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Introducing "Fast Space": Rethinking Access to Space

By Lt Col Thomas Schilling, USAF
With Charles Miller, Lt Col Peter Garretson, USAF, and Hoyt Davidson

About the Forum

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Abstract

The "Fast Space" approach to space operations is an ecosystem of concepts, capabilities, and industrial partnerships that make speed the defining attribute of advantage in space, on both the supply and demand sides. This approach, if implemented, will answer global multi-domain problems like command and control (C2), intelligence, surveillance, and reconnaissance (ISR), ballistic missile defense, and other challenges such as anti-access and area denial threats to space assets (A2/AD). Fast Space's architecture directly supports all of the future core missions articulated in the Air Force's recent *Future Operating Concept* (AFFOC)—multi-domain C2, global integrated ISR, and rapid global mobility. The critical enabler of this architecture is something we call Ultra-Low Cost Access To Space (ULCATS). The private sector already has the precursor technological and industrial capability to achieve ULCATS within four years, and enable a Fast Space-powered revolution. But a market-based "chicken and egg" problem exists—in that large markets only emerge when there is transportation infrastructure, but new transportation systems typically require the force of markets to finance. Because of the large and risky investment needed to develop commercial reusable launch vehicles, traditional financial markets have not yet solved this problem. A partnership marrying the strengths of both the US government and private industry using "other transactions authority" agreements could jump start a virtuous cycle of launch cost reduction, and provide the United States with critical agility to operate in and through the increasingly contested space domain.

Introduction

The United States military's current operational approach relies heavily on space for command and control, communications, and intelligence. Robert Work, the deputy Secretary of Defense, noted in a 2016 speech to the Air Force Association that enduring strategic stability rests on three pillars: strategic deterrence, conventional deterrence, and managing the strategic environment.[1] All of these pillars rely on secure space architecture. With insufficient present leverage from nuclear deterrence, our conventional advantage coming under threat by adversary investments around the world, and changing dynamics in the space environment under way, the US government is now no longer dominant in space.

With the three pillars of strategic advantage now at risk, the United States must chart a new strategy. What we call the "Fast Space" construct is an ecosystem of concepts, capabilities, and industrial partnerships that make speed the defining attribute of advantage in space, with regards to both supply and demand. On the supply side, this includes a sortie-on-demand launch capability made possible through launch systems with higher launch rates, sustainably lower costs, rapid turn-around, and higher reliability than currently available systems. On the demand side, Fast Space will enable users at all levels of conflict, from tactical to strategic, to acquire persistent command and control (C2), ubiquitous communications, on-demand intelligence, surveillance, and reconnaissance (ISR), and provide a new axes for kinetic effects.

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The Benefits of Fast Space

Previous programs, such as the X-37 military space plane, have repeatedly validated the substantial benefit potential to modern operations should the United States achieve a Fast Space-like architecture. There is strategic common ground between capabilities being developed in the commercial sector and the US military's needs. Big low Earth orbit (LEO) satellite constellations are being developed for commercial communications, and these constellations have applications for global dynamic C2 and strategic integration. Big LEO constellations are also being developed for commercial remote sensing, and offer opportunities for national security applications such as ISR and space situational awareness (SSA). Further, industry officials are motivated to capture the large potential market for space tourism and satellite constellations requiring high flight rates of reusable launch vehicles. The commercial focus on large constellations, and high launch rates of reusable launch vehicles (or RLVs) to support private spaceflight is creating an industrial capability that can enable rapid reconstitution and fast cycle times, as well as enable new means to accomplish rapid global mobility, air and space superiority, and global strike.

A maturing Fast Space architecture can directly enhance each of the *Air Force Future Operating Concept* (AFFOC) 2035 core missions:

Multi-Domain Command and Control: Fast Space enables a distributed, resilient capability to rapidly reconstitute small satellites enabling a persistent communications and data infrastructure for joint force operations. Fast Space minimizes the vulnerability of current space and land-based command and control assets by ensuring rapid reconstitution at a time and place advantageous to the United States.

Adaptive Domain Control: Fast Space will provide the Air Force with "the ability to operate in and across air, space, and cyberspace to achieve varying levels of domain superiority over adversaries seeking to exploit all means to disrupt friendly operations" within 45 minutes anywhere on Earth. Such speed minimizes the impact of distance and time, placing the Air Force in an advantageous position to deliver its core mission effects across each domain.

Global Integrated Intelligence, Surveillance, and Reconnaissance (GIISR): Fast Space will aid the Air Force in accelerating the decision-making cycle in a challenging world environment. The ability to rapidly deploy ISR assets with the capability to integrate through multiple domains will provide operational agility to the GIISR mission.

Rapid Global Mobility: By leveraging existing investments from the private sector in orbital and suborbital capabilities, the Air Force can expand global reach in and through the space domain to deliver the effects of Air Force core missions. Capabilities matured by industry for commercial markets can enable autonomous drone packages of ISR, C2, and strike capability to rapidly support US interests abroad—such as a threatened embassy in Africa, in the US Africa Command (AFRICOM) area of responsibility. Currently, response plans in AFRICOM and US European Command (EUCOM) involve responding to a threat in Africa with C-130s on alert at Ramstein AB, Germany. A low cost space access concept would enable the rapid intelligence needed to identify a threat, while also eliminating long logistics lines and insufficient crisis response time. This will give personnel and assets back to combatant commanders, while posturing additional capabilities as needed.

Global Precision Strike: As with rapid global mobility, Fast Space will allow low-cost sortie-based repeatable delivery of strategic effects anywhere in the world on a prompt and sustained basis through waves of repeatable, affordable sorties. By providing a deterrent capability that is independent of forward basing, this reduces the incentive of an adversary to attack our forward bases, and makes the US less dependent on vulnerable forward bases for power projection. By providing a GIISR platform and launch capability for C2, Fast Space provides yet another vector to enable human-machine combat teaming in order to maximize conventional capabilities with emerging global precision strike technologies.

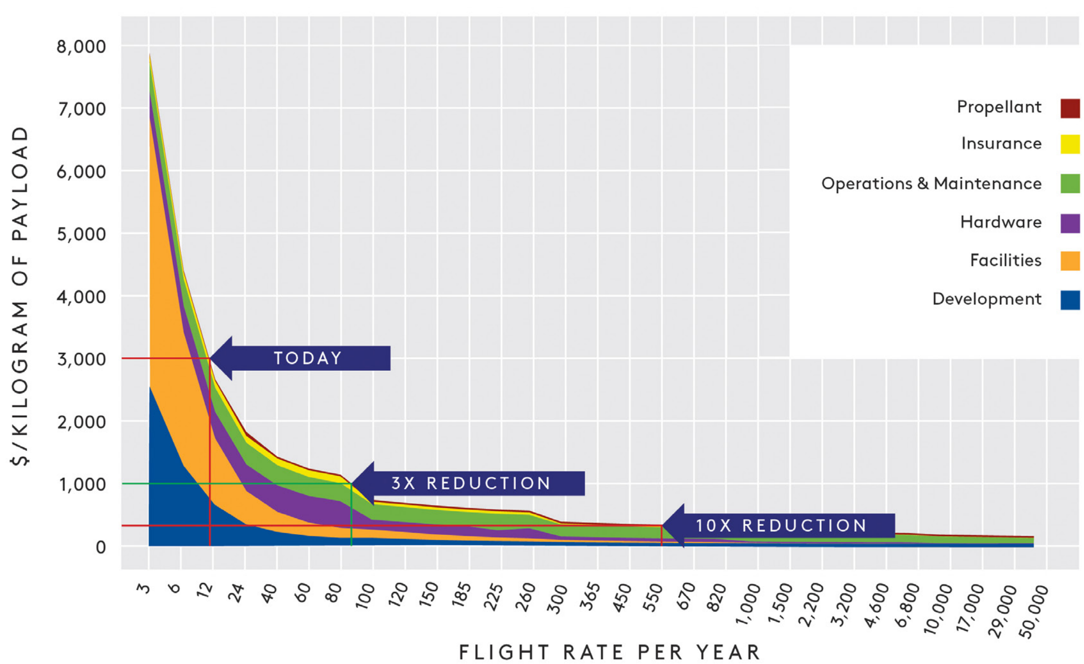
ULCATS Enables a Fast Space Strategy

A recent Air University (AU) study, *Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges,* concludes that the critical enabler of the Fast Space architecture is Ultra-Low Cost Access To Space (ULCATS). The study concluded that the US already has the precursor technologies to achieve ULCATS within five years.[2]

However, private industry and the market have not solved this problem because of a classic "chicken and egg" issue—which comes first, very large space markets enabled by ULCATS, or the large markets that need ULCATS? Large and risky investment is needed to further develop commercial RLVs. While private capital markets do fund comparably sized investments, they will only do so when the existing markets are both large and proven— which is not the current situation. While an ULCATS RLV would enable much larger markets if it were available, this option is currently not available, so smaller markets endure.

As detailed in the chart in figure 1, launch cost is principally a function of launch rate.[3] Today, the conditions exist for making ULCATS

Figure 1: Cost per kilogram rapidly decreases as flight rate increases



and Fast Space a reality in the near future. Several necessary conditions are changing simultaneously, though. First, significant private sector investment by American billionaires is going into the launch sector; second, technologies for RLVs (and other emerging approaches) are mature enough for fully-reusable launch vehicles; third, so-called "other transactions authority" (OTA) research and development agreements being used by the US government have proven their ability to significantly drive down the cost of development; and fourth, advances in modern manufacturing and engineering collaboration systems are driving costs down even further.

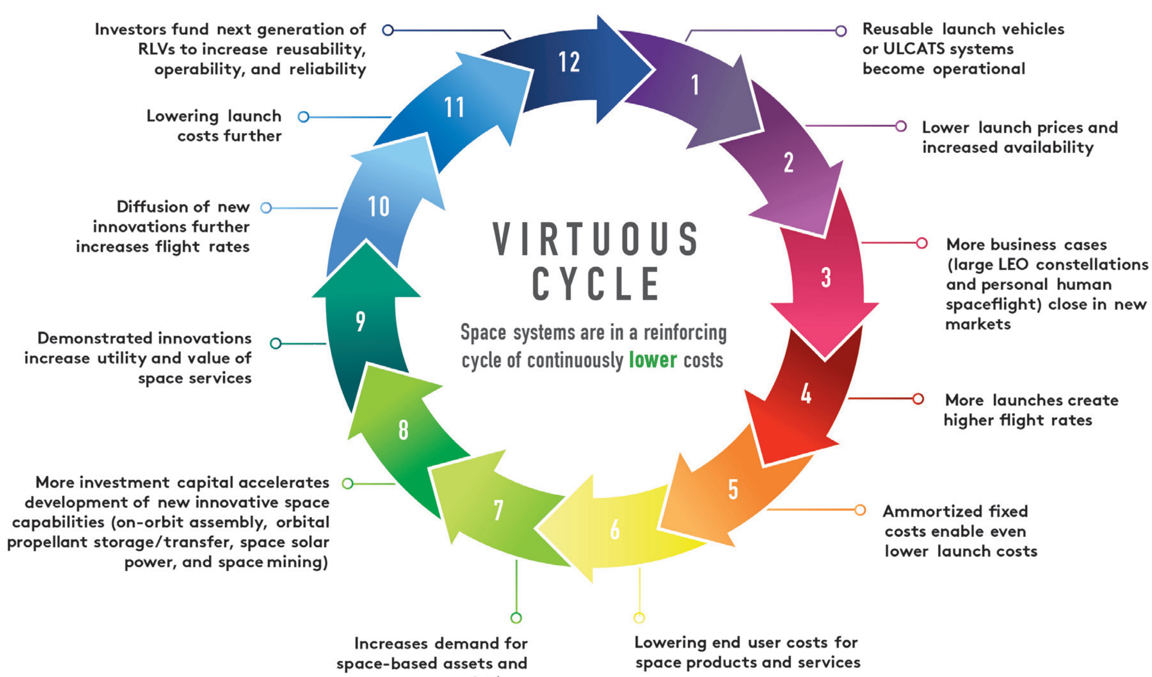
The AU study further concluded that private investors are ready today to share the risk with the US government to accelerate development of commercial fully reusable launch vehicles. This analysis concludes the initiative could jump start a commercial innovation cycle that leads to higher flight rates, decreasing costs, reducing entry barriers for more companies, further increasing demand and higher flight rates, thus reducing costs further.

The creation of transportation infrastructure that enables the US to jump on an industrial learning curve (as depicted in figure 1) where higher launch rates translate into lower launch costs also enables another virtuous cycle, the components of which are illustrated in figure 2.[4]

Near term, large satellite constellations provide an example of how smart government investment could stimulate such a virtuous cycle. Big satellite constellations in low-, medium-, and high-earth orbits have the greatest near-term potential to increase launch rates and support ULCATS. Unfortunately, commercial demand may not be great enough to make business cases because of the large amount of private capital required.

The projected costs for many of these small satellites are in the $500,000 to $2 million range when produced in large volumes. Launching 30 to 40 of these at a time is the most cost effective way to deploy such a constellation, but can represent a launch cost of one and a half to two and a half times that of the satellites themselves. For instance, one constellation project under development reported in 2016 that it intended to purchase 900 satellites at approximately $500,000 each, plus non-recurring costs. It would then launch 720 of them (at a cost of around $360 million) in 21 Soyuz launches for over a billion dollars. This launch cost would be almost three times the cost of the satellites themselves, not including non-recurring satellite costs. On the other hand, in a 2003 MIT study on projected

Figure 2: Virtuous cycle of reinforcing growth in markets, innovation, and investments



Iridium satellite costs, the satellite plus design development test and evaluation (DDT&E) costs were approximately 53 percent of total project costs, whereas launch and insurance were only 18 percent, or just 0.3 percent of the cost of the satellite component. [5]

With the small satellite revolution under way, we estimate that satellite manufacturing and DDT&E costs for a large constellation may be approximately 15 to 20 percent of total costs whereas launch and insurance could represent 30 to 40 percent, or approximately two times the satellite component.

If ULCATS existed today at three times the reduced cost, the total deployed costs of these constellations could be reduced sufficiently to allow more business cases to succeed. At current launch pricing, a big LEO constellation may struggle to achieve the 25 to 35 percent returns generally required by investors in large capital intensive projects with material technology, launch, and market risk, along with extended upfront periods of negative cash flow. However, a launch price reduction of three times or more could increase projected returns to within this range for some constellations. Savings include not only lower launch costs, but also the lower insurance costs and lower borrowing and interest expenses. The aggregate cost savings would in turn require less needed equity capital, making it easier to achieve the required investor returns.

ULCATS helps close the business case for large constellations—providing its own strategic advantage to the US, and then subsequently drives improved launch rates, which open new markets. The United States would then enjoy not only a US-flagged broadband carrier—providing strategic advantage—but also an industrial base capable of manufacturing thousands of small, low-cost satellites and providing frequent access to space.

Beginning the Virtuous Cycle and Policy Implications

However, the barrier to this change remains the "chicken and egg" problem described earlier. The Air University study concluded that a partnership marrying the strengths of both the US government and private industry through OTA agreements could start a virtuous cycle, which has many similarities to how the US government stimulated development of aviation in the early 20th century. To break the "chicken and egg" cost equation and make Fast Space a reality, the AU study recommends the US government act to jump start this virtuous cycle by partnering with US industry to develop both big LEO constellations (on the demand side) and ULCATS systems (on the supply side).

Creating an atmosphere for success for a ULCATS/Fast Space strategy has both commercial space policy and national security space implications. One of the key factors in bringing launch costs down will be a significant increase in flight rate. The current regulatory regime was designed for a world with expensive and infrequent launches — it is not equipped to license launches and payloads at higher sustained flight rates. The policy team working on the Fast Space initiative identified the following issues:[6]

- The Office of Commercial Space Transportation in the Federal Aviation Administration (FAA) is not currently able to process the number of commercial launches required to approach ULCATS in a timely fashion. Significant revisions to regulations and policies that assume a low flight rate are necessary.
- Government agencies with the authority to regulate the launch of certain types of payloads (the Federal Communications Commission for frequencies, the National Oceanic and Atmospheric Administration for remote sensing), are not equipped to license the number of payloads required to meet the projected flight rates to drive costs down toward ULCATS.
- The United States lacks a formal regulatory structure to approve innovative uses of space such as commercial propellant depots, Space Based Solar Power (SBSP), or lunar and asteroid mining, which creates investment uncertainty that could significantly impede new uses of outer space.
- Current launch sites are not capable of supporting the increased flight rate in terms of infrastructure and environmental clearances for the required number of launches.

To address these challenges, the United States needs to begin a comprehensive regulatory reform process across multiple agencies. We need to begin to transition public safety at launch ranges to a civil agency, and the US should create a commercial "airport-like" operating environment at federal ranges by transferring responsibilities to independent spaceport authorities. Both commercial launch and spacecraft licensing need to be restructured. Because more material will be in space, collision models need to be improved and research and development of orbital debris remediation and removal technologies needs to be conducted. Because of the need to simultaneously address many challenges across many different agencies of the US government, the AU study recommends the re-creation of the National Space Council, a body in the Executive Branch which helped coordinate civil and military space affairs until its dissolution in 1993, to lead these reforms.

Private investors such as Elon Musk, Jeff Bezos, and Paul Allen have demonstrated that American entrepreneurs are ready and willing to take risks in space. Just like in 1903 with the invention of the airplane, the United States has a significant lead with reusable space-launch systems. The advantages of developing the ecosystem of Fast Space extend well beyond purely military benefits. The economic potential in the marketplace of space is staggering. The AU study projects that the commercial space market could grow to an economy of nearly one trillion dollars a year, by accelerating growth in existing markets such as communications and remote sensing, and creating new markets. Some of these new markets include space tourism, asteroid mining, and space-based solar power.

Not only will these steps create more freedom of action for global vigilance, reach, and power projection, but it will also put the United States on an industrial learning curve that will fuel long-term economic power.

This marketplace will need to be protected and secured by a military force similar to how the US Navy secures the open oceans. The US Navy provides security and predictability across the global commons, which ensures a value system is maintained that respects individuals and the rule of law. The United States Air Force could partner with these private investors now to enhance our lead and ensure the American value system remains in place as the marketplace of space develops and matures. Without the security and predictability of the Air Force's presence, that marketplace will be susceptible to exploitation by adversaries who oppose America's values and interests. The United States would then pay a much higher price to regain the lead position, which it now maintains.

Conclusion

In a January 24, 2017 address, Air Force Gen John Hyten, the commander of US Strategic Command, noted that today there is a "huge commercial enterprise in launch, especially in satellite communications but also in imagery. OneWeb, SpaceX, CubeSat. All those things are out there right now, and a lot of folks in the military think that doesn't pertain to us. It pertains to us in two ways. Number one, it creates an economic environment that the United States military will have to defend at some point and it also creates an opportunity for us to take advantage of a commercial sector that we should be able to take advantage of to do the missions that we have to do."[7]

The United States can make a bold move now to help make this vision a reality. Utilizing OTA-based public-private partnerships, a menu of new capabilities for Air Force and joint service functions could be available to the president and combatant commanders within five years.

There are three steps necessary to make these capabilities available, though. First, the US must establish a purpose-built organization designed to partner with commercial industry and accelerate development of its capabilities. Second, we must restart the National Space Council to take an active role shaping the interagency and commercial policy environments. Third, we should take an active approach to developing requirements documents for affordable reusable launch vehicle systems with rapid turnaround and surge "launch-on-demand" capabilities. Not only will these steps create more freedom of action for global vigilance, reach, and power projection, but they will also put the United States on an industrial learning curve that will fuel long-term economic power.

Just like with the early history of powered flight, America could lose its lead to a fast follower—having both national security and economic impacts. Now is the time to take deliberate action to increase our lead and build the vehicles, payloads, and infrastructure to ignite this 21st century industrial revolution. ✪

Endnotes

1 Robert Work, "Remarks to the Air Force Association, As Delivered by Deputy Secretary of Defense Robert Work, National Harbor, Maryland, September 21, 2016" https://www.defense.gov/News/Speeches/Speech-View/Article/973907/remarks-to-the-air-force-association (accessed April 3, 2017).

2 Author's note: This paper is distilled from the Air University study *Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges.* The authors thank the study team for their valuable contributions to this endeavor.

3 Charles Miller, et al, *Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges*, Full Report, Draft, Air University, Maxwell AFB, AL, January 13, 2017.

4 Ibid.

5 Engineering Systems Learning Center, Massachusetts Institute of Technology, *MIT Industry Systems Study: Communications Satellite Constellations,* October 14, 2003.

6 Miller, *Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges*, January 13, 2017.

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About the Authors

Lt Col Thomas Schilling is a graduate from Louisiana State University with a Bachelor's in Business Administration. He is an air battle manager with over 2,500 hours on the E-3 Sentry Airborne Warning and Control System aircraft. Currently he serves as chief of the Commander's Action Group at Air University, where he works for Lt Gen Steven Kwast. For the past year, Schilling led AU's Fast Space/Ultra-Low Cost Access To Space (ULCATS) study.

Charles Miller is the President of NexGen Space LLC, and served as the principal investigator for the Fast Space/ Ultra-Low-Cost Access To Space (ULCATS) assessment for the US Air Force. A space entrepreneur, Miller was CEO of Constellation Services International, a satellite servicing venture and leading competitor for commercial space station cargo delivery. He later co-founded Nanoracks LLC, which has delivered more than 350 payloads to the International Space Station. Miller served as NASA Senior Advisor for Commercial Space from 2009 to 2012, and provides strategic advice on commercial partnerships with DARPA programs. He recently served on President Donald Trump's transition team for NASA.

Lt Col Peter Garretson is an instructor in joint warfare at Air University's Air Command and Staff College (ACSC) and leads Air University's Space Horizons Initiative. Garretson has participated in numerous Office of the Secretary of Defense and USAF wargames focused on future warfare and the role of space in conflict. He is the former Chief of USAF Future Technology, and served at the Defense Advanced Projects Agency (DARPA) as a USAF fellow, and at Los Alamos National Laboratory as an Academy Research Associate. Garretson has authored over 50 publications on topics such as space governance, space policy, strategic culture, and US military strategy.

Hoyt Davidson is the founder and Managing Partner of Near Earth LLC, an investment bank and advisory firm focused on commercial space and defense. Previously, Davidson was a managing director in the Telecom Group at Credit Suisse First Boston. Davidson's banking career began in 1987 at Donaldson Lufkin & Jenrette where he co-founded the firm's Space Finance Group, Wall Street's first dedicated coverage group for the commercial satellite industry. He also currently serves on the boards of XO Markets Holding Inc., the Space Foundation, and the National Space Society. He is also a past member of the Commercial Space Committee of the NASA Advisory Council.

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