Don't Forget "Access"
Space Launch Critical for Military Transformation

By Jeffrey Becker and
Gary Trinkle

The Secretary of Defense has identified the strengthening of Joint Warfighting capabilities and the transformation of Joint forces as among his top priorities. United States Joint Forces Command is dedicated to providing Joint context for Service-developed capabilities and to exploring transformative military capabilities. Recently, Joint Force Command's Joint Experimentation Directorate (J9) completed a study that is especially relevant to Space operators in the Army and throughout the other Services. This analysis, titled "Space Access as a Critical Enabler for Future Joint Warfighting" examines Space lift requirements for the future Joint force and considers alternatives to current chemical propulsion Space access strategies.

Project Alpha was established by Joint Experimentation as a "rapid analysis" group designed to scout the future and identify high-impact ideas in the area of Joint force transformation. The ideas and technologies examined by the Project Alpha analysis team are often unconventional and rarely mature; therefore, the purpose of a Project Alpha rapid assessment process is to endorse and refine an idea's potential rather than to establish an acquisition program.

This article will highlight the findings of Project Alpha's Space access report, including several potential solutions to the challenging technical problem of placing militarily significant payloads in orbit. The United States relies so heavily on a wide range of Space capabilities that access to the medium must be regarded as a "strategic center of gravity." Space planners must ensure that the correct mix of investments is found so that this reliance on Space capabilities does not become a vulnerability. The six-month Project Alpha "Space Access" rapid assessment process studied current and programmed Space access capabilities and evaluated whether these prospective Space lift capabilities will be sufficient to support future Joint operations.

A National Challenge

U.S. strategic-level guidance, including the Space Commission report, describes Space as a "vital national interest." In light of this guidance, a large number of concepts and technologies that rely on Space or exploit its unique characteristics have been developed. However, current launch technology is expensive, less responsive than it could be, and is often prone to costly errors. Compounding these drawbacks are unsuccessful reusable launch vehicle efforts that have been thwarted by the difficulties inherent in mastering the required technologies and a lack of programmatic and budgetary will. There is a disconnect between our military's need to access Space and our ability to get there cheaply and reliably. Our need for cheap and reliable access to Space and the lack of diversity in our systems means that the United States runs the risk of ceding asymmetric Space advantages by relying on quarter-billion dollar disposable launch systems. We do not sink our ships or crash our airplanes after each mission, yet we regularly do just this with Space launch vehicles.

Most military concepts of operations — both present day and experimental — assume the availability of Space for U.S. purposes. Communications, navigation, intelligence, and — increasingly — force enhancement and projection capabilities are usually considered an "assumed future reality" in planning and operations. Indeed, most future-oriented concepts such as the Army's Objective Force "sensor to shooter" grids, "common relevant operational pictures" and "network-centric warfare" all rely on these significant assumed Space capabilities to be success-

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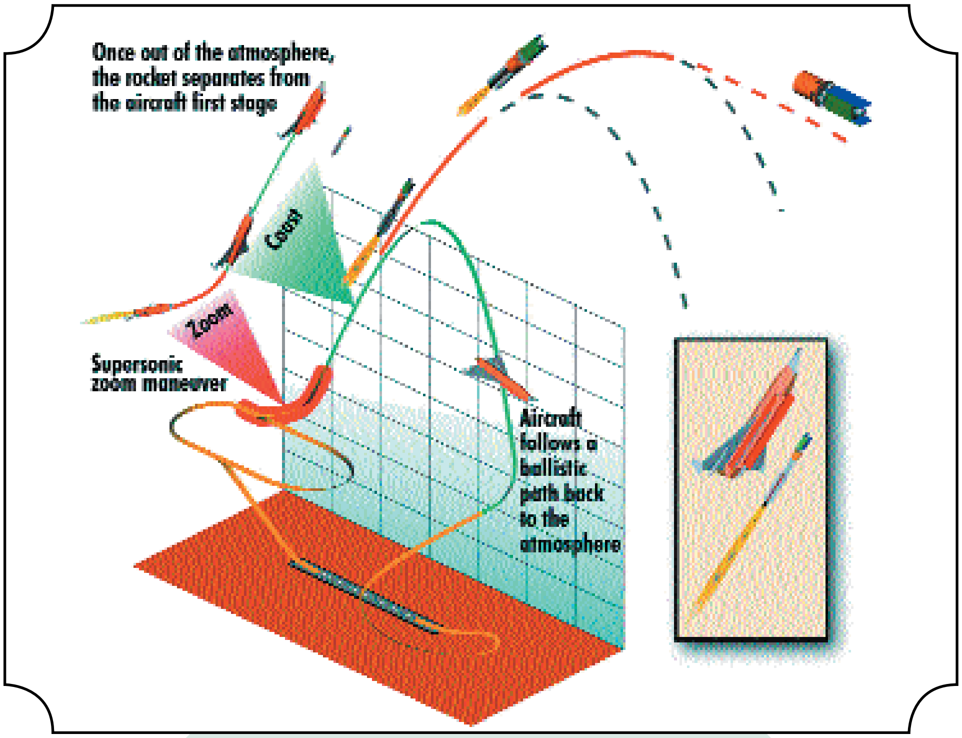

Figure 1

ful. One cannot assume, however, that the assortment of government and commercial launching mechanisms planned to be available in the 2015-2020 timeframe will be vastly more affordable, reliable, and responsive than those available today. The Space access report found that planned Space launch capabilities will rely heavily on the "evolved expendable launch vehicle" series of boosters to provide incremental improvements over today's capabilities. However, many concepts for Space force enhancement, Space control, and Space force application often rely on assumptions of vastly better Space access capabilities than the expendable launch vehicle program can provide.

Growing U.S. reliance on reliable access to Space must be squared with the fact that, in many ways, the current model for staged, disposable chemical propulsion rockets (such as the evolved expendable launch vehicle) has reached near-peak efficiencies. The Project Alpha Space access study found that current U.S. orbital access strategies should better accommodate the examination and development of alternatives to chemical rockets as the single method to reach orbit and that alternative Space launch capabilities should be given larger prominence in developmental efforts and experimentation venues.

To illustrate the wide range of alternative Space access capabilities, the rapid assessment process looked at five representative scientific initiatives in this area. The five alternatives were designed not as prescriptive recommendations, but rather to exemplify the varying stages of maturity and scientific complexity of ideas that exist outside of the current launch paradigm. Some of these ideas make claims so radical and revolutionary as to require extraordinary evidence if they are to be implemented. Advocates of transformative military change, however, are not doing their jobs if radical, yet plausible ideas remain unexamined. Indeed, today's unlikely capability may be tomorrow's assumed reality. The Project Alpha Space access report began the process of examining some of the revolutionary orbital access concepts that are under consideration in advanced technology labs around the world.

Alternative Space Access Capabilities

Reusable Exo-atmospheric Deployment

Future warfighting concepts, including the Army's Objective Force, emphasize small, highly dispersed, yet interconnected units to minimize vulnerability, increase flexibility, and respond rapidly to unpredictable and changing situations. Current Space architectures, however, often rely on large, expensive single boosters to loft satellites. These large expendables may never allow the United States to achieve the responsive launch capabilities that future military operations will require. One solution to this issue is to rely on larger numbers of mini-satellites, micro-satellites, and other smaller satellites launched from specialized aircraft capable of exo-atmospheric flight. The use of advanced reusable aircraft is a relatively straightforward method to achieve more responsive Space access by a hybridization of reusable and expendable vehicles designed to achieve orbit for small, yet highly capable payloads.

As depicted in Figure 1, one Defense Advanced Research Projects Agency technology initiative being studied is the efficiencies gained in cost to orbit when a very high-speed aircraft "zooms" to exo-atmospheric altitudes, then releases a small rocket and payload that burns as a second stage to place the small payload in orbit. A

(See Don't Forget "Access", page 45)

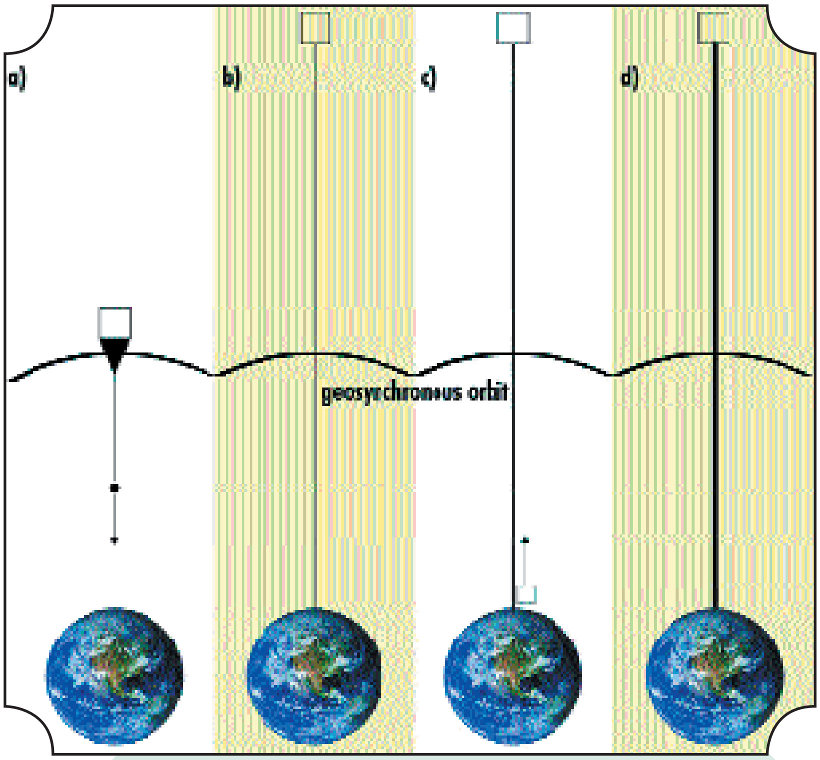

Figure 2

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number of aircraft and small expendable rocket technologies exist that may be used. What is clear is that significant efficiencies result because the air-breathing first stage can return to a base and be reused rather than burn up on re-entry. Additionally, reusable exo-atmospheric deployment allows for higher flight rates for the aircraft and placement of payloads to low Earth orbit (LEO) at a wide range of inclinations and locations other than the two major launch facilities the United States currently operates. Because the reusable aircraft are not associated with fixed launch facilities, they could also be deployable across the United States or globally if required.

Deploy on Demand Versus Launch on Demand

A key improvement and performance parameter desired by the Space community is the ability to get military payloads to Earth orbit in a matter of days or hours as opposed to today's months or years. Whereas many Space access studies focus on specific new platforms to improve the ability to reach orbit, the "deploy-on-demand" concept focuses on bridging the gap in responsiveness by using current launch systems differently. A deploy-on-demand architecture would place affordable micro-satellites dormant in orbit with their later use anticipated. Unlike current constellation "spares," these assets would ride piggyback aboard currently planned chemical propulsion launches in a "hitchhiking" mode. Once in orbit, these assets could be activated to replace or supplement existing military Space capabilities should conflict render them insufficient or unavailable. A deploy-on-demand supplemental architecture would require significant improvement in micro-satellite potential and experimentation to ensure that instantaneous activation and reliability of small satellites in support or replacement modes are possible.

ail Guns

Rail guns use a conductive projectile fired from a light gas gun into the rail gun. The projectile then slides between two parallel conductive rails and closes an electric circuit. The resulting current flowing in the circuit generates a magnetic field that accelerates the payload to orbit-achieving velocities. Rail gun systems would require specially hardened satellite packages to ensure satellite stability as it leaves the launch tube as well as hardening to address significant g-loading. The largest guns will subject the satellites to a thousand times the force of the Earth's gravity (1000g) for approximately one second. Although damage by this vast acceleration can be overcome in circuit design, it would require significant hardening of some of today's fragile satellite components such as solar cells or antenna structures. The rail gun does away with the need for significant propellant volumes aboard the launch vehicle because the massive electric generators and gas gun components used to launch the vehicle remain on Earth, allowing the payload to occupy a very large portion of the launch vehicle's mass. A fixed rail gun system may be able to generate up to 300 launches per year with payload of 10,000 pounds per launch. At these rates, the gas gun could potentially loft 1,500 tons a year into low Earth orbit. By comparison, the Space Shuttle (the largest current U.S. Space access vehicle) can place 63,500 pounds in orbit.

Slingatron

A slingatron is a propellantless, magnetic means of launching a projectile. Slingatrons can be configured in a variety of geometries, but the most common consists of a spiral track (or launch tube) that gyrates at a constant frequency about a set radius. Under proper conditions, a projectile entering the spiral at the center will undergo nearly constant tangential acceleration before exiting. The slingatron launcher offers the potential to conduct intercontinental bombardment, and to place nano-satellites and micro-satellites in orbit.

The Space Elevator

In the most basic description, the Space elevator is a cable with one end attached to the Earth and the other end roughly 60,000 miles in Space — over twice the distance to geosynchronous Earth orbit. Although a frequent device of science fiction, the Space elevator has moved out of the realm of pure speculation and into the "merely" fantastic because of recent advances in materials science. The Space elevator concept relies on a cable manufactured from ultrastrong, lightweight composite carbon nanotubes. Theoretically, a carbon nanotube structure is up to 40 times stronger than steel; when used in a Space elevator, it could be used to haul payloads to Space in much the same way as an elevator climbs to higher floors in a building. This is possible because the carbon nanotube cables are theoretically strong enough to hold together under the "orbital" dynamics of a very long cable pulled taut by the spinning of the Earth.

The illustration (Figure 2 on page 45) is a notional representation of the deployment scenario for the Space elevator. First, (A) a Spacecraft is sent to geosynchronous orbit where it begins deploying a small cable. As the cable is deployed, the Spacecraft floats outward to provide a stabilizing anchor for the emerging facility. When the end of the cable reaches the Earth, (B) it can be retrieved and secured at some point along the equator. Climbers of increasing size can then be sent up the initial cable (C) to reinforce the initial cable. Finally, (D) a usable, high-capacity cable is complete and can handle large capacity payloads that can be released into a number of differing orbits.

Funded by the NASA Institute for Advanced Concepts, research into the Space elevator indicates that once the apparatus is constructed it would have the capacity to lift — not launch — payloads of up to 50,000 pounds to geosynchronous orbits at costs per pound of between $50-$100. This is several orders of magnitude better than current day (or even projected) capabilities and would truly revolutionize the ability of the United States to access Space.

Conclusion

The Department of Defense currently uses Space capabilities to perform a variety of missions that are not easily or reliably achieved using other terrestrial means. In the future, this dependence shows little sign of dwindling. The Joint force will rely on Space for more than communications, navigation and intelligence functions and will begin to apply force in, through and from Space. None of this is possible, however, without access to Space in a timely efficient and flexible manner. Assured and reliable Space access will require a transformation in U.S. launch capabilities. The major insight gained from this study was that current funding priorities in the area of Space access have significantly constrained the Space access architecture to a continued dependence on disposable, single-use chemical propulsion to boost critical U.S. payloads to orbit. In the future, this approach may be insufficient to meet the needs of future Joint operational warfare and present significant exploitable vulnerabilities to adversaries in tomorrow's international environment.

Reliance on these expensive shuttle or disposable staged rocket technologies is increasingly unacceptable for the military exploitation of Space. Indeed, the problems of anti-access, critical mobile targets and hard and deeply buried targets place a premium on the unique capabilities that Space access provides.

These capabilities, including hyperspectral sensors, the global positioning system, missile defense, and even the application of force to, through, and from Space, will provide the United States with the anti-asymmetric strategies of choice against future (even current) adversaries. But these "high-demand, low-density" capabilities will remain so unless the United States is able to access Space more cheaply and responsively than it does today. Should the United States move to a wider vision of placing payloads in Earth orbit, the resulting dramatic reductions in launch cost and complexity will revolutionize U.S. capabilities to exploit Space as a military domain.

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