CINEMA: Attitude Control System

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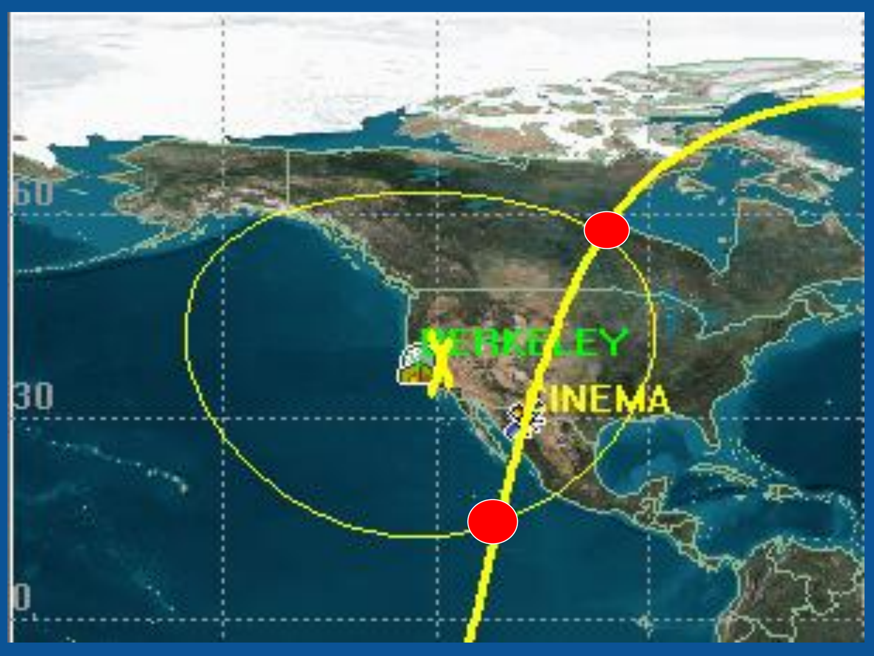
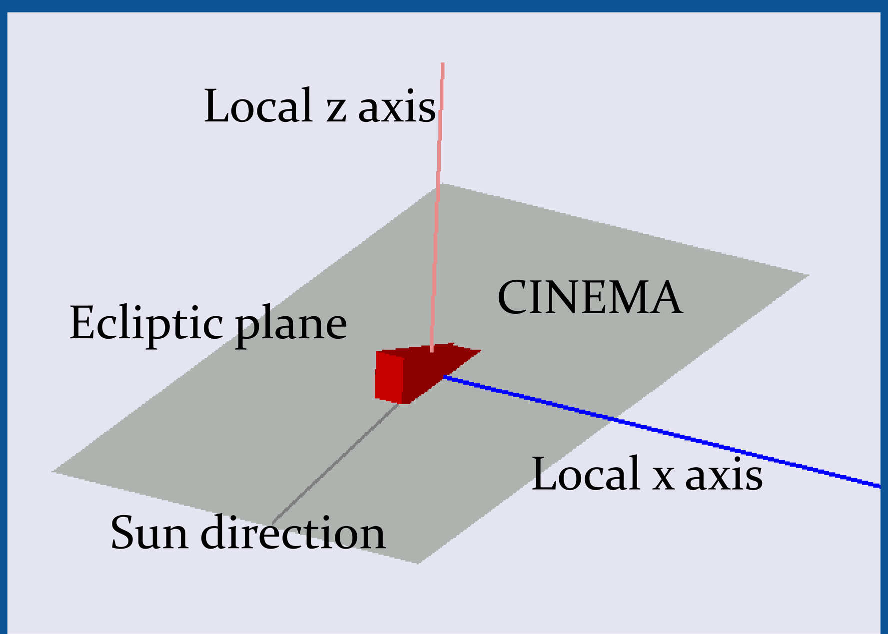
Purpose

CINEMA (CubeSat for Ions, Neutrals, Electrons & MAgneticfields) will image energetic neutral atoms (ENAs) in the magnetosphere, and make in situ measurements of electrons, ions, and magnetic fields at high latitudes. Its nominal orbit will be 650 km high with a 72 degree inclination. The behavior of the satellite is described by three dimensional nonlinear dynamics with the variable of angular velocity in three axes. The desired attitude is with the spin axis normal to the ecliptic plane. The main purpose of this poster is to focus on the control of this three dimensional nonlinear dynamic system. The ultimate goal is to control the spin axis of nanosatellites such that they align with the ecliptic normal within 5 degrees and to maintain a stable 4 RPM spin rate.

Introduction:

The on-board measurements available for control are a dual-slit sensor to find the elevation of the sun and a magnetometer to measure the orientation of the local magnetic field. Absolute magnetic field information is not available on-board, so it must be supplied from the ground. Torque is provided for control by an orthogonal pair of coils that interact with the Earth's magnetic field to produce a torque. The total power available for ACS is 15 W.





Experiment structure :

We are using a PIC microcontroller RS-232 port and a laptop serial port with our own protocol to construct the communication between the Simulink mode and the control software in the PIC. The following diagrams show the structures. The red diagrams present the PIC modules, the other diagrams present the Simulink modules .

- Shadow analysis
- Data space of Magnetic field and the Sun
- Orbit dynamics
- Albedo module
- Gravity disturbance
- Attitude dynamics from SimMechanics

- Solar panels model
- Sun Sensor model
- Battery model
- Serial port send module

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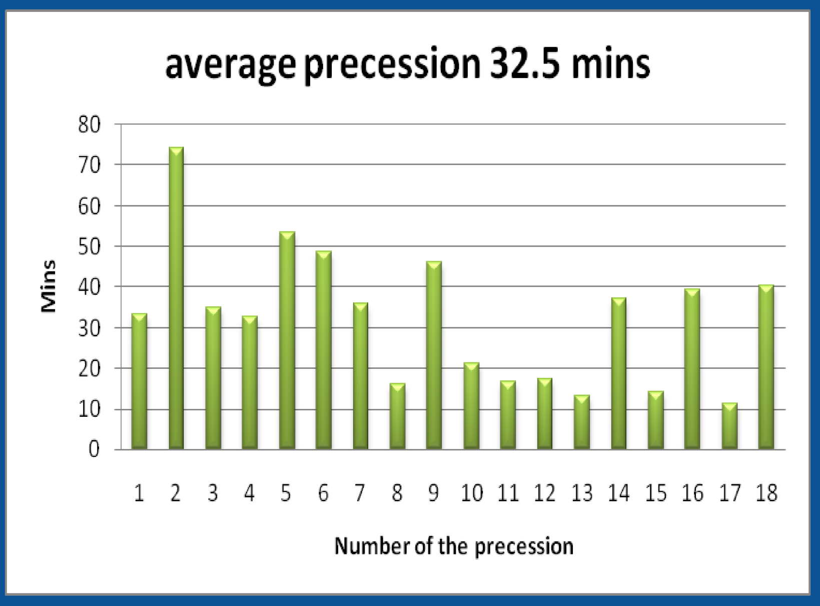
- Actuator model

- Magnetometer model
- Ground station
- Timer
- Decode sensor module
- Control logic
- Exception module
- Attitude estimator

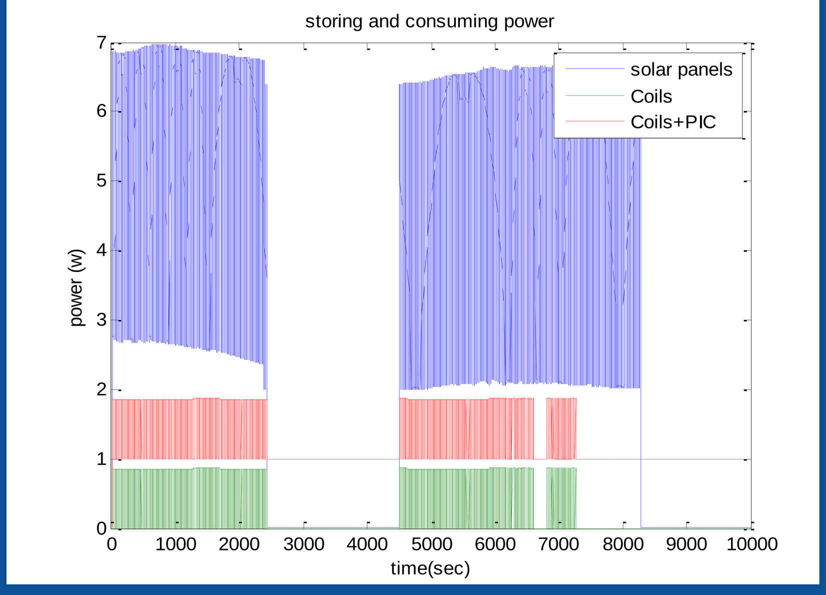
Control mode:

This includes: Detumble mode, spin up mode, and precession mode. During detumble mode, Control reduces the angular velocity. During spin up mode, CINEMA will speed up its spin rate to 4 RPM and align with its local z axis. After that, during precession mode, the local z axis aligns with the ecliptic normal.

Simulation results:

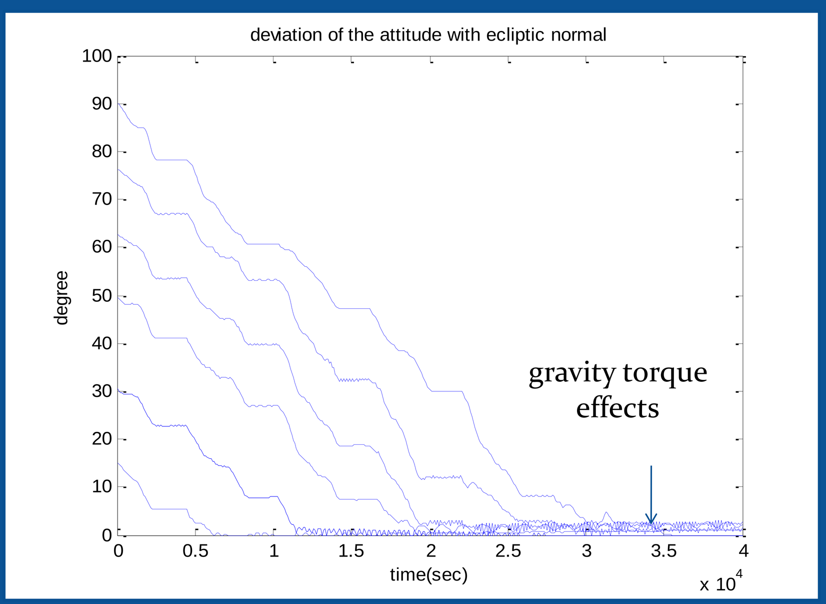


(a) average precession time

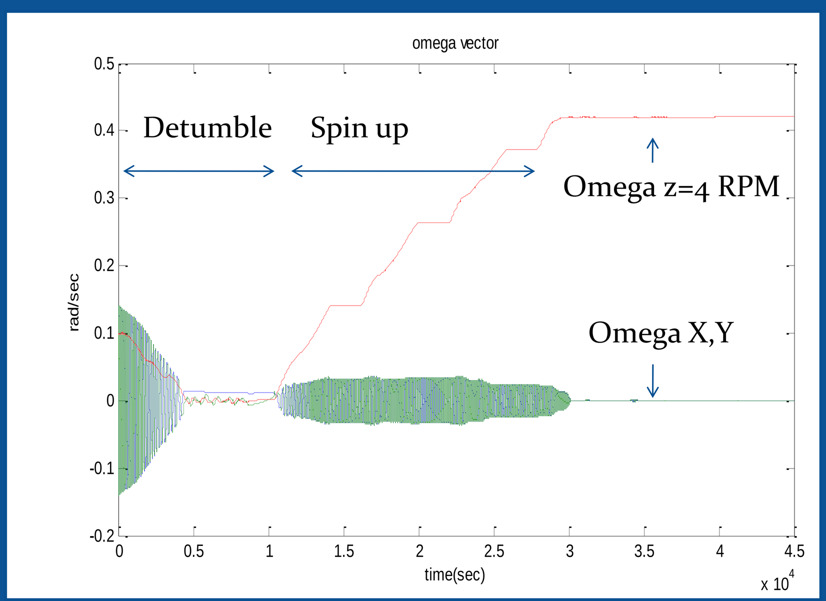


(b) storing and consuming power

Fig. (a) shows the time for the precession. Fig. (b) shows the power from the sun plus the effects from Earth's albedo and the power consumed by the coils and PIC. This also includes the part of the orbit in Earth's shadow

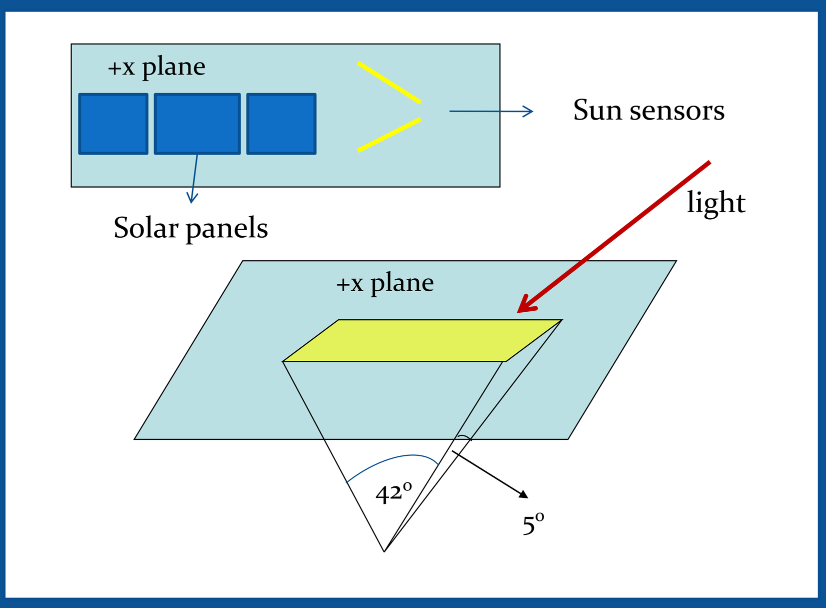


(c) Settling Time vs. Initial Deviation

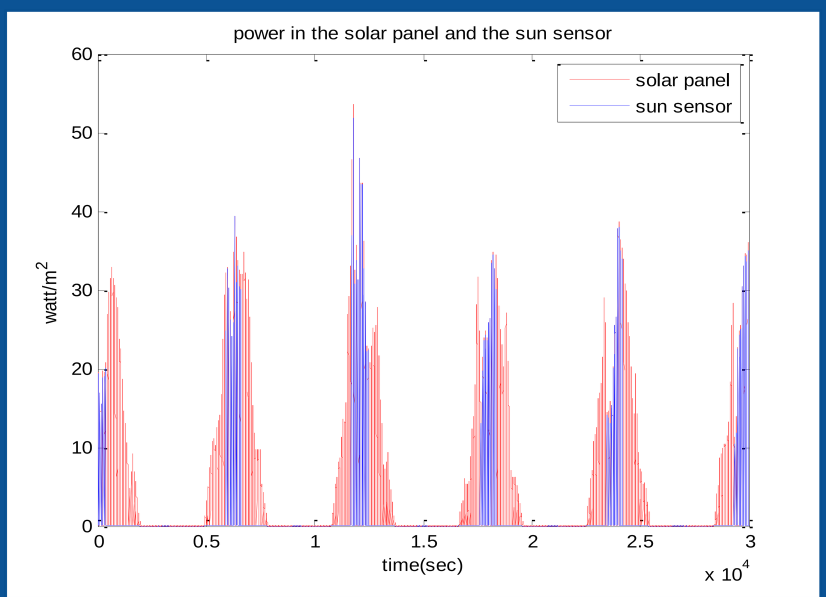


(d) omega vector

Fig. (c) shows different initial deviations after S/C deployment. Fig. (d) shows the detumble and spin up mode. The initial angular velocity decrease to a small number then spin up omega z to 4 RPM. During the transition, it reduces omega x,y.



(e) solar panels and sun sensors



(f) power of the albedo per unit area

Fig. (e) Models of the sun sensor and solar panels. Fig. (f) Power from the albedo in the sun sensors and solar panels. One can find that they achieve their highest value when the satellite passes over Antarctica.

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