

DEPUTY CHIEF OF STAFF,
INTELLIGENCE, SURVEILLANCE
AND RECONNAISSANCE

COMMERCIAL SPACE- BASED GEOINT

An
ISR HORIZONS FUTURE VISION



MAY 2015

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“We have excelled in the past in a closed system – we must excel in the open. ... [We must] reduce the barriers between our system and the explosion in the commercial market.”

Robert Cardillo
Director, National Geospatial Intelligence Agency
11 March 2015

Washington, D.C.

This near-term vision outlines the Air Force intelligence, surveillance, and reconnaissance (ISR) approach to a disruptive technology that fundamentally alters previous paradigms of information availability and mission assurance. The emerging space-based earth observation marketplace is unprecedented in size, scale, and vision, with the expressed intent to provide timely geospatial information and/or analytics to the broader commercial world. In short order, the Air Force and Department of Defense (DoD) will interact with these businesses as equal-footed customers, not as drivers of capability. The Air Force and DoD will no longer hold a monopoly on geo-referenced information so important to detection, monitoring, and targeting operations. At the same time, the increasing complexity of target access, demands that the Air Force employ all available means to monitor changes anywhere in the world at any time. Access to worldwide geospatial intelligence (GEOINT), a significant input to the targeting cycle and the most DoD-relevant portion of the earth observation marketplace, must be distributed and ubiquitous via direct downlink, commercial relay, or government ground stations. These commercial capabilities could be a powerful tool within this environment, offering an enormous opportunity to satisfy many Air Force and DoD requirements while minimizing risk, optimizing collection, and greatly increasing collaboration at relatively low cost.

The future strategic environment, rife with anti-access/area-denial threats and small, highly-mobile targets, demands the Air Force revolutionize its model of ISR integration with operations. The Air Force ISR Enterprise, working hand-in-hand with the broader intelligence community, must embrace commercial space capabilities and work to integrate them with warfighters and decision systems across all echelons. The desired effects would be to provide timely and direct imagery to support Unified Combatant Commanders, Joint Force Commanders, Combat Air Force, Mobility Air Force, Special Operations Forces, and Joint/Coalition Forces.

Today, the demand signal for timely, relevant, accurate, and tailored geospatial products has soared. The growth in demand has coincided with the emergence of global architectures poised to move data to customers with almost zero time delay. The customer base, now composed of both government and non-government entities all around the globe, has pushed commercial space-based GEOINT providers to develop machine-to-machine algorithms to almost instantly process and analyze data streams then produce customized results based on consumer needs. These market forces will persist regardless of US government involvement, but our window to influence their evolution may prove fleeting.

The national and joint communities, moreover, have similar needs for an increased flow of intelligence to feed time-sensitive assessments. The Air Force must work in close coordination with Army, Navy, Marine, Coast Guard, and national intelligence agencies to harness commercial GEOINT capabilities for the entire community. The National Geospatial-Intelligence Agency (NGA), in particular, will serve as an essential partner in constructing a roadmap and charting the way-ahead.

Linkage to Air Force Strategy

The Air Force 30-year strategic framework, *America's Air Force: A Call to the Future*, reflects on the imperatives of agility and inclusiveness as critical to future relevance, and commercial GEOINT can provide both. Commercial GEOINT fosters organizational agility by creating a cost-effective means to rapidly exploit cutting-edge advances in commercial technology. It builds inclusiveness via not only improved partnerships with the commercial GEOINT industry, but also by normalizing the use of unclassified imagery and analytics which can be easily shared among policy makers, the joint/interagency team, international partners, academics, industry, and even the press. Furthermore, commercial GEOINT offers a ready-built, dense, diverse, and resilient global sensor network which supports the framework's strategic vectors of 1) provide effective 21st century deterrence; 2) maintain a robust and flexible global integrated ISR capability; and 3) ensure a full-spectrum capable, high-end focused force.

AF ISR 2023: Delivering Decision Advantage – a strategic vision for the Air Force ISR Enterprise – similarly describes three core tenets and five priorities to shape the future. Commercial space-based GEOINT supports the AF ISR 2023 visions of Full-Spectrum Awareness and Delivering Decision Advantage. It supports the stated priorities of 1) rebalancing and optimizing integrated ISR capabilities; 2) strengthening integration, collaboration, and partnerships; and 3) revolutionizing analysis and exploitation. This document helps bridge the gap between AF ISR 2023 and more detailed force planning documents such as the Air Force Strategic Master Plan and the Core Function Support Plans. It is intended to guide capability roadmaps across the ISR spectrum including the Air Force Targeting Enterprise, Air Operations Centers (AOCs), and Distributed Common Ground System (DCGS). It will also help coordinate needed modernization efforts across the broader intelligence community.

The Air Force ISR Horizons project has published “Sensing as a Service” and “Battlespace Networking,” envisioning a next-generation ISR architecture which can efficiently and effectively collect, exploit, and disseminate intelligence to warfighters in a tactically-relevant time and manner. This vision, centered around a sensor-agnostic (neutral), time-dominant, upstream-fused environment, demands innovative approaches to target access and tracking. Such relationships with commercial providers, furthermore, will not be unprecedented. The DoD has leveraged commercial satellite communications (SATCOM) capabilities in large measure since the First Gulf War.

Commercial Imagery Background

Beginning in 2014, the commercial space-based GEOINT market began to boom due to a combination of improved quality, expanded awareness, and lowered financial entry barriers to meet a groundswell of demand from the business world. The market includes both legacy providers and a growing group of start-ups using small satellites to offer similar capabilities at greater quantity and lower cost. Commercial sensor capabilities have already evolved considerably beyond simple, high-resolution electro-optical imagery and now include multi-spectral, hyper-spectral, RADAR, infrared, and even high-definition video. These agile commercial firms will constantly refresh their hundred-satellite strong constellations with a steady barrage of new launches, offering incremental technological improvements and a disaggregated approach to survivability and resilience.

Commercial space-based GEOINT first emerged in the 1970s when firms began offering electro-optical imagery to a select group of users. Their products were limited by low resolution (approximately 30 meters) and poor accuracy (large margins of error in positional placement on the earth). The slow

collection, retrieval, processing, and delivery of the resultant images reduced the number of potential applications, particularly in the private sector. Consequently, imaging companies relied on government contracts as the foundation for financial sustainability. Even as capabilities improved drastically throughout the eighties, nineties, and early 2000s, the demand for commercially generated imagery remained low relative to the massive capitalization required to start and maintain such a firm.

By 2010, the commercial space market, and the GEOINT marketplace in particular, had undergone a dramatic shift. This shift led to a US government interagency review and approval of relaxed resolution thresholds for public sale to 0.40m panchromatic and 1.6m multi-spectral imagery. This change balanced the risks and benefits to national security while allowing U.S. companies to sell improved resolution imagery on a now competitive global market. By this time, satellite components had become more widely available and interoperable with other industries, making their fabrication and purchase much easier and cost-effective as the computer processing industry drove components ever smaller, making massive and expensive space buses increasingly unnecessary. Perhaps most importantly, national governments lost their monopoly over space launch as commercial providers competed to provide cheaper and more frequent launch opportunities. An industry that had required hundreds of millions to billions of dollars to put a single asset in orbit suddenly saw the possibility of putting hundreds of similarly capable platforms in orbit for a fraction of the cost. Venture capitalists and data brokers observed this market shift and began investing small quantities in start-ups, fueling an explosive growth in the number of commercial imagery providers. These companies, no longer indebted to the US or other national governments for their survival, found a burgeoning group of industry customers hungry for information on consumer trends, environment changes, or competitor activity. The US government has become just one customer among many.

In contrast to traditional commercial GEOINT providers, the emerging small satellite companies offer a wide range of capabilities, mission profiles, and delivery models. As of early 2015, projections indicate small satellites will vary in resolution from 0.5 to 5 meters, coverage gaps will range from 1 to 10 minutes for points on the earth, and imaging will extend from pole to pole thanks to a wide variety of orbit types and inclinations by 2018. The combination of constellations will generate imagery of the entire globe on a daily basis. Deriving operational value from these capabilities, though, demands flexible delivery models that reduce latency and make information available in operationally relevant timelines. The Air Force will be able to access GEOINT via direct downlink, commercial relay, web services, or a combination of all of these to shorten timelines and maximize impact. Tasking of the constellations will also vary from more traditional collection decks to purchase of streaming data. Regardless of access and tasking models, the Air Force must appropriately tag and track information gained from commercial providers to maintain data pedigree and custody to enable analytical and operational trust. Operational trust requires not only the tracing of information provenance, but also measures to control both quality and adversary access.

Tenets

Four tenets describe the optimum employment of commercial space-based GEOINT capabilities. They ensure that new systems will be integrated across the ISR Enterprise, embedded within the ISR and operations decision loops, and employed to the full benefit of the operational and tactical user base.

Density and Diversity in Sensing

Market changes have moved commercial space-based GEOINT from low-density to high-density constellations by launching many more satellites than ever before. The revisit rates of these emerging commercial constellations will dwarf those of current space-based capabilities. Frequent revisits will reduce gaps between collection to single-digit minutes for any point on the earth by detecting activity that may be missed at lower revisit rates, a vitally important factor in change detection and targeting. The emerging commercial constellations will also have a much more diverse mix of sensors, likely including visible, infrared, hyper- and multi-spectral, and RADAR. This combination will permit analysts to detect and locate more targets than before as well as discern changes in targets over both the short- and long-term, particularly when considered in conjunction with more exquisite national and service capabilities, thereby enabling a deeper characterization of the battlespace.

As noted in the *Sensing as a Service* vision, “sensing embraces a closed-loop concept of distributed computing and collaboration that optimizes the real-time mix of responsive sensing, automated exploitation and fusion, human analytical skill, and agile decision making. Sensing enables speed of command.” Diversity in sensing, which includes commercial space-based GEOINT combined with many other sources, will permit the Air Force to hold camouflaged, covered, buried, mobile, and fleeting targets at risk. Varied collection phenomenologies will also allow for continued ISR operations through, around, and into adverse weather. Greater tracking of weather patterns will generate a more coherent and fused battlespace awareness for command and control.

Tenets of Commercial Space-Based GEOINT

- Density and Diversity in Sensing
- Mission-Aware Collection Optimization
- Adaptive Delivery
- Dynamic Industry Engagement

Mission-Aware Collection Optimization

Commercial space-based GEOINT must be able to provide timely, flexible products that can service the varying DoD requirements from contingency operations to theater security, disaster response, and humanitarian assistance. As in the *Battlespace Networking* vision “*mission-aware information exchange*” tenet, commercial space-based GEOINT will act as a source of “information objects” that “will carry the metadata that controls how they will be prioritized, who can access them, and what parts of the information can pass through automated multi-level security gateways to reach other systems and networks, including legacy and coalition networks.” In short, commercial space-based GEOINT will serve as one input to collection and data management via system to system automation. At the same time, Air Force and DoD efforts to employ commercial space-based GEOINT collection management must link to larger national intelligence community and theater systems. However, nationally derived analytical algorithms will not necessarily fulfill all service-level needs.

Commercially derived algorithms carry enormous potential for first-order analysis because they harness the power of crowd-sourcing techniques in building information objects. Installation of flexible architectures will permit the results of these analyses to flow directly to multi-source visualization tools and to tactical customers for situational awareness around the world. Acquisition via data brokerage will alleviate some concerns about security of US ISR operations. These middle layers will allow for greater efficiency in tasking and information gathering while obscuring the targets of interest to the US government. A diverse base of ground stations, data downlink services, and data aggregation/management will generate a more robust but unconventional approach to ISR operations

security. When combined with airborne and national ISR collection, the Air Force will be better postured to satisfy the challenging ISR needs of the targeting cycle against mobile, agile targets.

Adaptive Delivery

Rapid delivery of enhanced analytics must occur at the lowest possible classification. Movement of unclassified commercial space-based GEOINT through classified analytical constructs will likely introduce significant time lag, thereby stunting the tactical viability of the information provided. Instead, the Air Force should employ a flexible architecture capable of aggregated analytics and dissemination as well as direct downlink to appropriate tactical users. Such a flexible model allows not only for tailored information provision but also for coalition building. The sharing of commercial space-based GEOINT will allow fielded forces, often working in multi-national coalitions, to operate from a common lexicon and awareness of the battlespace. They will be able to jointly prosecute targets of interest without fear of classification limitations and employing both US and Allied commercial systems. Forces engaged in combined operations will find their governments linked not only by security cooperation but also by economic integration of sources.

The targeting intelligence mission area is heavily reliant on GEOINT data and could leverage commercial space-based GEOINT in every step of the targeting cycle. Most importantly, commercial space-based GEOINT offers a readily available source for tipping and cueing of more exquisite national and airborne assets to generate approved target materials. Commercial space-based GEOINT offers a potent means by which to maintain custody of targets, monitoring changes and relaying them to the appropriate intelligence and operations personnel for prosecution.

The most important distinction between DoD and national consumers of GEOINT lies in the timelines necessary to impact decisions. Operational and tactical users often need information to affect decisions within minutes of collection while national, strategic decision-makers operate within more deliberate, multi-hour/day timelines. Consequently, the federated architectures described above must operate in conjunction with automated systems optimized to push analytics to the tactical user at the lowest possible level in the shortest possible time.

These same tactical users must also have access to appropriate reference GEOINT products for any point on the earth. Access to commercial space-based GEOINT thus will include avenues to gain and view information previously collected and indexed in a common database. In that way, tactical analysts and operators will have the ability to make updated judgments based on recent events with the benefit of access to the storehouse of materials previously made available relating the area at hand.

Dynamic Industry Engagement

The DoD and Services must realize that they will be customers, not owners of the commercially generated GEOINT. Opportunities to influence this rapidly changing industry will be fleeting as innovation, whether in space sensors or data processing, does not rest solely with the US government. Commercial firms also offer a significant source of new ideas that carry potential efficiency improvements or collection phenomenologies. Small startup companies address many of the same information technology, communications, and energy challenges that face the Intelligence Community (IC); ignoring those overlaps risks missing the best available ideas or, perhaps worse, giving the resultant information advantage to future adversaries.

Consequently, the services and DoD need to dedicate a cadre of knowledgeable people to monitor the emerging commercial space business while remaining cognizant of military operational needs. This team must build relationships with the commercial world to ensure continued access to these vital and dynamic sources of new ideas and monitor the continued viability of the business models adopted by each firm. The space business awareness team would function much like the corporate strategic investment groups found at companies such as IBM, Google, and Disney. As strategic advisors, this cadre would inform leadership about startup companies that have developed commercially-focused technologies that will deliver targeted, ready-soon innovation (within 36 months) to serve the broader ISR mission. Access to small repositories of capital investment funds would permit the business awareness team to influence or accelerate product development and mission-critical capabilities with the sole purpose of delivering these cutting-edge, commercially-focused technologies to ISR end users quickly and efficiently.

Partnering with independent companies dedicated to surveying the startup market for innovative technologies will address both commercial market and government needs. Such firms conduct extensive technical and business due diligence to ensure that promising portfolio companies deliver technical superiority. The business models of these emerging companies vary not only with respect to the method of delivery but also with the information delivered. Harnessing advancements in machine processing and object recognition, some firms have developed advanced algorithms and intend to provide first-phase (and beyond) analytics, even as other firms intend to provide raw data.

Summary

Ultimately, the Air Force requires persistence over targets in order to maintain custody and hold those targets at risk anywhere, anytime. Employing commercial space sensors could optimize the reallocation of exquisite sensors on to the targets that require more detailed knowledge with reduced fear of attack in anti-access or denied environments. Commercial space-based GEOINT is a diverse, distributed collection mechanism that the government can use without the onus of building or maintaining the physical constellations. The Department of Defense must explore the viability of these systems as important contributors to the ISR enterprise delivering a more agile and responsive system to global and theater requirements. The US has long enjoyed a near monopoly on information in operational theaters. The democratization of space access and information, however, means that the US must focus on generating knowledge from data faster and more efficiently. Commercial space-based GEOINT and related networks will optimize the employment of airborne, terrestrial, seaborne, cyber, and other space-based platforms. The resultant network of networks will integrate sensors at multiple levels of security from all domains in an adaptable, robust, and open Information Technology (IT) architecture.

This emerging commercial space earth observation marketplace will increase GEOINT collection resilience while concurrently offering the DoD global persistence against individual points. As hundreds of revisits and accesses per day combine with varied sensing phenomenologies the DoD will realize a revolutionary capability to maintain custody for targets of interest. Unlike that found with previous space-based technologies, the new marketplace will drive rapid technical refresh, necessitating an agile, federated, and distributed IT architecture to employ these new data. In short, US purchasing should focus on architectures, data conditioning, and analysis rather than sensor development and operation.

AF ISR 2023 challenges the Air Force ISR enterprise to break the linear relationship between the quantity of collection and the manpower needed to analyze the data and produce actionable intelligence. Another challenge, delivering decision advantage, requires data and refined intelligence to be made accessible, timely, and relevant for operational users. Commercial space-based GEOINT offers a partial

solution to many of these problems and a near-complete solution when combined with more exquisite service and national systems. The growth of the commercial space earth observation marketplace, due in large part to reduced costs of production, launch, and maintenance, holds great promise for the future of the ISR enterprise as it offers new means to provide GEOINT to all echelons in tactically relevant timelines. At the same time, the vitality of the industry via responsive space launch and multi-corporation competition brings with it the possibility of greater technical refresh and a continued exponential growth in capability over time. Commercial space-based GEOINT represents a global technology leveling; the Air Force must leverage the capabilities now to remain competitive with and aware of global adversaries.