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Operationally Responsive Space: A New Defense Business Model

ARTHUR K. CEBROWSKI and JOHN W. RAYMOND

Space capabilities are a prominent element within the collection of global advantages the United States enjoys today. Space is one of the “commons,” along with the sea and cyberspace, that constitute the triad of capabilities on which America’s global power rests. But several ominous trends now compel a reassessment of the current business model for meeting the nation’s needs for military space capabilities. While the existing model has served the nation well, a new business model is at hand and can now be readily grasped to propel us into the future.

Trends compelling this reassessment include: falling barriers to competitive entry into the commons of space, an increasing dependency on space capabilities, and emerging vulnerabilities in current space systems. In addition, there are systemic issues emerging across the spectrum that require a reexamination of how the nation acquires these precious assets. Such issues include: the fact that important space programs are in trouble for reasons either financial or technical; the growing need to recapitalize space capabilities; decreasing industrial base viability; reduced science and technology funding; and the need to develop space professionals. The current business model for space is unable to support, by itself, the combined weight of these accumulating pressures.

The context of space technology is also undergoing rapid change. While the cost to place a kilogram of capability on orbit remains expensive, the capability resident in every kilogram is soaring, given the unrelenting increase in information technology. This makes a new, complementary business model for space feasible. The door for much smaller satellites, weighing less than

1,000 kilograms, and even micro and nano-satellites is opening, allowing the Department of Defense to redefine cost and mission criticality curves, increase transaction and learning rates, and to favorably change the risk calculus. The old business model will not work in the development of these smaller satellites and cannot be modified to acquire the new capabilities. The new business model is derived from new technology, lower costs, and a new set of output-oriented metrics. As we move toward the age of the small, the fast, and the many, it's time to start applying these precepts to space.

There also is an operational imperative underlying the rapid adoption of this complementary and broader business model. Done correctly, this new model, with its flexibility and responsiveness, will ensure America's space superiority well into the future. Second, the model can serve as a test bed for the larger national military space program by allowing the Defense Department to leverage targeted science and technology investments while enhancing the professional development of military and industry space talent. So, national security space capabilities can grow out of this new model, but without the current problems and risks. Finally, by adopting this co-evolutionary process of pairing concepts and technologies, change can be influenced immediately. This model has at its core a generational development and acquisition strategy. In short, it is within our grasp to create new options in space, a process which itself can be a very powerful competitive advantage.

Operationally Responsive Space (ORS) is the term used to describe this new, complementary business model. Rather than teasing operational capabilities from systems designed and paced for larger national security capabilities, the full spectrum of critical capabilities are created from the bottom up. So, the new model is about defining a joint military demand function and providing joint military capabilities for operational- and tactical-level command-

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ers. Finally, the model emphasizes short cycle times and accelerated learning, providing high-speed iterative advancement in operational capabilities.

This new model is closely aligned with Harvard Business School Professor Clayton Christensen's Disruptive Innovation Model. The smaller satellites create what Christensen calls a new value network, in which a firm establishes a cost structure and operating processes to respond to the needs of a new class of customers. In the ORS model, the new class of customers is the operational and tactical commanders. According to Christensen, new-market disruptions target lower performance in "traditional" attributes, but improved performance in new areas, and target customers who historically lacked access to the product (i.e. non-consumption).¹

This new model directly competes against non-consumption by operational and tactical commanders. Today, small satellites provide lower performance in areas like resolution, power, and persistence. However, small satellites can provide great advantages in operational control, integration, responsiveness, costs, risk, and information-sharing among coalition partners. Over time, the capabilities of the new model should be expected to surpass the old.

Progress of Space Transformation

The US national security space team has made great strides in its 45-year history. Launched in the opening phase of the Cold War, national security space quickly evolved into a new source of national power. The connection between space and strategic deterrent forces was abundantly clear. The nation capitalized on converted weapon systems to develop the ability to launch small payloads into low earth orbit, graduating over time to placing larger payloads in higher orbits that proved vital for detecting the Soviet Union's ballistic missile threat.

Thirty years later, the battlefield value of military space capabilities was vividly demonstrated during Operation Desert Storm in 1991, which many experts deemed the first space war. In reality, space forces, like traditional military forces, used a robust Cold War force structure to defeat Iraqi forces and expel them from Kuwait. Nevertheless, operational relevance required the ability to distribute global space utilities to the theater commander and his subordinates.

One has only to compare 1991's campaign with Operation Enduring Freedom (OEF) or Operation Iraqi Freedom (OIF) to see how successful the United States has been at "operationalizing" its global space forces. One of the dramatic differences between Desert Storm and Operation Iraqi Freedom was the distribution of satellite-based wideband communications down to the tactical level. In Desert Storm, coalition military forces numbered 542,000 and they had 99 megabits per second of bandwidth available. In OEF/OIF, bandwidth

rose to 3,200 megabits per second, while forces were reduced to 350,000.² Satellite communications provided the backbone for Blue Force Tracking, shared situational awareness down to the individual level, and allowed operational- and tactical-level commanders to exploit an unprecedented speed of command. The nation's space capabilities directly increased speed of maneuver, the tempo of the fight, and the boldness and lethality of coalition forces. But much of this communications capability was provided commercially.

Additionally, the advances made in missile warning are significant. In Desert Storm, Defense Support Program satellites designed to detect Cold War ballistic missiles were able to give rudimentary theater missile warning. However, in the ten years since Desert Storm, advances in ground processing, on-orbit software, organization, command and control, and a theater warning concept of operations significantly improved the United States' theater missile warning capability. Finally, it is obvious that in the years leading up to Operation Iraqi Freedom, the United States made great advances in distributing the Global Positioning System signal to weapons, significantly increasing precision-strike capability.

These examples of increased bandwidth, theater missile warning capability, and precision show just how important space capabilities are in transforming the force and how far we have come in operationalizing these capabilities. But all along, the operational and tactical benefits constituted only what could be teased out of larger national security space systems. Furthermore, the sclerotic national program simply cannot maintain the pace required for future operations.

The Link to Strategy

One may ask why we need a new model, given the recent success of the existing space force. While it is true that US space forces provide an asymmetric advantage that no adversary currently matches, evidence suggests that the nation's current space supremacy is not guaranteed. An adversary might turn this asymmetric advantage into an asymmetric vulnerability if space supremacy cannot be maintained. The United States is the most heavily space-dependent nation in the world, along with its military, and there is no indication this dependency will change in the future.

Alfred Thayer Mahan, the prominent 19th-century naval historian and strategist, described the oceans as a Great Common. Today, space and cyberspace must be added to the list of commons that must be controlled. One of the recognized prerequisites to becoming a hegemonic power is the ability to operate in and control the commons. Therefore, it is expected that nations with such aspirations will try to erode the United States' ability to operate effectively in the commons and attempt to control the commons for their own uses.

The barriers to competitive entry are eroding in several key elements of military competition. The barriers to entry into space, which were so high during the Cold War, have eroded. No longer is space reserved for great-power nations alone. Space use has become much more common, and today a nation does not need to be a space player to employ space power. The commercial space communication and remote-sensing industries that emerged in the 1990s provide power derived from space, once reserved for the most powerful of nations, to any nation, organization, or even to individuals who desire its use. Additionally, the increasing capabilities of small, micro, and nano-class satellites have moved them from a realm more suited for university-backed experiments to an emerging niche with potentially significant military value. Today, nations can contract with universities not only to build microsats, but also to transfer the knowledge required to design, develop, and launch them.³

The United States, clearly the world's leader in the use of space, has abdicated to other nations a role in exploiting these smaller segments of the overall space industry. As the Department of Defense is at the threshold of transforming to a network-centric force, using the coherent effects of distributed military forces and systems to achieve the commander's intent, the newer, smaller elements of space capability are part of an emerging new toolset providing virtually unlimited potential.

But the Cold War attributes of existing space programs limit the ability to maintain space superiority required in today's rapidly changing strategic environment. Specifically, the mission criticality that grew out of the Cold War, and the very high cost of our sophisticated and highly capable space systems, lead to a high consequence of failure. The required corresponding risk-mitigation strategy places a premium on expensive, long-lasting, heavy, multi-mission payloads. These same attributes also force larger, higher-cost launch vehicles, with low launch rates and significant mission assurance oversight. Furthermore, the operational and tactical capabilities are based on mere afterthoughts.

Attributes of Operationally Responsive Space

Operationally Responsive Space is a new approach. Rather than trying to operationalize national space utilities, this model designs military capabilities directly for the operational commander. A key attribute of the model is that the field commanders drive the demand. That demand is joint military capability to meet operational- and tactical-level needs. Rather than treating our operational- and tactical-level commanders as a lesser requirement in the overall national space plan, this business model designs a capability to meet their specific warfighting needs. Done correctly, this approach can complement and add to national space capabilities. Some of the additional attributes of Operationally Responsive Space are as follows.

- *Demand function.* The operational level of war is at the theater level, and the operational commander normally is established only in conflict.⁴ This definition helps put the demand function into context. The operational commander requires a theater capability to satisfy a joint warfighting need (vice a national intelligence need) that is available during more constrained joint warfighting planning timelines. This demand function changes the space calculus. Specifically, it redefines the cost, risk, and mission-criticality variables, requiring lower-cost, smaller satellites with single-mission, sub-optimized, but effective payloads and far shorter life spans. The time function for responsiveness is then driven by adaptive contingency planning cycles rather than predictive futures or scripted acquisition periods. The objective is agility and dynamic fitness, not optimization.

- *Military capability.* Today's joint force commander requires capabilities that are horizontally networked, accessible by internet protocol, flexible, interoperable, joint down to the tactical level, and risk tolerant. Increasing the speed of command, which proved so vital in recent combat operations, requires high transaction rates, increased information rates, and a tolerance of ambiguity based on unpredictable demand.

- *Autonomous.* The model posits capabilities with the ability to launch and autonomously reach required orbits without months of "state-of-health" checks, calibrations, and configurations by large squadrons of ground-based satellite controllers.

- *Networked.* When space is accessible to the tactical or operational users, it changes the manner in which relationships occur and the way that organizations behave. While smaller satellites may not yet offer technologies that are groundbreaking, they can significantly alter the capabilities of a wider user base. The collective produces an understanding that is not replicated or deliverable by any single analyst or structured hierarchy. Leveraging space access by the entire defense establishment changes the methods and techniques that can be adopted by future users.

In a network-centric force, each satellite becomes a node within a tiered network of sensors such as larger space systems, unmanned aerial vehicles, or other air and surface assets. A network-centric approach uses the internet protocols throughout the entire life cycle of the satellite. That means integrating the payload remotely and using internet protocols for preflight testing, command and control, payload tasking, and data dissemination. This allows for increased fusion of data from multiple platforms while reducing life-cycle costs.⁵

- *Broadened user base.* There is no reason why this model must be confined to Department of Defense needs. Rather, it could mean an organic space capability for the larger national security community. One of the objec-

tives of Operationally Responsive Space is to make space assets and their capabilities available to operational and tactical users as an organic part of the Joint Task Force. One way of achieving this goal in space is to use the SIPRNET, the military's classified version of the Internet, to task, receive, and widely disseminate data. As the SIPRNET has matured as a core US warfighting command and control venue and the de facto standard for a preferred data-sharing service, the cost of gathering information has plummeted and the value of shared information content has soared. As a result, both the richness of information improves and the content reach expands exponentially.

Complementing "Big Space"

This new business model is not meant to replace the larger space program. Rather, they are complementary. Today, smaller satellites cannot provide the capabilities required to meet all national intelligence needs. However, just as the DOD has operationalized the larger space program to meet theater needs, these operationally-designed theater capabilities will also enhance our national and strategic space capabilities. Specifically, these satellites will help reduce the burden we are currently placing on our national systems and the organizations that operate them, enhance the persistence of national capabilities, assist in meeting force structure requirements mandated by current force planning constructs, and help ensure US forces are adaptable while facing an uncertain future.

Another role these systems could provide in the future is the ability to reconstitute larger space capabilities if adversaries succeed in finally developing capabilities to negate them. Although it is not replenishment in kind, smaller satellites could provide a subset of capabilities for national and military leaders. Over time, as both the technology and the concept of operations for small satellites mature, the gap between traditional space and smaller space capabilities will narrow.

Test Bed for Big Space

As the pace of change in the information age accelerates, so too must the institutional transactions that create capabilities from learning. Stagnation of institutional learning comes at the expense of creating future advantage. Today our space forces are at risk of becoming a strategically fixed target. The cost of sticking to slower generational turnover—a cycle that currently runs 15 to 25 years for US forces—is likely to be technological surprise in future conflicts.

Besides providing operationally relevant capabilities for the joint warfighter, this new business model will serve as a test bed for larger space

“The battlefield value of military space capabilities was vividly demonstrated during Operation Desert Storm.”

programs by providing a clear channel for science and technology investments, enhancing institutional and individual learning curves, and providing increased access to space for critical research and development payloads. Today, less than 20 percent of the DOD’s space research and development payloads make it into orbit, even while relying heavily on the Space Shuttle.⁶

Enlightened space science and technology stewardship requires the world’s sole superpower to compete with itself to avoid stagnation. Getting new technologies into space earlier to understand their ramifications and inform our conceptual context builds a learning curve for “big space” and provides a look at alternative futures.

By reducing cost, increasing transaction rates, and developing standardized buses (the hardware and software interfaces between payload and rocket), we change our risk-mitigation strategy. This will allow the United States to lower the cost of placing operational payloads into low earth orbit and simultaneously increases our ability to pursue research and development. Additionally, these same attributes will allow sub-optimized, simpler payloads to be launched into orbit.

The most important aspect of the test bed, however, is the institutional and individual learning that will take place. As an institution, DOD will learn there are alternative methods and processes to conduct space operations that could not have been developed through our larger space program. Additionally, the smaller satellite programs will provide great venues to pair seasoned space expertise with new prospects, allowing these efforts to cut their teeth in an area where failure is a data point and not a calamity.

Generational Science and Technology

Finally, this business model relies on a co-evolutionary process of pairing concepts and technologies in an effort to start influencing change immediately. The co-evolutionary techniques guide the Operationally Responsive Space approach to creating these capabilities. Techniques are used to stimulate disruptive innovation through the continuous development and refinement of operational concepts, processes, technologies, and organizations.

This approach should influence technology, policy, concepts of operations, acquisition processes, and public/private partnerships.

Operationally Responsive Space provides the ability to conduct a strategy of generational science and technology acquisition. This new business model brings the United States back to its space program roots. The model is similar to the space model used successfully for much of the 1960s and 1970s. All space systems started small and in low earth orbit and grew bigger in size and higher in altitude as technology and operational requirements matured. Analysis of the development of the Global Positioning System (GPS) satellite constellation provides some key guidelines that are adopted for incorporation into the new business model.

- *Creating leverage by targeting the investment of relatively small research and development dollars and the role of research laboratories.* The Global Positioning System grew out of research performed by the military services. The Naval Research Laboratory and Air Force Research Laboratory both targeted the investment of relatively small research and development dollars into key technologies required to develop the system. Over time, when DOD could not continue to fund two different systems, the two labs were directed to get together over a Labor Day weekend and come up with a single approach. The best attributes of both approaches were combined in the final system. It was determined that the Navy had the best clocks and orbits and the Air Force had the best signal structure. DOD directed the Air Force to take the lead in operationalizing the system, and the Naval Research Laboratory was funded for continued research and development.

- *Affordable access to space.* The successful development of the GPS constellation relied on testing clocks in space. The Naval Research Lab was able to get “free piggy-back rides” to space using excess capacity on the Agena rocket. Today, the cost, timelines, and risk associated with getting piggybacked research and development payloads into space would hinder the ability to advance new space technologies.

- *Generational approach.* The GPS actually grew out of a series of lab-sponsored experimental microsats. In total there were 15 navigational microsats and eight research and development satellites. Combined, these satellites served as stepping-stones to the operational Global Positioning System. They provided intermediate capabilities that allowed the development of new operational concepts, which directly affected the final orbital parameters adopted for the operational GPS system.

Operationally Responsive Space seeks to embed experimental capabilities into combatant commanders’ warfighting experiments. By doing so, operational concepts can mature in parallel with technology. By increasing transaction rates, next-generation technology and operational concepts can

be embedded into future payloads, leading to increased capability for the warfighter.

- *Public/private partnerships.* A critical attribute of the GPS acquisition program was the public/private partnership between the military services and the Rockwell corporation, which won the contract to build the first block of operational satellites. For about a year, engineers from Rockwell worked closely with the service laboratories to learn all the lessons they could before developing the operational system. This public/private team was crucial to the success of the program. Currently, the Defense Department's science and technology strategy falls short on several fronts. First, access to space does not afford a robust space science, technology, and research and development program. Second, there is a gap in translating research and development into operational capabilities. The new business model and co-evolutionary approach seeks to bridge this growing gap.

The Way Ahead

Over the past year, the Department of Defense has taken great strides to embrace this new business model. The Defense Secretary's Office of Force Transformation funded an initial operationally responsive space experiment, called TacSat-1, with the goal of providing an operationally relevant capability to the warfighter in less than a year at a cost of \$15 million. Actual results will be on the margin of both metrics, with a launch now planned for the summer of 2005.

In support of the TacSat-1 experiment, the Air Force has crafted a customized mission assurance approach for the oversight of a new commercial launch vehicle consistent with the nature of the TacSat-1 experiment. Additionally, the Air Force has worked closely with the commercial launch provider, SpaceX, to come up with innovative safety processes that will ensure public safety. At the same time, they have been willing to accept some degree of risk in operational suitability and effectiveness. This process is ongoing, and real organizational learning is happening, both in the Air Force and at SpaceX.

The TacSat-1 experiment has set the baseline for a co-evolutionary concept and the technology pairing process, and it has helped shape a stronger relationship between service labs. The Naval Research Laboratory is the program manager for the TacSat-1 experiment and has fabricated the satellite. The Air Force is following TacSat-1 with a second experiment that will build on the modest capabilities provided by the first TacSat. This is a realistic first step of generational science and technology efforts.

Finally, taking a broader view, the Defense Department is stepping up to make Operationally Responsive Space a near-term capability. General

John Jumper, the Air Force Chief of Staff, recently announced the Air Force's Joint Warfighting Space concept. The Air Force is leading a joint team to investigate Operationally Responsive Space technology paths, and the US Strategic Command is engaged to help define the corresponding avenues for new operational concepts.

But this is only a first step. The Defense Department needs to take some important additional steps to institutionalize this new business model. Critical to achieving the agility and flexibility demanded by an Operational Responsive Space model, the United States must develop standards for modular and scalable satellite buses. This will be a part of future TacSat plans and will increase the capabilities of smaller satellites.

Second, this new business model rests on reducing costs as a strategy. The Operationally Responsive Space model cannot afford to be burdened by traditional organizational tax rates which may cause the cost of future TacSats to be 50 percent more than necessary. This will significantly undermine transaction rates and the ability to assume risk, and it will result in a weakened business model.

The department also should develop a science and technology strategy that responds to operational issues defined by combatant commanders. Operationally Responsive Space needs to be placed firmly in the hands of the operators. The supporting science and technology effort should harness the core competencies of the country's national, service, and university-affiliated laboratories; enhance the industrial base; and utilize a generational acquisition approach to help bridge the existing gap between experimental and operational capabilities.

Today's strategic context demands that the Department of Defense undertake actions that are swift, bold, and specific. The new business model for space—based on a bottom-up approach operationally, technically, and financially—clearly meets those criteria. As the major defense power in the world, the United States military must dare to compete with itself to ensure sustained advantage. We must set our own standards. Space has long been an arena of American dominance. That must continue.

NOTES

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3. Surrey Satellite Technology LTD website, <http://www.sstl.co.uk/index.php?loc=32>.

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5. Eric Miller, "Virtual Mission Operations Center: On the Path to Transformational Communications Briefing," February 2004.

6. Robert Newberry, "Satellite Americano (XSM-1) Program Overview Briefing," Detachment 12, Space and Systems Missile Center, 8 September 2003.