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THE FUTURE OF UBIQUITOUS, REALTIME INTELLIGENCE: A GEOINT SINGULARITY

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Summary

When assessing the trends of global connectiveness, commercial remote sensing from space, and advances in artificial intelligence (AI), the trends point toward a future where information and overhead imagery will become available to the general public in near-realtime. The rise of large constellations with remote sensing satellites and capabilities ranging from synthetic aperture radar imaging, nighttime imaging, and infrared imaging is a global phenomenon. Coupled with AI analysis, data from different sensors can be combined, processed and made useful for a specific user's needs on handheld devices worldwide. Large constellations of communication satellites and the rollout of 5G in metropolitan areas will provide the data pipeline needed to reach users globally at broadband speeds. A scenario, coined the Geospatial Intelligence (GEOINT) Singularity, is a future where realtime Earth observations with analytics are available globally to the average citizen on the ground providing a tremendous wealth of information, insight, and intelligence. Civil application could include identifying an empty parking spot from space or tracking autonomous vehicles in smart cities. These developments will likely not be contained within the U.S. but will be a worldwide phenomenon. The opportunities seem immense, but what would the availability of ubiquitous, realtime intelligence mean to the military operator and warfighter? The U.S. approach to commercial remote sensing has been to regulate and limit the imagery that can be taken from space, but international capabilities will not be so easily curtailed. Has the time come for the military operator to find better ways to hide, rather than tell someone not to look?

Introduction

The industrial revolution marked a major turning point in history: almost every aspect of daily life was influenced in some way. Our society has been undergoing a similar revolution from a mass production society to an information society where the line between physical systems, data, and cyber becomes ever more blurred. Advances in AI are influencing our behavior, and interactions between humans and machines are becoming indistinguishable. [1]

Here, we discuss how advances in AI, satellite-based sensing and imaging, and an increasingly connected world enable a society with realtime access to global information, services, and intelligence at its fingertips. Whether such a future is real, or even achievable, is not debated here, but the trend is real. For the purpose of this discussion, the term *GEOINT Singularity*[2] is defined as ubiquitous intelligence available to the general public[3] in realtime (Figure 1). We cover advances in

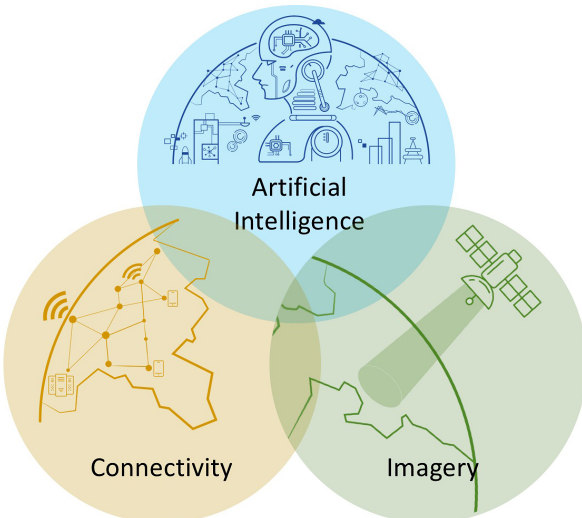

Figure 1: GEOINT Singularity. *GEOINT Singularity is the convergence, and interrelated use, of capabilities in artificial intelligence, satellite-based imagery, and global connectivity, where the general population would have realtime access to ubiquitous intelligence analysis.*

three areas—remote sensing data, artificial intelligence, and global connectivity—as enabling factors for a GEOINT Singularity. The focus here is on the effect on military operators and warfighters but acknowledges the privacy concerns of people around the world. Overhead imagery available to all (including governments) may certainly raise such privacy concerns. Some argue that the surprise attacks of the past are gone and that it is getting more difficult to stage an attack in a world that is becoming more transparent.[4] However, denial and deception (D&D) and disinformation techniques applied at appropriate levels will be key in military operations in a future of global realtime intelligence.

GEOINT Singularity is a hypothetical concept and, while we may certainly approach it, we may not actually reach it. There are several reasons why this could be so:

- Demand may not be sufficient for a commercial market providing access to remote sensing analytics in realtime on a global scale.
- The recipient of data may always experience a time lag to account for the time it takes to receive, analyze, and distribute data and analytics.
- Obtaining realtime analytics may be too cost prohibitive for a general user.
- Bridging the digital divide by deploying large constellations of communication satellites may only shift the divide to one side but not completely close the gap between those who have and have not.

Nevertheless, the trends are clear: proliferation of remote sensing space systems providing continuous monitoring; advancements in AI to analyze large data sets and provide analytics; and global communication and connectiveness, making such analytics accessible to a general user, are discussed in the following sections.

Artificial Intelligence, Machine Learning, and Deep Learning[5]

Often terms such as *machine learning* and *artificial intelligence* are used interchangeably. However, there is a distinction between these terms and they can be thought of as subsets of each other. **Artificial intelligence** (AI) is the overall umbrella term describing a branch of computer science studying the capability of a machine to imitate human intelligent behavior by performing tasks that typically require a human to perform such as visual perception, speech recognition, and complex decisionmaking. **Machine learning** is a particular method in the field of AI that provides computers the ability to learn without being specifically programmed for a particular task. Particular algorithms process input data and desired outcomes attempting to minimize prediction errors, for example, through a neural network algorithm. The more training data provided to the algorithm, the better (typically) the algorithm is in predicting the desired output. **Deep learning** is a subset of machine learning where the term "deep" refers to an increased number in hierarchies and layers in a neural network, providing it with ability to learn more complex relationships between input and output data.

Major Trends Leading to a GEOINT Singularity

Commercial, Space-Based Remote Sensing

In previous years, there was a clear trend to improve resolution of space-based platforms. However, the trend to continuously increase resolution seems to have slowed down, just like the well-known Moore's law has slowed from the original doubling of transistors on an integrated circuitry board every 12 months to now 24 months due to physics limiations. Today, companies are competing increasingly on multispectral capabilities, nighttime sensitivity, infrared, synthetic aperture radar (SAR) capabilities, and on revisit time. Recent commercial initiatives focus on decreasing revisit time by building constellations of satellites with a variety of capabilities instead of a single satellite. Companies seem to have concluded that it is more cost effective and profitable to launch a large number of small satellites rather than to invest in a few, heavy Earth-observation platforms like WorldView 3 (imaging at 0.31 meters resolution) from DigitalGlobe (now part of Maxar).[6] Planet, a U.S. company operating a constellation of Earth-observing small satellites, certainly adopted that early on with a mission statement to "image the entire Earth daily." Today, Planet has reached its goal by operating the world's largest constellation of small satellites with approximately 150 orbiting platforms.[7] Compared to WorldView 3, Planet images at coarser resolutions of 5, 3, and 0.72 meters (depending on the platform). This section provides just a few examples of remote sensing companies.

Planet is likely to see competition. EarthNow[8], a Seattle-based company backed by SoftBank, Airbus, Bill Gates (Microsoft), and Greg Wyler (OneWeb and O3b Networks) plans to launch about 500 small satellites offering video coverage with "live and unfiltered" footage of almost anywhere on Earth.[9] The company plans to provide the footage to smartphone applications with little time delay to track illegal fishing, animal migration patterns, and forest fires. Other possible applications include mapping and guiding traffic flows through a "smart city" and realtime media reports of events happening in remote sites. Military operators should pay attention. EarthNow intends to sharply reduce design and production costs by using an upgrade of the basic satellite platform and assembly-line manufacturing techniques already devised by OneWeb. The company says that by incorporating substantial computing power on each platform, called "the Model T of spacecraft," it will provide more timely and useful video images than its rivals. Even though each satellite would collect colossal quantities of data—far too much to send back to Earth in realtime—the software would be able to process it all onboard and only send back data that individual users want to see.

Live Earth[10], another example, is a Utah-based company built around advancements of optical sensor technology with the purpose of expanding the capabilities and uses of geostationary remote sensing systems. The plan is to offer instant access to live, continuous imagery of events on Earth. The imagery would not be as highly resolved as with an equivalent system in low Earth orbit, but instead emphasizes the unique attributes of a geostationary orbit for continuous monitoring. The proposed applications include natural disaster relief, maritime awareness, and national security. In particular, defense and intelligence customers, according to the Live Earth website, would benefit from intelligence on the movement of hostile forces.

While EarthNow and Live Earth are both U.S.-based companies and appear to have prominent backers with deep pockets, the international market also presents some competition. SatRevolution[11], a Polish company funded by the European Commission, is planning to develop a realtime Earth observation constellation. The satellite would reach a resolution of 0.5 meters using a 6U CubeSat with a deployable telescope. The company plans to launch 82 satellites achieving realtime electro-optical imaging with a revisit time of less than 1 hour. Possible applications include crisis response, environmental monitoring, smart city support, logistics, and traffic monitoring. The imager would consist of a hyperspectral imaging detector with adaptive optics and onboard AI processing. The first satellite on orbit is scheduled for 2019 (full operational constellation by 2023) with a four-hour revisit time and "realtime" capability by 2026. SatRevolution (being a Polish company) would not be subject to U.S. regulation and could image and sell information as they wish, subject to Polish and European law and regulation. Imaging in different spectral bands, including short-wave infrared imaging (SWIR), nighttime, or with synthetic aperture radar (SAR), as compared to imaging with increasing revisit frequencies, may not be the only concerns to the national security community and ultimately the military operator. Enter Data Analytics.

Data Analytics

Combining information from various spectral domains that provide complementary insights, or even with data from online records (Twitter, Facebook, and Instagram, for example), as well as using advanced analytics, deep learning, and AI in general will truly be a game changer. Remote sensing satellites produce vast amounts of data. So much data, in fact, that in 2017 the former director of the National Geospatial-intelligence Agency (NGA), Robert Cardillo, said that in about 5 years the agency would be dealing with "a million times more" data and in 20 years would need to employ 8 million analysts to handle the load.[12] The solution to this trend is automation in the form of AI. While the more traditional remote sensing companies, such as Maxar, Planet, and Spire pursue both hardware in space and analytics on the ground, other companies such as Ursa and Descartes Lab focus on data analytics alone.

The company Ursa Space Systems, headquartered in Ithaca, New York, recognized the disconnect between information-rich satellite data and those who could really use it. Ursa and its founder, Adam Maher, realized that there is a plethora of data already available and decided on a different approach rather than building SAR satellites. Ursa has been quite successful in analyzing existing data and making it usable for customers. For example, Ursa has developed a proprietary algorithm using data purchased from SAR satellite operators to analyze and estimate global strategic petroleum reserves. Typically, stockpiled petroleum reserves are officially reported by nations but are often deliberately inaccurate. Ursa can help investors understand what exactly is in storage. Typically, low storage means high demand, and high storage means an oversupply and a potential price drop. There is an interesting aspect to this company from a regulatory perspective. Since Ursa is simply purchasing global data and not actually operating satellites, it is not subject to the U.S. regulatory framework. Moreover, while some national security stakeholders may want to restrict U.S.-based SAR companies from selling specific data, Ursa and other companies can purchase data from non-U.S. companies. Such a restriction on U.S.-based data could be inconsistent with a national policy designed to enable the competitiveness of the U.S. space sector.

Similar to Ursa, Descartes Lab, a company, headquartered in Santa Fe, New Mexico, is focusing on data analytics rather than building hardware. They view the increase and diversity of data as a resource. To harness the power of multiple, complementary data sources and enable global-scale computation, Descartes Lab built a "data refinery" to clean up datasets and developed a platform with deep learning and other AI capabilities. Using SAR data, for example, the company has built models to identify new construction sites on the ground regardless of weather conditions. It can also identify agricultural field boundaries and automatically classify the crop growing in each field. Descartes Lab, according to a major new outlet, has been noted as a promising startup to watch among a list of companies "breaking industry barriers".[13]

Artificial Intelligence and Machine Learning

Technology trends are advancing, and there are indications that a "sixth wave of innovation" is coming. The Russian economist Nikolai Kondratiev first postulated the major cycles of innovation in 1925. The five initial major economic cycles have been defined as the industrial revolution; the age of steam and railways; the age of steel and electricity; the age of oil, cars, and mass production; and the age of information and communication. Each wave lasted from 40 to 60 years and consisted of alternating periods between high and slow sector growth.

The sixth cycle is postulated by some as an increase in resource efficiency.[14] A new wave would be heralded by massive changes in the market, societal institutions, and technology that all reinforce each other and are centered around connected intelligence with new devices, new applications, new business models, and new services. Space-based commercial remote sensing services that create massive datasets, joined by AI for analysis and product development, will be just one aspect of the innovation wave. Current prices for electro-optical data are around $5/km^2 image and prices are dropping at a rate of 3 percent to 5 percent per year according to EuroConsult.[15] New lower-cost data is expected to challenge current high prices as the electro-optical imaging supply is anticipated to expand rapidly in the coming years, increasing the supply. Some economists claim that this will add to competition and make it possible for supply to start outstripping demand. However, new markets have opened up as data-hungry AI has become more established and demand has increased. Further strengthening the trend is a noticeable shift from investment in new satellite operations to investment into new service companies aiming to exploit data based on change detection and predictive analysis.

Artificial intelligence, and deep learning in particular, hold the promise of enabling mass usage of satellite imagery services similar to how Geographic Information Systems (GIS) enabled the satellite remote sensing business to provide value to consumers 15 years ago.[4] GIS will continue to play a role as a foundation in storing, manipulating, and managing spatial data, similar to cell phone service as a foundation to providing the connectivity for apps on a smartphone. However, given the magnitude of data produced, AI will provide the analytics that sifts through the myriad satellite-based information, incorporate data from a variety of sources, and may even be used for on-orbit processing. NGA has been focusing on bringing automation to its geospatial analysis for some time, lamenting the fact that for all of its ability to amass satellite and other data, parsing that data often comes down to human analysts having to search images and videos in a time-consuming manual process.

General investments in AI are continuously growing. According to ABI Research,[16] the number of businesses adopting AI worldwide will increase significantly from 7,000 this year to 900,000 in 2022, with investments in AI growing at a rate of 4.5x. The future will make machine learning algorithms the norm for developing user applications rather than the subject of science fiction movies. Recent advancements in machine learning are significant. While complex algorithms have been limited to big tech companies like Google, Amazon, and Microsoft, today AI is becoming more affordable through a variety of open source software that allows building advanced self-learning systems.

Big data and machine learning are a match made in heaven. Machine learning without training data is impossible and training requires a lot of data. The more complex a machine learning algorithm gets, the more training data it requires. Last year, for instance, NGA collected more than 12 million images and produced over 50 million indexed observations.[17] AI has a great appetite for more data and will be the primary consumer of the immense increase in available data in the future.

While today the U.S. may still be a leader in AI, China is catching up. Years ago, IBM Watson began as a research project and first attracted headlines as the algorithm that beat human contestants in the TV show *Jeopardy*. Today, Watson is used across many sectors around the world to boost revenue and efficiency, and even save lives. However, China may soon be leading the development of AI. A few years ago, Chinese technology entrepreneurs were focused on repeating (and copying) Western success stories. Today, China is determined to be the tech industry leader in AI. In 2018, the total global investment into AI-focused startups amounted to $15.2 billion worldwide—of which China accounted for nearly half of that—while the United States' investment reached only about 38 percent.[18]

Global Connectivity

Many have postulated that global connectivity and advanced networking will drive the development of new products and services. Next generation technologies such as 5G, low Earth orbiting satellite constellations, and meshed networks will support data-hungry consumers and bridge the digital divide. For example, OneWeb, founded in 2012, started with financial support from companies including Airbus, Coca Cola, Qualcomm, and Virgin Group. The mission statement of OneWeb is to bridge the global digital divide by operating a global network of satellites in low-Earth orbit. In the summer of 2017, OneWeb received approval with an FCC license[19] to access the U.S. market with 720 satellites and service customers. The first six demonstration satellites launched in 2019.

Competition for global connectivity comes from SpaceX's Starlink, which also received FCC approval[20] but for over 12,000 satellites for a space-based Internet communication system. In particular, SpaceX plans to place several shells of satellite constellations in Earth orbit. Deployment of these constellations will take decades and estimated costs are nearly $10 billion, as Gwynne Shotwell, president and COO of SpaceX, stated in a TED Talk in May 2018. Terrestrial competition will come from 5G suppliers worldwide.

Certainly, the trend of increasing global connectivity with broadband services is clear. Global communication networks, whether space-based or terrestrial, promise to deliver data, analytics, and intelligence to a user worldwide. While these global communication networks target the general public as a customer, they often rely on government as an anchor tenant to make the costly endeavor financially feasible. Communication traffic from the public and potentially from military operators will be routed through the same networks making them opportune targets for deliberate disruption. The events of Ukraine in 2014 and Georgia in 2008 suggest that communication networks can break down quickly.

In addition to space-based and terrestrial-based networking advancements, access to intelligence, data, and analytics comes in the form of apps on smartphone devices. In 2014, Ericsson's annual global connectivity report predicted that by 2020, 90 percent of the world's population aged over 6 years will have a mobile phone. In June 2019, the Ericcson report[21] assessed that mobile broadband providers will service over 9 billion subscriptions worldwide by 2024 indicating the people will have multiple mobile broadband devices and multiple subscription (Figure 2). Note the worldwide population forecast for that time is around 8.1 billion people[22].

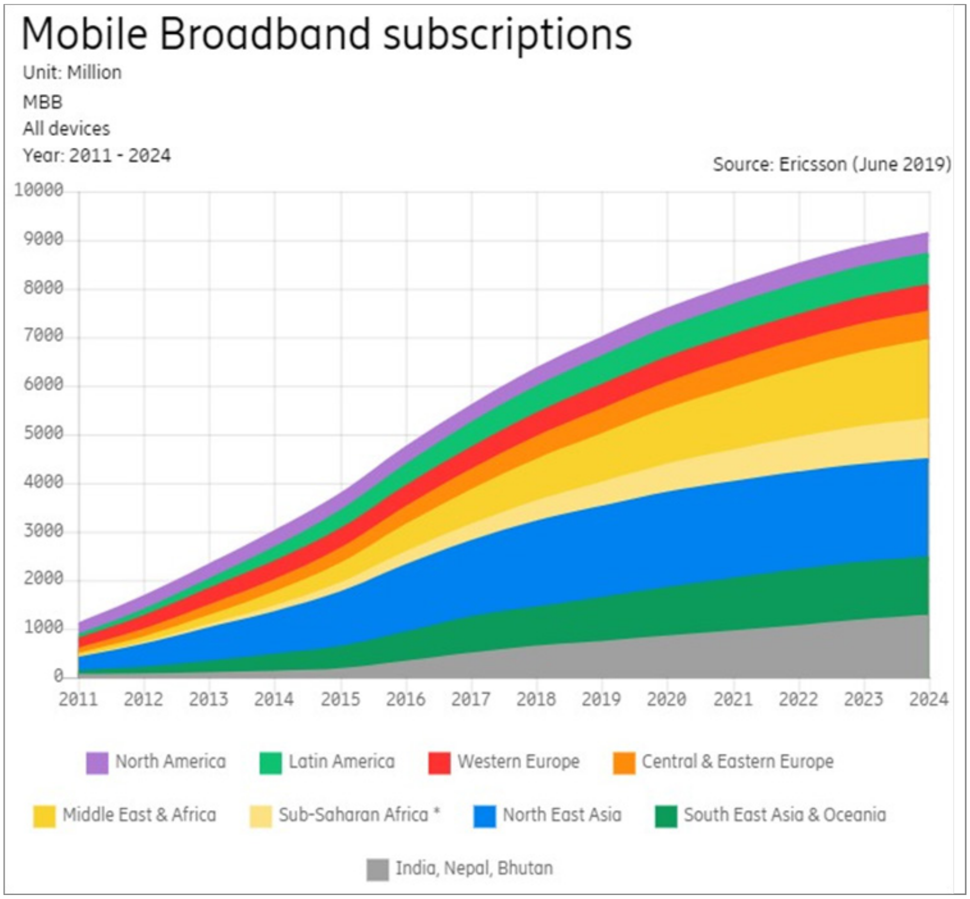

Figure 2: Ericsson Prediction. *Past and future broadband mobile subscriptions as of June 2019.*

Combining the described trends of (1) increasing imaging data supply through new satellite companies entering the field, (2) advancing AI, and (3) increasing global connectivity, the trend toward satellite-based information available in realtime to the general consumer is real—the GEOINT Singularity. While experts agree that increased commercialization of satellite-based remote sensing is leading to more global transparency, the effects on national security and military operations remain under debate. Some argue that the increased transparency will increase the predictability of adversaries: staging areas for surprise attacks in the physical domain will become difficult. Of course, this is a double-edged sword. The question remains: As we trend toward more global transparency, how can a policymaker assist military operators to still maintain the benefit of surprise? Traditionally, this has been attempted through licensing and license restrictions.

The U.S. Regulatory Framework for Commercial Remote Sensing

The U.S. framework for licensing commercial remote sensing systems was implemented through the National and Commercial Space Programs Act (2010) and the Land Remote Sensing Policy Act (1992), which state that no U.S. person or entity may operate a remote sensing space system without a license that has been authorized and granted by the Secretary of Commerce. The responsibility to license is currently delegated to the Administrator for the National Oceanic and Atmospheric Administration (NOAA). In addition to the legal framework provided by law, additional specifics are provided through the Code of Federal Regulations (CFR) in 15 CFR Part 960 and policies such as the National Space Policy of 2010 and NSPD-27, which is partially classified.[23] By law, the Secretary of Commerce can only grant a license that complies with all applicable international obligations (determined by the Secretary of State) and all national security concerns of the United States (determined by the Secretary of Defense). This is where interagency discussions take place. The Office of the Secretary of Defense will tend to advocate to satisfy national security concerns, and the Office of the Secretary of Commerce will tend to promote commercial competitiveness. Notable license conditions include resolution limits over Israel, traced back to the Kyl-Bingaman Amendment, and resolution limits of electro-optical imaging[24] at 25 cm. In addition to resolution limits, every license has a provision allowing for the U.S. government to invoke “shutter control.” According to general license provisions, shutter control is invoked during periods of exceptional circumstances to meet significant concerns about national security or foreign policy and requires a licencee to limit data collection and/or distribution at specific times and in specific geographic areas. However, the discussion is shifting given the tasks laid out in Space Policy Directive 2 (SPD-2)[25] and the recently published Notice of Proposed Rule Making by NOAA in May 2019.[26]

A Comprehensive Risk Assessment Framework

When license conditions are determined through an interagency coordination process, in particular those pertaining to national security, the stakeholders evaluate risks and benefits. The risks to national security from overhead imagery and information being disseminated broadly can be wide ranging: adversaries could track the movements of U.S. and allied military equipment, detecting patterns of training and operations; hyperspectral imaging can identify chemical compositions; short-wavelength infrared imaging can see through clouds; and SAR sensors can image at night. When determining risks to national security, one can define it as the risk of being seen or detected. The risk of an operation being detected during a specific time depends on two variables: the operation or mission occurring at a specific time and a satellite remote sensing system looking at the specific time in the specific direction with the right sensor (i.e., an observation occurring). Together, the operation and the observation provide the risk of detection as shown in Figure 3.

In order to reduce the risk of detection, the military operator can either choose not to operate or maneuver during a given time or to somehow control the observation. Shutter control is an option to limit the observation and thereby minimize the risk of detection. The process for requesting shutter control or limiting an observation is time consuming and has to progress from a military operator to the Chairman of the Joint Chiefs Staff, to the Secretary of Defense, and to the Secretary of Commerce, who then notifies the company operating the satellite. Nevertheless, it is important to keep in mind that such restrictions only apply to U.S. entities operating in space and do not apply to high-altitude pseudo satellites (HAPS; i.e., balloons) or international space companies and foreign

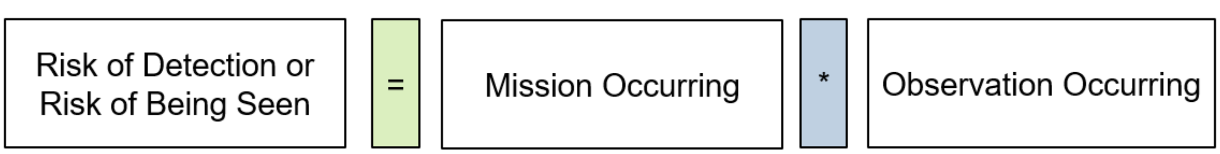

Figure 3: Risk of Detection. *The risk of detection can be summarized in two components: the risk from an observation occuring and the chances of a mission being conducted.*

governments. Diplomatic mechanisms exist for the U.S. government to request shutter control and other provisions specifically through space cooperation agreements, but those mechanisms remain largely untested and some say an untested capability is not a capability.

Capabilities of satellite remote sensing systems are not constant but continuously improve in various aspects. When assessing risks to national security, simplified here as *risk of detection*, the process of determining appropriate license conditions and the need for limiting observation traditionally only takes into account the known capabilities of past and existing space systems. This often leads to the statement that "policy lags behind capabilities." While it may not be possible to account for specific capabilities of planned and proposed systems because they may or may not become reality, the national security community should not be deterred from taking trends into account when assessing the risks to national security.

In consideration of the broader context, the risk of detection by limiting an observation comprises several components, out of which only one can be regulated—the U.S. commercial satellite remote sensing sector—whereas, imaging from high altitude platforms and by foreign nations cannot. Commercial imaging capabilities are certainly increasing, not just domestically but globally. In the changing world of increasing imaging capabilities, the risk of detection by observation could only be held constant (at best) if regulations are increased and strengthened. However, this would be inconsistent with domestic policies of advancing competitiveness of the U.S. commercial sector. Often the risk from unregulated capabilities (international commercial and governmental, HAPS) is neglected and license conditions are imposed based on domestic commercial platforms, as if the risk would only be from the domestic sector alone (Figure 4). However, imposing stricter regulations may provide a false sense of security because the growth of international capabilities is neglected. On the other hand, increasing regulation is free of charge and has no immediate cost imposed on those who advocate for it. This is a true "regulatory paradox" in the commercial remote sensing market.

Options to Break the Regulatory Paradox in Commercial Remote Sensing

Instead of increasing U.S. remote sensing regulation, other mitigation techniques will have to be found that also support maintaining U.S. commercial competitiveness. Options to reduce the risk of detection to the military operator could

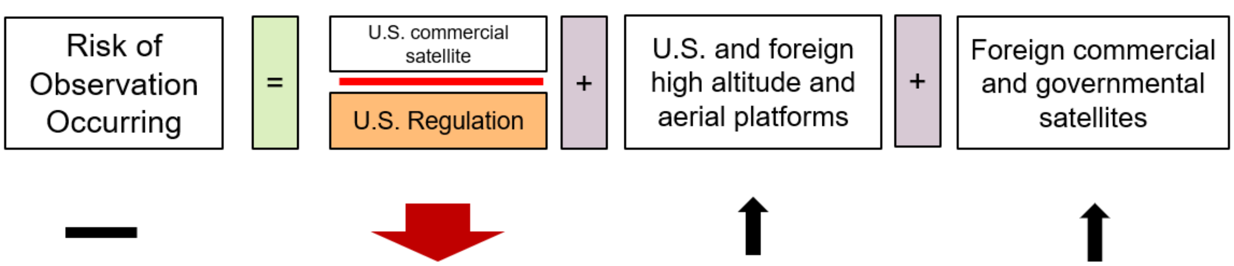

Figure 4: Risk of Observation. *In order to keep the risk of detection by observation steady (at best), regulatory restriction would have to increase and become more restrictive at the same time that international and domestic, unregulated capabilities are becoming more available. However, the U.S. government tends to lessen restrictions imposed on U.S. companies to enable competitiveness in the remote sensing market, which leads to an overall increase in the risk of detection. As restrictions decrease and international capabilities increase, military operators have no choice but to accept the additional risk or develop countermeasures and new doctrine.*

include limiting the advancements on data analytics, artificial intelligence, and global connectivity to maintain a certain opaqueness and element of surprise. However, those may not be viable in Western societies where the freedom of information is valued, and free markets and innovation are high priorities identified in national policies. Some argue that the risk of detection is already assumed in existing military doctrine, although how much risk is unclear.

If increasing regulation is not a good choice, what remains is to improve D&D and disinformation techniques to maintain the advantage or element of surprise. Surprise is one of the nine fundamental principles of warfare, described in the U.S. Army Field Manual.[27] Surprise is to strike the enemy at a time or place or in a manner for which they are unprepared. Surprise can decisively shift the balance of combat power. By seeking surprise, forces can achieve success well out of proportion with the effort expended. The U.S. Army field manual notes that rapid advances in surveillance technology and mass communication make it increasingly difficult to mask or cloak large-scale marshaling or movement of personnel and equipment. However, the manual does not appear to offer a solution.

Nearly 20 years ago, a thesis titled "The End of Secrecy" by Lt. Col. Beth Kaspar (U.S. Air Force), discussed the implications of transparency to U.S. military competitiveness and recommended a variety of activities ranging from innovating new doctrine and developing fast decisionmaking processes to integrating camouflage, concealment, and deception both vertically and horizontally into military operations. In her thesis, Lt. Col. Kaspar stated, "DoD should go back to basics and actively incorporate deception into all organizational levels and all levels of warfare". [28]

Typical denial and deception techniques, such as camouflage, are well known to military operators and warfighters. However, when approaching a GEOINT Singularity, traditional denial and deception techniques may not be sufficient and will have to be advanced in ways that cope with frequent and continuous observations in various bands of the electromagnetic spectrum. Fewer or no time windows will exist without a satellite passing over or other capabilities that could detect an activity. Conceptual D&D methods dealing with reducing transparency and maintaining an element of surprise are listed in Table 1; specific methods and programs of D&D are beyond the scope of this unclassified discussion.

Table 1 illustrates a number of potential active and passive measures that could be incorporated and taken during peace time or during times of heightened risks to national security. Active measures could be reserved for conflict situations against adversaries and may be inappropriate to use against assets operated by friendly governments or the U.S. private sector. Passive measures could be used at any time as they would not harm or negatively affect the operation of a remote sensing system. Note that none of these measures attempt to slow down the three trends towards a GEOINT Singularity but instead provide independent ways and means to permit a military operator to complete a mission while remaining undetected.

The approach of improving D&D techniques instead of regulating the domestic commercial satellite remote sensing sector bears several advantages, which include:

- Improving D&D techniques against domestic commercial capabilities will likely also advance those techniques against foreign military capabilities.
- Reducing the regulatory burden will permit the domestic commercial remote sensing sector to remain innovative and competitive on a global scale.

Table 1: Active and Passive Measures. Mitigating risks of detection from a military operator's perspective is dependent on the remote sensing capabilities and wavelength domain of the space remote sensing system and can be divided into active and passive measures.

	Active Measures (likely reserved for extreme situations)	Passive Measures
Electro Optical (EO) (visual spectrum) Synthetic Aperture Radar (SAR) Short-Wave Infrared (SWIR) Hyperspectral Imaging (HS)	♦ Jamming sensor ♦ Jamming communication links ♦ Lasing sensors ♦ Cyber defense methods ♦ Misinformation	♦ Lower emission and reflectivity ♦ Operate at night ♦ Operate under clouds ♦ Reduce size ♦ Exploit time delays ♦ AI spoofing ♦ Mimic innocuous activity

- Supporting increased innovation in the field of commercial remote sensing, artificial intelligence, and global communication will provide new capabilities for the nation, including for national security purposes.

- Using commercial imaging can be used to support public messaging without revealing the capabilities of governmental systems.

The advancements of new D&D (Table 1) may appear costly at first. However, it should be evident that simply placing remote sensing license restrictions is not free either. Remote sensing license restrictions simply delay the the cost to a later time when existing D&D methods have become ineffective due to the growth of foreign remote sensing capabilities.

At the same time Lt. Col. Kaspar called for new doctrine to deal with increased transparency, The RAND Corporation published a book about the "leading edge of global transparency" and highlighted policy issues with international security case studies in a world of increased transparency.[4] Both reports recognized and predicted a further increase in global transparency almost 20 years ago and called for innovative doctrine to handle the increased tranparency. It is unclear, however, how much military doctrine improved and integrated new D&D to keep up with the trend toward global transparency.

Conclusion

The general public may have increased privacy concerns when approaching the GEOINT Singularity, but military operators should be working now to mitigate the implications of the general public having access to ubiquitous intelligence in realtime. Traditionally, the national security community attempted to maintain a certain level of opaqueness or surprise by limiting commercial space-based imaging through regulation. However, that approach has provided a false sense of security and neglected developments that are not under U.S. regulatory control such as foreign commercial imaging companies and advancements of foreign military capabilities. A broader framework for assessing the risks to the military operator within the looming GEOINT Singularity has been proposed here, and the advantages of improving denial and deception techniques at a tactical and operational level have been discussed.

Strengthening U.S. remote sensing regulation only applies to the domestic commercial sector and can be summarized as a "don't look" approach. Given the advancements in the three critical areas of artificial intelligence, global connectivity, and satellite imagery, a different approach focusing on denial, deception, and misinformation to maintain the element of surprise may be more appropriate and more future-oriented.

References

[1] Amazon's Alexa, Google's Assistant, and Apple's Siri are just the beginning. For example, Google made headlines in 2018 by demonstrating how its Google Assistant could make a restaurant reservation on your behalf. The restaurant was real, but the "person" making the call was an AI system able to interact with humans on the phone.
[2] Adopted from: C. Herring, J. Googasian, S. Truitt "The Geo Singularity", USGIF Jan 2019.
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