high-duty constellations need thermal protection and structures that can survive repeated launches and reentries. NASA’s Thermal Protection Materials Branch has developed multiple reusable tile and composite TPS systems, including TUFROC, a toughened fibrous composite used on blunt-body re-entry vehicles.¹³ A newer C/SiC composite TPS developed by Oak Ridge National Laboratory and Sierra Space combines carbon fiber and silicon carbide to provide high-strength, high-temperature performance at low density.¹⁴





Enabling technologies transform satellites and space systems from passive tools into intelligent, autonomous platforms. AI, edge computing, quantum sensing, and advanced materials let orbital systems process data on-site, respond in real time, and operate with unprecedented efficiency and resilience. For organizations, these capabilities translate into faster decisions, lower operational costs, and the ability to manage complex global systems, from logistics networks to climate risk, more effectively than ever before.”

—Seraphim Space

The problems Layer 3 solves (and the value it creates)

Too much data, not enough bandwidth

Modern Earth observation (EO) missions generate terabytes of data per day, but downlink windows and bandwidth are limited. Technical reviews highlight that traditional ground-centric processing is too slow and costly for high-tempo missions, and that onboard data triage is becoming “exceptionally critical.”^{1,5,6}

Edge-computing analyses show that processing data in orbit allows satellites to transmit only high-value insights—such as detected ships, fires, or crop anomalies—rather than raw pixels, cutting bandwidth and enabling near-real-time alerts.^{7,8}

Enterprise value is faster situational awareness for logistics, insurance, energy, and governments; lower data-transport costs; and quicker cycle times for AI models.



Human-intensive operations and OPEX

Satellite communications (SATCOM) systems today still rely heavily on human operators, with high operating expenditures (OPEX) and slower response times. A 2023 MDPI study notes that new SATCOM systems increasingly use AI/ML to provide higher autonomy and control, but require orders-of-magnitude more onboard compute than legacy space-grade processors can provide.⁴

Enterprise value is AI-enabled operations centers can move from manual configuration and troubleshooting to exception-based management, lowering cost per satellite and improving service quality.

Latency-sensitive applications

For defense, disaster response, and autonomous systems, seconds matter. Satellite edge-computing guides emphasize that in-orbit processing can dramatically reduce latency for tipping and cueing (e.g., a satellite detecting a missile launch and immediately alerting other systems).^{8,15}

Enterprise value is safer autonomous logistics, faster cyber and physical threat detection, and more responsive grid and pipeline operations.



Limits of classical sensors and navigation

Quantum sensing reviews argue that quantum instruments can outperform classical sensors in gravity, navigation, and magnetic-field measurements, especially in GPS-denied environments.^{9,16,17} IDTechEx estimates the quantum sensor market could reach about \$1.9 billion in annual revenue by 2046, with navigation and remote sensing as key domains.¹⁰

Enterprise value is more precise resource mapping, better subsurface modeling for energy and mining, improved navigation resilience, and new environmental and industrial monitoring services.

Reusability and system lifetime limits

Thermal protection and structural fatigue limit how many times vehicles can be reused. NASA and academic studies highlight TPS as one of the most expensive and mission-critical subsystems in reusable launch vehicles.^{13,18,19} New C/SiC composites and ceramic matrix materials can operate at 1,400°C–2,000°C, allowing more reuses and lighter structures.^{14,20}

Enterprise value is lower cost per launch, higher fleet availability, and more flexible mission profiles—all feeding back into cheaper and more frequent access to Layer 1 and Layer 2 services.

What's new— and why this layer is different now

Onboard AI goes from demo to deployment

NASA's AI technology review shows a shift from early demonstrations (like EO-1's cloud-detection experiments in the 2000s) to actively exploring more complex onboard AI for remote sensing and autonomous guidance, leveraging commercial-off-the-shelf (COTS) accelerators screened for radiation.¹ A 2024 review on trusted autonomous satellite operations synthesizes techniques for anomaly detection, health monitoring, and mission planning as AI becomes integral to operations.³

Market analyses indicate that AI-defined satellite payloads—payloads whose behavior is largely controlled by software and ML—already represent approximately \$1.3 billion in annual revenue (2024) with projections to over \$6 billion by 2033 (approximately 18 percent CAGR).²¹

Satellite edge-computing as a distinct market

The global satellite edge-computing market was valued at around \$810 million–\$1.1 billion in 2024, with forecasts of \$6 billion–\$7.2 billion by 2033, growing approximately 19 percent–28 percent annually.^{5,6,7} Industry round-ups document a broadening ecosystem of edge-computing hardware and software suppliers, and forecast space edge systems alone reaching about \$840 million by 2030.⁸



Optical mesh networks and on-orbit data centers

The US Space Development Agency's Tranche 1 Transport Layer will field 154 operational satellites, each equipped with optical intersatellite links (OISLs) and Ka-band/radio frequency links to form a dynamically routed orbital mesh network.^{11,22,23} Recent demonstrations have proven two-way optical links between a satellite and an aircraft, as well as

standardized laser links between satellites from different vendors.^{12,24}

Analysts describe on-orbit data centers as a next phase, where AI-accelerated compute in orbit fuses multisensor data and hosts sovereign workloads for governments and enterprises.^{25,26,27}

Quantum missions moving toward flight

NASA's QGGPf mission, planned for launch near the end of this decade, will test a space-based quantum gravity gradiometer using ultra-cold rubidium atoms, with expected sensitivity improvements up to 10x over classical

sensors.⁸ NASA's broader quantum-sensing roadmap highlights cold-atom interferometers, atomic drag-free accelerometers, and quantum clocks as key technologies for future climate and planetary missions.^{9,16,28}

The challenges that must be solved next

1

Compute in a harsh environment

Radiation-hardened processors lag far behind commercial chips, making it difficult to run modern AI models. NASA notes that COTS accelerators can help but require radiation screening and fault-tolerant architectures.¹

4

Cybersecurity and supply-chain risk

As satellites become software-defined and AI-rich, the attack surface widens—edge nodes and optical networks must be treated as critical infrastructure, with secure update, identity, and monitoring patterns borrowed from terrestrial cloud.

2

Model robustness and verification

Reviews highlight that limited training data for novel environments and the difficulty of validating ML behavior under all conditions are major barriers to “trusted autonomy.”^{1,3,4}

5

Standardization of edge platforms

Market research points to a fragmented ecosystem of satellite edge-computing platforms, with orchestration (e.g., Kubernetes in space) and interoperability still emerging.^{5,24}

3

Materials qualification and lifecycle cost

TPS reviews stress that reusable systems must be extensively tested to manage thermal, structural, and manufacturing uncertainties, which can dominate the lifecycle cost of reusable vehicles.^{13,18,19,30}

6

Scaling quantum tech

Quantum-sensor market studies emphasize challenges in miniaturization, cost, and mass production of physics packages, even as the sector grows toward a projected \$1.9 billion by 2046.¹⁰

The opportunity map 2026–2035

NOW
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1-2 years

AI-ASSISTED OPERATIONS

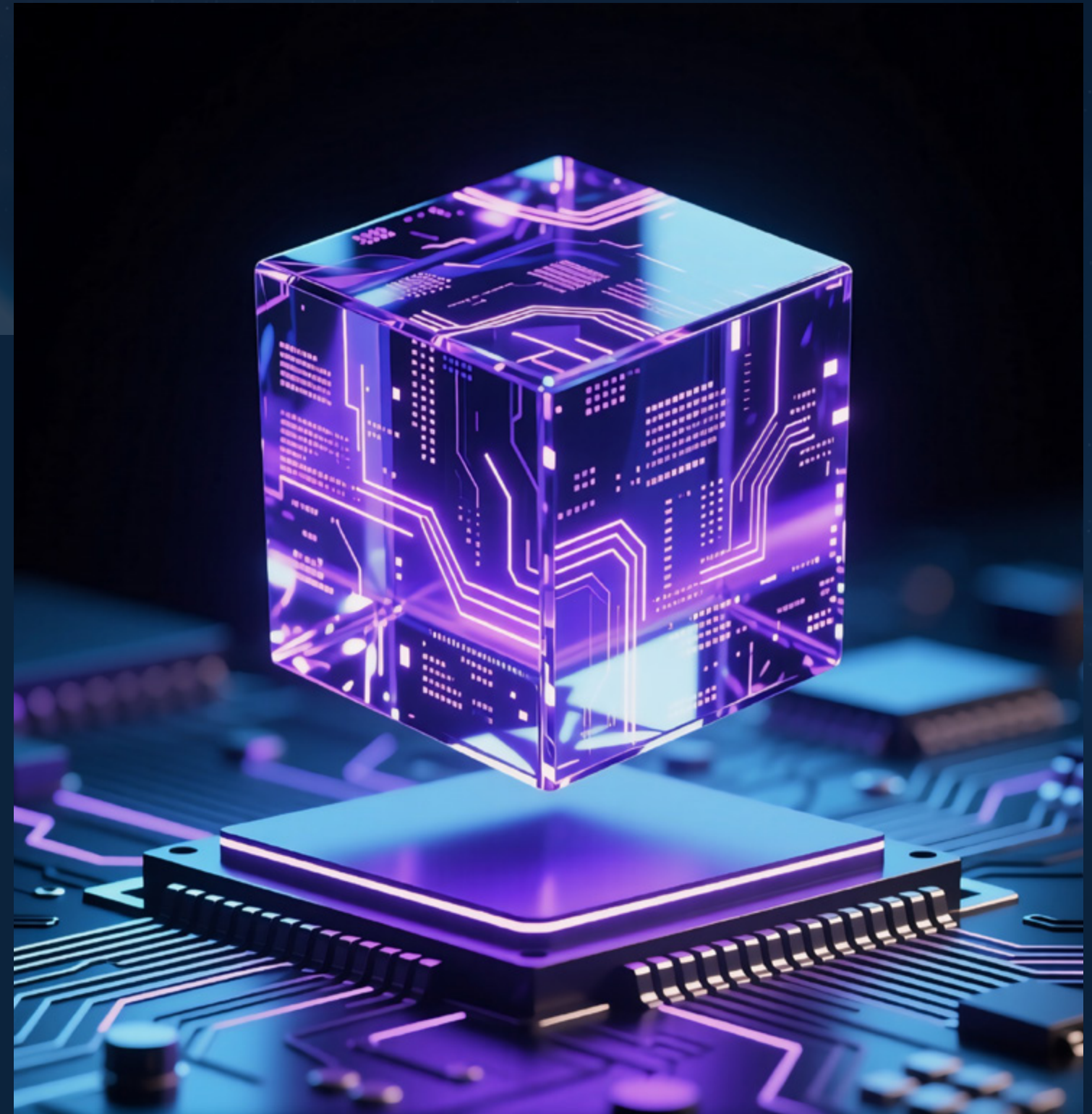
Deploy AI for ground-segment tasks such as anomaly detection and capacity planning, using techniques already described in satellite-operations literature.^{3,4,37}

PILOT SATELLITE EDGE-PROCESSING SERVICES

Partner with EO or SATCOM providers offering on-orbit processing (e.g., for real-time tipping and cueing) as the satellite edge-computing market scales from just over \$1 billion in 2024 toward multibillion by 2033.^{5,6,7}

MATERIALS AND REUSABILITY DUE DILIGENCE

For aerospace and logistics players, benchmark suppliers' TPS materials—like NASA's reusable tiles and emerging C/SiC composites—against cost-per flight and maintenance key performance indicators (KPIs).^{13,14,20}



NOW
NEAR
NEXT

3–5 years

CODESIGN AI-DEFINED PAYLOADS

Collaborate with satellite manufacturers to design software-defined payloads aligned with your sector, tapping into a satellite-payloads market projected to grow from approximately \$9 billion–\$11 billion in 2024 to \$21 billion–\$22 billion by 2030.^{12,13}

INTEGRATE ORBITAL EDGE INTO DATA PLATFORMS

Treat satellite edge nodes as just another edge tier in enterprise architectures, taking advantage of orchestration advances and merger and acquisition activity in satellite edge-computing/ Kubernetes vendors.^{24,27}

EARLY QUANTUM PARTNERSHIPS

Work with agencies and start-ups exploring quantum gravity, magnetic, and timing sensors, building internal use-cases in climate, navigation, and resource exploration as the technology matures.^{8,9,16,21}



NOW
NEAR
NEXT

5–10 years

ON-ORBIT DATA CENTERS AS AN EXTENSION OF CLOUD

Shift certain workloads—multisensor fusion, sovereign AI models, latency-critical inference—into on-orbit data centers as offerings mature and AI energy bottlenecks on Earth intensify.^{25,26,27}

QUANTUM-ENHANCED CLIMATE AND NAVIGATION SERVICES

UBuild products around quantum-enabled gravity and magnetic data for subsurface mapping, groundwater monitoring, and resilient navigation, leveraging missions like QGGPf and follow-ons.^{8,9,10}

FULL SOFTWARE-DEFINED CONSTELLATIONS

Operate fleets where payload behavior, routing, and even spectrum usage are dynamically configured via AI and optical mesh networks, building on the PWSA's standardized OISLs and optical-link milestones.^{11,22,23,24,26}



How Layer 3 creates value

for CFOs, CTOs/CIOs, CEOs, CHROs, and boards



CFO

KPIs:

- Cost per autonomous action (versus human ticket)
- OPEX per satellite or per terabyte processed
- Incremental margin from AI-enhanced data products.

Capital and risk lens:

- Edge-computing investments can be structured as service contracts, aligned with a market growing from just over \$1 billion to \$6 billion–\$7 billion by 2033.^{5,6}
- AI-defined payloads and quantum sensors have higher up-front costs but can create defensible, high-margin data franchises.^{10,21}

CEO

Strategic differentiation:

Use Layer 3 to shorten time-to-insight and automate complex decisions—whether routing ships, pricing insurance, or managing grids.

Ecosystem strategy:

Decide where to own enabling technology (e.g., proprietary models, quantum IP) versus partner with specialized providers.

CTO/CIO:

Architecture:

Integrate orbital edge nodes into a unified edge-to-cloud roadmap; align with broader edge-computing markets projected in the hundreds of billions by 2030.^{28,29,30}

Integration priorities:

Standardize interfaces to edge-processing providers and AI-defined payloads; plan for secure ML operations across ground and space assets.^{4,8,24}

Talent mix:
Data scientists with geospatial and edge-AI experience; quantum-aware systems architects; materials and reliability engineers for reusable systems.

Capability building:
Upskill existing analytics and cloud teams on remote sensing, orbital constraints, and AI safety in cyber-physical systems.^{1,3,4}

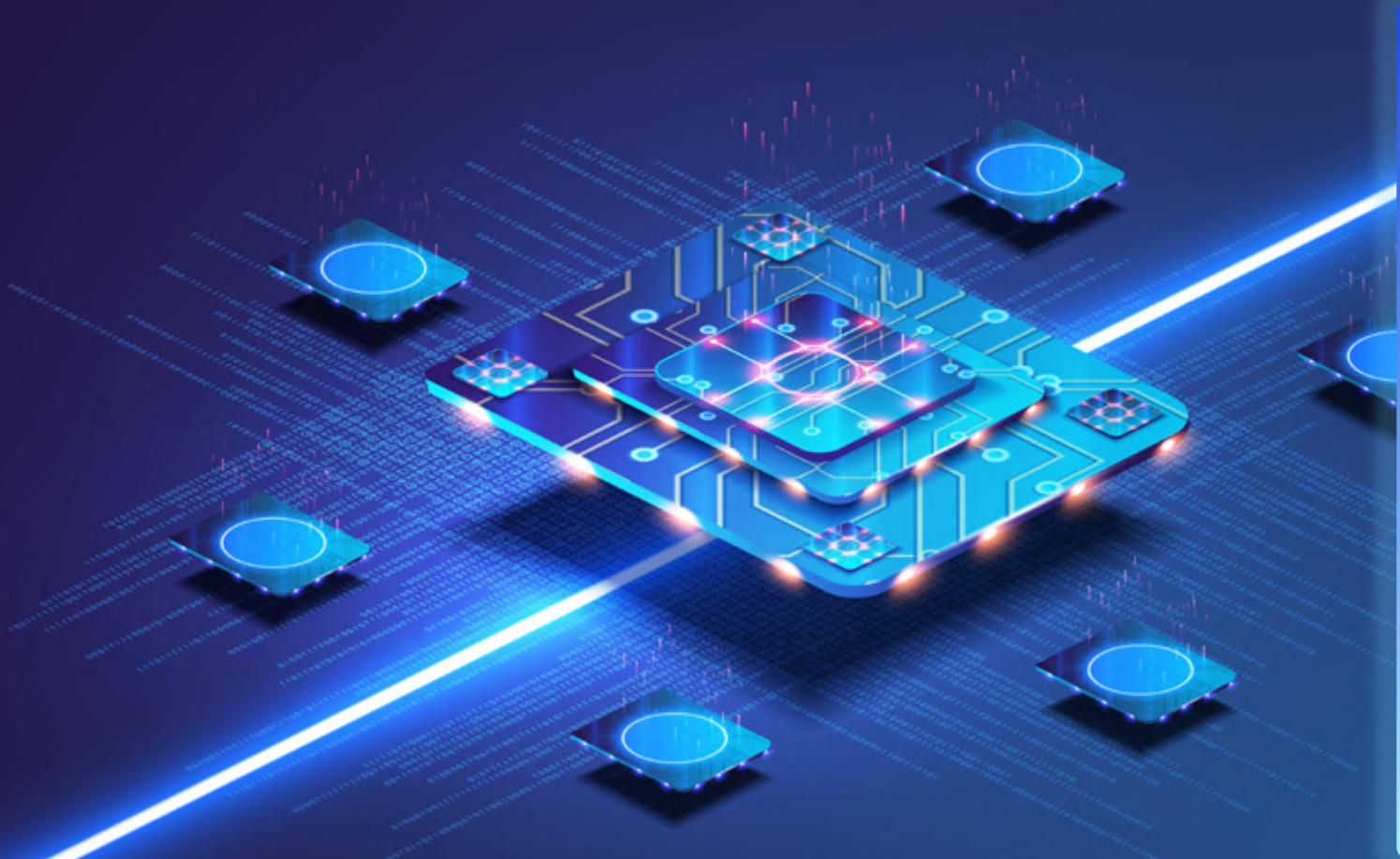
Oversight:
Ensure clear governance for AI in safety-critical systems; monitor dependencies on single suppliers for edge compute, optical networks, or quantum components.

Resilience and environmental, social, and governance lens:
Prioritize investments that improve climate intelligence and resource monitoring (quantum and EO), alongside resilience of digital infrastructure.

2032

A “Day in the Life”

When the space stack becomes a digital mesh



In 2032, a global infrastructure company runs a live “planetary twin” of its assets.

AI models run in an on-orbit data center, fusing radar and optical data from multiple constellations with gravity maps generated by quantum sensors similar to QGGPf, detecting subtle shifts in reservoirs and subsurface mass.^{8,9,25}

Satellite edge nodes classify anomalies—landslides, pipeline stress, transmission-line icing—onboard, sending only prioritized alerts over optical mesh networks like the PWSA Transport Layer.^{11,22,23,24} Ground systems receive these alerts in seconds, not minutes.

Operations teams barely talk about AI, quantum, or TPS materials. They talk about downtime avoided, losses prevented, and contracts won because they can guarantee performance under extreme conditions. Layer 3 has receded into the stack—but it is the reason the business runs as smoothly as it does.

What to do Monday morning



Immediate steps

Map where AI, edge compute, or advanced materials already touch your space or connectivity dependencies (directly or via vendors).

Ask existing satellite or network providers what on-orbit processing, AI-defined payload, or optical-link capabilities they have on their roadmaps.



Partnership and vendor considerations

For sectors like energy, mining, and logistics, pursue codevelopment agreements on AI-defined payloads and edge-computing services, so that constellation behavior is tuned to your requirements.

Engage early with quantum-sensing consortia and agencies to align on pilots, focusing on climate, navigation, and resource-mapping applications.



Diagnostic questions

Where are we bottlenecked by human-intensive satellite or network operations that could be automated?

Which of our use cases would benefit most from lower latency or selective downlink of only high-value events?

Do any of our critical operations depend on emerging quantum or AI components without a clear resilience plan?



Data, talent, and capability requirements

Build a cross-functional Enabling Technologies Taskforce (CIO, COO, CHRO, risk) to prioritize where Layer 3 can create measurable value in the next three to five years.

Start with targeted pilots—one AI-enabled operations use case, one satellite edge-processing partnership, and one quantum-data exploration project—and use them to inform larger bets.



Integration priorities

Design a reference architecture that treats orbital edge nodes, optical links, and AI-defined payloads as part of your edge-to-cloud continuum.

Establish an AI safety and autonomy review for any system that can make decisions about physical assets (grids, fleets, facilities).

LAYER 4

Downstream Applications

Space for industry and society



Introduction

Layer 1

Layer 2

Layer 3

Layer 4

Introduction summary

Layer 4—Downstream Applications—is where the space economy transcends rockets and satellites to become the invisible infrastructure powering everyday business, government, and society. This layer integrates launch capabilities, data and connectivity, and enabling technologies into concrete solutions for agriculture, energy, finance, insurance, logistics, cities, and public services. As humanity looks to expand into cislunar and deep-space economies, Layer 4 solves critical terrestrial and orbital challenges by delivering actionable insights, resilient connectivity, and precision timing

to sectors that underpin global prosperity. Earth observation (EO) and positioning, navigation, and timing/global navigation satellite systems (PNT/GNSS) services, for example, enable smarter crop management, climate risk analytics, disaster response, and financial market synchronization—functions that are essential for both planetary sustainability and the future of off-world industry. The downstream impact is profound: EO alone could add more than \$700 billion a year to global gross domestic product (GDP) by 2030, while GNSS timing now anchors the integrity of global financial systems.

As the space economy grows toward \$944 billion by 2033, downstream applications are projected to drive the majority of new value, transforming how organizations manage risk, optimize resources, and serve communities. Space-enabled solutions are already reshaping insurance, logistics, urban planning, and social protection, with satellite data powering rapid claims processing, route optimization, and targeted disaster relief. In the decades to come, Layer 4 will be essential for integrating lunar and deep space assets into terrestrial workflows, supporting resilient supply chains, and enabling new financial and

insurance products that leverage quantum-secure links and real-time environmental data. This is where “Space for Earth” becomes a board-level imperative, turning space technology from a research and development (R&D) curiosity into a cross-cutting enabler of enterprise transformation and societal resilience.



Introduction

Layer 1

Layer 2

Layer 3

Layer 4



Downstream applications enable space-based capabilities to be tailored to the specific needs of organizations, giving them new insights, global reach, and accelerated decisions. Early adopters of these applications will achieve a profound competitive edge.

—Neil Rae, Space Lead, KPMG UK

TRANSITION: **Problems to solve for the next five years**

To fully realize the opportunities of Layer 4 over the next five years, several critical challenges must be addressed. Fragmented adoption and uneven access remain barriers, with many organizations and countries lacking the technical capacity and awareness to integrate space-derived data into decision-making. Usability and “last mile” integration issues persist, as satellite outputs must be translated into fit-for-purpose indicators and actionable key performance indicators (KPIs) for diverse sectors. The resilience of PNT/ GNSS systems is increasingly vital, requiring multilayer architectures to guard against jamming and spoofing, especially as financial and infrastructure

systems become more dependent on precise timing. Capacity gaps in developing countries must be closed to ensure equitable access to space-enabled services, particularly in agriculture, disaster risk management, and social protection. Addressing these challenges will require coordinated investment in data integration, talent development, and cross-sector partnerships, setting the stage for the next wave of space-enabled growth and resilience. The following sections will explore these issues in detail and outline actionable strategies for executives and boards to position their organizations for success in the evolving space economy.

Executive summary

Layer 4 is where the space economy stops looking like rockets and constellations and starts looking like **everyday business infrastructure**. It is the layer where launch (Layer 1), data and connectivity (Layer 2), and enabling technologies (Layer 3) are combined into **concrete solutions for agriculture, energy, finance, insurance, logistics, cities, and public services**.

The overall space economy reached about **\$626 billion in 2025**,²⁷ with roughly **78 percent coming from commercial activity**.¹ Over the next decade, it is projected to grow from **around \$596 billion in 2024 to \$944 billion by 2033**, with **downstream applications identified as the main driver behind that \$348 billion increase**.²

EO is a prime example. A 2024 World Economic Forum report estimates that **EO insights could add more than \$700 billion a year to global GDP by 2030**, with a **cumulative \$3.8 trillion in economic value between 2023 and 2030**, and enable reductions of **up to 2 gigatonnes of CO₂-equivalent emissions each year**.³

The stand-alone EO industry today is still relatively modest—**around \$5 billion in annual market value**, projected to **exceed \$8 billion by 2033**⁴—but its downstream impact cuts across agriculture, infrastructure, climate, and security.^{3,4}

PNT and GNSS services provide another anchor. The European Union’s (EU) GNSS agency and European Union Agency for the Space Programme (EUSPA) market reports show billions of GNSS devices in use across **road transport, aviation, maritime, agriculture, emergency response, geomatics, and critical infrastructure**, with navigation and timing deeply embedded in nearly every economic sector.^{5,6} Time-keeping

rules now require **US automated trading systems to stay within 50 milliseconds of UTC (NIST)**, and European high-volume trading clocks within **100 microseconds of an atomic-clock reference**, underscoring how deeply financial markets depend on precise time from space-based systems.⁷

For leaders, Layer 4 is where “**Space for Earth**” becomes a board-level topic: EO-powered crop insurance and yield forecasting, GNSS-enabled autonomous logistics, satellite-derived climate risk signals for insurers, and quantum-secure links and timing in financial systems. It turns space from an R&D curiosity into a **cross-cutting enabler of enterprise transformation and societal resilience**.^{2,3}

In 2025, the overall space economy reached

\$626 B

78%

coming from commercial activity

By 2033 it is projected to grow to

\$944 B

Downstream applications identified as the main driver behind that increase



Downstream Applications—space-enabled solutions for industry and society. Layer 4 turns space from rockets and constellations into everyday business infrastructure. It fuses launch, data and connectivity, and enabling technologies into decision-ready solutions across agriculture, energy, finance, insurance, logistics, and public services—space for Earth that is measurable and board relevant. With EO and GNSS/PNT, leaders gain real-time visibility, precise timing, and resilience that lowers risk while unlocking new revenue. The mandate is simple: embed space-enabled data into the enterprise fabric so industry and society grow smarter, safer, and more connected strengthening dual-use applications and the intersection of defense, security, and space as a foundation for global resilience.

—Jonathon Gill, Global Sector Lead, Aerospace & Industrial Markets, KPMG UK

The problems Layer 4 solves (and the value it creates)

De-risking financial systems and payments

Precise timing from GNSS is now embedded in the financial sector. The National Institute of Standards and Technology (NIST) notes that **US automated trading systems must keep clocks within 50 milliseconds of UTC (NIST)**, while European high-volume trading clocks must be within **100 microseconds** of an atomic-clock reference to comply with regulations.⁷ Industry guidance highlights that banks and payment gateways use GPS-based

timestamps to **synchronize trades, interbank transfers, and payment gateways**, and that jamming or spoofing can cause **settlement failures and regulatory breaches**.¹⁶

Commentary from market analysts and navigation experts repeatedly emphasizes that the **global financial system now depends on GNSS-derived time**, and that this dependence creates both efficiency and vulnerability.¹⁷

Making cities and infrastructure smarter

EUSPA's 2024 EO and GNSS Market Report describes GNSS as a foundation for **road transport, rail, aviation, maritime, emergency response, and critical infrastructures**, enabling navigation, asset tracking, and time synchronization across sectors.⁶ EO data supports **urban planning, air-quality monitoring, and infrastructure maintenance**, as shown in European Space Agency (ESA) and United Nations (UN) case studies on land-use mapping, air-pollution tracking, and disaster damage assessment.^{10, 18}



True downstream breakthroughs occur when an application delivers value in moments where existing solutions fall short, embedding itself so seamlessly into decision-making that its impact is felt without users consciously recognizing it.

—Susumu Miyahara,
Space Lead, KPMG Japan



Managing climate risk and disasters

NASA reports that EOs are being used to **develop index-based insurance products for low-income customers in Central America**, reducing disaster risk by triggering payouts when rainfall shortfalls occur.¹¹ Peer-reviewed work associated with GPM shows that such index insurance can significantly reduce the need for households to **liquidate assets or savings after disasters**.¹³

Commercial providers are building on this. ICEYE demonstrates how **satellite flood monitoring** gives insurers “real-time situational awareness,” enabling them to **triage claims and deploy response teams more quickly** during UK flood events.¹⁴ EarthDaily describes how satellite analytics help insurers **identify climate-exposed assets and refine underwriting portfolios**, directly linking space data to climate-risk management.¹⁵

Feeding a growing, climate-stressed world

The Group on Earth Observations’ GEOGLAM program documents how EO data enables **within-season crop yield forecasts and postharvest estimates**, using remotely sensed vegetation indices to predict production and inform food-security planning.¹⁰ NASA’s Earth Science applications note that Landsat data helps **optimize crop inputs, manage irrigation, and support food-security decisions at national scale**.⁸

A 2024 World Economic Forum report estimates that EO-enabled applications in **agriculture, energy, mining, infrastructure, and finance** could collectively unlock **\$700 billion in value by 2030**, with these six sectors accounting for **94 percent of the total EO opportunity**.³

What's new—and why downstream is different now

Downstream as the growth engine

Novaspace's 11th Space Economy Report projects the global space economy to grow from **approximately \$596 billion in 2024 to \$944 billion by 2033**, explicitly stating that **downstream applications are the main driver of the projected \$348 billion growth**, as satellite-enabled services become integral across sectors like agriculture, logistics, and urban planning.²

Insurance and finance use cases mature

Recent research and case studies show insurers moving beyond experimentation. A 2025 literature review documents rapid post-2015 growth in **satellite-based agricultural index insurance**, while case studies from EarthBlox and EarthDaily show commercial insurers using EO data to **improve forestry underwriting and portfolio climate-risk screening**.^{12, 15, 23} (NHESS) NASA and Virginia Tech highlight partnerships where **satellite imagery allows quick agricultural damage assessments** after severe weather, speeding up claim handling.^{20, 24}

\$348 BILLION
growth, as satellite-enabled services become integral across sectors like agriculture, logistics, and urban planning.

Over
\$700 BILLION
opportunity by 2030

Better analytics and AI unlock more value

Deloitte and World Economic Forum analyses argue that EO data's **over \$700-billion opportunity by 2030** depends heavily on wider adoption of **AI, digital twins, and climate-tech platforms** that translate pixels into business intelligence.^{3, 21} NASA's "Earth Science at Work" profiles show commercial users integrating NASA data sets with their own analytics pipelines to optimize **retail siting, energy forecasting, and commodity trading**.²²



The challenges that must be solved next

1
Fragmented adoption and uneven access. Despite large potential value, the World Economic Forum notes that EO remains underused, and that barriers include **limited awareness, lack of integration with existing decision systems, and skills gaps.**^{3, 21}

2
Data usability and “last mile” integration. Academic work on EO impact stresses the need for **fit-for-purpose indicators, economic valuation methods, and sector-specific calibration** to translate satellite outputs into actionable KPIs.²⁵

3
PNT resilience. Policy papers emphasize that financial systems and critical infrastructure need **multilayer PNT architectures**—combining GNSS with terrestrial backups (like eLoran) to reduce vulnerability to jamming and spoofing.²⁶

4
Capacity gaps in developing countries. UN and academic studies show that many low- and middle-income countries lack **technical and institutional capacity** to fully use EO and GNSS data, even as index insurance and food-security projects demonstrate strong potential benefits.^{10, 19}

The opportunity map 2026–2035



Every board now oversees a space-enabled enterprise—whether they realize it or not. Timing, navigation, climate risk, and operational visibility all depend on satellites. The risk isn't using space technologies; it's failing to govern them.”

—Amanda Price, Head of High Growth Ventures, KPMG Australia

NOW
NEAR
NEXT

1–2 years

AGRICULTURE AND FOOD SYSTEMS

- Deploy EO-enabled yield forecasting and drought monitoring, drawing on established methods from GEOGLAM and Landsat programs.^{8, 10}
- Partner with insurers to use EO and rainfall indices for **index-based crop insurance** in emerging markets, following NASA and GPM pilots in Central America.^{11, 13}

INSURANCE AND REINSURANCE

- Integrate radar-based flood footprints and climate analytics to **accelerate claims and refine risk models**, mirroring ICEYE and EarthDaily offerings.^{14, 15}

FINANCE AND TRADING

Audit GNSS dependencies and timing architectures to ensure compliance with NIST and EU timing requirements for trading systems.^{7, 16}



NOW
NEAR
NEXT

3-5 years

CONNECTED MOBILITY AND LOGISTICS

Use EO and GNSS data to support **route optimization, port/rail congestion monitoring, and emissions tracking**, leveraging growing EO capacity and near-real-time analytics.^{3, 4}

CLIMATE-ALIGNED INSURANCE AND FINANCE PRODUCTS

Develop parametric and index-based products tied to **satellite-observed rainfall, vegetation, flood extent, or wildfire risk**, building on the academic and NASA portfolio of pilots.^{11, 12, 19}

SMART-CITY AND INFRASTRUCTURE MONITORING

Integrate EO-derived land-use, subsidence, and air-quality indicators into city digital twins and infrastructure asset-management systems, following UN and ESA case studies.^{10, 18}



NOW
NEAR
NEXT

5-10 years

PLANET-SCALE DIGITAL TWINS

Use fused EO, GNSS, Internet of Things, and climate models to maintain continuously updated digital twins of supply chains, grids, and ecosystems, anchored in the **\$700-billion EO opportunity** identified by the World Economic Forum.^{3, 21}

QUANTUM-SECURE AND SPACE-ENABLED FINANCE

Combine GNSS-backed time, emerging quantum-secure links, and resilient PNT architectures to support **next-generation financial market infrastructures**, where timing and security are strategic differentiators.^{7, 16, 26}

INTEGRATED SOCIAL-PROTECTION SYSTEMS

Build national systems that automatically adjust cash transfers, subsidies, and insurance payouts based on EO-derived indicators of drought, flood, and crop failure, scaling early pilots in Central America and Africa.^{11, 19, 25}



How Layer 4 creates value

CFOs, CTOs/CIOs, CEOs, CHROs, and boards



CFO

Key performance indicators (KPIs): Loss ratios in climate-exposed lines; avoided downtime and inventory loss; revenue from data-enabled products.

Value pools:

- Reducing catastrophic losses and claims-handling costs through EO-enabled risk modelling and faster damage assessment.^{14, 15, 23}
- Monetizing proprietary operational data by combining it with satellite data to offer **sector-specific indices and benchmarks**.

CTO/CIO:

Infrastructure and data strategy: Treat satellite data feeds as part of the **enterprise data fabric**, connecting EO and GNSS data into existing cloud, GIS, and analytics platforms.^{6, 22}

Integration priorities: Standardize interfaces and metadata so that different business units—risk, supply chain, sustainability—can all use the same EO and PNT data sets consistently.^{5, 25}

CEO

Strategic differentiation: Use Layer 4 capabilities to offer **more resilient, transparent, and climate-aware services**—for example, logistics guarantees backed by real-time EO visibility or insurance products with rapid satellite-verified payouts.^{14, 23}

Growth and market entry: Leverage satellite connectivity and data to enter **geographies where terrestrial infrastructure is weak**, building on examples from agricultural and social-protection pilots in low-income regions.^{11, 19}

CHRO

Capabilities: Geospatial analysts, data engineers familiar with EO/GNSS, and sector experts who can translate space-derived indicators into business actions.

Learning and development priorities: Cross-train existing analytics teams on EO basics and PNT/GNSS dependencies, using material from NASA and EUSPA as foundational training content.^{6, 22}

Board

Governance and oversight: Monitor dependencies on GNSS timing and satellite data as part of cyber-physical risk management, given explicit regulatory timing requirements and vulnerability to jamming and spoofing.^{7, 16, 26}

Environmental, social, and governance (ESG) and resilience: Ensure EO-enabled climate and nature metrics are integrated into sustainability reporting and scenario analysis, consistent with growing evidence that EO can materially reduce emissions and support climate adaptation.^{3, 15, 21}



Downstream applications are where space delivers tangible value to business and society. Earth observation, GNSS timing, and satellite connectivity turn raw orbital data into actionable insights that drive defense and security, disaster response, smarter agriculture, resilient cities, climate and sustainability, and financial and economic systems. Both governments and commercial organizations that leverage these applications gain not just insight, but resilience, efficiency, and the ability to innovate in ways that were impossible before. This is space’s most immediate and visible impact on the world we live in.”

—Seraphim Space



2030 A “Day in the Life”

Space-enabled, Earth-focused

It is May 2031. A diversified food and insurance group starts its Monday with a “risk and opportunity” briefing:

- The EO dashboard shows **vegetation indices and soil-moisture anomalies** across multiple continents, derived from a mix of public missions and commercial constellations. These indices feed yield models similar to those described by GEOGLAM and Landsat programs, generating in-season forecasts for wheat, maize, and rice.^{8, 10}
- Radar-based flood layers from a commercial provider update overnight after a major storm in Southeast Asia, helping the insurance arm **triage claims and prioritize on-the-ground inspections**, just as ICEYE does for UK floods today.¹⁴

- GNSS-derived time keeps trading systems in New York, London, and Singapore synchronized well within the 50-millisecond and 100-microsecond requirements set in the 2020s, while a terrestrial backup PNT system continuously cross-checks satellite signals.^{7, 26}
- Social-protection programs in Latin America read rainfall and vegetation indices from NASA-style GPM and EO feeds; if thresholds are breached, then **cash transfers and index-insurance payouts are automatically triggered** for smallholder farmers in drought-prone regions, an evolution of today’s pilots in the Dry Corridor.^{11, 19}

Most executives in the room never mention “space.” They focus on **loss ratios, yield forecasts, ESG metrics, and growth opportunities**. Yet every chart on the screen is backed by Layers 1–3—and orchestrated through the **downstream applications of Layer 4**.





Executive checklist

What to do Monday morning



Immediate steps

Map your dependence on space-enabled services: Where do EO, GNSS, or satellite connectivity already appear in operations, risk, and finance workflows?

Identify two or three priority use cases per business unit: An example would be yield forecasting in agriculture, flood-risk analytics in insurance, port congestion monitoring in logistics, or GNSS timing resilience in finance.



Diagnostic questions

Which decisions today suffer from **poor visibility or slow data** that EO and PNT could realistically improve?

How exposed are our critical systems to **loss of GNSS timing or satellite data**—and what backups exist?



Integration priorities

Connect key satellite data sources (e.g., one EO provider, one flood-risk provider, one GNSS-timing monitor) into your cloud and analytics platforms within the next 12–18 months.

Standardize metadata and governance so space-derived indicators become **first-class data assets**, not ad-hoc pilots.



Partnership and vendor considerations

For strategic sectors, pursue **multiyear agreements** with EO and PNT-reliant solution providers, aligning incentives to codevelop tailored indices and decision tools.

Engage with public-sector programs (NASA, ESA, EUSPA, UN) that already provide free or subsidized data and technical capacity for agriculture, climate, and disaster-risk projects.



Data, talent, and capability requirements

Build a small **Space-Enabled Analytics Hub** inside the analytics or strategy function, staffed with geospatial specialists, sector experts, and data engineers.

Use early pilots—EO-enhanced insurance, GNSS timing audits, climate-risk dashboards—to prove value quickly and build momentum for broader Layer 4 integration across the enterprise.



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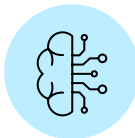
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