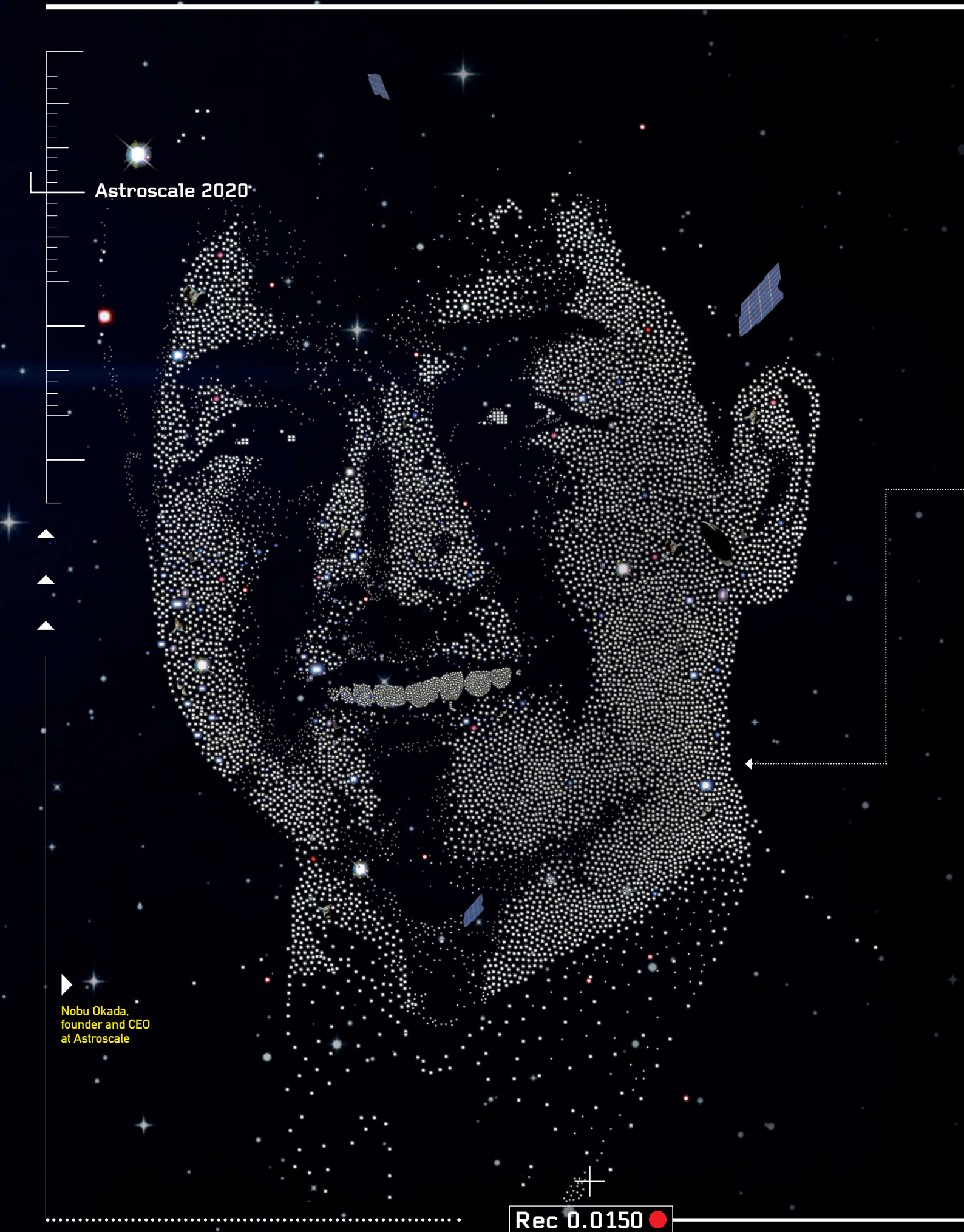
Astroscale 2020
Nobu Okada, founder and CEO at Astroscale
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HOW CAN THIS MAN, HIS TEAM (AND THIS UNIT) SOLVE THE SPACE DEBRIS PROBLEM

Illustration: Corey Jackson

When the first satellite was launched in 1957 and space exploration became a reality, so did the pollution of our universe. Dina Patel investigates the projects and standards that have been developed to remove the growing threat of space debris

The

Soviet Union launched the first artificial Earth satellite (Sputnik) in 1957, inspiring a generation of engineers and scientists: the Space Age had officially begun. Today, we rely heavily on the information communicated by the satellites orbiting Earth, from communications, transport, power and computer systems to weather predictions. Without these satellites, we would be unable to monitor the Earth's climate change or supply information for national security or mitigate natural disasters. But fast forward just over 50 years and we're at risk of losing this unique resource – because millions of pieces of man-made debris pollute space and risk satellite damage through collision.

Quality World speaks to space technology start-up company Astroscale, the European Space Agency (ESA) and BSI (British Standards Institution), about how they plan to aid the removal of dangerous orbital space debris.

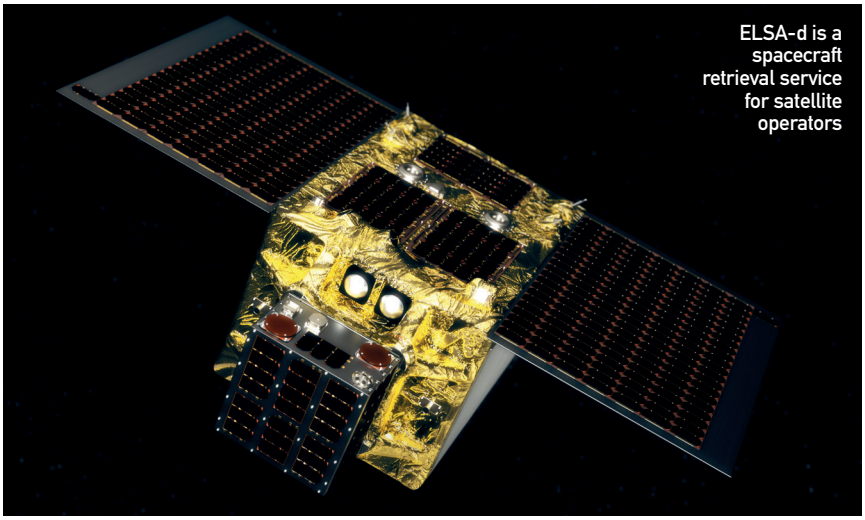
Astroscale

Astroscale was founded by IT entrepreneur Nobu Okada in 2013, who proposed using a start-up approach to address the business of space debris removal. They estimate that about 8,650 satellites in total have been put into space with 4,700 still there in orbit, but only 1,800 of those are functioning.

"We're here to run a business, but the main thing is that we contribute to society," says Jason Forshaw, European Research and Development Manager at Astroscale. "The 8,500 tonnes of space junk are completely a man-made problem. Some people have known about this issue since the 1960s, but of course, the general population has no idea because it's up there in space. Nobody really thinks about it."

Astroscale has grown in a short space of time from one office in Singapore, to two more in Japan and the UK, and has doubled its workforce in the past year. There are currently 17 employees working in the UK office.

The company's ELSA-d satellite, scheduled to launch in the first quarter of 2020, is designed to help bring retired or failed satellites out of orbit and back into the Earth's atmosphere, where they will burn on re-entry.



ELSA-d is a spacecraft retrieval service for satellite operators

"To date, we have raised over $100m, which is good, as it's difficult getting investment in the space industry," Forshaw says. "We have two main business lines – End-of-Life (EOL) and Active Debris Removal (ADR). ADR refers to taking care of existing space debris, a lot of which has been there since the 1960s. EOL refers to ensuring future missions are prepped suitably so that if anything goes wrong, we can remove the debris. A docking plate will be placed on satellites being launched into space. If they fail, we will be able to dock and take them out of orbit."

Forshaw, working under the Chief Commercial Officer, is responsible for developing the research and development strategy, bringing in funding, and building partnerships with the company's customers and suppliers.

> GOOD PRACTICE, OR COMMON SENSE, IS NOW BEING WRITTEN INTO STRICT QUALITY MANAGEMENT REQUIREMENTS

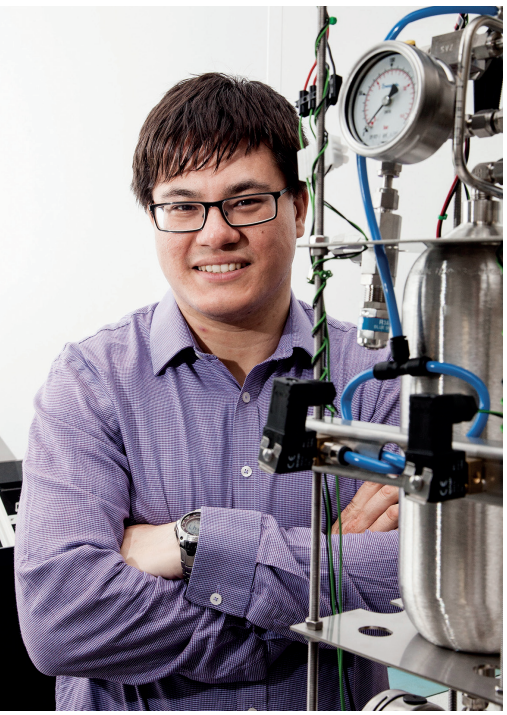
Speaking about the importance of the issue, he says: "People are starting to talk about space debris in the same way they talk about other sustainability issues like climate change. One of the biggest issues right now is plastic in our oceans. There are a lot of crises occurring at the moment, and the government and other entities need to decide what's important. Space debris is a critical issue because collisions have occurred in the past and they will occur in the future. The question is, how frequently will they occur? Almost everything we do on a day-to-day basis uses satellites in space – our mobile phones, GPS, computers, weather predictions, disaster monitoring, our TVs – virtually everything we can imagine – uses space."

ELSA-d

The planning stages for Astroscale involved looking at different technologies and deciding on the kind of sensors and systems that were needed on board to effectively remove objects in space. The company's mission will be challenging, as space debris can travel at speeds of up to 17,500 mph – fast enough for even a relatively small piece of orbital debris to cause significant damage to a spacecraft.

ELSA-d, scheduled to launch next year as a demonstration mission and operated from the National In-orbit Servicing Control Centre Facility in Harwell, UK, consists of two spacecrafts, a Servicer (160 kg) and a Client (20 kg) stacked together. The Servicer (the satellite removing the defunct or retired satellite – 'Client') is equipped with a magnetic docking mechanism, while the Client has a specific docking plate coated with a ferrous surface, which enables them to connect.

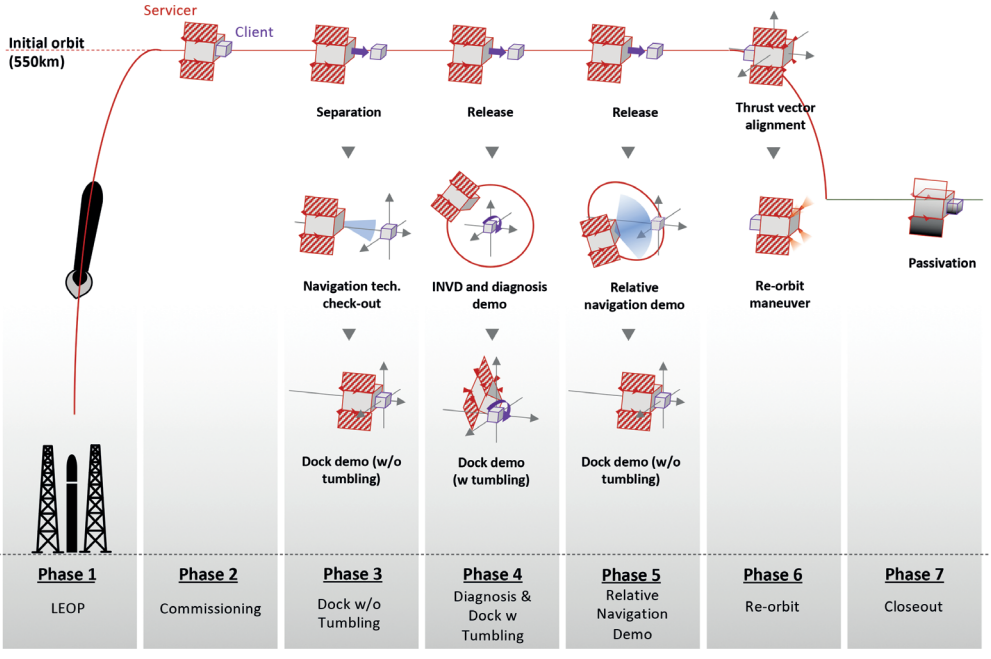
During the experiment in 2020, the Servicer will repeatedly release and dock with the Client in a series of technical demonstrations proving the capability to find, dock and remove debris. The launch will also test tumbling and non-tumbling



Left: Jason Forshaw, European Research and Development Manager at Astroscale

Below: The Astroscale team in Japan

Concept of operations: The main phases of the ELSA-d mission



Astroscale

docking. Tumbling docking is when the space debris rotates at speed. "This is a problem that's never been tested in space before. Nobody has ever been able to autonomously dock to a tumbling Client," Forshaw says. "Another capability we're testing is finding the Client by losing it and searching for it again. When we first go into space, we will have to find our customer's Client. If you can't find your Client, you can't get rid of it. Finally, Astroscale will be looking to get rid of the space debris by lowering it so that it can burn up in the Earth's atmosphere."

Identifying risks, standards and partnerships

Astroscale has been identifying customers to work with following the launch of ELSA-d in 2020. Large constellations consisting of thousands of satellites are planned to be launched in the next few years. "We've been working with various constellations to ensure that when they launch their satellites, they have this docking plate on board just in case it is needed," Forshaw says. "We're managing any risks by engaging early on with our suppliers and working through a requirements management process to try and handle technical risks."

Quality for the launch is handled by the company's mission safety group. "Safety is a prime concern for us," Forshaw says. "We want to operate very safely to give our customers confidence and we don't want to create any more debris in space. We have two people working in quality assurance and one person in product assurance. For the launch, we have been trying to work out the kind of processes and standards we need to use.

"In Japan you have the standards set by the Japan Aerospace Exploration Agency, and over here in the UK you have ESA. We also adhere to NASA's Electrical, Electronic and Electromechanical (EEE) Parts program by ensuring that our electronic components are compliant to certain standards.

"Also, BS ISO/DIS 24113:2011 Space systems – Space debris mitigation requirements ensures anything you launch into space comes down within 25 years. Of course, we are complying ➤

with this standard."

Working closely with the ESA, Astroscale has set up a strategic agreement which involves exchanging data and expertise relating to the ELSA-d mission. The ESA will also be sending the people that worked on their Rosetta mission (Rosetta was the first mission to orbit and land on a comet). They will be reviewing Astroscale's design and will be providing overall support. Going forward, Forshaw anticipates more growth with regards to its staff and customers as space agencies and commercial constellation providers continue with their missions into space.

The European Space Agency

The European Space Agency (ESA) is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.

Stijn Lemmens, Space Debris Mitigation Analyst at the ESA, tells *Quality World* that his main role is to identify the source of space debris, find out how we can stop producing more, analyse the consequences of what we left behind and how existing space debris can be cleaned up. "Day-to-day, it is my role to deal with the consequences of space debris. We have a fleet of about 20 operational satellites that need to avoid collisions with debris. This could be satellites disposed of after a mission, fragmentation debris generated by satellites that have exploded, or debris from previous collisions in orbit. In order to be aware of all the debris in orbit, we have to develop sensors, infrastructures and telescopes to observe the state of the environment around Earth. We also need to develop and improve methodologies on assessing the risks associated with our operations."

The ESA will provide information on space pollution to help Astroscale to target tumbling space debris. "They are doing something very brave," Lemmens says about Astroscale. "Their activities complement the techniques we are also developing. One of our focus points is to establish how tumbling objects are rotating before vehicles designed to capture them, such as Astroscale's mission, are launched into space. This is because not all technologies designed to capture targets in orbit will work with a high tumbling rate. One way out could be to enforce that all new missions should be designed to be captured, as also proposed by Astroscale."

Quality management at the ESA

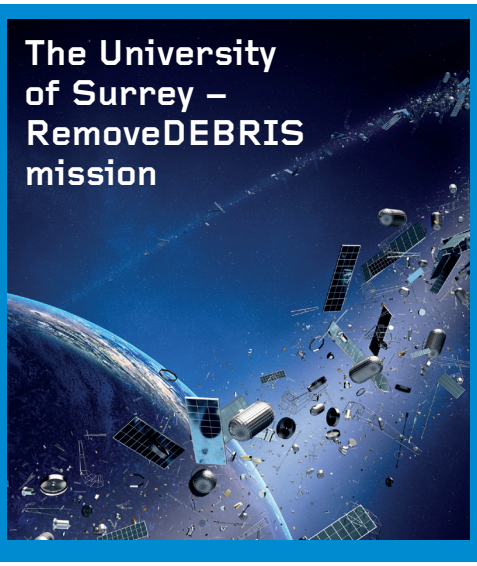
Cleaning up space is important, but most important is ensuring that future missions do not add to the existing pollution. "Quality management has really been making a change in this industry over the past 10 years," Lemmens says. "We adhere to BS ISO/DIS 24113:2011 Space systems – Space debris mitigation requirements for any new objects launched into space. For example, if you are launching into low Earth – any orbit below 2,000km above the Earth's surface – there is a requirement that your satellite needs to be taken out within 25 years of the mission being completed."

> MILLIONS OF PIECES OF MAN-MADE DEBRIS CURRENTLY POLLUTING SPACE THREATEN SATELLITE COLLISION

Lemmens says good practice, or common sense, is now being written into strict quality management requirements to bring about significant change in the way we use space flight. There will however, be challenges with communicating the dangers of space pollution. Everyone, he stresses, needs to be made aware that space is not endless, it is a shared resource and the way we behave on orbit now will have an effect in the future. ■

ESA/R. Palmari

Analysts at work in the space debris facility located at ESA's ESOC mission control centre, Darmstadt, Germany.



The University of Surrey is also working on addressing the build-up of dangerous space debris.

RemoveDEBRIS is a satellite mission to test four Active Debris Removal experiments. The satellite is designed, built and manufactured by a consortium of leading space companies and research institutions (including Airbus Defence and Space). Three experiments have already been carried out successfully in orbit. These include testing of a harpoon, net, and onboard vision-based navigation system. Each test has shown the satellite is able to provide accurate information about a piece of debris, its behaviour and flight of travel, and it can capture a deployed target using the onboard net and harpoon.

Professor Guglielmo Aglietti, Director of the Surrey Space Centre at the University of Surrey, said: "The RemoveDEBRIS project provides strong evidence of what can be achieved with the power of collaboration – pooling together the experience across industry and the research field to achieve something truly remarkable."

BS ISO/DIS 24113:2018 Space systems – Space debris mitigation

Dr Hedley Stokes, Space Debris Consultant at PHS Space Limited, says: "Orbital debris can be defined as objects of human origin that are in Earth orbit or re-entering the atmosphere, which no longer serve a useful purpose. It comprises satellites that have broken up due to collisions or explosions, payloads that have ceased operating, spent rocket bodies, mission-related objects, the products of surface deterioration of spacecraft, and other sources.

"Over the past sixty years, this unfortunate by-product of mankind's use of the region of space around the Earth has grown to such an extent that some orbits may become unusable in the not-too-distant future. The reason is simple. An impact from a debris particle as small as two millimetres travelling at several kilometres per second has sufficient energy to penetrate inside a satellite and cause significant damage. It is estimated that there are already over one hundred million debris objects larger than one millimetre orbiting the Earth today. Since the orbital debris problem is global in nature, international solutions are needed to slow its growth. With this in mind, the International Organization for Standardization (ISO) set up a working group about 15 years ago to oversee the development of a set of spacecraft engineering standards focused on debris mitigation.

"BS ISO/DIS 24113:2018 Space systems – Space debris mitigation requirements is the top-level standard in this family of standards. It contains high-level requirements which aim to limit the production of orbital debris in the future by ensuring that spacecraft and launch vehicles are designed, operated and disposed of in such a way that they will generate little or no debris throughout their orbital lifetime.

"In particular, the standard requires the following range of measures to be implemented in space systems: avoid the intentional release of debris, prevent break-ups in Earth orbit, minimise the risk of collision with other space objects, ensure removal from orbit once the mission is complete, and control the risk to the human population when re-entering the Earth's atmosphere. It is expected that widespread adoption of these measures by spacecraft manufacturers and operators will go a long way towards mitigating the growth in orbital debris.

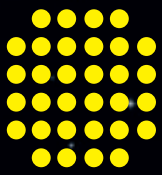
"This is essential given the rapid increase in the number of space companies during the past decade and the imminent launch of constellation systems comprising thousands of satellites orbiting the Earth. BS ISO/DIS 24113:2018 Space systems – Space debris mitigation requirements defines the primary space debris mitigation requirements applicable to all elements of unmanned systems launched into or passing through near-Earth space, including launch vehicle orbital stages, operating spacecraft and any objects released as part of normal operations."

The growing threat of space debris

170 million

There are millions of pieces of debris in orbit too small to be tracked

Smaller than 1cm



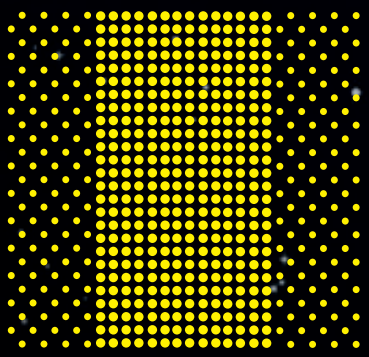
29,000

Thousands of pieces of space debris over 10cm in diameter are currently being tracked

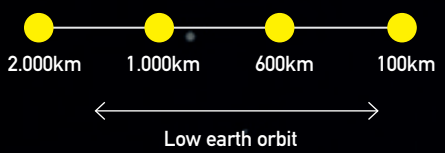
Greater than 10cm

28,100

Some debris is orbiting at vast speeds



Most satellites operate in low Earth orbit (between 800 and 2,000km) – the same area where the majority of space debris is found.



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