Issue Brief

Sustaining the U.S. Edge in Remote Sensing, Launch, and Advanced Technologies for National Security

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Introduction

The U.S. space economy has evolved significantly over the past 70 years. What began in the 1950s as a fully government-supported sector has transformed into a dynamic ecosystem increasingly driven by private sector actors. In the 1960s, the first hints of corporate involvement emerged alongside government-led missions, as post-war political forces and technological advancements launched Sputnik and paved the way for U.S. remote-sensing satellites. Since then, a combination of Cold War necessity, public investment, and groundbreaking research has shaped the trajectory of the space economy, culminating in a modern industry in which innovation and competition among private firms play a central role.

Today's space economy is experiencing unprecedented growth, generating technological advancements, economic opportunity, and geopolitical influence. Valued at $630 billion in 2023 and projected to exceed $1.8 trillion by 2035, the global space industry is increasingly valuable to modern economies.[1] From groundbreaking satellites to reusable launch systems, these advancements are as important to state economic interests as they are to global influence, security, and exploration.

The United States has invested in this transformation more than any other country, allocating $73.2 billion to space programs in 2023 alone.[2] This number is likely higher when combined with NASA's budget. Historically, government investments and strategic policies have driven widespread innovation and enabled private companies to scale operations and develop transformative technologies.[3] NASA's early contracts with SpaceX, for instance, helped support the company's development, and SpaceX's technological breakthroughs, in turn, lowered barriers for new entrants in multiple sectors of the space industry, but only those not in direct competition with SpaceX.[4] Payload providers can take advantage of SpaceX's lower launch costs, but new launch companies have a harder time breaking into the market. Payload and satellite bus manufacturers are also facing a more challenging environment as SpaceX markets its Starlink bus for other purposes.

International governments, not just the U.S. government, increased spending on the global space industry in 2023.[5] The space economy contributed $131.8 billion to the U.S. GDP in 2022.[6] Increasing venture capital investments in space companies indicates the potential for even more growth.[7] Moreover, space is becoming an increasingly contested environment with adversaries directly threatening commercial and government-owned space-based capabilities.

This paper summarizes CSET's prior research on the history and health of the remote sensing, launch, and advanced space capabilities markets. It explores the critical role of early U.S. government investment in fostering a competitive and resilient space sector, the technological advancements helping to drive industry growth, and the implications of market consolidation for the economy, innovation, and national security. It argues for sustained public-private collaboration, robust policy frameworks, and strategic investments to ensure that the United States remains the global leader in space technology.

Key Themes in the Space Economy

The U.S. Government Is a Key Industry Customer and Investor

Partnerships between public and private actors have been central to the growth of the space industry. As a financier and customer of space technology, the government has provided the stability necessary for the private space sector to flourish. Without this foundational support, space companies could struggle to find the financial resilience required to thrive in a high-risk, capital-intensive environment.

In 2023, the United States invested $73.2 billion in space programs, a figure that is most likely higher when combined with NASA's budget.[8] Data from the first quarter of 2024 shows the government continues to spend billions of dollars on space startups, primarily as a customer for their products and services.[9] Government support has historically played a particularly large role in helping launch-services companies mature from startups to market performers. For example, three of Rocket Lab's first five launches were in support of U.S. government customers.[10] SpaceX's first five Falcon 9 rocket launches were supported by NASA's Commercial Resupply Services program.[11]

Government investment takes multiple forms. These range from seed funds such as NASA's Small Business Innovation Research (SBIR) initiative, which supports early-stage companies, to bigger, bolder actions such as NASA's commercial cargo, crew, and lunar payload missions. Government investment also includes the Department of Defense's (DOD's) Space Development Agency (SDA), which seeks to leverage commercial technological development to contribute to the Proliferated Warfighter Space Architecture. This DOD effort has manifested in contracts for hundreds of satellites.[12] The newly established Space Force's budget is even larger than SDA's.

Government support does not always have to be monetary to have a substantial impact on industry. An easing of U.S. government regulations, namely through Title II of the Land Remote Sensing Policy Act of 1992, allowed remote sensing companies to obtain licenses to operate in space.[13] The federal government has also supported the sector by granting commercial firms access to specialized infrastructure. NASA, for example, opens its wind tunnels, vacuum chambers, and other testing facilities to private companies, which enables hardware validation without the need to invest in costly infrastructure.[14] Additionally, NASA and the National Oceanic and Atmospheric Administration (NOAA) provide open access to Earth observation and satellite data, which private firms can use to develop value-added services or test analytics capabilities.[15] A further nonfinancial contribution is workforce development: public

investment in university research, internships, and technical training programs has helped create a pipeline of skilled talent for the commercial space sector.[16]

Ultimately, government investments and policies can seed future capability to bolster the U.S. space market's resilience. These investments not only enable technological breakthroughs but also ensure the space industry can meet national security imperatives with the side benefit of enhancing commercial availability.

Technological Advancements by Government and Industry Enable Commercial Growth

Government-funded research and development (R&D) has enabled breakthroughs in space technologies and laid the groundwork for successful space businesses. Advancements made through research, testing, and evaluation (largely led by the DOD and academia) have impacted all aspects of the space industry. Most importantly, advances in electronics and materials science, often stemming from government investment in basic research, have made satellites smaller, cheaper, and easier to launch.[17] NASA's investments in miniaturized avionics and sensors, along with Defense Advanced Research Projects Agency (DARPA) support for microsystems technology, helped create the technical building blocks for today's CubeSats and other compact satellite architectures.[18] These innovations have since been adopted and improved upon by private firms deploying constellations of small satellites in low earth orbit (LEO).

Investments in basic and applied science are crucial to reducing costs and risks and enabling technological readiness. At the same time, private firms have built on these foundations, applying novel engineering and business models to scale and commercialize once-nascent technologies. Thus, the synergy between public funding and private innovation can continue driving the rapid progress in advanced space technologies.

Miniaturization

Technology miniaturization is a key trend that has been enabled by government-funded R&D. Smaller chips with more efficient processing capabilities have had a massive impact on satellite development and functionality, particularly those deployed in LEO, allowing these satellites to increasingly achieve performance levels rivaling those of their larger and more expensive counterparts.[19] While radiation in space can be challenging for smaller chips, the use of ever-smaller and cheaper chips in lower orbits has fueled the proliferation of satellites in LEO.[20]

Beyond chips, satellite miniaturization has also increased the number of satellites a company can launch because they weigh less, are cheaper, and perform comparably to larger, more expensive satellites. Consider the CubeSat platform, which was developed in 1999 primarily as a teaching tool but by 2007 was adopted widely for commercial purposes.[21] Overall, miniaturization helps space-based technologies become more efficient and accessible to new players in the industry.

Sensor Improvements

The remote sensing industry, which encompasses using satellites to make measurements at a distance, has benefitted from major advancements in computing power, as well as image sensor improvements in capability, sensitivity, resolution, and miniaturization since 2000.* The trade-off between sensor capability and size, weight, or required power is still an important factor for remote sensing companies, but the advancements made already have been key market enablers.

Continued advancements such as hyperspectral imaging and lidar (light detection and ranging) offer the promise of continually increasing the value of the remote sensing industry. These sensor improvements are enabling far-reaching applications in industries such as agriculture, archeology, disaster management, environmental conservation, defense, and urban planning.[22]

Launch Vehicle Innovations

The commercialization of reusable rockets by SpaceX greatly reduced the cost per launch.[23] While vertical integration (owning multiple aspects of the supply chain) also gives SpaceX an edge in the industry, the real standout is the technology: a first-stage reusable rocket with an expendable second stage.

Traditional rockets are expendable, meaning all parts are discarded after a single use. However, SpaceX's Falcon 9 rocket features a reusable first stage—the bottom portion of the rocket that contains the main engines and most of the fuel.[24] This stage returns to Earth and lands vertically after separating from the second stage, which continues to carry the payload into orbit.[25] Reusing this expensive component dramatically

* Using passive sensors such as cameras and active sensors such as radars, remote sensing spacecraft use the electromagnetic (EM) spectrum to measure activity on Earth and in space.

reduces the cost of launches and has allowed SpaceX to scale operations and experiment more aggressively.

This approach is taken further with SpaceX's next-generation launch system: Starship. Starship consists of two parts—the Super Heavy booster (first stage) and Starship itself (second stage)—and is designed to be fully reusable, meaning both parts will return to Earth after each mission and be flown again.[26] Recent tests of controlled landings for the massive Super Heavy booster demonstrate progress toward this goal, with successful trials showing potential for significant cost savings and more frequent launches, despite recent explosive tests (which are instructive in their own right.)

Reusability allows the company to experiment with different components of the launch vehicle, which is separate from the rocket, and test what works best at a reduced cost, further enhancing its ability to innovate.[27]

Launch Plays a Central Role in the Space Industry, Largely Because of SpaceX

Consistent and cheap launch services are essential for the space industry's growth. Technological improvements to launch vehicles are a key factor in cost reduction per launch. From 2000 to 2015, worldwide rocket operating costs mostly hovered between $10,000 and $20,000 per kilogram to LEO.[28] SpaceX's ability to reduce that cost by four to eight times made it a leader and a key enabler in the launch industry. As a result, more payloads—from satellites to crewed missions—can now be sent to space at significantly reduced upfront costs. This has not only fueled growth across various space sectors but has also lowered barriers to entry for new space companies. The outcome is a more competitive and innovative industry, exemplified by the recent surge of startups in remote sensing, advanced technology, and launch services.[29]

Technological advancements by SpaceX are reducing costs for launch at the same time that satellites themselves are becoming cheaper (albeit less reliable).* This is, in turn, driving more demand for satellite services and more competition in the space economy overall.[30] Figure 1 shows that the annual number of payloads has risen substantially since 2013, even when excluding Starlink satellite launches.

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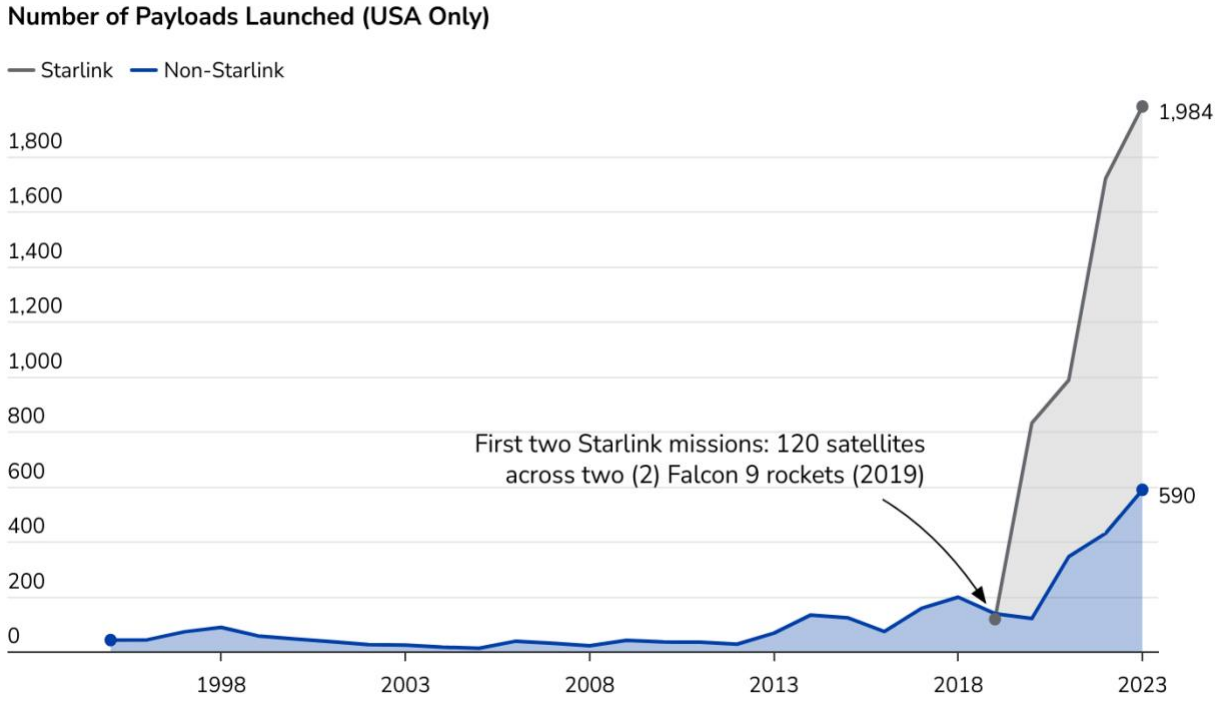
* Affordability comes with trade-offs: these satellites typically have shorter operational lifespans, lower fault tolerance, and fewer onboard redundancies, making them more vulnerable to failure. Despite the reduced reliability, their low cost and the ability to deploy them in large constellations (such as those used for broadband or Earth observation) make them an attractive option for many commercial and governmental missions.

Figure 1: Number of Payloads Launched (1980–2023)



Source: Gunter Krebs, "Chronology of Space Launches," author analysis.

SpaceX Leads Market Consolidation in Multiple Sectors

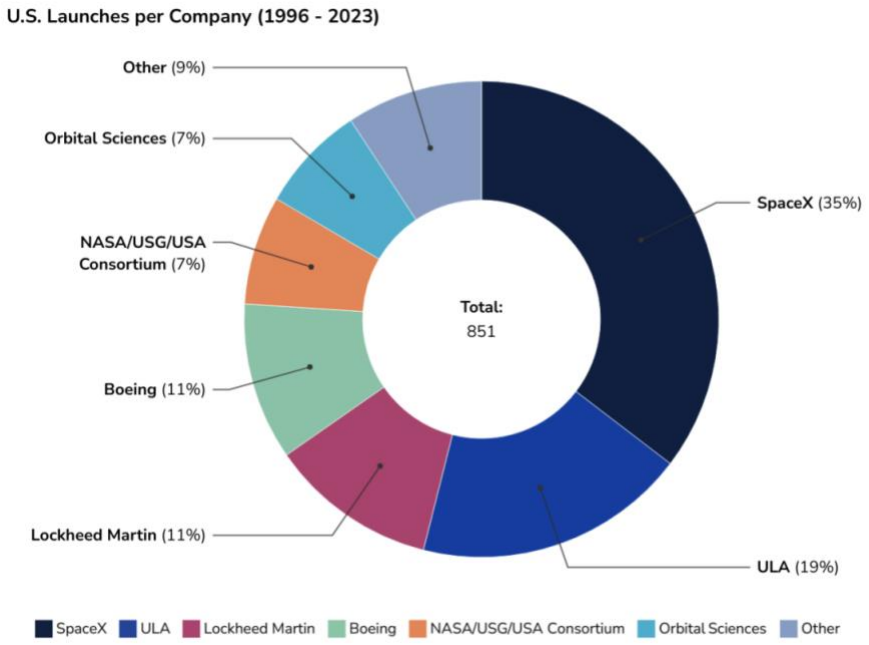
SpaceX has stimulated industry innovations and helped grow the broader space economy.[31] Its development of cheap and reliable launch vehicles has lowered cost barriers and reduced risk for new entrants, enabling other innovative companies to join the space industry. At the same time, SpaceX's singular position in launch services and Starlink's similar position in satellite communications create significant concerns about a consolidated marketplace.[32] If anything were to happen to SpaceX or its major suppliers, the entire marketplace could be at risk. Also, the company theoretically could use its overwhelming market power for monopolistic behavior, stifling meaningful competition and limiting disruptive innovation.

This lack of diversification could also affect national security, whether because of technical failures, corporate decisions, or geopolitical conflicts. As SpaceX becomes an indispensable player in the space economy, its influence over U.S. national security grows. SpaceX already receives 65 percent of DOD funding for venture-backed companies and 81 percent of U.S. government funding for venture-backed companies.[33]

The dominance of SpaceX in launch services is at least partly attributable to challenging financial barriers in the space industry. The space sector is capital-intensive, and even companies that raise significant capital may not be able to afford the costs of competing within the typical time horizons required to build successful space companies.*

As a matter of history, consolidation in capital-intensive markets such as the space industry is predictable.[34] However, it is undesirable as it reduces market resilience and limits innovation. The creation of the United Launch Alliance (ULA) in 2006, which merged Lockheed Martin and Boeing's launch operations under a government-backed effort, serves as a reminder of the risks of intervention in this sector. While the approach ensured reliability at a time when commercial competition was limited, it also led to a costly and innovation-stifling, near government-sponsored monopoly. Consolidation may benefit companies and consumers in some cases, but it also reduces the incentive for firms to invest in new and disruptive approaches.

Figure 2: U.S. Launch Company Share of Launches Over Time



Source: Michael O'Connor and Kathleen Curlee, "Shaping the U.S. Space Launch Market," Center for Security and Emerging Technology, February 2025.

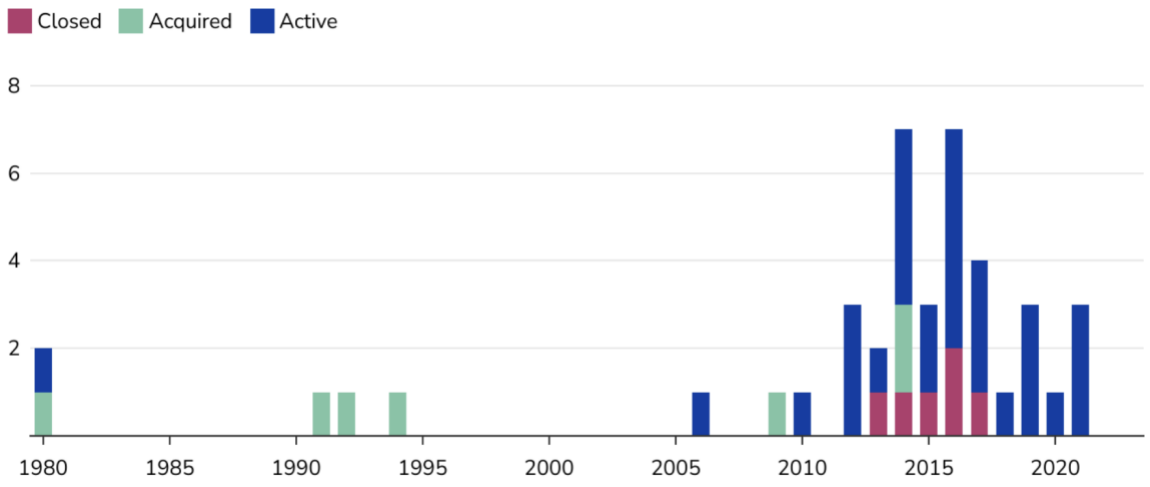
* Astra and Terran Orbital are two examples of companies that failed because of lack of revenue and inability to deliver technology.

While SpaceX's services are critical to the U.S. space sector, policymakers must be aware of the risks posed by market consolidation and lack of redundancy. Striking a balance between maintaining critical capabilities and preventing powerful incumbents from wielding harmful market power is essential. With today's more dynamic market, policymakers will likely be cautious about repeating past strategies that, while intended to preserve capability, ultimately constrained competition and technological progress.

The Space Sensing Market Is Poised for Growth

Technological advancements, lowered launch costs, and an influx of capital are fueling the creation of new space sensing companies (Figures 3 and 4). These companies are now able to seize new opportunities with sensing phenomenology that were previously inaccessible and expensive.

Figure 3: Remote Sensing Company Founding Dates and Statuses (1980–2021)



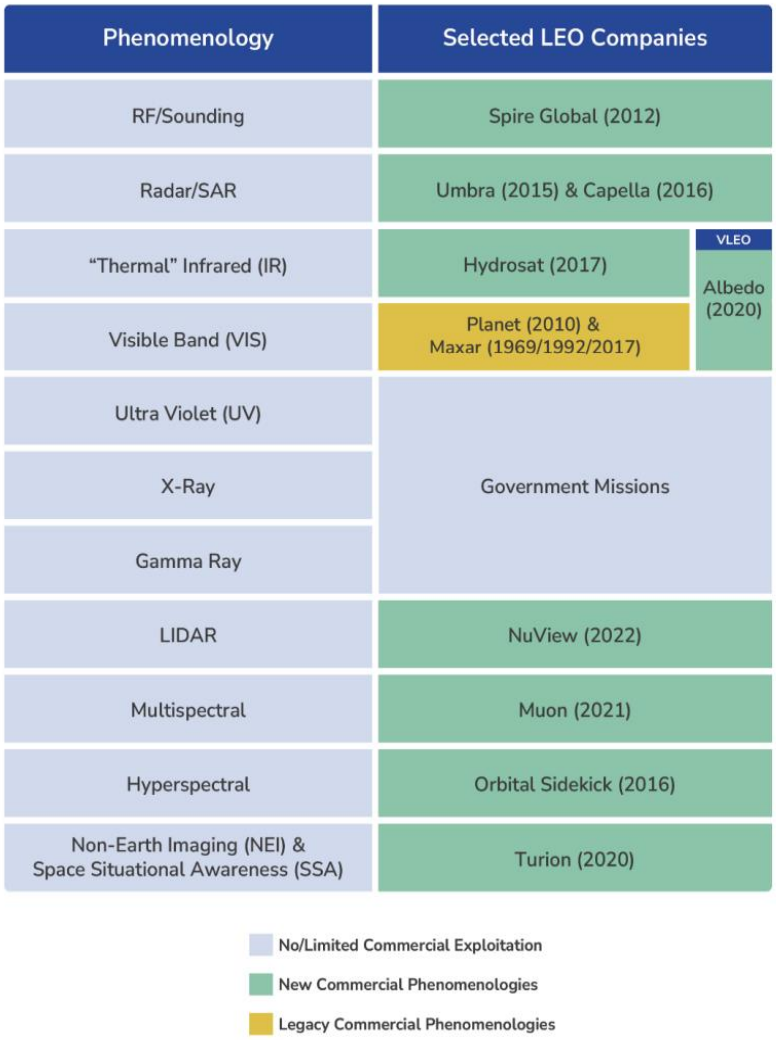
Source: Michael O'Connor and Kathleen Curlee, "Eyes Wide Open," Center for Security and Emerging Technology, July 2024.

Note: Closed refers to companies no longer in business; acquired refers to companies still active but have been purchased by another company and may or may not be operating under another name; active refers to companies still operating as of publication.

Traditionally, companies such as Maxar and Planet focused on capturing visible-light images of Earth. However, after 2012, new companies started developing and launching satellites using different sensing methods. One early example is Spire Global, which uses small satellites to track radio signals for ship monitoring, weather forecasting, and other applications. This trend accelerated around 2016, with many

new companies introducing advanced sensors that were once only used by governments.[35] These include radiofrequency (RF) sensing satellites, which detect radio emissions, and synthetic aperture radar (SAR) satellites, which can capture high-resolution images day or night, regardless of weather conditions.

Figure 4: Remote Sensing Phenomenology and Companies*



Source: Dates via Crunchbase and company websites; phenomenology via author analysis.

Some cutting-edge technologies, once rare even for government space programs, are now commercially available or in development. For example, hyperspectral satellites,

* Note that Maxar's founding date is based off of the founding date of Macdonald, Dettwiler and Associates Corporation (MDA) in 1969. Maxar went by the name Maxar Technologies until 2017.

which analyze light in fine detail to detect chemical compositions, are already in orbit. Emerging systems could expand space-based sensing even further, including non-Earth imaging satellites, which are relevant for debris management and space situational awareness (SSA), and lidar platforms, which can create highly detailed topographic maps for agriculture and climate applications.[36]

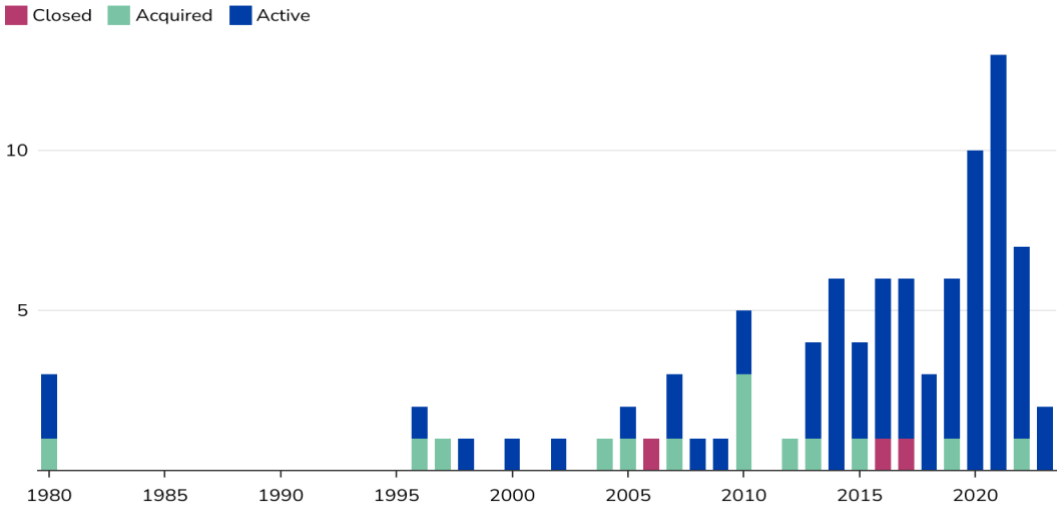
Many remote sensing satellites operate in LEO, where they can provide clearer images and stronger signals, require smaller ground antennas, experience less space radiation, and are cheaper to launch. Advances in computing, storage, and imaging technology have also made it easier to deploy large constellations of satellites in LEO. These constellations enable more frequent, high-resolution images at a reasonable cost. Some companies are now demonstrating capacity at even lower altitudes—very low-earth orbit (VLEO) at 100 to 400 km—which could offer even sharper images at a lower cost. Historically, most missions avoided VLEO because of environmental conditions such as atmospheric drag that shorten satellite lifespans.[37] If successful, VLEO could enable even more companies with higher-quality sensing data and lower costs for more services on Earth.

Advanced Technology Companies Show Economic and Security Promise

The influx of venture capital, advancements in launch technology, and increasing global interest in the space economy have created an environment for a new generation of space capabilities and companies. This new generation includes companies providing services in positioning, navigation, and timing (PNT); ground-based space situational awareness; space exploration; in-space satellite services; and in-space manufacturing.[38] These advanced technologies enable key national security capabilities such as having secure communications, resilient supply chains, persistent monitoring of space assets, and the ability to respond rapidly to threats or disruptions in orbit. As competition intensifies among global space powers, investment in these areas reflects a broader effort to secure technological leadership, protect critical systems, and ensure operational dominance in the increasingly contested space domain.

CSET's prior analysis looking at advanced space technologies using PitchBook data found an increase in the number of currently operating companies in the advanced technologies sector over the past decade, demonstrating growth in both value and total number of companies (Figure 5). This growth could represent important opportunities for the space economy and national security.

Figure 5: Advanced Technology Company Founding Dates and Statuses (1980–2023)



Source: Michael O'Connor and Kathleen Curlee, "Advanced Space Technologies: Challenges and Opportunities for U.S. National Security," Center for Security and Emerging Technology, June 2025.

Note 1: Companies formed before 1980 are included in the 1980 column.

Note 2: Closed refers to companies no longer in business; acquired refers to companies still active but have been purchased by another company and may or may not be operating under another name; active refers to companies still operating as of publication.

Lower launch costs, cheaper satellites, and government contract opportunities provide business advantages, but profitability remains challenging for these pioneering companies, much like it is for new launch-services companies. Advanced technology companies require not only further development of electronics and materials science but also patient funders and early customers to help them prove their use cases.

The government has multiple incentives to be an early customer of these new companies and champion of these emerging technologies (Table 1). SSA, for example, has important national security implications and will also be critical for the space economy as the number of objects in space continues to grow. Moreover, PNT is essential to military and economic activities, and governments worldwide are seeking alternatives to current GPS options. In-space satellite services can also impact national security and economic interests and are similar to SSA and PNT in that they can help with detecting, tracking, and maneuvering around other satellites. While government R&D plays a crucial role in accelerating progress and reducing costs, policymakers may need to further support these companies by being early customers and providing strategic funding and regulatory incentives to bridge the gap between innovation and commercial viability.

Table 1: Advanced Space Technology Subgroups

Subgroup	Description
PNT	PNT provides *position, navigation, and timing* services to users. The U.S. Space Force–operated GPS system is the most well-known example of such a system and service.
Ground-Based SSA	SSA, or *space situational awareness*, detects and tracks objects in space. The U.S. Space Force operates a large network of sensors called the Space Surveillance Network (SSN) to support this mission. This category is limited to commercial operators using ground-based sensors that are most similar to the Space Force's SSN sensors.
Exploration	*Exploration* includes technologies destined to orbit, measure, or land on other celestial bodies, or support other spacecraft doing so.
In-Space Satellite Services	This broad category includes the following technologies: • Space-based technologies to perform and support SSA • *Debris remediation*, or technologies that can manipulate space debris to remove it from orbit • *In-space servicing, repair, and refueling* of satellites • *In-space transport*, which helps satellites make large maneuvers after an initial rocket launch
In-Space Manufacturing	*In-space manufacturing* allows chemicals, pharmaceuticals, and other sensitive production processes to be done in space, where disturbances from gravity can be minimized to enable new products. It includes the manufacture of products for use in space or on Earth.

Source: Author analysis.

While the exploration industry may seem secondary to other advanced technologies that have more obvious national security applications, it plays a role in the vitality of the space market, inspiring the domestic workforce, attracting highly skilled immigration, and driving technological spinoffs—such as in semiconductor manufacturing.[39] Government funding remains dominant in exploration, but the funding approach has shifted from the past. Agencies now set high-level requirements for private companies to meet rather than dictating specific designs, and operations are increasingly managed by the companies themselves. A salient example is NASA's Commercial Crew Program, which sets requirements for crew transportation to the International Space Station (ISS) and awarded contracts to SpaceX and Boeing to develop spacecraft that align with NASA's safety and mission requirements.[40]

U.S. Policy Recommendations

The U.S. space industry is experiencing rapid and dynamic growth. As global competitors increasingly seek to challenge U.S. leadership in space, the U.S. government must take proactive steps to sustain its competitive edge. Drawing on insights from CSET's analysis, policymakers have an opportunity to support national security while fostering innovation and promoting healthy competition.

Foster Innovation Through Strategic Investment

The U.S. government, through Congress, NASA, DOD, and other relevant agencies, should foster the creation and incubation of new space companies that improve the resilience of the space marketplace for both economic and security goals by:

- Ensuring that federal funding—including contracts, grants, tax incentives, and support for infrastructure—accounts for the long lead times required for startups to reach profitability.
- Continuing to establish contracts with commercial vendors to accelerate the development of technologies with dual-use applications.
- Funding basic science, as well as R&D projects related to space technologies.
- Purchasing capabilities as a service from commercial vendors, for example, commercial space communications services.

Encourage Competition and Market Resilience

To safeguard U.S. space capabilities, the government must promote a competitive marketplace across all space sectors and support a diverse vendor base that can support both military and commercial needs. Without a competitive domestic market, the United States risks falling behind adversaries in space technology advancements and reducing its overall technological resilience. The government should:

- Continue efforts to diversify the space industrial base for national security and federal space exploration through strategic contracting efforts.
- Develop incentives for smaller, innovative companies to participate in government contracts by reducing regulatory burdens and offering streamlined contracting processes.
- Support the development of scalable, next-generation technologies that can address long-term challenges in space.

- Encourage collaboration between private companies and government agencies, such as NASA, to create dual-use technologies (e.g., remote sensing satellites, rendezvous and proximity operations (RPO), exploration, etc.).

Strengthen Regulatory Frameworks

While the space industry is not new, recent growth and innovation have created a need to reexamine government regulations over space. Domestically, fragmented policies across agencies such as the Federal Aviation Administration, Federal Communications Commission, and National Oceanic and Atmospheric Administration create inefficiencies, slowing innovation and increasing costs for private companies.[41] Particular attention is needed in emerging areas such as space debris management and in-space manufacturing.

Internationally, agreements such as the Artemis Accords already promote collaboration on issues such as space debris and sustainable exploration. However, broader international participation and updated frameworks are needed to address the rapidly evolving challenges of space.

To foster continued growth in commercial space activities while enhancing national security, the U.S. government should:

- Continue to update and streamline regulatory frameworks governing space activities, especially for space debris management and in-space manufacturing
- Continue to work with international partners to create common standards for best practices for space operations, including expanding established international agreements on space, such as the Outer Space Treaty and the Artemis Accords, and developing more hard power capabilities to deter adversarial advancements in space

Conclusion

The U.S. space industry—including launch services, remote sensing, and advanced technologies—is at a critical juncture. The sector is growing rapidly, but also facing intensifying competition and consolidation that threaten long-term resilience and innovation. While the United States leads the world in government investment and industrial capacity, these strengths must be actively sustained through deliberate policy and continued collaboration between public and private actors.

Strategic government investment underwrites many of the breakthroughs that fuel commercial success. The interplay between public funding and research and private capital and innovation has historically influenced and will continue to shape the dynamics of the U.S. space economy. However, high market concentration poses risks that demand thoughtful policy to maintain competition and resilience.

The United States stands at a pivotal moment to strengthen and solidify its leadership in the global space economy. Sustained investment in the space industry, coupled with the government's role as a reliable customer and partner for U.S. space companies, is vital. By reinforcing the foundation of public-private cooperation, promoting diversified market participation, and sustaining investment in critical technologies, the United States can protect its strategic edge and remain a cornerstone of global competitiveness and security.

Author

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