Reshaping Space Policies to Meet Global Trends

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Fifty years ago, the United States and the Soviet Union conducted the only significant national space programs, and only a small number of commercial entities were involved in space activities. Now, while the United States remains the main player, the space sector includes many more countries and integrates technologies and innovations from other sectors. Private funding for space-based ventures has increased dramatically, contributing to rapid growth of the private space sector. As a result, the space sector is changing from being largely driven by government and several large commercial enterprises to being more segmented and globally integrated and driven by commercial activity (Figure 1). What do these trends mean for the U.S. government agencies and departments that spend in excess of $43 billion annually on space-based activities?

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Space Enterprise Is Not an Island

In the early years of the space age, technologies were developed in and for the space sector and "spun out" into other sectors. Increasingly, though, the reverse is occurring, and technologies are spinning "into" the space sector from others, principally from advances in materials science, robotics, and information technology (IT) sectors, and often in the form of commercial off-the-shelf products. Falling costs and dramatic improvements in areas such as processing power, data storage, camera technology, solar array efficiency, and micro-propulsion have fed into a variety of space-related areas, including remote sensing and Earth observations, telecommunications, space science and technology, and exploration.

As a result, newer and lower-cost applications of space are emerging, making investing in space more beneficial and lucrative. Smaller, lighter, and more capable satellites make Earth observation and remote sensing within the reach of countries, corporations, and individuals alike. Use of high-throughput satellites can provide high-speed data communication that is many times faster than with traditional satellites. Using newer technologies and new business models, companies like SpaceX have developed reusable boosters, and are disrupting the launch market that had been controlled by heavyweights such as United Launch Alliance and Arianespace. Firms such as AGI, ExoAnalytic Solutions, and LED Labs are besting legacy government systems to provide space situational awareness (SSA) services that improve the ability to view,

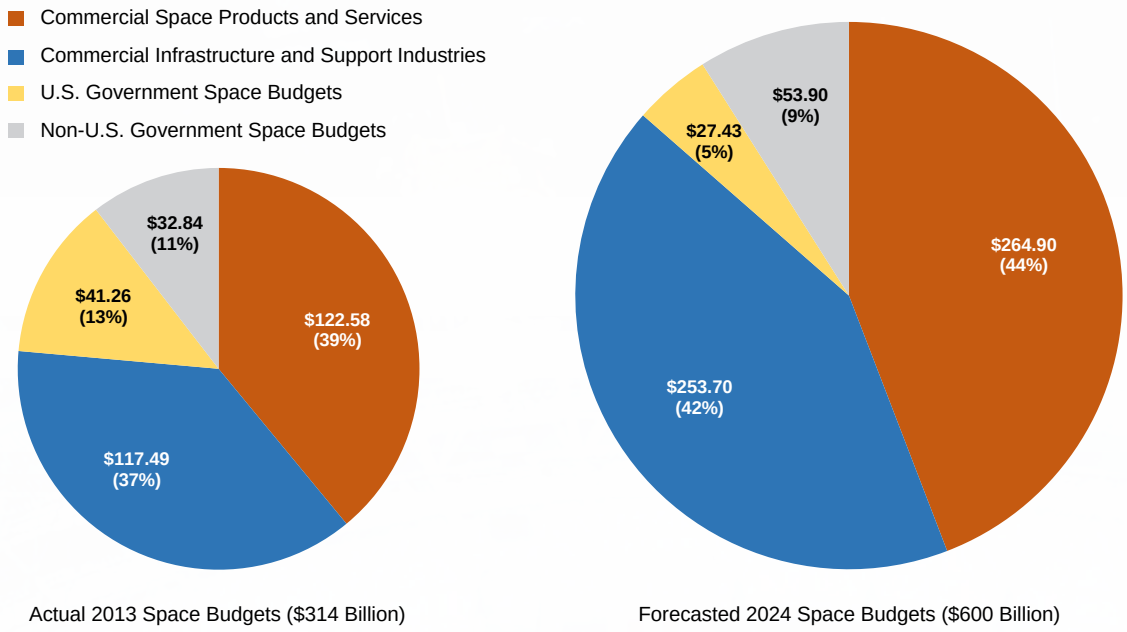

Figure 1. International Space Budgets

understand, and predict the physical location of objects in space, with the goal of avoiding collisions. The trend toward smaller satellites has yielded the use of CubeSats developed by private firms not only for commercial purposes like weather prediction, but also for national security–related activities such as rendezvous and proximity operations, and for scientific research into heliophysics, planetary science, and astrophysics.

Government Funding and Policies

Government agencies in the United States and around the world are under pressure to reexamine policies restricting the commercial development and sale of space goods and services, as illustrated by the debate in the U.S. Congress on using commercial rockets, extracting space-based resources, or selling space-based imagery. There is also pressure on agencies to begin to view and regulate space as a mainstream economic endeavor, not solely as a sector relevant to national security and science. This shift in emphasis is especially evident in the United States and Europe, where commercial solutions are increasingly being used to meet government needs, technology export controls are being liberalized, and regulations are being relaxed to allow the private sector to provide services such as high-resolution imagery and SSA that were previously restricted to the government.

Signals of Change

Global Investment

That space is changing is evident in many measurable ways. Although there have been government cutbacks in the United States, globally there has

been an increase in funding of space activity. Global investment in space activities increased at an annual rate of 6 percent between 2009 and 2013. In the broadest picture, almost 170 countries have some level of financial interest in satellites, up from 20 in the 1970s. Further, 60 of the more than 80 countries engaged in space-based activities in 2015 have invested $10 million or more in space-related applications and technologies, twice as many as in 2004. The increase has been especially noteworthy in countries such as Saudi Arabia (60-percent increase since 2009) and Brazil (40-percent increase). Overall, even by the most conservative estimates, global activity in space is expected to almost double in the next 10 years.

Other countries, such as India, are also demonstrating growing expertise in space exploration and technology development, while countries such as Israel, Singapore, South Korea, and the United Kingdom have begun to specialize in niche areas such as avionics, alternative approaches to launch, and data analytics, among others. The United Arab Emirates has plans to build a Mars probe and the first space research center in the Middle East, all the more impressive since the nation began its space activities only in the 1990s. Leveraging commercial products and services, including those from the United States, these and other countries are poised to become major space players and may well rival more established countries in a few years, particularly given the enduring perception that a presence in space brings prestige, geopolitical advantages, and economic opportunities.

Different Stakeholders

The presence of private companies in space is not a new phenomenon, but in the 1950s and 1960s, private companies operated under a model where investments went into a monolithic, capital-intensive industry driven by government. Now, the investments are less capital intensive, with different investors, especially those from the IT sector, being spurred by emerging markets. Some of these private investors are not motivated solely by profit, and they can provide long-term capital, previously the domain of governments only. Companies such as SpaceX, Blue Origin, and Bigelow undoubtedly intend to make money, but these companies' founders seem to be driven by a zeal—and a time horizon—that transcends that of a typical venture capital investor.

Another stakeholder in the space sector—one that did not exist when space was solely a government-driven sector—is the private consumer, who is both demanding and willing to pay for space-based services such as ubiquitous broadband access and near real-time situational awareness. These consumers are now contributors to the growing private sector. Add to this the emergence of concepts such as crowdfunding and citizen-led space activities, and the number of stakeholders in the space sector is dramatically higher than it was even a decade ago.

New Approaches

These stakeholders are also following different approaches to developing their space enterprises. Governments

in less-industrialized countries are increasingly using technology transfer and partnerships to build capabilities in specific areas of interest rather than investing in developing indigenous systems. It is no longer necessary to build a satellite or even operate it to get data from one. At the same time, there is also a shift from buying technology and products to buying services.

Participants in the private sector are focusing on cost innovation, following a philosophy of (1) developing products that are good enough rather than perfect and (2) prioritizing low cost over performance or reliability. This approach is reflected in the increased use of streamlined processes, cheaper components, open-source hardware and software, agile manufacturing, and production models (as distinct from the production of one-off products).

These trends are most evident in the small satellite sector, where risk and reliability are seen differently than in the traditional aerospace sector. For example, the Earth observation company Planet Labs can have a fifth of its CubeSats fail in orbit without losing a meaningful amount of its imaging capacity. Such an architecture becomes feasible only when satellites cost 2 to 3 *orders of magnitude* less than traditional satellites. Many small satellite firms (Spire, for example) see themselves not as aerospace firms but as information technology or media companies, so they are takeover targets for technology giants such as Google or Facebook, not for traditional aerospace firms such as Lockheed Martin or Boeing.

Implications for the United States

Developments such as those described here reveal that many of the subsectors of space, including Earth observation, space science and technology, exploration, and even SSA, are beginning to diverge into two segments. The first segment is a government-driven one that develops massive systems such as the James Webb Space Telescope or Space Launch System rockets. These systems have exquisite capabilities that require hundreds of millions to billions of investment dollars to develop and operate. The second is a less-capable but also less-expensive consumer-oriented segment. Largely centered in Earth observation data and services today (and telecommunication and other services in the future), the segment is globalizing rapidly and will inevitably spread to other subsectors of space. It is therefore not difficult to believe that the future holds both domestic and international implications for the United States.

For example, the emergence of new applications (e.g., commercial radio frequency sensing or signals intelligence) presents unprecedented challenges not only to U.S. government organizations such as the National Reconnaissance Office that control such national security–centered activities, but also to regulatory agencies such as the Department of Commerce that have no systems in place for such new applications Similarly, with SpaceX, OneWeb, and other private companies planning to launch satellite constellations comprising thousands of satellites, the same system of spectrum licensing

by the Federal Communications Commission will not work.

Globally, the challenges will be even more complex given how space is increasingly described as congested, contested, and competitive. The guidelines surrounding space debris are currently nonbinding and difficult to enforce. Compounding the challenge are the high cost of debris mitigation and the prospect of the United States having to share debris mitigation technologies with less-wealthy nations and nonspace actors that are launching spacecraft.

Today's space community must also address previously unknown challenges such as the loss of electromagnetic spectrum; the lack of global standards and regulations for activities related to serving satellites or other objects on-orbit; the development of deep space mining or in situ resource utilization; the rise of cyber terrorism; and the legacy of pollution from launches. These and many other challenges now confronting global space powers require an appropriate response.

With more countries and private sector firms operating in space and seeking to take on additional roles by participating in international space organizations, the domestic and global governance landscapes will continue to become more complex. The United States and other traditional space-faring countries will have diminished control of global decisions related to space activities, and they will be under greater pressure to accommodate the needs of the private sector and countries with emerging space capabilities.

Ready for Wildcards

As efforts to develop and implement policy changes to address these and other challenges proceed, it will be useful to ensure that any changes are alert to unknown and unforeseen situations—*wildcards*—that might overturn these trends. Wildcards could be related to technology developments. A dramatic breakthrough, such as perfecting the ability to reliably and cheaply reuse multiple stages of rocket engines or developing specialized carbon nanofibers that make technologies such as space elevators feasible, could dramatically reduce the cost of access to space.

Wildcards can also emerge from geopolitical developments. Drastic changes or responses to the Outer Space Treaty or other international rules governing space, or aggressive weaponization of space, could affect how liberal the U.S. government will be with respect to international collaborations. Other wildcards that could upend the current trajectory include a debilitating space weather disaster or cyber-event that cripples space-based services for an extended period, a space-debris cascading event that degrades use of space, or the discovery of a large asteroid or comet headed toward Earth. Any policies need to be robust to these wildcards.

Even if no wildcards enter the picture in the near term, or if policies are implemented that are responsive to multiple alternative futures, hasty change is not advised. For example, the government does not necessarily need to use capabilities that become available from outside the government just because they are available.

Policy makers need to decide which capabilities are so important that they should not be outsourced, procured, or purchased from outside the government. Such decisions are likely to be complex, and will probably have political implications, so policy makers must also plan for the consequences of these decisions.

Change in the Wind

It seems clear that the space sector will continue to undergo transformation as it increasingly, if gradually, diverges from the military/government users. More governments worldwide can be expected to act on their space aspirations by participating in space activities in different ways, and a globalized private sector (even if mostly centered in the United States) will begin to provide more space-based products and services. As the number of actors increases, the space sector will likely see increased competition and overcrowding, both literally and metaphorically. This, in turn, will serve as a driver for more products, services, and governance structures that can support the needs of the ever-expanding sector.

It is also clear that the U.S. government will need to adapt to these changes by reshaping its space departments and agencies and by leveraging developments beyond their conventional boundaries. Toward this end, the government will need to harness its vision, openness, agility, and risk tolerance; incorporate a well-matched mix of centralized planning and decentralized execution; and expend the resources required to implement these changes.

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