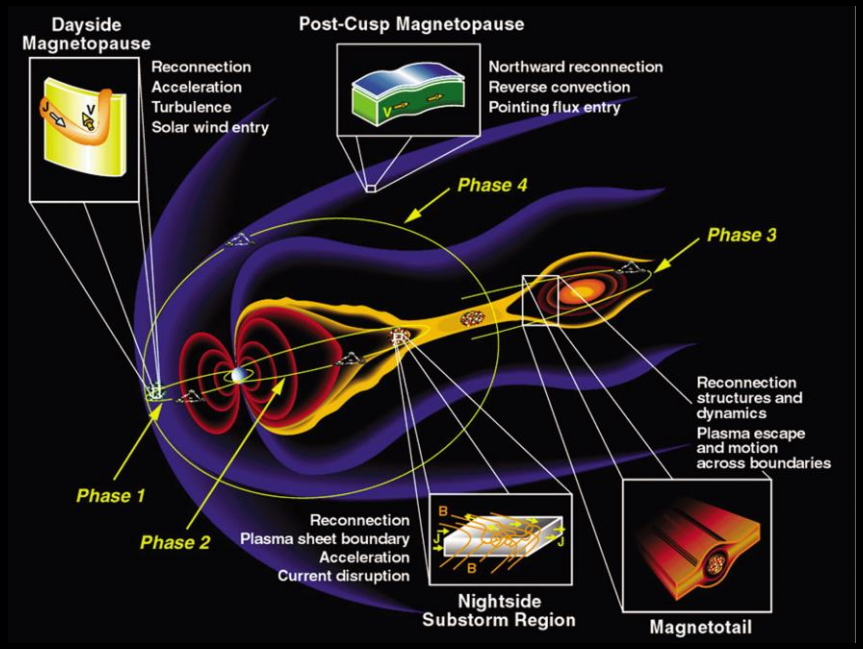
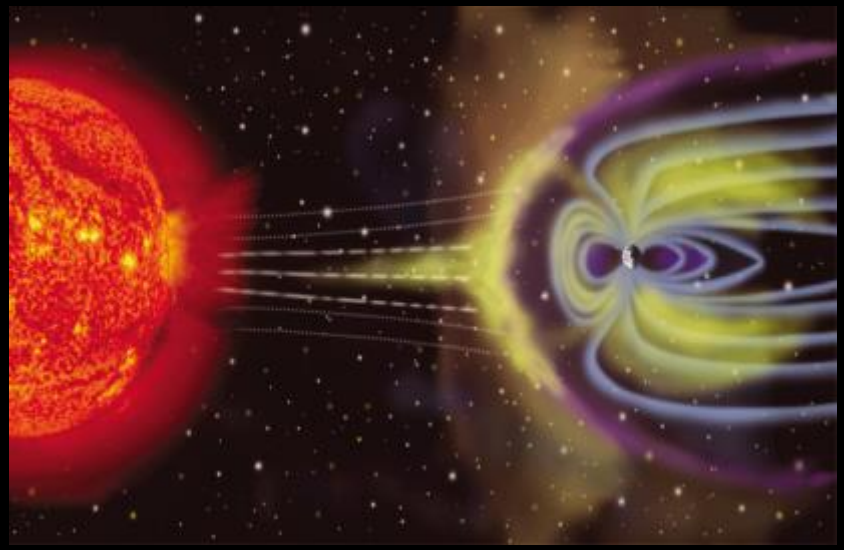
NASA TableSat Generation III: QuadSat Swarm

Advisor: Dr. May-Win Thein
Mechanical Engineering, Ocean Engineering
CS 791

NASA MMS Mission

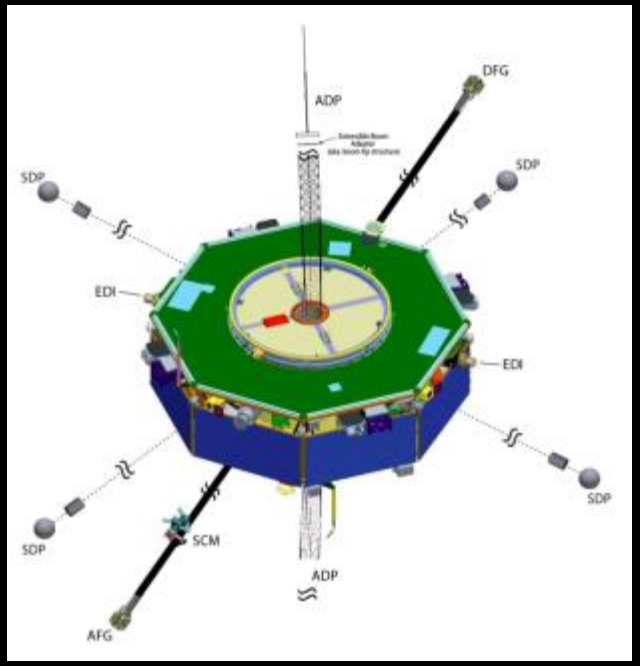
Using Earth's magnetosphere as a laboratory to study the reconnection process



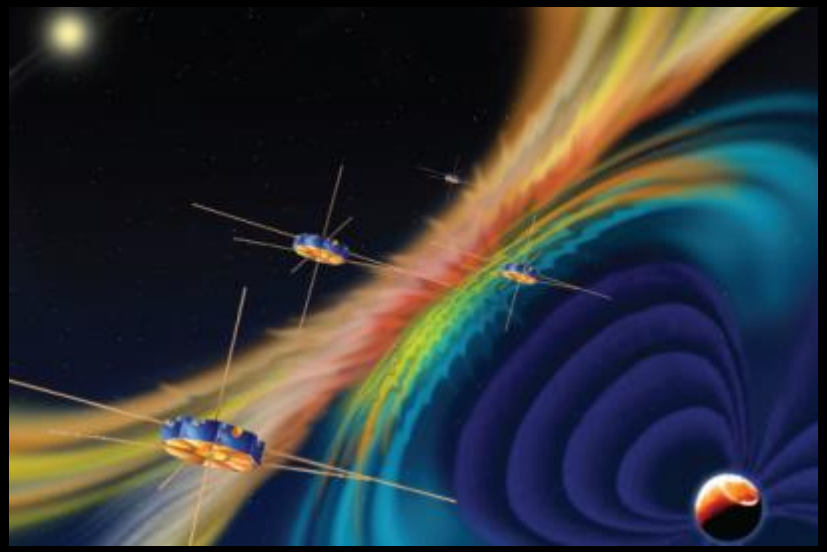


NASA MMS Spacecraft

- Spin-stabilized spacecraft at 3 RPM
- Four 60 meter-long spin-plane double probe (SDP) wire booms
- Two 12.5 meter-long axial double probe “Eiffel Tower” booms (ADP)
- Electric field sensors attached at the ends of the booms
- Four MMS spacecraft in precise tetrahedral flying formation

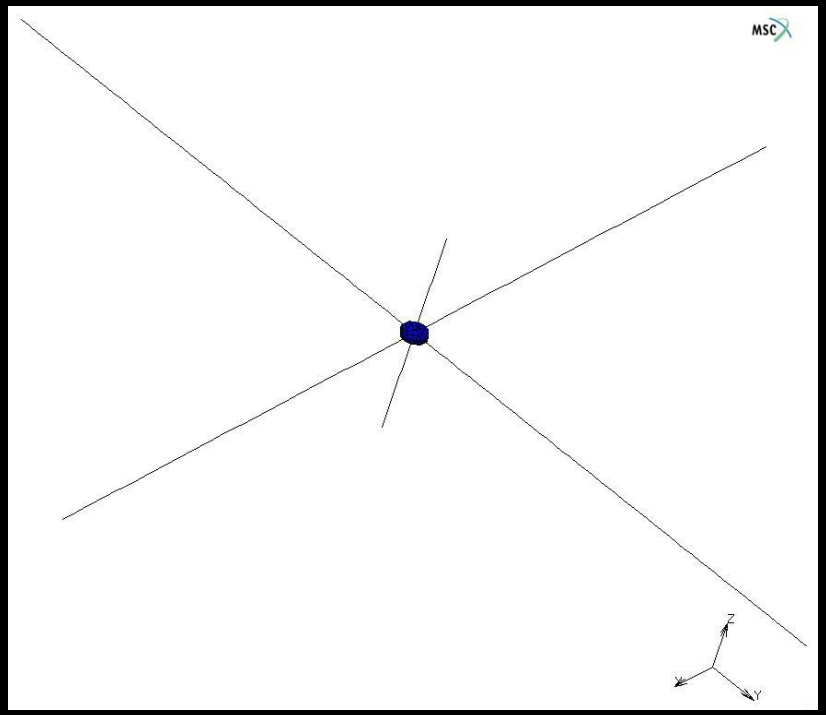


NASA MMS Spacecraft



NASA MMS Constellation
Tetrahedron Formation
(artist rendition)

MMS Spacecraft (to scale)



NASA MMS Orbit

MMSOrbit.mpg

Courtesy of NASA/Goddard Space Flight Center Conceptual Image Lab

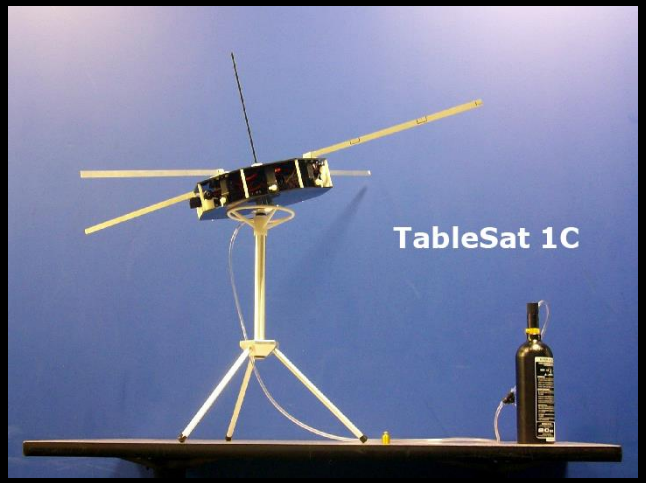
Project & Research Goals

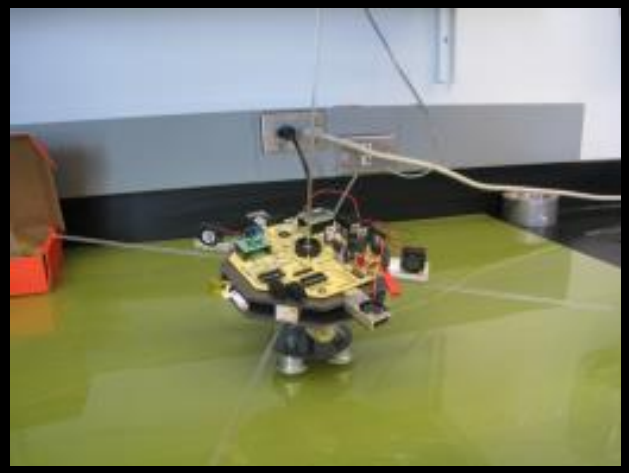
- Develop test bed to test advanced control system and estimation techniques
- Observe qualitative properties of the boom dynamics and their effects on the spacecraft dynamics
- Single-blind study on boom and spacecraft dynamics used to confirm NASA's findings

Previous TableSat Generations I & II

The Tabletop Satellite (TableSat): Multiple generation project designed to act as test bed for spacecraft and s/c boom dynamic behavior

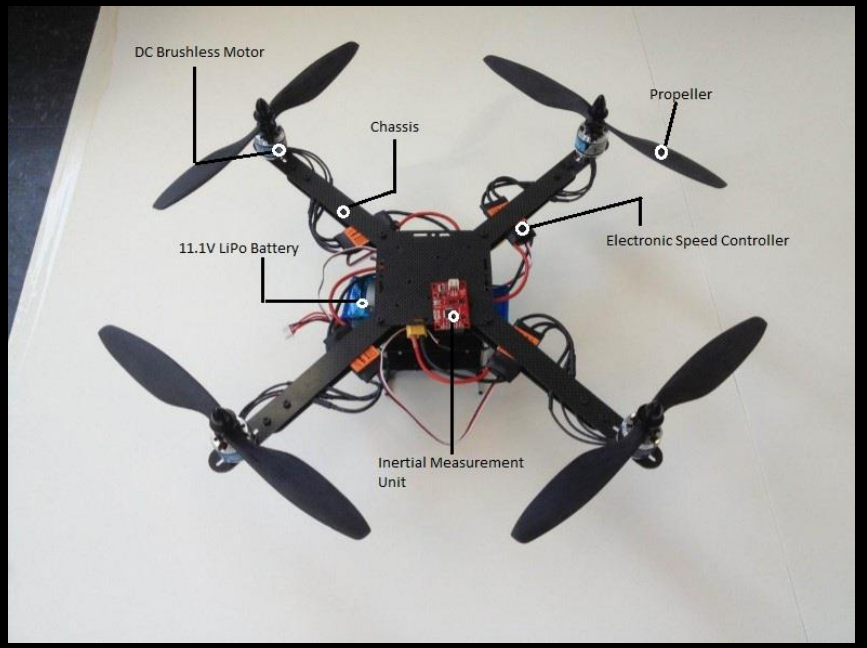
- **TableSat Generation I** analyzed boom dynamics with a limited 3-DOF test bed (yaw, and limited pitch and roll)
- **TableSat Generation II** test bed limited 5-DOF (limited 3-DOF rotation, 2-DOF translation)





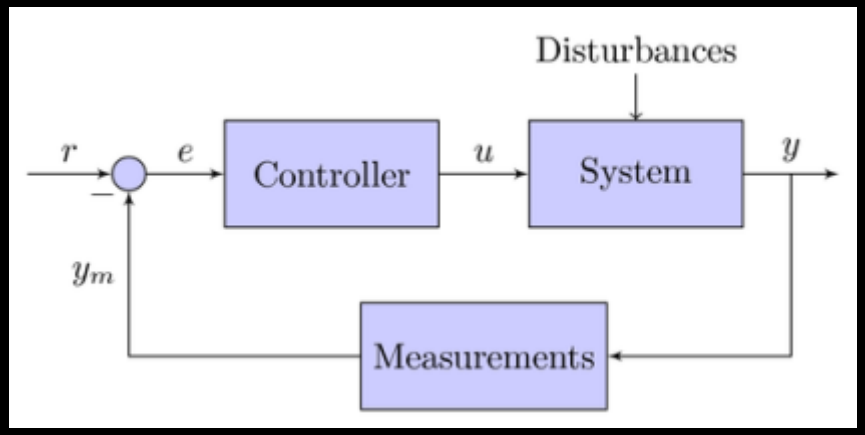
NASA TableSat Generation III: QuadSat

- Create a satellite test bed capable of full 6-DOF motion (full 3-DOF rotation and full 3-DOF translation).
- Create multiple models (swarm) with the ability to ***autonomously*** fly in a controlled formation.
- Analyze boom and body dynamics.



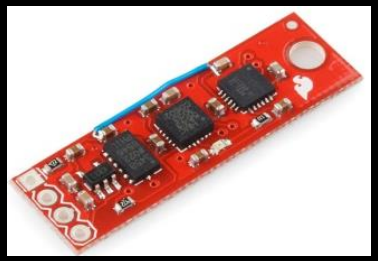
NASA QuadSat: Control System

- Implementation of a closed-loop feedback control systems (PID and graduate student controllers)
- Feedback control data provided by on-board sensors
- Vision Positioning System provided by ground station and/or on-board sensor suite
- Real time processing of test bed's x-y-z translation (orbit) and roll-pitch-yaw rotation (attitude)

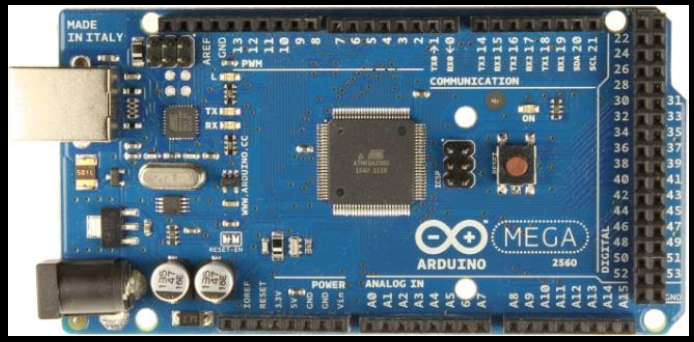


Electrical Components

- Motor drivers/Electronic Speed Controllers
- Microcontroller
- Transceiver
- DC Brushless Motors
- Batteries
- Speed Controllers
- Sensors
  - Inertial Measurement Unit
  - Ultrasonic Range finder(s)
  - Pressure sensor
  - Light sensors
  - GPS (indoor/outdoor)
  - etc.



http://chionophilous.wordpress.com/2012/02/10/connecting-to-sparkfuns-9dof-sensor-stick-i2c-access-to-adxl345-itg-3200-and-hmc5843/



http://www.electroschematics.com/7963/arduino-mega-2560-pinout/

CS 791 Logistics

- Interdisciplinary project: ME/ECE/CS
- Testing:
  - Indoor lab environment
  - UNH Kingman Farm
- Possible collaborative multiplatform development/communication (time allowing)
  - Autonomous Surface Vehicle
  - ET NavSwarm Unmanned Ground Vehicle
- Resources:
  - NASA GSFC
  - UNH Graduate Students
- NASA Goddard Space Flight Center (GSFC)
  - Pursued funding by Attitude Control System Branch
  - Possible travel to present results to NASA GSFC
    - Flight Dynamics Analysis Branch
    - Attitude Control Systems Branch

Questions?