KPMG

Astro Economy

Navigating the opportunities in today's space economy for tomorrow's leaders

Contents

Introduction

Welcome to a series of enlightening discourses that are much more than a read—they are a catalyst for innovation, expansive exploration, and strategic foresight. We call this a compass of opportunities, a strategic tool to navigate the immensity of the burgeoning space economy. Compiled within these series are perspectives and explorations into the dynamic currents shaping various industrial sectors, not only within the confines of our planet, but also extending into the vast expanse of the cosmos.

Commencing with "Dynamics of Disruption," we daringly dive into the controversial geopolitical complexities and disruptions formulating in the global space economy. Unmasking the various interactions between commerce, geopolitics, and security, this series underlines the need for robust policies to navigate the high-stakes risks and opportunities. It sets the stage for diplomatic relationships and public-private partnerships to leverage space exploration for peaceful conflict resolution and advancement.

Next, we present "Data Fusion," a meticulously crafted journey designed for leaders pulsating at the heart of innovation. This series propels readers from the confinements of conventional leadership into the future of integrated data fusion, where the potential of the space economy awaits harness. We transition from envisaging opportunities to actioning them, calling for visionary CEOs to shape their industry's future.

The third series, "A Galaxy of Opportunities," provides a thorough embodiment of the significant scope that the space industry holds. It addresses the convergence and integration of terrestrial markets with space ventures, fostering an era of unparalleled economic growth, innovation, and cosmic mobility. Each featured perspective unravels the critical role of private investment, transparent foresight, and ethical considerations in space exploration, all while showcasing the transformative shifts awaiting on the horizon.

Together, these compelling journeys underscore the necessity of venturing beyond terrestrial confines, adapting, and strategically positioning organizations within a transforming commercial space landscape. As we journey through the next 18 months, they serve as strategic considerations to drive economic dynamism both on Earth and beyond. So, we extend an invitation to all the visionaries, pioneers, and innovators. Embark on this voyage and embrace a galaxy of opportunities wrapped within a universe of data fusion, disruption dynamics, and impactful implications. Thus, let's start our expeditions and together forge an epic saga of astronomical growth, innovation, and strategic dynamism.

Brian Miske
National Ignition Leader, KPMG

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Dynamics of Disruption

Dive into the controversial geopolitical complexities and disruptions formulating in the global space economy

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Global demand for space-based capabilities

Neil Rae, Dr. Hina Kazmi, and Brian Miske

The global space economy totaled an estimated $546 billion in 2023, with an average annual growth of 5 percent to 8 percent over the last decade. It is projected to reach about $1.4 trillion by the year 2040.[1] This includes commercial activity and government spending on civil space and does not include defense spending. More than 75 percent of the economy is generated through commercially produced in-space goods and services, while government spending for both civil space exploration programs and investments through public-private partnerships makes up the balance.

In-space commercial goods and services

Satellites provide a multitude of services, like remote sensing, navigation, meteorology, and broadband connectivity. The demand for space-enabled data has expanded greatly in the past five years. This has been driven by routine and affordable launch options, advances in data analytics and capacity, and the increasingly low costs of building satellites. Examples of space-enabled services include real-time tracking movement of goods, disaster management, geospatial data for urban development and agriculture, climate impact assessment, medical support to inaccessible locations, and remotely monitoring critical resources.

Government agencies are among the growing customer base, particularly military use of commercially available geo intelligence data,[2] enhancing open-source intelligence capabilities. More widely, the National Oceanic and Atmospheric Administration has established a Commercial Data Program to integrate commercial space data as part of its normal operations.[3]

As commercial satellite launches have rapidly accelerated to deliver in-space services across nearly all economic and many government sectors, in-space assets are considered critical infrastructure for nations.

Space transportation and exploration advancements

A key aspect of the commercial space sector is the growth of launch service providers, supporting space tourism and national objectives to return humans to the moon and ultimately to Mars. This includes development of a diverse range of launch vehicle options that can carry small satellites to large payloads, to destinations such as the International Space Station and the moon. The next decade and beyond will focus on commercializing human space travel options and expanding

in-space habitats, both in low Earth and lunar orbits. The modern commercial space age has shifted these objectives into high gear with no sign of slowing down.

Global expansion of space activities

The United States has been the hub of most of the commercial space activity in the world. The US annual civil space budget exceeds all other nations combined. The total US space economy has contributed about $212 billion in gross output over the 11-year period between 2012 and 2022. However, within the past decade, more than 82 countries have launched at least one satellite in orbit. While for the rest of the world, government funding is mostly responsible for fueling the commercial sector growth, government funding in the US totals less than private investments in the overall space economy.

The US has a robust space economy following decades of investment in launch infrastructure, expertise, training, and a highly skilled workforce. This has established a diverse range of large prime contractors, with an extensive supply chain. Many foreign space companies have established US subsidiaries, to take advantage of the booming US space economy.

International blocs and landscape for strategic alliances

As the economic and strategic significance of space grows, regional alliances are forming to enable mutually beneficial sharing of resources, expertise, and capital investments and to enhance safety, security, and sustainability. These alliances are also strategic in aiming for advantage in the military, intelligence, and diplomatic domains, through capabilities such as surveillance, communication, navigation, and missile defense systems.[4]

The Artemis Accords, led by the United States and joined by 36 signatory nations, represent a significant step forward in the collaborative exploration and utilization of outer space. Building upon the foundational principles set forth by the United Nations (UN) Committee on the Peaceful Uses of Outer Space, the Accords aim to promote the peaceful conduct of space activities and the equitable sharing of scientific data among participating nations.

In addition to these fundamental goals, the Artemis Accords also establish a framework for enhanced cooperation, including principles of interoperability through the adoption of common standards, the protection of important heritage sites on the moon, and the delineation of work safety zones to facilitate safe and effective collaboration in the exploration and utilization of outer space.

It is important to note that the Artemis Accords are a nonbinding political alliance, and as such, participating nations have the flexibility to pursue alternative approaches to their space activities. However, the Accords provide a valuable foundation for promoting international cooperation and coordination in space exploration and serve as a roadmap for future endeavors in the peaceful and responsible utilization of outer space.

There is a strong commercial component to space expansion, where private companies choose and prioritize their own investments, albeit with an eye on government customers. The interplay between commercial and political competition includes a complex set of actors and a range of emerging political and commercial constraints that may affect their access, opportunities, and security in the space domain. These constraints may include sanctions, boycotts, or sabotage from hostile parties, as well as compliance with limiting policies or standards from friendly nations.

As the primary space-faring nation, the US has a unique opportunity to strengthen its leadership by maintaining and expanding its global space alliances. The International Space Station (ISS) remains an inspirational example of partnership. Even during the toughest of political challenges, it has served as positive diplomatic exchanges between the US and Russia, as they shared experiences, launch services, and scientific research.

> “Organizations need to make smart choices to capitalize on the increasing demand for space-based services. This means understanding the changing global landscape and forming new partnerships.”
>
> **Neil Rae**
> **Director, UK Head of Space, KPMG**

> This is a critical time for the US to set the tone by harmonizing and simplifying regulations and laws across its disparate regulatory regime with bipartisan support.

Key areas of influence to support space growth

Surveys repeatedly show that a majority of Americans strongly favor that the US remain a leader in space exploration.[5] This will require bipartisan support to demonstrate consistent US leadership on the global stage. By expanding its sphere of influence, and leading through treaties, technical innovation, and capital investment, the US should consider the following three key areas of influence.

I. Security and regulation to enable safe collaboration in space

Successful growth in space requires a stable and secure environment, where both governments and commercial organizations can deliver capabilities and services with confidence that they will not be disrupted intentionally. The challenges of space exploration beyond Earth orbit will require collaboration at a truly global level.

The space policy and regulatory framework should establish norms and rules for responsible and sustainable behavior in space to enhance trust and cooperation across all parties.

Achieving this will require collaborative leadership, building on the experience of the ISS, underpinned by more transparent sharing of information and technology internationally.

II. Regulatory simplification to enable cooperation and commercial growth

Current US regulations mainly reflect a more risk-averse posture of government-led space activities than current commercial ventures. This is made more complex by the various agencies that regulate different parts of space missions, from telecommunication satellites to cargo and crew missions to the ISS. Existing regulations do not cover emerging technologies like commercial in-orbit habitats, commercial lunar landers, or lunar fuel storage facilities. Moreover, the Outer Space Treaty Article 6, explicitly requires all nations to authorize and monitor all nongovernment activities that launch from their countries.[6] To be compliant with this article, the US federal agencies and Congress are considering proposals to oversee this gap in regulatory guidelines, termed mission authorization.

III. Financial roles of government as the catalyst for change

The US collaboration with the space industry has historically been based on a traditional government-contractor relationship, governed by the Federal Acquisition Regulations (FAR). This construct dictates complex terms and conditions and results in the government facing almost all the financial risk. The National Aeronautics and Space Administration (NASA) still uses this mechanism to procure the development and launch of various science missions.

However, NASA and the Department of Defense have taken more commercial approaches, under the Other Transaction Authority (OTA), to develop new exploration systems and other relevant technologies, such as the development of new crew and cargo modules for transport to the ISS after the retirement of the Space Shuttle.

NASA's use of OTAs, namely Space Act Agreements (SAAs), have enabled public-private partnerships. The SAAs are nonprocurement agreements, in which both parties can bring financial investments to research and prototype new technologies. Such partnerships are primarily responsible for accelerating the new commercial space age and have proven to be mutually beneficial.

By partnering with NASA, firms can access the agency's expertise and its unique infrastructure, such as various test facilities. Companies use these valuable government resources with various financial arrangements, from fully reimbursable to fully funded.

The US has benefited from these partnerships through cost sharing with the private sector outside the rigid regulatory requirements under the FAR. According to the NASA Partnership Office, the agency now issues 600 to 800 domestic and international partnership agreements annually. These numbers include a wide range of other partnerships in addition to space exploration.

NASA should continue to broaden its use of OTAs, as both a cost-saving and industry collaboration mechanism. As more and more nations enter the space sector, SAAs with international partners will play a vital role in expanding and strengthening international collaboration.

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Commercial space development amid adversarial interests

A perspective

Jacob Hacker, Will Lewis, Brian Miske, and Grant McDonald

Abstract

The article, "Commercial space development amid adversarial interests: A perspective" delves into the rise of space as a commercial and geopolitical arena and the emerging patterns of cooperation and conflict therein. It discusses the impact of earthbound geopolitical realities on commercial space operations, accentuated by significant events including Russia's anti-satellite weapon test. The power dynamics among space-faring nations—US, China, Europe, Russia, India, and Japan—are extensively deliberated, with each examined based on their characteristics of launch, in-space presence, commercial space sector, and space situational awareness. Finally, the article posits an urgent call for harmonious space policies to manage the threats in this expanding realm and ensure space exploration is harnessed for the collective good.

As the space economy grows, strategies are needed to limit threats from nations seeking to disrupt or weaponize space.

It is said that history often repeats itself; it is also said that history moves faster in the modern age. Whether either is true, it certainly applies in the context of how the geopolitical world on Earth impacts commercial operations in space.

On November 15, 2021, Russia launched an anti-satellite (ASAT) weapon that struck Russian satellite COSMOS 1408. The test marked the fourth time a country had deployed an ASAT, joining the US,[1] China,[2] and India.[3] COSMOS 1408 was operating in lower Earth orbit (LEO) just as the previous ASAT targets had been.

However, Russia's test differed from previous ones in significant ways. The US and Chinese tests had taken place when commercial operations in LEO were relatively sparse.[4] There were even significant differences in the commercial deployment between India's 2019 ASAT test and Russia's 2021 test. Most notably, in the time between India's ASAT test and Russia's, Starlink had deployed approximately 1,800 satellites in orbit.[5]

India's ASAT test was intentionally conducted on a satellite far lower in orbit to ensure that the debris would burn up in the atmosphere more quickly. The victim satellite in the Indian ASAT test also released far less debris.[6] Russia, alternatively, destroyed COSMOS 1408 at 490 km, close to many commercial orbits, which released approximately 1,800 pieces of trackable debris.[7]

The debris field immediately threatened the ISS, forcing the astronauts and cosmonauts onboard to prepare to evacuate.[8] More symbolically, the test also immediately damaged the previously collaborative relationship between Russia's Roscosmos and NASA.[9]

Orbital debris fields from the Russian ASAT test, spanning an orbital range of 300–1,100 km, remain an operational hazard for LEO operators.[10] This is where the bulk of large commercial LEO operators have deployed their systems, including Starlink, OneWeb, Planet, and Spire, as well as a vast array of smaller constellations and stand-alone satellites. For the foreseeable future, long-term debris fields from the COSMOS 1408 test will be traveling through viable and important commercial orbits. This demonstrates just one aspect of how nations could disrupt space.

Now, history is repeating itself only three years later. US Intelligence is reporting that Russia is developing new space weapons to specifically disrupt commercial space services.[11] Collectively, Russia's previous ASAT test and the recent news that Russia continues to develop weapons capable of widespread damage in space are a clear demonstration that the global geopolitical environment has, does, and will pose risks and threats to commercial space actors.

> "The commercial space industry has grown to develop an unprecedented presence in space, particularly lower Earth orbit. Unfortunately, this growth has coincided with a new era of geopolitical aggression and the weaponization of space has gone from a distant hypothetical to a pressing reality. This paper examines this new environment and its potential impact on the future of commercial space endeavors."
>
> Will Lewis,
> Director, ACSP

The rise of space as a geopolitical arena

Major space powers and their capabilities

While the arena of space has grown, both geopolitically and commercially, there are only a few geopolitical entities capable of shaping space policy or influencing events in space. Considered here are the United States, China, Europe,[12] Russia, India, and Japan. These five nations and a geopolitical union are uniquely positioned to drive, shape, and threaten the present and future of commercial space operations, making them the current "Space Powers" on Earth. Here, we evaluate each Space Power based on the following characteristics of its space industry, with a focus on a broad set of essential capabilities that are critical to Space Sovereignty:[13] Launch, in-space presence, commercial space sector, space situational awareness (SSA), lunar presence, and deep-space and science missions.

The United States

The US is a clear Space Power in every sense of the word, and has often been the first mover and standard setter in all aspects of space. It has a robust launch industry that has facilitated an unparalleled presence in space in LEO, on the moon, and beyond.[14]

The US also has a unique advantage in SSA technologies and information, with a significant amount of public and private infrastructure deployed to track space debris and alert operators, both domestic and foreign, of potential conjunction events between spacecraft or between spacecraft and debris. The US has further leveraged its SSA capabilities diplomatically, securing collaborative agreements with countries across the globe based on the principle of SSA sharing.[15]

One could split the US space industry into government and commercial space and there would be two space powers. The US commercial space industry would, on its own, compete for a place on a list of Space Powers. This was punctuated recently by the successful landing on the moon of a private US space company, an accomplishment that has not been achieved by two of the Space Powers on this list.

> Outer space is becoming increasingly competitive, both from a commercial and military perspective. As well, the potential for conflict has grown between allies and adversaries. There is every indication this geopolitical congestion will continue to increase at an accelerated pace. As such, there is a growing need to protect the space domain to ensure there is access for all and not just the powerful states."
>
> Grant McDonald,
> Global Aerospace and Defense Leader, KPMG

China

China is second only to the US in launch and in-space presence, most notably continuing to operate its own space station while contemplating greater satellite deployments in the region.[16]

China undoubtedly has some significant SSA programs,[17] although there is limited information about their capabilities. However, China has had to maneuver its space station at times to avoid commercial satellites from other administrations.[18] This suggests robust SSA capabilities, although it is possible that the US may have alerted China to the possible conjunctions.

China's commercial space industry is growing quickly but raises questions as to whether any aspect is truly "commercial."[19] However, China boasts a host of lunar and deep space[20] successes that minimize the impact of a relatively muddled public-private divide within its domestic space industry.

Europe

Europe, the only Space Power that is a coalition of nations rather than a single state, is more fairly grouped with the other three Space Powers than with the US. While it does have its own launch vehicle, the transition to a new model has been difficult,[21] and increasing the cadence of launch has not yet proved feasible. There are also questions as to how sustainable European launch will be without access to and reliance on Russian launch technology.[22]

As a result, Europe's in-space presence is significantly lower than that of China and the US. Europe's SSA capabilities are still under development[23] and, likewise, similarly limited as compared to China and the US but consistent with the other Space Powers on this list.

However, Europe still boasts a long-standing commercial space industry and a number of critical science and civilian[24] space deployments. It has successfully conducted several deep-space missions but has not yet landed on the moon.

Russia

Not so long ago, Russia would have been considered a peer of China and a near-peer to the US. Currently, though, the Russian space program, which should be considered distinct from the Soviet program that once competed on equal footing with the US, has seen its launch capabilities and in-orbit presence diminish while its peers have continued to grow and diversify their respective space industries.

One place where Russia may retain superlative capabilities is in SSA. The Russian SSA network, the SKKP, has existed for decades[25] and has continued to evolve with more modern capabilities like the US SSA network.[26] There may also be some indication that Russia has on-orbit SSA capabilities that may be unrivaled,[27] at least outside of the US.

Russia's capabilities in space have dwindled,[28] and its in-space presence is now relatively dated and small. Its presence is also primarily government, as the Russian commercial sector, such as it exists, has achieved little.[29] Russia gets points for its continued role in the operation of the ISS but otherwise has recently tried and failed to land on the moon,[30] leaving another Soviet milestone out of reach for Russia's modern space industry.[31]

India

India would not have been on the Space Powers list five years ago. It has made remarkable progress in a short period of time, with its sovereign launch capabilities growing to support more frequent and ambitious government missions as well as commercial opportunities for launching domestic and foreign[32] spacecraft.

India's late start in space means its in-space presence is relatively limited among the Space Powers. Its commercial space industry[33] and SSA capabilities[34] are likewise nascent but growing rapidly, including a plan to dramatically increase India's launch cadence over the next 15 months.[35]

India recently completed a successful lunar landing,[36] solidifying its position as a global space power with this remarkable accomplishment. India's footprint beyond the moon is more limited in scope, showing that it still has, quite literally, a long way to go before it can measure up to the US and China's space industries.

Japan

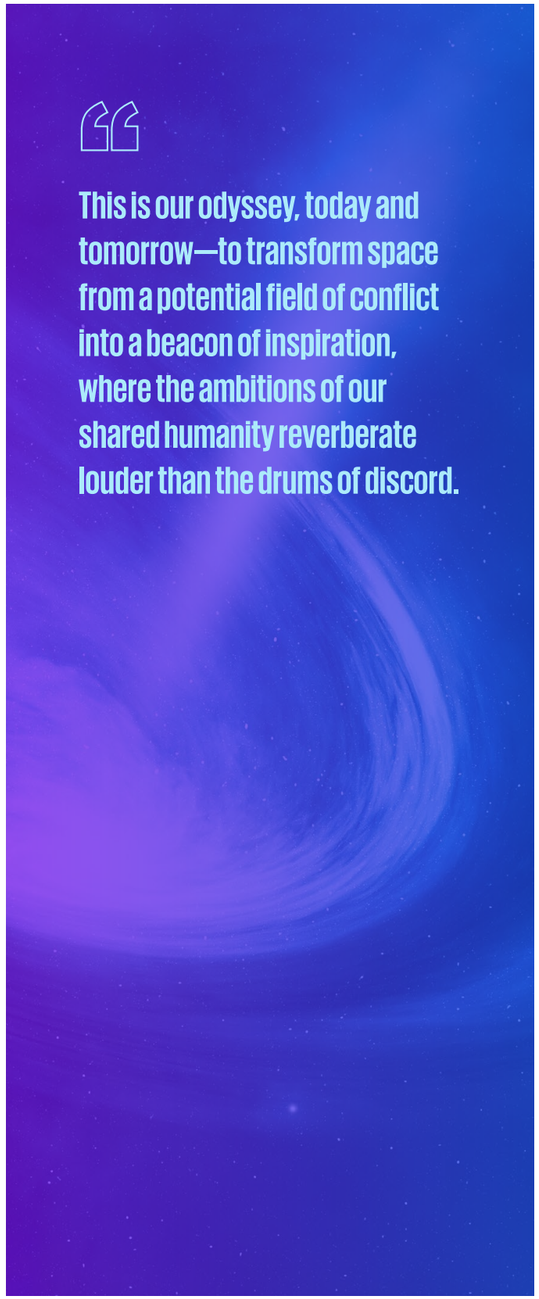
Japan has certainly earned a role on the Space Powers list, offering an impressive list of achievements, mostly on a small scale, which have built up over several years. Japan has sovereign launch capabilities and is transitioning to a new rocket[37] that achieved its first successful launch in 2024.[38]

Japan's long-term focus on space gives it a steady, if not an especially explosive or diverse, presence in space, including commercial operators[39] and a number of science missions.[40] Japan also features legacy SSA capabilities with new systems coming online to enhance its ability to track space debris and detect potential conjunctions.[41]

Japan successfully landed on the moon in 2023[42] and has launched significant science missions beyond the moon.[43] Japan doesn't offer the scale of the largest Space Powers nor the promise of Space Powers with larger populations and resources. However, Japan has successfully built one of the most independent national space programs on the planet, securing a spot as a key stakeholder in space.

Conclusion

Is the final frontier of space becoming the next stage for conflict, global supremacy versus collaboration? The advent of space technology and exploration has undeniably transformed both geopolitics and commercial domains. The US, China, Europe, Russia, India, and Japan have emerged as significant space powers, navigating this arena of competition and collaboration. Recent events, like Russia's ASAT weapon test and additional provocations, emphasize the urgent need for harmonious space policies to mitigate threats in this expanding realm. While the US leads the charge in terms of space sovereignty, other nations including China, India, and Japan are showing accelerated growth and potential. As we extend our boundaries beyond Earth's atmosphere, managing these evolving dynamics responsibly becomes indispensable. The challenge, therefore, is not just about exploring the universe, but also about how we ensure that this exploration is harnessed for the greater good. This is our odyssey, today and tomorrow—to transform space from a potential field of conflict into a beacon of inspiration, where the ambitions of our shared humanity reverberate louder than the drums of discord.



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Formulating policy pathways

Navigating geopolitical tensions in space

Jacob Hacker, Will Lewis, Brian Miske, and Grant McDonald

Abstract

The article, "Formulating policy pathways: Navigating geopolitical tensions in space," discusses the increased importance of space in geopolitical strategies due to technological advancements and the rise of the commercial space industry. The piece highlights the potential use of space for militaristic purposes, as shown by recent actions from Russia and debates between major Space Powers. Further, commercial space activities are now entwined with geopolitical interests, affecting the operations of multinational companies. The article then suggests strategic routes: updating regulations around technology exports, establishing international norms, enhancing space traffic monitoring, and fostering alliances between Space Powers. The US-Australia partnership is given as an example of how interdependence can help maintain peace and encourage responsible behavior in space.

While space was theoretically weaponized during the Cold War era, the commercial industry was not a consideration. The US conducted a nuclear test in space[1] and the Soviet Union developed space-based weaponry in the early years of the Cold War's Space Race.[2] But after the Outer Space Treaty was signed, there was a cessation of hostilities for a long period of time.

Peace has reigned in space for about 60 years, and this has enabled a global commercial space industry to blossom and develop a host of applications that benefit billions of people on Earth. But that peace can no longer be taken for granted as the Space Powers exchange escalating rhetoric about the militarization of space. This comes as the Russian invasion of Ukraine has demonstrated the value and scope of space imaging, sensing, and communications in conflict zones.

Before the recent reveal of a potential Russian space weapon with nuclear components, representatives of the US have raised concerns about Russia and China weaponizing space.[3] China has responded in kind, accusing the US of looking for cover in order to justify its own weaponization of space.[4] Russia, alternatively, has openly contemplated targeting US commercial space systems in response to its role in providing the Ukrainian military with communications and surveillance data.[5]

This isn't the only instance of terrestrial geopolitics creeping into commercial space. When Russia invaded Ukraine, it effectively seized 36 One Web satellites that had been launching from Kazakhstan. That launch facility is no longer available to commercial operators doing business in the west. Furthermore, Russia's launch components, once a prominent feature of western launch vehicles, have been phased out. Meanwhile, in Taiwan, it appears there may be a geopolitical issue brewing regarding Starlink connectivity being withheld from the island.

These considerations may continue to creep upwards in orbit as international norms in space are debated. The US-led Artemis Accords, which is nonbinding, sets forth principles for the civil exploration of space and explicitly recognizes the importance of Space Commerce.[6]

In parallel,[7] China and Russia have launched an initiative to jointly develop an International Lunar Research Station (ILRS) and have invited all nations to join. While not quite a statement of principles, the ILRS has similarly aspirational statements about the peaceful exploration and use of space for all humankind.[8]

There are currently 36 signatories to the Artemis Accords and 8 to the ILRS.[9] There is no country signed on to both, although there are western nongovernmental organizations supporting the ILRS. How these parallel affiliations will develop, and their impact on commercial space operations has yet to be seen. But it's not difficult to envision a future in space with parallel, mutually exclusive norms of operation that could complicate the provision of global space services.

Current risks

New intertwining of commercial space and geopolitical struggles will enhance risks to commercial operators and some of these risks are already coming to bear for satellite operators.

Cybersecurity and threat

Cybersecurity presents a significant challenge for satellite services, particularly concerning the threat of network hacking or unauthorized usage. Such cyber threats can compromise the integrity and reliability

> "There is a need for enhanced regulation as it has not kept pace with the exploration and exploitation of space and its resources. Better governance will ensure that increasing levels of space innovation can be achieved in a sustainable manner, as well as potentially preventing potential conflicts in space which threaten otherwise peaceful activity."
>
> Grant McDonald,
> Global Aerospace and Defense Leader, KPMG

of these satellite networks. The current geopolitical conflict involving the Russian invasion of Ukraine underscores these risks. Notably, it has highlighted the potential vulnerabilities faced by commercial satellite operators amid geopolitical crises. Early in its invasion, Russia hacked Viasat Earth stations to disrupt communications in Ukraine.[10] More recently, there have been reports that Russian services are coopting and accessing the Starlink to benefit from the large constellation's connectivity that is intended to assist Ukrainian troops.[11]

Conceptually, these issues are not new. ISIS reportedly relied on satellite connectivity during its reign of terror.[12] But the sophistication of the disruptive parties and the scale of the potential impact have, much like the current geopolitical crises facing the globe today, scaled up significantly since a decade ago.

Orbital strikes

The threat of strikes on orbital targets is, fortunately, hypothetical at this time. However, there are clear indications that at least some of the Space Powers have[13] or are[14] developing[15] satellites that can attack or disable other, on-orbit satellites.

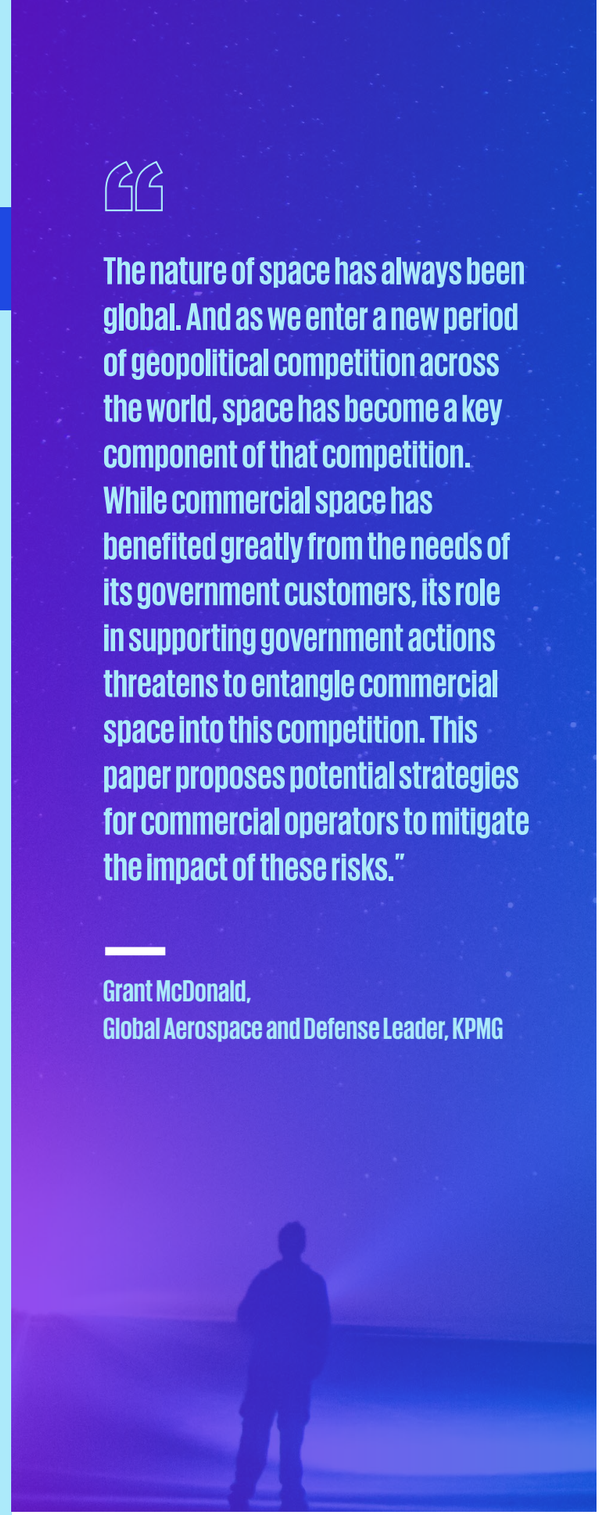
As commercial companies continue to develop new and innovative rendezvous and proximity operations, where commercial spacecraft are designed to service or monitor other in-orbit space craft, it is easy to see how these systems could trigger a miscommunication between the Space Powers because of the potentially offensive capabilities of such systems.

Obstruction and interference

National deterrence, interference, and obstruction often arise from strategic geopolitical conflicts, working as tools to inhibit rival nations from making substantial advancements in their geopolitical standing. A relevant parallel may be found in efforts to stymie nuclear programs of certain nations.[16]

To date, there are no readily obvious attempts to sabotage commercial space systems due to geopolitical concerns.[17] However, there are a host of possibilities that could arise. The history of the five successful ASAT tests and operations have demonstrated that even the destruction of a friendly satellite could lead to the destruction of other satellites or rendering parts of LEO uninhabitable for all spacecraft. Other traditional methods of sabotage, either on the ground or in space, remain theoretical harms that could arise as the geopolitical stakes rise in space.

Not all the recent developments have trended in a negative direction. In 2019, on the heels of India's ASAT test, it was unclear what direction India would go as a nascent Space Power. However, its test had a relatively modest impact on the space environment,[18] and in the aftermath of that test, India has ascended to new civil and commercial heights in space.



India’s future in space is promising with a growing commercial sector[19] and unparalleled human capital.[20] It has signed the Artemis Accords but possesses the resources to chart its own path going forward, and that path has appeared to be entirely peaceful in the wake of its ASAT test. What we can learn from India’s ASAT test is that if a country is given the opportunity to benefit from space, it will eventually take steps to preserve it.

Securing supply chains and infrastructures

Vulnerabilities in launch, communication, and sensing capabilities—Supply chain issues can create vulnerabilities in terms of successfully deploying space missions in a timely manner. Some powers, such as Europe, are still adapting their launch capabilities to a less-integrated global economy. Changes in the availability of materials or components can create difficulty in sourcing technical solutions and can raise the cost of designing and building spacecraft.[21]

While some terrestrial hardware has been compromised, communications from satellite networks tend to be secure. But existing space communications infrastructure can be targeted, as many systems have widespread Earth station networks that would be difficult to secure worldwide. This would be a space analog to what already occurs in the terrestrial network when fiber cables are sabotaged.[22]

Satellite networks are also susceptible to jamming by generating a competing signal that interferes with the satellites ability to receive communications.[23] NGSO systems that are essential for communications and imaging can be particularly susceptible to would-be jammers.[24] Interfering with satellite signals can not only disrupt communications or the transmission of images from space in conflict zones but also broadly disrupt applications that many take for granted, e.g., Global Navigation Satellite Systems (GNSS), such as global positioning system (GPS).[25]

Public and private sector reliance on space assets

Satellite and space services feature prominently in everyday life. People frequently search for directions, counting on the location data from the GPS and Galileo GNSS systems. Weather satellites are the source of the majority of our weather prediction capability and have demonstrated repeatedly that they offer significant benefits in terms of lives and property damage for the modern world.[26]

Similarly, satellite broadband connectivity is a growing segment of space, with a number of geostationary orbit and NGSO systems offering connectivity directly to millions of consumers across the world.

Each of these services is present in the daily lives of massive and growing segments of the population and offer significant public benefits. And the space systems that provide these services are vulnerable to jamming[27] and physical threats. Potential geopolitical disruptions to these services would be felt by populations far removed from conflict zones or the space operations centers of commercial operators.

To maintain momentum in commercial space, governments and companies must find ways to mitigate these disruptions. For example, enabling technical standardization through liberalized rules for space technology exchanges between aligned countries could help reduce delays and minimize cost increases. Space is global, far beyond the Space Powers, and the ability to standardize technical interfaces and equipment globally could foster a more resilient supply chain.

Another mechanism for limiting disruptions to space infrastructure is to develop stable and open communication protocols for public and private commercial stakeholders. Government intelligence agencies often collect information related to threats to commercial stakeholders, including those in space. And commercial operators are best suited to monitor the health of their systems networks. Developing standard protocols for public and private stakeholders to communicate with one another on a regular basis and in the event of a potential crisis, which is already done for possible on-orbit conjunction events,[28] could help mitigate some perpetual resiliency issues the commercial space industry may face due to continuing geopolitical disruption.

Automation and other innovations to reduce disruption

Automation could potentially help reduce the disruption of geopolitical events. Automated communication providing regular updates, for example, could ensure that critical and time-sensitive information is distributed in a timely manner. Information about potential adversarial actions or ongoing network breaches could help foster joint public-private response to future geopolitical disruptions.

Another potential mechanism to reduce the impact of earthly events on space would be to develop an international institution for managing space. Such an institution must be seen as neutral in order to obtain global buy-in. For example, the International Telecommunications Union (ITU) has been enabling the coordinated use of radio frequencies internationally by satellite systems for decades. The ITU is respected by its member states, including the parties to the Artemis Accords and the ILRS, and a similar organization for space operational norms could help achieve stability in the face of growing geopolitical unrest.

“As the boundaries of geopolitical influences and commercial aspirations extend to space, the need for a unified global approach in policymaking becomes paramount. The success from alliances and collaborations in space showcases a valuable path forward, emphasizing that joint strategic action is pivotal in navigating this rapidly evolving landscape and safeguarding commercial interests.”

Brian Miske,
National Ignition Leader, KPMG

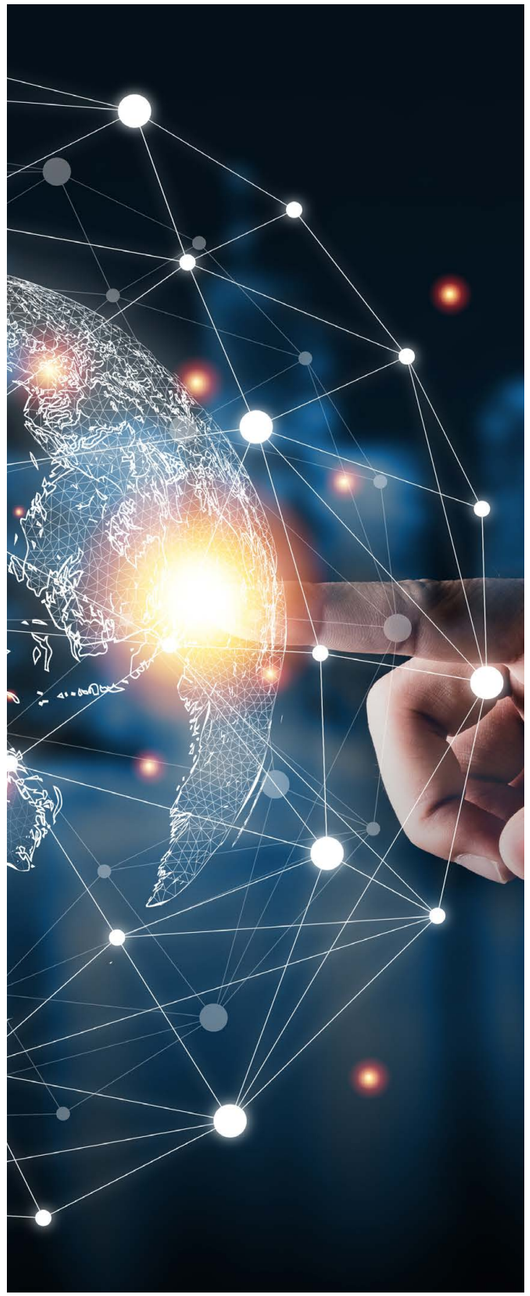
Policy pathways to mitigate risks

Update export controls and technology transfer restrictions

The US has already recognized the value of information and technology sharing as a means for effective space diplomacy. It must ensure that its export controls permit commercial operators to transfer relevant technology. A lack of flexibility in the application of International Traffic in Arms Regulations (ITAR), for example, could further limit the exchange of critical space safety technology between the US and its allies.

The US has previously recognized this principle and loosened ITAR restrictions on space technologies.[29] However, it has been a decade since these changes were made, and the US should continue to ensure that its export regulations continue to permit information and technology that will facilitate global investment in the peaceful use of space.

Many companies that establish in US allied and partner nations prioritize a US presence, with the compelling pull of capital and customer base, though are concerned about how this may limit their future customer base, ownership structure, and supply chain. International capabilities will be fundamental to the ongoing success of the US space sector, and diversified supply chains only enhance the redundancy and resilience of the US industrial base. While positive signs have come from Technology Safeguard Agreements, and expansion of the US Defense Industrial Base, better mechanisms are required to facilitate this inclusion while maintaining sovereignty.



Develop international norms of behavior and consequences for violations

Space has long required some level of peaceful collaboration among nations. Beyond the oft referenced and little applied Outer Space Treaty, the use of radio frequency in spectrum is debated internationally through the ITU. Spectrum use norms are established and generally accepted.[30] There is nothing like the ITU internationally yet, for normalizing operations and behaviors in space.

The global community should consider establishing something like the ITU that can set norms outside of the two developing Space Power poles of the US and China. In the event that this cannot be achieved, the US and China must strive to find common ground on certain norms of behavior in space. This can be accomplished through direct negotiation or either commercial or neutral government intermediaries and then encourage their various allied coalitions to adopt those norms as well.

Trade and launch sanctions may help encourage many smaller space actors to abide by international norms. Space Powers will likely operate on their own terms and in their own interests, but countries without sovereign launch capabilities may be more susceptible to international influence and pressure. If China, the US, Europe, India, and Japan jointly agree to not launch actors that engage in certain activities on-orbit, it would severely curtail the options for reliable launch services.

Increase space traffic monitoring and attribution capabilities

There are mechanisms to avoid risks as the density of deployment grows. Certain technologies will be essential for the continued safe deployment of commercial space systems, particularly in lower Earth orbit.[31] As discussed below, new radar and sensing capabilities are being used to make space safer for civil and commercial use and also to secure a commitment from other countries to the continued peaceful use of space. However, stringent export controls could pose an obstacle to this "diplomacy through technology" approach, and governments should take steps to review and update export regulations that may stymie the export of these technologies to like-minded countries.

The ability to share time-sensitive information quickly and seamlessly will also be essential for the safe management of space traffic that is managed by different nation-states. The US has laid the groundwork for sharing information regarding potential conjunction events.

As noted above, the Space Powers continue to enhance SSA capabilities while the commercial sector is starting to offer supplemental SSA services and capabilities. However, the US is leading a diplomatic effort to make its SSA data available to countries with low to moderate footprints in space as a means toward building norms around sharing SSA data and taking collaborative efforts to avoid collisions between space objects. These sharing efforts will both enhance the quality of SSA[32] and help build the foundation for establishing some operational norms outside of the typical terrestrial alliances that shape geopolitics on Earth. They may, however, alienate China and Russia if the international "norm" for SSA is perceived to be US led.

Foster interdependence through alliances

The US relationship with Australia is an example of how the Space Powers can encourage other space stakeholders to operate according to international norms of responsible behavior. The US and Australia have long had a collaborative relationship, and that extends into space. As a result of this relationship, both the US and Australia have benefited while creating a unified front on space policy.

The Australian relationship is unique, but the underlying philosophy of operating in a collaborative manner in terms of space capabilities as a best practice can be replicated globally.

The US and Australia entered into an agreement to allow US rockets to launch from Australia.[33] Such a move allows for the export of typically controlled technology to facilitate Australian growth in space as well as new commercial opportunities for US launch vendors. On the flip side of this relationship, the US is establishing a deep space SSA network to monitor Cislunar space.[34] Australia is one of the countries that will house one of the three deep space radars that will monitor this area of space. This capability will be far more advantageous to the US than Australia in the short term, but it gives Australia incentive to responsibly operate in space.[35]

Conclusion

The ongoing tension between major Space Powers has brought into focus the geopolitical influences on commercial space operations and the potential threat of militarization of space. In this evolving landscape, the article suggests strategic responses such as updating controls on technology exports, establishing international norms of behavior, boosting space traffic monitoring, and fostering alliances between Space Powers. The unique yet replicable alliance between the US and Australia, for example, underscores the value of codependent collaborations in space. To navigate the new space landscape and safeguard commercial interests, proactive policymaking through a united, global approach becomes more essential than ever.

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Shaping global access to space

Leveraging stakeholder interests for collective gain

Jacob Hacker, Will Lewis, Brian Miske, and Grant McDonald

Abstract

The article, "Shaping global access to space: Leveraging stakeholder interests for collective gain," elaborates on the compelling possibilities provided by the burgeoning space economy. It emphasizes the necessity for peaceful exploration, and makes the case that conventional terrestrial warfare tactics could have cascading destructive effects when implemented in space. The piece stresses the role of public-private partnerships in influencing global interest toward preserving space for civil and commercial use, leveraging diplomatic and commercial influence to maintain peace in space. Ultimately, as the prospect of geopolitical conflict extending into space continues to increase, the responsibility falls on Space Powers, commercial enterprises, and the global community to foster a commitment to peaceful use of space.

The opportunity of the new space economy

The new space economy offers untold possibilities to expand current space economic verticals and to develop new services that start to orient the economy from terrestrial interest to those on-orbit.[1] But the opportunity and possibility can only be achieved if the long-lasting peace in space continues.

Promoting the peaceful exploration of space

To promote peace and cooperation in space, it is essential to understand that traditional strategies used in terrestrial conflicts may not be effective in this unique domain. The destruction of even a single spacecraft, as demonstrated by ASAT tests, can have far-reaching consequences, negatively impacting numerous other satellites. This chain reaction of destroying satellites means that any nation with space capabilities risks significant harm to its own assets if it initiates an orbital attack. Retaliation in space is not a simple matter and can lead to immediate or future self-destruction. These realities must be considered when assessing the risks of any offensive action in space.

There may be instances where certain space-capable nations feel marginalized or compelled to pursue attacks in order to address geopolitical imbalances, even at the potential cost of chaos on adversaries. In such cases, commercial players have a crucial role to play in reinforcing diplomatic

efforts to prevent such scenarios. This underscores the immense importance of fostering a collaborative and peaceful environment in space. To achieve this, governments and commercial space operators must provide incentives for global interest in preserving space for civil and commercial purposes. Countries without a significant space presence need to understand and value stability and safety in space. By doing so, we can promote global access and shared interests in space.

> **Commercial players have a crucial role to play in reinforcing diplomatic efforts to prevent such scenarios, underpinning the paramount importance of fostering a collaborative and peaceful environment in space."**

Promoting global access and shared interests in space

The unique dynamics of space conflicts suggest that repercussions are not straightforward, with the potential for immediate or future self-harm. This factor must be delicately considered in evaluating the risk of any potential actions within and across commercial space. Yet, should space-capable nations feel disadvantaged or driven to engage in actions to address geopolitical inequalities, the resulting disruption for their rivals may exceed their own challenges. Therefore, it's crucial that commercial entities play a significant role in supporting diplomatic efforts to avoid these scenarios; this highlights the need for promoting peace and cooperation in space.

An obvious risk is Russia, which may not be willing to enter agreements that include nations that oppose its geopolitical objectives. However, their ILRS and terrestrial trade partners could conceivably constrain Russian actions in space if given the proper incentive.

China is already motivated to preserve its huge stake in space, giving it incentive to keep Russia from causing irreparable harm in space.[2] However, it might take a broader coalition of Russia's Global South trading partners and the larger ILRS coalition to dissuade an increasingly belligerent Russian presence in space.

When we say everyone needs a space strategy, it begins here. Numerous countries stand to gain significantly from space services, which are often underestimated by the established Space Powers. These services include civil Earth observation and scientific data, broadband connectivity for areas with limited internet access, and involvement in international space missions. Such opportunities could broaden the list of countries that profit from the peaceful utilization of space. However, the costs of these services often exceed the budgets of nations with restrictive access to space. Space Powers, with the exception of Russia, in tandem with the commercial industry, could create packages of these crucial services. These could be offered freely to nations willing to leverage their research or trade relationships to ensure the preservation of space.

The role of public-private partnerships

Collaboration between government and commercial enterprise is essential. Commercial operators can communicate and advocate to governments and can often do so in a way that is distinct and possibly more lucrative for national interests than geopolitical diplomacy. Commercial operators already engage with national governments across the globe to open new markets for sales and new locations for infrastructure. There is an opportunity in those communications to underline and emphasize the importance of peace in space to the local government's national space aspirations, whatever they may be.

All aspects of space now include some blend of commercial and public investment and the effort to maintain harmony must be coordinated between both commercial and public stakeholders. Partnerships must reflect that shared interest and responsibility.

Governments could consider the implementation policies that foster commercial space development, thereby enhancing its significance to the global community encompassing more than

> **There is growing competition in both commercial and military sectors of outer space. Striking the right balance between competition and collaboration is essential for achieving the highest level of innovation and scientific advancements in space. The private sector is increasingly competitive in meeting economic objectives in space, and many countries are striving to assert themselves as Space Powers and achieve military dominance in space. However, by continuing to focus on international alliances and promoting cooperation among governments and corporations, collaboration in all areas of space can be achieved."**
>
> **Grant McDonald,**
> **Global Aerospace and Defense Leader, KPMG**

just the Space Powers and their allies. Increasingly, the responsibility also falls on commercial space enterprises to inspire governments to conserve space for peaceful commerce and scientific exploration. This responsibility may extend to backing diplomatic space endeavors of governments, as well as working to soften the impacts in space due to aggressive governmental actions. Commercial space is well positioned to work together, both domestically and internationally, to help build trust with global stakeholders. Commercial operators can facilitate lines of communication between Space Powers and other countries in the event of emergencies. As drivers of innovation and valuable space-based services, commercial operators can also help peace-minded nations to develop incentives and carrots to facilitate international cooperation for the preservation of space, particularly lower Earth orbit.

Government call to action

The Space Powers, other than Russia, must work to incentivize the global community to recognize the value of the collaborative and shared use of space. The US diplomatic efforts that are based on space situational awareness data provide a blueprint for success. There are other space applications, earth observation, and broadband connectivity, which might encourage other nations with less developed space programs to support global norms for space operations. The Space Powers have access to these services in spades—it is now time to use them to preserve their existence.

A multilateral standards body is also critical. The ITU offers a blueprint, but it seems unlikely that it has the resources or member support to expand into a space-oriented approach.[3] It's hard to envision the UN creating a new organization in the current geopolitical climate. A Chinese or US-led body is unlikely to succeed, nor would Japan or Europe be viewed as neutral parties.

A number of other industries show that member-led and industry-led organizations can be very successful in setting norms for industries to operate. This could be an option for the space sector, and organizations such as CONFERS are already demonstrating their ability to lead here.

> "Inclusive space strategies can provide nations significant benefits through Earth observation, broadband connectivity, and international space missions, making it necessary to develop affordable service packages to ensure the universal and peaceful utilization of space."
>
> Brian Miske, National Ignition Leader, KPMG

Other industry examples include:

- The international SWIFT payment network, which is governed by 25 international banking executives
- Energy market operators, such as the Australian Energy Market Operator, which oversees generation, transmission, distribution, and financial markets of energy
- Stock exchanges, such as the NYSE, were originally formed by stockbrokers, and many were still member owned until recently. Some exchanges, such as the Bombay Stock Exchange, remain member owned.

India, however, as a member of both BRICS and the Artemis Accords, could represent a sufficiently independent party to lead a multilateral effort and rally the smaller global space stakeholders to take interest in the process. India alone has the blend of neutrality and space credentials to potentially engage the various parties that can't or won't engage directly and work towards building a forum for developing an international standard for operations in space.

Finally, the Space Powers must take steps to pressure their allies who might threaten the collective use of space with force. They are, collectively, the richest countries on Earth,[4] which gives them considerable leverage, collectively, to encourage the global community behind preserving space.

Commercial call to action

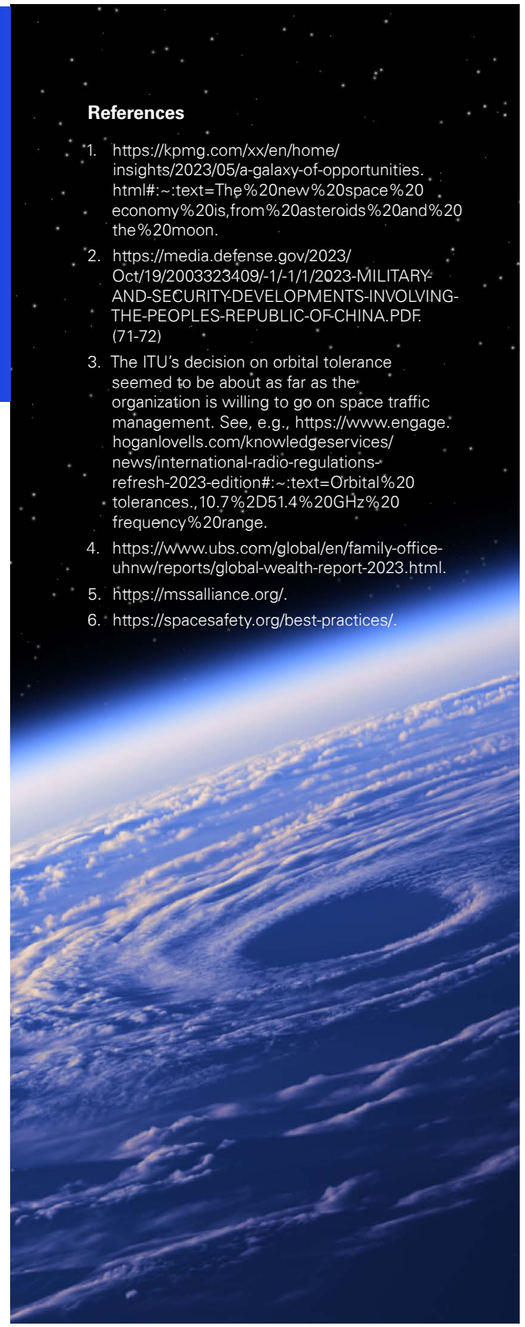
The commercial industry also has an important role to play. Many of the valuable space services discussed above come from commercial or partially commercial sources. Commercial space operators engage governments and commercial stakeholders across the world. It is incumbent on the commercial sector to emphasize the need for peace in space.

Commercial actors should also collaborate, as they often do for spectrum[5] or orbital debris,[6] on this message globally. For the commercial space sector, the prospect of geopolitical conflict rising to space is unfathomable. It is critical, then, that commercial stakeholders start incorporating the need for peace in space into the advocacy and lobbying.

Conclusion

The Space Powers have generally facilitated the unprecedented development of the modern space sector by maintaining harmony in orbit. However, as the geopolitical situation on Earth deteriorates, the prospect of conflict in space has increased.

There are ways to foster a renewed global commitment to the peaceful use of space through proven diplomatic and economic methods. We have proposed steps that both the public and private sectors can take to preserve their access to space and our ability to benefit from their services.



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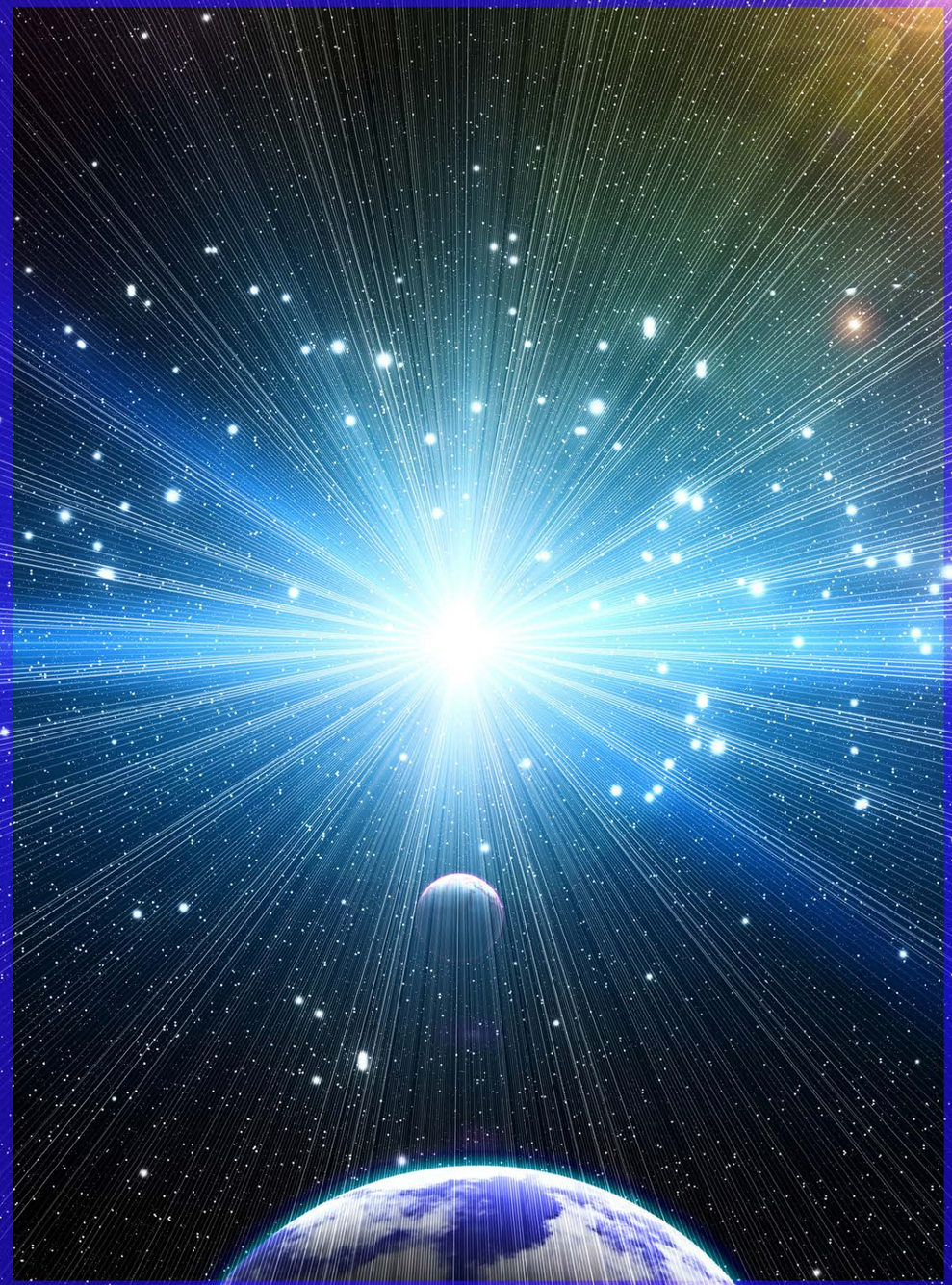


The cyber-physical future

Neuromancer may be more prophecy than novel

Brian Miske and Zaheer Ali

The year is 2024, and the boundary between the digital and physical worlds has blurred beyond recognition. William Gibson's seminal 1984 novel, *Neuromancer*, envisioned a future where cyberspace and the physical realm are intertwined in ways that were once purely the stuff of science fiction. As we stand on the precipice of this new reality, it becomes increasingly clear that Gibson's vision is not merely a speculative narrative but a prescient prophecy. This cyber-physical future, characterized by the seamless integration of digital and physical experiences, has already arrived, though many of us have yet to fully grasp its implications.

The cyber-physical convergence: Gibson's vision realized

In *Neuromancer*, Gibson introduced the concept of cyberspace, a virtual reality landscape navigated by console cowboys and hackers. Today, the notion of a distinct, immersive digital realm is not just a fictional construct but a lived experience. Technologies such as artificial intelligence (AI), virtual reality (VR), and the Internet of Things (IoT) have paved the way for a world where the digital and physical coexist in a symbiotic relationship.

Organizations, particularly in the public, private, and academic sectors, are at the forefront of this transformation. The concept of digital twins—virtual replicas of physical entities used for simulation and analysis—has evolved into a more profound integration. No longer merely a tool for improving efficiencies or predicting outcomes, these digital counterparts are part of a broader cyber-physical ecosystem where actions in the digital domain have immediate and tangible effects in the physical world.

For instance, in the manufacturing industry, IoT-enabled sensors and AI-driven analytics create a feedback loop that continuously optimizes production processes. Smart cities leverage interconnected systems to manage everything from traffic flow to energy consumption in real time. In healthcare, digital twins of patients allow for personalized treatment plans and proactive health management. These examples illustrate that the cyber-physical convergence envisioned by Gibson is not a distant future but a current reality.

> “In our cyber-physical world, data is essential, connecting all systems and driving critical decisions in both military and financial sectors.”
>
> Brian Miske
> National Ignition Leader, KPMG

Organizations at the nexus of cyber-physical integration

While the cyber-physical future impacts individuals, its effects are more pronounced within organizations. The scale and complexity of integrating digital and physical systems are such that institutions are better equipped to navigate and capitalize on these changes. The corporate world, academia, and public sector entities are not just participants but drivers of this evolution.

Corporations, for example, are leveraging data fusion—
a strategic process of combining diverse data sets from internal, external, terrestrial, and space-based sources—to enhance decision-making and operational efficiency. This integrative approach transforms disparate data into actionable intelligence, enabling organizations to operate with unprecedented agility and insight. Companies like those in digital engineering and aerospace systems are pioneering the use of digital twinning and data fusion to create dynamic models that respond to real-world conditions in real time.

Academia, too, is embracing the cyber-physical paradigm. Universities are not only integrating advanced technologies into their research and teaching methodologies but also collaborating with industry and government to drive innovation. These partnerships are crucial in developing the frameworks and solutions needed to manage and harness the power of cyber-physical systems.

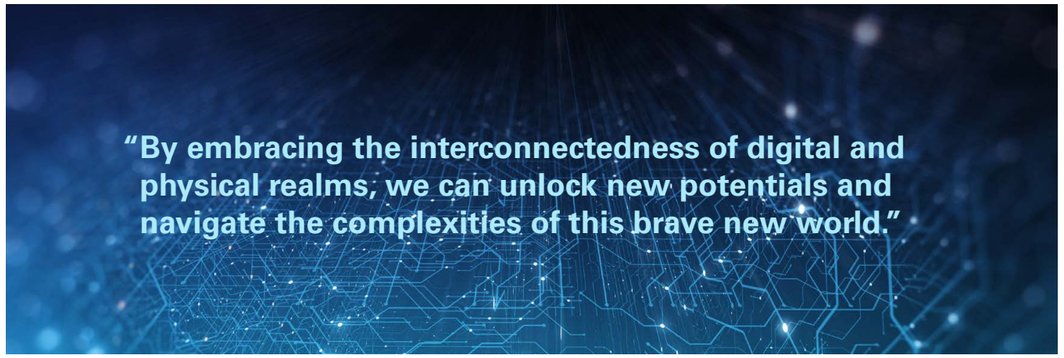
Public sector organizations are increasingly reliant on cyber-physical systems for infrastructure management, public safety, and service delivery. Smart grids, autonomous transportation networks, and digital public services exemplify how governments are utilizing technology to enhance the quality of life and operational efficiency.

Beyond digital twins: Embracing the blended reality

The term “digital twin” suggests a duality—a separation between the digital and the physical. However, this distinction is becoming increasingly irrelevant. We are moving towards a blended reality where the digital and physical are not parallel worlds but interwoven dimensions of the same existence.

In this cyber-physical reality, data is not just a commodity to be leveraged; it is the very fabric of existence. Organizations must adopt a mindset that goes beyond the concept of digital twins and recognizes the fundamental interconnectedness of all systems. The cyber-physical environment is characterized by multidirectional data streams where the digital influences the physical and vice versa.

This reality is evident in the military and enterprise sectors, where data-driven decision-making and real-time information processing are critical. For instance, the integration of unmanned aerial systems into national airspaces requires sophisticated cyber-physical coordination to ensure safety and efficiency. Similarly, in finance, AI-driven trading systems operate within a cyber-physical framework that responds instantaneously to market conditions.



The implications of this integrated reality are profound. Organizations must develop strategies that encompass both cyber and physical dimensions, treating them as a unified whole. This requires a holistic approach to data management, cybersecurity, and operational design. It also necessitates a cultural shift towards viewing data as an essential element of existence, akin to air or water.

The path forward: Embracing the cyber-physical reality

To thrive in this cyber-physical future, organizations must embrace several key principles:

Holistic integration: Develop strategies that integrate digital and physical systems seamlessly, recognizing their interdependence.

Data-centric operations: Treat data as a critical resource, essential for survival and growth in a blended reality.

Adaptive systems: Invest in technologies and processes that enable real-time responsiveness and adaptability.

Collaborative ecosystems: Foster partnerships across sectors to leverage collective expertise and drive innovation.

In conclusion, the world envisioned by William Gibson in *Neuromancer* is not a distant dystopia but a burgeoning reality. The cyber-physical future is here, and organizations are at the forefront of this transformation. By embracing the interconnectedness of digital and physical realms, we can unlock new potentials and navigate the complexities of this brave new world. As we move forward, it is essential to recognize that our existence now spans both cyberspace and the physical world, and success will depend on our ability to thrive in this integrated reality.

This article serves as the precursor to a series that will delve into the transformative effects of data fusion on our rapidly developing cyber-physical realm. As our digital and physical worlds increasingly intertwine, data fusion emerges as a powerful tool able to harness vast amounts of internal, external, terrestrial, and space-based data to generate profound insights—ultimately bridging the gap between digital innovation and tangible experiences. In the upcoming series, we will explore specific use cases, strategic implementations, and the extensive effects of this integration across various industry sectors. As we transition into a hybrid existence where data becomes as essential as air or water, our understanding and effective application of data fusion will shape our ability to thrive in this evolving reality. This paradigm shift is the focus of our forthcoming exploration, aimed at unveiling the transformative potential of embracing data fusion in this cyber-physical convergence.

Data fusion

The future of commercialization at the enterprise level

Brian Miske and Zaheer Ali

Abstract

This article delves into the concept of data fusion, exploring how merging varied data categories—both internal and external, terrestrial, and space-based—can revolutionize corporate performance and decision-making, setting the stage for the ultimate commercialization of data at the enterprise level.

How data fusion from space-based sources enhances strategic thinking and decision-making for business leaders

Data fusion is not only a technical concept but also an approach to strategic thinking that bridges the gap between various data sources, be it terrestrial or space-based, to create a holistic, unified decision-making platform. When thinking about this, one must imagine the data as shattered glass from many vases out of which many different mosaics could be arranged. How one arranges those pieces, which to include, which to leave out, and where to put them is what data fusion is all about. It combines data science, data engineering, and the various methods of AI, but perhaps most importantly, the human ability to see patterns that no other entity, so far, can. Data fusion must be carried out in the way that Professor Dima Budker teaches students to do physics: "If you design a beautiful experiment, the universe will reveal itself to you."

Data fusion

The act of bringing internal, external, terrestrial, and space-sourced information leveraging multiple data sets of any degree of difference or relation to understand phenomena, in particular those phenomena that seem to have little or no connection to much of the data fused, resulting in often surprising insight and knowledge.

For the C-suite and executives, embracing data fusion principles is imperative, not just to stay afloat but to lead in an increasingly tech-dominated business landscape. The prowess of data fusion lies in its potential to magnify operational visibility, enhance adaptability, and amplify decision-making accuracy. In essence, it provides a fulcrum for corporate strategies, allowing for the generation of powerful insights that contribute to the growth and sustainability of an enterprise. When adequately harnessed, data fusion aids in establishing a robust, data-informed strategy and execution framework that ensures performance optimization and assures competitiveness. Consequently, integrating different data sets via data fusion is non-negotiable for modern leaders seeking innovative solutions to complex business challenges and unearthing fresh opportunities for advancement in the commercial space arena.

Data fusion: From the ground to the sky and beyond

There has often been a refrain: "Think outside the box." But we propose to you: "Think outside the atmosphere." As we progress into the era of data-driven strategies, it's important to recognize that the box, the confines within which businesses often draw data, extend far beyond traditional boundaries—both metaphorically and literally. Internal organizational data and external data are valuable assets, but in the quest to inspire innovation, we should extend our data sources beyond terrestrial confines to space-based data. Liberation from the stereotypical data sources can enhance business operations in ways that are as vast and diverse as space itself.

Internally generated data is the lifeblood of an organization. It provides insights on historical performance, current situation, and future projection. Likewise, external data—market trends, customer behavior, competitor analysis—serves as crucial context within which businesses operate. By intelligently merging these sources through data fusion, businesses can capture a more cohesive picture of their business landscape, allowing for informed, strategic decisions. However, as technology is advancing, so should our data sourcing. The uncharted territories of space provide exceptional novel data points—from satellite imagery to meteorological data, communication networks data, and even celestial body data—which represent a new dimension of data, one that, when integrated into the scheme of things, can offer unparalleled, innovative insights and capabilities.

In essence, terrestrial data sources are the roots keeping the organization grounded, but space-based data is the water that enables growth in directions we didn't perceive possible before. By harnessing the power of space-based data and coupling it with data fusion, businesses have the potential to reshape their operational efficiencies, enhance strategic decision-making, and ultimately drive revolutionary innovations in their field. It urges businesses to move from a provincial view to a planetary view, thus creating an integrative ecosystem of data resources, shedding new light on business operations.

Why executives need to adopt a new data perspective with data fusion

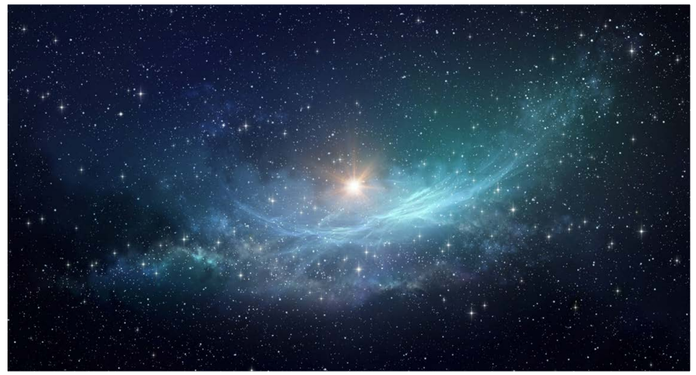
Data, in its diverse facets, offers profound potential. However, its full utility remains untapped when viewed through a conventional lens. The centered approach of focusing on a single or limited set of data sources constrains an executive's vision, making it myopic in a dynamic and complex business environment. The requirement is for an appreciative shift towards a broader, more inclusive data outlook. This new perspective, facilitated by data fusion, unhinges the restrictive data narrative, promoting a versatile and integrated understanding of different data sets, be it internal, external, terrestrial, or even space-based.

Data fusion, with its integrative approach, serves as a vital tool informing strategy and guiding execution. It is a catalyst for a revolutionary shift from a tunnel vision of data-driven decision-making, to one which appreciates the broad mosaic of insights that emerge when divergent data sets are fused effectively. This shift equips executives to decipher complex interplays across multiple business facets, thereby enabling the crafting of robust, comprehensive strategies and fostering an operational agility necessary for a competitive advantage in today's tech-dominant landscape. Hence, it is crucial for executives to not only incorporate, but also embrace this transformation in their data perspective, appreciating the increased value, depth, and breadth of insights brought on by data fusion's versatile, integrated approach.

> **By transcending terrestrial limits and embracing the vast expanse of space-based data through data fusion, we not only broaden our horizons but fundamentally transform our approach to innovation, decision-making, and growth—think not just outside the box, but beyond the atmosphere.**
>
> **Brian Miske**
> **National Ignition Leader, KPMG**

Conclusion

In this age of digital evolution, the principles of data fusion and commercial space strategy are quickly becoming essential to strategic planning for businesses, much like the arrival of the internet did in 1996. Commercial space has morphed from a clinical aerospace and defense industry vertical acting now as a cross-cutting foundation influencing all organizational layers. Embracing this shift has become non-negotiable for staying relevant and competitive. Businesses leveraging space-based data through data fusion can unlock unimagined potential, bolster efficiency, enhance adaptability, and set on a trajectory of unprecedented growth. Our next article, "Envisioning the effects and applications of data fusion," will break down the magnitude of opportunities that foreseeably lie within this exciting and transformative junction.



Key considerations for the C-suite

CIOs

Chief Information Officers

- How can we integrate space-based data sources with our existing data infrastructure to enhance data fusion capabilities?
- What technologies and platforms are available to ensure the seamless integration and analysis of diverse data sets, including space-based and terrestrial data?
- How can data security and privacy be maintained when incorporating external data sources, especially space-based data, into our data fusion processes?
- In what ways can we leverage data fusion to improve our information technology infrastructure's efficiency and scalability as we incorporate more diverse data sources?
- What metrics or key performance indicators should we establish to measure the impact of data fusion on our organization's performance and decision-making processes?

CTOs

Chief Technology Officers

- What emerging technologies can we adopt to enhance our capabilities in data fusion, particularly with incorporating space-based data?
- How can we ensure our technology stack is adaptable and scalable enough to handle the increased complexity and volume of data from data fusion initiatives?
- What partnerships or collaborations could we explore to advance our data fusion capabilities, especially in the realm of space-based data?
- How can we foster a culture of innovation within our tech teams to encourage the exploration and implementation of data fusion technologies?
- What challenges do we foresee in integrating traditional terrestrial data with space-based data, and how can we proactively address these?

CDOs

Chief Data Officers

- How can we effectively manage and govern the diverse data sets required for data fusion, especially with the inclusion of space-based data?
- What strategies can we implement to ensure the quality and integrity of fused data from multiple and diverse sources?
- How can data fusion drive more informed decision-making and strategic planning within our organization?
- What are the potential use cases and opportunities for our organization by integrating space-based data into our data fusion efforts?
- How can we foster collaboration across departments to ensure the successful implementation and utilization of data fusion insights?

CAIOs

Chief AI Officers

- How can AI and machine learning (ML) technologies be applied to enhance data fusion processes, particularly with space-based data?
- What are the challenges in applying AI/ML to fused data from diverse sources, and how can these be overcome?
- How can we leverage AI to extract actionable insights from fused data sets to drive business value?
- What ethical considerations should we take into account when using AI for data fusion, especially when involving space-based data?
- How can AI and data fusion together accelerate innovation and product development within our organization?

COOs

Chief Operating Officers

- How can data fusion, particularly with the inclusion of space-based data, optimize operational efficiencies across our organization?
- What operational challenges might arise from integrating space-based data into our decision-making processes, and how can these be addressed?
- How can we align our operational strategies with insights gained from data fusion to enhance competitiveness and market responsiveness?
- What infrastructural investments are needed to support the operational use of fused data, including space-based inputs?
- How can we ensure cross-departmental collaboration and alignment in implementing and benefiting from data fusion initiatives?

Envisioning the effects and applications of data fusion

Brian Miske and Zaheer Ali

Abstract

This article serves as a catalyst, "shock and awe" to business leaders into recognizing the vital need for revolutionizing their strategic planning. It underscores the importance of integrating a comprehensive space strategy, underpinned by the principles of data fusion. We should stress how commercial space has undergone a paradigm shift from being an isolated vertical to becoming a key foundation that penetrates all layers of an organization in today's rapid digital evolution. It frames the understanding, and adopting this cross-cutting influence of space is non-negotiable for businesses that aim to stay relevant, innovative, and competitive. By harnessing space-based data and leveraging data fusion principles, organizations can unlock unimagined potentials, enhance efficiency, boost adaptability, and witness unprecedented growth trajectories. Ignoring this evolution is not an option (correlation to the internet in 1996).

In today's fast-evolving digital landscape, the strategic integration of data fusion and space-based insights is not only a competitive advantage but also a critical necessity. This article explores the transformative power of data fusion, emphasizing the need for business leaders to adopt a comprehensive space strategy to stay ahead in the increasingly competitive market. We delve into the concept of order effects in data fusion, explore potential use cases, and highlight how understanding these effects can enhance predictive capabilities and foster proactive, innovative business strategies.

Data fusion

The act of bringing internal, external, terrestrial, and space-sourced information leveraging multiple data sets of any degree of difference or relation to understand phenomena, in particular those phenomena that seem to have little or no connection to much of the data fused, resulting in often surprising insight and knowledge.

The paradigm shift: Space as a foundational component

The commercial space industry has transcended its traditional boundaries, evolving from a niche vertical into a critical foundation that impacts all facets of modern organizations. This shift mirrors the transformative impact of the internet in the 1990s, which revolutionized business operations and communication. Today, space-based data, when integrated with terrestrial and internal datasets through data fusion, provides unprecedented insights that drive strategic decision-making across all levels of an organization.

Understanding order effects in data fusion

Data fusion involves the integration of diverse data sources to generate comprehensive and actionable insights. The concept of order effects refers to the cascading impact that fused data can have across various organizational functions. By combining data sets from different origins—internal, external, terrestrial, and space-based—businesses can unlock insights that were previously hidden in silos.

1

First-order effects: Enhanced data accuracy

By integrating multiple data sources, organizations can improve the accuracy and reliability of their data sets. For example, combining satellite imagery with terrestrial data can enhance geographic information systems (GIS), leading to more precise mapping and better resource management.

2

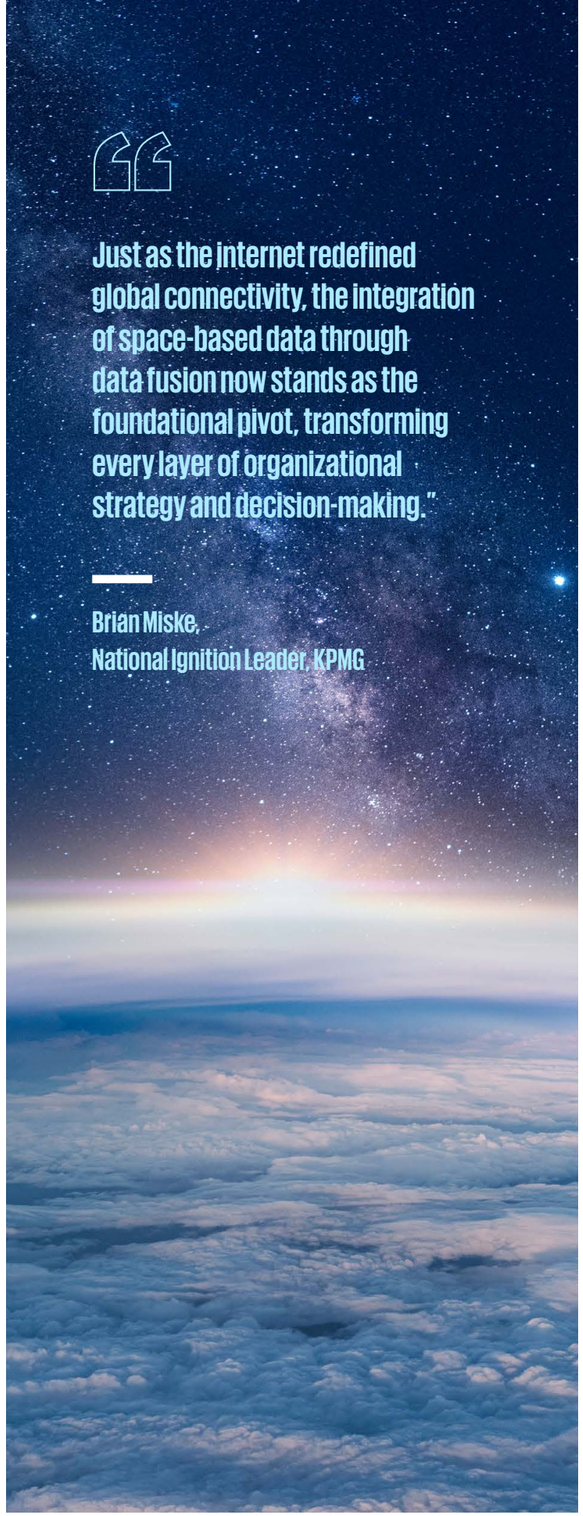
Second-order effects: Improved decision-making

With more accurate data, decision-making processes become more informed and strategic. For instance, in the agricultural sector, fusing weather data from satellites with ground-level crop data can optimize planting schedules and improve yield predictions.

3

Third-order effects: Strategic innovation

The most profound impact of data fusion is its ability to drive innovation. By leveraging diverse data sources, organizations can identify new opportunities and develop innovative solutions that were previously unimaginable. For example, in healthcare, integrating patient data with environmental and genetic information can lead to personalized treatment plans and more effective disease management.



Potential use cases of data fusion

For those at C-level positions, data fusion presents comprehensive benefits in decision-making, strategic planning, and competitive positioning. Given the increasing importance of data-driven intelligence, data fusion offers a profound understanding of business operations—revealing hidden patterns, forecasting market trends, and enabling more accurate risk assessments. This means leaders in the C-suite can make swift, informed decisions in response to changing scenarios. Chief financial officers, for example, can attain a deep understanding of fiscal dynamics, refine budget forecasts, and optimize resource allocation. For chief marketing officers, consumer behavior insights gained through data fusion could be invaluable in devising effective marketing strategies. Similarly, chief human resources officers, might use it for strategic workforce planning and effective talent management. Ultimately, data fusion provides C-level executives the strategic tools to drive transformative change, fostering corporate resilience and growth.

Data fusion can revolutionize various business functions by providing holistic insights that drive efficiency, adaptability, and growth. Here are some potential use cases across different organizational levels:

1

Front-office operations: Customer insights and personalization

Sales and marketing teams can use data fusion to gain deeper insights into customer behaviors and preferences. By integrating CRM data with social media analytics and space-based demographic data, businesses can create highly personalized marketing campaigns that resonate with their target audience.

2

Middle-office operations: Process optimization

Data fusion can streamline middle-office functions by enhancing process efficiency and reducing operational risks. For instance, in supply chain management, combining satellite tracking data with logistics information can optimize route planning, reduce delivery times, and minimize costs.

3

Back-office operations: Risk management and compliance

Back-office functions such as risk management and compliance can benefit significantly from data fusion. By integrating financial data with external economic indicators and regulatory information, organizations can better anticipate market fluctuations, ensure compliance, and mitigate risks.

Boosting predictive capabilities with data fusion

One of the most significant advantages of data fusion is its ability to enhance predictive capabilities. By analyzing fused data sets, organizations can develop more accurate predictive models that inform proactive decision-making and strategy development. This capability is crucial in a rapidly changing business environment where anticipating future trends can provide a significant competitive edge.

1

Predictive maintenance in manufacturing

In the manufacturing sector, combining machine sensor data with environmental data can predict equipment failures before they occur, reducing downtime and maintenance costs.

2

Market trend analysis in retail

Retailers can fuse sales data with social media trends and economic indicators to predict consumer behavior and adjust inventory levels accordingly, optimizing sales and reducing waste.

3

Financial forecasting in banking

Banks can enhance their financial forecasting models by integrating internal financial data with external market data and geopolitical information, improving investment strategies and risk management.

Embracing the future: A call to action

The integration of space-based data and data fusion principles into business strategy is no longer optional; it is a fundamental requirement for staying competitive in today's tech-dominated landscape. Business leaders must recognize the transformative potential of these technologies and proactively incorporate them into their strategic planning.

1

Develop a comprehensive space strategy

Organizations must develop a robust space strategy that leverages data fusion to enhance decision-making, drive innovation, and improve operational efficiency. This strategy should encompass all business functions and prioritize the integration of diverse data sources.

2

Invest in advanced data analytics and AI

To fully harness the power of data fusion, businesses need to invest in advanced data analytics and AI technologies. These tools can process vast amounts of data, identify patterns, and generate actionable insights that inform strategic decisions.

3

Foster a culture of innovation

Embracing data fusion requires a cultural shift towards innovation and continuous improvement. Organizations must encourage their teams to explore new data sources, experiment with innovative solutions, and adopt a forward-thinking mindset.

Conclusion

In conclusion, the future of business lies in the strategic integration of data fusion and space-based insights. This transformative approach not only enhances efficiency and adaptability but also unlocks unprecedented growth opportunities. By embracing these principles, organizations can stay ahead of the curve, drive innovation, and thrive in the rapidly evolving digital landscape. Ignoring this evolution is not an option—business leaders must act now to harness the full potential of data fusion and secure their place in the future of business.

By leveraging the power of data fusion and space-based insights, organizations can revolutionize their strategic planning, enhance predictive capabilities, and foster proactive, innovative business strategies. The time to act is now—embrace the future of data fusion and transform your business for success in the digital age.

Key considerations for the C-suite

CIOs

Chief Information Officers

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- What technologies and platforms are available to ensure the seamless integration and analysis of diverse data sets, including space-based and terrestrial data?
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Disrupt or be disrupted

The imperative of a space strategy rooted in data fusion principles

Brian Miske and Zaheer Ali

Abstract

This article sends a wake-up call to business leaders, stressing upon the absolute necessity to infuse their strategic planning with a space strategy, leveraging data fusion principles. It emphasizes how space has evolved from being a mere vertical to a core component that intersects all facets of a modern, agile organization. Discuss the escalating applications of space-based data fusion and present real-life use cases that extend to front-, middle-, and back-office functions. Make a powerful statement on the transformation of space from a strictly vertical role to a broad-spectrum influence that intersects and enhances all business operations. Take a bold stand on why the incorporation of a robust space strategy, anchored in data fusion principles, is no longer a corporate luxury but an urgent survival need in today's competitive, tech-dominated business landscape.

How data fusion helps different business functions with examples

In today's fast-paced digital world dominated by technology, the ability to disrupt or be disrupted has become a decisive factor for firms aiming at survival and growth. Among the leading-edge tools in this context is data fusion, which integrates varying data sets—including those sourced from space—to provide holistic, insightful information to catalyze business strategy formulation. Data fusion has transformed from being an optional add-on to becoming a powerful game-changer that drives business operations across functions, including front-, middle-, and back-office operations.

Data fusion

The act of bringing internal, external, terrestrial, and space-sourced information leveraging multiple data sets of any degree of difference or relation to understand phenomena, in particular those phenomena that seem to have little or no connection to much of the data fused, resulting in often surprising insight and knowledge.

Data fusion principles connect the dots between varied data types, facilitating a comprehensive understanding of the business ecosystem that extends across all operational levels. This is different from digital twinning, which is an end-to-end digital representation of a business unit or enterprise that can be used for sensitivity analysis and other simulations. For example, in the front office role, sales and marketing teams can utilize real-time, synthesized data to understand nuanced customer behaviors and preferences, enhance customer relationship management, and shape personalized marketing strategies. Simultaneously in the middle- and back-office functions, such extensive data insights can guide process optimization, risk management, cycles of innovation, and cost savings, thereby directly influencing the organization's bottom line and competitive positioning.

Embracing a space strategy, in particular in space data, underpinned by robust data fusion principles, has therefore transcended the realm of corporate extravagance and turned into an absolute necessity in the current business landscape. By doing so, organizations can tap into an ever-evolving data environment, leading to continual enhancement of operational effectiveness, agility, and the ability to stay ahead of the curve in this immensely competitive, technology-driven global market. The strategic use of data—terrestrial and space-sourced, internal and external—is not just a passing trend, but a definitive shift in the modern, agile way of doing business.

How space strategy and data fusion impact business functions

The landscape of business is changing at an unprecedented rate, driven by the constant evolution of technology. In the midst of this rapid transformation, adopting a space strategy, powered by data fusion principles, is becoming an indispensable aspect for organizations looking to remain competitive and innovative. Space, traditionally considered as a mere vertical or specialized sector, has evolved into a comprehensive facet of business that intersects nearly every aspect of an organization's operations.

> "Mastering space strategy and data fusion is essential, transforming businesses with insights that transcend traditional boundaries, propelling them into a future of competitive edge and innovation."
>
> Brian Miske
> National Ignition Leader, KPMG

Space-based data, when integrated and fused with internal, external, and terrestrial data sets, brings about a wealth of insights, influencing business decisions and strategies at all levels. It provides businesses with an unparalleled perspective, extending beyond traditional market surveys or regular business stats to include real-time, geo-located information about market trends, customer behavior, and potential risks or opportunities. This is not confined to a specific function but spans across front-, middle-, and back-office operations—actively shaping sales strategies, optimizing supply chains, guiding risk management, and aiding in business continuity planning.

The broader influence of space-linked data fusion significantly enhances an organization's adaptability quotient. By establishing predictive and prescriptive models over reactive decision-making, businesses are not only keeping pace with market trends but also gaining a lead. The ability to anticipate the future, based on comprehensive data fusion, ultimately leads to better resource allocation, improved operational efficiency, minimized risks, and maximized returns, thereby ensuring enhanced business performance in the long run.

Thus, space has grown beyond its traditional role and is now a pervasive influence on all business aspects when harnessed correctly via data fusion. Neglecting this fundamental shift could potentially result in corporations lagging in the competitive tech-dominated business landscape. Therefore, it's crucial for business leaders to recognize the expansion of space from a narrow sector to a wide-reaching factor in corporate strategy and operations. Space strategy, rooted in data fusion principles, is more than just a trend—it's a necessity for businesses to thrive in this digital age.

How space strategy and data fusion can boost business performance

Unequivocally, we exist in an era of digital Darwinism, where technology and society are evolving faster than businesses can naturally adapt. This phenomenon is amplifying competition and favoring the survival of the most innovative. Given this context, business leaders must swiftly respond to the call of data fusion, a paradigm-shattering process of uniting disparate internal, external, terrestrial, and even space-sourced data sets to immensely boost corporate decision-making and enterprise performance. The integration of a robust, well-rounded space strategy underpinned by data fusion principles is not merely an option; it is an urgent imperative for success and survival in today's rapidly evolving technological landscape.

Space is no longer simply "out there"; it has permeated the core of agile, modern organizations, intersecting all facets of business operations. A robust space strategy provides access to a previously untapped resource: data from the cosmos. When combined with terrestrial and internal data through data fusion, space-sourced information provides a more profound understanding of business trends and environments, enhancing operational adaptability and innovation across all business functions.

> "Space-sourced information provides a more profound understanding of business trends and environments, enhancing operational adaptability and innovation across all business functions.

Key considerations for the C-suite

CIOs

Chief Information Officers

- Integration of space-sourced data with the existing IT infrastructure.
- How can space strategy provide competitive advantage in our industry?
- How scalable is our IT infrastructure to accommodate space-sourced data?
- Are there any specific IT challenges in implementing a space strategy?
- What system updates are necessary for seamless data fusion across all data sets?

CTOs

Chief Technology Officers

- Analysis of the potential tech platforms to harness space-sourced data.
- How can we build a tech stack that fully supports space data fusion?
- What tech resources do we need to invest in for effective data fusion?
- How does space strategy align with our existing technology roadmap?
- Can we initiate partnerships with space-data providers to enhance our tech capabilities?

CDOs

Chief Data Officers

- Assurance of data privacy and resolving potential ethical issues.
- What processes do we need to establish for data privacy and integrity?
- How can we ensure the ethical handling of sensitive data sourced from space?
- What forms of data governance are required for space data fusion?
- How do we navigate the challenges inherent in handling data from diverse sources?

CAIOs

Chief AI Officers

- Adoption of AI tools to analyze and draw insights from space-sourced data.
- What is our strategy to incorporate AI in managing data from diverse sources?
- How can we improve our AI models using space-sourced data?
- Can space data enhance our existing AI capabilities in predicting behaviors?
- How do we track and measure return on investment on integrating AI with space strategy?

COOs

Chief Operating Officers

- Consideration for the use of space-sourced data to streamline operations.
- How can we leverage data fusion to optimize our supply chains?
- Can our operational efficiency be improved by space-sourced data?
- How can we best incorporate a robust space strategy in our existing operations?
- What operations can be significantly influenced by space-sourced data?

Space-based data fusion promises real-world use cases, extending across front-, middle-, and back-office operations, and facilitating businesses to gain sharper insights, make more informed decisions, and in the process, carve out a competitive edge. For instance, customer intelligence—derived from fusing various datasets—can enhance front-office operations by providing nuanced insights into market trends and customer behaviors, thereby boosting efficiency of sales and marketing initiatives. Simultaneously, back-office functions can leverage this comprehensive picture drawn from fused data to streamline processes, anticipate risks, and drive cost efficiencies.

Therefore, the need of the hour is to recognize the transformation of space from a vertical role to a broad-spectrum influence that intersects and enhances all business operations through the power of data fusion. Failure to do so could signpost disruption by competitors who are making strides in harnessing space-sourced data. In this digital age marked by technological advancements, businesses must proactively embrace a space strategy anchored in data fusion principles. It's no longer a luxury, but an overriding necessity. Any delay could spell missed opportunities, the risk of obsolescence, and an invitation to disruption in this ever-evolving market.

Moving forward: The exponential power of data and space strategy

Business leaders have a special opportunity today. Space data is more useful than ever, and with data fusion, we can gain more insights. This puts organizations in a great position to improve their future. We're on the edge of a big shift in the way businesses create their strategies. Soon, space will be a big factor that impacts every part of an organization.

A strategy that uses space and data fusion can help all parts of a business by improving decision-making, finding new solutions, and making everything work better. Business leaders need to innovate or risk being left behind. Even small businesses can do better than big companies if they use data fusion effectively. In many ways, data fusion is an equalizer, especially when companies can find strong platforms and tools as a service. There is a build-versus-buy question here, but it is easily answered by considering what enables and organization to move faster. Much like the bus in the movie *Speed*, dipping below a certain velocity is death for an organization.

It might take some time and investment to create a strategy that depends on space and data fusion, but the benefits should be worth it. By doing this, a business can improve its operations, understand customers better, reduce risks, and keep track of market trends. It also allows businesses to adapt quickly and see new opportunities.

Space isn't just something far away; it's also a big part of our digital systems and business plans. Right now, brave leaders need to consider using a strategy that uses space and data fusion. It's a chance to break through barriers, redefine old ideas, and explore unknown paths towards growth.

Taking this step is urgent and full of potential. Those who seize this opportunity and boldly venture into this new territory, using a space strategy, are likely to leave a lasting mark on the business world.

Will you dare to disrupt?

KPMG

Leveraging data fusion for defense

A new frontier in the space economy

Brian Miske

Abstract

In a heightened race for space, data fusion emerges as a critical tool for transforming military operations and intelligence gathering. This article elucidates its role in enhancing situational awareness, operational adaptability, and decision-making within defense agencies. It also explores the emergence of "spaceports" in the burgeoning space economy, where data fusion enhances real-time surveillance and SSA. From creating accurate digital twins for better mission readiness to innovative scenario planning and more efficient training programs, data fusion offers an unrivaled strategic edge. Nevertheless, the comprehensive adoption of data fusion brings along the need for personnel skilled in data-driven operational environments, including cyber operations. The future promises unprecedented opportunities for defense and economic revival, hinged on our readiness to harness data fusion and optimize space infrastructures.

In this period of rapid technological advancements, the arena of military operations stands at a critical junction. Nowhere has this been more conspicuous than in the domain of intelligence gathering and decision-making. It is within this vibrant matrix of change that a process known as "data fusion" emerges as a lynchpin for future progress.

Data fusion

The act of bringing internal, external, terrestrial, and space-sourced information leveraging multiple data sets of any degree of difference or relation to understand phenomena, in particular those phenomena that seem to have little or no connection to much of the data fused, resulting in often surprising insight and knowledge.

The strategic competence of data fusion

Data fusion involves the assimilation of various, frequently disparate data sets—whether terrestrial, space borne, internal, or external. This process finds itself at the forefront of novel approaches to national defense, essentially constituting a vital component in the modern military toolkit. It represents a departure from traditional methods, fostering operational adaptability, enhancing efficiency, and providing a thrust for the commercialization of data-centric insights.

Its significance certainly extends beyond the mere amalgamation of data. The synergy of AI entwined with data fusion is primed to dramatically transform military intelligence, predictive strategies, and tactical decision-making. It's a truth fully acknowledged that the benefits of adopting data fusion are irrefutable for defense organizations, including the National Reconnaissance Office (NRO), the Department of Defense, and the United States Space Force (USSF). Furthermore, given their ownership of most of the space-based platforms for defense, the NRO and USSF have the leverage to amplify their relevance to the system, a positioning that could serve as a learning curve for the private sector.

Spaceports: The nerve center of the new space economy

An economy centered on the exploration and utilization of space is gradually unfolding. Within this economic sphere, "spaceports" are quickly becoming more than mere launch pads for spacecrafts. They transform into symbols of resilience, mirroring a nation's strategic preparedness and standing as potent drivers for economic growth and workforce development. Furthermore, the knock-on effects of a spaceport to the region's economy are transformative.

Viewed through the data fusion lens, the value chain of launch infrastructures expands from launch site to a multifaceted hub of activity. They evolve into arenas that foster innovation while concurrently supporting local economies by providing job opportunities for a diverse range of roles, from engineers to logistic and support staff. Operating in tandem with the commercial sector, they serve as conduits for income streams that stimulate broader economic growth.

Harnessing the power of space situational awareness

To navigate successfully in a climate riddled with geopolitical volatility and profound security challenges, military leaders must comprehend the strategic potential of spaceports and data fusion. In this evolving vista, spaceports hold a crucial role. They act as vital touchpoints between civil space agencies, commercial space exploration endeavors, workforce development, and economic development. Moreover, fostering SSA serves strategic foresight by providing insights into the space environment. Understanding the dynamic behaviors and characteristics of space objects is critical to preserving and ensuring free access to space; however, it is not enough. Data about atmospheric weather, solar flares and ejections, etc., must all be fused.

The integration of data fusion and adoption of space-centric infrastructure are not without its challenges. Funding construction, regulatory compliance, managing the geographical distribution of economic impact, and long-term market sustainability are significant considerations, though solutions lie in diversification and partnership. By investing beyond traditional space activities, military institutions can expand. Concurrently, forging partnerships, both domestic and international, mitigates risk and amplifies economic advantage.

The dawn of the new space economy is at hand

Far more than a platform to explore the boundless frontier of space, it is a potent vehicle for economic development and national security. The magnitude of potential success—or failure—is inextricably linked to our readiness to harness data fusion, optimize space infrastructures, and seize the opportunities this new era presents. **The time for action is now.**

Data fusion emerges as a strategic tool for the military. By leveraging its capability in areas such as predictive analytics, forecasting, simulations, and digital modeling, military leaders can significantly enhance strategic decision-making. The dawn of this new era promises not only a strategic edge in defense and space operations but also a potential for an unparalleled economic resurrection, subject to our readiness to embrace the challenges and opportunities it brings.

"For military leaders, the utilization of data fusion offers a heightened strategic edge. As a tool encompassing predictive analytics, robust forecasting, practical simulations, and precise digital modeling, its potential to enhance tactical decision-making is unmatched."

Key considerations for the C-suite

Spaceport applications

- How can we employ data fusion in real-time surveillance of spaceport launch and recovery operations?
- How can we optimize data fusion for prelaunch weather forecasting and scheduling?
- In what way can leveraging data fusion offer us an integrated view of spaceport operations and enhance SSA?
- How do we ensure the acquired data fusion intelligence is filtered down to tactical levels for optimal spaceport operations?

Situational awareness

- How can we integrate data fusion technologies into our current command and control systems to enhance situational awareness?
- How can automated processes from fused data extracts better direct our quick and rapid-impact strike decisions?
- How does continual access to fused data enhance our forces' situational understanding (FSU)?
- How do we guarantee that our intelligence systems can quickly process and deliver operational objectives based on fused data?

Digital twins

- How can we leverage the data from our current operational combat systems to develop high-fidelity digital twins?
- What data fidelity is required to ensure these digital twins improve the depth of our mission understanding and readiness?
- What mechanisms should be in place to measure the accuracy of digital twins and their impact on mission effectiveness?
- How do we secure our digital twin data while ensuring mission-command accessibility?

Increasing domain awareness

- How can we employ data fusion to enhance our integrated air and missile defense capabilities?
- Can the fusion of cross-domain data optimize our joint targeting process?
- How can we develop standard operating procedures that leverage data fusion to identify and track emerging threats across all domains?
- How can data fusion expedite decision cycles in joint all-domain command and control missions?

Scenario planning and forecasting

- How can we use data fusion for advanced predictive analytics to create more accurate threat forecasts?
- How can data fusion techniques be employed to validate our scenario-based training and readiness exercises?
- In what ways can data fusion bolster our planning for multidomain operations (MDO)?
- What process improvements should we incorporate to consistently validate our forecasting models?

Simulation and modeling

- Can we leverage the fused data to build better synthetic training environments (STEs)?
- How can we employ data fusion to innovatively model and simulate adversary actions and threats?
- What's the best way to ensure our models dynamically update as new multisource intelligence becomes available?
- How do we successfully translate the vast amount of simulation data into actionable operational strategies?

Training

- Can fused data provide insights into autonomous and live training exercises to enhance force readiness?
- How can data fusion transform virtual and constructive training by developing multidomain operational scenarios?
- How can iterative feedback from data fusion refine our adaptive training programs and improve combat readiness?
- What protocols need to be enhanced to make sure lessons learned from data-driven training are transferred to real-world situations?

Future skills

- What new skills will our warriors need to leverage the results of data fusion in their operational environment?
- With the increasing importance of cyber operations, how does data fusion impact skill requirements for our cyber personnel and cyber mission force?
- How can we best groom the next generation of leaders to harness the power of data fusion in defense strategies?
- How can we identify and map out future career paths and skill sets based on data fusion predictions?

A Galaxy of Opportunities

Sub-Series 1: In-depth exploration of the current realities, emerging trends and economic viability of the burgeoning space industry

KPMG

Navigating space & capital markets

Unlocking commercial space's potential for capital markets

Brian Miske

In the grand theater of global economics, a new act is beginning, one set amidst the stars and propelled by the possibilities of the cosmos. The commercial space industry, an emerging player in the world of finance, beckons investors and economists to scrutinize its potential and challenges. This perspective provides a spotlight on the economic dynamics that shape the commercial space sector, offering insights into its market influences, growth strategies, regulatory landscapes, risks, and the pivotal role of government policies.

Economic perspective of the commercial space industry

The commercial space industry stands as an unparalleled frontier brimming with economic prospects. It presents a compelling narrative characterized by innovation, substantial revenue potential, and a transformative impact on economies. Its appeal extends beyond lofty ambitions to tangible and quantifiable opportunities. By spearheading cutting-edge technologies, this sector not only stimulates economic growth through investments in research and development but also cultivates a thriving ecosystem encompassing suppliers, manufacturers, and a skilled workforce. The potential for market expansion is evident in satellite-based services, the burgeoning space tourism sector, and the prolific generation of Earth observation data, which finds applications across diverse industries like agriculture and urban planning. Furthermore, the industry's capacity to disrupt conventional business models, reduce launch costs, and drive competitive dynamics further underscores its economic significance. As economists and investors embark on this cosmic odyssey, a central question arises: How can we effectively harness this vast potential while prudently managing associated risks? The imperative now lies in conducting a comprehensive economic evaluation, far beyond mere speculation, to chart a strategic course through the uncharted waters of the space economy and unlock the substantial financial rewards it holds.

Market dynamics and growth strategies

A. Market analysis and target segments

Understanding the commercial space industry's demand landscape and identifying viable market segments is crucial for savvy investors. By analyzing potential markets, assessing competition, and appraising the industry's growth potential, investors can strategically position themselves to reap the rewards of this burgeoning sector.

B. Public-private partnerships for infrastructure development

Public-private partnerships represent a powerful avenue to expedite the industry's growth. Collaborations in infrastructure development, including spaceports and launch facilities, can optimize resource allocation and reduce the financial burden on either sector. Such partnerships pave the way for innovative solutions and efficient resource utilization.

C. Financial levers to attract investment

Capital investment is the lifeblood of industry growth. Attracting capital can be achieved through strategic financial mechanisms such as specialized space-focused investment funds, public listings, and tax incentives. These measures incentivize investors to actively engage with the commercial space industry, unleashing its vast economic potential.

D. Risk mitigation and insurance solutions

In an industry rife with uncertainty, a prudent risk mitigation strategy is indispensable. Tailored insurance solutions and robust risk assessment models serve as safety nets, providing reassurance to investors while minimizing financial exposure. This, in turn, fosters confidence in the sector.

E. Talent acquisition and skill development

The commercial space industry's success is intricately tied to the availability of a skilled and innovative workforce. Investment in education, collaboration with research institutions, and the creation of attractive career paths are vital components for nurturing a robust talent pool that can drive innovation and excellence.

Key questions for nontraditional space organizations:

What are the current and projected market trends in the commercial space sector?

How do these trends align with our organization's capabilities and goals?

Who are the key players in our target segments, and what strategies have made them successful?

What specific needs or gaps exist in the market that our organization can address?

How can we differentiate ourselves from traditional space players and new entrants?

Are there untapped niche markets or underserved segments that we can target?

Infrastructure assessment: What infrastructure investments are necessary for our organization's space endeavors?

Are there existing public-private partnerships in place that can benefit our growth plans?

How can we leverage existing spaceports, launch facilities, and other infrastructure to reduce costs and accelerate growth?

What expertise or resources can our organization contribute to public-private partnerships?

How can we align our infrastructure needs with government or private initiatives to maximize efficiency?

What potential regulatory or legal hurdles might arise in partnership agreements, and how can we address them proactively?

What is our organization's financial strategy for funding space ventures?

How can we attract investors and secure the necessary capital?

Are there specialized investment funds or financial instruments tailored to the commercial space industry that we can leverage?

What unique value proposition can our organization offer to investors in this competitive landscape?

How can we create a compelling financial roadmap that showcases the profitability and growth potential of our space initiatives?

Are there creative financing options, such as crowdfunding or strategic partnerships, that align with our organization's goals?

Risk assessment: What are the specific risks associated with our space operations, and how can we assess and quantify them?

Are there industry benchmarks or best practices for risk management that we should adopt?

How can we create a culture of risk awareness and mitigation within our organization?

What insurance solutions are available to safeguard our investments and operations?

Are there industry consortia or risk-sharing arrangements that align with our risk tolerance?

How can we balance risk mitigation efforts with the imperative to innovate and take calculated risks in the pursuit of growth?

What skills and expertise are critical for our space endeavors, and how can we attract and retain top talent?

Are there educational institutions or research partners that can help us develop a skilled workforce?

How can we create a culture of innovation and entrepreneurship to foster talent growth?

What strategies can we employ to compete for talent against established space organizations?

How can we offer attractive career paths and professional development opportunities to attract talent?

Are there collaborative initiatives with educational institutions or vocational programs that align with our talent needs?

Government policies: Catalyzing growth and competition

Streamlining regulatory processes:

Efficient regulatory processes facilitate innovation and market entry. Simplified licensing and approval procedures can encourage entrepreneurship, reduce the barriers to entry, and enable a more vibrant and competitive industry.

Financial incentives and funding:

Governments play a pivotal role in fostering growth through financial incentives and funding. By allocating resources and offering grants, they can stimulate research and development, providing vital impetus for the sector's expansion and competitiveness.

International cooperation and standardization:

In our globally connected world, international cooperation and standardization are essential. Governments should engage in diplomatic efforts to establish a unified framework that fosters a level playing field and promotes healthy competition on a global scale.

Challenges and potential risks: An economic lens

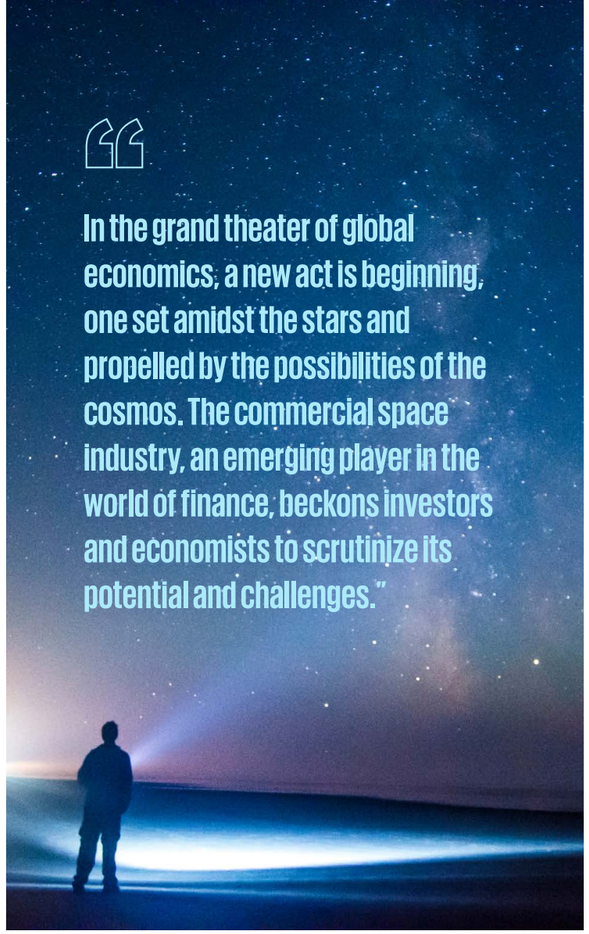
Technological and operational risks

A. Rapid technological advancements:

The pace of technological change in the commercial space industry is breathtaking. While this drives innovation, it also introduces the risk of investments becoming quickly obsolete. Businesses must navigate this landscape by continuously investing in research and development to stay at the forefront of technological advancements.

B. Operational complexity:

Space missions, be they launching satellites or conducting scientific experiments, are highly complex operations. The margin for error is razor-thin, and even minor glitches can result in significant financial losses. Robust operational planning and contingency measures are essential to mitigate these risks.



C. Supply chain vulnerabilities:

Many components used in space missions are highly specialized and can be sourced from limited suppliers. Supply chain disruptions, whether due to geopolitical tensions or natural disasters, can halt operations and escalate costs. Diversifying supply chains and ensuring redundancy in critical components are risk mitigation strategies that require careful economic consideration.

Legal and regulatory complexities

A. Intellectual property and space law:

Intellectual property rights in space, such as patents for space technologies, can be intricate and contested. Clarity in legal frameworks is crucial to protect the interests of businesses and investors. Navigating the complexities of international space law and establishing transparent guidelines for intellectual property management are vital economic considerations.

B. Jurisdictional issues:

The issue of jurisdiction in outer space remains a challenge. Clear delineation of responsibilities and liabilities for space activities is essential for businesses to assess risks accurately. Ambiguity in jurisdiction can lead to costly legal battles and hinder economic growth in the sector.

C. Environmental regulations:

As the commercial space industry expands, concerns regarding space debris and environmental impact grow. Regulating and mitigating these impacts is not only a moral imperative but also an economic one. Businesses must factor in the costs associated with debris management and sustainable practices into their operations.

Market uncertainties and competition

A. Volatility in demand:

The commercial space industry's demand is subject to fluctuations influenced by factors such as geopolitical tensions, economic conditions, and technological advancements. Predicting market demand accurately is challenging, making it difficult for businesses to plan investments and expansions effectively.

B. Emerging technologies:

Rapid advancements in technology can disrupt existing market dynamics. New entrants with disruptive technologies can quickly alter the competitive landscape, causing established players to adapt or risk obsolescence. Businesses must allocate resources for ongoing innovation and be agile in responding to technological shifts.

C. Economic and geopolitical factors:

Global economic events and geopolitical tensions can have a profound impact on the commercial space industry. Tariffs, trade disputes, and political instability can disrupt supply chains, affect international partnerships, and create uncertainties that impact economic decision-making.

Seizing the emerging opportunities

The commercial space industry, once confined to the realm of science fiction, is now a tangible economic frontier. Its potential for innovation, market expansion, and economic growth is unprecedented. To seize the emerging opportunities, organizations must act decisively today.

Investors and entrepreneurs should embrace the industry's potential, strategically position themselves in target segments, and leverage financial mechanisms and risk mitigation strategies to navigate this dynamic sector. Joining the Association of Commercial Space Professionals (ACSP) is a recommended step for networking and knowledge exchange.

However, the role of the US government is pivotal. To spark capital markets, investments, and growth in the commercial space industry, the government should streamline regulatory processes, provide financial incentives, and champion international cooperation. By creating a conducive environment for innovation and competition, the government can catalyze the industry's economic potential, propelling it to new heights.

In this new act of the global economic theater and space race, the stars are not just in the sky but in the hands of visionaries, investors, and policymakers who dare to reach for them. The commercial space industry is not merely the final frontier; it is a burgeoning marketplace of infinite possibilities waiting to be explored, and it is time to embark on this cosmic journey.

Capital connections

The intersection of commercial space activities and global financial markets

Brian Miske and Kristin Haug

Abstract

This is the second of three articles related to the series "The Horizontal Expansion of the Space Industry: Creating New Market Opportunities, Driving Innovation, and Influencing Global Capital Markets." The convergence of commercial space activities with global financial markets is generating a dynamic investment ecosystem underpinned by technological advancements and evolving capital market trends. In this article, the second of the series, we explore this intricate interplay and its implications for the space industry, examining the influence of capital markets on the burgeoning sector as it undergoes a technology-driven shift. We discuss the challenges and opportunities faced by investors, highlighting the extended investment horizons and substantial capital requirements characteristic of space ventures. Furthermore, we uncover parallels between the commercial space sector and other innovative industries, such as biotechnology, renewable energy, and artificial intelligence, drawing valuable insights into the unique investment dynamics and risk assessment models adapted to these pioneering fields. By investigating the intersection of commercial space activities and global financial markets, we pave the way for a comprehensive understanding of the landscape, fostering the development of innovative approaches and frameworks necessary to create a more inclusive, accessible, and profitable space ecosystem.

Investigating the interplay between commercial space activities and the global financial landscape

As the commercial space sector converges with the global financial landscape, we witness a fascinating interplay between two unrelated fields. The growing commercialization of space, along with technological advancements, has transformed investment and innovation dynamics, creating numerous opportunities and challenges as these two sectors intersect.

This remarkable interaction can be observed within capital markets, where the commercial space sector has created a unique ecosystem of high-risk ventures and sizable investments. The capital-intensive nature of the space industry has redefined conventional ideas of risk and return, attracting various investors to the space domain.

The outlook on investment dynamics in the space industry is grounded in realism. While we recognize the vast opportunities for investors in space commercialization, it is essential to acknowledge that there are inherent risks associated with this rapidly expanding and attention-grabbing sector. This balanced understanding can also be observed in other sectors and technology endeavors, which have experienced similar levels of risk.

For instance, industries such as biotechnology, renewable energy, and artificial intelligence have followed comparable trajectories, showcasing immense potential for growth and innovation while also presenting significant risks and uncertainties. By analyzing these parallels, we can gain valuable insights into the unique challenges and opportunities that arise when investing in groundbreaking fields, helping us navigate the complexities of the space industry with a balanced perspective.

Considering space as a horizontal industry for both traditional and nontraditional companies requires an understanding of two crucial factors: the substantial capital needs and the extended investment horizons. Space ventures demand significant funding due to high development costs and lengthy timelines for returns, as activities often take years or decades.

As the space industry continues to attract diverse investors, including government entities, private venture capitalists, and institutional investors, innovative approaches for evaluating and managing investment risks are necessary. By addressing the unique challenges and adapting strategies accordingly, both traditional and nontraditional space companies can contribute to building a more inclusive, accessible, and profitable space ecosystem.

Additionally, the impact of capital markets extends beyond merely funding space ventures; it influences the direction and governance of space activities. The emergence of private space companies and entrepreneurial ventures has changed investment and innovation dynamics, with traditional space agencies now competing against private companies for market share and profitability.

The connection between commercial space activities and the global financial landscape has also prompted a change in investment patterns, risk assessment models, and new frameworks. While government expenditure once dominated the space industry, the surge of private capital has introduced competition and entrepreneurship into the space sector. One of the new frameworks can be focused on the rise of spaceports and launch facilities around the world. This exemplifies the shift from a vertical to a horizontal space industry model. These facilities cater to a spectrum of launch vehicles, fostering a diverse ecosystem of space access and stimulating the growth of commercial space transportation services.

This confluence of the space industry and other sectors not only brings about unparalleled investment levels, but also fosters technological breakthroughs and collaborative efforts across diverse fields. For instance, the emergence of space-based internet constellations has led to partnerships between space firms and telecommunication leaders, highlighting the far-reaching impact of space technology and its capacity to reshape conventional industry limitations. By considering broader second- and third- order effects, we can better understand the subsequent implications of incorporating space technology into different industries.

The dynamic interplay between commercial space activities and the global financial landscape forms a transformative junction, redefining investment patterns, risk assessment models, and technological innovation. The melding of these two sectors has reshaped the space industry, ushering in a more entrepreneurial, commercially driven, and competitive environment. As this relationship continues to evolve, it will undoubtedly influence the future of space exploration, technological innovation, and economic growth.

As we venture further into this interaction and its inherent complexities, it becomes crucial to explore the numerous opportunities and obstacles that arise when these traditional and nontraditional sectors merge and redefine the space industry. By examining the challenges and potential solutions in this evolving landscape, we can better understand the implications and future of this transformational convergence.

> “Investment in space will be transformational for the capital markets, leading to an acceleration of the level of commercial innovation, which will benefit life both on earth and in space.”
>
> Grant McDonald
> Global Aerospace and Defense Leader, KPMG

The convergence of commercial space activities and the global financial landscape:

Opportunities and challenges

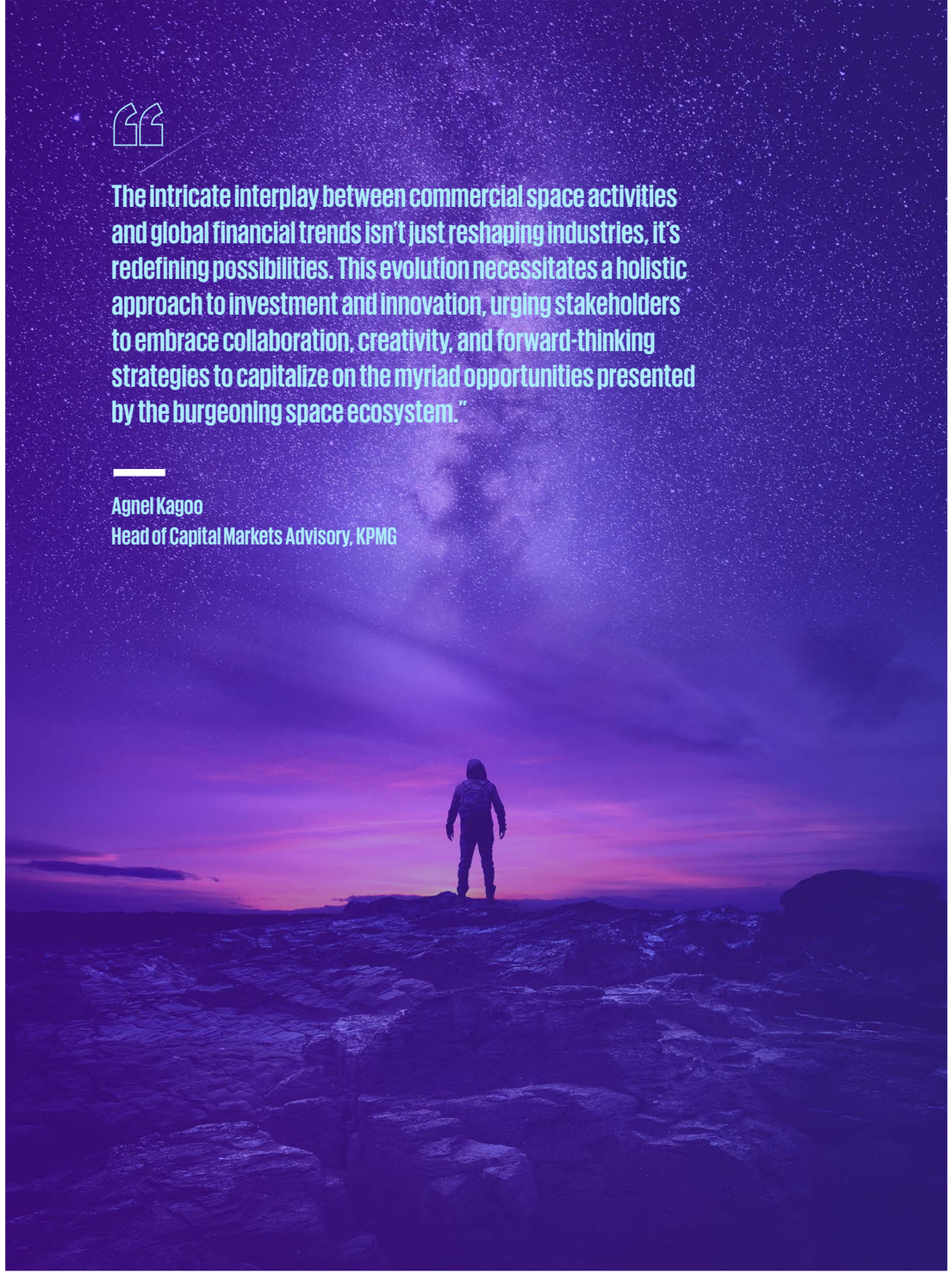
The integration of commercial space activities and the global financial landscape has ushered in a new frontier filled with opportunities and challenges, as the inexorable force of technology and the fourth industrial revolution reshape investment dynamics within the space industry. The applications are vast.

This convergence has propelled the space industry into a golden age of commercialization, marked by a surge of innovation, investment, and entrepreneurship, which drives efficiency and market-driven advancements. However, it also presents numerous challenges, as traditional investment practices and regulatory frameworks must adapt to the unique demands and complexities of space ventures.

Capital markets play a pivotal role in this transformation, fueling space ventures and, in turn, being reshaped by them. As a result, capital markets face the need to develop innovative approaches to risk assessment models, investment horizons, and financial valuation methods suited to the space economy's dynamic landscape. The impact of capital markets on space commercialization also encourages a diverse array of investors to enter the field, ranging from venture capitalists and angel investors to institutional funds and sovereign wealth funds.

Investments in space technology have yielded considerable returns, altered risk assessment models, and prompted extensive research to understand the transformative effect of capital investments in space ventures. However, the fusion of commercial space activities and global finance also brings challenges, including regulatory uncertainties, market ambiguities, and increased competition that demand critical attention.

The progression of technologies generates a domino effect across the space exploration sectors, consequently attracting attention from capital markets and financial institutions.



"The intricate interplay between commercial space activities and global financial trends isn't just reshaping industries, it's redefining possibilities. This evolution necessitates a holistic approach to investment and innovation, urging stakeholders to embrace collaboration, creativity, and forward-thinking strategies to capitalize on the myriad opportunities presented by the burgeoning space ecosystem."

Agnel Kagoo
Head of Capital Markets Advisory, KPMG

As the complex interplay between commercial space activities and the global financial landscape continues to evolve, capital markets emerge as a cornerstone of this transformation, nurturing space ventures and adapting to the space economy's ever-changing needs. Exploring this unique ecosystem of financial opportunities and challenges, we must consider the innovative approaches and sustainable growth strategies required to effectively navigate the intricacies of this rapidly developing landscape.

The influence of capital markets on space commercialization:

A unique ecosystem of financial opportunities and challenges

The space industry finds itself at the crossroads of substantial investments and high-risk ventures, which leads to an ecosystem of financial opportunities and challenges that redefine the landscape of commercial space activities. Innovative technologies, along with the emerging space economy, are reshaping the dynamics of capital markets, compelling financial institutions to foster ingenuity and adjust their investment approaches and risk evaluations while navigating the novel opportunities arising from exceptional progress across numerous sectors. As the space industry rapidly expands, capital markets' influence becomes more profound, reshaping conventional investment models and spurring innovation.

"Innovative technologies, along with the emerging space economy, are reshaping the dynamics of capital markets, compelling financial institutions to foster ingenuity and adjust their investment approaches and risk evaluations while navigating the novel opportunities arising from exceptional progress across numerous sectors."

Brian Miske
National Ignition Leader, KPMG

> The space industry goes beyond being just an investment arena; it acts as a driving force for worldwide innovation and collaboration, generating unparalleled prospects and welcoming a fresh age of interconnectivity across multiple sectors."
>
> Brian Miske, National Ignition Leader, KPMG

This transformation is characterized by the merger of significant capital investments and high-risk ventures, captivating a diverse group of investors from various areas. This change prompts the reevaluation of traditional financial strategies, leading to the emergence of innovative investment approaches suited for the space industry. The intricate interplay between commercial space activities and global financial trends suggests an era of transformation and growth, paving the way for a more inclusive, accessible, and profitable space ecosystem that impacts not only space exploration but also a multitude of industries. Capital markets not only fuel space ventures but also are transformed by them. In response to the industry's high-risk nature, novel financial instruments have emerged, such as space-focused venture capital funds, exchange-traded funds (ETFs), and special-purpose acquisition companies (SPACs). The industry's growing commercialization attracts a diverse range of investors, eager to capitalize on upcoming opportunities.

"The intricate interplay between commercial space activities and global financial trends suggests an era of transformation and growth, paving the way for a more inclusive, accessible, and profitable space ecosystem that impacts not only space exploration but also a multitude of industries." — Brian Miske

Several case studies and expert opinions reveal the transformative impact of capital investments in space ventures, demonstrating the potential for substantial returns and risks. As a result, innovative investment paradigms, risk assessment models, and financial instruments emerge, reflecting the unique demands of space activities and initiating a transformative shift in the financial landscape.

Overall, the unique ecosystem of the space industry presents financial opportunities and challenges driven by the convergence of significant capital investments and high-risk ventures. The space industry goes beyond being just an investment arena; it acts as a driving force for worldwide innovation and collaboration, generating unparalleled prospects and welcoming a fresh age of interconnectivity across multiple sectors. This evolving interplay propels a new era in the space industry's financial trajectory, revolutionizing investment strategies, risk assessment methodologies, and financial valuation frameworks.

In conclusion, the convergence of commercial space activities and global financial markets has created a dynamic and transformative investment ecosystem, redefined the landscape of the space industry, and reshaped conventional investment models. Capital markets have emerged as a cornerstone in this transformation, nurturing space ventures and adapting to the ever-changing needs of the space economy. As this relationship continues to evolve, it will undoubtedly shape the future of space exploration, technological innovation, and economic growth.

Key considerations

1. How can traditional financial institutions and investment models adapt to the unique challenges and risks associated with commercial space ventures? What new financial instruments and risk assessment frameworks are required to effectively navigate the intricacies of this rapidly developing landscape?

2. As the space industry continues to expand and attract diverse investors, what collaborative efforts and partnerships can be forged across various sectors to harness space technology's potential to reshape conventional industry limitations and drive further innovation?

3. How can regulatory bodies and policymaking adapt to the rapid commercialization of the space industry and the growing influence of capital markets on space activities? What measures need to be implemented to create a more inclusive, accessible, and sustainable space ecosystem?

Exploring these thought-provoking questions will allow us to better comprehend the commercial space activities and global financial markets convergence and adapt to the evolving landscape that it brings.

KPMG

Redefining frontiers

The pivotal role of space ventures in shaping capital markets and Earth-based industries

Brian Miske and Kristin Haug

Abstract

The third article in our series, explores the transformative impact of space ventures on capital markets and their influence on diverse sectors, such as telecommunications, transportation, agriculture, and defense. As space technology expands its reach and reshapes the global investment landscape, it demands innovation in financial instruments, risk assessments, and investment strategies. We explore the emergence of novel financial instruments designed for space commercialization, such as venture capital funds, ETFs, and SPACs. In addition, we examine how capital markets can adopt a horizontal approach across multiple sectors to drive innovation, uncover potential synergies, and expand ideas on the sources of funding. This, in turn, can create new market opportunities and respond to the unique challenges and rewards of space-related ventures. By fostering sectoral interconnectedness and driving sustained, systemwide innovation, space technology is spearheading a sea change in global industries and prompting a reevaluation of traditional financial frameworks. Through its pervasive impact, the space industry is not only redefining frontiers in the investment domain but also fostering transformative advancements and collaborative growth in terrestrial sectors worldwide.

The transformative impact of space ventures on capital markets

Space ventures are changing the way financial institutions and capital markets operate, creating a new era of innovation and investment possibilities. These new opportunities make financial markets think differently, leading to fresh ideas and improved ways of assessing risks. Space ventures are forcing financial institutions to think creatively and develop new investment models, risk assessments, and financial strategies.

New financial instruments designed for space commercialization are also emerging, such as venture capital funds focused on space, ETFs, and SPACs targeting space ventures. This shift shows the growing importance of the space industry in the financial world. Investors of all types, from venture capitalists to established aerospace companies, are now investing in the space industry, marking a notable change in investment portfolios. This diversity shows the influence of space ventures on the evolving dynamics of capital markets.

One example of space ventures leading to changes in capital markets is the interest in space-based internet constellations. Financial institutions are developing new risk assessment methods and investment strategies to benefit from potential returns and manage the risks related to the space industry. Capital markets and public sectors play a key role in this evolution.

Capital markets can accelerate access, adoption, and investment in the space industry by shifting from the traditional aerospace and defense sector verticals to a more horizontal approach encompassing multiple sectors. This holistic approach can drive innovation, leverage synergies and cross-sector opportunities, enhance funding sources, and create new market niches. Several strategies can be implemented to achieve this vision:

Encourage cross-sector partnerships:

Financial markets can promote collaboration between space companies and other industries, such as telecommunications, agriculture, mining, logistics, and data analytics. These partnerships will foster the development of innovative space applications and services that cater to diverse markets, attracting investment from a broader range of sectors.

Foster innovative financial instruments

Capital markets can develop and promote financial instruments tailored to the unique needs of space-related activities that span multiple sectors. Examples include space-focused venture capital funds, ETFs, and SPACs targeting space ventures. These tools can provide space companies with the necessary capital to invest in multisectoral projects and opportunities.

Educate and engage investors

Capital markets can educate potential investors on the benefits and opportunities of investing in the space industry as a cross-sector driver of growth. Webinars, seminars, and conferences focusing on synergies between the space industry and other sectors can foster increased interest and investment in this area.

Government policies and incentives

Regulatory bodies can introduce policies and incentives that encourage investment across sectors, such as tax benefits, public funding, and challenge grants related to space projects with cross-sector applications. This approach can facilitate the flow of capital into space enterprises engaging in multisector initiatives.

Support incubators and accelerators

Capital markets can support the creation and growth of incubators and accelerators focused on space start-ups with cross-sector applications. These programs help early-stage companies develop and commercialize their groundbreaking technologies, driving innovation and attracting investment in the space industry.

Develop sector indices and benchmarks

Financial markets can create sector indices and benchmarks that track the performance of space-related companies across multiple industries. This approach will make it easier for investors to identify investment opportunities and monitor the performance of their portfolio in the space industry.

As the space industry continues to evolve and reshape risk management and investment frameworks, its influence on capital markets shapes investment strategies and financial methods, signaling an exciting future where the space industry plays a pivotal role in the direction of global investment. By fostering a horizontal approach and promoting connections across sectors, capital markets hold the potential to accelerate access, adoption, and investment in the space domain. This integrated strategy can lead to diversified investment portfolios, drive innovation, and fuel economic growth. It will propel the global space industry forward while unlocking new opportunities for businesses and investors alike. In this context, it becomes increasingly relevant to explore the realm of space technology investments, particularly as they offer unprecedented returns and reshape risk assessment models for the financial industry.

Space technology investments :

Unprecedented returns and reshaping risk assessment models

The investment landscape in space technology has undergone a remarkable transformation, marked not only by exceptional returns but also by a growing trend toward interindustry collaboration. As space technology evolves and expands into various sectors such as telecommunications, transportation, agriculture, and defense, it presents exciting opportunities and challenges for investors. This shift has prompted a reassessment of traditional financial frameworks and risk assessment models to better accommodate the complexities and uncertainties inherent in space-related ventures.

Investments in space technology have generated unprecedented returns, exemplifying the potential rewards of commercialization and technological advancements in the space industry. This potential has attracted a broad range of investors, reflecting the transformative impact of space technology on the broader investment landscape. To accommodate the unique demands of space-related activities, investors are adopting innovative approaches to assess, manage, and invest in high-risk, high-reward ventures. The opportunities are evolving at a rapid rate.

As space technology investments continue to transform the investment landscape and reshape traditional financial frameworks and risk assessment models, they also pave the way for innovations that extend beyond the realm of finance. The expanding frontiers of space technology have a pervasive impact on Earth's industries, prompting a new era of interconnectedness and innovation across diverse sectors. With this foundation, we now transition to explore the numerous ways space technology influences industries on Earth and the emerging opportunities that arise from this confluence of advancements and collaborations.

> "The rapid horizontal expansion of the space economy is challenging conventional wisdom, pushing boundaries, and fundamentally altering the dynamics between commercial space activities and global financial markets. This evolution underscores the need for innovative strategies to navigate this emerging area effectively and presents tremendous opportunity for capital markets participants fueling this growth."
>
> Kristin Haug
> Head of Financial Services, KPMG Ignition

Expanding frontiers:

The pervasive impact of space technology on Earth's industries

Space technology, once seen as limited to exploration and satellite communication, now reaches across multiple industries on Earth, reshaping sectors such as telecommunications, transportation, agriculture, and defense. This groundbreaking influence sparks interdisciplinary innovation and collaboration, enhancing our modern societal landscape.

Originally perceived as exclusive to space exploration and satellite communication, space technology now permeates various Earth-based industries, transforming fields such as telecommunications, transportation, agriculture, and defense. This revolutionary impact promotes interdisciplinary ingenuity and collaboration, enriching the contemporary societal framework.

There are a multitude of private and commercial company initiatives that vividly demonstrate space technology's profound effect on telecommunications. By seeking to deploy satellite internet constellations, these projects pioneer global connectivity, and the integration of satellite constellations in telecommunication infrastructure embodies this shift, bridging the digital divide.

Additionally, transportation systems have reaped the benefits of space technology. Satellite navigation systems like GPS and Galileo have significantly enhanced maritime, aviation, and land-based transportation's navigational accuracy, safety, and efficiency, fostering a more connected world. Even the defense industry has undergone substantial transformations due to space technology's integration. Space-based technologies, such as satellite imaging and communication systems, have bolstered national security and military operations by providing improved global situational awareness and strengthened communication capabilities. Additionally, space technology has made inroads into agriculture as satellite imagery, remote sensing, and GIS revolutionize farming practices. Breakthrough innovations in these technologies enable intelligent forecasting, targeted farming techniques, and efficient resource management, ultimately increasing productivity and championing long-term sustainability.

The pervasive influence of space technology across various terrestrial sectors, including telecommunications, transportation, agriculture, and defense, showcases its capacity to drive innovation, economic growth, and interdisciplinary cooperation. Capital markets play a crucial role in developing and accelerating the space economy by providing the necessary funding for cutting-edge projects and fostering public-private partnerships. As space technology evolves, capital markets facilitate the transformation of traditional industries, enabling the emergence of unique cross-sector collaborations that accelerate technological progress and interconnectedness. By mobilizing resources, promoting investment in promising ventures, and supporting an ecosystem that drives growth, capital markets further unlock the potential of the space economy and its broader implications for the future.

In conclusion, space ventures are transforming the global capital markets and Earth-based industries by driving innovation, fostering multisectoral synergies, and creating new market opportunities. Through the development of novel financial instruments, cross-sector collaborations, and innovative approaches to risk assessment and investment strategies, capital markets are poised to leverage the growing potential of the space industry. As the space economy evolves, so do the ways it impacts various terrestrial sectors, leading to an era of interconnectedness and growth across industries, from telecommunications and transportation to agriculture and defense. By supporting the flourishing space economy, capital markets have the ability to redefine frontiers, prompting a reevaluation of traditional financial frameworks and unlocking new opportunities for businesses and investors worldwide.

> **Navigating the space economy requires a different mindset. It's not just about profit, it's about patience and vision. Operational risks, regulatory uncertainties, and space's unforgiving nature demand a commitment beyond traditional investments. Capital markets participants entering this arena must understand that it's a marathon, not a sprint. But for those who endure, the rewards are limitless, and the opportunity to shape the future of space commerce is unparalleled."**
>
> **Peter Torrente**
> **National Head of Banking & Capital Markets, KPMG**

Key considerations

1. How can capital markets capitalize on the transformative impact of space technology across multiple sectors, and what innovative strategies should they employ to encourage interindustry collaboration and investment?
2. How can financial institutions adapt their risk assessment models to better account for the unique challenges and high-reward potential associated with space ventures, particularly as the space economy continues to expand and redefine global investment landscapes?
3. In what ways can financial institutions and investors harness the invaluable opportunities arising from the confluence of space technology advancements and collaborations to drive growth and innovation in Earth-based industries?

The convergence of space and terrestrial industries

Fostering innovation and economic growth

Brian Miske

Abstract

The horizontal expansion of the space industry facilitates cross-sector innovation and new market opportunities. It also represents a paradigm shift, bridging the gap between space and terrestrial industries and catalyzing innovation across various sectors. Enabled by the increasing commercialization of space activities led by private companies, this transformation offers new market opportunities and disrupts traditional industry structures. In this article, the first of three, we explore the impact of the horizontal expansion on global capital markets and the broader economy, outlining how the space industry is set to revolutionize industries and address global challenges.

A perspective on how this horizontal expansion is creating new market opportunities and driving innovation across sectors, challenging the conventional understanding of space as an isolated domain

The horizontal expansion of the space industry signifies a remarkable shift in perception and approach, propelling us into a new era of innovation and growth that transcends traditional industrial boundaries. As the space industry evolves from a vertical to a horizontal model, it breaks free from its long-held image of an isolated domain and begins adding value to a wide range of industries and customers. This industry shift is propelled by the increasing commercialization of space activities, led by pioneering private space companies. As space technology becomes increasingly integrated into a diverse range of terrestrial industries—from telecommunications and agriculture to transportation and defense—the landscape of the space industry is rapidly evolving into a more potent, multisectoral domain.

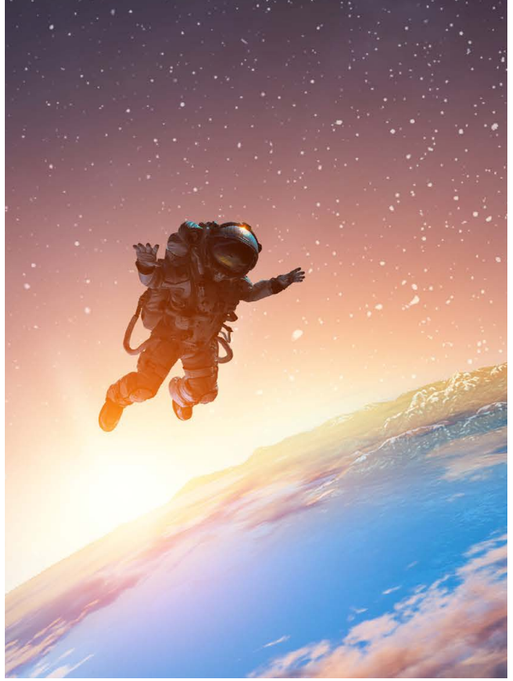
The horizontal expansion of the space industry is not without its challenges, as companies navigate the complexities of integrating space technology into terrestrial industries. However, the potential for new market opportunities and the drive for innovation across sectors make the horizontal expansion of the space industry a compelling and transformative phenomenon.

The far-reaching implications of the horizontal expansion of the space industry continue to challenge conventional thinking by creating new market opportunities and driving innovation across multiple sectors. This nexus of space and terrestrial industries has led to the development of groundbreaking technologies and previously unimagined solutions to global challenges, including climate change, natural disasters, and resource management. As the space industry's influence becomes more pervasive, it continues to reshape the global economy, pushing the boundaries of human achievement ever further. The horizontal growth of the space industry not only represents a departure from the traditional focus on aerospace manufacturing, satellite launches, and space exploration but also heralds a promising new future where space permeates every aspect of our lives on Earth.

According to the Space Report, "The global space economy reached a new high of $546 billion in 2022, an increase of 8% from a revised 2021 figure of $506 billion. As in 2021, nearly 80% of this year's space spending stemmed from commercial revenue, which is divided into two sectors: Products and Services, and Infrastructure and Support Industries."[1] Growth is occurring across commercial sectors as well as government. "The Department of Defense's unclassified space spending totaled $17.1 billion in 2022. Space Foundation also estimates total defense space spending, including classified and unclassified budgets for all military branches and intelligence agencies. This estimate reached $42.9 billion last year, a 21% increase year-over-year."[2]

Embracing the power of collaboration, NASA is fostering dynamic partnerships with private firms to accelerate and streamline the return to the moon. As the space industry intertwines with our daily lives, capital markets are unlocking unseen opportunities, fueling innovation and growth in a constantly evolving landscape. By leveraging a competitive and self-investment-driven approach, these alliances are giving rise to a thriving lunar economy, transforming space exploration and commercialization. "True commercial partnerships for development and operation of some elements of the exploration architecture represent the most rapid and cost-effective path to return to the Moon. In these partnerships, NASA outlines high-level mission objectives and safety requirements, but does not dictate system designs. Companies are required to compete for awards and to co-invest; and they are paid on a fixedprice basis only upon achieving pre-defined milestones. Further, these industry-led partnerships allow NASA to be one customer of many, stimulating a vibrant, commercial lunar economy. Already, due in part to the stability that NASA brings to the market as a customer, numerous private companies are developing lunar systems and signing commercial contracts with customers around the world."[3]

> "As the space industry intertwines with our daily lives, capital markets are unlocking unseen opportunities, fueling innovation and growth in a constantly evolving landscape."
>
> **Brian Miske**
> National Ignition Leader, KPMG



The perspective on the space industry:
Transition from vertical to horizontal

The space industry has undergone a remarkable transformation in recent years, shifting from a predominantly vertical orientation to a more comprehensive horizontal perspective. This change has been sparked by the increasing commercialization of space, as private companies emerge as key players in the sector. Consequently, space technology and services have begun integrating into a broader array of terrestrial industries.

Traditionally, the space industry has centered on government-funded exploration, military applications, and satellite communication, maintaining its vertical structure. However, the rise of private space ventures has revolutionized the sector, not only accelerating technological advancements but also expanding the industry's scope to encompass commercial space activities. As a result of this diversification, the space industry's horizontal expansion is taking precedence over its vertical roots.

> **"This shift is absolutely a reality today not only in the very visible successes of commercial space ventures but also in the growing number of innovators in this 'space' developing solutions to terrestrial challenges through technology that is or will be deployed in space."**
>
> **Lorna Stark**
> Line of Business Leader, Government andw Healthcare, KPMG

"To realize a $1 trillion space economy by 2040, we must continue to unleash private enterprise and rely on government experience to provide the demand signals, the frameworks, and the security that incentivize market action.[5]"

The Morgan Stanley report demonstrates this shift, estimating that, "the revenue generated by the global space industry may increase to more than $1 trillion by 2040."[4] The thriving commercial space sector, which is driving the industry's horizontal expansion, is fueled by a diversification of space activities. This encompasses space tourism, satellite constellations for global internet coverage, pharmaceutical research, in-space assembly and manufacturing, and asteroid mining, all of which contribute to the industry's transformation.

The evolving space industry now attracts individuals driven not only by the allure of exploring space turning science fiction into reality, but also by the opportunities it presents for pioneering new enterprises, generating prosperity, and fostering employment. This newfound perspective highlights the tremendous potential and promise the maturing sector holds. Indeed, the space industry's growth is increasingly recognized as a powerful catalyst for groundbreaking advancements and economic development. This shift in perspective has far-reaching implications, as it challenges the notion that space is an isolated domain. The integration of space technology into various terrestrial industries, such as telecommunications, agriculture, transportation, and energy, has created new market opportunities and driven innovation across a multitude of sectors. The US Chambers of Commerce identified the need to broaden to the space economy beyond the confines of the traditional vertical to seize the opportunity. "To realize a $1 trillion space economy by 2040, we must continue to unleash private enterprise and rely on government experience to provide the demand signals, the frameworks, and the security that incentivize market action."[5]

Moreover, the horizontal expansion of the space industry has prompted the development of a new space ecosystem, complete with new participants, business models, and investment opportunities. As an example, the growth of small satellite constellations has disrupted traditional satellite manufacturing and launch markets, providing cost-effective and frequent access to space for a myriad of applications, including Earth observation and global connectivity.

The space industry's intersection with terrestrial industries highlights its transformative potential as it evolves into a horizontal, multisectoral domain. As the space industry expands from a vertical to a horizontal framework, it emphasizes its increasing relevance and impact on the global economy and its capacity to spur technological advancements and economic growth.

In conclusion, the horizontal expansion of the space industry marks a significant paradigm shift, challenging the conventional perception of space as an isolated domain dominated by national governments and instead highlighting its integration with various terrestrial industries. The increasing commercialization of space activities, led by pioneering private companies, has fueled this transformation, created new market opportunities and drives innovation across sectors. As the space industry continues to expand and permeate many aspects of human life, it holds significant potential to revolutionize industries and address global challenges.

Key considerations

1. How can organizations adequately prepare to capitalize on the emerging market opportunities presented by the convergence of space and terrestrial industries, and identify sectors where space technologies could have a transformative impact?

2. As the space industry transitions from a vertical to a horizontal model, what strategies should businesses adopt to navigate the complex integration of space technology within their terrestrial operations, and mitigate the potential risks involved in venturing into this new domain?

3. How can governments and private investors work together to support the development of the space economy, while ensuring an equitable distribution of benefits and opportunity and minimizing potential environmental and geopolitical risks associated with expanding commercial space activities?

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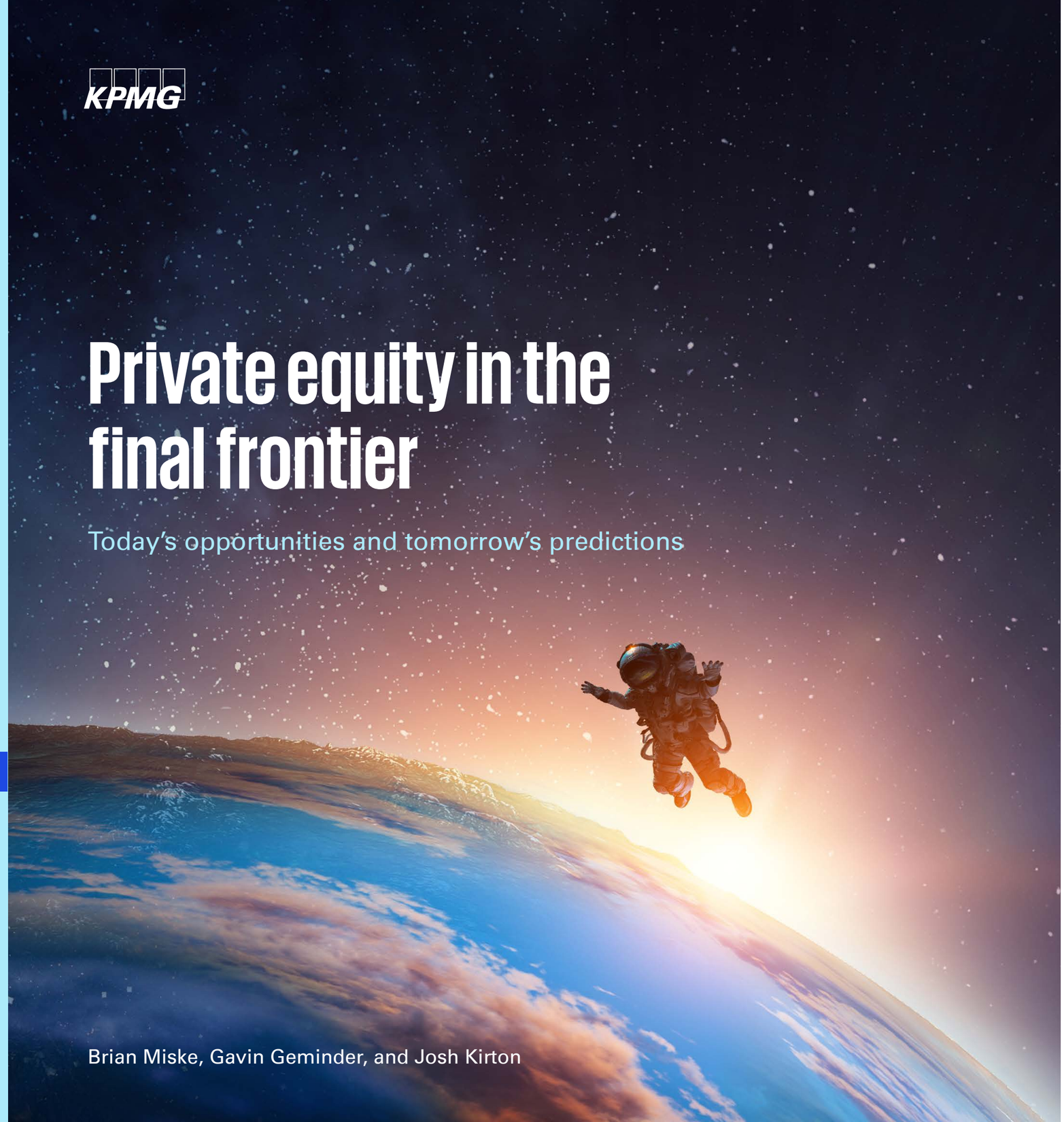
Private equity in the final frontier

Today's opportunities and tomorrow's predictions



Brian Miske, Gavin Geminder, and Josh Kirton

Abstract

This provocative article examines the burgeoning role of private equity in the commercial space sector. It canvasses the current investment landscape, characterized by an influx of investors seeking growth in the high-stakes arena of space commerce, and contemplates the future of these ventures. Against this backdrop, the article posits a thesis that these new entrants are encountering a unique set of challenges that necessitate inventive approaches and strategic foresight. The core intellectual offering of this piece is the "Space Integration Ladder," a strategic framework devised to assist these industries in evaluating their space venture readiness and plotting a pragmatic course toward not just aiming for but also securing a stronghold among the stars. This article is poised to serve as a vital strategic compass for private equity firms eager to navigate the space economy's complexities and to stake their claim in what may be the final frontier of commercial enterprise.

Introduction

The allure of space—the infinite expanse with its celestial bodies and boundless opportunities—has long captured human imagination. Today, it beckons a new category of explorers: private equity firms and innovative sectors aiming to commercialize the cosmos. This article thoroughly examines this nascent venture field, where the potential for growth is as vast as space itself. However, the leap into this final frontier is not without its perils. This article not only charts the current investment landscape marked by a seismic shift from government to private undertakings in space but also diagnoses the unique challenges that await the uninitiated and the prepared alike.

In recent years, the commercial space industry has been catapulted from science fiction to tangible reality, evolving into a competitive theater where startups and behemoths alike strive to claim their stake. Visionary entities such as SpaceX, Blue Origin, and Virgin Galactic have demonstrated that space is no longer an exclusive playground for superpowers but a field ripe for private ingenuity and capital. These pioneers have catalyzed a dynamic investment ecosystem—one where technological leaps, declining launch costs, and an expanding market create a fertile ground for financial engagement; according to PitchBook, the space tech market is poised to grow at an 11% CAGR to $321B by 2025.[1] Yet, the celestial

market presents a new stratum of investment considerations for private equity firms used to earthly enterprises, from orbital mechanics to extraterrestrial resource rights.

The unique challenges facing private equity in space extend beyond the complexities of rocket science. This article delves into the specific hurdles that distinguish space finance: operational risks spanning from launch anomalies to the harsh space environment, prolonged capital lock-in periods, and an evolving regulatory framework yet to catch up with commercial ambitions. The journey to profitability in space ventures is a marathon, not a sprint, punctuated by regulatory uncertainties, such as the Federal Communications Commission (FCC) in the US issuing its first fine for space debris[2] and the need for substantial, patient capital.

To demystify these challenges and enable investors to set a course for success, we introduce the "Space Integration Ladder"—a thorough framework that allows private equity firms to evaluate their strategic position and readiness for engaging with the space economy. This tool is designed to help firms not only venture optimistically into space but also do so with a calculated trajectory that helps maximize the probability of successful orbit in the commercial space sector. It is a synthesis of market wisdom, technological assessment, and strategic acumen—a guide for those who seek to pioneer responsibly and profitably in the high frontier. As we embark on this exploration, the article provides a panoramic view of today's opportunities and crafts a predictive lens to glimpse tomorrow's fiscal considerations.

> **The space tech market is poised to grow at an 11% CAGR to $321B by 2025.**

> **The 'Space Integration Ladder' is our North Star in the celestial realm of space investments. It's more than a framework; it's a roadmap to success. From the Foundation stage, where we evaluate our readiness and forge key alliances, to the Expansion stage, where we boldly explore new frontiers, this ladder guides us through the complexities of space commerce. With it, private equity firms can make informed decisions, navigate the unknown, and secure a lasting foothold among the stars."**
>
> **Gavin Geminder,**
> **Advisory PE Leader at KPMG**

The Space Integration Ladder: A framework for success

As private equity and nontraditional players set their sights on the commercial space sector, the ***"Space Integration Ladder"*** emerges as a vital framework to facilitate their successful entry and progression. This tailored model enables firms to measure their space sector investment readiness and craft strategies attuned to the industry's unique intricacies.

Structured into three progressive stages—Foundation, Growth, and Expansion—the ladder provides a roadmap for ascent.

FOUNDATION

At the Foundation stage, firms take stock of their technological acumen, sector-specific knowledge, and resource base, then begin exploring strategic alliances with established space entities, deploying smaller capital allocations to test, learn, and lay the groundwork for future endeavors.

GROWTH

Moving up to the Growth stage, the focus shifts to utilizing strategic partnerships and tapping into the market's momentum to foster advancement. It's at this pivotal point that firms must weigh venture choices against a backdrop of risk assessment, capital deployment, and projected returns, ensuring alignment with their overarching investment goals.

EXPANSION

The pinnacle, the Expansion stage, represents a firm's full-fledged immersion in the space economy, marked by exploring opportunities in vertical integration and emerging technologies. This level demands an expansive strategic outlook and unwavering commitment, with an emphasis on scalability, competitive positioning, and revenue diversification. At this juncture, firms not only participate in the space value chain but also shape its future trajectory.

Private equity pioneers in the space economy – Illustrative transactions:

KKR | RFA Rocket Factory

In August 2023, KKR completed a €30 million convertible bond investment in launch service provider Rocket Factory Augsburg AG (RFA) alongside existing strategic investor OHB. KKR believes that RFA's launch service offering is well-positioned to benefit from the growing global demand for cost-effective and flexible access to space. According to KKR Partner Christian Ollig, "[RFA's] exceptional track record of achieving technical milestones and their unwavering focus on cost leadership are precisely the right strategy for future success in the global marketplace."[7]

Advent International | MAXAR

In May 2023, Advent International, alongside minority investor British Columbia Investment Management Corporation, completed their acquisition of Maxar Technologies in an all-cash deal that valued the company at an enterprise value of $6.4B. Maxar is a provider of comprehensive space solutions and secure, precise, geospatial intelligence.[8]

Veritas Capital | FRONTGRADE

In January 2023, Veritas acquired CAES Space Systems (later rebranded to Frontgrade Technologies) through a leveraged buyout for an undisclosed amount supported by $68M of debt financing. Frontgrade is a provider of high-reliability, radiation-hardened solutions for space applications. According to Veritas Chief Executive Officer and Managing Partner, Ramzi Musallam, "[Frontgrade] is uniquely differentiated by the breadth of its technical capabilities and segment expertise, as well as its long history of delivering critical solutions to customers…we will deploy our significant government technology experience working with Mike Elias and rest of the [Frontgrade] team to accelerate growth and value proposition to customers."[9]

Private equity pioneers seizing commercial opportunities in the space economy

The commercialization of space shows no signs of slowing down, and investment trends indicate a growing interest from private investors. Since 2014, private investors have deployed $298 billion into 1,832 unique companies.

Private capital is heavily concentrated in specific aspects of the space economy, with investors in the space economy allocating 87% of their capital to the satellites industry. Just 11% of private capital flowed to launched-related companies and a meager 2% to emerging space industries, including logistics, stations, lunar, and industrials.[3] Rapid technological advancements and decreasing costs will continue to disrupt the industry further, offering numerous commercially viable opportunities for private equity firms in the space economy.

Private investment in the space economy, much like in other industries, has not been immune to ongoing macroeconomic challenges like higher interest rates. 2023 saw a 25% year-on-year decline in investment in the global space economy compared to 2022.[4] Yet, the expected improvement in global market conditions driven by forecasted interest rate cuts and continued demand for space services has created optimism for a rebound in space economy investments in 2024 and beyond.[5]

In the future, private equity firms are expected to play an increasingly prominent role in driving innovation and capitalizing on emerging opportunities within the commercial space industry. Accompanied by significant advancements in rocket technology, satellite miniaturization, and space tourism, private equity investments are predicted to fuel the growth of space-related ventures across various sectors.

Private equity firms that strategically position themselves along the Space Integration Ladder and leverage the unique advantages of the commercial space industry are expected to reap substantial financial returns and secure crucial advantages in this evolving landscape. Speaking after the recent investment in Maxar Technologies, Advent International Managing Partner Shonnel Malani commented:

> **[Space] has changed in its risk-return profile. Formerly a high-risk sector, which was typically heavily subsidized by governments, space is now an exciting area of growth that private equity can invest in credibly and responsibly."[6]**

As the industry continues to evolve, private equity firms must closely monitor market dynamics, actively pursue partnerships, and adapt their investment strategies accordingly. Those who recognize the immense potential of the final frontier and successfully navigate the ever-changing space industry landscape can expect to harvest remarkable rewards while charting a path into previously unexplored realms.

Space Integration Ladder overview:

The Space Integration Ladder is a visual framework that helps companies assess their readiness and strategically position themselves for success in the commercial space industry. It consists of three distinct stages: Foundation, Growth, and Expansion.

FOUNDATION STAGE:

Firms at the Foundation stage conduct thorough assessments how space economy investments align with the risk/return profile of current and future funds, resource availability, and sector-specific expertise to confirm their readiness for space-related investments. This involves seeking to forge pivotal strategic alliances with established space entities and identifying priority external hires to bolster the depth of available knowledge. With this knowledge, firms at the Foundation stage begin to deploy capital to test and learn.

GROWTH STAGE:

Ascending to the Growth stage, firms actively exploit market opportunities and pursue strategic collaborations to propel their presence in the space sector. Here, the imperative is to judiciously select partnerships and investments in space ventures, ensuring they are in harmony with the firm's risk/return profile, investment horizon, capital commitments, and technical expertise.

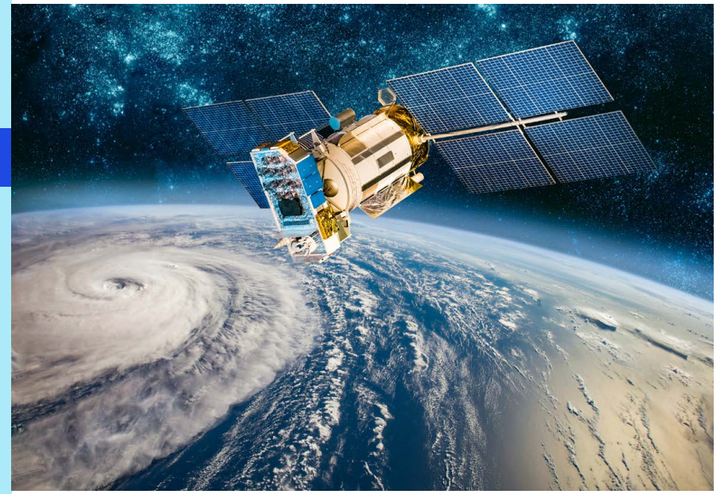
EXPANSION STAGE:

At the apex, the Expansion stage, firms are deeply enmeshed in the space sector's value chain. This stage is marked by the exploration of opportunities in vertical integration or the advancement of nascent space technologies, such as space-based services, the direct establishment of a space presence, satellite launches, or involvement in space tourism, indicating a firm's ambition to double down on commercial space opportunities.

Using the Space Integration Ladder:

Stage 1: Foundation—developing a robust base and strategic vision for venturing into space investments.

1. Analyze how exposure to space economy investments aligns with the risk/return profile of current and future funds.
2. Benchmark your capabilities against industry standards to understand your competitive stance.
3. Analyze the space economy and develop a strategic plan outlining clear objectives for entering the sector and priority areas to begin investing capital.
4. Identify the skills and industry acumen needed to make and oversee future space economy investments and, where needed, deepen the depth of available knowledge through external hires.
5. Initiate dialogues with established space companies, research institutions, and technology providers to build networks with subject matter experts.
6. Start with smaller capital allocations to test the waters and learn about commercial opportunities in the space economy.



Stage 2: Growth—establishing strategic partnerships, calibrating investment choices, and positioning for growth within the space sector.

1. Negotiate and formalize partnerships or joint ventures that enable shared resource utilization, risk mitigation, and knowledge sharing.
2. Leverage partnerships to gain access to subject matter professionals with insights into industry trends, regulatory environment, and technological advancements.
3. Develop a portfolio approach to balance high-risk, high-reward ventures with more stable investments, ensuring alignment with the risk/return profile of current and future funds.
4. Invest in capacity-building within your firm to ensure you have the expertise to manage and support space economy investments effectively.

Stage 3: Expansion—fully capitalizing on commercial space opportunities by exploring vertical integration and nascent technologies.

1. Review and refine your investment strategy to emphasize scalability and sustainable growth within the space economy.
2. Explore opportunities for vertical integration or the development of emerging space technologies to establish a competitive edge.
3. Consider larger, more transformative investments or acquisitions that can significantly advance your position in the space economy.
4. Stay abreast of trends and technological breakthroughs to ensure your firm remains a relevant and dynamic player in the market.

Conclusion

Embarking on the Space Integration Ladder is an exhilarating journey of perpetual evolution, strategic refinement, and bold progression. Private equity firms embracing this model commit to a vibrant cycle of meticulous evaluation, robust development, strategic alliances, discerning investments, and ambitious scaling. By systematically advancing through each echelon of this framework, they sharpen their competitive edge and align their operations to seize the boundless prospects emerging within the rapidly expanding commercial space frontier. This is not merely a process, but also a strategic odyssey that propels firms to new heights of industry prominence and success in the cosmic marketplace.

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The space imperative

Shifting perceptions in infrastructure and commerce

Brian Miske

Abstract

Amid the expanding space economy and our increased dependence on space systems for day-to-day functioning, the need to balance risks across the US economy and national security is more pressing than ever. Recognizing space systems as critical infrastructure is crucial for addressing vulnerabilities and fostering a reliable framework for collaboration and proactive risk management. It is evident that traditional and space-adjacent organizations must align with the rapidly evolving space sector, integrate new technologies, and ensure resilience against potential disruptions. Collaborating with NASA, Department of Defense, and the US Space Force presents opportunities that will shape the future, ensuring responsible utilization and global security.

In an interconnected world, our reliance on space systems for day-to-day operations is becoming increasingly evident. As the space economy expands, so does the economic impact of various market segments within the space sector, raising the need for examination to balance risks across the US economy and national security.

One crucial step in the modernization effort is to designate space systems as part of the national security infrastructure. The vulnerabilities within the space sector stem from inconsistencies in implementing security best leading practices, dependence on outdated technology, and the use of unencrypted communication networks.

While the 1960s space race was marked by competition and the historic moon landing, today's space race involves a broader range of global participants, focusing on collaborative missions, the growth of commercial space endeavors, and technological advancements. This ultimate progression is accompanied by controversy and complexity related to concerns about space weaponization, strategic competition, and conflict extending beyond Earth and the need for regulatory frameworks to address geopolitical tensions and ensure the peaceful and responsible use of outer space.

The inclusion of space systems into critical infrastructure highlights the interconnectedness between space-based systems and other crucial sectors, emphasizing the dynamic nature of cyber threats and security.

Adding the 17th sector — space systems

The significance of space systems and other space segments as critical infrastructure can't be understated.

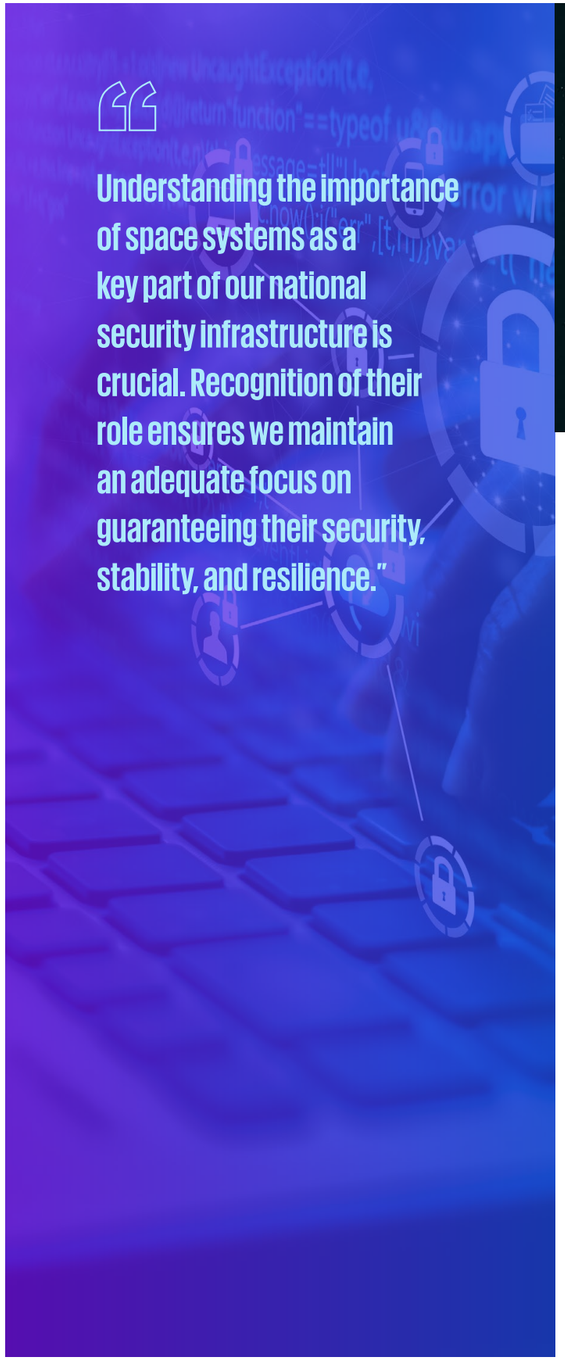
"In the United States, there are 16 critical infrastructure sectors whose assets, systems, and networks are deemed vital. The incapacitation or destruction of these sectors would have a debilitating effect on national security, economic security, public health, or safety."[1]

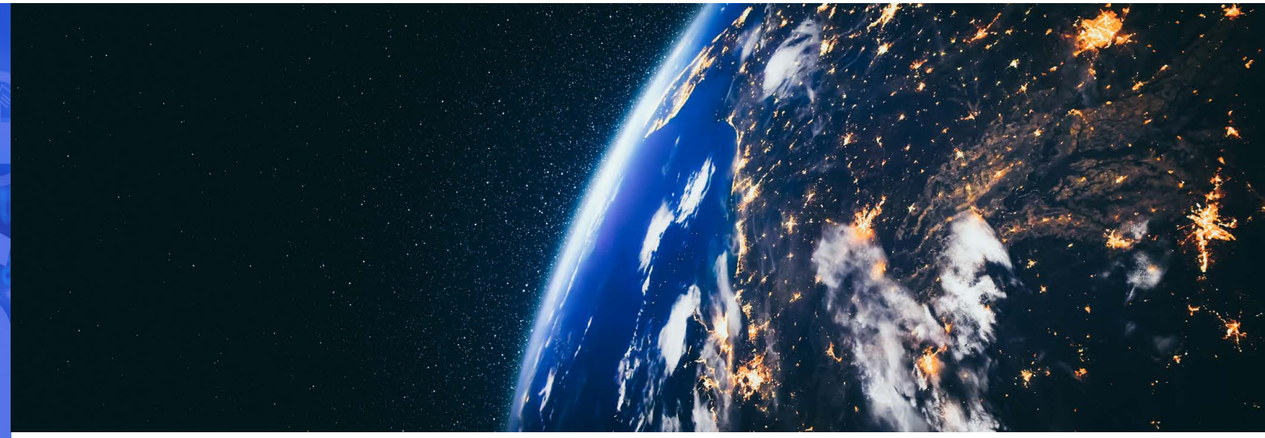
As a result, it is essential to acknowledge space systems and space segments as part of critical infrastructure in order to ensure their security and resilience. This recognition aligns with Presidential Policy Directive 21 (PPD-21) and supports the national policy to strengthen and maintain secure, functioning, and resilient critical infrastructure.[2]

Recognizing space systems as critical infrastructure would facilitate a robust framework for collaboration between the government and the sector, deemed vital to U.S. interests. It would enable more efficient information sharing, particularly in regards to escalating threats such as satellite hacking. Additionally, it would outline clear responsibilities within the sector to proactively manage risks against state-sponsored cybercriminals and hackers, boosting resilience and security within this fast-growing sector.

Cyber threat and security

Cyber threats and security must do more than simply keep up with malicious actors; they must also foresee and address the wider, interconnected challenges facing the ecosystem of space systems, including their commercial, civil, and military interdependencies. In today's increasingly digital world, cybersecurity threats against satellites are a very real concern. Malicious actors can introduce malware into the systems of these orbiting devices, enabling them to gain control, disrupt operations, or even sever communication with terrestrial systems. In extreme cases, such a cyber assault might provoke a satellite's systems to overheat to the point of explosion, resulting in a catastrophic 'kinetic boom'.





Furthermore, the intentional distortion of clock systems by cyber malware presents a considerable risk. This potential disruption has serious and widespread implications, impacting everything from governmental operations and commercial activities to civil services and various critical infrastructures. The impairment of essential systems such as navigation and communication networks and precise timing applications across multiple industries can significantly threaten national security, disrupt financial markets and even impact personal mobile devices.

Understanding the importance of space systems as a key part of our national security infrastructure is crucial. Recognition of their role ensures we maintain an adequate focus on guaranteeing their security, stability, and resilience.

Given the complex and diverse nature of the space sector, careful consideration must be given to designating specific space system assets as critical infrastructure. While certain elements such as launch facilities and commercial satellites already fall under the umbrella of critical infrastructure sectors, relocating them under a designated space systems category could have secondary and tertiary effects on existing communication and coordination operations. It is essential to strike the correct balance between speedily enhancing security and resilience in the space sector and avoiding possible harm to the now protected systems.

NASA's role in space sector risk management

The idea of appointing NASA as the space sector's risk management agency (SRMA) has sparked industry discussions, with focus on its expertise and industry connections. Yet, effectively managing cryptographic risks and cyber resilience could require specialized capabilities within the selected agency.

The evolution of the space sector, as it becomes a crucial component of modern infrastructure, demands a re-evaluation of its recognition as a vital area. This re-evaluation should include a thorough examination of vulnerabilities extending to the space sector, taking into account both immediate security risks and the potential of the sector, encompassing innovations such as asteroid mining and expanded telecommunication capabilities.

While these developments are promising, the industry must ensure it addresses vulnerabilities and endeavors to create a future that effectively balances risks and opportunities.

The trajectory of our space endeavors in the years to come could be influenced by the way we approach recognizing space systems as critical infrastructure. Our responses could dictate our advances and effectiveness in space utilization, set a model for global cooperation or competition, and above all,

determine the security of our everyday terrestrial lives. As the voices advocating for extensive inclusion of space systems as critical infrastructure grow louder, our responses could shape the future we share.

Accelerating integration of commercial and defense

The shift in military operations towards using commercial space assets shows the increasing importance of space systems for national security. The Pentagon's upcoming commercial space strategies aim to transparently outline how private space companies will be integrated into military missions, underscoring the growing reliance on private space technologies in defense. The U.S. Space Force is setting clearer guidelines for working with space companies, creating opportunities for traditional and nontraditional space organizations to be directly involved in military space operations. "The strategies are coming as the Department of Defense deepens its relationships with commercial space companies".[3] The new strategy will define specific roles for space companies, allowing them to offer valuable services like space domain awareness and collision warnings. This opens the door for traditional and nontraditional space companies to provide specialized services to the government.

As geopolitical and global economic challenges evolve, adversaries advance in space capabilities. Collaborating with NASA, DoD, and Space Force's commercial strategies creates chances for space companies to handle various operations, from regular procedures to crisis response, which boosts their importance in the global space community and opens up opportunities to generate revenue.

The participation in the Pentagon's responsible space behaviors and collaboration with the US Office of Space Commerce further elevate the significance of traditional and space-adjacent organizations within the international space community and emphasize their role in commercial and military space operations.

This underscores the importance of acknowledging space systems as a crucial component of the national security infrastructure. The rapid pace of transformation in the space and related industries presents significant hurdles, revealing the interwoven relationship between space system operations and national security, particularly through issues such as inconsistent security practices and outdated technology. The possible designation of NASA as the agency responsible for managing risks in the space sector also underscores how closely linked space systems are to national security, necessitating a comprehensive strategy to address vulnerabilities and promote responsible space usage and global security.

Leaders across traditional and nontraditional space organizations need to ask new questions with growth opportunities. These discussions emphasize the intricate balance needed to maximize the opportunities presented by space systems while managing the associated risks, especially in the face of growing threats and the changing landscape of space security.

> **The trajectory of our space endeavors in the years to come could be influenced by the way we approach recognizing space systems as critical infrastructure.**

> **"The rapid pace of transformation in the space and related industries presents significant hurdles, revealing the interwoven relationship between space system operations and national security, particularly through issues such as inconsistent security practices and outdated technology."**
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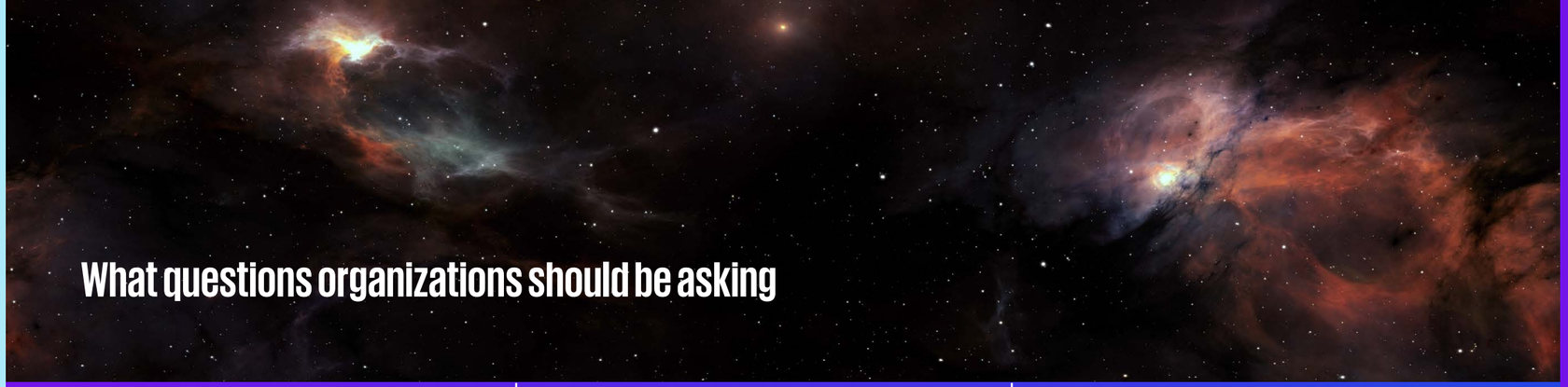

What questions organizations should be asking

Traditional space sector organizations

How do we adapt to the rapidly evolving technology in the space sector?

Traditional space organizations should be probing their ability to adapt and evolve alongside emerging technologies. With advancements like reusable rockets, miniaturized satellites, and breakthrough propulsion technologies, maintaining competitiveness and relevance entails staying at the forefront of innovation and incorporating these technologies into their operations.

Are we adequately prepared for space's increasing role in global security?

Given heightened geopolitical tensions and the weaponization of space, traditional space organizations should evaluate their readiness to navigate the evolving landscape of space security. This includes assessing capabilities in cybersecurity, space situational awareness, and potential countermeasures.

Space adjacent organizations

How can we leverage space technology to enhance our existing operations and value propositions?

Satellite telecommunications, Earth observation data, and other space-based technologies can serve to greatly improve operations in many sectors, from logistics and agriculture to climate science and defense. Space-adjacent organizations should, therefore, be considering how to effectively and efficiently integrate these technologies to achieve strategic advantages.

Are our systems resilient against potential disruptions to space services?

With an increasing dependency on space-based services, space adjacent organizations need to evaluate their resiliency and contingency strategies should these services be compromised. This involves assessing their reliance on GPS navigation, satellite communications, and other such services, and planning for alternatives or redundancies in the case of an outage.

Commercial organizations

Can we operate under the legal and regulatory frameworks governing space activities?

The legal and regulatory environment for space is complex and highly variable, involving a mix of international treaties and national regulations. Commercial organizations venturing into space activities should assess their compliance with these regulations to avoid costly legal entanglements and ensure responsible space practices.

How can we ensure the sustainability of our space operations over the long term?

Factors such as space debris pose significant challenges to the sustainability of space operations. Commercial organizations should, therefore, ask if they have sound practices in place for mitigating debris and ensuring the long-term viability of their orbital assets. Sustainability also extends to financial prospects, so understanding market dynamics and customer needs is critical as well.

Conclusion

Traditional space organizations and space-adjacent industries are urged to act swiftly and adapt to this evolving landscape. As space technology increasingly plays a key role in global security and daily operations, traditional space organizations should focus on integrating cutting-edge technologies such as reusable rockets, miniaturized satellites, and state-of-the-art propulsion systems. Moreover, they must bolster their capabilities in cybersecurity and space situational awareness to navigate the heightened geopolitical tensions and weaponization of space. On the other hand, space-adjacent industries should proactively leverage space technology to enhance their existing operations across multiple sectors, including logistics, agriculture, climate science, and defense. It is essential to ensure that these organizations possess resilient systems capable of withstanding potential disruptions to space services, emphasizing the need for alternative plans and redundancies. Commercial organizations venturing into space activities need to ensure strict compliance with legal and regulatory frameworks governing space activities while also setting the stage for sustainable space operations and understanding the dynamic financial prospects within this rapidly growing sector. Therefore, it is paramount for both traditional space organizations and space-adjacent industries to proactively adjust and prepare their operations as integral components of these rapidly evolving and interconnected space systems. Management agencies, address vulnerabilities and chart a course toward responsible space utilization and global security.

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Ethical considerations in the space value chain

Lee Anderson and Brian Miske

Delving into the moral dimensions of commercial space endeavors, we assess the responsibilities and obligations of stakeholders across the value chain, ensuring both growth and fairness.

The new space era of ethics

Space exploration has always required navigating ethical questions. From the high-risk nature of human space flight to the origins in weapons technology and wartime competition, governments were solely responsible for the public perception of space exploration and for the consequences when things didn't go as planned. In the new space age, however, the number of participants has increased exponentially as has the role of the private sector. That transfer of stewardship from public to private hands brings us to an inflection point where ethical questions take on a new urgency. We are not only challenged to anticipate the impact of space exploration at a higher volume, but also that of a true space economy. Across the value chain, organizations and governments must bring self-awareness and long-term thinking into their decision-making.

Navigating ethics within exponential change

As the space value chain integrates more completely into our global infrastructure and national security operations, the pace of change introduces unique challenges. Private organizations who are leading the charge in modernizing space systems are moving faster, and with fewer guardrails, than their government counterparts. New customers and new industries are being courted, and new business models emerging based on lower launch costs and increased accessibility to different space environments.

Additionally, the increase in activity has prompted a higher level of awareness among the public. For many, this becomes a question of opportunity cost: why are we spending so many resources in space, when we have so many problems to address on Earth? This pervasive argument requires organizations to be clear on the benefit of their activities to Earth's stakeholders, and to have an effective communication strategy.

Because space is considered nonsovereign territory by the Outer Space Treaty, there are many unanswered questions about the ethical use of resources in space, and how to ensure it remains a stable environment for all stakeholders on Earth. Resources can be rare minerals and water, or even real estate. There is much we do not know about how the increase in launch activity and number of satellites on orbit will impact the environment. Questions such as, "What is happening to the atmosphere when space craft burn up on re-entry?" or "What if the Kessler Syndrome were to occur?" are becoming more urgent.

The lack of regulation creates a kind of Wild West, first-come-first-served environment. It also creates a perverse advantage to moving quickly before too much data exists that might lead to regulatory bottlenecks. All of these dynamics and more are creating a complex landscape for decision-makers whose businesses depend on space-based activity. The exponential changes in activity, impact, and awareness bring up challenging questions about how to grow a scalable space economy while maximizing benefits to people on Earth.

Value chain:
Optimizing risk through an ethical lens

Increased activity in space comes with risk, and it is the responsibility of leaders in the space sector to ensure those activities provide more benefit than they create harm. Across the value chain, consideration of direct and indirect ethical implications can help businesses optimize risk. Separating the exercise of ethical risk optimization from organizational risk helps distinguish ethical considerations that could have adverse impacts on the business. This analysis can be summarized with two key assessments: (1) clarity on the benefits the activities generate – what is the value and who benefits, and (2) know what to track for a clear and up-to-date view on potential risks or harm. By plotting this assessment across the value chain, organizations can see both potential opportunities for value add and potential areas of adverse impact in their space activities.

UPSTREAM

Organizations will be considering the impact of resource extraction and processing, manufacturing, and launch. The direct implications are highly localized and direct to specific communities, while indirect implications are global and impact everyone on Earth.

MIDSTREAM

Organizations will be considering the applications of data, cybersecurity and data protection, and the servicing of satellites in orbit, including the International Space Station. Questions about what belongs in space, who is responsible, and how to govern without regulation will be top of mind for organizations, regulators, and the public.

DOWNSTREAM

Organizations will be considering the actual and potential return of space-sourced resources to Earth, the marketing and advertising of and in space environments, and the premise of space tourism. Highly visible downstream activities are prime opportunities for public messaging about the why of space exploration, and the value returned to people on Earth.

> "With the trend toward greater horizontal activity in space, evidenced by the dramatic increase in commercialization, while remaining competitive, we will also see a greater degree of collaboration across the space ecosystem. This will benefit not only commercial space companies but governments and the general population as well."
>
> Grant McDonald
> Global Aerospace and Defense Leader, KPMG

1) Potential benefits and beneficiaries of activities on the value chain 2) Potential ethical risks to monitor

- Research and development
- Resource extraction and processing
- Manufacturing and assembly
- Launch services
- Satellite operations and data collection
- Cybersecurity and data protection
- Satellite servicing
- Space ground systems
- Return of resources from space to Earth
- Applications and user services
- Marketing and advertising in/of space
- Space tourism

Current ethical challenges

Innovative organizations are forming to benefit from the lower cost of launch and improved technological capabilities that enhance their core services and make new service offerings possible. At all stages of the value chain, new business models are creating value both directly and indirectly for their customers and broader segments of the population. Satellite communications constellations, for example, promise to make real-time communication possible across the globe, even where current telecom infrastructure doesn't exist. This promises huge benefits and social mobility opportunities, and the chance to leapfrog expensive infrastructure projects. However, access to these new channels has already been subject to ethical debate regarding who should have access, when, and who controls access.

Other new business models depend on space-based data gathering. Broadly speaking, these businesses create or pay for access to different Earth observation capabilities and the analytics layers that turn that data into actionable information. Much of this data is used in ways that benefit people on Earth and provides economic value. However, ethical questions around how the data is used and preserved, especially with the increasing application of artificial intelligence and machine learning, are bringing awareness to the risks related to surveillance and equity.

In addition to daily lives and livelihood being considered, our use of the space environment is also an ethical challenge. The risk is very real for space to become inaccessible if responsible behavior in orbit is not followed. Space debris remediation is an urgent priority for the global space community as the cadence of launch increases and our reliance on space-based infrastructure gets further entrenched. Beyond Earth's orbit, we have been sending and leaving "stuff" on the moon and Mars for decades. As activity increases, organizations will need to be transparent about their efforts to preserve space environments based on what we have learned from unintended consequences to our environment on Earth.

Who gets to put things in space or go to space is largely a question of economic means. What you can do once you get there, beyond the bounds of prelaunch guardrails like ITAR, is largely unregulated. It is in these unregulated grey areas that ethics become our strongest tool for ensuring sustainable access to the space environment in the long term.

Leaders in ethical behavior will seek to understand the potential social and economic disparities introduced through their activities and those of the broader industry. Those organizations will also monitor the long-term implications of their activities, across the value chain, to Earth and to the space environment. Equally important to risk mitigation is wide-spread value creation. Clearly articulating the known benefits, engaging with those communities to ensure the impact is known, and measuring the impact over time will help space organization remain aware of added value opportunities.

Ethical challenges differ for different stakeholders:

Government space agencies

Stewardship:

How to support a robust and diverse economy?

How to protect our nation's critical infrastructure?

How to create coalitions and allies in the space ecosystem?

Private industry (start-ups, incumbents)

Access:

Who gets to go to space?

What should we send to space?

Perception:

How to communicate the broad-reaching benefits of a space economy for Earth?

Policy makers

International norms:

How to govern without regulation?

How to regulate while supporting innovation?

How to protect the space environment from bad actors?

Who owns resources mined in space?

Customers and space-adjacent

Intentions:

How to support a robust and diverse economy?

How to protect our nation's critical infrastructure?

How to create coalitions and allies in the space ecosystem?

Position your organization to be a leader

There is incentive to create better systems for tracking the impact of space activities on the economy. Demonstrating to governments, investors, and the public how space activities can improve quality of life and safety for people on Earth can help sustain and propel the progress made over the past two decades. A challenge remains in tracking the adjacent impacts of the industry, which are difficult to map comprehensively, much less quantify. However, the direct impacts such a weather monitoring and access to information are compelling enough to want to protect and expand access.

Public perception and discourse will continue to be a catalyst for identifying ethical questions that businesses should account for in their decision making.

The beneficiaries of space activities won't all be shareholders. However, the broader public might not be aware of how space activity benefits them. Similarly, those who are likely to experience the most harm may not have a voice in the room or a seat at the table. An ethical approach would ensure that leaders in the new space era take the following steps, proactively mitigating harm to lives on Earth and in space, in the pursuit of a sustainable space economy:

1. Building ethical considerations into the business model
2. Understanding and communicating the benefits to customers and broader populations
3. Awareness of risks and a clear strategy for monitoring key indicators
4. Ethical governance to abide by both regulations and agreed norms.

> "In an interconnected cosmos of industries and markets, the ethics of space exploration and operation must spread horizontally across the entire value chain for true success to be achieved."
>
> Brian Miske, National Ignition Leader, KPMG

How KPMG professionals can help

Government space

Collaborating with state and federal governments on key space matters, including policy and program design, implementation, and economic analysis

Legal and Regulatory

Helping to navigate the complexities of the legal and regulatory compliance requirements of operating in space

Reporting and predictive modeling

Customizing reporting solutions, data visualization, and intelligent forecasting to maintain up-to-date view of operational impacts for informed decision-making in the space ecosystem

Strategic Business Planning

Developing tailored business plans, incorporating market insights and regulatory guidance to help ensure the successful execution of space initiatives

Risk Mitigation

Working with leadership to establish enterprise risk management and monitoring for impacts related to doing business in the space ecosystem

Contributors

Brian Miske
National Ignition Leader, KPMG
bmiske@kpmg.com

Gavin Geminder
Advisory PE Leader, KPMG
ghgeminder@kpmg.com

Grant McDonald
Global Aerospace and Defense Leader, KPMG
grantmcdonald@kpmg.bb

Neil Rae
Director, UK Head of Space, KPMG
neil.rae@kpmg.co.uk

Jacob Hacker
Head of Strategy and Enablement, KPMG
jhacker1@kpmg.com.au

Lee Anderson
KPMG Ignition
leeanderson1@kpmg.com

Kristin Haug
Head of Financial Services, KPMG Ignition
khaug@kpmg.com

Josh Kirton
KPMG Ignition
jkirton@kpmg.com

Will Lewis
Director ACSP
will@acsp.space

Dr. Hina Kazmi
Director ACSP
hina@acsp.space

Zaheer Ali
COO, Positon AI & Professor at ASU
Thunderbird School of Global Management
ali.zaheerabbas@gmail.com

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