Metis

Study

Space security

No. 13 | August 2019

Summary

There has been a recent resurgence of interest among state actors and an increasing number of private stakeholders in the exploration and commercialisation of space. This renewed activity has resulted in a number of security issues and challenges. The present study not only examines the role of satellites as critical infrastructures indispensable for the functioning of modern societies but also addresses some of the problems associated with space debris. It also focusses on space weapons and the growing risks they pose to space objects and emphasise the importance of further developing international law with regard to space security. Finally, the study takes a look at ways of safeguarding German and European interests in space.

Cosmological context

The Sun, a yellow dwarf, has existed for about 4.6 billion years in a universe that is approximately 13.8 billion years old. Our solar system, including Earth, which is about 4.5 billion years old, is part of the Milky Way, which has a diameter of 105,700 light years[1] and contains between 100 and 250 billion stars. The Milky Way is part of the Local Group, which has a diameter of 8 million light years and comprises 54 galaxies. The Local Group belongs to the Virgo Supercluster, which has a diameter of about 150 to 200 million light years and is, in turn, part of the Laniakea Supercluster that has a diameter of 520 million light years. Recent findings have revealed that Laniakea, with its 100,000 galaxies and various equally large neighbouring superclusters, is part of an even larger structure. The diameter of the observable universe is estimated to be 93 billion light years. Researchers currently believe that the unobservable universe has a diameter of at least 23 trillion light years.

Other distances relevant to current space activities are rather modest by comparison. The Voyager 1 space probe, which was launched in 1977, is the most distant man-made object from Earth. Having left our solar system in 2013, it has been travelling in the direction of AC+79 3888 – a star that is 1.7 light years away and that the probe is expected to reach in about 40,000 years. Voyager 1 has so far travelled a distance of 0.0022 light years, i.e. about 22.5 billion kilometres.[2] Evidently, human space travel and space security are still very much limited to our solar system and to distances from Earth that can be covered with currently available propulsion technology.

The present study examines the existing framework of international law as it relates to space while also addressing the growing problem of space debris. Then it discusses various space weapon concepts. Following this, the potential militarisation of space, the need to further develop international law and the growing importance of private actors are explored. Finally, the study suggests ways to safeguard German and European security interests in space in the future.

Space law and space debris

There is no clear definition of where the boundary lies between airspace and outer space. According to the most commonly used definition, outer space begins at an altitude of 100 kilometres above sea level. This boundary is

1 A light year is an astronomical unit of length. It is the distance that light travels in a vacuum in one Julian year at a speed of 300,000 km/s. One light year therefore measures 9.46 trillion kilometres.

2 The National Aeronautics and Space Administration (NASA) updates the mission status of its Voyager space probes every second at https://voyager.jpl.nasa.gov/mission/status/.

known as the Kármán line. The basis of international space law is the Outer Space Treaty, which entered into force in 1967 at the height of the Cold War space race. It defines principles governing the space activities of states. According to Article II of the Treaty, "Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means." The exploration and economic use of outer space should be carried out for the benefit of all mankind. In other words, the economic and scientific activities of individual states and private actors must be performed for the benefit and in the interest of all countries. In addition, Article IV states that the Moon and other celestial bodies must be used exclusively for peaceful purposes.[3] The Outer Space Treaty also contains provisions with regard to liability for damage caused by space activities (Article VII) and to the prevention of the harmful contamination of space. The Committee on the Peaceful Uses of Outer Space (COPUOS) has drafted numerous additional and supplementary agreements to the Treaty. These include the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (1968), the Convention on International Liability for Damage Caused by Space Objects (1972), the Convention on Registration of Objects Launched into Outer Space (1975) and the Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979). A proposal for the Prevention of an Arms Race in Space (PAROS) has always been blocked by the United States, Russia and China, who argue that there is no multilateral solution in sight.

Some of the space agreements, such as the prevention of space debris or the Moon agreement, have yet to be put into practice. Space or orbital debris particularly threatens the future of manned space travel as well as new and old satellites and the future commercialisation of outer space. In January 2019, the European Space Agency (ESA) estimated that more than 128 million pieces of debris measuring less than 1 centimetre, about 900,000 pieces ranging in size from 1 centimetre to 10 centimetres, and about 34,000 pieces larger than 10 centimetres are orbiting Earth (see Fig. 1). Most of this debris consists of the remains of space launches and old satellites. A small percentage of space debris is produced by the destruction of satellites during weapons tests.

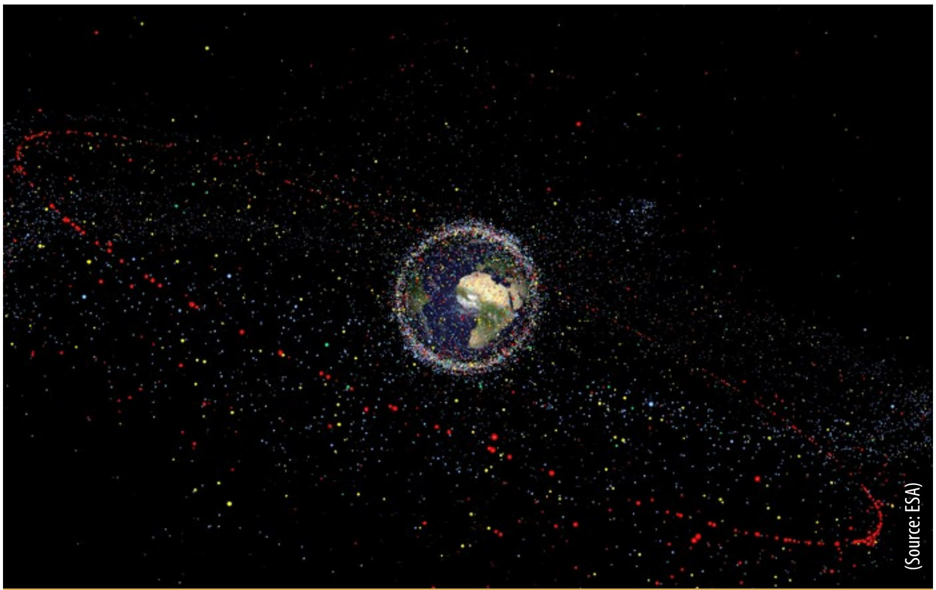

Fig. 1 *Model representation of the distribution of the currently registered space debris in near-Earth orbit.*

An increase in space debris and the resulting higher probability of coincidental collisions may lead to what is known as the Kessler syndrome. This is a scenario in which collisional cascading causes an increase in the number of small orbiting objects. This chain reaction may be initiated by collisions with objects of greater mass which, in turn, increase the likelihood of even more collisions and debris. This would considerably jeopardise the long-term viability of space stations or satellites in low Earth orbit. Future generations may be unable to use low Earth orbit or only be able to use it to a limited extent. Satellites would continually have to avoid collisions with debris and manned launches could only be performed within an extremely narrow time frame. Modern launch systems could help reduce low Earth orbit pollution through the return of their core engines to Earth for reuse.

Concepts for space weapons and their implementation

Although the Outer Space Treaty specifically prohibits the deployment of nuclear weapons and other weapons of mass destruction, a large number of concepts

3 There is disagreement between the States Parties to the Treaty about the admissibility of space systems such as military reconnaissance satellites or ballistic missiles passing through outer space during their flight.

on conventional and nuclear space weapons have been developed over the past few decades. While some of these weapon systems never progressed beyond the planning stage or could not be developed further due to technical problems, other weapons are already being used, in particular sea-, air- and ground-based anti-ballistic missile (ABM) and anti-satellite (ASAT) systems. Below is an overview of the most common concepts.

Launching missiles from Earth continues to be the easiest way to destroy satellites. During the Cold War, the United States and the Soviet Union developed a number of sea-, air- and ground-based ABM and ASAT systems. While in the 1960s and 1970s their lack of precision made it necessary to equip these missiles with nuclear warheads, enhanced precision means this is no longer necessary. At present, the United States possesses such capabilities with its Standard Missile 3 (SM-3), whereas the Russian Federation can deploy the PL-19 Nudol system. In 2007, China destroyed the ageing Fengyun-1C weather satellite with its Dong-Feng 21 (DF-21) medium-range missile during an anti-satellite missile test. This test provoked international protest as it caused the formation of a large cloud of debris that forces the International Space Station (ISS) to regularly perform evasive manoeuvres. A similar test conducted by India in March 2019 destroyed an Indian satellite in a much lower orbit, with approximately 60 % of the debris having burnt up in the atmosphere by mid-2019.

The opposite direction, i.e. attacks on a planetary surface from space, for instance by using inert projectiles (*Rods from God*) to produce kinetic effects, has only been addressed at the conceptual level, even though these concepts have existed for decades. In the Cold War, these bunker busters were designed to destroy mainly fallout shelters. According to this concept, a satellite consisting of a magazine of tungsten rods and a directional thrust system could be used as a weapon. Due to the force of gravity, a tungsten rod released into orbit would gather immense speed on its way to the Earth's surface. Deflecting such projectiles approaching from a very wide angle and at high speed would be extremely difficult. With eight orbiting satellites, it would be possible to hit any target within 15 minutes without previous warning, which is twice as fast as the time required when deploying currently available intercontinental missiles. However, apart from the question of legality, there are certain disadvantages to this concept, including technical obstacles to ensuring precision and the high costs of placing ammunition in orbit.

The Almaz programme, also known as *Guns in Space*, was a Soviet space programme designed to deploy military manned space stations in orbit. One of the space stations (Almaz 2, also called Salyut 2) was fitted with a 23 millimetre Rikhter rapid-fire cannon in addition to the reconnaissance equipment. This revolving cannon had a theoretical rate of fire of 2,000 rounds per minute. The cannon was tested once by firing 20 rounds. In order to aim the fixed cannon at targets, the entire station would have had to be manoeuvred. Almaz 2 is the only known military manned spacecraft ever flown.

There are also concepts for co-orbital ASAT weapons, most of which are satellites in low Earth orbit that could ram other satellites. Non-kinetic weapons, on the other hand, are designed to destroy satellites by means of lasers, microwaves or other electromagnetic radiation. The aim is to raise the temperature of small objects in order to change their orbit in such a way that they enter the atmosphere and burn up. Originally, this system was developed to take space debris out of orbit. However, it also fulfils dual-use criteria as it may be employed as a weapon against operational satellites and optical or technical devices and solar sails. Theoretical tests to irradiate space debris have been conducted using high-powered lasers.

Electronic means for jamming radio telecommunications of communication satellites, such as the Counter Satellite Communications System, are already in use. Using electronic means to temporarily or permanently jam satellite communication systems avoids destroying them and also helps prevent further space debris which, in the worst case, could pose a threat to the attacker himself and his objects in space.

Even though satellites in orbit are relatively secure, the increased use of cheap high-gain antennas has made them vulnerable to hacking and hijacking. Hackers could also attack the computer systems of ground stations in order to gain control over satellites. Cyber security has only recently become a factor in satellite design. Several attacks on NASA systems and satellites, most of which were not secured, have been registered in the past. Theoretically, attackers could even gain access to the Hubble Space Telescope systems. Above all, they could cause military or civilian communication satellites to crash or, at the least, could seriously disrupt or simply take over important services based on these satellites.

Militarisation of space?

The large number of existing and potential future weapon systems and weapons in Earth orbits indicates an increasing threat posed to objects in low Earth orbit. This was exacerbated in 2019 by the termination of the Intermediate-Range Nuclear Forces Treaty (INF) between Russia and the United States and by India's ASAT test. Space is increasingly becoming an important domain for the leading industrial nations to project power on a global scale. In the 2000s, a new race for economic and military capabilities in space started. Since then, the number of satellites operated by public and private stakeholders has multiplied. Investments in new space projects continue to increase and state actors such as China, Russia, the US and France are establishing their own space forces or comparable organisational elements in order to protect their space capabilities. Destroying or jamming critical infrastructures in space may seriously harm potential adversaries and hamper their reconnaissance and command and control capabilities. US forces in particular are increasingly at risk of having their space capabilities eliminated by other powers, primarily China and Russia, which would end the predominance of the US military and the American approach to war.[4] Disrupting a nuclear power's space capabilities would eliminate its nuclear second-strike capability and thus destabilise the nuclear balance.

It would seem, therefore, that space is once again becoming the arena for a global arms race, this time between the US, NATO, China, Russia and India. However, this is a process that involves high costs and major technological challenges and will therefore take some time. A single failure may set back all efforts made by the respective actor.

It is doubtful whether space law in its current form can curb this development. Even during the Cold War, space law was unable to prevent increased military use of outer space, nuclear tests in the upper atmosphere and continuous pollution of the low Earth orbit. Space law must be modernised substantially in order to adequately address future developments in the military and civilian use of space (dual use).

Against this background, it is also important to consider the required international legal framework for deploying nuclear, kinetic or other kinds of planetary defence systems against comets, meteors and exocomets. At its annual conference in May 2019, the NASA Planetary Defence Coordination Office took the position that in the long term such countermeasures will make the deployment of orbital weapon systems necessary.

In the meantime, increasing commercialisation of space activities by private actors has led to a growing number of potential actors in space. Whereas only state actors had previously made leaps in space travel possible by means of (partly secret) technological achievements, medium-sized and large technology companies are now playing a significant role in top-level space research, although many of them cooperate with government institutions. Business activities could therefore become a security risk for government capabilities whenever economic interests run counter to security policy. What is more, the growing number of low Earth orbit activities will increase the risk of the Kessler scenario. Aspirations of individual companies to advance mining in the solar system could also set off a gold rush in space and intensify the arms race between major powers. And finally, increased space use by private actors will enable a growing number of these actors to access capabilities previously reserved for states, such as geo-reconnaissance and geo-monitoring capabilities and data transmission via orbital relay stations. On the whole, this development may have far-reaching security implications for states because ultimately it will be purchasing power alone that determines access to critical information and infrastructures.

Space security as a catalyst for European security integration?

So far, only the US, China, Russia, India and France have space elements within their armed forces. They are either assigned to individual services, such as the air force, or are entirely independent. Germany has so far refrained from establishing a military space branch within the Bundeswehr, even though its capability structure is similar to that of other nations. As a high-tech nation with a modern civil society, Germany is highly dependent on satellite infrastructure. Similar to US forces, the Bundeswehr requires unrestricted access to space-based information and communication channels.

Germany currently takes the view that conflict prevention and compliance with international law in the form of the Outer Space Treaty are essential. However, in order to ensure that dynamic developments in space travel comply with international law, to reduce the risk of an arms race in orbit and to urge private actors to take appropriate responsibility, Germany should intensify the further development of space law together with its partners.

International law could, for instance, stipulate that a security cordon of 50 kilometres be established around each satellite in order to counter the use of kinetic weapons in orbit. Any violation of such a radius should be sanctioned. This would enable states to better protect their critical satellite infrastructures against collisions or hostile actions by other states and commercial actors. Such a proposal, however, is considered a breach of international law by some because it may lead to the creation of national territories in orbit. In addition, it could be determined whether the use of ASAT weapons should be subject to approval by the UN Security Council or another UN organisation. Moreover, the prevention and removal of space debris must be internationalised. International and national requirements should also apply in future to private actors since currently only governments are liable for any damage caused in space. The creation of a space council composed of all aerospace nations, similar to the Arctic Council, could also help to build trust and serve as a coordination and de-escalation mechanism.

4 The current US approach in military conflicts is founded on satellite-based C4ISR systems (command, control, communications, computers, intelligence, surveillance and reconnaissance). These not only facilitate unrestricted reconnaissance, command and control, detection and navigation as well as continuous communication but are also essential for the control of unmanned weapon systems and precision weapons.

In addition to diplomatic efforts aimed at the peaceful use of space for the benefit of the entire human race, Germany can take action at NATO level and, together with its European partners, at multilateral level. Without German participation in the current efforts of individual states to boost space capabilities, it is likely that Germany's space interests will depend increasingly on protection by NATO and EU allies. Such dependence, coupled with the vulnerability of systems, may lead to increased susceptibility to disruptions affecting Bundeswehr capabilities as well as Germany's economic interests and civil society.

In mid-2019, NATO adopted a space strategy which enabled it to declare space an operational domain and thus heighten the deterrent effect. To this end, member states will provide additional resources to protect NATO satellites against kinetic attacks and hackers. This means that Germany is, at least indirectly, involved in protection measures taken in space.

Germany can also cooperate more closely with its European partners France and the United Kingdom to protect common security interests in space. In this trilateral constellation, Germany's position would be rather weak with limited opportunities to shape processes in the event of disputes. Bilateral cooperation with France could be intensified and, at the same time, pave the way for an EU approach.

In the long term, formulating a common space strategy and creating a European Union Space Force (EUSF) could contribute to protecting European and German security interests in space. This would not only strengthen Europe's position within NATO but also help to establish a complementary initiative at EU level. The EUSF could also serve as a catalyst to further integrate European forces and help defend common EU interests – in particular unrestricted access to space and space-based services – using military force if need be. In addition, the EUSF would contribute to reducing the unnecessary duplication of capabilities at national level and provide the framework for a common European security and defence policy in space.

IMPRINT

Publisher

Pilot Project Metis
Bundeswehr University Munich
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Title Image

Bill Jelen on Unsplash

Original title

Sicherheitspolitische Dimensionen der Weltraumnutzung

Translation

Federal Office of Languages

ISSN-2627-0609