Big laser for small debris

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Remember how Imperial destroyers smashed asteroids in 'The Empire Strikes backs'? You can almost consider that old fashioned. Thanks to the CLEANSPACE project, space debris as small as 1 cm could soon be tracked down by Earth-based lasers.

The protection of satellites is a pressing issue. If we were to replace the approximately 1 000 active satellites in orbit today, the estimated cost would be around EUR 100 billion. Many sectors of the economy would be impacted, and society as a whole would have to suffer the consequences.

Various technologies have been considered to resolve this issue. From DARPA's scavenging robots and ESA's cargo freighters - both due to

launch in 2015 - to Japan's fishing nets, scientists' brains teem with ideas. Laser technology is one of these. Proposed by NASA in 2011, the concept of a laser station used to modify the trajectory of space debris is increasingly looking like a suitable solution.

The CLEANSPACE (Small debris removal by laser illumination and complementary technology) project, which has been running for three years and is due to end this month, looks into the role laser technology could play in the removal of small debris - the most problematic for orbiting satellites. Their main objective is to define a technology roadmap for surveillance, identification and tracking, to be used with a possible ground-based laser protection system.

Dr Christophe Jacquelard, who coordinates the project, agreed to discuss some of its main outcomes.

What are the main objectives of the project?

The CLEANSPACE study is an answer to FP7 Security research call SPA-2010-2.3.02 'Need to protect space assets from on orbit collision'. It aims to answer this need by defining the necessary requirements for the safe and routine removal of small space debris in Low Earth Orbit with a ground-based high-energy laser station. Such technology would protect valuable space assets from destructive on orbit collisions.

What is new or innovative about the project?

Using a laser to modify the trajectory of space debris is new and we defined a global architecture of such a ground-based system. But the more innovative part of the project is at the technical level: laser matter interaction in a vacuum has been studied, coherent coupling of laser beams of moderate energy has been demonstrated, and the suitability of

ceramic technology to develop large-size samples with a complex shape and luminescent dopant repartition has been tested. In order to ensure lasting international support and a smooth debris removal process, an international organisation has been proposed and finally simulation tools have been developed to evaluate trajectory modification for single-pass or multiple-pass operation.

How would your global architecture work exactly?

Such a system can create for each shot a very small thrust on space debris by ablating a very thin layer of its surface. The repetition of thousands of shots of such lasers reduces the velocity of the space debris, pushing it into a lower orbit. This concept can allow both for changing the course of a piece of debris - thereby avoiding a predicted collision with valuable space infrastructure - and ultimately for the removal of the waste, as its new course leads to atmospheric re-entry.

What were the main difficulties you faced and how did you resolve them?

No major issue was faced during the project, thanks to a very competent team, a team of people with experience who got to know each other, who didn't change from the beginning to the end. I would like to take the opportunity of this article to say that it was a pleasure for me to work with all of them, benefiting from their various fields and nationalities.

Of course, we faced some important decisions during the course of the CLEANSPACE project, as we were constantly looking for optimisation. The more important one was when we merged the two initial laser concepts (one from each main laser partner and external activities) to define a third laser architecture using the best concepts for its predecessors, and especially the actively-coupled Nd:Yag ceramic

amplifiers.

What are the next steps for the project, and follow-up plans after it ends?

When CLEANSPACE comes to an end, we believe the ground-based laser station we envisioned can be up and running within 10 years. The realisation of this system can be separated into two phases. Phase one will deal with necessary technology steps, primarily laser development, integration of several technologies into a demonstrator, implementation of a first debris monitoring and cataloguing network and policy implementation.

The second phase can be started only upon commitment of the European Union and other major space faring nations to ground-based 'laser debris removal' (LDR) and an agreement to fund the construction of an LDR system. Within this phase, the LDR station will be constructed and the high-energy laser, the telescope and some additional optical components will be fabricated and integrated into the station. It seems feasible to complete this second phase within five years.

Are you pleased with the results of your research?

The project organised a demonstration day before the end of the project to disseminate the main technical results and to show the four experiments we made: one named 'Debris tracking Mock-up', one which illustrates 'laser propulsion', a 'laser coupling demonstrator' and finally a 'disk laser demonstration'. Participants had the opportunity to find out more about the concept and to see how a laser can move an object in a vacuum environment (because the space debris environment is a vacuum).

Have any businesses or governments showed interest in deploying the CLEANSPACE technology yet? When do you think it could materialise?

The business model of such a system is still to be developed and it was not part of CLEANSPACE. However we developed a roadmap for a ten-year effort.

The amount of debris in Low Earth Orbit is rapidly increasing with, in the short term, potential collisions between debris and space assets and a possible chain reaction. Removing five big pieces of debris per year with automatic missions is useful but we must tackle as well reducing the population of small debris which will still increase for decades. The CLEANSPACE project is a solution for small debris, and this is what we emphasized when discussing with businesses.

More information: www.clean-space.eu/

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