SPACE DEBRIS AND SPACE SITUATIONAL AWARENESS

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Abstract: *Over the past several years, many scientists have offered possible solutions to the ever growing cloud of space junk circling the Earth. The different ideas are commented with view of the possible use on purpose to influence a strategic decision making process. An accent on the risk due to the probable unpredictability of the outcome is made.*

КОСМИЧЕСКИ ОТПАДЪЦИ И ОЦЕНКА НА СИТУАЦИЯТА

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Абстракт: *През последните няколко години доста учени предлагат възможни решения на все по нарастващите проблеми заради космическия боклук около Земята. Коментирани са различни гледни точки с оглед на възможното им целенесочено използване за влияние върху вземането на стратегически решения. Акцентира се на риска от вероятната непредсказуемост на резултата.*

More than 5,500 tonnes of junk now clutters the region of space above our heads: more than 60 objects at a height of about 850km, and two thirds of those weigh more than three tonnes each - many moving near a speed of 7.5km/s. 10% of all objects in Earth's orbit are satellites, while the rest is rubbish: spent rocket stages, defunct satellites, acceleration blocks and other debris. The debris presents a risk not only to other man-made satellites in orbit, but occasionally also to the International Space Station and manned space missions. Recently a couple of dangerous encounters of ISS with space debris (the last one in June, 2011, a 300m distance fly-by) were reported to the public. In 2007, China demonstrated an anti-satellite system, destroying one of its own defunct satellites and creating 2,000 extra bits of debris in a used satellite-field at a H=800km. A similar test was done by the USA in February, 2008. Although there have been some near-misses and a few minor collisions, in 02.2009 for the first time two intact US and Russian satellites have crashed into each other and created even more junk. And while the amount already up there is of concern, what is even more troubling is the possibility of space and the debris up there falling prey to the Kessler Syndrome, after the NASA scientist who first described it in 1978: in the longer-term, computer modelling work has identified a worrying effect called a "collision cascade", a kind of domino effect where collisions create more debris, which generates further collisions, creating even more debris banging into each other on chaotic trajectories.. Eventually, you reach the point where you can't sensibly launch satellites into the orbits you want because they'll get pounded to pieces. Satellite shielding is effective for objects below 1cm. But beyond that size collision avoidance - commanding the satellite to move out of the way of debris - may be the most prudent option. This is one of the reasons why the satellite operators and international agencies quite deliberately have agreed that retired hardware - old satellites or spent rocket stages - should be removed from space within 25 years of the end of service. Over the past several years, many scientists and armchair enthusiasts alike have offered up a possible solution to the ever growing cloud of space junk circling the Earth. A lot of ‘crazy’ ideas are constantly discussed like for e.g. some sort of very large net strung between two large, heavy satellites that make slow orbits scanning from one pole to the other. Once the net hits a certain quota, close it up, drop it back to earth. Another proposal suggested a cloud of tungsten be sent up to coat the trash, causing it to grow heavy enough to fall to Earth. Using lasers for shooting down the debris is an interesting option too. Using large deployable surfaces to increase the drag on these objects so they fall to Earth rapidly is also a possible solution to the space litter problem. Another one is to perfect nanobots or some other technology that can break down the junk into its respective elements. There is a suggestion that a satellite carrying among other things a solid propellant that could be affixed to a large piece of space junk, be launched. The satellite would have two robotic arms: one to grab hold of the piece of junk, the other to affix the propellant device that once activated, would guide the piece of junk towards Earth, where it would burn up in the atmosphere. Such a satellite would be capable of de-orbiting 35 large objects over a 7 year period. It would target about 50 large rocket bodies that are currently orbiting in the sun-synchronous orbital region near the Earth, which is where most of the catastrophic collisions in the near term are likely to occur. The proximity operations and manoeuvring talked about here is not easy, but the technology for the idea that you go and attach yourself to something in orbit is becoming more credible. Nevertheless, the greater problem may be political and could be seen as a threat to operative systems. Russia's space surveillance facilities include an "Okno" optical tracking system near Nurek, Tajikistan, and a "Korona" long-range radar and optical tracking centre at Storozhevaya in south-west Russia. China is developing its own systems.

The US Space Surveillance Network (SSN) is the most sophisticated system for tracking objects in orbit. The US already makes available some data from its Space Surveillance Network. But this US Air Force data, known as two-line elements, is of relatively low quality, with satellite positions only accurate to within 20-30km (distances which are covered in 3-4 seconds at typical low Earth orbit velocities of 7.5 km/s). Additional uncertainties are introduced when satellite orbits are extrapolated days or weeks ahead. This is because spacecraft are perturbed by drag, solar radiation pressure and the Earth's gravity field. The more inaccurate the initial data on a satellite's position, the more inaccurate these predictions will be. In addition, for a satellite constellation in low-Earth orbit, two-line element data might throw up hundreds of potential collision alerts every day. Many satellite operators simply lack the financial resources to perform detailed analyses on each potential collision. The US Air Force maintains a second, more precise database of information on the same orbital objects. But these more accurate data are deemed far too sensitive to share publicly - for fear the data could give away clues about the capabilities of US sensors. However, keeping close tabs on all the junk up there is beyond even the resources of the US military who operates 25 centers around the world to track objects in space. High accuracy surveillance is reserved only for a handful of high-value assets such as the space shuttle, the space station and multi-billion-dollar spy satellites. Space-based systems, which provide accurate weather data, telecommunications and satellite-navigation services, play an increasingly vital role in Europe's economy. Until now, Europe has been largely dependent on the US for knowing what is going on in space, but for some time this situation is regarded as inadequate. In November 2008, space ministers approved a 49.5-million-euro proposal to prepare the way for a European system which will stand watch over orbital debris, near-Earth objects (NEOs) and solar activity. Together these phenomena could threaten lives and infrastructure in space and on the ground. An advanced capability to monitor such threats is known as Space Situational Awareness (SSA) , which will need to formulate a data security policy as well as consider what infrastructure has to be built and how existing sensors might contribute. Radars are generally used to track objects in low-Earth orbit, while optical telescopes are often used to observe objects further away from the Earth. The advantage of a space-based sensor is that it is above the clouds and is unaffected by the day/night cycle, so its tracking can be far more frequent. Electronic eavesdropping can be used to assess whether or not satellites are active. The existing facilities might include France's GRAVES (large-scale system adapted for space monitoring) radar system, which can survey objects in low-Earth orbit up to distances of 2,000km, the Zimmerwald optical telescope observatory in Switzerland, and the ESA Space Debris Telescope in Tenerife, Spain. The 'Saphhire' satellite system (Canada's Department of National Defence), will carry an optical telescope for tracking satellites in high orbits, especially geosynchronous orbit (GEO). These preliminary services should provide users with access to a catalogue detailing the orbits of functioning spacecraft and debris. From 2011 on ESA is looking at a ten-year timeline for development of the full system. Beyond 2011 there is a need to build new state-of-the-art facilities to achieve high performance, including the ability to track objects down to 10cm in size. But for true space situational awareness, it will also be necessary to track objects more frequently. This means monitoring the locations of satellites multiple times each day. They should also alert satellite operators to potential collisions between their spacecraft and other objects in orbit. In the event that a possible collision is identified, users could request a more detailed analysis of the objects' trajectories using a high power radar such as the Tracking and Imaging Radar (TIRA) in Wachtberg, Germany. ESA has also been talking to NASA and the US DoD about the potential for making the European and American networks interoperable, or compatible. There is a certain level of independence Europe wants to have in its ability to protect its own space assets. But it also offers the opportunity to get more out of two systems. The US has concerns that the European network could be used by hostile nations in attacks on American targets. Britain's participation presents particular questions because of its "special relationship" with America. Sources say that, in principle at least, there is a willingness on both sides to work together on SSA, though some in Europe remain wary of US intentions. A policy directing how the data will be used is also important for Europe's system, given the sensitivities over sharing information from military sensors. One thing that would have to be done is to have data anonymity. A way to address the issue might be to place a software application between the sensitive data and end users. Information provided by participating countries would be used to train this interface. People will be quite glad to put things in as long as you can't trace things back and work out the power and capability of the sensor. Users would then obtain the answers they require without ever seeing details of the satellite positions.

From identifying a hostile or benign object to attributing an attack SSA is a critical component of a security strategy in space. Large numbers of state and non-state actors use space-based products and it is estimated that over 115 states own, or have a share in, satellites. Increasingly, information-intensive operations and the realities of long-range power projection are inducing an increasing dependency on space. The militarisation of space and counter-space weapon systems are a reality. In an international system where asymmetry and hybrid threats are king, the space domain is ripe for exploitation by dominant powers and those on a lesser footing alike. The norm against space-based WMDs holds strong and space-based kinetic weapons are economically infeasible, but it does not require a state actor with a modified ballistic missile interceptor, or a non-state actor with jamming or spoofing capabilities to achieve an effect. A small piece of debris will suffice. With the importance of controlling the narrative in casualty-sensitive societies, "smart" weaponry and precision targeting are accepted necessities. It is not hard to envision how the elimination of just those specific space-dependent capabilities would play out in a 3-rd world conflict. If you develop the SSA-system, it could contain additional capabilities. The first priority is to build ground-based infrastructure. But it is not to be excluded that later in the programme, space-based monitoring could take place. If there is a problem with our satellite, we would like to have the ability to analyse precisely what is wrong with it. One way of doing that is from the ground using telescopes. Another is to have a satellite in orbit which could approach the damaged satellite and carry out a close inspection to see what is happening. Space surveillance is one thing, but to get to space situational awareness you need more than either optical sensors for high altitudes and radar for low altitudes. You need details from satellite operators. The space domain is primarily populated by private - not public - entities. Only around 20% of satellites in geosynchronous (GEO) or low earth orbit (LEO) are solely dedicated to military functions.

This is a concern as certain US military satellites and ground-stations have some, albeit limited, hardening measures, whereas civilian systems - where the emphasis is on costs rather than threats – do not. In the era of the "comprehensive approach" and NGO's satellite dependency on imagery, coordination, communications and meteorological information, even the loss of civilian satellite use can have a pronounced military impact. But the consequential impact of satellite disruption can extend far beyond military operations as the use of space permeates the civilian sphere in ways that tend to be taken for granted. From navigation, telecommunications and broadcasting to meteorological observation, environmental monitoring and supporting international trade and finance - civilian satellite use ranges from convenience to necessity and, in a similar vein to the military, dependencies are increasing. Most space-related technologies have the potential of dual-use, with varying levels of effect- from relatively simple transmitters acting as jamming or spoofing devices for blocking or hijacking a satellite's signal, to deliberately colliding one satellite with another; from modifying missile defence interceptors, to using miniature repair satellites as covert saboteurs. One solution to this predicament is the development of redundant systems and resilient technologies as a means to mitigate the costs of space "loss" and to employ some semblance of denial deterrence. The deployment of micro and nano satellites (less than 100kg and 10kg respectively) is an innovative options. The proposed ideas involve satellites being launched individually or in networked clusters that provide a redundant flexibility should key satellite nodes come under attack. However, these capabilities frequently require advances in microelectronics, lightweight materials, power sources and advanced networked systems. What's more, if quick deployment is the idea, then the delivery system needs to be capable of extended storage and high readiness – which is no mean feat.

Space debris was once the principal concern of space surveillance, but a different threat comes from near-Earth objects - the primordial rocks left over from the formation of the Solar System. It has been difficult to find funding for facilities directed exclusively towards NEO discovery. Existing ground and space telescopes used for astronomy or military activities are eminently suitable for logging asteroids and comets. The third big peak in discovery of near-Earth objects below the 1km size was with the US GEODSS system used for looking at satellites. The US military allowed those satellites to be used for NEO detection while they weren't being otherwise utilised. Space weather is the third component of

ESA's SSA programme. The bulk of this discipline is concerned with solar activity. Radiation from flares and coronal mass ejections (CMEs) on the Sun may launch X-rays and high energy particles towards Earth.

Space situational awareness is also regarded as an important step towards the holy grail of space traffic management. A system analogous to that which currently governs the movements of aircraft is still some way off. When access is assured, space is a mission enhancer. It is now becoming a mission enabler. By failing to effectively address our vulnerabilities there, the “loss” of space has all the potential to become a “mission disabler”. We should not wait for the lights to go out.