The Implications of Innovation in Space-Based Remote Sensing on Maneuver Warfare

by LTC Brad Townsend

Space technology is on the cusp of significant change that will substantially impact the nature of maneuver warfare in the near future. Change in space is being driven by sudden and dramatic decreases in the cost of reaching orbit, and the development of ever smaller and cheaper satellites that can be launched by the dozens to create networked global constellations far more capable than the larger and far more expensive satellites of the recent past.

The rapid pace of these developments and their implications for future warfare are something the military space community is finding difficult to understand and adapt to. As the space community struggles to understand the implications of these new capabilities within the space domain and wrestles with substantial organizational change, scant attention is being given to how these new capabilities will impact mounted-maneuver warfare.

Existing space capabilities enable modern armored warfare at both the tactical and operational level. The Global Positioning System (GPS) timing signal enables force tracking and effective encrypted communications. Beyond-line-of-sight communications and network access are functions of satellite-communications capabilities. Though underappreciated in the era of counterinsurgency operations, space-based infrared satellites underpin the effectiveness of time-sensitive warning and interception of inbound missile threats to ground forces.[1]

For the foreseeable future, these capabilities will continue to support maneuver operations in largely the same way they do today, albeit with more bandwidth and precision. One area of advancing space technology that will change how armored units operate is the rapid increase in the quantity and quality of near-real-time satellite imagery, especially to disadvantaged adversaries.

Surprise 'left hook'

In 1991 U.S. forces executed a sweeping "left hook" through the desert that bypassed Iraqi defenses, surprising the defenders and quickly overwhelming them. The battered Iraqi army, under constant air attack and struck in the flank by rapidly advancing armored forces, collapsed. A number of factors made this maneuver possible. The newly fielded and still only partially complete GPS constellation allowed accurate navigation across the otherwise featureless desert. Also, the coalition was able to safely stockpile enough fuel and other logistical necessities for this force to operate without outrunning its supplies.

Perhaps the most crucial factor in the attack's success, however, was the ability of coalition forces to stage in secrecy. With complete control of the air, the coalition was able to prevent the Iraqi military from conducting any aerial reconnaissance. Even a single high-altitude reconnaissance flight would have revealed the scope and scale of the coalition attack. With this information, the Iraqi army could have repositioned forces and constructed defenses to defend its flank.

It is highly unlikely that even with insight into the coalition battle plan, though, the Iraqi army could have changed the outcome of the Gulf War, but it certainly could have raised the price of victory.

The "left hook" of the Gulf War was a stunning success that is unlikely ever to be repeated due to evolving space capabilities that are making operational deception by large formations impossible. The movement of individual companies or even isolated battalions may go unnoticed due to the fog of war, but the unobserved positioning of larger forces is no longer possible. The U.S. Air Force may continue to dominate the skies and prevent aerial observation of staging areas by unmanned aerial vehicles or other aircraft; however, it cannot prevent satellites from passing overhead in the course of their normal orbits.

To be clear: the Desert Storm "left hook" could never happen again unnoticed. The recent and rapid proliferation of remote sensing satellites that produce various forms of satellite imagery has dramatically changed the paradigm of space support and its effects on maneuver warfare.

The U.S. military is not accustomed to considering the impact of satellite observation on operations because it has been largely irrelevant at the tactical and operational level. Until recently there were only a handful of imaging satellites in existence, and they could only image relatively small portions of the Earth's surface from low-Earth orbit (LEO).

Unlike geosynchronous orbit (GEO) where satellites remain stationary relative to the Earth's surface, imaging satellites are in LEO, between 250 and 400 miles in altitude. They circle the Earth once every 90 to 120 minutes. For reference, GEO satellites operate at an altitude of 22,300 miles above the Earth. At this altitude, they "fall" around the Earth at the same rate the planet rotates, meaning that they remain nearly stationary relative to a point on the equator. However, GEO is much too far away for any tactically useful imagery; as a result, all imagery satellites use much lower orbits, so they can only see a portion of Earth's surface at any one time. This low altitude, combined with the high cost of imaging satellites, created limitations for the tactical usefulness of satellites because it was possible to image only a relatively small area each day.

Limitations

Low altitude is just one of the limitations on imagery satellites that have limited the tactical relevance of satellite imagery to analyzing terrain. Even if an imagery satellite passed over the battlespace, it did not necessarily mean that everything within it was imaged.

The cameras on board satellites have many limitations driven by resolution limits, the satellite bus and by simple time. For example, the swath width of WorldView-3, one of the most advanced traditional commercial satellites in orbit today, is just 13.1 kilometers. (Albeit with a best-case resolution of 0.31 meters, it is much better than an average Google Earth image.[2]) Limited swath width means that this "exquisite" (large, highly sophisticated satellites usually based in GEO for imagery, missile warning and intelligence-community missions) platform can choose to image a strip of territory 13.1 kilometers wide once a day, or it can make several increasingly lower-quality sweeps of a selected area before traveling out of view.

The satellite must then pass over a ground station, download its collected imagery and have it processed and analyzed. The speed of this process varies depending on urgency, but at least another day would pass before analysts could draw any useful conclusions from satellite imagery. These limitations historically prevented satellite imagery from impacting tactical decision-making and limited it to strategic roles.

Space-industry transitions

These traditional limitations on satellite observation are rapidly disappearing, driven primarily by a recent dramatic decrease in the cost of reaching orbit and the rise of small, inexpensive satellites that capitalize on this development. The space industry is transitioning from a positive-cost spiral to a negative-cost spiral. Under the previous paradigm of the positive-cost spiral, the high cost of reaching orbit reinforced the need for high-quality exquisite satellites, which in turn incentivized the launch provider to develop extensive risk-avoidance measures, further driving up cost. These factors are now inverted, resulting in a negative-cost spiral.

Cheaper launches are justifying the launch of smaller, less expensive satellites, which can be built in greater numbers and placed in lower orbits where they will have greatly decreased orbital lifespans due to atmospheric drag. Orbiting at a much lower altitude than traditional imagery platforms compensates for the reduced capability of the optics on board these smaller satellites. One company that is capitalizing on this paradigm shift is Planet Labs. It now operates a constellation of hundreds of small satellites that image the entire surface of the Earth each day at resolutions high enough to be operationally and tactically relevant.

The proliferation of small observation satellites and launch platforms capable of putting them in orbit is allowing ever-smaller nations to develop a space presence. Even minor global powers such as Nigeria now possess multiple active satellites.

For military operations, one of the poorly understood implications of this transformation in space is the impact this will have on military planning. The staging of armored forces in preparation for operations such as the "left hook" carried out during the Gulf War can no longer occur in secrecy. While it is possible to control the airspace within a theater, satellites have freedom of passage, and it will be extremely difficult to prevent many third-party imaging satellites from imaging the battlespace each day. Any significant military operation is likely to draw the

interest of these third-party observers, and the ease of information transmission in the modern era will make it impossible to prevent even the most disadvantaged opponent from gaining access to this valuable open-source intelligence.

There are a limited number of methods of preventing an opponent from gaining access to satellite imagery. During the Gulf War in 1991, the United Nations mandated an embargo on the sale of commercial imagery to Iraq.[3] This worked; however, the circumstances were unique and unlikely to be repeated. At the time, China did not possess satellite-imagery capability, and the Soviet Union was preoccupied with difficult internal reform and negotiations with the North Atlantic Treaty Organization (NATO) and the United States over the future of Eastern Europe. In addition, there was only one non-U.S. commercial provider, the French-owned SPOT satellite (Satellite Pour l'Observation de la Terre – literally, "Satellite for observation of Earth"), which could produce only 10-meter resolution imagery.

By 2001, the situation with commercial satellite imagery had not changed significantly. The first true U.S. provider of commercial imagery, Earthwatch, only succeeded in reaching orbit with its first satellite, QuickBird 2, in October 2001.[4] This satellite was capable of producing images with resolutions of less than one meter, far better than was available to any non-governmental entity at the time. Under the terms of its licensing agreement, the U.S. government retained the right to exercise "shutter control" over Earthwatch and prevent it from selling its imagery of Afghanistan.[5] Rather than potentially damaging the credibility of the nascent U.S. imagery market, the Department of Defense instead chose to purchase all the imagery produced by Earthwatch on an exclusive basis.[6] While expensive, this buy-to-deny tactic effectively denied high-resolution imagery to media outlets and prevented them from accidentally revealing key details of U.S. military maneuvers to the Taliban.

Despite retaining the ability to exercise shutter control over U.S. imagery providers, doing so or attempting a tactic of buy-to-deny in today's environment would be futile. While it would prevent U.S.-based providers from selling or releasing any potentially harmful imagery, it would not apply to third-party providers based in countries that oppose U.S. actions. Geopolitical rivals who possess far greater on-orbit capabilities today than they did a decade ago would be easily capable of tracking U.S. military movements from orbit. Releasing imagery of U.S. troop build-ups and locations will no doubt be a less than subtle method of expressing dissatisfaction with U.S. military actions operating under the guise of freedom of information. Even if domestic media outlets refrained from televising analysis of this imagery, it would not prevent it from falling into the hands of a disadvantaged opponent, providing an intelligence windfall to an opponent that would otherwise be blind to the disposition of U.S. military forces. It would also make military deception exceptionally difficult as demonstrated by Russian forces in Ukraine.

The difficulty of military deception in the face of high-resolution commercial imagery was demonstrated in Ukraine when the presence of Russian forces was revealed using commercial satellite images. Few serious observers doubted that Russian forces were involved in Eastern Ukraine, but isolated ground-level images and reports were easy to dismiss as fabrications, providing the Russian state with a useful degree of plausible deniability. Releasing classified satellite imagery taken from national platforms would no doubt have proven Russian involvement, but it would also have provided insight into the specific capabilities of sensitive national platforms, something that nation-states are understandably reluctant to do. NATO resolved this dilemma using commercial imagery provided by the U.S.-based company DigitalGlobe. These images of large convoys of Russian military forces exposed the lie that significant Russian ground forces were not present in Ukraine.

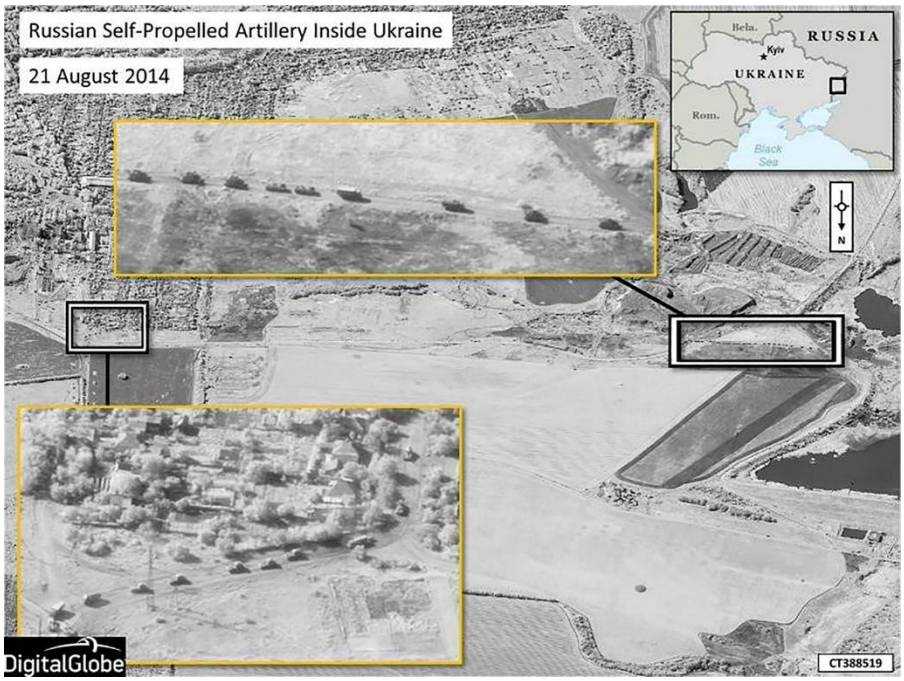

Figure 1. DigitalGlobe image showing Russian military units within Ukraine Aug. 21, 2014. (*Source: NATO, Supreme Headquarters Allied Powers Europe, news release Aug. 28, 2014, "New Satellite Imagery Exposes Russian Combat troops inside Ukraine," http://shape.nato.int/new-satellite-imagery-exposes-russian-combat-troops-inside-ukraine*)

NATO's decision to use U.S. commercial imagery assets to expose Russian involvement in Ukraine did not come without cost to DigitalGlobe. Following NATO's release of the images, DigitalGlobe saw a $14.5-million decline in Russian business from a high of $23 million in 2013.[7,8] The company cited several potential causes for the downturn in Russian business. These included the downturn in the Russian economy due to sanctions, although this did not affect DigitalGlobe's legal ability to sell imagery to Russian customers. Potentially the most significant reason cited by the DigitalGlobe chief executive officer was the "very public use of DigitalGlobe imagery by the U.S. government and the NATO alliance showing Russian troop locations and, more recently, purporting to prove that missile strikes in Ukraine came from batteries located in Russian territory."[9]

This assertion by the company cannot be proven, but it neatly explains the nearly complete disappearance of revenue from Russian sources following the publication of the photos by NATO. Political exposure represents a unique risk that U.S.-based companies take when providing imagery to the military and government, potentially jeopardizing its non-governmental business.

Russia is not alone in having its clandestine military actions exposed to a global audience. Commercial imagery has also revealed the Chinese military build-up in the South China Sea. High-resolution imagery provided by DigitalGlobe has made it possible for the media to analyze China's gradual build-up in the area carefully. Media outlets and think tanks have revealed details of Chinese build-ups from the number and type of aircraft based on newly constructed airfields to the presence of radar tracking stations.[10]

The idea that military build-ups now occur entirely in the public eye is something the global military community is beginning to adjust to. What the world has not yet seen is daily high-resolution satellite imagery from a conflict of interest to the American public.

Likely scenarios

Consider the impact of ubiquitous surveillance on two likely scenarios where significant U.S. armored formations could feasibly become involved: North Korea and the Baltic/Polish frontier. These scenarios involve opponents with vastly different space capabilities. Russia is a great space power by any measure, with the third-largest number of active satellites in orbit – behind the United States and China. Russia also has a robust space launch

capability.[11] In contrast, North Korea represents a disadvantaged state with no domestic space capability. Within these two scenarios, different factors would influence operations in space and on the ground.

Russia possesses domestic-surveillance capabilities that would allow it to observe the movement and positioning of U.S. military formations. As the current administration now considers space "a warfighting domain just like the air, land and sea," active measures to deny Russia the ability to use its space based remote-sensing capabilities may occur.[12] Assuming that it is possible to deny Russia the ability to observe U.S. forces from space using military force – incidentally leading to the first war in space with potentially devastating consequences for space support to U.S. forces – then Russia would still not be blind. Even if NATO is willing to authorize attacks against Russian satellites, it would undoubtedly abstain from attacking assets belonging to third parties, notably China. Nominally, Chinese commercial assets would likely be willing to sell Russia imagery as well as communications bandwidth and other space-enabling capabilities on its satellites. The impact of attempting to deny Russia the use of its space assets would, in operational terms, have left it no weaker thanks to Chinese or other third-party support. Meanwhile, highly vulnerable U.S. and NATO space assets would likely be devastated by a conflict in space.

North Korea represents a different case from Russia. Since North Korea has no space assets to attack or any known ability to attack U.S. space assets, conflict in space would not occur. In a scenario where North Korea attacks South Korea and China chooses not to become directly involved, a United Nations resolution condemning North Korean actions and banning the sale of commercial imagery could be possible, as occurred in 1991 with Iraq. However, it is unlikely that China or Russia would not continue to provide clandestine intelligence support to North Korea. In addition, unlike in a conflict in Eastern Europe involving NATO powers that possess most of the non-U.S. commercial imagery capabilities, conflict in Korea would not directly involve many of these countries. This lack of direct involvement could allow these nations to continue to sell imagery of the conflict zone, creating a useful source of accurate open-source intelligence. This intelligence support would make large operations similar to the landings at Inchon in 1950 impossible, as they would not go unobserved and could never achieve the necessary level of operational surprise.

Another factor to consider is that both these scenarios involve conflict in parts of the world that are infamous for extreme weather conditions that may provide windows of opportunity to remain unobserved from space. This is only partially true. While typical electro-optical imagery taken in the visible spectrum is subject to the vagaries of weather, space-based synthetic-aperture radar (SAR) is not. This all-weather capability was an expensive niche capability with extreme technical challenges and limited commercial potential – until recently. That is changing rapidly as companies based in Italy, Finland and Canada are on the leading edge of efforts to launch constellations of SAR satellites.[13] These satellites eliminate the need for unobstructed daylight imagery, which typically drives the placement of imagery satellites in orbits where they pass over the targeted area as close to noon as possible to minimize shadows.

Figure 2. SAR image of ships passing through the Panama Canal taken by Airbus TerraSAR-X, Sept. 26, 2013.
(Image provided by Airbus Defense and Space upon request from the author)

Surprise not possible

The primary outcome of the growth in space-based surveillance is that operational surprise is no longer possible. This statement is not without caveats. While some experts argue that ubiquitous surveillance from space will soon allow observation of military movements in real-time, making stealth and military deception irrelevant, that is an exaggeration.[14] It is true that large armored formations will never again be able to mass in secrecy to bypass an enemy, as happened in Iraq in 1991 and again in 2003. It is also true that there will remain an upper limit on the amount of observation possible from space. Even hundreds of small satellites operating in a constellation will face limitations in the area they can observe during any one pass.

Furthermore, there is a limit on the effective use of large quantities of data. A lag will always exist between the moment an image is taken and when that data is transmitted, received and analyzed. This window of opportunity will continue to narrow from the roughly 24 hours that is the current likely window between useful third-party observations today down to less than eight hours over the next decade. As a result, even though operational surprise may not be possible, tactical surprise is still a real possibility.

Beyond the impact of space-based surveillance on operational surprise, there are several implications for armored forces. First, as discussed, there is only a small window in which low-level tactical surprise can be achieved. As a result, mounted reconnaissance forces must have the combat power to rapidly defeat an opponent's screening forces and identify weaknesses not apparent from overhead imagery in the enemy defense exploitable by follow-on forces. This calls for formations organized more along the lines of the older divisional cavalry squadron rather than its less-combat-capable successor organizations.

Second, because the time available to concentrate armored forces will be short, and future opponents will likely have access to weapons of mass destruction, commanders must plan for and accept limited gains. Rather than a single knockout blow, the maneuver commander will need to plan multiple, small and sequential operations to throw an opponent off-balance. These operations will demonstrate conventional superiority and achieve the limited military objectives necessary to obtain political goals without triggering strategic escalation.

Conclusions

The central thesis of this article is that practitioners of armored warfare must be aware of and ready to adapt to the operational impact of near continuous space based surveillance. There is a decreasing window in which armored forces can mass for offensive action unobserved, even if they possess air superiority. Commanders must accept the limitations this creates and be prepared to accept limited gains using limited forces.

Corps- and division-level maneuvers will never again achieve the operational surprise they did in 1991 or 2003. This does not mean that maneuver warfare is no longer relevant; the opposite is true. In a future dominated by information, military units must be able to mass quickly while possessing the combat capability to defeat localized enemy forces and consolidate gains rapidly – something that armored forces are uniquely capable of doing.

LTC Brad Townsend is a doctor of philosophy fellow at Air University, School of Advanced Air and Space Studies (SAASS), Maxwell Air Force Base, AL. He is transitioning to the Joint Staff, J-5 Space Policy, at the Pentagon. His previous assignments include futures planner, CJ-5 Resolute Support Headquarters, Afghanistan; S-3, 1st Space Battalion, Peterson AFB, CO; course director, National Security Space Institute, Peterson AFB; assistant program manager/payload engineer, National Aeronautics and Space Administration Astronaut Office, Johnson Space Center, Houston, TX; and commander, Joint Tactical Ground Station (JTAGS), Qatar. His military schools include the Command and General Staff College, National Security Space Institute (Space 200 and Space 300), JTAGS Operator's Course, Functional Area 40 Space Operations Course, Armor Captain's Career Course and Cavalry Leader's Course. LTC Townsend holds a PhD in military strategy from the U.S. Air Force SAASS; a master's of philosophy degree in military strategy from the U.S. Air Force SAASS; a master's of science degree in space-systems operations management from Webster University; a master's of science degree in astronautical engineering from the Air Force Institute of Technology; and a bachelor's of science degree in mechanical

engineering from the U.S. Military Academy, West Point, NY. LTC Townsend is a member of the Army Strategic Policy Planning Program, and he has four combat deployments.

Notes

[1] "United States Space Command: Operations Desert Shield and Desert Storm Assessment," January 1992, https://nsarchive2.gwu.edu/NSAEBB/NSAEBB235/25.pdf.
[2] "WorldView-3 Fact Sheet," ***DIgitalGlobe***, accessed April 15, 2019, https://dgv4-cms-production.s3.amazonaws.com/uploads/document/file/128/DG2017_WorldView-3_DS.pdf.
[3] Denette L. Sleeth, "Commercial Imagery Satellite Threat: How Can U.S. Forces Protect Themselves?" Master's thesis, Naval War College, 2004.
[4] "Commercial Remote Sensing: A Historical Chronology," ***DigitalGlobe***, April 9, 2010.
[5] "General Conditions for Private Remote-Sensing Space System Licenses," National Oceanic and Atmospheric Administration, 2016.
[6] Duncan Campbell, "U.S. Buys Up All Satellite War Images," ***The Guardian***, Oct. 17, 2001.
[7] "DigitalGlobe: Securities and Exchange Commission Form 10K 2014," Longmont, CO: ***DigitalGlobe***, Dec. 31, 2014.
[8] Peter Selding, "DigitalGlobe Revenue up Despite Steep Drop in Russian Business," ***Space News***, Aug. 1, 2014, http://spacenews.com/41459digitalglobe-revenue-up-despite-steep-drop-in-russian-business/.
[9] Selding.
[10] "A Constructive Year for Chinese Base Building | RealClearDefense," accessed April 17, 2019, https://www.realcleardefense.com/articles/2017/12/15/a_constructive_year_for_chinese_base_building_112784.html.
[11] "UCS Satellite Database," Union of Concerned Scientists, accessed July 26, 2018, https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database.
[12] "President Donald J. Trump Is Establishing America's Space Force," The White House, Feb. 19, 2019, https://www.whitehouse.gov/briefings-statements/president-trump-establishing-americas-space-force/.
[13] Debra Werner, "Not Convinced of the Promise of Commercial Radar Satellites? Meet the Radar Mafia," ***SpaceNews.com***, May 22, 2018, https://spacenews.com/not-convinced-of-the-promise-of-commercial-radar-satellites-meet-the-radar-mafia/.
[14] Christian Brose, "Why the U.S. Needs a Revolution in Military Affairs," ***Foreign Affairs***, May 2019, https://www.foreignaffairs.com/articles/2019-04-16/new-revolution-military-affairs.

Acronym Quick-Scan

GEO – geosynchronous orbit
GPS – Global Positioning System
JTAGS – Joint Tactical Ground Station
LEO – low-Earth orbit
NATO – North Atlantic Treaty Organization
SAR – synthetic-aperture radar
SAASS – School of Advanced Air and Space Studies