

Entrepreneurial Opportunities and Trends in the Emerging Global Space Ecosystem

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Abstract

We are at a watershed moment. The world's most innovative minds are now reimagining space in terms of an off-earth global economy geared toward the production of goods and services for the enhancement of life on Earth. In 2021, the global space economy rose to \$469 billion US, the largest annual growth since 2014. Additionally, today's space economy is 55% higher than a decade ago, resulting from a five-year trend of uninterrupted growth.

The global space ecosystem has created new channels for commerce to flow and for business to be done, and every day the future is being built. A domain once only accessed by governments, space today is the pioneering home for new products, services, and approaches that are redefining critical infrastructure while creating new jobs and innovations that benefit more people than ever before. Perhaps more significant will be the creation and energization of secondary and tertiary markets. As we continue to push the boundaries of what is possible, people from all walks of life are required to grow and sustain these new industries.

This paper will focus on entrepreneurship in the global space economy and will discuss emerging market segmentation and trends along with the opportunities, challenges, and skillsets required to grow into and grow within this burgeoning ecosystem. Utilizing the key concepts of Space Foundation's Space Commerce Institute, this paper charts a course that would allow the future workforce to self-select into this exciting industry and find their place within it. Space Commerce Institute was designed to keep pace with the rapidly changing landscape to provide participants with the right tools and guidance to stay ahead of the curve.

The goal is to better understand tactics and strategies to enhance new business creation and workforce development in the space industry. There is a place for everyone in the emerging global space ecosystem. This talk will help illuminate how to choose the right path.

Keywords: Space Entrepreneurship, Space Adjacency, LEO Commerce, Space Market Segmentation, Space Commerce, Space Economy

1. Introduction

The Global Space Economy is at a watershed moment. Not long ago, humans engaged with space as a means of exploration and national security in an effort spearheaded by the wealthiest nation-states. Space was a canvas, a proxy, showcasing earth-oriented capabilities designed for earth-bound ends. Over the last decade, our very conception of space has changed. Now, the world's most innovative minds are reimagining space in terms of an off-earth global economy geared toward the production of goods and services for the enhancement of life on earth or beyond; moreover, this sector is growing rapidly. Just this summer, the Space Foundation [1] reported that the space economy reached \$469 billion last year, the largest annual growth since 2014; in 2020, Morgan Stanley [2] projected revenue generation of more than \$1 trillion by 2040.

The parameters of the global space ecosystem have expanded, shifting from an earth-bound to off-earth phenomenon; accompanying that shift has been a parallel shift in revenue source. Earlier this year, McKinsey & Company [3] reported both an increase and a diversification in private-sector space

investment. The year 2021 saw a record \$10 billion in private investment in space ventures; over the past fifteen years, private-sector funding has also diversified by venture and by orbit, expanding beyond Medium-Earth Orbit (MEO) and Geostationary Orbit (GEO) to Low-Earth Orbit (LEO) and suborbital ventures and to lunar and deep space ventures.

The burgeoning space ecosystem has created new commerce channels and, concomitantly, new opportunities for entrepreneurs. Perhaps of more long-term interest will be the creation and energization of secondary and tertiary markets, whose advent and development will both sustain and increase human space exploration and economic expansion in space. This paper will review the development of human conceptions of space over the past century and will situate the emerging global space ecosystem in relation to this history. It will then analyze this burgeoning space economy, describing emerging market segmentation and discussing the concept of "space adjacency." Finally, it will offer a roadmap for choosing the right path in the global space ecosystem: while each company's entry will look slightly

different, there is a place for everyone in the global space ecosystem.

2. Shifting Conceptions of Space

Human beings have been preoccupied with the cosmos for as long as we have recorded history; it seems that looking outward has forced us to account for the deepest questions we have about ourselves, our potential, and our purpose. Vázquez [4], for example, has suggested that Plato's cosmology bears an important relationship with how that philosopher treated questions of time, change, and eternity.

In the last century, space became a proxy, or indeed a focal point, for the identity not of individuals but of nation-states; the Soviet launch of Sputnik 1 in 1957 ushered in the first space age, and the context of that launch is indelibly linked to Cold War competition between the Soviet Union and the United States. The best and brightest minds on earth therefore conceived of space as an arena for displays of national dominance. Harrison et al. [5] point out that these two powers were responsible for "93 percent of all satellites launched into space" between 1957 and 1990, and further that "the U.S. and Soviet space programs were directly linked to military power, in particular nuclear forces...approximately 70 percent of all satellites launched [during this period] were military satellites." At the outset of actual human spaceflight, world governments, particularly militaries, defined the parameters and strategic direction of space itself.

This was not simply an accidental outgrowth of the Cold War, though NASA was itself formed in response to Sputnik [6]. Rather, it was a concerted effort, especially by NASA administrator and Kennedy-appointee James E. Webb, to carve out what historian Joan Lisa Bromberg [7] calls "a bigger role for government" in the first space age.

In some sense, government and military strategic leadership continues to define our engagement with space today. De Zwart and Stephens [8] show that many new space players, such as India, interact with space primarily as a means of pursuing national security aims and, more properly as a means of displaying —perhaps recklessly—national security capabilities. Since the German V-2 rocket program during WWII, space technology has been linked to military technology, and that fusion continues to shape space exploration to this day [8].

While government funding and government priorities were the catalyst for the first space age and continue to shape important space outcomes, recent archival research underscores the role that a more collaborative vision of space has played in human conceptions of and interactions with space. Davis Cross [9] shows that, while space is often considered

to be synonymous "with high-stakes national competition and conflict," much of space exploration can be "characterized as consistent and purposeful cooperation among space actors." Space, for Davis Cross, has emerged over the past century as an important part of the global commons, a "peaceful domain for all of humankind," and an expression of what she calls humanity's "ultrasocial" nature.

The emerging global space ecosystem carries forward important elements of each of these traditions of human engagement with space. On the one hand, governments still set strategic space goals, provide some funding, and play an important regulatory role. On the other hand, government enterprises are themselves collaborative and international. CBC recently reported [10] on the crucial role Canada will play in NASA's Artemis I mission: "unlike the Apollo program of the 1960s, Artemis is an international effort," and Canada's contribution of key technologies and personnel—including astronauts—will be an important part of that international effort.

Another important feature of the emerging global space ecosystem is the extent to which private and commercial space enterprises are incorporated into this new collaborative, international landscape. NASA announced collaboration with five U.S. companies to develop and evaluate Artemis lander design concepts, leveraging the focused know-how of established firms like Northrop Grumman and the agility of new space companies like SpaceX to return human beings to the moon [11].

Publicly-traded space enterprises also shape fundamental conceptions of space. As key companies such as Astra Space, Momentus, and Rocket Lab go public [12], company boards will respond not just to strategic priorities of the governments under which they are incorporated but also to the strategic and economic priorities of an international group of stockholders. Moving forward, the commercial space landscape will remain anchored by familiar segments, such as governments and major contractors, but will be defined by new and emerging technologies and companies.

According to a 2022 report from the Space Foundation [13], commercial activity accounts for 77% of the global space market: international companies are participating in international, collaborative ventures—and driving the bulk of investment and energy supporting these ventures. In order to take advantage of entrepreneurial opportunities in the emerging global space ecosystem, it's important for individuals and companies alike to understand that the new space age is not unrelated to spacefaring of the past. Rather, in carrying forward two key features of the first space age—competition and collaboration—and combining those key features

with the dynamism and agility of private enterprise, the new space age is at once a natural continuation of human spacefaring and, at the same time, an era that combines competition and collaboration, government leadership and private ingenuity, in ways unique to our contemporary moment.

3. The Global Space Economy: Emerging Market Segmentation

The emerging global space ecosystem is characterized by emerging markets. Since the new space age is fundamentally tied to technological capabilities, technological progression will unlock new marketplaces. New industries will enter the market, in turn unlocking further markets and further opportunities for growth.

It is common for the analysis of elite firms such as Morgan Stanley to divide the space industry into two segments [2]. One segment is elements of the market classically associated with space: aerospace, defense, telecom, and satellite broadband. The other segment is what Morgan Stanley, for example, calls “Second Order Impacts,” which covers everything not classically associated with space. While this breakdown is a useful metric of how much the space industry has progressed beyond defense contractors concerned more strictly with rocket launches and related activities, the term “Second Order Impacts” obscures the dynamic relationship between technological maturation and orbital marketplaces, a phenomenon better captured by the term “space adjacency.”

This is an important pattern for investors, researchers, and companies interested in being part of this phenomenon to recognize, since it opens an aperture for early access to adjacent markets; we project that this progression will be cyclical, characterized by new technological capabilities opening markets, enabling access to further markets and further capabilities around further orbits.

3.1 LEO Market Characteristics

Economic activity in LEO already demonstrates the relationship between technological advancement and market activity. New companies like Rocket Lab and SpaceX have dramatically reduced cost per launch and cost per pound of payload, dropping overall costs of space access for companies eager to benefit from the burgeoning LEO satellite market; this in turn has fostered a dramatic increase in the number of satellites currently in orbit. Baldock [14] found that the combined successes of Starlink, OneWeb, and Project Kuiper have made LEO satellites “one of the hottest topics in the international telecoms sector.” Amazon’s announcement of deals with Arianespace, ULA, and Blue Origin for 83 launches highlights the relationship

between dropping launch costs and growing activity in a particular marketplace: by 2029, the full constellation of 3,236 satellites will have been launched. Compared to the 4,550 satellites total in orbit earlier this year [15], comparative launches by not just Project Kuiper but also competitor companies stand to fundamentally reshape the market.

LEO boasts economic activity beyond the smallsat market; economist Matthew Weinzierl [16] has divided a sample of active commercial space companies into several subsectors, including companies focused on space access, remote sensing, satellite data access and analytics, and habitats and space stations. While Weinzierl’s analysis demonstrates an already-vibrant and growing marketplace in LEO, there are five technological factors, four having to do with launch and one having to do with reentry, that will help open LEO as a whole for business in the way demonstrated by the LEO smallsat market.

Firstly, perfecting reusability for more launch components will extend the lifespan of launch vehicles and bring orbit access within reach like few other factors. Dek et al. [17] commented on the recent trend towards reusability displayed by private space companies, noting the “significant cost reduction and increased economies of scale” reusability affords. Secondly, launches will need to be ever more reliable. A government program with a budget in the hundreds of millions can absorb failures and malfunctions in launch components in a way that a company scraping together \$5 million to launch a satellite with Rocket Lab simply cannot afford [18]. Controlling launch risk will allow smaller companies with leaner budgets to enter the market more confidently: perceptions of safety, here, are a crucial component of market activation. Thirdly, launches must continue to be more routine, which allows companies to make plans based on consistent and reliable schedules. Comparing 2010 and 2022 data from the popular website spacelauncheschedule.com suggests that launches are already trending in this direction, which will help smaller companies without the bandwidth for a bespoke launch participate in this market [19, 20]. These three factors together point to the fourth overarching technological factor: cheap launch. When launch companies can pass savings on to customers, more companies can become part of the space ecosystem.

As capabilities in LEO mature, a fifth technological factor will need to come into play in order for LEO to advance as a marketplace: precision re-entry back to earth. LEO, after all, isn’t simply an arena for satellites; companies engaged in producing goods and services in space for earth delivery will need to be able to trust that space access companies are

also reliably earth access companies, and precious materials need to be delivered safely to their final destination.

The maturation of these five technological factors will spark new industries, such as material miniaturization, and enliven and reshape old ones. The medical sciences, for example, are poised to be fundamentally reshaped by research in LEO: Krishnan Ganapathy comments in *Neurology India* that it is a “sign of the times that [the publication] has deemed it appropriate to bring out a special supplement on ‘Extra-Terrestrial Neurosciences’,” referring to the research performed under microgravity conditions on the LRRK2 gene, research that stands to “contribute to the management of Parkinsonism” [21]. Similarly, market maturation in LEO will fundamentally change the textile industry: the hostile and harsh environment beyond the earth’s atmosphere demands gear that is up to the task, and composites scientists are already hard at work engineering garment solutions for the dangers of space. In one case, Cwalina et al. [22] “demonstrate that replacing the standard neoprene-coated nylon absorber layers with woven aramid textiles intercalated with colloidal shear thickening fluids...can provide a meaningful enhancement to the cut and puncture resistance of the thermal micrometeoroid garment,” protecting astronaut bodies from micrometeoroid and orbital debris particles without sacrificing lightness or flexibility.

As LEO opens and energizes, those seeking to understand the emerging space ecosystem should remember two things. First, the nature of business activity is already diverse. Second, the relationship between technological advancement and orbital access won’t be linear, but rather holistic. In other words, space access companies, to use Weinzierl’s term, won’t cease to be successful once additive manufacturing is a vibrant LEO business. Rather, the space ecosystem in LEO will be an organic whole, and rocketry, data analytics, health research, and textiles will all be mutually supporting industries.

3.2 MEO and GEO Market Characteristics

The next orbits in altitude, MEO and GEO, will similarly require technological advancements to unlock their market potential. In order to travel from LEO to MEO, spacecraft will need to be able to refuel and receive other services, such as repair and maintenance, from LEO; achieving this will untether missions from Earth’s surface.

MEO access is attractive because the perspective of Earth is far more complete: unlike a company like Starlink, which must rely on thousands of satellites to offer full coverage of the Earth’s surface, just three MEO satellites can provide continuous coverage of the Earth’s surface. Applications in communications will

become especially useful once human beings penetrate deeper into space in order to support communications back to Earth, and the same is true of current and future applications in GEO. Because MEO and GEO capabilities in part rely on LEO-based capabilities, market activity in these orbits also points to how the emerging global space ecosystem will be ever-more space-based and space-focused rather than primarily an earth-tied marketplace.

3.3 Beyond Earth Orbits

Once we see the GEO market opening—and further markets into space, such as the moon and Mars—the next wave of technological maturation will likely be long-term human life support. Human beings will be spending increasingly long amounts of time in space; accessing very distant orbits and beyond will require strides in supporting health and well-being on long voyages and in hostile environments.

Any industry involved in sustaining fully flourishing human lies on earth will be implicated in sustaining fully flourishing human lives in space: sectors like energy, health, space habitats, environmental assessment, and agriculture will also become sectors involved in and exposed to the space industry. Space colonization has already captured the imagination of writers and investors alike, but science fiction doesn’t actually grasp the robust marketplace reality: the workforce and the industries engaged in such an enterprise will be incredibly complex and profoundly intertwined.

A popularly exciting industry promises to be asteroid mining. Neil deGrasse Tyson has made headlines [23] for proposing that the world’s first trillionaire will be an asteroid miner. Far from treating ideas like this as a pipe dream, researchers like Hein, Matheson, and Fries [24] are beginning to propose “techno-economy [analyses] of asteroid mining” in order to understand its real economic potential and to translate an idea into a profitable reality. While some investors are already treating asteroid mining as such a profitable reality—Kenneth Research [25] reports that the global asteroid market reached \$1 billion in 2022—there are still fundamental technological challenges that need to be addressed. Perfecting precision re-entry and energy storage will in turn anticipate strides in this exciting marketplace: opportunities in the future can therefore also drive marketplaces and technologies that we perceive as closer to home, helping to bring those capabilities into reality.

4. Nontraditional Entities and Space Adjacency: A Complex Global Ecosystem

A review of emerging market segmentation clarifies how technology-driven market building will

foster orbital marketplaces that are increasingly complex and interdependent. While space in the popular imagination evokes shooting rockets off and high-res space images, the actual marketplace is a more global, varied, and interconnected phenomenon.

According to the Space Foundation's most recent quarterly report, 29.4% of the global space economy in 2021 was devoted to "commercial infrastructure and support industries," a share of the economy valued at \$137.8 billion [13]. Infrastructure maintenance will make neither headlines nor blockbuster movies, yet entities like this account for a plurality of market activity in the emerging space ecosystem.

Morgan Stanley [26] points to 10 key drivers of the "New Space Ecosystem," and it's useful to note the variation between and among these drivers. The global space economy is certainly anchored by entities pursuing satellite launch, satellite internet, deep space exploration, and lunar landings, but the global space economy is just as much driven by companies tackling space debris, manufacturing entities, and space tourism firms. Along with space research, earth observation, and asteroid mining, these ten drivers are notable for their variation as much as they are for their cutting-edge position in the global space ecosystem.

Downstream adoption of space-based capabilities will also mean that end-users will drive demand for new, improved, and tailored space services. The United Nations [27] highlights benefits that space-based functionality already provides for agricultural applications, including data informing decision-makers about soil conditions, rainfall assessment, and irrigation timing. The U.S. Department of Defense and SpaceX are working on cargo shipping solutions that pass through space [28]. Industries like agriculture and shipping as a whole would therefore do well to understand that they are already implicated in the space age and self-select into this economy.

Research and Development straddles the line between utilization of space and enabling space. Companies and laboratories that can further space technology and space capabilities need not focus exclusively on the space ecosystems—or the needs of human beings in outer Earth orbits—in order to benefit from and contribute to the global space ecosystem. At the same time, advanced research and development firms that can recognize their "space adjacency" early will have the opportunity to leverage their position and benefit from the industry.

Students of the global space economy should watch fifteen established and emerging technologies. Some, such as energy and energy storage or satellite servicing and repair, fit with narratives of space technology fostering space economic activity. Others, though, such as material miniaturization, biometrics, or artificial intelligence, are either niche technologies

poised to become major space players or are established and legacy fields traditionally unassociated with the new space age. The new space age—and the emerging global space ecosystem—is characterized less by a proliferation of launch sites. Rather, a vast network of industries and contractors characterize our moment. Such an integrated space economy therefore requires a more capacious definition of space engagement.

5. Overcoming Barriers and Self-Selecting for Space: Challenges to Avoid and Skillsets to Adopt

For individuals and companies seeking exposure to this exploding market, perceived barriers to entry can sometimes cool enthusiasm, yet the market's momentum and complexity mean that there isn't a single roadmap to success for either an individual or a company. This should give prospective entrants hope: this marketplace is remarkably welcoming to customized entries calibrated to particular goals.

5.1 Legacy Industries and Thinking Locally

Members of legacy industries, or individuals who have come to professional maturity in them, such as agriculture, tourism, and transportation, might feel passed by by the new space age, siloed into traditional boundaries of the industry. This can be a real barrier to entry, since ventures will consider themselves already far removed from this ecosystem.

A solution to this problem, and one skill for prospective entrants to adopt, is to think as locally as possible. What industries are in your area—industries that you or your company are already part of and familiar with? Agriculture is a useful worldwide example: many countries count agriculture as a significant component of GDP, and exposure to the space ecosystem with the use of satellite imaging can offer streamlined information without demanding a fundamental shift in current practices, tools, or personnel. The Agricultural and Horticulture Board in the UK estimates that space-based services like this can offer up to an 8% improvement over best yields [29]. Slight industry exposure can therefore yield significantly more profitable results.

While entrants might think locally in terms of industry, they might also think locally in terms of human capital. Many local industries enjoy concentrations of human capital with particular skillsets—from foodservice to chip manufacture and shipping—that can easily be retooled to help serve the space ecosystem. The enterprising entrepreneur can leverage local human excellence for the space ecosystem without reshaping local skills and proclivities. As Morgan Stanley's research shows [26], moving confidently in the new space age is as much about recalibrating legacy talent as it is about

novel technological breakthroughs, and investors and researchers alike should take account of the holistic nature of the industry.

5.2 Investor Hesitancy, Inflated Scale, and Thinking Globally

Two additional roadblocks are investor hesitancy and misperceptions about the scale of investment required. Space can sometimes be perceived as a risky venture; the role that massive infusions of capital have played over the past ten years by space backers like Elon Musk and Richard Branson can also suggest that only billionaires can play in this market.

Thinking globally can redress both of these roadblocks for investors, companies, and entrepreneurs alike. Commercial partnerships at home and abroad can be a good solution for entities seeking market exposure and market literacy without adopting too much risk or infusing too much capital. New and agile space companies are increasingly supported by global investment; investors can diversify their portfolios at a pace and scale suited to their particular needs. Companies can also consider terrestrial applications for their business: many firms will benefit from a strategy that recognizes a variety of opportunities for on-Earth and off-Earth applications alike.

Understanding the capacities of the global marketplace can also allow new entrants to choose an area in which to hyper-specialize: the integrated global ecosystem allows for specialization without having to develop redundancies in, say, launch capacities or spacesuit design. Shared launch and pay-per-pound payload deals can moderate scale of investment.

5.3 Networking and Thinking Connectedly

A final issue facing many prospective entrants to the global space ecosystem is a perceived lack of an established network. Interest is one thing; community and differentiated expertise is quite another.

Individuals and enterprises interested in self-selecting into the global space economy should remember the various consultancies, professional development seminars, and industry conferences that exist to build these kinds of relationships and connections. Entities that can help connect interest with community and with excellence can help jumpstart innovation and connect unique competencies. At the same time, legacy space players should remember the value of outreach as a component of their overall business strategy, offering mentorship, guidance, and support to the next generation of space entrepreneurs.

Space Foundation's Space Commerce Institute [30] was founded to support entrepreneurs and companies alike as they take advantage of the most

dynamic economy in the world. As this paper has shown, each player's exposure to the space marketplace will look radically different: Space Commerce Institute offers pillars of support tailored to each prospective player's unique needs. A dynamic and high-growth company may benefit most directly from Space Commerce Institute's consulting services, while a fledgling entrepreneur may find value in the education courses it offers. Prospective market entrants should take advantage of the rich industry resources, such as those Space Commerce Institute offers, available to them.

6. Conclusion: A Place for Everyone

Everyone's pathway into space will be different. Participating in such a globalized and interconnected ecosystem means that entering and growing in the market can be as customized and unique as the company entering the marketplace. From the beginning, space has been at once competitive and collaborative; as government strategic direction collaborates with private agility and expertise, the new space market will offer proliferating opportunities for a host of legacy and space-adjacent industries alike. New Space is everywhere, and there's a place for everyone in the emerging global space ecosystem.

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