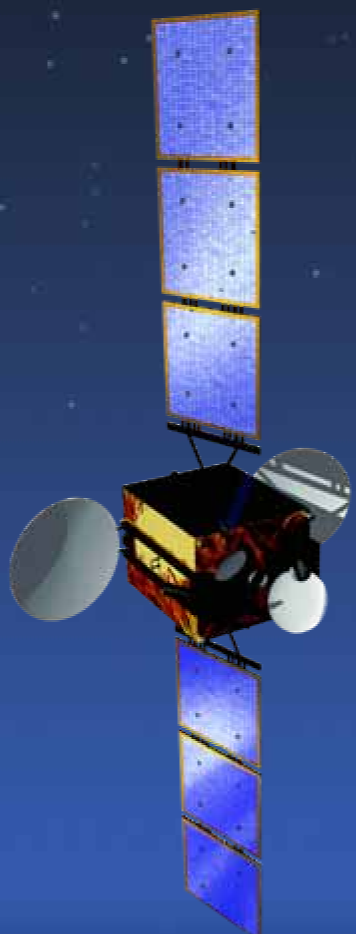
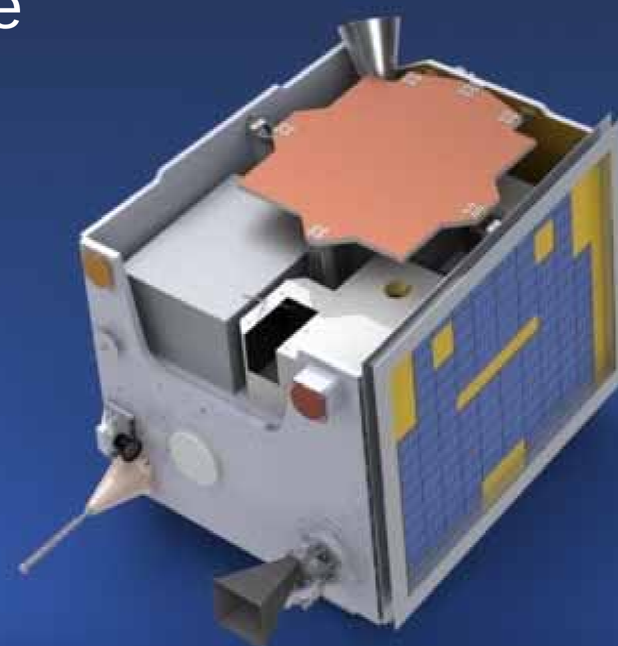
SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*

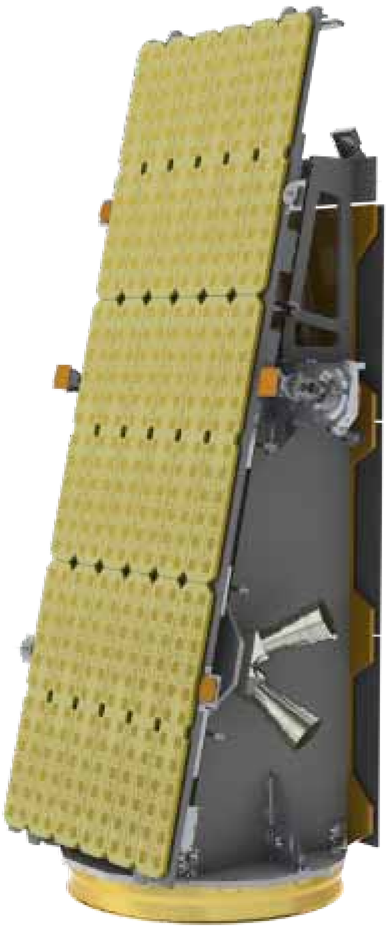
EO Opportunities through the Technology Demonstrator Satellite (TDS) Programme





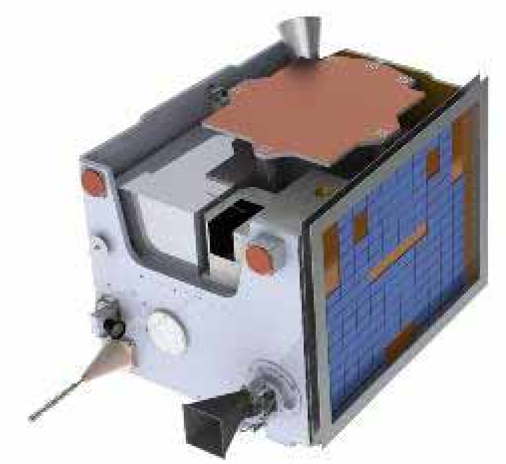
Structure

- TDS rationale and philosophy
- Baseline TDS
- System-level demonstrator concepts
- i-TDS
- Conclusions



Technology Readiness Levels

- **TRL 1** Basic principles observed and reported
- **TRL 2** Technology concept and/or application formulated
- **TRL 3** Analytical and experimental critical function and/or characteristic proof-of concept
- **TRL 4** Component and/or breadboard validation in laboratory environment
- **TRL 5** Component and/or breadboard validation in relevant environment
- **TRL 6** System/subsystem model or prototype demonstration in a relevant environment (ground or space)
- **TRL 7** System prototype demonstration in a space environment
- **TRL 8** Actual system completed and “flight qualified” through test and demonstration (ground or space)
- **TRL 9** Actual system “flight proven” through successful mission operations



TDS target region is TRL 6-8

The hardest transition for both sub-system technologies and mission concepts

UK High Level Issues

- The TechDemoSat programme represents the “facility in orbit” required to deliver the IGS growth objectives
  - The opportunities described here are the logical continuation of that approach
- A part of a national programme, the TechDemoSat missions will be controlled from the EO-Hub at ISIC
  - The TDS missions will form part of the future income stream for ISIC
  - The T+IC programme might potentially include funding which could be applied to these missions
  - Indeed, the TDS programme is the logical “exploitation route” for T+IC-developed technologies
- The TDS programme is an important opportunity to bring industry, academia, and government together in a common programme, as presumed in the ISIC approach

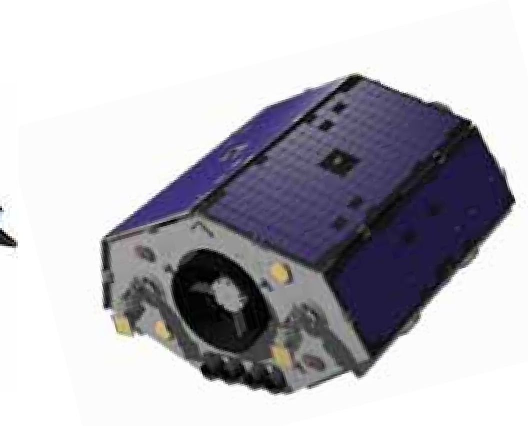
TDS Philosophy

- **Range of sub-system technologies, sharing a common bus and timesharing operations**
  - A “demonstration” or “qualification” approach for all hardware and software contributions allows the timesharing concept to work
- **Mission provides rapid flight qualification and enables early enhanced access to market for payloads**
  - The principal rationale for TSB/SEEDA/UKSA involvement
- **Synergies between payloads are identified where possible, but this aspect is not a design driver**
  - An encouraging aspect of TDS-1 was the amount of synergy which emerged
- **Open to all-comers in industry and academia**
  - The organisation developing the technology must find funding for payload but access to platform resources and launch are 'free'

SSTL Platforms

- SSTL has three heritage platforms that are suitable for TDS missions





	SSTL-100	SSTL-150	SSTL-300
Payload Mass	30 kg	50 kg	70 kg
Power	30 W	50 W	70 W
Data rate	8 Mb/s	40 Mb/s	105Mb/s
Volume	250x220x146 mm	770X500X900 mm	400 (D) x1000 (L) mm

- The SSTL-150 design was adopted as the baseline for the TDS-1 mission after a trade-off of capability versus cost

Launch Options

- A commercial launch
  - As sole payload
  - As a ride-share partner
- A “cheap” launch on a developmental launch vehicle
  - Clearly introducing risk
- A “quid pro quo” launch in return for payload space on the mission
  - The approach adopted for TDS-1
- A “quid pro quo” launch in return for data from the mission
  - A possible approach for a system-level demonstration

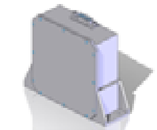
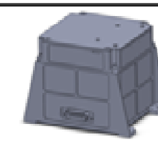
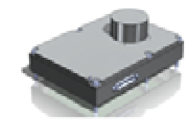
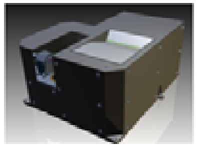
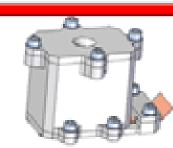
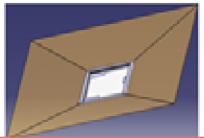
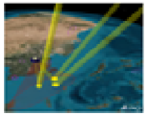
Technology Demonstration Satellite – TDS-1

- **Concept**
  - A demonstration mission providing on-orbit flight experience for next-generation technologies. Funding and support from TSB, SEEDA, UKSA

- **Baseline Platform – Enhanced micro-satellite**
  - Payload Mass – 50kg
  - Power – 50 W
  - Data Rate – 40 Mbit/s
  - Volume - 770 x 500 x 900 mm

- **Demonstration Contributors**
  - SSTL, Surrey Space Centre, External contributors: RAL Space and Oxford University, MSSL, Cranfield University, SSBV, Langton Star Centre & STFC

TDS-1 Payloads

Payload	Supplier	Description	Illustration
MuREM	University of Surrey (Surrey Space Centre)	The Micro (μ) Radiation Environment Monitor (MuREM) is a miniature radiation environment and effects monitoring payload.	
ChaPS	Mullard Space Science Laboratory (MSSL)	The Charged Particle Spectrometer (ChaPS) is designed to measure electron and ion populations in the orbit of the host spacecraft.	
LUCID	Langton Star Centre	The Langton Ultimate Cosmic ray Intensity Detector (LUCID) allows characterisation of the energy, type, intensity and directionality of high energy particles.	
CMS **EO payload**	University of Oxford / RAL	The Compact Modular Sounder (CMS) is a set of compatible optical, detector, cooling and electronic sub-systems which can be used to implement miniature infrared remote sensing spectrometers or radiometers.	
HMRM	Rutherford Appleton Laboratory	The Highly Miniaturised Radiation Monitor (HMRM) is a an ultra-compact, low power radiation monitor developed for re-use on future ESA missions.	
CubeSAT ACS	Satellite Services Ltd	The CubeSAT ACS payload is a complete 3-axes attitude determination and control subsystem for Cubesats.	
DOS	Cranfield University	The De-Orbit Sail (DOS) is intended to demonstrate a novel means for de-orbiting a satellite at the end of its mission lifetime through deploying a sail to increase aerodynamic drag.	
Sea State Payload **EO payload**	Surrey Satellite Technology Limited (SSTL)	Passively monitors ocean roughness via detecting reflected GPS signals and provides orbit determination via dual-band GPS (SGR-RESI).	

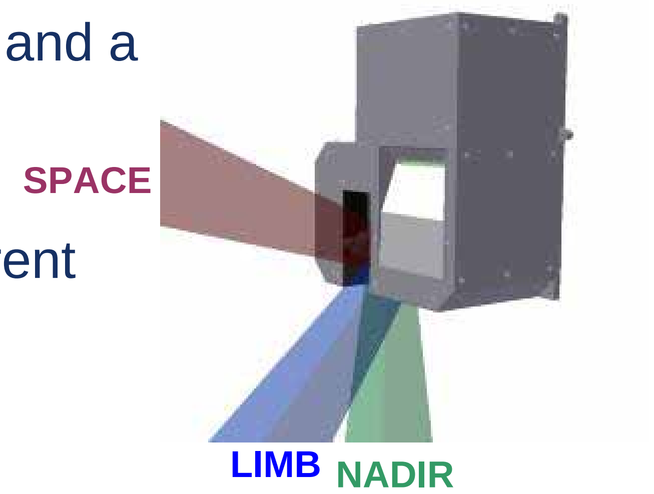
CMS – Functional Overview

- A set of compatible optical, detector, cooling and electronic sub-systems which can be used to implement miniature infrared remote sensing spectrometers **or** radiometers

- The CDHU, supplied by RAL, consists of an ARM processor and Actel FPGA which performs real time spatial and temporal averaging of data

- In standard operation mode the instrument views sequentially the nadir mapping view, space and a calibration target

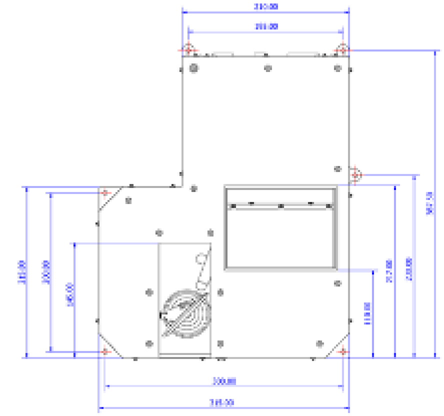
- During payload tests limb viewing and different integration times can be substituted

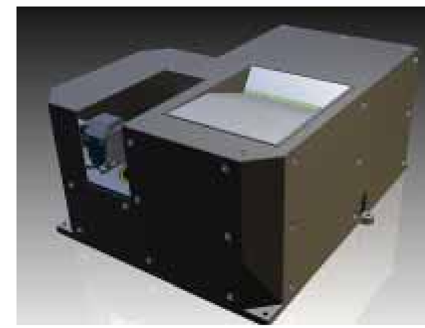


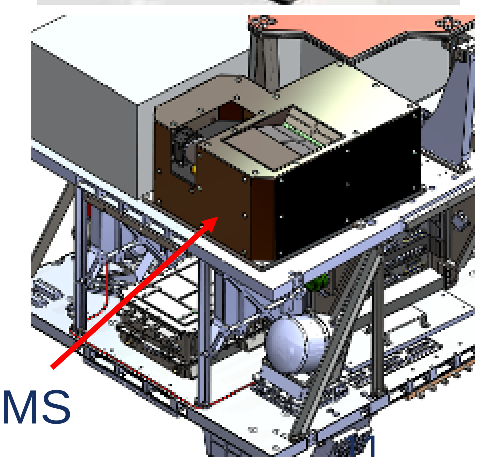
- **Developed by University of Oxford / RAL**

CMS – SPECIFICATION

- Mechanical
  - Base dimensions 380mm x 315mm x 186mm
  - 6 x M5 fixings to the top of the payload Panel
  - Mounted such that unit has FoV for Earth, Space and Limb
  - Mass 4Kg
- Electrical
  - 26W Male High Density D-Type (Data)
  - 25W Male Standard D-Type (Power & CAN)
  - Connected to 2 +28 V low power battery switches (electronics and payload heater)
  - 4Mbit/s synchronous serial data link
  - Interfaced to HSDR and FMMU via separate LVDS chips for redundancy
- Command & Control
  - Primary and redundant CAN architecture







CMS

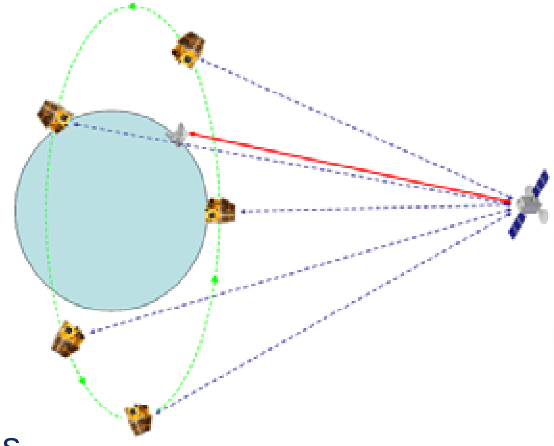
Future TDS

- Follow on TDS - missions come along like busses every 18-24 months
  - Allows potential candidate technologies to adopt a suitable schedule
- Future TDS design will be modified to accommodate a range of bus interfaces (CAN, 422, SpaceWire, 1553 etc.)
- Also able to fly cubesat technology with I2C/PC104 interface
- We are examining how to launch cubesats from/alongside TDS on future launches
  - Potential for formation flying experiments
- Future TDS payloads probably selected via competition by TSB
  - Down-selection activities may be handled by ISIC/T+IC

Enhanced Platform Capabilities

- **On the next TDS mission it is hoped that the platform will offer enhanced capabilities**
  - **On-board processors**
    - Provides the opportunity to implement significant on-board data processing with consequent advantages in:-
      - Speed of product delivery
      - Data rates/bandwidth required
      - Power required

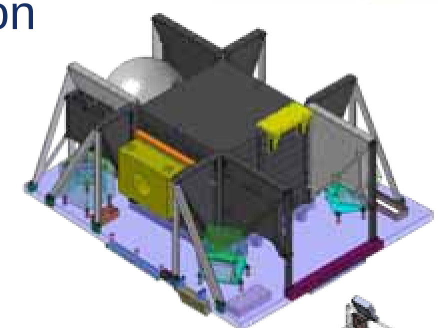
    - Significant implications for:-
      - High resolution imaging systems
      - Hyper-spectral sensors
      - Radar sensors
      - Future communications systems
  - **Inter-satellite links**

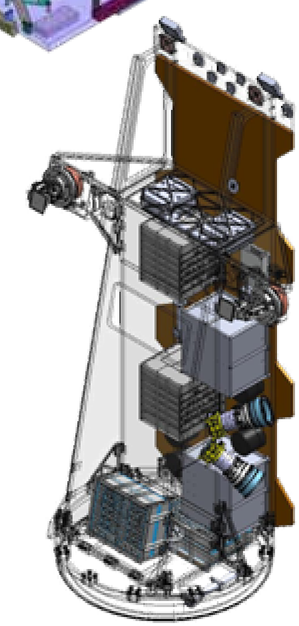


    - Provide near-real-time ability to:-
      - Command the satellite
      - Return data from the satellite
      - Monitor the telemetry from the satellite
    - Significant Implications for:-
      - Timeliness of data services
      - Resilience through alternate communications paths

TDS-2 Timescales

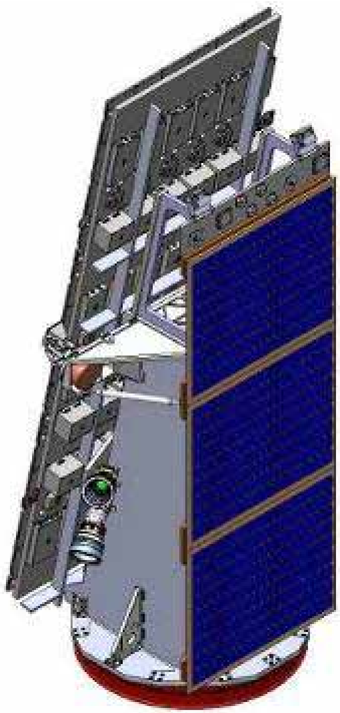
- Need for agreement on:-
  - The preferred launch date
    - End 2013 is suggested as a compromise between the practical constraints of building the system, and the requirement to enter the market as soon as possible
  - If 2013 is selected, this implies the following timescales:-
    - Call for ideas soon
    - Deadline for submissions in the Autumn.
    - Review of payloads and selection of platform by early 2012
    - We will invite TSB and UKSA to make budget provision for FY 2012/2013 and beyond
  - Ongoing issues with launch, and the potential need for teaming to find a cost-effective way to reach orbit, suggests a parallel activity to find a launch partner





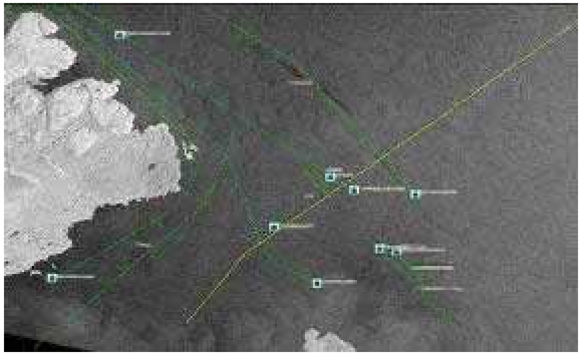
System-level Demonstrator Concepts

- Missions built around one overarching application with clear downstream services
- Exploits synergies between different payloads
- Missions could have demonstration phase followed by operational phase with industry “buying back” the satellite
  - e.g. maritime services / NovaSAR
- SSTL involvement would be to provide a larger low-cost platform and mission priming role
- Potential payload technologies which we might we wish to fly alongside the SAR with complementary maritime surveillance capabilities include:-
  - Frequency Monitoring Package (QinetiQ)
  - AIS (ComDev)
  - GNSS Reflectometry (SSTL)
- If you have a prototype maritime surveillance payload, we’d like to talk to you!
- Data products need to be sufficiently well-developed to make a “downstream data service” a viable “quid pro quo” for the launch



Potential Customer Organisations

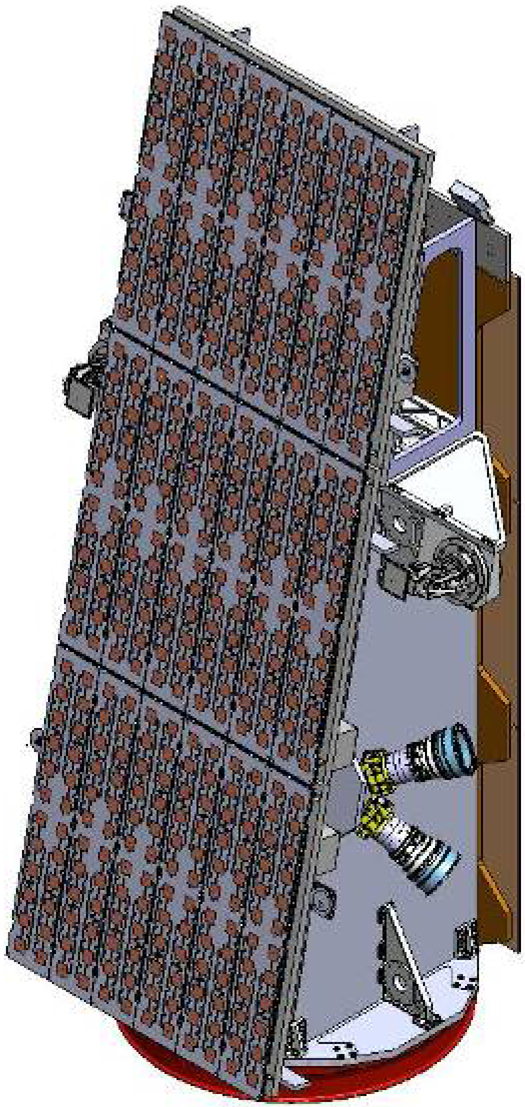
- A more operational focus demands consideration of potential customer organisations
  - **UK**
    - •National Maritime Information Centre (NMIC)
      - Royal Navy
      - Customs
      - UK Border Agency
      - Coastguard
      - SOCA
  - **Europe**
    - •European Maritime Safety Agency (EMSA)
    - •EDA
  - **US**
    - •Department of Defense (DOD)
    - •National Reconnaissance Office (NRO)
    - •Department of Homeland Security (DHS)



SAR image augmented by AIS

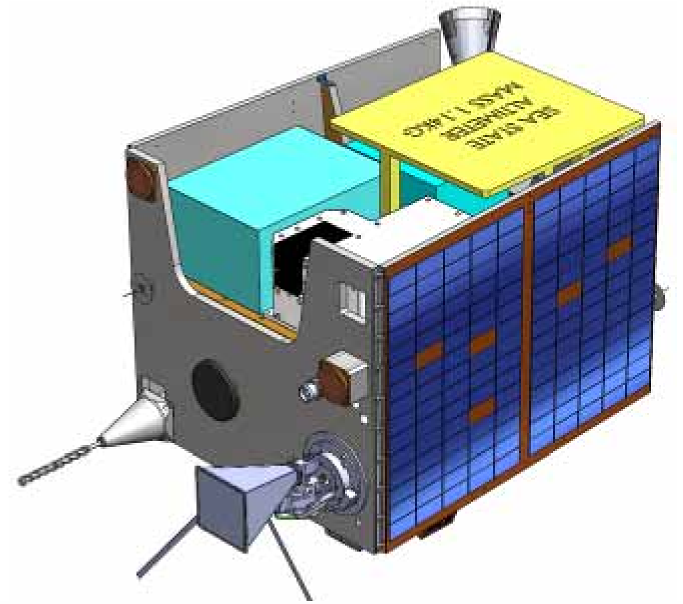
Current Status

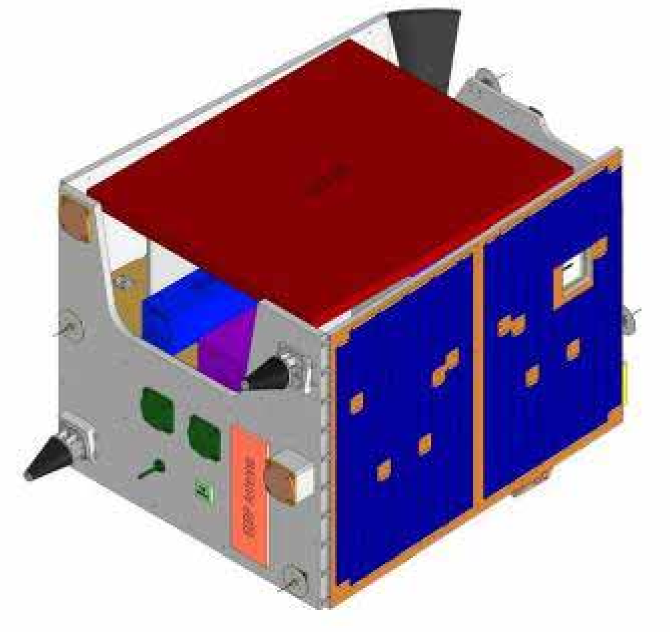
- Preliminary design of NOVASAR-S platform completed by SSTL
- PDR successfully held February 2011
  - Avionics equipments identified and are mainly heritage equipments used on previous SSTL missions
- It was originally anticipated that the rest of the development would be done under a contract (1st export customer)
  - Demonstration in orbit will help us to find that customer
- We now need to accelerate this development with funding from TSB and UKSA to make this platform the baseline for a demonstration mission
  - Need to ensure the timescales for instrument build and platform build are mutually compatible to enable a launch by the end of 2013



i-TDS

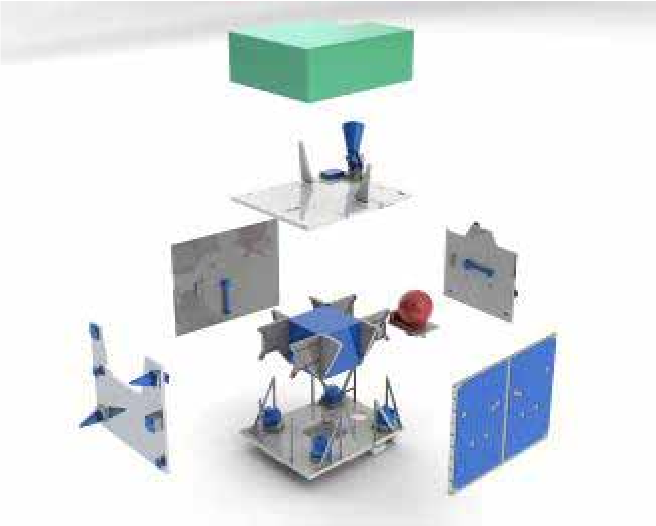
- International TDS
  - SSTL will offer paid access to space for payloads on a per kilo / resources / complexity / basis
  - Timesharing as per TDS, or calculated on a financial basis
  - Concept will be marketed to the global space community





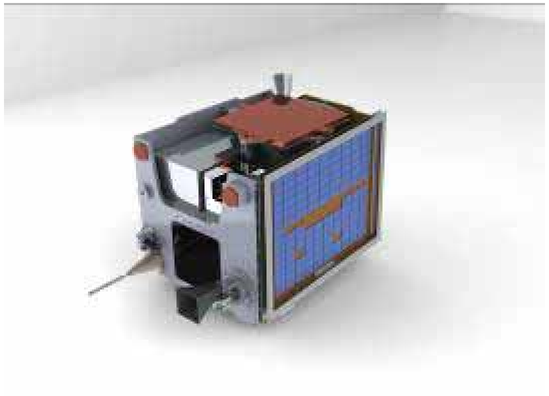
Payload Considerations

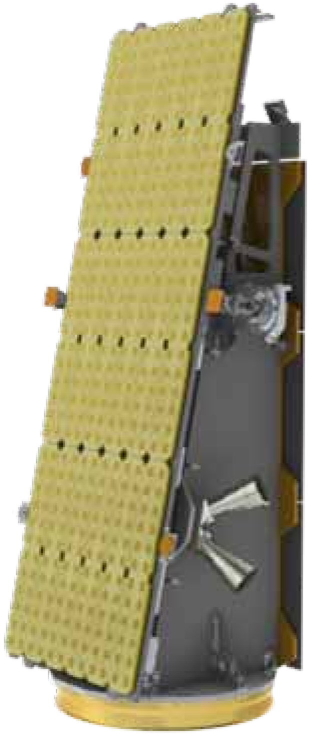
- If you do have a potential candidate payload for TDS, these are some of the potential parameters for discussion
  - Mass
  - Volume
  - Power
  - Data storage requirements
  - Data downlink requirements
  - Satellite/experiment orientation during operations
  - Required platform pointing accuracy and stability
  - Physical mounting
  - Orbit type and orbit maintenance
  - Mission/experiment lifetime
  - Thermal control
  - Time sharing and duty cycle
  - Day/night operation
  - Radiation shielding
  - Launch vibration environment
  - Environmental limits (e.g. RF interference)
  - Bus protocols (e.g. 1553, RS422, Space-wire, CAN bus)
  - Meta-data requirements (e.g. time inputs from GPS)



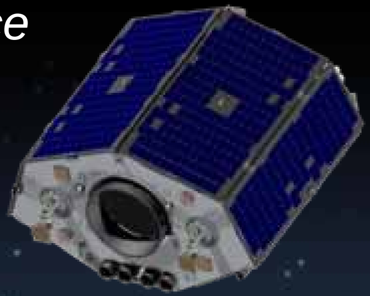
Conclusions

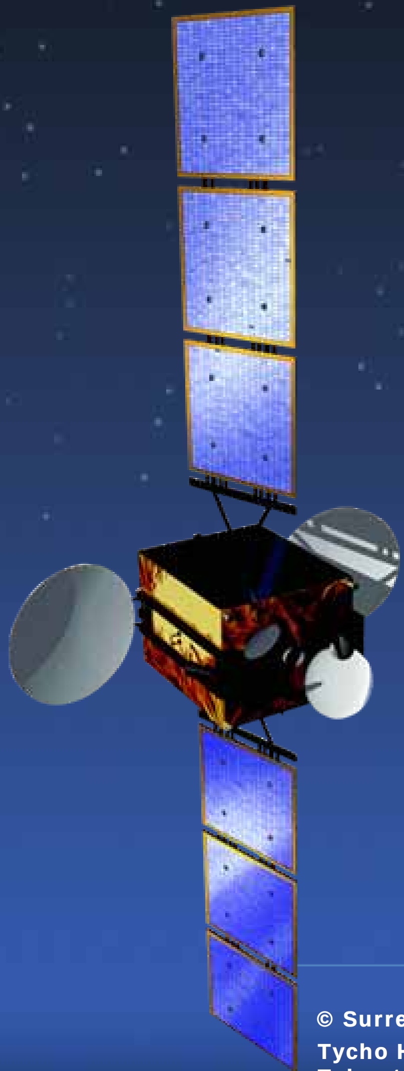
- The TDS programme offers the UK a rapid route to market for emerging EO technologies
- Demonstration in space is still essential for risk reduction
- TSB and UKSA support for a “test facility in orbit” is extremely valuable
- The TDS initiative is fully consistent with IGS and ISIC/T+IC objectives





Changing the economics of space





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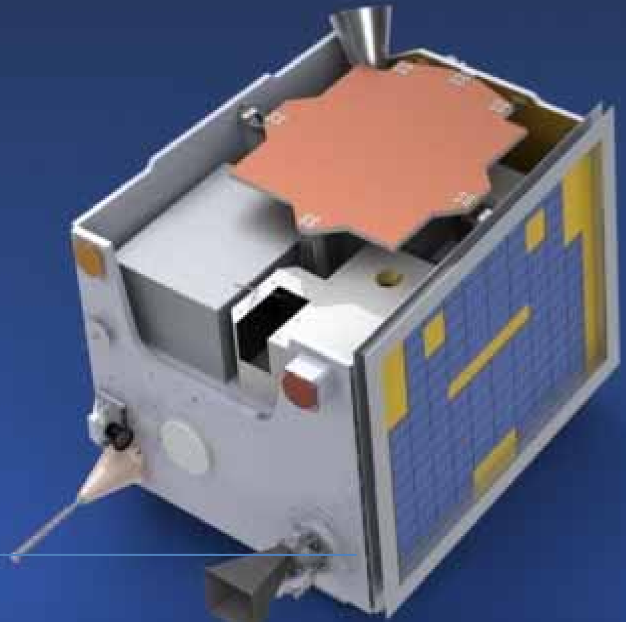

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