German Aerospace Center

Clearing the way for satellites - increasing space awareness

12 October 2011

Space debris poses an increasing threat to our orbiting assets. In a joint effort with national and international partners DLR scientists and administration as well as the German Air Force are working to put in place a space situation surveillance system.

Astronautics has become one of the key capabilities in modern industrial societies. Possible fields of application include providing weather forecasts, satellite TV or global access to the internet, navigation, energy supply or banking. Space technology has become an indispensable ingredient not only in the lives of individuals but also for entire societies. The same goes for the armed forces or for effective disaster management, neither of which can do without satellite-assisted services such as Earth observation, communication and navigation. In Germany public service departments such as the police, ambulance services, civil protection authorities and the Federal Army all rely on infrastructures and benefits gained from satellite usage.

Germany operates about 40 satellites and satellite payloads, which makes us one of Europe's leading space-faring nations. The legal obligation associated with this status implies that Germany has to take responsibility for the secure operation and disposal (for example by a controlled re-entry) of its own satellites, which is not an easy task. There are more than 20.000 elements of debris larger than 10 centimetres in size floating around the Earth totally uncontrolled. They mostly consist of disused satellites, rocket fragments or other pieces of wreckage. Given this, a piece of debris comes within the critical range of a satellite approximately every two weeks during its operation. Evasive manoeuvres are performed at a rate of one per month. Calculating these operations requires accurate orbit data. The US has collated and, for the major part, made publicly available a catalogue under the title of USSTRATCOM TLE listing this orbit data. However, the data is frequently inaccurate and makes additional measurements necessary if an acute hazard arises. Also, the objects listed are larger than 10 centimetres, leaving all the smaller pieces unaccounted for.

10 February 2009: Satellite Crash over Siberia

The first collision between two satellites occurred on February 10, 2009 over Siberia at an altitude of 776 kilometres and at a relative velocity of 11.7 kilometres per second. It involved one of the USA's communications satellites and a dysfunctional Russian military satellite.

Protecting and safeguarding the operability of space-based systems requires us to be able to produce a status report. This is the basis for identifying and evaluating all objects and processes in near-Earth space. Generating this knowledge requires continuous and systematic recording, localisation and orbit monitoring (space surveillance) and the identification and technical analysis of any space objects found (space reconnaissance) using both optical and radar systems. These systems can detect objects as small as 1 cm in a near-Earth orbit up to a height of about 1,000 kilometres above ground, and compute their orbital data. Optical systems are usually the less costly ones, but they require cloudless skies and are primarily suited for high-Earth orbits. Radar systems work continuously in any weather and at any time of day.

Early warning systems for solar storms and asteroids

Space weather also plays a part in the overall assessment of the situation in near-Earth space. Besides causing fascinating polar lights to appear in the ionosphere, space weather may also damage a satellite's sophisticated on-board electronic systems. Space weather is caused by the Sun catapulting energetically-charged particles into space in a process called coronal mass ejections. When the Earth gets in the way of these particles, the result is anomalies in the ionosphere. The Advanced Composition Explorer Satellite positioned between the Sun and the Earth can detect solar storms at an early stage, and can issue a warning signal 10 to 45 minutes before they arrive at the ionosphere, leaving enough time to shut satellites down, thus avoiding damage or even complete failure. Ionospheric currents represent a hazard to terrestrial assets too such as high-voltage power grids and substations. They can also cause critical measuring errors and signal failures in all modern communication and navigation systems. Early ionospheric information and forecasting could limit the incidence of such malfunctions. For this reason, DLR is currently setting up a forecasting service (called Space Weather Application Centre Ionosphere, or SWACI) at its Neustrelitz site.

A further threat is posed by near-Earth asteroids and so-called Inner Earth Objects whose orbits come close to that of the Earth itself. An incident on another planet causing a slight alteration in their orbit could result in them colliding with the Earth. Currently, ten objects of this category have been detected and catalogued. DLR's AsteroidFinder project is intended to spot more of them and to analyse their size, backscatter and risk of collision with the Earth.

The Space Situation Centre managed by the Air Force

A national German Space Situational Awareness Centre (GSSAC) was set up in Kalkar, Uedem in 2009 with across-the-board facilities under the management of the German Air Force and a prominent participation of DLR's Space Administration. The Centre is still in an initial phase of development, and its first task will be to generate a status report on the situation in near-Earth space. Successful multi-agency cooperation has been practised for some years at the National Air Policing Centre (NLFZ SiLuRa) located on the same site. The new centre's activities will include the following tasks, to be performed nationally, or as part of an international cooperation effort:

- monitoring and protecting space-based systems
- warning the population in anticipation of any possible re-entry hazards
- providing operational support for the armed forces
- assisting satellite operators.

Since space-based systems have become so critical to the successful functioning of a State and of society in general, space situational awareness (SSA) in addition to its technological relevance also has gained a political dimension, which is reflected by the large number of agencies involved:

- National programmes: individual EU member states consider these to be relevant for the consolidation of their own SSA competence. In Germany the Ministry of Defence and the Department of Economics and Technology are working closely together to assess national SSA capabilities. Moreover, there are firm plans to increase activities regarding French-German cooperation initiatives. Both countries have the necessary technical equipment and complement each other perfectly.
- Cooperation with third-country partners: the US has a Space Surveillance Network in place consisting of 17 radar units, eight telescopes and a space-based sensor for detecting and tracking orbital debris and satellites.
- SSA within ESA: at the European level, ESA has been running an SSA preparatory programme since 2008. Its tasks include carrying out feasibility studies, designing research and technology demonstrators and making proposals for the governance structure of an effective cross-border space surveillance system in Europe. Germany is the second biggest financial contributor to this preparatory programme.
- SSA in the European Union: after the ratification of the Lisbon Treaty, the EU and specifically the EU Commission have been showing an increased interest in space sector activities, as the GMES programme or the upcoming GALILEO fleet demonstrate. Recognizing its dependence upon this sensitive infrastructure, the EU considers itself politically responsible for its protection.

Pooling national capabilities

Space awareness is not merely a technological endeavour. Its policy implications, too, must be addressed very carefully. In an international context, clarifying the handling of data, i.e. who has control over systems deployed and data gained is a top priority for any international SSA System. On a national level the main issues revolve around the political will to justify these systems since they are very costly. If one sees SSA as an international field of action, the challenge will be to decide how national capabilities can be bundled within the framework of a governance and technical model yet to be defined. This is the only way of ensuring the best possible protection of the infrastructure both in space and on the ground, which is in the best interest not only of the state but also of the economy and ultimately of each one of us.

Scientists from all of DLR's main research areas are involved in this project, which at the same time forms part of DLR´s security research, a cross departmental programme under which defence and security-related research and development activities are being planned and controlled.

The supreme political responsibility is shared between the Ministry of Defence, the Ministry of Economics and Technology and DLR Space Administration which provides the civilian personnel, such as the deputy director of the German Space Situational Awareness Centre. In this project, DLR thus combines scientific research with its own political role, two fields of activity which complement each other in an excellent way.

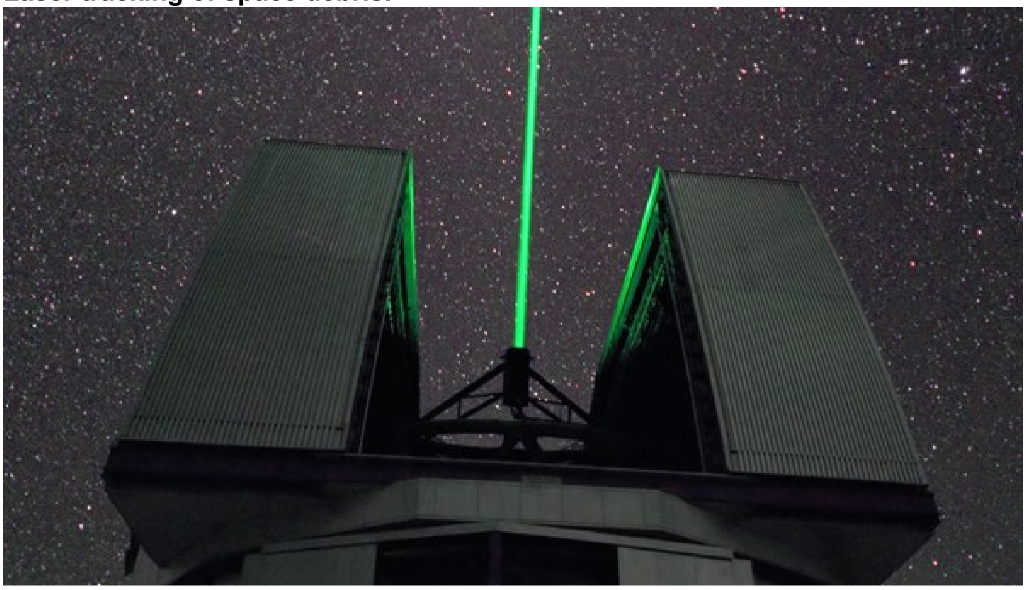
Contacts

Dr. Martin Hellmann
German Aerospace Center (DLR)
martin.hellmann@dlr.de

Dr. Hauke Fiedler
German Aerospace Center (DLR)
hauke.fiedler@dlr.de

Thomas Cherdron
German Aerospace Center (DLR)
thomas.cherdron@dlr.de

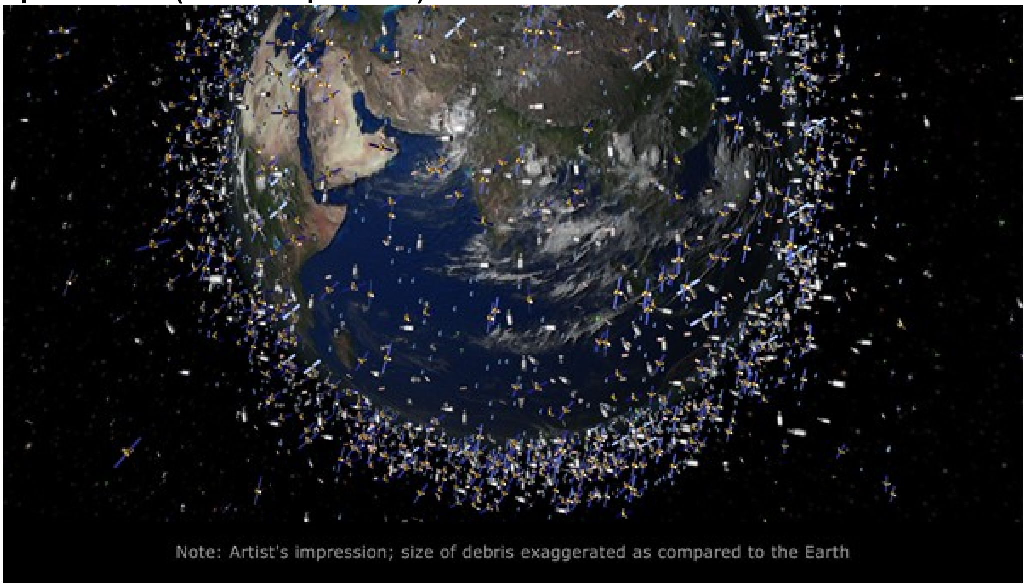
Laser tracking of space debris.



Laser tracking of space debris.

Credit: ESO.

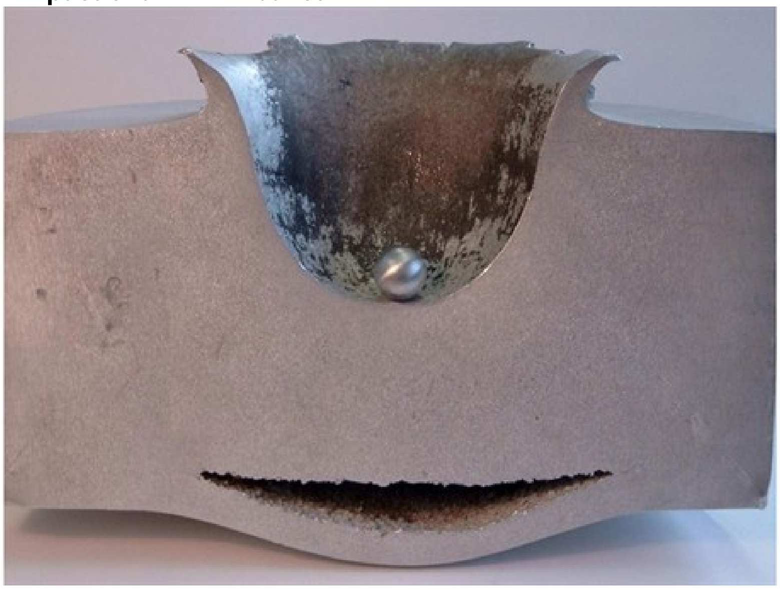
Space debris (artist's impression)



Space debris (artist's impression): 20,000 pieces larger than 10 centimetres orbiting the Earth.

Credit: ESA.

Simulated impact of a 12 mm bullet



Simulated impact of a 12 mm bullet on to an 8 cm aluminium plate at a velocity of 7 kilometres per second.

Credit: ESA.

Contact details for image and video enquiries as well as information regarding DLR's terms of use can be found on the DLR portal imprint.