BRAVE NEW WORLD OF HOSTED PAYLOADS

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Arguments in favor of flying government-sponsored hosted payloads aboard commercial satellites have gained significant traction in recent years. The space community seeks to satisfy the increasing demand for space-based information with robust systems and also reduce the costs of supplying that capacity. Hosted payload solutions can fill the programmatic seams between flagship and small size satellites system and hold great potential to enhance the resilience of US national security space systems architectures and achieve desired cost savings. Integrating these capabilities with existing commercial systems will present significant challenges and involve accepting new programmatic risks. Despite the advantages, integrating national security and intelligence hosted payloads aboard commercial satellites raises unique contracting, policy, and Law of Armed Conflict issues.

MULTIPLE FORCES ARE WORKING TO DESTABILIZE THE US AND ITS SPACE SYSTEMS ADVANTAGES

Over the last 20 years, systems relaying data and providing information from space have become critical to the conduct of wars and peacekeeping, not just in our everyday life. Very simply, space has become an integral part of modern life and all

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military operations. Its systems provide an array of capabilities that offer the United States (US), its allies, and coalition partners tremendous asymmetric advantages in terms of intelligence, surveillance, reconnaissance, communications, missile warning, precision navigation and timing. These capabilities give an awareness and understanding that enhances US capabilities to conduct operations the way no other armed forces can today.

There are multiple forces working in parallel to destabilize these important asymmetric advantages:

- The US economy
- A congested, competitive and contested environment
- Aggregated and complex satellite systems, and soaring costs
- Important new space systems have completed developments and are just beginning to deliver wanted capabilities
- Next generation systems, while able to reduce costs in the long run, will cost money in the short run

The US economy – Ongoing fiscal policy disputes between the executive and legislative branches are making it likely the US national space budget will decrease. The economy has floundered over the last half decade and funds are not readily available to be spent on discretionary accounts. While the national security space community and its manned spaceflight and civil space exploration cousins did not spawn these problems, they all will be dramatically affected by expected reductions in program resources. As to the overall space industry, even moderate growth in commercial missions will not be enough to offset the crippling effects of lower government spending. This, in turn, may lead to even higher prices for US national security systems.

Congested, competitive, and contested environment – Compounding the fiscal problems, managers are challenged by "the three C's" of the space domain: congested, competitive, and contested.[1] There are huge incentives for states to invest in and use space, and the spread of space-enabled technologies has accelerated and new players have gained access to the domain. Added to this, an ominous number of new kinetic and non-kinetic anti-satellite (ASAT) technologies have been developed, tested, deployed, and employed in recent years. States with sufficient resources can now reach out to space and "touch" satel-

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[1] In an April 14, 2010 speech at the National Space Symposium, Deputy Secretary of Defense William J. Lynn said the US Space Posture Review proceeded under the premise space has become "congested, competitive, and contested." He then elaborated:

> Space has become congested with both satellites and debris. More than 60 nations operate 1,100 systems on orbit. And satellites are not the only thing crowding space. 20,000 known pieces of orbital debris also clutter the skies over earth. Tens of thousands more pieces are too small to reliably track, but are still dangerous to spacecraft operations. The increase in orbital debris and working satellites poses operational challenges to both military and civil space. Space has also become more competitive. More nations work in space than ever before. Numerous and diverse commercial actors offer rival systems and services. By one count, more than 9,000 satellite transponders will be active by 2015. Some satellites work together in systems that many different nations cooperatively run or benefit from. GPS is an example of a space technology with widespread benefits. But most satellites operate on their own, serving the needs of their client rather than the common good. Whatever their purpose and ownership, the sheer number of communication satellites raises the specter of interference. We are approaching a point at which the limitless frontier no longer seems quite so limitless. Finally, space is becoming contested. We can no longer take access to space for granted. Some nations have jammed satellite signals to prevent their people from watching coverage of protests. Other nations have developed the ability to destroy satellites in low-earth orbit. And still other nations have technologies that can disable or permanently damage space platforms. Our space assets could be targeted as part of a deliberate strategy to deny us access to the space domain. By crippling key sensors and platforms, such anti-access tactics could offset the tremendous conventional dominance our space assets enable us to bring to bear. Never before have our space assets been so vulnerable to disruption. Since the environment in space has changed, our approach must change as well. We need a new strategy that takes into account the congested, competitive, and contested space environment that we operate in.

William J. Lynn, Remarks at National Space Symposium, Broadmoor Hotel, Colorado Springs, Colorado (Apr. 14, 2010), http://www.defense.gov/speeches/speech.aspx?speechid=1448.

At a November 30, 2010, NDU Conference on "Securing Space Assets for Peace and Future Conflict," Ambassador Gregory L. Schulte, Deputy Assistant Secretary of Defense (acting) for Space Policy, characterized congested, competitive and contested as "the Three C's." *See*, http://www.defense.gov/home/features/2011/0111_nsss/docs/20101130%20DASD%20Remarks%20on%20Securing%20Space%20Assets%20at%20NDU.pdf.

lites through a variety of means, and achieve one and even more of "the five Ds": deception, disruption, denial, degradation, and destruction.[2] So much for the "ultimate high ground."

The January 11, 2007 test of a Chinese ground-based, direct-ascent anti-satellite (ASAT) interceptor against one of their own defunct Feng Yun-1C weather satellites sparked marked unease across the US space community, indeed, across all space-faring nations and the international commercial satellite marketplace. The test was deplorable as China had emerged as global military and economic superpower less than 30 years after it was only considered a basket case, incapable of functioning. Nevertheless, with its test, China sadly signaled a willingness to put at risk the very systems vital to global economic success and its own success, and halt the progress achieved by it and other space-faring nations. The test also demonstrated the broad strategic importance of space capabilities is also their deadly weakness – it is far too easy to neutralize satellites because their predictable orbits make them easy targets for those with advanced weapon systems. Satellites suffer from their own set of unique, inherent vulnerabilities, which are largely the consequence of orbital mechanics. These weaknesses are well recognized and invite destruction, damage, and even just mischief delivered by even the least significant adversary; state and

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[2] Deception involves those measures designed to mislead by manipulation, distortion, or falsification of evidence to induce one to react in a manner prejudicial to his or her interests. Disruption encompasses the temporary impairment of the utility of space systems, usually without physical damage. These operations can include the delaying of critical, perishable operational data. Denial means the temporary elimination of the utility of the space system, usually by stopping access to a system without creating any physical damage. This can be accomplished by such measures as cutting electrical power or network connectivity to the space terrestrial nodes, or to computer centers where data and information are processed and stored. Degradation entails the permanent impairment of the utility of space systems, usually with physical damage. This can include attacks against terrestrial nodes and capabilities, and may also include the use of information operations attacks. Destruction features the permanent elimination of the utility of space systems. This includes any means to interdict critical terrestrial nodes; use of attacks to destroy uplink and downlink facilities, electrical power stations, and telecommunications facilities; and attacks against the satellites themselves.

James D. Rendleman, *Strategy for Space Assurance*, *in* SPACE STRATEGY IN THE 21ST CENTURY: THEORY AND POLICY 111, fn. 5 (Routledge, Eligar Sadeh, ed., 2013) (*citing to DOD Strategic Deterrence Joint Operating Concept (SDJOC)*, 44-45 (Feb. 2004)) [hereinafter *Strategy for Space Assurance*].

non-state actors may purposefully seek to deny US advantages in space through a variety of negation and prevention acts.

Aggregation – The US Government contracts to build and fly only a very few space systems. As a result, its acquisition offices want to wring every mission advantage they possibly can out of each satellite. That has also meant managers tinker with their programs in an attempt to bundle capabilities. With bundling, the government consolidates as many requirements as possible onto a single "flagship" satellite. Bundling is also called "aggregation."

Aggregation is used to build stronger cross-mission advocacy and secure additional funding because satellite systems are often difficult to resource. This has an undeniable downside. It saddles a program with tremendous technical and resource management risks. Establishing and maintaining the necessary exacting engineering baselines responsive to those risks is exceedingly complex and often undoable. Immense "flagship" class satellites are burdened also by equally extensive and labyrinthine ground systems. As a result of this confluence of factors, flagship systems come with crushing multi-billion dollar price tags. The technical, resource, and complexity attributes of flagship systems effectively limit the type of organizations that can acquire them to governments, militaries, and very large, multinational satellite service providers. The US Government acquired a number of these systems during recent decades, as it could draw on a vast national economy to secure resources needed to do so, but with recent economic, fiscal, and monetary troubles, this approach is fast becoming unpracticable .

Delivery of current generation of systems – New satellites, having survived years of acquisition activities, are beginning to be delivered in earnest to operators. The capabilities these systems deliver to operators are far superior to those provided by earlier generations. Unfortunately, the fact that their acquisition took so long, makes them, in a sense, obsolete upon delivery. With delays, insidious failures emerge; especially as the crushing attributes of Moore's Law come into play — long-delayed programs deliver decades-old technologies to a mission.[3] As an example, the latest US Government satellite communications (SATCOM) system, the Wideband Global SATCOM (WGS) system, is an important acquisition, but one should despair because WGS only offers one-tenth of the capacity of recently deployed commercial systems. Then, with all the pain endured in producing these flagship systems, many feel the US space community should just pause as they begin to enter the US inventory and cherish whatever success achieved by them before moving on to new, painful follow-on programs.

The hunger to acquire and operate bloated flagship systems is typical of government acquisition process that has gone truly mad. Decades of government-charted studies of the defense industrial base have documented the serious, interrelated systemic factors causing space acquisition to go awry; nearly all highlight the same institutional and resource shortcomings. And flagship systems acquisitions tie up immense resources. In

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[3] According to Paul Brooks,

> When a satellite is being designed the owners look for ways to extend its mission. The designers then put more payloads on the spacecraft to deliver more value, but then the cost goes up…This creates more financial risk which then requires greater assurance that everything will work as planned. The greater assurance lengthens the lead time. You ultimately end up with very large missions and by the time the payload is launched, it is out of date. We noticed that this pattern repeated itself in the satellite industry and, unlike other technology-driven markets, there weren't huge increases in performance and large decreases in cost. We believe that Moore's Law should apply to spacecraft as well….

See Greg Berlocher, *Small Satellite Technology: Gains Open Space to More Players*, VIA SATELLITE, Aug. 1, 2008, http://www.viasatellite.com/via/features/Small-Satellite-Technology-Gains-Open-Space-to-More-Players_23881.html. According to Webopedia, the observation was made in 1965 by Gordon Moore, co-founder of Intel, that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented. "Moore predicted this trend would continue for the foreseeable future. In subsequent years, the pace slowed down a bit, but data density has doubled approximately every 18 months, and this is the current definition of Moore's Law, which Moore himself has blessed. Most experts, including Moore himself, expect Moore's Law to hold for at least another two decades." *See Moore's Law,* http://www.webopedia.com/TERM/M/Moores_Law.html (last visited Sept. 5, 2013). Moore, then Fairchild Semiconductor's Director of R&D, edited and published his observation, in what was originally an internal company paper, as Gordon E. Moore, *Cramming more components onto integrated circuits*, 38(8) ELECTRONICS, 114-117 (April 19, 1965).

recent years, acquisition debacles on national security and civil flagship systems such as the Space Base Infrared System (SBIRS), Future Imagery Architecture (FIA), National Polar-orbiting Operational Environmental Satellite System (NPOESS), the James Webb Telescope, and others have become emblematic of these problems. These acquisitions siphoned off vast resources and intellectual capital that could have been used to field other vital space capabilities. Similarly, NASA's long close embrace of the now retired Space Shuttle and on-going International Space Station programs, and their archaic 1960s-1980s technologies, eviscerated much of the agency's scientific enterprise, and drained resources that could have been better invested to bolster and invigorate a struggling aerospace industrial base and support new science and technology research activities vital to maintaining US global scientific and engineering leadership. Anecdotes abound of space shuttle engineers who have transitioned to new careers to keep income flowing to their families. Some now flip houses (that is, purchase, upgrade, and sell them) and others have moved to the booming Dakotas to work as petroleum engineers.

Transition to the next generation – The space business has always strived to begin development of a next generation of systems while building out and launching the last generation. SBIRS began in the late 1990's, long before the last Defense Support Program (DSP) satellite was placed in orbit[4], the Global Positioning System (GPS) III was begun before the Air Force had even launched the first satellite in its GPS IIF block, and the same with Advanced Extremely High Frequency (AEHF), WGS and even the Evolved Expendable Launch Vehicle (EELV). Entities positioned to profit from current acquisitions do not want to move on. Some of these companies now make the case, with a little sleight-of-hand and a wee bit of revisionist history mixed-in, that the US has never begun the development of a next generation of systems while still building out the current

[4] Actually, the author understates the DSP-SBIRS overlap. His career touched on programs aimed at replacing DSP during the 1980s. They eventually evolved into what became the Air Force's SBIRS system and the Missile Defense Agency's Space Tracking and Surveillance System (STSS).

version. With the combination of the acquisition problems, complicated by the economic, fiscal, and monetary challenges facing the nation, many are willing to listen and forgo investments necessary to prepare for next generation space activities. Doing this and delaying the transition compounds the error, making the issues of affordability and resilience bigger than they should be as such moves only delay inevitable and much-needed programmatic and investment decisions. The US needs to invest early in technology development and plan for its next general space systems as this has been shown to reduce overall costs over the long-term.

WISE LEADERSHIP IS NEEDED TO MOVE THE SPACE COMMUNITY FORWARD

With fiscal realities and growing military threats, these trying times demand smart and wise leadership within the US space community. Leaders must be prepared to challenge the underlying assumptions of the current space acquisition paradigm and forge new business models with different logic, inherent costs and resulting mission architectures. Program managers must be charged to lead their acquisition teams through rapid, sound and detailed systems engineering and integration. Fortunately, technology innovations achieved over the last decade have made possible important new satellite mission architectures. These technologies enable the use of small satellite constellations, hosted payloads, and disaggregated systems to achieve mission success. They offer tremendous flexibility and agility, and can satisfy important survival objectives, and the potential to achieve space mission goals more frugally, efficiently and effectively.

Implementing these technology and programmatic options will involve and bring about new and different challenges. Given pressing economic and fiscal challenges, the level of acceptable risks will change, and managers must anticipate them. Establishing and maintaining proper engineering baselines is difficult to achieve for flagship programs that take many, many years to develop. And improperly baselined programs cannot be executed successfully – by even the best systems program office.

The SBIRS and FIA fiascos began with inadequate engineering preparation; this foolishness was compounded by an early failure to acknowledge, on both the government and contractor side, the true scope of resources needed to achieve technical success given their ambitious objectives and planned complexity. The architectures and the technology readiness levels needed to support their programmatic objectives were inadequate, and these inadequacies were matched to cost-objectives and programmed resources that were hopelessly optimistic.

Flagship programs last for decades and are continually confronted with pressures to allow for requirements creep. Program managers are often pressed to make short-term decisions based on public financial reporting and accommodate transient funding instabilities. Nevertheless, they must continually fight or accommodate temptations to make changes to their requirements. Demands for change occur throughout the life of long-duration programs. Further, various players take interests in the capabilities a large system might provide, and try to hitchhike their wants on them, imposing their own additional requirements, further exacerbating requirements instability. Given expanding program lengths, it is not easy to fight off requirements creep as users demand more and more as they become more knowledgeable and sophisticated as to what state of the art could provide. While the desires to continually evolve are legitimate, making changes on flagship programs can be very expensive and could serve as program killers.

Funding instability is simply a fact of life in the Department of Defense (DoD), and funds are continually moved about as priorities change within the executive and legislative branches. This requires continual re-planning, with many involved not understanding the re-planning's cost and schedule impacts. Further, when one decides to stretch programs the decision not only introduces more risk, which is not likely adequately budgeted for, but it also adds long term cost, for which the programs later get blamed. In addition, decisions made in corporate boardrooms, often imposed by quarterly financial reporting pressures for public companies, precipitate short term decisions. Those decisions often generate undesirable long-term negative effects.

Finally, managers must also understand the international and domestic laws that affect their programs and constrain their decision-making and ultimate satellite ground and on-orbit operations. As the legal issues are identified and worked, the understanding of what constitutes acceptable risk will evolve, and must then be balanced by the manager against cost, adaptability, technology insertion, resilience, and other technical and programmatic factors. Program managers must therefore employ attorneys to identify, minimize and defeat legal and programmatic risks challenges.

THE NEED FOR OPTIONS: FLAGSHIP SYSTEMS SUFFER FROM THE SPACE ACQUISITION VICIOUS CIRCLE

Flagship systems are often confronted by an insidious phenomenon described as the "Space Acquisition Vicious Circle." In the Circle, each attempt to resolve problems in the acquisition process creates new problems and expense. As a result, space systems become more and more complex and expensive, with less and less room for failure. As described by Major General Thomas "Tav" Taverney (USAF, Ret.), in his essay "Resilient, disaggregated, and mixed constellations," the aggregation of mission requirements generates very damaging consequences:

- It takes many years to build these highly integrated bundled mission capabilities. With this reality, the US government customer demands that its contractors integrate advanced technology into a developed system, so that it is not totally obsolete when finally deployed. Unfortunately, try as they might, the resulting long schedule adds obsolescence along with technology and schedule risk to a system that is ultimately launched.

- The resulting high cost and risk minimizes the number of new program starts. The circular thinking behind this is if the US government cannot afford to approve many new starts, program planners, in an honest attempt to get the warfighters the space capabilities they need, think they should structure scarce, new programs to get everything out of them that can be funded.

- As users demand more and as a result of the previous step, acquirers design more and more complex systems to meet a greater number of aggregated requirements. This has the unfortunate consequence of generating complex and expensive sets of technical requirements for space acquisition efforts. Sometimes these requirements are at cross purposes (e.g., precision navigation and timing systems with nuclear detection capability). As a result, very complicated payloads are proposed, and they turn out to be very expensive and high risk to build and operate.

- Another unintended consequence is the resulting satellite systems are heavy, complex, and expensive to develop and operate. Spare satellites for such systems are unaffordable. With no spares, the acquirers must significantly increase system reliability, again increasing overall program cost. That means the system must be designed to work the first time, every time. It also means intense and expensive reviews of every developmental step, and even more extensive testing to be sure everything is very reliable and meets the multiple (and sometimes incompatible) requirements. That then drives cost and schedule. As the system becomes more expensive, less tolerance for risk is allowed. The system becomes too big to fail. So this leads to even more program reviews, senior service reviews, independent reviews, testing, and expense—and the vicious circle continues.

- Since this acquisition approach of buying aggregated satellites is expensive, funding needed to develop robust ground systems just like the funding for sparing [Author's note: space parts, systems] is equally complex, and unaffordable.

- Ultimately, we are left with satellite systems that are very expensive and with heavy payloads, long development cycles, and no spares. Unfortunately, with no spares, programs cannot afford a launch failure. This all demands 100 percent launch success rates, which are also impossible to achieve. This in turn results in very expensive, risk averse, and expensive launch processing. [Author's note: And little to none of that expense and risk is absorbed by the contractor, nor should it be! That makes the program even more expensive for the US Government customer.] The concern about risk drives demands for extensive launch reviews, both developer and programmatic, along with independent reviews. Launch afforda-

> bility calls for fewer satellite systems, which results in a lower launch rate. As launch rate is the single biggest driver in the cost of launch, this now compounds our launch affordability problem. With very low launch rates we get expensive launches, or we get expensive launches because our rate is low. As launches become more and more expensive, the US government is compelled to reduce their number, which means we can only launch a select few important payloads. As launch costs are driven up, resistance rises to increasing the launch rate or using our launch vehicles by other agencies or commercial satellite builders. Finally, as costs skyrocket, we can't afford to launch a wide variety of missions.[5]

The Space Acquisition Vicious Circle cannot be exited easily. It is not easy to forge success with programs that must integrate a myriad of complex technologies; few are completed within the usual optimistically planned resources and schedules. Controlling risks is critical in space programs, and adequate cost and schedule risk margins are essential, but difficult to maintain. Not adequately accounting and budgeting for risk, however, results in huge costs in the form of overruns and unplanned delays. And there is usually little programmatic room to spare. Even though some US satellite systems do have large constellations (read: GPS), the US Government does not usually acquire spare satellites to cover the risk of launch or on-orbit failure. So when the US Government loses a launch, it also loses critical capabilities for its warfighters and peacekeepers.

In the end, despite best efforts, most large space programs are unable to successfully contain costs and limit engineering problems. Still, many seek the selection and honor to serve as space program managers. Once selected, they are consigned to an eternity of useless efforts and unending frustration as they roll programmatic boulders up hills with zeal that would earn the sympathies of their equally condemned brother, Sisyphus.[6]

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[5] Thomas D. Taverney, *Resilient, disaggregated, and mixed constellations*, THE SPACE REVIEW (Aug. 29, 2011), http://www.thespacereview.com/article/1918/1.

[6] In Greek mythology, Sisyphus is said to have been a king who was punished in the afterlife in the Underworld for his chronic deceitfulness. He was compelled to roll an immense boulder up a hill, only to watch it roll back down, and to repeat the action forever. On the other hand, successful program managers are better confused with

ACHIEVING AFFORDABILITY AND RESILIENCE THROUGH INNOVATION IS VITAL TO FUTURE SUCCESS

Despite the challenges posed by the five major destabilizing factors, space systems must satisfy two important objectives—first, they must be "affordable". Affordable is defined as "what one can bear the cost of." Of course, what was affordable 20 years ago, may not be affordable today. In today's parlance, "affordable" should perhaps mean costs that are 20-25 per cent lower than current ones to acquire and perform missions. Therefore, the next generation of systems need to be developed so they present the needed mission capabilities in a more cost-effective and efficient manner. Second, space systems must be "resilient". Resilience is the ability to recover from or adjust easily to misfortune or change. In the case of national security space, this means recovery or adjustment from losing a satellite occurring as a result of hostile acts, accidents, or as result of damage caused by the space environment. National security space systems, and commercial systems for that matter, must prepare for and increase the odds that they can survive an unexpected attack (the quintessential space Pearl Harbor) and reconstitute/augment themselves in a manner such that they can effectively deliver services that support their warfighter customers.

How should the affordability and resilience imperatives be reconciled in the current space acquisition environment?

Affordability. More often than not, when buying the same type of systems, the US Government has continued to do business as usual — buying more and more expensive and complex systems, sometimes with compromised engineering approaches that creates new problems. The failure to reform, spending more, and allowing delays can be characterized as a joking form of insanity: doing the same thing over and over again the same way and expecting different results.[7] Now, most large prime

great Greek hero Hercales, who, in his Fifth Labor, cleaned the Augean stables. This assignment was intended to be humiliating and impossible, not impressive. Heracles rerouted the rivers Alpheus and Peneus to wash out the dung.

[7] The joking observation is attributed to Albert Einstein.

contractors are burdened with immense overhead costs and are unable to provide agile solutions to evolving acquisition needs.

Complexity and the attendant high costs burden launch, operations, and sustainment. Managers try to ensure 100 percent reliability, and this causes prices to spiral upward on all but the least capable microsatellites. Satisfying the "affordability" imperative demands that the total cost of space systems be reduced to what the nation can and will pay. The space acquisition community has been directed to take a number of steps it hoped would save money – for example, it has been directed by Congressional committees to trim acquisition costs by reducing management reserves; and directed by the Secretary of Defense to de-funding and de-scoping much wanted programs. These actions conserved a few dollars. Some directions encouraged managers to skimp on essential mission assurance and risk reduction engineering activities. This, in turn, dramatically increased overall program risks. Saddled with reduced systems engineering and appropriate risk reduction, some programs failed. Other grew to behemoths that squandered national treasuries and drained contractor corporate reserves. When their managers realized penny-wise, pound-foolish strategies had led to catastrophes on must-have, can't-fail programs, they had to return to the Congress to secure additional funds.

There is no single technology fix or magical management process that can solve affordability issues. Space systems and their support systems are expensive, and have been throughout the Space Era. Their acquisition can be improved and refocused with innovative new technologies and operations concepts. Rather than consolidating resources on flagship class satellites, with their attendant cost problems, managers could move to unbundle their systems. Constellations or clusters of small satellites and hosted payloads, and block purchases of such systems, could enable programs to survive severe fiscal constraints.[8]

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[8] COMMITTEE ON EARTH STUDIES, ET AL., THE ROLE OF SMALL SATELLITES IN NASA AND NOAA EARTH OBSERVATION PROGRAMS 43 (2000) [hereinafter THE ROLE OF SMALL SATELLITES IN NASA].

The miniaturization of payloads and the development of small capable spacecraft provide opportunities to employ innovative constellation architectures to satisfy mission needs. Small satellite technologies have significantly advanced in recent years; new, small buses can now be used host the miniaturized payloads to support a wide variety of missions. Small satellites will be more fully discussed in the next section.

Another way to reduce cost may be found through the innovative use of commercially available systems. That is, using satellites buses and systems already coming off existing satellite manufacturers production lines. Heretofore, this approach has been discounted, as the US Government usually buys only a few satellites and the ones they buy are often unique, one-of-a-kind systems. Employing a commercial approach will require that managers perform a risk and cost analysis — balancing their ability to build and install payloads on uniquely-tailored and manufactured satellite buses verses moving to integrate those payloads on more readily available and generic commercially buses. The National Academies Space Studies Board has found that commercial "production" satellite buses offer the potential for reducing costs. "However, they generally have to be tailored—with attendant costs—to accommodate existing Earth observation payloads."[9] The Board also observed that designing payloads to match existing bus capabilities offers greater cost-effectiveness, though caution must be exercised not to compromise the mission.[10]

Happily, the commercial space industry has grown and is thriving, and it produces very capable buses, often with significant excess capacity. The US Government now can take advantage of existing product lines and their low-risk. Another, even

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[9] *Id.* at 36.

[10] *Id.* at 35. The Board noted that very low costs are experienced only with simple spacecraft performing limited missions. "Small spacecraft can be relatively expensive when they retain the complexity required to meet demanding science objectives (pointing accuracy, power, processor speed, redundancy, etc.)…The true cost of a mission must also include the investment in technologies around which the activity is built. Leveraging advanced technology to lower mission costs is laudable, but understanding the true cost of the mission requires consideration of such prior investments, particularly when they are directly supportive of the mission (e.g., preexisting sensors)."

more innovative, approach being evaluated is using commercial rideshares, and hosted payloads, which have potential not only to reduce bus cost and risk, but also to share launch costs with other payloads. This not only reduces cost and risk, but allows the DoD to focus on developing the critical satellite asset, its payload. Hosted payloads will be discussed later.

Resilience. In a contested, congested, and competitive space domain, "resilience" demands the United States retain access to vital space capabilities, even if those capabilities are targeted by adversaries or compromised by the space environment, on-orbit debris, or unintended electromagnetic interference. This must be done because the US is more dependent on space than any other nation, not only for national security but its private sector as well. Disrupting space systems offers a means by which adversaries can eliminate the significant asymmetric advantages they offer.

How should important space systems be protected? A synergistic strategy to assure the US access to space capabilities depends on four mutually supportive elements, or pillars: global engagement, space situational awareness (SSA), deterrence and defense, and a responsive infrastructure.[11] A responsive infrastructure enables the US to present agile responses to changes in the space environment, defeat man-made threats, and assure a continuing viability of space capabilities. And given the growing threats, US space operators should need more payloads on orbit, and more readily deployable as spares, despite persistent "affordability" constraints.

Of course, in hoping to achieve savings with new systems approaches, this will require substantial lowering of launch costs, something the DoD thus far has been unable to do. Increasing the numbers of payloads on orbit, whether achieved through small satellites or hosted payloads, could secure the economies of scale needed to support spacelift innovation and recoup investment in those technologies. In addition, by operating under a concept of employment that envisions regular, not

[11] These themes have been expounded on by the author in: James D. Rendelman, *Space Assurance for the 21st Century*, 5 (2) HIGH FRONTIER, 46-53 (Feb. 2009), and *Strategy for Space Assurance*, *supra* note 2.

infrequent or as-needed, replenishment of space systems, decision-makers would potentially have sufficient numbers of systems on hand to conduct rapid reconstitution or augmentation operations in response to a national emergency.

Many are coming to realize that spending a little more now could provide significant savings in the future, and increase overall mission resiliency by inserting more satellites into orbit and thus decreasing the impact of losing a single (or several) systems. Sustainment and reconstitution schemes could replenish and ensure access to needed space capabilities. Their use would require support by robust and reinvigorated launch systems with satellites inserted into orbit with a myriad of air launched and ground launched systems being used. Interestingly, if these spacelift systems are sufficiently diverse, they would create a strategic dilemma for an adversary as the diversity and span of activities means the adversary cannot guarantee a complete decapitation of replenishment capabilities if conflict activities were directed toward space systems. Launch diversity would achieve a form of resilience. While multiple launches of small satellites present a higher risk of loss due to launch or satellite anomalies, the impact of a single failure would not be significant. A follow-on satellite would already be in production, ready to be launched in event of loss. Compare this situation to a flagship program, where the loss of scarce expensive satellite would send the warfighter reeling, scrambling to fill the capability void.

SMALL SATELLITE SYSTEMS CAN AUGMENT FLAGSHIP SYSTEMS

A mixed fleet of small and large satellites can provide the flexibility and robustness needed for any given mission, and achieve desired affordability and resilience objectives. Recent developments of highly capable small satellites offer tremendous flexibility. Constellation designs leveraged by responsive small satellite systems can take advantage of important new technology innovations, especially those that are rapidly emerging from the global marketplace. Miniaturization of components offers sophisticated capabilities, useful for a wide variety of operational and science and technology missions. The exact mix depends on the mission's particular needs. In a sense, the US Government already performs a comparable form of these trade-offs in the way it obtains communications bandwidth for its far-flung forces, using a mix of commercial and government satellites.

Small satellite should lower costs. They provide a wonderful opportunity to use rapid building block or spiral development acquisition approaches; these can help keep programs simple and successful. The use of simpler space hardware should result in shorter development timelines, increased resilience, and reduced risk; shortened development cycles allow for spirally-developed block versions of each bus, payload and other parts of the system. Programs could achieve success with larger, more predictable buys of satellite buses that can rapidly accommodate insertions of the new payload technologies, and thus unwind the Space Acquisition Vicious Cycle. Smaller satellites can improve the much needed connections between users and the program offices, breaking down "big requirements" (which can often take years in conventional acquisition programs to satisfy) into smaller, more manageable, "little requirements," Thus, the small satellite approach enables acquirers to deliver needed capabilities faster within rapidly changing technology refresh cycles.

The Space Studies Board has noted that small spacecraft offer tremendous opportunities for low-cost missions. The Board also concluded small satellites system acquisitions present favorable economic opportunities if employed as part of a replacement strategy for failed sensors or for sensors with limited design life or reliability.[12] Other secondary benefits could be achieved—the US aerospace industrial base and engineers employed in it could be reenergized by acquisition strategies that require or allow for continuous engineering improvements and tweaks to these space system. As observed by the Board:

> Small satellites offer new opportunities to address the core observational requirements of both operational and research missions. Small satellites, in particular single-sensor plat-

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[12] THE ROLE OF SMALL SATELLITES IN NASA, *supra* note 8, at 58.

> forms, provide great architectural and programmatic flexibility. They offer attractive features with respect to design (distribution of functions between sensor and bus); observing strategy (tailored orbits, clusters, constellations); faster "time to science" for new sensors; rapid technology infusion; replenishment of individual failed sensors; and robustness with regard to budget and schedule uncertainties. New approaches to observation and calibration may be possible using spacecraft agility in lieu of sensor mechanisms, for example. Small satellite clusters or constellations can provide new sampling strategies that may more accurately resolve temporal and spatial variability of Earth system processes. (cit.om.) With advances in technology and scientific understanding, new missions can be developed and launched without waiting for accommodation on a multisensor platform that may require a longer development time.[13]

In establishing an optimal mix of satellites, the design trade-offs between flagship class and small satellite systems involve a host of calculations. Presently, small satellites in LEO are the choice for network services. The lower altitudes allow for simple and portable terminals due to smaller attenuation and shorter propagation delays for the small satellite signals. This helps enable services that require large throughputs. Small satellites can also leverage a variety of launch options. On the downside, the lower altitude and associated smaller spot beams demand large constellations to achieve global coverage. Managing and coordinating the satellites with large number of earth stations and managing complex handover schemes between satellites is major drawback for such systems.[14]

Operators of small satellite constellation can cost-effectively satisfy mission needs through: low earth orbit (LEO), multi-plane Walker constellation patterns[15]; insertion of multiple sat-

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[13] *Id.* at 41.

[14] Rizwan Mustafa Mir, *Satellite Data Networks* (Aug. 14, 1997), http://www.cse.wustl.edu/~jain/cis788-97/ftp/satellite_data/index.htm#Elbert (*citing* BRUCE R. ELBERT, THE SATELLITE COMMUNICATION APPLICATIONS HANDBOOK (Artech House, Inc., MA., 1997).

[15] Many constellations designs can be used to satisfy the needs of a particular mission. Coverage can be optimized to reduce the number of satellites needed to sustain a continuing view of particular location on the Earth by at least one satellite in the con-

ellites on each launch; selection of mature technology readiness level (TRL) sensor or communication payloads and satellite buses; block acquisition approaches; simplified platforms/buses; and common mission control/ground systems. The increasing ability of information systems to aggregate, analyze, manage, and research data collected from multiple small satellites with different payloads may make possible the best of the low cost factors from this architecture. Technology improvements and miniaturization could be leveraged with cross-linked systems employing new and advanced internet protocols for telemetry, tracking and command (TT&C) and data sharing and flexible downlinks to users. A variety of mission payloads could be fielded on a common bus, using architectures somewhat similar to the overly-ambitious, innovative but failed Teledesic communication satellite system.[16] Despite high hopes, the Teledesic business case did not prove to be a success, but its failure was more an artifact of changed demand for the capabilities the system would have provided, not design.

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stellation and most are designed so the satellites in them have similar orbits, eccentricity and inclination. With similar orbits, on-orbit perturbations generally affect each satellite in approximately the same way helping operators reduce excessive station keeping, reduce propellant consumption, and increase satellite life. Each satellite can be phased and this enables constellation satellite separation to avoid collisions or interference at orbit plane intersections. John G. Walker explored different types of constellation solutions. A class of circular orbit geometries that has become popular is the *Walker Delta Pattern* constellation, and it is used by the nascent Galileo navigation system. Near-polar constellations with an orbital seam between ascending and descending planes are named the *Walker Star Pattern* because all of the orbits cross near the Poles. If viewed from above one of the Poles, the satellite orbital planes intersect to make a star. *See* SERVICE EFFICIENT NETWORK INTERCONNECTION VIA SATELLITE: EU COST ACTION 253, 218 (John Wiley & Sons Ltd., Y. Fun Hu, et al. eds., 2002), http://onlinelibrary.wiley.com/doi/10.1002/0470845929.app1/pdf (*citing* John G. Walker, *Some circular orbit patterns providing continuous whole Earth coverage*, 24 J. BRIT. INTERPLANETARY SOC'Y,369–384 (1971), and John G. Walker, *Satellite constellations*, 37 J. BRIT. INTERPLANETARY SOC'Y, 559–571 (1984).

[16] Teledesic's promoters wanted to provide high data rate (broadband) fixed and mobile services. Its original design called for 840 active satellites (actually 924 satellites, including in-orbit spares) in 21 planes in a sun-synchronous, inclined circular LEO. Teledesic then changed its design from 40 active satellites in 21 planes at 695-705 km altitude, to one consisting of 12 planes of 24 active satellites (288 satellites) at a 1350 km altitude, and attempted a move to laser inter-satellite link technologies. Lloyd Wood, *Big LEO tables* (Aug. 17, 1999), http://personal.ee.surrey.ac.uk/Personal/L.Wood/constellations/tables/tables.html.

A number of national security missions are amenable to LEO small satellite systems — communications, reconnaissance, missile warning and defense, and weather come to mind. Commercial operators, such as OrbComm and Iridium Communications, Inc, have already deployed smaller, short-life, yet capable satellites with streamlined mission control architectures. OrbComm has used small satellites built by German OHB System AG (the bus) and by Orbital Sciences Corporation (the payload). The OrbComm, Iridium, and Galileo constellations employ or will employ well-designed Walker patterns to provide ubiquitous 24/7 coverage of much of the globe.

Other benefits can be secured with small satellite systems. For example, space debris is a growing problem. The issue has generated considerable concerns since the late 1970s and early 1980s. The 2009 Iridium collision with a defunct Soviet Cosmos satellite only highlighted the growing problem. Much of the space-faring community is moving to apply best practices in order to reduce the on-orbit collision risks. LEO missions are deorbited more efficiently. Of course, the life of satellites and associated debris on orbit is mostly a function of its orbit, mass, and density; small satellites at the low end of circular orbits deorbit in relatively short order unless station-keeping activities are continually performed by a satellite operator. In contrast, flagship satellites placed in higher altitudes can remain on orbit for hundreds or thousands of years.

Continued replenishment of small satellite constellations do enable a worthy solution to the Moore's Law conundrum discussed earlier, assuming operators take advantage of the opportunities to replenish the constellations and continually update their systems. Ultimately this could decrease the cost of systems and permit more rapid insertion of new technologies, sensors and processors into mission constellations. In addition, tying these opportunities to sustainment strategies could mitigate the long periods of time required to resolve on-orbit anomalies. Small satellites concepts also provide an opportunity to orchestrate de-orbits of mission sensors and busses so we can assess their performance and defects, and then use them to explore ways to improve satellite manufacturing techniques and also understand how to make systems more reliable.

Hosted payload solutions can fill the seams between flagship and small satellites

Acquirers must continually seize upon the best design approaches. The use of mixed systems of flagship and large numbers of small satellite supports affordability and resilience objectives through an important new de-bundling architecture concept known as *disaggregation*. The Air Force is now moving to take the disaggregation concept one step further. It is exploring possibilities of using hosted payloads to disperse important space-based capabilities among the large number of commercial satellites. A hosted payload is an "instrument or package of equipment that is affixed to a host spacecraft and operates in orbit making use of available capabilities of that spacecraft, including mass, power, and/or communications."[17] A host satellite or spacecraft is a "satellite bus with subsystems capable of maintaining operation of multiple payloads; the entity holding the primary contract with the spacecraft manufacturer is considered to be the host operator."[18]

Commercial buses and rideshares offer significant opportunities to improve mission reliability, reduce cost, and increase responsiveness. There are six major manufacturers of commercial communications satellites operating in GEO: Thales Alenia Space, Boeing Corporation, EADS Astrium, Lockheed Martin Commercial Space Systems, Orbital Sciences Corporation, and Space Systems/Loral. A new block of the LEO-based Iridium NEXT constellation will be coming on line, perhaps in 2015 or shortly thereafter. All of the major commercial GEO fixed satellite operators (Eutelsat, Intelsat, SES, and Telesat) have declared themselves receptive to hosting payloads, as have non-GEO users such as ORBCOMM and Iridium.[19] Companies such as Orbital, ATK, and Boeing are building commercial LEO capable hosted payload satellites, and commercial MEO systems like those planned by Germany's OHB is not far away.

The primary advantage of flying a hosted payload on a commercial host spacecraft as opposed to flying on a govern-

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[17] Futron Corporation, *Hosted Payload Guidebook*, 10 (Aug. 2010).

[18] *Id*.

[19] *Id.* at 6.

ment-host mission is leveraging the faster tempo of commercial programs, and using the speed and access to orbit to achieve lower costs.[20] And while many science missions have been limited to LEO, given the expense of getting to GEO, the use of hosted payloads on commercial satellites provides a terrific low-cost opportunity to assure improved access to higher orbits by the DoD and other agencies.[21]

As noted by Futron in its *Hosted Payloads Guidebook*, other advantages offered by hosted payloads include:

> …a reliable and predictable launch schedule, with a large choice of launch vehicles (commercial operators usually are on the manifest of several launchers, in order to be better prepared for contingencies); the use of existing mission support facilities; and the fact that, once on-orbit, the primary payload operator will take care of all operations and maintenance of the host spacecraft as well as (if requested) data downlink and processing. In addition, since commercial spacecraft are insured, the hosted payloads on those spacecraft can also be insured, helping defray the costs of a replacement mission in the event of a launch failure.[22]

Commercial operators have already shown themselves to be highly reliable and dependable partners in satisfying US satellite communications and remote sensing needs. Their systems are built at a relatively moderate cost, and the industry has often employed the use of plug-and-play buses to achieve this result and flexibility. Plug-and-play interoperability offers big advantages and the industry is fast moving to the standard. While the US Governments has talked about plug-and-play bus approaches for years, the volumes of systems purchased, unique requirements, and inability to turn inside a commercial decision loop has left this a largely unrealized opportunity. Nonetheless, hosted payloads can become an important and viable part of the future space constellations, since it would not be difficult to design military payloads to fly on commercial buses.

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[20] *Id.* at 2.
[21] *Id*.
[22] *Id*.

Among the first major U.S. government payloads hosted on commercial GEO systems were the two non-military L-band Wide Area Augmentation System (WAAS) packages operated by Telesat and Intelsat for the prime contractor, Lockheed Martin, under contract to the Federal Aviation Administration. One WAAS payload is carried on Telesat's Anik F1R, and was built by Astrium and launched in September 2005. Iridium and ORBCOMM, and other operators already have hosted government payloads. In addition, the India National Satellite System (INSAT) has hosted several India Space Research Organisation (ISRO) payloads, all of them either scientific or technology demonstrators in nature.[23] Recently, the Americom Government Services' Commercially Hosted Infrared Payload (CHIRP) attracted considerable attention for its successes. Designed to reduce risks in developing wide field-of-view starring infrared sensors, the CHIRP Wide Field of View staring sensor was developed by SAIC, along with the payload processing capability, while the team was led by SES Americom, with Orbital Sciences Corporation providing the bus, bus integration, and TT&C. The U.S. Air Force–funded Overhead Persistent Infrared (OPIR) payload is now hosted on board a commercial communications satellite, SES-2 (a SES World Skies system) and is approaching its second year of operations.

Similarly, the Australian Defence Force placed a hosted payload on Intelsat 22, with a Boeing-built 702B bus, to provide UHF communications for Australian and American military forces in the Middle East and Afghanistan.[24] That effort went from contract to on-orbit capability in 35 months. This pace approaches what enthusiasts might call the "speed of need." Intelsat General, vice-president of hosted payload programs, Don Brown, proudly bragged the Australian arrangement required "an extraordinary bit of creative contracting" to add the UHF payload, provided by the ADF, onto the satellite, but the country saved over $150 million compared to alternative approaches. According to Brown, an independent analysis of the project con-

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[23] *Id*. at 3.

[24] Jeff Foust, *An opening door for hosted payloads*, THE SPACE REV. (*Oct. 29, 2012), http://www.thespacereview.com/article/2179/1.*

cluded the hosted payload approach "was 50% more effective economically than flying the payload as its own satellite, and 180% more efficient than leasing the capacity—assuming the capacity was available at all to lease."

The opportunity commercially hosted payloads offer to the US and allied governments is awesome. Nearly 200 launches to GEO are planned over the next decade, and many of their space operators welcome hosted payloads. If only half of these 200 satellites are built with buses with enough weight and power capacity to accommodate additional payloads that still leaves 100 platforms available for vital new hosted payloads. Of course, the amounts paid to primary satellite operators vary considerably as every platform comes with unique limitations and demands. Price drivers for program go-aheads include the size and mass of the proposed hosted payload, the need for ancillary services for payload operations, payment structure, lost opportunity costs, impacts on the host business case, launch vehicle choices, insurance, export controls, and the like.

Primary commercial communications satellites payloads typically have a lifetime of 15 years, and often more. Many hosted payloads, in contrast, are likely to have shorter lives, depending on the mission type (tech demo, operational demo, gap-filler, or operational). This mismatch should be less of an issue, or a non-issue, for hosted communications payloads, which can be easily designed and constructed to operate for as long as the primary spacecraft. Even for shorter life systems, the hosted payloads provide the host operator assured bandwidth sales early in the life of the commercial communications satellite, an important economic windfall, giving the host time to find buyers for the bandwidth being used first by the hosted payload, and achieve a win-win for all. In addition, as the spacecraft ages and its power output decreases, the loss of one hosted payload allows the host operator to transfer the power to its other paying customers, maintaining his income stream. On the other hand, long host platform life may present an opportunity for enhanced data continuity that has not typically been made available to past payload missions.

Using standardized commercial buses as dedicated platforms for payloads is another significant option that could be considered by a manager, as it allows customers to focus on developing their payloads, and significantly reduce the risk of custom satellite bus builds. Of course, employing commercially based architectures will demand more responsive government decision-making, and shorter and more flexible development timelines.

Developing and executing the hosted payload strategy is taking longer than some innovators in industry and government officials would like.[25] The current US national security space architecture rests on large, multi-mission flagship satellites and the culture is having difficulties adjusting to idea that it reduce requirements for smaller mission platforms. In addition, adequate planning by each hosted payload owner and the host must occur. The earlier a hosted payload's requirements are incorporated into the host's planning process the greater the likelihood the two systems can be successfully integrated. Institutionalizing systems engineering needed to support such planning and analysis should produce value and capability over the long run for both. Hosted payloads must coordinate vital engineering issues such as payload location, line of sight/look angle requirement, antennae and electronic interference issues, and orbital locations.

There is a danger a host could integrate too many hosted payloads and thus take on the objectionable attributes of flagship systems with potentially conflicting sensors, electromagnetic interference, and missions. Also, if providing a hosted payload, the government must adhere to the strict constraints imposed by the federal acquisition regulations and other law. Once it has installed a potentially long-lived payload, the government accepts negotiating risks with the host if it does not adequately anticipate the needs for future contract extensions, and realities of sole-source negotiations. Finally, procurement, construction, and launch schedules for commercial satellites are different. Government rules can be onerous and demand long-looks at issues; commercial acquisition may demand quick turn

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25 Warren Ferster, *NASA Eyes Air Force Contracting Vehicle for Hosted Payloads*, SPACE NEWS (Apr. 22, 2013), http://www.spacenews.com/article/military-space/34982 nasa-eyes-air-force-contracting-vehicle-for-hosted-payloads#.UZ8DEJXn-Hs.

decisions. A government hosted payload and host are alternately more and less flexible and more driven by time constraints than their counterparts, depending on the matter at hand.

USING HOSTED PAYLOADS TO AUGMENT DISAGGREGATED SATELLITE ARCHITECTURES WILL NOT BE EASY

The integration of hosted payloads is no small matter, and the key is to "do no harm". This usually means the hosted payload needs to be independent of the primary payload and not interfere with or impact the primary mission. These issues were solved on the CHIRP program, and always must be considered when integrating a payload on a commercial host.

A perfect engineering solution is useless unless and until it can be implemented. Given the strategic importance of space systems, engineers should not be surprised to find legal and policy concerns intrude on all elements of the space system mission design process. Design and architecture decisions should not be made in an environment devoid of context. The complete span of legal, policy, and diplomacy implications should therefore be fully considered and integrated when planning for and executing space activities. Program managers, engineers and their legal advisors should work together to craft a space system, anticipating law and policy issues in order to avoid potential "show stoppers" – adverse decisions that could be directed by government leaders, customers, suppliers, legislators or courts, and the international community. Managers and engineers need to appreciate the need, the means, and time it takes to comply with applicable laws and deal with competing policy interests.

Another big challenge confronting the government is aligning its acquisition timelines with the commercial hosts. Recognizing this, the Air Force's Space and Missile Systems Center (SMC) Hosted Payload Office has sought commercial sector assistance to develop the appropriate mechanisms for use with the Hosted Payload Solutions (HoPS) indefinite delivery, indefinite quantity (IDIQ) contract construct.[26] The average time spent on a commercial satellite's procurement, from concept definition to operations, is about 32 months.[27] This process generally involves: 5 months for the requirements definition, RFP generation, proposal evaluation, and contract negotiation; and average 24 months for satellite construction; and 3 months for the launch campaign, orbit-raising, and in-orbit testing together.[28] In contrast, government schedules for the same types of acquisitions can be five years and even longer if the primary mission is complex.[29] Only time will tell whether the Air Force's hopes for speeding its acquisition timelines will be satisfied.

To the extent allowed by law, hosted payload program managers would be wise to approach prospective hosts early before they acquire their satellites. By doing this, an agreement can be finalized setting the payload requirements before the operator concludes its final contract with its satellite manufacturer. That, of course, raises an important fiscal issue — before the government approaches a host it should have the funding to proceed, which means it anticipated the need in a prior fiscal year and budgeted for it — a tall order. If done right, this conversation should enable interface definition requirements to be identified and incorporated into the hosted payload request for proposal (RFP), and help avoid satellite platform incompatibility issues.[30] Alternatively, the host could specify its interface requirements. While accommodations for hosted payloads can often be made in the negotiation phase, once set, the schedule is usually inflexible. "The satellite owner typically is time-constrained and unwilling to let the construction or launch schedule slip due to considerations specific to the hosted payload."[31]

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[26] Anne Wainscott-Sargent, *All Eyes on Hosted Payloads*, SATELLITE TODAY.COM (June 1, 2013), http://www.satellitetoday.com/via/features/All-Eyes-on-Hosted-Payloads_41221.html. HoPS IDIQ contracting will be discussed in the next section.

[27] *Hosted Payload Guidebook*, *supra* note 17, at 5.

[28] *Id*.

[29] *Id*.

[30] *Id*. at 6.

[31] *Id*. at 5.

As noted, the commercial satellite's construction schedule is usually far more aggressive than the government's; the government's hand is usually slowed by numerous rounds of reviews and analysis demanded by federal acquisition regulations (FAR) and US acquisition policies. And those reviews are sometimes delayed or otherwise held hostage by the whims of senior executives and the hierarchy involved in the acquisition, by the attendant decision processes, and by executive-level availability to preside over the reviews. So while the US Government might proclaim it is, in principal, in favor of short commercial schedules, it has had great difficulty in accommodating them. As a result, it can be expected to resort to decision-making along its usual protracted timelines.[32]

Leveraging Hosted Payload Capabilities Will be Buffeted by Contracting Challenges

The contracting challenges are all too real and must be comprehensively addressed if the US Government hopes to fully embrace the hosted payload construct. According to Doug Loverro, recently the Executive Director of SMC, and now serving as Deputy Assistant Secretary of Defense for Space Policy, the Air Force planned to build on the success of CHIRP with a follow-on program called CHIRP+, again using hosted payloads to test infrared sensors, but the effort ran into roadblocks in the US Congress, where House appropriators deleted funding for the follow-on hosted payload effort, instead allocating resources for ground segment technologies.[33] Another setback occurred when the DoD failed to secure a deal to host payloads on Iridium's next-generation constellation of LEO communications satellites; some suggest this lost a once-in-a-generation opportunity

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[32] If wanted and needed, speed can be achieved. The early years of the National Reconnaissance Office (NRO) provide a shining example on the establishment of a lean, mean, and effective space acquisition teams. The NRO recognized that streamlined processes and procedures would enable it to speedily and effectively achieve its significant national mission objectives. This produced intense pressure to create tight, cohesive government-contractor management teams. Given the need for speed, specially selected young officers were given authority and power to act to move acquisition activities to success.

[33] Foust, *supra* note 24.

to put payloads on an ideal system that could provide the DoD provide global coverage.[34] Money issues did not scuttle the contract — rather no appropriate contract vehicle was found sufficient to secure agreement. On this lost opportunity, Loverro observed: "We didn't have the right contractual relationships established to make this easy, to make it not a Herculean effort."[35]

This has led the SMC to embrace IDIQ contract vehicles as a first step in moving towards a normal, accessible, and repeatable hosted payload arrangement.[36] SMC's Hosted Payload Office has announced its long-anticipated HoPS IDIQ contracting vehicle. Colonel Scott Beidleman describes the Hosted Payload Office's role as of "matchmaker between government payloads and commercial hosts," with the HoPS vehicle providing a framework for establishing a set of pre-qualified commercial vendors able to bid on government payload opportunities. The Air Force expects the pre-qualification will be completed by the end of the 2013 calendar year followed by the first delivery order contract by March 2014.[37] Actually, it is not just pre-qualification; the Air Force is relying on industry to identify the opportunities that will lead to the HoPS contract vehicle's success. News reports indicate SMC is expected to select up to 14 hosted payload service providers, and 9 of them will involve GEO satellites, with the remaining 5 dedicated to LEO and medium Earth orbit (MEO) satellites.[38] The selected contractors likely will be a mix of satellite operators, manufacturers and related service providers and US-based[39], no doubt for export control and other policy reasons.[40]

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[34] *Id.*
[35] *Id.*
[36] *Id.*
[37] Wainscott-Sargent, *supra* note 26.
[38] Ferster, *supra* note 25 (*citing* David Anhalt, vice president of government solutions, Space Systems/Loral of Palo Alto, Calif., and Hosted Payload Alliance board member).
[39] *Id.*
[40] While nearly all of the world's biggest satellite operators and hosted payload advocates are incorporated and/or headquartered overseas, these companies also have US subsidiaries that routinely do business with the DoD. *Id.*

NASA recognizes the opportunities hosted payloads offer, and is collaborating with the SMC to secure them by leveraging the HoPS contracting vehicle. If mission funding and a commercial host can be found, the agency's $90 million Tropospheric Emissions: Monitoring of Pollution (TEMPO) mission could be among the first to take advantage of the HoPS vehicle. The TEMPO decision go-ahead will be made sometime in 2014.[41] NASA is pursuing other hosted payload opportunities, including demonstrations of a heliophysics deep-space atomic clock experiment (GOLD), a laser communications technology demonstration (LCRD), and the Global-scale Observations of the Limb and Disk mission, which will study Earth's upper atmosphere.[42]

Despite the high hopes for the HoPS IDIQ contracting vehicle, there are still many considerations to be addressed if the US Government hopes to successfully employ hosted payloads. While the HoPS contracting vehicle is hoped to facilitate the use of available space aboard commercial satellites and establish technical standards for payload accommodations, in most circumstances, one can expect each payload and host situation will differ despite best efforts. After all, hosted payload solutions are to be employed to update payload technologies. Contracting matters must be addressed for the overall process to be successful, and a complex variety of technical, resource, schedule, and other risk aspects must be addressed and their solutions integrated into the final system, including: the hosted payload and its mission; prospective satellite platforms; unique attributes of the hosted payload and host spacecraft manufacturers, operators, and sustainers; launch solutions; ground systems; and financing. Multi-party government, satellite operator, satellite manufacturer, hosted payload manufacturer arrangements and their attendant contracts must be developed. Program managers must comply with US law and federal acquisition regulations as they make informed decisions with regard to acquisition competitions, termination liabilities, payment structures, and

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[41] *Id*. (*citing* NASA spokesman Steve Cole).

[42] *Id.* (citing Janet Nickloy, director, aerospace mission solutions, Harris Corp., and David Anhalt). See also Wainscott-Sargent, *supra* note 26.

use of multi-year contracts.[43] Tight commercial satellite contracting schedules must be accommodated. Wise systems engineering practices also dictate the government, where possible, understand its options for acquiring and deploying large number of identical, hosted payloads on multiple satellites, to include contract option exercise dates, cost, schedule, and related factors.

Government programs have unique requirements that must be met for a contract to be formalized. Hosted payload agreements should be structured accordingly.[44] The government might want to seek to contract for access to a hosted payload expected to provide service for at least 15 years, but for the government, negotiating a 15-year contract is pretty much impossible. Instead, it might seek a contract with 15 years of options. This all presents legal and business risks the host operators and government negotiators need to navigate. "Satellite operators that are unfamiliar with doing business with government customers may be surprised at certain conditions necessitated by federal procurement rules" For example, the federal government includes "termination-for-convenience provisions" in its contracts with private companies. And any satellite operator counting on revenue for the life of a satellite could face a "rude surprise" if it receives notice from a government customer that a contract will be terminated.[45]

The US Government will not accept the same kind of liability and indemnification language commonplace in contracts with private sector customers.[46] Although indemnification is a standard commercial term, it is only found by exception in fed-

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[43] 10 U.S.C. §2306b allows the DoD to enter into multi-year contracts and Federal Acquisition Regulation §17.101 provides the DoD with the authority for multi-year contracts for up to 5 years, with a ceiling of $500 million. §17.101 was used as the legal basis for the ClearView/NextView acquisition of imagery. FAR §217.171 authorizes the DoD to enter into multi-year contracts for services, limited to 5 years. *Hosted Payload Guidebook*, *supra* note 17, at 13.

[44] Paul Dykewicz, *Creative Solutions and Cooperative Negotiations Can Bridge Legal Issues-Part I*, HOSTED PAYLOADS BY SPACENEWS (Aug. 24, 2011), http://www.hostedpayload.com/blog/creative-solutions-and-cooperative-negotiations-can-bridge-legal-issues-part-i (*citing* Phillip L. Spector, Intelsat executive vice president, business development, and general counsel).

[45] *Id*.

[46] *Id*.

eral government contracts, as it cannot indemnify a contractor without express statutory authority. Many times, managers and their contracting officers will not object to accepting contingent liabilities and indemnities which do not impact their current funding. In contrast, government contractors are generally not willing to accept the same risks from the government which they would readily accept from a commercial customer. Similarly, the contractor often moves to negotiate shifting more risk to the government than they would a commercial customer. The government generally does not agree to contracts with liquidated damages provisions or indemnifications. If a host contractor screws up and causes harm to the government, the government may often act more generously than commercial customers would and, as appropriate, may waive the contractor's liability to the government

As noted, US Government is subject to restrictions or specific requirements with regard to multi-year contracts, assignments, progress or "milestone" payments, contract termination and dispute resolution.[47] While the government's ability to make long term commitments is limited, but once it can and does make such a commitment the contractor is usually assured of it will abide by the commitment. As to assignments, transfers of the ownership of a host satellite can be made more complicated since the transfer of contractual obligations with the government usually requires government approval and retention of contingent liabilities. Payment arrangements are generally flexible, but are negotiated and must be specified. Government contracts can be terminated for the convenience of the government, and the equitable adjustment concept can be applied to contract changes. Government contracting offers special alternative dispute forums to resolve disputes. The Armed Services Board of Contract Appeals (ASBCA) is routinely used.[48]Going to

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[47] Mark Andraschko, et al., *The Potential for Hosted Payloads at NASA* (NASA Langley Research Center: Hampton, VA, 2012), http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120003420_2012003757.pdf.

[48] According to the ASBCA, it is a neutral, independent forum which has a primary function to hear and decide post-award contract disputes between government contractors and the DoD and other entities with whom the ASBCA has entered into agreements to provide services. The majority of matters on its "docket involve appeals

court is still the natural progress of things for any dispute involving the government.

Host satellite operators have said they will accept termination-for-convenience language, but only if it is accompanied by a "large, pre-negotiated" termination fee that would protect the operator's expected revenue stream for a specific number of years.[49] They claim such conditions are typically included in contracts when a government customer buys satellite service on a short-term basis on existing satellites.[50] These conditions would conflict with general termination for convenience provisions for which a central tenet is the contractor will not be paid for work which is not performed. At this point, the government is not offering multi-year contracts with termination liabilities built-in, and commercial contractors are still engaging the government about hosted payload contracts.

Hosted payload contracts presently have two primary components. The first deals with integration of the hosted payload onboard the host and its launch to orbit. From the government's perspective, it is to be structured simply as a fee for work to be completed and does not address any issues related to host satellite revenue streams. The second component addresses the use of the hosted payload and associated ground support for a certain number of years. If the government is able to secure Congressional approval for a multi-year contract, it could then offer the host a commitment commensurate with an extended payload life revenue stream. Absent a multi-year contract, the government program office would have to request authority to deviate from requirements that it include a provision in the contract granting it termination for convenience rights, obtain budget approval, and secure appropriations to cover such a termination fee provision.

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by contractors from government contracting officers' final decisions or failures to issue decisions." *See* www.asbca.mil (last visited Sept. 5, 2013).

[49] Dykewicz, *Creative Solutions and Cooperative Negotiations Can Bridge Legal Issues-Part I*, *supra* note 44 (*citing* Phillip L. Spector).

[50] *Id*. According to Spector: "This requirement is especially important when an operator is building a non-commercial payload for a military customer, i.e., a payload that cannot easily be resold in the commercial marketplace."

In the end, the government must make well-thought-out decisions as to how it hopes to acquire desired mission capabilities with hosted payloads. The government could contract to obtain additional payload capabilities, and access data from the payload, from the host satellite operator/manufacturer, and define and set the requirements for the contractor to achieve. Alternatively, the owner/operator of the host could procure a payload from third parties based on government specifications. Or, as a third alternative, the government could separately procure the payload hardware to be integrated onto the host. Responsibilities and risks must be allocated among the hosted payload, the manufacturer of the hosted payload, the owner/operator of the host commercial satellite, the manufacturer of the satellite, and the launch services provider.

The government and host satellite owner/operators must also study the payload's mission fit and ascertain whether it will be adversely affected by criteria such as schedule and technical difficulties. If the government provides the payload hardware, or plays a significant role in the design and development of the overall system, strict compliance with delivery schedules will be required. If the government is late, commercial hosts may want to negotiate contract provisions that provide reimbursement for lost opportunities, and other expenses. If the commercial host is late, or the host satellite fails on-orbit before the hosted payload's mission can be completed, the contract could call for the satellite operator to be penalized if the government does not reasonably get its expected services. Financial aspects of hosting and annual operation fees may need to be differentiated to more accurately ascribe these damages.

Contracting Must Anticipate Systems Engineering and Operational Priorities

When contracting to acquire, integrate, and operate hosted payloads, managers must anticipate many potential difficulties, including: prelaunch delayed deliveries of the hosted payload and the host satellite; launch delays and failures; on-orbit failures, partial losses or technical problems of the hosted payload and host; reduced on-orbit life; and station-keeping challenges.

When the US Government provides the hosted payload, it must account for important systems engineering tasks performed by the respective payload and host entities to ensure the payload is properly integrated. The government and commercial host must also identify and track technical changes to the payload that could adversely impact the host and its ability to perform its primary mission as well as any other hosted payloads. Typically, the US Government will demand a host provide a contractual commitment to avoid interfering with the hosted payload, whether by any host satellite operation or other hosted payload.

After launch, the US Government or its contracted operator, usually must turn on, check out and calibrate the hosted payload, perform required acceptance testing, and start its normal operations. Then, it must monitor the payload's operations to ensure it is performing its mission and, importantly, also ensure it is not interfering with host spacecraft and other payloads. The government must also ensure its contracting processes address issues such as operational communications and coordination between the host satellite's operations site and the hosted payload operations site, and delivery of data once the hosted payload begins operations.[51]

Given the government's unwillingness to indemnify a host satellite operator from potential claims for the operations of its hosted payload, the host could seek to limit its liability by "handing off" operating control of the hosted payload to a government customer.[52] In this way, it is argued the government user not only takes control, but also the responsibility for the health and safety of the hosted payload asset. In many cases, the government will demand this control. The operator could also negotiate for the government to agree to share part of the cost to insure a satellite.[53] In general, the insurance costs would be allocated to overhead accounts and mostly certainly charged in rates for all of the host's customers.

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[51] *Hosted Payload Guidebook*, *supra* note 17, at 14.

[52] Paul Dykewicz, *Creative Solutions and Cooperative Negotiations Can Bridge Legal Issues-Part II*, HOSTED PAYLOADS BY SPACENEWS (Aug. 26, 2011), http://www.hostedpayload.com/blog/creative-solutions-and-cooperative-negotiations-can-bridge-legal-issues-part-ii (*citing* Phillip L. Spector).

[53] *Id*.

The host satellite operator purchase of a policy to protect itself against a potential loss is "vital" in the event of a launch failure or another catastrophic anomaly before the payload is handed over to the government customer. The contractor host would be expected to negotiate with its government customer to share some portion of launch costs, and even attempt, as an element of its negotiating strategy, to charge the government for the cost of the entire launch.[54] Nevertheless, some cost sharing would be appropriate if it helps compensate the host for its need to use a larger launch vehicle to accommodate the government payload or to cover the loss of revenues that otherwise might be generated if commercial transponders on the commercial satellite system had been included instead of the hosted payload.[55]

Government technical advisors can use the hosted payload/host contract to ensure the satellite owner/operator provides the necessary interface specifications for integrating the hosted payload and address the requisite elements of a hosted payload qualification document to certify the payload and support systems have complied with the interface specification. Coordination of issues such as schedule and launch readiness, test plans for flight-qualified hardware, and updates on issues that could impact the mission, should be addressed as well.[56]

Commercial hosted payload priorities should be expected to be nearly always secondary to the host's primary payload. Their operations will be suspended in favor of the primary in event satellite resources are limited or lost, or if the hosted payload's operations threaten the host or disrupt its primary payload. Why is this? The fees generated from hosting are usually much less than those generated by the host's primary mission. Understandably, secondary payloads on government host spacecraft are treated in much the same fashion, though the government is not expected to relax its usual requirements.[57] The Government should be expected to insist the host contractor follow US Government space debris mitigation guidelines, though ad-

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[54] *Id.*
[55] *Id.*
[56] *Id.*
[57] *Hosted Payload Guidebook*, *supra* note 17, 15.

ditional launch, on-orbit, and end-of-life directions are imposed via licensing actions taken by the Federal Aviation Administration Office of Commercial Space Transportation (FAA/AST) and Federal Communications Commission (FCC). Of course, negotiations can reallocate the priorities resident in nominal and in unusual circumstances, and provide exceptions in certain circumstances. They can establish the protocols and procedures for taking actions to suspend or limit the hosted payload's operations. The government and the host can also negotiate terms for compensation or allowances, if any, for such limitations, or for circumstances where the host satellite fails.

EXPORT CONTROLS AND NATIONAL POLICIES CANNOT BE IGNORED

Contracting, systems engineering, and operational issues aren't the only problems that arise with a greater use of hosted payloads. Integrating hosted payloads on the wide variety of platforms owned, launched, and operated by entities found in the international space-faring community is complicated by export controls. US law and policy dictate transfers of articles, technologies, designs and other information that relate to space systems be limited or controlled. These controls seek to stop and slow the proliferation of missile technologies and the technologies that can be used to deliver weapons of mass destruction. The attendant US Government licensing processes make payload integration more complicated, and in some cases much more costly. Indeed, export control issues associated with licensing the launch of the CHIRP payload were not insignificant, as the SES-2 satellite host was launched on an Ariane 5. SES management argues there would have been a "significant additional charge" if they had chosen to launch the satellite on a Russian Proton.[58]

Export control considerations should play a role in any program seeking to place a hosted payload aboard a non-US host satellite. Nearly all commercial satellites use non-US launchers

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[58] *An opening door for hosted payloads*, *supra* note 24 (citing *Tim Deaver, SES Government Solutions at AIAA Space 2012 panel, Pasadena, California).*

or satellite integrators. Some hosts plan to integrate non-US components in the bus or in the primary satellite payload, or plan to integrate other non-US hosted payloads. Flying a hosted payload on a commercial satellite demands managers and attorneys navigate through the attendant policy approvals and obtain appropriate licenses from the US Government. Of course, balancing national security and economic interests during the Cold War was arguably less complicated. The major competitors then were the US and the old Soviet Union, and commercial interests played only a minor role. With the disintegration of the Soviet Empire, globalization and large new commercial space markets emerged. In this new environment, striking a balance between national security and economic interests has proved exceedingly difficult for US policy makers, industry, and academia.

The Arms Export Control Act (AECA)[59] governs the sale and export of defense articles and services and related technical data.[60] Designated space-related articles and services are subject to the AECA. The AECA requires exports of space articles, services and related technical data meet US national security interests. The US Munitions List (USML), which is contained within the International Traffic in Arms Regulations (ITAR), specifically designates articles such as rockets, spacecraft, space electronics, and guidance equipment. Defense services are also included, defined as furnishing help "in the design, engineering, development, production, processing, manufacturing, use, operations, overhaul, repair, maintenance, modification or reconstruction of articles." An export does not have to cross a border; thus, an export occurs when an individual discloses technical data concerning a spacecraft or rocket to non-US entities or citizens, even if the disclosure occurs within the US. The articles and services may be determined to be so important by the US Government that they are deemed to be non-releasable even to

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[59] *See* Arms Export Control Act of 1976, 22 U.S.C. §2751-2799. 22 USC § 2778 provides the authority to control the export of defense articles and services.

[60] US export control policies predate the Cold War. The US Department of State began to regulate munitions trade in 1935, seeking to ensure strategic exports support both national security and foreign policy prerogatives.

allies, close partners, and sometimes one or more members of a coalition.[61]

Nearly all members of the space community, foreign and domestic, consider the US export control rules to be burdensome and onerous. International partners are also wary. The rules undermine potential international partnerships. In attempting to bolster national security by more strictly controlling the transfer of space technologies, the US may have actually harmed its own national interests. There is a substantial paperwork component associated with complying with export controls. These rules are said to have driven small suppliers out of the US export marketplace as they usually lack the economies of scale to respond properly to export requirements. Some argue the limits also contributed to a substantial decline of US commercial satellite market share and fostered the development of significant space capabilities of competitors abroad. The potential for US criminal liability arising out of violations of the regulation is generally agreed to have cost the US space industry billions of dollars in sales in the international marketplace. The US communications satellite industry has lost market share to international competitors who claim their systems, products and services are "ITAR-free".

Recent legislation has encouraged the US Executive branch to review and revamp the regulations, and seek further relief where appropriate from the Congress. The Administration has responded and is making moves consistent with the direction.[62]

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[61] Of course, other nations also secure their technologies for diplomatic, military and economic reasons. So program managers must be prepared to develop the means to integrate their payload on the host compliant with comparable controls imposed by non-US states.

[62] The relevant changes to export controls occurred as a result of changes in a number of National Defense Authorization Acts ("NDAAs"). With the Cold War over, responsibility for the export of some "dual-use" US commercial communication satellites was transferred from the State Department to Commerce in 1992. From 1996 to 1999, communications satellites were placed on the Commerce Control List (CCL) found in the Export Administration Regulations (EAR), which were issued pursuant to the Export Administration Act (EAA). Commerce generally approved proposed exports of commercial satellites, components, and related services and applied a presumption of releasability consistent with its charter to promote U.S. economic interests at home and abroad. This changed after the Chinese scandals of the 1990s. §1513 of the 1999 Strom Thurmond NDAA directed all satellites and related items be subject to the ITAR, and

On May 24, 2013, as part of the Obama Administration's ongoing export control reform effort, the Department of State proposed to amend the ITAR and revise the USML Category XV (Spacecraft Systems and Related Articles). The changes are intended to reduce unnecessary, outdated, or disproportionate regulations, revise their scope, and clarify them in order to reduce confusion and any uncertainty about their interpretation. Under the proposed rules, only articles designated by the DoD to have an "inherently military" purpose or those that provide unique intelligence or military value and are only sourced from within the United States will remain subject to USML controls. The proposed rules also revise the definition of "defense service" under the ITAR which now specifically includes the furnishing of assistance for certain spacecraft related activities.[63] Further, under the changes, many satellite and other space related articles would be moved from the USML to a new Export Control Classification Number (ECCN) enforced under the Department of Commerce's Bureau of Industry and Security (BIS) Commerce Control List (CCL). These items still will be subject to national security, regional stability, and anti-terrorism controls, and some will also be subject to missile technology controls.[64]

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removed the President's authority to change their jurisdictional status (as to whether regulated by the Department of State or Commerce). *See* Strom Thurmond National Defense Authorization Act for FY 1999. Pub. L. No. 105-261. As noted, problems in export control enforcement emerged, and so §1248 of the 2010 NDAA (Public Law 111-84) required the Secretaries of State and Defense to assess the risks associated with reconsidering the statutorily-imposed policy. Their review identified certain satellites and related items that do not contain technologies unique to the United States, are not critical to national security, and are more appropriately controlled by the Commerce's Export Administration Regulations (EAR), which allow for creation of license exceptions for exports to certain destinations and complete controls for exports to others. The proposed rule changes reflect the recommendations of the resultant report. §1261 of the 2013 NDAA (Public Law 112-239) removed requirements imposed by the 1999 NDAA, and §38(f) of the AECA returned to the President the authority which regulations govern the export of satellites and related articles and to "determine what items, if any, no longer warrant export controls."

[63] The revisions contained in the proposed rule implement part of State's plan highlighted under Executive Order 13563, completed on August 17, 2011.

[64] The proposed changes revise the definition of "space qualified" articles to reflect the amended definition agreed to in the 2012 Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies, www.wassenaar.org (hereinafter Wassenaar Arrangement). The proposed rules holds that "space qualified"

As proposed, hosted payloads owned by, or built for, the U.S. Defense Department and launched on commercial satellites remain on the ITAR's Munitions List, specifically "Department of Defense-funded secondary or hosted payload, and specially designed parts and components therefore."[65] This proposal has caused some confusion. Some in industry contend that the revised rule, rather than achieving cost-saving ways, will complicate industry efforts. "Categorizing by funding source, instead of the actual technology, is not smart, and probably not what the drafters intended."[66] Satellite Industry Association (SIA) President Patricia Cooper has commented that the new language "is unusual in the export control environment."[67]

John A. Ordway, an attorney specializing in satellite export control issues, has observed that "the hosted payload language leaves too much room for confusion. For example, he said, at what point is a given payload considered 'funded' by the Department of Defense? A payload financed by the private sector following an agreement that the U.S. military will lease it may be covered, or may not."[68]

At the time of writing this article, the industry is asking the State Department to provide additional clarification on the new rules the relate to hosted payloads. In its comments, citing the topic, the SIA urged that the revised export control system not establish a "double licensing" requirement, where both a Commerce Department and a State Department license would be required for export. SIA argued that "double licensing" requirements "run contrary to the goal of streamlining and simplifying the existing system."[69]

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articles are those that are "designed, manufactured, or qualified through successful testing, for operation at altitudes greater than 100 km above the surface of the earth." *Id.*

[65] Peter B. Selding, *Proposed ITAR Changes a Mixed Bag for U.S. Satellite Industry*, SPACENEWS (June 14, 2013), http://www.spacenews.com/article/satellite-telecom/35794proposed-itar-changes-a-mixed-bag-for-us-satellite-industry#.Ub7-aZXn_De.

[66] *Id.*

[67] *Id.*

[68] *Id.*

[69] Marc Boucher, *SIA Submits Comments on ITAR Draft Rules*, NASA WATCH (July 12, 2013), http://nasawatch.com/archives/2013/07/sia-submits-com.html

Other US laws, regulations, and policies apply to exports of space data, hardware, and services.[70] These may limit or slow attempts to employ hosted payloads. Given the challenges, and the reality that no construction, launch or operation will occur until the ITAR issues are resolved, the government entity procuring the hosted payload's launch and on-orbit operation will be well served by getting involved in facilitating the export control paperwork processing to help ensure appropriate licenses are issued. The constraints of export controls are not insurmountable, but planning to work within them and obtain government license approvals should be started early in the acquisition process. Obtaining approvals through the bureaucracy can be lengthy, so the involved parties need to build time into the contract and manufacturing schedule. Early outreach to US State Department's Directorate of Defense Trade Controls and to non-US agencies regulating the activities of the host satellite operator owner/operator and the launch operators can be helpful in ensuring US government hosted payload interests are secured.[71] The hosted payload program managers can help ensure relevant people in the regulatory agencies understand the

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[70] For example, US policies relating to release of classified information are driven by important guiding principles. *See generally*, National Security Decision Memorandum (NSDM) 119, *Disclosure of Classified United States Military Information to Foreign Governments and International Organizations* (July 20, 1971), *available at* https://www.hsdl.org/?view&did=463374, and Exec. Order No, 12958, Classified National Security Information (1995), *as amended by* Exec. Order No. 13292, Further Amendment to EO 12958, as Amended, Classified National Security Information (2003), and by other executive orders.

See also, the Export Administration Act of 1979, Pub. L. No. 96-72, 93 Stat. 503. The Export Administration Act of 1979 (EAA) governs the export of most dual-use unclassified articles and services (having both civilian and military uses) not covered by the AECA. The EAA controls exports on the basis of their impact on national security, foreign policy, or supply availability. With the expiration of EAA in 1994, the President declared a national emergency and exercised authority under the International Emergency Economic Powers Act, Pub. L. No. 95-223, 50 U.S.C. 1701 et seq., to continue the EAA export control regulations then in effect by issuing Executive Order 12924 on August 19, 1994.

[71] Paul Dykewicz, *Clearing Export Control Hurdles for Hosted Payload Operators*, HOSTED PAYLOAD BY SPACENEWS (Jan. 5, 2012), http://www.hostedpayload.com/blog/clearing-export-control-hurdles-for-hosted-payload-operators (*citing* international law practitioner, Nancy Fischer).

hosted payload mission, its equipment, and their potential sensitivities.[72]

Some suggest US national space policies can also constrain attempts to employ hosted payloads, though that has not happened. For example, the 2010 US National Space Policy provides in pertinent part:

> Government payloads shall be launched on vehicles manufactured in the United States unless exempted by the National Security Advisor and the Assistant to the President for Science and Technology and Director of the Office of Science and Technology Policy, consistent with established interagency standards and coordination guidelines. Where applicable to their responsibilities departments and agencies shall:
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> ––Work jointly to acquire space launch services and hosted payload arrangements that are reliable, responsive to United States Government needs, and cost-effective[73]

Some hosted payload advocates have expressed worries about this specific policy language, suggesting an ambiguity in the term "Government payload" could result in enforcement of a rule that would be an obstacle to the greater use of hosted payloads. Given the small market share US vehicles have in the commercial space launch market, most commercial satellites are launched by non-US systems, like the Ariane, Proton, and Zenit.[74] As observed by Dr. Jeff Foust, if strictly interpreted, the "Government payloads shall be launched" provision would seem to either require government agencies to get administration approval for hosted payloads on international launch systems, or somehow sharply limit the number of opportunities for flying hosted payloads.[75] It all depends on how "payload" is defined. For satellite manufacturers and satellite operators, payload re-

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72 *Id.*

73 OFFICE OF THE PRESIDENT, NATIONAL SPACE POLICY OF THE UNITED STATES OF AMERICA 5 (June 28, 2010), http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

74 Jeff Foust, *When is a Hosted Payload Not a Payload?*, HOSTED PAYLOADS BY SPACENEWS (Nov. 3, 2011), http://www.hostedpayload.com/blog/when-is-a-hosted-payload-not-a-payload.

75 *Id.*

fers to, in essence, the heart of the satellite: its transponders, sensors, cameras, or other instruments that are the reason for flying the spacecraft. But for launch providers, payload typically means something else: the satellite or satellites the rocket is carrying to orbit.[76]

Foust suggests the definitional distinction makes sense:

> …in both cases the term "payload" refers to the purpose for building the satellite or performing the launch—but the cause for confusion becomes clear. So what is the intent of the language of the policy? You can make a case that when the policy refers to "payload," it's referring to satellites, and not to payloads carried on satellites. The policy is a space transportation one, so the terminology is launch-centric. Other passages in the policy refer to, for example, "intermediate and larger payloads" that clearly mean satellites, not their contents. Also, when this policy was drafted in 2004, hosted payloads were not widely discussed, particularly using that specific term.[77]

If one wants to apply and enforce the more limiting interpretation, Foust has written that a conservative way ahead could be adopted by program managers:

> Given the limited domestic commercial launch opportunities for hosted payloads at least in the near future, one possibility is to encourage that such hosted payloads be launched domestically, but not require the same approvals for non-U.S. launches as would be needed for full-fledged government satellites. This will give government agencies and satellite operators and manufacturers the flexibility to optimize the use of hosted payloads on commercial spacecraft, while keeping in mind the need to help restore a robust commercial launch industry in this country—objectives that need not be at odds with each other.[78]

Thus far, the "launched on vehicles manufactured in the United States" proviso has not been interpreted by the US Government to limit integration of hosted payloads onto commercial

[76] *Id.*
[77] *Id.*
[78] *Id.*

satellites launched by non-US entities. Thus, this may be more a tempest-in-a-teapot, meaning it is a situation that has been exaggerated out of proportion, and no dramatic revision of the policy is required.

LAW OF ARMED CONFLICT AND RELATED CONSIDERATIONS

Cynics might contend space warfare possibilities pose significant challenges to hosted payload arrangements, especially for those host satellites owned and operated by non-US entities. They could argue spacecraft operators need to consider the risks and consequences of flying payloads that support US military activities. That there is a danger in the event of military conflict, their satellites, ground nodes, and communications links could be targeted by third parties who are belligerents to the US government, who would argue that their attacks should be characterized as lawful.

In practice, these concerns have turned out to be overblown. Commercial providers have demonstrated a willingness to work with the US Government because their business and integration plan matches its customer's needs. Indeed, commercial satellites already provide significant and vital communications bandwidth and remote sensing capabilities for far-flung US forces.

The conduct of US military space activities is an accepted practice and fully consistent with international law, including the United Nations (UN) Charter, the Outer Space Treaty, other agreements, and customary international law. But the imperative to comply with international law, by itself, will not always dissuade adversaries from seeking to engage in space warfare or prepare for such conflict.[79] Fortunately, the steady expansion

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[79] There are caveats to this point. The Limited Test Ban Treaty restricts nuclear explosions in space. *See* Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water, Aug. 5, 1963, 14 U.S.T. 1313, T.I.A.S. No. 5433, 480 U.N.T.S. 43 (effective Oct. 10, 1963). Article IV of the Outer Space Treaty restricts military activity and prohibits placing "nuclear weapons or any other kinds of weapons of mass destruction" into orbit or permanently affixing them to a celestial body. *See* Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, art. IV, *opened for signature* Jan. 27, 1967, 18 U.S.T. 2410, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty].

and exploitation of military, civil, and commercial space capabilities by the international community has fostered a greater understanding of their strategic and geopolitical implications. As a result, global policymakers have counseled the exercise of great restraint with regard to decisions to attack space-based systems. Nearly all states appreciate the perennial consequences of space conflict — the debilitating problems and physics of space debris; the indiscriminate, disabling consequences of employing nuclear weapons in space; the loss of space-enabled technologies important to modern societies; and the loss of stability in the space domain which is increasingly globalized in an interdependent world. "[M]ilitarily increased space debris would in turn endanger satellites belonging to neutral States."[80]

Given the all too real dangers of producing space debris, an adversary kinetically engaging one satellite would threaten the space activities and interests of all other nations, and potentially complicate its own security interests as a result. "Deterrence can be greatly reinforced if an adversary has to contend not only with a U.S. response, but with an international response also."[81] International cooperation can complicate adversary plans and intentions. It creates more stakeholders in the orderly use of the space environment. Given this, national security and defense strategies emphasizing international space cooperation are not devised in a vacuum. Increased international cooperation bolsters peace and security. The US National Space Policy anticipates these approaches and positively engages the global space-faring community when it vows the US will assure and defend the use of space by responsible parties:

> The United States will employ a variety of measures to help assure the use of space for all responsible parties, and, consistent with the inherent right of self-defense, deter others from interference and attack, defend our space systems and con-

[80] Michel Bourbonniere & Louis Haeck, *Jus in Bello Spatialis*, SPACE STUD. INST. 141-151, 147 (1999).

[81] John B. Sheldon, *Space Power and Deterrence: Are We Serious?*, MARSHALL INST. POL'Y OUTLOOK 1–5, 3 (Nov. 2008).

> tribute to the defense of allied space systems, and, if deterrence fails, defeat efforts to attack them.[82]

There are limitations to an adversary's right to use force. Before using force, it must analyze targeting decisions within the context of Law of Armed Conflict (LOAC) humanitarian law considerations.[83] The LOAC is a collection of international law that sets boundaries on the use of force during armed conflicts through application of fundamental principles or rules of necessity, distinction, and proportionality. US military capabilities and operations are designed to precisely comply with LOAC.[84] Its principles and rules are derived from a combination of treaty, customary international and municipal (domestic) law. The LOAC sets limits on when and what degree of force may be used; targeting; and treatment of noncombatants. LOAC targeting rules are very relevant to concepts of space warfare. LOAC principles must be considered before using force against space-based systems, or against their terrestrially-based space system support, command & control, and user components.

The LOAC principle of proportionality prohibits the use of force exceeding that needed to accomplish a military objective. Professor David Koplow argues it is unlawful to "undertake an attack that would inflict excessive damage on non-combatants,

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[82] *National Space Policy*, *supra* note 73, at 3.

[83] For a good discussion of LOAC as it applies to space warfare activities, see generally P.J. Blount, *Limits on Space Weapons: Incorporating the Law of War into the Corpus Juris Spatialis*, *in* PROC. OF THE INT'L INST. OF SPACE L. 1, 4.

[84] DoD policy is to comply with the LOAC "in the conduct of military operations and related activities in armed conflict, however such conflicts are characterized." U.S. DEPT. OF DEFENSE, DOD LAW OF WAR PROGRAM, Dir. 5100.77, para. 5.3.1 (1998). Chairman, Joint Chief of Staff Instruction (CJCSI) provides the U.S. "will apply law of war principles during all operations that are categorized as Military Operations Other Than War." Chairman of the Joint Chiefs of Staff Instruction, *Implementation of the "DoD Law of War Program"*, CJCSI 5810.01, para. 5.a, (1999). Under the US military's Standing Rules of Engagement (SROE), "US forces will comply with the Law of War during military operations involving armed conflict, no matter how the conflict may be characterized under international law." Standing Rules of Engagement for US Forces, *Purpose and Scope*, CJCSI 3121.01B, §1(d) (2005).

when compared to the direct, concrete military advantage to be gained from the action…"[85] Koplow also contends:

> When a military force anticipates (as it virtually always must) that a proposed attack would generate both positive, direct military value (in damaging or destroying enemy military assets or personnel) and undesired harm on civilians (and on neutrals and other non-belligerents) or their effects, then the attacker must pause to assess the comparative value of those two factors. Admittedly, this calculation is inherently opaque and inexact, as it requires weighing starkly incommensurable variables, but (proportionality) requires the attacker to consider whether, with all things considered, the strike is "worth it." (cit.om.)
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> Long-term, as well as immediate, effects must be considered, and the attacker is obligated to attempt to gather the data necessary for making an informed, mature judgment, including assessing the possible harms inflicted on nationals of neutral countries, and even on the natural environment. (cit.om.) If the anticipated collateral damage is excessive—if the reasonably expected hardship to protected sites is greater than the benefits that the operation can accomplish—then the attack must be modified or aborted. (cit.om.)[86]

With the proportionality principle, the attacker must balance incidental loss against military advantage. This requires a balancing test between the substantial, actual, and direct military advantage anticipated by attacking a legitimate military target and the expected incidental and unfortunate civilian injury or damage. Under this test, excessive incidental losses are prohibited. The principle encourages combat forces to minimize collateral damage. This principle is also reflected in Additional Protocol 1, which prohibits "an attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be ex-

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[85] David A. Koplow, *ASAT-Isfaction: Customary International Law and the Regulation of Anti-Satellite Weapons*, 30 MICH. J. INT'L LAW 1187-1272, 1243 (2008-2009).
[86] *Id.* at 1246.

cessive in relation to the concrete and direct military advantage anticipated."[87]

An action causing excessive or catastrophic damage to civilians or to property should be proscribed. The principle of proportionality offers some guidance with regard to using force against space systems: since collateral damage to civilians is considered a natural consequence of combat, the proportionality test should be applied to determine if an attack on a dual-use object warrants the consequences to the innocent. Similarly, Bourbonniere and Hoeck argue:

> The resulting debris from the use of force in space must be factored in the proportionality calculus of military operations. In this case space benefits from an indirect protection regime. Space is protected not in itself but as an application of other rights of international law.[88]

In applying the proportionality test to certain satellite missions, one could conclude then that some hosted payloads performing should not be lawfully attacked; this includes interfering with space-borne payloads providing national technical means (NTM)[89], missile warning, emergency communications and even perhaps precision navigation and timing capabilities. As such, commercial operators could conclude that including certain vital national payloads on-board as hosted payloads would not pose additional risks in a conflict because the US adversary targeting calculus might conclude that attacks on its satellite are unlawful because of proportionality considerations.

Space-borne NTMs serve an important role. They assure adversaries that they have complied with arms control treaty terms; provide transparency, enhancing confidence in actions of

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[87] Geneva Convention, *Additional Protocol I,* at art. 51(5)(b). Protocol I is a 1977 amendment to the Geneva Conventions clarifying and affording protection to potential victims of armed conflict. It was signed by not ratified by the United States Senate. A number of its articles are recognized as customary international law. Under Article 51, indiscriminate total war is unlawful.

[88] *Jus in Bello Spatialis*, *supra* note 80.

[89] "National technical means" is a phrase that appeared in the context of verifying the provisions of the 1972 Strategic Arms Limitation Treaty (SALT I) and Anti-Ballistic Missile Treaty. The term includes a variety of monitoring technologies, including imagery, remote sensing, radars, and more.

others, and diffusing tensions; and help stem the potential of a nuclear holocaust, which would produce a catastrophe whose damaging effects would be global in nature. Preserving access to hosted payloads performing such missions would appear to be protected by the proportionality principle; hence, this would proscribe any attacks on such systems to destroy, disable, or otherwise interfere with them. Proscribing such attacks would satisfy the higher needs and general interest of the whole international community.

Perhaps similar arguments could be made with regard to missile warning and emergency communication capabilities performed by hosted payloads. These systems would help the US understand, manage and limit the extent of damage associated with exchanges of weapons of mass destruction, all to the benefit of the global civilian community. Arguments that such considerations proscribe attacks on space-based precision navigation and timing capabilities could also be made. Proponents for this position would be bolstered by demonstrating the dimensions of the effects and global chaos that could occur in the commercial and civil communities as a result of the destruction of these capabilities. While these arguments are less compelling from ones tied to preventing conflict with weapons of mass destruction, they could be made just the same and, perhaps, accepted.

CONCLUDING THOUGHTS

In selecting space system architectures, programs managers must work the trade space, balancing capabilities offered by exquisite single-point-failure flagship class spacecraft with those presented by more numerous and redundant small satellite systems, and ultimately hosted payloads. Moving to fly significant government-sponsored hosted payloads onboard commercial satellites, in place of building flagship, government-only systems, has gained significant traction in recent years as the demand for space-based information has increased, along with the costs of supplying the demand. Hosted payloads hold great potential to augment the resilience of US national security space systems architectures and achieve cost savings by getting