Orbital Environment Simulator

Samir Rawashdeh

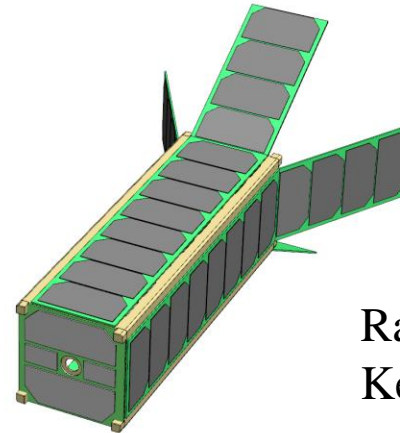Space Systems Laboratory

University of Kentucky

Overview

- Introduction

- Implementation Details

- Capabilities

- KySat-1: Passive Magnetic Stability

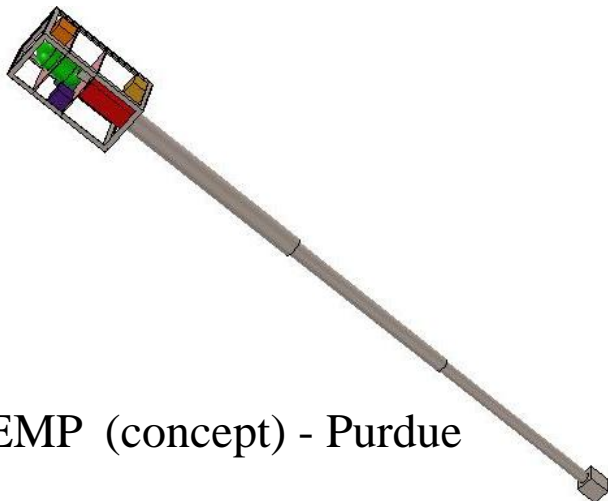- RamSat: Aerodynamic Stability

- Future Enhancement

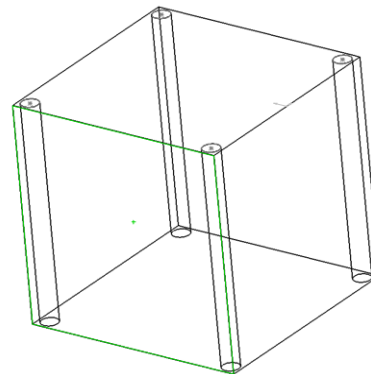# Introduction

Passive Stability Systems

- **Aerodynamic**
- **Passive Magnetic**
- **Gravity Gradient**

RamSat (concept) –
Kentucky Space

Magnet Placement in KySat-1

PuTEMP (concept) - Purdue

Challenges

- Determining Pointing Accuracy
- Magnetic Hysteresis Damping Behavior
- Uncontrolled Axis of Freedom
- Behavior in 6DOF
- Effect of Gyroscopic "Stiffness"

Orbital Environment Simulator

- Adjustable Spacecraft Description and Orbit
  - Mass and Inertia Matrix
  - Magnets and Hysteresis Material
  - Geometry (Aerodynamics)
  - Orbital Elements
- Simulate Effect of Orbital Environment on Satellite Attitude (in 6DOF):
  - Gravity Gradient
  - Magnetic Torques
  - Magnetic Hysteresis Material
  - Aerodynamic Torque

Simulink® Modeling

- Model-based Design
  - Graphical description of dynamics
  - Definition of initial state
  - Solve differential equations and propagate the systems state over time
- Hit "play" and watch events unfold.

Attitude Propagator

Kentucky Space - Orbital Environment Simulator
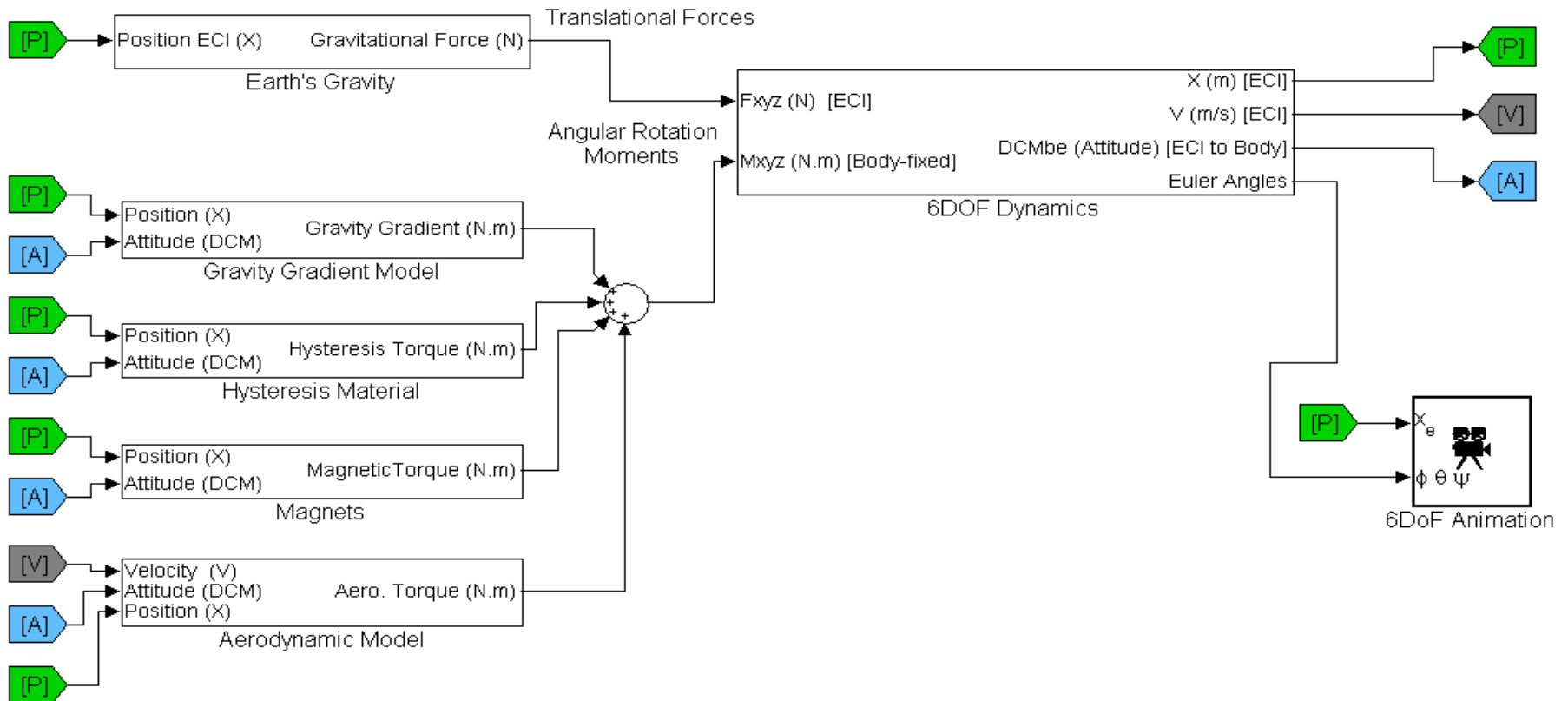
Capabilities

- Attitude Propagation (Aerodynamic, Gravity Gradient, Magnetic, and Hysteresis)
- Stability System Design Verification
- Plotting and Animation (STK)

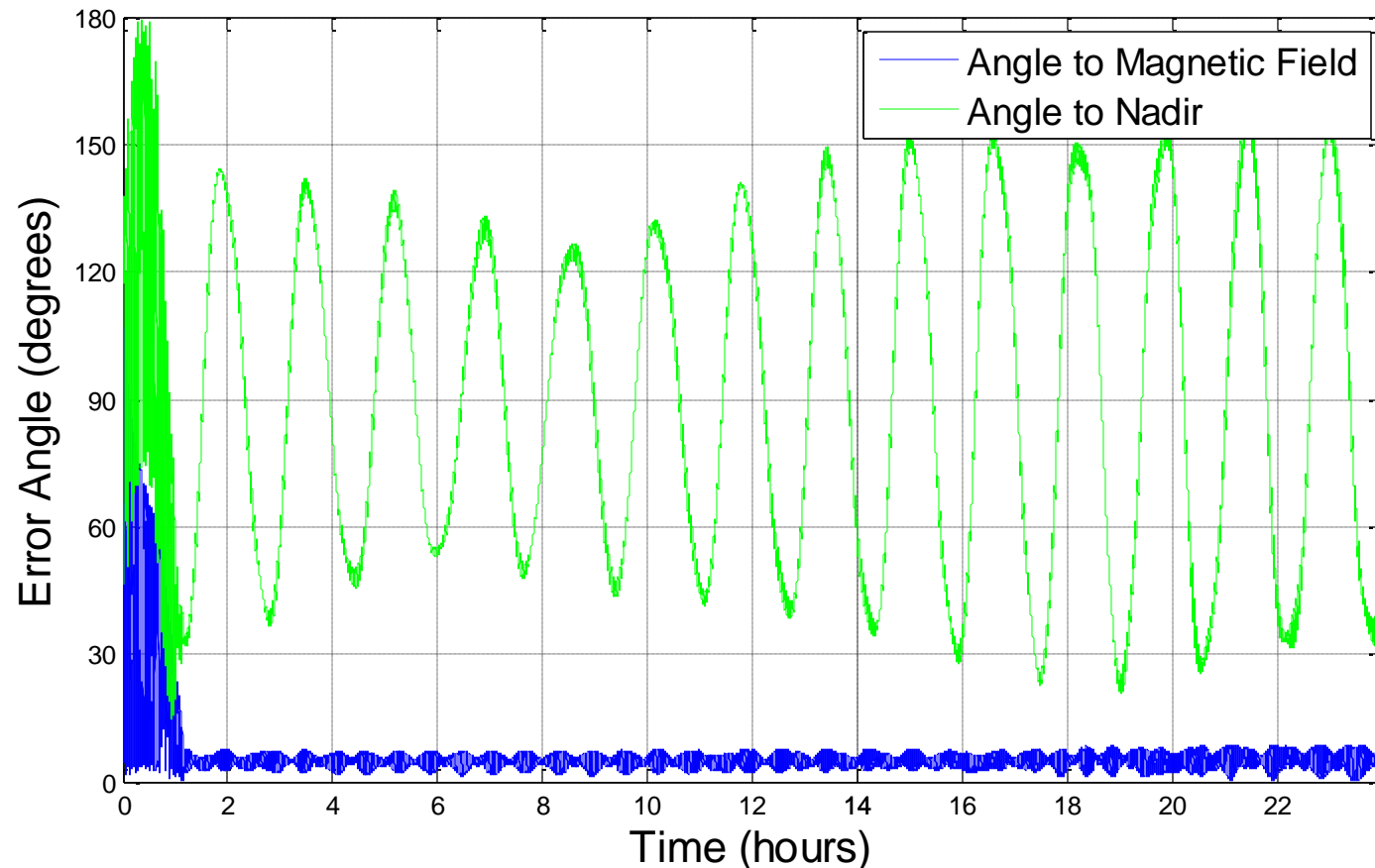- Case Studies:
  - KySat-1
  - RamSat

KySat-1: Magnetic Stability

□ **Align with Magnetic Field**

   ■ Permanent Magnets

□ **Dampen Motion**

   ■ Hysteresis Material (HyMu80)

North Pole

16.1

26.6

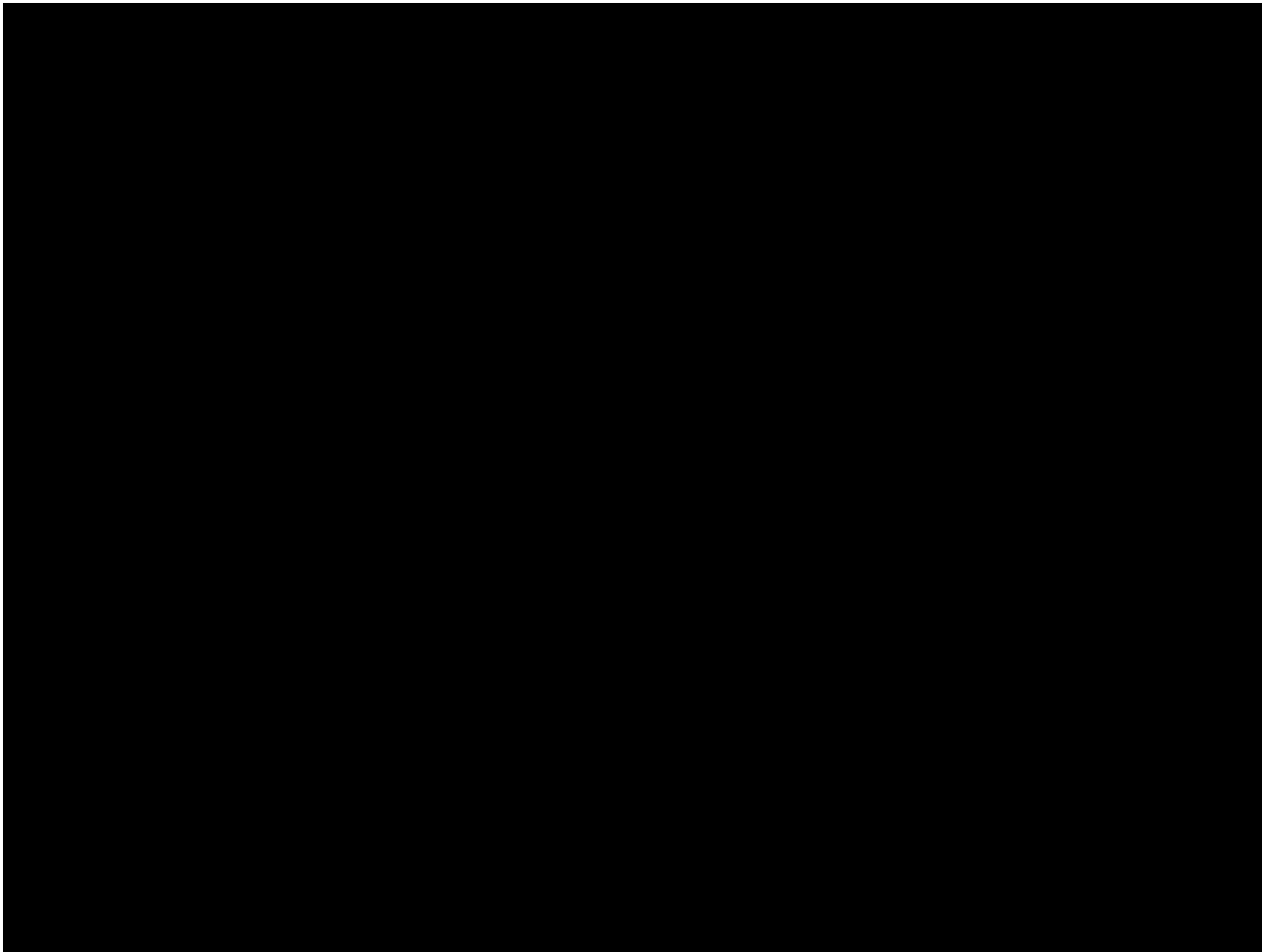40.89

60
45
30

South Pole
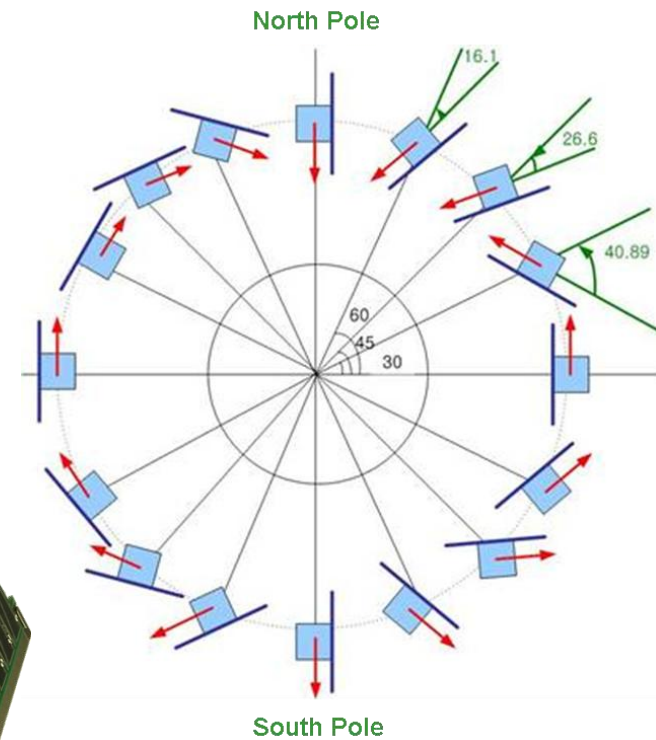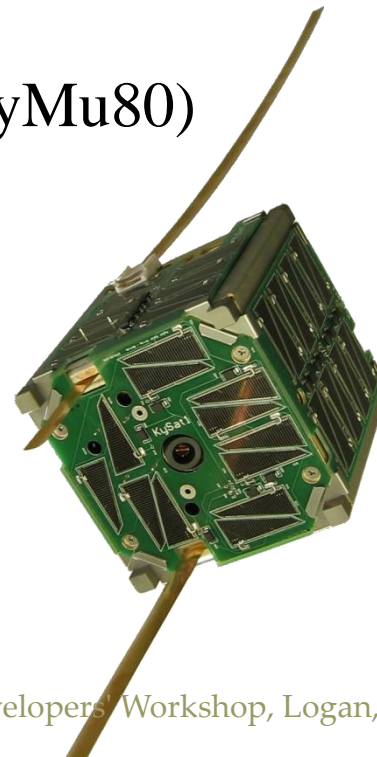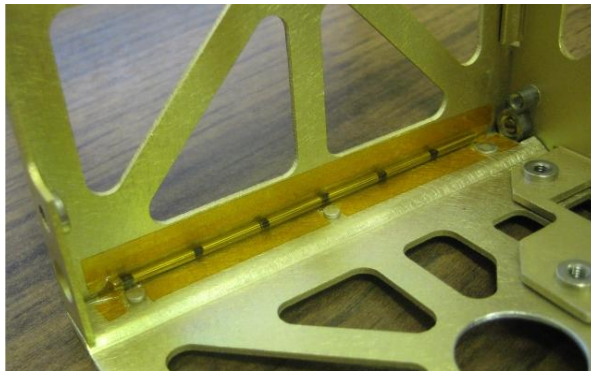
KySat-1: Simulation

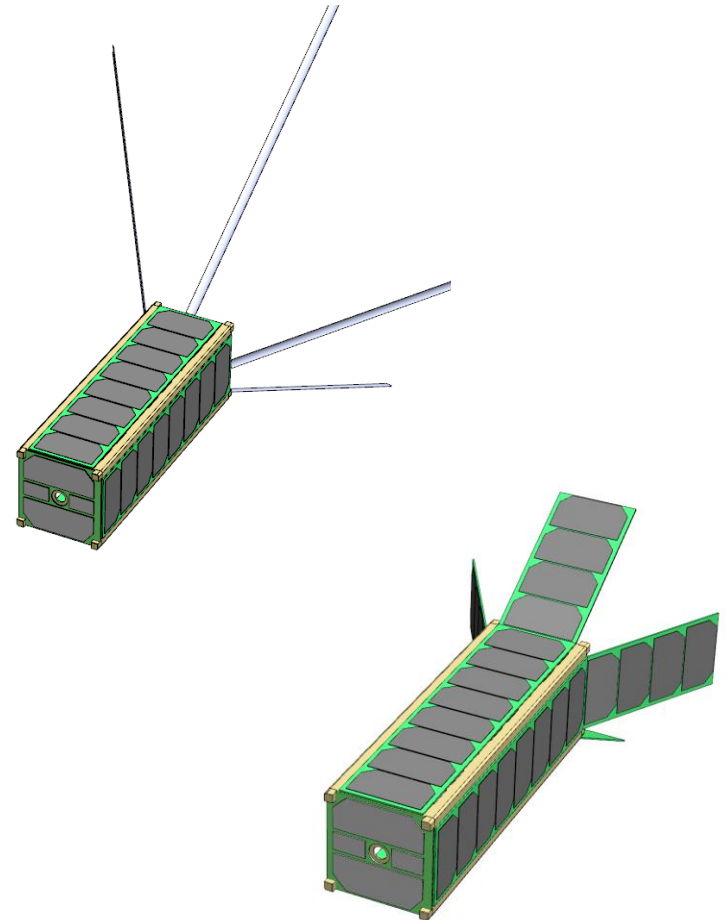**Simulated Time Response of the KySat-1 Passive Magnetic Stability System**

KySat-1: Animation
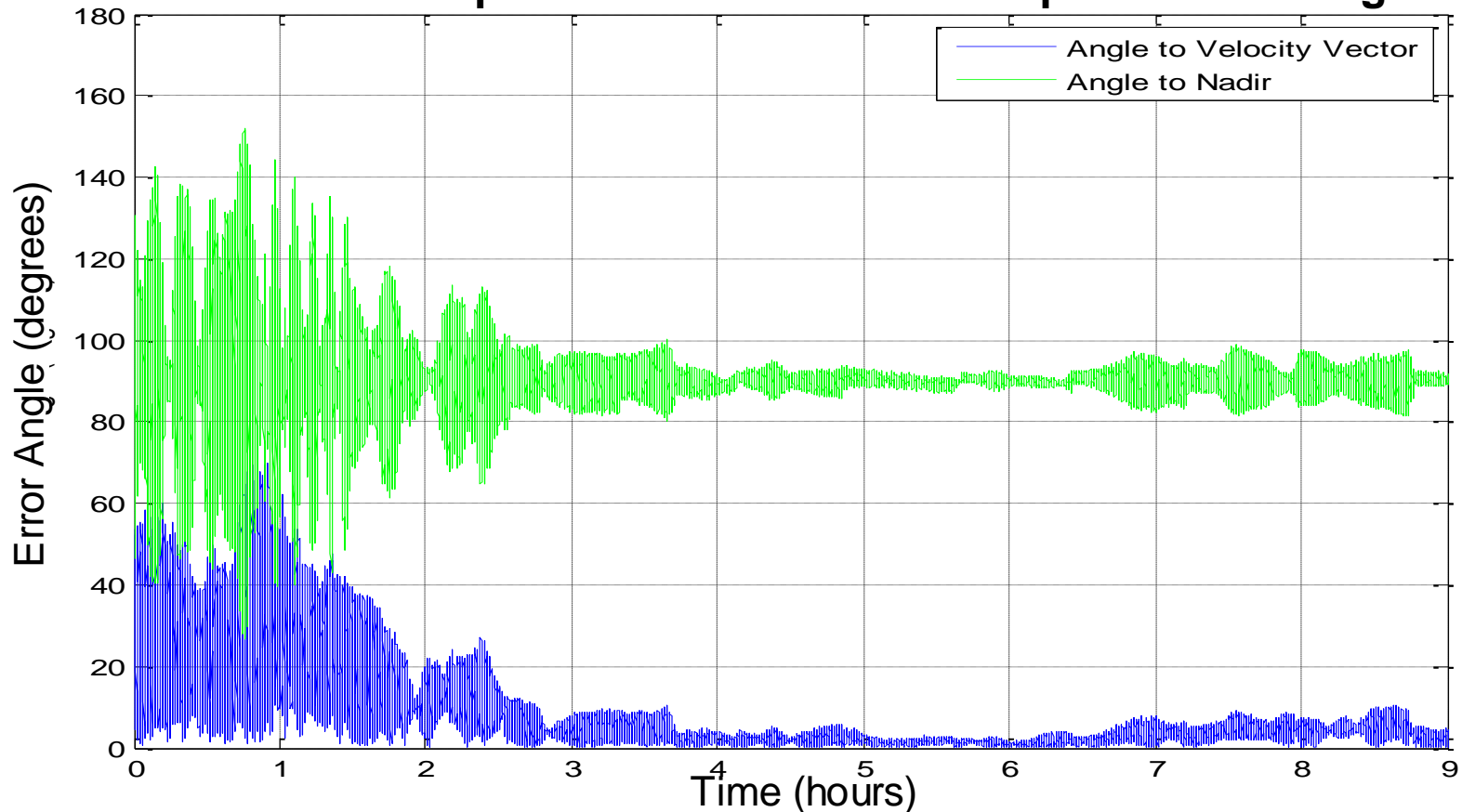
RamSat: Aerodynamic Stability

- Ram-facing
- Maximum altitude
- No roll control

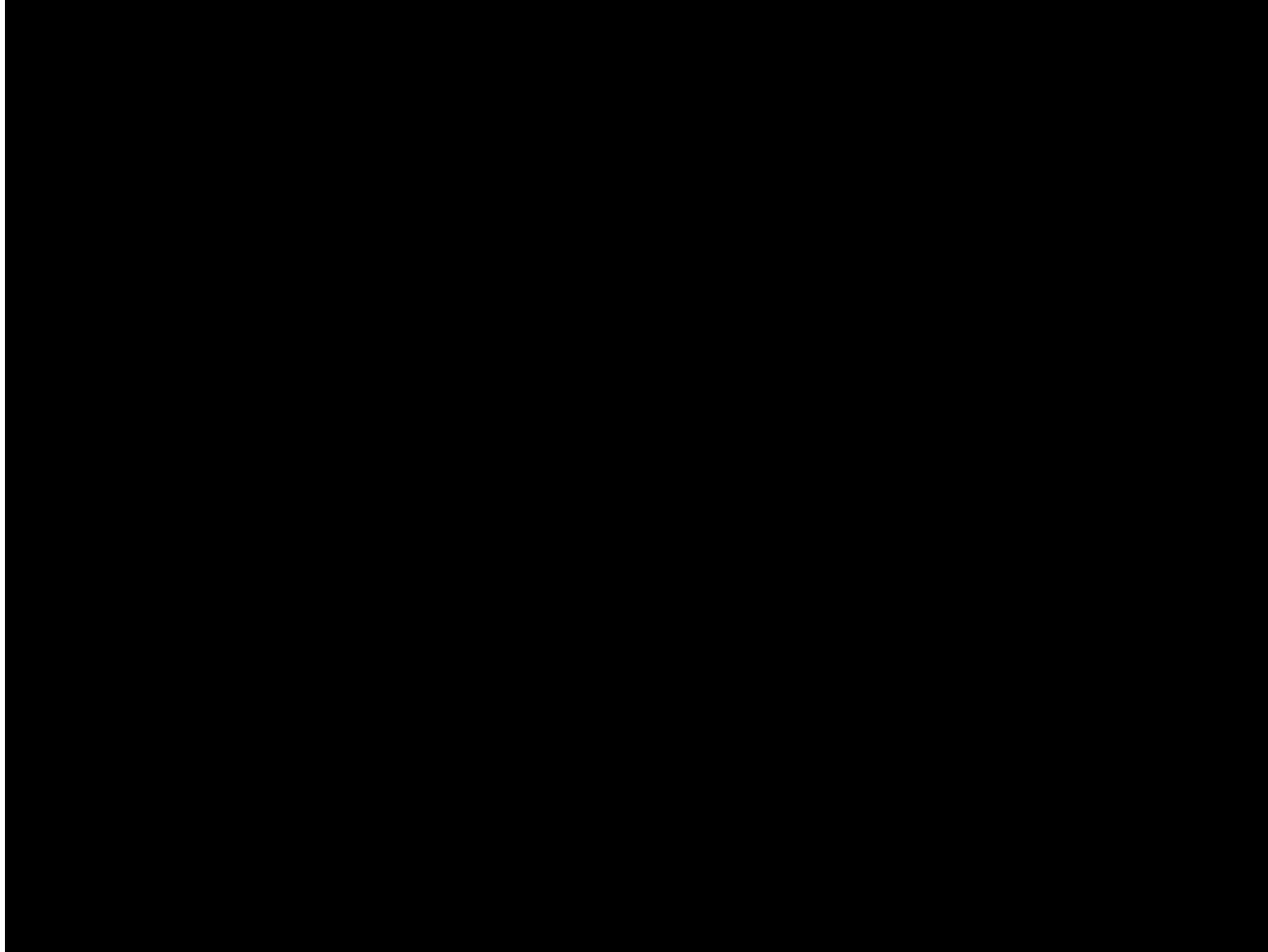- Simulation:
  - 20cm full width panels
  - 30° deployment angle

RamSat: Simulation

Simulated Time Response: RamSat with 20cm panels at 30 degrees
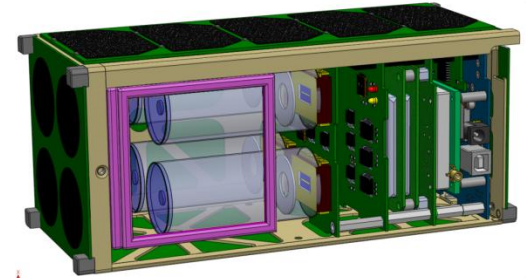
RamSat: Animation

Future Enhancements

- Active Attitude Control Systems
  - Torque Coils
  - Reaction Wheels
  - Momentum Wheels
  - Thrusters
- System Design Choices
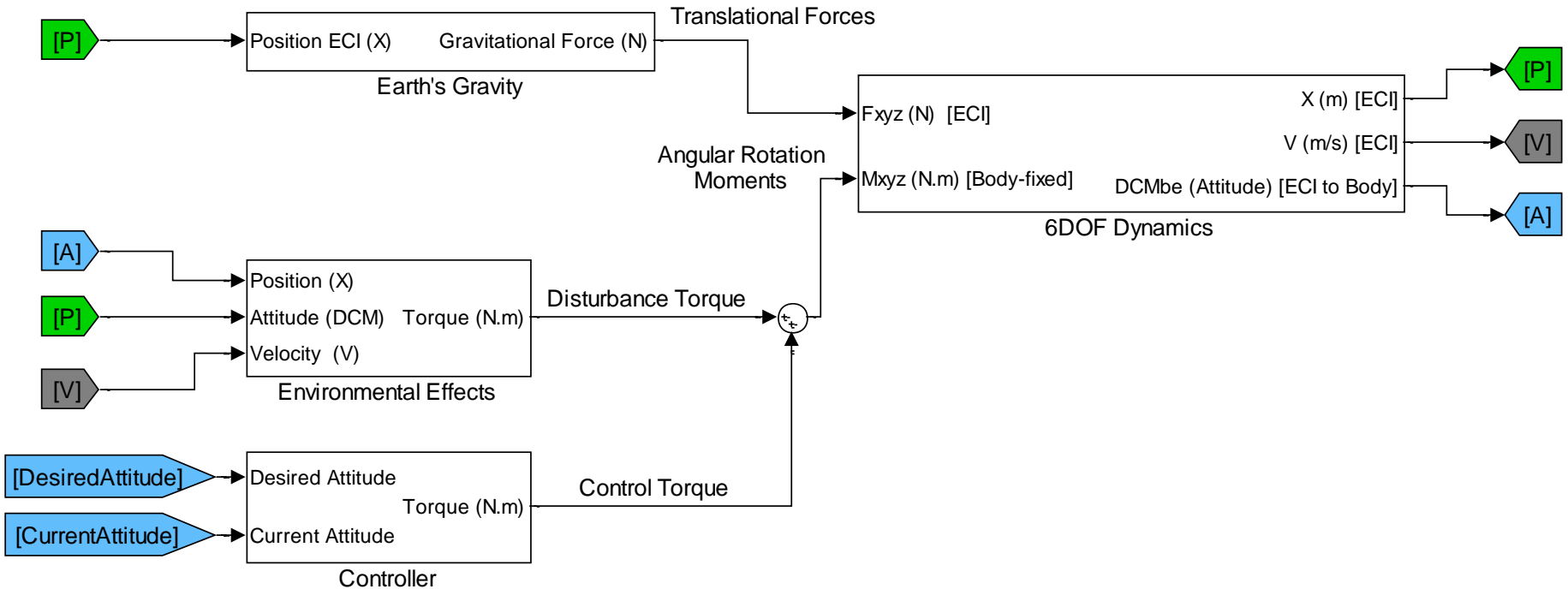(e.g. reaction wheel size, torque coil strength)
- Control Logic Development

Danjon (concept) – Kentucky Space

Reaction Wheels
sinclairinterplanetary.com

Active Control

Kentucky Space - Orbital Environment Simulator

Thank You

Samir Rawashdeh

Space Systems Laboratory
Electrical & Computer Engineering
University of Kentucky
sar@ieee.org

www.kentuckyspace.com