CUSTOM
ADCS
SOLUTIONS

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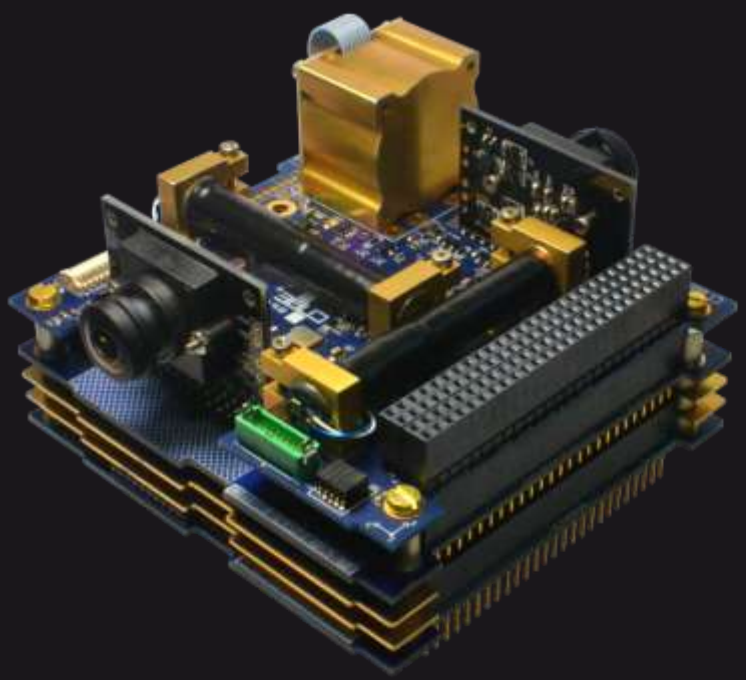
CubeADCS

Description

CubeADCS bundles offer custom solutions for a variety of satellite requirements. The ADCS OBC can also serve as a main satellite OBC. Each bundle consists of an integrated stack of CubeSpace components with UART, I2C, and CAN interfaces to other satellite subsystems. High-level ADCS software libraries are also available on any CubeADCS bundle. The bundles are compact and have low power consumption.



Standard Configurations

- **CubeADCS Magnetic:** Pure magnetic control
- **CubeADCS Y-Momentum:** 3-axis stabilisation
- **CubeADCS 3-Axis:** 3-axis control

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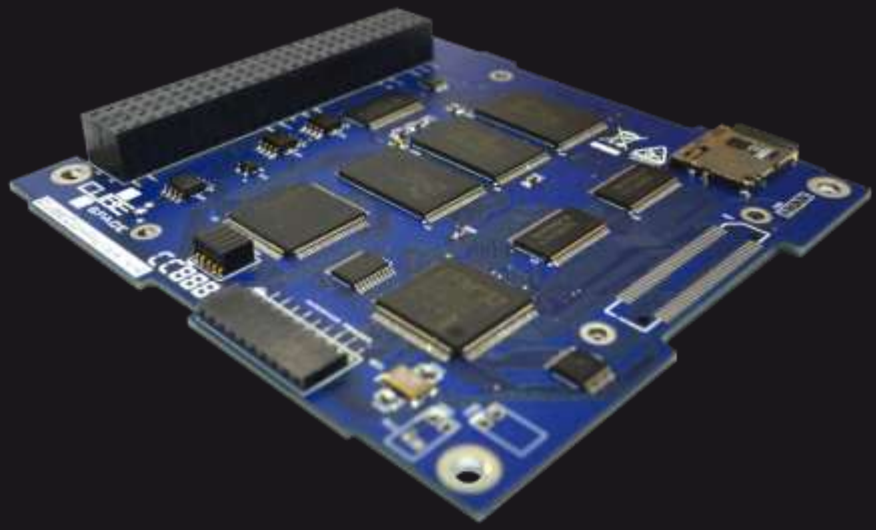
CubeComputer

Description

CubeComputer is a radiation-tolerant, generic OBC for nanosatellites. It can perform all the required ADCS operations and serve as the satellite's main OBC. The module is based on ARM Cortex-M3 architecture and includes an FPGA-based EDAC.



Features

- High performance, low power 32-bit ARM Cortex-M3 based MCU
- 4-48MHz @ 1.25 DMIPS/MHz
- Internal & external watchdog for added reliability
- 256 KB EEPROM
- 4 MB flash for code Storage
- 2 x 1 MB external SRAM for data storage
- SEU protection by means of an FPGA-based EDAC
- SEL protection by detecting and isolating latchup
- currents
- MicroSD socket for storage up to 2 GB

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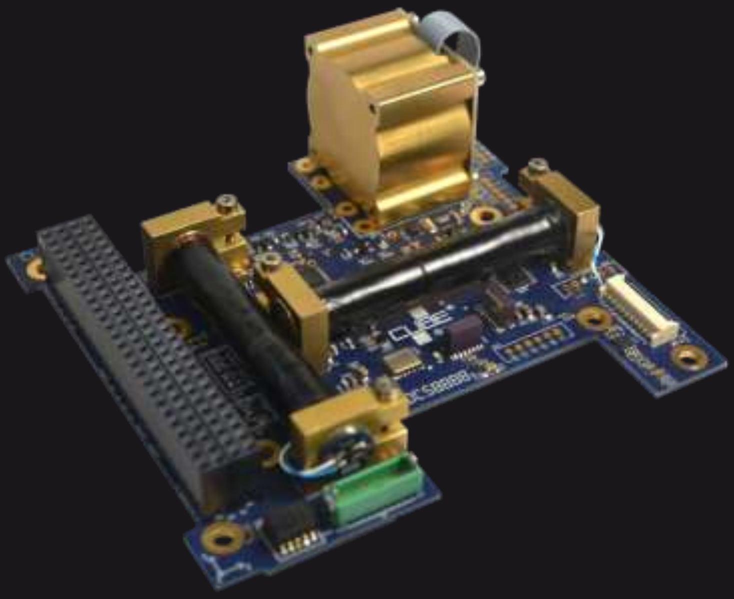
CubeControl

Description

CubeControl is an actuator and sensor interface module for nanosatellites with advanced attitude control requirements. It is capable of controlling magnetorquers and momentum/reaction wheels. It can also interface with magnetometers, coarse sun sensors, and rate sensors. The module can be configured to include any desired combination of actuators and sensors, depending on the mission requirements.

Actuators & Sensors

- 3-axis Magnetorquers
- Up to two 3-axis magnetometers
- Up to three Momentum/Reaction wheels
- Up to ten Coarse sun sensors
- 3-axis MEMS rate sensors



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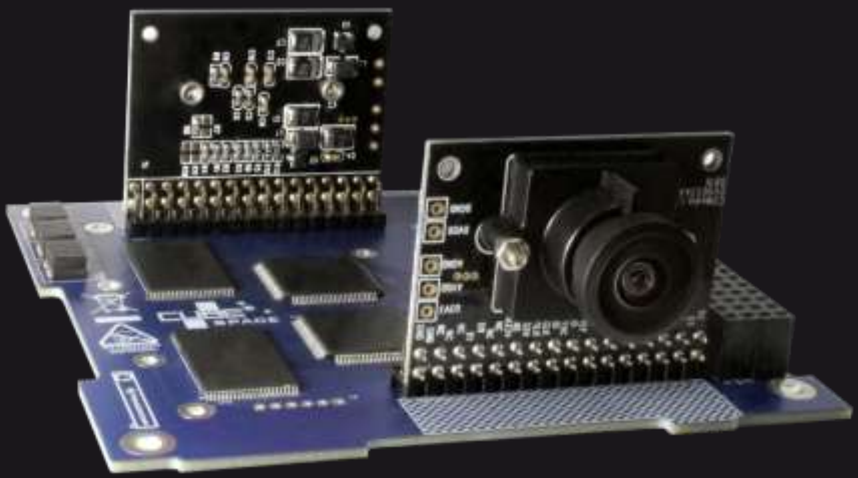
Description

The CubeSense module is an integrated sun and nadir sensor for attitude sensing. It makes use of two CMOS cameras - one dedicated to sun sensing and another for horizon detection. The sun sensor has a neutral density filter included in the optics. Both cameras have wide FOV optics. The primary outputs of the sensor are two angles that can be used to calculate the sun and nadir vectors relative to the CubeSense camera boresights.

CubeSense



Features

- **1024 x 1024 pixel CMOS image sensor**
- **190 FOV fisheye lens**
- **Configurable placement options for each camera**
- **Dual FPGA/SRAM system for redundancy**
- **Sun and Nadir accuracy: <0.2° (3σ)**

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CubeTorquer

Features

- $\pm$ 0.2Am^2
- 2.9Am^2/A
- 2.5% Linearity
- 10mm diameter X 60mm length
- $\pm$ 30Ω

CubeWheel

Features

- Brushless DC motor with vacuum-rated bearings
- Mountable in 3 axes
- 12-bit angular rate feedback
- Integrated electronics with speed controller and
- I2C, UART, and CAN interfaces

www.cubespace.co.za

nSight-1 and ZA-AeroSat

Shared Technology

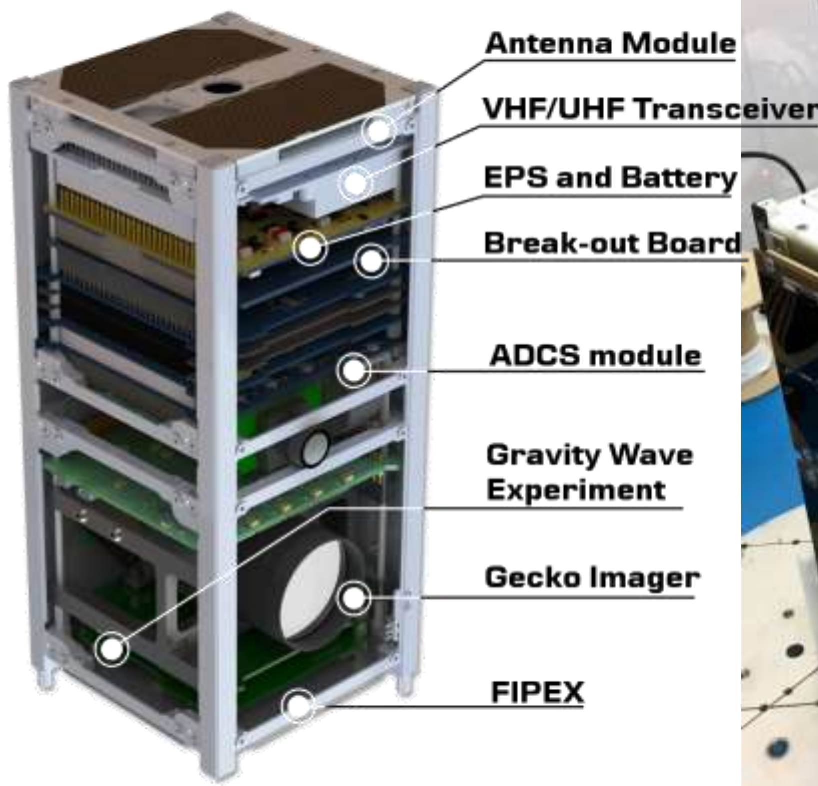
- FIPEX Science Unit
- Avionics
- Gravity Wave Experiment
- ADCS Hardware
- Flight Software

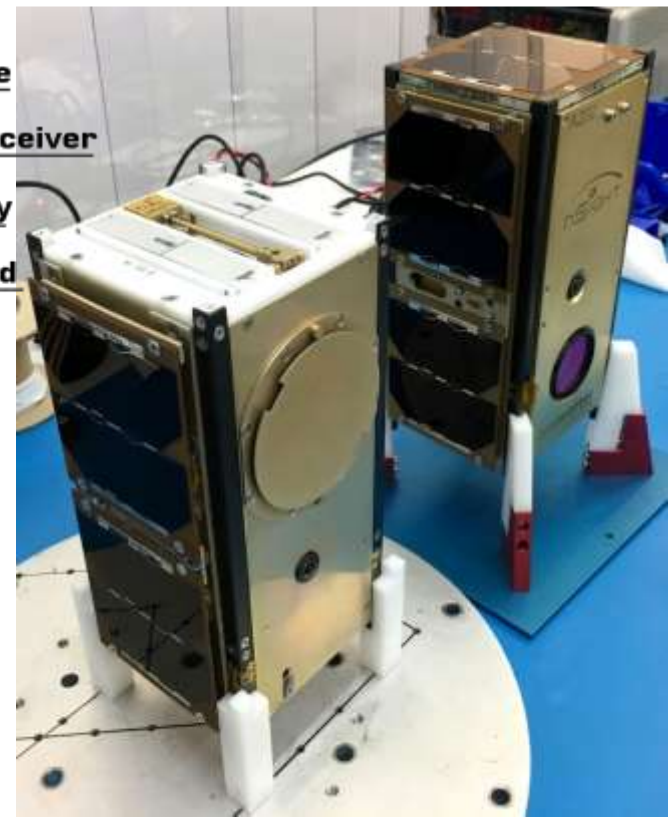
ZA-AeroSat

- Star Sensor
- S-Band transmitter
- Aerodynamic stabilization

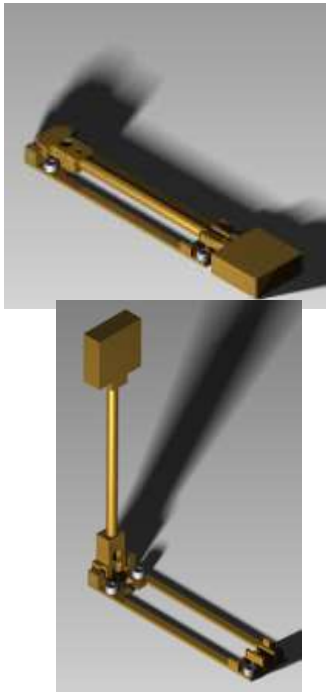
nSight-1

- Gecko Imager



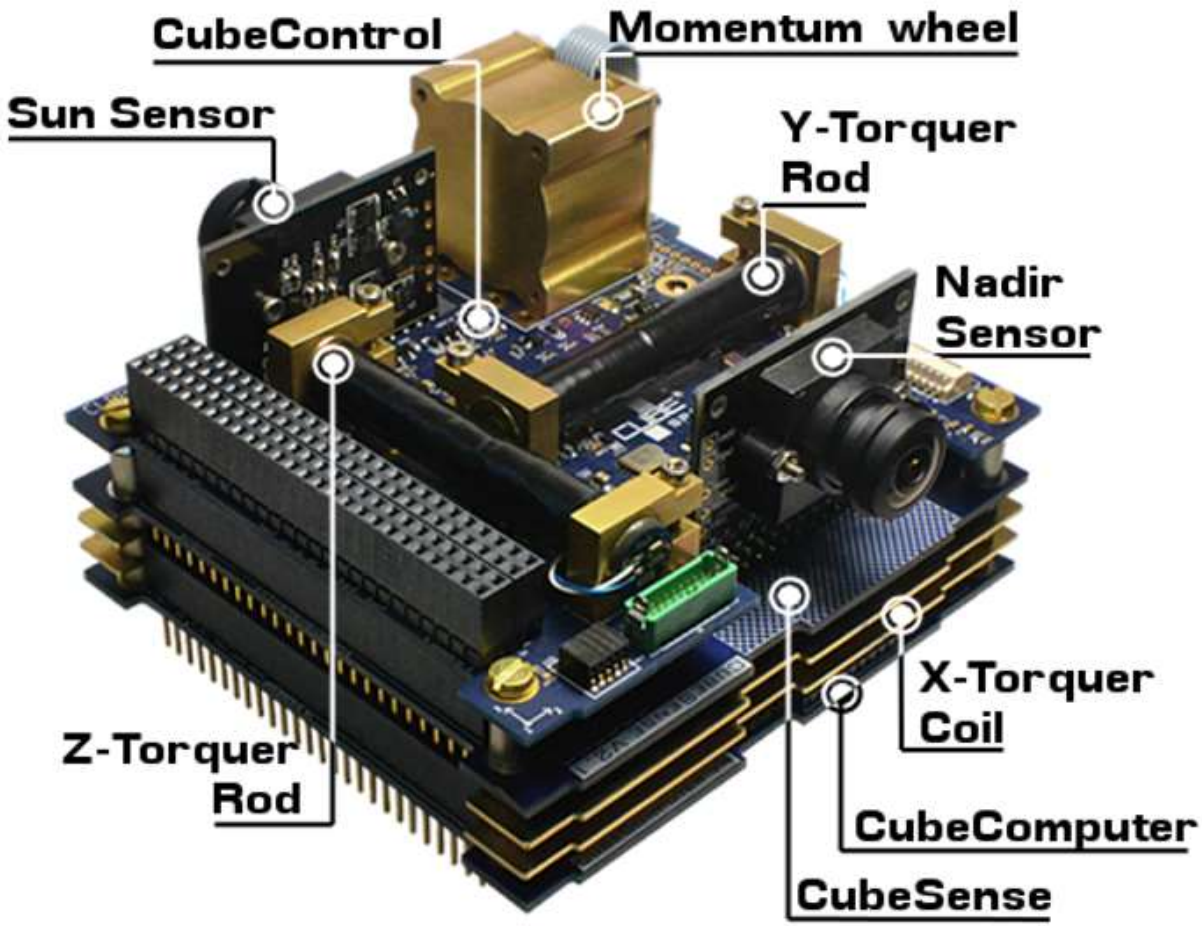


ADCS Hardware



Deployable Magnetometer

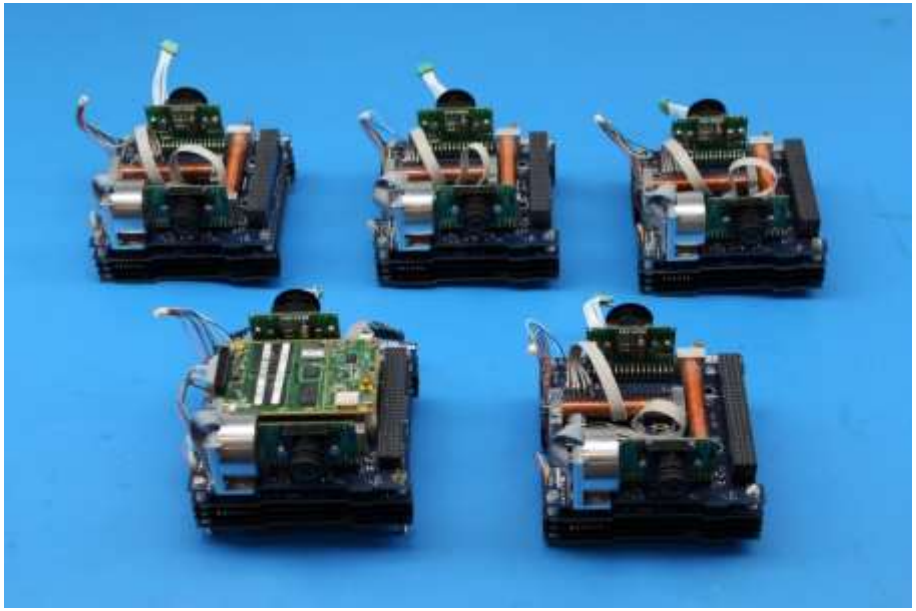
Coarse sun sensors



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

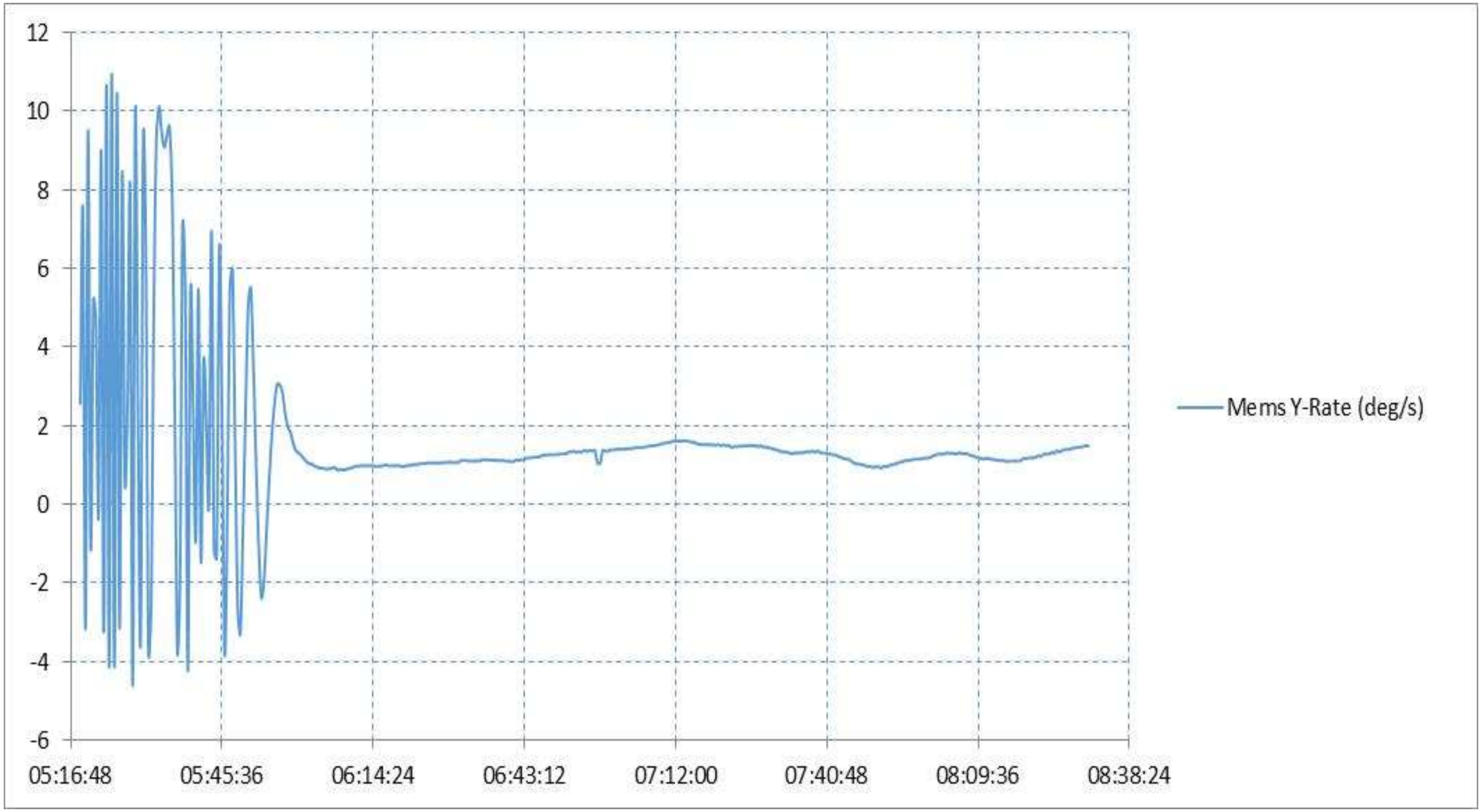
ADCS Hardware Heritage

- 15 ADCS units supplied to QB50 teams
- 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 to teams by the end of 2014
- (nSight-1 is actually using one of the original QB50 bundles!)



Deployed from the ISS

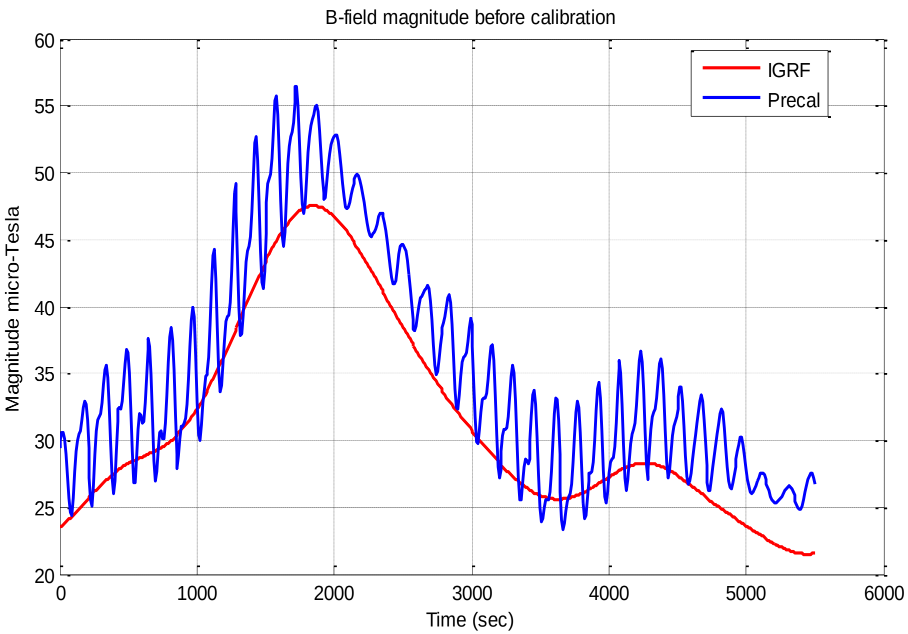
Bdot detumbling result

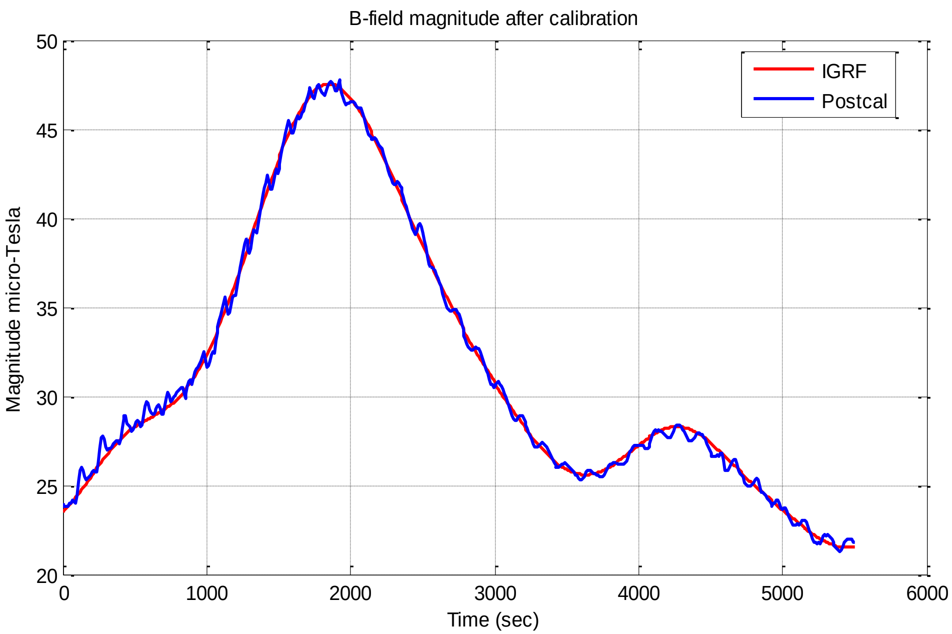


Detumbling result as measured by the MEMS Y-Rate sensor, fully detumbled in less than 1 hour

02/06/2017

Magnetometer Calibration Result





Before calibration
(σ = 2.848 μT)

After calibration
(σ = 0.365 μT)

Y-Wheel Mode
(3-Axis stabilised)

- Extended Kalman Filter
  - Full state estimation from vector measurements
  - Model vectors in ORC frame (sun, nadir, B-field)

$$\hat{\mathbf{x}}(k) = \begin{bmatrix} \hat{\boldsymbol{\omega}}_B^I(k) \\ \hat{\mathbf{q}}(k) \end{bmatrix}$$

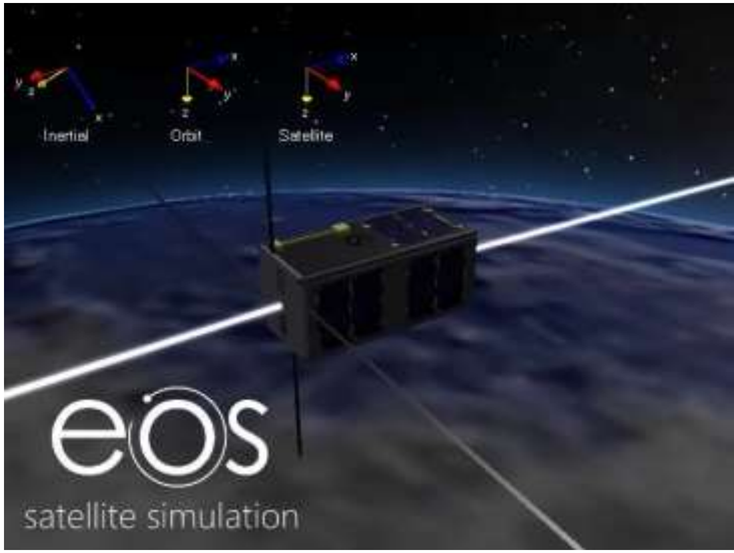
$$\mathbf{e}(k) = \overline{\mathbf{v}}_{meas}(k) \times \hat{\mathbf{A}}_{O/B}\, \overline{\mathbf{v}}_{model}(k)$$

- Y-momentum wheel controller
  - X-product Magnetic controller to manage Y-wheel momentum at -1 milli-Nms and damp roll & yaw:

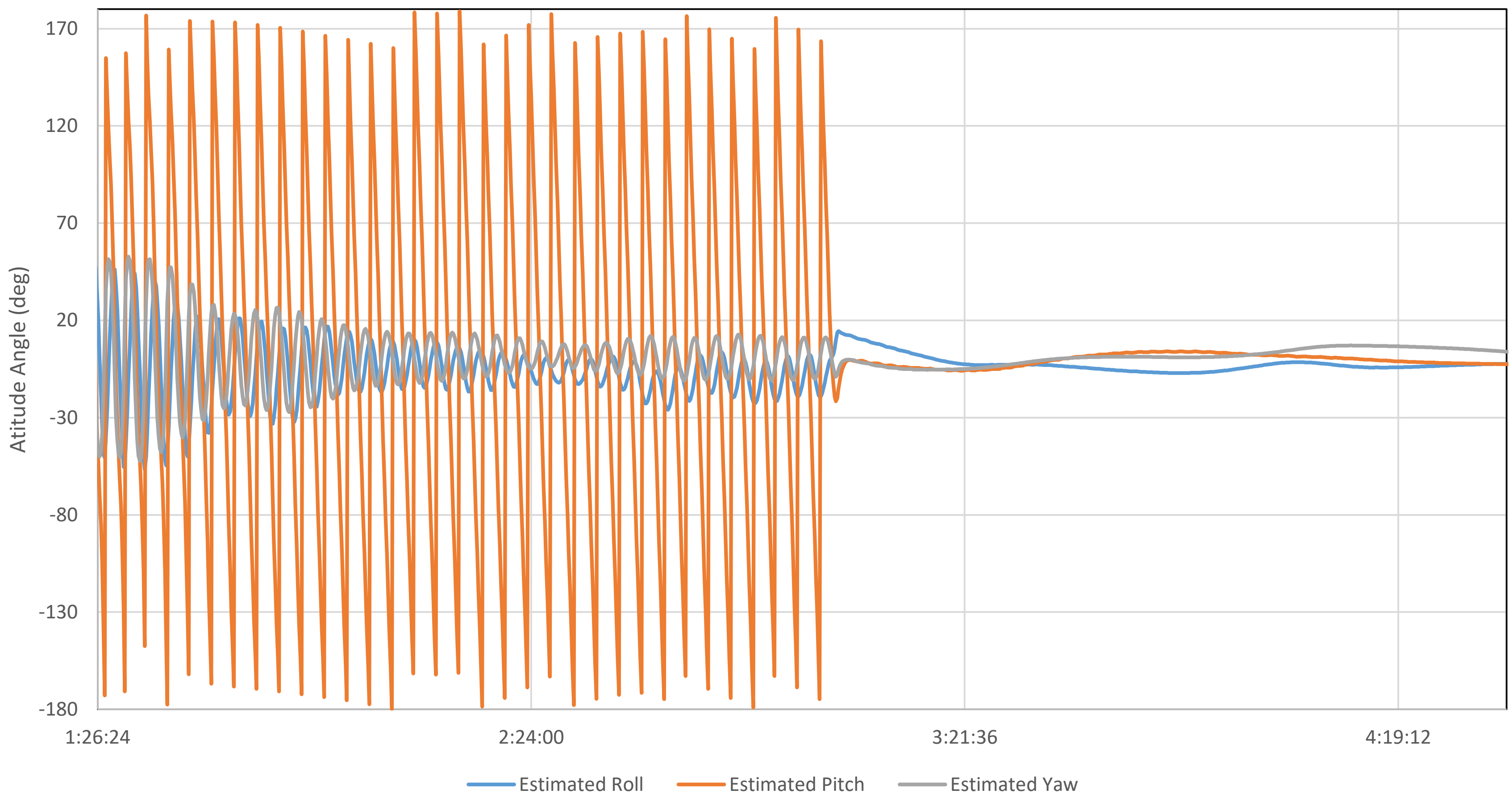
$$\mathbf{e} = \begin{bmatrix} K_{dx}\hat{\omega}_{xo} + K_{px}\hat{q}_1 \\ K_{wy}\left(h_{wy} - h_{wy-ref}\right) \\ K_{dz}\hat{\omega}_{zo} + K_{pz}\hat{q}_3 \end{bmatrix} \quad \mathbf{M}_{PWM} = \mathbf{e} \times \mathbf{B}_{meas} / \left\|\mathbf{B}_{meas}\right\|$$

  - PD controller for Y-wheel to control body pitch axis:

$$N_{ywheel} = K_{dy}\hat{\omega}_{yo} + K_{py}\hat{q}_{2e}$$

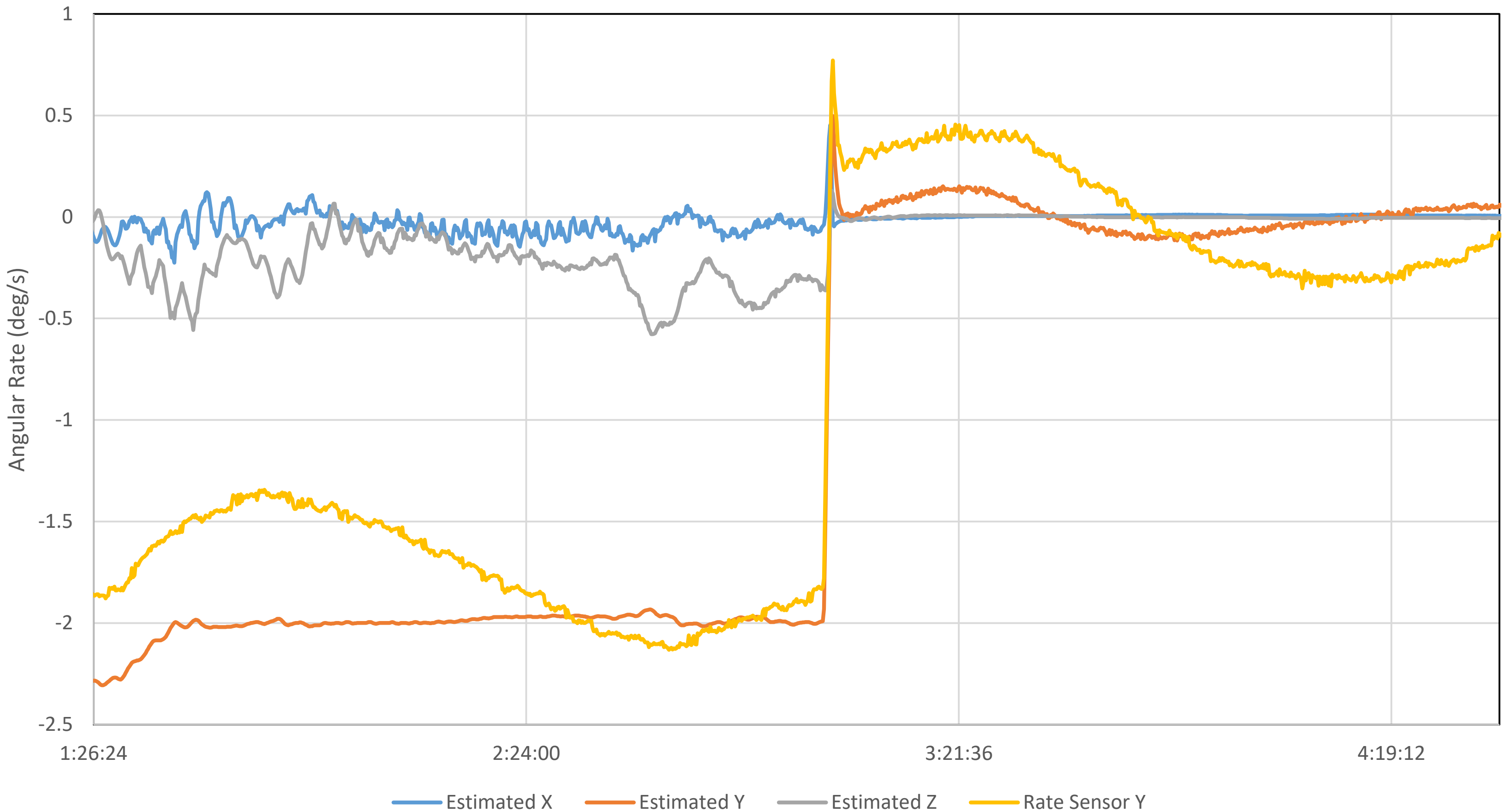


ADCS stabilization



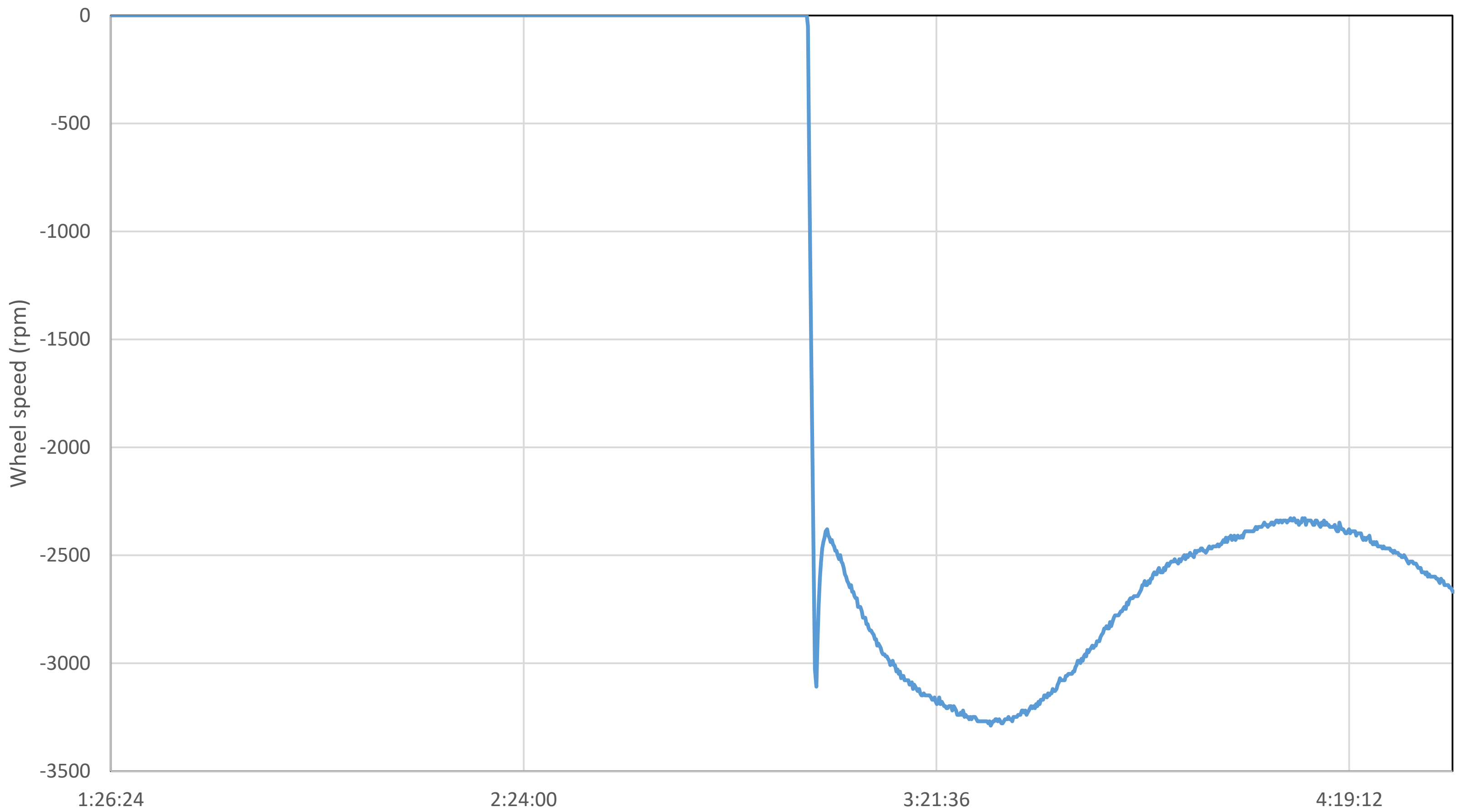
Stabilization result as estimated by the Magnetometer EKF
21/06/2017 @ 01:25:10 to 04:34:40

ADCS stabilization



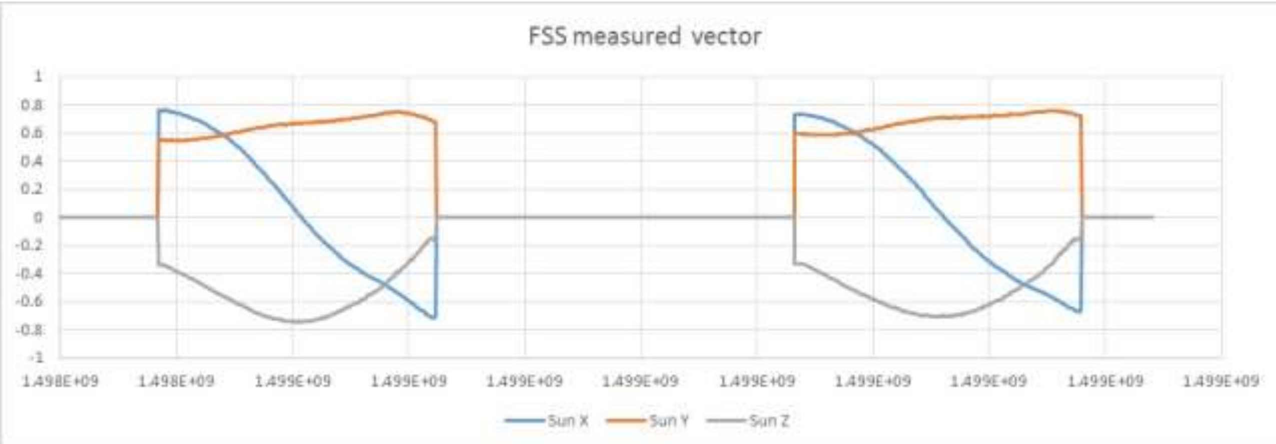
Stabilization result as estimated by the Magnetometer EKF
21/06/2017 @ 01:25:10 to 04:34:40

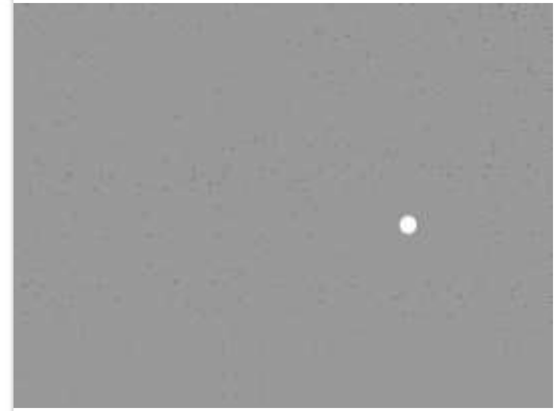
ADCS stabilization

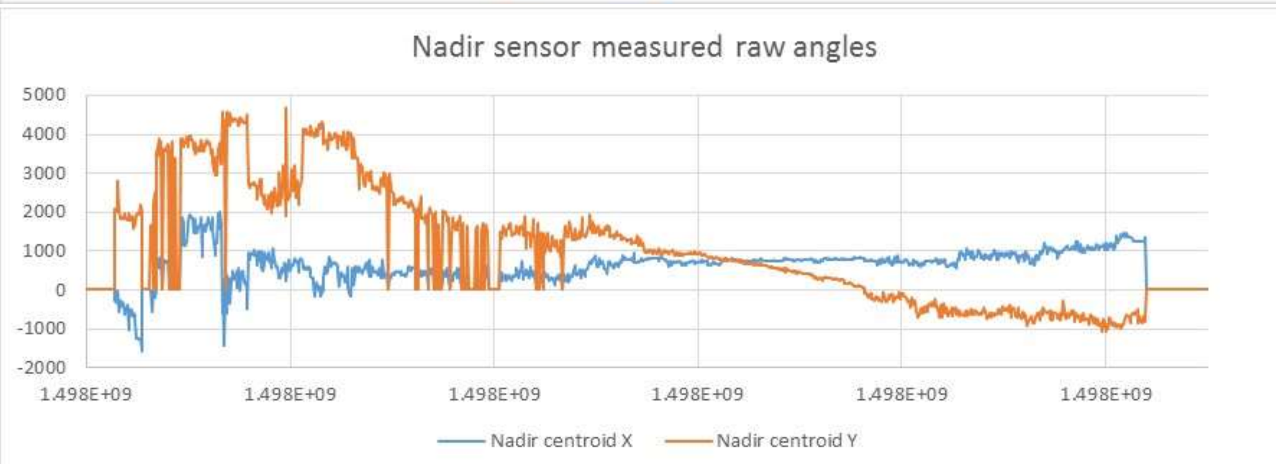


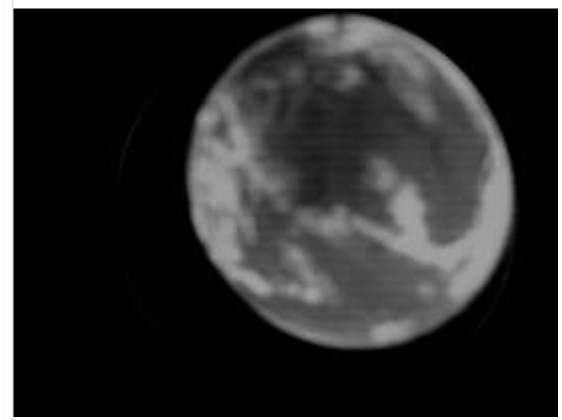
Y-Wheel speed during attitude stabilization
21/06/2017 @ 01:25:10 to 04:34:40

Sun/Nadir sensor commissioning



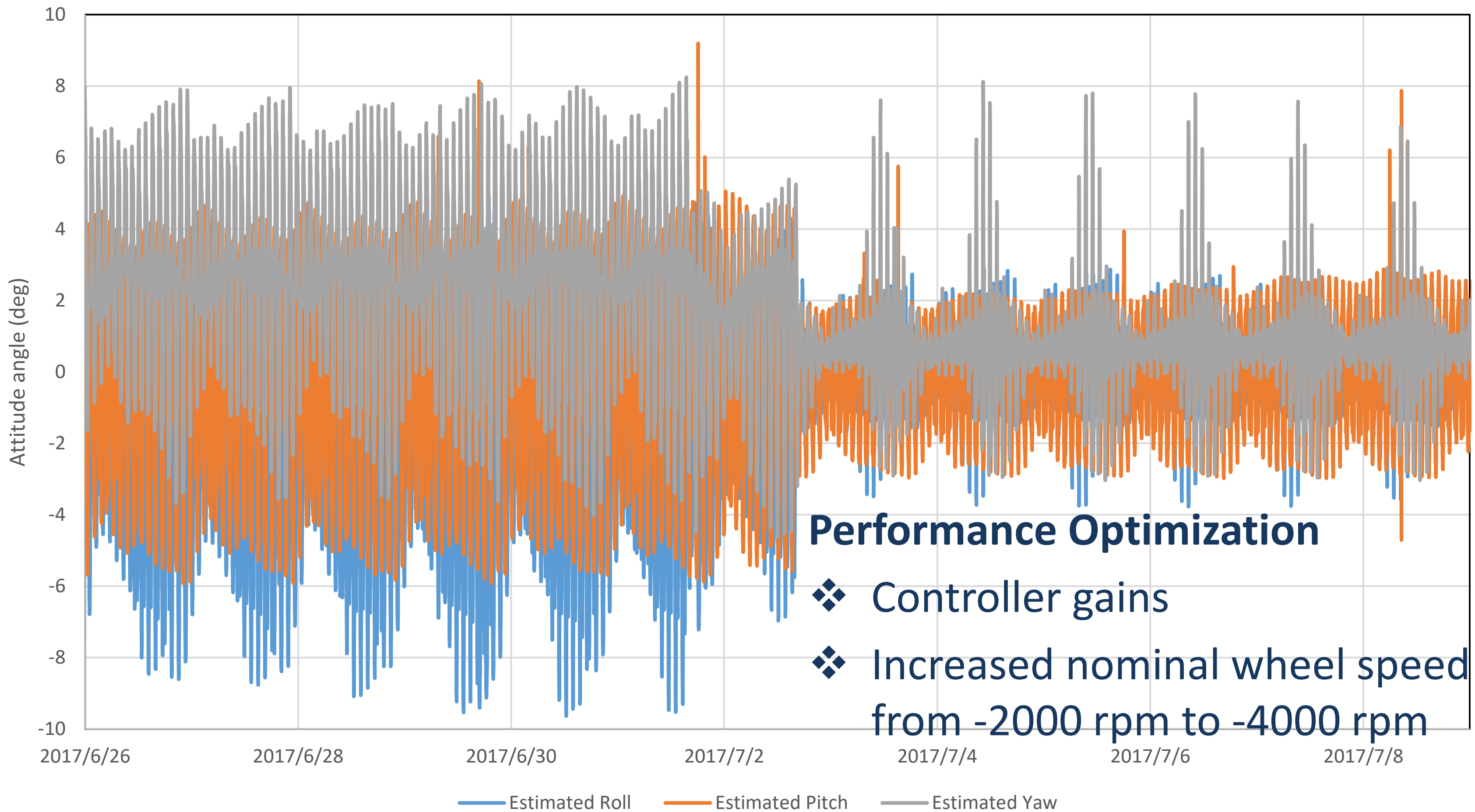






- The sun sensor works reliably, except for occasional reflections when it gives a measurement error
- The nadir sensor is slightly out of focus and the reflections from the panel opening cause measurement errors

Y-Wheel control In-flight performance

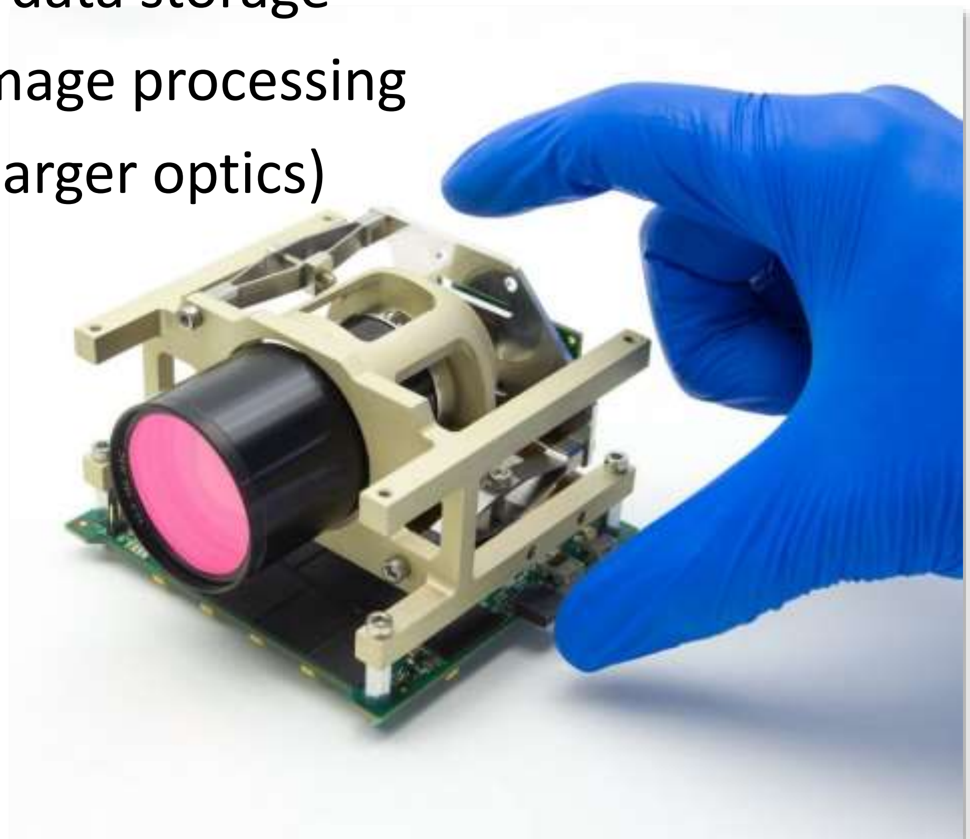


Y-Wheel momentum control over 2 week period estimated by the Magnetometer and Sun EKF
25/06/2017 to 09/07/2017

SCS Gecko Imager

- Modular design
- Compatible with CubeSats
- High-speed high-capacity mass data storage
- FPGA processor for real-time image processing
- High frame rate capability (for larger optics)

Characteristics	
Form factor	< 1U
Mass	< 480 g
GSD	31 m from ISS orbit
Image Sensor	2.2 Megapixel RGB
Storage	128 GB
Rad. tolerance	Tested to 30 krad TID
Space heritage	2017 !



nSight-1 Imaging

More Imaging