WE LOOK AFTER THE EARTH BEAT

OmniSat-HAPI Constellation

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University of Leicester

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Overview

- New mission concept to measure tropospheric nitrogen dioxide (NO_2) content with high temporal resolution.

- Mission concept:
  - The High-resolution Anthropogenic Pollution Imager (HAPI) instrument
  - The TAS-UK OmniSat nanosatellite concept

- Winner of ESA SysNova R&D Studies Competition for Innovation.

Scientific Rationale

- Nitrogen dioxide (NO_2) is a key atmospheric pollutant.
- Correlation with human mortality, hospital admissions and respiratory illness.
- Cost:
  - ~ €20 billion per year to UK economy
  - ~ €600 bn across the EU
  - > €1 tn globally.
- Current measurements are low resolution, available once or twice per day.
- UK well placed to lead new downstream service development and delivery.

The HAPI Instrument Concept

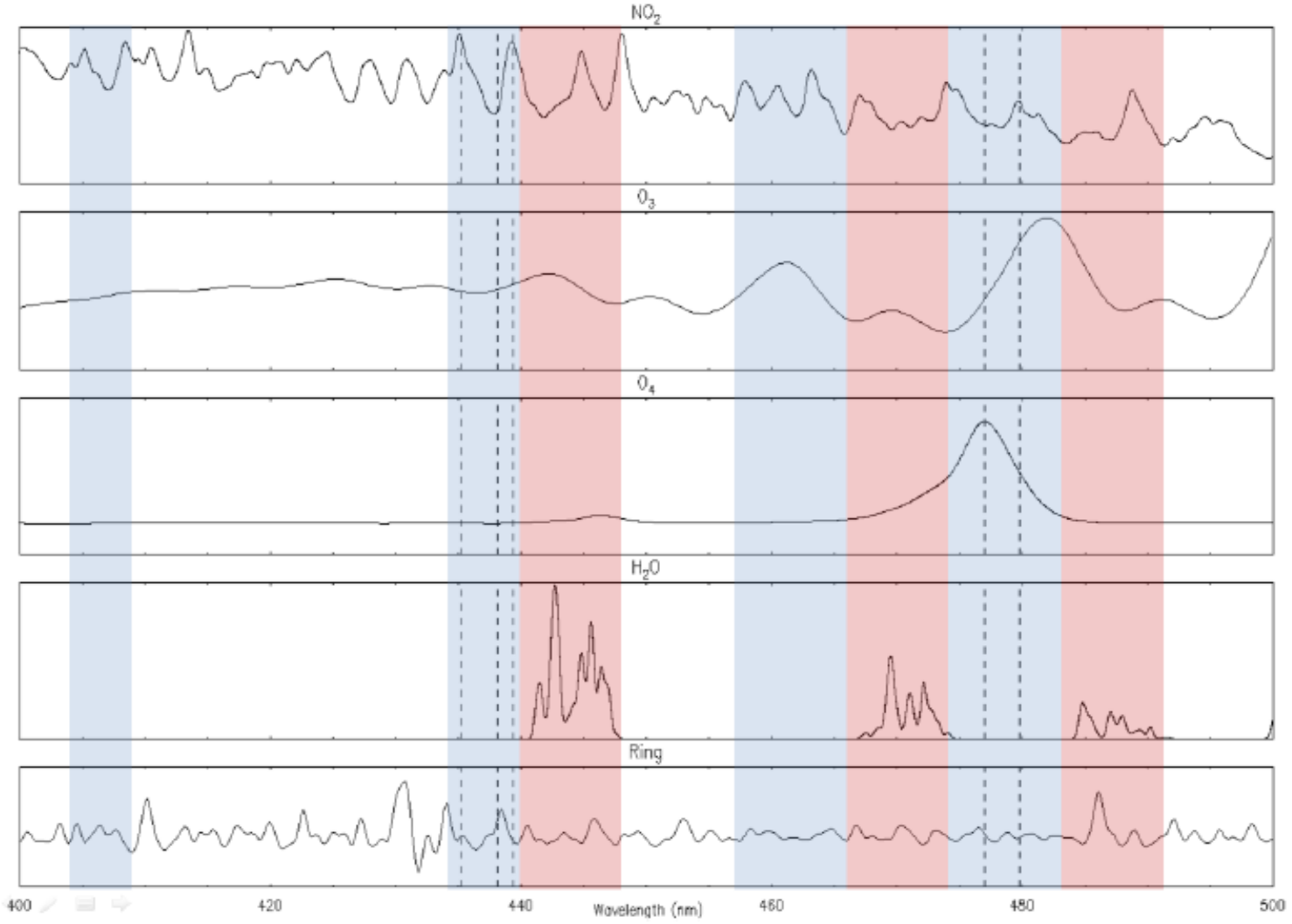
Evolution of instrument concept

- CompAQS/UCAM (Ultra Compact Air Quality Mapper)
  - Discrete wavelength retrieval
  - Neural network retrieval
  - Filter array detector

- High-resolution Anthropogenic Pollution Imager (HAPI)
  - Discrete wavelength retrieval
  - New direct retrieval
  - Separate filter imaging systems
  - High maturity of component technologies.

The High-Resolution Anthropogenic Pollution Imager (HAPI) instrument concept.

- Rather than use hyperspectral information in a traditional DOAS fit, derive NO_2 from discrete spectral bands, and configure a new instrument design.
- Heritage: TOMS, Brewer, DIAL

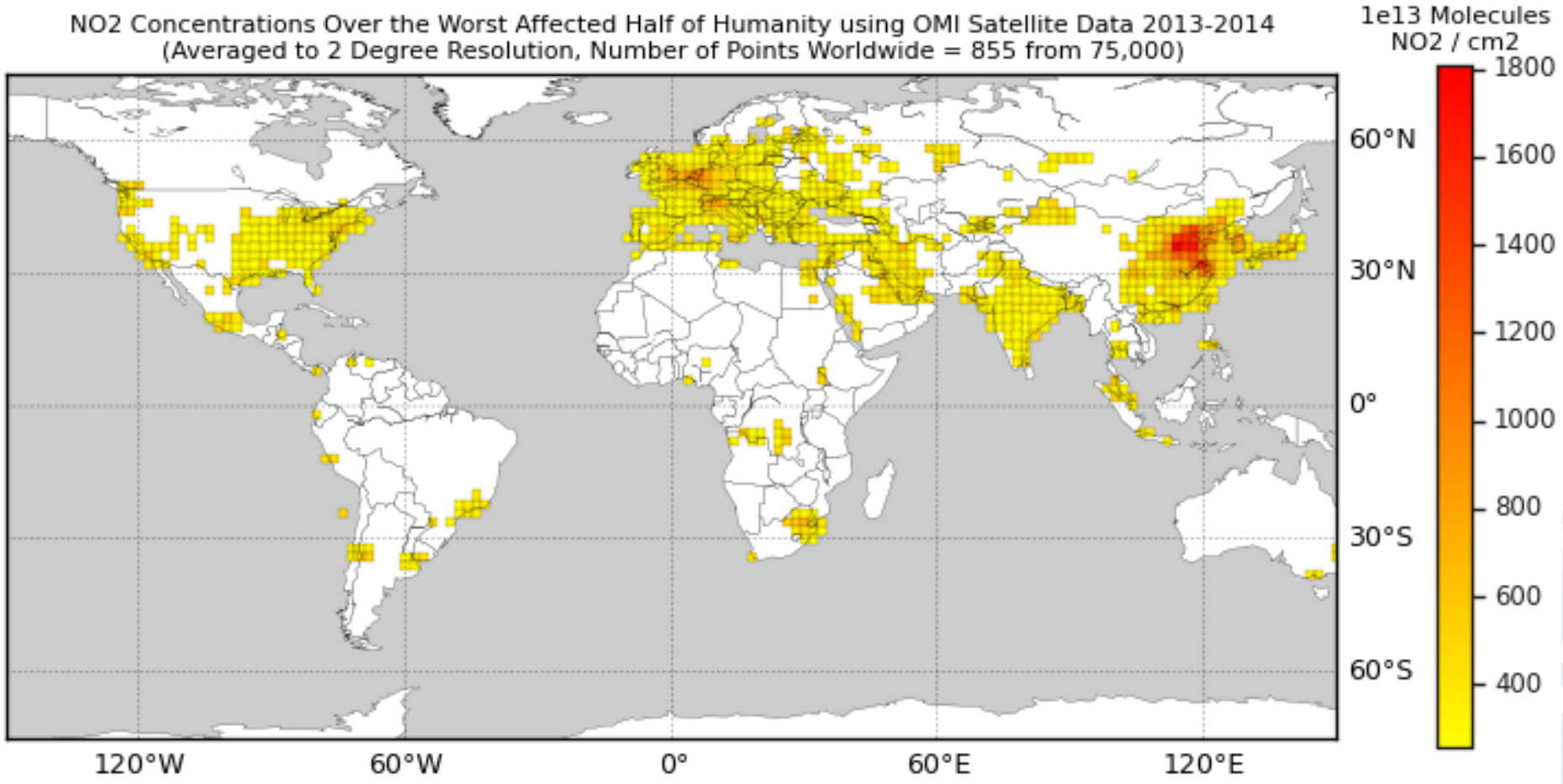


Instrument Performance

- Tropospheric NO_2 detection
- 300m GSD
- Cloudiness of the scene
- Accuracy of $2x10^{15}$ molc/cm^2 of NO_2
- Compressed data

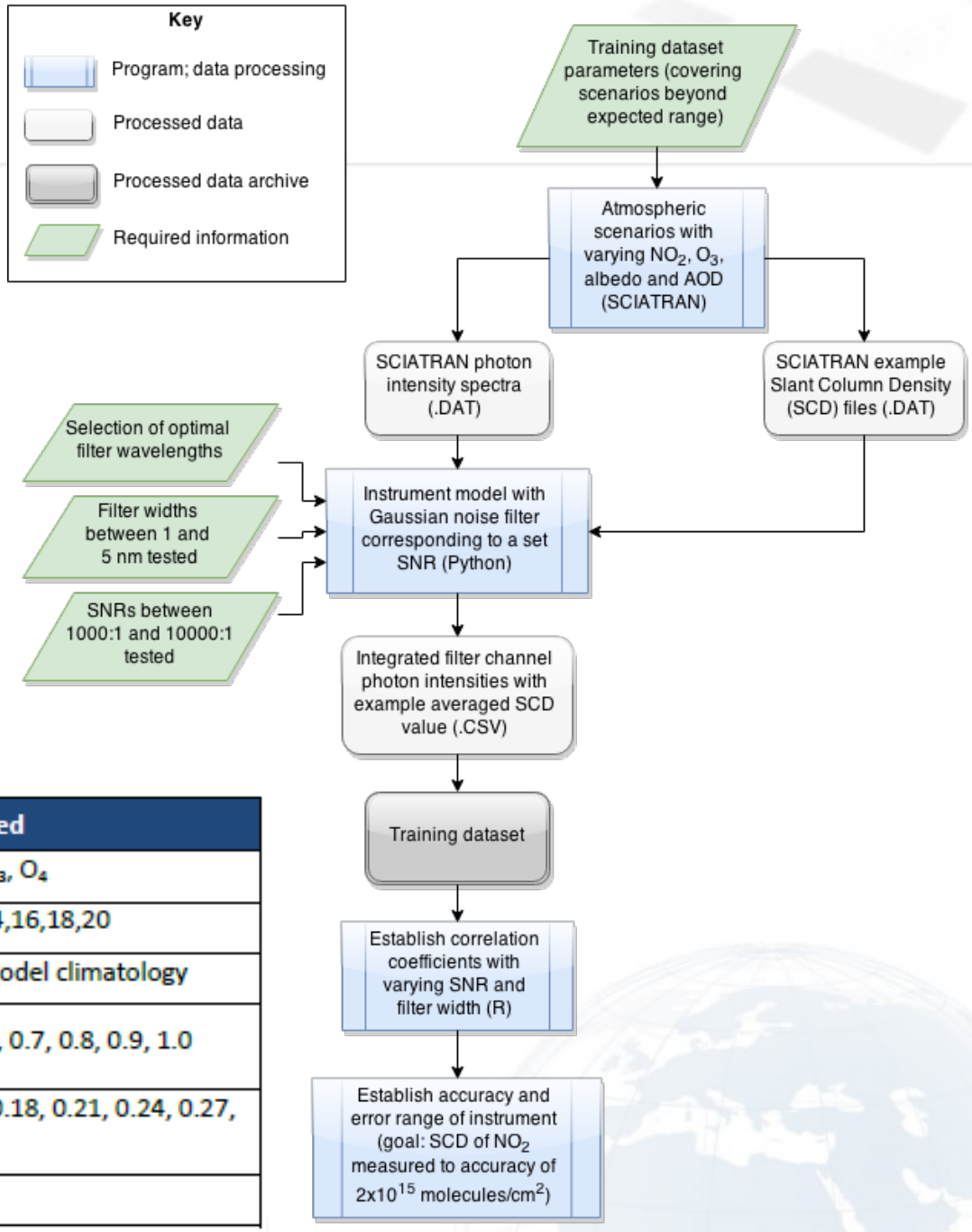
Locating NO_2 emission hotspots

- NO_2 concentrations over the most polluted half of humanity
- ~3% of the Earth's total surface



The instrument model

- A range of scenarios input into a radiative transfer model.
- Spectra and slant columns produced.
- Spectra processed through an instrument model, varying filter FWHM and SNR.
- A retrieval developed, and performance assessed.



Parameter	Values used
Species	NO_2, H_2O, O_3, O_4
NO_2 boundary layer VMR (ppbv, 2km high box profile)	0,2,4,6,8,10,12,14,16,18,20
O_3 profiles	10 profiles from MPIC model climatology
Aerosol optical depth (550 nm, SCIATRAN default extinction profile)	0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0
Surface albedo (Lambertian, wavelength independent)	0.03, 0.06, 0.09, 0.12, 0.15, 0.18, 0.21, 0.24, 0.27, 0.30
Viewing Geometry	Nadir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The OmniSat Design Concept
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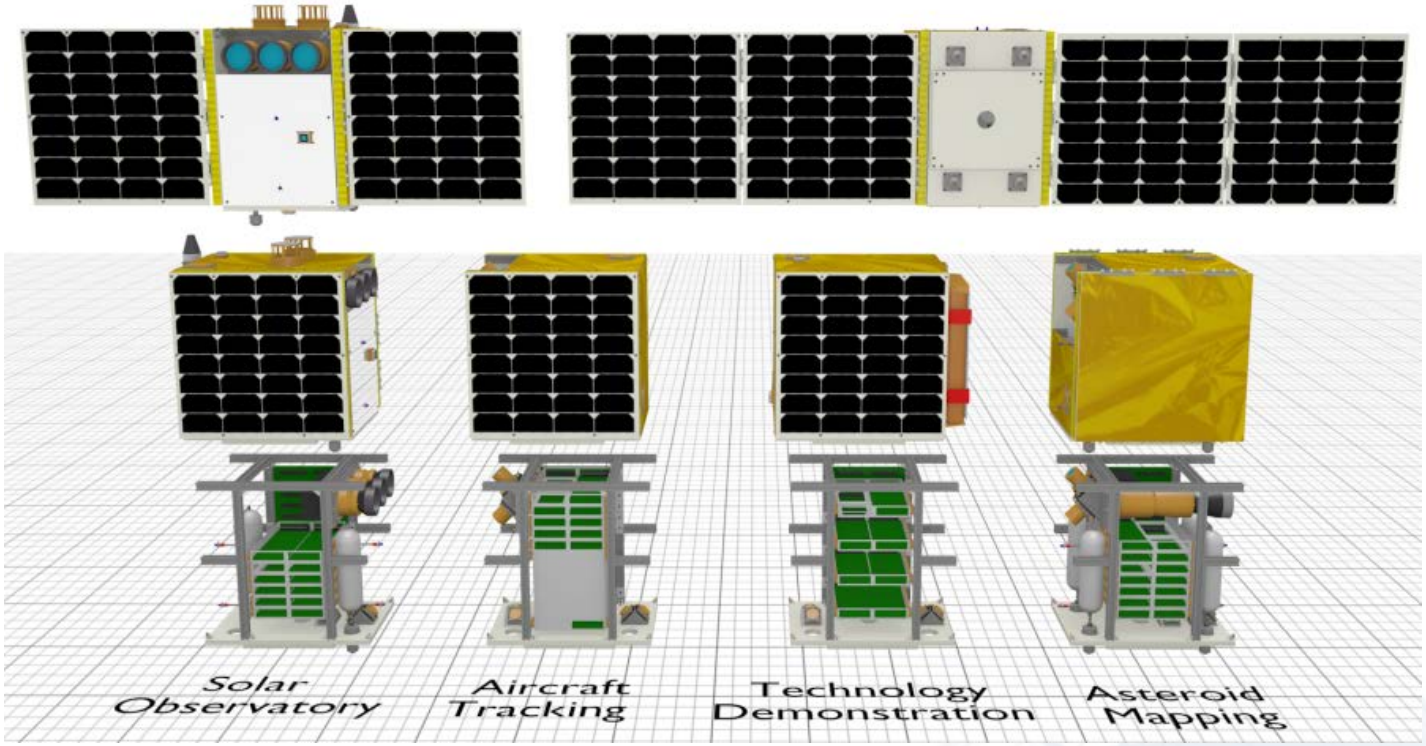
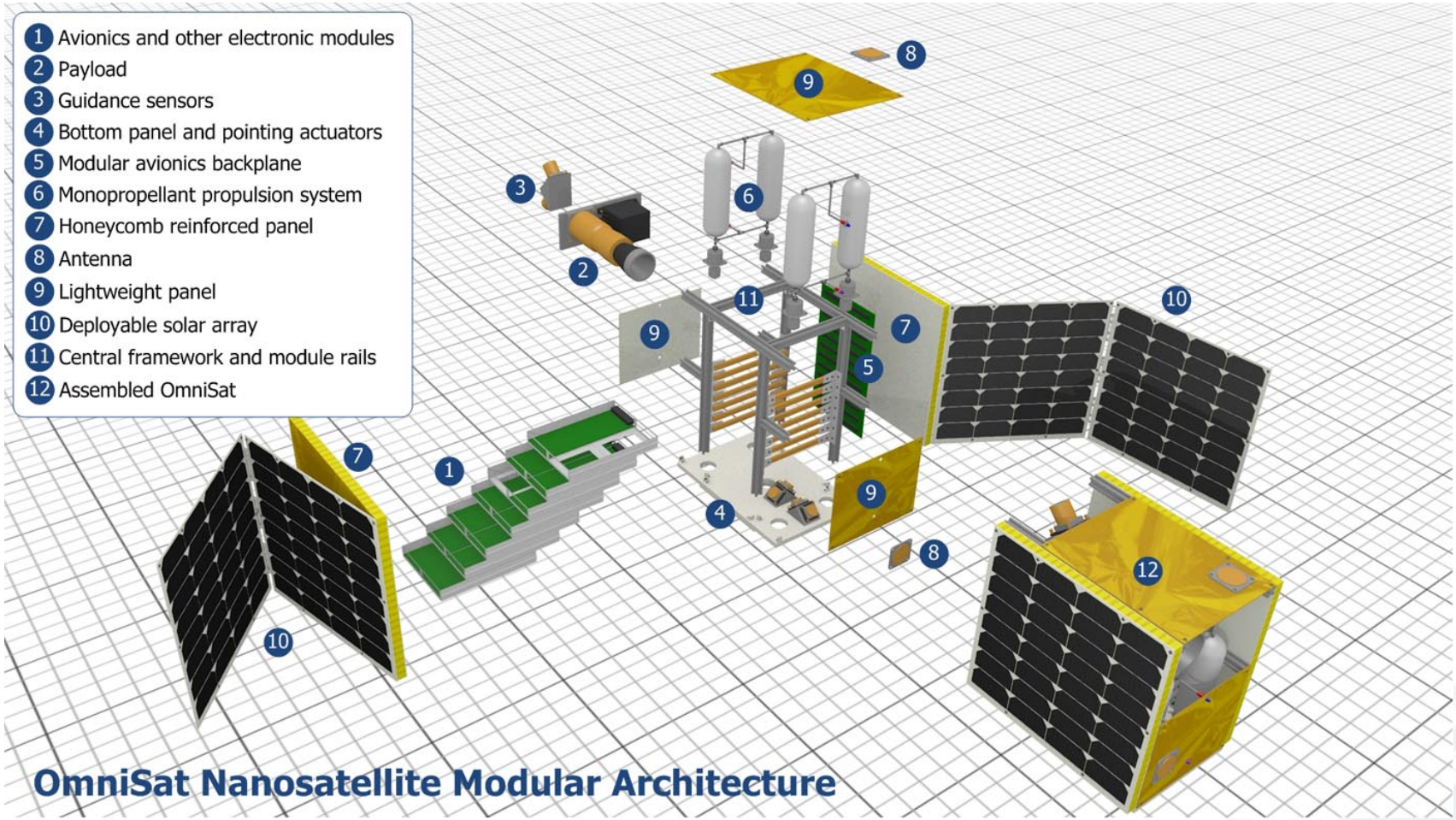
OmniSat Background

- Outcome of recently completed ESA study (Ref. TEC-SYE/2011.11/AS)

- OmniSat platform
  - Modular
  - Flexible
  - Capable
  - Reliable
  - 150 m/s delta-V
  - 400km – 1000km
  - 20 – 50 kg

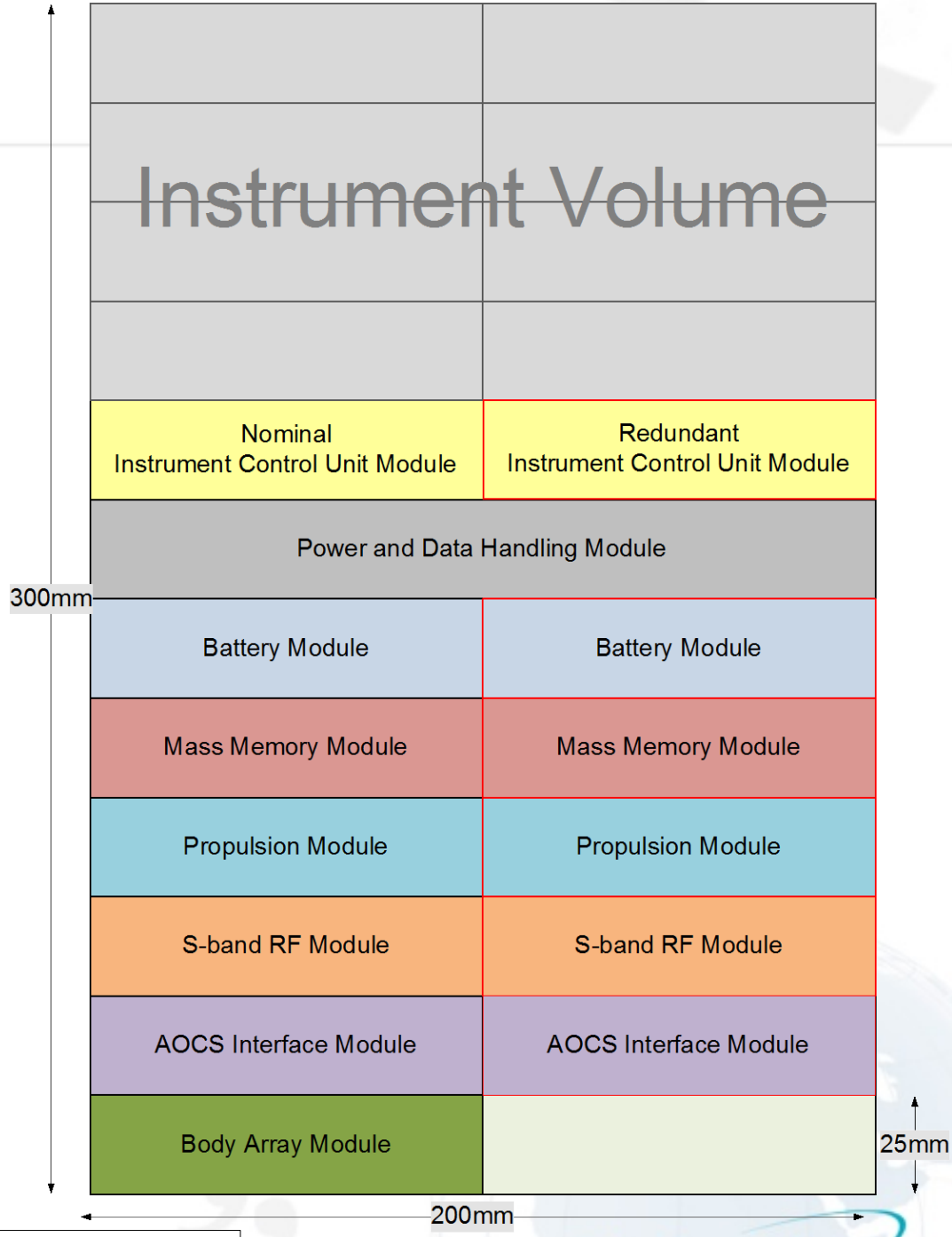


Modular Nanosatellite



OmniSat-HAPI Module Design

- Mass
  - 28.6 kg total (inc. 20% margin)
- Power
  - 11 W average
  - 60 W peak
- Volume 32 litres
- 4 year lifetime
- Three-axis stabilisation
- 75 ms^{-1} delta-V
- Up to 5 Mbs^{-1} downlink S-band

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OmniSat Performance
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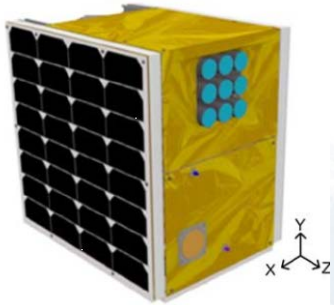
OmniSat performance overview

- Power provided by 3 body mounted solar arrays and a redundant 5 Ah battery
- AOCS performance
  - Fixed Earth target
  - 30º off nadir slew
- Hydrazine propulsion system
  - 75 m/s delta-V
  - Operational orbit of 650 km
  - 25 year debris requirement
- AOCS requirements
  - Fixed Earth target
  - 30º off nadir slew



OmniSat performance overview

- Power and Data Handling
  - Handles cross strapping
  - Fully redundant
  - Supports SPI, UART and CAN bus interfaces
  - No master slot
- 10 GB mass memory
  - Up to 9 days worth of HAPI data
  - Flight spare or continual back up
- Communications
  - S-band uplink: up to 100kb/s
  - S-band downlink: up to 5Mb/s
  - Optional X-band module

Reliability and Redundancy

- Flexible level of redundancy
- High redundancy OmniSat
  - 5 extra redundant modules
  - 2.2 kg mass difference
  - Same volume
  - Reliability of 0.97 for 4 year mission
  - Up to 21/24 satellites remaining after 4 years

OmniSat-HC Mission Concept and Design

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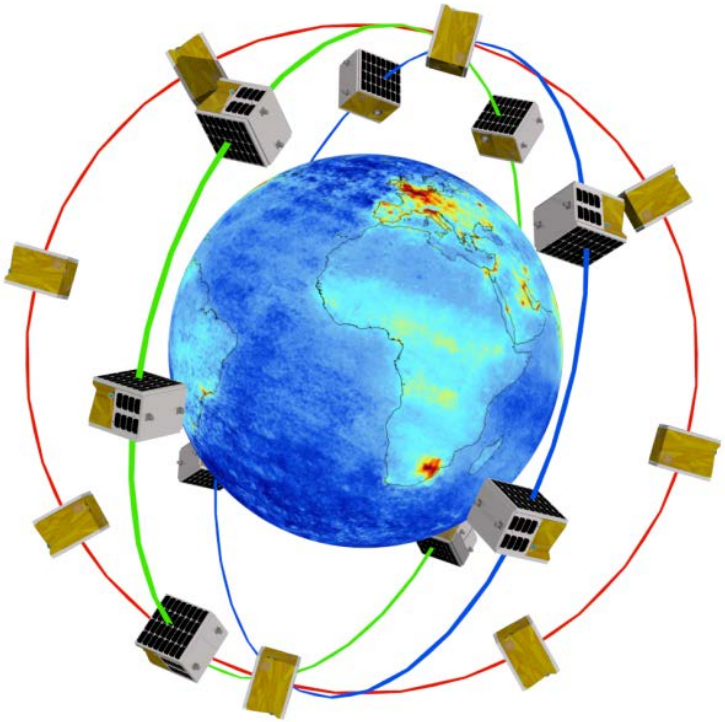
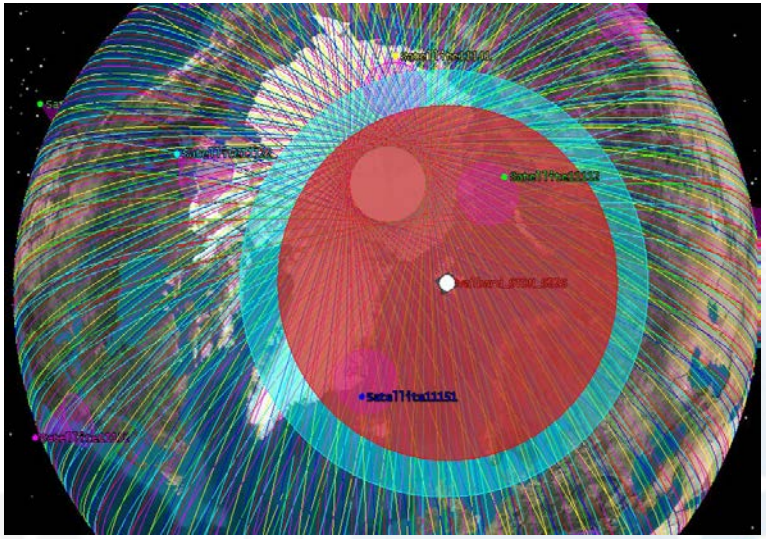
Constellation Design

- 24 OmniSats in a Walker constellation
- P3S8F1: 3 planes, 8 OmniSats per plane, 15º phasing
- 300 m spatial resolution
- 200 km swath
- 650 km orbit altitude
- Svalbard/Trollsat Ground Station
- **<2 hr delay from capture to end user**
- **Data every 1.6 hours (average)**





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Study Conclusions and Future Work

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Summary of Conclusions

- A mission concept to measure tropospheric nitrogen dioxide (NO_2) content with high temporal resolution over the diurnal cycle has been devised.
- SysNova R&D Studies Competition for Innovation winner:
  - CDF follow on study in September
  - Further analysis of the instrument and platform agility
- HAPI instrument demonstration now required to raise TRL from 3 to 6.
- No unachievable technical challenges are foreseen.

Thank you

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