Cosmic Cleanup

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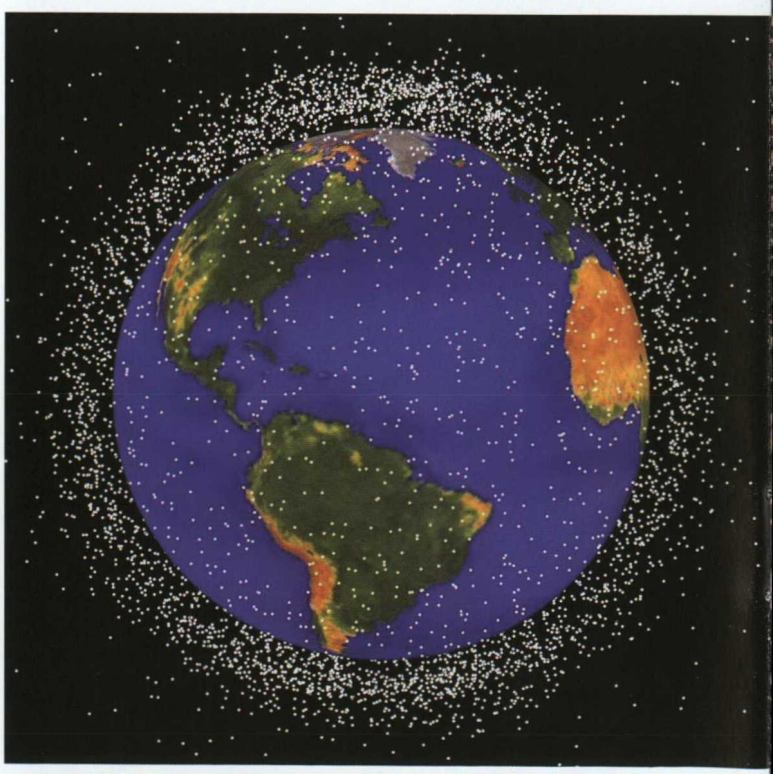
In the movie "Gravity," fragments of an old, disused satellite crash into a space station. The collision results in the formation of a high volume of debris, which in turn damages more satellites, causing the breakdown of GPS and the Internet, putting our planet on the brink of chaos. Although this is merely a science fiction blockbuster, the situation it depicts could easily occur in Earth's orbit. How can we prevent it from happening?

We all make use of space-based technology whenever we use the Internet, mobile phones or GPS, but not many people are aware of the potential problems that go along with it. From the very earliest days of humankind's exploration of space, we have been filling it with junk. Unfortunately we know very little about this space debris. While we do occasionally hear in the media of astronauts losing items such as gloves or cameras during space walks, these are just trivial incidents.

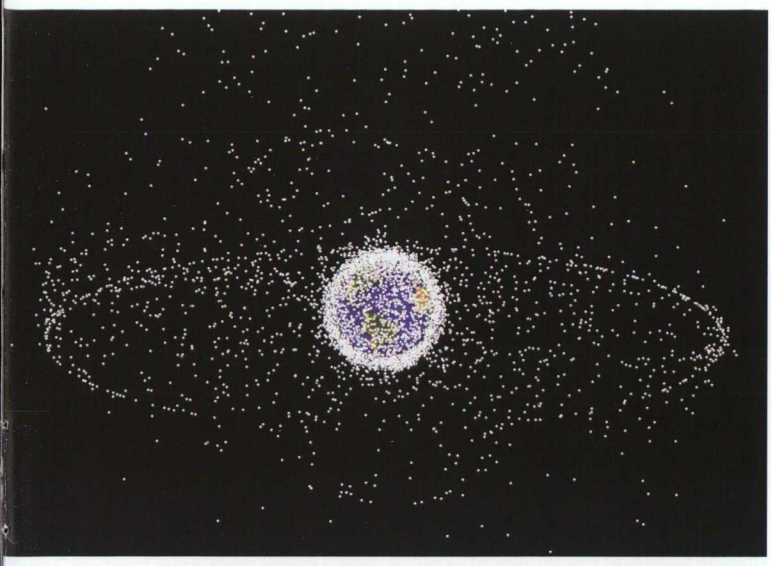
A catalogue of space debris prepared by NASA (National Aeronautics and Space Administration) and NORAD (North American Aerospace Defense Command) lists around 19,000 items. These are mainly large pieces of junk which can be tracked from Earth's surface, such as disused satellites, their fragments, and pieces of multistage rockets. All such objects have a diameter greater than 10 cm and weigh over 1 kilo. However, it is estimated that there are five and a half metric tons of debris captured in near-Earth orbits, likely including around 29,000 items with a diameter greater than 10 cm, around 60,000 greater than 5 cm, 700,000 greater than 1 cm, and around 200 million particles of 1 mm and above.

We have effective methods of protecting satellites from collisions with pieces smaller than 1 cm across, and the orbits of large items are catalogued, which means they can be avoided. The problem lies with space debris pieces with diameters between 1 and 10 cm, because their position in Earth's orbit is unknown. However, due to their very high speeds of between 6 and 10 km/s, such objects can puncture satellite walls, causing severe damage.

As part of the Seventh Framework Programme, the EU is financing five research projects aiming to improve safety in space. One of them is CLEANSPACE, a program to develop a model of protecting satellites in orbit from debris of this sort, between 1 and 10 cm across, preventing chain reactions of new debris being formed. As part of this project, scientists are working on creating a system to actively and precisely track space debris and remove it from orbit using high pulse repetition rate lasers. Such a laser pulse will cause a jet of plasma to shoot from the object, altering its orbit and therefore pushing



Low Earth orbits (between 200 and 2000 km above Earth's surface) are the most heavily polluted with space debris (computer simulation)



Numerous satellites and high volumes of space debris are present in geosynchronous orbits, particularly orbits at approx. 35,785 km above Earth's surface (computer simulation)

it into the upper layers of the atmosphere, where it will burn up.

The CLEANSPACE consortium includes nine participants: project coordinators CILAS (Compagnie Industrielle des Lasers), as well as DLR Deutsches Zentrum fur Luft- und Raumfahrt e.V., ASTRIUM Space Transportation, Universitat Rovira i Virgili, Universite Claude Bernard-Lyon 1, Universite de Limoges, and three Polish institutions: the PAS Institute of Low Temperatures and Structural Research, the Astronomical Observatory at the Adam Mickiewicz University in Poznań, and the company Astri Polska.

Each participant has a particular set of tasks. The PAS Institute of Low Temperatures and Structural Research has been tasked with developing nanoceramics meant to cover the lamp of the laser pumping system. It should be stressed that the laser being developed as part of the project has never been constructed, because the required parameters of the laser pulse are far beyond the existing ones. It will have impressive parameters: in order to change the orbit of a piece of space debris, the laser needs to generate energy of at least 10 kJ. The duration of each pulse will range from a few nanoseconds up to a few tens of nanoseconds, with a power of 10-12 W. Such a powerful pumping laser would flood the active laser material with light with wavelengths ranging from UV to near infrared, which could cause serious thermal shock destroying the laser. This can be prevented by inserting a filter between the lamp and the laser rod; such a filter should absorb the entire radiation of the lamp and return light with an adjusted wavelength to the absorbtion spectrum of the active ions in the laser material. The wavelength of the pumping light would have to be slightly shorter than the wavelength of the laser emission.

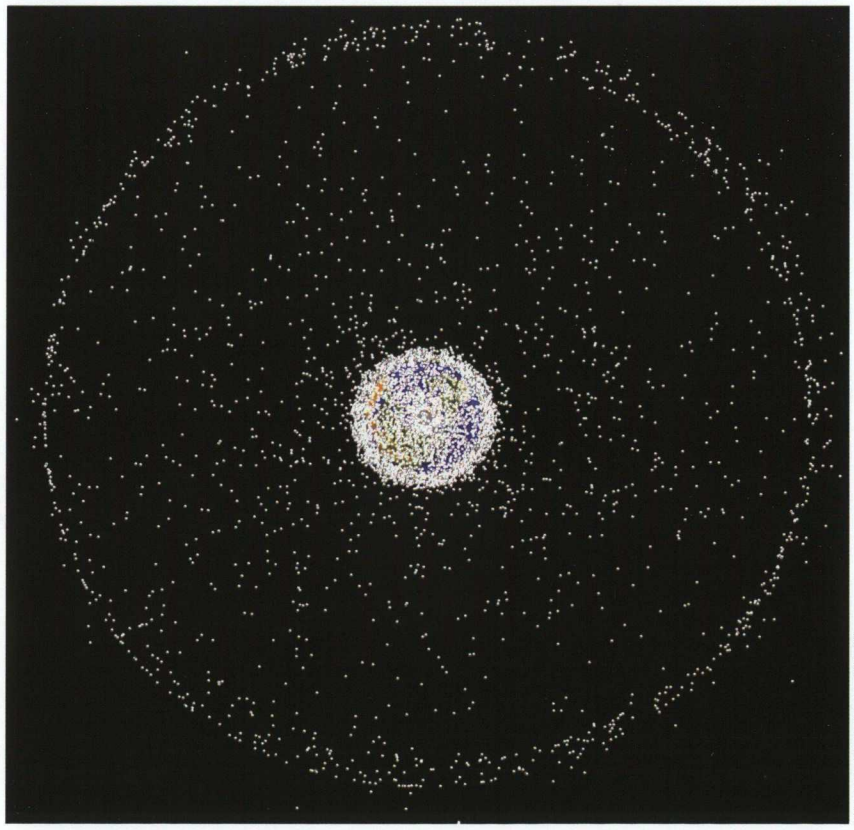
The CLEANSPACE project is drawing close to its conclusion, with a report presenting the proposals and feasibility of how such a space-based laser could be constructed and used. The next stage should involve actually commencing construction of a system to protect humankind's precious satellites and spacecraft in Earth orbit. For this to become a reality, countries which already have space technologies should be involved in future developments, which will require decisions to be made on the political as well as scientific level. These topics have also been considered under the CLEANSPACE project.

In closing, we can point out that "Gravity" had a budget of around US$80 million, whereas the budget for our project was tens of times smaller. ■

Further reading:

www.clean-space.eu

View from the North Pole, depicting the density of objects in low and geosynchronous orbits (computer simulation)



NASA Orbital Debris Program Office (3)