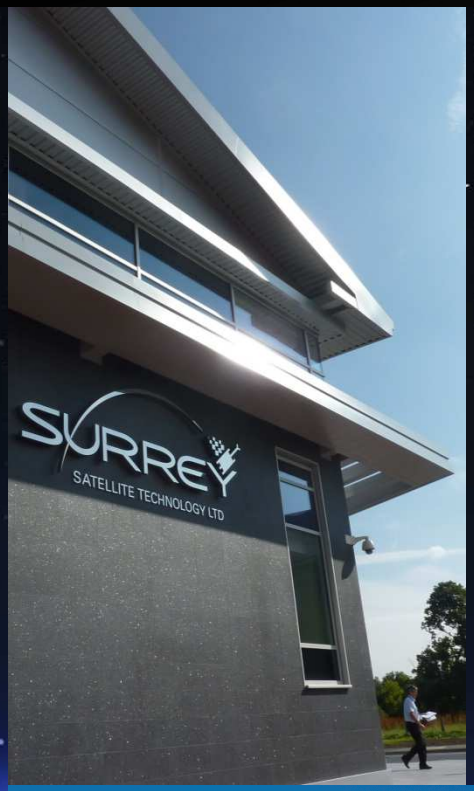

SURREY
SATELLITE TECHNOLOGY LTD
KG
KANEMATS
UNISEC Global Meeting
Tokyo, July 2015
(Pre-workshop for the 4th Mission Idea Contest for
Micro / Nano Satellite Utilisation)

SSTL Overview



- UK small satellite mission provider
- - owned by 99% Airbus Defence & Space 1% University of Surrey
- Incorporated in 1985, employs 500 staff across facilities in the UK (Surrey, Kent, Hampshire) & US (Colorado)

SSTL – The Stats

34+

Years+ in operation.
6 Oct 1981 to date.

43

SSTL satellites launched

21

Satellites in manufacture

22

Payloads in manufacture

5

Number of SSTL constellations deployed and under contract (DMC, RapidEye, F7, DMC3, Kanopus)

Changing the Economics of Space

As at July 2014


SURREY
SATELLITE TECHNOLOGY LTD
KG KANEMATS
SSTL's fleet of small satellites
Cubesats
SSTL-X50
SSTL 100
SSTL 150
SSTL 300
SSTL 300 S1
SSTL NovaSAR
SSTL GMP-T

Japanese Collaborators

SSTJ – Resource Provider into MIC

Leverage SSTL's expertise to assist MIC participants through:

1. **Mentoring – providing technical advice**
2. **Work-shop participation**
3. **Training & Development**
4. **Provision of heritage platforms and subsystems**

SSTL Available Resources

Full mission capability from definition through to launch, commission, operations & exploitation

Mission Definition and Design

Sub Systems Design and Manufacturing

Assembly & Integration

Testing

Environmental Testing

Launch

Mission Commission & Operations

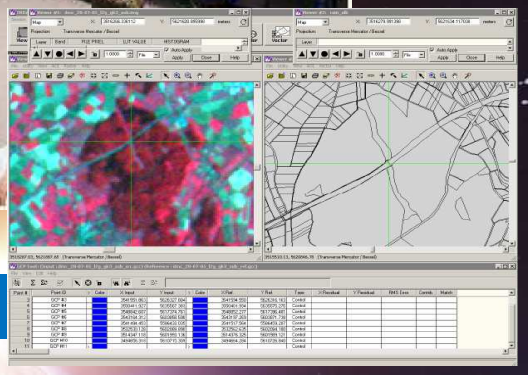


Image Processing & Application

SSTL collaborations with Japan Space Industry include:

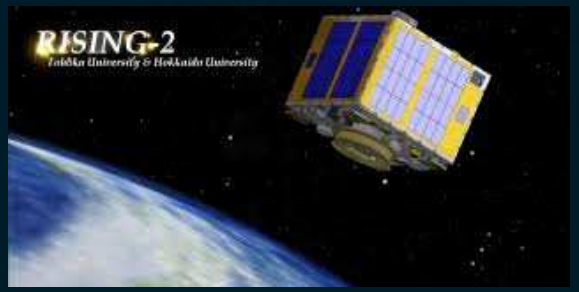
1. Mission Concept Studies
2. Microsatellite Mission Training
3. Space Market Study & Analysis
4. Technical (spacecraft, platform & equipment) Studies
5. Subsystem provision (EM & FM)
5. Ground Station Provision / Training
6. Down stream data service provision

Japanese Missions Supported by SSTL

JAXA / MELCO SLATS – SSTL provided Study support and is supplying GPS space receiver

NICT SOCRATES – AES prime. SSTL supplied reaction wheels

ChubuSat – MHI / Nagoya Uni. SSTL's 10SP-M reaction wheel based-lined on Chubusat series



Tohoku Uni. Rising-2. SSTL supplied GPS receiver

JAXA Tsukuba SDS-4 SSTL supplied 10SP-M reaction wheels

SSTL Micro / Nano Platforms Provision

- enabling MIC participants to focus on the mission concept

SSTL Satellite Platforms

- A wide range of platforms for small satellites
- Many heritage missions and structure configurations
- All based on SSTL standard avionics*
  - Standard power and data interfaces

- Highly flexible and configurable, using heritage equipment and system configurations
  - S-band TM/TC, 28V power bus, CAN OBDH
  - Heritage structure configurations or new structure
  - Single string / dual or multiple redundancy avionics
  - Scalable power systems with body mounted or deployed panels
  - A range of AOCS sensors and actuators
  - Various propulsion system solutions
  - Various payload support solutions, including high speed data recorders and downlink

* SSTL is now introducing new “Fireworks” avionics on the SSTL-X series, which eventually will be rolled out across other platforms. KazSTSAT will fly this avionics set in 2016. Cubesats and GEO Commsats are special cases using largely custom avionics

Platform Heritage

SURREY SATELLITE TECHNOLOGY LTD

KG KAYNEMATS

STRaND-1
SSTL C-1

Nano-X
SSTL-FLY

Low complexity platform
- Typically <50kg
- <£5M
- <1 year

KazSTSAT
PicoSAT
AlSAT-1
NigeriaSat-1
UK-DMC-1
UK-DMC-2
Deimos-1
NigeriaSat-X
exactEarth-1
AlSAT-1b

X-50
SSTL-100

Highly flexible platform
- Simple payload interfaces
- Typically 50-300kg
- £5-15M
- 1-2 years

TOPSAT
Beijing-1
RapidEye (x5)
Sapphire
TechDemoSat-1

SSTL-150
SSTL-150E
ESPA variant

CFESAT
OTB-1

NigeriaSat-2
DMC3 (x3)
Kanopus (x8)
NovaSAR
Formosat-7 (x6)

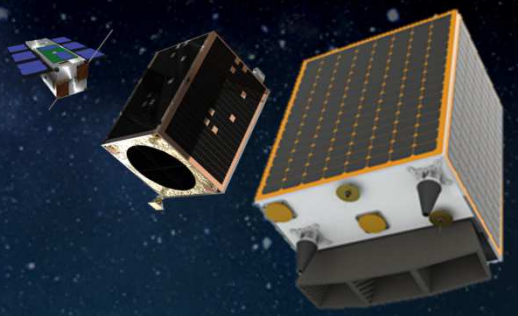
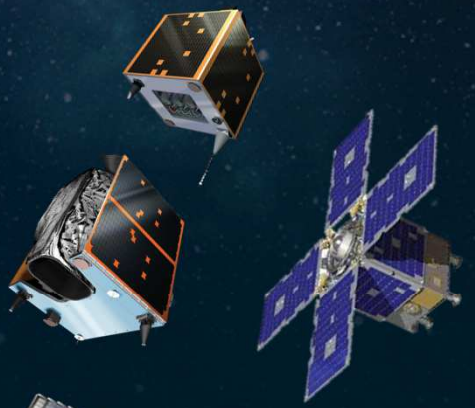
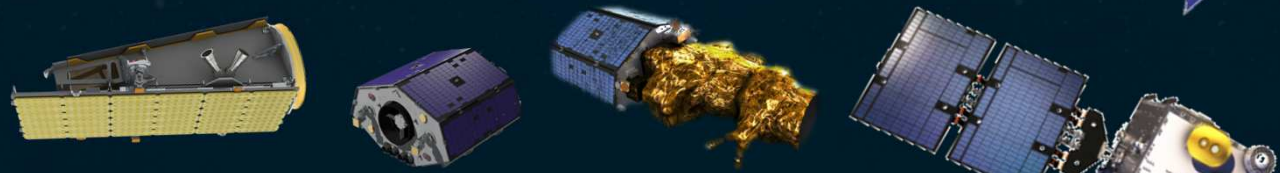
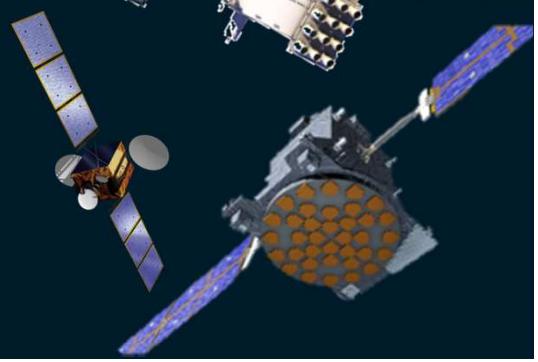
SSTL-300
SSTL-600
LEO & MEO

Giove-A

Quantum

GMP-T
GEO

High performance platform
- System optimised for payload
- Typically 200-800kg
- £10-20M
- 2-4 years

Nano / Microsatellite Platforms

Platform	Cube-X	Nano-X	SSTL-X50	SSTL-100	SSTL-150
Payload					
Mass (kg)	<2 or <5	<4 or <9	<45	<50	<60
Power OAP (W)	<6W or <12W	<3.6W or <15W	35W 85W peak	17-24W 85W peak	<50
Volume	2U or 5U (L shaped)	12x19x19 20x20x23	53x40x43	314x257x240	Int. 25x28x23 Ext. 77x73x25
Spacecraft					
Total mass (Kg)	<7 or <11(dry)	<16 or <36(dry)	50 - 150	75- 125(dry)	<180 (dry)
Volume (cm^3)	3U or 6U	12U or 27U	53x43x40	84x68x95	124x133x130
Design Lifetime	1-2 years	1-2 years	5 year	5 year	7 year

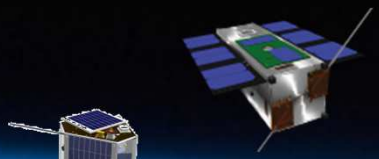
Only main platforms shown

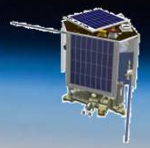
Typical specifications

Low complexity platforms

- CubeSAT
- Nano-X
- SSTL-X50

SSTL “Cube-X” Cubesats





- Heritage: SNAP-1; STRaND (2013).

- For professional missions where a Cubesat is the appropriate nanosatellite solution
  - E.g. contractual requirements to meet certain mission objectives
  - Leverages SSTL mission engineering capabilities
  - Typically 3U, 6U, 12U, 15U, 24U or 27U form factor
  - Wide range of launch opportunities
  - Using third-party avionics where appropriate

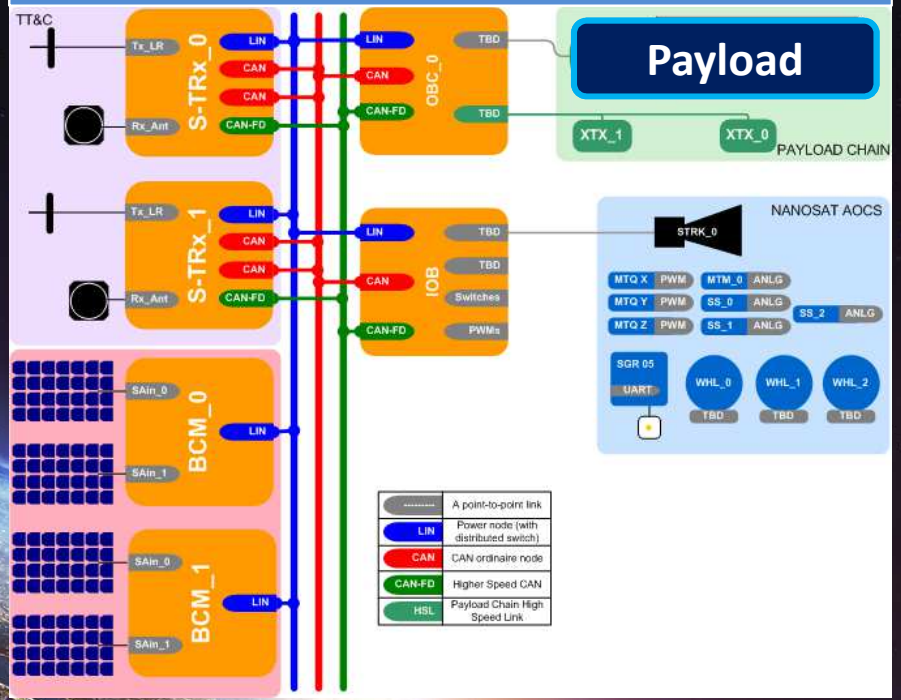
- Leverages University of Surrey Surrey Space Centre science and technology cubesat mission programme
  - CubeSail – de-orbit
  - AARest – autonomous assembly & reconfiguration
  - QB50 – EU thermosphere science mission

SSTL Nano-X

- Scalable Nano/Microsat platform
- Targeted at very low cost, fast delivery missions
- Based on SSTL “Fireworks” avionics
- Partial redundancy in key systems

Typical platform characteristics	
Mission mass	Up to 40kg
Payload mass	Up to 20kg
Payload power	29W (without deployable panels)
Data interface	Up to 1 Gbps
Pointing Control	0.1deg
Downlink rate	Up to 50Mbps
Design lifetime	1 to 2 years

Typical block diagram



SSTL X-50

The X50 offers a highly flexible microsatellite platform, featuring an innovative modular avionics suite, that can be scaled up or down to match the needs of a wide variety of payloads. High speed data storage and processing makes it extremely capable for high data volume applications, such as video from space and high resolution imagery.

Payload Accommodation & Services

Payload Mass	Scalable, typically up to 45kg
Payload Volume	Scalable, typically starting from: 0.5 m x 0.4 m x 0.3 m
Payload Orbit Average Power	Scalable, typically up to 35 W (can be increased with additional arrays)
Payload Peak Power	Scalable, typically up to 85 W (can be increased with additional arrays)
Payload FoV	Unobstructed FoV possible

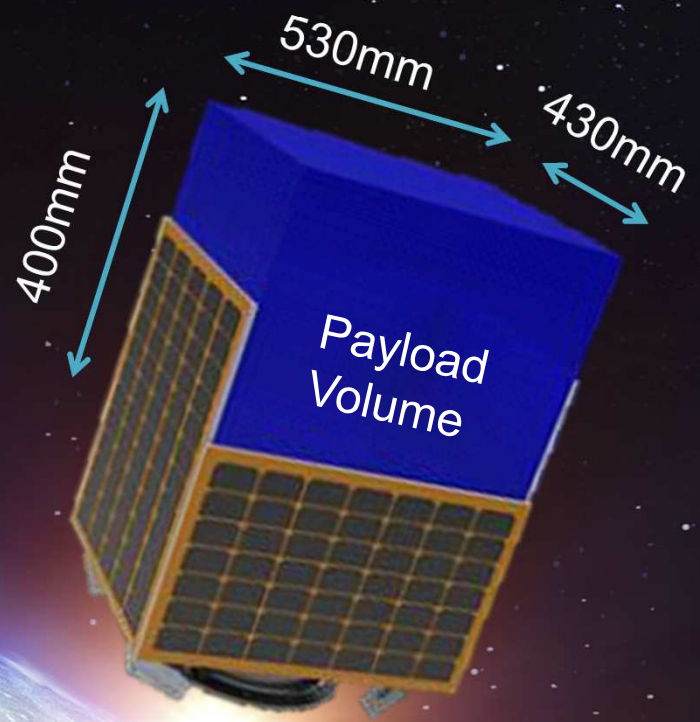
Platform Services

System robustness	Redundant Design – no single point of failure	
Data Bus	CAN bus standard Also featuring: RS485, LVDS, UART	
High Speed Data Interfaces	GigaBit per second payload data bus direct to data storage or downlink.	
On-Board Data Storage	Standard 2 TB Optional upgrade to 4 TB	
Power Bus	28V Unregulated	
Comms System Interfaces	S-band Uplink	Up to 600 kbps
	S-Band Downlink	Up to 2.2 Mbps
	X-band Downlink	Up to 1Gbps

SSTL X-50

- Targeted at low cost, fast delivery missions
- Production engineered for automated manufacture and test
  - Fast delivery (12-24 months)
  - Cost efficient for constellations
- Dual redundant avionics
  - Scalable power and OBDH
  - Gbps payload interfaces, Tbyte storage, 3-axis control
- First flight KazSTSAT in 2016

Supported Orbit Types	Sun synchronous (standard) Low altitudes supported
	Non sun sync (optional upgrade)
Attitude Modes	Earth Referenced (standard)
	Inertial Reference Platforms Available
Design Lifetime	5-7 years
Satellite Mass	Total mass typically in the range 50 – 200 kg
Satellite Dimensions	Typically less than 1 m^3
Compatible Launchers	Dnepr, Falcon-1, H-IIA, Soyouz, Delta-IV



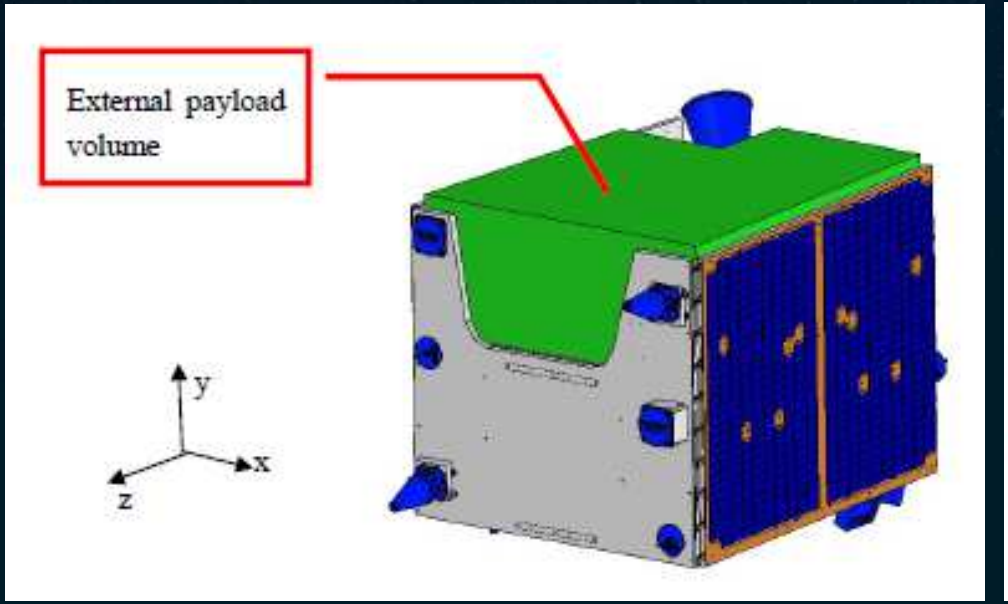
SSTL-150

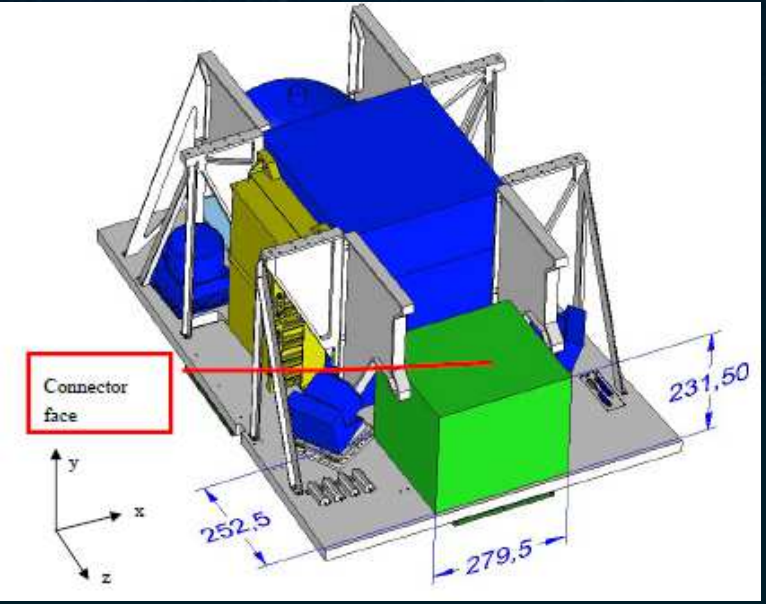
- Dual redundant avionics
  - Scalable power and OBDH
  - 3-axis control, Agile
- Extensive heritage
  - 9 spacecraft
  - Listed in the NASA ID/IQ catalogue

Typical platform characteristics	
Mission mass	100-165kg
Payload mass	Up to 60kg
Payload power	50W (without deployable panels)
Pointing Control	0.07deg
Downlink rate	X-band, Typically 400Mbps
Design lifetime	7 years

SSTL-150 payload accommodation

- Internal volume ~250x280x230mm
- External volume ~770x730x250mm





SSTL-150 missions

Beijing-1 (2005)

TOPSAT (2005)

RapidEye (2008)

TechDemoSat (2013)

Sapphire (2014)

SSTL Subsystems

- enabling MIC to access low-cost , heritage platform subsystem

Heritage Subsystems are available through SSTJ

- S-band TM/TC, 28V power bus, CAN OBDH
- Heritage structure configurations or new structure
- Single string / dual or multiple redundancy avionics
- Scalable power systems with body mounted or deployed panels
- A range of AOCS sensors and actuators
- Various propulsion system solutions
- Various payload support solutions, including high speed downlink and data recorders

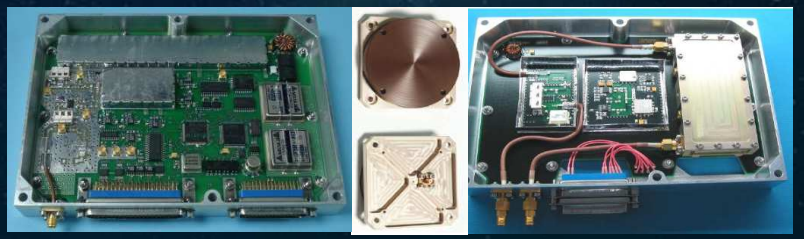
Subsystems from SSTL

Complete data handling, storage and down-link solution over X-band

A range of GPS receivers to suit all budgets

SGR-ReSI is a remote sensing instrument design for use with:
a) Multi constellation
b) Multi frequency
Flying on TDS-1 and to fly on Cygnss

S-band TM/TC Platform Suite

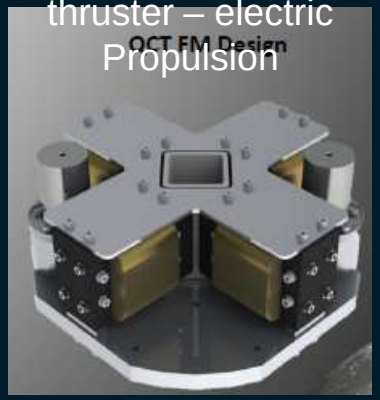


A range of reactions wheels with oil or dry lube for fine pointing and rapid manoeuvring

Hold down and release mechanism

Bi-Axis SADM

Quad confinement thruster – electric Propulsion



Procyon and Rigel-L Star Trackers offering 5 & 3arcsec accuracy; 4Hz and 16Hz up-date rate

MIC Participant can access SSTJ extensive capabilities

- Collaborative mission design
- Mentoring & Workshop participation
- Platform manufacture & training
- Manufacturing licenses for future missions
- Platform Subsystems

Thank you

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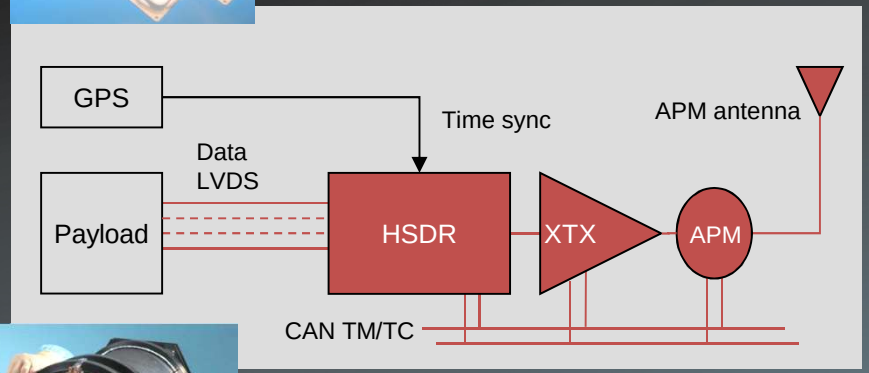
Changing the economics of space

www.sstl.co.uk

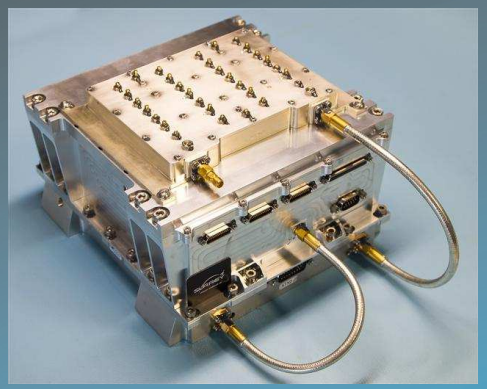
X-Band Payload Downlink

- High Speed Data Recorder, HSDR
  - Virtex-4 FPGA with PowerPC & DDR2 memory
  - 16 GByte data storage
  - LVDS or SERDES 5Gbps data inputs
  - FMMU with 125 Gbytes non-volatile memory
- X-band Transmitter, XTx400
  - 10 to 500 Mbps data rate
  - 5 and 12W output
  - BPSK, QPSK or 8PSK modulation
  - Convolution or TCM encoding
- Antenna Pointing Mechanism, X-APM
  - Two-axis mechanism, slew rate <20º/S
  - Pointing accuracy in hemisphere <0.25º
- X-Antenna
  - Narrow beam high gain horn
  - Boresight gain of 15 or 18dBi

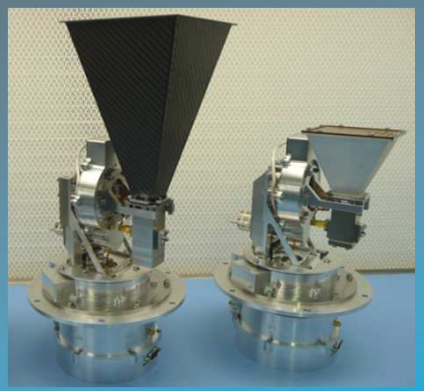


X-BAND DOWNLINK CHAIN

HSDR



X-BAND TRANSMITTER



X-BAND APM

Reaction Wheel Portfolio

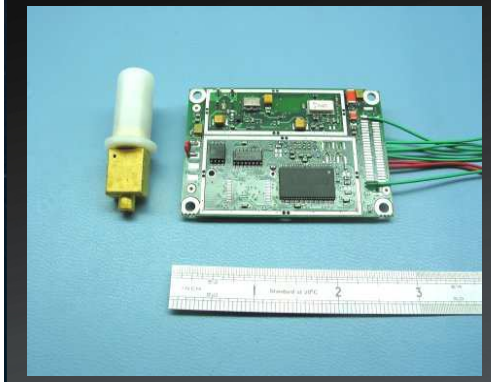
A cluster of wheels can be delivered to meet specific customer requirements

	10SP-M	100SP-M	200SP-M
			
Wheel Momentum	0.42 Nms (max)	1.5 Nms (max)	12 Nms (max)
Wheel Torque	10 mNm (max)	100 mNm (max)	200 mNm (max) @ 28V
Wheel MOI	0.0008 kgm²	0.0028 kgm²	0.023 kgm²
Wheel Speed	±5000 rpm	±5000 rpm	±5000 rpm
Speed resolution	±0.0088 rpm	±0.0088 rpm	±0.4 rpm
Speed control	<0.1 rpm (rms)	<0.05 rpm (rms)	0.6 rpm (rms)
Update rate	5 Hz (typ)	5 Hz (typ)	0.043 Nm/A
Mass	0.96 kg	<2 kg	5 Hz (typ)
Dimensions (max)	101 x 109 mm (diam	120 x 120 x 100 mm	3-Phase Brushless DC
Power	5 V, 24-32 V supplie	5 V, 24-32 V supplies	4-Quadrant PWM Current Loop
			5.2 kg
			240 mm Diameter x 90 mm Height

10SP-M RW with integral electronics

GPS Receivers

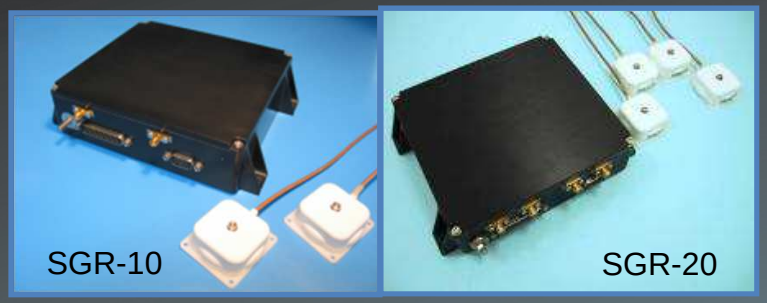
GNSS receivers provide critical navigation telemetry to the spacecraft bus: position, velocity, and GPS time. They also provide pulse per second (PPS) signals that are used by the OBC to ensure synchronisation



Space GNSS Receiver (SGR) on a card
12 x L1 channels, single antenna
Low power and mass:

- Power: 0.8 W @ 5V
- Mass: 45 grams (inc screens)
- Dimensions: 70 x 45 x 10 mm

SGR-07
12 x L1 channels, single antenna
Power: 1.6 W @ 28V
Mass: 450 grams
Dimensions: 120 x 78 x 48 mm
TTC interface: CAN-SU RS422
Active patch antenna included



Professional-grade multi-antenna Space GPS receivers
24 x L1 channels
SGR-10: Two patch antennas included
SGR-20: Four patch antennas included
Antenna configurations:

- Co-visible: Antennas mounted on space-facing facet for rapid acquisition
- Extra-visible: Antennas mounted on opposite facets for extra visibility

TTC interfaces: CAN-SU & RS422
Active patch antennas included

Typical Performance for SGR-07, -10, -20

- Position to 10m (95%)
- Velocity to 15cm/s (95%)
- Time to 500ns
- Time To First Fix (warm) 70 – 90 s
- Time To First Fix (cold) 210 – 300 s

SGR-ReSI & GNSS Receivers

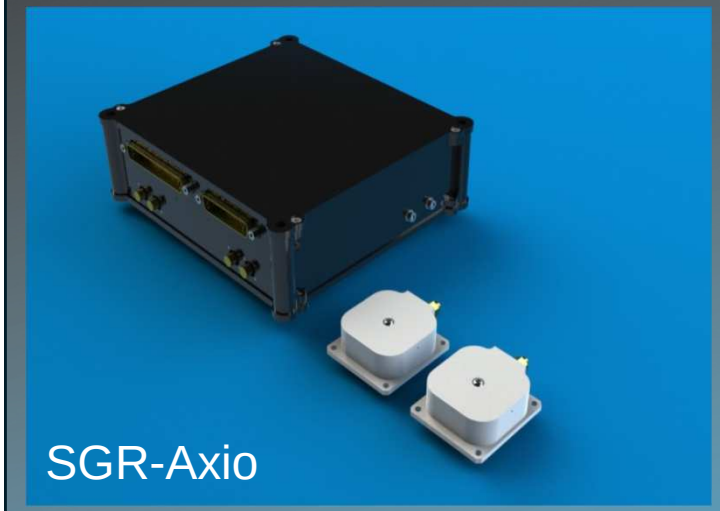
GNSS-based Remote Sensing Instrument – FPGA-based receiver with on-board processing capability. Can also be re-programmed in-orbit to upgrade capability.

SGR-ReSI

Applications include:

1. Radio Occultation
2. GNSS Reflectometry
   - Detecting GNSS signal reflected off the Earth's surface, to obtain geophysical data
   - Measurable parameters may include:
     - Ocean roughness
     - Ice edge sensing
     - Soil moisture

Will fly on CYGNSS, The University of Michigan's 8-nanosatellite constellation, designed to measure hurricane formation



SGR-Axio

SGR-Axio innovative design derived from the ReSI instrument. The SGR-Axio to be configured to support

- GNSS signals from: GPS, Galileo and Glonass
- Reconfigurable co-processor
- Support for up to 4 antennas
- 24xL1 channels
- Power / Mass: ~ 4W / 1Kg
- CAN-SU / RS422 interface

Solar Array Deployment Mechanism

The SADM provides a continuous transfer of solar array power and signals to the spacecraft while sun tracking on a small Low Earth Orbit (LEO) spacecraft. This technology has been derived from technologies developed on the Antenna Pointing Mechanism (APM).

The SADM can be supplied as a single sun tracking axis or Bi-axis (sun tracking axis + trim axis) and with or without drive electronics.

Physical Characteristics		
	Single Axis SADM	**Bi-Axis SADM**
Dimensions (mm)	Ø 157 x h 160	Ø 203x h 240
Power Consumption (28 V_{BUS})	3W	3.6W
Mass (kg)	<3.3Kg ± 5%	<5.25Kg ± 5%
Radiation (SADE)	5 kRad (Si)	5 kRad (Si)
Random vibration	8.35G_{rms} in all axes	8.35G_{rms} in all axes
Lifetime	6 years LEO Orbit (< 800Km)	6 years LEO Orbit (< 800Km)
Temperature	-30° C to +70° C operating -40° C to +80 ° C non-operating	-30° C to +70° C operating -40° C to +80° C non-operating
Number of Qualification Cycles	>70 000 full rotation of 360°	>70 000 full rotation of 360° >4000 Back & forth between ±60°

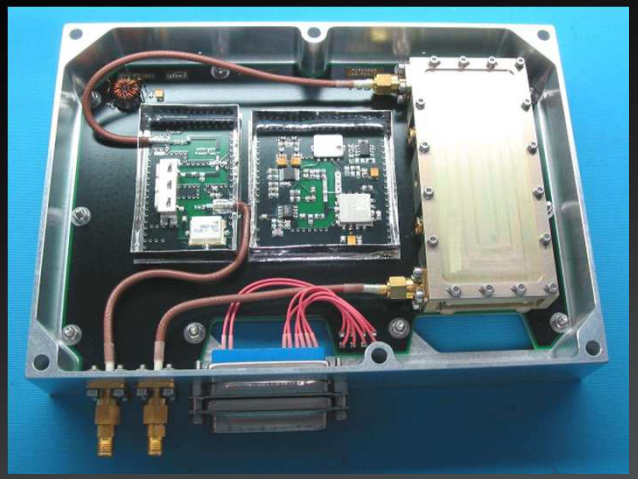
Cost-effective star trackers for missions with med- and high accuracy attitude determination requirements

	Procyon	Rigel-L
Attitude accuracy (1-σ) **Bias** **Relative Accuracy** **EOL for a single CHU**	 **X/Y < TBD arcsec** **Z < TBD arcsec** **X/Y < 5 arcsec** **Z < 50 arcsec** **Tracking rate @ 0.1 deg/s** **CHU temp @ 15 degC** **Operating at 4 Hz**	 **X/Y < 3.0 arcsec** **Z < 3.5 arcsec** **X/Y < 3 arcsec** **Z < 25 arcsec** **Tracking rate @ 0.5 deg/s** **CHU temp @ 15 degC** **Operating at 4 Hz**
Update Rate	**1Hz – 4Hz**	**1Hz – 16Hz**
Maximum tracking rate	**2 deg/s, 2 deg/s/s**	**6 deg/s, 2 deg/s/s**
Exclusion angles (standard baffles)	**Sun: 30 deg** **Earth: 30 deg** **Tolerant to Moon in FOV**	**Sun: 30 deg** **Earth: 29 deg** **Tolerant to Moon in FOV**
Interface	**CAN/RS422/ RS485**	**CAN/RS422/ RS485**
Power **Single CHU** **Double CHU**	**Supply 16-50V** **10W at 28V** **12W at 28V**	**Supply 16-50V** **10W at 28V** **12W at 28V**
Radiation	**< 10kRad**	**< 10kRad**

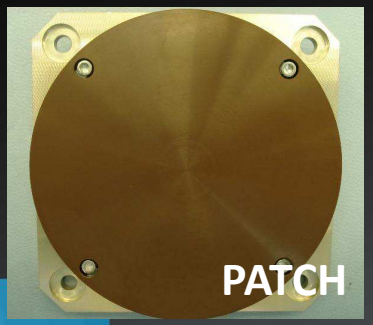
CHU – based on APS technology
DPU – miniaturised OBC750

S-band TM/TC Platform Suite

HERITAGE S-BAND RECEIVER

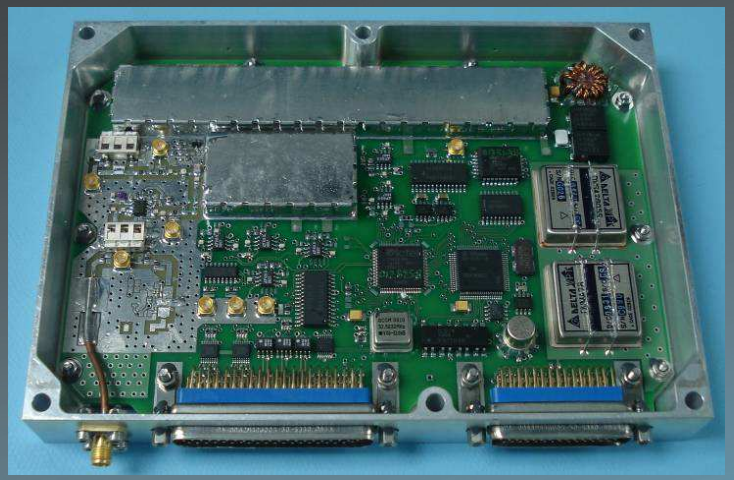


Data rate: 9.6 kbps or 19.2 kbps
Modulation: CPFSK
TTC interface: CAN-SU



S-BAND PATCH AND QUADRIFILAR HELIX ANTENNA

HERITAGE S-BAND TRANSMITTER



Data rate: 9.6 kbps - 8 Mbps
Modulation: BPSK or QPSK
Coding: ½ rate k=7 convolutional
200 mW RF output power
Optional HPA
- 2 W heritage unit
- 4 W heritage unit

TTC interface: CAN-SU

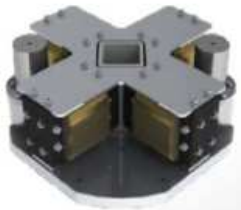
FlexRx – Space qualified on TDS-1

Flexible, compact S-Band Receiver
- Data rate: 9.6 – 600 kbps
- Modulation: CPFSK, BPSK + others
- Dimensions: 190 x 135 x 31 mm
- Mass: < 0.9 kg
- TTC interfaces: CAN-SU & RS422

Electric Propulsion (EP) - Quad Confinement Thruster (QCT): SSTL / SSC Collaboration

Key Competitive Capabilities & Target Mission Scenarios:

- Thruster vector control without moving parts
- Low-power operation
- Low-cost and low-power, small satellites
- Replacement for inert gas and resistojet technology
- QCT-200 is baselined on the SSTL NovaSAR mission – 2016 launch

	Technology	Target Performance	Commercial need
	QCT-40	• Input power: 40W • Propellant: Various (Xe, Butane, H2O, etc) • Specific impulse: 250s • Thrust: 3.3mN • Thrust efficiency: 10% • Power/Thrust: 12.1 W/mN	Candidate technology for replacement of the heritage Xenon resistojets on SSTL 50kg - 200kg platforms.
	QCT-200	• Input power: 200W • Propellant: Xenon • Specific impulse: 1200s • Thrust: 10.2 mN • Thrust efficiency: 30% • Power/Thrust: 19.6 W/mN	Low cost and low power EP alternative for the growing small satellite industry (100kg - 500kg platforms).
	QCT-1500	• Input power: 1500W • Propellant: Xenon • Specific impulse: 1600s • Thrust: 95.6 mN • Thrust efficiency: 50% • Power/Thrust: 15.7 W/mN	Low cost alternative to Hall effect thrusters and gridded ion engines for GEO platforms.