RemoveDEBRIS

Final Pre-flight Update for the RemoveDebris ADR Mission

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Agenda

- Mission Introduction, Video and Pre-flight Configuration
- Mission Launch Overview
- Operational Timelines
  - High Level Mission Timing
  - Net Demonstration
- Conclusion and Publications

Credit: SSTL, 2017

Introduction

Project Specification

- A European Commission FP7 project, €15.2 million[1]
- 9 Partners, over 60 staff
- Project duration: 4 – 5 years Start: Oct 2013 Launch: Jan – Feb 2018

Technologies and Payloads

- Capture technologies with a net and harpoon
- De-orbiting technologies with a drag augmentation sail
- Proximity rendezvous operation technologies with vision-based navigation and LiDAR

Mission Concept

One chaser (main platform) which holds the payloads. Two targets (CubeSats) which are ejected as "artificial debris" to test the technologies

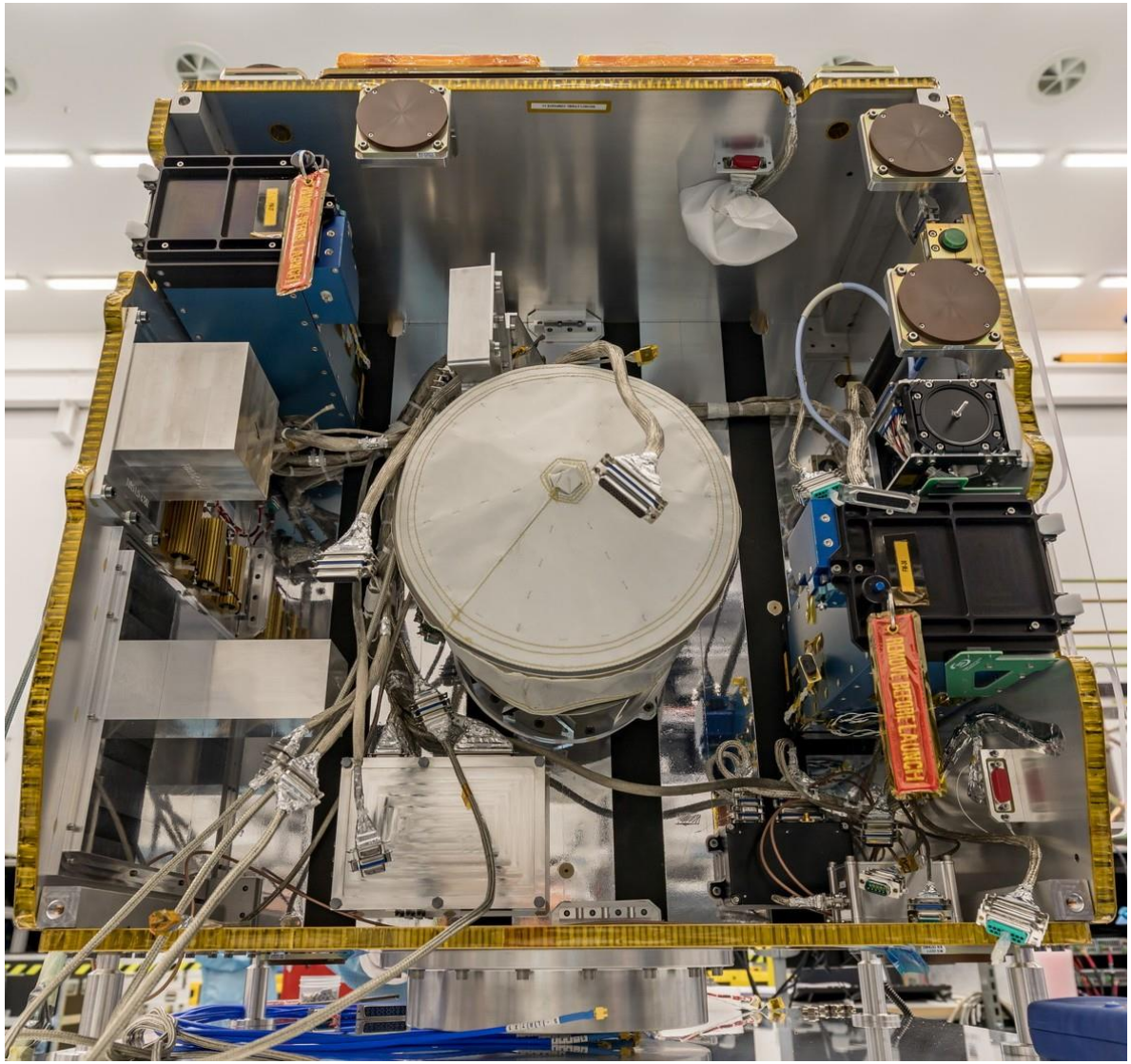
Novelty

A Low cost ADR mission to demonstrate, de-risk and mature key ADR in-orbit technologies

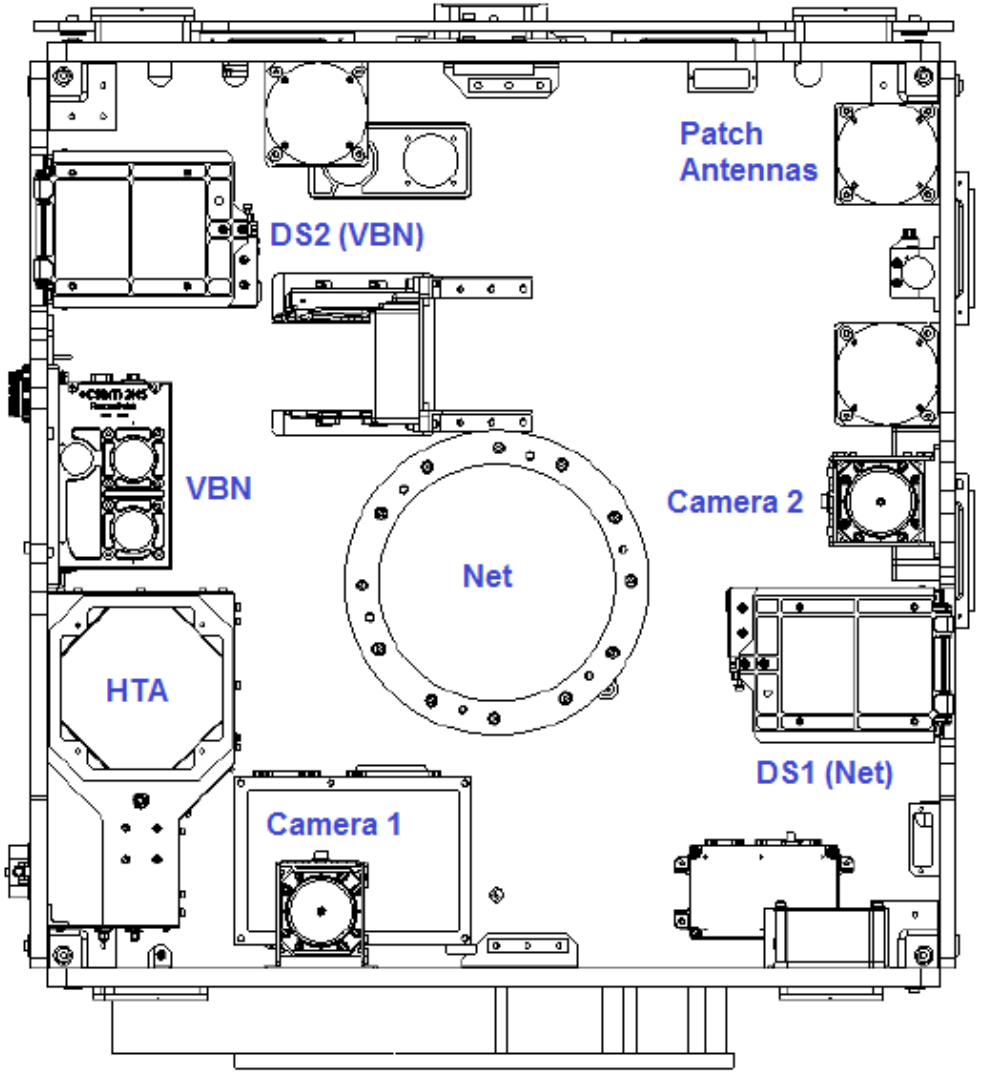
[1] European Commission Participant Portal

Mission Video

Configuration – Platform – I

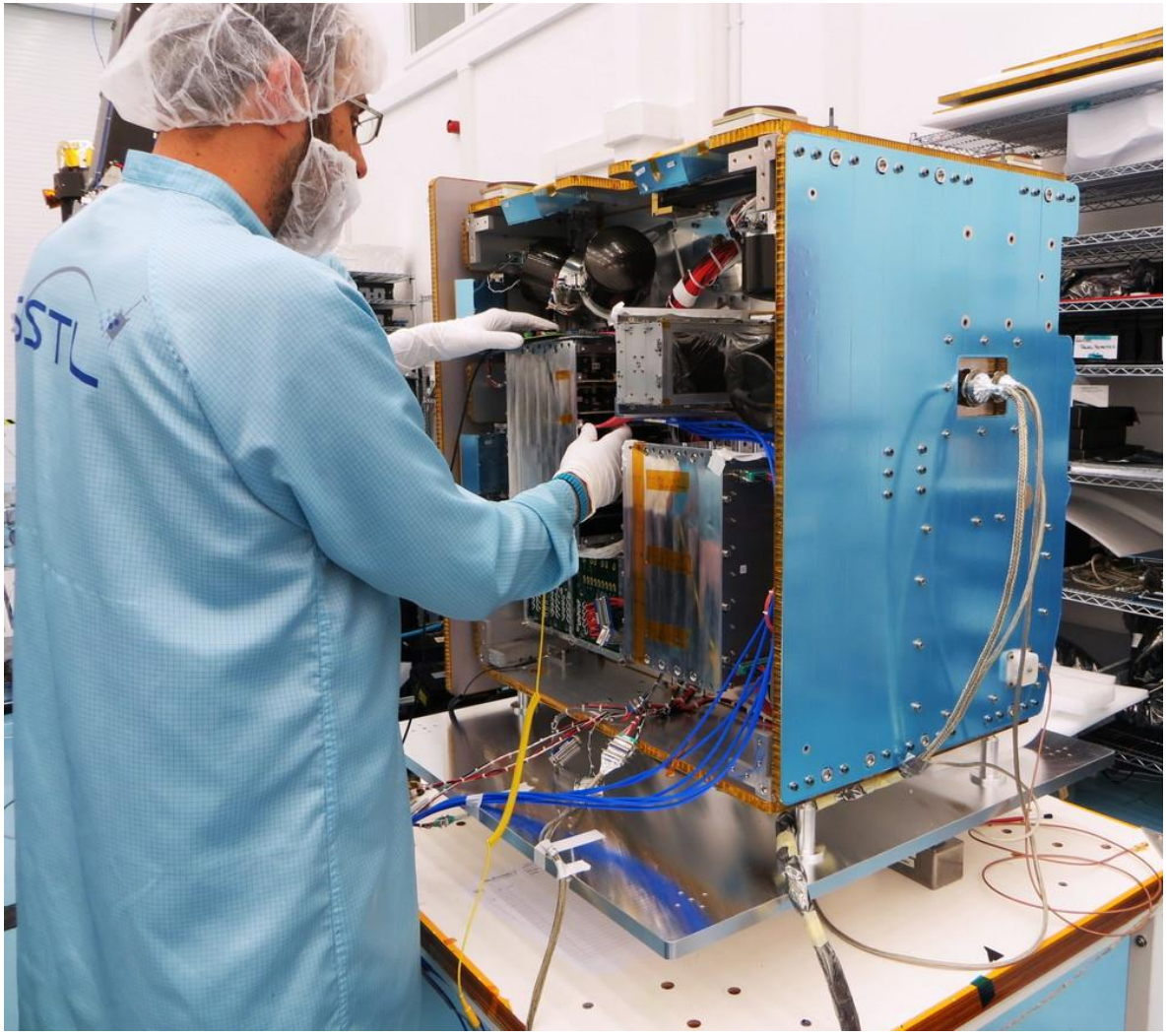


Credit: SSTL, 2017

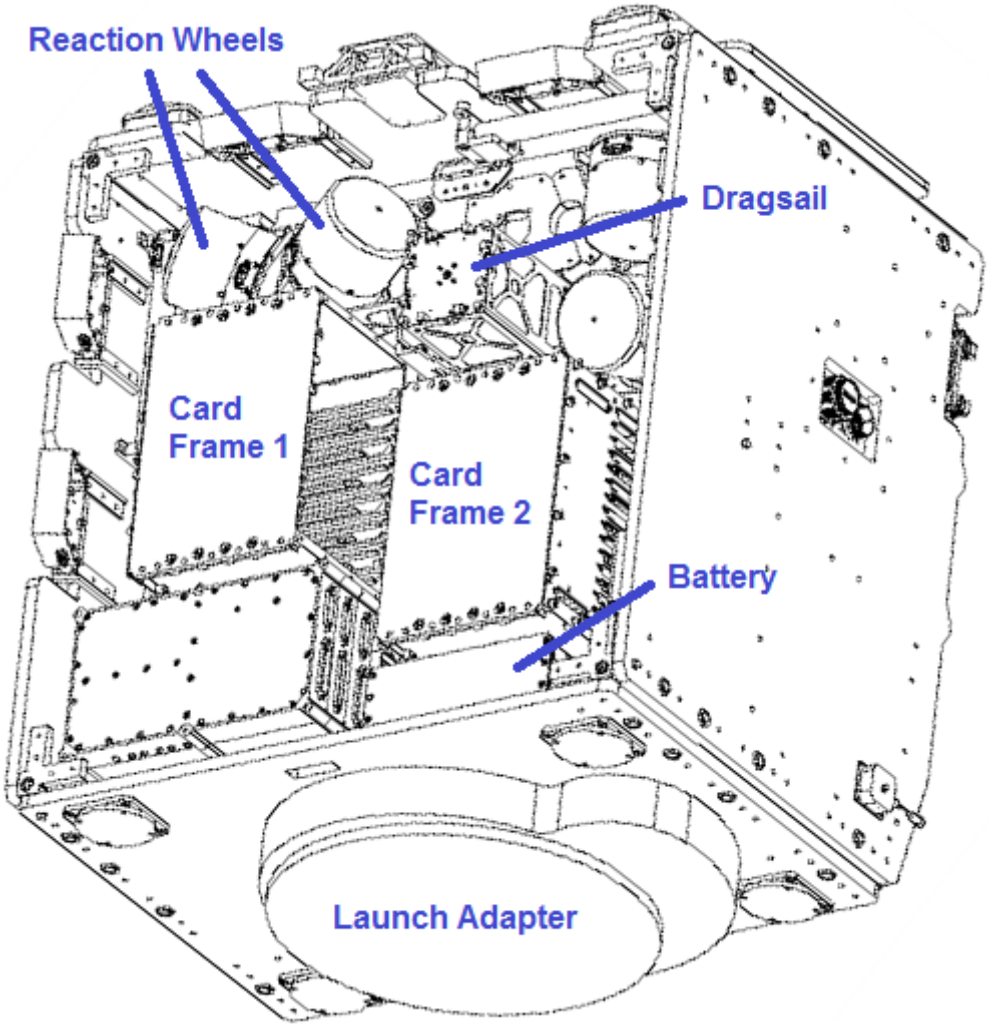


* HTA and VBN mass dummies

Configuration – Platform – II



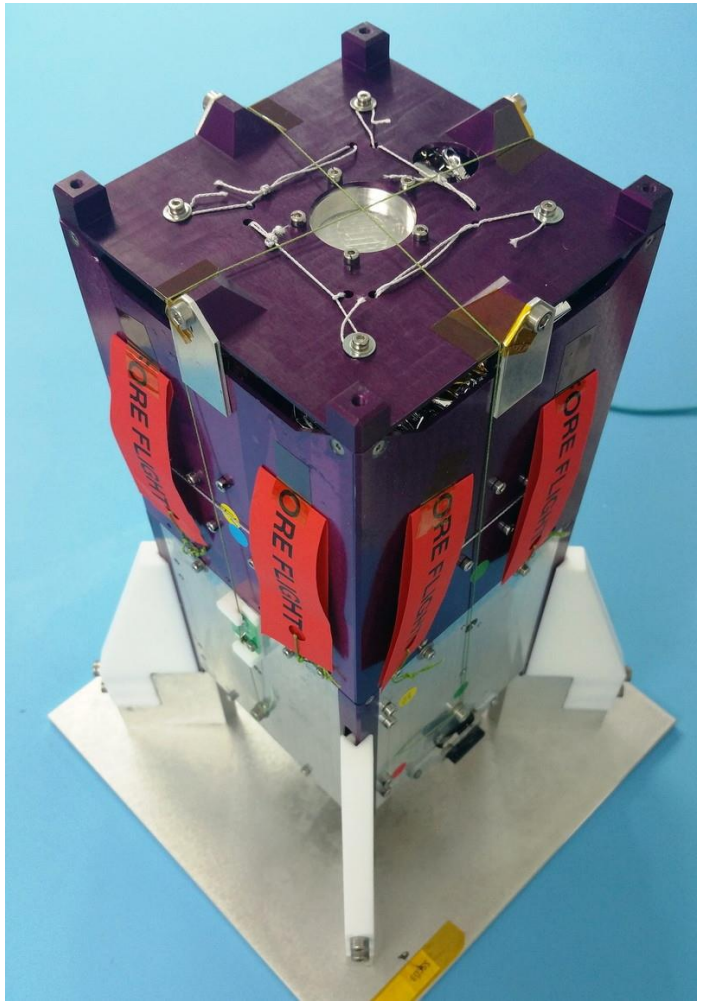
Credit: SSTL, 2017



Configuration – CubeSats

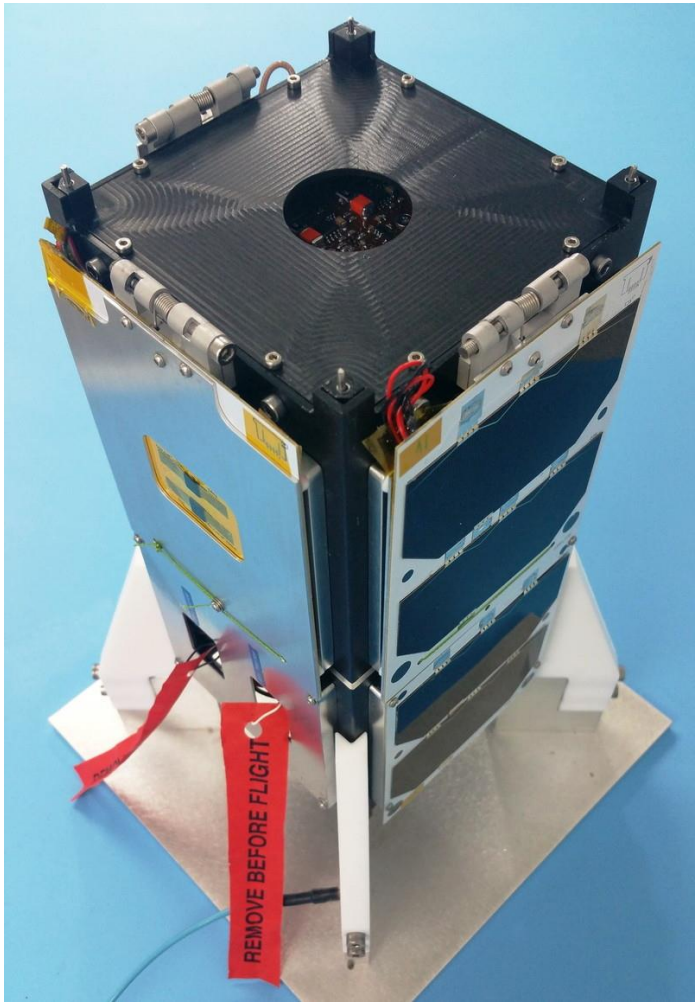
DS-1 and DS-2

- Final CubeSat FMs inserted into deployer FMs and inserted on to platform.



DS-1 (FM)

DS-1 (Final SEET Deployment)



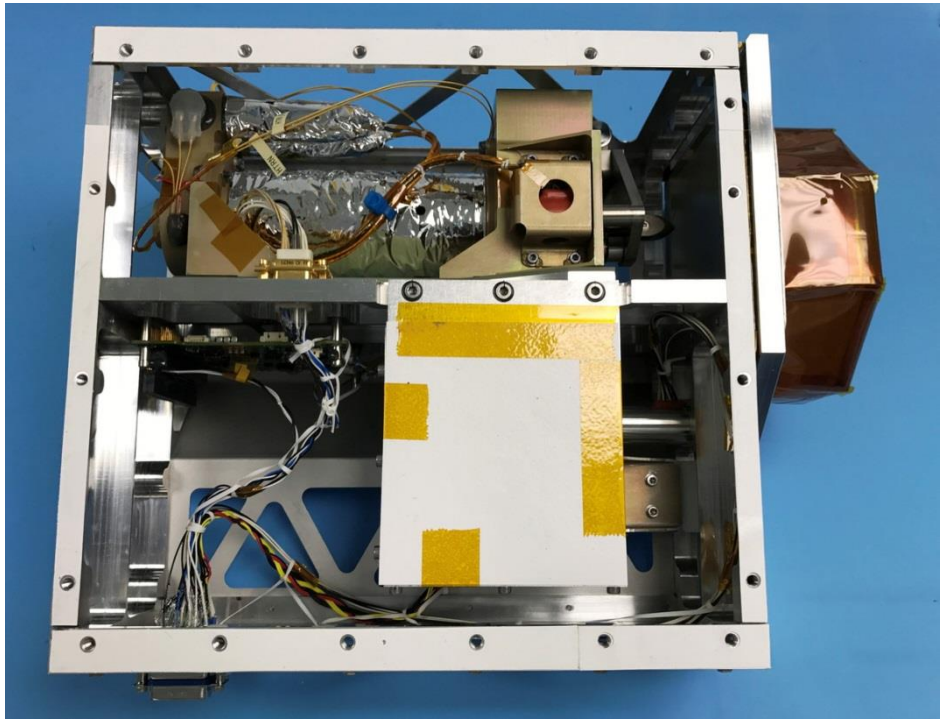
DS-2 (FM)

Configuration – Net, Harpoon

Net and Harpoon

- Harpoon FM underwent a final firing test and final deployment test.
- The HTA (Harpoon Target Assembly) consists of the FM structure (includes deployable boom, target, processing board, 2 x frangibolts) and FM Harpoon.

Net (FM)



HTA (FM)

HTA (Deployment Test)

Configuration –VBN, Dragsail

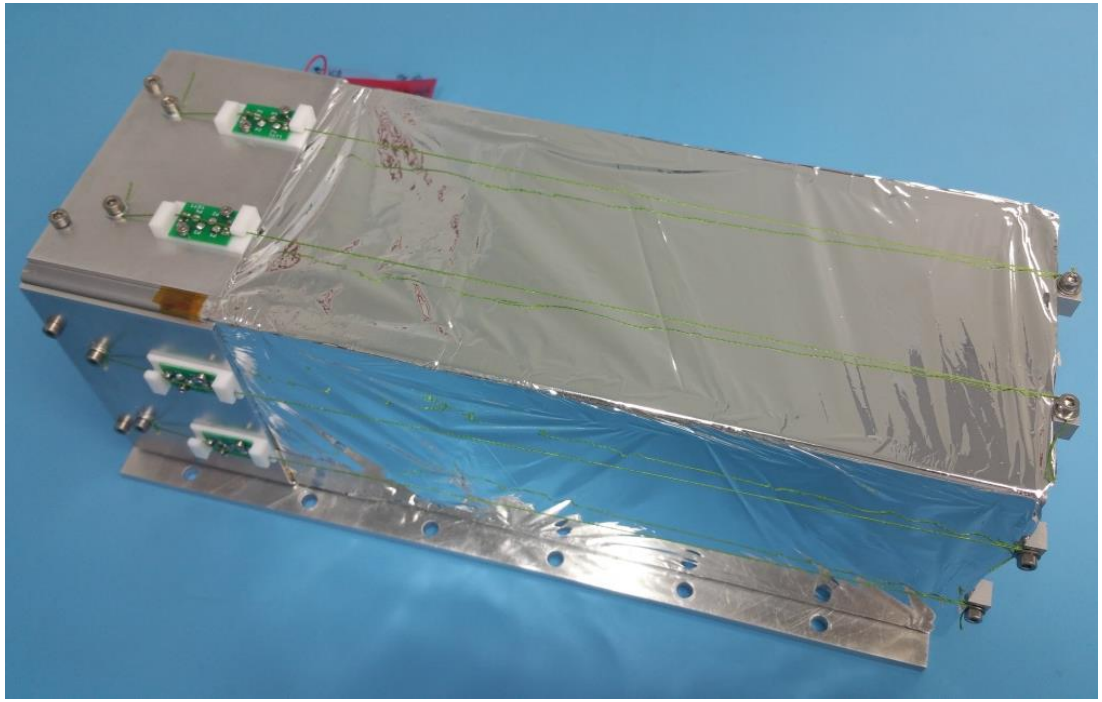
VBN

- FM completed with full SEET (data transfer and download).

Dragsail

- FM completed, integration into platform complete.

VBN (FM)

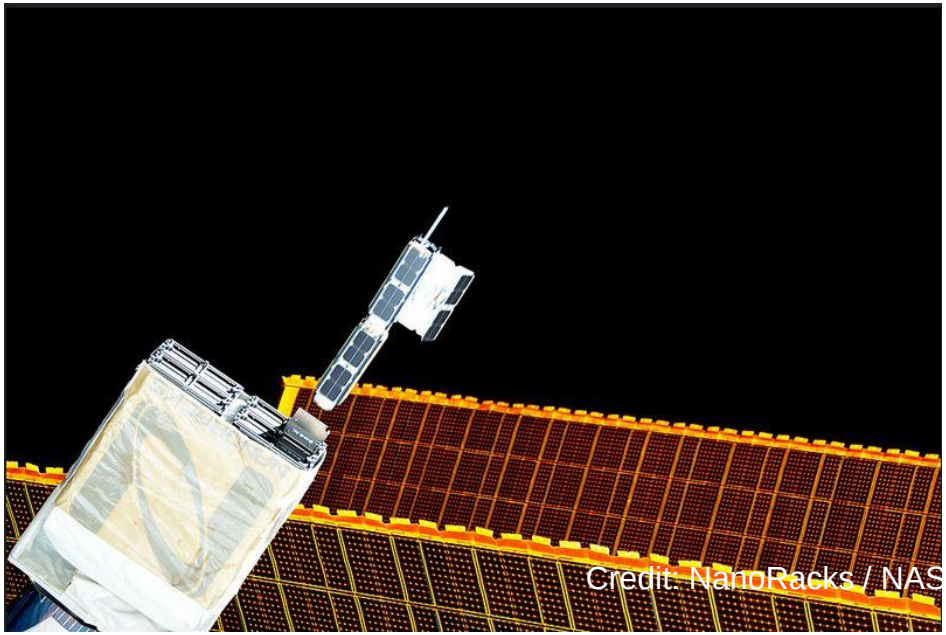


Dragsail (FM)

Launch Sequence – I

Launch Specification

- Launch agent: NanoRacks (US)
- Launching to: International Space Station (ISS)
- Supply vehicle: SpaceX Falcon 9 & Dragon capsule
- Launch pad: Space Launch Complex 40, Cape Canaveral Air Force Station
- Date: Q1 2018
- Orbital details: ~380 km orbit, 51.6 degrees inclination
- Satellite mass: ~100 kg



Launch Sequence – II

1

2

3

4

5

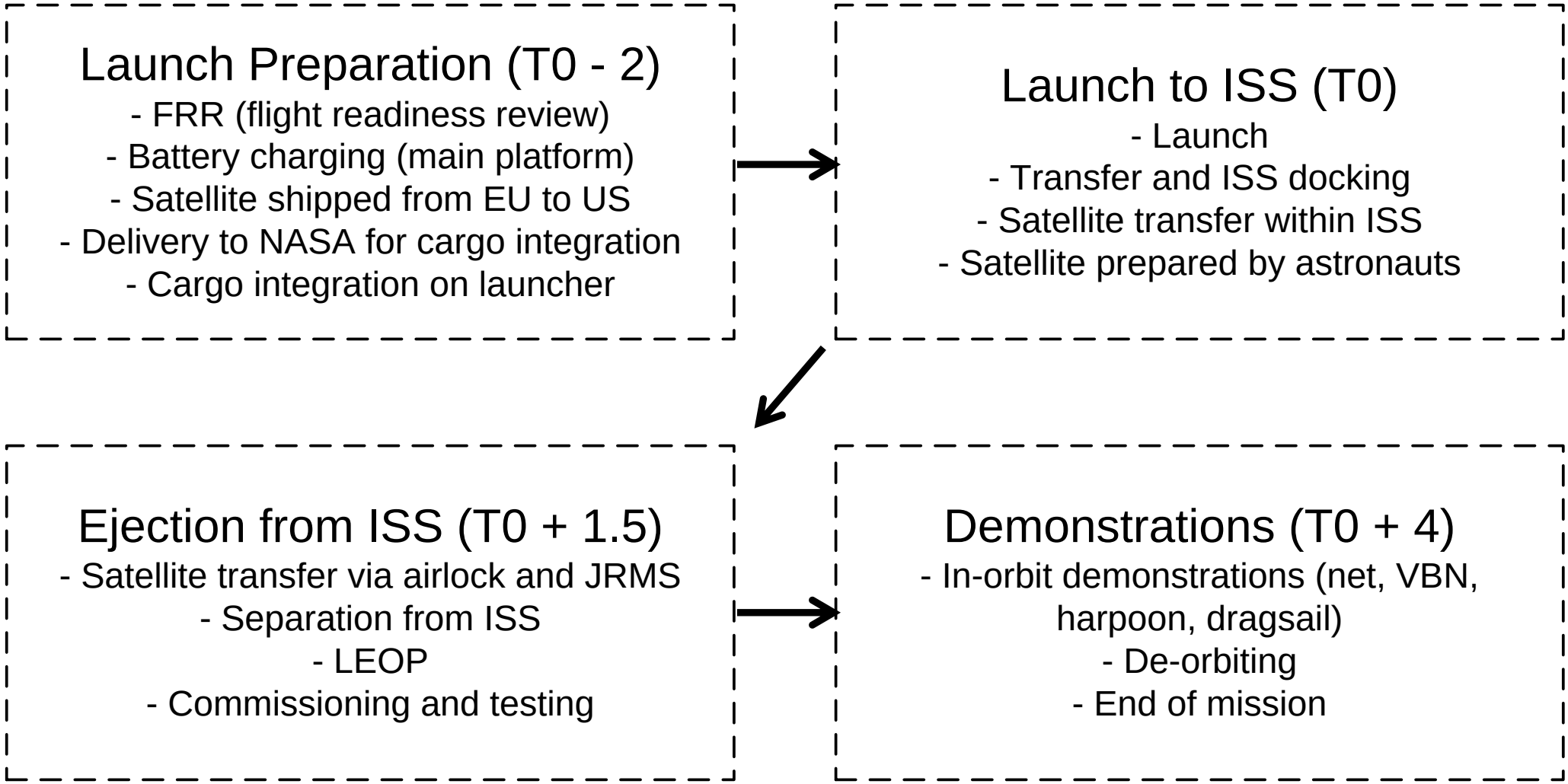
Launch Process

1. Platform is packaged into a crew or cargo transfer bag (CTB) within a "clam shell" which protects it.
2. After the bag is launched to the ISS, the bag is unpacked by astronauts and both clam shell and protective side panels are removed.
3. Astronauts install the platform on to the Japanese experiment module (JEM) air lock. The air lock then depresses and the slide table extends.
4. The platform is grappled by the JRMS, a robotic arm system.
5. The robotic arm positions and releases the platform into space, where commissioning and main operations of the mission can commence.

Launch sequence credits: NanoRacks / NASA / SpaceX

High Level Mission Timing

Time in Months

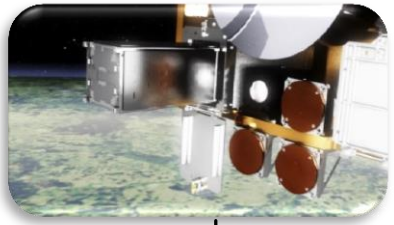


Net Demonstration Sequence

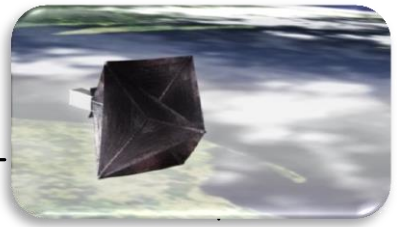
Demo Opening
- Query platform status and whether to start experiment (T0 - 42 hr)
- Start charging DS-1 and net capacitors
- Point platform to nadir
- Turn on platform services (2 x PIUs, 3 x supervision cameras, 2 x VBN cameras) (T0 - 21 hr)

VBN Test Phase
- Record images from VBN, transfer to PIU and download to Earth (T0 - 18 hr)
- Ensure good images and fully charged devices
- Upload camera parameters (T0 - 6 hr)

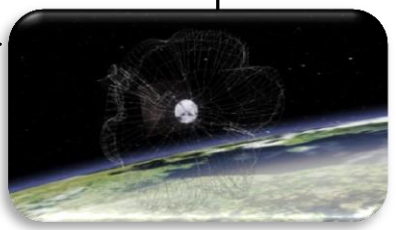
CubeSat Ejection
- Point platform to start attitude (T0 - 1 hr)
- Start cameras & VBN recording (T0 - 5 s)
- Activate ISIPOD and net timer (T0)
- CRS cuts, releases DS-1 (T0 + 65 s)



Net Ejection
- DS-1 inflatable deploys (T0 + 100 s)
- Net switches 1 and 2 activate (T0 + 191 s)
- Platform AOCS activated for attitude disturbance (T0 + 192 s)



Demo Closing
- Stop supervision cameras & VBN recording (T0 + 400 s)
- Terminate net devices (T0 + 500 s)
- Transfer VBN data to PIU and download to Earth (T0 + 3 days)
- End demonstration (T0 + 20 days)



Conclusions – I

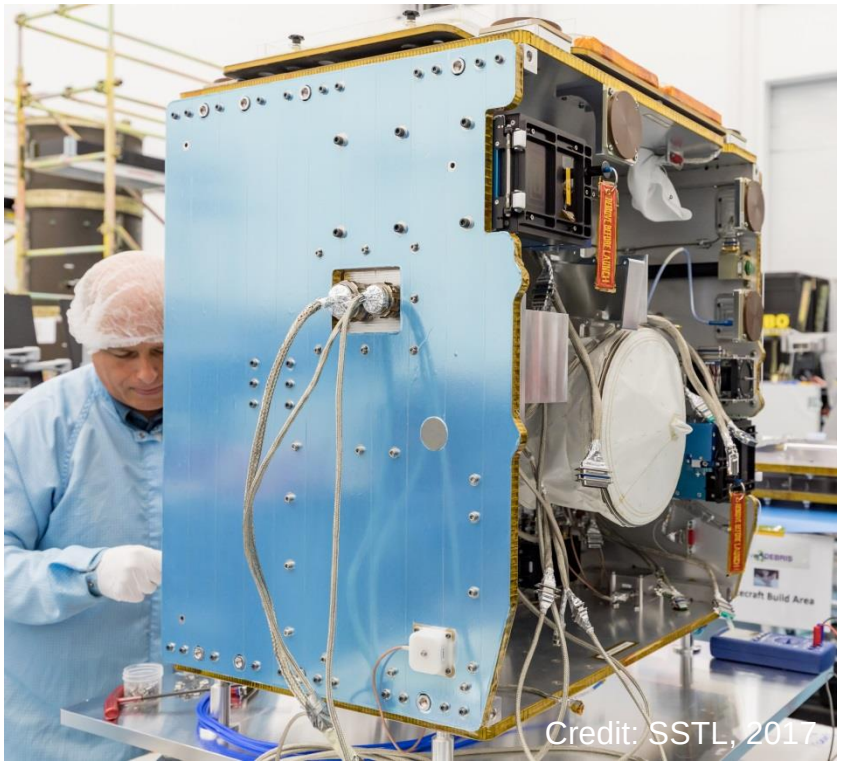
Progress

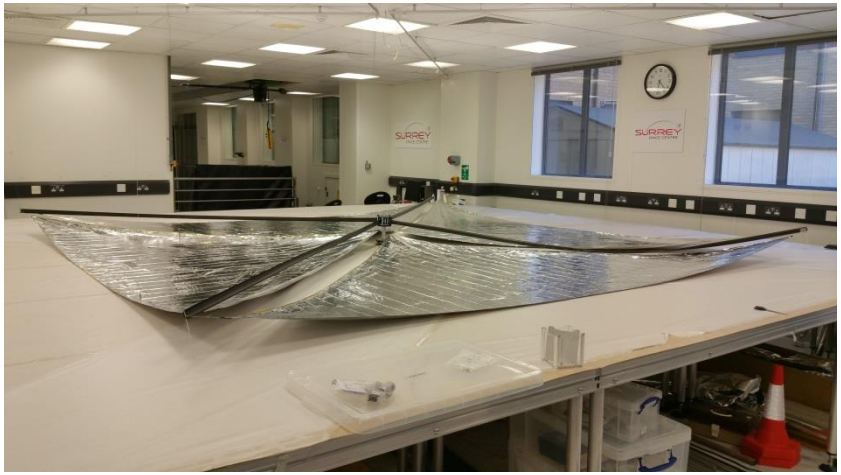
- Presentation (and corresponding paper) has examined the final mission configuration, the mission timing and payload demonstration sequences as part of the operations planning.
- Early next year mission to launch.

Novelty

A low cost mission to demonstrate, de-risk and mature key ADR in-orbit technologies, aiming to be:

- One of the world's first Active Debris Removal in-orbit demonstration missions.
- The first use of a harpoon or net in space for debris capture.
- The first 100 kg satellite to be launched from the ISS.
- The first use of CubeSats as "artificial debris".





Conclusions – II

Publications (last 2 years)

- Forshaw, J. L., Aglietti, G., Salmon, T., Retat, I., Hall, A., Chabot, T., Pisseloup, A., Tye, D., Bernal, C., Chaumette, F., Pollini, A. and Steyn, W. H. (2017), "The RemoveDebris ADR Mission: Launch from the ISS, Operations and Experimental Timelines", 68th **IAC**, Adelaide, Australia.

- Forshaw, J. L., Aglietti, G., Salmon, T., Retat, I., Roe, M., Burgess, C., Chabot, T., Pisseloup, A., Phipps, A., Bernal, C., Chaumette, F., Pollini, A. and Steyn, W. H. (2017), "Review of Final Payload Test Results for the RemoveDebris Active Debris Removal Mission", **Acta Astronautica**, doi:10.1016/j.actaastro.2017.06.003.

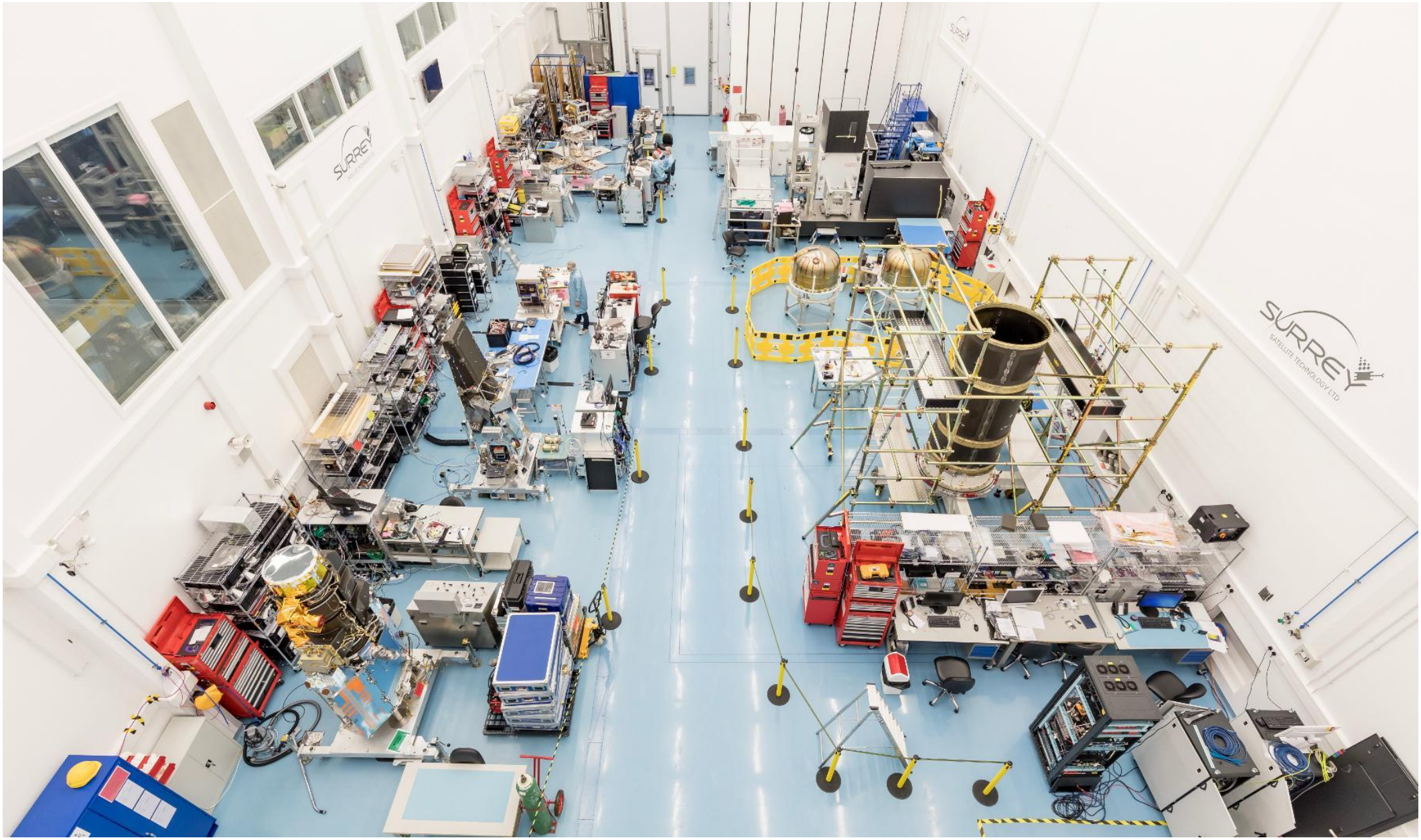
- Forshaw, J. L., Aglietti, G. S., Salmon, T., Retat, I., Burgess, C. , Chabot, T., Pisseloup, A., Phipps, A., Bernal, C., Chaumette, F., Pollini, A. and Steyn, W. H (2017), "The RemoveDebris ADR Mission: Preparing for an International Space Station Launch", *7th European Conference on Space Debris*, **ESA ESOC**, Germany.

- Massimiani, C., Forshaw, J. L., Aglietti, G. (2016), "CubeSats as Artificial Debris Targets for Active Debris Removal Missions", Final Stardust Conference, **ESA ESTEC**, Nordwijk, Netherlands.

- Forshaw, J. L. (2016), "The RemoveDebris ADR Mission: Overview of CubeSat "Artificial Debris" Targets", **CNES** 4th European Workshop on Space Debris Modeling and Remediation, Paris, France.

- Forshaw, J. L. (2016), "RemoveDEBRIS: An EU Low Cost Demonstration Mission to Test ADR Technologies", ESA **Clean Space Industrial Days**, **ESA ESTEC**, Nordwijk, Netherlands

Questions?



Credit: SSTL AIT Hall, LinkedIn, 2017