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Is Operationally Responsive Space the Future of Access to Space for the US Air Force?

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THE KEYSTONE OF the operationally responsive space (ORS) concept is a responsive launch capability. Without such space lift, improvements designed to establish suitable space assets and infrastructure will prove significantly less effective. Air Force Space Command (AFSPC), with support from the Air Force Research Laboratory (AFRL) and the Defense Advanced Research Projects Agency (DARPA), is currently conducting preliminary system-acquisition studies, technology development, and concept demonstrations to make responsive launch a reality. This article presents opposing ORS arguments.

Yes: Operationally Responsive Space Lift Is Essential to US Space Superiority.

The US Space Transportation Policy, issued on 6 January 2005, recognizes the United States' need to augment space capabilities in a timely manner by placing critical assets in space. The policy sets the following goals and objectives:

> 2) Demonstrate an initial capability for operationally responsive access to and use of space—providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements. . . .
>
> 4) Sustain a focused technology development program for next-generation space transportation capabilities that dramatically improves the reliability, responsiveness, and cost of access to, transport through, and return from space, and enables a decision to acquire these capabilities in the future.[1]

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Vice Adm Arthur Cebrowski, USN, deceased, director of force transformation in the Office of the Secretary of Defense, referred to ORS as a new defense business model, the key element of which is operationally responsive support to theater combatant commanders, as opposed to the current space model, which is based upon remnants of the Cold War.[2] As such, an ORS space-lift system must be timely (e.g., mission execution must fit within a joint force commander's timeline) and affordable (e.g., the cost/benefit ratio must be comparable to that of other mission capabilities or provide a unique capability at reasonable cost).

Responsive space systems delivered to space with responsive launch systems include replacement and augmentation satellites for communication; navigation; and intelligence, surveillance, and reconnaissance. Launch could support an evolving mission area of force application from or through space with the use of common aero vehicles to carry strike weapons. The US Marine Corps even envisions transporting a Marine reconnaissance platoon from the continental United States (CONUS) to anywhere in the world within hours to conduct missions with special operations forces. Such a system would provide the theater commander unprecedented flexibility and capability to produce desired effects.

An analysis of alternatives completed by AFSPC in 2004 concludes that "ORS can provide significant military utility at the campaign level" through the use of responsive space-asset delivery.[3] The greatest impact occurs when the enemy has offensive counterspace (OCS) capabilities and the United States uses responsive launch vehicles and satellite systems to maintain on-orbit capabilities. This ability to sustain and supplement on-orbit assets could become particularly critical if potential adversaries can destroy or disable our satellites—reportedly, China has this capability. Force application and OCS missions also provide significant military utility, with the former increasing as a function of theater access.[4] The United States has less access to some regions of the world as a result of the decreased forward presence of its forces and globalization of terrorism. Within that operational environment, the analysis of alternatives determined that a hybrid launch vehicle (HLV), a reusable first stage with expendable upper stages, was the most affordable solution to meet mission requirements. A subsequent study, by this author, developed a potential concept of operations for an HLV system which showed that no insurmountable technology challenges existed.[5]

ORS HLV wings located in the south central and southwestern United States will provide the combatant commander unprecedented strike capabilities without the burden of deployed assets or aerial-refueling resources required for long-range bombers. Inland CONUS basing offers an inherent degree of physical and operational security not available at deployed locations, as was the case with Atlas F intercontinental ballistic missiles (ICBM) at sites in southern and southwestern areas, including rural Oklahoma, Texas, and New Mexico.

One cannot overstate the strategic benefits of an ORS system. For example, in the days immediately following the attacks of 11 September 2001, suppose that intelligence assets had pinpointed the location of al-Qaeda leadership in a remote region of Afghanistan outside the range of Tomahawk cruise missiles. Without overflight permission already in place, launching air strikes would have proved politically impossible; however, with a responsive space-lift vehicle, we could have completed attacks within a few days—or hours if a vehicle had been on alert.[6] Despite the smaller payload of an HLV compared to that of a B-1, B-2, or B-52, the HLV's increased kinetic energy and tactical surprise offset that detriment. As the sortie rate increases, the cost-efficiency also increases, providing the Air Force an alternative to the recapitalization of its long-range attack aircraft.

The HLV's flexibility (the reusable first-stage booster is configured with different upper-stage vehicles, depending upon the mission) represents a key feature of the ORS system, enabling a single capital investment to support multiple mission areas. The ORS concept effectively operationalizes the space-support mission, increasing its ability to provide force application (strike from, through, or in space), force enhancement (satellites supporting air, land, sea, and space operations), and offensive as well as defensive counterspace (attaining and maintaining space superiority).

Prior to a formal decision to pursue an ORS program, as provided in the US Space Transportation Policy, a number of activities within the Air Force and the Department of Defense (DOD) have sustained the momentum and made progress in establishing the technology basis. DARPA's Responsive Access, Small Cargo, Affordable Launch (RASCAL) and Force Application and Launch from CONUS (FALCON) programs attempted to identify and develop low-cost, responsive launch concepts. The RASCAL program focused on concepts for launching small vehicles from high-speed, high-altitude aircraft, whereas FALCON concentrated on developing low-cost, expendable launch vehicles that could demonstrate ORS requirements. The DOD canceled RASCAL in February 2005 in order to focus on FALCON, which continues to investigate two distinctively different concepts: a conventional, multiple-stage, ground-launched rocket and a rocket deployed from the back of a C-17 cargo aircraft.[7] Under the FALCON program and with funding from the DOD's Office of Force Transformation, the Space Exploration Corporation (SpaceX) has demonstrated many low-cost and responsiveness attributes of ORS during preparation for the inaugural launch of its Falcon-1 small launch vehicle.[8] FALCON remains important to the future development of the HLV since the expendable rockets developed under the program could be used as upper stages on the reusable booster.

The Affordable Responsive Spacelift (ARES) program, the next step towards demonstrating the feasibility of an ORS system, set a goal of developing a subscale launch vehicle that demonstrates the characteristics of the HLV's reusable first stage. ARES has just begun system-concept studies, but its progress will shape the future of the ORS launch vehicle.

The operational responsiveness of an ORS system is not science fiction. Burt Rutan made history in October 2004 when his privately funded SpaceShipOne aerospace plane completed its second suborbital trip into space. Rutan and other start-up companies have demonstrated that it doesn't take a large, government-funded program to build a launch vehicle. Profit from commercial launch services, including space tourism, serves as their motivation; however, the systems required to enable such a business may use the same systems and technologies needed by the ORS launch vehicle. If these programs can launch operations responsively, development of an Air Force operational capability can proceed with substantially decreased risk.

Current trends in the air and space community show why this is possible. First, today's computer technology allows us to go from idea, to computer, to machine-shop floor, to final part in a fraction of the time it used to take. Second, the recent slump in the world space-launch market, coincident with a period in which the National Aeronautics and Space Administration (NASA) had no major hardware-development program, has permitted these new companies to hire technical experts who have experience in developing major space systems. This situation, coupled with the rapid increase in affordable computing capabilities and commercial engineering-analysis software, allows relatively few experienced engineers to produce designs that would have required much larger teams only a decade ago. Third, the economic potential of space tourism, combined with the wealth of a few dot-com company entrepreneurs, has opened up innovation and risk taking. DARPA projects encourage this type of innovation with significantly less government oversight than occurs in a typical DOD research and technology project. Building upon this philosophy, an ORS launch-vehicle program will prove successful.

A responsive HLV capability will serve as the foundation for ORS, which is critical to the future national security of the United States. A building-block approach now under development will ensure that full-scale operational system development does not proceed until we have mitigated all significant risks; therefore, success of the FALCON and ARES programs is a critical first step. Such a capability will allow the United States to reduce its reliance on forward-deployed forces and will either maintain or decrease response time. Obviously, much work lies ahead, not the least of which is the writing of doctrine to guide the building of organizational structures; strategy; and operational tactics, techniques, and procedures. However, ORS will become another paradigm-shaping event for the Air Force.

No: Expectations for an ORS Launch System Are Overly Ambitious and Put the Entire Concept at Risk.

The ORS mission-needs statement essentially began as a set of technology-push requirements meant to drive technology to determine the feasibility of such a concept. We have insufficient capability-pull from the war fighter to justify the cost of fielding such a system. Furthermore, unannounced responsive launches from the CONUS would produce a destabilizing effect due to possible confusion with strategic ICBM launches.

Admittedly, the United States needs many of the capabilities that an ORS system would purportedly provide, such as responsive replenishment of on-orbit space assets. However, attempting to do so with a single, partially reusable launch vehicle is a mistake. Several times in the past, we have attempted to create one aircraft platform to perform multiple mission roles (e.g., the F-4, F-111, A-12, etc.) with only limited success. Redeveloping an existing platform (e.g., the F-16) to conduct a different role has produced better results.

Many ideas concerning responsive launch within the ORS construct have their origins in Air University's *Spacecast 2020* study of 1994, which postulated a military space plane known as Black Horse that not only delivered satellites to orbit but also launched strike weapons.[9] When the National Space Policy of 1996 gave NASA responsibility for developing reusable launch vehicles, the Air Force could only participate in NASA's concept development; it also either monitored or became actively involved in that organization's DC-X, X-33, X-34, X-37, Integrated System Test of an Air-Breathing Rocket, and other technology and launch-vehicle demonstrator projects.[10]

Much of the passion for increasing US space-system capabilities originates with the paradigm-changing demonstration of space systems during Operation Desert Storm. The use of space capabilities continued to grow during the 1990s, with a significant increase in the use of precision-guided munitions aided by the global positioning system during Operation Allied Force. During this same time frame, many people within the space community advocated increased space-combat roles. One could almost hear their argument (one they never actually verbalized): "Just give us a strike system, and we'll win the war from our consoles in Colorado." Emphasizing their role in Desert Storm, they began to promote breaking away from the Air Force to create their own service—the US Space Force. With regard to competition for budget resources, space advocates became a "space mafia"—the modern equivalent of the legendary "bomber mafia"—arguing that space had yet to receive sufficient resources for its programs.

Also during this time—the late 1990s through about 2001—studies supporting AFSPC's long-term planning and research reports continued to develop the idea of a military space plane. The influence of space-sanctuary advocates, who oppose the militarization of space due to destabilization and proliferation worries, was waning, and the idea of using space for military purposes in a more aggressive manner gained greater acceptance. This period also saw a tremendous surge in commercial launch-vehicle development to support placement of commercial communication satellites in low Earth orbit.[11] The launch-vehicle and mission concepts that offered the potential to significantly reduce cost and increase responsiveness, as proposed by private companies, fit nicely within the military space-plane concepts, indicating to the plane's advocates that they were on the right path. Meanwhile, the Air Force began to become expeditionary, but AFSPC still tended to view its support as global and functionally based.[12] However, the nonspace Air Force busily flew missions in Allied Force and Operations Northern Watch, Southern Watch, Enduring Freedom, and Iraqi Freedom and did not have time to provide requirements for what we now call effects-based capabilities to support ORS development.

Built upon that history, the AFRL developed a set of requirements for its space operational vehicle (SOV) concept. These requirements sought to drive technology-development projects—that is, they were so aggressive that only advanced technologies or unproven system concepts could possibly satisfy them. The mission-needs statement, approved for ORS in 2001 by the Joint Requirements Oversight Council, has served as the basis for many subsequent launch-vehicle and propulsion-system technology projects. The analysis of alternatives study used requirements derived from this statement, specifying the reduction of launch-vehicle call-up times from months to days and of final preparation and launch from days to hours. The requirements also mention the ability to sustain multiple sorties per day during contingency operations, which might necessitate turnaround of the vehicle for a subsequent mission within hours of landing.

From this history of the responsive launch vehicle—whether it's called a military space plane, an SOV, or an ORS launch vehicle—one sees that the concept has emerged from the expansion of space capabilities through a technology-push program and that it has had inadequate capability-pull from the war-fighter community. Much of the support for a responsive launch concept depends upon obtaining access to space at lower costs. Claims of the low-cost-access-to-space companies in the 1990s, continuing with the more recent and better funded entrepreneurial companies, are accepted almost religiously.

These businesses are deceiving themselves and their supporters. Building the first test vehicle might prove relatively straightforward, but seeing such a system through production and operation will not. Such companies can operate inexpensively in the early phases of development because they have no past liability; no large, aging infrastructure to maintain and operate; no large pension and retiree health insurance funds to maintain; and no large bureaucracies to do the little things that have to be done. As a program matures, as such a system must, one will find no substantial cost difference between a system from one of the United States' traditional launch-vehicle companies and a system from one of the new companies.

The goals of low-cost responsive launch are not new. An essay on an online air-and-space-news Web site notes that the goals of the Pegasus and Taurus launch vehicles, developed by Orbital Sciences Corporation, differed little from those of ORS launch.[13] In fact, an Atlas F ICBM had more mass capability and better responsiveness than the small launch vehicles under development in DARPA's FALCON program today. Given the likenesses between the early Atlas vehicles and the SpaceX launch vehicles, one should not be surprised by their similar responsiveness.[14]

The AFRL has been using technology-push SOV requirements to perform research and technology studies of propulsion systems. Based upon the sortie rate and requirements for turnaround time, these studies have indicated a potential advantage of using liquid oxygen/liquid methane engines, leading many of the lab's current projects to focus on methane-fueled rocket-engine concepts. Methane has a slight performance advantage over rocket-engine-grade kerosene (RP-1); however, its density (almost 50 percent lower than kerosene) demands a larger vehicle. Moreover, the fact that it must be stored as a cryogenic liquid, at approximately -250° F, means that a methane-fueled vehicle would require more ground operations than one fueled by kerosene. Interestingly, the Soviet Union developed seven liquid oxygen/methane rocket engines for missiles and launch vehicles but never fielded any of them for operational use.[15] One can infer that the Soviets concluded that the increased size and operational complexity of the vehicle offset the performance advantage. Hence, one might expect the Air Force to come to the same conclusion, particularly when it develops the next iteration of responsiveness requirements for an ORS launch vehicle with effects-based operations in mind.

Perhaps we won't need an HLV to support the ORS construct—some other combination of systems may provide a better solution. A recent Air Force futures war game held at Air University included the capabilities of an ORS system and those of near-space balloons. Postgame analysis concluded that ultrahigh-altitude (often referred to as near-space) balloons, coupled with conventional attack aircraft, offer better support to the war fighter than does the responsive launch vehicle.[16] Thus, instead of spending a great deal of time and money developing and fielding a system that may not provide the capabilities expected of it, the use of near-space balloons, converted ICBMs, or other inexpensive, expendable launch vehicles might be a better solution.

Inclusion of a global strike capability might have a destabilizing effect on world affairs in times of heightened geopolitical tensions. Given an HLV that can deliver either a satellite payload to orbit or a common aero vehicle with a strike weapon to a terrestrial target, a third-party nation might detect the launch and fear a nuclear attack by the United States. Regardless of whether such fears have any foundation, the Cold War forged a paradigm that ICBMs deliver nuclear weapons, and a US adversary or a nation not friendly to the United States could have difficulty distinguishing the launch of an HLV from that of an ICBM with strategic weapons, despite the fact that the trajectories might differ. The world community would have to accept the uncertainty that a reentry vehicle could deliver a conventional precision-guided munition—in essence, we would be asking the world to trust us in a time of hostilities.

The political environment in a time of such uncertainty could restrict the operational usefulness of the ORS system's force-application capability. For example, if we determined that, in response to our planned delivery of a weapon by means of an HLV, a nation with theater or intercontinental nuclear capabilities might increase its readiness posture and thus amplify the risk of a launch on US forces or the United States itself, we would not execute the mission. Advocates of global strike dismiss such concerns, however, arguing that communications with the regional nations would prove sufficient to mitigate the risk. Nevertheless, would such communications affect the responsiveness and strategic surprise of the ORS system? Probably so.

In summary, these concerns indicate that the Air Force's operationalization of space is moving too fast. To date, primarily technologists—within the space community—have conducted ORS studies and planning. We may or may not need the capabilities derived from those studies to support the theater combatant commander. For example, we could make improvements in the responsiveness of existing expendable launch vehicles to sustain and supplement space assets without developing a new vehicle. Failure to meet low-cost goals and the detrimental effects of cost overruns and schedule delays will surely doom the ORS program, especially in light of strains on the Air Force budget caused by aircraft-recapitalization needs. ❑

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Notes

1. "Fact Sheet: U.S. Space Transportation Policy, January 6, 2005," n.p., http://www.ostp.gov/html/SpaceTransFactSheetJan2005.pdf.
2. Arthur K. Cebrowski and John W. Raymond, "Operationally Responsive Space: A New Defense Business Model," *Parameters* 35, no. 2 (Summer 2005): 67–77, http://carlisle-www.army.mil/usawc/Parameters/05summer/cebrowsk.pdf.
3. Col Pamela Stewart, "AFSPC Operationally Responsive Space Lift (ORS) Analysis of Alternatives" (interim status brief, Core Technologies for Space Systems Conference, Colorado Springs, CO, 4 November 2003).
4. Ibid.
5. Maj Kendall K. Brown, "A Concept of Operations and Technology Implications for Operationally Responsive Space," *Chronicles Online Journal*, 1 June 2004, http://www.airpower.maxwell.af.mil/airchronicles/cc/brown2.html.
6. The day-to-day operations of an operationally responsive space-lift wing will have much in common with those of CONUS-based strategic aircraft during the Cold War.
7. "RASCAL—Responsive Access, Small Cargo, Affordable Launch/SLC-1," *GlobalSecurity.org*, http://www.globalsecurity.org/space/systems/rascal.htm; and Jeremy Singer, "Pentagon Cancels RASCAL Small Launcher Effort," *Space News*, 2 February 2005, http://dev.space.com/spacenews/militaryspace/newrascal_020205.html.
8. The inaugural flight of the SpaceX Falcon-1 vehicle failed on 25 March 2006, 29 seconds into the flight. The failure of this first flight does not diminish the progress made towards demonstrating the capability to launch a vehicle with a small support team and relatively little infrastructure.
9. "Spacelift: Suborbital, Earth to Orbit, and on Orbit," in *Spacecast 2020 Technical Report*, vol. 1 (Maxwell AFB, AL: Air University, 1994), http://www.fas.org/spp/military/docops/usaf/2020/app-h.htm.
10. "Fact Sheet: National Space Policy" (Washington, DC: The White House, National Science and Technology Council, 19 September 1996), http://www.ostp.gov/NSTC/html/fs/fs-5.html.
11. Development of commercial launch vehicles decreased significantly beginning in 1999 and 2000 when satellite-based telecommunications did not realize their market potential. Terrestrial fiber-optic networks and towers for local cellular phone systems provided a lower-cost solution.
12. The key exception within AFSPC was the increased development of deploying space capabilities, including the creation of space weapons officers by sending career space officers to the Air Force Weapons School to increase the integration of space capabilities at the theater-operations level.
13. Jeff Foust, "Operationally Responsive Spacelift: A Solution Seeking a Problem?" *Space Review*, 13 October 2003, http://www.thespacereview.com/article/52/2.
14. Atlas ICBM variants deployed around the United States in the early 1960s, which used liquid oxygen and kerosene propellants, relied upon the modest performance of a gas-generator-cycle rocket engine. The key enabling feature of the Atlas vehicle was the construction of its pressure-stabilized propellant tank, a new concept at the time, which minimized the booster vehicle's inert mass. The SpaceX Falcon-1 launch vehicle also uses the same propellants, same rocket-engine cycle, and a state-of-the-art design and fabrication approach—also designed to minimize the inert mass.
15. George C. Sutton (author of *A History of Liquid Propellant Rocket Engines* [Reston, VA: American Institute of Aeronautics and Astronautics, 2005]), interview by the author, December 2005.
16. Thomas R. Searle, "The Air Force of the Future: Thoughts from the Future Capabilities War Game of 2004," *Air and Space Power Journal* 18, no. 2 (Summer 2004): 19–26, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj04/sum04/vorsum04.html.