منتدى عمان للأعمال
OMAN BUSINESS FORUM

Sultanate of Oman سلطنة عُمان
وزارة التجارة والصناعة وترويج الاستثمار
Ministry of Commerce, Industry & Investment Promotion

حوارات تجارة
Tejarah Talks

Issue 5 of 6 - 2024

REAL CONVERSATIONS
REAL IMPACT

SPACE: THE NEW ECONOMIC FRONTIER

About Tejarah Talks

INSPIRE EDUCATE ENTERTAIN

Tejarah Talks is organized by Oman Business Forum in association with the Ministry of Commerce, Industry & Investment Promotion. With a firm focus on Oman's current and future business, export and investment environment, Tejarah Talks is a series of informal, interactive evening discussions that brings together some of Oman's most inspirational and innovative thinkers and doers to share their stories, insights and ideas with an enthusiastic crowd. It is a platform for positive interaction.

Tejarah Talks

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SESSION PANEL

Panelist **Hamed Al Shekaili**
Director, Space Program Projects, Ministry of Transport, Communications & Information Technology

Panelist **Ammar Al Rawahi**
Chief Commercial Officer
SatMENA

Panelist **Said Abdul Ghafoor Saifudeen**
Chief Executive Officer
Star Drones

Moderator **Jamal Al Asmi**
Executive Producer
RealityCG

Talking Point 1

THE FUTURE ABOVE

The New Space Economy marks a shift from government-led exploration to a dynamic, private-sector-driven industry. Unlike the state-dominated efforts of the past, today's space activities prioritize commercial viability and practical applications, opening the door for a broader range of participants. From weather forecasts to smartwatches, space has become a quiet constant in our daily lives. Yet, its role is expanding far beyond its origins, promising economic and social transformations that may rival the revolutions brought by the internet or electricity.

The sector covers a wide range of pursuits, including satellite telecommunications, Earth observation, space tourism, asteroid mining and the emerging field of on-orbit manufacturing. It also hints at long-term ambitions such as interplanetary travel and sustainable human presence beyond Earth. Leading businesses like SpaceX, Blue Origin and Virgin Galactic are advancing these efforts with innovations in reusable rockets and commercial spaceflight. Meanwhile, a mix of start-ups and established companies are finding opportunities in satellite technology and space-based data services, supporting industries on Earth and laying the groundwork for future ventures.

SPACEX

Virgin GALACTIC

BLUE ORIGIN

By 2035, the space economy is projected to reach US$1.8 trillion - more than double its 2024 value of US$630 billion. This is not only about rockets and satellites, it is also about a new era of innovation and connectivity

Footnotes

1 Dr Sebastian Buckup, Space is booming. Here's how to embrace the US$1.8 trillion opportunity, World Economic Forum.

2 Ibid

Beyond the Stars, Back to Earth

The real story of space is not just up there - it is about how it is shaping life down here. Industries as varied as logistics, banking, retail, agriculture and even disaster management are already seeing the influence of space-enabled technologies. Satellites, once the domain of specialized agencies, now drive everyday tools like Uber and global supply chain management systems. As costs drop and access broadens, these technologies are moving from niche applications to reshaping entire sectors.

Dr. Sebastian Buckup, Head of Programming and Member of the Executive Committee at the World Economic Forum captures the transformation: "Space technologies are delivering greater value to a more diverse set of stakeholders than ever before. As costs reduce and accessibility rises, these technologies could reshape whole industries and have as much impact on business and society as smartphones or cloud computing."[1]

Drivers of Growth

At the heart of this space-based shift are tools that serve the needs of an interconnected planet. Key drivers include communications, positioning and navigation systems and Earth observation services. These are not just new toys for techies they are foundational tools for industries ranging from agriculture to urban planning. The breadth of applications ensures that space's impact will extend far beyond traditional aerospace players, filtering into sectors as diverse as construction and insurance.

Supply chain management is one of the obvious beneficiaries. With satellite data enabling precise tracking of goods, logistics is becoming faster, cheaper and more efficient. Similarly, in food and beverages, the last-mile delivery of perishable items is poised for transformation through smarter route planning and improved storage monitoring.

The numbers back up the excitement. Launch costs have dropped tenfold in the past 20 years, while the number of satellites launched each year has surged by 50%. Meanwhile, investments in the space sector are reaching record levels, exceeding US$70 billion in just two years[2]

Talking Point 1 - The Future Above

The New Frontier

Space's potential is not limited to technological upgrades – it is also about expanding human ambition. Applications once confined to science fiction are becoming viable markets. Space tourism, for example, is no longer a concept we just see in Hollywood blockbusters. By 2035, it is expected to generate US$4 - 6 billion annually, mainly through orbital stays aboard private stations catering to ultra-wealthy adventurers.

Space tourism it is expected to generate US$4 - 6 billion annually By 2035

But the broader economic opportunities lie in creating the infrastructure needed for this new frontier. From mega-rockets to debris-clearing technologies, space requires foundational systems akin to building railroads and ports during the Industrial Revolution.

THE KEY IS SYNERGY
"THE FUTURE OF SPACE IS NOT JUST ABOUT THE DESTINATIONS WE BUILD BUT ABOUT THE ECONOMIC ECOSYSTEMS WE CREATE ALONG THE WAY."[3]
MICHAEL SUFFREDINI, CEO, AXIOM SPACE

AXIOM SPACE

More Than Profit

The space economy is not only about financial returns. It holds the potential to address some of the world's most pressing challenges, from climate change to inequality. Satellites are already critical tools in disaster management, tracking hurricanes, floods, wildfires and other climate-driven catastrophes. As technology improves, so will the ability to predict and respond to these events, saving lives and resources.

Agriculture stands to gain as well. Precision monitoring of crops and natural resources through satellite imaging is improving yields and reducing waste, even in remote regions. Beyond food security, space-enabled tools are helping bridge the digital divide, bringing education and healthcare to underserved areas through enhanced connectivity.

Environmental applications are equally promising. Satellite data can monitor methane leaks from ageing infrastructure and track deforestation in real time, providing tools for governments and organizations to address climate crises with greater precision.

Footnotes
3 Ibid
4 Spacewatch Global, World Economic Forum & McKinsey Report Estimates US$1.8 trillion Space Economy.
5 Ibid

By 2035, the space economy could reach US$1.8 trillion if costs continue to fall and accessibility improves

Embracing a New Era

By 2035, the space economy could reach US$1.8 trillion if costs continue to fall and accessibility improves. Even at its most conservative estimate of US$1.4 trillion, the sector promises to redefine industries and open new avenues for growth. This is not just about technological ambition – it is about fostering economic ecosystems that serve people and the planet.[4]

Ryan Brukardt of McKinsey & Company frames the challenge and opportunity: "Businesses in a growing variety of sectors - such as agriculture, construction, insurance and climate change mitigation - can and will all be drivers of the new and expanding space economy. By understanding and embracing the full potential of space, public and private players can position themselves as leaders, unlocking long-term benefits."[5]

EXPANDING SPACE ECONOMY
"UNDERSTANDING AND EMBRACING THE FULL POTENTIAL OF SPACE, PUBLIC AND PRIVATE PLAYERS CAN POSITION THEMSELVES AS LEADERS, UNLOCKING LONG-TERM BENEFITS"
RYAN BRUKARDT

McKinsey&Company

Space for Sustainable Development

What makes today's space exploration particularly compelling is its direct relevance to life on Earth. Satellites are enabling precision agriculture, monitoring climate change and facilitating global communication networks. For example, the European Space Agency's Copernicus program has revolutionized environmental monitoring, offering high-resolution data on deforestation, air quality and water resources. These capabilities are crucial as nations strive to meet sustainability targets under frameworks like the Paris Agreement. However, the space sector is not without challenges. Orbital debris, regulatory uncertainty and the militarization of space are emerging as significant obstacles. The question, therefore, is not just how humanity will expand into space but how it will manage this growth sustainably.

The European Space Agency's Copernicus program has revolutionized environmental monitoring, offering high-resolution data on deforestation, air quality and water resources

Supported by the European Union

Copernicus Europe's eyes on Earth

Talking Point 2

WHY GO TO SPACE?

This is a question often met with awe or skepticism. But behind the spectacle of rockets and starry ambitions lies a pragmatic argument the potential for economic transformation. Space is no longer just about exploration; it is about extending humanity's reach into a new, resource-rich frontier.

Footnotes

6 Peter Garretson, Sky's No Limit, IDSA Occasional Paper No 9
7 The Guardian, Newt Gingrich promises moon base by the end of his second term
8 James Petholoukis, Space, the Final Economic Frontier (And Maybe a Cure for 'Secular Stagnation'), American Enterprise Insitute
9 Mauro Bolanovsky, Roger Backhouse, Secular stagnation: The history of a heretical economic idea, Centre for Economic Policy & Research
10 Matthew Weinzierl, Expanding economic activity in space may offer a solution to secular stagnation, PNAS
11 Ibid

The Moon, once symbolic of Cold War rivalry, now represents a crucial stepping stone in building a sustainable space economy. Its low gravity, proximity to Earth and abundance of natural resources position it as the ideal location to test technologies and systems for deeper space exploration. As defense and space consultant Peter Garretson noted, the Moon is central to integrating the inner solar system into Earth's economic sphere. In the process, it may help cultivate industries, innovation and jobs that flow across the planet.[6] The strategic benefits are clear. A permanent presence on the Moon could catalyze the development of new manufacturing and logistics systems, enabling growth in the nascent space economy. In fact, a lunar base could eventually evolve into a colony - or something more ambitious. While Newt Gingrich's 2012 idea of making the Moon America's fifty-first state might sound far-fetched, the principle is the same: the Moon could serve as a springboard to the rest of the solar system.[7]

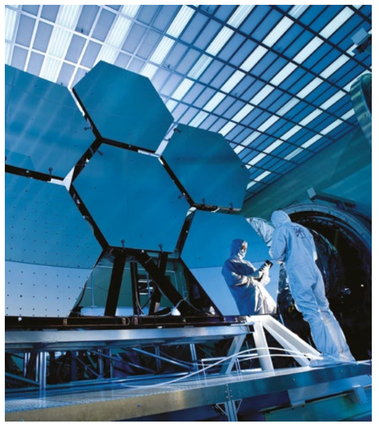
Stagnation vs Opportunity

Expanding into space may address a long-standing economic challenge. Harvard business professor Matthew Weinzierl has argued that space could help combat "secular stagnation," a condition where sluggish growth, low productivity and weak investment create a persistent drag on economies.[8] This concept, originally articulated by economist Alvin Hansen in the 1930s, has resurfaced in the years following the Global Financial Crisis.[9] Weinzierl suggests the unique demands of space exploration - large public and private investment, infrastructure development and technological innovation - could reinvigorate economic growth on both supply and demand fronts.

On the demand side, Weinzierl estimates that returning to peak levels of public-sector space investment could inject US$1.5 trillion to US$3 trillion into the economy over two decades.[10] These funds would not just support lunar missions they would also inspire private-sector participation, multiplying the economic impact. Meanwhile, the supply side of the equation benefits from space's potential to spark innovation. Historically, space exploration has driven advances in technologies ranging from GPS to communications satellites. With launch costs plummeting, thanks to companies like SpaceX, the commercial space sector is positioned to become a key driver of productivity growth.

Space also offers something Earth no longer has - an endless frontier. Historically, physical frontiers like the American West spurred innovation and dynamism. Weinzierl suggests space can play a similar role, providing humanity with access to untapped resources such as rare earth elements, space-based solar power and the unique research environment of microgravity. This combination of technological advancement and resource availability could create an economic expansion without precedent.[11]

Public-sector space investment could inject US$1.5 trillion to US$3 trillion into the economy over two decades



SPACE COULD HELP COMBAT "SECULAR STAGNATION" A CONDITION WHERE SLUGGISH GROWTH, LOW PRODUCTIVITY AND WEAK INVESTMENT CREATE A PERSISTENT DRAG ON ECONOMIES.

MATTHEW WEINZIERL
HARVARD BUSINESS PROFESSOR

Talking Point 2 - Why Go to Space?

The Costs & The Returns

Of course, building a space economy comes with a large price tag. Elon Musk has estimated the cost of establishing a Martian city at US$10 trillion - double the annual investment of the United States.[12] But even more modest goals, such as sustaining a lunar presence would require significant funding. Weinzierl points out that the Apollo program's US$25.8 billion budget - equivalent to around US$300 billion today - represents a tiny fraction of federal spending during its era.[13] Matching that level of investment today would require US$62 billion to US$82 billion annually, while still leaving room for the private sector to amplify the effort.

This investment would not only build infrastructure - launch services, habitats, transportation systems and more - but also fund ambitious projects like space-based solar power and resource extraction. In essence, a space economy requires the same foundational work as any frontier: roads, towns and the tools to connect them. It is a long-term commitment but one with far-reaching implications.

Innovation & Individualism

The cultural aspect of space exploration also cannot be ignored. It fosters a spirit of innovation and individualism akin to the energy of Silicon Valley. Hundreds of space-focused start-ups now emerge annually, funded by a growing pool of venture capital. These companies are reshaping the sector, moving it from one dominated by government contractors to a dynamic, high-risk, high-reward environment.

Why Not?

Venturing into space is not just about reaching for the stars. It is about addressing the challenges we face here on Earth – particularly, climate change and the consequences of it, like threats to our food and water supply. Space offers a path to reinvigorate economies, expand humanity's horizons and create new opportunities for generations to come. A bold step, but one firmly grounded in logic. The question is not whether we should go to space – it is why we have not gone further already.

Footnotes

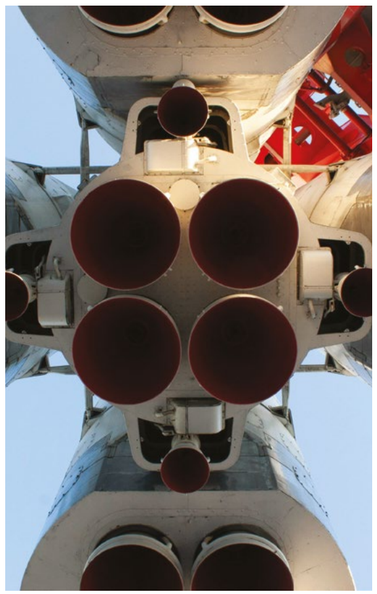
12 Musk's city on Mars next 'logical step' for humanity, Asia Times

13 Matthew Weinzierl, Space, the Final Economic Frontier, Journal of Economic Perspectives

Talking Point 3

THE QUIET ENGINE

At first glance, space might seem distant, an ethereal expanse far removed from daily life. But look closer and its fingerprints are everywhere. The unseen threads of space technology weave through nearly every corner of the global economy – from guiding shipping vessels to enabling emergency disaster responses. What was once the domain of superpowers racing for glory has become a shared and indispensable infrastructure for modern life.



This shift is neither accidental nor sudden. Over decades, breakthroughs in rocket reusability, leaps in computing power and novel policy tools have steadily driven down the costs of accessing space. Meanwhile, commercial interest has surged. Today, payloads are launched not just by traditional giants like the US and China but by an unprecedented number of nations and private enterprises. Space, as an economic landscape is no longer exclusive it is expansive.

Yet, despite its growing reach, space remains a frontier of uncertainty, shaped as much by legal ambiguity as by technological ingenuity. The 1967 Outer Space Treaty - ratified by over 100 nations - prohibits national claims of sovereignty, complicates property rights and by extension, economic development.[14] Without ownership, how do nations and corporations justify investments in mining or orbital real estate? These challenges form the backdrop to a complex question: How do we balance the economic opportunities of space with its ethical and environmental dilemmas?

OVER DECADES, BREAKTHROUGHS IN ROCKET REUSABILITY, LEAPS IN COMPUTING POWER AND NOVEL POLICY TOOLS HAVE STEADILY DRIVEN DOWN THE COSTS OF ACCESSING SPACE

Footnotes

14 UN Office for Outer Space Affairs, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies

15 Luisa Corrado, Maureen Cropper, Akhil Rao, Space exploration and economic growth: New issues and horizons, PNAS

The Weight of History

To understand space's potential, it helps to look back. During the 1960s and 70s, space exploration was all about state-led ambition. The Apollo program was not just about reaching the Moon - it was an economic and scientific catalyst. Technologies born in the space race, from GPS to miniaturized electronics, spilled over into civilian industries, boosting productivity and shaping the world we know today.

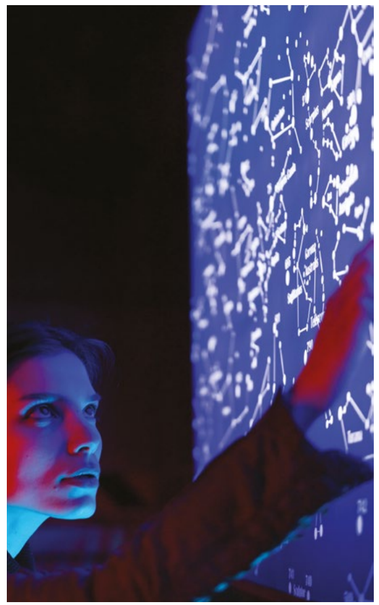
But the golden age of space was not without limits. By the 1980s, public investment began to wane with governments delegating tasks to private companies or abandoning them altogether. The economic impact followed suit. Research suggests that during the early decades of space exploration, spillovers into GDP growth averaged 2.2% over a 20-year horizon. By the 2000s, as public spending retreated, that figure fell to less than 1%.[15] These patterns hold lessons for today's policymakers. Investments in space can impact economies across the board but their scale depends on the structure and intent of funding. Can modern space powers replicate the successes of the Apollo era in an age dominated by private enterprise? Surely, the answer lies in redefining the roles of public and private sectors.

Tug-of-War

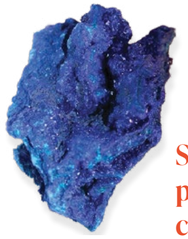
The modern space economy is a complex relationship involving government ambition and private ingenuity. Governments still lay the groundwork, funding basic research and crafting regulatory frameworks. But private corporations - bolstered by billionaires and venture capital - have taken the lead in innovation. They develop reusable rockets, deploy satellite constellations and envision futures where mining asteroids is as routine as drilling oil in the Gulf of Masirah.

This move raises questions about balance. Private firms are driven by profit, often prioritizing short-term gains over long-term public benefits. By contrast, public investment tends to prioritize shared knowledge and global good. How can these two approaches coexist? One promising model is the public-private research and develop partnership, where governments, universities and corporations collaborate to fund and share breakthroughs. But even these partnerships need to navigate tricky waters, balancing IP rights with the need for transparency and equitable access.

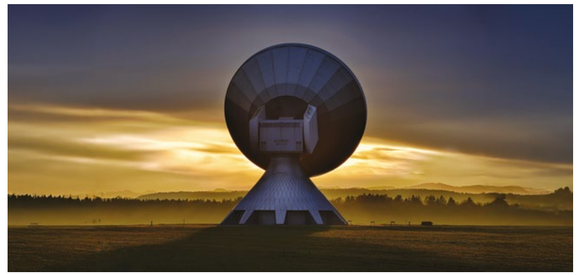
The absence of clear ownership in space further complicates the equation. The lack of property rights in orbit has already led to overpopulation of satellites and the growing threat of debris collisions. As mega-constellations proliferate, how do we ensure that space remains usable? Policy must evolve quickly, regulating not just the deployment of satellites but their lifecycle, environmental impact and eventual disposal.



Talking Point 3 - The Quiet Engine



Space teems with resources - platinum cobalt and other critical minerals



Space Resources

While satellites dominate today's conversations, the next frontier lies further out: mining. Space teems with resources - platinum, cobalt and other critical minerals - that could reshape Earth's industries. But this promise comes with questions. Would mining space reduce the environmental toll of Earth-based extraction? Or would the costs of launching, operating and returning goods outweigh the benefits? The answers are not simple.
Initial investment in space mining would likely be astronomical - pun intended. However, over time, as technologies mature and demand for clean energy metals rises, space mining might become not just viable but essential. Models suggest that transitioning mining operations from Earth to space could mitigate some of the environmental degradation associated with resource extraction. This, however, would require a coordinated effort - a global pact to align economic incentives with environmental protections.

Space as a Global Commons

Space is more than an economic opportunity it is a shared heritage and a fragile commons. Its benefits - climate monitoring, disaster prediction and global connectivity - must be balanced against its vulnerabilities. Mismanagement of orbital space could render it unusable for future generations. Similarly, the benefits of space exploration must not widen inequalities on Earth, concentrating power and wealth in the hands of a few nations or corporations. This is where governance is key. International cooperation, though often slow and fraught, offers the best hope for addressing collective challenges. Whether it is coordinating debris removal, managing spectrum allocation or setting rules for resource extraction, space requires a global approach. It is not just a question of economics it is a test of humanity's ability to think beyond borders.

Climate Imperative

Satellites, once symbols of technological prowess are now indispensable instruments in the fight against climate change. Their vantage point from orbit offers a unique lens on the planet's health, providing detailed data on greenhouse gas emissions, deforestation and even the efficiency of renewable energy grids. This is not just a boon for scientists but also for investors seeking clarity in the increasingly crowded world of environmental, social and governance (ESG) metrics.

Satellite imagery is helping close the data gap in ESG. Investors, no longer satisfied with vague assurances are demanding hard numbers and space is delivering. These technologies do not just observe they project. They tell us which industries are at risk from rising sea levels or changing weather patterns. For companies navigating this uncertain landscape the insights from orbit can mean the difference between survival and irrelevance.

Look Up, Think Ahead

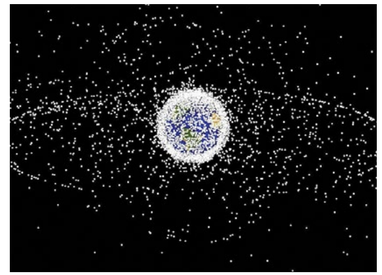
As we stand on the cusp of a new space age, the stakes could not be higher. Space is no longer a realm of distant dreams - it is a force shaping economies worldwide. How we manage it will define not just our relationship with the cosmos, but with each other. In the end, space is less about what is out there and more about what it reflects.

Our capacity for ambition, collaboration and care. If we get it right, the heavens may yet become a source of growth, equity and sustainability. If we fail, we risk not just losing the sky, but the ground beneath our feet

Footnotes

16 21st Century Tech, 12,597 Satellites Orbited Earth At The End Of 2023 – Now There Are Far More

NASA may have its sights set on Mars, but it is relying on private companies to handle the nuts and bolts of getting there



Rise of Capital

Even amidst the chaos of the COVID-19 pandemic, space proved resilient drawing record levels of private investment.
This surge reflected a growing recognition that traditional aerospace giants and emerging commercial firms could coexist - their capabilities complementing rather than replacing each other.

The rise of SPACs - special purpose acquisition companies - has also opened a fresh pipeline for capital, particularly for ventures with long timelines. Space, with its inherently long horizon, seems tailor-made for this type of financial structure. And as private firms venture further into satellite launches and low Earth orbit (LEO) operations, they find themselves increasingly embraced by government agencies. NASA may have its sights set on Mars, but it is relying on private companies to handle the nuts and bolts of getting there.
This symbiosis - between public vision and private execution – is the foundation of the modern space economy.

Space Junk

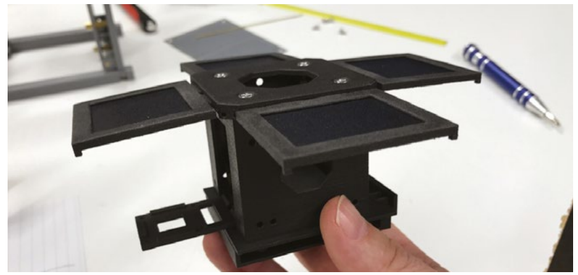
Space, once a vast and empty expanse is becoming congested. At the time of writing this report there are at least 12,000 working satellites circling the Earth. Considering that the Space Age began 67 years ago with the launch of Sputnik 1, the skies have become very crowded above our planet.[16]
This proliferation brings with it a darker reality - orbital debris. Old spacecraft, defunct satellites and fragments from collisions create a lethal minefield for new launches and operational satellites alike. The threat of "space junk" has moved beyond theoretical. Some government agencies admit they are struggling to track the sheer volume of debris, leaving room for private companies to step in with innovative solutions. Cleaning up orbit may not sound glamorous, but in a world increasingly reliant on space, it is becoming an urgent necessity.

12,000
WORKING SATELLITES CIRCLING THE EARTH THREATENED BY SPACE JUNK

- Japan recently launched a space junk removal satellite called ADRAS-J
- The European Space Agency has signed a service contract with a Swiss company that is building a satellite called ClearSpace-1 scheduled for launch early in 2025. It will provide a range of in-orbit satellite functions including space junk de-orbiting removal services
- Space Force, the military arm of the US space program is recruiting and providing project money to companies developing Active Debris Remediation technology

USSF

Talking Point 3 - The Quiet Engine



What is our place in the universe?
There is an obvious, logical answer to the question. You are currently located somewhere on the surface of a giant rotating sphere approximately 40,000 kilometers in circumference, at a distance of roughly 150 million kilometers from the sun, near the edge of a galaxy about 100,000 light-years across.

Telecom's Orbit of Influence

Telecommunications has long been at the heart of the space industry and its role is expanding. Satellite operators are exploring the full range of orbital altitudes - geostationary, medium Earth and low Earth orbit (GEO, MEO and LEO) - to deliver seamless broadband services. These efforts are redefining how we communicate, navigate and do business. LEO, in particular, is becoming a hotbed of debate, with companies vying to design the most efficient satellite constellations. From providing in-flight connectivity to commercial airlines to supporting maritime navigation, the possibilities seem endless. But alongside this innovation comes the need for global cooperation. Regulators like the US Federal Communications Commission and the International Telecommunication Union (ITU) are grappling with questions of spectrum allocation and orbital debris, underscoring the importance of treating space as a shared resource.[17]

US Federal Communications Commission and the International Telecommunication Union (ITU) are grappling with questions of spectrum allocation and orbital debris, underscoring the importance of treating space as a shared resource

Technical Breakthroughs

The technological breakthroughs of the Fourth Industrial Revolution have created an unexpected connection with space exploration. Innovations in materials science and 3D printing have drastically lowered the cost of launches, making missions more affordable and frequent. Rockets, once towering monuments of inefficiency are now being built lighter and smarter, while reusable spacecraft have shifted the economics of orbital travel.

This is not theoretical. A rocket engine that once required months to construct can now be manufactured in less than a day using advanced printing techniques.[18] The implications extend well beyond launch pads - microgravity environments in space may soon host factories capable of producing delicate fibre-optic cables, tools or even pharmaceuticals in ways that are impossible on Earth. These advances are redefining not just how we reach space, but why.

Small satellites, once curiosities in the shadow of their massive counterparts have become the industry's quiet revolutionaries. Cheaper to produce and easier to deploy, they now make up 94% of all spacecraft launches.[19] These tiny marvels are creating vast networks for broadband communications, environmental monitoring and agricultural optimization. They represent a democratization of space, allowing smaller nations and private entities to leapfrog traditional barriers to entry.

94%
OF ALL SPACECRAFT LAUNCH ARE FOR SMALL SATELLITES

More Players in a Crowded Sky

Space was once the playground of superpowers, it is now a global marketplace. The US remains the undisputed leader, its US$73 billion annual investment outpacing all competitors, but the field is widening.[20] China's space ambitions, backed by over US$14 billion in funding in 2023 are fast closing the gap.[21] Its ambitious programs include a next-generation telescope and satellite networks that challenge Western dominance. Meanwhile, smaller nations like Rwanda and Costa Rica have joined the space race, launching satellites that mark their arrival on this most aspirational stage.[22]

The private sector has emerged as an equal partner, if not a rival, to national agencies. SpaceX, Blue Origin and Virgin Galactic headline a commercial boom that has tripled the industry's value since 2005. Yet their innovations are not limited to billionaire dreams of space tourism - they are pushing the boundaries of satellite communications, LEO infrastructure and sustainable technologies. Even smaller companies, such as Argentina's Satellogic and Finland's ICEYE have secured footholds in the competitive satellite market, proving space is no longer the exclusive domain of the wealthiest or the most powerful.

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SATELLOGIC

ICEYE

Footnotes

17 Federal Communications Commission FCC 24-21, https://docs.fcc.gov/public/attachments/FCC-24-21A1.pdf
18 NASA, Additive Manufacturing Subtracts from Rocket Build Time
19 Landry Signe, Hanna Dooley, How space exploration is fueling the Fourth Industrial Revolution, Brookings
20 Novaspace, New historic high for government space spending mostly driven by defense expenditures
21 Via Satellite, China's Push for a More Commercial Space Industry
22 The Rio Times, Kigali Innovation City: Rwanda's US$2 Billion Tech Gamble

Talking Point 4

SHIMMERING LIGHTS

The orbiting satellites above us are more than shimmering points of light in the night sky they are the hidden scaffolding of the modern world. Quietly but decisively, satellites power the global economy and sustain the digital fabric of our lives. From enabling seamless communication to aiding disaster management, their role is indispensable. Today, over 12,000 operational satellites circle the Earth and this number is poised to grow, driven by rising demand for connectivity, data and innovation.

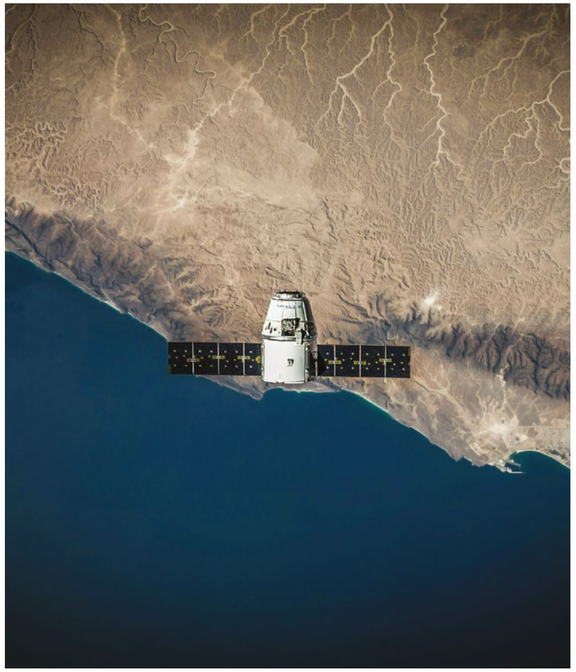
Footnotes

23 Satellite Industry Association, 27th Annual State of the Satellite Industry Report

24 Ibid

Backbone for Connectivity

Satellites are at the heart of the digital economy. They facilitate the streaming of movies, enable international financial transactions, guide navigation systems and monitor crop health. While we may take these capabilities for granted their underlying infrastructure is complex and vital. Global Positioning System (GPS) satellites, for example, form the backbone of ride-hailing apps like Uber and delivery services like Amazon. Similarly, Earth observation satellites provide critical data for agriculture, environmental monitoring and urban planning.



The commercial satellite industry continues to make up the largest portion of the global space industry. Commercial satellite industry revenue in 2023 increased to US$285 billion, accounting for 71% of the world's space business.[23] This figure is expected to grow steadily as satellites find new applications in areas such as autonomous vehicles, precision farming and climate science.the Caribbean.

US$285 billion satellite industry revenue in 2023

- During 2023, the overall global space economy generated revenue of US$400 billion. The commercial satellite industry continued to be dominant, increasing to US$285 billion and accounting for 71% of the world's space business.
- Satellite Manufacturing – thanks to continued innovation, satellite capability and lower manufacturing costs, global satellite manufacturing revenues grew to US$17.2 billion in 2023.
- Launch Services – once again, affordability and innovations led to increased launch activities and a historic high number of global launches. A total of 190 commercially procured launches were conducted and global launch revenues were US$7.2 billion in 2023.
- Services – increasing satellite broadband subscriptions and revenue along with remote sensing revenue growth combined to help generate a total of US$110.2 billion in satellite services revenue during 2023.
- Satellite Ground Segment – continued growth in global navigation satellite services (GNSS) and network equipment helped generate revenue of more than US$150.4 billion in 2023.
- Space Sustainability Activities – Commercial satellite sustainability activities began generating significant revenue during the year and this accounted for more than US$300 million in revenue during 2023.[24]

Talking Point 4 - Shimmering Lights

CubeSats

The rise of small satellites - or CubeSats - has revolutionized the space economy. Unlike traditional geostationary satellites, which can weigh several tons and cost upwards of US$100 million to build and launch, CubeSats are lightweight, modular and cost-effective. This democratization of space has opened doors for universities, start-ups and emerging economies allowing them to deploy satellites for education, research and commerce.

In 2022 alone, over 2,800 small satellites – 601 to 1,200 kilograms - were launched, accounting for 97% of all spacecraft deployed that year, according to Bryce Tech data.[25] SpaceX and Rocket Lab are at the forefront of this revolution, offering affordable launch services and pioneering reusable rocket technologies. As of September 2024, there are 6,426 Starlink satellites in orbit –a satellite network developed by SpaceX to provide low-cost internet to remote locations. By 2027, the Starlink network is expected to expand to 12,000 satellites delivering global broadband coverage and addressing connectivity challenges in remote and underserved areas.[26]

Revolutionizing Industries

Satellites are transforming industries in profound ways. In agriculture, Earth observation satellites enable precision farming by monitoring soil moisture, detecting crop diseases and predicting weather patterns. This data helps farmers increase yields while reducing water and fertilizer usage. The World Economic Forum believes pest control alone, made possible by hyperspectral and optical satellite imagery could save close to a billion tonnes of crops every year.[27] The financial health of those who farm and therefore feed is an essential part of eliminating food insecurity – and by optimising agriculture, satellites boost the earnings of those farmers. A cost reduction of just 5% would amount to savings in input of up to US$8 billion.[28] According to the UN FAO cutting food waste could add US$175 billion to growers' earnings.[29]

Australia's Hotspots

In disaster management, satellites provide critical support during emergencies. Digital Earth Australia (DEA) Hotspots, managed by Geoscience Australia is a national fire monitoring system that can see unusual temperature "hotspots". The system was originally developed in collaboration with three Government agencies – in response to the devastating fires that swept through New South Wales in 2001.

Hotspot data over Australia is collected 24 hours a day by 6 different satellites. Some collect data 2-4 times a day, whereas Himawari-9, a geostationary Japanese weather satellite, collects data every 10 minutes. Satellite sensors detect areas with high levels of infrared radiation.
These "hotspots" could be sparked by abnormally high heat from industry, smoke plumes or bushfires, for example. The data is relayed to ground stations and then sent for processing.
The processed data is pushed to DEA Hotspots for viewing. It is used to identify potential fire locations and threats to communities.[30]

Bridging the Digital Divide

Perhaps one of the most significant societal impacts of satellites is their ability to bridge the digital divide. In 2023, nearly 3 billion people worldwide remained without internet access, according to the ITU. Satellite constellations like Starlink, OneWeb and Amazon's Project Kuiper aim to change this by delivering high-speed internet to remote regions where terrestrial infrastructure is unfeasible.

Arctic

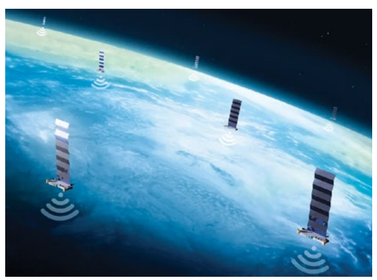
For the indigenous communities of the Arctic - spread across vast terrain - traditional communication infrastructure is often nonexistent. LEO satellite networks, led by companies like Starlink and Telesat, have been a game-changer. These networks provide high-speed, low-latency internet to even the most remote settlements, connecting residents to critical resources.[31] In Alaska, Starlink's pilot deployments have enabled real-time telemedicine services, giving residents access to specialized healthcare consultations without the need for costly travel. Similarly, indigenous leaders in northern Canada have used satellite internet to conduct governance meetings and advocacy efforts, ensuring their voices are heard on national platforms.[32] LEO satellite networks also enhance climate adaptation efforts in these regions.
With Arctic temperatures rising at nearly four times the global average, real-time satellite data helps indigenous communities track environmental changes, predict weather patterns and manage hunting and fishing schedules more effectively.

17,000 islands

Indonesia, home to over 17,000 islands, faces unique challenges in providing broadband connectivity to its dispersed population. Traditional fibre optic infrastructure is limited to major urban areas, leaving thousands of islands underserved. Recognizing this gap, the Indonesian government partnered with Hughes Network Systems and satellite provider PSN to expand internet access using geostationary and LEO satellites. This initiative has been instrumental in driving economic growth in remote areas. Satellite internet allows small businesses to participate in e-commerce, enabling artisans and fishermen to sell products directly to urban markets. Additionally, remote healthcare clinics now use satellite connectivity to consult with specialists in Jakarta, improving patient outcomes.

One standout example is the island of Sulawesi where satellite-enabled connectivity has helped local entrepreneurs increase incomes through online marketplaces. Educational access has also improved with rural schools integrating e-learning tools into their curricula.[33]

These two examples underscore the societal impact of satellite-based internet services. Each highlighting not only the technological ingenuity behind LEO satellites but also their potential to level the playing field for underserved populations. As satellite networks continue to expand, their role in bridging global connectivity gaps will only grow, fostering new opportunities for education, healthcare and economic development in some of the most remote corners of the world.



As of September 2024, there are 6,426 Starlink satellites in orbit –a satellite network developed by SpaceX to provide low-cost internet to remote locations

AUSTRALIA'S NATIONAL FIRE MONITORING SYSTEM CAN SEE UNUSUAL TEMPERATURE 'HOTSPOTS'

Digital Earth AUSTRALIA

THE INDONESIAN GOVERNMENT PARTNERED WITH HUGHES NETWORK SYSTEMS AND SATELLITE PROVIDER PSN TO EXPAND INTERNET ACCESS

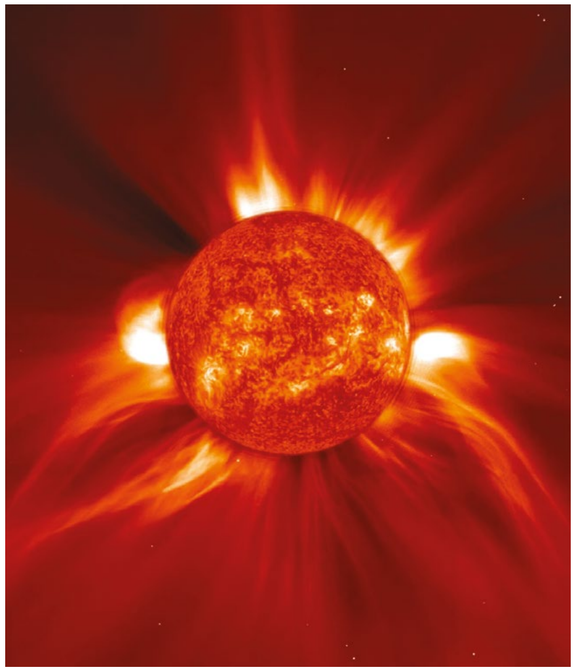
HUGHES NETWORK SYSTEMS | PSN

Footnotes

25 Bryce Tech, Smallsats by the Numbers 2024
26 Tereza Pultarova, Elizabeth Howell, Starlink satellites: Facts, tracking and impact on astronomy, Space.com
27 World Economic Forum, What are hyperspectral imaging satellites - and how can they help combat climate change?
28 Green Business Journal, Global food insecurity is sky-high - satellites can help
29 Ibid
30 Australian Space Agency, Australia's emergency services rely on space
31 Internet Society, Building More Affordable and Reliable Internet Access in the Arctic
32 Eye on the Arctic, Could Ulukhaktok's community network be an internet model for other communities?
33 Intimedia, Building a Connected Future: Empowering Connectivity Through Satellite Technology in Indonesia

Talking Point 5

A MEGA STORM



Imagine this - a normal morning, satellites silently facilitating millions of transactions, GPS guiding planes and Earth's magnetic field holding steady against the Sun's steady pulses. Then, without warning, the Sun erupts - a massive coronal mass ejection (CME) bursts forth, launching billions of tons of charged particles directly toward Earth. Within hours, the planet's magnetosphere is overwhelmed, geomagnetic currents rage and satellites across low and high orbits go dark. The scenario is not plucked from a science fiction film it is a potential reality and the consequences would reverberate across every aspect of modern life.

At the heart of the risk is the sheer power of a CME. These solar events, which hurl plasma and magnetic fields into space at speeds up to 3,000 kilometers per second, interact with Earth's magnetic field, inducing electric currents both in orbit and on the ground. The largest such event on record, the Carrington Event of 1859, ignited fires in telegraph offices and painted auroras across skies as far south as the Caribbean. In 1989, a far smaller geomagnetic storm knocked out Quebec's entire power grid,

CME HURL PLASMA AND MAGNETIC FIELDS INTO SPACE AT SPEEDS UP TO 3,000KM PER SECOND

leaving millions in the dark. Now, in a world dependent on satellites for everything from high-frequency trading to climate monitoring, the stakes are higher.A Carrington-scale storm in today's space-dependent society could devastate economies and cripple critical infrastructure, making the 2008 financial crisis seem like a mild inconvenience.

Footnotes

34 International Insurance Society, Solar Storms and Cybersecurity

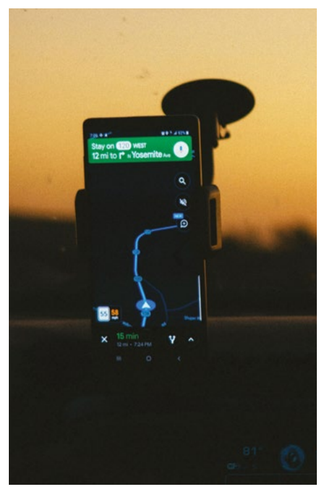
35 The Blackout Report, Biggest Blackouts in History: Québec 1989 Solar Storm

Vulnerability

Satellites are among the most vulnerable assets in the face of a mega space storm. Packed with sensitive electronics these orbiting workhorses rely on precision components that are highly susceptible to radiation. A direct CME impact could fry microprocessors, short-circuit power systems and render satellites inoperable. The loss of even a fraction of the approximately 12,000 operational satellites could upend global communication networks, weather forecasting systems and navigation platforms. For industries that rely on satellite infrastructure - aviation, logistics, energy and agriculture - the disruption would be catastrophic.

The financial implications are staggering. A 2024 International Insurance Association article estimated that a Carrington-scale CME could lead to global economic losses of up to US$2.6 trillion - roughly 3.6% to 15.5% of annual GDP - with recovery taking years.[34] GPS-based industries alone, which underpin everything from shipping routes to precision farming, contribute over US$1.4 trillion annually to the global economy. A prolonged outage could paralyze sectors that depend on precise timing and location data, from emergency services to financial markets.

GPS-based industries alone, contribute over US$1.4 trillion annually to the global economy



Earthly Fallout

The effects would not end in orbit. On the ground, geomagnetic currents induced by a CME could wreak havoc on power grids, pipelines and undersea cables. In a worst-case scenario, transformers could overheat and fail, triggering cascading blackouts across continents. The interconnected nature of modern energy grids means that a local disruption could snowball into a global crisis. During the 1989 geomagnetic storm, Quebec's powergrid collapsed within 90 seconds, leaving 9 million residents without electricity for up to 9 hours.[35] Multiply that scale by every industrialized nation and the economic toll becomes unimaginable.

Moreover, undersea communication cables - critical for global internet connectivity - could also suffer from geomagnetic surges. Unlike satellites, which are frequently updated, these cables often have lifespans exceeding 25 years and many lack the shielding needed to withstand powerful geomagnetic disturbances. Their failure would sever connections between continents, affecting financial transactions, data flows and even military operations.

Talking Point 5 - A Mega Storm

Mitigation

Faced with these risks, the question is not if a mega space storm will occur – it is when. According to NASA, CMEs capable of causing widespread damage strike Earth roughly once every 100 years. Given that the Carrington Event occurred over 160 years ago, we are statistically overdue. Preparing for such an event requires a combination of technological innovation, policy action and international collaboration.

First, satellite manufacturers are exploring ways to harden components against radiation. Advances in materials science have led to the development of radiation-resistant semiconductors and shielding technologies that could extend the operational lifespans of satellites during geomagnetic storms. Companies like Lockheed Martin and Northrop Grumman are integrating these materials into next-generation spacecraft but retrofitting existing fleets remains a daunting challenge.

Second, predictive space weather monitoring systems are becoming indispensable. The US National Oceanic & Atmospheric Administration (NOAA) operates the Space Weather Prediction Center which provides early warnings of solar activity. However, these systems require large-scale investment to improve accuracy and lead times.

Finally, international cooperation is paramount. The UN Office for Outer Space Affairs is working to standardize guidelines for mitigating space weather risks, but progress has been slow. Nations must collaborate on data sharing, joint investments in resilient infrastructure and coordinated responses to ensure no country is left unprotected.

CMES CAPABLE OF CAUSING WIDESPREAD DAMAGE STRIKE EARTH ROUGHLY ONCE EVERY 100 YEARS

New Reality

A mega space storm is not just a theoretical threat – it is a wake-up call for a society increasingly reliant on space-based technology. Carl Sagan once described Earth as a “pale blue dot,” fragile and interconnected. That fragility extends to the space infrastructure that powers modern life. Addressing the threat of a CME is about ensuring the continuity of our interconnected world.

As we push further into space exploration, with missions to Mars and beyond, the risks of space weather will only grow. In preparing for these challenges, we must balance ambition with responsibility, recognizing that the same infrastructure that enables progress also makes us vulnerable too. In the words of Neil deGrasse Tyson, “We are part of this universe; we are in this universe. But perhaps more important than both of those facts is that the universe is in us.” Safeguarding that connection is a key priority.

Talking Point 6

COMMERCIAL SPACE

The commercial space industry is transforming into one of the most dynamic and high-potential sectors of the global economy. What began as an extension of state-led ambition has evolved into a vibrant marketplace where private companies are leading the charge. From space manufacturing to mining celestial resources, the industry is unlocking new frontiers of economic opportunity. As McKinsey projects, the space economy is expected to grow to US$1.8 trillion by 2035 with commercial ventures driving much of this growth. The focus is shifting from merely reaching space to building sustainable industries that impact life on Earth & beyond.[36]

Footnotes

36 McKinsey & Company, Space: The US$1.8 trillion opportunity for global economic growth

37 Do Innovation, Current In-Space Manufacturing Technologies

38 Popular Mechanics, How Space Crystals Could Lead to New Cancer Drugs

39 Boston Consulting Group, More than a Space Programme: The Value of Space Exploration to Empower the Future of Europe

Industry Beyond the Earth

One of the most compelling developments in space commercialization is the rise of in-orbit manufacturing. Microgravity environments in space offer unique conditions for producing materials that are either difficult or impossible to create on Earth. Fibre optics, advanced alloys, pharmaceuticals and even human organs are emerging as potential products of space-based manufacturing.

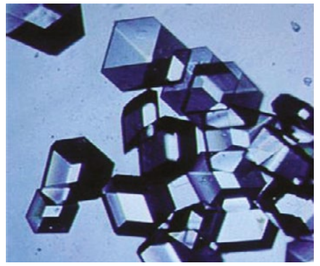
For example, Florida-based Redwire has demonstrated the potential to produce ZBLAN fibre optic cables in microgravity which could be up to 100 times more efficient than traditional silica-based cables.[37] These advancements promise to revolutionize telecommunications by reducing data loss over long distances.

REDWIRE HAS DEMONSTRATED THE POTENTIAL TO PRODUCE ZBLAN FIBRE OPTIC CABLES IN MICROGRAVITY WHICH COULD BE UP TO 100 TIMES MORE EFFICIENT THAN TRADITIONAL SILICA-BASED CABLES

REDWIRE

Breaking Bad in Orbit

Growing crystals in orbit is a big deal. In this regard, the International Space Station (ISS) is an ideal platform for crystallization experiments because crystals grown in microgravity are often larger and more well-ordered than Earth-grown crystals. Higher-quality crystals can result in improved data to determine a protein's structure. The more information researchers have about a protein's structure, the better they can understand how it functions and design drugs that work with the protein. Indeed, if researchers know the structure of what a protein looks like, they can then better design molecules to fit into that protein and turn it on or off –the basis for a lot of drugs. Merck & Co, for example, likes these orderly crystals for formulating cancer immunotherapy drugs. Oak Ridge National Laboratory has used ISS-grown crystals to develop an antidote for nerve gas. While The Michael J. Fox Foundation grew crystals of a protein identified with Parkinson's disease.



ISS NATIONAL LABORATORY

The International Space Station (ISS) is an ideal platform for crystallization experiments because crystals grown in microgravity are often larger and more well-ordered than Earth-grown crystals

The current medical research on board the ISS is a reminder of the benefits that routine spaceflight could bring. Humanity now has only a toehold in space and microgravity science is so new that the equipment to do it is just now being developed and tested. When people talk about industrialization of space, they may not think about a cure for cancer but the key to that kind of breakthrough may one day be found overhead in LEO.[38]

The economic promise of in-orbit manufacturing is vast. A report by the Boston Consulting Group estimates that the market for space-made goods could exceed US$20 billion annually by 2035, driven by demand for high-performance materials and medical breakthroughs.[39] However, challenges remain, including the high costs of launching raw materials and scaling production technologies. Companies like Varda Space Industries and Nanoracks are actively working to address these issues by developing re-entry systems and modular production platforms.

Talking Point 6 - Commercial Space

Mining the Moon & Asteroids

Beyond Earth, celestial bodies like the Moon and asteroids are being eyed for their resource potential. These extraterrestrial resources could play a major role in supporting humanity's ambitions for long-term space exploration while addressing critical resource shortages on Earth.

Asteroids, for example, contain abundant reserves of precious metals like platinum, gold and rare earth elements. NASA estimates the total value of resources on a single metallic asteroid, such as 16 Psyche could reach US$10,000 quadrillion. Private companies including Japan's ispace and Los Angeles-based TransAstra and AstroForge are investing in technologies to locate, extract and process these resources. TransAstra's proposed "optical mining" approach uses concentrated sunlight to extract volatiles and metals and could be a game-changer for the sector.

Closer to home, the Moon is emerging as a key target for resource extraction. Its polar regions contain vast deposits of water ice, a resource critical for sustaining life and producing rocket fuel. Additionally, the Moon's surface is rich in helium-3, a rare isotope with potential applications in nuclear fusion. China and the US are leading the charge, with China's Chang'e missions and NASA's Artemis program laying the groundwork for lunar resource utilisation.

The economic and strategic implications are profound. Between 2020 and 2021, the global space economy value rose 9% to US$469 billion and is predicted to be worth US$1.8 trillion by 2035 - more than double its current value - providing materials for Earth-based industries while enabling deep-space missions.[40] However, the sector faces regulatory hurdles, as the earlier mentioned 1967 Outer Space Treaty prohibits claims of sovereignty over celestial bodies, complicating ownership and profit-sharing frameworks.[41]

NASA

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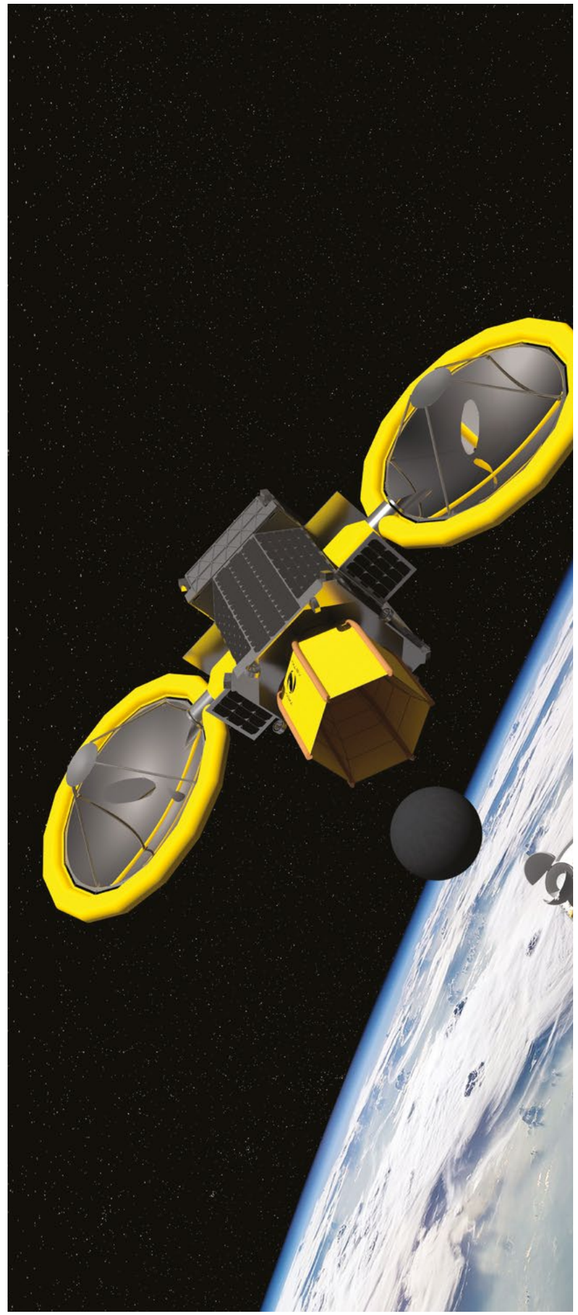


Footnotes

40 TechTarget, A rising space industry will create new jobs and products

41 Arms Control Association, The Outer Space Treaty at a Glance

42 ESA, Cost vs. benefits studies

Energy from Above

Another transformative application of space technology is space-based solar power (SBSP). This concept involves capturing solar energy in space where sunlight is uninterrupted by weather or atmospheric interference and transmitting it back to Earth via microwave or laser beams. The potential is enormous - a single square kilometre of solar panels in orbit could generate as much power as 1,000 square kilometres on Earth.

Japan, through its Space Solar Power Systems (SSPS) program and China with its ambitious plans for a solar power station in orbit by 2030 are leading SBSP development. In the private sector, companies like Solaren and Northrop Grumman are exploring scalable solutions to bring this technology to market. The European Space Agency (ESA) is also investigating SBSP as part of its "Solaris" program which aims to accelerate renewable energy adoption globally.

In early 2022, the ESA commissioned two independent cost vs. benefits studies of Space Based Solar Power for terrestrial energy needs from Frazer-Nash in the UK and Roland Berger in Germany.

The aim of the studies were to provide ESA and its Member States with the necessary technical and programmatic information regarding the feasibility and potential of SBSP to provide environmentally sustainable, affordable and clean energy for Europe to meet its growing future energy needs and 2050 Net Zero goal. The studies were completed in August 2022 and both concluded that:

- SBSP could provide competitively-priced electricity to European homes and businesses by 2040, displacing fossil-fuel sources of power and complementing existing renewables such as solar PV and wind, reducing the need for large-scale storage solutions.
- When deployed at scale, SBSP would provide substantial environmental, economic and strategic benefits for Europe, including energy security.
- A lot of challenging technology developments are still needed to mature the feasibility of collecting gigawatts of power in space, per satellite and delivering it efficiently and safely to users on Earth. But Europe has the main building blocks already and developments in the required technology areas will have widespread applications both on Earth and in space.
- If Europe is to benefit from this game-changing capability in time to make a difference for climate, awareness raising, especially amongst the energy sector and public authorities and further investments in technology R&D are needed now.

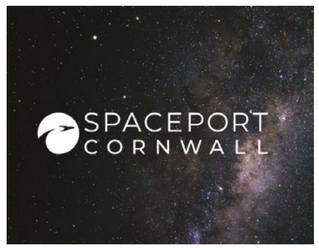
SBSP appears to have strong benefits as a complementary energy source alongside terrestrial renewable energies in our path towards decarbonization. But it also has many challenges, both technical and non-technical that would need to be addressed to provide sufficient confidence prior to any decision in 2025 to undertake a full development program.[42]

Talking Point 6 - Commercial Space

Spaceports Revolution

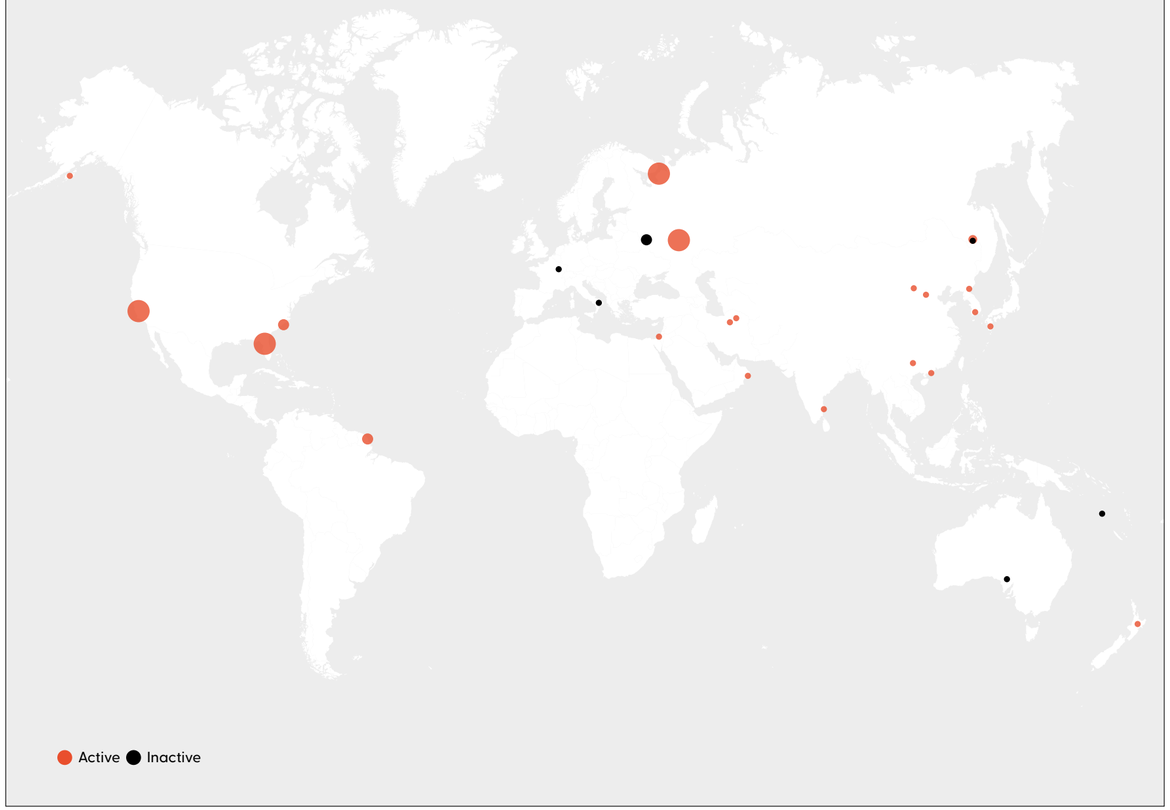
Space launches become more frequent, the infrastructure supporting them is evolving rapidly. Commercial spaceports are emerging as critical nodes in the space economy, facilitating launches, landings and testing for both government and private missions. Today, there are more than 35 operational spaceports worldwide, with new facilities under construction in countries ranging from Oman to the UK.

Spaceport America in New Mexico, Mojave Air and Space Port in California and Spaceport Cornwall in the UK are leading examples of how these facilities are supporting a growing range of activities. From hypersonic flight testing to suborbital tourism, these hubs are not only enabling innovation but also driving regional economic development. The UK government estimates that Spaceport Cornwall could contribute US$253 million to the local economy over the next decade, creating hundreds of jobs in aerospace and related industries.[43] As the space economy continues to expand, it offers not only economic opportunities but also a chance to redefine humanity's relationship with the cosmos. It is no longer just about exploring the final frontier - it is about creating a marketplace that serves the planet while preparing for life beyond it.



Spaceport Cornwall could contribute US$253 million to the local economy over the next decade

THERE ARE MORE THAN 35 OPERATIONAL SPACEPORTS WORLDWIDE, WITH NEW FACILITIES IN COUNTRIES RANGING FROM OMAN TO THE UK



Footnotes

43 Spaceport Cornwall, Wider Impact

Talking Point 7

ASPIRATIONAL TRAVEL

For decades, space tourism existed only in science fiction novels. Today, companies like Virgin Galactic, Blue Origin and SpaceX are spearheading efforts to make space accessible not just to astronauts but to private citizens. These are not mere technological feats they represent a cultural shift, reimagining travel as a bridge between Earth and the cosmos

Footnotes
44 Morgan Stanley, Creating Space
45 UBS, Future of Space Tourism: Lifting off? Or has COVID-19 stunted adoption?

Space Tourism Potential

Morgan Stanley projects that by 2030, space tourism could generate annual revenues of US$10 billion, driven by increased accessibility and evolving consumer demand.[44] A report from UBS echoes this optimism, suggesting the broader space economy - fueled by tourism, satellite services and orbital manufacturing - could exceed US$900 billion by the end of the decade.[45] The impact of this growth extends beyond ticket sales. Space tourism stimulates investment in propulsion technologies, reusable rockets and orbital habitats. It also creates jobs across multiple sectors, including aerospace engineering, hospitality and logistics. Virgin Galactic alone anticipates hiring thousands of personnel globally as it scales operations with positions ranging from spacecraft maintenance technicians to customer experience specialists.

BY 2030, SPACE TOURISM COULD GENERATE ANNUAL REVENUES OF US$10 BILLION, DRIVEN BY INCREASED ACCESSIBILITY AND EVOLVING CONSUMER DEMAND
MORGAN STANLEY

Ticket to Ride

Despite its promise, space tourism remains prohibitively expensive for most. A seat aboard a Virgin Galactic flight costs US$450,000, while Blue Origin's tickets are rumored to command a similar premium. These price points confine the experience to the ultra-wealthy, raising questions about inclusivity and long-term scalability. However, industry leaders are optimistic about cost reductions. SpaceX's reusable rockets have significantly lowered the cost of space launches. The company's Falcon 9 rocket can be relaunched with minimal refurbishment, drastically reducing expenses per mission. A standard Falcon 9 launch is priced at US$62 million, substantially less than competitors' offerings. Analysts suggest that with technological advancements and increased competition, ticket prices could fall to US$50,000 within the next 20 years, making space tourism accessible to a broader segment of the population.

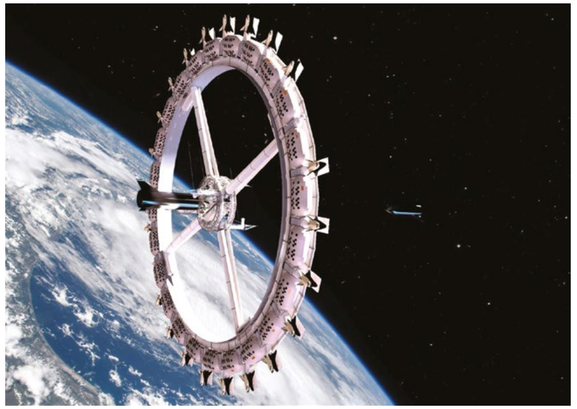
Ticket prices could fall to US$50,000 within the next 20 years, making space tourism accessible to a broader segment of the population

Talking Point 7 - Space Tourism: Aspirational Travel

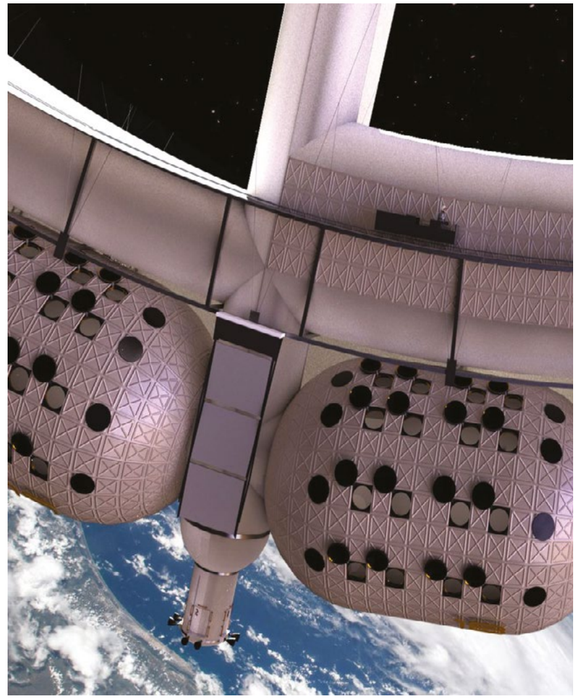
Beyond Suborbital

While suborbital flights dominate the current landscape, the future of space tourism lies in orbital and even lunar travel. SpaceX has already sold tickets for its circumlunar mission, originally planned for 2023 but postponed, will take eight private citizens on a week-long journey around the Moon aboard its Starship vehicle. Meanwhile, companies like Axiom Space are developing private space stations designed to host tourists, researchers and commercial enterprises.

Space hotels, once a staple of Isaac Asimov novels are becoming a tangible reality. Space Development, a US-based start-up aims to launch the world's first luxury space hotel, Voyager Station by 2027.[46] The rotating structure, designed to create artificial gravity will feature suites, restaurants and recreational facilities. While initial costs are likely to remain high, such ventures represent the industry's ambition to create lasting infrastructure in LEO.



Launch the world's first luxury space hotel, Voyager Station by 2027. The rotating structure, designed to create artificial gravity will feature suites, restaurants nd recreational facilities.



Footnotes

46 Architectural Digest, A Hotel in Space Could be Operational in Just Five Years

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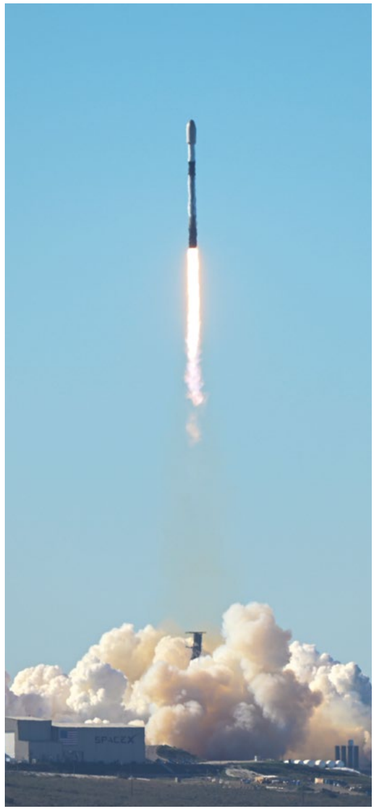
Environmental & Ethical Issues

As with any emerging industry, space tourism faces scrutiny over its environmental and ethical implications. Rocket launches produce significant carbon emissions, contributing to climate change. A single SpaceX Falcon 9 launch emits approximately 336 metric tons of CO^2, equivalent to the annual emissions of 70 cars. While the overall impact is small relative to global aviation it raises concerns about sustainability as the frequency of launches increases. In response, companies are exploring greener alternatives. Virgin Galactic, for example, is developing hybrid rocket engines that use cleaner-burning fuels. Blue Origin's New Shepard rocket is powered by liquid hydrogen and oxygen which produce water vapor as the primary byproduct. Additionally, organizations like the World Economic Forum are calling for standardized carbon accounting frameworks for the space industry to ensure transparency and accountability.

Ethical considerations extend beyond environmental impact. Critics argue that space tourism represents a misallocation of resources, prioritizing luxury experiences for the wealthy over pressing challenges on Earth. Proponents, however, counter that the industry drives technological innovation with applications far beyond tourism, from improving satellite connectivity to advancing materials science.

A SINGLE SPACEX FALCON 9 LAUNCH EMITS APPROXIMATELY 336 METRIC TONS OF CO^2, EQUIVALENT TO THE ANNUAL EMISSIONS OF 70 CARS



Talking Point 8

UPS & DOWNS

The Outer Space Treaty provides a framework for peaceful space activities but is ill-equipped to address the complexities of today's commercial landscape. Policymakers must navigate these challenges carefully to foster innovation while ensuring sustainability. Moreover, the environmental impact of commercial space activities is a growing concern.

The commercialization of space is not without its hurdles. The cost of entry remains high with launches priced at tens of millions of dollars despite cost-cutting innovations like reusable rockets. Regulatory challenges also abound, particularly around spectrum allocation, orbital debris management and international cooperation. The Outer Space Treaty provides a framework for peaceful space activities but is ill-equipped to address the complexities of today's commercial landscape. Policymakers must navigate these challenges carefully to foster innovation while ensuring sustainability. Moreover, the environmental impact of commercial space activities is a growing concern. Rocket launches contribute to carbon emissions, while the proliferation of satellites raises the risk of orbital congestion and debris collisions. The ESA estimates there are over 36,000 pieces of space debris larger than 10 centimeters currently orbiting Earth, a figure that grows with each new satellite launch. Addressing these challenges will require robust international agreements and the development of technologies for debris removal and collision avoidance.

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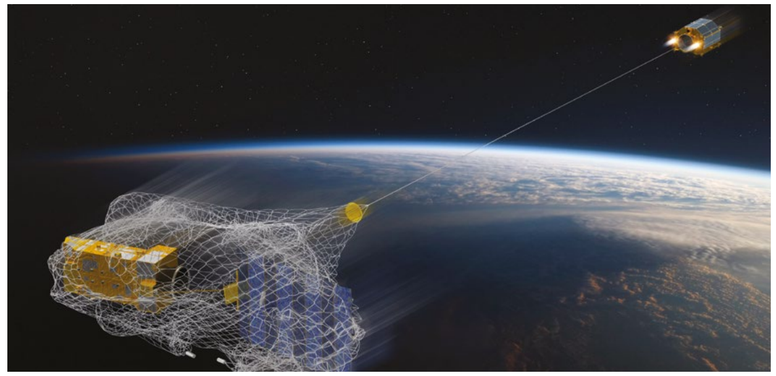


NASA

COLLABORATION ON COMMERCIAL CREW PROGRAM WITH

SPACEX

REDUCED THE COST OF TRANSPORTING ASTRONAUTS TO THE ISS

50%

Pushing Boundaries

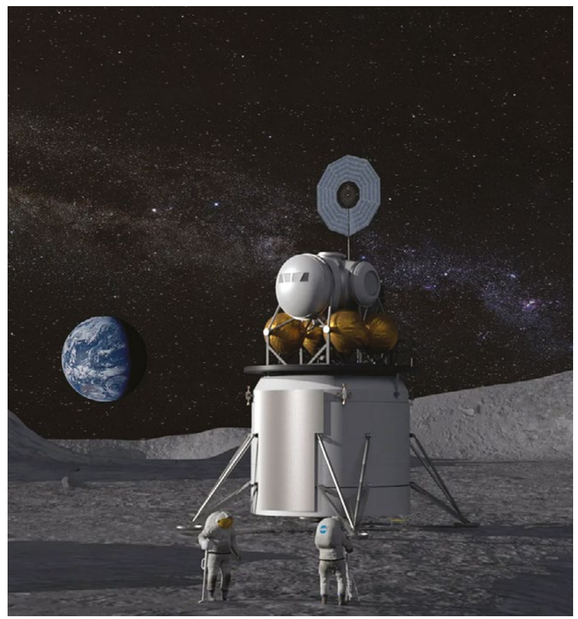
Despite challenges, the commercial space sector's potential to drive economic growth and innovation is unparalleled. As the OECD highlights in its Space Economy in Figures report, private-sector investment in space technologies has impacted aerospace to telecommunications. Start-ups are emerging at an unprecedented rate, supported by venture capital and government initiatives. In 2024, US tech venture debt could rise to US$14–16 billion, up 25% from 2023 levels, a clear indicator of investor confidence in the sector's long-term viability.

The future of commercial space will likely hinge on public-private partnerships. Governments have a key role to play in funding basic research, setting regulatory standards and providing a stable environment for innovation. Private companies, on the other hand, bring the agility and market-driven focus needed to commercialize technologies effectively. This symbiosis has already produced remarkable results, such as NASA's collaboration with SpaceX on the Commercial Crew Program, which has reduced the cost of transporting astronauts to the ISS by nearly 50%.

The commercialization of space is no longer a question of "if" but "how." As private companies push the boundaries of what is possible, the sector is poised to redefine industries, create new markets and reshape how humanity interacts with the cosmos. From satellites that bring broadband to remote villages to space hotels that promise unparalleled views of Earth, the commercial space industry is transforming dreams into realities. Yet, success will depend on addressing the challenges of sustainability, accessibility and regulation. The companies that rise to these challenges will not only reap economic rewards but also contribute to humanity's broader aspirations - connecting communities, addressing global challenges and inspiring the next generation of explorers.

Talking Point 9

THE NEXT GOLD RUSH



The Moon has reemerged as a strategic focal point for space exploration not only for its proximity to Earth but for its resource-rich landscape. As discussed earlier, its polar regions contain significant deposits of water ice, a crucial resource for sustaining human life and producing rocket fuel. Water ice can be split into hydrogen and oxygen, creating a sustainable fuel source that could enable deeper exploration of the solar system.

Water ice can be split into hydrogen and oxygen, creating a sustainable fuel source that could enable deeper exploration of the solar system

Footnotes

47 Eco News, The most powerful energy source in history, on the Moon: NASA has the plan to bring it here

48 IEA, Executive Summary, The Role of Critical Minerals in Clean Energy Transitions

Helium-3, a rare isotope on Earth but abundant on the lunar surface is another bonus. Its potential as a clean, efficient fuel for nuclear fusion reactors has long been recognized by experts estimating that just 25 tons of helium-3 could power the entire US for a year.[47] However, the extraction of helium-3 poses engineering and logistical challenges, requiring innovative mining technologies capable of operating in extreme lunar conditions.

In recent years, international interest in lunar mining has surged. NASA's Artemis program, aimed at returning humans to the Moon by 2025, includes a focus on resource utilization. Meanwhile, China's Chang'e lunar missions have successfully collected and analyzed lunar samples, demonstrating the feasibility of large-scale extraction efforts. Japan, Russia and the EU are also developing plans for lunar exploration and resource exploitation.

Just 25 tons of helium-3 could power the entire US for a year

Why Space Mining Matters

The growing interest in space mining is underpinned by the rising global demand for critical minerals. In a scenario that meets the Paris Agreement goals the demand for lithium, nickel, cobalt, manganese and graphite rises significantly over the next two decades to over 40% for copper and rare earth elements, 60–70% for nickel and cobalt and almost 90% for lithium. EVs and battery storage have already displaced consumer electronics to become the largest consumer of lithium and are set to take over from stainless steel as the largest end user of nickel by 2040.[48]

Talking Point 9 - The Next Gold Rush

Legal & Regulatory Challenges

Despite its promise, space mining faces legal and regulatory difficulties. The Outer Space Treaty prohibits claims of sovereignty over celestial bodies. This raises complex questions about ownership, profit-sharing and the commercialization of space resources. How, for example, can companies secure property rights over an asteroid? And how should the benefits of space mining be distributed among nations? In response to these challenges, several countries have enacted national legislation - the 2015 US Commercial Space Launch Competitiveness Act, allows private entities to own and sell space resources, stimulating investment in space mining. Similarly, Luxembourg's 'SpaceResources.lu' initiative has established the country as a hub for space resource activities, offering legal certainty to companies involved in the exploration and use of space resources. The UAE's Federal Law 12 (2019) enables the commercial exploitation of space resources, while Japan's Space Resources Act (2021) provides for the ownership of mined space resources by licensed companies.[49]

However, these unilateral approaches risk creating a fragmented regulatory landscape. Experts, including those at the Brookings Institution have called for the development of an international framework to govern space mining activities. Such a framework could establish guidelines for resource extraction, environmental protection and equitable benefit-sharing, ensuring space remains a global commons rather than an economic free-for-all.[50]

Tech Behind the Vision

Advances in robotics, AI and propulsion systems are key enablers of space mining. Autonomous mining robots capable of operating in extreme environments are being developed to extract and process materials on-site, minimizing the need for costly transportation. Meanwhile, advancements in ion propulsion and reusable rockets are reducing the cost of accessing and operating in space, bringing asteroid and lunar mining within reach. A notable example is NASA's OSIRIS-REx mission which successfully collected samples from the asteroid Bennu in 2020. These samples will provide critical insights into the composition of asteroids and the feasibility of large-scale mining operations.[51] Similar missions, such as Japan's Hayabusa2 are expanding the scientific and technical knowledge required for future commercial ventures.

Footnotes

49 Space Generation Advisory Council, Space Resource Regulation: From National Approaches to the Need for a General Framework

50 Landry Signe, Hanna Dooley, How space exploration is fueling the Fourth Industrial Revolution, Brookings

51 NASA, OSIRIS-Rex, Origins, Spectral Interpretation, Resource Identification, and Security – Regolith Explorer

52 OECD, Space Sustainability

Disturbing Asteroids

As with any extractive industry, sustainability must be at the forefront of space mining efforts. The environmental risks of disturbing asteroids are not fully understood and the potential for unintended consequences - such as altering an asteroid's trajectory cannot be ignored. Moreover, the ethical implications of exploiting extraterrestrial resources demand careful consideration.

To address these concerns, the OECD and other organizations have emphasized the importance of integrating sustainability principles into space mining strategies.[52] This includes minimizing waste, protecting the scientific value of celestial bodies and ensuring mining activities do not exacerbate inequalities on Earth. Public-private partnerships will be essential in achieving these goals, combining the innovation of the private sector with the oversight and resources of governments.

THE IMPORTANCE OF INTEGRATING SUSTAINABILITY PRINCIPLES INTO SPACE MINING STRATEGIES. THIS INCLUDES MINIMIZING WASTE, PROTECTING THE SCIENTIFIC VALUE OF CELESTIAL BODIES AND ENSURING MINING ACTIVITIES DO NOT EXACERBATE INEQUALITIES ON EARTH

Bold New Chapter

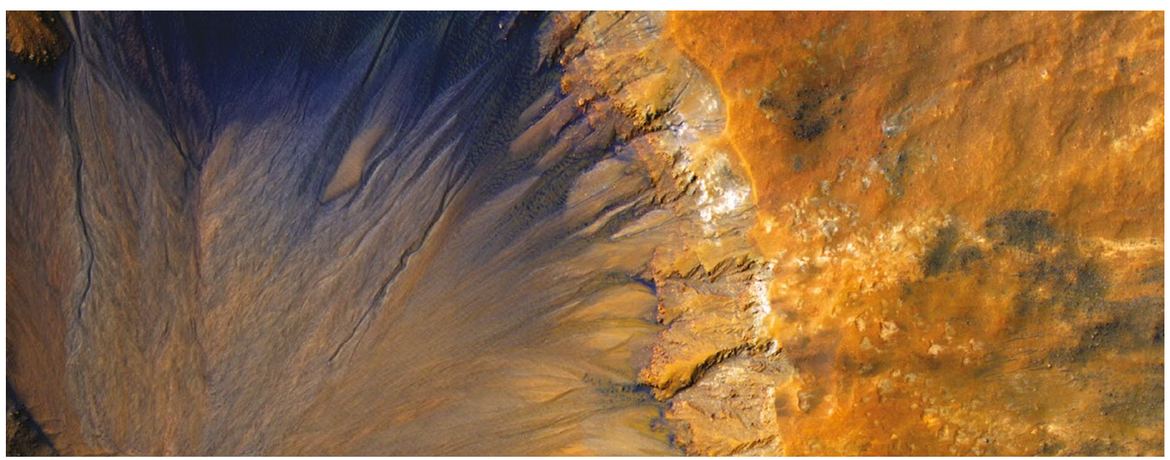
Space mining represents a bold new chapter in our relationship with the cosmos. It offers the promise of abundant resources, economic growth and technological innovation while also posing profound ethical and regulatory challenges. As countries and companies race to claim their share of this extraterrestrial bounty, the need for cooperation, sustainability and foresight has never been greater. Ultimately, the success of space mining will depend on our ability to balance ambition with responsibility. If done right, it could unlock a new era of prosperity, enabling humanity to thrive both on Earth and beyond.

Talking Point 10

TO — THE MOON & BACK

If Carl Sagan were with us today, he might look at our tentative steps toward Mars and remind us that "we are a way for the cosmos to know itself." And Neil deGrasse Tyson would likely point out the irony of humans striving to reach Mars while struggling to fix potholes back on Earth. Between their perspectives lies the heart of space exploration - the awe-inspiring ambition to transcend our planetary boundaries and the pragmatic challenges of getting there.

Talking Point 10 - Beyond the Moon



Mars: The Ultimate Frontier?

Mars is the goal that both excites and humbles space agencies and private enterprises alike. NASA's Artemis program, set to return humans to the Moon by 2025 is not merely a nostalgic nod to Apollo – it is a tactical rehearsal for the more audacious journey to the Red Planet. SpaceX is not content with just landing on Mars it aims to establish self-sustaining human settlements, complete with agriculture, energy systems and habitats designed to withstand the harsh Martian environment.

But let is not underestimate the huge challenges. First, there is the issue of distance. At its closest approach, Mars is still 54.6 million kilometers away, requiring a journey of 6 to 9 months. Keeping astronauts alive and psychologically stable during that time is no small feat. Life-support systems will have to be closed-loop, recycling air, water and waste with near-perfect efficiency. Then there is the money. The US spent US$25.8 billion on Project Apollo between 1960 and 1973 or approximately US$300 billion when adjusted for inflation. The Mars Science Laboratory Curiosity project cost US$2.53 billion. If we compare a lunar mission to a Mars mission - which may not be exactly fair – costs range from around US$100 billion to US$500 billion per mission - probably closer to the US$500 billion or more given the ISS alone cost US$150 billion. Then there is the Martian environment with average temperatures of -60°C and an atmosphere composed of 95% carbon dioxide, Mars is not rolling out the red carpet for human visitors. Radiation levels on the planet's surface are roughly 100 times higher than those on Earth, posing significant risks to human health. Scientists are exploring solutions, from underground habitats shielded by Martian regolith to advanced materials capable of absorbing radiation but these are still in experimental stages.

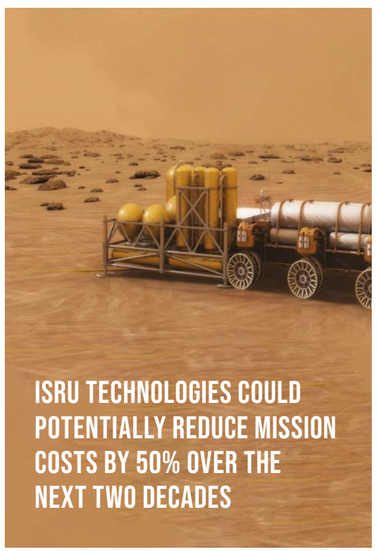
THE US SPENT US$25.8 BN ON PROJECT APOLLO BETWEEN 1960 AND 1973 OR APPROXIMATELY US$300BN WHEN ADJUSTED FOR INFLATION

Footnotes

53 SRT, In Situ Resource Utilization: The Future of Human Settlements in Space

Why Mars Matters

So, why endure such monumental challenges? The rewards, both tangible and intangible could redefine humanity's future. Mars offers a treasure trove of scientific opportunities. Its surface bears signs of ancient rivers and lakes, hinting at the possibility of past life. Discovering even microbial fossils would fundamentally alter our understanding of biology and our place in the universe. Economically, Mars could serve as a stepping stone for deeper space exploration. Its gravity, roughly one-third that of Earth's makes it an ideal launchpad for missions to the asteroid belt and beyond. Moreover, the planet's resources - water ice, carbon dioxide and potentially usable minerals - could support in-situ resource utilization (ISRU) reducing the need to transport supplies from Earth. Transporting materials from Earth to space is expensive due to the high costs associated with launching payloads. For example, it costs approximately US$10,000 per pound to send material into orbit.[53] By utilizing resources found on Mars, ISRU technologies could potentially reduce mission costs by 50% over the next two decades.



ISRU TECHNOLOGIES COULD POTENTIALLY REDUCE MISSION COSTS BY 50% OVER THE NEXT TWO DECADES

Global Cooperation

While Mars captures headlines, the broader landscape of space exploration is increasingly shaped by collaboration. Despite geopolitical tensions on Earth, the ISS remains a wonderful example of what nations can achieve together. Operated by NASA, Roscosmos, ESA, JAXA and CSA - the ISS has hosted over 270 astronauts from more than 20 countries since its inception in 1998 conducting groundbreaking research in microgravity.

Emerging space nations are adding fresh perspectives to this global endeavour. India's Chandrayaan-3 which successfully landed near the Moon's south pole in 2023 and the UAE's Hope Probe orbiting Mars since 2021, highlight the growing ambitions of countries beyond the traditional space powers. China, too, has established itself as a formidable player with its Tiangong space station and plans for lunar exploration.

The private sector is amplifying this spirit of cooperation. Partnerships like that between SpaceX and Axiom Space to develop private space stations, or Airbus's collaboration with Northrop Grumman on lunar logistics, demonstrate how shared goals can transcend borders. As the space economy grows such alliances will be key to reducing costs, pooling expertise and accelerating innovation.

THE BROADER LANDSCAPE OF SPACE EXPLORATION IS INCREASINGLY SHAPED BY COLLABORATION

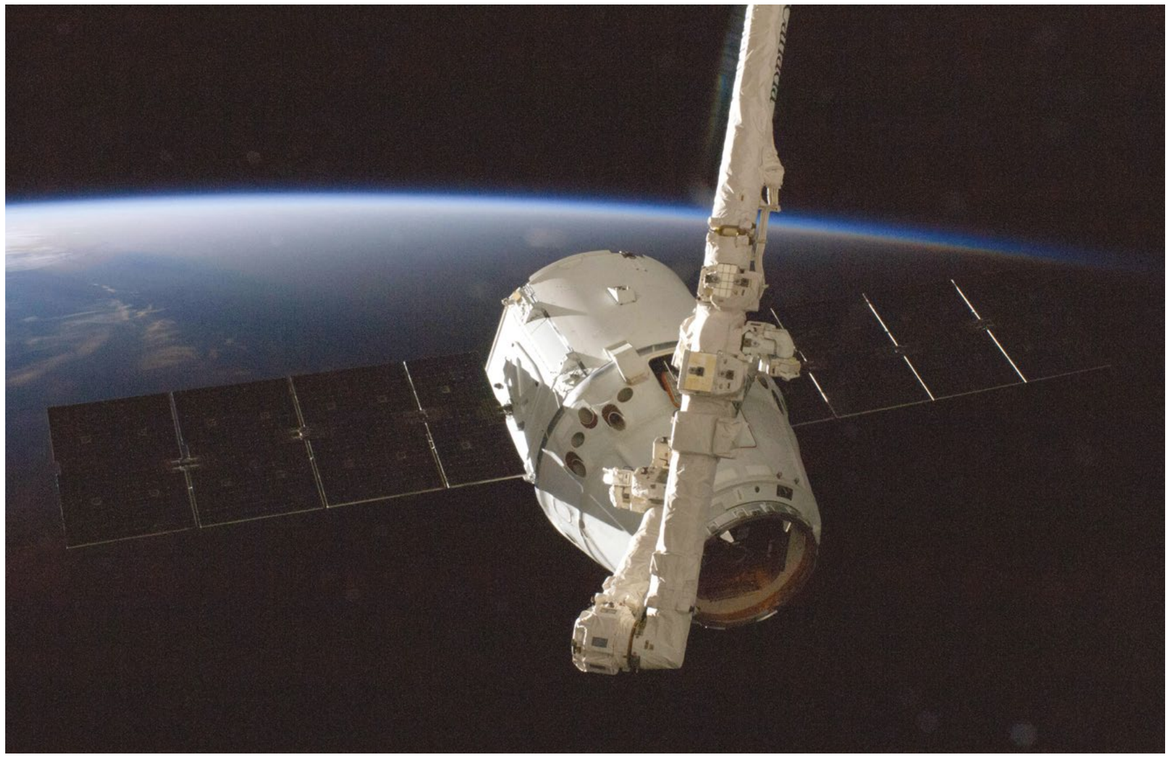
AXIOM SPACE

SPACEX

AIRBUS

NORTHROP GRUMMAN

Talking Point 10 - Beyond the Moon



2035 Vision

By 2035, space exploration is expected to be as integral to human life as the internet is today. Advances in AI, robotics and materials science are poised to transform every aspect of the sector, from spacecraft design to mission planning. The economic implications are remarkable. Industries that once seemed futuristic - orbital manufacturing, space-based solar power and asteroid mining - are expected to become multibillion-dollar markets within the next decade. For example, the Japanese Aerospace Exploration Agency (JAXA) is working on a space-based solar power system that could transmit energy to Earth via microwaves, potentially generating US$200 billion annually by 2040.[54] But with great opportunity comes great responsibility. The rapid expansion of space activities necessitates robust governance frameworks. Who owns the resources extracted from asteroids? How do we manage orbital congestion with over 36,000 pieces of debris already posing risks to satellites? The UN Office for Outer Space Affairs is working on updated protocols but progress has been slow.

JAPANESE AEROSPACE EXPLORATION AGENCY (JAXA) IS WORKING ON A SPACE-BASED SOLAR POWER SYSTEM THAT COULD TRANSMIT ENERGY TO EARTH VIA MICROWAVES, POTENTIALLY GENERATING US$200 BILLION ANNUALLY BY 2040

Footnotes

54 Interesting Engineering, Japanese researchers want to demonstrate space-based solar power by 2025

BEYOND THE STARS

Carl Sagan once said: "The cosmos is within us. We are made of star-stuff." The future of space exploration is not just about technological milestones or economic gains – it is about the enduring human desire to explore, understand and transcend. He might add that our exploration of Mars and beyond is not an escape plan but an insurance policy, ensuring the survival of our species in the face of existential threats. As we look to 2035 and beyond, the journey to the stars is as much about introspection as it is about ambition. Space holds the promise of uniting humanity through shared challenges and opportunities. The ultimate question is not whether we can reach Mars or mine asteroids but whether we can use these endeavours to build a more equitable, sustainable and enlightened world. In the words of American science writer, Sharon Begley: "Somewhere, something incredible is waiting to be known." The challenge is ours to accept.

"SOMEWHERE, SOMETHING INCREDIBLE IS WAITING TO BE KNOWN."

SHARON BEGLEY

Q&A

SPACE FOR EVERY AMBITION

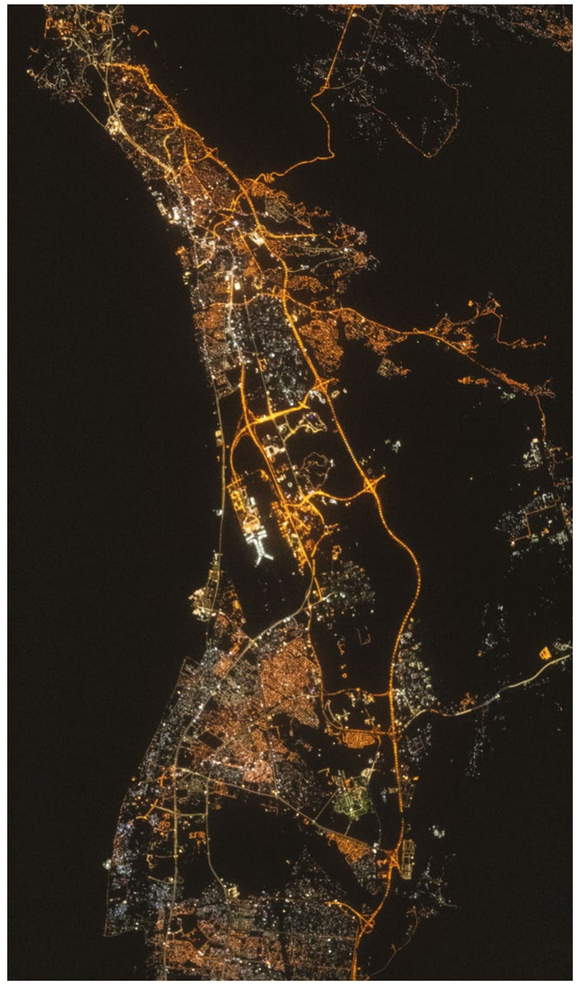
We sat down with Eng. Ahmed Akaak, CEO, SEZAD to talk about how Duqm is emerging as a new player in the global space economy. With its strategic location near the equator and strong logistics infrastructure, Duqm offers unique advantages for space launches. Eng. Ahmed explains how satellite technology is driving progress in fisheries, renewables and manufacturing while also supporting Oman Vision 2040 and the country's 2050 Net Zero target. He outlines a practical vision of how space can drive sustainable growth, create opportunities for local talent and establish Oman as a competitive force in this growing sector.

ENG. AHMED AKAAK
CEO
SEZAD

The space industry is projected to reach US$1.8 trillion by 2035. What is driving this growth and why does it matter?

Space has shifted from the exclusive domain of governments to a bustling commercial environment. In 2024, the global space economy is valued at over US$600 billion and around 80% of activity in space is enterprise driven. These are not just numbers - they reflect real-world applications that impact us all. Whether it is enabling precision agriculture or enhancing disaster response, space technologies are woven into our daily lives. The private sector is leading this charge, unlocking economic opportunities and delivering solutions to global challenges. For Oman, the space industry aligns perfectly with the goals of Oman Vision 2040. Indeed, by investing in the industry we diversify our economy, build local expertise and leverage high-tech industries to ensure long-term economic resilience.

In 2024, the global space economy is valued at over US$600 billion and around 80% of activity in space is enterprise driven



Q&A

Satellites are a central part of the space industry. How can they benefit Oman?

Satellites provide essential data that touches every aspect of Oman's development. For agriculture, they offer insights on soil health and water availability, helping farmers across Oman optimize irrigation and boost yields. In fisheries, they monitor fish stocks and water temperatures, helping SEZAD-based tenants practice sustainable management of a vital industry. But it goes beyond resource management. Satellites strengthen our capacity to deal with climate risks by improving weather forecasts, providing early warnings for cyclones and droughts. This technology also builds in-country value by fostering expertise in data analytics, creating skilled jobs and supporting Oman's 2050 Net Zero target.

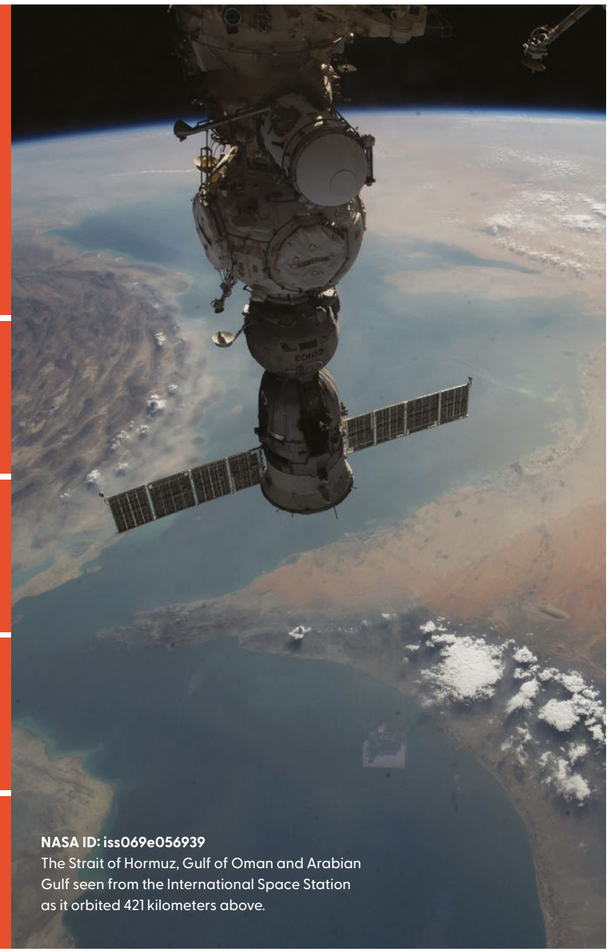
SATELLITES PROVIDE ESSENTIAL DATA THAT TOUCHES EVERY ASPECT OF OMAN'S DEVELOPMENT

Agriculture
Offer insights on soil health and water availability, helping farmers across Oman optimize irrigation and boost yields.

Fisheries
Monitor fish stocks and water temperatures, helping SEZAD-based tenants practice sustainable management of a vital industry.

Climate Risks
Improving weather forecasts, providing early warnings for cyclones and droughts.

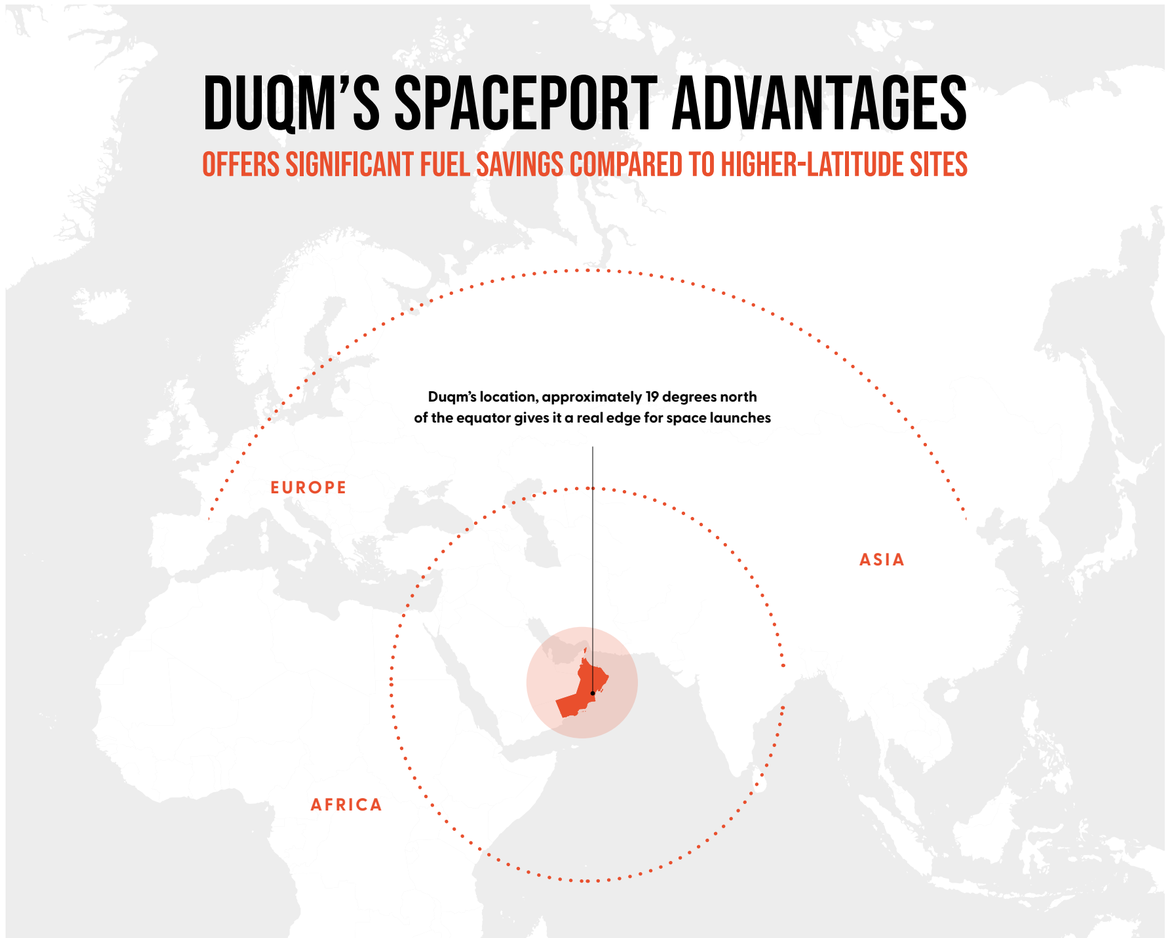
In Country Value
Build in-country value by fostering expertise in data analytics, creating skilled jobs and supporting Oman's 2050 Net Zero target.



NASA ID: iss069e056939
The Strait of Hormuz, Gulf of Oman and Arabian Gulf seen from the International Space Station as it orbited 421 kilometers above.

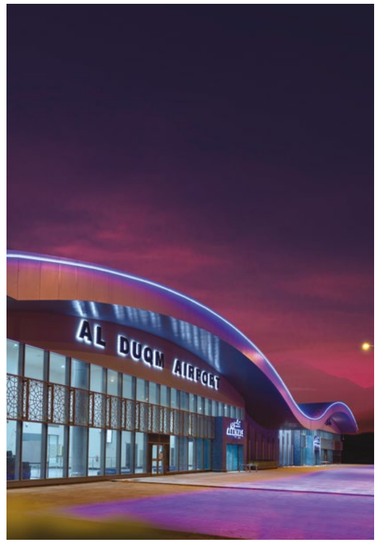
What are Duqm's geographical and logistical advantages as a spaceport?

Duqm's location, approximately 19 degrees north of the equator gives it a real edge for space launches. While it is not as close to the equator as French Guiana's Guiana Space Centre (5° N) or India's Satish Dhawan Space Centre (13° N) it still offers significant fuel savings compared to higher-latitude sites like Cape Canaveral (28.5° N) or Baikonur Cosmodrome (46° N). This is because eastward launches from Duqm can still take advantage of the Earth's rotational velocity, providing a boost that lowers fuel requirements and increases efficiency.



Q&A

But Duqm's appeal is not just about geography – it is about infrastructure too. SEZAD's outstanding logistics network which includes a hi-tech port, airport and access to points across Oman and beyond via world-class roads and highways strengthens our position as a contender in the regional space sector. The Etlaq Spaceport is clearly an important initiative, designed not only to provide launch services but also develop local capabilities in logistics, aerospace engineering, avionics and manufacturing. But perhaps what is most exciting is the broader impact. Launching rockets is just one part of the story. The real opportunity lies in building an industry that drives innovation, creates jobs and supports economic growth. With applications ranging from satellite data processing to systems engineering, the benefits extend well beyond the launchpad. Duqm is looking to carve out a role in the global space economy, particularly within the region. With strong partnerships and the right investment this ambition is entirely achievable



.What role can SEZAD play in integrating space technologies into other sectors?

Today, satellites monitor fish stocks and migration, optimize supply chains for our manufacturers and identify ideal locations for solar and wind energy projects. By collaborating with international companies and fostering local expertise, SEZAD can make sure these technologies deliver tangible benefits - enhancing sustainability, boosting efficiency and driving growth in sectors that are important to Duqm and Oman.

SEZAD can make sure these technologies deliver tangible benefits - enhancing sustainability, boosting efficiency and driving growth

The private sector is playing a bigger role in space. How is SEZAD adapting to this shift?

Without doubt the rise of companies like SpaceX and Blue Origin have reshaped the space industry, demonstrating how innovation and cost efficiency can create new commercial opportunities. SEZAD is learning from this shift by fostering partnerships that align private sector agility with Oman's strategic goals. I want to be clear, with a robust support ecosystem of pro-business regulations, outstanding infrastructure and a strong emphasis on innovation we have created an environment offering real opportunity, right now – an environment where businesses can succeed. At the same time, we are also working to help local firms and talent benefit from these advancements. From harnessing satellite technologies to applying space data in renewables, manufacturing, logistics and fisheries we are making sure our tenants' success supports Oman's long-term economic development. In-country value is something that is very important to us.

With a robust support ecosystem of pro-business regulations, outstanding infrastructure and a strong emphasis on innovation we have created an environment offering real opportunity, right now

What message do you have for young Omanis considering a career in space?

Clearly, the space industry offers a wealth of possibilities far beyond the traditional image of astronauts. It is a field that needs engineers, data scientists and environment specialists who want to shape the future. With exciting projects like the Etlaq Spaceport, young Omanis have a chance to get involved in initiatives that have a global impact. Imagine designing satellites that improve regenerative agriculture or using space-based data to support Oman's 2050 Net Zero journey. These are real opportunities where ambition and innovation can make a huge difference. For those ready to take on the challenge, the space sector provides a unique path to drive Oman's progress while addressing some of the world's most pressing issues.

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THANK YOU
TO OUR PANELISTS & ALL
THOSE WHO ATTENDED

1. Hamed Al Shekaili
2. Ammar Al Rawahi
3. Said Abdul Ghafoor Saifudeen
4. Q&A
5. Great turn out

4

5

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