Space assets and emerging threats

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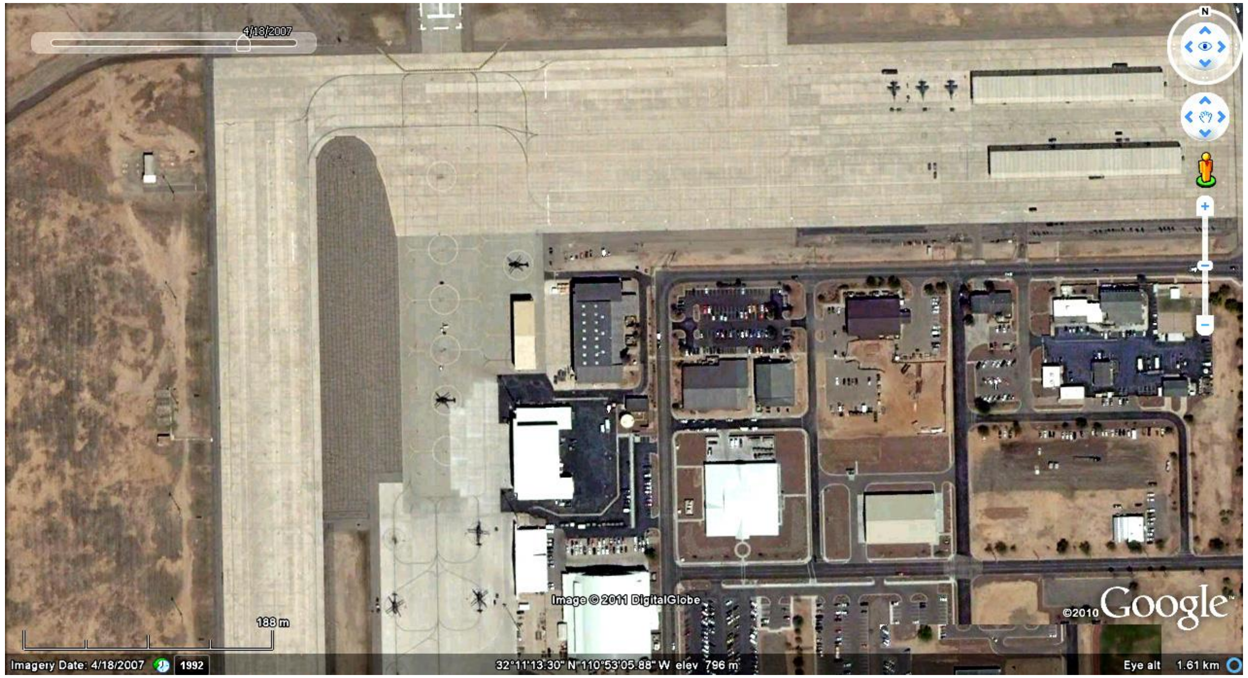
Introduction

Space assets

- Significant information could be gained by both military and commercial observation satellites:
  - a) about WMD related activities of a state; and
  - b) on on-going conflicts within a state as well as between states;
- Such information is then often transmitted by communications satellites;
- These and other applications of spacecraft, such as navigation and meteorological satellites, could make them very sensitive and therefore prone to attack;
- Three trends evolved:
  - (a) use of satellites to enhance potentials of terrestrial weapons;
  - (b) monitoring crisis areas, refugee movements and verifying arms control and disarmament treaties; and
  - (c) development of anti-satellites (ASAT) weapons to destroy satellites in orbits;
- Considerable impetus was the result of the Cold War;
- However, at the end of this, the military use of space continued and expanded;
- Consider first some capabilities of remote sensing satellites.

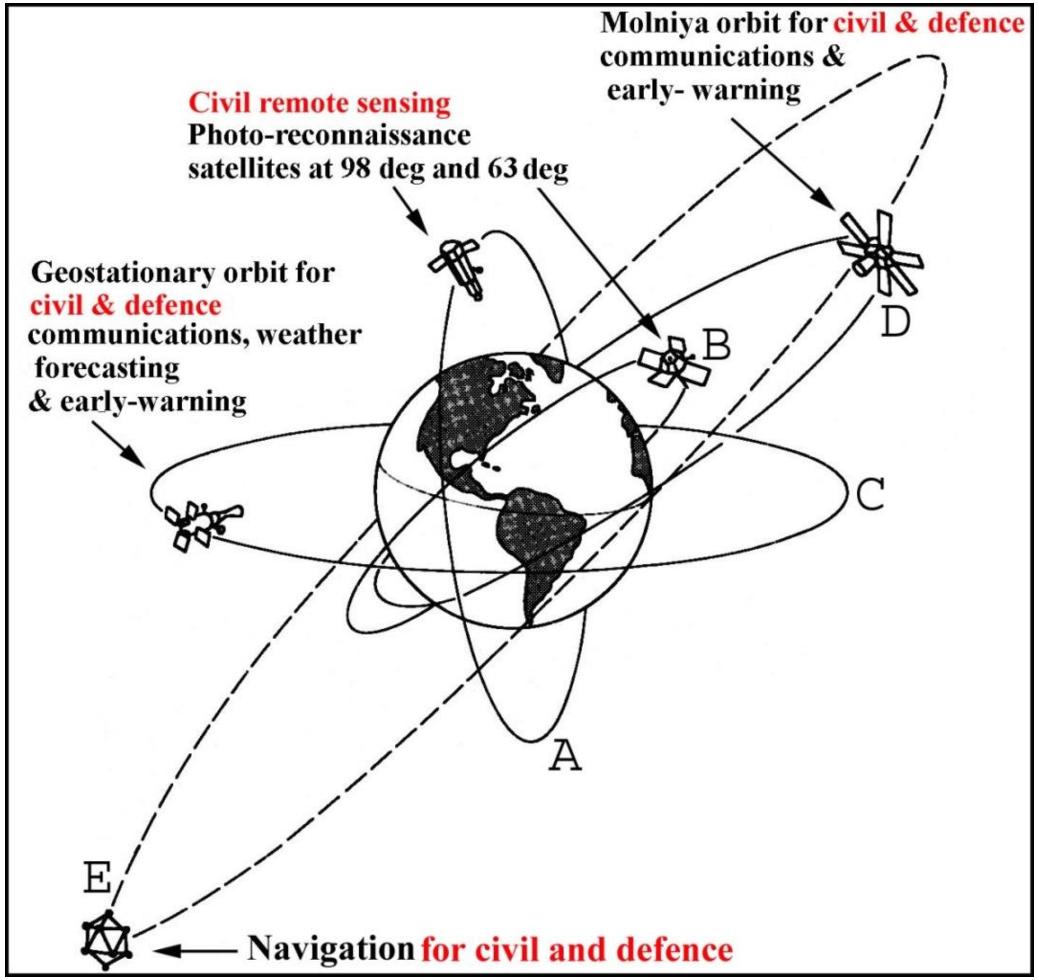
An example of an image acquired by a civil remote sensing satellite

Davis-Monthan AFB (USA), Digital Globe image 18042007



Space assets

- Satellites are orbited at different altitudes and at various angles between the orbital plane and the earth's equatorial plane;
- These will depend on the missions of the spacecraft;
- With the increased capabilities and growing dependence on civil and military uses of satellites their vulnerability to both natural and man-made threats is becoming apparent;
- The threat to satellites is posed by various types of weapons aimed at orbiting spacecraft and by increasing number of debris;
- Only the land- and space-based kinetic energy and some land-based laser weapons are considered because of their immediate threats to space assets.



Some major space faring states

Country	Early-warning satellites	Communications satellites		Navigation satellites		Meteorological satellites		Observation satellites		Indigenous launch vehicle	Space weapons
		D	C	D	C	D	C	D	C		
China	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
Europe		✔	✔	✔	✔	✔	✔			✔	
France		✔	✔	✔	✔	✔	✔	✔		✔	
India			✔		✔		✔	✔		✔	
Israel								✔		✔	
Japan			✔		✔		✔	✔		✔	
Russia	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
USA	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔

Space weapons

- A space weapon is that which can damage, destroy, permanently disrupt the functioning of, or change the flight trajectory of space objects of other states;
- Such weapons can be broadly grouped into three: nuclear, non-nuclear and non-dedicated space weapons;
- The latter are those that do not destroy satellites but they destroy their command, control, communications and space surveillance equipment which are vital to the efficient operations of spacecraft.

Space weapons

continued

Various space weapon systems and their deployment modes, both existing and potential are summarised below

Weapons						
Type	Deployment mode					Status
	Ground-space	Space-space	Space-air	Space-ground	Air-space	
NUCLEAR						
Endoatmospheric	X (1)					Existing
Exoatmospheric	0 (2)					Existing
X-ray laser	0	0 (3)	0 (3)	X (3,4)	0	Investigated
NON-NUCLEAR						
Projectiles (e.g., Kew, U.S./F-15 MHV, Soviet ground-based missiles, rail guns)	0	0	0	0	0	Investigated; Soviet direct ascent reportedly deployed
Neutral particle beams		0				Investigated
Lasers	0 (5)	0	X (3)	X	0	Investigated
Radio-frequency weapons	0	0	0	0	0	Investigated

Key:
X = ballistic missile defense only.
O = ballistic defense and ASAT capabilities.

1 = essentially ground to atmosphere.
2 = possible electromagnetic pulse weapon.
3 = 1967 Outer Space Treaty bans deployment.

4 = mainly for upper atmospheric applications.
5 = laser deployed preferably on top of mountains.
MHV = miniature homing vehicle.

Space weapons
continued

- It should be pointed here that most of the weapons listed in the table are either conceptual or are being researched upon;
- Only the ones that either exist or will be realised soon are considered here;
- As a result of such development active protection of one’s own space assets, has also become necessary;
- In the following some of the space weapons (mainly kinetic-energy weapons – KEWs) are reviewed

Space weapons

continued

- The early ASAT weapons fell under the category of kinetic energy weapons (KEW);
- Essentially the idea was to hit a satellite in orbit by a co-orbital weapon or a ground- or an air-based missile;
- A problem with such an ASAT weapon is that it takes time to reach its target and an impact can create considerable amount debris that can harm one's own satellites as well as those of others;
- Both the USA and the former USSR developed, tested and deployed KEWs;
- China also began its own research in KEW technology in the 1980s;
- Others, for example India, have shown interest in the development of such weapons;
- In the 1960s the ASAT weapons deployed nuclear warheads;
- However, it was soon realised that such weapons were not very useful as they were indiscriminate weapons that could destroy all nearby satellites that included one's own spacecraft and may even affect some of the ground facilities due to, for example, EMP effects;
- Consider first the development and deployment of US ASAT weapons.

Summary of US ASAT weapons-KEWs

Type of weapons	Orbital range (km)	War head	Kill radius (km)	Status	Number deployed
Nike-Zeus	320	-	-	Test	-
Thor IRBM	1,100	1 Mt nuclear	8	Test Feb 1964-April 1975	-
Bold Orin missile on B-47 bomber	-	-	-	Investigated in 1950s	-
Modified anti-radiation homing missile on F-15	In a test P78-1 Solwind satellite destroyed	Kinetic Kill Miniature Kill Vehicle	Direct hit	Tested on 13Sept. 1985	Cancelled
Sea-based SM-3 missile	LEO	Direct assent	Direct hit at 10km/sec	Tested on 20 Feb. 2008	Hundreds on board several ships
US Army & Missile Defense Agency	LEO	Direct assent	Direct hit	-	Two types of interceptors
Advanced Technology Risk Reduction Sat	1,300	Direct assent co-orbital guided by IR sensors	Direct hit	First placed in 2009	6 in orbit
Micro Satellite Technology Experiment deployed	In LEO & GSO	Direct impact	Direct hit	LEO deployed in 2006 and in GSO in 2014	2 in LEO weigh 230kg

Summary of US ASAT weapons
Current status of DEWs & space plane

Laser ASAT	Space plane
Ground-based laser tested on 17 October 1997 against a MSTI-3 satellite in orbit at 420km;	Rocket powered X-37B plane launched in 2010 in 400km orbit;
While 1Mw Mid-Infrared Advanced Chemical Laser (MIRACL) failed, a 30w beam used for alignment of system and tracking temporarily blinded the satellite;	Two potential ASAT X-37B planes would be deployed in turn for a year or so;
Thus, a commercially available laser with a 1.5m mirror could be an effective ASAT weapon.	

Summary of Russian ASAT weapons

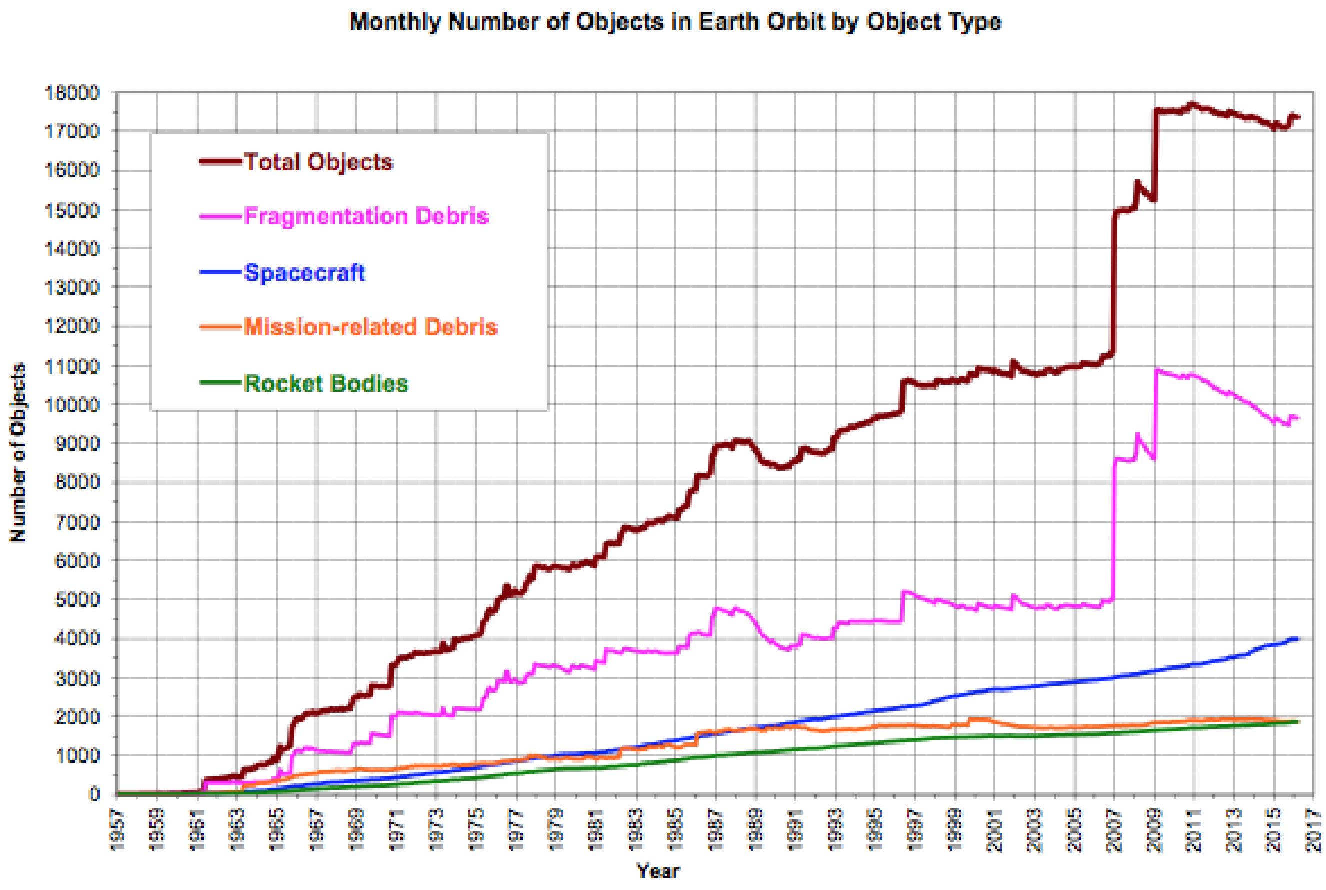
Type of weapons	Orbital range (km)	War head	Status	Number deployed
Co-orbital satellites	Orbital altitude between 230km and 1,000km	Explosive near a target or direct collision	Began testing in 1967	Several tests in 1971; declared operational in 1973
Co-orbital system	Interception altitude increased to 16,000km	-	Remain operational between 1978-1986	-
Small manoeuvrable satellites	In low earth orbits	-	Testing began in 2013	Two experimental satellites launched in May 2014 and March 2015
Air-launched missile on MiG-13	-	Probably direct hit type	Kontack system	-
Air-born laser	-	Laser to blind sensors on board targets or damage the target	No details available	-

Summary of Chinese ASAT weapons

Type of weapons	Orbital range (km)	War head	Status	Number deployed
Direct assent missiles	About 845km in Sun-Synchronous orbit	SC-19 direct hit to kill missile	Tested in 2005 and 2006 but the 2007 resulted in large number of pieces of debris	-
Small satellites	Between 840km and 10,000km	Direct hit to kill	SJ-6F and SJ-12 tested in 2013 and 2014; SY-9 land-based missile tested in 2014	-
Dong Neng 3 direct ascent missile	-	Direct hit to kill	Tested in October 2015	-
Co-orbital ASAT	-	Shiyan-7, Shijian-15 and Chuangxin-3	Tested in July 2013	-
In addition jamming communications and blinding sensors	-	Land-based laser may have been part of tracking system	-	-

Space debris

- These various ASAT systems will require testing aggravating an already serious debris problem;
- First ever accidental in-orbit collision between two satellites occurred on 10 February 2009 at 776km altitude;
- A US privately own communications satellite, Iridium 33, and a Russian Strela-2M military communications satellite, Cosmos 2251 collided;
- Over the half century of space activities, some 6,600 satellites have been placed in orbit of which about 1,100 are still operating;
- More than 17,000 object are tracked by the US Space Surveillance Network, 5-10cm in LEO and 0.3m-1m in GEO.



Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" includes satellite breakup debris and anomalous event debris, while "mission-related debris" includes all objects dispensed, separated, or released as part of the planned mission.

Summary of some collision, close encounters and breakups

Satellite name	Date of collision/close encounter	Damage	Safety measure
OV 2-1 rocket body	1965	Accidental explosion-473 pieces	-
Nimbus 4 rocket body	1970	Accidental explosion-376 pieces	-
US Fltsatcom-13	3 May 1980	Predicted distance from DSP-F4 9.4km and reduced to 3.5km a few day later	Fltsatcom-1 performed evasive manouvre
US Fltsatcom-1	During 2nd half of 1981	Eight close encounters with US SBS-1 satellite, five between 2.6km and 6km; and five encounters with four other satellites	Collision avoidance manoeuvres performed
Cosmos 1275	Disappeared on 24 July1981	Battery exploded creating 300 objects	-
ASM-135 ASAT	1985	A satellite destroyed resulting in thousands of debris larger than 1cm	-
SPOT 1 rocket body	1986	Accidental explosion-498 pieces	-
Cosmos 1484	18 October 1993	Broke up in a similar manner as Cosmos 1275	-
SPOT 2 rocket body	1996	Accidental explosion-754 pieces	-
Cerise, a French military micro-satellite	24 July 1996	Stabilisation boom damaged by debris from Ariane booster	Regained attitude control by reprogramming the payload
CRISTA-SPAS-a communications satellite	12 August 1997	Passed very close (3.1km) to an old rocket motor from 1984 Shuttle	Failed to reach the GSO
Russian Mir station	15 September 1997	US satellite MSTI-2 passed close (~500m)	Mir not manoeuvred

Summary of some collisions, close encounters and breakups

continued

Satellite name	Date of collision/close encounter	Damage	Safety measure
Russian Mir station	28 July 1999	Close encounter with a rocket body	Mir not manoeuvred
Several Shuttle missions: STS-44, -48, -53, -72, -82			In each at least five manoeuvres were carried out
International Space Station (ISS)	26 October 1999		Altitude raised to avoid close encounter with a satellite rocket
CBERS 1 rocket body	11 March 2000	Accidental explosion-431 pieces	-
TES rocket body	2001	Accidental explosion-372 pieces	-
ISS	28 March 2002	Passed within 14km of a Delta 2 rocket	ISS manoeuvred to avoid collision
Russian Briz-M booster stage	19 February 2007	Carried Arabsat-4A communications satellite; over 1,000 pieces were identified by 21 February 2997	-
Fengyun-1C	2007	Intentional Collison – 3,428 pieces	ASAT test
Cosmos 2421	10 February 2008	Disintegration – 509 pieces	-
Irudium 33	2009	Accidental explosion with Kosmos 2,251 - 628 pieces	-
Cosmos 2251	10 February 2009	Accidental explosion with Iridium 33 – 1,668 pieces	-
Briz-M	16 October 2012	Amount and size of debris unknown	After a failed 6 August Proton-M launch
Russian BLITS laser-ranging satellite	22 January 2013	Hit by debris probably from 2007 Chinese ASAT test	-

Some proposals

- **It is now generally recognised that space capabilities, including relevant ground facilities, are vital to national and international security and to maintaining global peace;**
- **An essential element for this is adequate notification of outer space activities such as pre-notification of launches, possible break-ups in orbits or premature re-entry of space objects causing potential harm to the earth’s atmosphere and on the ground;**
- **Thus, *a serious commitment* to the outer space law such as adherence to the Registration Convention is important;**
- **It is also essential to give a serous consideration to negotiations on a possible ASAT Treaty.**

An anti-satellite treaty

- If space weapons are developed and deployed, it would be very difficult to convince other space faring nations not to embark on their own space weapon programmes;
- It is important that negotiations at the CD commence as soon as possible.
- At present, three countries have developed a limited ASAT capability with weapons deployed either on ground-, air, or sea-based.
- The ground-based systems have considerable limitations as a satellite has to be in line of sight of the weapon;
- Air-launched capability was investigated to overcome this limitation as, in theory, an aircraft can fly under any orbit of a potential target;
- However, inability to have many airbases around the globe makes this system still not an ideal one;
- A somewhat better option is a surface ship or a submarine based ASAT weapon because they can be deployed any where in the world;
- Submarine based ASAT can also be invulnerable to attack;

A possible high-altitude ASAT Treaty

- It is estimated that the Russian ASAT can reach 5000 km;
- On 17 October 1997, the US used its ground-based laser against an old US satellite launched in May 1996 in a circular orbit at an altitude of about 430km;
- The low power 30-watt laser used for alignment of the system and tracking of the spacecraft was sufficient to blind the satellite temporarily;
- In contrast, the nearest high-orbit satellites are the navigation satellites at about 20,000 km;
- Current ASATs could carry out high-orbit attacks only if they were modified and attached to significantly large booster rockets or increased laser power;
- The fact that none of the three states currently possesses high-altitude ASATs in orbit is a reason for focusing arms control efforts in this area particularly when no ground-based systems are deployed yet;
- It should be remembered, however, that there are some communications satellites that have their perigee heights considerably lower than 20,000 km and may have to be addressed separately;
- A measure that could limit testing and deployment, in any environment, ASAT weapons aimed against high-altitude spacecraft is suggested;
- A resolution presented by the Soviet Union to the UN General Assembly on 16 August 1985 has already mentioned monitoring of compliance with agreements which have already been concluded or will be concluded with the view of preventing an arms race in outer space';
- Thus, the basis for an international verification agency already exists.

Improve transparency in outer space

- As a first step strengthen the compliance with the ***U.N. Convention on Registration of Outer Space Objects (1975)*** **under which state parties require to provide basic information about their satellites launched into outer space;**
- **The obligations under the Registration Convention are mandatory;**
- **By and large, provision IV.1.(e) has not been fulfilled, since nearly three-quarters of the satellites launched serve military purposes and hardly any of them have been described to the UN Secretary-General as having military uses;**
- **Until the registration convention is strengthened, it may not be possible to improve the transparency or the space-traffic control.**

Improve space traffic control

- **The current openly available catalogues are not very accurate for effective traffic control;**
- **The actual locations of space objects are only determined occasionally to check the predictions;**
- **We have already heard about the efforts to improve space traffic control procedures;**
- **It can be further be suggested that, as a first step, an *International Data Centre (IDC)* could be established in Vienna at, for example, UNOOSA, where data provided by participating countries on space objects in orbits could be collated and compiled; the data could be, for example, the telemetry emitted by satellites, their shapes, sizes, and orbits, the launching country, and the designation of satellites;**
- **The second step could be that the IDC could establish some equipment necessary to track objects in space to verify the Registration Convention and also data that might be available from various states on orbital debris;**
- **The latter would be to check measures that may be used on orbital debris mitigation.**

Orbital debris mitigation

- We have also heard about the Inter-Agency Debris Coordinating Committee (IADC) that has drawn up a set of guidelines;
- However, these are not legally binding;
- In any case, so far, Russia and India have blocked the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) from adopting the guidelines;
- It might be suggested here that the COPUOS adopts a possible “Convention on Limiting and Eliminating Debris in Orbits (CLEDO)”;
- The verification of such a convention could be carried out by the above proposed International Data Centre.

Some conclusions

- It is now generally recognised that space capabilities, including relevant ground facilities, are vital to national and international security and to maintaining global peace;
- A vital element for this is adequate notification of outer space activities such as pre-notification of launches possible potential break-ups in orbits or premature re-entry of space objects causing potential harm to the earth's atmosphere and on the ground;
- A serious commitment to the outer space law such as adherence to the Registration Conventions.

Some conclusions

continued

- **Commercial remote sensing satellite capabilities are such that not only can they contribute to arms control treaty verification but in other areas of security also;**
- **For example: conflict reduction, peace agreements, peace keeping operations and humanitarian assistance;**
- **The latter would be for detection of refugees and monitoring their movements and size in order to deliver them aid;**
- **However, any legal measure or a code of conduct proposed may run into difficulties as they may be perceived as controlling the development of new space faring countries from acquiring the capabilities reached by recognised space capable nations possibly another NPT situation;**
- **Also many of the measures existing or proposed do not have any verification mechanism;**
- **Thus, we may encourage more *<u>Regional Satellite Centres</u>* in, for example, South Asia, the Middle East, East Asia, Latin America and Africa similar to the current *European Union Satellite Centre*, or even time may have come for an International Satellite Centre.**