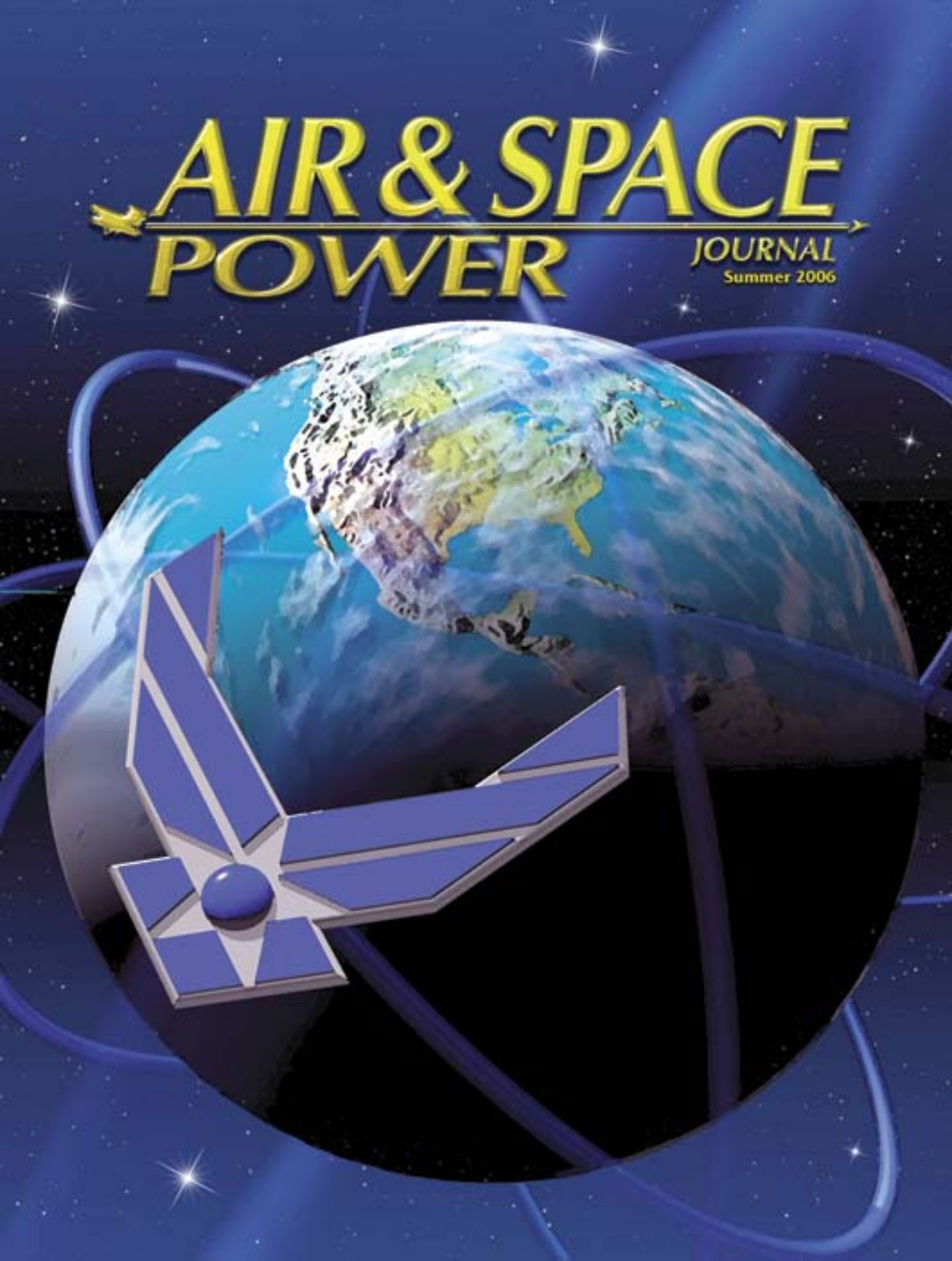
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The Myth of the Tactical Satellite

Lt Col Edward B. Tomme, USAF, retired

Editor's Note: This article is derived from a much more detailed, fully documented paper entitled "The Strategic Nature of Tactical Satellites" *available at the Web site of Maxwell Air Force Base's Airpower Research Institute: https://research.maxwell.af.mil/papers/ay2006/CADRE/tomme.pdf. While this article discusses the case of a single optimized low Earth orbit, the longer paper demonstrates that the results discussed here are quite general. It details the optimization technique and its underlying assumptions, discusses sensor limitations in depth, and debunks common arguments against the study methodology.*

Editorial Abstract: Many current proponents insist that "tactical" satellites are a must-have asset since they give the tactical war fighter a significant, palpable advantage in the battlespace. Colonel Tomme, however, argues that developing, funding, and producing these satellites constitute misdirected attempts to convince field commanders that satellite capabilities exist for battlefield exploitation. The author suggests that these proponents need to shift their focus toward the strategic realm, where measurable satellite effects can be meaningfully realized.



The wise are not wise because they make no mistakes. They are wise because they correct their mistakes as soon as they recognize them.

—Orson Scott Card
Xenocide, 1991

THE CONCEPT OF operationally responsive launch to get tactically useful payloads into orbit quickly and cheaply has been around for many years.[1] Operationally responsive launch has yet to be realized but is much closer to reality. There is a definite need for a capability to place inexpensive payloads into space on a very short time schedule.

Developing *tactically* useful payloads that can take advantage of responsive launch, however, is a different matter. A combination of *physical constraints* placed on satellites by orbital mechanics and *operational requirements* placed on their payloads by the missions that can be performed from space prevents all but the most rudimentary tactical missions from being attainable for the foreseeable future. Even if these missions can be performed from space, they will end up costing hundreds of thousands to several million dollars per hour overhead, a cost that would seem to place them beyond the reach of tactical or even theater commanders. Continued funding of the tactical satellite program under the misguided notion that such satellites can provide tactical effects on the ground only serves to drain scarce budgetary resources from other programs that *can* provide the desired effects.

The myth of tactical satellites is that they are tactical. As currently envisioned, there is no mission where a tactical satellite can provide primarily tactical effects.[2] To use computer programming language, "tactical" is a reserved word. When one uses that word to sell a program to a warrior, the warrior has a very specific understanding of what that technical term means—applying to small-scale, short-lived events, usually involving troops in contact.

The ability to launch small payloads into orbit on an operationally responsive timescale, however, does have its utility. The tactical satellite program needs a change of name and a change of focus, as the effects it can provide lie much closer to the strategic end of the spectrum of conflict. Such a change of focus would allow operationally responsive launch to compete in the *strategic* arena where it actually has a great deal of utility. In this case, however, tactical satellites appear to be a round peg in a square hole—a solution being forced into a mission where there are much better answers.

Background

The following table summarizes the optimized number of satellite passes, pass durations, and gap times for one reasonable circular

Table. Contact time and cost data for a 500 km circular orbit over Baghdad

Mission	*500 km Circular Orbit*				
	Average Number of Passes per Day	Average Pass Duration	Average Gap between Passes	Average Percent Useful Time Overhead (Duty Cycle)	Cost per Hour Overhead
	SINGLE SATELLITE				
Signals Intelligence (SIGINT)	9.7	7 min. 47 sec.	2 hr. 20 min.	5.6	$ 43K
Communications/ Blue Force Tracking (Comm/BFT)	8.7	6 min. 12 sec.	2 hr. 39 min.	3.9	61K
Imagery	4.6	1 min. 40 sec.	5 hr. 10 min.	0.5	429K
	FIVE-BALL CONSTELLATION				
SIGINT	48.6	7 min. 47 sec.	28 min.	27.8	43K
Comm/BFT	43.5	6 min. 12 sec.	32 min.	19.4	61K
Imagery	23.0	1 min. 40 sec.	1 hr. 02 min.	2.7	429K

Note: The hourly cost for a single satellite and a constellation of satellites is the same in this table due to the fact that adding a second satellite doubles both the coverage time and cost.

orbit altitude, chosen because it is about as high as any funded tactical satellite Advanced Concept Technology Demonstration (ACTD) is designed to orbit.[3] The parameters used to generate these results define the *tactical satellite program* as that term is used in this article.[4] The goal acquisition price per satellite and booster is no more than $20 million each.[5] They are designed to last between six months and one year to reduce the construction costs.[6] Again, I have not assumed numbers that will lead to a predetermined solution that will not support tactical satellites; these numbers are those espoused by tactical satellite proponents.

As can be seen from the table, signals intelligence (SIGINT) and communications/blue force tracking (comm/BFT) missions get significantly better performance than imagery missions. This difference is due to the severely constrained field of regard (FOR) available to imagery missions. Figure 1 shows the relative FORs, the area on the ground that its sensors

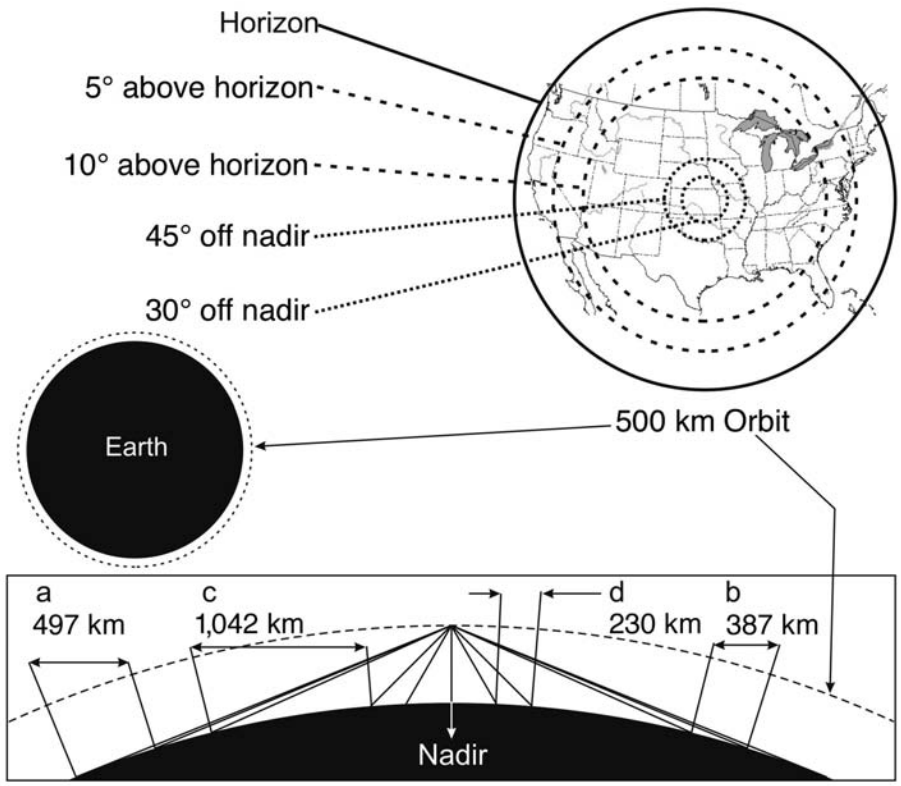


Figure 1. Fields of regard from 500 km. While it may appear at first glance that there are two points of view expressed in this figure (the ground-based point of view, above the horizon, and the satellite-based point of view, off nadir), the terms actually describe the same information. For any given altitude, any satellite-based FOR can be converted into a ground-based angle and vice versa. The conversion is a complicated function that depends upon satellite altitude. The two terms used are the ones commonly used operationally for the different mission types.

Note: In the upper portion of the figure, the dotted lines represent imagery-related FORs, the dashed lines represent comm/BFT-related FORs, and the solid line represents the SIGINT-related FORs. The middle-left portion shows the earth and a 500 km orbit to scale. The lower portion shows an enlarged side view of the FORs for the 500 km orbit. The distance labeled "a" is the difference between the radius of the horizon FOR and the five degrees above horizon FOR; b: between five and 10 degrees above the horizon FORs; c: between 10 degrees above horizon and 45 degrees off-nadir FORs; d: between 45 and 30 degrees off-nadir FORs.

can use, available to a satellite in a 500-kilometer (km) circular orbit—higher orbits would have similarly proportioned but larger FORs.[7] It should be obvious to any tactical war fighter that the levels of coverage shown in the table are inadequate for tactical needs. A tactical war fighter needs persistent imagery. Getting a snapshot every hour or so is not very useful at the tactical level, where the timescale of the action is measured in minutes or seconds.

SIGINT and comm/BFT missions are similarly ineffective from low Earth orbit (LEO) circular orbits. It is almost inconceivable to contemplate sending commanders into combat after telling them that they would only be able to communicate five minutes out of every half hour. A larger network similar to the 66 satellites in the Iridium constellation can provide good coverage, but even at a relatively inexpensive $20 million per satellite per year, the expense of such a network exceeds the reach of the tactical commander.[8]

In this article I will present the tactical satellite program in the best light possible. *I will assume that the satellites will work perfectly; they can be placed at will in the desired, optimized orbits; they will meet cost and lifetime goals; and the assumptions made about FORs will be as generous as possible. I will also assume perfect environmental conditions so the onboard sensors will always be able to perform their SIGINT, imagery, communications, and BFT missions. The goal is to show that even when all systems work better than advertised, the tactical satellite program still fails to provide tactical effects on the ground.* These generous programmatic assumptions will demonstrate that the failure to provide effects is not due to engineering shortfalls, where more money might solve the problem, but is due to physical limitations that cannot be overcome until the satellites become inexpensive enough to field constellations of hundreds simultaneously. By postulating the existence of a perfectly working technological product, we can then concentrate on evaluating the operational-utility part of the problem.

What is meant by a "perfectly working technological product" is a point worthy of discussion. From various briefings and published articles attributed to tactical satellite proponents, the goals of the generalized tactical satellite program appear to be to launch the energy equivalent of a 1,000-pound payload into a 100-nautical-mile (185 km) circular orbit.[9] Furthermore, the program seeks to keep it there for six months to a year at an acquisition cost of about $20 million per satellite and booster combined.[10] The results in the table assumed the use of an optimized orbit designed to give the maximum time for the satellite overhead, or *contact time.*[11] By optimizing the contact time, we also maximize the average number of satellite passes per day, maximize pass duration, minimize the amount of time the satellite is *not* overhead or *gap time,* and minimize the cost per hour overhead. These orbits are not necessarily the ones that are used operationally, as those orbits may be optimized for different constraints such as a constant-solar-illumination angle. However, these orbits give the absolute best cases for time and cost; all other orbits will necessarily give less time and will cost more per hour overhead.

Physical Constraints on Orbiting Objects

There are a number of "truisms" associated with orbits. They are presented here without proof. First, to optimize contact time, the inclination of the orbit should be very close to the latitude of the target. Second, increasing the orbital altitude increases the contact time.[12] This result is due to two causes. One can see farther when one gets higher.[13] Increasing altitude physically increases the size of the FOR, which in turn has a positive effect on contact time. Additionally, moving to a higher orbit slows the satellite down a bit, more closely matching its speed with that of the earth's rotation. The FOR thus moves more slowly across a target, also tending to increase the contact time. Finally, it is a truism that targets near the equator and the poles receive better optimized coverage than midlatitude targets.

As discussed above, a tactical satellite's orbital parameters will be limited by the energy that can be supplied by the booster. A booster that can put a 1,000-pound payload into a 185 km circular orbit could also put a 500-pound pay-

load into a highly elliptical orbit with a perigee of 500 km and an apogee of 8,000 km.[14] If properly oriented, such a "magic orbit" will overfly the same point on the earth once per day and can provide a huge, slowly moving FOR during parts of its orbit, resulting in hours per day of coverage instead of mere minutes.[15]

We now have a good idea of how to optimize a satellite's circular orbit to obtain the maximum contact time over a specified target—put it as high as possible and match its inclination to the desired target's latitude. To optimize a magic orbit, we only need to make sure it is oriented properly in space using a specific set of orbital parameters. For the remainder of this article, I will assume the use of orbits optimized to maximize contact time. *This assumption will further ensure that we examine the operational utility of the tactical satellite concept in the best possible light: a platform that perfectly meets program goals and has been launched into an orbit that gives it the best chance for tactical success.*

Sensor Constraints on Optimized Orbits

As shown in figure 1, there are a number of FORs that can be applied to a satellite in any orbit. These FORs are based on the designed mission of the satellite. It would be nice to be able to use the huge horizon FOR all the time, but it is actually valid only for a few SIGINT missions. For other SIGINT missions as well as for the communications, BFT, and imagery missions, it is not. The reason the horizon FOR is not generally valid is due to sensor requirements. For SIGINT, communications, and BFT missions, the emitter of the signal being detected must have an unobstructed line of sight (LOS) to the sensor on the satellite.

SIGINT sensors can take in and analyze any signal they can detect. Thus, there is generally no requirement for them to be a certain angle above the horizon. If the terrain is flat and they can see all the way to the horizon, great. If there are mountains in the way, the sensor simply waits until it establishes LOS to the emitter and then begins collecting. For these reasons, I assume the horizon FOR is valid for most SIGINT missions.

Communications, BFT, and imagery missions are different. They cannot use the horizon FOR. Tactical comm/BFT capability has to be there all the time. Comm/BFT providers typically require their platforms to be at least five degrees above the horizon, with 10 degrees being more commonplace. While this requirement does not guarantee coverage in the bottom of a deep canyon, it does ensure that the odd tree, house, or hill will not normally interfere with direct LOS to the platform. As seen in figure 1, restricting the FOR to five degrees above the horizon has a significant effect on the performance delivered by an optimized orbit.

Imagery sensors are even more tightly constrained. Not only must they have LOS like the other missions, but they cannot look too far away from the vertical (nadir) without introducing a host of problems. These problems include foreshortening, excessive atmospheric degradation, and decreased resolution that can make analysis exceedingly difficult, if not impossible. Additionally, many imagery sensors operate in the visible-light region. It is extremely difficult for these sensors to function at night. Even night-capable infrared sensors have a hard time penetrating significant cloud cover.

Figure 2 shows the end result of the combination of orbital and sensor constraints for all latitudes on tactical satellites in 500 km orbits optimized to maximize contact time. Choosing any other orbit to achieve required mission goals will necessarily decrease coverage and increase cost.

The results in the table and figure 2 ignore the nontrivial limitations of weather and darkness and present optimized numbers that reflect an ability for imagery sensors to operate at full capability 24 hours a day/seven days a week (24/7); this assumption significantly overstates the actual capability.

The Operational Utility of Optimized Tactical Satellites

It is now time to examine space missions and compare the requirements placed on sat-

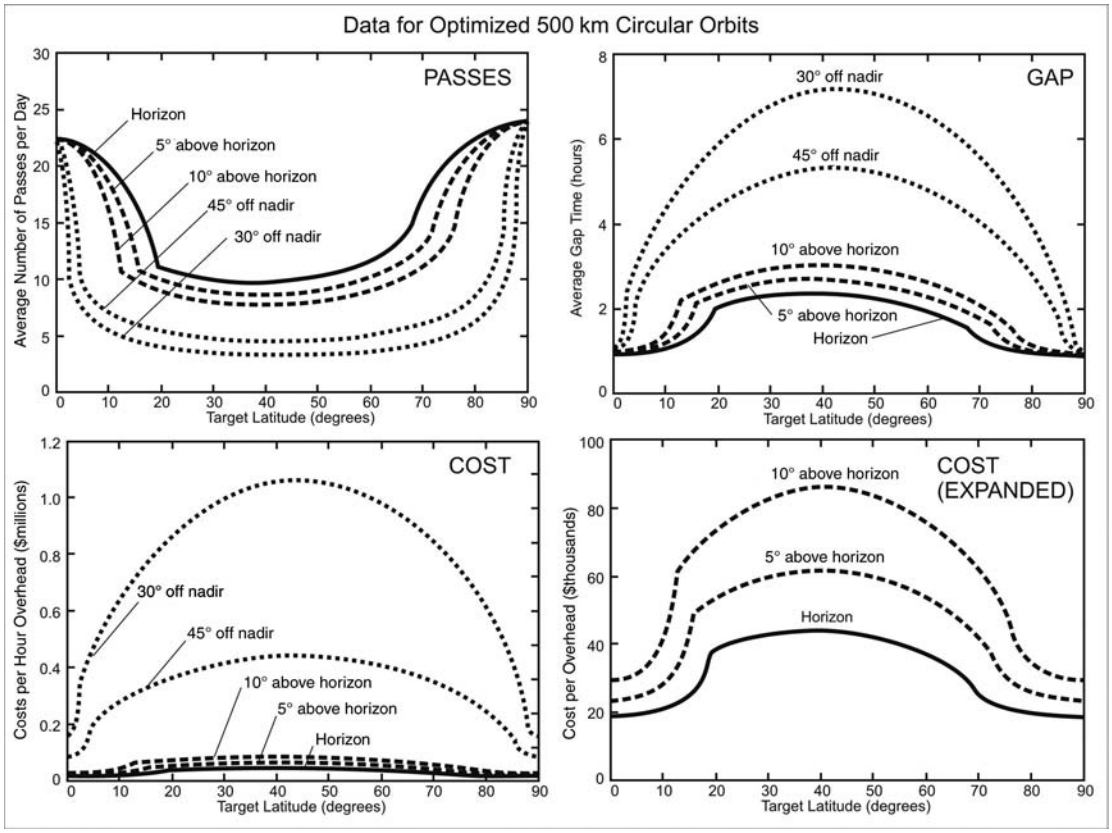


Figure 2. Number of passes, average gap time, and cost data for a tactical satellite in a 500 km orbit.

Note: The curves represent data for three mission types: SIGINT (solid), comm/BFT (dashed), and imagery (dotted). Cost data are shown in two panes as the scales between imagery and the other missions are quite disparate.

ellites with the constraints we have studied to this point. US joint space doctrine spells out four primary space mission areas: space force application, space support, space control, and space force enhancement.[16] Space force application consists of attacks against terrestrial targets by systems operating from or through space. Space support is the mission area that involves cradle-to-grave support of on-orbit assets. Space control ensures friendly use of space while denying it to adversaries and includes both offensive and defensive measures. Space force enhancement multiplies joint force effectiveness through heightened battlespace awareness. It includes the functions of intelligence, surveillance, and reconnaissance (ISR); tactical warning and attack assessment; environmental monitoring; communications; and precision navigation and timing. In this section of the study I will attempt to find niches in these mission areas for which tactical satellites are suited.

Space force application is not affected by the preceding discussion of orbital optimization, as no orbiting weapons are currently foreseen for the tactical satellite program. The *mass* of weapons such as lasers that could have an effect on the planet's surface would be much greater than the 1,000-pound tactical satellite reference mass. Conventional intercontinental ballistic missiles could possibly provide force-application effects within the weight range of the tactical satellite booster,

but they are not satellites and will not be discussed in this article.

Likewise, space support is not a mission that has been discussed in the literature as a mission for tactical satellites. Space support from such things as launch facilities, operations centers, and the space communications and control network will be required for constellations of tactical satellites, but it will not provide a tactical effect to warriors on the ground. Tactical satellites will require space support but will not provide it. Note that I do not include the cost of any of this required space support in my cost calculations, as it is at present a relative unknown compared to the postulated $20 million per booster and satellite quoted by tactical satellite proponents.

Space control certainly seems to be within the purview of the reference energy (orbit/mass combination) of the tactical satellite program. Being able to responsively launch a satellite with the capability to maneuver in close proximity to other satellites would be a boon to those tasked with exercising both lethal and nonlethal shutter control on the space capabilities of hostile nations. However, such control is unquestionably a strategic mission with immense political ramifications and global effects. Employing it may provide advantage to tactical war fighters on the ground—many strategic actions do—but the advantage will be indirect. Thus, space control from a responsive launch platform will not be discussed further, since we are concerned with providing tactical effects on the ground.

After examining and eliminating the first three space missions from consideration, one sees that the only remaining space mission for which tactical satellites appear most useful is space force enhancement, the traditional role of most satellites. In fact, this mission appears to be the only one discussed to any degree in the literature dealing with tactical satellites. We will examine each of the five subelements of space force enhancement individually below, using the circular LEO and magic orbits discussed previously as baseline points of reference.

The tactical warning and attack assessment mission deals with providing timely notification of enemy use of ballistic missiles and nuclear detonations to the president and secretary of defense. This mission is currently performed from geosynchronous Earth orbit (GEO) by platforms such as the handful of Defense Support Program (DSP) satellites.[17] Such a mission would certainly be impossible from LEO without a constellation of hundreds of satellites, as it would require continual monitoring of the entire globe. While tactical satellites in magic orbits could conceivably perform the mission, it would still take between 12 and 20 of them to provide continual global coverage, at an acquisition cost of at least $240–400 million per year—a cost comparable to a single DSP bird, which is designed to last much longer. The mission is also undeniably strategic.

The environmental-monitoring mission provides data on space and terrestrial weather that could affect military operations. The Defense Meteorological Satellite Program (DMSP) platforms are one part of the current implementation of this mission element.[18] Tactical war fighters rely heavily on DMSP information to help plan their actions. Likewise, execution of the precision navigation and timing space mission element through the global positioning system (GPS) gives war fighters an enormous edge on the battlefield. GPS birds orbit much higher at about 11,000 km, making an orbit about every 12 hours.[19] Both systems are unarguably strategic, though, and replacement would not be the job of a small number of tactical assets. Additionally, were the DMSP or GPS constellations knocked out of service by some hostile act, it is difficult to imagine a situation where constellations replenished by responsively launched assets would be any less vulnerable to whatever brought the original systems down.

In contrast to the three subelements just discussed, the ISR and communications mission subelements do appear to have a need for tactical enhancement. Unfortunately, the cost-performance constraints of any responsive-launch boosters envisioned in the foreseeable future make tactical satellites poorly suited to be the source of that enhancement. I will discuss these constraints first in relation to circular LEO and then magic orbits.

The primary limitation to all tactical satellite applications from LEO is the very rapid passes of a relatively small FOR. LEO satellites do not and cannot provide persistence, an effect of paramount importance to warriors on the ground. This limitation is a severe constraint even for the best-case horizon FOR. From the truisms discussed above, it is obvious that to mitigate the rapid FOR pass, one should move to a higher altitude. However, there are drawbacks to this solution in addition to the reduction of payload mass in the energy trade for extra altitude.

While increasing the contact time and reducing the cost per hour overhead, raising the altitude has a negative impact on signal strength. Using the basic $1/r^2$ law for the attenuation of an electromagnetic signal, one sees that increasing altitude enough to significantly affect the FOR pass rate even more significantly decreases the signal strength received by the satellite.[20]

Large antennae for reception of radio signals can be manufactured relatively easily, and they are a relatively low-mass portion of the payload. To double the signal-collecting ability of an antenna, it is only necessary to double the antenna *area*, so compensating for the decreased signal strengths in most LEO orbits does not require an insurmountable increase in mass. The actual antenna sizes depend upon the required received signal strength, which is highly variable. Thus, it appears technically doable to put optics and antennae in LEO on tactical satellites.

That said, it remains for us to determine whether the effects provided by satellites in these LEO orbits are valuable to a tactical war fighter. The primary factors involved are, in decreasing order of importance to tactical warriors, coverage opportunities, coverage time, and cost. *To be truly useful to a tactical war fighter, effects have to be felt inside of the decision cycle of the enemy.* Information must be provided rapidly enough that it can influence the next friendly move before the enemy has time to readjust.[21] The table clearly shows that even at the 500 km altitude over Baghdad, the gap times are much longer than the timescale of a tactical engagement.

To get 24/7 persistence from even a SIGINT mission at 500 km would take a constellation of about 80 satellites.[22] It is quite evident that even at the relatively inexpensive projected cost of tactical satellites and their projected lifetimes that these numbers make persistent tactical satellite presence unaffordable. The acquisition cost of such a system would be at least *$1.6 billion each year.* It is for just such reasons that tactical satellite proponents instead propose very limited constellations, usually of five or fewer satellites, to provide what they call "tailored persistence."[23] Such persistence is obviously stroboscopic at best, providing a flash of utility periodically with large gaps of blindness in between.

On the other hand, even the relatively sparse constellation of five satellites discussed above would make such enemy communications and movement blackouts extremely difficult to employ for their *strategic* operations—operations where the timescale is long compared to the revisit rate. In most foreseeable situations, it would appear to be counterproductive to stop operations this frequently. On the other hand, for tactical engagements where the timescale is measured in minutes or seconds, much shorter than the satellite revisit rate, the overhead information will likely be too late and too sporadic to be of much use to friendly forces. "Tactical" satellites thus employed in LEO for SIGINT and imagery applications appear to be much more useful for strategic missions.

The budgetary numbers associated with tactical satellites greatly exceed the costs of putting existing manned and unmanned aircraft or proposed lighter-than-air, near-space assets over the battlefield. The persistence that these nonorbital platforms provide could be truly tailored to the pace of the battle instead of giving pseudorandomly-timed stroboscopic flashes of insight.[24]

The above discussions deal with the SIGINT and imagery missions, where even the sparse information provided by a small constellation could be of some use. On the other hand, sparse constellations of satellites in LEO have no chance of providing a useful communications capability. During an engagement, communi-

cations are needed when the warrior needs them, not when they are available. The tail can't wag the dog. Sporadic, pseudorandomly-timed communications capabilities will not support a tactical mission. Tactical commanders need the information available to them when *they* need it, not when the sensor is available to give it to them.

Apparently, tactical satellite proponents devised the magic orbit to counter the LEO coverage problem I have just discussed. The relatively long hang times over the target mean that five or six satellites could conceivably provide the 24/7 persistence that is unaffordable from LEO. This solution attacks only one of the two constraints on getting tactical effects from space—orbital mechanics. By moving much further away from the earth in an attempt to slow down the satellite passes, this solution compounds the other constraint—the payload's ability to perform the mission.

Using the 500 km orbit as the baseline, one finds that the average magic orbit distance from the target is 17 times further than the LEO. As an example of a specific effect on payload performance that such an increase in range will have, to get a one-meter optical image of Baghdad from the average magic distance of 8,500 km would take at least a 5.1 meter optical aperture (the size of the large telescope mirror at Mount Palomar Observatory in California) instead of the 0.36 meters required from 500 km.[25] For this reason, it would seem impractical to use the magic orbit for conventional imagery applications.

Similarly, a communications or SIGINT antenna in a magic orbit would have to increase in size to be as sensitive to signals as its LEO counterpart. Satellite communications on the move is a highly desired capability in the field.[26] Many people are familiar with satellite phones with their simple, easy-to-use whip antennae. These phones are generally run through the 66-satellite Iridium system orbiting in LEO at about 780 km. Iridium satellites use a set of three 1.6 square-meter (m^2) antennae for reception.[27] Having the satellites so close to the earth in LEO is the reason that the phones can employ antennae that don't require precise pointing at and tracking of the rapidly moving satellites. At their average distance above the horizon, magic orbits are 11 times further than even the Iridium constellation. The signal reaching them from the ground would thus be at least 120 times weaker. Since weight is a huge factor in getting to these higher orbits, increasing the size of the antennae to about the required 200 m^2 does not seem feasible. Without significantly larger antennae on the satellite, the ability to use whip antennae on the ground becomes problematic and would most likely require the use of the familiar small dishes to increase signal strength.

However, the use of a high-gain dish antenna is even more difficult for communicating with satellites in magic orbits. As discussed previously, it is currently difficult and therefore operationally prohibitive for troops on the move to stop, set up a dish antenna, and point it toward the *stationary* communications satellites that currently exist. This difficulty is significantly compounded when a *moving* satellite in a magic orbit has to be found and tracked in the middle of a tactical engagement. In contrast to the soldier on the ground who needs to manually point his antenna, many unmanned aerial vehicles (UAV) are already controlled through satellite links. It seems feasible for these links to be through satellites in magic orbits. However, the severe environment inherent in this orbital regime will likely be the ultimate arbiter of success for any magic orbit solution.

The requirement for satellites in magic orbits to regularly traverse the inner Van Allen belt will call for some mitigating engineering design to ensure that the one-year goal lifetime can be met. This mitigation can come in one of two ways: by using radiation-hardened, space-qualified components or by adding additional shielding to protect the cheaper commercial off-the-shelf electronics. The first method will almost certainly cause the budgetary goals of the program to be exceeded. The second method will add significant weight to the system. Neither solution seems palatable.

It is a physical fact that the constraints imposed by orbital mechanics and those imposed by sensor limitations work contrary to each other. Choosing a higher orbit that slows

down the satellite pass to improve persistence ends up requiring huge increases in payload physical size, mass, and cost in order to maintain the standard of performance. It is an interesting "Catch-22": put the satellite low enough that it's affordable, and it's only marginally useful due to limited pass times, but put it high enough to be useful, and it's no longer affordable except at the strategic level.

Even with the favorable assumptions I have used in this analysis, it is clear that the ability of tactical satellites to deliver tactical effects is severely limited. Less optimistic (and more realistic) assumptions would further tip the balance against the utility and suitability of tactical satellites for tactical applications. As I have shown, there are severe physical constraints on satellites in circular LEO and elliptical magic orbits that conflict with tactical mission requirements. It seems highly impractical, if not impossible, to perform tactically useful imagery, communications, SIGINT, and BFT missions within these constraints, especially if cost remains a consideration.

Conclusion

Tactical satellites as currently defined by proponents aren't tactical. Just having a tactically responsive launch rate, if achievable, doesn't make an asset tactical. Just being much cheaper than other orbital platforms does not make an asset tactical. To meet the program goals briefed by tactical satellite proponents to senior military leaders, a tactical asset must also provide tactically relevant effects on the ground on a timescale that is less than that of a tactical engagement.

All is not gloom and doom for the tactical satellite program. Many of its goals are extremely worthwhile and will definitely benefit the nation and its defense. Standardizing busses and developing plug-and-play payloads will do a great deal to bring the cost of space effects down to earth. Being able to launch responsively will have a huge impact on space control options available to the national leadership. Being able to provide very cheap augmentation to expensive, hard-to-reconfigure national assets would be a boon to strategic planners. Being able to cross-correlate information from GEO and LEO birds for short time periods will make many strategic analysts extremely happy. It's not the program that is bad; it's simply misdirected. By using the word "tactical," proponents lead warriors to make unsupportable assumptions about the program's actual capabilities. Their focus needs to shift toward the strategic where the effects they advertise are possible to achieve and are useful.

In the end, it is much more appropriate for mythical *tactical* satellites to compete for funding against other strategically oriented programs. When they compete with and win funding against programs that actually have the potential to serve warriors on the ground, they detract from Congress's intended budgetary goals. Continuing to fund tactical satellites out of budget lines intended directly to serve the tactical war fighter does a disservice to both the taxpayer and the warrior on the ground. ❑

Notes

1. For example, see Maj Richard A. Hand, Maj Bonnie Houchen, and Maj Lou Larson, eds., *Space Handbook: A War Fighter's Guide to Space,* vol. 1 (Maxwell AFB, AL: Air University Press, 1993).

2. Air Force Tactical Exploitation of National Capabilities has a mission of finding tactically relevant uses for national assets, including satellites. While many tactical uses for satellites are possible, the global nature of an orbit makes the primary mission of these satellites strategic. "Air power *can* be global in its reach and ability to impose effects on an opponent, whereas space power, by its very nature, can *only* be global." Benjamin S. Lambeth, *Mastering the Ultimate High Ground: Next Steps in the Military Uses of Space*, RAND report MR-1649 (Santa Monica, CA: RAND, 2003), 45.

3. "TacSat-2/RoadRunner Micro Satellite Fact Sheet," February 2006, http://www.vs.afrl.af.mil/FactSheets/RoadRunner.pdf (accessed 4 April 2006); and "SpaceX Selected for Responsive Space Launch Demonstration under DARPA FALCON Program," SpaceX Web Site, 20 September 2004, http://www.spacex.com/index.html?section=media&content=http%3A//www.spacex.com/press11.php (accessed 6 November 2005).

4. There is no all-encompassing "tactical satellite program"; instead, there are a number of research efforts being conducted by Air Force Space Command's Space and Missile Systems Center (AFSPC/SMC), the Air Force Research Laboratory (AFRL), the Defense Advanced Research Projects Agency (DARPA), and others. The goals and parameters quoted throughout this article are generalized numbers based on numerous sources cited below.

5. In 2004 the advertised baseline cost for a tactical satellite and launch was $15 million. DOD, *Operationally Responsive Space Experiment: TacSat-1*, US Government White Paper (Washington, DC: DOD Office of Force Transformation, 17 October 2003), 2. By early 2005, the price was being quoted as $20 million to $30 million. Andy Pasztor, "Pentagon Envisions Operations with Small Satellites," *Wall Street Journal*, 26 August 2005. The current TacSat 2 will cost at least $50 million, barring further problems. Col Pamela Stewart, AFSPC Directorate of Plans and Requirements, "Responsive Space Near-Term Plan" (briefing, Air Force Scientific Advisory Board, Colorado Springs, CO, 27 April 2004). See also Col Rex Kiziah, AFRL, "Joint Warfighting Space" (briefing, Schriever III War Game, Nellis AFB, NV, 8 February 2005); and "Joint Warfighting Space: Not (Just) an Idea, Not Yet a Program," *Inside the Pentagon*, 6 May 2004, 1.

6. Kiziah, "Joint Warfighting Space." See also T. Ryan Space et al., "Transforming National Security Space Payloads," Paper no. RS2-2004-2001 (Los Angeles: Proceedings of the Second Responsive Space Conference, American Institute of Aeronautics and Astronautics, 19–22 April 2004); and Maj Scott Cook, AFSPC Directorate of Plans and Requirements, "Tactical Satellite (TacSat)/Joint Warfighting Space (JWS) Demonstration Program" (briefing, Headquarters AFSPC, Peterson AFB, CO, 6 January 2005).

7. The results presented in the table are based on quite optimistic fields of regard for the different mission types: horizon for SIGINT, five degrees above the horizon for comm/BFT, and 45 degrees off nadir for imagery. The numbers become much less favorable when more realistic fields of regard are used (10 degrees above the horizon for communications and 30 degrees off nadir for imagery). Cost data are based on the full year of service and the $20 million acquisition cost only, without factoring in infrastructure, daily operations, or personnel costs. Information on how the numbers were derived and much more detailed orbital-optimization calculations are provided in the longer version of this article.

8. Iridium Satellite Web Site, 12 November 2005, http://www.iridium.com/.

9. A booster can supply a certain amount of energy to a satellite. That energy is a somewhat complicated combination of the satellite's altitude and mass. The boosters currently envisioned for the tactical satellite program, DARPA's FALCON and SpaceX's Falcon 1, both have the approximate capability to put 1,000 pounds in a 100-nautical-mile orbit. They can put lighter payloads into higher orbits as long as the combination of payload mass and orbital altitude is less than the energy available from the booster.

10. Kiziah, "Joint Warfighting Space"; and Capt Beth Stargardt, AFRL Space Vehicle Directorate, "Tactical Space Employment for Joint Warfare" (briefing, Joint Forces Command Joint Space Concept Development and Experimentation Workshop, Norfolk, VA, 31 March 2004).

11. Data for circular orbits computed by the author using equations derived in M. W. Lo, "The Long-Term Forecast of Station View Periods," *The Telecommunications and Data Acquisition Progress Report 42-118, April–June 1994* (Pasadena, CA: Jet Propulsion Laboratory, 15 August 1994), 1–13, http://tmo.jpl.nasa.gov/progress_report/42-118/118J.pdf (accessed September 2005); and M. W. Lo, *Applications of Ergodic Theory to Coverage Analysis*, Paper no. AAS 03-638 (Big Sky, MT: Proceedings of the AAS Astrodynamics Specialist Conference, August 2003).

12. This truism is actually only true to certain altitudes. At a height at which one can almost see an entire hemisphere, raising the altitude further only marginally increases contact time. Additionally, the absolute maximum contact time would occur when a geostationary satellite is in view; that contact time would be 24/7. Moving higher than geosynchronous Earth orbit actually decreases the contact time. Since we are dealing with tactical satellites in LEO for this study, though, these limitations on the truism don't come into play.

13. T. S. Kelso, "Basics of the Geostationary Orbit," *Satellite Times*, May 1998, http://celestrak.com/columns/v04n07/ (accessed July 2005). In fact, it is possible to *actually* see an entire hemisphere only from a point an infinite distance away. A satellite in geostationary orbit can see only about 42 percent of the globe and cannot see locations with latitudes higher than 81 degrees.

14. James R. Wertz, "Coverage, Responsiveness, and Accessibility for Various 'Responsive Orbits,'" Paper no. RS3-2005-2002 (Los Angeles: Proceedings of the Third Responsive Space Conference, American Institute of Aeronautics and Astronautics, 25–28 April 2005), http://www.responsivespace.com/Papers/RS3%5CSESSION%20PAPERS%5CSESSION%202%5C2001-WERTZ%5C2001P.pdf (accessed 8 November 2005).

15. Rich Tuttle, "Air Force Studies Unique Orbit for Projected Family of Small Sats," *NetDefense*, 11 March 2004.

16. Joint Publication (JP) 3-14, *Joint Doctrine for Space Operations*, 9 August 2002, ix–x, IV-5–IV-10, and A-1–E-4.

17. "Defense Support Program Satellite Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/dsp.htm.

18. "Defense Meteorological Satellite Program Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/dmsp.htm.

19. "Navstar Global Positioning System Fact Sheet," 26 October 2005, http://space.au.af.mil/factsheets/gps.htm.

20. Ideal electromagnetic waves propagate as spheres or angular sections of spheres. The π area of a sphere is $4\pi r^2/3$. As the energy contained at any particular wave front must remain constant over time, the intensity of the wave at any point on that wave front must decrease to counter the spherical increase in the wave-front area. Thus, as the wave-front area increases as r^2, the intensity must decrease as $1/r^2$.

21. John R. Boyd, "A Discourse on Winning and Losing," Air University Library document no. MU 43947, August 1987. Unpublished briefing notes and essays.

22. Byron Hays, *Responsive Space/Tactical Satellite Utility Analysis* (briefing, Brig Gen William Shelton, director of Plans and Policy, US Strategic Command, April 2004).

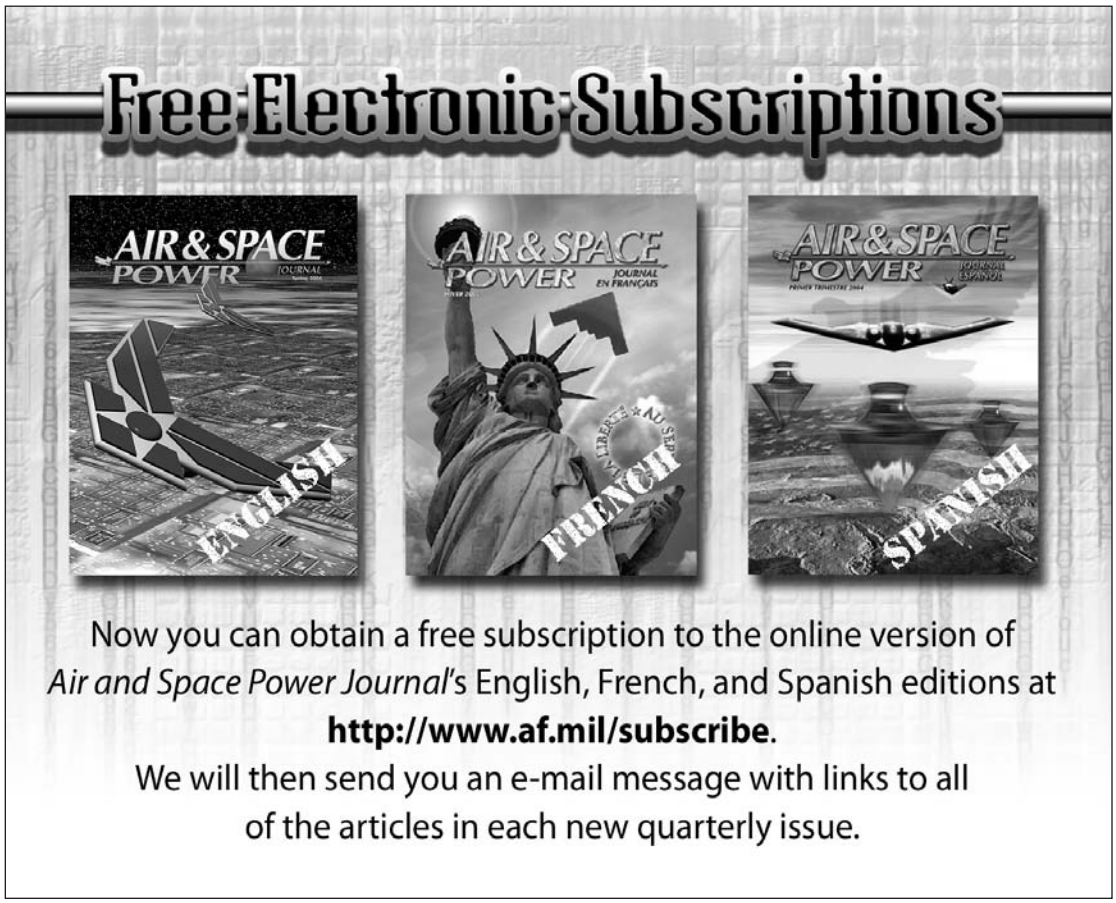
23. Kiziah, "Joint Warfighting Space."

24. Orbital passes are not actually randomly distributed; they are, in fact, quite well determined, especially when highly variable perturbations such as atmospheric drag are neglected. However, for most orbits, the pattern of repetition for the satellite passes is not easily discerned by the warrior on the ground. Unless the orbit has been specifically tailored to do so (and in which case the satellite will not be providing the optimized maximum coverage time), the warrior cannot say, for example, "I will get two passes a day—one at noon and one at midnight—for the next two weeks." The pattern of repetition is vastly more complicated than that. For this reason, I will use the term *pseudorandom* to describe the pattern of satellite passes over a spot on the earth.

25. The wavelength used for this calculation was 400 nanometers (middle of the visible region). Distances were based on the slant range from the satellite to the edge of the FOR. The actual optics required to achieve the stated resolutions would be larger, as the diffraction limit is based on theoretically perfect seeing conditions.

26. David Hardy, "TacSat Demo Status: Senior Leader Vector Check" (briefing, AFRL, Kirtland AFB, NM, 22 September 2004).

27. Visual Satellite Observer's Web Site, "Catch a *Flaring/Glinting Iridium" (updated 6 March 2002), http://satobs.org/iridium.html (accessed 26 October 2005).



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- CAPT Randall G. Bowdish, USN, "Campaign, Operation, and Battle Analysis" (http://www.airpower.maxwell.af.mil/airchronicles/cc/bowdish.html)
- Col Francis R. Stevens Jr., USAF, Retired, "My Father and I and Saburo Sakai" (http://www.airpower.maxwell.af.mil/airchronicles/cc/stevens.html)

The *ASPJ* editorial staff always seeks insightful articles from anywhere in the world. We offer publication opportunities in five languages, as noted above. To submit an article in any of our languages, please refer to the submission guidelines at http://www.airpower.maxwell.af.mil/airchronicles/howto1.html. ❑

Ricochets and Replies

We encourage you to send your comments to us, preferably via e-mail, at aspj@maxwell.af.mil. You may also send letters to the Editor, Air and Space Power Journal, *401 Chennault Circle, Maxwell AFB AL 36112-6428. We reserve the right to edit the material for overall length.*

NEAR SPACE 2015

In his article "Near Space 2015: A Conceptual Vision of Near-Space Operations" (summer 2006), Maj Mark Steves seriously underestimates India's communications capabilities. I specifically disagree with his assumption that India by 2015 would need a US "near-space craft" for enabling communications during an earthquake on its coast. Even today, India is well connected by satellite communications provided by the INSAT series. By 2015 our capabilities will be even more advanced. India might indeed appreciate US assistance in the event of a natural disaster, but we have enough space assets to look after our needs.

K. K. Nair
New Delhi, India

THE MYTH OF THE TACTICAL SATELLITE

Kindly convey my heartiest congratulations to Lt Col Edward B. Tomme, USAF, retired, for his article "The Myth of the Tactical Satellite" (summer 2006). In one masterstroke, the colonel has put the entire conundrum in perspective and blown away a lot of myths from propagandists—and he does so in terms easily understood by practitioners and laypersons alike. While it is understandable that the colonel has focused only on the land aspect, the worrisome trend that is slowly spreading is the advocacy of "tactical maritime surveillance satellites"—something that sounds patently oxymoronic. I would like to highlight one thing, which may or may not have been covered in the extended version of Colonel Tomme's paper. While one can have high-gain antennae that would detect faint signals at extended ranges, imagine the number of signals that the same receiver will pick up in a dense field of view, such as when the satellite reaches its lowest altitude. Weeding out the spurious and multipath emissions will prove to be a Herculean task, thus further complicating efforts to separate the grain from the chaff—especially when the satellite is in a signals-intelligence role. The author has focused primarily on imaging sensors in the visible and infrared bands. How about synthetic aperture radar or inverse synthetic aperture radar, technologies that have opened up exciting possibilities for overcoming the ill effects of atmospheric disturbances and poor visibility? In the maritime domain, ships have now been mandated to install an Automatic Identification System (AIS) under the United Nations Convention on the Law of the Sea. These operate in the VHF/

UHF band and work on the principle of self-organizing time-division multiple access. Simple back-of-the-envelope calculation indicates that an AIS receiver fitted on a low-Earth-orbit satellite can provide tactical-level information on a near-real-time basis. However, for it to be of any use over a particularly large ocean expanse, there ought to be augmentation in either of the following two forms: (1) additional satellites or (2) tactically deployable unmanned aerial vehicles that can be triggered by a satellite feed to patrol areas indicated to have the most threat.

Cdr V. Srivatsan, Indian Navy
New Delhi, India

IRAQ AMIDST TWO FORMS OF TERRORISM: THE POWER OF PERSPECTIVE

Congratulations to both *ASPJ* and General Qaa'id for an excellent article ("Iraq amidst Two Forms of Terrorism," spring 2006). It's absolutely critical that we hear directly from our coalition partners. It's even more important to get their understanding and interpretation of the facts on the ground before, during, and after Operation Iraqi Freedom.

We must understand the culture, the mental terrain, of those we work with as well as those we work against. Reading General Qaa'id's lyric prose gives one a glimpse of the power of expression required for ideas to compete in Middle Eastern cultures. It's very different from the clinical approach taken by US authors. The general's words show the power of vivid imagery while losing none of their intellectual content and impact.

In fact, reading his article provides an insight into and example of what we must do to compete in the war of ideas for both Iraqi Freedom and the war on terrorism. The measured and cold statements we make about freedom and progress are not resonating with people whose mental filters are tuned to metaphor and allegory. Maybe it's time to hire an Iraqi poet instead of a translator to get our message out.

I was struck by a profound message while reading General Qaa'id's words when he said, "Some say that America invaded Iraq. I call it liberation of my country from the regime of a tyrant and his accomplices. In fact, Saddam brought America to Iraq. . . . But he forgot the power of God, who harnessed the strength of the United States to liberate Iraq after Americans died in the terrorist attacks of 11 September 2001" (8–9).

This is a powerful message coming from an Iraqi leader. Iraqi Freedom was not a war between the US-led coalition and Iraq. The coalition was merely a tool used by God to liberate Iraq from Saddam's tyranny.

The fact that I find this so striking shows the effect of my own cultural filters. The metaphor is not unknown in our culture—just little used today. Numerous invasions and catastrophes have been interpreted as God's action to set the world right and take vengeance on evildoers. Was not Attila the scourge of God against Europe?

General Qaa'id has outlined a powerful narrative of the war against terrorism. God abhors violence against Muslims and innocents—both the state-sponsored violence of Saddam Hussein and the bloody actions of terrorists. God is great enough to use every tool, including non-Muslims, to redress these wrongs. In this context, the United States is but a tool to liberate Muslims, end the evils of terrorism, and provide Muslims the freedom to practice their faith and contribute to a global civilization.

To compete in a war of ideas, we've got to speak to the audience in a way they understand.

Col John Jogerst, USAF
Hurlburt Field, Florida

TECHNICAL EDUCATION FOR AIR FORCE SPACE PROFESSIONALS

The authors of the article "Technical Education for Air Force Space Professionals" (winter 2005) are pleased with the progress cited in Lt Col Thomas Peppard's letter (summer 2006) concerning our article, especially in that much of that progress is in concert with the article's recommendations. However, we respectfully

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and our organization by earning a degree. The way to climb the ladder, as one example, is to have a graduate degree.

During a quick look at the "how to" titles in the leadership/management section of a bookstore, I found the book *How to Become CEO* by Jeffrey J. Fox. Serving as the leader of a commercial enterprise is different than serving as a military officer, but there are some close similarities. In the chapter "Do Something Hard and Lonely," Fox says that one should "do something that you know very few other people are willing to do. This will give you the feeling of toughness. . . . It will mentally prepare you for the battle of business." He also writes that one should "do something that is hard and lonely . . . like studying late at night for a graduate degree, while everyone else is asleep." These quotations correlate directly with Colonel Krisinger's statement that "the military profession is no different from traditional professions." Corporate America emphasizes the graduate degree, encourages it, pays for it, and acknowledges it on annual performance appraisals. So should we. Two additional years of studying during nights and weekends, sometimes during lengthy deployments and under indirect fire and austere climatic conditions, show an individual's true dedication to our profession.

Maj Larry Colby, USAFR
Niagara Falls Air Reserve Base, New York

MYTH OF THE TACTICAL SATELLITE

I wish to congratulate Lt Col Edward B. Tomme, USAF, retired, for his article "The Myth of the Tactical Satellite" (Summer 2006). I formerly served as director, Program C, National Reconnaissance Office, and based on my personal experience with the development, acquisition, and operation of tactically responsive space systems, his article is one of the few realistic assessments of the operationally responsive space (ORS) "bandwagon" that I have seen. The author might also consider that when one looks seriously at the requirements process, development and acquisition (including vehicle/payload storage and replenishment), ground infrastructure, training, and so forth that would be necessary to support some of the claims currently associated with ORS, then doubts about the concept's feasibility increase by several orders of magnitude. Once again, this is an excellent article!

Rear Adm Thomas Betterton, USN, Retired
Naval Postgraduate School
Monterey, California

THE AIR FORCE'S MISSING DOCTRINE

I would like to congratulate Maj Kenneth Beebe on his article "The Air Force's Missing Doctrine: How the US Air Force Ignores Counterinsurgency" (Spring 2006). The author hit on an issue that I have been asking about for the last few years regarding the service's disregard of counterinsurgency (COIN) at the strategic and operational levels. We are entering an age when COIN will become a larger part of Air Force operations (such as al-Qaeda's presence in Africa, the Fuerzas Armadas Revolucionarias de Colombia insurgents in Colombia, etc.). Even though the Air Force prides itself on forward thinking, I think we are far behind the power curve when it comes to COIN. The egregious part of this issue is that airpower has been used in COIN since the British were bombing Iraqi rebels immediately following World War I. This isn't a new issue, yet somehow we fail to address it.

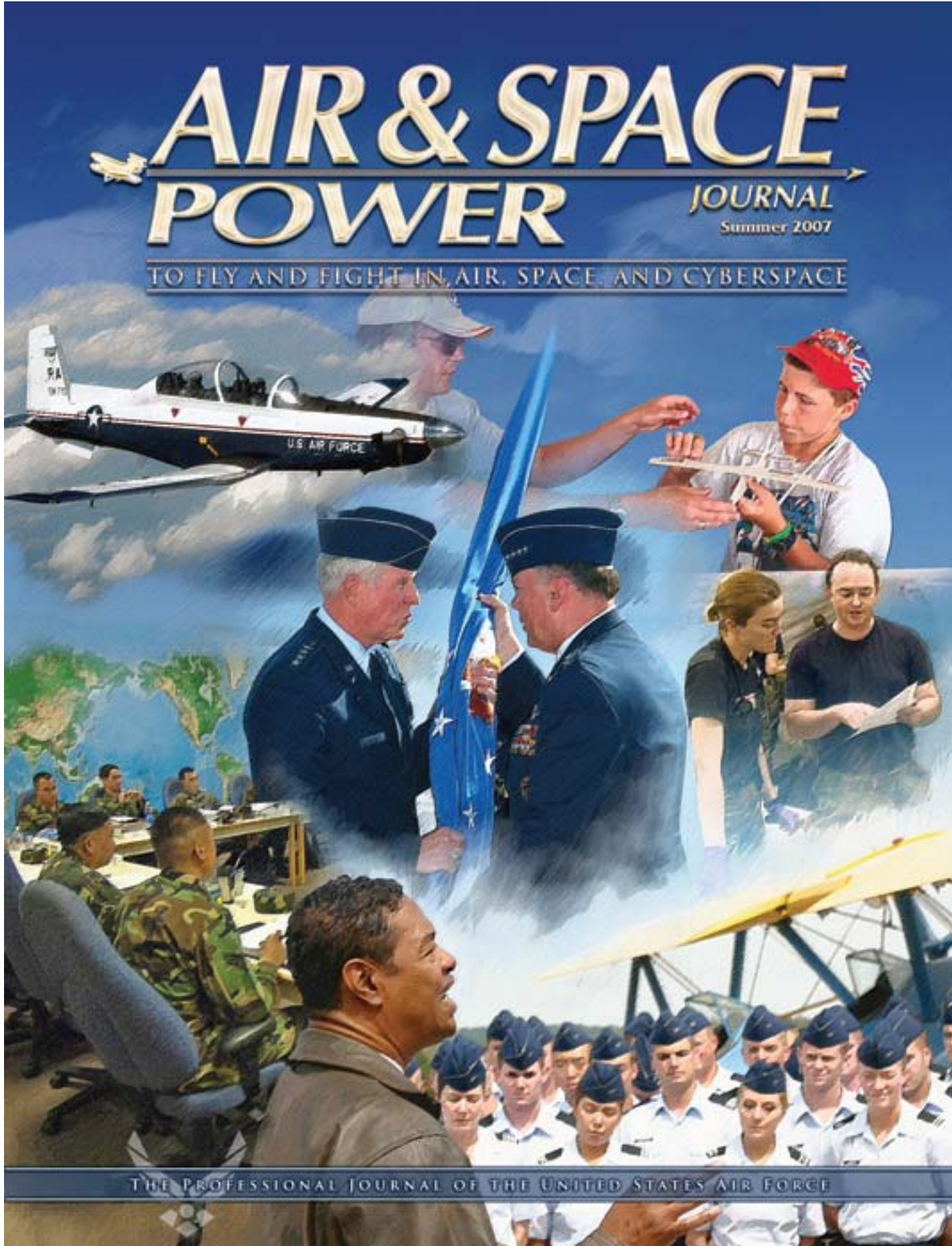
I believe there is a crucial need for newer aircraft, similar in operational ability to the C-130, that can support the Air Force's role in COIN. The problem that I have found is that the service doesn't find it in its best interest to support this kind of financial investment; senior leaders would rather invest in larger projects that support major theater conventional war (Col John Boyd is rolling over in his grave).

I would like to note that Sir Robert Thompson led one of the most successful COIN operations ever, which included effective use of airpower, in the Burma campaign of World War II and again during the Malaysian Emergency of 1948–60. I thank the *ASPJ* staff for publishing Major Beebe's article. It is the first

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from being merely a means, has very often been considered an end—a highly attractive activity for which no other can provide an adequate substitute" (218). The Argentinean action is probably closer to van Creveld's conception of war than to Clausewitz's. Once again, thanks to Major Pereyra for an intriguing article.

Wing Cdr Z. I. Khan, Bangladesh Air Force
Dhaka, Bangladesh

MYTH OF THE TACTICAL SATELLITE

I wholeheartedly congratulate Lt Col Edward B. Tomme, USAF, retired, for his article "The Myth of the Tactical Satellite" (Summer 2006). I have spent a career in the military-launch business, which has been and is now spending significant dollars to develop the "responsive launch" capability for these mythical "tactical" satellites. One thing that seems lost on many people is the cost of the infrastructure to support rapid launch. Even inexpensive boosters cause launchpad damage that must be repaired, and they require trained crews that must be there and ready for unplanned launches. All the boosters and satellites must be prepurchased and maintained in storage in a flight condition. It can't be done with military crews as there is neither career growth nor continuous activity to maintain training. Thus, we pay contractors. This capability will cost hundreds of millions of dollars to preposition, and it might take weeks to launch a constellation of six to 10 satellites. And what would happen if one of the boosters or satellites failed during the constellation deployment? Until we develop a true tactical capability, our tactical-satellite demonstrations test strategic-augmentation systems that can be deployed as secondary payloads on other strategic missions or use current small boosters like Pegasus, Athena, and so forth.

Col Michael T. Baker, USAF, Retired
Redondo Beach, California

Airmen provide America with air, space, and cyberspace dominance—the first and essential enduring requirement of a successful military operation.

—Hon. Michael W. Wynne, Secretary of the Air Force

The Merge

In air combat, "the merge" occurs when opposing aircraft meet and pass each other. Then they usually "mix it up." In a similar spirit, Air and Space Power Journal*'s "Merge" articles present contending ideas. Readers can draw their own conclusions or join the intellectual battlespace. Please send comments to aspj@maxwell.af.mil.*

Editor's Note: For a reply to this article, see "Tactical Satellites: It's Not 'Can We?' but 'Should We?'" by Lt Col Edward B. "Mel" Tomme, USAF, retired, in this issue.

Tactical Satellites

The Rest of the Story

LTC Bob Guerriero, USA*

RETIRED AIR FORCE lieutenant colonel Edward Tomme's interesting article "The Myth of the Tactical Satellite" (Summer 2006) outlines some of the challenges associated with employing a satellite in a tactical role. The author does an excellent job of describing the physical constraints of satellite operations due to orbital mechanics and payload size, weight, and power issues. However, the article includes some inaccurate assumptions about the nature of tactical operations and the potential value of a tactical satellite for the war fighter on the ground, thus leading to a wrong conclusion.

Colonel Tomme begins his article by discussing what the term *tactical* means to a war fighter: "The warrior has a very specific understanding of what that technical term [*tactical*] means—applying to small-scale, short-lived events, usually involving troops in contact."[1] From an Army perspective, *tactical* does have a specific meaning, but it is not limited to Colonel Tomme's. Army Field Manual (FM) 3-90, *Tactics*, states that "the *tactical level of war* is the level of war at which battles and engagements are planned and executed to accomplish military objectives assigned to tactical units or task forces" (emphasis in original).[2] FM 3-0, *Operations*, defines a *battle* as "a set of related engagements that last longer and involve larger forces than an engagement" and an *engagement* as "a small tactical conflict between opposing maneuver forces, usually conducted at brigade level and below."[3] Colonel Tomme's article implies that all tactical operations are engagements, lasting minutes or hours. In reality, they can last for days, weeks, months, or longer. The planning in advance of such operations can take equally as long.

Any discussion of tactical satellites must also consider the *operational level of war*, defined by FM 3-0 as "the level at which campaigns and major operations are conducted and sustained to accomplish strategic objectives within theaters."[4] A tactical satellite might prove most useful at this level. Because operations can last anywhere from days to years, a theater commander could find the data and support provided by a tactical satellite extremely valuable. At the operational level of war, the commander faces the challenge of linking the tactical employment of units to the fulfillment

*The author is assigned to the Directorate of Combat Development, Future Warfare Center, US Army Space and Missile Defense Command, Colorado Springs, Colorado.

of strategic objectives. To succeed, he or she must leverage both strategic and tactical capabilities, including satellite assets.

Colonel Tomme's article also leaves the reader with the impression of tactical satellites as a replacement for existing constellations of satellites: "A tactical war fighter needs persistent imagery. Getting a snapshot every hour or so is not very useful at the tactical level. . . . It is almost inconceivable to contemplate sending commanders into combat after telling them that they would only be able to communicate five minutes out of every half hour."[5] Finally, when referring to the mission of the Defense Support Program (DSP), Colonel Tomme remarks that "it would still take between 12 and 20 of them to provide continual global coverage."[6] Because these statements tend to narrow the focus to tactical satellites alone, as if they are the only assets available to the war fighter, they inaccurately convey the idea that these satellites fail to meet war-fighter needs. In reality, commanders have a myriad of capabilities available, each suited to a particular application, and tactical satellites could complement these other capabilities.

Tactical war fighters do need persistent imagery, but they neither expect nor require that it come from a tactical low Earth orbit (LEO) satellite alone. A commander relies on the collective ability of ground-based, fixed-wing, and space-based collectors to provide persistence across the spectrum. A tactical satellite that complements other intelligence, surveillance, and reconnaissance (ISR) platforms by providing some specific pieces of information, even just once per day, could be extremely valuable to a commander. Similarly, no commander expects a LEO satellite to serve as a primary means of tactical communications. Many other systems serve this function, but a tactical satellite could augment these systems by providing some specialized, intermittent communications and data access. Finally, no one considers tactical satellites a replacement for the entire DSP constellation, with its global missile-warning mission. Instead, a tactical satellite could complement this constellation by offering an enhanced battlespace-characterization capability. The DSP performs this function now with its overhead nonimaging infrared sensors, but missile warning naturally takes precedence over battlespace characterization, thereby limiting the DSP's utility in that role.

Finally, Colonel Tomme questions the value of any tactical satellite to a tactical war fighter, maintaining that ISR missions are not practical because "the gap times are much longer than the timescale of a tactical engagement."[7] He also argues that "sparse constellations of satellites in LEO have no chance of providing a useful communications capability."[8] In fact, tactical satellites in LEO or high-Earth orbits could perform many extremely valuable missions for theater commanders.

An imagery intelligence or signals intelligence (SIGINT) payload on a tactical satellite, directly downlinked to the theater and available for dynamic retasking by the theater collection manager, could make great contributions by supplementing other resources available to the commander. The advantage of the tactical satellite lies in its responsiveness to the theater commander, who could receive direct support from a space-based asset. One of the most valuable capabilities of space-based ISR platforms remains the ability to collect information over denied territory without an adversary's knowledge. The best use of such a tactical system would entail collecting intelligence over an area selected as the location of an imminent operation, when that area is either denied territory or one that the commander does not want to draw attention to. Even one pass per day could provide useful and actionable information, especially during the monitoring of an area for changes during the days leading up to an operation. Ideally, we would tailor the payload to support operations in a particular theater so that it would provide information not already collected by other sensors. Some examples include a nonimaging spectrometer that could detect the manufacture of weapons of mass destruction, a microwave SIGINT collector, or an infrared sensor that might have a limited lifespan due to cryogen cooling requirements.

We can also envision valuable communications payloads for tactical satellites—even for

intermittent communications. Take for example a communications package that receives low-probability-of-detection transmissions from covert operators and then relays them through other systems to a theater headquarters. By selecting a LEO asset to do this, we could use a relatively low-power ground transmitter and thus lower the probability of detection. A payload of this type would stay overhead only intermittently, and an operator could send updates just at specific times and for limited durations. For a covert operation lasting days or weeks, requiring only periodic updates to the commander, this arrangement might prove completely sufficient. Including a laser-communications payload on this satellite would substantially increase the amount of data transmitted in a short time. We would never use such a system to provide continuous communications; rather, when needed, it would complement other means of communication available. We could also utilize this type of tactical satellite for long-term tracking of friendly or enemy personnel, vehicles, or equipment. Again, thanks to the low-power requirements for transmitting to a LEO satellite, small transmitters in enemy territory could go undetected for long periods of time and would consume very little power. Granted, this system allows only intermittent monitoring capability, but for long-term tracking of personnel or equipment movement, we do not always require or desire continuous updates.

We should not dismiss the value of tactical satellites. They can fill an important role as complements to other existing constellations and assets while providing a level of responsiveness to theater commanders not available from strategic systems. Realizing the potential of these satellites will require the same level of creativity, determination, and perseverance that has made our strategic constellations so successful for over 40 years. ❑

Colorado Springs, Colorado

Notes

1. Lt Col Edward B. Tomme, "The Myth of the Tactical Satellite," *Air and Space Power Journal* 20, no. 2 (Summer 2006): 90, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/sum06.pdf.
2. Field Manual (FM) 3-90, *Tactics*, July 2001, par. 1-4, http://www.dtic.mil/doctrine/jel/service_pubs/fm3_90a.pdf.
3. FM 3-0, *Operations*, June 2001, par. 2-12, http://www.dtic.mil/doctrine/jel/service_pubs/fm3_0a.pdf.
4. Ibid., par. 2-5.
5. Tomme, "Myth of the Tactical Satellite," 92.
6. Ibid., 95.
7. Ibid., 96.
8. Ibid.

We will begin the crucial part of preparing Airmen for combat operations by increasing the emphasis on combat skills training during our basic military training courses, and we will reorient our continuing education training programs to emphasize language and culture.

—Air Force Strategic Plan, 2006–2008

Tactical Satellites

It's Not "Can We?" but "Should We?"

Lt Col Edward B. "Mel" Tomme, USAF, Retired*

THE ARGUMENT BY LTC Bob Guerriero in favor of tactical satellites, which appears in this issue, is one of the few attempts I have seen at a rational rather than an emotional rebuttal to the arguments presented in my article "The Myth of the Tactical Satellite" and the in-depth study from which that article was derived.[1] I appreciate the thought that went into his rebuttal; however, he appears to have missed the point of those works. In neither piece did I claim that conducting such missions as communications, imagery collection, signals intelligence (SIGINT), or blue-force tracking was impossible using so-called tactical satellites. In fact, I devoted a large portion of those works to showing exactly how effectively we could perform those missions from space. What I claimed was that using tactical satellites to perform those missions was highly impractical when constrained by a limited budget. The point of that detailed research was to give senior decision makers a tool with which to measure the actual opportunity cost of such an endeavor.

According to Colonel Guerriero, "A tactical satellite that complements other intelligence, surveillance, and reconnaissance (ISR) platforms by providing some specific pieces of information, even just once per day, could be extremely valuable to a commander."[2] The unstated corollary to his assertion suggests that such a capability will also cost money—money that we could use elsewhere. Undoubtedly, commanders on the ground would rarely turn down an additional satellite photo of their area of responsibility. Having a gap-filling capability to compensate for the weaknesses of other assets would also be a plus. However, before commanders sign up to own that capability, they should know the opportunity cost of getting that image and weigh it against their tactically sized budgets. In a vast majority of tactical situations, some other means of obtaining that photo exist—means that are responsive to the tactical commander instead of being slaves to orbital mechanics. Those means are almost invariably much more affordable, much less predictable to opposing forces, and thus much more effective. When such means are available, the rationale for going to space to get that photo seems counterproductive. It's not that those missions *can't* be done from space; it's that in most cases, they *shouldn't* be done from space. The opportunity costs are huge. The money that commanders would need to spend to buy a single satellite to produce that one picture per day could buy quite a bit of alternative equipment, including nonorbital systems that would likely prove more effective since they don't spend most of their time halfway around the globe.

Space-based assets have two things in their favor that in many cases mitigate their expense: freedom of overflight and relative immunity to threats of physical destruction.† The big operational drawbacks to satellites are excessive predictability and extremely limited persistence. Those combinations of factors tend to make satellites very useful in the strategic role. In contrast, tactical areas of interest are almost always significantly less than global, in most cases well within the footprints of nonorbital

*Colonel Tomme's final Air Force assignment in 2006 was as deputy director, Air Force Tactical Exploitation of National Capabilities (TENCAP), where he directed programs designed to extract tactical effects from strategic overhead assets.

†The recent Chinese antisatellite launch considerably dilutes this advantage.

assets. Colonel Guerriero states that "tactical operations . . . can last for days, weeks, months, or longer,"[3] implying that individual engagements and battles between small maneuver forces can be linked in time and space to form a single tactical operation.* It is a near truism that all military activity involving troops in contact does occur at the tactical level. It is also fairly clear that when a series of battles or engagements starts to last "days, weeks, months, or longer," the level of control should shift up to the operational or strategic levels of war. It seems obvious that the longer an operation lasts, even though, in truth, it consists of a series of related tactical events, the further up the spectrum of war it must progress. Without such a progression of command attention, the rationale for having higher levels of command would not exist. Regardless of personal interpretations of Army doctrine, operations lasting for significant periods and/or extending across substantial spatial extents would appear to warrant the attention of higher-level command, and hence should be classified collectively as something other than tactical operations.

Why is the definition of the level of war so germane to the problem of the so-called tactical satellite? It all boils down to *truth in advertising*. Advertising is how any product goes after customers and, ultimately, funding. Selection of the name *tactical satellite* appears to have its basis in sex appeal; the term sells the concept to an acquisitions staff desperately looking for ways to enhance delivery of command, control, communications, computers, intelligence, surveillance, and reconnaissance effects to the lowest level of war fighter whose inability to receive those effects adequately during Operation Iraqi Freedom has been well documented.[4] Who could refuse to buy a program that promises to deliver tactically controlled space effects directly to the front lines at an ostensibly affordable price? Unfortunately, the deliverable effects publicly touted as the raison d'être for funding a tactical-satellite program, apparently designed to gain maximum attention from potential funding sources, appear unachievable within a constrained budget.

The marketing campaign related to tactical satellites is uniform in its message of direct tactical support. For example, the Air Force Space Battlelab and the Army Space and Missile Defense Battle Lab demonstrated the innovative Virtual Mission Operations Center (VMOC), a program designed to allow control of tactical satellites from the field, to Air Force Space Command commanders. That demonstration touted the use of untrained enlisted personnel in a simulated field environment outside of the Fourteenth Air Force headquarters building to show the system's capability to give a tactical soldier the ability to direct satellite collections and access the products in real time. The obvious implication of this demonstration was to show that the capability would be pushed out into the foxholes where even the lowest-level soldier could task orbital assets and immediately use the space data he or she had requested. Article after article in the press stressed directly taskable support to warriors in the field with statements such as "We believe we will give the soldier on the ground the ability to control a spacecraft payload," "Today's technology is close to giving a foot soldier and the tactical warfighter the kind of space capabilities needed," and "[This capability will] directly benefit the troop on the ground."[5] Briefings by senior officials in the Air Force Research Laboratory (AFRL) heightened anticipation among senior Air Force leadership of direct tactical tasking and support from space.[6] An article on TacSat-3 in the *Air Force Times* even bore the headline "Satellite in Works to Beam Battlefield Pictures to Troops." That article went on to say, "When the Air Force began beaming pictures of the battle space from airplanes to small units of ground troops, it was a breakthrough. Now, the Air Force Research Laboratory is looking at doing the same with pictures from satellites. . . . The key to the experiments is to show a satellite can fly over the theater and that a soldier on the ground can directly task the satellite and

*Extending this assertion to its logical but absurd conclusion, one could consider all of World War II a single tactical engagement.

get information."[7] Without question, the marketing thrust is geared toward the idea that tactical satellites will provide direct support to tactical war fighters.

The problem with this coordinated marketing campaign relates to the need for truth in advertising, discussed above. In all likelihood, the effects tantalizingly advertised by tactical-satellite advocates will not find their way to the front lines at all. As shown in "The Myth of the Tactical Satellite," the least expensive tactical satellite used for imagery will cost a commander about $500,000 per hour overhead in acquisition costs alone and will provide only a stroboscopic glimpse of the battlefield, less than two minutes out of every five hours or so. Furthermore, per-hour cost isn't the only issue. Many years prior to actual need, senior leaders will have to make decisions concerning which missions may require augmentation; planners must program resources to develop and acquire the necessary single-purpose satellites and launch vehicles; and all this investment must then go into suspended animation for an undetermined period of time to await an unspecified tactical need in an unknown geographical area.

Those acquisitions and logistical costs add up quickly, but prioritization of access to the asset during the limited time it is overhead will be an even more pressing problem. It is naïve to believe that such prioritization will occur at less than the operational level of command, if not higher. Colonel Guerriero as much as admits this point himself when he describes the operational level as the one at which "a tactical satellite might prove most useful."[8] Additionally, anyone who has worked with imagery or SIGINT knows that substantial analysis goes on before publication of any product because the raw data is difficult for amateurs to interpret. Getting these products to the field would not be as simple as picking up developed photos from Wal-Mart. It is highly doubtful that the fabled sergeant in the foxhole directing a satellite to give him an image of the enemy over the next hill will ever exist, given the current physical and fiscal constraints on tactical satellites. Even if he does not personally direct the sensor, the odds that his need to obtain one of the very few images captured during a pass will rise to the top of the queue seem very low, considering the numerous, simultaneous tactical engagements likely to be in progress at the time. The resources are just too precious.

One could certainly move a family's household goods across the country with a fleet of Ferraris that one had to buy specifically for that job and then garage them for an indefinite period before the family even had orders to move. Obviously, however, a number of more operationally and fiscally responsible paths to the desired end state exist. Our goal should not be to go to space just because we can.

In conclusion, we must definitely look to space when it offers the most effective way to accomplish the mission. Without a doubt, a mission requiring global coverage or even overflight of denied territory beyond the range of airborne or near-space sensors plays to the strength of space. We could even envision missions in which receiving information exfiltrated from Colonel Guerriero's small covert-operations team is important enough to warrant launching an asset costing several tens of millions of dollars. However in the vast majority of realistic situations, given the existence of so many more effective ways to support our tactical warriors during the relatively short timescales and across the relatively small areas in which they operate, it appears that promoting the theory of "space because we can" is an unaffordable, unresponsive, ineffective, and ill-advised course of action. ❑

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Notes

1. Lt Col Edward B. Tomme, "The Myth of the Tactical Satellite," *Air and Space Power Journal* 20, no. 2 (Summer 2006): 89–100, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj06/sum06/sum06.pdf; and idem, *The Strategic Nature of the Tactical Satellite*, Research Paper 2006-1 (Maxwell AFB, AL: Airpower Research Institute, College of Aerospace Doctrine, Research and Education, n.d.), https://research.maxwell.af.mil/papers/ay2006/CADRE/tomme.pdf (accessed 31 January 2007).

2. LTC Bob Guerriero, "Tactical Satellites: The Rest of the Story," *Air and Space Power Journal* 21, no. 2 (Summer 2007): 28.

3. Ibid., 27.

4. Lt Col Edward B. Tomme, *The Paradigm Shift to Effects-Based Space: Near-Space as a Combat Space Effects Enabler*, Research Paper 2005-01 (Maxwell AFB, AL: Airpower Research Institute, College of Aerospace Doctrine, Research and Education, n.d.), https://research.maxwell.af.mil/papers/ay2005/ari/CADRE_ARI_2005-01.pdf (accessed 17 January 2007).

5. Patrick Chisolm, "Micro-Eyes in Space," *Military Geospatial Technology* 4, no. 3 (14 July 2006), http://www.military-geospatial-technology.com/article.cfm?DocID=1547 (quotation attributed to Peter Wegner, the AFRL responsive-space lead) (accessed 12 December 2006); Maryann Lawlor, "TacSat Delay Ignites Frustration," *Signal Connections* 3, no. 9 (15 June 2006), http://www.afcea.org/signal/articles/templates/SIGNAL_Article_Template.asp?articleid=1154&zoneid=188 (quotation attributed to Peter Wegner) (accessed 2 February 2007); and Michael Kleiman, "Responsive Space Demonstrator Ready to Roll," Air Force Print News, 5 November 2006, http://www.af.mil/news/story.asp?storyID=123030853 (quotation attributed to Neal Peck, TacSat-2 program manager) (accessed 12 December 2006).

6. AFRL briefing, Dr. David Hardy, "TacSat Demo Status: Senior Leader Vector Check," Washington, DC, 22 September 2004; and AFRL briefing, Col Rex Kiziah, "Joint Warfighting Space," Schriever III War Game, Nellis AFB, NV, 8 February 2005.

7. Bruce Rolfsen, "Satellite in Works to Beam Battlefield Pictures to Troops," *Air Force Times*, 13 November 2006, http://www.airforcetimes.com/legacy/new/0-AIRPAPER-2320736.php.

8. Guerriero, "Tactical Satellites," 27.

More than ever, we depend on our allied Airmen to succeed, and they depend on us. We must fly and fight as one. We teach, we partner, we learn—and in building friendships, we build trust. America's security today and in the future depends on building successful international partnerships, one Airman at a time.

—Hon. Michael W. Wynne, Secretary of the Air Force