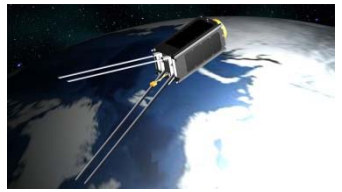


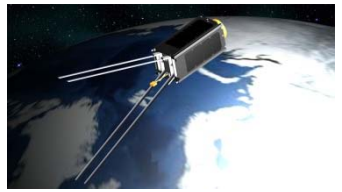
A Historical Overview of the University of Stellenbosch's Satellite Projects over the past 25 years

WH (Herman) Steyn

whsteyn@sun.ac.za

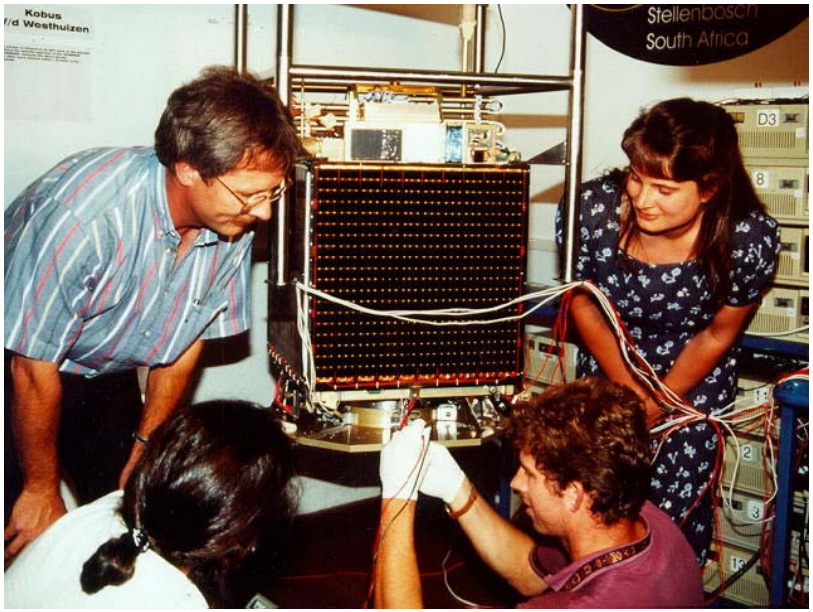
KNOWLEDGE

SUNSAT Birth

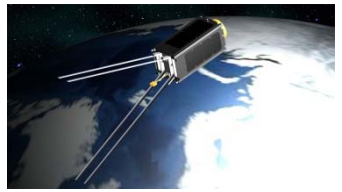


- SUNSAT student project in E&E Eng Department of Stellenbosch University started in 1992

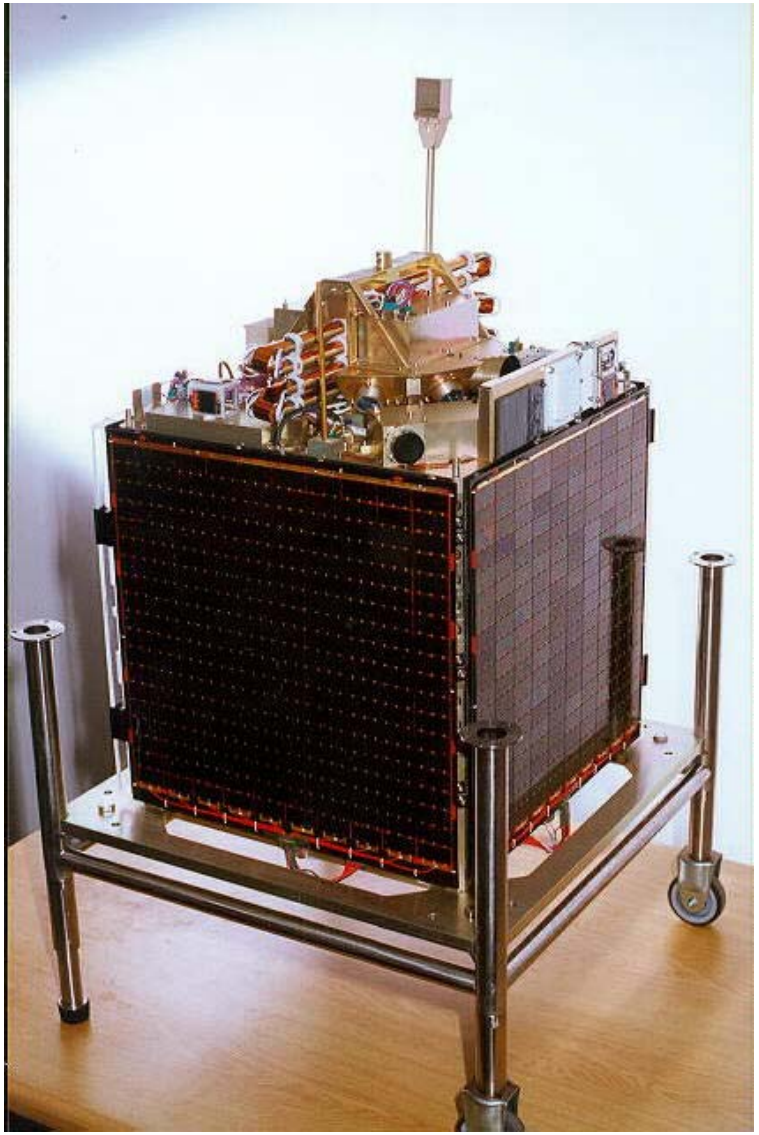
- Aims were to:
  - Train engineers for a future SA space industry
  - Challenge graduate students
  - Inspire school kids in science
  - Have international cooperation
  - Get sponsorships from SA industry



SUNSAT Project



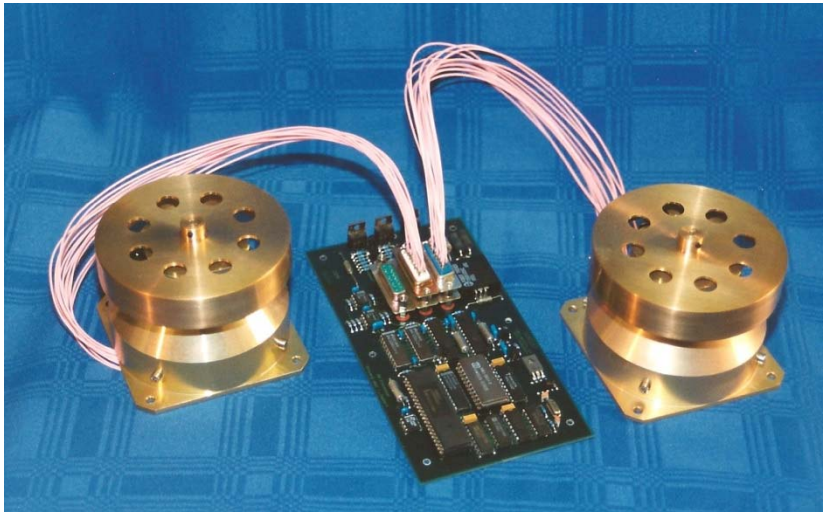
- Africa's first indigenous (locally built) orbiting satellite
- Satellite was designed and developed without any technology transfer help
- Developed by graduate students and staff in period 1992-1998
- Produce more than 100 Masters and PhD degrees
- First microsatellite (64kg) with SPOT-5 type 3-band multispectral resolution camera
- 3456 pixel push-broom sensor giving a 52 km swath and 15 m GSD from 800 km

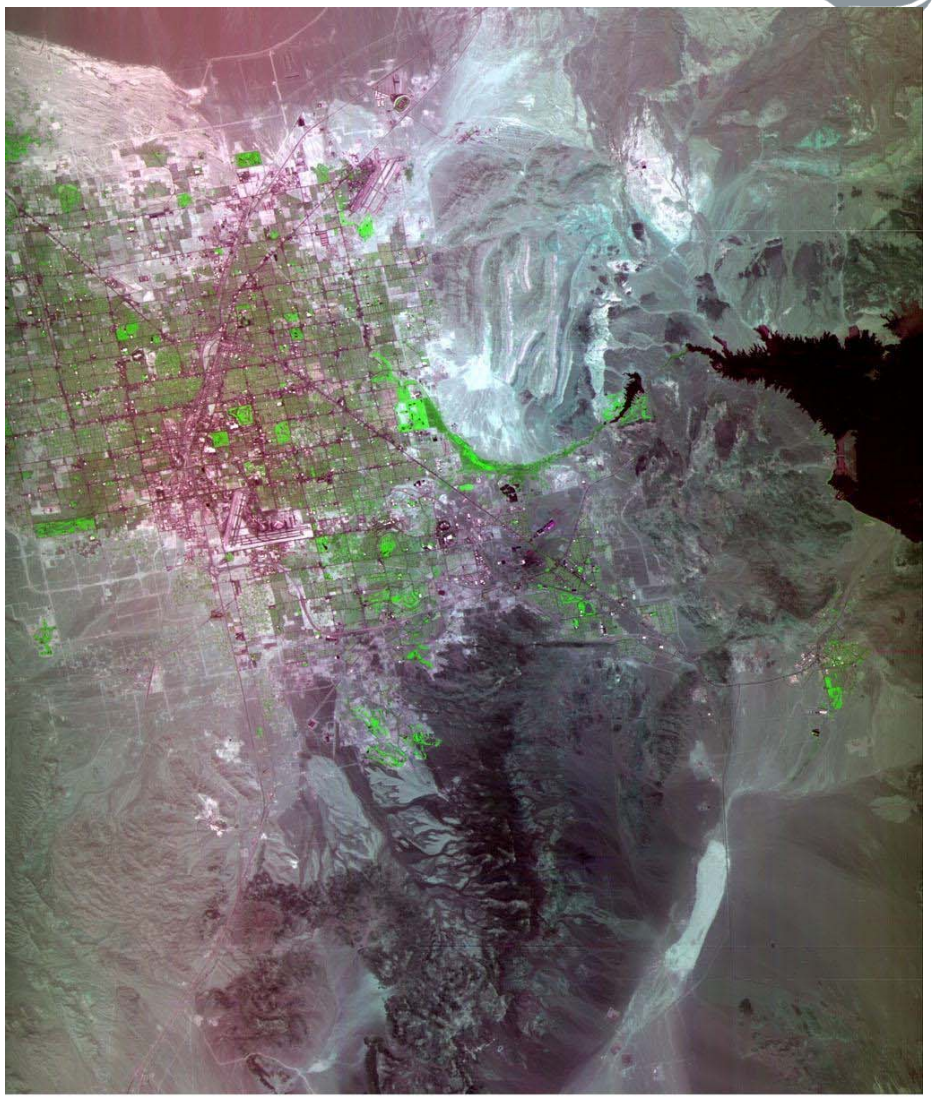


SUNSAT Launch

- NASA GPS receiver and laser reflectors for earth gravitation research
- Free piggyback launch with the Danish Örsted microsatellite and USA Argos satellite as the primary payload
- Launch 23/2/99 on Delta II USAF
- Elliptical orbit altitude 640 to 850 km
- Radio amateur payload was huge success (store & forward, voice repeater)
- Orbital useful life almost 2 years, last contact made in January 2001
- Most probably a battery malfunction

SUNSAT Imaging





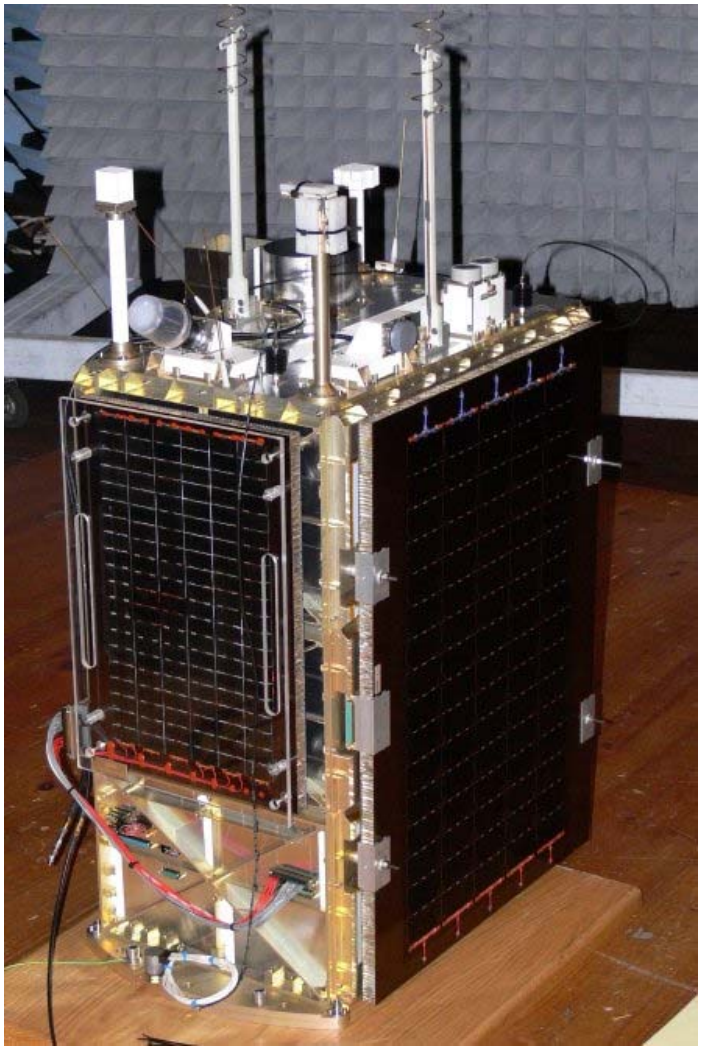
SUNSAT - Imager (15m GSD)

Imaged from Kitsat-3

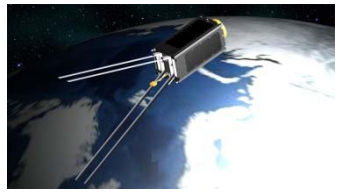
Las Vegas (USA)
99/06/11 20:02:03

Sumbandila Satellite Project

- **83 kg Microsatellite (DST sponsored)**
  - 505 km 9 am/pm sun-synchronous orbit
  - 6.25 m GSD Imaging in 6 spectral bands
  - Viewfinder for real time image steering
  - 24 Gbyte onboard image storage
  - 3-Axis Reaction wheel stabilized
  - Email Communication system
  - Propulsion system for drag compensation
  - Expected orbital life 3-5 years
- **Satellite build by SunSpace in 15 months**
- **Stellenbosch University did the project management and ADCS development**
- **Launch 17 Sept 2009 @ 17h55:07 GMT from Baikonur Kazakstan on a Soyuz-2 rocket**

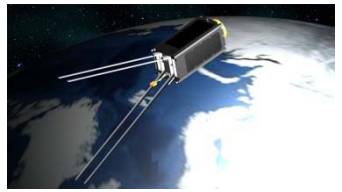


ADCS Product Examples

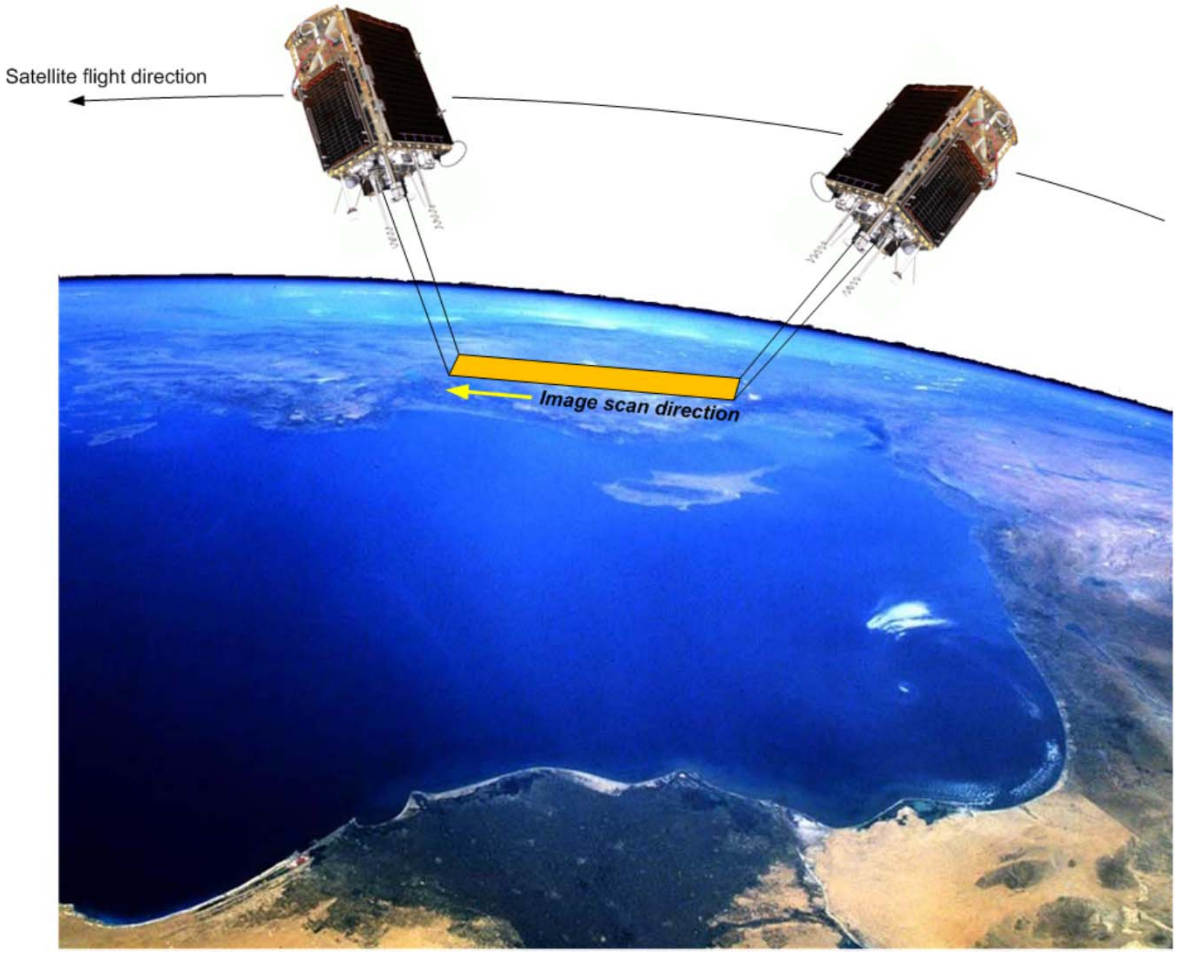


- Control Moment Gyro, Reaction wheels
- CMOS camera based sun and earth sensors
- Magnetic control units, MT & MM
- AODCS simulation programs
- Star Trackers, GPS Receivers, etc

Sumbandila Imaging
FMC4 scanning with Reaction wheels

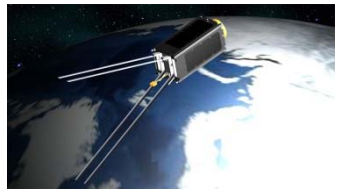


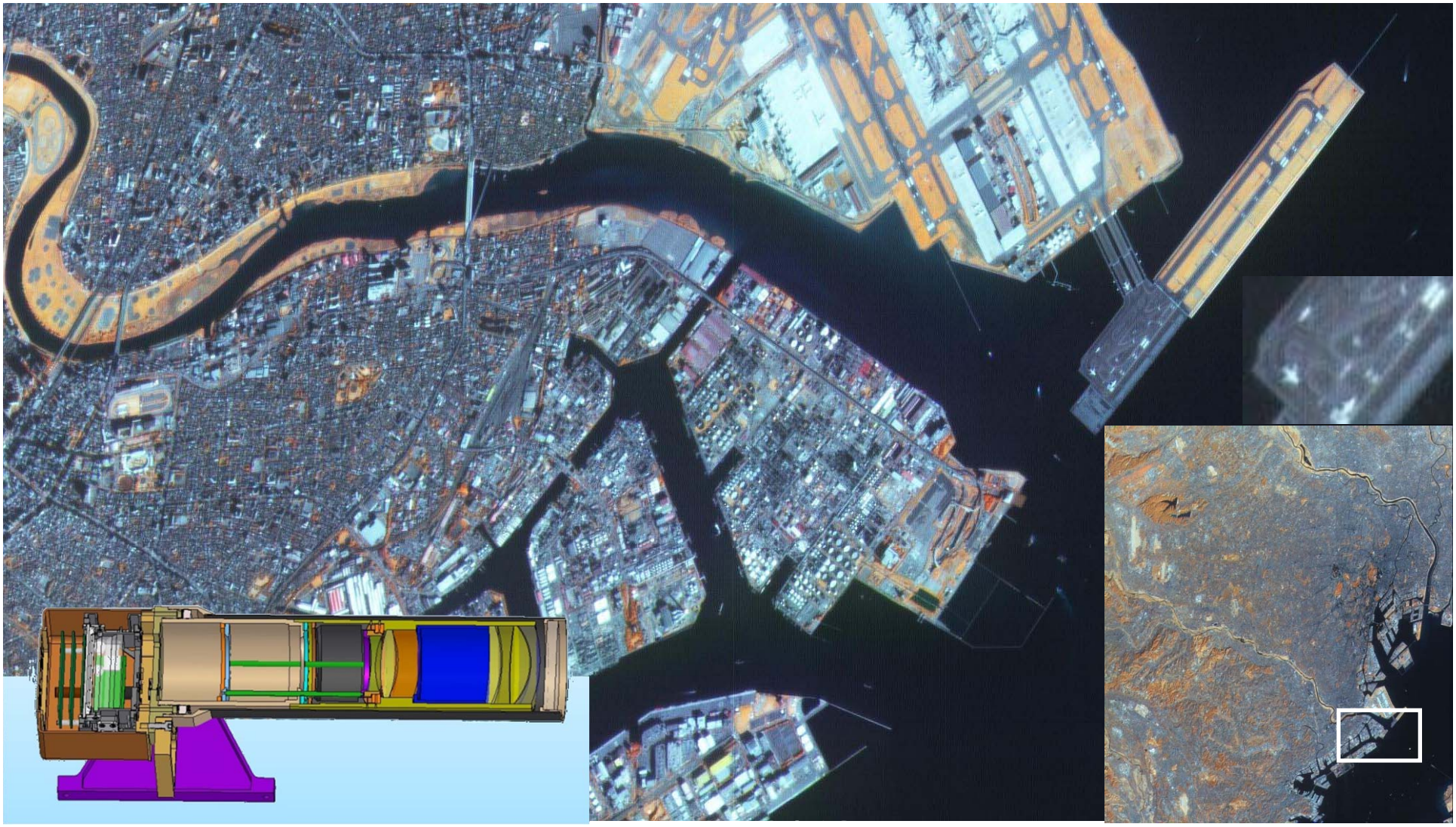
- **Pitch forward ≈ 13 deg**
  Roll = required amount for off-track image target
- **Increase pitch rate to ≈ -0.6 deg/sec**
- **Scan image for 34 sec at constant rate for a 60 km image strip through target**
- **Stop at pitch ≈ -13 deg**
- **Return to nadir pointing**
  Pitch & roll = 0 deg



Imaging Product (SumbandilaSat)

Tokyo Haneda Airport Area (≈ 12 km x 8 km)





Tsunami Damage (SumbandilaSat)
Sendai 05/04/11 (right side image)

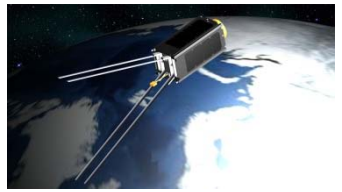
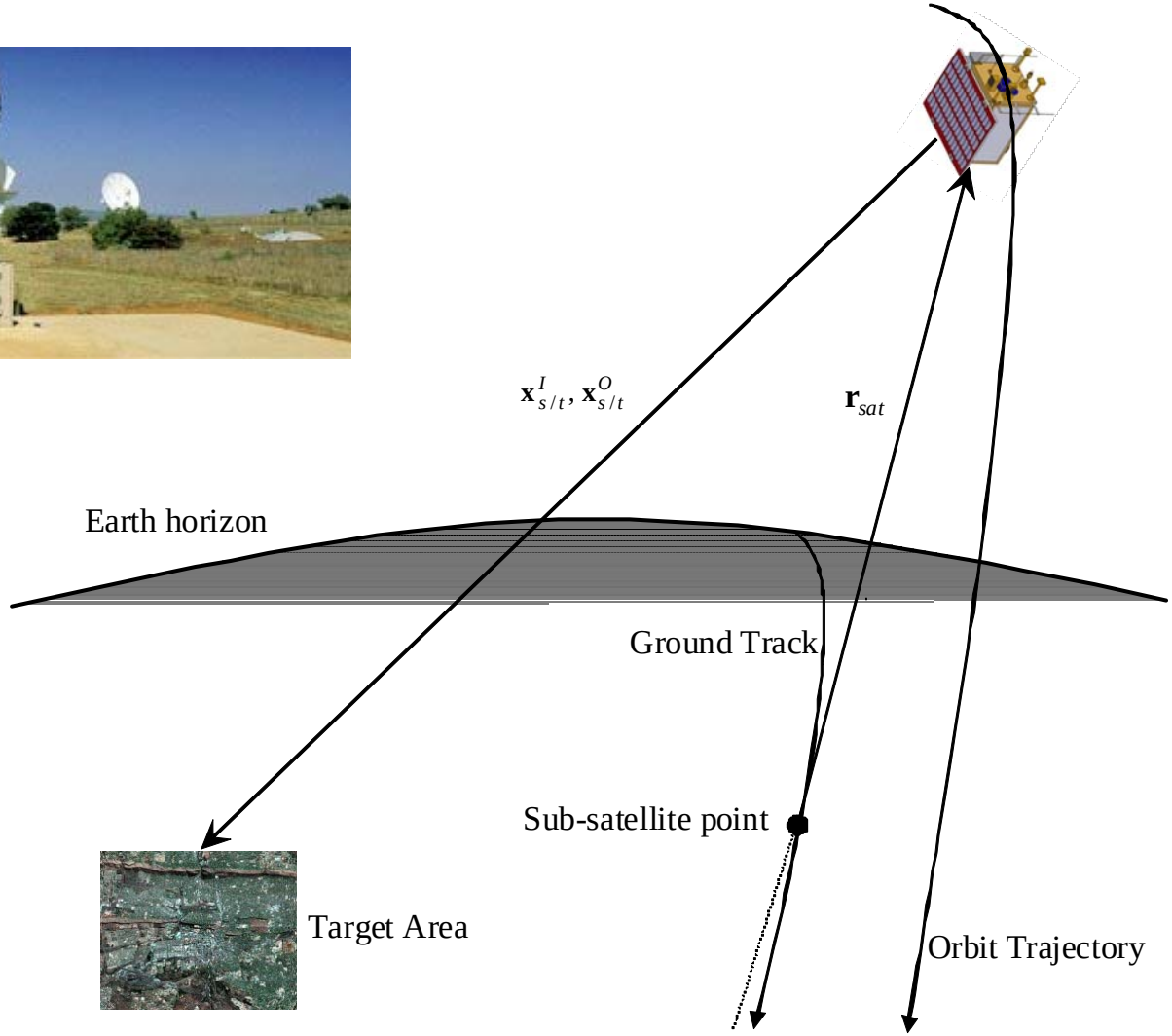
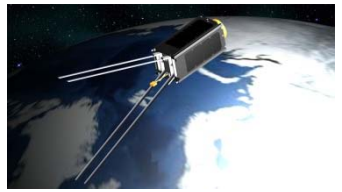


Image Data download: Target Tracking towards Ground

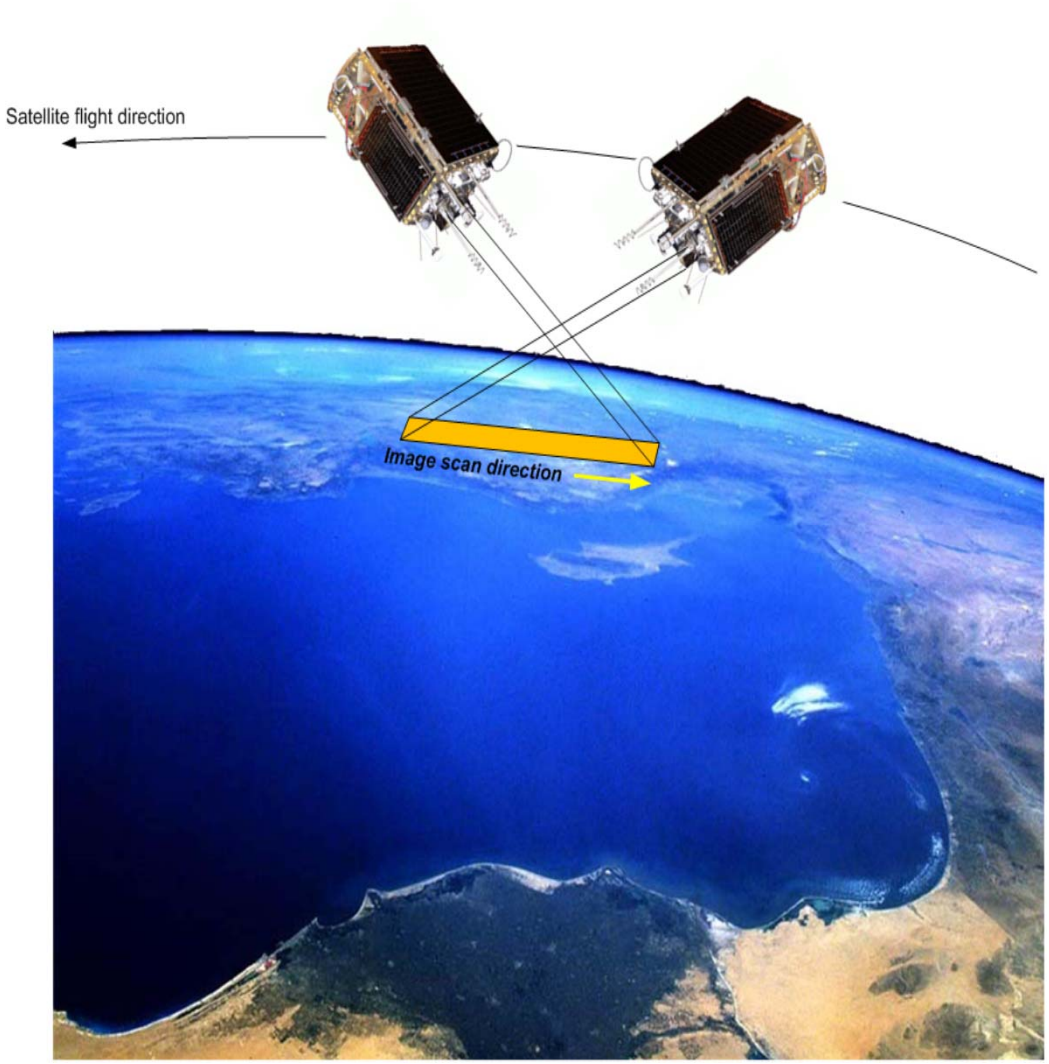


Sumbandila Imaging

New FMC4 scanning with only X-wheel

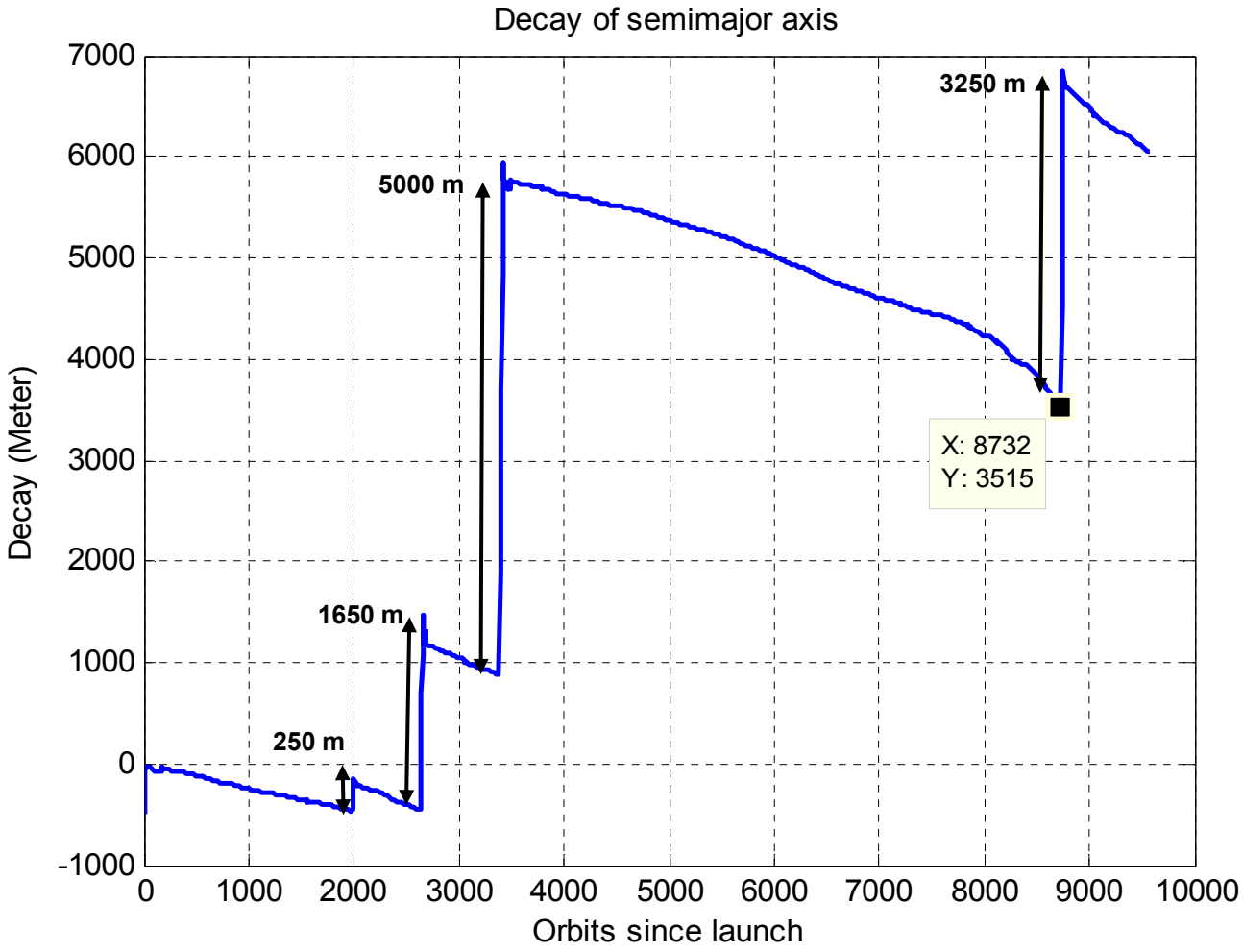


- **Satellite in constant Y-spin of -0.955 deg/sec. Phase pitch angle to reach zero at image centre (using only magnetic control)**
- **At 60 sec prior to image centre give required roll offset using X-wheel**
- **Scan image for 34 sec at -0.955 deg/sec rate for a 60 km image strip through target**
- **Return to zero roll angle and stop X-wheel 60 sec after image centre**

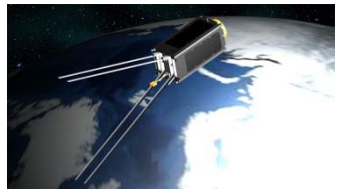


Propulsion: Orbit Maintenance SumbandilaSat

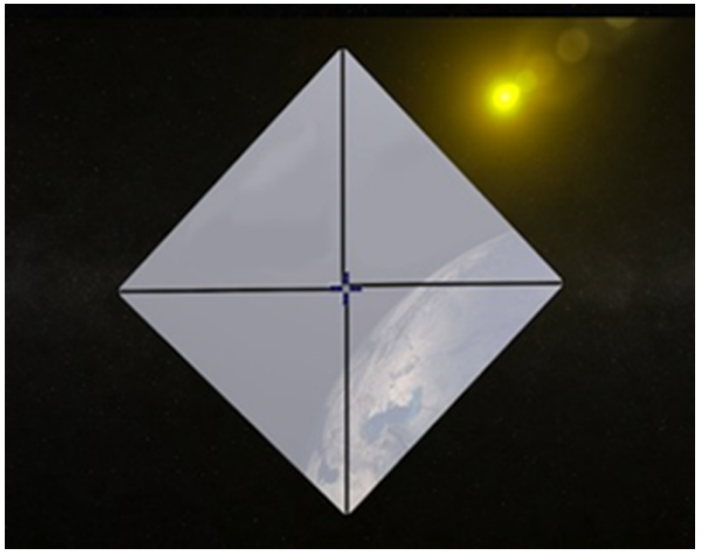
- On 26th January 2010 the butane propulsion fired for a total of 75 sec to lift the orbit ≈ 250 m
- On 9 to10th March 2010 a total of 20 x 30 sec firings was used to lift the orbit another ≈ 1650 m
- On 27 to 30th April 2010 a total of 34 x 60 sec firings was used to lift the orbit another ≈ 5000 m
- On 14 to 16th April 2011 a total of 20 x 60 sec firings was used to lift the orbit another ≈ 3250 m
- Final orbit perigee and apogee: 498 x 502 km

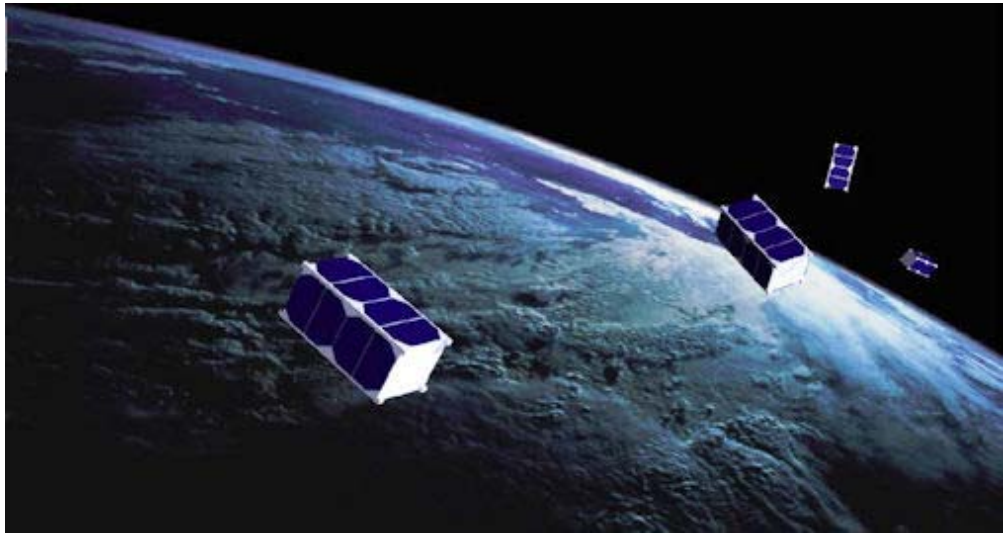


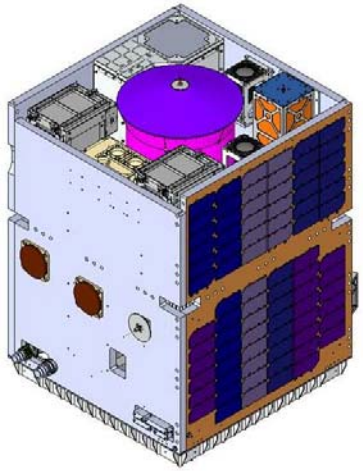
SU current Satellite Missions



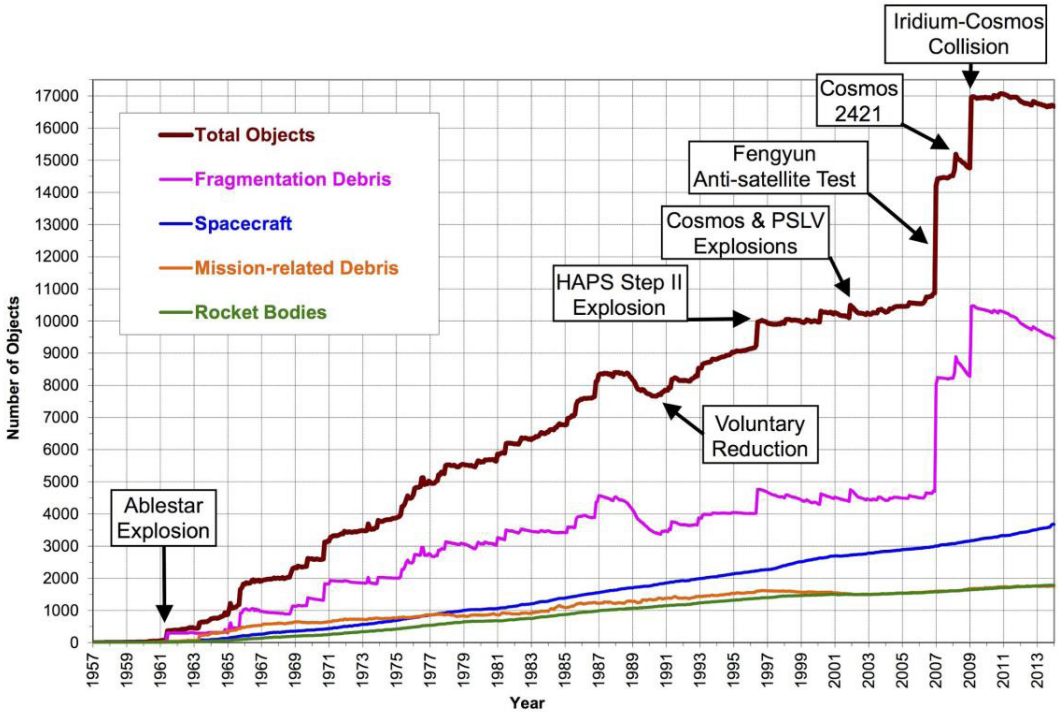
1. EU FP7 DeOrbitSail Project
2. EU FP7 RemoveDebris Project
3. EU FP7 QB50 Earth Science Mission

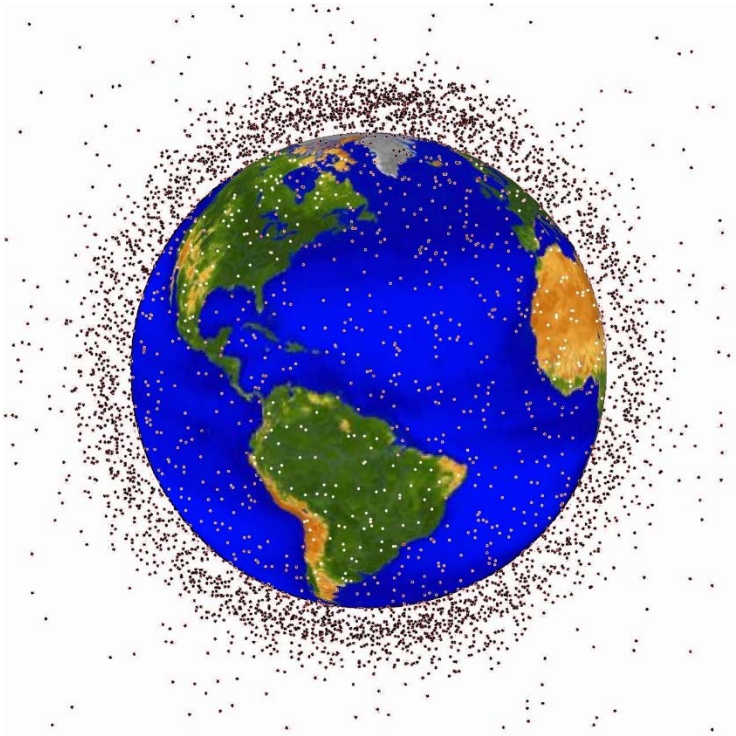






Background: Space Debris

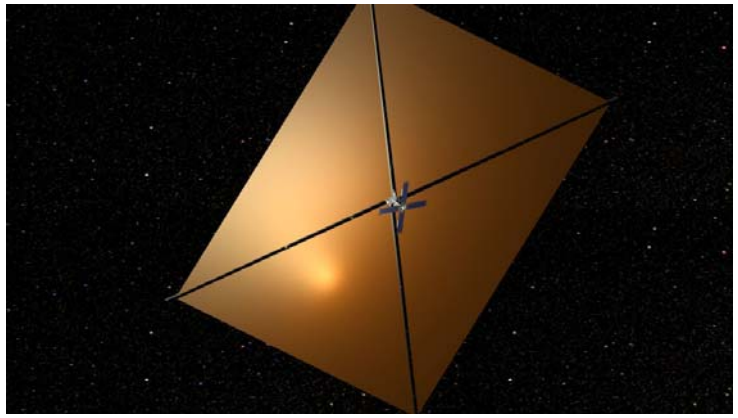




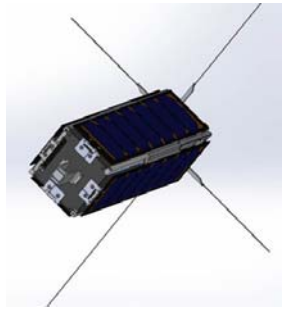
- Objects in the chart are limited to larger than 10 cm due to limited radar tracking capabilities
- The actual number of objects in orbits is estimated to be 370,000 (> 1 cm)
- Estimated 5,500 tons of man made objects currently orbiting earth, less than 2000 operational satellites

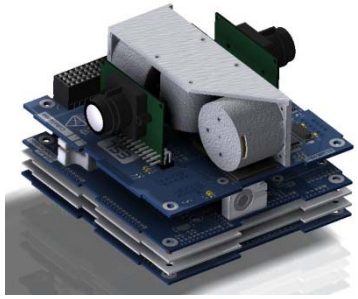
Participant in FP7 EU projects

- **DeOrbitSail**:
  - Coordinator: Surrey Space Centre (SSC)
  - SU contributing the ADCS of 3U CubeSat
  - Launched July 2015
  - Project Aims:
    - Deploy 16m^2 drag sail at 620 km
    - Do active attitude control for maximum aerodynamic drag during de-orbiting



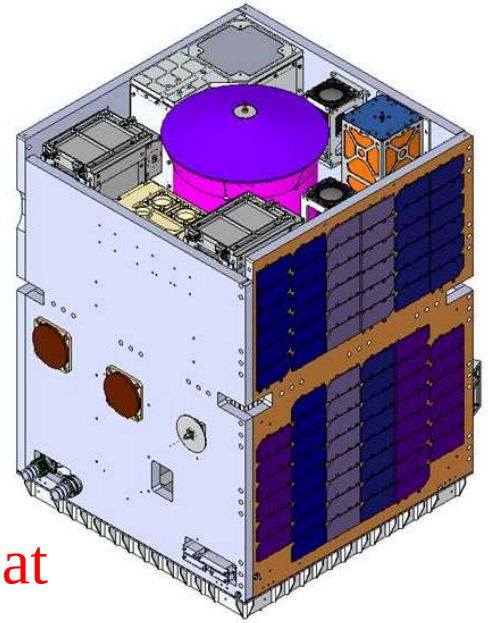
- **RemoveDebris**:
  - Coordinator: Surrey Space Centre (SSC)
  - SU contributing the ADCS for DebrisSats (2 x 3U CubeSats)
  - Launch date mid 2018
  - Project Aims:
    - Chaser microsatellite release 2 Debris CubeSats
    - Demonstrate automatic removal using a net and a harpoon to capture “debris”
    - De-orbit “debris” using inflatable balloon, tether



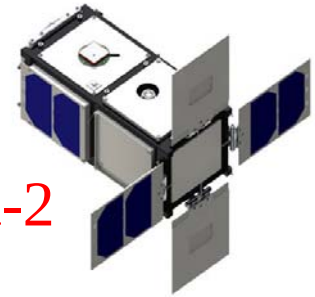


FP7 RemoveDebris project

- Sponsor: European Commission *(The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 607099)*
- Purpose: flight demonstration of ADR technologies with a microsatellite & debris dummies (Cubesats)
- Timeframe: 2013 – 2018. Flight middle 2018
- Partners:
  - Universities: Surrey (UK, coordinator), Stellenbosch (S. Africa)
  - Research institutions: CSEM (CH), INRIA (F)
  - SME (private company): ISIS (NL)
  - Space primes: Airbus DS (D, F, UK), SSTL (UK)



RemoveSat

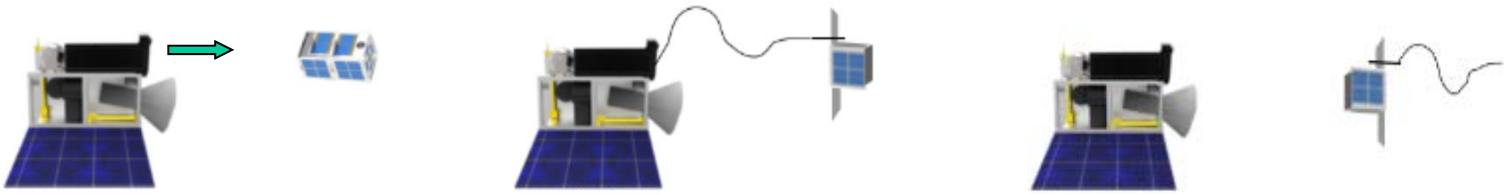


DebrisSat-2

Flight demonstrations

1 Net capture experiment

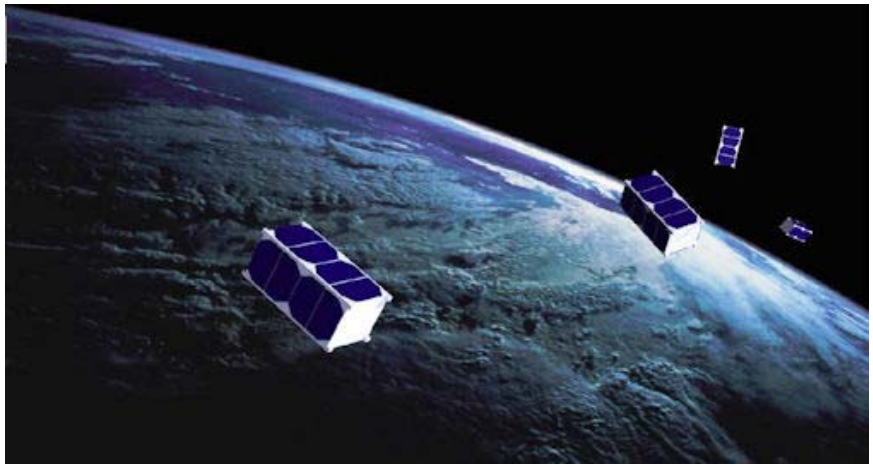
2 Harpoon capture experiment



3 Vision Based Navigation

QB50 Science Mission

- **EU FP7 science mission**
  - 31 x 2-unit & 5 x 3-unit CubeSats
  - Launched into a 415 km LEO from ISS
  - In-situ science down to 200 km
  - Obtain models for re-entry research
  - Launch 28 CubeSats April/May 2017 using Nanoracks from the International Space Station for release into orbit

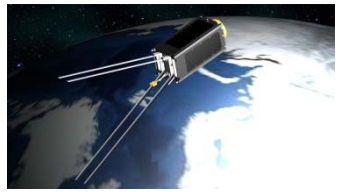


- **International Cooperation**
  - Invited participation of teams from 27 countries, we became involved in 2013
  - Provide a large number (500 to 1000) of university students with practical space science and technology experience
  - About 50 PhD and 250 Masters theses expected internationally as a result of QB50 project

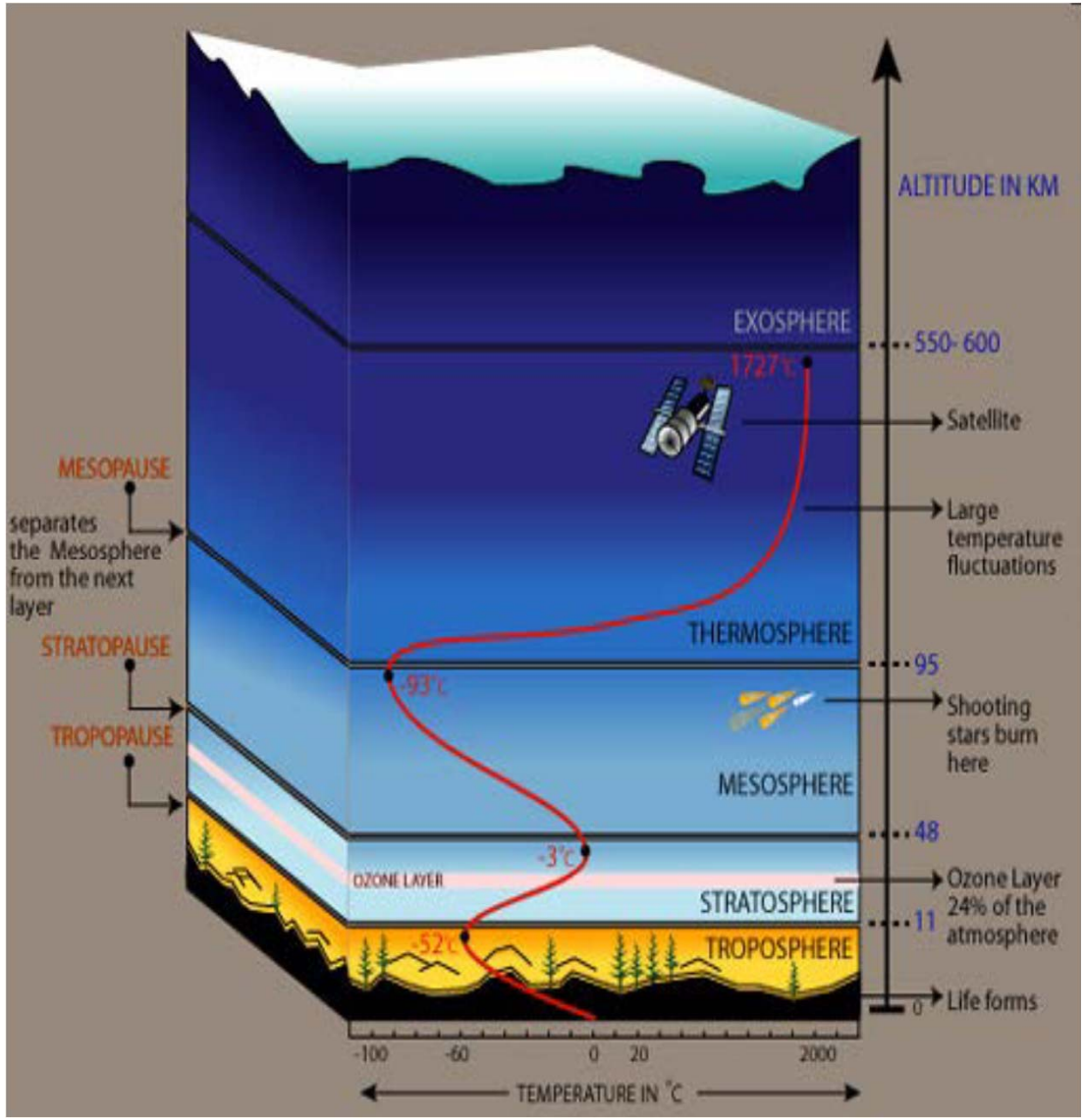
QB50

SEVENTH FRAMEWORK PROGRAMME

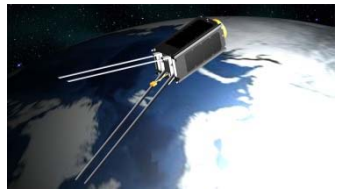
QB50 Mission Objective



- To study the spatial and temporal variations of key constituents (neutrals, ions, plasma) and parameters in the largely unexplored lower thermosphere
- Improve currently existing atmospheric / ionospheric models for reentry research
- Science can only be done with low cost nanosatellites due to the short mission life



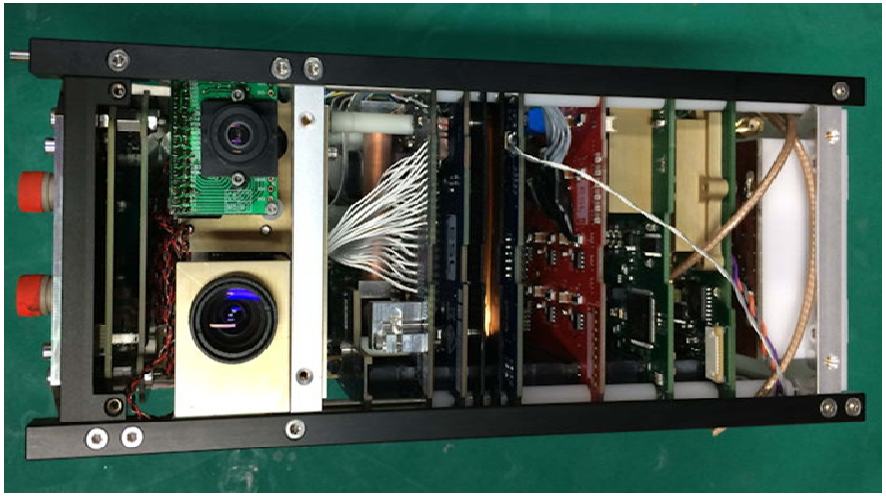
Our QB50 Participation

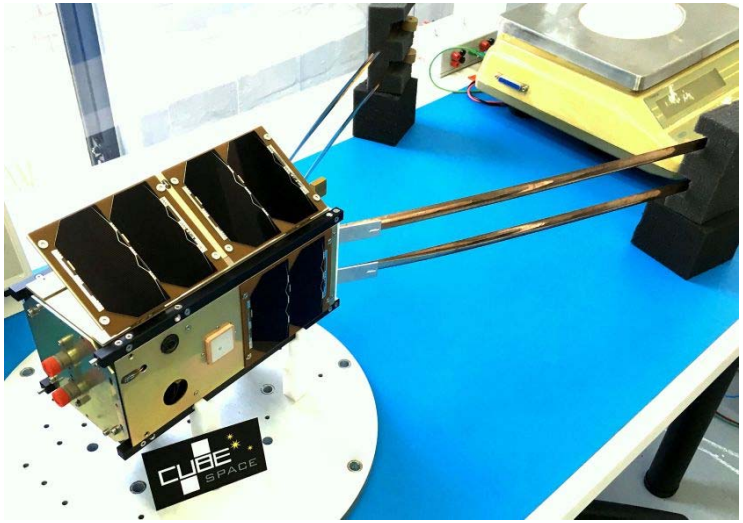


ZA-AeroSat (initially Africa's only contribution to QB50)

- SU project to design and manufacture 2U CubeSat
- Collaborate with CPUT – supply the comms payload
- Demonstrate passive aerodynamic stabilisation (antennae used like the feathers on a shuttlecock)
- Main payload: FIPEX science sensor
  - To measure the flux density of atomic and molecular oxygen
- New CubeStar star tracker experiment
  - Small: Size 5 x 3 x 7 cm, Mass < 90 g
  - Low power: 350 milli-Watt average
  - Accurate: 0.01 degree RMS bore sight error
- Novel experimental gravitational wave sensor

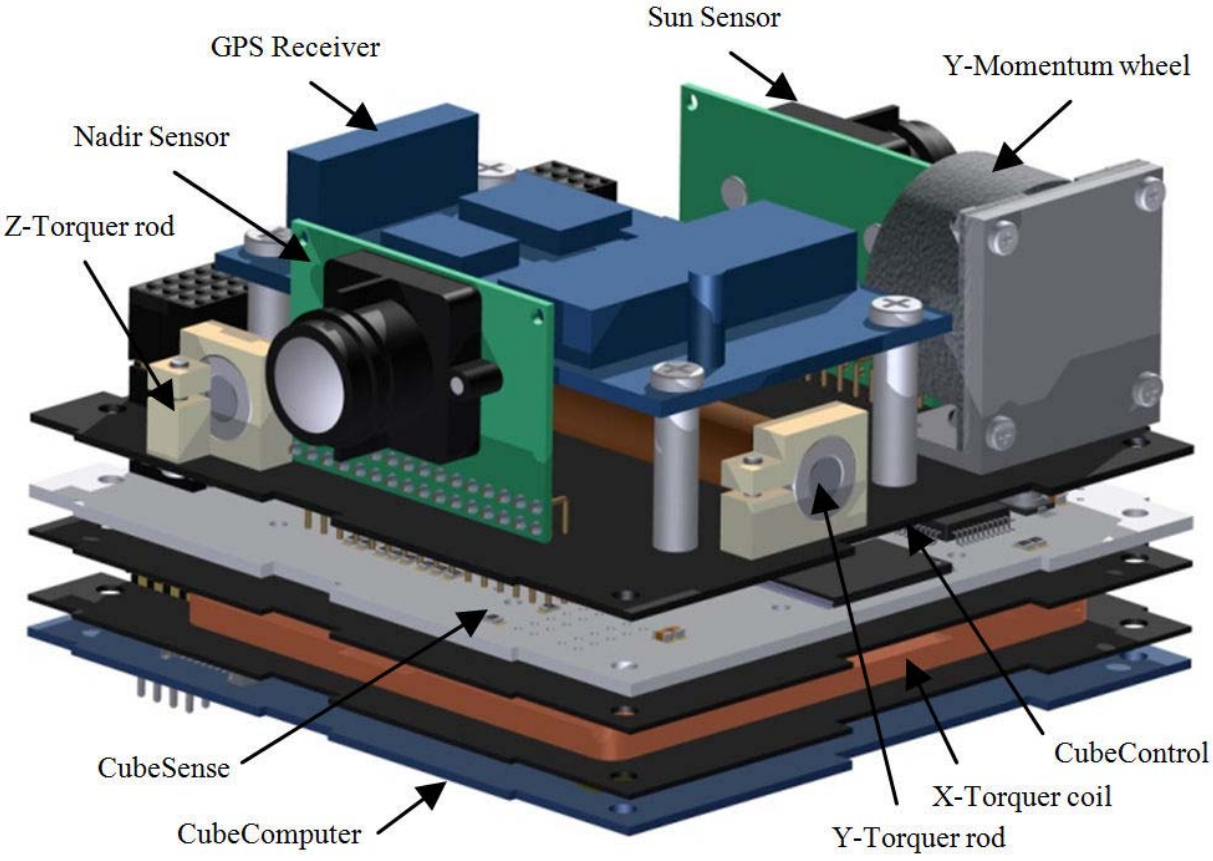
CubeStar





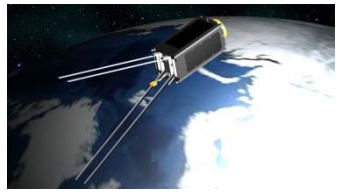
Stb Univ developed Nanosatellite Control Hardware

Deployable Magnetometer



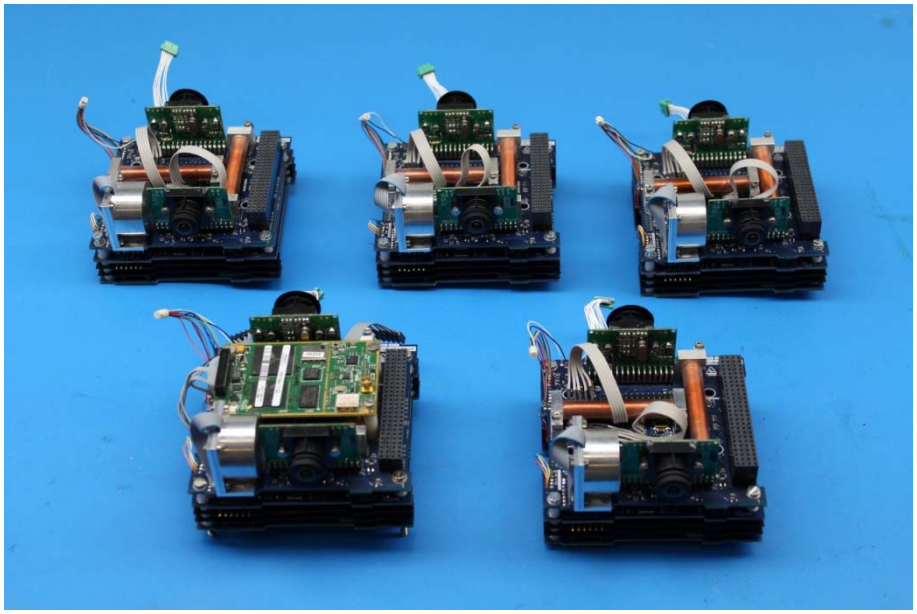
ADCS Bundle: **Size = 95 x 90 x 56 mm, Mass = 397 gram**

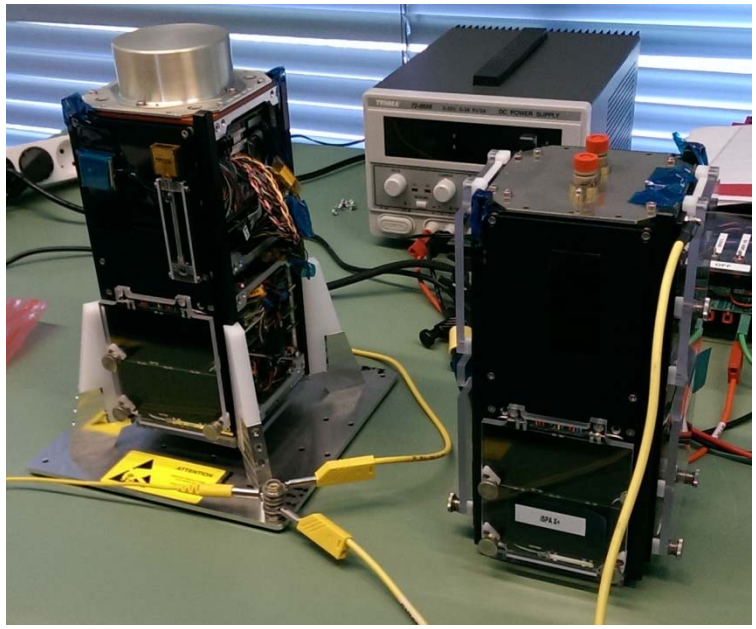
QB50 ADCS Bundles



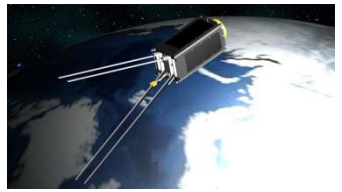
Contribution to other QB50 teams

- SU and the Surrey Space Centre at the Univ of Surrey in the UK developed these ADCS bundles
- 15 ADCS units for 2U CubeSats were supplied to teams lacking ADCS capability
- Delivery of 3 units in January 2014 to precursor QB50 flight (2 x 2U CubeSats) launched 18th June 2014, ADCS commissioned and still operational
- All other units were completed and delivered by end of 2014 to the QB50 teams

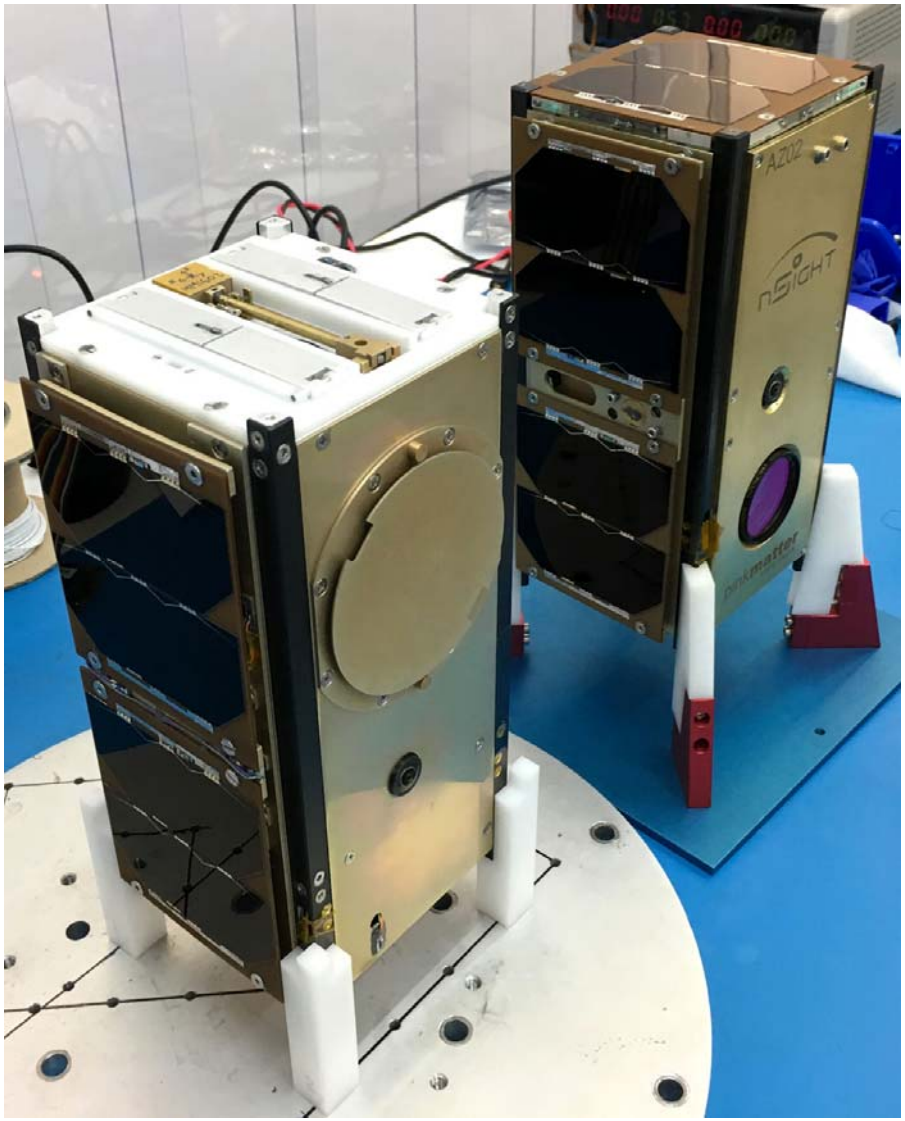




South Africa's QB50 Satellites



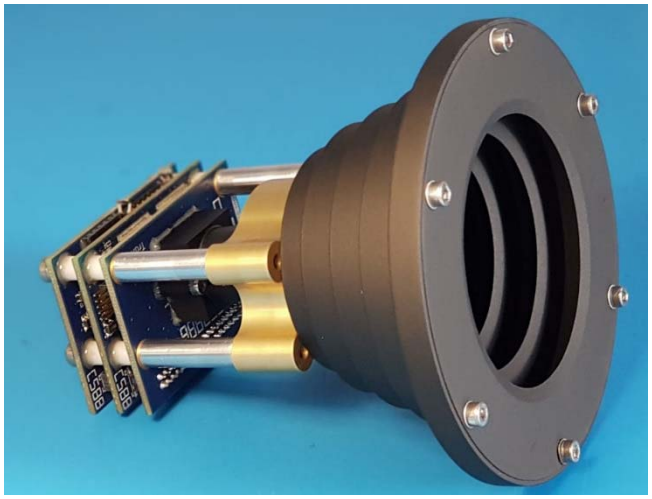
- ZA-AeroSat 2U CubeSat from the University of Stellenbosch (ESL & CubeSpace)
  - Fipex science sensor
  - CubeStar nano star sensor
  - Gravity wave sensor
  - Aerodynamic stabilisation
- nSight-1 2U CubeSat from Space Commercial Services (SCS)
  - Fipex science sensor
  - SCS Gecko CubeSat imager
  - CubeSpace avionics and OBC

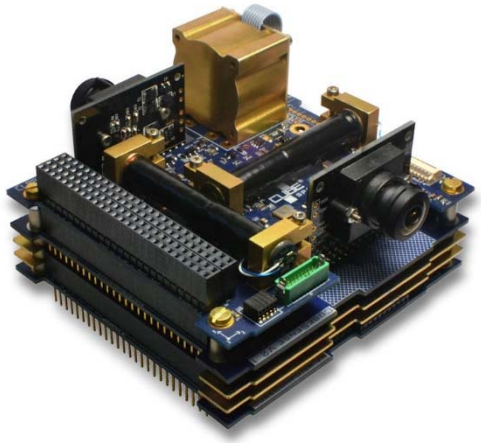


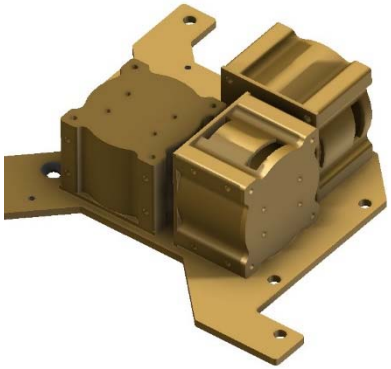
CubeSpace Products

Online Available @ CubeSatShop & CubeSpace websites:

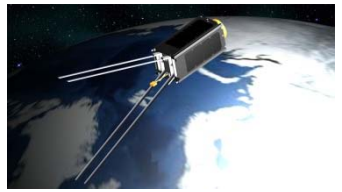
CubeComputer/CubeControl/CubeSense/CubeStar/CubeTorquer/CubeWheel/CubeADCS







Thank You !



Questions ?