

# Is a space weapons ban feasible?

## Thoughts on technology and verification of arms control in space

**Regina HAGEN and Jürgen SCHEFFRAN**

The international community has acted jointly, through the United Nations, to ensure that outer space would be developed peacefully. But there is much more to be done. We must not allow this century, so plagued with war and suffering, to pass on its legacy to the next, when the technology at our disposal will be even more awesome. We cannot view the expanse of space as another battleground for our Earthly conflicts.

United Nations Secretary-General Kofi Annan<sup>1</sup>

In the coming period, the US will conduct operations to, from, in and through space in support of its national interests both on the earth and in space.

The Commission to Assess United States National Security Space Management and Organization<sup>2</sup>

In less than fifty years, outer space technologies, and specifically satellites, have revolutionized many aspects of science and everyday life: communication, navigation, meteorology, astronomy and Earth science are just a few of the fields that can be named in the civilian sector. The military has also seized upon the use of satellites for optical and electronic reconnaissance, early warning, communication, navigation, weather forecast and geodesy. In technologically advanced countries, satellites are now an essential part of military command, control, communication, computer, intelligence, surveillance and reconnaissance (C<sup>4</sup>ISR) systems. Today, more than 170 dedicated military systems (United States, 110; the Russian Federation, 40; others, 20) are in Earth orbit, complemented by many dozens of dual-use commercial systems. The fact that many assets have both civilian and military applications is one reason why the question of militarization and weaponization of space is so complicated.

During the Cold War, both the United States and the Soviet Union pursued dedicated space weapons programmes. At that time, however, neither side actually developed, tested and deployed an operational space weapon system that posed a credible military threat to the other country. The programmes came to a halt in 1984 after the Soviet Union announced an anti-satellite (ASAT) test moratorium in 1983.

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However, work on missile defence systems continued in the United States in the 1980s and 1990s. The corresponding development programmes were viewed with scepticism by large parts of the international community for two reasons: it was feared they would increase strategic instability and lead to new arms races on Earth, and it was pointed out that a portion of the projected missile defence technologies would also be suitable for space weapons purposes. Those worries were nourished by a series of documents (above all by the United States Space Command) in which the United States publicly announced its plans for 'space control', 'space dominance' and 'space superiority', making missile defense a 'Trojan Horse' for space war.<sup>3</sup> In this context, the 1972 Anti-Ballistic Missile (ABM) Treaty played a significant role in restricting the development and testing that could have led to ASAT and other space weapons capabilities.

Under the administration of George W. Bush and his team, the military role of space is being pursued with even greater vigour. Secretary of Defense Donald Rumsfeld made it clear that he foresees the military need to conduct not only air, land and sea operations but also 'independent space operations'.<sup>4</sup> As the ABM Treaty stood in the way of such plans, the withdrawal of the United States in June 2002 did not come as a surprise.

In spite of this, deployment of operational missile defence and space weapons systems remains several years ahead. Therefore, there is still time to urge for a broad range of diplomatic efforts, ranging from confidence-building measures to control regimes, as well as negotiations on a comprehensive space weapons ban. In recent years, the international community has renewed its discussion of the issue of Prevention of an Arms Race in Outer Space (PAROS). To bolster dialogue, existing proposals have been updated and new proposals have been brought forward by NGOs as well as by governments.<sup>5</sup>

This article discusses some technical aspects of verification of a space weapons ban with a focus on the prohibition of anti-satellite weapons.<sup>6</sup> Since a ban would be difficult to achieve in the current political environment, some might claim that it is premature to discuss the feasibility of its verification.

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It might also be argued, however, that acknowledging the challenges and opportunities for verification posed by the medium of space might help us to think more openly, creatively and successfully about how to reverse the alarming inertia towards space weaponization.

In order to gain acceptance for any prohibition of space weaponization, it is crucial to work out convincing verification concepts. Means for and scope of verification, technical limits to verification, confidence levels in verification, and possible loopholes for cheating are all issues that need to be addressed before a space weapons ban might be considered feasible. As a rule, however, this important aspect is neglected. For example, the joint working paper *Possible Elements for a Future International Legal Agreement on the Prevention of the Deployment of Weapons in Outer Space, the Threat or Use of Force Against Outer Space Objects*, introduced at the Conference on Disarmament by China and the Russian Federation in June 2002,<sup>7</sup> omits any mention of verification because the issue 'is rather complicated and the ideas are diversified'.<sup>8</sup>

### ***Space arms control—obstacles and supporting factors***

The part of outer space in which relevant activities could take place—and would therefore have to be observed—is vast: it ranges from around 100km above sea level to the geosynchronous orbit at 36,000km. Almost unnoticed by the larger public, space has already become quite cluttered. More

than 8,000 man-made objects larger than 10cm are currently mapped in an Earth orbit. These include operational satellites (around 7%), rocket bodies (around 15%) and space debris (fragmentation and defunct satellites, 78%). It is therefore difficult to track all space objects and distinguish between harmless and potentially threatening objects and activities. Taken on their own, these factors might be considered discouraging, but one must remember that although space is large, it is transparent and allows for remote tracking, surveillance and observation with optical, infrared, radar, electronic, electromagnetic and other technologies—thereby facilitating the verification task.

Space objects can fail for a variety of reasons: component failure and degradation; design, development, production, programming or mission errors; interruption of ground communication due to natural reasons, jamming or ground station attacks; collision with space debris; physical attack; blinding of sensors; hacking; deception; hijacking; and other reasons. Verification mechanisms might be confronted with the difficult task of attempting to trace a system failure back to a specific cause.

Verification efforts could be boosted by the fact that all space objects are currently launched from Earth. Accordingly, (expensive) space observation technologies can be complemented by (inexpensive) pre-launch verification measures (such as on-site inspection of payloads or societal verification/whistle-blowing).

Space has become indispensable for commercial, economic and scientific uses. Significantly, this is no longer true just for the most technologically advanced nations but for a steadily increasing number of states. Most space objects, from satellites to space vehicles, are potentially dual-use. Confidence in the verifiability of a space weapons treaty would be limited by the technical capabilities of the verification system to discriminate between permitted satellites and prohibited space weapons systems.

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Lastly are the practical difficulties of starting any talks on this issue. The United States has consistently blocked discussions on PAROS in the Conference on Disarmament, a body that takes decisions by consensus. In addition to this difficult political environment, the lack of generally accepted definitions for terms like 'space', 'space weapon' and 'peaceful uses' complicates any discussion of this topic.

### ***Potential ASAT weapons and their verification***

A variety of objects and weapons could be used for an ASAT attack, each requiring different verification measures that offer varying levels of effectiveness. The following sections outline some basic features, risks and potential verification measures for a range of space objects.

#### MANOEUVRABLE SPACE OBJECTS

Any manoeuvrable spacecraft, whether manned or automated, can be used for ASAT purposes. It could push the target off its orbit, bump into it to break it up, employ electronic jamming or laser blinding devices, or release explosives, chemicals or radioactive materials. In addition to these hostile activities, a manned space vehicle such as the Space Shuttle or the Russian Soyuz could hijack the target object, in the same way they can perform a rendezvous with a space station or a satellite that is due for repair.

Manoeuvrability of any spacecraft, however, is confined by fuel availability. Furthermore, to date rendezvous have only been performed with 'cooperative' low orbit targets, even in the case of the Soviet co-orbital ASAT test series of the 1970s and 1980s. To precisely encounter or come very close to a 'non-cooperative' and fast moving target is difficult and requires precise orbit data and demanding trajectory calculations. A rendezvous is further complicated if early warning is available (which could not only come from the target's on-board sensors, but also from other means, such as Earth-bound tracking systems) or if the target has certain manoeuvring capabilities on its own (e.g. to minimally change its orbit or trajectory). In any case, this precise manoeuvring capability is currently available to only very advanced and experienced space-faring nations.

However, rendezvous manoeuvres will become more common for repair (as has been achieved twice with the Hubble telescope), upgrading or refuelling of space objects. Satellite manoeuvrability is gaining in importance for cluster missions for distributed reconnaissance and environmental observation (i.e. a task is split in several subtasks that are performed by different satellites within a cluster), relocation of reconnaissance satellites over conflict areas, steering space objects out of the way of space debris, etc. As a result, experience with space manoeuvres will proliferate to more countries or satellite operators.

An attempt of another nation's spacecraft to approach its target in an ASAT mission could be detected with existing tracking systems and on-board sensors (optical tracking, interpretation of ground communication data, interception of the payload's telemetry signals) with high probability. As a rendezvous is initiated by co-orbiting and approaching the target object over a certain time period, it allows early warning and leaves some time to inquire into the intentions of the manoeuvring object. Inquiries are made easier as space objects can be traced back to specific launches and therefore to specific operators, owners or at least launching states.

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To prevent misinterpretation of a non-aggressive rendezvous manoeuvre as an ASAT attempt, advance notice of any manoeuvres and rendezvous would be helpful. As any manoeuvrable object could be used for hostile purposes, verification is not possible in the sense of verifying the non-existence of such objects. To make up for this deficit, convincing confidence-building measures should be included

in a space weapons ban. These could include transparency regarding the capabilities of spacecraft and/or their fuel reserves, intended orbit, and pre-announcement of dislocation and rendezvous manoeuvres. Thus, only deviations from predicted and intended trajectories would have to be tracked and verified.

#### SPACE MINES

Space mines are a specific class of manoeuvrable space objects insofar as their sole purpose is to destroy a satellite if instructed to do so. As any other spacecraft, a space mine must change its orbit and trajectory to approach the target satellite for an attack. To do so, the space mine would need support from ground- or space-based tracking systems and on-board homing sensors. Alternatively, immediately after its release from the launching vehicle a space mine could attempt to approach and attach itself to the target satellite unobserved—only to detonate when the destruction mechanism is triggered. Target destruction could be achieved by a nuclear explosion, conventional explosives, emission of projectiles or shrapnel, and direct collision to destroy the satellite with kinetic energy. A space mine could put at risk a single satellite or—if considerable amounts of shrapnel were released—a larger area or complete orbit.

A space mine's approach could be detected with radar systems in low altitudes and with optical systems in higher orbits, allowing time for reaction from the targeted side. This would, however, no

longer be possible if the space mines were very small (in the 5–10cm range and therefore undetectable by space surveillance networks). Fast space mine acceleration would also pose a problem, because the target satellite could not manoeuvre away in time, but a mine would require considerable fuel reserves to sustain acceleration.

Concealing a space mine within a satellite with permitted functions would be difficult to detect until the approach manoeuvre is initiated. Only pre-launch inspection of payloads could ensure that no such capability is hidden. In doubtful cases, space objects could be inspected by dedicated inspection satellites.

In order to design reliable space mines and improve approach accuracy, multiple tests would be required. Even if testing were prohibited, though, it could prove difficult to distinguish between prohibited tests and permitted manoeuvre activities.

Once again, verification of space mines would be difficult if it were demanded to confirm non-existence. Verification of non-use would be greatly assisted if information on any object, its purpose and trajectory were given prior to launch. Notification of trajectory changes could be made compulsory for all states parties to an ASAT ban. Nuclear space mines are technically feasible and would be effective over longer distances, but are already prohibited under Article 4 of the Outer Space Treaty.

#### GROUND-BASED CONVENTIONAL MISSILES

Space rockets, ballistic missiles and mid-course missile defence systems are all designed to traverse space and release an object (the payload, warhead or interceptor vehicle). Therefore they also have the potential to destroy a satellite. Destruction can be caused by a conventional explosion, by projectile emission (shrapnel) or by the kinetic energy of a direct hit collision of the warhead with the target object.

In order to destroy a satellite, the attacking vehicle must approach the target object with very high accuracy. This means that the following factors must be calculated perfectly: the exact position of the satellite on its orbit at a given time;<sup>9</sup> the exact position of the missile launch pad on Earth; the missile's acceleration, the velocity and range; and its trajectory. This implies also that only satellites on specific orbits can be reached from a given launch pad on Earth. Even then, an ASAT missile could only attack one satellite at a time, unless large amounts of shrapnel were released and a whole orbit polluted over time.

Between the 1960s and the early 1980s, both the United States and the Soviet Union conducted several rendezvous manoeuvres and conventional ASAT tests with little success. The Soviet Union announced an ASAT test moratorium in 1983, and testing stopped the following year.

Technologies for ASAT and for missile defence have much in common. In both cases, interception must either occur in the course of a rendezvous or co-orbital manoeuvre or by crossing the satellite trajectory with high relative velocity at just the right moment. With their current series of missile defence tests, the United States is gaining experience that could also be applied to ASAT weapons. No other country comes close with the technology for such endeavours. At the same time, the American missile defence programme is proof of the difficulty of hitting an object in space.<sup>10</sup>

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Any testing of a ground-based conventional missile, for ASAT or missile defence, would be easy to observe with existing systems. Infrared sensors on early warning satellites can detect a launch due to its hot exhaust plume. Tracking radars and telescopes could follow the manoeuvre. Telemetry signals can be collected with simple radio beacon receivers.

As long as ballistic missiles are not prohibited and destroyed, it is not possible to exclude ASAT capabilities by missile-owning nations. The advancement of missile defence programmes aggravates the problem, as experience with missile defence tests would increase the confidence of an attacker in system operation for ASAT purposes. Any negotiation of an ASAT ban would also have to consider the issue of ballistic missiles.<sup>11</sup>

#### GROUND-BASED NUCLEAR MISSILES

If a nuclear-tipped missile were used as an ASAT weapon, target accuracy would not need to be as high as in the case of conventional missiles. The explosive power would be effective over several kilometres and destroy any object within that range. The primary effect of interest in this case is the system-generated electromagnetic pulse (EMP). Also of interest for satellite destruction are thermomechanical shock by overheating and ionization burnout of electronic components by absorption of x-rays. A one megaton weapon exploded halfway between Earth and the geosynchronous orbit could generate EMP currents as high as 50–100A/m<sup>2</sup>—enough to destroy any unprotected satellite in line of sight and to cause considerable damage to electronic systems on Earth that are not specifically hardened.

Of the countries with longer range ballistic missiles and nuclear weapons arsenals, only the United States has tested nuclear weapons in space. Since entry into force of the Partial Test-Ban Treaty in 1963, nuclear explosions in space are prohibited and would violate international law. Any use of nuclear weapons in space could be detected by early warning satellites observing the missile launch and by space-based radiation sensors, thereby leaving no doubt as to the identity of the attacker. As in the case of conventionally armed ballistic missiles, the capability for an ASAT attack with a nuclear warhead exists as long as nuclear warheads and ballistic missile arsenals are maintained.

#### AIR-LAUNCHED CONVENTIONAL INTERCEPTORS

Satellite disruption with a conventional air-launched missile is more challenging from a technical point of view. Interception could occur by co-orbiting or crossing the satellite trajectory; where in the latter case the relative velocity (delta-v) between the interceptor and the target can be fairly high. The limiting factors are range and maximum capacity of the aircraft and consequently the payload characteristics of the rocket, i.e. only light-weight warheads can be launched beyond low Earth orbits (LEO). As in the case of other conventional ASAT systems, high manoeuvring accuracy is required to approach the target close enough.

Airborne ASAT launches have a clear advantage over ground-launched ones: the ability to launch the missile in a specific direction and from the most advantageous point for the mission, including the equator.

The United States conducted a series of twelve tests of air-launched missiles (Bold Orion) in 1958 and 1959, with one test specified a success. In the mid-1980s, tests for the Prototype Miniature Air-Launched System (PMALS) were conducted, consisting of a small two-stage missile with a miniature homing device launched from an F-15.

As air launches have considerable advantages for both commercial and military purposes, several air-launch programmes are under development and corresponding test programmes are being conducted. The only existing air-launch system so far is 'Pegasus', carried aloft by Orbital's L-1011

carrier aircraft to around 13,000m where the Pegasus rocket is released. Since the initial flight in 1990, Pegasus and the updated Pegasus XL version have flown almost thirty missions.

In the Russian Federation, several commercial enterprises are working on similar projects, such as using the Antonov AN-124-100 'Ruslan' as the carrier system. Another project proposes using the An-225 'Mriya' carrier aircraft, the world's largest heavy lifter with a maximum payload capacity of 260 tons. It is planned that the carrier would not launch a rocket but an expandable, re-usable orbiter. A similar design is under development for a United States Air Force project, using a modified Boeing 747-400F as the carrier for the proposed Space Maneuver Vehicle to lift 3,000kg payloads to LEO.

In the case of an air-launched intercept, there is little time for early warning. In an ideal constellation, a missile could hit a satellite just ten minutes after its launch from a plane. The aircraft could take off from any airfield where the runway is long enough. Verification of appropriate launches is difficult, as it is hard to distinguish between an ASAT mission of the carrier aircraft and a permitted one. If an airborne missile attempts to manoeuvre close to a satellite, this may possibly be observed with ground- and space-based tracking systems and telemetry receivers, but in practice may prove infeasible because of short warning times.

Due to the existence of air-launch systems for commercial and other military purposes, it would not be possible to verify the non-existence of such systems. Instead, verification of this technology in the framework of an ASAT ban would have to fall back to confidence-building measures, on-site inspections, and verification of non-test and non-use for ASAT purposes.

## DIRECTED ENERGY WEAPONS

Outer space seems to be the ideal medium for directed energy weapons. Because laser weapons programmes are the most advanced in the field of directed energy, they are used as an example in this section. Lasers have numerous advantages. Large distances can be traversed at the speed of light in fractions of a second, and the vacuum creates no attenuation of the beam energy. In theory, any object within line of sight could be 'zapped'. With their predictable orbits, satellites would be 'sitting ducks' vulnerable to laser attack—to blind the sensors, overload the electronics, cause thermal or physical damage, or overheat special satellite components (e.g. sensitive payload optics or attitude control sensors).

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Consequently, laser weapon development programmes have been conducted for many years, although hampered by physical and technical problems. Amongst these differences are the high energy requirements to power the laser, the need for precision targeting mechanisms, and the lack of system serviceability. Currently, the United States is working on ground-, air- and space-based laser systems for missile defence, all with inherent ASAT capability. And the Russian Federation has reportedly worked on a space-based laser weapon programme. The first Energiya mission in 1987 carried Polyus, an 80 ton satellite, which included equipment for laser tests. The mission failed to reach orbit, and no further attempts are known.

### Ground-based laser

For ASAT purposes, the laser beam would be focused through the atmosphere, either directly to the target or to a transmission mirror satellite. Atmospheric disturbances, attenuation and beam

widening over large distances must be compensated by higher energy beams. The ground-based Mid-Infrared Advanced Chemical Laser system (MIRACL), originally developed for President Reagan's Star Wars programme, was test-fired against a phased-out Air Force satellite in 1997, and the United States Army has continued refining the system since then in the framework of missile defence. Together with Israel, the United States is also working on the ground-based Tactical High Energy Laser (THEL) system. While energy supply is less of a problem for a ground-based laser, it can only attack satellites above the horizon and would be both limited to its deployment site and to attacking satellites on a lower orbit. On the other hand, this capability would be sufficient to blind the sensors of other nations' reconnaissance satellites—either temporarily or permanently—and thus prevent them from surveying the particular area within reach of the laser system.

### Airborne laser

Flying at high altitudes, an airborne laser features high mobility and less atmospheric transmission loss. Putting a large laser into an airplane is not an easy task, and vibrations, air manoeuvres and turbulence during flight impair operation. The United States Missile Defense Agency, the United States Air Force and industrial companies are working cooperatively on the Airborne Laser (ABL) project and want to demonstrate its capability in ballistic missile shoot down in 2004. The ABL could potentially also be used in an ASAT mode.

### Space-based laser

A space-based laser would be a very powerful weapon, as it could be used at any time against any target in space, in the air or on the ground. Similar to an airborne laser, a space-based laser would destroy an object by focusing and maintaining a high-powered laser beam until it causes destruction of the target. In preparation for a first strike attack, a few laser weapons deployed high enough in space could attempt 'sky sweeping' to destroy another nation's command, control, communication and intelligence (C<sup>3</sup>I) to reduce the adversary's second strike capability.

The development of space-based lasers is hindered by significant technical problems, such as power supply. The United States Space-Based Laser project (SBL), originally scheduled for in-flight test in 2012, is troubled with delays and has recently suffered budget cutbacks.

It seems that as yet, no laser weapon has been developed that could actually be used in an ASAT mode. In all likelihood, development of the ABL that could be used against satellites is far ahead of ground-based and space-based lasers. At this stage of development, the most effective means to prevent lasers from being used as ASAT weapons is a ban on testing laser weapons. Any tests under realistic conditions—be it on the ground, in the air or in space—would be detected by existing systems. The heat dissipation can be observed by space-based infrared sensors. In addition, high-energy lasers are huge systems that could be detected by reconnaissance satellites or—if they are deployed in space—by tracking systems.

If ASAT laser weapons were deployed, their use could be verified by infrared sensors, by observation of unexpected illumination or by a signal emission of the target satellite. As in other cases, it would be difficult to verify an ASAT laser ban if they are an accepted component of missile defence systems.

## ***Realistic verification and risk reduction***

A multitude of technologies, tools and measures could be employed to verify a ban on ASAT weapons. As a transparent medium, space provides ideal conditions in particular for remote tracking and surveillance of space objects and activities.

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The *prohibition* of interference, deliberate concealment measures and encryption that impede verification minimizes the likelihood that cheating on the treaty provisions goes unnoticed.

*On-site verification* of Earthbound production, launch and infrastructure facilities could be conducted by inspectors; more permanent verification can be facilitated by observers as well as by on-site monitoring instruments and detectors. In the case of credible cheating allegations, on-site inspections might even be conducted in space by using dedicated remote control or manned verification spacecraft. Human intelligence and societal verification (including whistle-blowing) add to the reliability of the verification results.

For several decades the United States has maintained a global *Space Surveillance Network* (SSN, under control of the United States Space Command) to detect, track, catalogue and identify all objects in Earth orbit larger than 10cm, with a primary interest in operational satellites. The SSN consists of United States Army, Navy and Air Force operated ground-based phased-array and conventional radars and optical sensors (telescopes) at twenty-five sites worldwide. Combined, the network makes up to 80,000 satellite observations each day. The SSN's Ground-Based Electro-Optical Deep Space Surveillance (GEODSS) telescopes are scheduled to be upgraded to identify an object size of 5cm and larger. The Russian Federation operates a similar system, although it is less capable.

The European Space Agency maintains the ESTRACK Network to track its own satellites and those of their industrial customers. Furthermore, the European Union in the framework of the Common Foreign and Security Policy maintains its own satellite centre (the former WEU Satellite Centre at Torrejón, Spain).

The so-called '*national technical means*' that are used for (military) reconnaissance and spying are also suitable tools for verification purposes. These include early infrared warning satellites to detect space launches of missiles and rockets; reconnaissance satellites with optical cameras, infrared or microwave sensors to observe suspected ASAT facilities such as launchers, rockets or laser systems; ground-, air- and space-based electronic and electromagnetic surveillance systems to intercept communication signals of suspicious facilities, which could with some probability also receive telemetry signals of prohibited weapons tests in space.

Similar to other arms control treaties, a space weapons agreement could include provisions to set up an *international monitoring system*. The system would include a variety of verification means globally and make relevant data available to all states parties to the treaty.

*On-board sensors* on important satellites could collect pressure, acceleration, heat and radiation data and notify ground control of any deviation from the expected status. In case of a satellite failure, the sensor data could help to determine the cause of failure and exclude or confirm the likelihood of an ASAT attack.

*Confidence-building measures* could further enhance reliability of the treaty regime. Advance notice of any launches, including information on the functions and capabilities of the object to be launched, would be an easy way to prevent mistrust. Multinational space activities, including mission design, development, production and operation, might reduce suspicions and could serve as a hedge against cheating attempts.

Lastly, *reducing risk* through means other than verification can add to one's perception of security. Feasible measures to increase survivability of space objects—and therefore decrease vulnerability to both natural disturbances and ASAT attacks—include:<sup>12</sup>

- physical hardening against nuclear radiation, laser irradiation or collision with small objects;
- manoeuvrability to escape a potential physical threat;
- autonomy from ground control to reduce the risk of communication failure or interruption;
- deception of attacking sensors;
- attack warning sensors on-board important spacecraft;
- 'keep away' safety areas (buffer zones) to increase the warning time;
- redundancy and distribution of important functions to several satellites (clustering); and
- provisions for quick replacement of crucial satellites in case of a failure or attack.

### ***Conclusion—understanding the principles of treaty verification***

The question of verification of arms control treaties is often narrowed down to particular verification problems or to technical capabilities of (existing) monitoring systems. In so doing, it is generally ignored that broadly accepted verification principles should also be defined. This is important because treaty verifiability is not a precisely measurable value in itself but should be evaluated in the context of the security risks associated with or prevented by treaty compliance. It is therefore useful to keep in mind a few principles of verification.

- Arms control should enhance international stability and reduce the risk of an unrestrained arms race.
- A proper balance should be maintained between the activities that ought to be verified (acceptance threshold) and the activities that can be verified (monitoring threshold).
- Generally, the expenditures for verification should be proportional to the security gain achieved and the risks that remain.
- Verification encompasses several parallel processes. In addition to technical monitoring systems, political, legal, diplomatic and military processes are important factors when it comes to assessing treaty compliance, predicting the risk of cheating and providing for sufficient time to initiate adequate countermeasures in the case of treaty violations.
- Due to the imperfection of available verification means, there remains a residual risk. This can be further reduced by defensive and cooperative measures that offset any advantage a party might gain by cheating.

In essence, two factors determine the reliability of measures to verify an ASAT ban: the availability of specific technologies (which is rapidly increasing in many fields) and the inherent dual-use capability of relevant technologies and systems.

An ASAT ban would be adequately verifiable if development, testing and deployment of ASAT systems with advanced technologies were completely prohibited. This would include ballistic missiles, missile defences, nuclear weapons, carrier airplanes and high energy lasers—and is very unlikely. More

realistically, a space weapons ban could restrict only specific weapon systems. A residual risk inevitably would remain from systems that are not covered by the ban but could be used in weapons mode. For example, long-range missiles, manoeuvring spacecrafts, and air- or ground-based lasers could all be used for satellite attacks. An ASAT ban would therefore have to be bolstered with a range of confidence-building measures and transparency agreements.

For this to be achieved, all claims of 'space dominance' and desires for 'force projection into, through, from, and in space' must be given up. The further the development and testing of relevant systems advances—for either civilian or military programmes—the more costly and less reliable eventual verification will be. An atmosphere of trust and non-military conflict resolution would omit the perceived need for the weaponization of space—and ensure that 'Star Wars' remains science fiction.

## Notes

1. Address delivered to the opening meeting of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), Vienna, 19 July 1999, available at < <http://www.oosa.unvienna.org/unisp-3/>> under 'Statements'.
2. Commission to Assess United States National Security Space Management and Organization, 2001, *Report of the Commission to Assess United States National Security Space Management and Organization*, 11 January. The Commission was chaired by Donald Rumsfeld. Full text available at < <http://www.defenselink.mil/pubs/space20010111.html>> .
3. Select examples include: United States Air Force Scientific Advisory Board, *New World Vistas. Air and Space Power for the 21<sup>st</sup> Century*, 1995; United States Space Command, *Vision for 2020*, 1997; US Space Command, *Long Range Plan. Implementing USSPACECOM Vision for 2020*, 1998; United States Secretary of Defense Bill Cohen, *Memorandum: Department of Defense Space Policy and Department of Defense Directive, Number 3100.10, July 9, 1999, 'Space Policy'*; and Air Force Space Command, *Strategic Master Plan for FY02 and Beyond*, 9 February 2000.
4. Commission to Assess United States National Security Space Management and Organization, *op. cit.*
5. For a comprehensive discussion of Prevention of an Arms Race in Outer Space and the texts of and comments on several space weapons ban proposals, see *INESAP Information Bulletin*, no. 20, August 2002, which also contains a detailed bibliography on the topic compiled by Jürgen Scheffran. Available at < <http://www.inesap.org/bulletin20/bulletin20.htm>> .
6. In doing so, the *Proposed Treaty on the Limitation of the Military Use of Outer Space* (Göttingen, 1984) is used as an example. This proposal considers a ban on ASAT weapons, on weapons in space and on space-based systems for direct guidance of nuclear weapons, including a ban on manned military command centres in space. This treaty was drafted by H. Fischer, R. Labusch, E. Maus and J. Scheffran and presented at the Conference of Scientists Against the Militarization of Space, July 1984, in Göttingen, Germany. The full treaty text is available at < <http://www.mcmd.org/SpaceWeaponsBan/GoettingenTreaty.pdf>> and has been re-printed in *INESAP Information Bulletin*, no. 20, August 2002.
7. CD document CD/1679 of 28 June 2002.
8. Fu Zhigang, First Secretary of the Chinese Mission to the United Nations in Geneva, in his article The Joint Working Paper by China and Russia in *INESAP Information Bulletin*, *op. cit.*
9. The orbit of a satellite is defined by its inclination relative to the equator, the point in orbit furthest away from Earth (apogee) and the point in orbit closest to the Earth (perigee).
10. See the Union of Concerned Scientists, *Limitations and Artificialities of the Testing Program*, available at < [http://www.ucsusa.org/global\\_security/missile\\_defense/page.cfm?pageID=1026](http://www.ucsusa.org/global_security/missile_defense/page.cfm?pageID=1026)> .
11. For more details, see Andrew Lichterman, Zia Mian, M.V. Ramana and Jürgen Scheffran, *Beyond Missile Defense*, INESAP Briefing Paper no. 8, April 2002, available at < [http://www.inesap.org/pdf/Briefing8\\_02.pdf](http://www.inesap.org/pdf/Briefing8_02.pdf)> .
12. Extensive information on hardening and self-protection technologies is given in United States, Office of the Secretary of Defense, *Space Technology Guide FY 2000–01*, Department of Defense, available at < <http://www.c3i.osd.mil/org/c3is/spacesys/STGMainbody.pdf>> .

