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Precise 3-axis Attitude Control for SPORT Cubesat

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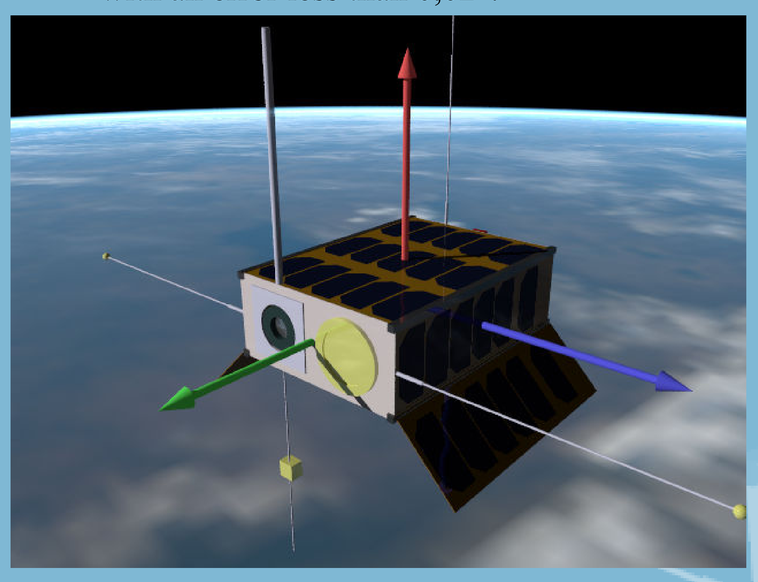
INTRODUCTION

The SPORT Cubesat (6U form factor) mission aims to improve the knowledge about several phenomena related to space weather:

- IVM (Ion Velocity Meter),
- GOE (GPS Occultation Experiment),
- FME (precise Fluxgate Magnetometer Experiment),
- SLP (Sweeping Langmuir Probe),
- EFP (Electric Field Probe)
- SIP (Sweeping Impedance Probe).

The main requirements for the ADCS are:

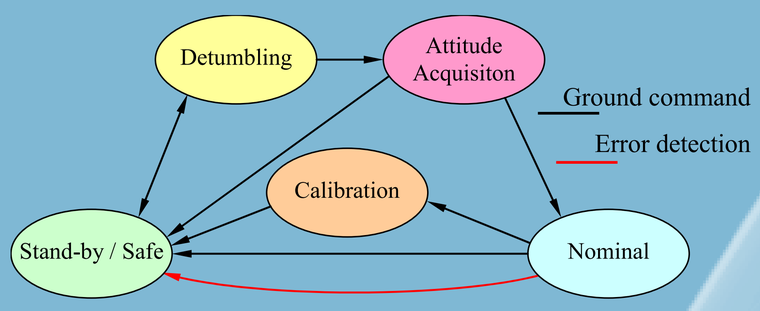
- The nominal attitude should be Earth pointed, with an error less than 0.1° (3σ).
- The attitude shall be determined on board with an error less than 0,02°.



The ADCS shall be composed by:

Equipment	Qnt	Type	Technology	Accuracy	Range
Star Sensor	1	3 axis	CCD	0,01-0,1º	20º
Magnetometer	1	3 axis	Mag resistive	0,2 μT	100 μT
Sun sensor	1	2 axis	Photodiodes	0,5º	+/– 60º
Gyroscopes	1	3 axis	MEMS	15º/h	225º/s
Reaction wheel	3 / 4	1 axis	BLDC	5 rpm	0,01 Nms
Magnetic torquers	3	1 axis	Air core	-	0,13 Am^2
Computer	1	32 bit	AVR	-	-

The ADCS operating modes are



SENSOR AND ACTUATOR MODELS

Star sensor (SS): detection of Earth in the sensor's FOV, detection of Sun in the baffle's excluding zone, axis dependent gaussian noise.

Magnetometer (MAG): bias, bias instability and random walk, based on sensor's Allan Variance

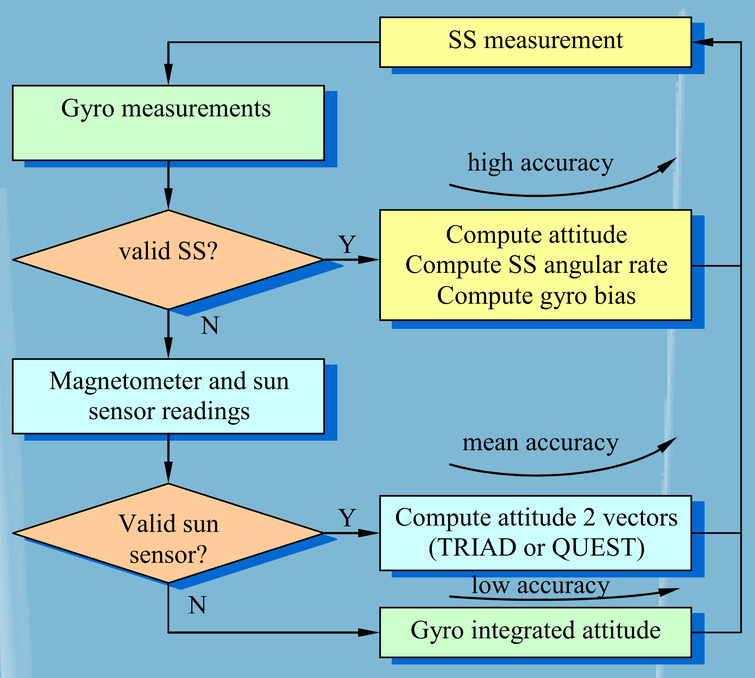
Digital Sun sensor (DSS): detection of the Sun in the sensor FOV and direction dependent gaussian noise.

Gyroscopes (GYR): bias, bias instability and angle random walk, based on sensor's Allan Variance curve.

Reaction Wheel (RW): maximum torque, maximum angular rate, zero speed dead band, angular rate measurement noise and speed control loop.

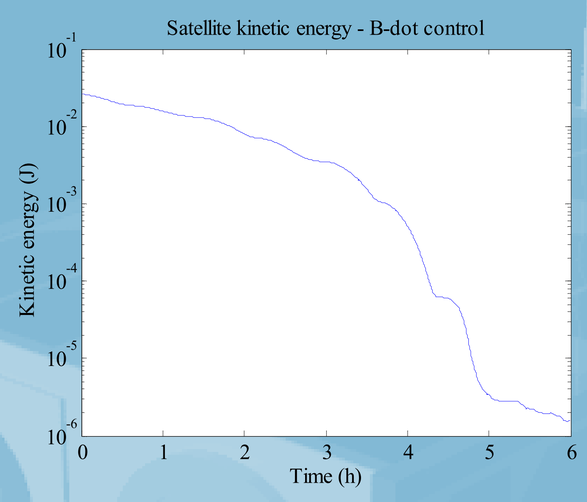
Magnetic torquers (MT): magnetic moment and maximum PWM duty cycle

ATTITUDE DETERMINATION

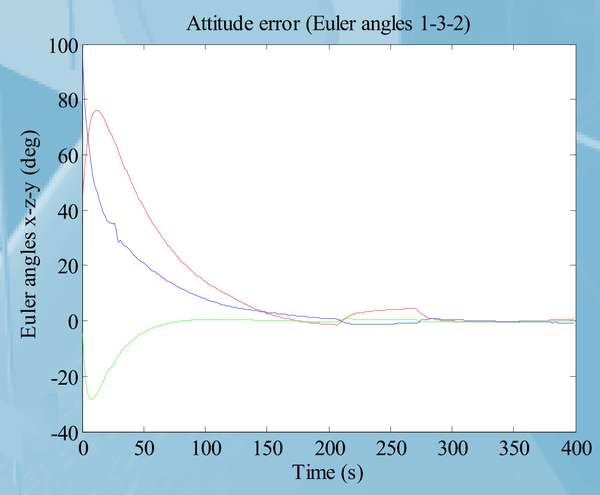


ATTITUDE CONTROL SIMULATION

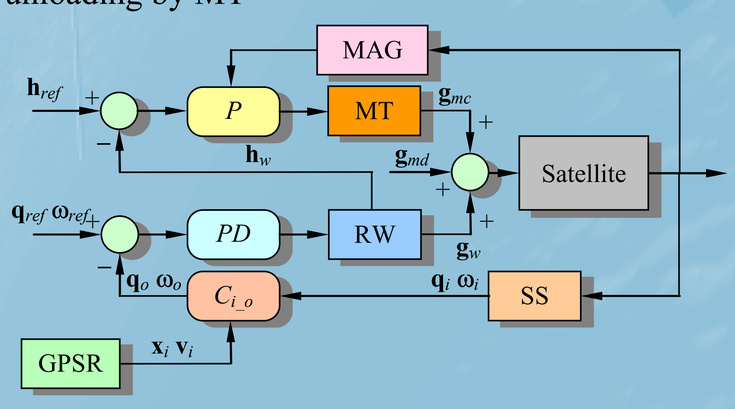
Detumbling mode (DM): B-dot control

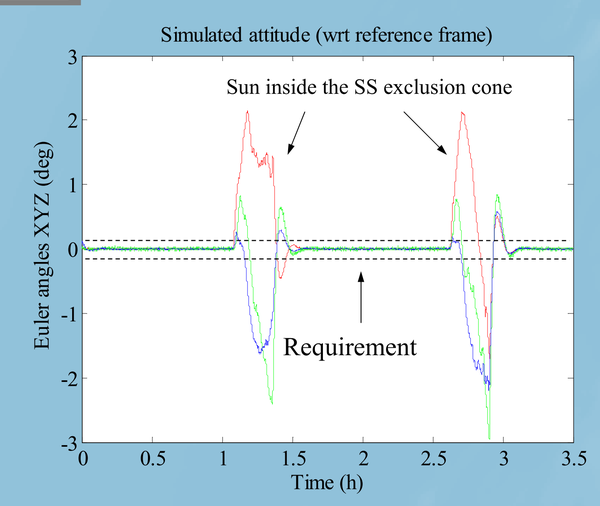


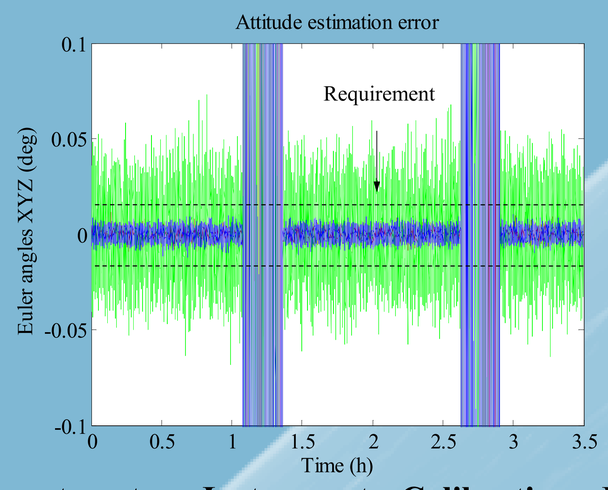
Attitude Acquisition Mode (AAM): PD control with high gains



Nominal Mode (NM): PD control and RW unloading by MT

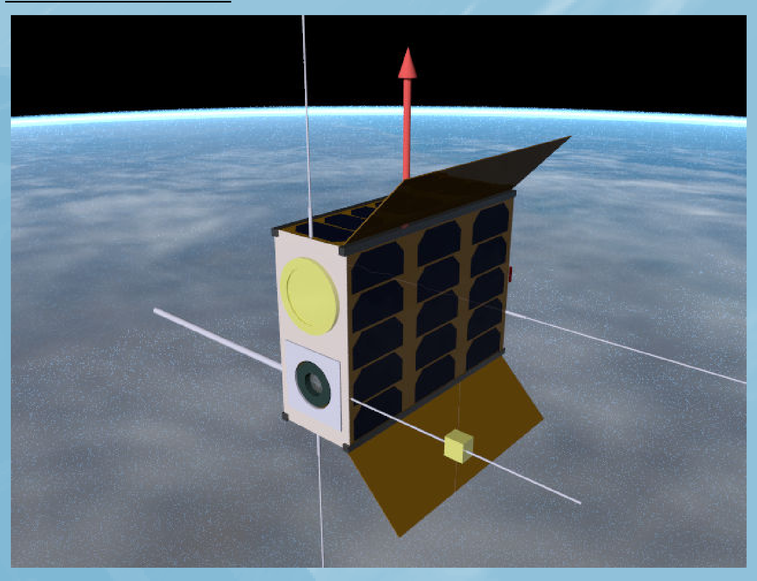


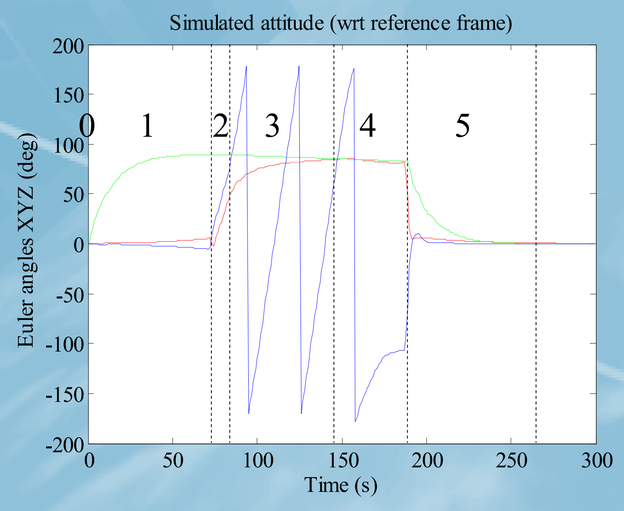


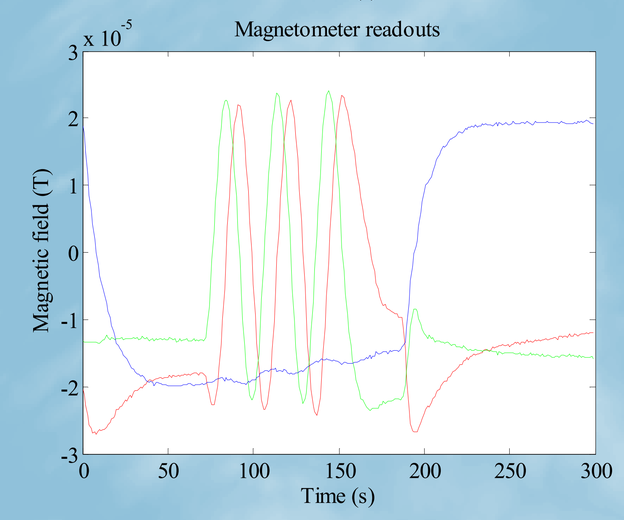


Magnetometer Instrument Calibration Mode (MICM): autonomous attitude manouvers, angular velocity vector control.
Rotating axis: Roll, Pitch and Yaw.
Sub-maneuver 0: Nominal attitude
Sub-maneuver 1: Pointing the rotation axis
Sub-maneuver 2: Accelerate to the angular rate
Sub-maneuver 3: Keeping a inertial rotating axis
Sub-maneuver 4: Decelerating
Sub-maneuver 5: Pointing to nominal attitude

Pitch maneuver:







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