Space

Tomorrow and Beyond

The growing Department of Defense (DoD) dependence on space has reached the point where a solid plan for the future is a must. The Air Force Space Command is focused on improving resiliency and bringing down costs by using smaller satellites, simpler designs, and fewer on-board systems.[1] Similarly, the Space and Missile Systems Center commander, Lt Gen Ellen Pawlikowski, is looking ahead to a simpler, more-affordable constellation made possible by disaggregating current capabilities. She has predicted that "military space capability of the future likely will rely less on constellations of sophisticated military-specific satellites and more on some level of simplified military spacecraft coupled with supplemental on-orbit capability like payloads hosted on commercial satellites."[2]

A strong space future is possible but only if the United States embraces the challenge. My objective assessment of what the future holds for space includes key challenges for current programs, next-generation programs, and future architectures. It offers a framework for a realistic, affordable, step-by-step plan for sustaining current performance as the national security space (NSS) architecture evolves over the next 50 years. The overarching requirement is to maintain capabilities adequate to keep up with a rapidly evolving threat—a task made more difficult by a fiscal environment where budgets are unlikely to grow. The process itself is relatively straightforward: establish the starting point, set the goal, fix what we already know we will need, allow for surprises, and build for the future.

Start from Where We Stand

Because world economies today face a growing dependence on space, there is concern that our space assets are increasingly vulnerable and a nearly universal agreement that the procurement process must be streamlined to reduce the time from development to production. We need to understand how to maximize production efficiencies, even when fiscal constraints preclude economical order quantities; how to provide budget flexibility to keep up with evolving threats; and how to sustain strategically vital architectures that cannot be allowed to fail. A 50-year future starts with today's realities: a growing threat in a near-peer environment, continuing budget constraints, new technology, and a motivated workforce.

The Growing Threat

In discussing operational implications of the new Air-Sea Battle concept, chief of naval operations, ADM Jonathan Greenert, and then-Air Force chief of staff, Gen Norton Schwartz, highlighted the value of the global commons and the need to be able to counter threats in these domains, noting that "free access to the ungoverned 'commons' of air, maritime, cyberspace and space is the foundation of the global marketplace."[3] Today, realistic threats cover a wide spectrum of possibilities that threaten that global marketplace. At one extreme is a protracted armed conflict with a near-peer adversary; at the other, inadvertent denial of service caused by something as simple as a backhoe accidentally cutting a fiber-optic cable. In between are widely available basic jamming techniques, invisible but pervasive cyber attacks that could cause widespread outages, dramatic acts of terrorism, and even kinetic destruction caused either intentionally by an adversary or accidentally by orbital debris.

China's destruction of its own satellite demonstrated it could probably destroy an adversary's satellite as well. Jamming of any space vehicle is also in the capability mix. Earlier this year, there were reports that Iranian spoofing of global positioning system (GPS) signals caused a classified US drone to crash. More recently, North Korea is reported to have jammed GPS signals affecting maritime shipping and commercial airline flights.

It is time for a full-spectrum, risk-versus-consequence analysis of the threat; development of cross-stovepipe, interservice solutions; and greater consideration of allied support. The focus of this reevaluation—greater resilience—is likely to involve a more-robust architecture that includes improved space situational awareness (SSA), greater functional redundancy across a wider variety of platforms, international cooperation across missions, and additional self-protection for satellites.

Budget Constraints

For the next several years, US space programs will be engaged in an intense search for more-affordable solutions. The fallout from sequestration and continuing resolutions (CR) is likely to make the budget picture worse. One approach to the mismatch, called *disaggregation*, includes cost, schedule, performance, and risk implications that have not yet been addressed. New starts of smaller satellites are frequently alleged to be less expensive than upgraded programs of record (POR). Recent studies by the Office of the Secretary of Defense (OSD) Cost Assessment and Program Evaluation (CAPE) office suggest that a constellation of smaller satellites large enough to match current capabilities could be far more expensive, especially when launch, command and control, data integration, infrastructure, and conversion costs are included. For any new start, independent of size, the actual cost is extremely hard to predict and likely much greater than expected. Additionally, under CRs, new starts are few to none.

These unanswered questions strongly suggest that the near future of space development must be an evolutionary one. At the same time, we are in an affordability hole and unable to climb out by continuing business as usual. We cannot fail to invest in space; therefore, we must rethink *how* we invest to make certain we are acquiring efficiently, leveraging our current investments, and inserting new capabilities only when needed. We must identify the real problems and the real gaps, and then "reach for the attainable," perhaps by exploring next-generation solutions that can be implemented at lower cost because the initial research and development has already been paid and the technology has matured. Above all, we need a plan that leverages current programs, evolves to new capabilities without creating gaps in performance, and minimizes risks to ongoing military operations.

New Technology

Realistic technology forecasts typically underestimate both the speed at which technology changes and the culture shifts that result. Companies that have anticipated the speed and magnitude of technology change are today the largest and most successful in the private sector. The history of space operations is replete with examples of quantum improvements in capability as programs have evolved. A realistic (and probably underestimated) space technology forecast for the next 20 years includes a dramatic increase in knowledge density, laser communications, component miniaturization, and more efficient networking—all of which will reduce even further the SWaP (size, weight, and power) requirements for the same or greater capability. Now is the time to explore evolving technologies that will maintain capability in the near term while evolving to a better future by enabling new systems, derivative technologies, and capability insertions through progressively more demanding testing, exercises, and operational evaluations.

Motivated Workforce

Realistic program objectives and an enthusiastic workforce can reenergize the nation's industrial base and contribute to an "image makeover" for the aerospace industry. The nation has never failed to supply qualified, innovative scientists and engineers when there has been a national sense of urgency, whether for the high production rates of World War II, the secret physics of the Manhattan Project, General Schriever's development of the intercontinental ballistic missile, the national imperative to counter improvised explosive devices (IED), or the exponential increase in remotely piloted aircraft (RPA) operations. What matters now is focusing on objectives that offer utility to the war fighter heretofore only imagined in science fiction novels and that capture comparable benefits for mankind.

Establish a Goal

If you don't know where you are going, any road will get you there.

—Lewis Carroll, *Alice in Wonderland*

In the next 50 years, space will become even more valuable to mankind, as will its utility to the war fighter. As space communications, navigation, and ISR (intelligence, surveillance, and reconnaissance) capabilities have improved over the years, more and more users have become dependent upon products, services, and capabilities from space. The conundrum we still face, however, is the difficulty of building capabilities that should be based on new—and unknown—threats and requirements. What we do know are the kinds of "functions" that will be required, such as communications, navigation, precision timing, ISR, weather observation, threat warning, and damage assessment. We also know the directions technology is taking us—smaller, faster, more-capable, more-integrated, better-networking, more-resilient architectures, and the "cloud." We know as well that it would be a mistake to design based on today's technology.

Discussions with space leaders over the past several months identified at least six goals for future-space we should be striving toward, some of which have not yet been formally recognized by senior decision makers.

Goals for Future-Space	
Freedom of Operations	Freedom to operate in space and, if needed, to deny that ability to an adversary.
Universal Support	Ubiquitous, transparent, secure support to our forces and to those of our allies, including dependability, reliability, maintainability, survivability, and information security.
Balanced Resilience	Support as resilient as the forces space supports—space should never be the weakest link.
Look-Ahead Knowledge	"Feed-forward" intelligence available "before" demand. If a user needs information, a video, or an image, the system should be primed to put an answer at their fingertips. The goal should be to get intelligence to the users before they even know they need it. No one should ever be surprised, after the fact, that there was space support available they did not know about.
Seamless Functionality	If a user wants "a picture," that picture should include all known sources of data, such as satellite imagery, airborne imagery, full-motion video, SIGINT, HUMINT, etc., from the military as well as the intelligence community, and in an easy-to-use format. This goal is absolutely key to the "look-ahead knowledge" goal.
Sentient Partnership	The past 50 years have shown the utility of space for communications, navigation, ISR, environmental monitoring, disaster response, and resource management. More recently, space has become an integral part of logistics, supply, maintenance, and even medicine, banking, and retail sales. We are witnessing a steady migration of space into the central nervous system of the world's economies, and at speeds we would never have imagined in the twentieth century. What we do on Earth today, we will be doing in space as well by 2030—and probably sooner. In that sense, space is destined to become an intelligent—sentient—partner for the world.

Taken in aggregate, these goals provide a vision for future space: *the right-sized force multiplier, mankind's greatest ally, and the war fighter's best friend*—ubiquitous, reliable, accurate, and responsive.

- Right-sized. Enough to do the job—and not a machine screw more; balanced resilience.

- Force multiplier. Our forces are stronger with space than without it. At an operational level, space really does let our forces do more with less.
- Mankind's greatest ally. Space makes Earth a better planet.
- The war fighter's best friend. The key will be when every war fighter knows deep down inside that space effects will be there when needed, even better, that space will be there before one even knows it is needed.

Fix What We Must

The third step is to fix only that which we can afford to fix and that we will need for the future. Deliberate planning will make future architectures more attainable with lower risk. While much of the supporting information is classified, the NSS architecture is on solid footing during a peacetime or nonhostile space environment, but we do not appear to be prepared for overt conflict with a near-peer adversary. Beyond that, our lack of "last mile" connectivity and our continuing mission data stove piping do not encourage look-ahead knowledge or seamless functionality.

The Future of National Security Space Communications and ISR

Goals for the future (see above)	Attainable through current programs?	Attainable through out-year budgets?
Freedom of Operations	**Yes,** at least in conventional conflicts (e.g., Iraq, Afghanistan).	**At risk**. Given growing threat and no change in architecture, freedom of operations will be less assured than it is today.
Universal Support	**No**. Not secure, not ubiquitous, not transparent—"last mile" and disadvantaged user problems.	**At risk**. Despite improvements in peacetime tactical communications, basic "last mile" and disadvantaged user problems will remain.
Balanced Resilience	**No**. Generally vulnerable if attacked.	**No**. Increased vulnerability as adversaries develop better weapons.

The Future of National Security Space Communications and ISR (continued)

Goals for the future (see above)		Attainable through current programs?		Attainable through out-year budgets?
Look-Ahead Knowledge		**No**. Stovepipe information paths—response time in minutes to hours.		**No, but better**. Same problems but commercial options will improve peacetime response.
Seamless Functionality		**No**. Stovepipe dissemination relies on stickies and sneaker nets for much of the integration.		**Improving** by default as processing software grows in capability and throughput.
Sentient Partnership		**No**. Not secure, not integrated, not in anyone's plans.		**No**. No change expected from today's stovepipes.

What must we do to turn the "No" and "At risk" items to "Yes"? The fastest, safest path is to augment today's foundation and sustain current production and operations as we move toward new capabilities. This path mitigates risk in schedule delays as well as in cost growth. A 50-year architecture requires moving forward aggressively but in steps measured by the art of the possible and the science of the real world.

At US Strategic Command, Gen Bob Kehler is stressing the value of working with our allies in future space operations. In addition to the operational advantages of his initiative, there is the potential for cost sharing. "What we know from looking at every military operation that we undertake is that there is value in combined and coalition operations. It's time for us to bring those concepts to space," he observed.[4]

We must look to the future realistically: "Eyes on the stars, feet on the ground." Take advantage of what is already available and recapitalize what we already have. Regardless of what the future may hold, now is not the time to abandon what we have in favor of something new but unproven—for two reasons.

First, we can take advantage of existing production programs that are already demonstrating quantum improvements in capability. As these new systems are coming online, we have much to learn about them, not only how they behave in routine operations, but also how we can use them beyond their original intent. We have just begun to figure out all the ways we can use these new capabilities. Innovative applications—a perpetual strength of our nation—are particularly noteworthy in space programs. At the same time, we can continue to pursue capability insertions, one-of-a-kind experiments, and preproduction prototypes that look toward operational requirements of 2050. Avoid future Nunn-McCurdy breaches by taking time now to improve the technology readiness level (TRL), determine the full cost of replacement architectures, assess the risk associated with each increment, and quantify full-scale production requirements.

Second, there is no backup today if proposed replacements do not come to fruition as quickly as promised. Previously, when the DoD replaced an entire constellation, we had backups when development of replacements took longer than expected. We had spare defense meteorological satellite program weather satellites to tide us over while we waited for an NPOESS (national polar-orbiting operational environmental satellite system) program that was ultimately cancelled. Several defense support program (DSP) missile-warning satellites sustained the nation's highest-priority ISR program while the SBIRS (space-based infrared system) was developed. More-durable DSCS (defense satellite communications system) satellites—lasting 5–10 years beyond their design lifetimes—helped provide coverage while wideband replacements were developed. Backup Milstar strategic communication satellites protected a "launch on need" capability while the AEHF (advanced extremely high frequency) satellite was developed.

Today there are no spares, no backups. The replacement for the cancelled NPOESS is still in discussion. The SBIRS is barely into its initial deployment and has not yet reached IOC (initial operational capability). AEHF satellites, the MUOS (mobile user objective system), and WGS (wideband global SATCOM) have just begun operations; spares are budgeted, but the satellites have not been in operation long enough to tell how well they will perform over the long haul. This is not the time to be changing horses midstream, especially when we know from history that once the operators get their hands on a new space system, they find new and often astonishing ways to use it that even the designers hadn't thought about. Fortunately, Congress has recognized the potential break in capability, and the House Appropriations Committee has added language supporting additional SBIRS and AEHF satellites.

We have to build on what we have today—a prudent approach until we have the technology and the processes in place to make the next leap to the future. New systems should be developed as capability insertions are proven. Unfortunately, we do not have the luxury of compounding affordability problems by adding developmental funding for yet-to-be-proven programs.

At this stage, then, it is extremely important that we fix what war fighters have indicated they are likely to need in future conflicts:

- ubiquitous ISR over denied areas, even in the presence of a near-peer adversary;
- secure communications for tactical forces on the move;
- improved mission data processing to facilitate seamless functionality;
- greater architectural resilience, networking existing capabilities, and improved space situational awareness and spacecraft protection; and
- more affordable systems of systems and families of systems

Ubiquitous ISR

The growth in the military's demand for intelligence, surveillance, and reconnaissance information continues unabated. Adding to the wealth of ISR data, more and more combat forces are bringing their own tactical platforms with them into combat, allegedly to reduce their dependence on national systems that are perceived to be unresponsive. With the ISR evolution underway, we need to open the trade space and include off-ramps to what could be a more resilient overhead persistent infrared (OPIR) architecture than a wide-field-of-view (WFOV) approach offers based on third-generation infrared surveillance (3GIRS) technology. Other digital focal plane arrays may provide a clearer path toward our objectives—their technology demonstrators should be part of the future program.

Secure, Protected, Tactical Communications

While strategic communication remains the highest priority, now is the time to move toward secure, protected, communications for tactical forces facing growing threats, whether basic jamming, kinetic attacks, or cyber disruption. In the military communications world, the single biggest operational shortfall is the paucity of secure, protected, tactical communications to the war fighter on the "front lines" (recognizing, of course, that the "front line" has never been so poorly defined as it is on today's battlefield).

To fix this shortfall, initiatives are being considered that will add communication transponders in orbit, either on dedicated military satellites or using military payloads hosted on commercial communication satellites. Just putting more transponders into space may not be sufficient.

What we need are more platforms integrated in a high-capacity network of communications elements—in space as well as in other layers. We are not taking advantage of a broader set of options to provide greater access to more-secure tactical communications. To evolve as rapidly as possible, we need to explore emerging approaches for providing widespread protected communications to tactical forces, including the integration of the space layer with non-space contributors and the use of smaller "repeater" communications satellites where appropriate. These "inserts" may be key to evolving an affordable 2050 space architecture.

There is every reason to believe that the same or better service can be provided at less cost—if we take a network approach. The problem is that there is no incentive for anyone with a vested interest in the status quo to support a change. There is no "benevolent dictator" with the authority to divert the next dollar in space to an integrated network architecture that will benefit war fighters and other operational users. The way ahead, then, begins by putting a "crew chief" in charge of networking platforms to create new and improved capabilities. Next, develop a migration strategy to achieve the architecture while funding programs that demonstrate progress toward our objectives; kill programs that do not. Coordinate the new network with the aerial and ground segments. Demonstrate the cost-effectiveness by tallying the *full* cost associated with a space program—including the ground entry points and user terminal costs.

Once the layers have achieved some level of interoperability, tailor redundancy and assign network management to the appropriate layer. For example, signal processing currently being done onboard a satellite may be accomplished in another layer at less cost. Consider transmitting a signal in a different form through an airborne communications node (ABN) over a battlefield if there are insufficient radios capable of receiving the satellite signal directly.

Improve Mission Data Processing

One of the five tasks given Air Force ISR chief Lt Gen Larry James by Secretary Donley was to develop a roadmap for intelligence processing, exploitation, and dissemination (PED) tools, including what investment opportunities may exist in the future.[5] This is no easy task. In some ways, the PED issue is more déjà vu than anything else. Remember when a significant portion of the overhead imagery was ignored because there was simply too much of it to work with—the "left on the cutting room floor" complaint? We are there again, only this time more digital, more voluminous, and far more complicated. The solution then was to improve the software, expand automated processing, and give the analyst more sophisticated workstations. This time, it is more of a personnel issue—how to recruit, train, and retain sharp, capable people who are up to a daunting task that is going to get even more complicated. The ground layer, aerial layer, and space layer will need to be integrated, as will nontraditional ISR sources. We need to pursue customized user applications—with ready access to information domains—just as Apple changed the multimedia domains for music and books. It may turn out that much like iPhones and Wikipedia, processing improvements will be developed as apps by the users themselves, evaluated, approved, and embedded on the SIPRNET—a terrifying prospect for the information security (INFOSEC) mavens, but a logical fallout from today's e-generation.

Greater Resilience

Today's air, land, and maritime forces are highly dependent on space systems, and the result is almost astonishing. We can hold any target on the face of the earth at risk—if it is not moving too fast. That is not a guaranteed capability, however, particularly if we were to engage with a near-peer adversary. The command and control of RPAs, for example, uses commercial satellite communications (SATCOM) vendors, and the mission intelligence produced by the RPAs is relayed via unprotected SATCOM. Passing military data through commercial pipelines is a vulnerability that will become more critical as we place greater reliance on RPAs and the concurrent bandwidth required to support them. In fact, any unprotected link adds vulnerabilities that we must consider when looking at force-on-force scenarios. The Army's soldier radio, for example, uses an unprotected GPS link that is subject to jamming, hence the urgent requirement for making protected communications available to tactical forces.

Military forces facing an uncertain future will require greater resilience in space operations. It is time now to start working on balanced resilience. Since the threat isn't binary, resilience should not be either. Make resilience more affordable by starting with what we already have available: greater interconnectivity of existing programs, more capable networks, and more backup services. "More space," if achieved solely by disaggregation, is not necessarily the best answer. Cost/utility/resilience trades must be done systematically and analytically. Analyze cross-domain and networking approaches for their contribution to resilience; likewise, space situational awareness and self-protection initiatives. Resilience to nontraditional threats—such as cyber—must also be considered, as should contributions from international and commercial platforms.

More-Affordable Systems of Systems and Families of Systems

The challenge of improving the government's weapon system acquisition process could—and no doubt will—keep a small army of designers, builders, managers, and overseers busy for the next millennium.[6] Because of the magnitude of the problem, it is extremely important to get this right. Fortunately, we appear to be making some progress, as government and industry have worked hard to overcome shortcomings.

Air Force leaders expect to save at least 10 percent of the often billion-dollar price tag of new satellites with the implementation of the Evolutionary Acquisition for Space Efficiency (EASE) initiative, one element of the Efficient Space Procurement (ESP) process. ESP is comprised of proven tenets: block buys of satellites, stable research and development investment in foundation programs, fixed-price contracting, a modified full-funding approach, and capability insertion into the foundational program of record. This could be the single most important acquisition reform undertaken by the Air Force, because it targets core issues that have driven acquisition problems for decades.

Beyond ESP, if we have any hope of a brighter future, we must work toward a space acquisition strategy that balances cost and risk. We need an "acquisition makeover" that will allow processes to keep up with changes in requirements. This will require not only changes to the "how we buy," but also changes in how we "buy smarter." The result will revitalize our industrial base as industry seizes the initiative to help the government reduce cost. Part of these savings will come from the commoditization of space and part from the utility (and inevitability) of managed services, but the majority will come from the know-how and initiative of the aerospace industry. Acquisition reform must enhance program cost efficiencies while retaining quality control and program mission assurance. One solution would be to standardize component certification criteria across the industrial base so second- and third-tier suppliers do not have duplicative processes for the same component. Another would be to bundle processes across programs managed by a single prime contractor, which would increase buying power, improve visibility into supply chain performance, and incentivize innovation at the second- and third-tier levels. Other efficiencies may accrue from "normalizing" space logistics into a more traditional Air Force Materiel Command–like structure. Still other improvements would enable industry to acquire production capacity tailored to capability insertion and technology innovation. The result would be to gain resource and management efficiencies across multiple programs.

Anticipate the Unknown

This step is designed to make allowances—operational contingency planning—for the inevitable adversarial, technological, and political surprises. We must be prepared—in advance—for new threats from potential adversaries, changes in military requirements, advances in technology, and other factors that will demand maximum flexibility in design and minimum time in development. In a technology-dominated world, the surprises ahead will be bigger and will come at us faster than we have ever experienced. That makes it all the more urgent that our conceptual thinking includes a toolkit of look-ahead options for a broader range of contingencies. Smarter architectures, more flexible satellites, better integration with other contributors—all are more possible today than they were even 10 years ago. Three tactical initiatives will help us anticipate the unknown:

1. **Hedge our Bets**. Make allowances for the "known unknowns"—changing threats, changes in technology, and changes in international arrangements. Design for the flexibility to provide a stable mitigation of risk. For example, the "plug-and-play" concept has been around for several years as a means to provide more flexibility in satellite design. The tradeoff has usually shown, though, that the SWaP cost associated with preconfiguring commonality is not worth the postulated flexibility. But what if the satellites themselves were plug-and-play capable inside a more flexible, tolerant, and resilient architecture? Using secure, SIPRNET-based communications and a common command-and-control (C2) architecture, any satellite could be compatible with any ground station. The overall architecture would be more tolerant of developmental delays, resilience would be enhanced, and more companies would be able to compete for block changes and new programs.

2. **Pay for Brainwaves**. Incentivize innovative thinking in all quarters, at all levels. The key here is "incentivize." In today's environment, that usually translates to "more money," but selectively offered.

3. **Create Disruption**. Assume the inevitability of, and begin to plan for, disruptive behavior by a potential adversary. Selectively invest in self-disruption as a hedge.

Build for the Future

The final step is to pursue technologies we know will make a difference by 2050. Evolution to the future is already underway. The Air Staff (AF/A3) is scoping solutions for 2025–30.[7] The following examples are illustrative of technologies that are "just around the corner."

- **Progressive Synchronization**. Build a comprehensive enterprise "migration plan" for synchronizing current production programs with the development of lower-cost complements and replacements.
- **Lower-Risk Sensor Technology**. Implement a 10-year, low-risk path for exploiting new technology like the overhead persistent infrared (OPIR) wide-field-of-view (WFOV) sensor.
- **Next-Generation Communications**. Lay the foundation for next-generation communications by making near-term budget decisions consistent with future-space objectives. Any forecast invariably involves more networked constellations using technologies already developed either in industry (e.g., the Cisco Internet Routing in Space program) or on government design boards like the cancelled transformational satellite (TSAT) program.
- **Nontraditional ISR**. We already know the utility of using the amazing onboard ISR electronics of advanced weapons like the F-22 and F-35 to augment other denied-area ISR sensors. One of the unintended benefits from using these systems as sensors as well as shooters is that they become their own blue force tracking (BFT) device, which means they gain BFT utility without adding systems on board. Similar benefits would be available on the ground, where Soldiers' GPS coordinates would be passed using highly secure circuits through the Cloud to friendly forces (targeters, weapon system operators, search and rescue, etc.).
- **Consolidated Satellite Operations**. In addition to the resilience benefits of cross-domain command and control, sheer economics will force more-efficient satellite C2. Commercial programs already save money by consolidating satellite operations; they have been doing it for years. GPS is one of the few military programs where an entire constellation is managed by a few operators. Getting humans out of the health-and-status loop will save money, reduce workload, and improve efficiency. By 2030, satellite health-and-status

operations will routinely be done autonomously. Tasking operations will be controlled by end users through automatic prioritization and scheduling. By 2050, operations will be even more automated, more integrated, and less labor-intensive.

- **Extending the Cloud into Space**. Expanded networks are an inevitable part of our future—not only within the space layer but also with and across the aerial and ground layers. The users are already demanding more real-time access to information from all domains without being burdened by the "data glut" they experience now. Today's war fighter uses information from a wide variety of contributors from terrestrial stovepipes. Including the space layer in a secure cloud will increase architectural resilience and make a quantum leap in knowledge available to every war fighter. As General James has noted, "It is an environment where you honestly [won't] care about what your source of data is. You're data agnostic. You're sensor agnostic. But you have the ability to reach into the network, reach into the cloud—however you want to define that—and gather the data you need to get as an analyst to solve the problem that you've been given."[8]

- **Sentient Partnership**. Ground-breaking experiments could establish a prototype feasibly by 2025, fully operational by 2050. We can no longer "talk around" the relationship between military and commercial activities in space. Because space is an economic *and* military center of gravity, the military has a role to play. Gen Howell Estes articulated a vision for space early in his tenure as commander of US Space Command (August 1996–August 1998) when he talked about the emergence of space as an economic center of gravity. In an excerpt from his April 1997 speech to the US Space Foundation's annual symposium, he stated,

> Commercial space . . . will become an economic center of gravity, in my opinion, in the future and as such will be a great source of strength for the United States and other nations in the world. As such, this strength will also become a weakness, [and] vulnerability. And it's here that the U.S. military will play an important role, for we will be expected to protect this new source of economic strength.

Conclusion

Now is the time to implement the evolution needed to achieve a strong space foundation for the next 50 years. The ideas presented in this article should be our first step toward a dynamic future for national security space, regardless the realities of the present. It all begins with a clear vision:

Space: The right-sized force multiplier—mankind's greatest ally, and the war fighter's best friend—ubiquitous, reliable, accurate, and responsive.

Make no mistake, much work lies ahead. But the value of rethinking future-space is clear:

Goals for future-space	Prototype capabilities feasible in 2050 if we start rethinking space today
Freedom of Operations	**Yes**, with full-up networks, robust resilience, global team-work
Universal Support	**Yes** – secure, ubiquitous, transparent – "last mile" connectivity, disadvantaged user-friendly
Balanced Resilience	**Yes** – no advantage to an adversary to attack space first
Look-Ahead Knowledge	**Yes** – negative response time – there before the war fighters realize they need it
Seamless Functionality	**Yes** – Wikipedia-like integration – the users contribute to the solution automatically – mission-focused integration flushes the data glut
Sentient Partnership	**Almost** – beachhead by 2030, operational by 2050

Based on the ideas and proposals in this article, three conclusions are evident. First, we do not have to wait until 2050. A strong 2030 space future is possible—but only if we step up to the challenge. Second, success depends on a national consensus to take the necessary steps. Third, the path to revolutionary space architecture begins with evolutionary thinking. Space is already becoming mankind's greatest ally. American ingenuity, creativity, and determination are all that are needed to make space the war fighter's best friend.

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Notes

1. "Commander Looks to the Future at Space Symposium," USAF AIM Points, 20 April 2012.

2. Michael C. Sirak, "Changing the Space Composition," *Air Force Magazine*, 19 September 2011, http://www.airforcemag.com/DRArchive/Pages/2011/September%202011/September%2019%202011/ChangingtheSpaceComposition.aspx.

3. Norton A. Schwartz and Jonathan W. Greenert, "Air-Sea Battle: Promoting Stability in an Era of Uncertainty," *American Interest*, 20 February 2012, http://www.the-american-interest.com/article.cfm?piece=1212.

4. "U.S. Eyes Combined Space Operations with Allies," *Reuters*, 19 April 2012.

5. Amy McCullough, "Eye on Future ISR," *Air Force Magazine*, 30 April 2012, http://www.airforcemag.com/DRArchive/Pages/2012/April%202012/April%2030%202012/EyeonFutureISR.aspx.

6. Interestingly enough, the only guidance that has survived the test of time came from HP co-founder and former deputy secretary of defense David Packard 40 years ago: "Hire the best people you can, give them what they need to get the job done and then get out of their way."

7. McCullough, "Eye on Future ISR."

8. "Lt Gen Larry James: Air Force Will Combine Space, Cyber and Airborne ISR Capabilities," *Inside Defense*, 26 April 2012.