SPACE AGENDA 2025

RATIONAL EXUBERANCE: UNDERSTANDING VALUE AND PERFORMANCE IN THE SPACE ECONOMY

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Executive Summary

Policymakers, commercial and government space stakeholders, and the space investment community rely on fair assessments of the space economy's value and performance. However, accurate valuations are far from straightforward as various approaches have different strengths and weaknesses. Methodologies include:

- **Top-down** – Measures "use side" revenues and sales forecasts. These estimates may capture adjacent market value with connected industries as banks and investors try to value business synergism and growth opportunities. However, top-down valuations may include double counting, particularly if analysts sum values from both "make" and "use" sides of the space value chain.

- **Bottom-up** – Measures "make side" inputs from capital, labor, energy, materials, and purchased services. Valuations are designed to avoid double counting but exclude adjacent markets, which may miss emerging growth opportunities.

- **Derived Economic Value** – Uses a third-party valuation as the basis to project growth. Provides expedient forecasts but may be unrealistic in the absence of original research or due diligence.

In addition to valuations, published financial data examine relative movement of traditional and start-up space sector companies to provide performance, volatility, and growth insight. These include space funding indexes, publicly traded space stock performance indexes, and exchange traded space sector funds (ETFs).

Despite the rising profile of the global space economy to investors and stakeholders, valuation and forecasting methods remain an imprecise art. For instance, bias might sneak into space sector valuations such as "straight line" forecasts, a tendency to project the past into the future without full consideration of all factors affecting the longer-term space economy. Additionally, embedded conflicts of interest could exist with "sell-side" analyst reports and could introduce bias.

Taking a longer-term view, the value of the space economy will become amplified as satellite capabilities, such as remote sensing, positioning, and communications, continue to grow as fundamental enablers in other industries. Ultimately, the space economy's value will become a critical but also a less distinctive economic quantity within the larger global economy.

Introduction

The commercial space economy is an area of high interest for policymakers, the media, the financial community, and the public, especially in terms of measuring the return on government and private sector investments that underpin it. Over the last two decades, the commercial space sector has experienced significant technological breakthroughs and rapid growth in commercial investment. This has, in turn, fueled interest in determining exactly how consequential the space economy is in terms of its value, trajectory, and its impact on the future of human activities in space and socioeconomic benefits on Earth.

Measuring this growth, trajectory, and impact is not easy. The space sector has sobered up after several years of hyper-liquidity, fueled by low interest rates, a strong private capital market, and a SPAC frenzy.[*] Market exuberance is now giving way to healthy skepticism within many industries, including the space sector. While the "trillion-dollar space economy" looms large in many published space sector valuations, actual profitability remains elusive for many companies.

In the remote sensing sector, strong revenue growth and demand has not led to profits and some firms have implemented layoffs to reduce expenditures. In the space launch sector, spectacular recent successes from a few firms has likewise not led to widespread profitability and some analysts believe the sector could experience a shortfall of capacity in the short term followed by longer term market saturation and excess capacity.[1] The satellite communications (SATCOM) sector, long the largest source of industry revenues, is now responding to market challenges and competition through inorganic growth strategies, as they strive for synergy in part by merging GEO, MEO, and LEO networks.[†]

It is critical that policymakers have a solid grasp of the various methods that are used to measure the space economy because those estimates in turn influence many other important public policy decisions. To that end, this analysis evaluates multiple space sector valuation approaches. It also provides an overview of different estimation methods, tools for interpreting space sector valuations, and useful indexes to track publicly traded companies in the space sector. Economic data from space valuations and space indexes are designed to provide insight to commercial space companies, institutional and private investors, satellite service providers, and government stakeholders who depend upon space capabilities. However, before any investment decisions are made, it is important to understand the methodology and constraints behind these economic estimates.

Economic Valuation Methods

"Knowing what to measure and how to measure it makes a complicated world much less so."

—Steven D. Leavitt, Freakonomics: A Rogue Economist Explores the Hidden Side of Everything

There are several ways to calculate the size of the economy or a specific sector of the economy. This analysis classifies space sector valuations into three basic methods, based upon studying a range of widely circulated commercial, government and nonprofit space sector reports.

[*]Special Purpose Acquisition Companies, or reverse mergers. In 2021, multiple space companies used the SPAC mechanism to go public with what turned out to be unrealistic revenue projections and eventual crashes in share prices. https://www.cnbc.com/2023/10/12/investing-in-space-a-reality-check-on-spac-frenzy-revenue-projections.html.

[†]Mergers and acquisitions include Eutelsat/OneWeb, Viasat/Inmarsat, and Intelsat/SES, creating future hybrid GEO, MEO, and LEO space networks for increased utility for commercial, civil, and defense purposes.

- **Top-down models.** Do not capture all business activity details. This methodology is often used by commercial banking and investors, and includes revenue estimates and sales forecasts.
    - *Advantages.* Captures adjacent market value and synergies with "reach" industries. This can be important as economists try to value business synergism or network effects. Can be less time-consuming to create.
    - *Disadvantages*. Often prone to optimistic forecast models.
- **Bottom-up models.** Use capital, labor, energy, materials, and purchased services for measuring industry inputs and gross domestic product. Methodology is designed to avoid double counting and does not include adjacent markets. This methodology is often used by governments as they have easier access to the underlying data.
    - *Advantages*. Provides a detailed view of specific products within an economic sector.
    - *Disadvantages*. Possibly provides a pessimistic view as this method does not give full consideration of the added value for adjacent market synergy. Also requires a significant amount of time to prepare detailed bottom-up estimates.

A third hybrid model has emerged, which we refer to as *derived economic value estimates*.

- **Derived Economic Value Models.** Involve a third-party valuation as the basis to project growth. Table 1 shows that several financial institutions derive their top-down forecast using the Satellite Industry Association's (SIA) annual State of the Satellite Industry Report (SSIR) as the basis.
    - *Advantages*. Provides an expedient way to forecast. If the derived model uses a trusted source as the basis, this method can provide some level of legitimacy.
    - *Disadvantages*. May not be grounded in actual business data; may allow a more favorable prediction of market value without original research or due diligence.

In general, top-down valuations are an easier way to develop an estimate as the analyst can avoid the intensive bottom-up calculations across capital, labor, energy, material, and purchased service inputs. However, this methodology can involve unintentional double counting of inputs because the calculation method lacks precision and the data lacks granularity to catch potential problems when quantifying reach or adjacent markets.

Adjacent Markets, Business Synergy, and Network Effects. A complicating factor to evaluating the value of the space industry is the emergence of network effects and linkages with adjacent markets. Some space sectors, such as SATCOM, are experiencing network convergence as multiple segments (GEO, MEO, LEO) combine with nonspace segments (terrestrial wireless and broadband) and will benefit from an economic principal known as "business synergy" or "network effects" wherein the joint activity of several networks (and their constituent markets) makes the sum value greater than the parts. To consider just one concrete example, consumers may be willing to pay more for a cellular telephone service that incorporates SATCOM to close coverage gaps, but the entire price those consumers pay is clearly not attributable to the satellite segment. On the other hand, the value provided by the satellite segment may be significantly greater than the direct price charged for it by the SATCOM provider. Metcalfe's Law, coined by Robert Metcalfe (the inventor of Ethernet), states that "the value of a network is proportional to the square of the number of connected users. As the physical cost of the network grows linearly, its value grows exponentially." Put simply, networks become more valuable as more users join.

Both satellite operators and terrestrial mobile network operators, for instance, could view satellite-enabled direct-to-device "D2D" or the combining of terrestrial and satellite communications as a means to amplify value through networks effects or synergies.[2] As another example, the availability of commercial cloud analytics could multiply the value of satellite

remote sensing data, as the geospatial data merges with other types of data to contextualize and make it more valuable. Exemplifying this strategy, the U.S. Department of Defense is undergoing a cultural shift towards cloud synergies to harness commercial capabilities and take advantage of private sector innovation, such as advanced data analytics.[3]

Comparing Space Economy Valuations

There are a growing number of products that attempt to use the methodologies discussed above to create a valuation for the space economy with a wide range of results. A detailed assessment of these various valuations was published by the Institute of Defense Analyses Science and Technology Policy Institute (IDA-STPI) in 2020.[4] The STPI report included a discussion of what to include in the definition of "the space economy" and whether that should include activities that are enabled by space but are primarily generated terrestrially. Importantly, the report noted that including supplier industry revenues can lead to double counting if those revenues are primarily funded by government expenditures that are also directly counted in the market valuation.[5]

The following section discusses several prominent space industry market estimates in more detail, which are summarized in Table 1. In addition to the space sector valuations listed in Table 1, the Organization for Economic Cooperation and Development (OECD) published "OECD's Space Economy in Figures," which details overarching trends in space innovation and the economic significance of space infrastructure and its role in the broader economy. The report also summarizes each OECD country's[‡] institutional space budget as a share of gross domestic product and provides a comparative perspective of national space sectors.[6] A relative perspective is important as the United States and other countries strive to retain dominant or competitive space sector positions for various commercial, government, or defense advantages.

Satellite Industry Association's State of the Satellite Industry Report – Top-Down Valuation. For the past 27 years, the Satellite Industry Association (SIA) has published the "State of the Satellite Industry Report" (SSIR). Analytics and engineering firm BryceTech has independently produced the report for over a decade.[§] The report uses unique datasets, including proprietary surveys, in-depth public information, and independent analysis. The SSIR applies a revenue-focused model which summarizes global satellite industry data across the following segments: satellite services, satellite manufacturing, satellite launch, space sustainability activities, and ground equipment. The report estimates total global revenue for each of these segments. The report also includes metrics reflecting segment activity; for example, number of satellites launched or subscribership for different services.

The SSIR aggregates satellite industry segments to provide an estimate of the global satellite industry ($285 billion), and an estimate of the global space sector ($400 billion) that includes government budgets. It should be noted that one of the segments in this aggregated estimate, manufacturing, is a "make" segment of the satellite sector, and others are "use" segments.[**] As a result, depending on the intended purpose, it may be appropriate to adjust this estimate to exclude "make" values to accurately estimate the size of all the "use" segments of the satellite industry. (Manufacturing is about 6 percent of the total value of $285 billion) (see Figure 1).[††]

[‡]Thirty-eight member countries spanning North America and South America to Europe and Asia-Pacific.
[§]BryceTech CEO Carissa Christensen is a member of the CSPS Senior Advisory Council, a group of outside experts who support CSPS research.
[**]This is related to the concept of gross output which measures the value of products throughout the value chain. According to Bureau of Economic Analysis, gross output double counts "the value of intermediate products (which are used by others in their production processes) and final products (which count toward GDP)." Gross output is sometimes referred to as "gross duplicated output."[**]
[††]All monetary values are stated in United States dollars, $USD. B = billion.

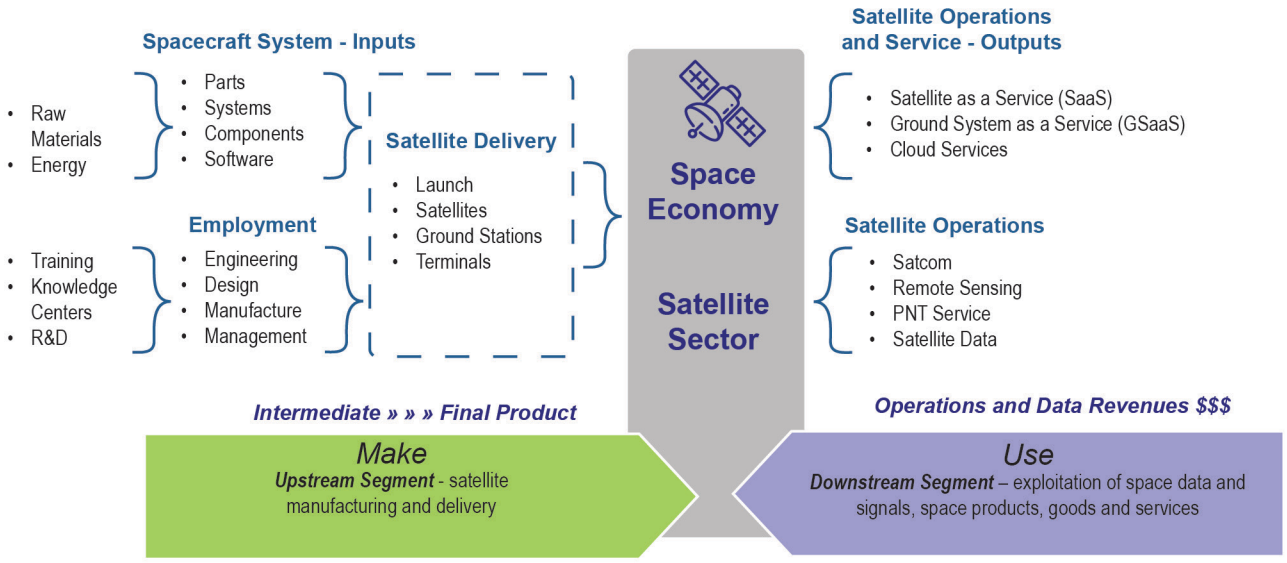

Figure 1: Notional diagram to illustrate the two sides of the satellite economy (a subset of the larger space economy). *The "Make" side includes inputs, starting with various raw materials, parts, and components. Inputs also include labor from personnel involved in delivering a satellite to market. The "Use" side of the sector involves the delivery of satellite-generated products and services such as SATCOM, remote sensing, geospatial data, and PNT services.* ***Note****: Double counting can occur when a valuation includes both the "make" side input values and "use" side outputs or revenues.*

Importantly, the SSIR emphasizes the *satellite* industry (including commercial, civil, and defense) rather than the entire space sector and does not provide details on the entire space sector- (non-satellite-) related activities such as research and human exploration.[7] Also, while the SSIR measures past growth, it does not provide future growth projections. While it is not all-encompassing, the SSIR's steady annual tempo and analytical rigor for collecting and managing unique datasets has earned it a respected position within financial analyst circles. It often serves as the current value baseline for several market projections by UBS, Morgan Stanley, and Bank of America and others. In brief, the SSIR report has become a stepping off point for financial analysts to create their own valuations which often include adjacent industries, such as telecommunications, supply chain, weather, location-based services, and other sectors benefiting from space data and applications.

World Economic Forum (WEF) – Top-Down Valuation. The World Economic Forum's 2024 report "Space: The $1.8 Trillion Opportunity for Global Economic Growth," coauthored with McKinsey & Company, takes a top-down approach to measure both the size of the space sector or "backbone" and the "reach" or adjacent industries that support or use space sector assets or services.[‡‡] The WEF report recognizes that reach is about "space increasingly playing a role in everything from the weather forecast you look at in the morning, to the dinner that gets delivered to your door, and the call you make from your smart watch." The report emphasizes that space will be more about "connecting people and goods" and that adjacent industries will generate more than 60 percent of the increase in the space economy by 2035.[8] This vision

[‡‡]The Executive Director of CSPS serves as a member of the World Economic Forum's Global Futures Council on Space Technology, but was not involved in the creation of the McKinsey report.

is in line with what Klaus Schwab, executive chairman of the World Economic Forum and author of *The Fourth Industrial Revolution*,[§§] refers to as a "staggering confluence" giving an exponential rise and mutually reinforcing progress "across the digital and biological worlds."[9]

WEF's 2035 forecast for the space economy shows that the backbone value is $775 billion, and the reach value is $1,035 billion. Although some might be concerned that the report has greatly exaggerated the size and growth prospects for the space sector, without including industry reach, the forecast would ignore the potential upside from network effects and adjacent industry growth. For instance, a 2024 McKinsey forecast notes that the total value for the Internet of Things (IoT) ecosystem might be $12.6 trillion by 2030. Given that satellite connectivity plays a critical role in the IoT market, it is reasonable to attribute some of this forecasted value for adjacent and rapidly expanding sectors.[10] But while many agree that "industry reach" should be counted as part of the space sector valuation, others recognize the potential for double counting and exaggerated estimates. One space business expert acknowledged the usefulness of the WEF valuation but also cautioned that the estimate "could use a haircut...perhaps 25 percent or so."[11]

U.S. Bureau of Economic Analysis (BEA) – Bottom-Up Valuation. The Bureau of Economic Analysis (BEA) within the U.S. Department of Commerce conducts assessments of several different economic sectors. In 2020, they released their first report on the U.S. space economy. The most recent BEA report, released in June 2024, estimates that the U.S. space economy amounts to $131 billion. At first glance, this seems low compared to other estimates, but this value addresses only the U.S. space economy, not the global space economy. If one assumes (based upon SIA's analysis) that the U.S. space economy is 37 percent of global industry, then the global space economy amounts to $354 billion, a level fairly close to several other current global estimates (see Table 1).

The Department of Commerce's BEA report applies "KLEMS" data, for inputs (K=capital, L=labor, E=energy, M=materials, and S=purchased services). These categories are considered "intermediate inputs that are consumed by industries in their production of goods and services" instead of finished or final product.[12] In an effort to avoid double counting, economists use intermediate goods to calculate gross domestic product (GDP). By using this bottom-up methodology, commonly referred to as value added approach, economists can avoid double counting intermediate goods once when purchased and again when the final goods are sold.

[§§]WEF defines the First Industrial Revolution as mechanized production using water and steam, followed by the Second using electric power to create mass production. The Third used electronics and information technology to automate production. The Fourth creates a fusion of technologies, "between the physical, digital, and biological spheres." (https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/.)

Table 1: Space Sector Valuations by Method and Organization[13]						
Financial Institutions (Top-down, listed banks started with SIA estimates)	**Method**	**Past Year**	**$ Billions**	**Forecast Year**	**$ Billions**	**Forward CAGR**
UBS (July 2023)*	TD/SIA	2016	$340	2040	$926	4.3%
Morgan Stanley Research*	TD/SIA	2016	$340	2040	$1,100	5.0%
Bank of America Equity Research*	TD/SIA	2016	$340	2045	$2,700	7.4%
Goldman Sachs* No 2016 est.; used SIA's 240 B to calculate percent growth for 2040 forecast	TD/SIA	2016	$340	2040	$2,000	7.7%
Citi Global Perspectives (May 2022)	TD/SIA	2020	$370	2040	$1,000	5.1%
Government and Nonprofit Institutions (Top-down except BEA; base estimates are original)	**Method**	**Past Year**	**$ Billions**	**Forecast Year**	**$ Billions**	**Forward CAGR**
IDA—Science and Technology Policy Institute (March 2020) – Excludes several space activities, goods, and services to avoid double counting	TD/with strict methodology	2016	$166	None	None	None
The Space Foundation—Annual Space Report (July 2024)	TD	2023	$570	2027	$772	7.9%
U.S. Chamber of Commerce**	TD	2017	$385	2040	$1,500	6.1%
Satellite Industry Association (SIA) and BryceTech (June 2024)****	TD, surveys, unique datasets	2023	$400	None	None	Past growth 2-5%
World Economic Forum/McKinsey (April 2024)	TD	2023	$630	2035	$1,800	9.1%
Bureau of Eco	BU	2024	$354	None	None	None

LEGEND: TD = top-down, BU = bottom-up, CAGR = Compound Annual Growth Rate

*Based upon SIA's estimate $340 billion for 2016. ** Based on the 2017 Space Foundation estimate, *** BEA provided U.S. values, to calculate global space sector value, applied SIA's metric that U.S. market share is 37 percent to yield a global space economy amount. **** SIA does not project growth. However, the past industry revenue growth was 2 percent and without the declining satellite TV market the industry grew 5 percent.

Indexing the Space Industry

Most financial analysts recognize market valuation as an imprecise art. They often turn to quarterly or annual financial reports to track changes and gain insight into industry health and trends. It follows therefore that another type of indicator is needed—one that focuses on *relative* movement rather than an absolute value. Indexes simplify and summarize financial report data and communicate insights across key disciplines such as economics, politics, market analysis, or various types of earth, environmental, or social sciences. Whether for tracking stock prices, ocean temperatures, consumer prices, social trends and attitudes, indexes are typically used to track *relative change* rather than absolute numeric value. Note a

shortcoming of market indexes is that they only track publicly traded companies, which is significant for the space sector as some significant commercial players are privately owned companies. A few space sector indexes are described below, including funding indexes to track private capital space sector investments, publicly traded stock indexes to track performance of space-related stocks, and exchange traded funds to track space investments across a range of themes, such as traditional space, new space, and aerospace defense.

Space Funding Indexes

- **Seraphim Space Index** (since 2017). This venture capital (VC) firm, based in the United Kingdom, provides a yearly index on space sector funding and acquisition activity.[14]

- **Space IQ: Space Investment Quarterly** (since 2015). Equity investments range from seed to late-stage investments across the globe and across different space sectors (e.g., communications, positioning, imaging, satellite manufacturing and components, and launch).[15] Space Capital built this database to track 1,831 unique companies with a total investment value of $291 billion.[***]

- **IPOX® SPAC** (since 2020). This index is designed to track the aftermarket performance of Special Purpose Acquisition Companies (SPACs) in the U.S.[16] Looking forward, this index will likely have limited utility for the space sector as few new space companies are choosing SPACs to go public.

Publicly Traded Stock Performance Indexes for the Space Sector

- **S-Network Space Index (SPACE).** One of several S-Network Global Indexes and aims to be a benchmark for the space industry. SPACE is linked to the Procure Space exchange traded fund (UFO).

- **S&P Kensho Space Index.** A subsector of S&P Kensho New Economy Index. It covers 30 companies where space-related activities "serve as a principal component to their business strategy."[17]

- **SpaceWorks NewSpace Index™ (NSI).** Provides insight into how publicly traded start-up space companies[†††] are performing relative to two U.S. stock indexes: the Standard and Poor's (S&P) 500 and the Dow Jones Industrial Average (DJIA).[18] The index further classifies companies into launch, satcom, infrastructure, and satellite imaging subsectors to gain focused insight.

- **SpaceWorks Traditional Space Index (TSI).** Covers traditional space companies, such as Lockheed Martin and Northrop Grumman.

A relative performance comparison, developed by SpaceWorks (see Figure 2), measures four indexes' performance over time. Historical performance over the past year shows that the NewSpace Index (NSI) *outperformed* the Traditional Space Index (TSI) by almost 13 index points over a one-year time frame beginning in August 2023 (see Figure 2). However, this does not reflect the historical *underperformance* of the NSI since January 2021, during a time when many Special Purpose Acquisition Companies (SPACs) emerged and then imploded. The longer-term story is quite different as a base investment of $100 during January 2021 in the NSI would amount to a September 2024 value of only $18 compared to a TSI value of 119.

The volatile performance of the New Space Index underscores the importance of financial and technical screening of new space vendors. This is particularly critical for potential customers of new commercial space as they strive to understand the risks that their suppliers could go out of business. It also highlights the degree to which major commercial and

[***]Space Investment Quarterly surpasses index functionality. Database functions allow users to mine and filter.
[†††]*Satcom* - AST Spacemobile, Satixfy Communications, Spire Global, Inc. *Launch* – Astra Space, Rocket Lab, Virgin Galactic, Virgin Orbit Holdings delisted. *Imaging* – BlackSky Technology, Planet Labs, Satellogic. *Infrastructure* – Intuitive Machines, Momentus, Mynaric AG, Redwire, Sidus Space, Terran Orbital.

governmental buyers could drive the success of new commercial space companies if the buyers become better partners to improve return on investment (ROI) for new space providers.

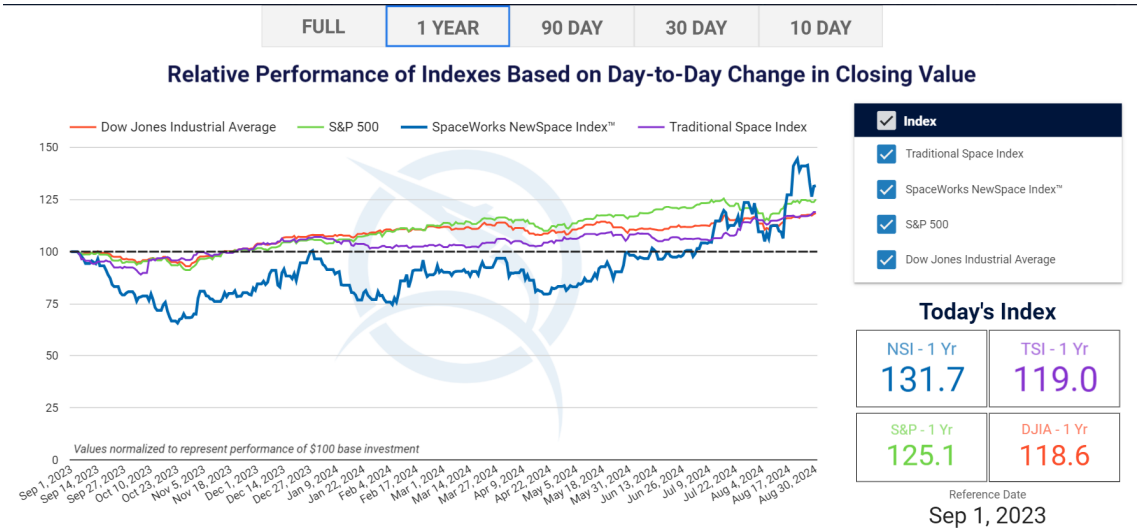

Figure 2: The relative performance of 15 new space companies listed in SpaceWorks' NewSpace Index‡‡‡ (NSI), compared to S&P, Dow, and Traditional Space Index (TSI) averages, provides insight into investor sentiment, trends, risks, and growth. *(Source: With permission from SpaceWorks; https://www.spaceworks.aero/new-space-index/.)*

Exchange Traded Funds (ETFs) for Space

"Don't look for the needle in the haystack. Just buy the haystack!"

— John C. Bogle, The Little Book of Common Sense Investing, 2017

Exchange Traded Funds (EFTs) are typically open-ended funds§§§ and provide a thematic style of tracking and performance for countries, regions, or specific industry sectors. For investors, ETFs provide diversification across a target industry or industry subsector that interests them. There are a wide range of market applications and motivating forces for a space sector index and new and surprising use cases can always emerge. Ideally, the index could inform users or markets on their past performance and potential future trends. A few examples of space-related ETFs are listed below:

‡‡‡Originally 16 companies, down to 15 companies as Virgin Orbit Holdings was delisted.
§§§As opposed to closed-end funds, any number of shares can be issued, there is no limit to the number of shares that can be issued. Most mutual funds are open-ended.

Table 2: Space Indexes (Performance Data Calculated on August 30, 2024)			
ETF Examples (Trading Symbol) (as of August 30, 2024)	**1-year Performance**	**3-year Performance**	**Net Assets**
Procure Space ETF (UFO) – since 2019. Seeks investment results in an equity index called the S-Network Space Index.	-8.3%	-13.7%	$33.1M
ARK Space Exploration and Innovation ETF (ARKX) – since 2021. Aims for long-term growth, 80% of assets in equity securities that fall into investment scheme. Sponsor: ARK Investment Management LLC.	-2.1%	-9.2%	$226M
SPDR S&P Aerospace and Defense ETF (XAR) – since 2011. Open-ended investment fund. Sponsor: SSGA Funds Mgt.	+29.1%	+14.3%	$2.25B
Invesco Aerospace and Defense ETF (PPA) – since 2005. Tracks investment results of the underlying SPADE Defense Index. Open-ended investment fund. Sponsor: Invesco Capital.	+22.4%	+11.8%	$3.6B
iShares U.S. Aerospace and Defense ETF (ITA) – since 2006. Tracks growth of the Dow Jones U.S. Select Aerospace and Defense Index composed of U.S. equities. Sponsor: Blackrock Fund Advisors.	+22.8%	+10.9%	$6.57B

While a general space sector index (either a publicly traded stock index or an ETF) is a *composite* variable made up of individual observed items, ideally, users could filter for specific space capabilities. A well-designed space sector index to inform space stakeholders would involve creating a composite performance measurement across satellite imaging; satellite communications; positioning, navigation and timing (PNT); data architecture and analytics; and perhaps more pioneering ventures, such as space tourism, lunar habitats, and space-based solar power.

Informing Government Investors

The United States depends upon commercial space innovation to deliver a range of defense and civil applications, including imaging, communications, and positioning and navigation. With demand highly concentrated within the government sector, civil and defense space customers can shape and influence the market for goods and services. However, with that market power comes responsibilities and statutory requirements to ensure the economic health and viability of the space industry.

Space sector market valuations and indexes serve as important tools for making both practical public and private investment decisions and meeting government acquisition requirements. For instance, both NASA and National Oceanic Atmospheric Administration (NOAA) must abide by requirements for Anchor Tenancy (51 USC 50506), which calls for the government buyer to ensure that a commercial space provider's long-term viability is not dependent upon a continued government market, and that private capital underlying the space venture is not at risk. Additionally, there are statutory termination liability requirements, so if government terminates such contracts for its convenience, it must provide funds to the space provider to cover termination liability.[19] To ensure that the government is making responsible funding decisions, these requirements seem fair. But it also means that the onus is on a government buyer to spend taxpayer dollars wisely. To this end, valuations and indexes can generally inform a government buyer or investor about space economy conditions, trends, and investment risks.

Recommendations for Understanding Space Economy Valuations

With a wide range of published space economy valuations, both government stakeholders and industry analysts might find themselves desperately grasping for profundity. Here are some guidelines for understanding market valuations and trends:

- For a conservative value–avoid or discount top-down valuations that include "reach" industries, as these most likely involve some double counting. Instead, bottom-up valuations provide a more direct measure of economic impact, such as job creation.

- For investors and analysts seeking growth opportunities and new spin-off space applications for adjacent industries, top-down valuations which include synergy value can be particularly useful. Perhaps discount this value to correct for double counting.

- Government, industry, and investors should exercise caution as commercial investment analyst reports are sometimes underwritten by marketing departments with a financial incentive to generate investor interest in specific companies. Moreover, their reports tend to be derived from baseline estimates already provided by trade associations. Instead, space stakeholders should rely on economic reports derived from nonprofit, nongovernmental organizations, trade associations, and government organizations such as BEA.

- Use space sector indexes to gain a historical perspective on risk and performance and to inform future investment decisions and timing.

Whether buying space services, seeding innovation through grants, or optimizing value for money for a public private partnership—industry reports, valuations, and indexes will become increasingly important for data-driven decisions. As the industry continues to grow and mature, more analysts will regularly publish research on the space economy. This bodes well for reducing risk and uncertainty across a range of space investment decisions, particularly anchor tenancy contracts, and the long-term ability to support future defense and civil space programs and initiatives.

The crucial issue for policymakers and investors alike is to find the right balance between optimism and pessimism. Nearly 10 years ago, several optimistic space market projections emerged from investment banks and nonprofit organizations that sparked a surge in enthusiasm for commercial space. While weakening market signals over the intervening years have undercut many of those projections, "zombie statistics" seem to have taken on a life of their own and are still routinely cited in the media and op-eds. In reference to the situation, space columnist John Holst stated, "[A] reanimation of some space industry numbers that should have been left for dead is a repeating cycle."[20] Investment bank sell-side equity research analysts have been criticized for contributing to these high addressable market estimates. Today, investment banking research is often seen as a marketing expense, without rigorous or objective economic methodology.[21]

"Wall Street indices predicted nine out of the last five recessions!"

—Paul A. Samuelson in* Newsweek, *Science and Stocks, 1966

Extrapolating past results may not adequately address future market potential for some industries that are entering a steep growth or contraction cycle. Despite the need for grounded current estimates, analysts should avoid "straight line bias," a tendency to project the past into the future. In fact, sometimes the straight-line trend will not continue and the projection could be an S- or U-shaped trend. Space sector analysts and decisionmakers should also be wary of too much gloom. It can be difficult to measure the socioeconomic impact of new technologies and applications, which can have immense unforeseen impacts. An example of this is space-based positioning, navigation, and timing (PNT), whose nonmilitary impact was radically underestimated when originally developed in the 1970s. The confluence of PNT with the information

technology boom starting in the 1990s and later its role as a fundamental enabler of telematics and location-based services was transformative, yielding benefits that far surpassed the Department of Defense's investment.[****, 22]

There are also potential benefits from the space sector's mutually reinforcing adjacent industries. As an example, emerging direct-to-device capabilities[††††] will allow the world's 6.9 billion consumer grade smartphones to connect with satellites in areas underserved or unserved by terrestrial mobile network operators. In terms of revenue expansion, the $2.3 billion satcom market[‡‡‡‡] merging with the $2 trillion global wireless telecommunications market could significantly extend the value of space.[23] Other industrial sectors, ranging from supply chain logistics, agriculture, and pharmaceuticals will continue to look to space applications for operational advantages or new discoveries. Perhaps, in an ironic twist, a future economist may measure the economic value of purely space activities as zero because the space economy will be so intertwined with the ledgers of adjacent industries and a growing national and global economy.

[****]A comparison by National Institute of Standards and Technology of GPS's comprehensive costs to only its private sector benefits for 2010 through 2017 produced a benefit-to-cost ratio of about 100 to 1.
[††††]Direct-to-device refers to the ability of satellites to communicate directly with end user devices, such as smartphones, without needing specialized receivers or terminals.
[‡‡‡‡]For mobile voice and data over mobile satellite services (MSS) allocated spectrum.

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