PATHFINDER

AIR POWER DEVELOPMENT CENTRE BULLETIN

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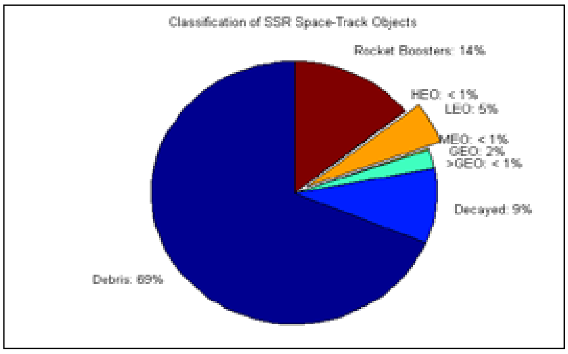
THE ISSUE OF SPACE DEBRIS

Although Australia has only limited military space assets, access to space-based systems is critical to the operational efficiency of the Australian Defence Force (ADF). In fact, almost 50 per cent of the capabilities identified within the Defence Capability Plan have a first-order dependence on space for communications; ISR; meteorology and position, navigation and timing information. In other words, the ADF is very heavily reliant on the products and services derived from space-based systems, necessitating a clear understanding of the challenges of operating in space.

One of the major hazards of military flying is the danger of ingesting/striking a foreign object that would cause unwanted damage that could be lethal. While a number of remedial measures have reduced this risk, collisions with other flying objects still constitute a grave danger to flying activities. In the 21st Century, Air Force's operating environment includes space and operations in space also have the inherent risk associated with collision and debris damage.



SSR lists for 8 Nov 10—37 207 objects with 2949 satellites

There are numerous objects orbiting the Earth. The most common are functioning and non-functioning satellites ranging in mass from 1 kg for a microsatellite to about 1154 kg for a US Defense Meteorological satellite. There are also the platforms that are used to insert these satellites into orbit after separation from the launch vehicle, which remain in orbit long after their purpose is served. Depending upon the height of the orbit, the launch vehicle itself can remain in orbit for a short time after the release of the payload and platform.

Then there is the detritus—the orbital junk—from the launch process, which includes parts that separate from the launch vehicle or satellite for whatever reason. Common debris includes nose-cone shrouds, hatch covers, outer skins ruptured by solar thermal changes, and spilt engine coolant and unused rocket fuel. But by far the most unpredictable and dangerous are the bits and pieces left over from satellite collisions. This debris in turn can lead to further collisions and the creation of new fragments.

Even Australia has contributed to the space debris problem. Australian space activities have left a spent rocket booster, used to launch Optus B2 in 1992, and five decommissioned geostationary telecommunications satellites that remain in a graveyard orbit.

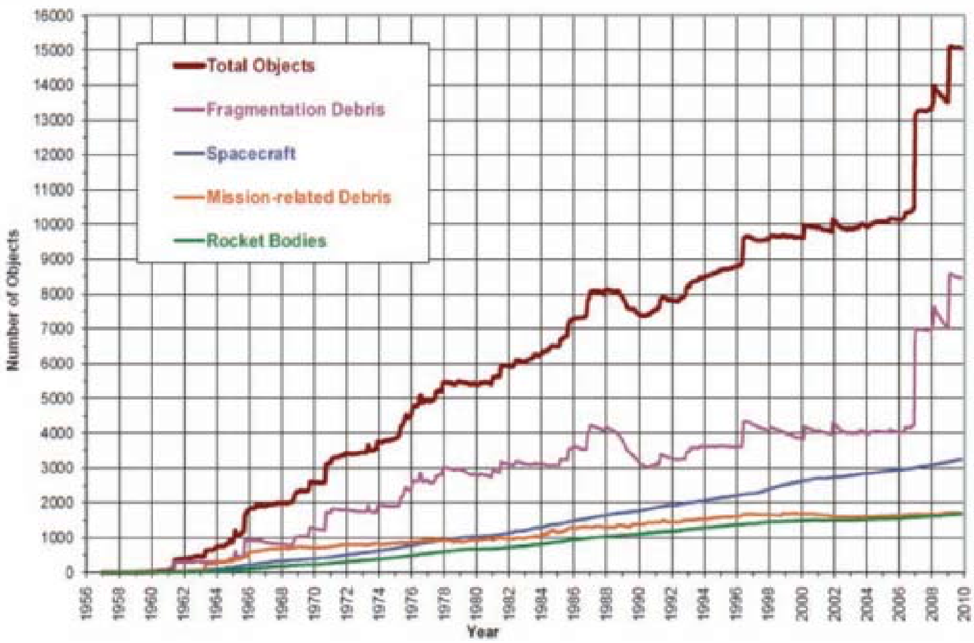
There are also natural objects found in Earth's orbit like meteors, disintegrating comets and asteroidal particles captured by Earth's gravity, which can remain in orbit from a few hours to centuries, depending upon their individual kinetic energy.

This orbital debris, in combination with the shear volume of space that needs to be monitored, the small size of many of these objects, and the speed at which they travel, pose a significant threat to satellites and a daunting challenge for those responsible for managing space capabilities. For example, objects in stable Earth orbits are typically travelling at speeds of about 28 000 km per hour, in low-Earth orbit (~800 km altitude) to 11 000 km per hour in the geostationary belt (~36 000 km altitude). At these speeds, even a collision with a fleck of paint can severely damage a satellite.

Because of the threat that orbital debris poses to satellites, the US Air Force Space Command (AFSPC) has developed a dedicated global network of sensors to track objects in Earth orbit, which includes satellites and debris that are 10 cm or greater in size. A large number of smaller objects are also known to exist in orbit but are too small to be tracked by this system. The tracked objects are recorded in a 'space catalogue' that was started in 1957 following the launch of the Russian Sputnik I.

AFSPC uses the space catalogue to produce an unclassified weekly Space Situation Report (SRR). For example, on 8 November 2010, the SSR listed 37 207 resident space objects in Earth orbit of which only 2949 are functioning satellites.

A major contributor to space debris are satellites that have exceeded their original design specifications and continue to function and those that remain in orbit after completion of their missions instead of re-entering the Earth's atmosphere as originally planned. For example, the US Vanguard 1 test satellite launched in 1958 with mission expiry in 1964, is not expected to de-orbit for another 240 years.



Growth trend in space objects

Some of the objects that are now considered space debris were deliberately inserted into orbit. Between 1961 and 1963, the US military inserted into orbit millions of 1.787 cm copper needles, code-named the 'Westford Needles', in an attempt to create a radio-reflective ring around the Earth. This ring was to be used to reflect radio signals and relay messages in the event of communications satellites being disabled during a nuclear war.

Why is there so much concern about space debris? With the increase in the volume of space debris there is an increased likelihood of a collision. While collisions between even small space objects would be a problem, it becomes far more significant when two large bodies collide. For example, a collision involving an 8-tonne rocket booster and a 5-tonne decommissioned satellite could potentially create thousands of new fragments, resulting in scenario called a "Kessler Syndrome". In this scenario, the density of objects already in low Earth orbit is so high that collision fragments could cascade—each subsequent collision generating further debris, which increase the possibility of further collisions. The worst-case result could be unusable Earth orbits and transits to outer space becoming extremely hazardous for hundreds of years.

Asteroids also pose a risk to both orbiting objects and the Earth itself. Asteroids range in size from the largest, Ceres, with a diameter of about 1000 km, to ones that are the size of small boulders. The vast majority of all interplanetary material that reaches the Earth's surface originates as fragments resulting from colliding asteroids. Although the Earth is bombarded with more than 100 tons of dust and sand-size particles daily, NASA estimates an average interval of about 100 years for asteroids larger than about 50 m to reach the Earth's surface.

The increasing congestion in space demonstrates the importance of having adequate counter measures and processes in place to reduce the risk of damage to systems that are vital for the effective functioning of modern military forces. Improved space situational awareness as well as the ability to predict risks of collisions and, where feasible, take precautionary measures to protect space capabilities is a critical requirement for a force that is reliant on space-based systems.

> *'A 1-kg object impacting at 10 km/s, for example, is probably capable of catastrophically breaking up a 1,000-kg spacecraft if it strikes a high-density element in the spacecraft. In such a breakup, numerous fragments larger than 1 kg would be created.'*
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> *Orbital Debris: A Technical Assessment*, National Academy of Sciences, 1995, p.4.

- *Orbital debris poses a significant threat to space systems*
- *Earth orbits are becoming increasingly congested*
- *Space situational awareness is essential for a space-enabled force*

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