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Panel 1: Security of the Space Environment: Vulnerabilities and Challenges[1]

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At first congratulations for organizing this intersting meeting. It is to be hoped that the European Union is not only capable to draft a new space policy on political and economical grounds but is also playing a more active role in the field of space arms control. I will at first present a more technical analysis of the problem and then I will try to formulate the challenges which are emerging from my point of view.

Thanks you also for providing me with the opportunity to present our analysis about vulnerabilities and Challenges for this distinguished audience. I will at first present a more technical analysis of the vulnerabilities of man-made objects in outer space and then I will try to formulate the challenges which are emerging from my analysis.

1. The importance and increasing relevance of OS

This year the international community celebrates the 40th anniversary of the Outer Space Treaty (OST) in a climate where many realize that the so-called "weaponization of space" comes closer. New published Space Policies, the January 11th, 2007 Chinese A-Sat-test and the increasing availability of space technologies are underlining the necessity to introduce new regulations to prevent the introduction of weapons into space.

The space environment is evolving rapidly in terms of actors, space applications and space traffic. Each year at least one new country accesses to space. Today ten nations have the capability of independent access to space and 28 states have the capability of "suborbital launches". Increasingly, private firms are offering commercial launch and orbital services.

The benefits for this increasing use of space applications such as communication, navigation, earth observation are obvious. Space-based services are crucial for the functioning of modern societies and the breakdown of critical infrastructures would have numerous societal consequences.

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[1] This talk is based on the article Götz Neuneck / André Rothkirch: The Possible Weaponization of Space and Options for Preventive Arms Control, in: ZLW German Journal of Air and Space Law, Vol. 55 (4) Winter 2006, S. 501-516

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The sustainable and undisturbed operation of the space-based infrastructure is important and crucial for further welfare and development. Today, many space applications in the range of communication, reconnaissance and navigation are indispensable for worldwide acting armed forces. An increasing number of countries are developing and operating satellites with military applications. Early warning, verification or monitoring from space platforms are more or less stabilizing technologies. Today, existing satellites have “passive functions”, i.e. they are not capable of directly eliminating adversarial satellites. To this day, however, no state has deployed active reliable “space weapons” permanently. The introduction of SWs would not only mean an international taboo break, but it could trigger a whole chain of new developments: new threat scenarios, costs for additional means of protection and the danger of an arms competition between some space-faring nations in space.

2. The vulnerability of objects in space and current technological developments

Today, the technologies for deploying objects into space which can harm satellites are becoming available in major space faring nations. Like every kind of technology, also space and missile technologies are ambivalent, i.e. they can be used for civilian as well as for destructive purposes.

Technically, there exist several „principles“ to hit, blind or destroy objects in space: kinetic energy weapons (KEW), directed energy weapons (DEW), and nuclear explosions in space.

Kinetic energy weapons

Satellites circulate on predictable orbits around the earth and are much more vulnerable to kinetic attacks than warheads from ballistic missiles (BM), which are hardened for re-entry. Satellites cannot be shielded against effectively against collisions at orbital speeds with debris larger than 1 cm.

The effectiveness of a potential kinetic SW depends on several important factors:

1. The access to space and space technologies to launch space-based weapons (e.g. Launch capabilities: space launch vehicles (SLVs) or ballistic missiles)
2. This includes Ground stations and radar components
3. The characteristics of the orbits (e.g. altitude and motion in LEO or GEO)
4. The vulnerability of the target (e.g. solar panel, sensors, energy supply of a satellite)
5. The deployment and manoeuvrability of the SBW and the target

Microsatellites are potential candidates of future space weapon systems. Relatively inexpensive launch and deployment costs make their use as a weapon against other satellites affordable. However, microsatellites have to be manoeuvred close to the target. Therefore they need fuel and the corresponding orbit manoeuvres are observable. Extensive tests, globally distibuted earth stations and years of technological development are required. After all, only the leading space-faring nations have today such capacities.

Missile Defense

The Hit-to-kill-Technology of the planned US BMD programme can also be effective against satellites. The ground-based interceptors could lift the „kill vehicle“ to a height of 6,000 km and can reach satellites in LEO. The US Ground-based Midcourse system also includes ground-based radars and space-based sensors (SBIRS-Satellites), which are, together with the deep space surveillance network and the NORAD radars, capable of tracking satellites precisely in outer space. Other space-based missile defense systems such as the „Brilliant Pebbles“ have been planned under the GPALS-Program[3] in the Bush-I-Administration. Several hundred autonomous manoeuvring small satellites were intended to intercept missiles in the midcourse phase of a ballistic missile. The new BMD programmes under the Bush-II-Administration is dedicated to ground-baed midcourse intercept, but could have also the capability to lift to higher orbits to attack satellites. Some argue that the United States is not doing enough to protect the US from the missile threat. They

[3] GPALS: Global Protection Against Limited Strikes.

say that “only a space-based systems can provide a truly global defense” and they urge to add space-based intercept components to the multi-layered missile defense system. Former US ambassador to the CD Robert Grey said: “Space weaponization is purported to be the last step in a layered missile defense system”.

Directed Energy weapons

High-Energy Lasers (HEL) in principle can harm or destroy targets such as missiles or satellites from a long distance in a very short time.[4] They have an inherent ASAT potential and first developments have been extensively explored by Russia and the USA during the Cold War. Today, they are intended for use in US missile defense projects.

Within the US missile defense programs, the Airborne Laser (ABL) is designed to use a HEL to intercept a missile in the boost phase. Certainly such a system, if it ever works, also has an inherent ASAT capability against LEO satellites.[5] Another HE-Laser was chosen for the Space-based Laser (SBL) being developed for missile defense purposes. In December 2002 the MDA announced to start a „test bed“ for space-based weapons (SBW). The technology is far from being operational, but a space-based laser could have the capability to reach satellites in a GEO. There is the fear that other nations could use ground-based lasers to blind satellites. It is believed that around 30 countries have access to low-powered lasers which could “dazzle” unprotected satellites.

High Altitude Explosions

A nuclear explosion in orbit can damage or destroy satellites by radiation within a large distance and can pose a serious long-term problem. Civilian and military satellites can be disabled by a low-yield (10-20 kt) high-altitude (125- 300 km) nuclear detonation. An US project „HALEOS“ came to the conclusion that a nuclear detonation against low earth orbit (LEO) satellites could „disable all LEO satellites not spe-

[4] Jan Stupl and Götz Neuneck: High Energy Lasers: A Sensible Choice for Future Weapon Systems? in: Security Challenges 1/2005 , S.135-153.
[5] See for details: David Wright, Laura Grego: Anti-Satellite Capabilities of Planned US Missile defense System, Disarmament Diplomacy, December 2002/January 2003. See at: www.ucs.usa.org/global/space_weapons.

cifically hardened to withstand radiation generated by that explosion".[6] The project considered several scenarios such as "warning shots" or the „deliberate use of a nuclear warhead". In one scenario 12 % of the Globalstar satellites and 6 % of the Iridium satellites might be disabled due to their satellite constellation by prompt X-rays. In addition the lifetime of satellites might decrease due to an increasing ambient radiation in LEO. Countermeasures for these cases are hardening or replacement of satellites. Deployment of a nuclear device is prohibited by the OST or by the unratified Comprehensive Test Ban Treaty (CTBT), but in a crisis a simple nuclear warhead could be delivered by a medium range ballistic missile in a very short time, causing much harm to civilian as well as to military satellites. On the other hand such an event can be traced back to the culprit, which would lead to the condemnation of such a country. A country which decides to use nuclear weapon in orbit would face severe international consequences.

The Chinese ASAT-Test

On January 11th, 2007 China tested a direct ascent ASAT System and destroyed the Chinese Feng Yun 1C weather satellite with a direct collision at roughly 850 km altitude. The technology which was used was a combination of a modified Intermediate Range BM and a hit-to-kill interceptor equipped with an optical or radar tracking system. The test showed that China is now capable to shoot down satellites over its own territory. As my colleague G. Forden in his analysis pointed out thatthis test was not only much more impressive than the Russian co-orbiting ASAT-Tests carried out during the 1980s but it shows also the Chinese sophistication in space operations which can lead to the capability to hit even satellites in geostationary orbit. The Chinese rational for developing its ASAT weapons is not clear, but the time to find international solutions to the problem is limited.

The test also showed that the US and Russia have no monopoly on ASAT capabilities any longer. Other nations such as India might follow.

The Chinese test also showed other serious consequences of unrestrained ASAT weapon development: the danger of space debris. Uncontrolled space fragments are a perilous problem for other satellites, because it is travelling at speeds of 7.5 km/sec. The FY-1C, which had a mass under one ton, was fragmented into different

[6] High Altitude Nuclear Detonations (HAND) Against Low Earth Orbit Satellites ("HALEOS"), Defense Threat Reduction Agency (DTRA) - Advanced Systems and Concepts Office, April 2001, http://www.fas.org/spp/military/program/asat/haleos.pdf (13.11.02).

orbital debris. The test doubled the density of debris larger than 1 cm in the 850 km altitude. for at least 5 years and therefore will also double the risk of a catastrophic collision in this region. Because the disintegration of the satellite took place so high where the atmospheric density is quite low, a large fraction of the debris will remain in orbit threatening other satellites for decades. ESA by the way is operating 59 Satellites under 900 km altitude. This event and the explosion of a Russian Proton rocket stage increased the space debris by roughly 20% in the first weeks of 2007.

Space Weapons Testing: The space debris problem

A decision to test and deploy weapons in space might not only make space weapons more attractive to other nations; it also affects the common use of space in general. The particulate environment of the earth is not an empty space – natural (meteoroids or comets) and artificial (man made) objects can be found in the space environment. They travel through earth orbital space at high velocities and pose a risk to orbiting objects. Orbital debris is is the result of about 45 years of space exploration – parts of spacecrafts, remains of intentional and unintentional explosions as well as mission related objects. Each of these objects can be classified by e.g. its source (‘debris type’) or its size. Using the particle size one often distinguishes between small objects with particle sizes below 1mm, medium sized objects with sizes between 1mm to 1cm and large objects with sizes greater than 10cm. The number of objects varies with orbit parameters and size. Small sized objects are more frequent than larger objects, resulting in different mean times of debris impacts on target objects (e.g. spacecrafts). Mean times of impacts can vary from days to several thousand years. Although the probability a spacecraft colliding with large fragments is low, such an impact would have catastrophic results. A collision with medium fragments would cause significant damage to a spacecraft and possibly mission failure. Small fragments can cause component damage, spallation or degradation of spacecraft surfaces.

In general one can protect a spacecraft against space debris by shielding the craft or by manoeuvring to avoid a collision. Shields can protect against fragment sizes up to ~1cm, depending on the shield type. Despite the progress in shield development, spacecrafts in near earth orbits are at increasing risk being damaged. Small fragments of size below ~1 cm are particularly dangerous because they are not trackable (or only barely so). In this case manoeuvring is not applicable. The chance of failure due to collision with small fragments is about one percent per year for an average small satellite in an 800 km orbit.[7] Scientists assume an increasing number of collisions in the coming two decades, which will also raise the number of fragments in orbit. Depending on the parameters (e.g. specific orbit, fragment mass, fragments cross sectional area, radiation pressure etc.) the fragments can remain in earth orbit up to several thousand years. 'By continuing space travel as hitherto mankind would overflow space with debris in that way, that it is no longer utilisable. Because of model uncertainties it is questionable if this situation would appear after 70 or 130 years. That it appears is assured'[8].

In addition to the dilemma of space debris in general, a possible introduction of space weapons may aggravate the space debris danger. Although there are no weapons deployed in space now, several weapons to attack satellites have been developed[9] and various scenarios on the benefit of space weapons have been thought about. The accomplished tests of the Russian coorbital ASAT Program and the destruction of the Solwind satellite by the US military created hundreds of fragments of trackable debris. Remaining fragments can still be found in orbit. Aside the direct intention to destroy a spacecraft by the arising of debris, each launch needed to deploy space assets creates some amount of debris. It is assessed that at the altitude of 900 km the space debris density is so high that a "cahin reaction" of the disintegration of more satellites is likely. That means that the collisions are producing new fragments which generate new collisions and so on.

3. The Challenges for the European Union

For the prevention of a space weaponization it ought to be crucial to confute the arguments of the advocates in the US administration and to establish lasting and sus-

[7] Joel R. Primack. Debris and future space activities. Powerpoint presentation of invited talk at conference on future security in space, at new place (near Southampton, England) on May 28-29, 2002, available at http://physics.ucsc.edu/cosmo/mountbatten.pdf (PDF-File from Powerpoint presentation) .

[8] Free translation of Dietrich Rex: Wird es eng im Weltraum? Die mögliche Überfüllung erdnaher Umlaufbahnen durch die Raumfahrt, in: Carolo-Wilhelmina Mitteilungen II/1996, Braunschweig 1996. See also
http://www.tu-bs.de/institute/fmrt/raumfahrt/veroeffentlichungen/space/spacedebris.html (May 03).

[9] E.g. nuclear anti-satellite weapons (nuclear ASAT) like Gorgon, USSR or Safeguard/Sentinel, US, an orbital ASAT system (Istrebitelny Sputnik, USSR) or the Air Launched Miniature Vehicle (ALMV), US. The orbital and the ALMV ASAT have been tested successfully. The status of the systems in not fully transparent.

tainable rules for space arms control. Good reasons for preventive arms control in space are the limited number of space-travelling nations, the complex and expensive technologies for weapon purposes and the good verification possibilities: Space is a transparent medium in which a limited number of artificial celestial bodies move on calculable trajectories. In terms of preventive arms control it is feasible to monitor satellite trajectories and manoeuvres in a transparent, international way.
A unilateral but costly answer to the problem of space debris or direct threats to satellites is by hardening space systems. The following "passive countermeasures" are possible but will certainly raise the costs of spacecraft significantly:

- Hardening of satellites against heat, shock, radiation or jamming
- Evasive action of satellites by manoeuvres, hiding, decoys
- Redundancy and Repairing
- Deployment in less threatened orbits
- Substituting of destroyed satellites

Another way would be to include „active countermeasures," such as the deployment of new ASATs (defensive satellites, bodyguard satellites) or the integration of active defense systems. But these measures will fuel an arms race in space where space-faring nations feel under pressure to introduce orbital weapons to protect their own space assets. In the end, treaties to prevent testing and use of ASATs are more effective than costly investments in hardening satellites or deploying SWs that might not work effectively.

A "To do list" for the European Union should include the following concrete steps:

- to establish a coherent and peaceful European Space Surveillance System
- to work out "rules of the road" and operational constraints on satellites intended to damage or destroy satellites and to discuss them with all partners in the field of space cooperation
- to prepare and propose an international ban on debris-producing ASAT-weapons and discuss this in the United Nations
- to invest financial means to work out the verification technologies and procedures to verify such a treaty from the ground

The European Union, which has become an important space actor due to its ambitious space plans and its cooperation with the United States, Russia, China, Canada, Brazil etc., should not cede the initiative in the field of future space security to other states. The EU ought to become active independently in the range of space arms control. It increasingly invests, both economicaly and politically, in its space program and cooperates with Russia, China and India in the fields of launch technologies, Galileo and scientific space projects. It must be the task of its security and foreign policy to take care that a potential future European military space program precludes space weaponization and that other space nations contribute to the weapon-free status of space. The same interest should be shown by the space faring nations such as Russia, China, India, Japan and Brazil. The EU Commission should establish a contact with these states and sign a joint declaration on renouncing space weapon deployment. Simultaneously, first steps towards confidence-building in space could be initialised and negotiations for a sustainable weapon ban regime should be induced.