SURREY
CHANGING THE ECONOMICS OF SPACE

How CEOI funded work is supporting DarkCarb

An innovative approach to infrared imaging

CEOI Emerging Technologies Challenge Workshop

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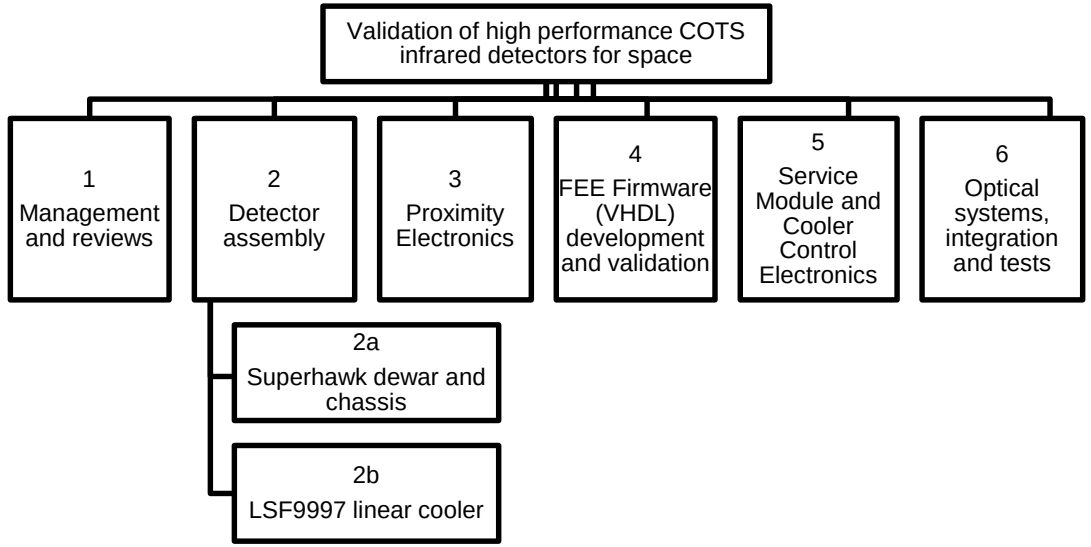
21st April 2021

CEOI project overview

Validation of High Performance COTS Infrared Detectors for High Spatial Resolution Imagery from LEO Constellations

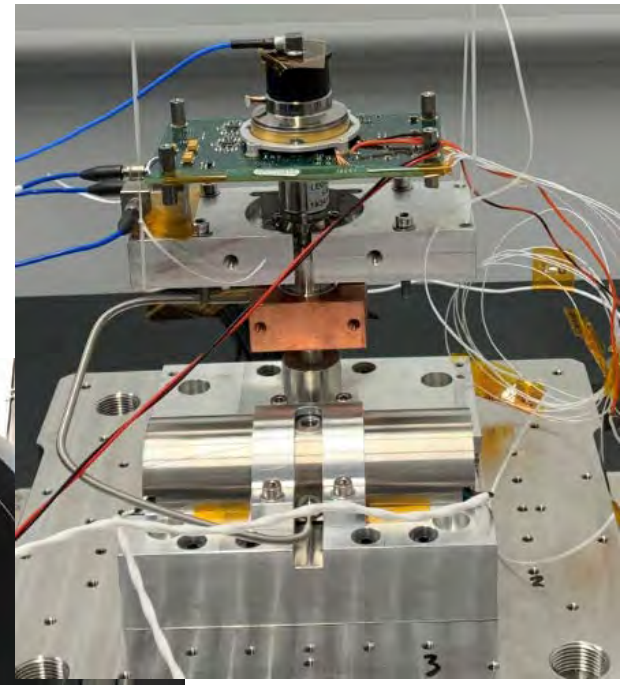
- **Project's objective:** Validate the use of high performance COTS infrared detectors for high spatial resolution imagery from LEO constellations. The collaboration will allow the two organisations to jointly exploit their existing capabilities with the aim of developing world-leading UK infrared EO technologies. This will form the basis of a working relationship for future operational and commercial space missions.

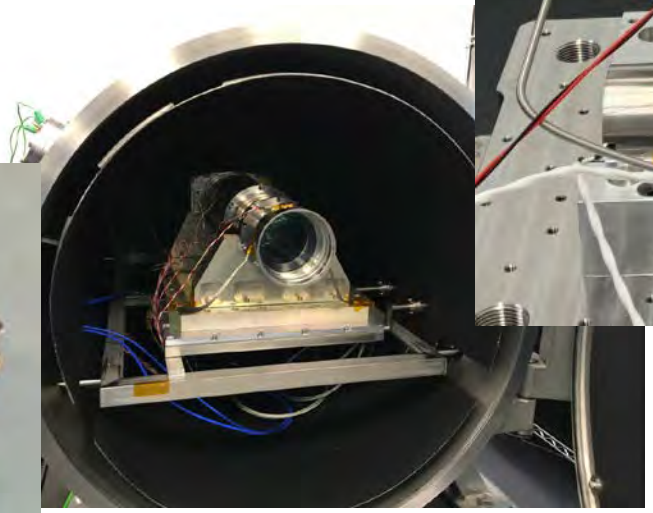
- ✓ Smallest pixel in the world
- ✓ One of the largest size detector available
- ✓ High thermal sensitivity

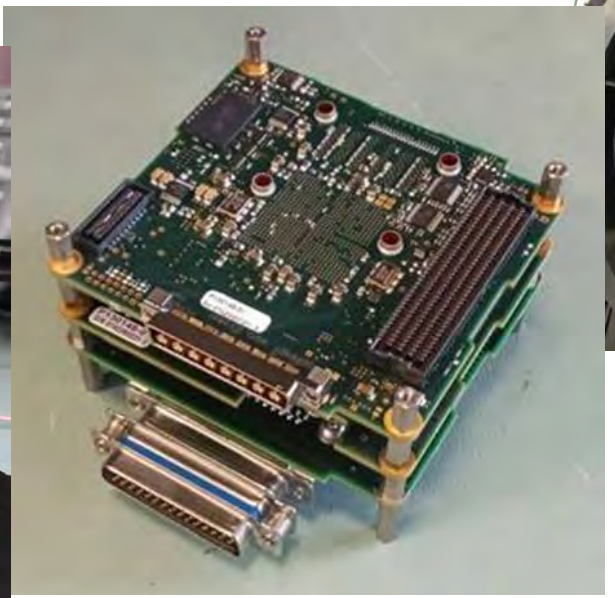


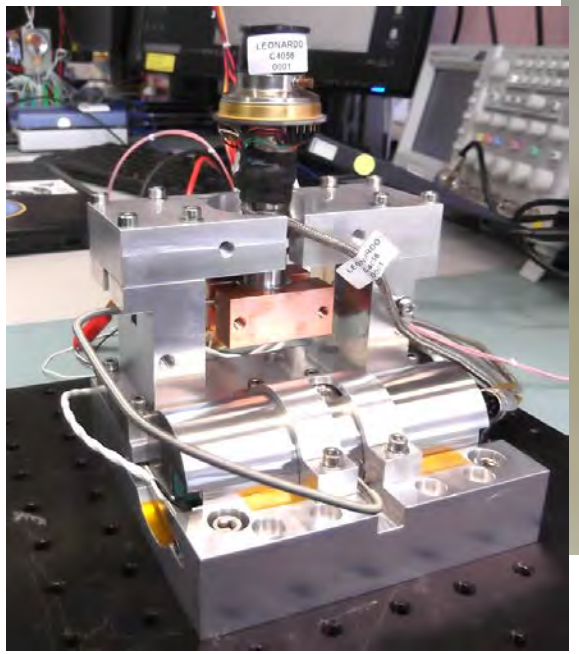
CEOI project overview

- The proximity electronics have been successfully redesigned to SSTLs design standards and show good noise performance
- TVT and vibration testing has shown the designs are suitable for use as intended
- Micro vibration performance testing on the cooler has yielded useful results to feed into the mission design



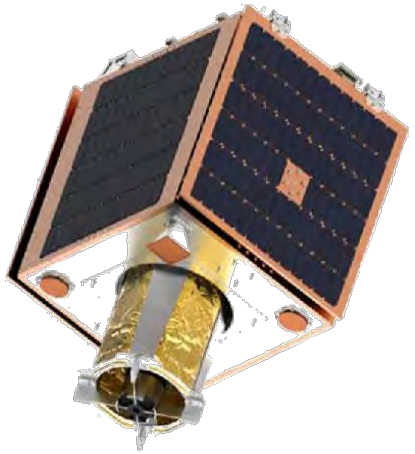






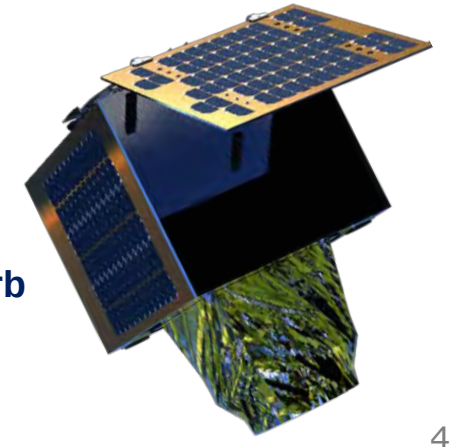
Darkcarb Overview

- Dark Carb objective: provide low-cost high-resolution IR videos
  - ➔ Demonstrator mission, follow up to Carb-2's success
  - ➔ Small, agile platform with high revisit times
  - ➔ Low-cost, short schedule model for large constellations



Carbonite-1

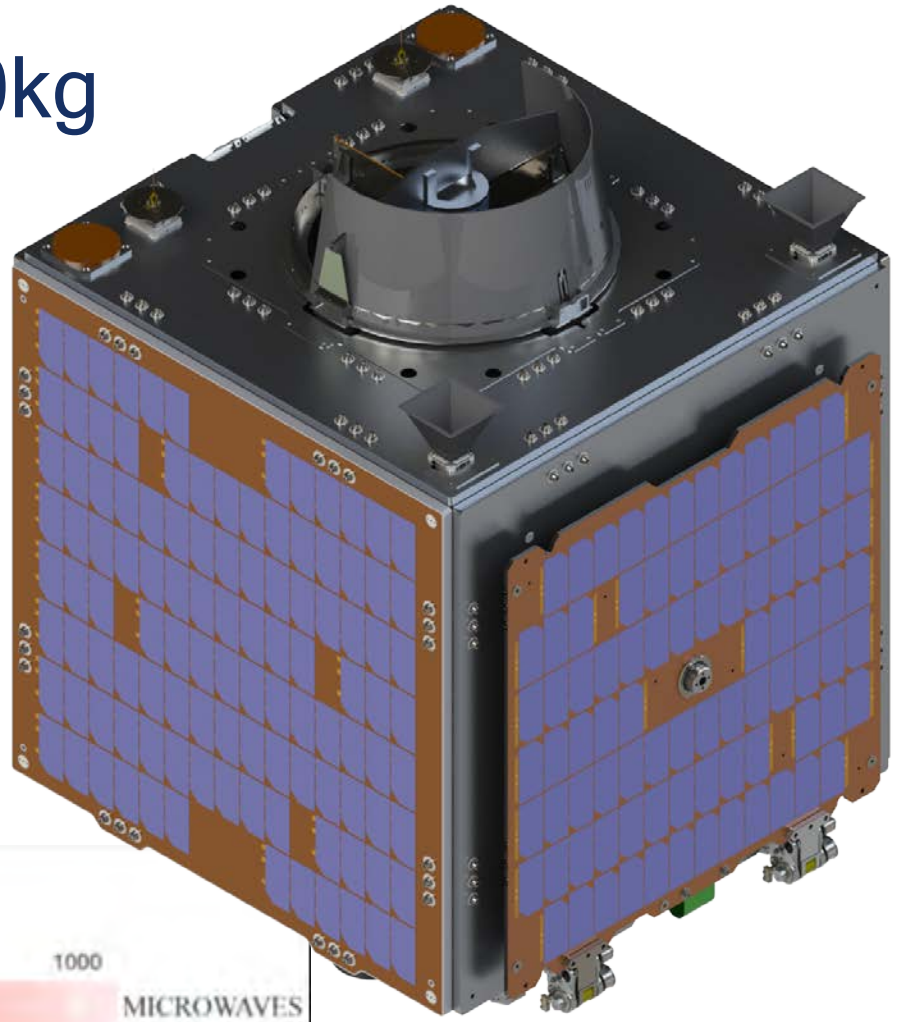
Carbonite-2

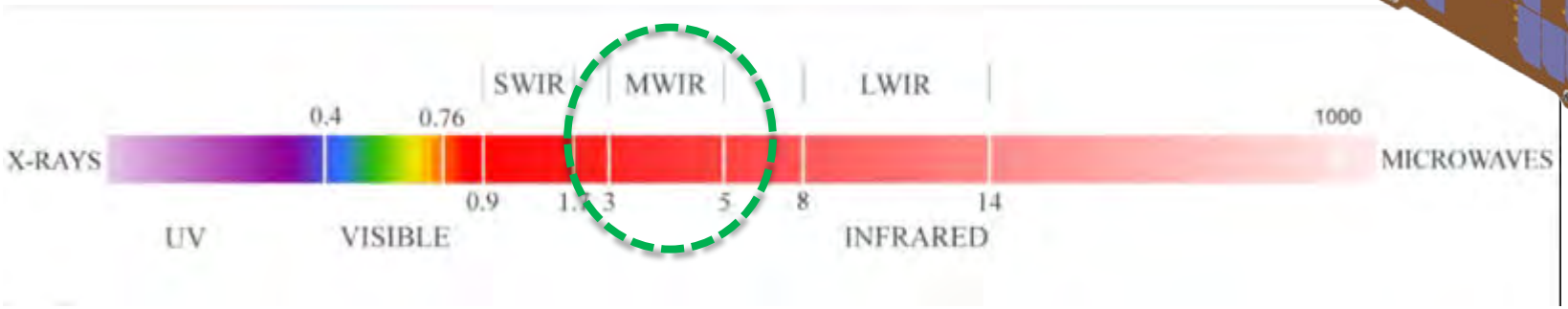


Dark Carb

DarkCarb overview

- Carbonite class spacecraft ~120kg
- ~ 760*760*920mm
- Cooled Thermal MWIR
- 3.5m GSD
- Day and night imaging
- Video and Stills



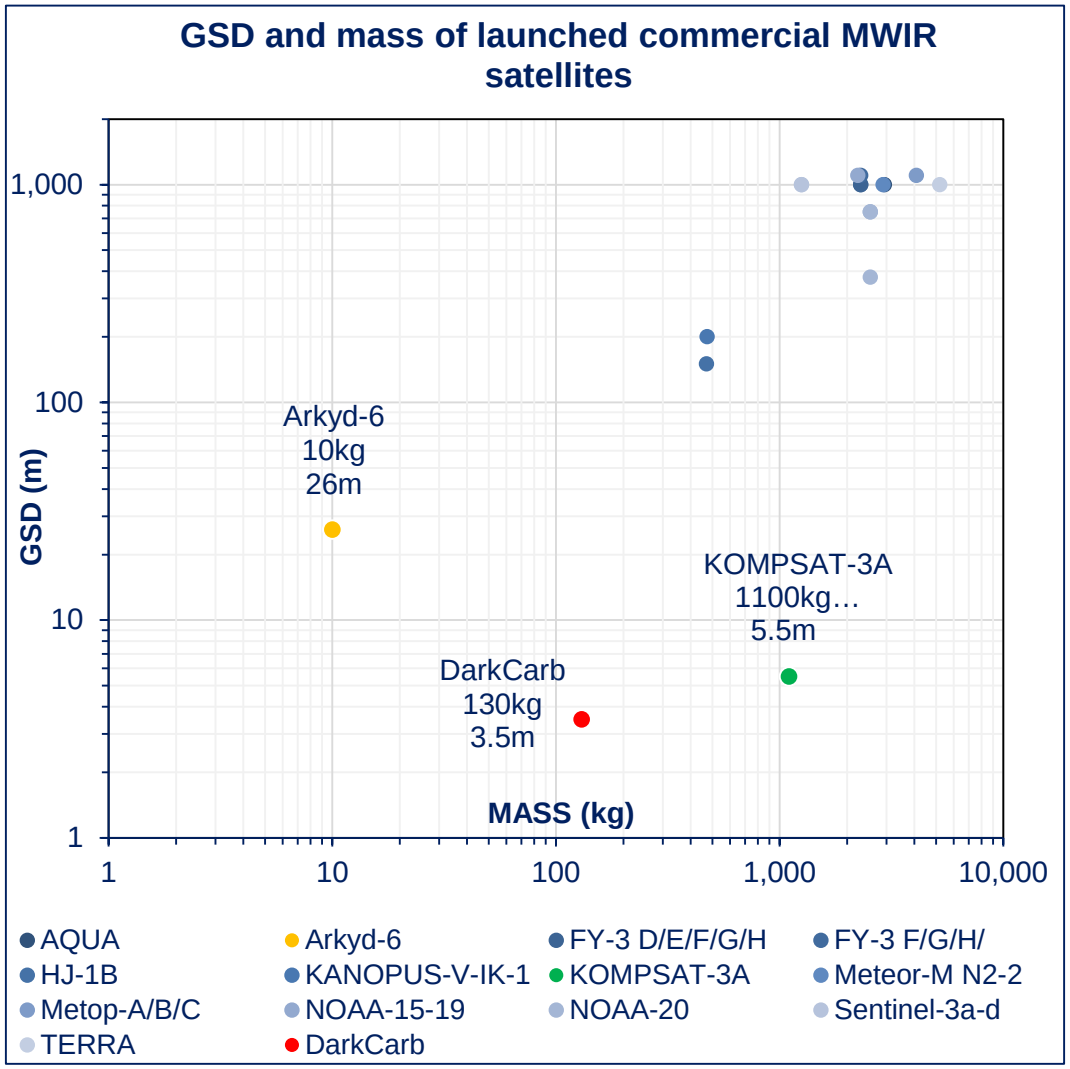


Applications

- Industrial monitoring
  - Operation of industrial installations
- Disaster response support
  - Monitoring of fires, volcanoes, etc.
- Environmental monitoring
  - Mapping of heat islands in urban areas
  - Hot liquids (pollution)
- Defence and security
  - Monitoring of large vehicles, aircraft, ships, etc.
  - Change detection during night time
  - Cost-effective production of quantitative data for surveillance

Dark Carb trade-off (1/2)

- Dark Carb thermal imager is targeting a high 3.5m GSD within a low-cost, low-mass satellite



KOMPSAT-3 MWIR image at 5.5m GSD

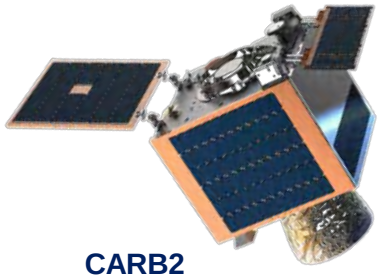
*Courtesy Korea Aerospace Research Institute, JACIE 2016

Dark Carb trade-off (2/2)

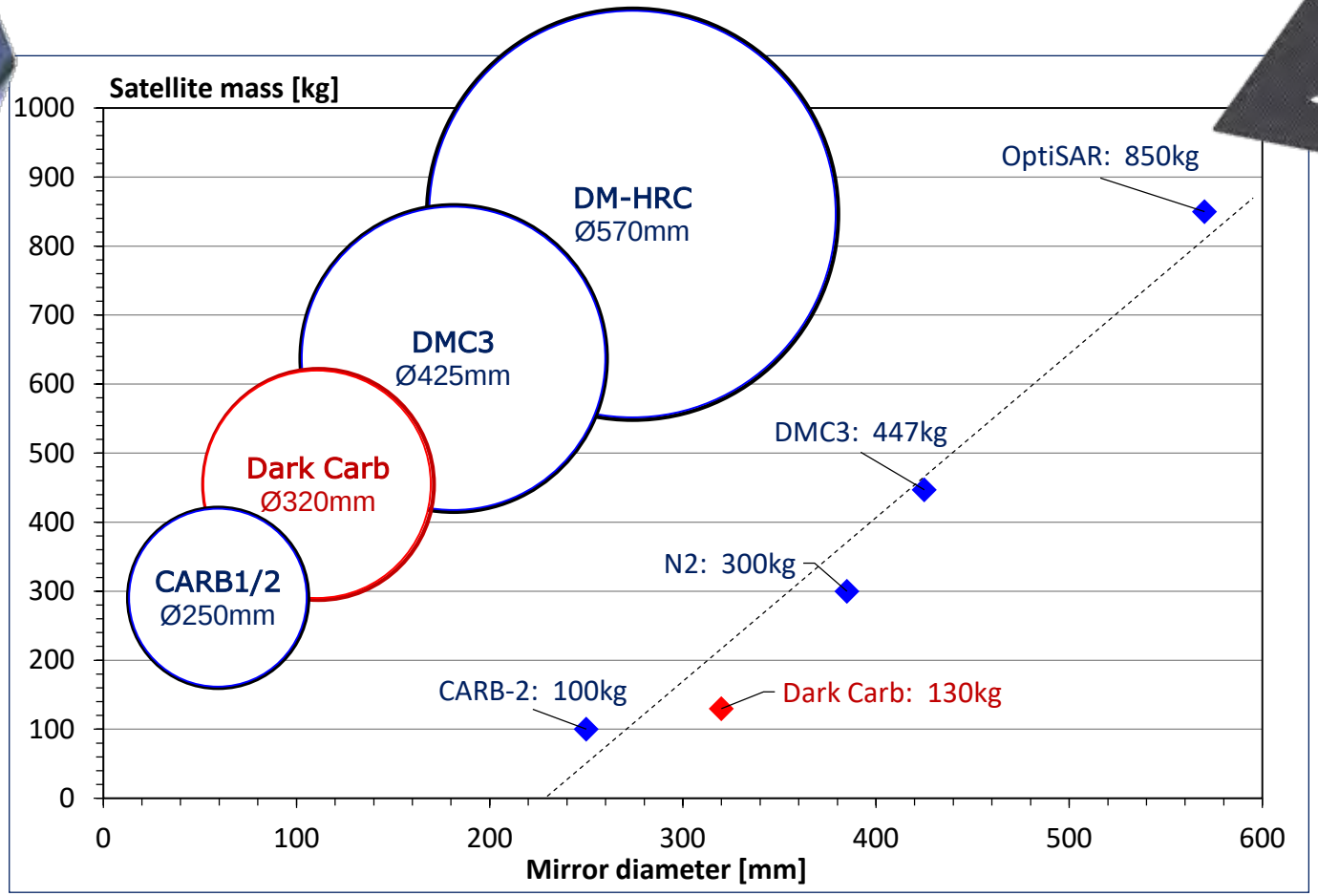
- In order to design a low-cost small satellite mission, the imager aperture has to be limited

➔ **Ø320mm primary mirror was selected as the best compromise**

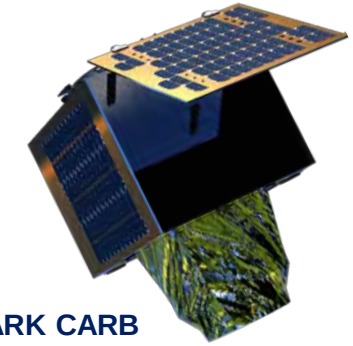
DMC3
447kg – Ø425mm



CARB2
100kg – Ø250mm

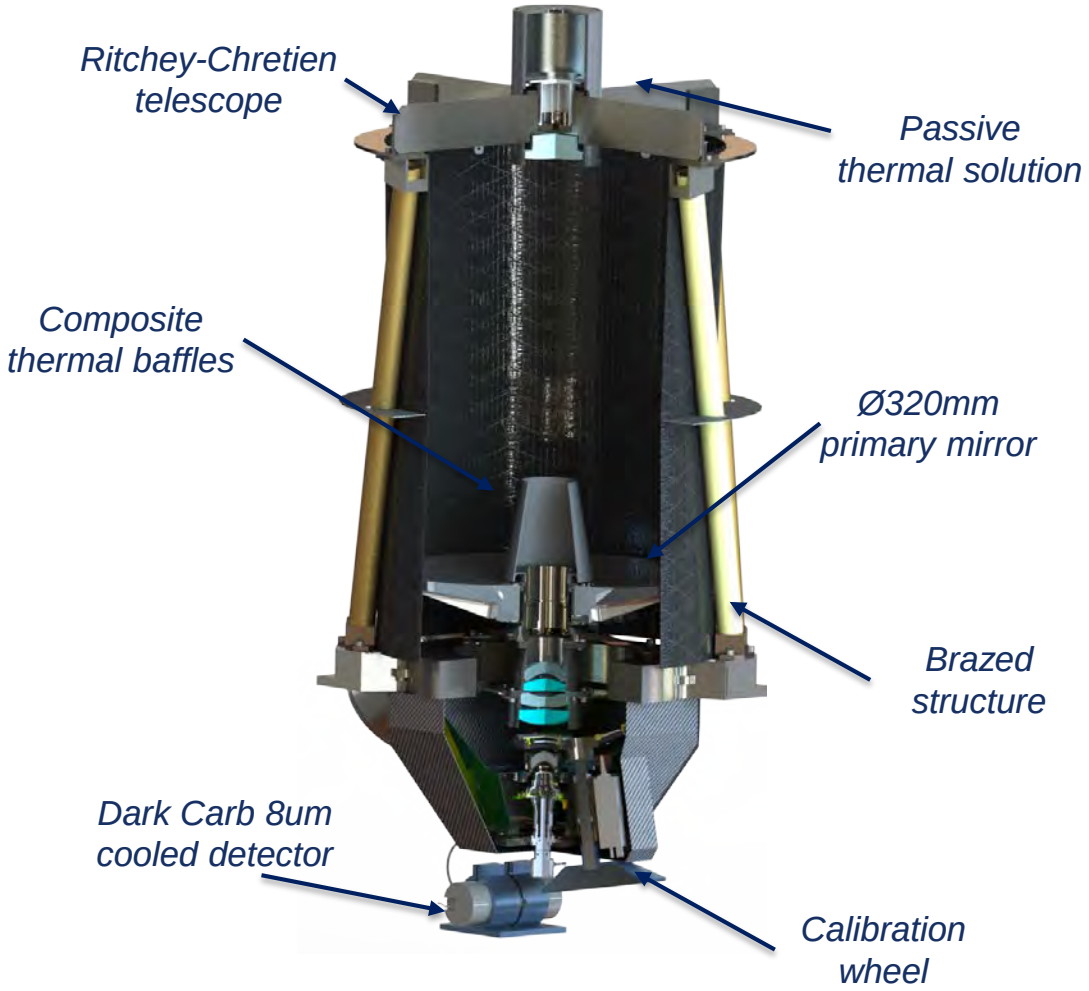


OptiSAR
850kg – Ø570mm



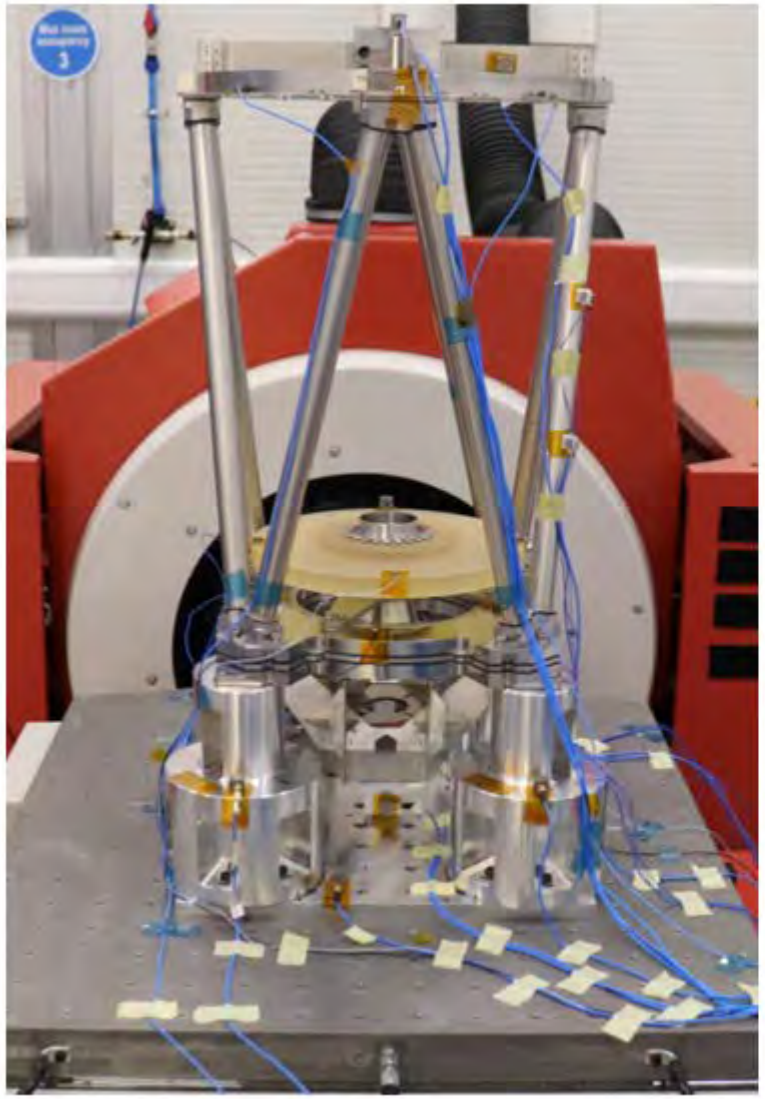
DARK CARB
130kg – Ø320mm

Dark Carb imager key facts



Parameter	Value
Waveband	Mid-wave infrared (3.7 - 5.0 µm)
GSD	3.5 m ±0.1m
Swath	3.6 x 4.4 km (FOV = 0.68°)
Video	60s per target = 3.4GB 1 to 25 FPS at 14bits
Thermal sensitivity	ΔT <2K @300K
Imager resolution	On-axis MTF (optics + detector) @half Nyquist >20%
Mass	30kg (inc. all electronics and thermal)
Power	16W (average) and 50W (peak)

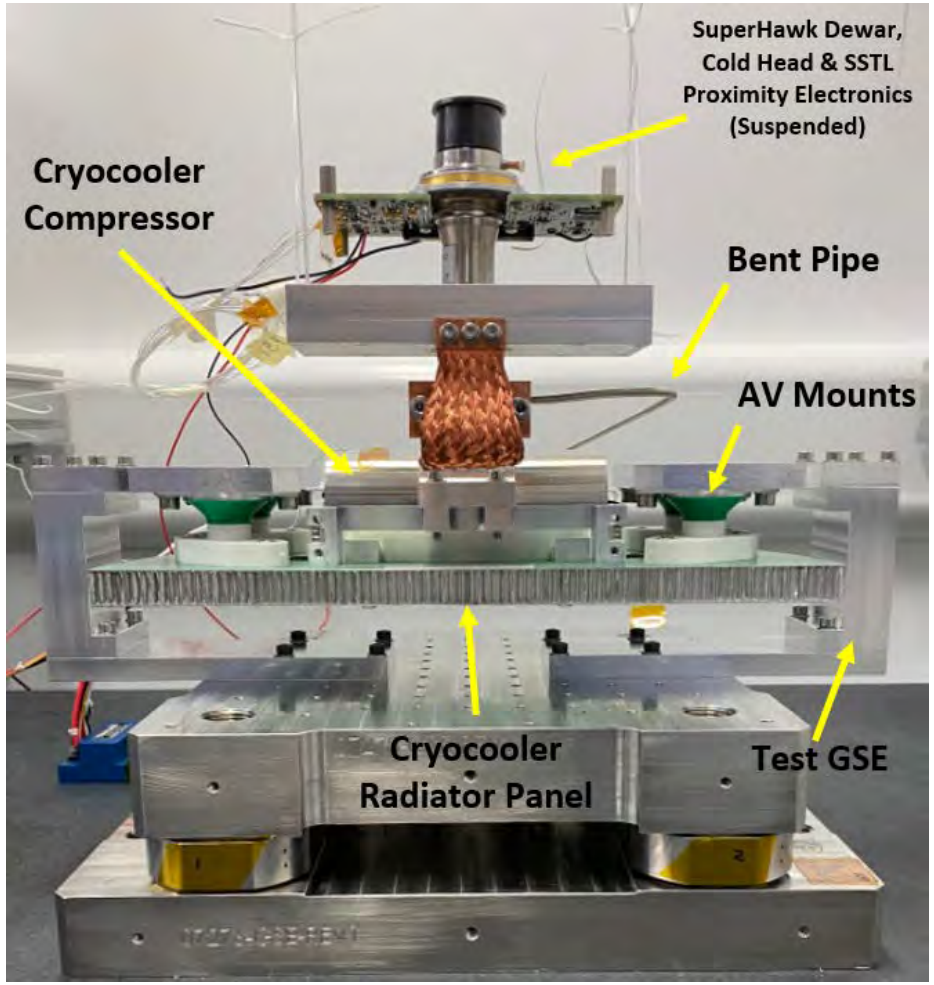
The development continues



Vibration

Telescope structure

The development continues

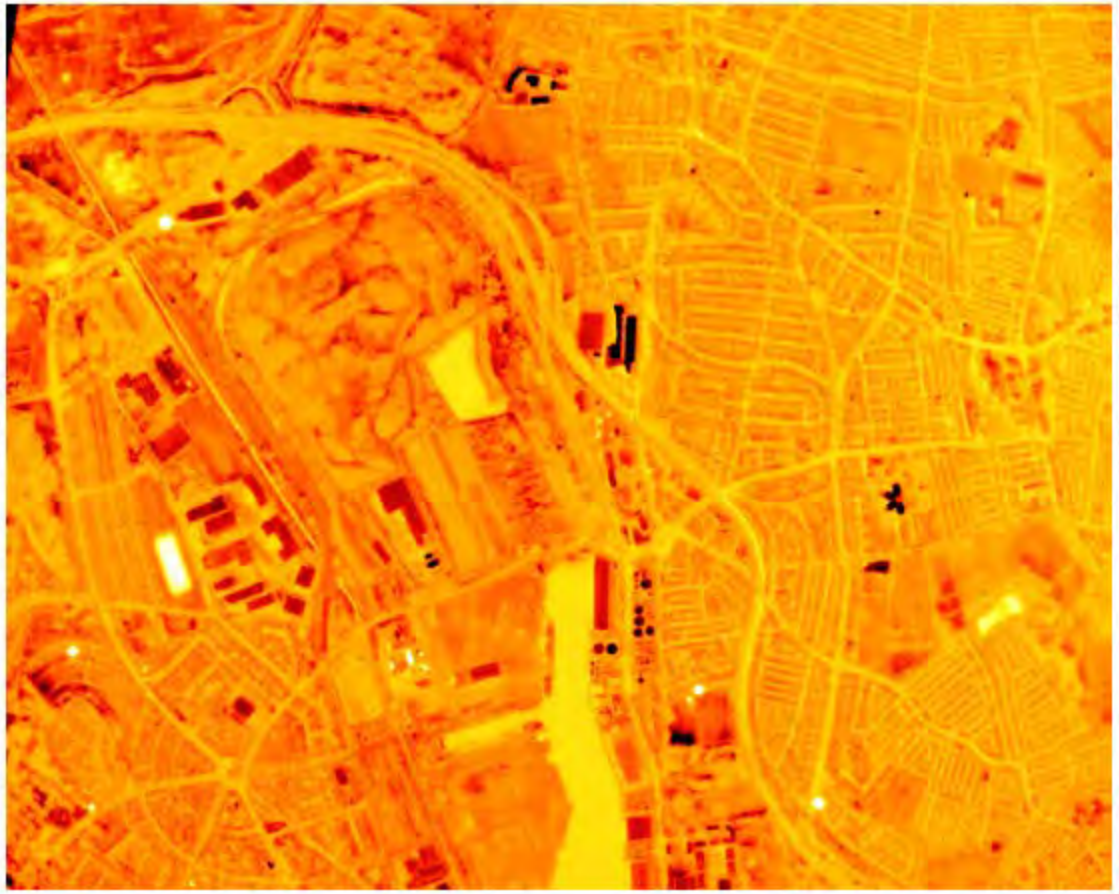


Cooler micro vibration testing

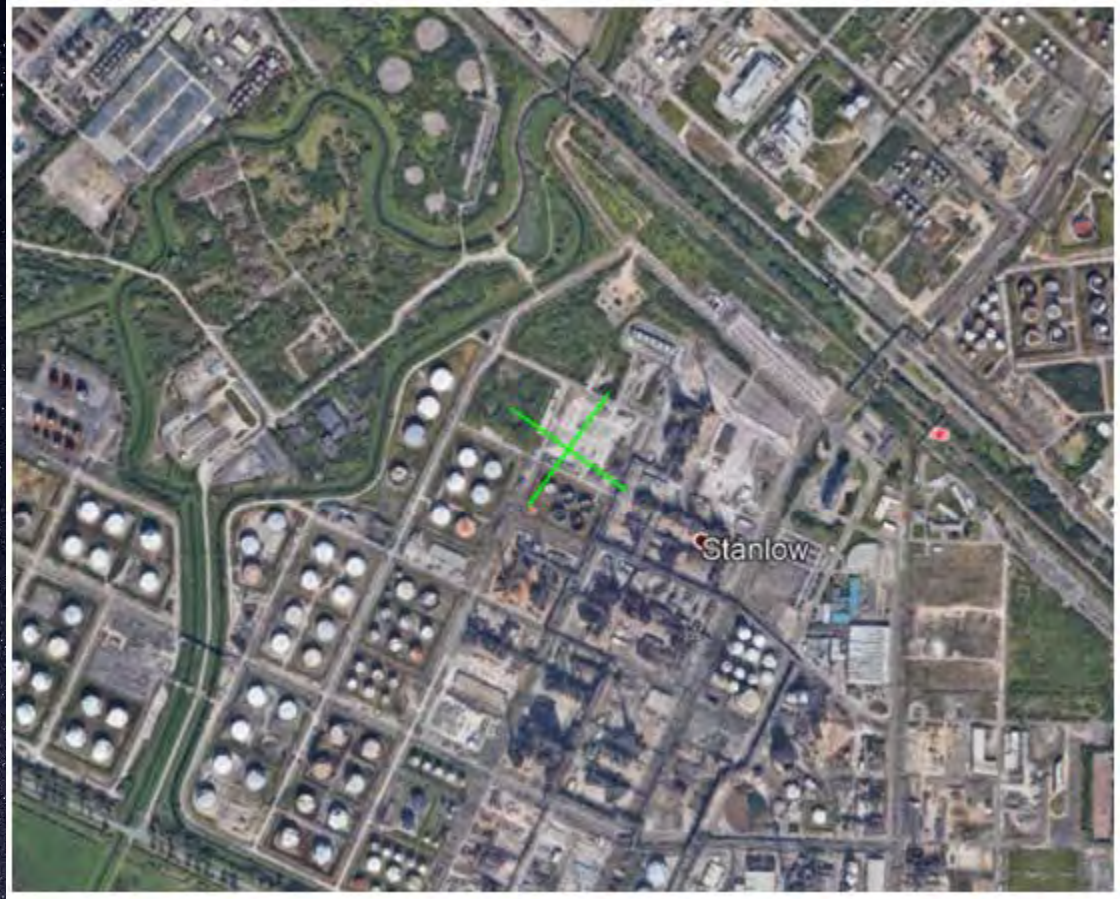
Calibration mechanism

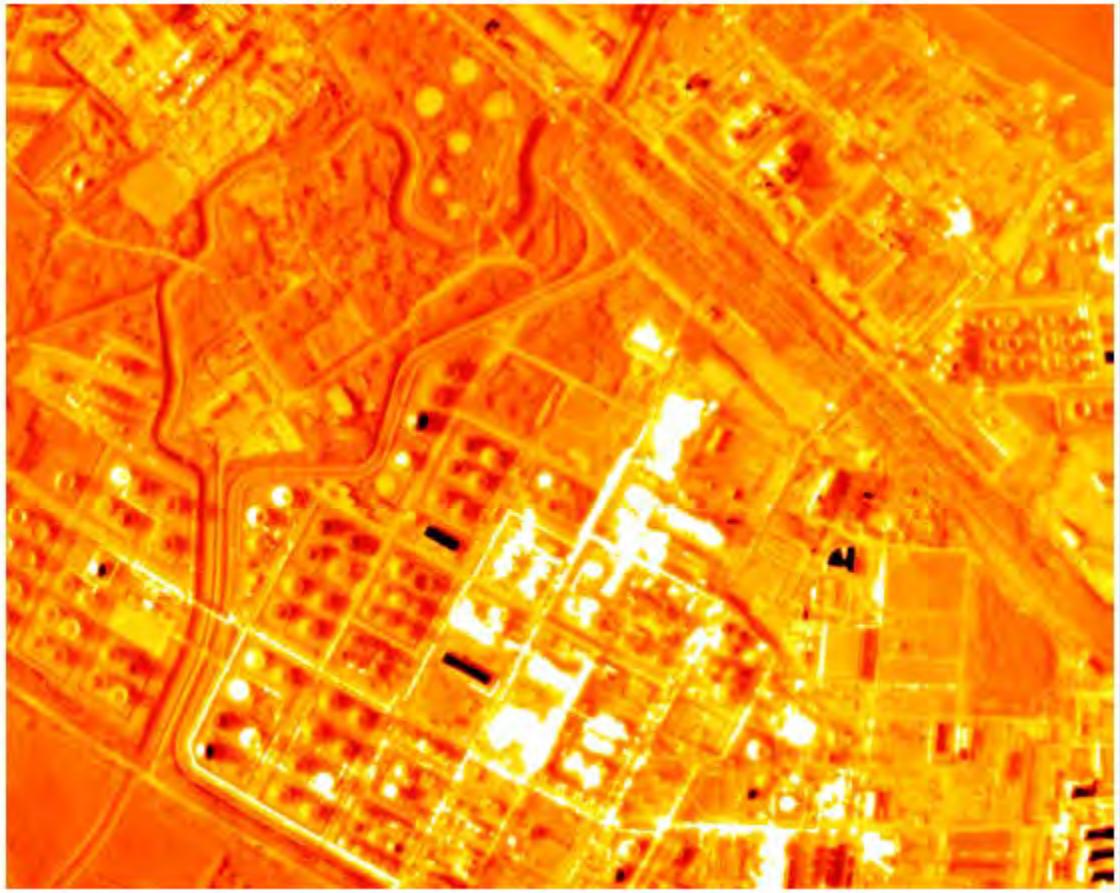
Airborne Trials

Flight 2 – 20:22, 8000ft

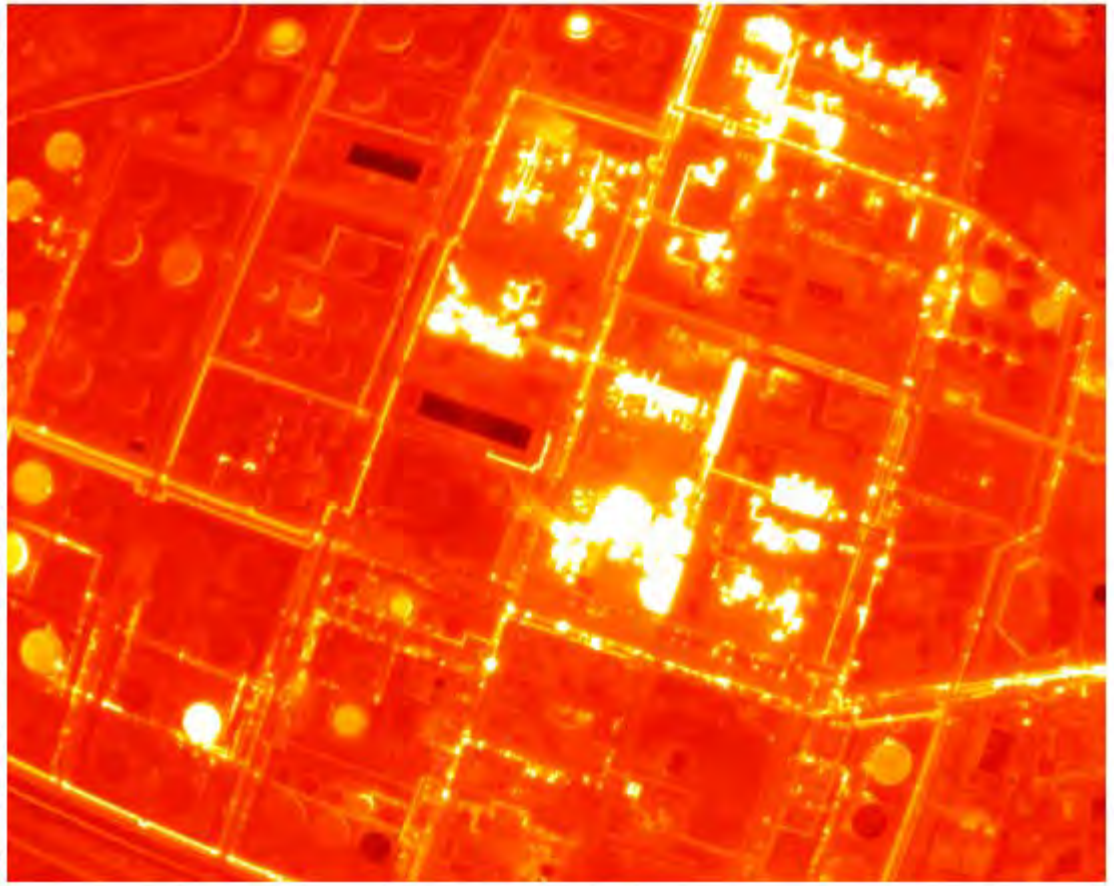


Flight 1 – Day 16:14, 8000ft



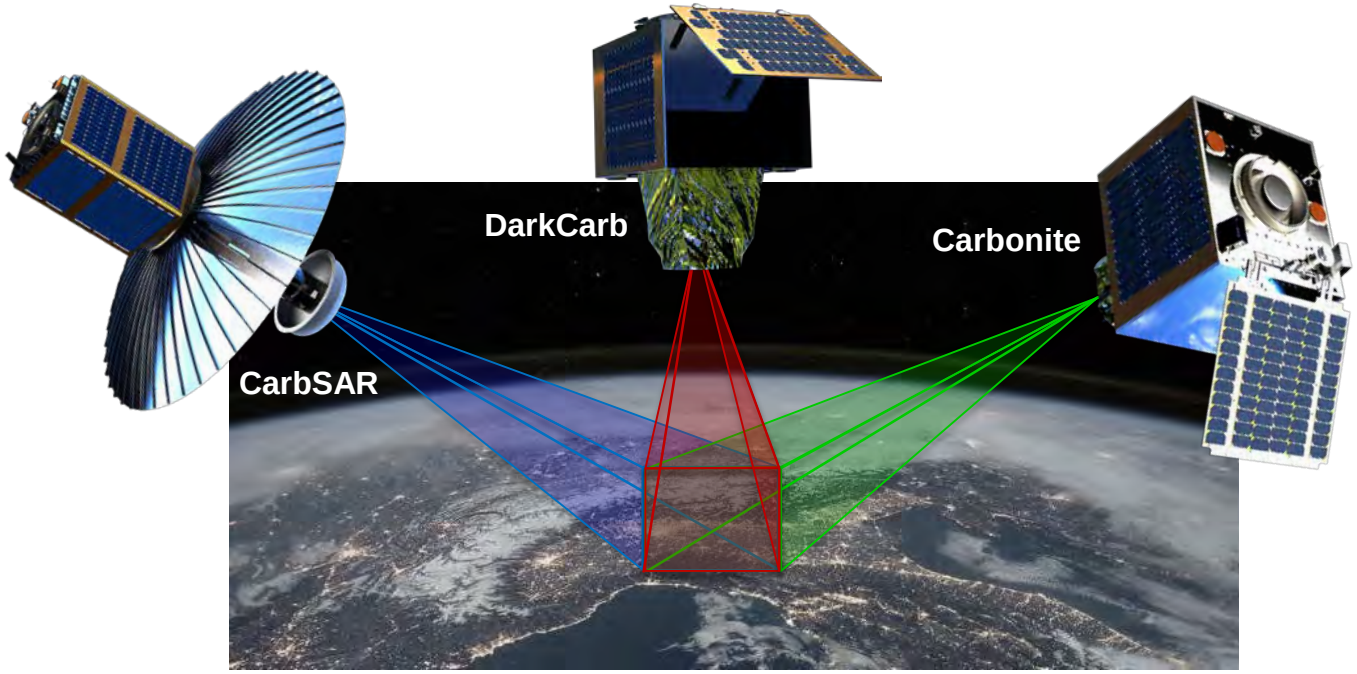


Flight 6 – 19:32, 3800ft



Looking to the future

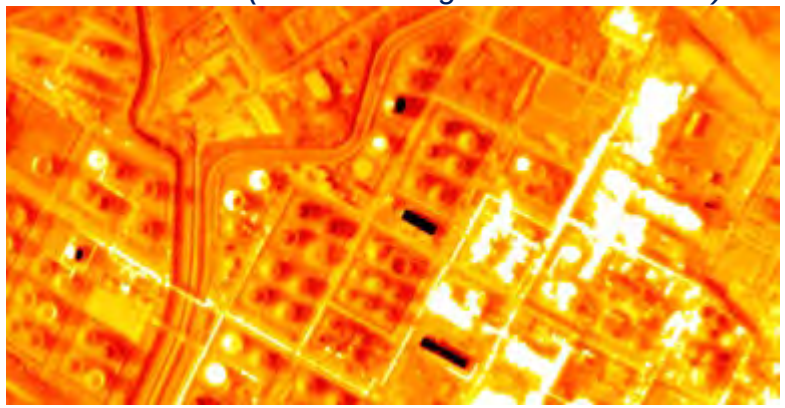
- Carbonite constellation sensor fleet:



Potential for higher resolution infrared and SAR data through ***inter-satellite PAN-sharpening*** *and other* ***data fusion applications***

NovaSAR *(from space)*

Dark Carb *(Airborne image not correct GSD)*



Carbonite-2 *(from space)*

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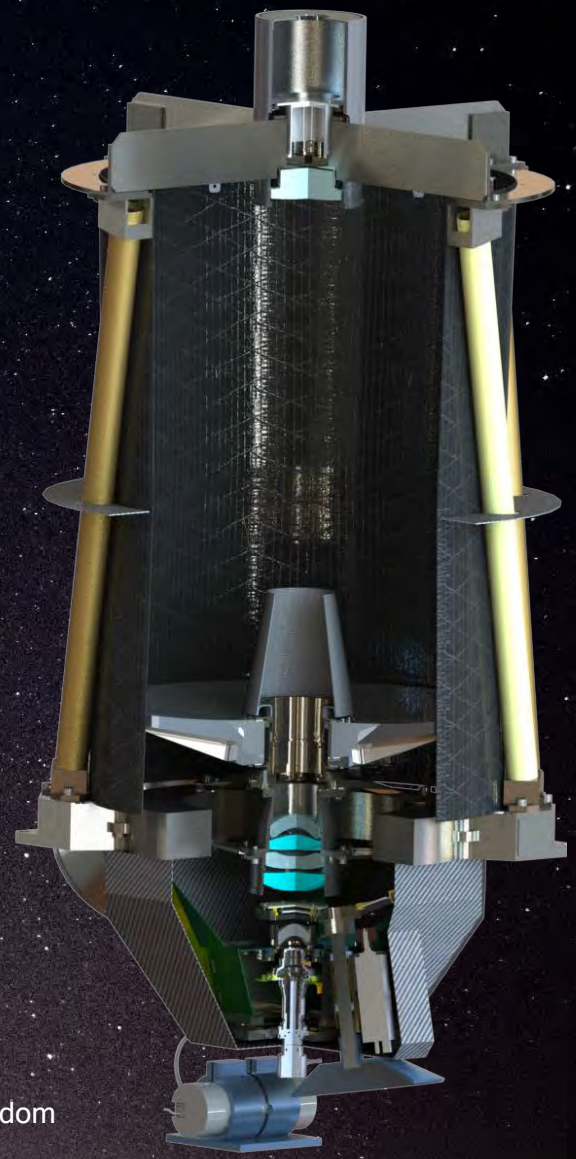
Thank you!

Contact: a.haslehurst@sst.co.uk



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