PROSPECTS OF VERIFYING SPACE WEAPONS TREATIES

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Abstract

Present space treaties ban deployment of nuclear weapons and other weapons of mass destruction in outer space. Questions of verification are not discussed in these treaties. Here, however, the prospects of verifying present and possible future space treaties are discussed. In this context also conceivable space weapons are discussed and exemplified. The possibilities of discerning between space weapons and non-weapons satellites have to be taken into account when negotiating space weapons regulations. It seems as if such a discernment would be possible, at least to some extent. There are various techniques available for verification of space weapons treaties. Verification techniques are to be designed according to treaty provisions in relation to weapons characteristics. Possible technical verification means are exemplified. We conclude that the prospects for verifying many types of space weapons regulations, involving various weapon types, are good.

Introduction

The idea of weapons in space is much older than the space age, and already in the beginning of the 1960's, soon after the first satellite launch, the first treaty concerning space weapons was signed. It was the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and under Water. Later in the 1960's, the Outer Space Treaty (the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies) was signed.

These treaties ban testing of nuclear weapons in space and the placing of weapons of mass destruction in space. Still, 35 years after the beginning of the space age, there are only two treaties dealing partially with weapons in space.

To the best of our knowledge, there are no weapons in space today. However, space weapons research is, under great secrecy, being conducted in laboratories around the world. Some of the weapons concepts have been tested with reduced power and performances as compared to the fully developed weapons. Examples of these latter weapons are various laser weapon designs.

This lack of knowledge of space weapons characteristics will affect the whole discussion in the paper. Also, the determination of the prospects of verifying space weapons treaties will depend on the future treaty regulations. This means that the best we can do is to discuss possible space weapons and their characteristics in relation to various monitoring techniques. From that, one can then infer the types of space treaties that are verifyable and what can be regulated in them.

Space weapons

Definitions

Even though the purpose of this paper is not to rigorously define the term "space weapons", a short discussion on that important issue seem appropriate. One of many proposed definitions of space weapons is the following[1]:

"A space weapon is a device stationed in outer space (including the moon and other celestial bodies) or in the earth environment designed to destroy, damage, or otherwise interfere with the normal functioning of an object or being in outer space, or a device stationed in outer space designed to destroy, damage, or otherwise interfere with the normal functioning of an object or being in the earth environment. Any other device with the inherent capacity to be used as defined above will be considered as a space weapon."

This and similar types of definitions, how excellent and necessary they may be, can not be used in connections with questions pertinent to monitoring issues. The problem of space-object classification will always occur, i.e. one is always confronted with the problem of deciding whether a space weapon is a space weapon or not.

All weapons that are, in some way, intended to interfere with satellites and their functions could be called anti-satellite weapons, for short ASATs. The term ASAT will here, however, only be used for ground-based kinetic kill weapons.

In this paper, we will, furthermore, restrict the discussion to space weapons which are either space-based weapons or anti-satellite weapons when in space. Therefore, we shall not discuss the monitoring of anti-satellite weapon launch sites.

Space weapons can be intended for use against:

* satellites
* missiles
* ground-base targets

One can of course always include in the space-weapon definition anti-personnel devices, as in the example above[2], but we are not considering these here.

Types

It is impossible to use definitions like "a device stationed in outer space ..... designed to destroy ..... an object ..... in outer space"[3] when discussing monitoring possiblilities. For the purpose of discussing the prospects of verifying space weapons treaties, we are compelled to be more concrete. We thus choose to discuss space weapons of the following types:

* ASATs, i.e. objects launched to collide with satellites

* space mines, i.e. "hypothetical devices that could track and follow a target in orbit, with the capability of exploding on command or preprogrammed to destroy the target"[4], or simply satellites designed to explode in the vicinity of a target satellite[5]

* beam weapons:
  - lasers
  - neutral particle beams weapons
  - high power microwave weapons (HPM weapons), i.e. weapons emitting high power microwave radiation, usually radiation at powers above one GW (one billion watts)[6]

* radio-waves, which can be used to jam telemetry signals, communication links, and data transfer

* nuclear weapons

Weapons can be used against other targets than originally devised for. It is, e.g., often much easier to disable satellites than intercontinental ballistic missiles (ICBMs), and that for the following reasons:

* ICBMs have to be detected quickly after launch and the trajectory must be calculated very rapidly, whereas satellites move for long times in almost the same orbit.

* ICBMs are hardened, whereas satellites are not.

This means that weapons developed against ICBMs would be more effective against satellites than against ICBMs.

A weapon concept conceived of a couple of years ago in the SDI (Strategic Defense Initiative) program consists of a system of a large number of small satellites, so-called Brilliant Pebbles. These small satellites are intended to be placed in great numbers in low Earth orbit where they are to collide with their targets. The purpose is to use them as a defence against ICBMs, but probably they could also rather easily be used against satellites.

Verifying compliance with a space treaty regulating, in some way, the deployment of space mines could be difficult, for the following reasons. Firstly, a space mine could be disguised as a non-weapon satellite. Secondly, a space mine could be made to explode far from its target satellite: the space debris of a detonated space mine could be used for destroying a satellite in a crossing orbit under the right conditions. The advantage of this mode of procedure would be that the explosion could not for certain be claimed as intentionally. The disadvantage would be the low hit probability, due to the dispersion of the explosion fragments, and the possibility of damaging other satellites not aimed at.

To use nuclear weapons against satellites, which are fairly fragile, do not seem to be very cost effective. However, such weapons could be used against the Earth. An orbiting nuclear weapon could be sent down towards the Earth and made to detonate either high up in the atmosphere (in order to create a widespread electromagnetic puls) or close to the ground over a chosen target.

Space treaties

NTBT

The first treaty with bearing on space weapons is the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and under Water (also called Nuclear Test Ban Treaty (NTBT)). Article I of the treaty states[7]:

"Each of the Parties to this Treaty undertakes to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control:
(a) in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas.
(b) ....."

It should be noted that the existence of nuclear weapons in outer space is not banned, only nuclear explosions are.

OST

The other of the two treaties regulating space weapons is the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (also called the Outer Space Treaty (OST)). Article IV of the treaty states[8]:

"States Parties to the Treaty undertake not to place in orbit around the Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, install such weapons on celestial bodies, or station such weapons in outer space in any other manner.
..... the testing of any type of weapons ..... on celestial bodies shall be forbidden."

The treaty forbids the presence of weapons of mass destruction (including nuclear weapons) in outer

space. This means that weapons using nuclear explosions as energy source (e.g. X-ray lasers) are banned from space.[9] This is, however, only the case if the nuclear explosion device, used for the energy production of a space weapon that is not mass destructing, is classified as a nuclear *weapon* and not just a weapon *component*.

The presence, in outer space or on celestial bodies, of weapons that are not mass destructing is not banned. The testing of weapons on celestial bodies is, however, forbidden. The question of weapons on celestial bodies will not be delt with in this paper.

Future regulations

There are several possible ways to tackle the question of weapons in space:

* No action at all, i.e. the legal situation of today is judged to be adequate.

* Limitation:
  - on certain weapon parameters
  - on the number of weapons allowed to be deployed

* Banning of:
  - weapon-technology components
  - weapons research
  - weapons testing
  - weapons deployment
  - weapons usage
  - certain types of weapons

The banning of nuclear reactors in Earth orbit, proposed by organizations of American and (then) Soviet scientists, can be seen as a weapon-technology components ban. Such a ban could constitute a way of impeding the development of many space-based weapons, and that for two reasons:

* at present, there seem to be no alternative for the energy production of some types of space-based weapons[10]

* nuclear reactors are easily detectible[11]

The possibilities of verifying a ban on weapon research will not be discussed in this paper. Technical means of verifying other types of ban and limitations will, however, be discussed in the following.

Verification techniques

Space weapons can be inspected:

* on ground (before launch)
* from ground
* from space

On-ground inspections are also, in this case, called pre-launch or on-pad inspections.

Obtaining information of space weapons, or potential space weapons, from a distance has to be made by means of detecting electro-magnetic radiation, or maybe by detecting particles. Examples of telemonitoring are:

* taking photographs of the objects, using:
  - cameras mounted on ground-based telescopes
  - cameras on satellites

* spectral registration, which can be used to draw conclusions about the object

* measuring the position of the objects in order to determine its orbit, as given by its orbital elements

The orbit of a satellite (relative to the Earth or relative to other satellites) gives information about its function.

Large specially constructed telescopes are needed if the telescopes are to be ground-based in order to obtain images with adequate, i.e. high, resolution. However, using space-based cameras, smaller lens systems would be sufficient if the observing satellite were to make close encounters with the satellite under observation. At a distance of 1000 km (from-ground monitoring) the

lens or mirror diameter would need to be a factor 100 times larger than at a distance of 10 km (in-orbit monitoring), i.e. a telescope on ground with a diameter of 10 m would give the same resolution of 10 cm as a 10 cm lens in space.[12] The biggest astronomical telescopes of today have mirror diameters on the order of 5 m.

This classical photographic monitoring technique uses reflected light, or emitted infra-red ligth. However, new radar techniques that make it possibl to obtain detailed images of satellites, even in three dimensions, are envisaged for the future.

Weapons using nuclear reactors would emit charged particles (such as positrons), neutrons, and gamma rays. The detection of these would most easily be done from space. The radiation types and their energies could probable be used to differentiate satellites equiped with weapons using nuclear reactors from other types of nuclear reactor equiped satellites. However, the most easily detected radiation from nuclear reactors is infra-red radiation.[13]

Since many weapons produce heat (more heat than that of civilian satellites) when activated, space weapons could be revealed during weapons testing. The emitted infra-red radiation makes the heat sources easy to detect. In many cases, heat is emitted even some time after the weapon has been used, thus making it possible to detect a space weapon even after a weapon testing, e.g., has been carried out.

Many space weapons will need large amounts of energy, either for orbital manoeuvring or for the weapon effect. This will especially be the case for exotic weapon types, such as:

* laser weapons
* neutral particle beam weapons
* high power microwave weapons

Depending on laser weapon type, laser weapons will need either large amount of chemical or electric energy. Neutral particle beam weapons might need fuel supplies of maybe 50 or 100 tons.[14] High power microwave weapons need enormous amount of electrical energy. Storing large amount of energy in space is, at least today, one of the major obstacles confronting the new exotic weapon technologies. Until new techniques for storing energy are developed, the storage facilities will be easily detectible.

There are no realistic chances of detecting laser beams in space. At low altitudes (about 200 km) there are, however, a small possibility of detecting laser light scattered by atmospheric molecules if the sensor is within a few km from the laser. At altitudes of about 250 km (or more) this is, however, practically impossible.[15] Due to the drag caused by the atmosphere at low altitudes, laser weapons will probably be placed at orbits above 250 km.

Each weapon type will also present characteristic features specific for that weapon. The kill mechanisms will present features that would in most cases distinguish a space weapon from a non-weapon. Laser weapon systems could use large mirrors; some types of lasers would have to be very elongated, as would also neutral particle beam accelerators and rail-guns, or, with another name, electromagnetic guns. A rail-gun is an electromagnetic launcher, i.e. a huge gun using electromagnetic forces instead of chemicals as propellant. The barrel might be as long as 25 m and only about a third of a meter in diameter.[16] A neutral particle beam weapon uses a linear accelerator in which charged particles are accelerated by electromagnetic forces. The particles' charges are neutralized before they leave the weapon. The length of such accelerators might be from 25 m to maybe 100 m.[17] Thus, these new types of exotic weapons, which still are only in the research or development phase, would be rather easy to monitor.

The short electromagnetic impulses used in rail-guns to propel the

projectiles, or the ones from neutral particle accelerators, would create electromagnetic radiation that should be detectible outside the weapon and would thus constitute a monitoring means. Rail-guns are, however, not only discussed for possible weapons usage but also as launchers of cargo. This non-weapon usage of rail-guns could be difficult to distinguish from the weapon usage of rail-guns if both types were to be deployed in space.

Electrically pumped lasers might also be monitored by electromagnetic field detection. Other types of lasers are chemically pumped. Chemicals released into space would permit, not only to detect the laser, but also to determine the exact type of chemical laser being monitored.

Kinetic kill weapons, i.e. weapons shooting as more conventional weapons or using the whole satellite as a bullet, or space mines blowing itself up, could be more difficult to detect. A space mine could, e.g., be hidden inside a satellite having an appearance of a ordinary non-weapon satellite, or even be a real satellite which could be sacrificed.

The large structures mentioned would be easily detectible from long distances, from ground for instance. Smaller, and maybe hidden, features would need to be either monitored on ground at launch, i.e. on-pad inspection, or from a close pass-by of a special observation satellite.

Some type of weapons are best monitored while in use. A jamming device, e.g., is more or less an ordinary radio transmitter, although it may be sending a more powerful radio signal. The jamming transmitter could be localized using ordinary bearing techniques, i.e. the signal registered from two, or more, spatially separated space-based receivers. A high power microwave weapon could also be detected and localized in this way.

Methods for in-space monitoring that are under discussion include the probing of satellites using, e.g., soft X-rays or neutral particle beams. The purpose is to obtain information of the interior of satellites not seen from the outside.

Problems and prospects

Ambiguities

Satellites and technical facilities can sometimes be peaceful devices and sometimes weapons. Just a few examples of this type of ambiguity[18]:

* a *solar power satellite*, i.e. a satellite for the conversion of solar energy to microwave radiation could perhaps also be used as a *high power microwave weapon*

* a *mass driver* for launching material into orbit from moons and asteroids could be a *rail-gun weapon*

* a large *optical telescope* could be mistaken for a *laser weapon* facility

* an *ion rocket* could have features in common with *neutral particle beam weapons*

* a *particle accelerator* for research have features in common with *neutral particle beam weapons*

* a *microsatellite* could be a *Brilliant Pebble*

* a *laser communication satellite* could be mistaken for a *laser weapon*

* a nuclear reactor for civilian purposes is similar to a nuclear reactor powering a weapon

Even if there are ambiguities at superficial levels these ambiguities can in many cases be resolved. Different monitoring techniques can often be used for monitoring one and the same space object. The combined use of different monitoring techniques would not only in many cases resolve ambiguities by increasing the probability of positively discriminating weapons

from non-weapons but, when appropriate, also identify the weapon type.

Thresholds

To distinguish between peaceful usage i.e. non-weapon usage, and weapon usage, it is often enough to measure some parameters of the system. One could agree to allow deployment of satellite systems where certain parameters are below specified thresholds.[19] The detection of a satellite system having values on these parameters above the thresholds would then be an indication of a potential weapon application.

The purpose here is neither to go into any technical details concerning suitable parameter types nor of suitable threshold values. Examples of parameters that might be used are power and brightness. These could be used to differentiate between communication satellites on the one hand and HPM and laser weapons on the other, because communication, either with radio or laser, makes use of very much less power than an HPM weapon and a laser weapon respectively.

To choose a suitable parameter can nonetheless be a difficult task since the most obvious parameters could be "hidden".[20] Observable parameters might, however, be obtained from the more basic ones.

Tags

Tagging, i.e. using tags on satellites, would be a way to perform cooperative monitoring. If the tags were mounted on ones own satellites one could talk of cooperative self-monitoring means. Tags, in the form of sensors mounted on the satellites, could be used for:

* orbit change detection
* kinetic impulse detection
* heat detection
* radiation detection

Both orbit change detection and kinetic impuls detection would be obtained by measuring accelerations of the satellite.

The data from the tags, i.e. the sensors, could be transmitted down to Earth according to one or a combination of the following rules:

* *Threshold triggered*:
  data are transmitted when a predetermined parameter value is exceeded.

* *Inspection determined*:
  data are transmitted when a party wants information on the system.

* *Time interval determined*:
  data are transmitted at certain predetermined time intervals.

* *Randomly*:
  data are transmitted at random time intervals.

Furthermore, tests could be agreed upon to be performed in space, either on request or, e.g., shortly after launch, in order to verify that the satellite system do not contain any potential weapon functions. A test could be monitored by:

* on-ground facilities

* special satellites in orbit

* equipment on board the satellite where the test is carried out (with subsequent transmission of data down to Earth)

In order to be certain that the data received on Earth are correct, the transmitted data could be authenticated using various ingenious techniques.

UN role

A suitable infra-structure, consisting of an organization responsible for the data collection and handling, is likely to be necessary in order to properly maintain data bases of monitoring facilities and space objects. Especially, monitoring launchings of space objects and orbit tracking would have to be done and registered in data bases in order to always be

able to determine who is legally responsible for a space object.

An agency could be used for the determination of whether or not a malfunctioning, or another type of damage, was caused by a hostile attack. The identification of the attacker would of course also be of great importance. Merely having these capacities could deter a potential attacker from using space weapons.

Agencies for space surveillance have been proposed independently by several authors; examples are ISSA (International Space Surveillance Agency)[21] and IASS (International Agency for Space Surveillance)[22]. The UN would be the natural parent organization for a space surveillance agency.

Conclusions

In spite of the fact that there are numerous technical means to construct space weapons, there are only two space treaties dealing with space weapons. As we have seen, there also exist several technical possibilities to monitor such weapons. The mere existence of technical means for monitoring space weapons, or the effects of them on satellites, could deter states from deploying or using space weapons.

Many of the possibilities are, however, for the time being mere theoretical ideas that have to be thoroughly studied. Also, most of the weapons mentioned here are hypothetical making it difficult to be specific in stating how effective various monitoring techniques will turn out to be.

Even though there can be ambiguities, it seems to be possible to monitor all types of space weapons and to verify possible future space treaties. Treaty-specific verification would pose constraints on various parameters to be monitored and would thus reduce the spectrum of monitoring capabilities to investigate. A detailed analysis of verification possibilities has to combine on the one hand space weapons types and characteristics and on the other space treaty regulations, which can only be done when these are known or assumed.

Regularly monitoring of space objects, and especially of those that on some grounds look suspicious, would probably be necessary in order to discover and distinguish space weapons. Indicative of weapon functions capabilities could, e.g., be some types of orbital manoeuvring or excessive heat radiation.

Connected to verification issues are questions pertinent to the organizational affiliation of the monitoring devices. It seem natural that the UN should, in some way, be responsible for the verification of UN space treaties.

Planetary-based weapons have not been included in the space weapon definition used here. However, the possibility of basing weapons on celestial bodies in the future should not be overlooked in discussions on preventing an arms race in outer space. A discussion on the monitoring possibilities of these weapons has, however, to await more information on the weapon types and techniques that might be envisaged for planetary basing.

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