SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*

RemoveDebris Mission: Briefing to UNCOPUOS

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RemoveDebris Mission

- “RemoveDebris” is an European Union (EU) Framework 7 (FP7) research project to develop and fly an in-orbit demonstrator mission that aims to de-risk and verify technologies needed for future Active Debris Removal (ADR) missions
- It is *not* an end-to-end demonstration of a full ADR mission
- It will demonstrate the use, on-orbit, of some of the key aspects of a ‘real’ ADR mission
- Multi-partner consortium, with the Surrey Space Centre (Uni. Of Surrey) acting as project coordinator
- The project has a limited budget, which means that high pay-off scenarios have been traded carefully against their risk profile
- The consortium partners recognise the potential sensitivities surrounding ADR and its associated technologies
- This presentation aims to present the RemoveDebris mission to the community, to raise awareness, and to gather feedback on the proposed mission

Project Team

Name	Project Role
University of Surrey – Surrey Space Centre (SSC), UK	Project co-ordinator, CubeSat development and de-orbit technology development
Surrey Satellite Technology Ltd (SSTL), UK	Satellite platform provider, satellite operations
Airbus Defense and Space (AD&S), Germany, France, UK	Mission and System Engineering, Net development, vision-based navigation development, harpoon development
Innovative Solutions in Space BV (ISIS), Netherlands	CubeSat deployers and subsystems
Suisse d'Electronique et de Microtechnique SA - Recherche et Development (CSEM), Switzerland	LiDAR camera
Institut National de Recherche en Informatique et en Automatique (Inria), France	VBN algorithms
Stellenbosch University – Electronic System Laboratory (ESL), South Africa	CubeSat ADCS hardware and software

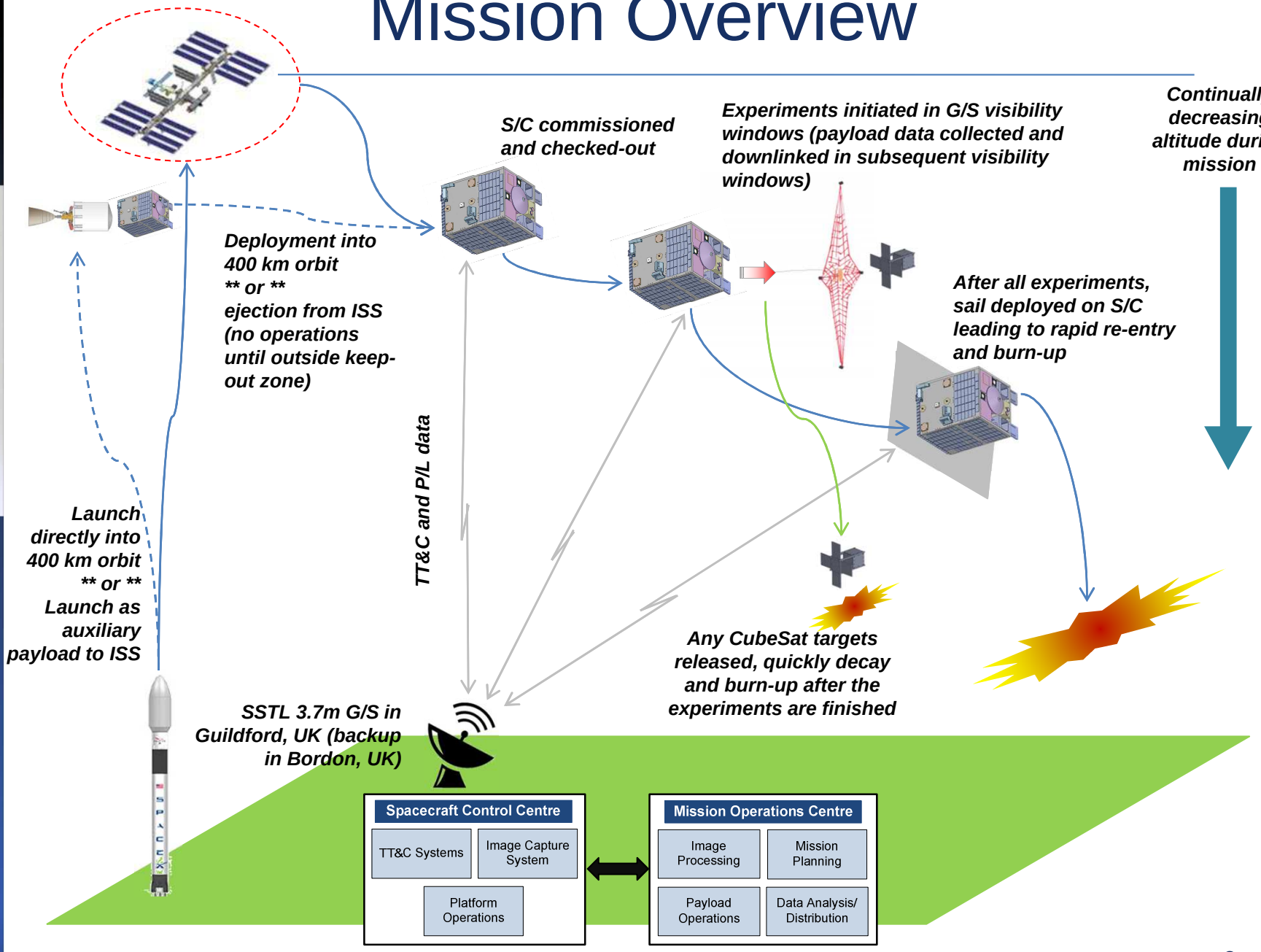
Mission Overview

- The mission has as its primary aim, the raising of Technology Readiness Levels (TRL), and gaining on-orbit experience with:
  - A debris capture system based on a ***Net***
  - A debris capture system based on a ***Harpoon***
  - Visual Based Navigation (VBN) using ***Optical, Infrared*** and ***LIDAR*** cameras
  - Deployable drag augmentation devices (***Sails***)
- The core concept behind the mission, is to use a small-satellite (~100kg) as a 'mothership', on which the payloads are carried, and from which CubeSats (~3kg) are released and used as 'pseudo-debris' targets
- Mission aims to launch Q2/3 2016
  - Currently in detailed design phase, with advanced bread-boarding and engineering model testing underway

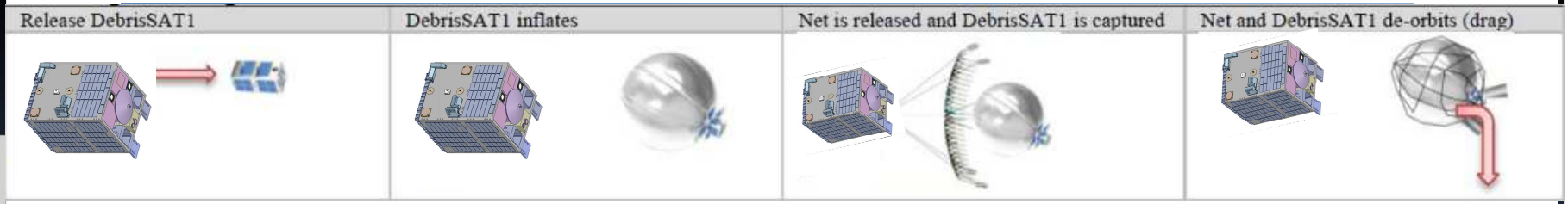
Mission Overview

- The “RemoveDebris” mission obviously does not want to produce any excess debris in orbit from its activities
- The current mission baseline is therefore to fly the mission at low altitude (<400km) where orbital residence times for the different parts of the mission will be low (<3 years)
- Parts of the mission involving close proximity operations between the mothership and CubeSats have been designed to be passively safe (objects will naturally drift apart)
- The consortium is in discussions with several launch providers and no launch has been yet selected
- One potential option is the US company NanoRacks to obtain a launch from the International Space Station (ISS)
  - Launch via airlock on the Japanese Experiment Module (JEM)
  - Carriage to the ISS via cargo re-supply flights (SpaceX or Orbital Sciences)

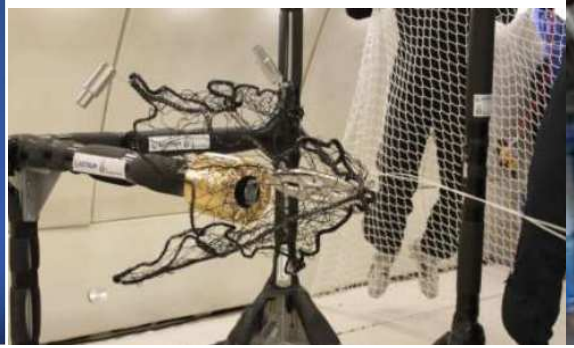
Mission Overview

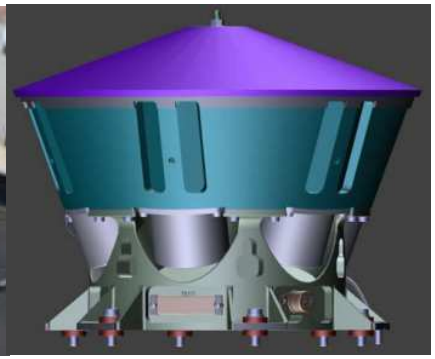


Payloads (Net & CubeSat)



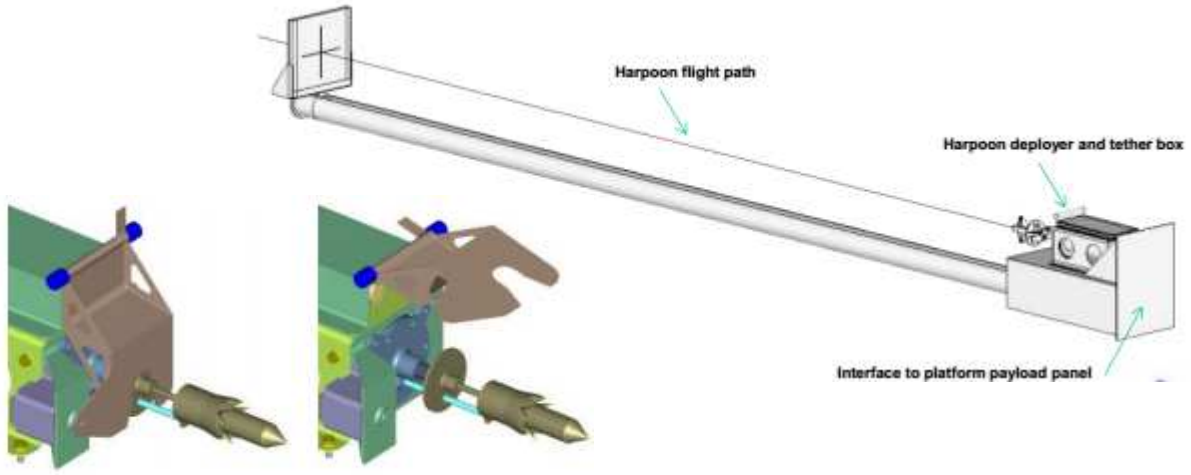
- Purpose:
  - Capture of a non-cooperative target (debris) via a thrown net
  - Demonstrate net deployment, target capture and closure of net
- Airbus Defence and Space has tested a small net system in Bremen drop tower (Ø 1.5 m) and parabolic aircraft (Ø 1 m)
- Low probability of missing the target, as the Cubesat is ejected at low velocity (few cm/s) and the net is large (Ø ~5m) compared to the size of the target and the expected dispersions
- The net will not be connected to the mothership (no restraining tether) and no towing will be conducted (too complex and risky for the mission profile)

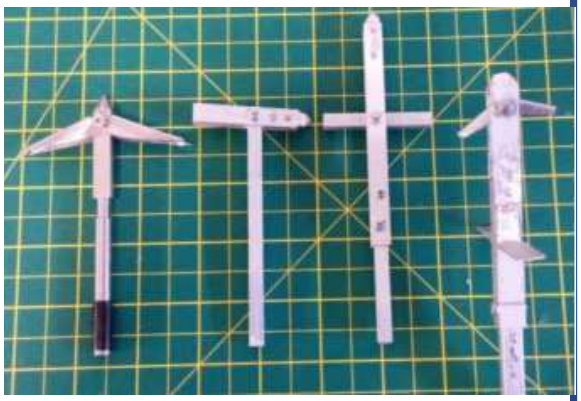




Payloads (Harpoon)

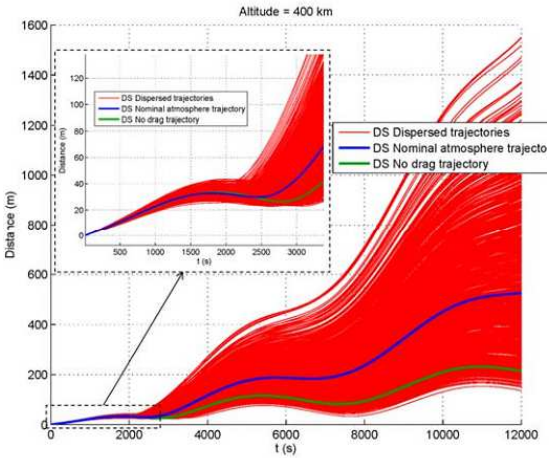
- The Harpoon is a small (~25cm long) barbed projectile, that is fired at ~20m/s towards a target
  - The Harpoon punctures the outer layers of the target (e.g. Alu panels) and ‘fish hook’ barbs deploy to lock the Harpoon into place which can then be towed via an attached tether
  - Deployed via a cold gas generator and tear-pin mechanism
- For RemoveDebris the original objective of firing the Harpoon against a free flying CubeSat is no longer preferred ; it is envisaged to fire at a fixed target plate deployed on a boom from the Mothership
  - Concerns over miss probability and secondary debris production with a CubeSat target (don’t want to leave the Harpoon as its own orbiting object!)
  - Still allows key demo of deployment mechanism and zero-g flight, whilst significantly reducing risk
  - Target pate will have a Kevlar bag on its rear side to capture any secondary debris produced

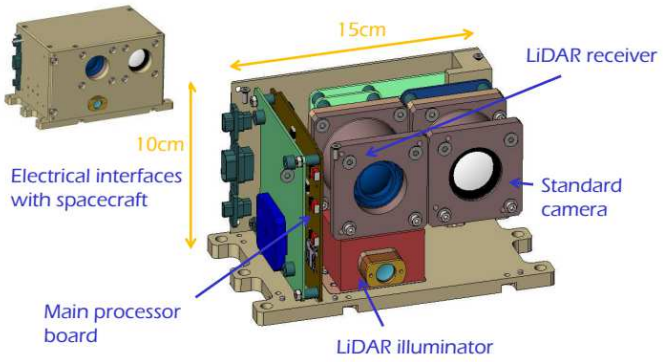


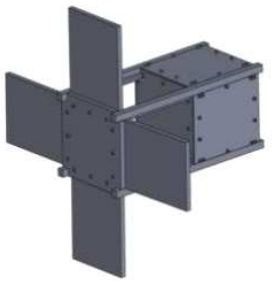


Payloads (Visual Based Navigation)

- For the VBN experiment, a second CubeSat will be deployed as an observation target for the sensors
  - VBN sensors will observe the CubeSat as it drifts away from the Mothership
- The VBN trajectory has not yet been confirmed, but it is likely a passively safe trajectory will be chosen for regulatory/safety reasons
- No attempt will be made to perform formation flying, rendezvous, target ‘chasing’, or any other close proximity operations
  - By controlling the CubeSat ejection angle, the momentum transferred to/from the Mothership and CubeSat can be used to design trajectories which do not re-contact after many orbits
  - Differing ballistic coefficients cause the inter-satellite range to continually increase
  - Verified by Monte Carlo simulation
  - Still allows a good range of lighting/background conditions to be sensed







Safety is a Mission Priority

- The mission has been designed with as safe a concept-of-operations (CONOPS) as possible
  - Altitude of mission will ensure rapid re-entry of all elements (Mothership and CubeSats)
  - Risk of secondary debris production or collisions minimised (Harpoon fired against fixed plate is the preferred solution, no formation flying)
  - Passively safe trajectories are currently envisaged
- Launch from ISS (if chosen) will bring its own set of safety requirements, especially given the number of mechanisms involved in the mission
  - Electrical inhibits for power system
  - Mechanical inhibits for deployers and payloads (e.g. mechanical safety barrier incorporated into the Harpoon deployer design)
  - Delay (30mins) between ISS deployment and activation (outside of keep-out zone before any activity on the spacecraft)
  - Safety requirements understood and being incorporated into final design
- The consortium is dedicated to producing a safe, yet ambitious mission, that will be one of the first key missions in demonstrating debris removal technologies

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Thank You

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