András Edl[1]

Stealth Satellites, Trust and Deterrence

Introduction

The New Space age is characterised by an increased number of spacecraft and satellites placed in orbit by old and new space actors. This traffic is hard to manage on its own and is made more difficult by the growing space junk problem. In addition, the changing geopolitical landscape and the rising tensions between the United States, China and Russia make the space environment more competitive and a possible domain for conflict. New, emerging space-faring middle powers like Iran, Brazil, India, Japan and a multitude of small countries also add variables to the already complex space environment, not to mention multinational corporations and startups with disrupting technologies and innovations.

Space Situational Awareness

To solve the issues arising from such a complex environment and the activities conducted within new regulations and real-time knowledge of objects and activities would be required. Thus, Space Situational Awareness would be a key factor in solving the space junk problem and other security issues. To be able to determine what happens and why allows stakeholders to take a responsible and accurate course of action. Due to this reason, every country or company active in space relies heavily on these capabilities and the most important actors in space allocate considerable funding to SSA development. Some of the obtained data is shared worldwide because it is in the best interest of all parties to be able to avoid accidents. At the same time, anything which can damage or limit the opponent's SSA systems can guarantee significant advantages in a conflict. On the other hand, these kinds of weapons might come with a heavy price because

[1] Ludovika University of Public Service, EJRC – Institute of Space Law and Policy. ORCID 0000-0002-4250-7112 e-mail: edlandras@gmail.com

https://doi.org/10.36250/01192_08

they will increase the chance of accidents, could produce additional debris, and further damage the relations between the two sides. Because the chance of damaging their own space infrastructure is also present an initial attack could result in a Pyrrhic victory.

There is also a trend of satellites taking part in SSA observation. These in-orbit satellites would have major advantages compared to Earth-based radars. They are closer to the observed objects; therefore, the resolution might be better. The usage of optical sensors would not be obstructed by clouds or night time, and satellites could also function above areas where there is no land-based observation facility, like the middle of the Pacific Ocean. And finally, space-based sensors could detect or use wavelengths which do not penetrate Earth's atmosphere.[2] There are already satellites even in higher orbits, to provide more accurate data about the space environment. Since 2014, the U.S. Space Force operates the Geosynchronous Space Situational Awareness Program (GSSAP) with at least four satellites close to the valuable geosynchronous orbit. The satellites' capabilities are classified but they can approach objects in these orbits and carry out enhanced surveillance.[3] There is also the intention to attach cheap additional sensors to satellites which otherwise would not offer SSA services. These hosted payloads can be attached even to foreign satellites, as happened to the Japanese region-specific navigation system the Quasi-Zenith Satellite System (QZSS).[4]

Deterrence, transparency and trust

Due to the possible long-term damages, strategists think about how to avoid serious damage to their assets, while also limiting events which could even threaten space as an environment important to the whole of humanity. The strategy of deterrence – ideally combined with other elements – seems to be one of the viable routes to avoid conflicts in space or the terrestrial realm. The Western interpretation of deterrence has two main methods: deterrence by denial and deterrence by punishment. The first is based on the idea that the enemy will not succeed with their attack. The second aims to deter with the promise of

2 Eves 2022.
3 Air Force Space Command 2017.
4 Hitchens 2022.

retaliation, after the attack. Even when the initial attack might be successful, the cost will be much higher than the benefits of it. Russian and Chinese deterrence concepts have different approaches, they also include coercion and put a bigger emphasis on deception.[5]

Regardless if coercion is involved or not, it is important to note that any of these approaches are rooted in human psychology and the key component is the image created in the enemy decision-makers' minds. For deterrence strategy to work, the enemy requires knowledge about the adversaries' capabilities. Therefore, apart from having the means to execute an effective retaliation or defend against an incoming attack, deterrence also requires credibility and communication. This is the only way current (and to some degree future) adversaries might be deterred before they commence their attack. The potential rival therefore must know to some degree what capabilities the opposing party has, otherwise they would not fear the consequences or the failure of an attack.

Earth observation and SSA both help to evaluate the adversaries' possible intentions and true capabilities. Of course, all countries try to hide or obscure some of their equipment and deceive their rivals, but they can also count on observation and a lot of information will be available for their adversaries. This is good news when the actual potential of one's military power is enough to deter the enemy.

An additional benefit arising from accurate Earth observation and SSA could be a higher degree of transparency. Other countries will simply see what is going on in their region or even globally. It makes building up military forces secretly on a mass scale nearly impossible. Likewise, infrastructure developments can be spotted from space and this alone is sometimes enough to verify if the other country keeps their end of the deal in case of a disarmament agreement. Seeing what the opposing side is up to makes it easier to build trust between nations because there is a reduced chance of unpleasant surprises. The underlying psychological foundations are the same when meeting an unknown, possibly hostile person and seeing what is in their hand or what they are looking at because both can be a basis to deduct intentions. In conclusion, transparency and trust building are one of the most important tools in conflict prevention.

[5] Edl 2022: 256–269.

Stealth Satellites 1.0

Despite the advantages mentioned above, there is a strong incentive to hide one's capabilities or mislead the enemy because, during an actual conflict, this might secure a victory. The concept of stealth satellites, therefore, is a logical extension of the stealth and deception techniques applied on Earth. In the early stages of the Cold War, the United States already experimented with these kinds of satellites which were supposed to be undetectable to the Soviet Union's SSA forces. There is information about a program which started in the 1960s and after spending 10 billion USD the program supposedly produced two stealth satellites launched in the 1990s. These highly classified orbital platforms, under the code name "MISTY", were launched in 1990 and 1999.[6] The special design and surface of the satellites were able to decrease the chances of detection and identification. In so doing the potential enemy could not target these assets with ASAT weapons, unlike regular satellites which can be easily tracked and targeted. Neither could the rivals predict when they would fly over a certain area and use this information to hide and conceal their movements during that time.

In theory, the program was shut down after a few test satellites. Meanwhile, various concepts emerged about how to build such a potent spacecraft. One idea involves a special outer hull for the satellite, clad or painted with dark, special radar-absorbent material. Another idea would deploy mesh screens to interfere with radar returns. The third idea had inflatable materials at its core, these devices could inflate and hide the satellites behind them until they had to photograph something important.[7] The technology for such inflatable components and machines developed significantly since the 1990s. One such module is currently part of the International Space Station (ISS). With the expertise and sufficient dedication, the building of such a satellite would be even easier today.

In addition, due to strategic advantages, great powers tried to conceal and disguise some of their activities as something else. However, a rocket launch is a highly visible action, observed by all major powers with surveillance capabilities. Therefore, they cannot hide the launch itself, but disguise some parts of the payload as something else for example a piece of space junk. Both the

6 David 2005.

7 National Reconnaissance Office 2016.

United States and Russia claimed to have identified satellites.[8] After years of observation, the seemingly inactive objects started to change orbit or perform another type of action. A similar technique is also possible: launch a satellite and place a decoy object in its likely orbit, so the competitors follow that object, while the real satellite moves away in secrecy. This is a normal competition between deception and detection, highly reliant on technical capabilities.

Another similar method would be to claim that the payload of an otherwise successful launch got damaged or destroyed. Certain rumours appeared surrounding a launch performed by SpaceX in early 2018. The payload was manufactured by Northrop Grumman, one of the top producers of arms and military equipment for the Pentagon. All concerned parties were extremely secretive about the payload called "Zuma". The operators of Zuma, its purpose, or what happened exactly during the launch are still unknown. After the launch, news started to spread that there was something wrong with the launch and the payload got destroyed. SpaceX denied any such problems and claimed the rocket worked perfectly, but they – just like the Pentagon or Northrop Grumman – refused to give any information about the payload. The explanation was given that there was some problem with the payload and could not separate from the second stage but this was not confirmed.[9] CelesTrek raw satellite data still has Zuma on its list (COSPAR ID 2018-001A) but with no details about the satellite's orbit, which is not unusual for classified projects.[10]

Private corporations

A serious counterargument against the deployment of disguised or stealth spacecraft and devices would be the ever-growing civilian space sector. SSA services are provided by companies like LeoLabs which focuses on the LEO region. The company keeps improving its radar network, and it had six operational tracking stations in 2023 March, which are spread across the globe. Two of them are in the Southern hemisphere, giving a company an advantage in a geographical area – and the skies above – where the lack of dry land makes it more difficult to position tracking stations. In addition, LeoLabs will work together with

[8] Pappalardo 2018.
[9] Rogovay–Trevithick 2018.
[10] CelesTrak 2023.

the U.S. Department of Commerce to establish a new civil-led Space Traffic Management (STM) system. The company also secured a deal with the Japanese Air Self-Defence Force and will support Japan's SSA capabilities.[11]

Other private companies provide high-resolution Earth observation images or various valuable data. They offer their services to governments (theoretically they could sell the same data to multiple interested parties), their coverage is already good and it will only improve with mega-constellations or further developments. This cooperation and interconnection between governments and the private sector could also offer the opportunity to hide a government satellite in a constellation or a few extra sensors on privately owned spacecraft.

One rapidly expanding subsector of private observation services is the SAR (Synthetic Aperture Radar) industry. The technology was originally a highly classified military tech. Initially, these radar devices were installed on the board of aeroplanes, like the SR-71 Blackbird, the first stealth aircraft. SeaSat, the first civilian SAR satellite entered orbit in 1978, but for a while, it was a lone example of its kind. At the same time, military SAR satellites were already numerous. In our present days, SAR technology is widely accessible and multiple private companies sell these kinds of images. The undeniable advantages are that clouds, fog, haze, smoke, or night time do not affect the picture quality, which is not the case with optical satellites.[12]

Startups are also numerous in the multispectral Earth observation domain. Orbital Sidekick Inc. (OSK), intends to deploy 6 identical satellites in 2023 to provide commercially available images. The small constellation is named GHOSt for Global Hyperspectral Observation Satellite. The hyperspectral imagery sensors will capture waves in the visible and the short-wave infrared region. The satellites will be around 100 kg of weight each and a SpaceX Falcon 9 rocket will carry the payloads into space. The company intends to sell the images to civilian and military customers. The design will make it especially effective to aid national defence, infrastructure monitoring, environmental and agriculture monitoring.[13]

[11] LeoLabs 2022.
[12] Scoles 2022.
[13] eoPortal 2022.

Stealth Satellites 2.0

Even considering the above-mentioned changes in Earth observation and SSA, it seems that there is a resurgence in stealth satellite research. Chinese scientists and decision-makers find the development of such capabilities important. According to Chinese news outlets a research team in Nanjing, led by Kong Xiangku has developed a special coating suitable for the space environment which will reduce the reflected radar signals' strength by 80%. They also claim that the team could fully coat a satellite in a honeycomb pattern, with special composite materials, which would make detection by radar nearly impossible. Maintenance of these satellites cannot be carried out like for stealth aircraft on Earth, so the coating and the frame must endure repeated spikes in temperature and cosmic radiation. It cannot be too heavy either, so the research team had to use lightweight materials, like paper or plastic to construct the coating, which they theoretically managed to keep under 3 mm thickness and a maximum weight of under 6 kg per square meter. Other solutions were proposed as well, like hiding the satellite behind a piece of space junk, and painting it with a special black layer so it blends into the space background. One patented Chinese design proposes a "transformer" satellite. This would orbit Earth as a small, compact object, and only unfold solar arrays, antennas, etc. and get active when needed. Until that times come, the compact form has a 300 times reduced radar signature.[14] Needless to say, similar research efforts are on the way in other countries as well. Some of them are far less secretive about their results. There are even advances in making composite materials not only able to absorb microwaves or radar waves but as it is very useful in space, radiation shielding was also improved.[15]

Yet another Chinese research team seems to be making progress in manufacturing a flexible material which can hide objects from radar satellites. Assuming the reports are true, this layer on its own will not be sufficient to disguise a spacecraft. But combined with other layers and methods, even satellites could be made highly resistant to multiple detection methods.[16]

One of the promising fields of new research is quantum technology. The four main areas of research are quantum computing, imaging, communication

[14] EverythingRF Editorial Team 2021.
[15] Cha et al. 2022.
[16] Tiwari 2022.

and sensors. The area of sensors seems to be the most advanced and closest to military applications. There are already examples of cooperation between research institutions and arms manufacturers, like the one between BAE Systems and a technology hub led by the University of Birmingham. As a first step maybe no fundamentally new technologies will emerge, but quantum capabilities can enhance existing methods. These sensors can measure gravitational forces, electric or magnetic fields, temperature and also time. A radar boosted with quantum tech could detect smaller objects and maybe even stealth aircraft.[17] So-called ghost imaging is also in the experimental phase. China and the U.S. both conducted tests and they aim to use the technology in satellites as well, especially to detect stealth aircraft. This technology would analyse the tiniest changes in light reflection so even current camouflage or high-tech coating would be obsolete.[18] One other possible application could be the combination of gravity gradiometers and quantum clocks – in case miniaturisation and cost-effectiveness reaches a certain level – this might allow engineers to design equipment that can detect the mass of objects, thus identifying unusual variations for a specific surrounding. The devices could be installed on satellites as well, but this technology still has to mature and has a long way to go.[19]

The research in this field and the deployment of such satellites could seriously damage trust building, lead to a new kind of armament race and have a double effect on deterrence. It might increase and decrease the effectiveness of deterrence at the same time. The problem cannot be solved by states alone or with more R&D investments in SSA, but the international community must participate in this endeavour as well.

Parallel paths in research

Predicting the future with 100% certainty is of course impossible. However, a few possible trends or challenges to overcome might be assumed. The reappearance of stealth satellites, and the dire need for sophisticated sensors in Earth observation and space situational awareness (including space junk detection), will encourage companies and research institutions to further experiment with new technologies,

[17] Neumann 2021.
[18] Griffin 2018.
[19] Kubiak 2020: 7–8.

besides the ones mentioned above. The space landscape will be increasingly complex and stealth and detection will interact and fuse with other types of space activity or devices.

Launches, payloads and the resulting (seemingly) space junk can and will be observed from more angles and with different types of sensors, including the help of private corporations. In-orbit servicing will not only make it possible to extend the lifespan of satellites but to update and modernise sensors or attach no equipment to already deployed high-capability spacecraft. The dual use of co-orbital manoeuvres and the capability to grab or dock with other satellites will also result in the unavoidable parallel development of hunter-interceptor satellite capabilities. These might approach to grab enemy satellites to force them to enter Earth's atmosphere. Jamming or damaging targets in other ways can be more effective from close proximity as well. Russia and China experimented with such co-orbital manoeuvres since the late 2010s.[20] Although reported less frequently, the U.S. does follow suit with their systems.

These tests in return gave rise to the concept of bodyguard satellites. The core idea is to deploy multiple smaller spacecraft to examine and neutralise any possible threats to the central satellite. The applied countermeasures could be to simply push away any hazardous spacecraft or space junk, although this would be time and propellant-consuming. Onboard lasers, jamming or spoofing are also an option. Using kinetic ammunition to destroy them would create a dangerous debris cloud, therefore this method is not recommended.[21] However, applying stealth technology to the interceptor satellites would yet again make the protection of the most valuable space assets increasingly difficult, therefore installing better, mostly short-range sensors to the bodyguard system and using them combined with the more capable detection networks is plausible.

Conclusion

Taking into consideration the latest events and reports it is clear that there is a renewed interest in the development of stealth satellites. The need to avoid detection not only is a natural reaction to the more sophisticated and wide-spread surveillance networks, but also a fail-safe mechanism to still have some

[20] Sankaran 2022; Weeden 2022.

[21] Mowthorpe 2022.

orbital capabilities left if the more visible and prominent systems are seriously obstructed or damaged. Possibly, a small number of stealth satellites – especially with more potent SSA systems, supported by private service providers – might not disrupt the balance of power and would not seriously damage transparency and trust between adversaries. It might even improve it a little because the rivals could count on being observed by undetectable spacecraft as well. But the advancement and proliferation of stealth technology can destabilise the current space architecture and encourage space powers to engage in a new round of arms race. Widely accepted international agreements could slow down or even stop this type of rivalry in space, but based on current trends the banning of stealth tech research is not likely. Strategic planners therefore must think ahead and incorporate the growing threat of such satellites into different levels of guidelines, protocols, action plans, etc. New and more capable SSA systems could limit the spread of such spacecraft, which would be preferable to keep transparency and trust between potential rivals and to keep deterrence as an effective tool of conflict avoidance in space.

References

Air Force Space Command (2017): *Geosynchronous Space Situational Awareness Program.* Online: https://www.afspc.af.mil/About-Us/Fact-Sheets/Article/730802/geosynchronous-space-situational-awareness-program/

CelesTrak (2023): *Satcat.* Online: https://celestrak.org/pub/satcat.txt

Cha, Ji-Hun – Jang, Woo-Hyeok – Noh, Jung-Eon – Choi, Won-Ho – Kim, Chun-Gon (2022): A Space Stealth and Cosmic Radiation Shielding Composite: Polydopamine-Coating and Multi-Walled Carbon Nanotube Grafting onto an Ultra-High-Molecular-Weight Polyethylene/Hydrogen-Rich Benzoxazine Composite. *Composites Science and Technology,* 230(1). Online: https://doi.org/10.1016/j.compscitech.2022.109711

David, Leonard (2005): *Anatomy of a Spy Satellite.* Online: https://www.space.com/637-anatomy-spy-satellite.html

Edl, András (2022): Deterrence in Space. *Hadtudomány,* 32(1), 256–269. Online: https://doi.org/10.17047/Hadtud.2022.32.E.256

eoPortal (2022): *GHOSt (Global Hyperspectral Observation Satellite).* Online: https://www.eoportal.org/satellite-missions/ghost#overview

EverythingRF Editorial Team (2021): *Chinese Researchers Develop Stealth Technology for Small Satellites.* Online: https://www.everythingrf.com/news/details/12890-chinese-researchers-develop-stealth-technology-for-small-satellites

Eves, Stuart (2022): *Reasons to Conduct SSA from Orbit.* Online: https://gnosisnetwork.org/blog/reasons-to-conduct-ssa-from-orbit/

Griffin, Matthew (2018): China's New "Ghost Imaging" Satellites Will Make US Stealth Obsolete. Online: https://www.311institute.com/chinas-new-ghost-imaging-satellites-will-make-us-stealth-obsolete/

Hitchens, Teresa (2022): *Space Force Plans Multiple Hosted Payloads for GEO Belt Monitoring.* Online: https://breakingdefense.com/2022/01/space-force-plans-multiple-hosted-payloads-for-geo-belt-monitoring/

Kubiak, Katarzyna (2020): *Quantum Technology and Submarine Near-Invulnerability.* London: European Leadership Network. Online: https://www.europeanleadershipnetwork.org/wp-content/uploads/2020/12/Quantum-report.pdf

LeoLabs (2022): *Newsroom – Press.* Online: https://leolabs.space/newsroom/?np=3

Mowthorpe, Matthew (2022): The Russian Space Threat and a Defense Against It with Guardian Satellites. *The Space Review,* 13 June 2022. Online: https://www.thespacereview.com/article/4401/1

National Reconnaissance Office (2016): *Stealth Satellite Sourcebook.* Online: https://spp.fas.org/military/program/track/stealth.pdf

Neumann, Norbert (2021): *Will Quantum Transform Defence Capabilities? Yes and No.* Online: https://www.army-technology.com/analysis/quantum-defence-computer-sensing-nato-china-us-uk-eu-submarines-radar-bae-systems/

Pappalardo, Joe (2018): *Space Junk Could Provide a Perfect Hiding Spot for Tiny Spy Satellites.* Online: https://www.popularmechanics.com/military/research/a25349950/nro-satellite-space-junk/

Rogovay, Tyler – Trevithick, Joseph (2018): *The Secret Zuma Spacecraft Could Be Alive and Well Doing Exactly What It Was Intended to.* Online: https://www.thedrive.com/the-war-zone/17612/the-secret-zuma-spacecraft-could-be-alive-and-well-doing-exactly-what-it-was-intended-to

Sankaran, Jaganath (2022): *Russia's Anti-Satellite Weapons: An Asymmetric Response to U.S. Aerospace.* Online: https://www.armscontrol.org/act/2022-03/features/russias-anti-satellite-weapons-asymmetric-response-us-aerospace-superiority

Scoles, Sarah (2022): *Spies' Night Eyes: Once-Restricted Tech Is Helping to Spot Russian Troops, Chinese Missile Sites and Raging Wildfires.* Online: https://www.grid.news/story/science/2022/05/23/spies-night-eyes-once-secret-tech-is-helping-spot-russian-troops-chinese-missiles-and-raging-wildfires/

Tiwari, Sakshi (2022): Invisible to Radars, China Claim Development of 'Stealth Tech' that Can Conceal Its Tanks & Military Infra on the Ground. *The EurAsian Times,* 15 April 2022. Online: https://www.eurasiantimes.com/china-claim-development-of-stealth-tech-that-can-conceal-its-tanks/

Weeden, Brian (2022): *Russian Co-orbital Anti-satellite Testing.* Online: https://swfound.org/media/207373/swf-russia-co-orbital-asat-may-2022.pdf