Keeping space in check

Space has always presented humans with a dilemma between the desire to explore and the desire for military advantage. But as **Laura Grego** explains, scientists have an important role to play in regulating the use of space for the good

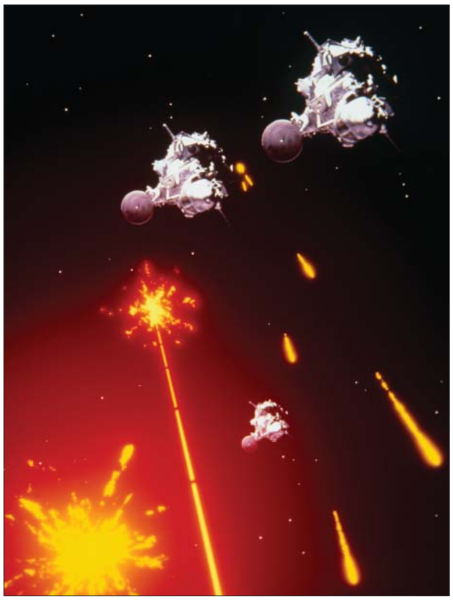
On 4 October 1957 the Soviet Union launched the first artificial Earth-orbiting satellite: Sputnik 1. This stunning technical achievement demonstrated the human desire for knowledge and discovery. But it also had an important political dimension: the technology that lofted an aluminium sphere 60 cm in diameter into orbit was closely related to the technology that could deliver a ballistic missile halfway round the world. This was a chilling prospect at a time when both the US and the Soviet Union were putting enormous effort into developing more powerful and more compact nuclear weapons.

Even today – 15 years after the end of the Cold War and 4500 orbital launches after Sputnik – we continue to struggle with the dual nature of space technology as the stuff of both our dreams and our nightmares. In the past 50 years, space has demonstrated its enormous potential for generating both scientific knowledge and economic growth. Currently, over 50 countries either own satellites or have a share in one, and satellite services such as telecommunications and the Global Positioning System are used in almost every spot on the globe. Meanwhile, the ability of space to confer a military advantage has also been exploited.

During and after the Cold War both the US and the Soviet Union explored technological approaches to controlling space. Today, spending on military space programmes – particularly in the US – grows apace. Indeed, the aggressive space-weapons rhetoric used by the current Bush administration and the destruction this January of a satellite in a test of China's nascent antisatellite weapon system have brought new saliency to the issue of space weaponization.

Controlling space with weapons

Early space-control weapons were designed to target enemy satellites or missiles. In the 1960s, the Soviet Union began testing its "Co-Orbital" antisatellite system – a weapon that would be launched into the same orbit as the target and detonate upon close approach. A number of tests were conducted, leaving bits of orbiting debris that are still present today.



Julian Baum/Science Photo Library

Under fire We must resist the weaponization of space.

Although these tests were suspended in the 1980s, by that time the US had begun to develop its "air-launched miniature vehicle" antisatellite system, in which a missile launched from a high-altitude F-15 aircraft would ascend directly to the targeted satellite and destroy it with the force of its impact. The weapon was tested against a satellite for the first and only time in 1985, when it completely fragmented an aging weather satellite. The last tracked piece of debris from that test did not "de-orbit" until 17 years later.

Shortly afterwards, the US – under the directive of President Ronald Reagan – mounted an ambitious ballistic-missile defence initiative commonly known as Star Wars. The project envisaged using space-based weapons – such as nuclear-powered X-ray lasers and missile-based interceptors – to defend the US against a massive nuclear attack from intercontinental ballistic missiles. However, while well funded, the technical basis of the ambitious project was unrealistic. For example, the technology for space-based X-ray and other lasers did not exist. What remains of Star Wars today is much smaller and more modest. Still in place are a ground-based missile-defence segment and some small space-based missile-defence research programmes.

However, when the current US administration arrived in 2000, it included a number of influential people who were very enthusiastic about space weapons, such as former defence secretary Donald Rumsfeld. This enthusiasm led to aggressively worded policy documents that called for weapons to be placed in space and aimed at satellites. One of the most provocative concepts was space-based ground-attack weapons, which promised the ability to attack any part of the world quickly and without deploying troops abroad. Various weapons ideas included using precision-guided munitions or even tungsten "rods from God" that would penetrate the ground to destroy hard or buried targets.

Attack from above

Some of these ideas were (and still are) technically infeasible or based on advances in technology that are unlikely to take place in the near future. However, aside from both any technical flaws of the weapons themselves and the political wisdom of developing a space-based ground-attack system, physics places strong constraints on the usefulness of such a system. For instance, space-based weapons are subject to the "absentee" problem – the fact that weapons based in low Earth orbit move very quickly relative to the surface of the planet and are therefore unlikely to be in the right place at the right time to attack a time-sensitive target. A space-based ground-attack weapon that would be competitive with ground-based alternatives, having for example a 1 hour response time, would be very expensive because many tens of satellites would be needed to have one in place for striking a particular target at a particular time.

The absentee problem is even more severe for space-based "boost-phase" ballistic-missile defences, which must respond on much shorter timescales if they are to be effective. A missile's boost phase (the time during which the engines are firing) only lasts a few minutes, which means that hundreds if not thousands of interceptors would be required to get an interceptor in place in time to destroy just one launching missile. Successfully engaging two missiles launched simultaneously from the same location would require twice as many interceptors and an enormous economic commitment.

Yet even if the engineering and financial challenges involved in developing such a massive and capable system were to be overcome, such a system would have other serious flaws imposed by physics. For example, the missile defence could be overcome simply by launching a few missiles at a time or by using a cheaper, short-range missile to knock out one of the interceptors and leave a "hole" for the long-range missile to pass through. In short, the technical, financial and political challenges of space-based ground-attack and missile-defence weapons make them unlikely to be realized in the foreseeable future. Nevertheless, humankind's success with space technology has led to other issues of space security that are with us right now.

Space arms race

Despite being very useful, the problem with satellites is that they travel repeatedly over predictable, observable orbits, and are generally unarmoured because launching heavier objects is more expensive. Satellites are thus obvious targets for an enemy, using either missiles launched from the ground or highly manoeuvrable lightweight satellites. In addition, the ground stations that control satellites also serve as targets for "low-tech" antisatellite attacks.

This inherent vulnerability of satellites could generate a competition between satellite offence and defence, and thus trigger a space arms race. As well as diverting economic, technical and political resources away from more useful pursuits, a space arms race could foster mistrust between nations and thus hinder progress on pressing global issues such as nuclear non-proliferation and climate change. Furthermore, in a crisis situation, the increased military reliance on satellites for precision-guided munitions, communications and intelligence gathering can rapidly destabilize a situation. For example, computer simulations of battle show that the loss of an important satellite, such as a big spy satellite, can escalate a conflict quickly, since such an act causes the opponent to retaliate with all its might.

Finally, in addition to the threat from space-based weapons or antisatellite technologies, our occupation of space for the last 50 years has turned low Earth orbit in particular into a bit of a junk-yard (see "Our orbiting junk-yard" on page 39). Unrestrained testing and the use of destructive antisatellite weapons can litter space with vast amounts of debris, thus threatening to render parts of it unusable. Since debris travels at about 7.5 km s^{-1} in low Earth orbits, a collision between a satellite and even a small piece of debris about 1 cm in size can destroy a satellite.

Debris from routine space operations, such as discarded equipment and fragments of exploded rocket bodies, already number in the tens of thousands, and the wilful destruction of a satellite can rapidly increase the debris density. For example, the modestly sized 1 tonne target satellite in China's test earlier this year completely fragmented, and because the satellite had been orbiting at an altitude of 850 km, where the atmospheric density is very low, much of this debris will remain in orbit for decades, spreading out into a shell encasing the Earth. The destruction of just one large satellite, such as a photo-reconnaissance satellite, at such an altitude would double the amount of dangerous debris in low Earth orbit.

Physics places strong constraints on the usefulness of a space-based ground-attack system

Space diplomacy

Antisatellite weapons and space-based weapons cannot eliminate the security issues associated with space, such as the vulnerability of satellites, and the competition for resources and military advantage. In fact, they are more likely to generate new ones. However, another anniversary reminds us that we have other tools to work with: diplomacy and law.

The year 2007 marks the 40th anniversary of the signing of the Outer Space Treaty, which has since been ratified by nearly 100 countries. The treaty lays out the principles by which space operations should be guided, stating that, "The exploration and use of outer space, including the Moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind." It also laid down important laws, including a ban on stationing weapons of mass destruction in space or on celestial objects, and extending the reach of the United Nations charter to space.

Technology has advanced greatly in the 40 years since the Outer Space Treaty was signed, and many more countries now have interests and aspirations in space. The anniversary of both the beginning of the space age and the space arms-control age presents an opportune time to update and expand the body of space law by, for instance, banning the intentional destruction of satellites and developing international "rules of the road" that coordinate and regulate space operations.

As scientists, while we commemorate the great achievements of the past, we should also look forward to the next 50 years of the space age, advocate for the peaceful and sustainable use of space, and use our expertise to explain to the public just how dangerous and short-sighted it would be to weaponize space. We should encourage our leaders to take these next steps to safeguard our common heritage in space and security on Earth.

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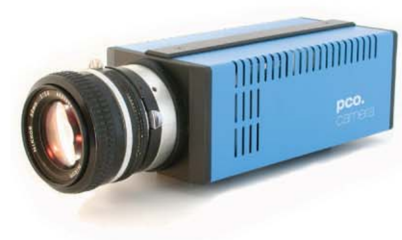

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