

Assuring Space Support Despite ASATs

by Robert Butterworth
President, Aries Analytics, Inc.
Fellow, George C. Marshall Institute

Boast not thyself of tomorrow; for thou knowest not what a day may bring forth
Proverbs 27:1

No battle plan survives contact with the enemy (attributed to Helmuth von Moltke the elder, Colin Powell, and Murphy). U.S. space systems slipped past that truth for a long time because they were not part of a battle plan. They helped with information about enemy forces, movements, intentions, and other battlefield elements (weather, location, terrain), all very useful, but losing them on the opening day of battle would have made little difference to immediate operations in defense of the Fulda Gap.

Today's situation is quite different. Space systems are deeply embedded in U.S. war plans, as they have become integral components of U.S. weapons networks and tactical operations. Without them, force movements would be slower and less coordinated, weapons systems would be less responsive and less accurate, and tactical operations in general more costly. There would also be a strategic penalty in the form of less timely global reconnaissance, for which there are no substitutes.

These developments have naturally made space systems the target of enemy action. To prevail against the U.S., a local adversary might hope to avoid an all-out war by achieving his local objectives quickly and then suing for peace, leaving the U.S. with no attractive military or diplomatic options. To do so, he would have to thwart the ability of the U.S. to project power promptly, and that, in turn, would require sufficiently inhibiting or degrading the space support on which fast-moving American tactical operations depend so heavily for navigation and timing, intelligence, weather, force tracking, and communications.

Threats

Consideration might turn first to attacks on ground stations, the terrestrial nodes of American space power, but for military campaigns these facilities are less attractive targets than might at first appear. Redundant communications pathways, mobile facilities for command and control, and direct downlink systems make it difficult to predict the battlefield consequences of damage to a particular ground station. Moreover, critical ground stations are located within the United States; attacks on them could prove difficult and highly escalatory.

Interfering with data streams would be far less provocative; indeed, targeted jamming of satellite communications in peacetime, at least, apparently has occasioned nothing stronger than diplomatic demarches. Here again, the military appeal of these attacks might be quite limited. Certainly jamming can corrupt or overwhelm some data streams, and very high power jammers might interfere with GPS signals in limited areas. But it is hard to be confident about the battlefield effects of such efforts unless the communications network of the U.S. forces, and their responsive options, are fully understood. Precision-guided weapons, for example, might be equipped with supplemental advanced inertial navigation or other targeting

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systems, and denying GPS then might not significantly degrade warhead lethality. In addition, the wartime effectiveness of jamming on data streams is difficult to demonstrate conclusively in peacetime testing.

Quicker and more certain results would come from physically destroying the satellites. With current technology, the preferred option would probably be direct ascent boosters to deliver kinetic or explosive weapons. This approach would principally threaten satellites in low earth orbits; the longer flight times required for high altitude targets (or for coorbital intercept) would give the U.S. more time to detect and defeat the attack. More technologically advanced threats—directed energy weapons and high orbit space mines—do not seem likely to become operational weapons within the next decade or so.

Responses

Satellites can be defended against some kinds of direct kinetic attacks. They can be moved out of range of the attacker's terminal engagement sensors, if there is enough warning and accurate track of the interceptor and enough understanding of the kill mechanism, and if the satellite has been designed to withstand the loads created by the movement. There may be ways to confuse or defeat the sensors used to detect and track the target satellite, either in initial acquisition or in terminal engagement. The target might also be protected by active defenses, although with intercept occurring only about ten minutes after launch, the defenses will probably need to be directed energy rather than kinetic weapons. Either case would require precise situational awareness—exact information about the technology and operation of the attack—together with major advances in command and control for the defenses.

Even without enemy action, satellites in orbit might provide less space support than needed. Satellites might be lost to collisions with debris or other objects; or essential

components might fail. Or it may be that pre-war planning proved inaccurate, that more support is needed to meet unforeseen needs, or that demand for space support at the outbreak of crisis proves much greater than had been anticipated.

These problems are not remedied by defenses; instead, they call for a supplemental capability, to augment capacity to meet surging needs and to replace lost or failed sensors. Some of this supplemental capability might be found already in orbit: the communications and intelligence satellites of commercial entities and allied governments. While not all of the products of these systems will be militarily useful to the U.S.—and probably none will possess the capability of analogous U.S. government systems—the diversity of information they could provide and the speed with which it could be available would surely prove advantageous.

More capable systems, fully compatible with U.S. forces and fully under U.S. control, could in principle be stored in orbit; the engineering requirements for long-term storage and return to full operation seem well understood. At the same time, these systems might themselves suffer on-orbit misadventures, might potentially be targeted, and might prove useless in the face of unforeseen needs. Still, this approach offers the fastest, and probably the most expensive, path to the most capable supplementary systems.

Supplements might be provided more cheaply and more reliably if they were stored on the ground, ready to be launched in response to the developing needs of joint force commanders. If these supplemental systems could be launched and brought into operation quickly enough, the time required for adversaries to detect, track, and assess them might deter antisatellite attacks completely. If launched before hostilities began, these supplements would confront adversaries with the need to prepare revised and more complicated plans for attacks in space, perhaps with less confidence

that all important systems were in the cross-hairs. If launched as replacements for satellites initially lost to enemy action, the supplements would shrink the advantage that was sought in attacking the original satellites. If the U.S. coupled its supplemental replacements with vigorous offensive counterspace actions of its own, an enemy's initial attacks would leave the U.S. with a diminished yet effective set of space assets and the enemy with none. All in all, being able to supplement or restore needed capability in orbit would likely prove a stabilizing and deterring influence; not being destructive weapons themselves, the supplements could scarcely be considered escalatory.

Major Elements

Timeliness is the key to the projected deterrent effect of supplemental satellite systems, and for the next few years, at least, its possibilities are governed by a version of Einstein's physics. Timeliness is a function of mass: The bigger the satellite, the larger the launcher, the fewer the launch site options, and the longer the time from call-up to orbit. Larger satellites are also more expensive, as are larger boosters and longer flight preparations; one can generally expect that the same budget will buy fewer large supplementals than smaller, cheaper ones.¹

Fewer and larger, more and smaller—which package would better suit the needs of joint force commanders? A larger satellite would probably better approximate the capability of the legacy constellation of intelligence/surveillance/reconnaissance (ISR, or “spy”) satellites. But with larger numbers come greater capacity, more frequent revisits, a diversity of collection geometries, and more targets to confound enemy planning.

On balance, more and smaller seems the preferred approach, if they can be launched quickly and if they can perform militarily useful functions. The first requirement, quickly responsive launch, can be met right away, using boosters from the Air Force's longstanding Rocket System Launch Program (RSLP) and

mobile range equipment developed by the Air Force Research Laboratory over the last few years. The boosters, decommissioned ICBMs, were designed for rapid launch under austere conditions, and the mobile range equipment frees them from dependency on the established launch sites in Florida and California, which could be targeted for sabotage or other hostile action.

In the past few years there has been more programmatic emphasis on using the rubric of “responsive launch” to fund development work on new launchers, including reusable upper stages. But recent events encourage giving priority to a proven capability.² The smallest RSLP boosters, or actually the Minotaur modifications of them, can launch about 1200 pounds, and a larger version about 3800 pounds, to a 100 nautical mile orbit inclined at 28.5 degrees; the largest is sized to deliver 1200 pounds to a geosynchronous transfer orbit. As the Air Force Science Advisory Board concluded in 2004, “Space launch of 1,000-lbs to LEO in 48 hours from call-up is achievable. . . .”⁵

But would those launches be worthwhile? After saying that the launch is achievable, the Scientific Advisory Board continued: “. . . but is of limited military utility for some missions, particularly those requiring persistence derived from large constellations of satellites.” Design calculations show that technology does allow satellites in this weight class to provide useful data and services. The recent Tacsat program was intended to demonstrate that conclusion experimentally, with four satellites carrying different principal payloads: a low resolution electro-optical imager on Tacsat-1, direct data link communications on Tacsat-2, a hyper-spectral imager on Tacsat-3, and mobile data communications on Tacsat-4.

As these payloads suggest, the Tacsat program did not reflect the urgent operational needs likely to arise in the new strategic context. Its payloads were selected to demonstrate technologies and advance the version of the 1990s' “faster, cheaper, better” mantra embodied in 2001 in the Office of Force Transfor-

mation.⁴ Of the four payloads, the least useful for combat support is probably the first, which provides low-quality imagery and only in daylight and fair weather at that. For combat support, a synthetic aperture radar would be preferable, as the Army urged in recommending payloads for Tacsat-3,⁵ and operational and tactical electronic intelligence collectors would probably also be in high demand. Constraints of mass and power-aperture technologies would limit these satellites to low earth orbits providing each with only a single pass, effectively three minutes or so, of coverage of a specific target three times each day (systems dependent on daylight could expect only one three-minute opportunity). Hence the Advisory Board's caution that persistent coverage would require many satellites: ten would be needed to revisit the target every 45 minutes and more than 200 for continuous coverage.⁶ The Board's report did not explain why it emphasized such short revisit periods; surely there would be substantial military utility in being able to maintain at least the frequency of coverage provided during normal peacetime operations, however short of "persistence" that might be.

The numbers are less daunting for small communications satellites, which can function at higher orbits. If protected against the severe radiation found in the van Allen belts, six of them launched into particular highly elliptical "magic" orbits can provide continuous coverage. (The satellites are launched into two planes of molniya orbits with apogee at 7843 kilometers and perigee at 520 kilometers; the ground track repeats every three hours.) Though the elliptical orbit planned for Tacsat-4 is different, it will still require radiation protection and should allow demonstration of improved communications coverage in regions where direct paths to geosynchronous satellites are shadowed by terrain.

Assured Space

U.S. space systems are now targets, the inevitable consequence of their integration

into U.S. military operations, and some of them can now actually be engaged by some potential adversaries. Many options are being urged in response, including active defenses, preemptive strikes, retaliation, sharing arrangements with companies and allies, arms control negotiations, and rapid augmentation. Within each option there are competing priorities; in pursuit of rapid augmentation, for example, one can find demands for new industrial practices, common aero vehicles, reusable upper stages, and new launch site developments. But if priorities are set by military needs, surely an initial operational capability takes precedence.

Notes

1. Cost estimates depend on the configuration of launchers and satellites and associated equipment needed to execute the concept of operations, and as 2006 Rand study gently noted, "the [operationally responsive space] operational concepts are in the formative stages." Congressionally mandated National Security Space Launch Panel, "National Security Space Launch Report," (Santa Monica, CA: Rand Corporation, 2006), p. 42.
2. As the head of AFRL's "responsive space" efforts reported in 2006, "The Minotaur family can probably contribute the most of ORS in the near-term based on their available quantities and their existing, proven solid rocket components." Tom Doyne, Peter Wegner, Randy Riddle, Mike Hurley, Mark Johnson, and Ken Weldy, "A Tacsat and ORS Update Including Tacsat-4," paper presented at the AIAA-LA section/SSTC Responsive Space Conference 2006, downloaded February 2007 from http://www.responsivespace.com/Papers/RS4%5CPapers%5CRS4_4006P_Hurley.pdf
3. USAF Scientific Advisory board, "Report on Operationalizing Space Launch," 1 July 2004 (SAB-TR-04-03), p. 2.

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4. In 2006 one of the leaders of the Tacsat work at AFRL described the program as a test bed of three different areas: “We’re exploring technologies that will enable the development of small, low-cost satellites fairly rapidly. We’re also exploring CONOPS for those experiments. And we’re exploring different acquisition methods such as leveraging things being done in the airborne world, like unmanned aerial vehicle sensors and payloads, and porting those over to spacecraft.” Quotations attributed to Peter Wegner in Patrick Chisolm, “Micro-Eyes in Space,” *Military Geospatial Technology Online*, 19 November 2006, accessed 17 February 2007 from <http://www.military-geospatial-technology.com/article.cfm?DocID=1547>
 5. Despite wide agreement on the utility of a small SAR, the Air Force rejected the Army’s proposal as being untimely in terms of the schedule for the large Space Based Radar

program. According to press reports, the Air Force study director argued on 22 November 2004 that “We could do a [synthetic aperture radar capability] within the time frame but it would have been a different antenna and receiver technology [than was expected to be used for Space Based Radar]. . . . And so the question was, do we wait and put it on Tacsat-4 or -5 and do more of a demonstration of the technology that [the] Space-Based Radar program is aiming for? Or do we do a demonstration of a technology that Space-Based Radar would never use?” (Original article attributed to *InsideDefense.com*, 29 November 2004; cited version here downloaded January 3, 2008 from http://www.oft.osd.mil/library/library_files/article_425_010405_2.doc.) As events soon proved, Space-Based Radar would never use any technology: it was canceled a few months later.

6. AdvisoryBoard, pp. 21ff.