Preventing an Arms Race in Outer Space

Submitted by Clive Hughes

Key points

• Space systems enable global communications, navigation and Earth observation and thus enable a wide range of vital military and civilian activity for security, projecting military power, international development and global prosperity.

• Space weapons are designed to counter the strategic and military benefits of space systems and they can deliver a range of effects from denial of service to destruction of space objects. They are based on Earth and in space, so any arms race exists is not confined to outer space itself.

• It is difficult for a State to predict the impact of its operations to interfere with the space systems of another State. If the aggressor State believes it is operating below a certain threshold and the victim state perceives it otherwise, there is a risk of escalation and conflict.

• Space weapons can masquerade as benign space capabilities, making it hard to assess whether there really is a space arms race in progress and difficult to prohibit such weapons, whether in space or on Earth.

• Doing nothing is not an option. Norms of responsible space behaviours, legally binding or otherwise, can help states avoid escalatory actions and address underlying drivers of contested or adversarial relationships.

Introduction

1. In order to devise effective measures to prevent an arms race in outer space, we first need to know whether an arms race in outer space is occurring and, if so, to characterise the nature of that arms race and understand what is driving it. To do that requires an understanding of space systems, the level of integration with civil society, the threats to and from those systems, the impact they have on relations between States and, conversely, how relations between States shape the development or use of space systems and threats to them.

Space Systems

2. Space systems provide three main services: communications (SATCOM), position, navigation and timing (PNT) and intelligence, surveillance and reconnaissance (ISR), or, from a civilian perspective, earth observation (EO). These services enable a wide range of vital civilian and military activity for security, projecting military power, international...
development and global prosperity. As such, States have also developed weapons to interfere with these systems in order to deny the advantages they provide.

3. Space systems are developing rapidly. New ways of delivering SATCOM, PNT and ISR are materialising. For example, we see the emergence of technologies that can deliver SATCOM and PNT from Low Earth Orbit (LEO) alongside the traditional Geostationary Orbit (GEO) and Medium Earth Orbit (MEO). We are also seeing the emergence of novel space activities such as on orbit servicing and on-orbit manufacturing. In the not too distant future, we may see technologies such as the ability to provide solar power to Earth from space. These new space capabilities may also find themselves under threat or used in a threatening way.

4. Space systems have three segments. The space-segment is composed of satellites or spacecraft in orbit. The Earth-segment consists of ground-stations and user-equipment (e.g. mobile phones). The signals that link these two segments comprise the third segment.

Space Weapons

5. Although the term “space weapon” is hard to define, a number of States possess Earth-based and space-based capabilities that can deny, disrupt, degrade, damage or destroy the three segments of space systems. These capabilities include direct-ascent anti-satellite (DA-ASAT) missiles, electronic warfare (EW), cyber-operations, directed energy weapons (DEW), and orbital anti-satellite (ASAT) systems. Space situational awareness (SSA) capabilities underpin the operation of these counterspace capabilities.

6. DA-ASAT missiles are launched from earth and typically destroy their targets through collision (not the use of explosives). The use of DA-ASAT missiles in a conflict would likely create large amounts of space debris and would likely result in many orbits becoming permanently unusable with significant ramifications for the provision of critical services from space. However, even the testing of such weapons is hugely problematic. Several space-capable countries have tested them against their own satellites with significant and long-lasting impacts on the operations of spacecraft of other countries due to the creation of debris. DA-ASAT capabilities may proliferate as more countries develop the capacity to conduct space launches.

7. EW is the jamming or spoofing of signals emitted towards and from a satellite to disrupt use of position navigation and timing (PNT) signals or communications signals. The effects from EW are typically known to be reversible and temporary. Many nations consider EW key to their defence doctrine.

8. Cyber-operations against a satellite system could target both the ground and space-based components of the space system. The effects of a cyber-attack could be reversible or irreversible and range from exfiltration or manipulation of data to the permanent loss of a satellite.

9. Directed energy weapons use focused energy (such as from a laser or high-powered microwave) to disrupt or disable space systems. The effects from DEWs depend on the power of the system.

10. Orbital counterspace systems could achieve their effects in multiple ways. These include, but are not limited to: spaced-based EW, space-based DEW, projectiles, collision and non-cooperative rendezvous and proximity operations (RPO).

11. Even with reversible EW, cyber or DEW operations, the knock-on impacts on critical infrastructure and on civilians are difficult to predict and could be significant and life threatening. Greater than expected impacts could lead the victim to respond with greater than expected measures in response against the aggressor leading to a cycle of escalation.

Dual-use systems

12. Most space weapons, whether Earth-based of space-based, would possess features that allow them to be portrayed, or indeed used, as benign capabilities. For example:
• Civilian terrestrial laser systems, which can provide a critical service for SSA by providing satellite laser ranging information, could be modified to dazzle optical sensors on satellites;

• EW satellites would be designed to uplink or downlink jam other satellites, which would require them to produce sufficiently powerful electromagnetic signals in the same frequency bands of communications satellites. Due to these requirements, EW satellites would share many features with their target and look just like a regular communications satellites;

• DEW satellites would have payloads with lasers or similar high-energy systems. To target other satellites, they would need to accurately orient themselves and have high quality SSA data. Very similar technology is needed for laser communication links between satellites and space-to-ground links. These links provide high data transfer rates and enable technologies such as satellite-provided internet;

• RPO based attacks could involve a counterspace satellite moving very close to its target and performing an unauthorized action. For example, a satellite with a grappling arm could come within a few metres of its target before grappling and moving the satellite out of its intended orbit or damaging components of the satellite, such as solar panels. However, the same capability could be used to perform debris removal missions or conduct SSA missions for space traffic management, which are becoming increasingly necessary especially in valuable low earth orbital and geostationary orbital slots.

An Arms Race in Outer Space?

13. The primary reason States develop space weapons is to target SATCOM, PNT and ISR services to undermine the advantages they confer. One way to defend and protect against these counterspace capabilities is to improve the resilience of space systems and the development of capabilities to defend against them. Can this situation be described as an arms race in outer space? There are several points to note in this regard:

• Space weapons (as described in this paper) exist on Earth and in Space, so if there is an arms race, it is not confined to outer space itself;

• The incentive to develop space weapons will persist so long as SATCOM, PNT and ISR enabling systems exist. It prompts the question: are satellites that provide PNT, SATCOM and ISR services part of an arms race in outer space, and if so, how should they be treated in terms of international normative action?

• Space weapons may be disguised or even function as benign systems. This makes it difficult to describe and quantify whether an arms race exists;

• Space is not just State-to-State. There are a diverse number of space actors, including non-state actors and those that use space systems,

• Space weapons intersect with other weapon types such as cyber and anti-ballistic missile systems, which also makes it difficult to characterise/quantify space arms race in isolation.

14. We could imagine a situation in which we prohibit all of the space weapons described in this paper but leaving PNT, ISR and SATCOM services available to States. Given that PNT, ISR and SATCOM systems enable military activity on Earth, the incentive to breach the prohibition on space weapons would be very strong in a contested global environment. The dual-use nature of space weapons would provide a potential cover to do this clandestinely, adding to the incentive to circumvent the ban (as already noted, technologies used for EW and DEW are also inherent in SATCOM systems and therefore can be portrayed as such). The ability to verify compliance with a prohibition on space weapons is very limited adding yet further incentive to cheat. In such a scenario, States would have to assume the non-compliance of other States and prepare accordingly. Such a situation would invest already contested relations between States with further uncertainty and risk.
15. We could imagine a second situation in which we do not prohibit space weapons. This is the current situation, and it is a problematic one. As already noted in the paper, there is significant scope for misunderstanding and miscalculation in the use of space weapons and a concomitant risk of escalation and conflict. With increasingly contested, or even adversarial, relations between States, there is a growing risk of inadvertent conflict.

16. But there are potential mitigations. If States could agree that certain actions or effects should be avoided, or that certain space activities should be conducted in accordance with agreed standards, the scope of misunderstanding and miscalculation could be reduced. While the nature of space capabilities is difficult to verify, space activities are generally observable and with increasing fidelity, which could help provide a degree of assurance of compliance with a set of behavioural norms. This would help address the underlying issues driving contested relationships. Such norms, agreed as political commitments in the first instance, could include:

(a) States should provide advance notification of defence and security exercise that could have an impact on space systems and services in order to reduce the risk of misunderstanding or misperception of their intentions;

(b) States should not destructively test their counter-space capabilities in space;

(c) States should ensure satellites under their jurisdiction and control or operating on their behalf do not conduct counter-space testing activities that impair the safe operation of satellites under the jurisdiction and control of another state;

(d) States should ensure satellites under their jurisdiction and control or operating on their behalf do not physically connect with satellites under the jurisdiction and control of another state without prior consultation and consent;

(e) States should avoid jamming or spoofing activities against space systems that generate collateral impacts on civilian activity over large areas, such as disruption of air traffic or emergency services;

(f) States should not cause the permanent loss of command and control of satellites of other States;

(g) States should not cause permanent damage to the imaging sensors of satellites of other States.