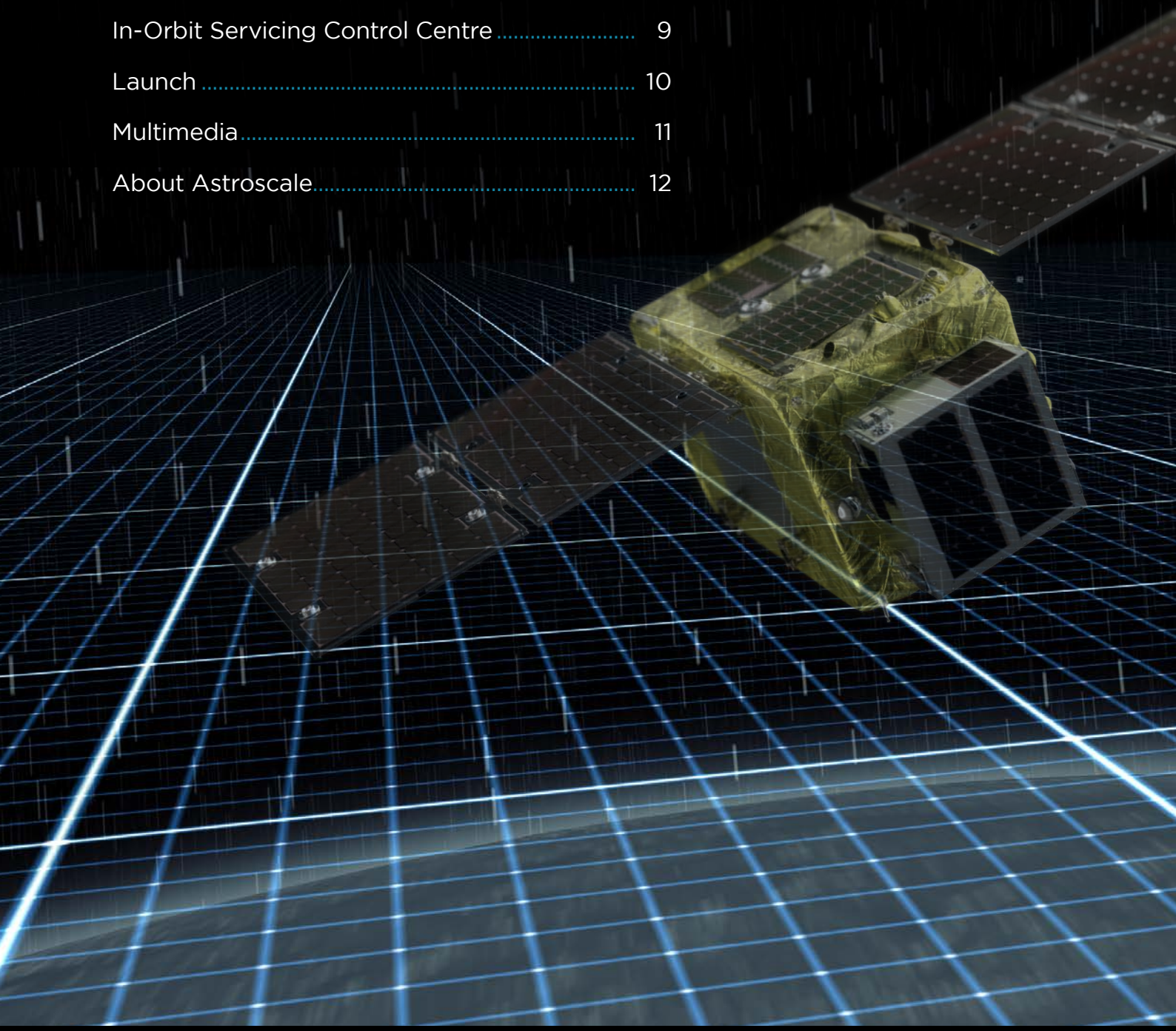
Astroscale

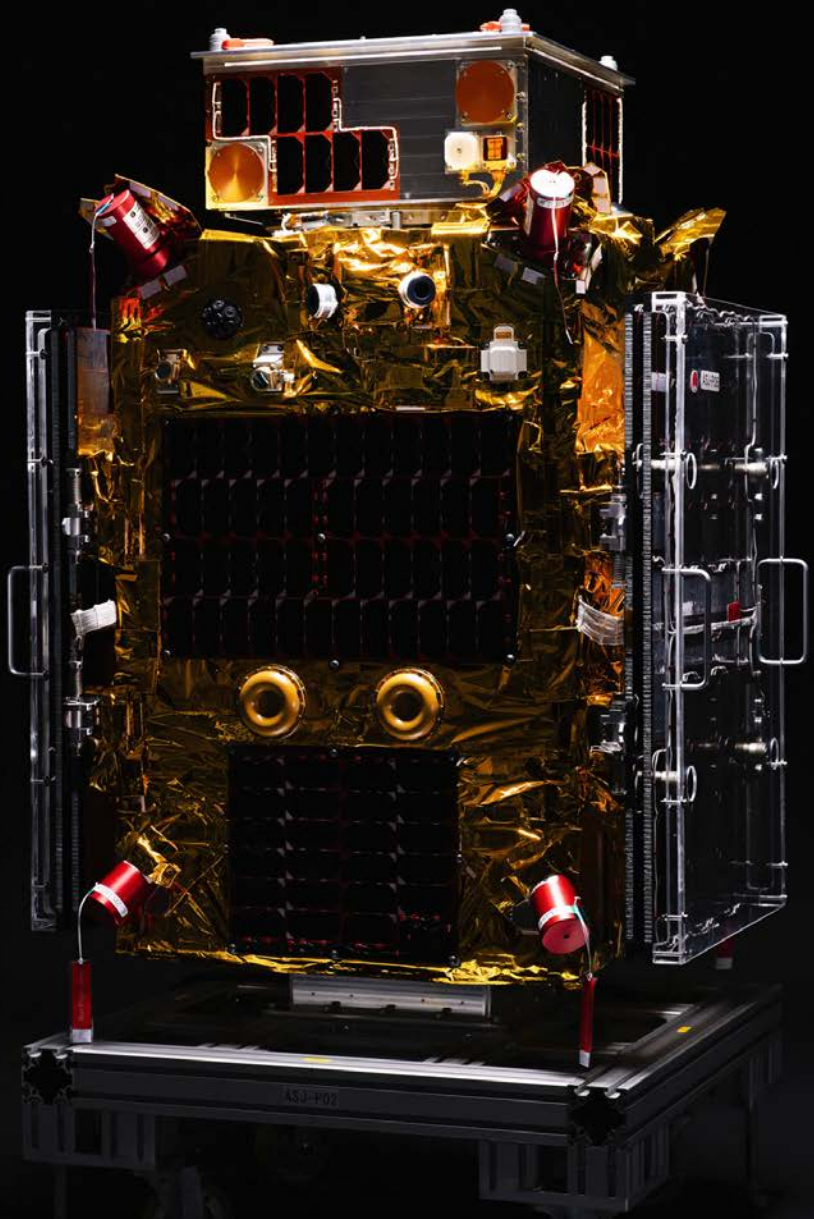
ELSA-d Press Kit

2022

Contents



Introducing ELSA-d



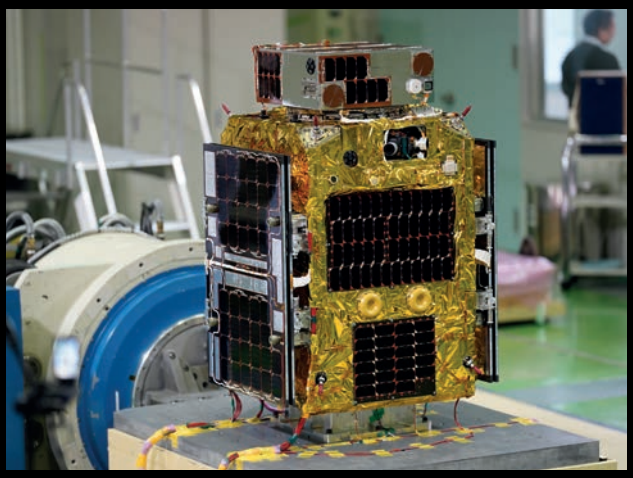
Creating a sustainable space environment

Every day billions of people around the world rely on data from satellites to go about their lives. We exchange messages, talk to family and friends, check the weather and manage finances. Satellites are also used to manage and mitigate natural disasters, monitor the Earth's climate, and provide national security information. In short, satellite data powers modern life on Earth. And now the sources of this data is at growing risk of being destroyed by space debris. The rise of large commercial satellite constellations in low Earth orbit (LEO) will provide services that improve quality of life on Earth. They will also lead to an increase in the number of objects in key orbits, raising the risk of further debris creation and threatening the very services space systems provide. The European Space Agency estimates the 5,000 working satellites share their orbits with more than 9,800 tonnes of space debris, or an estimated 30,630 debris objects tracked by the Space Surveillance Network. With over 10,000 satellites scheduled to launch in LEO over the next 10 years, we need pro-active strategies for post-mission debris disposal to maintain the safe use of LEO orbits for the benefit of humankind.

The End-of-Life Services by Astroscale (ELSA) program is a spacecraft retrieval service for satellite operators. ELSA-d (demonstration) is the

Introducing ELSA-d (continued)

Electromagnetic compatibility testing in February 2020



Vibration testing at JAXA's Tsukuba Space Center in February 2020

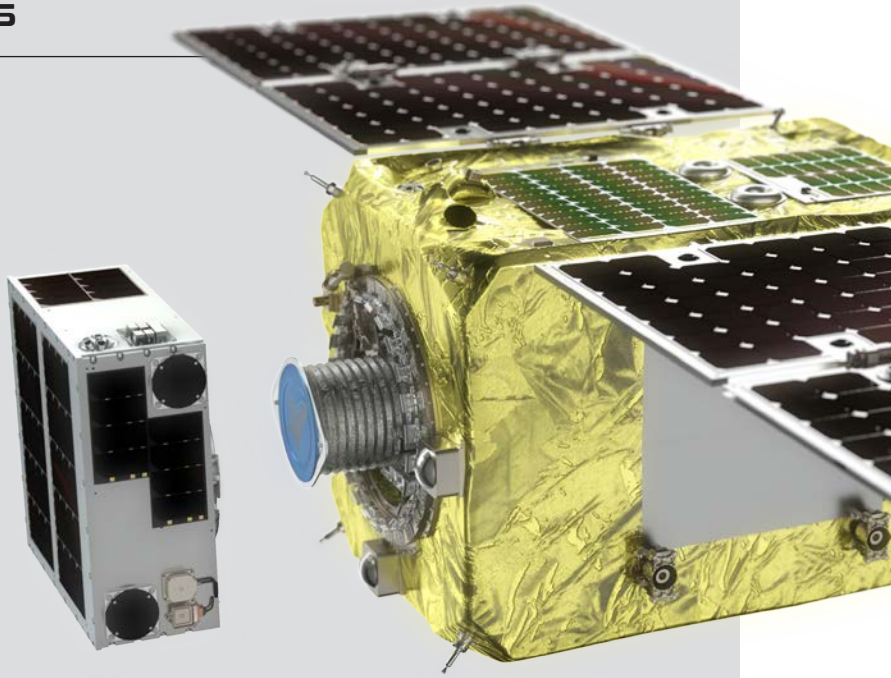
first mission to demonstrate the core capabilities necessary for debris docking and removal. ELSA-d consists of two spacecraft: a servicer satellite (~175kg) and a client satellite (~17kg), launched stacked together. The servicer satellite was developed to safely remove debris objects from orbit, equipped with proximity rendezvous technologies and a magnetic docking mechanism. The client satellite is a piece of replica debris fitted with a ferromagnetic plate that enables the docking. The servicer will repeatedly release and dock with the client in a series of technical demonstrations, proving the capability to find and dock with defunct satellites and other debris. Demonstrations include client search, client inspection, client rendezvous, and docking. These capabilities are extremely challenging to demonstrate, and all are either rarely accomplished in space or are entirely unprecedented. ELSA-d is operated by Astroscale's Mission Operations and Ground Segment teams from the In-orbit Servicing Control Centre – National Facility at Satellite Applications Catapult, Harwell Campus, UK.

ELSA-d Highlights

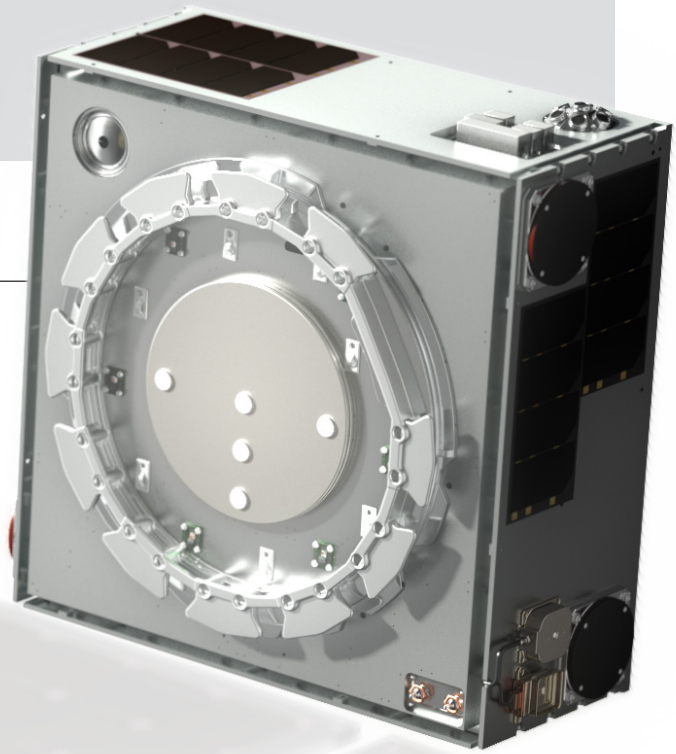
- ELSA-d is the world's first commercial end-to-end debris removal demonstration mission.
- ELSA-d will demonstrate the end-to-end debris removal service, including client search, inspection, rendezvous, docking, and de-orbit. These technologies and capabilities are critical to debris removal and applicable to a variety of other on-orbit services.
- In addition to the technological demonstrations, ELSA-d will also develop operational best practices in rendezvous and proximity operations.
- With ELSA-d, Astroscale is launching a new era of space sustainability and further defining the on-orbit servicing ecosystem.

Prelaunch checks at the Baikonur Cosmodrome in February 2021

ELSA-d Key Features

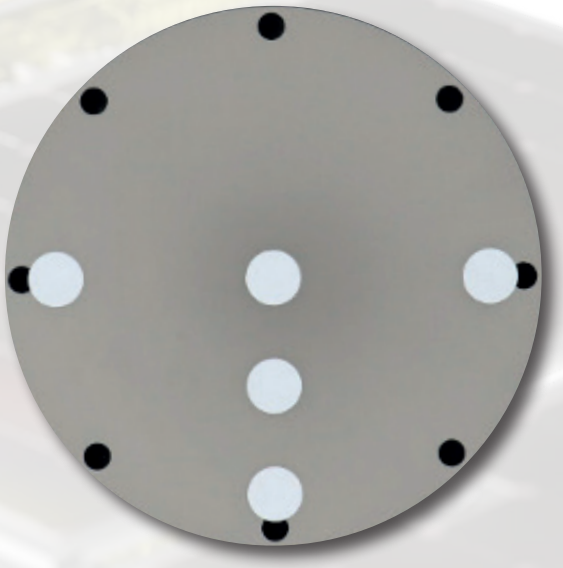


- End-to-end rendezvous solution including far-range and short-range approaches
- Client search and approach from far-range with relative navigation sensors
- Fly-around inspections of client with operator assessment
- First generation docking plate tested for commercial release to future proof satellites and enable removal and servicing if they fail
- At-night magnetic capture of clients
- Re-orbit, de-orbit and passivation capabilities
- Safety evacuations and passively safe trajectories in mission design
- Full ground segment, custom-designed for on-orbit servicing



Docking Plate

The servicer is fitted with Astroscale's first generation docking plate (DP), successfully tested for the first time on August 25, 2021. The plate is an integral part of ELSA-d's rendezvous suite and includes retroreflectors and a fiducial pattern to enable reliable proximity Guidance, Navigation, and Control (GNC) operations.



The docking plate is now available commercially, designed with flexible flush mount or different truss leg size options. Lightweight, unobtrusive and low in cost, the plate is designed for magnetic and robotic grappling systems to enable de-orbiting and servicing. Preparing all satellites with a docking plate will reduce the future costs of removal and ensure space remains safe and viable to support the growth of our thriving space ecosystem.

Mission Overview

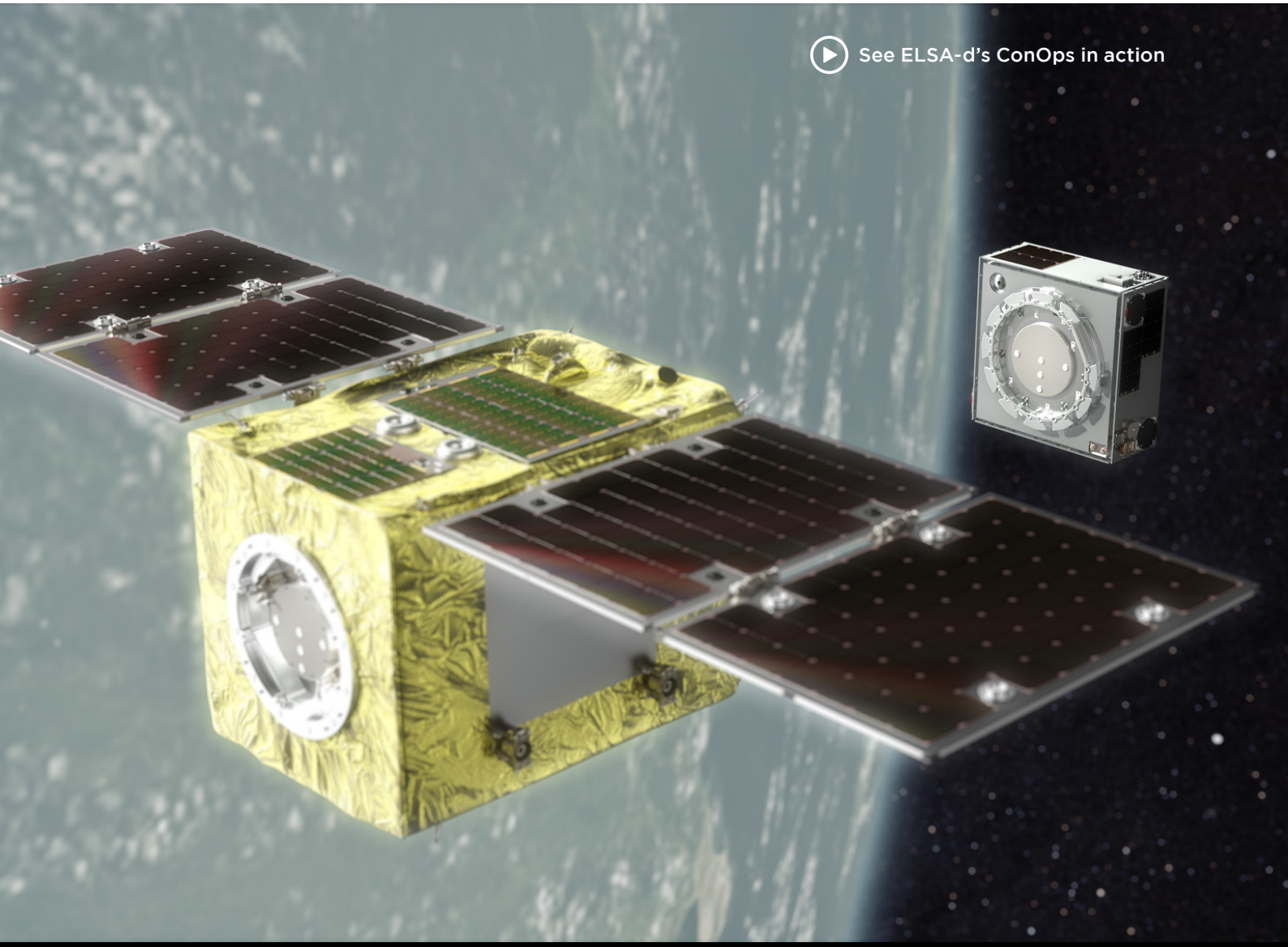
The ELSA-d mission will demonstrate several capabilities and technologies needed for future on-orbit services. While the ELSA-d mission will prove technologies that can be directly applied to customers, there are some slight differences to a future servicing mission.

For the ELSA-d mission, the client is commandable, ensuring demonstrations can be tested in a simplified manner earlier in the mission. The Concept of Operations (ConOps) is designed to gradually increase the complexity and risk with each phase and can be adjusted because the servicer is launched together with the client.

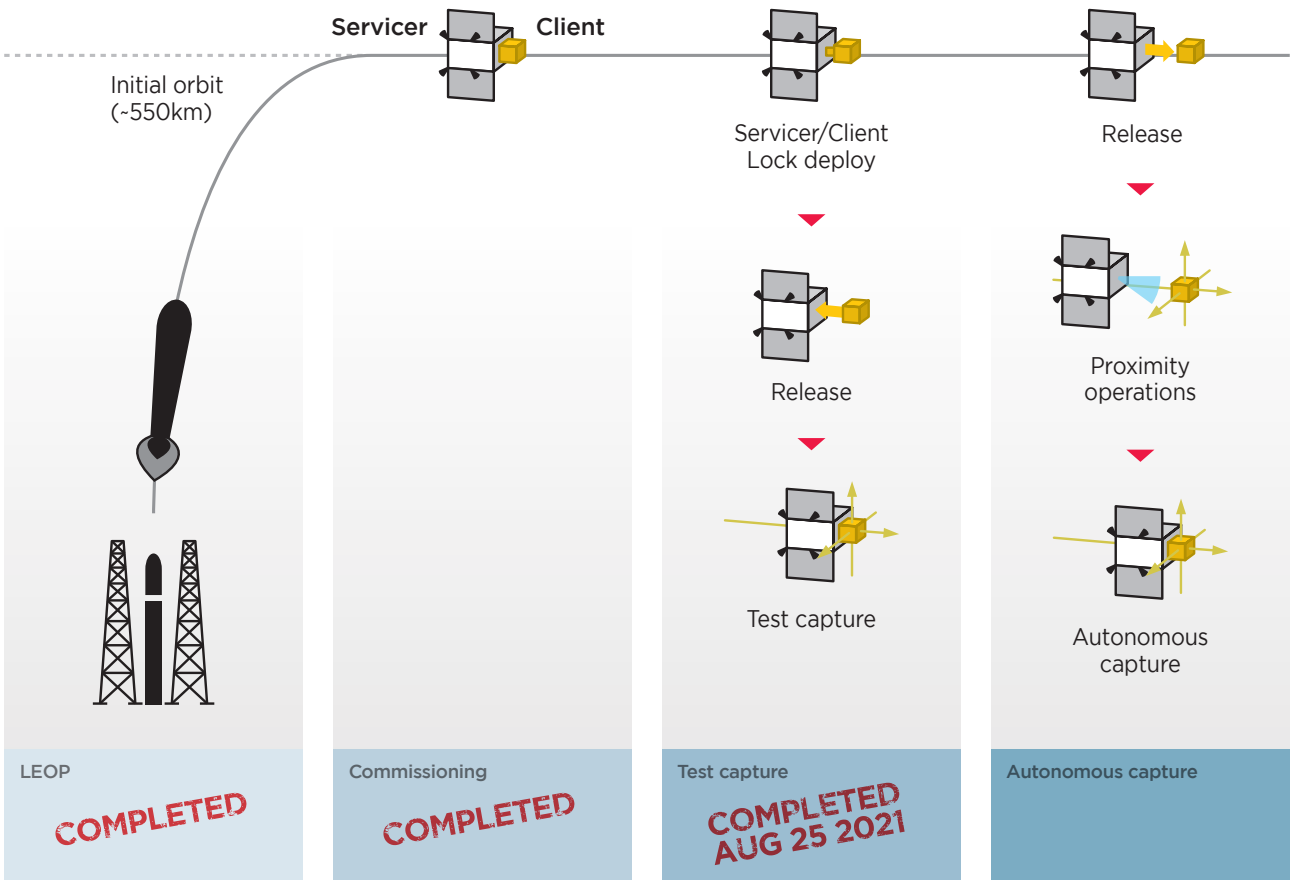
This compares to a full commercial service where the significant task of finding the client would be among the first mission actions. In addition to an advanced magnetic rendezvous and docking suite capture system, the spacecraft will include other elements of a classical satellite bus: power, propulsion, communications and processing.

The mission ConOps is divided into four phases. The phases are designed to generally increase in complexity, ensuring less risky demonstrations are attempted first.

- LEOP
- Commissioning
- Test capture
- Autonomous capture



Mission ConOps



Launch and Early Orbit Phase and Commissioning

These phases have been successfully completed. During these phases, the servicer and client were launched together into an operational orbit of roughly 550km. The servicer underwent commissioning, tested interfaces with the ground segment and ensured subsystems were calibrated, resulting in a system that was ready to start the demonstrations. The client was activated using the client activation unit and underwent the majority of its commissioning prior to separation.

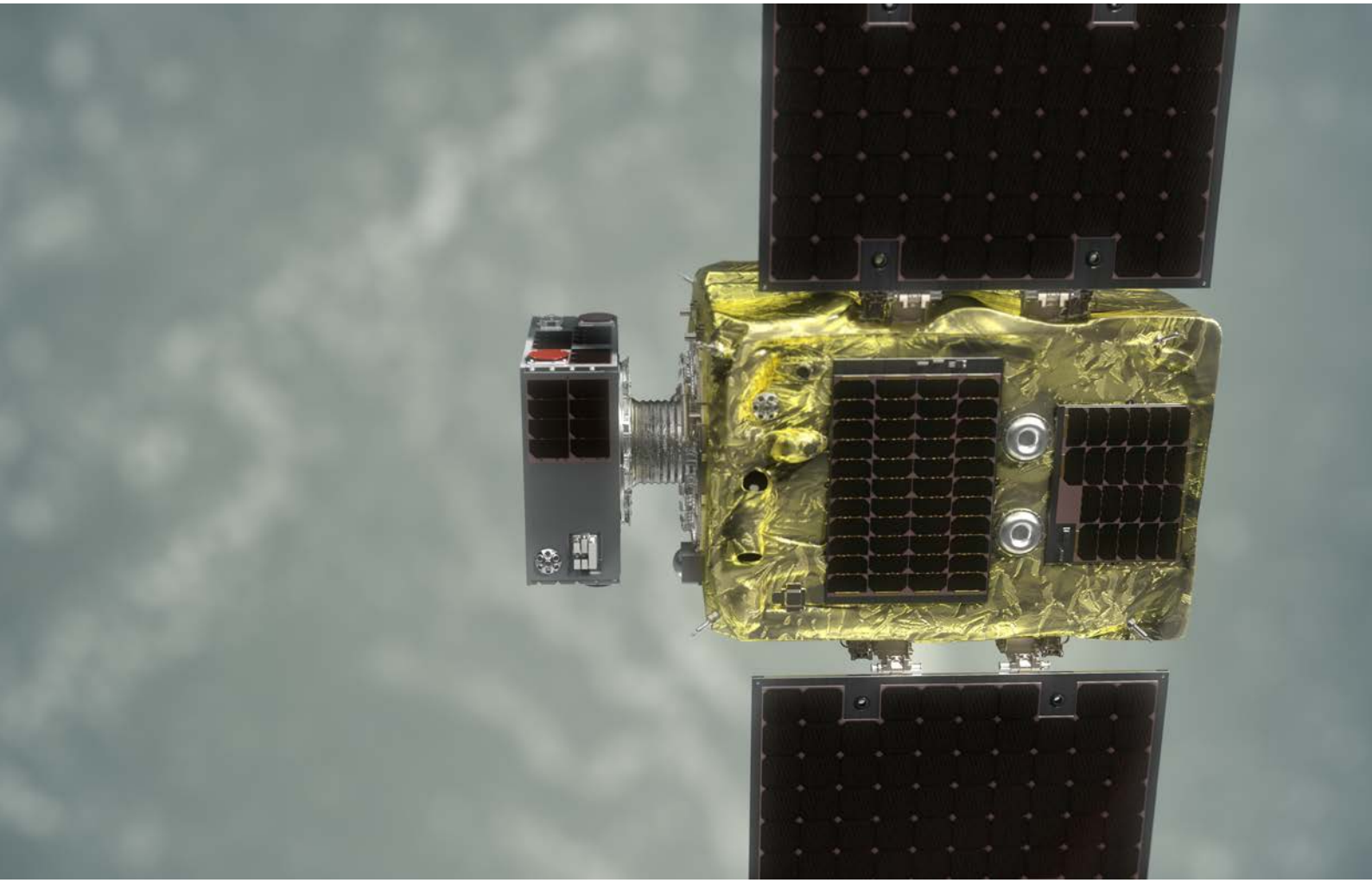
Test capture

This phase was successfully completed on August 25, 2021. A mechanical locking mechanism held the client and servicer together during launch and commissioning. The first step of test capture was to unlock this mechanism to prepare the client, servicer, and magnetic capture system for the demonstration. Once unlocked, the magnetic capture system held the client to the servicer, so it is now ready to repeatedly capture and release the client in future demonstrations, a unique feature of the ELSA-d capture system. During this phase, the client was separated from the servicer for the first time for a short distance and then captured to validate the magnetic capture system. During this release and capture period, the rendezvous sensors were checked out and calibrated, and relevant ground system infrastructure and operational procedures were verified.

Autonomous capture

The method of rendezvous and docking will test a combination of on-board autonomous software and advanced ground processing of telemetry and commands. After separating from the client, the servicer will be commanded to initially hold at a set distance and orientation, while training its sensors on the client. When the client attitude is determined to be within an acceptable range, the servicer will be commanded to go in for the capture. Guided by range sensors and cameras, the servicer will safely approach the client while its 6-degrees-of-freedom motion control enable it to match the rotation rate between the capture device and client during its final approach, concluding with a safe capture.

Mission ConOps (continued)



Test capture

This demonstration will pave the way for future end-of-life services, with several key technologies required for capturing orbital debris to be proven, including:

- autonomous guidance
- navigation and control algorithms
- closed loop control with various hardware navigation sensors
- autonomous thruster rendezvous maneuvering and attitude control
- autonomous 6-degrees-of-freedom rate matching with the client during final approach and capture
- full extension and client capture with the magnetic capture mechanism
- complex satellite operational procedures for rendezvous missions.

Mission Statistics

Entity	Property	Value
Servicer	Size	Approx. 660 x 640 x 1100mm (with no solar array deployed)
	Mass	~175kg
	GNC (command)	GNC OBC, GNC sensor handling unit
	GNC (sensing)	Star trackers, Gyro sensors, Magnetometers, Sun-sensors, Accelerometers, GPS receiver
	GNC (actuation)	Reaction wheels, Magneto-torquers
	GNC (RDV)	Navigation cameras, Visible-range cameras, Blue lighting device, Laser range finder, Low power radio
	Capture	Magnetic capture system
	Comms	S-band (Uplink, Downlink), X-band (Downlink)
	Power	Deployable double solar array, Power distribution module, Battery control module, Second converter batteries
	Propulsion	Green propellant chemical propulsion system
	C&DH	Data handling unit (BUS OBCs, TCMs), Spacewire router
	Other	Retro-reflector, Client separation mechanism & activation unit
Client	Size	Approx. 480 x 500 x 225mm
	Bus	~17kg satellite with OBC, EPS, S-band COM, AOCS
	Docking plate	First generation docking plate mounted on client
	Other	Retroreflector, Visual camera, Illuminator (LEDs)

In-Orbit Servicing Control Centre – National Facility

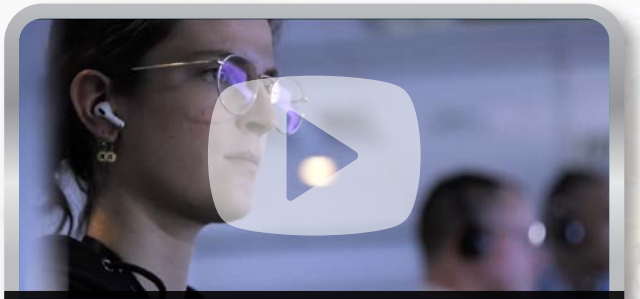
In 2018, Astroscale UK was named Prime Contractor of a £4 million grant from UK Research Innovation (UKRI) to build an In-Orbit Servicing Control Centre – National Facility at the Satellite Applications Catapult in Harwell, Oxfordshire, UK.

This state-of-the-art facility will form the basis for future missions to clean up space debris and conduct other on-orbit servicing operations.

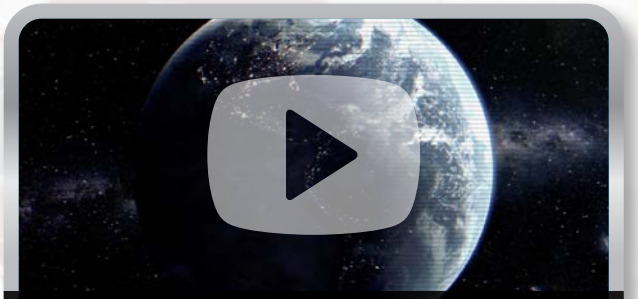
Launch

Vehicle:	Soyuz-2
Soyuz-2 Cluster Mission:	CAS500-1
Orbit:	SSO 497.8 km, LTAN 11.00
Space Port:	Baikonur, Kazakhstan
Date & Times:	Liftoff was on **Monday, March 22, 2021,** at:
	09:07 Moscow (MSK)
	02:07 Washington, D.C. (EDT)
	00:07 Denver (MDT)
	15:07 Tokyo (JST)
	06:07 London (GMT)

Multimedia



Meet our Mission Operations Team



7 Year Marathon for Clean Space

Breaking New Ground for On-Orbit Servicing

Astroscale's ELSA-d: Leading the Way with On-Orbit Servicing

'Test Capture' Demo Success

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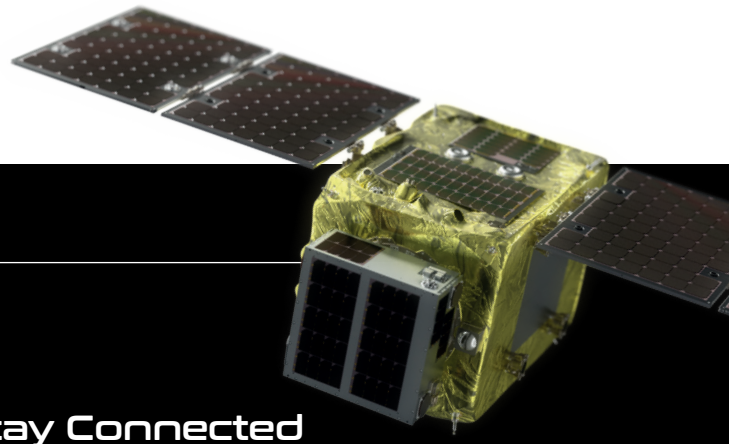

About Astroscale

Astroscale is the first private company with a vision to secure the safe and sustainable development of space for the benefit of future generations, and the only company solely dedicated to on-orbit servicing across all orbits.

Founded in 2013, Astroscale is developing innovative and scalable solutions across the spectrum of on-orbit servicing missions, including life extension, in situ space situational awareness, end-of-life services, and active debris removal, to create sustainable space systems and mitigate the growing and hazardous buildup of debris in space. Astroscale is also defining business cases and working with government and commercial stakeholders to develop norms, regulations, and incentives for the responsible use of space.

Headquartered in Japan, Astroscale has an international presence with subsidiaries in the United Kingdom, the United States, Israel, and Singapore. Astroscale is a rapidly expanding venture company, working to advance safe and sustainable growth in space and solve a growing environmental concern.

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ELSA-d website section:
https://astroscale.com/missions/elsa-d

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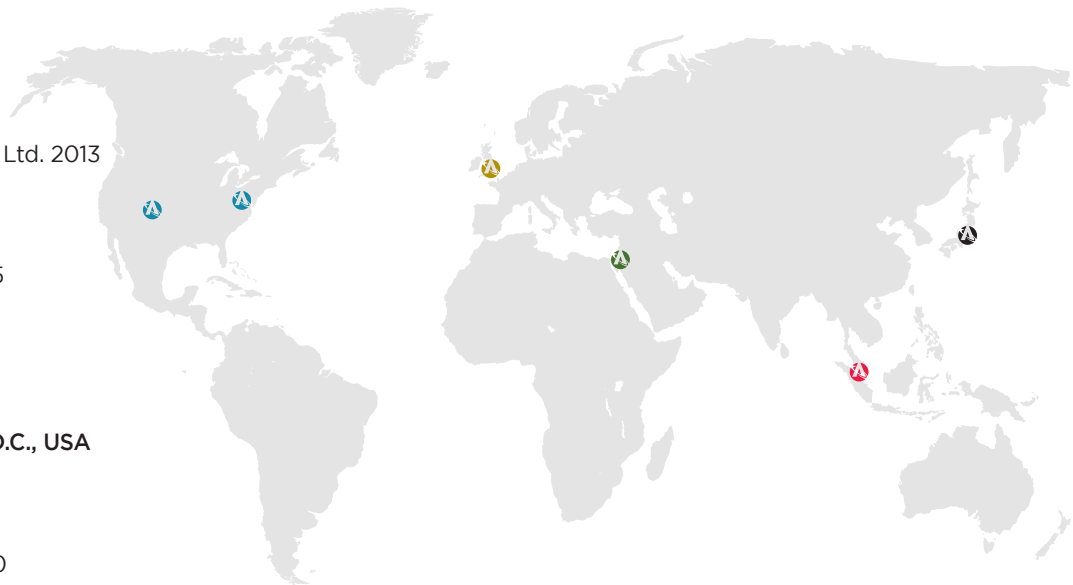

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