A Boring Space Innovation Paper

Sarah Mineiro, Adjunct Senior Defense Fellow, Center for a New American Security

There are a few enduring fundamentals about space—laws of physics, unifying human inspiration, and mundane Star Trek tropes—almost everything else seems to be up for debate. The players, dominant market forces, and technological advances in the space sector are all rapidly changing. In 2019 the United States established the United States Space Force, a new military service dedicated to organizing, training, and equipping space guardians. In November 2020 SpaceX sent four astronauts to the International Space Station in the first flight of NASA's Commercial Crew Program. Recently, Morgan Stanley projected that the global space economy may be the next trillion-dollar industry. Everywhere you look there is substantive change in the private space economy – with a notable exception – the consistent tension between private sector innovation and government regulation.

Below are a few recommendations on how to navigate through this tension:

Identify and Reward Winners

Fundamentals vs Pumpamentals

In space you can fake it until you make it – or until the laws of physics and your investors tell you your idea will (literally and figuratively) not fly. With the frothy venture capital (VC) market there is an overwhelming paradox of choice when it comes to small space start-ups to support. Nonetheless, the private sector as well as government customers are in the difficult position of having to pick winners from a crowded and enthusiastic field. The first discriminator here should be the technical engineering approach to the product being offered. Whether it is a Software-as-a-Service (SaaS) solution, an all-up system, or a space-related hardware subcomponent all of it requires solid engineering processes in order to facilitate unique market placement. These are the "fundamentals" of working in the space domain. No amount of investor enthusiasm can compensate for a poorly managed untalented engineering team. Investor enthusiasm is important as well. I generally refer to this as "pumpamentals." The ability to articulate the unique market position of a product to investors is necessary for attracting capital, talent, and other resources. Some of the most well-known venture capital funds start with investing in "smart people solving difficult problems," the ordering of the words implies their priority. Private investors and government customers must do their homework in the unique quantitative and qualitative metrics for success in this domain, choose winners, and invest accordingly.

COTS

Contrary to popular belief, rewarding winners does not mean handing out $500k participation trophies to every small company that joins a conference with the letter "X" appended to its name and sponsored by a shiny new DoD organization. Rewarding winners means holding frequent, fair, and meritocratic competitions to determine the best products on the market and awarding meaningful contracts to the winners of these competitions. One example of this is found in the Commercial Orbital

Transportation Services (COTS) contract let by NASA in 2005. Instead of specifying detailed requirements, the program identified cargo and crew capabilities and allowed the bidder to choose which capabilities to offer. Additionally, NASA required commercial partners share in the costs of system development to help ensure companies had "skin in the game" when developing their systems on time, to specification, and within budget. What ensued is an innovative milestone driven competition that led to SpaceX Dragon becoming the first commercial spacecraft to deliver cargo to the International Space Station in 2012 followed by Orbital Sciences Corp in 2013. Both NASA and private industry won and were rewarded.

Don't Over-regulate

SAR

In the late 1980's and early 1990's the National Oceanic and Atmospheric Administration (NOAA) through its licensing process discouraged private investment in commercial space-based synthetic aperture radar (SAR), investors fled to other countries where they fielded commercial space-based SAR. A byproduct of denying the investment of U.S. capital in U.S. companies dedicated to space-based SAR was that the U.S. ceded any authority to regulate the dissemination of SAR data to third-parties. As it turns out, the countries that invested heavily in space-based SAR have different interpretations of data usage, resolution, and thresholds for sale than the U.S. Only recently has NOAA promulged a new rule for licensing the operation of private remote sensing space systems. It presciently describes the "problems with existing regulatory approach" while referencing SAR:

"Take, for example, the U.S. SAR industry. Commerce license conditions prevent such licensees from imaging at finer than 0.5 meters impulse response (IPR), while some foreign competitors sell data at .24 meters IPR. Even a regulatory approach that allows U.S. licensees to sell data at .24 meters IPR would only let U.S. industry meet, not exceed, their foreign competition. This creates a market opportunity for foreign entities to sell data at finer than .24 meters IPR. The U.S. Government has no control over such foreign SAR systems and must adapt to protect its operations, making such a regulatory approach ultimately ineffective and counterproductive. This approach is also reactive: It presumes that the most highly capable U.S. remote sensing licenses should be conditioned until circumstances render the condition obsolete, rather than presuming that U.S. industry's capabilities should not be conditioned at the outset."

The bottom line here is that in many cases commercially driven innovation in the space sector greatly outpaces the USG's ability to develop and promulgate policy that promotes U.S. interests.

ITAR-Free

Another oft-cited example of realizing the secondary- and tertiary- effects of over-regulation come in the form of "ITAR-free satellites." For a majority of spaceflight history, satellites have been regulated as a defense article under the International Traffic in Arms Regulations (ITAR) on the United States Munition List (USML). Recent reforms to export control regime have moved most dual-use components and satellites to the Export Administration Regulations (EAR) on the Commercial Control List (CCL). In 2002 Alcatel Space started marketing "ITAR-free satellites." In a report led by the Air Force Research

Laboratory which conducted a survey of 274 space companies the companies claimed that $2.35 billion of foreign sales had been lost between 2003-2006 due to ITAR license rejections. Over 80% of respondence stated that U.S. export regulations had incentivized foreign companies to offer ITAR-free products. Even while there remains healthy skepticism about the veracity of the business case for ITAR-free satellites, it remains a poignant example for the space community about how over-regulation can foster foreign competition.

Value what is important

Risk Taking

Space is an inherently risky business but for a long time the preponderance of that risk was absorbed by the government. For decades the technical, operational, financial, and policy risk of space system development resided largely with the government in traditional cost-plus contracts that produced exquisite capability. For contractors, profit was essentially guaranteed and the achievement of bespoke technical requirements could drive costs up significantly. With the rise of private investment in the space sector companies are now incentivized to absorb more technical and financial risk betting that their risk taking will lead to more robust returns on investment.

The absorption of these risks by private investment should be welcomed by the government with an enabling policy framework that incentivizes innovation, but this is not always the case. See the previous examples of over-regulation above. The reality is that even with the willingness to absorb technical and financial risk if their business proposition is "too innovative" companies may also face significant policy risk that the government has not been able to resolve yet. Space continues to be a place where private sector innovation outpaces policy formulation but there remains hope. SpaceX's ascent to winning national security space launches, being the first private company to send cargo and astronauts to the ISS, as well as winning the Human Landing System all bear witness to a motivated private investor helping to shape governmental policy through space innovation.

One more cautionary tale – it is a counterintuitive business risk for space companies to assume that the government will be their primary tenant customer and sell that to the VC market.

Investment in key technologies

It is now widely recognized that much of space hardware is relatively commoditized make it relatively easy and affordable to procure and customize through modular payloads. The question now becomes what are the next big technologies to invest in? Investing in innovative propulsion technologies whether its space solar power, ion propulsion, miniaturization of hall thrusters, chemical propulsion, and nuclear power will help free up more resources in the critical size, weight, and power (SWaP) calculus for spacecraft design.

Another area ripe for investment is artificial intelligence in the context of space systems. Artificial intelligence research and development was estimated to be approximately $37.5 billion in 2018 and is expected to increase to approximately $97 billion by 2023. AI has been used in the processing, exploitation, and dissemination (PED) process for

years. Programs like DoD's MAVEN have used space-based data to train AI algorithms for years now providing critical intelligence to deployed soldiers in the field. While many SaaS providers currently use AI algorithms to customize and hasten the PED of their product, there is more work to be done for bespoke customer requirements and innovation.

Closely related should be increased investments in automation and mission autonomy. With the rise of disaggregated architectures (whether Starlink or the Space Development Agency's pLEO constellation), the requirements for satellites to perform collision avoidance maneuvers as well as dynamically route data across the constellations will be on the rise. With objects flying at each other with closing velocities at 15 km per second machine-to-machine automated maneuvers should be planned for and executed with human-on-the-loop cognizance.

Investment in people

Lastly, let's recognize that the most important resource that the space economy should invest in is the dedication, inspiration, and creativity of its people. No progress is made without people, no progress should be made without recognizing their value. This is more than just tropes about STEM education (which is terribly important), this is about recognizing and celebrating diversity and inclusion in all parts of our space economy across the defense, civil, and private sectors.

The first U.S. commercial use of space occurred in 1962, with the launch of Telestar 1, sponsored by AT&T and Bell Telephone Laboratories. A tremendous amount has changed since then. The challenge for U.S. industry and the government is now to ensure that the power of innovation continues to propel us through space as well as propelling our betterment here on earth.

This article was drafted for a workshop at Perry World House, the University of Pennsylvania's global affairs hub. The workshop was made possible in part by the generous support of Carnegie Corporation of New York. The statements made and views expressed are solely the responsibility of the author.