EARLY STAGE DEVELOPMENT OF DYNAMIC SIMULATION PLATFORM FOR REACTION WHEELS CONTROLLED CUBESAT MODEL

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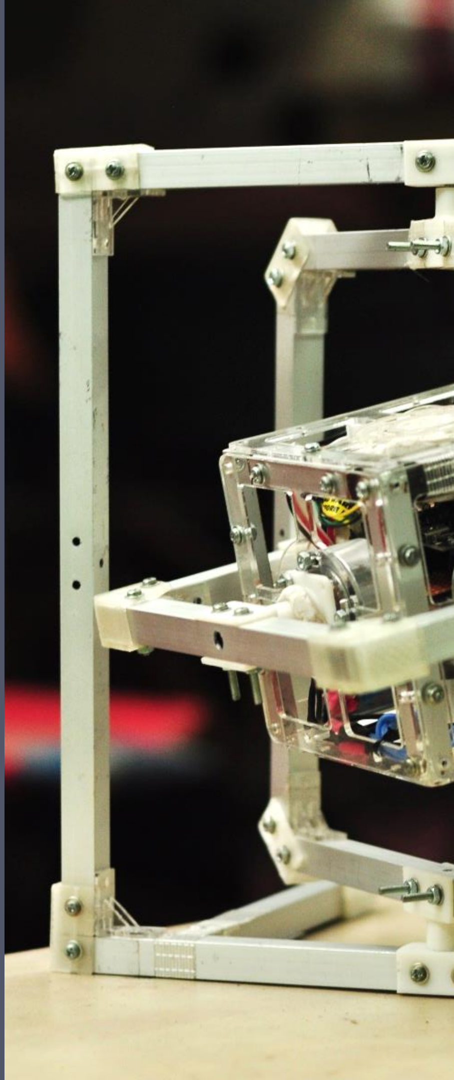
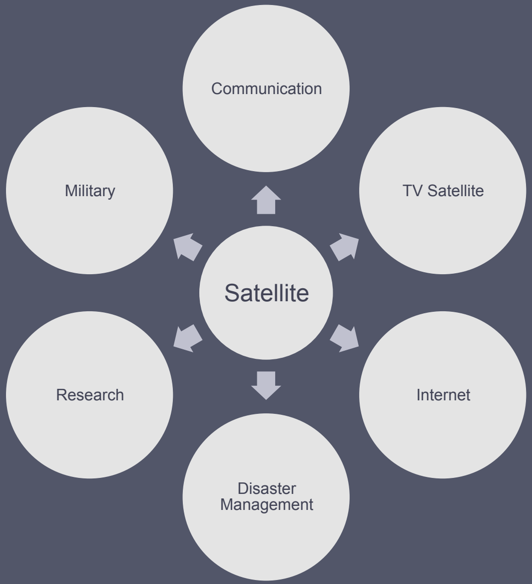
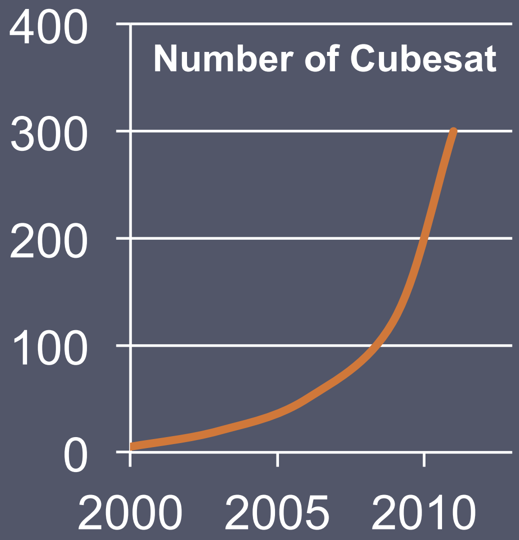
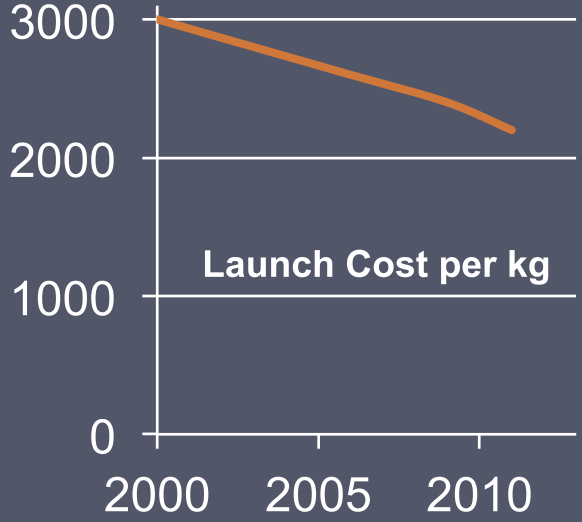


Background







Design Process is **necessary**

Research Purposes

1. To develop a Cubesat Dynamic **Design Tool** to support the design process of the simulation platform.

2. To design, manufacture, test, and evaluate a simple **Cubesat model** and an **inertia platform** to support it. (*hardware simulation platform*)

3. To develop a **simulation system** to run the simulation process, including the interface between embedded system and station, user interface, and functions needed. (*software simulation platform*)

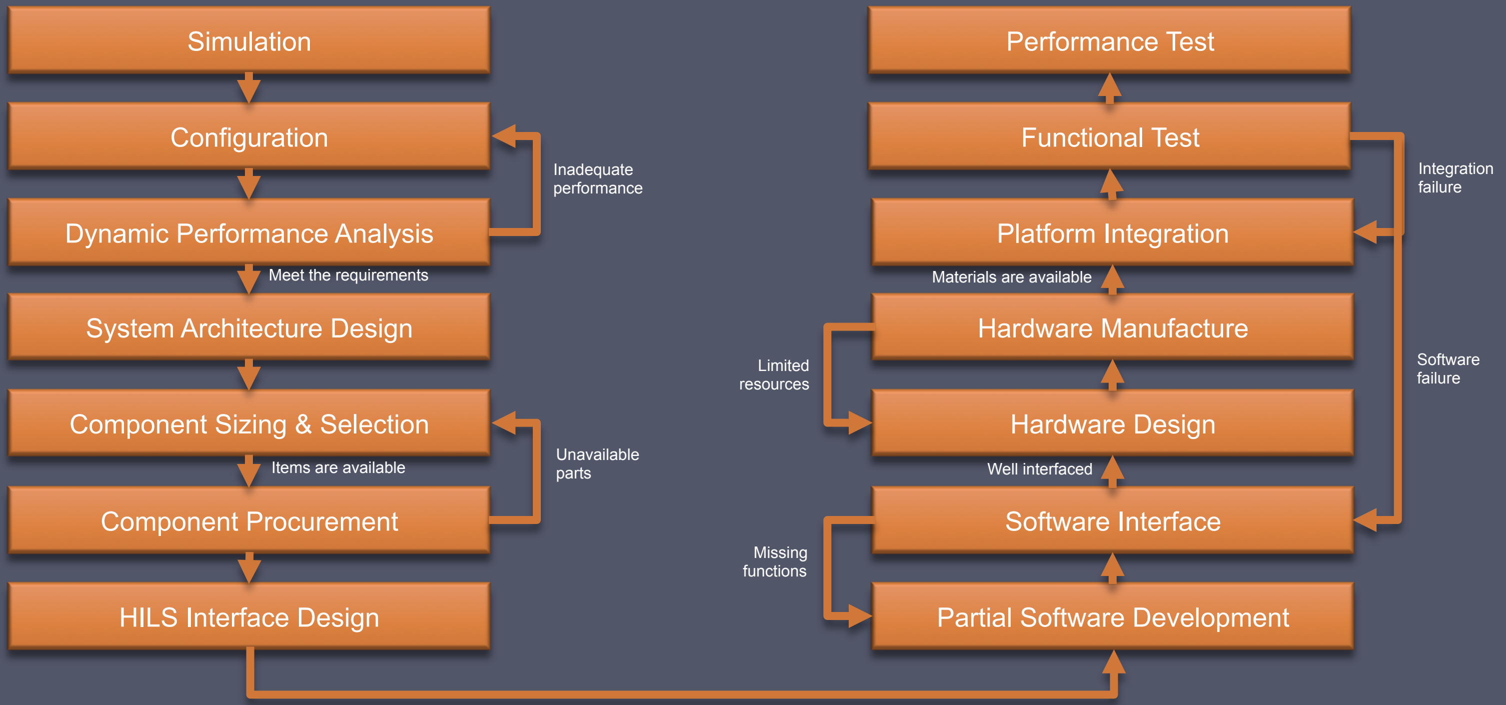
Scope of Problem

1. The platform is **designed for Cubesat**, sized 10 x 10 x 10 cm and weigh less than 1 kg.

2. The **embedded system** is replaced by **microcontroller**.

3. The **actuators** that are used are **modified motors** to mimic the function of reaction wheels.

Methodology



Config Tool

Design Tools

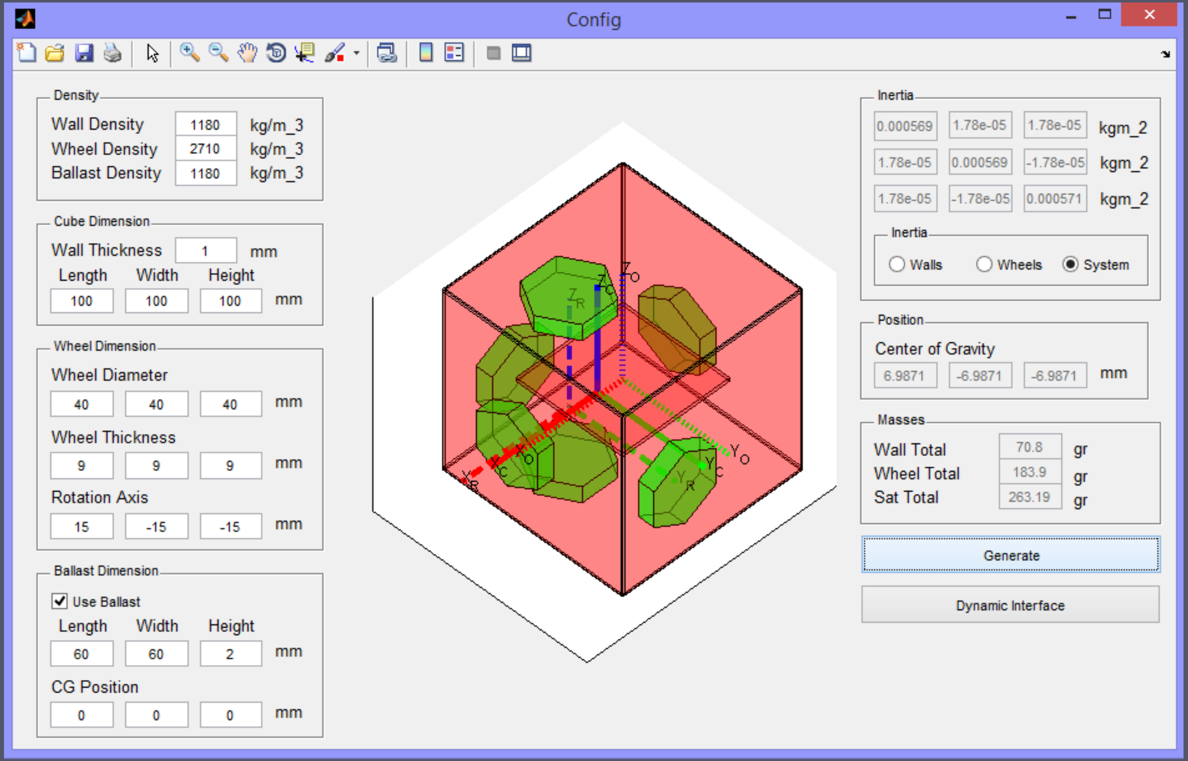
Configuration Tool Interface

Density of the components

Dimension of the Cube

Dimension and Configuration of the Reaction Wheels

Dimension and Configuration of Ballast



Inertia Matrix of specific group of Components

Position of Center of Gravity

Total Mass of specific group of Components

Open Loop Tool

Design Tools

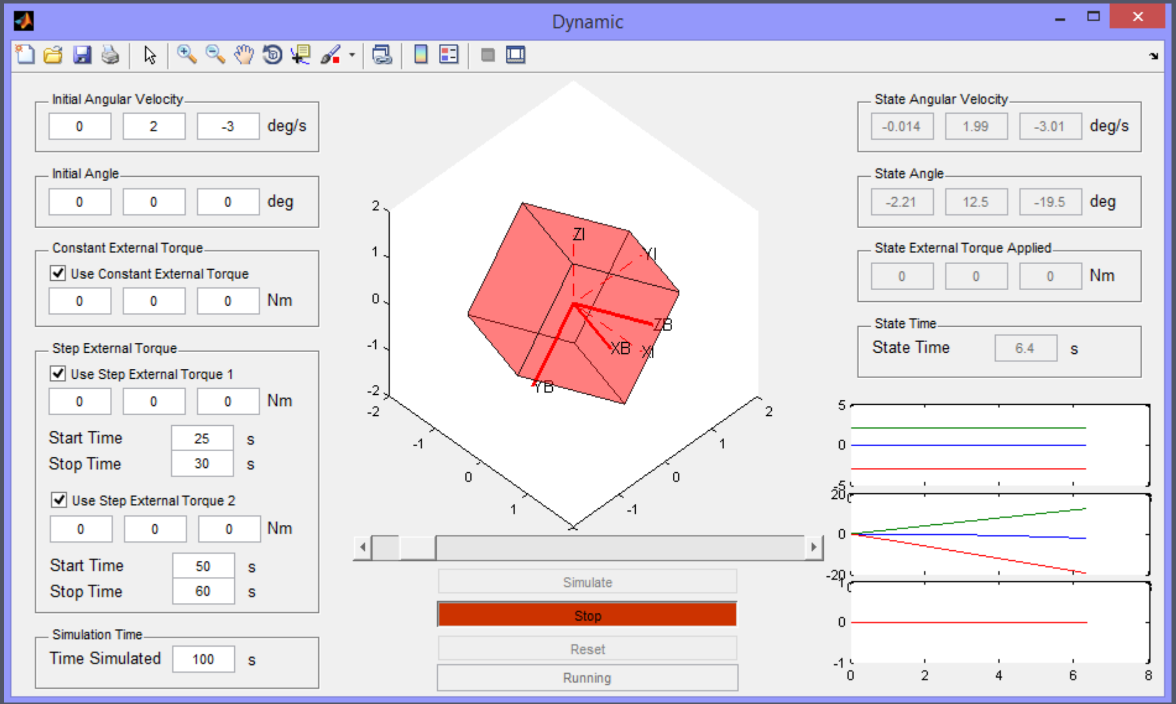
Open Loop Simulation Tool Interface

Initial condition of Cubesat

Constant External Torque

Temporary External Torque

Simulation Period



State condition of Cubesat at given time

Simulation time

Plot of state condition of Cubesat at given time

Closed Loop Tool

Design Tools

Closed Loop Simulation Tool Interface

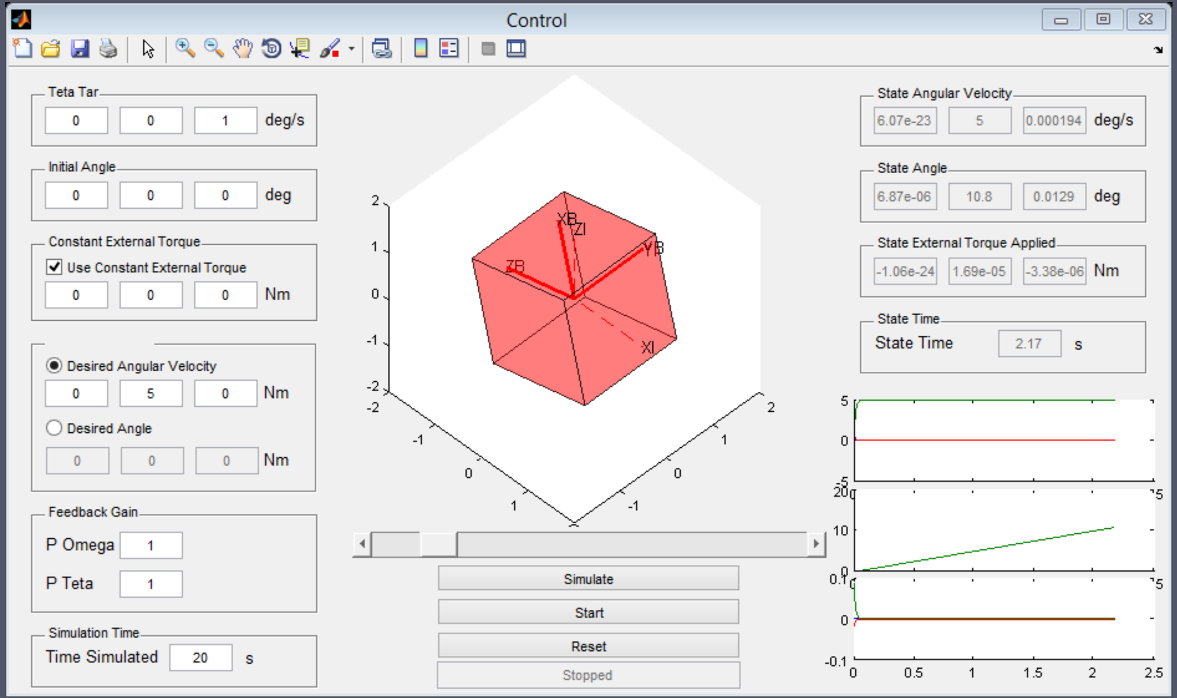
Initial condition of Cubesat

Constant External Torque

Desired Condition

Feedback Gain

Simulation Period



State condition of Cubesat at given time

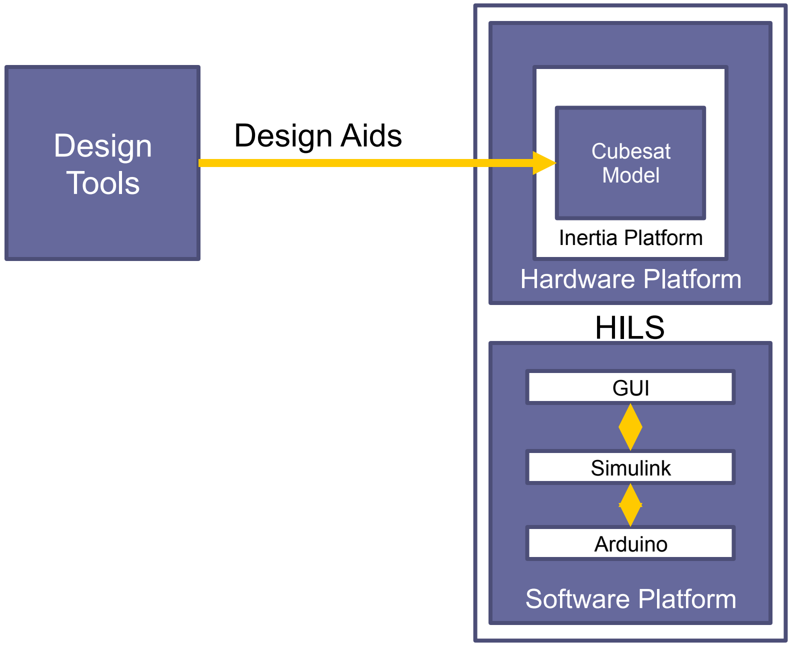
Simulation time

Plot of state condition of Cubesat at given time

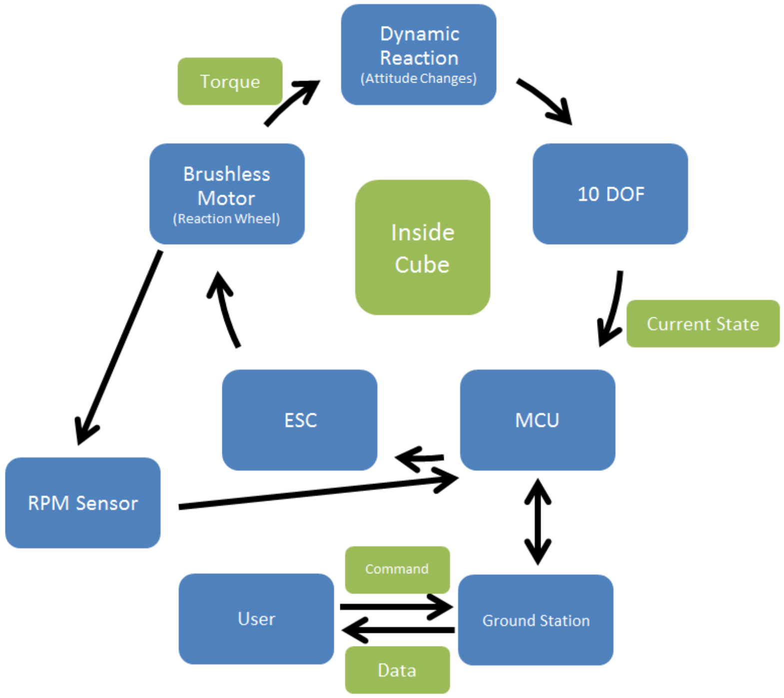
Simulation Platform

Software

Whole System Architecture



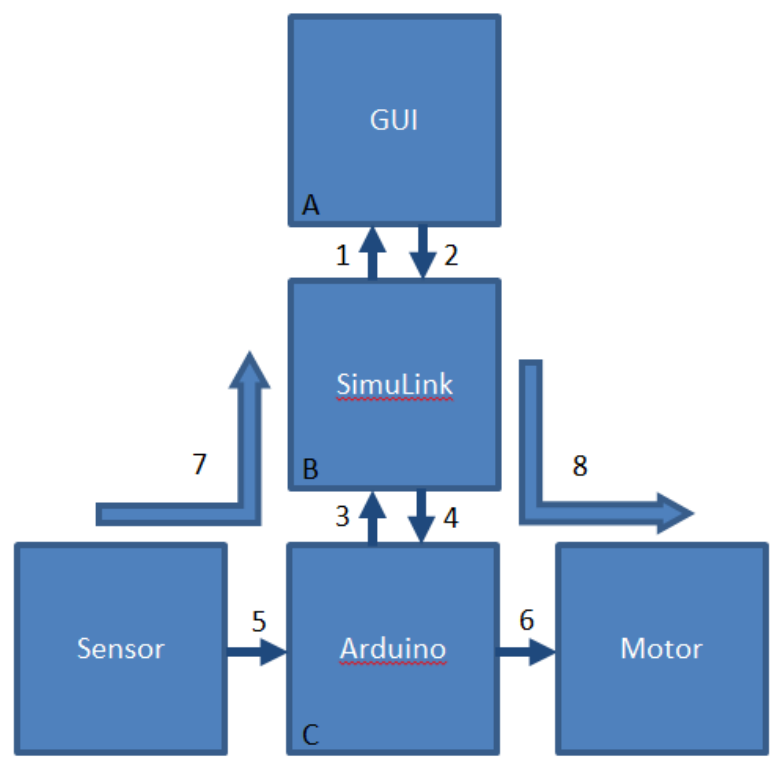
Simulation System Workflow



Software Development

Hardware In Loop Simulation

1	Simulink to GUI **(Real Time Object)**
3	Arduino to Simulink **(Serial Receive)**
5	Sensor to Arduino **(Digital Motion Processing/ Complementary Filter)**
7	Sensor to GUI

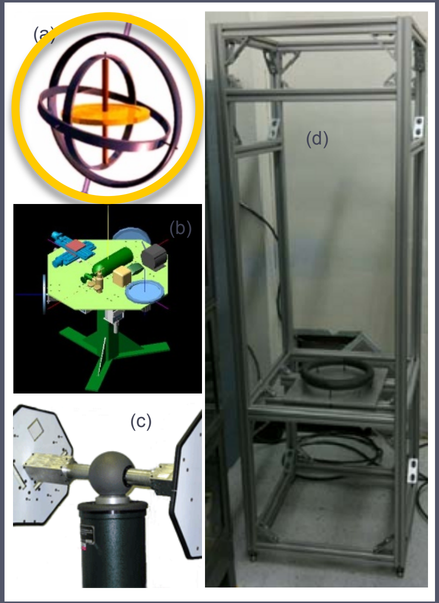


2	GUI to Simulink **(Assignin/ Set_Param)**
4	Simulink to Arduino **(Serial Send)**
6	Arduino to Motor **(Servo PWM)**
8	GUI to Motor

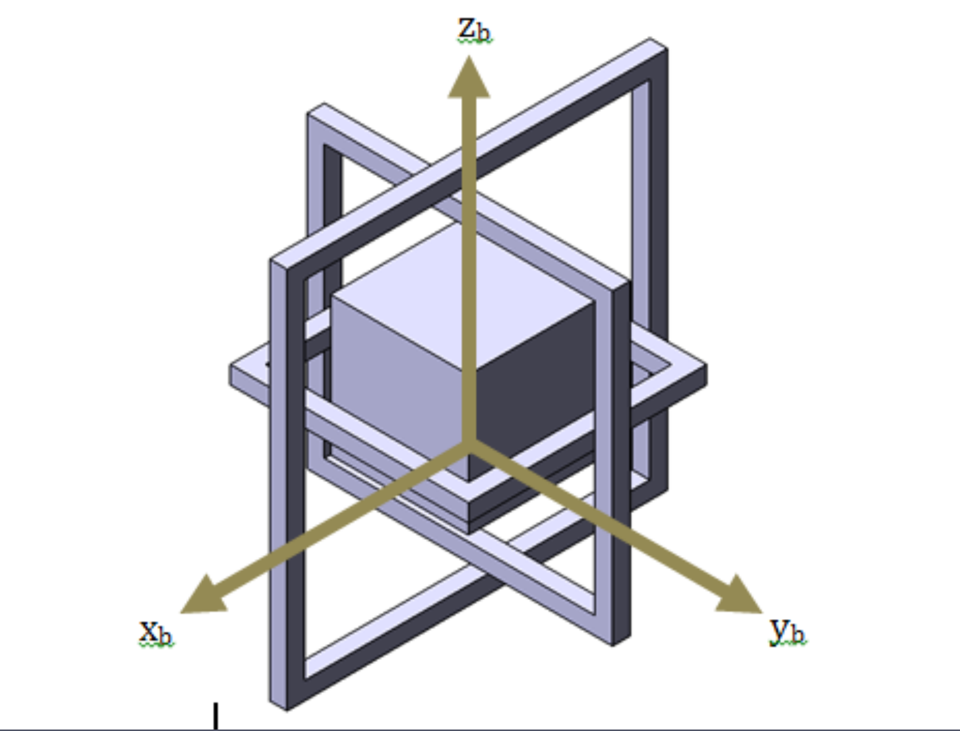
Inertia Platform

Simulation Mechanism

a. **Gyroscopic Platform**
b. Air Bearing Tabletop
c. Air Bearing Dumble
d. Magnetic Levitating Platform



Inertia Platform Configuration

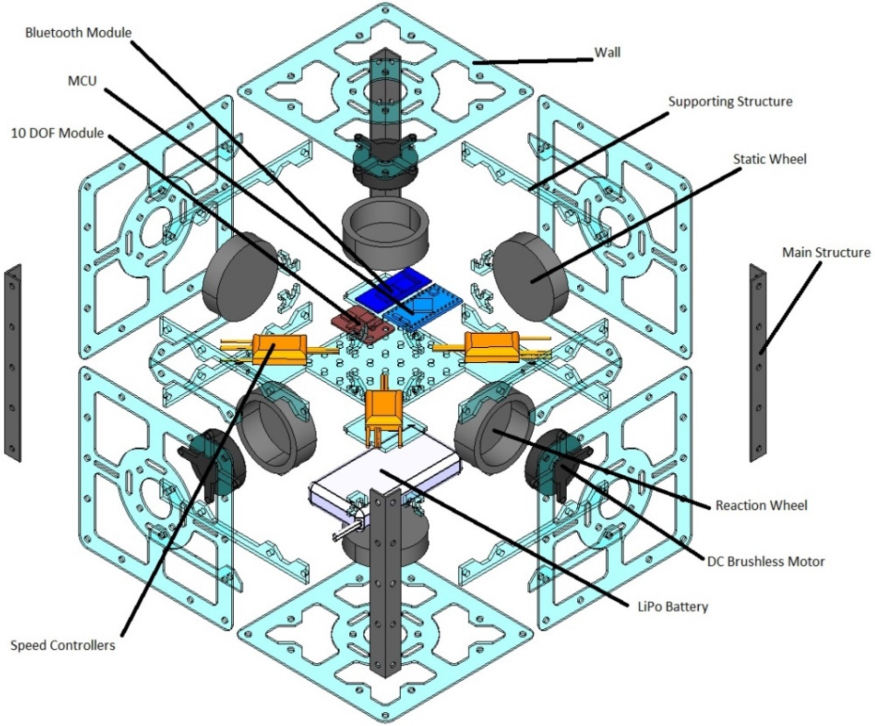


Cubesat Model

Modeled Subsystems

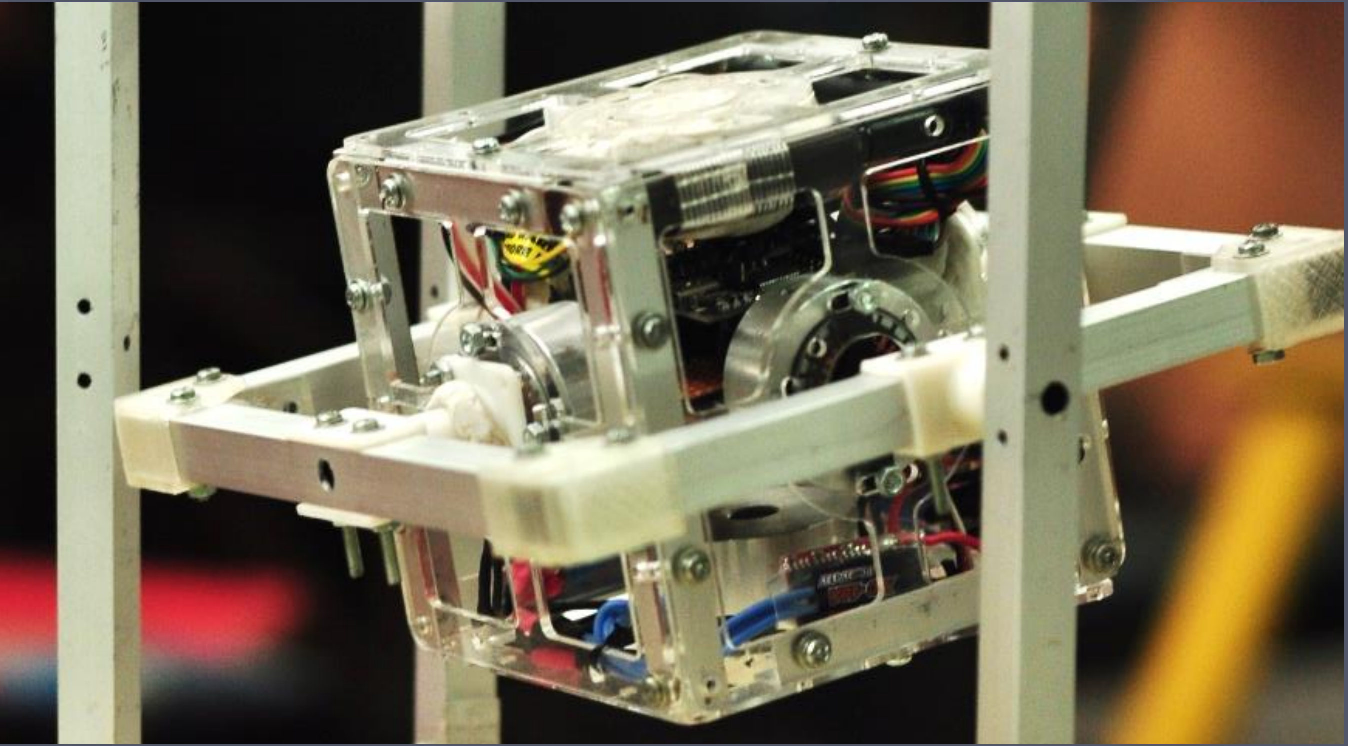
Structure	Aluminum & Acrylic
Thermal	-
OBC/OBDH	Microcontroller
ADCS	IMU – Reaction Wheels
EPS	Battery
COMM	Radio Telemetry
Propulsion	-
Payload	-

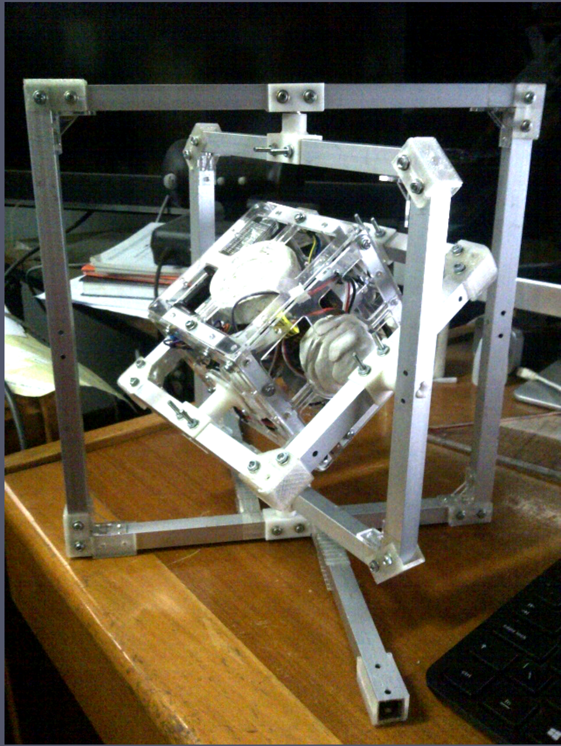
Cubesat Configuration



Here it is…

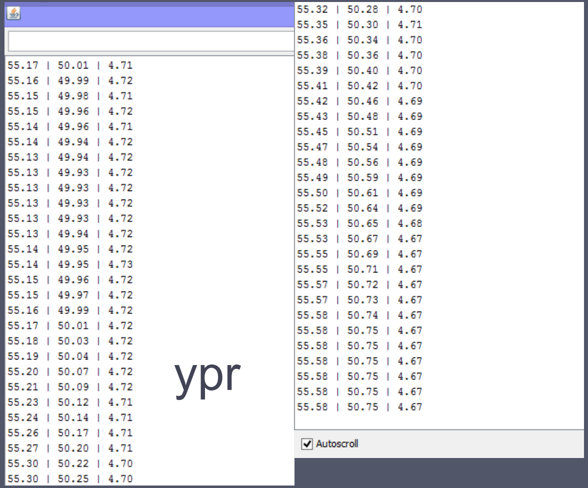
Simulation Platform



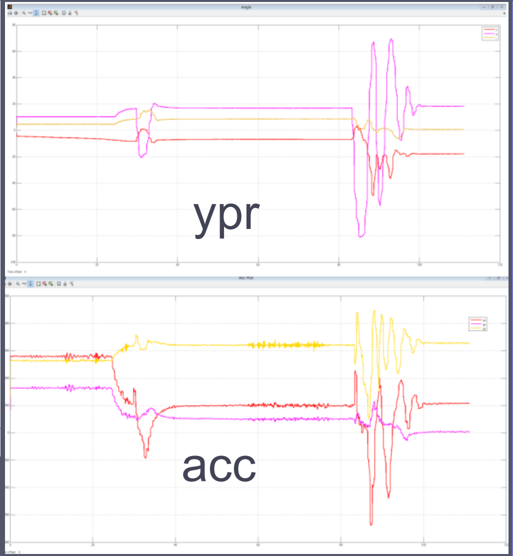


Command & Data

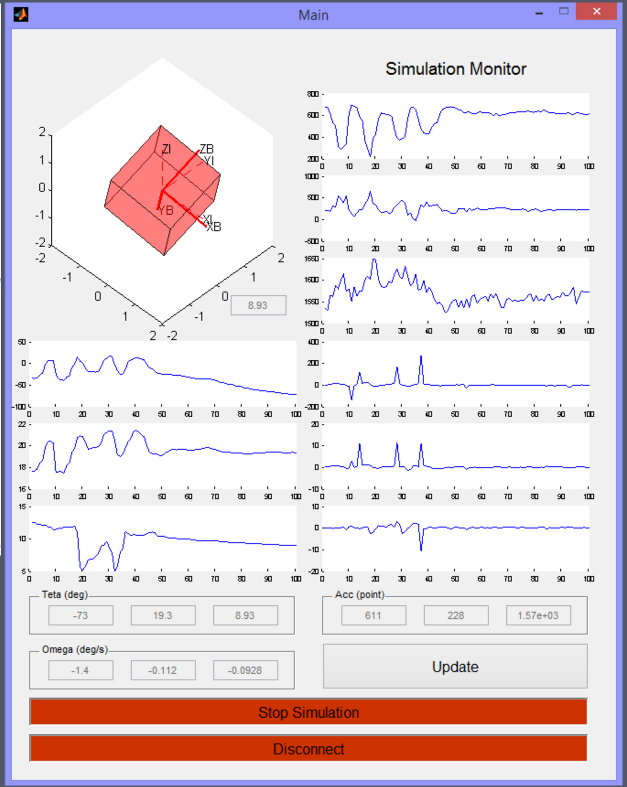
Arduino Sensor Reading



Simulink Serial Receive



GUI RTO Receive

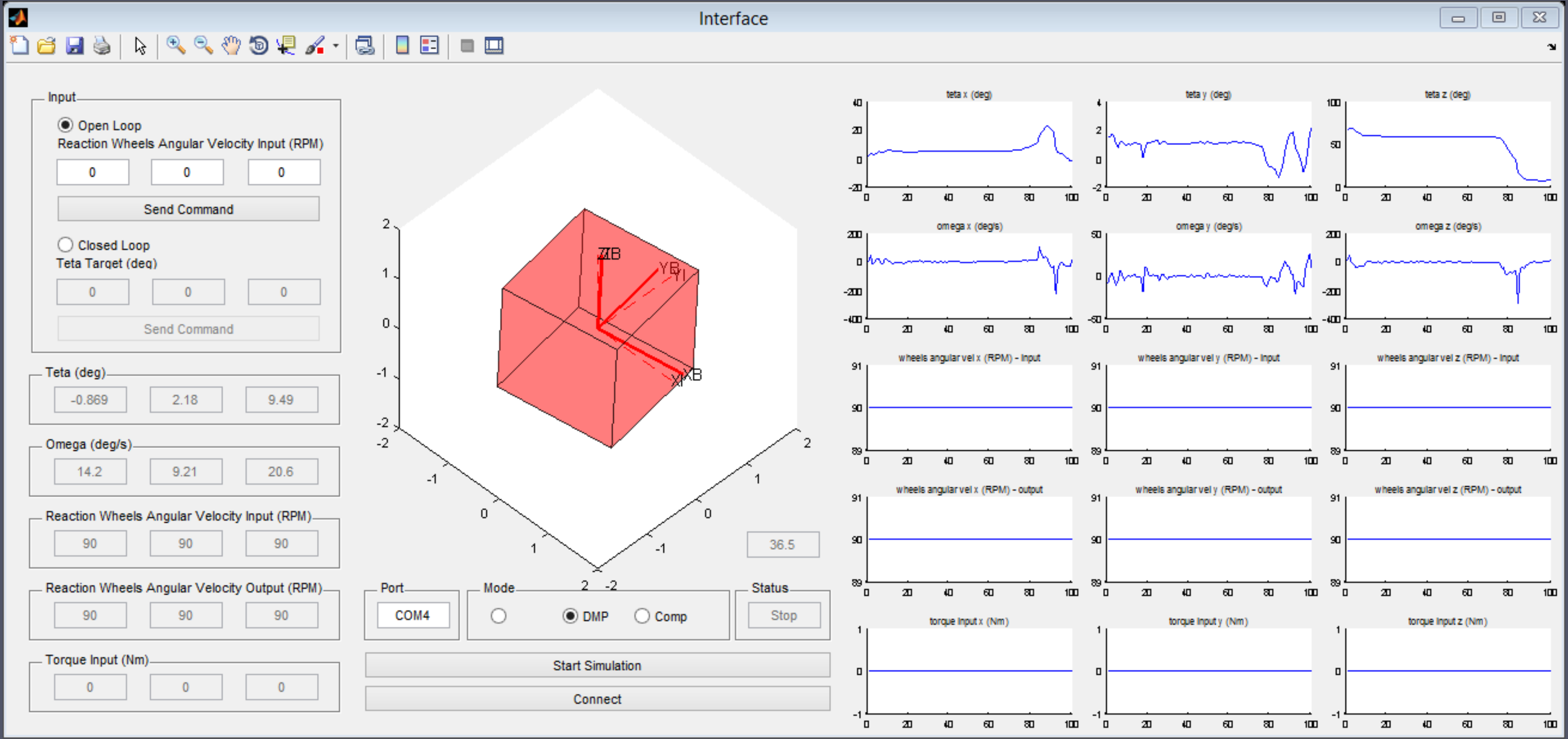


Command Assigning

Simulink Serial Send

GUI Simulation Update

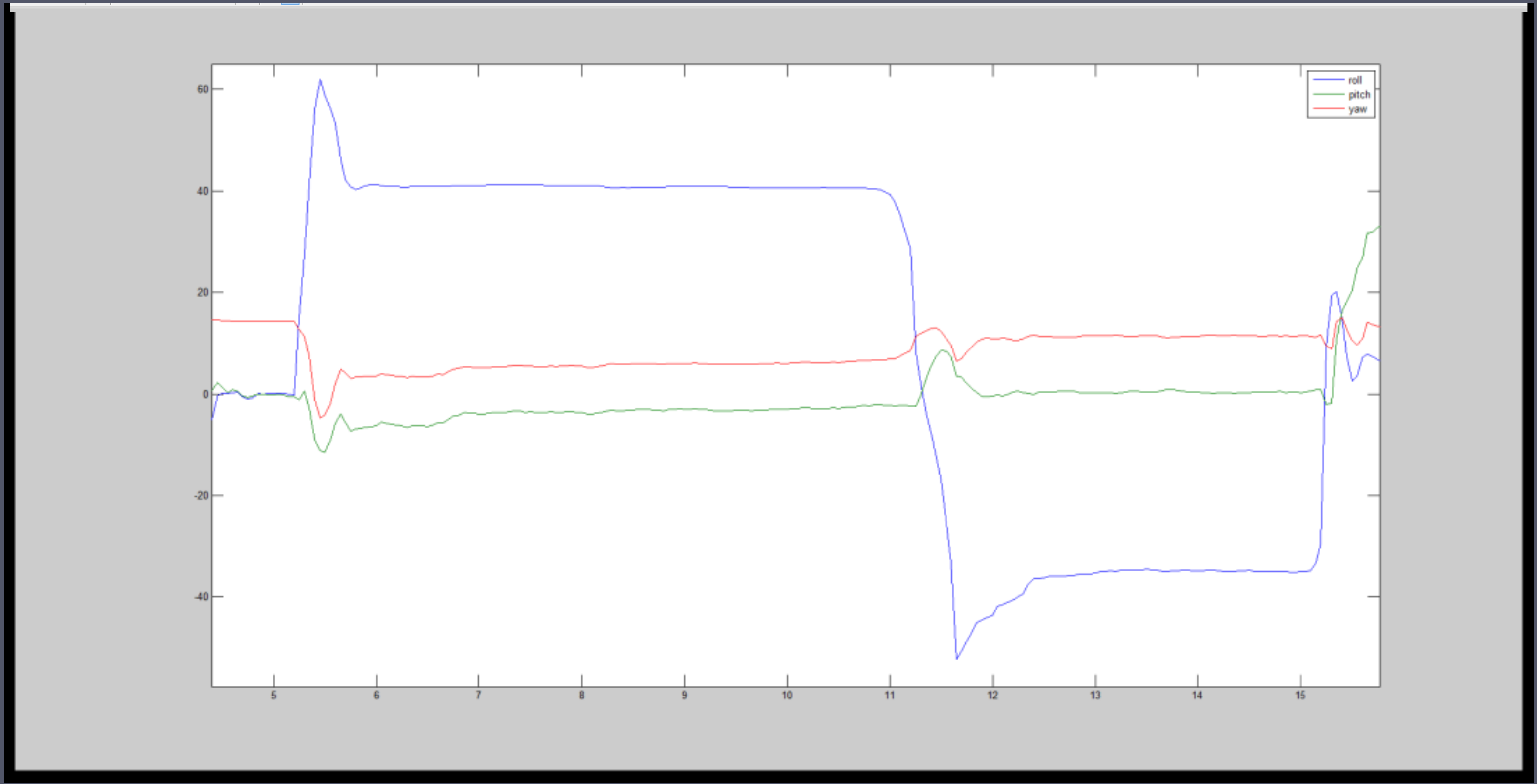
GUI


Interface
Input
Open Loop
Reaction Wheels Angular Velocity Input (RPM)
0
0
0
Send Command
Closed Loop
Teta Target (deg)
0
0
0
Send Command
Teta (deg)
-0.869
2.18
9.49
Omega (deg/s)
14.2
9.21
20.6
Reaction Wheels Angular Velocity Input (RPM)
90
90
90
Reaction Wheels Angular Velocity Output (RPM)
90
90
90
Torque Input (Nm)
0
0
0
ZB
YB
YI
XIXB
36.5
Port
COM4
Mode
DMP
Comp
Status
Stop
Start Simulation
Connect
teta x (deg)
teta y (deg)
teta z (deg)
omega x (deg/s)
omega y (deg/s)
omega z (deg/s)
wheels angular vel x (RPM) - input
wheels angular vel y (RPM) - input
wheels angular vel z (RPM) - input
wheels angular vel x (RPM) - output
wheels angular vel y (RPM) - output
wheels angular vel z (RPM) - output
torque input x (Nm)
torque input y (Nm)
torque input z (Nm)

Functional Test

Test & Evaluation

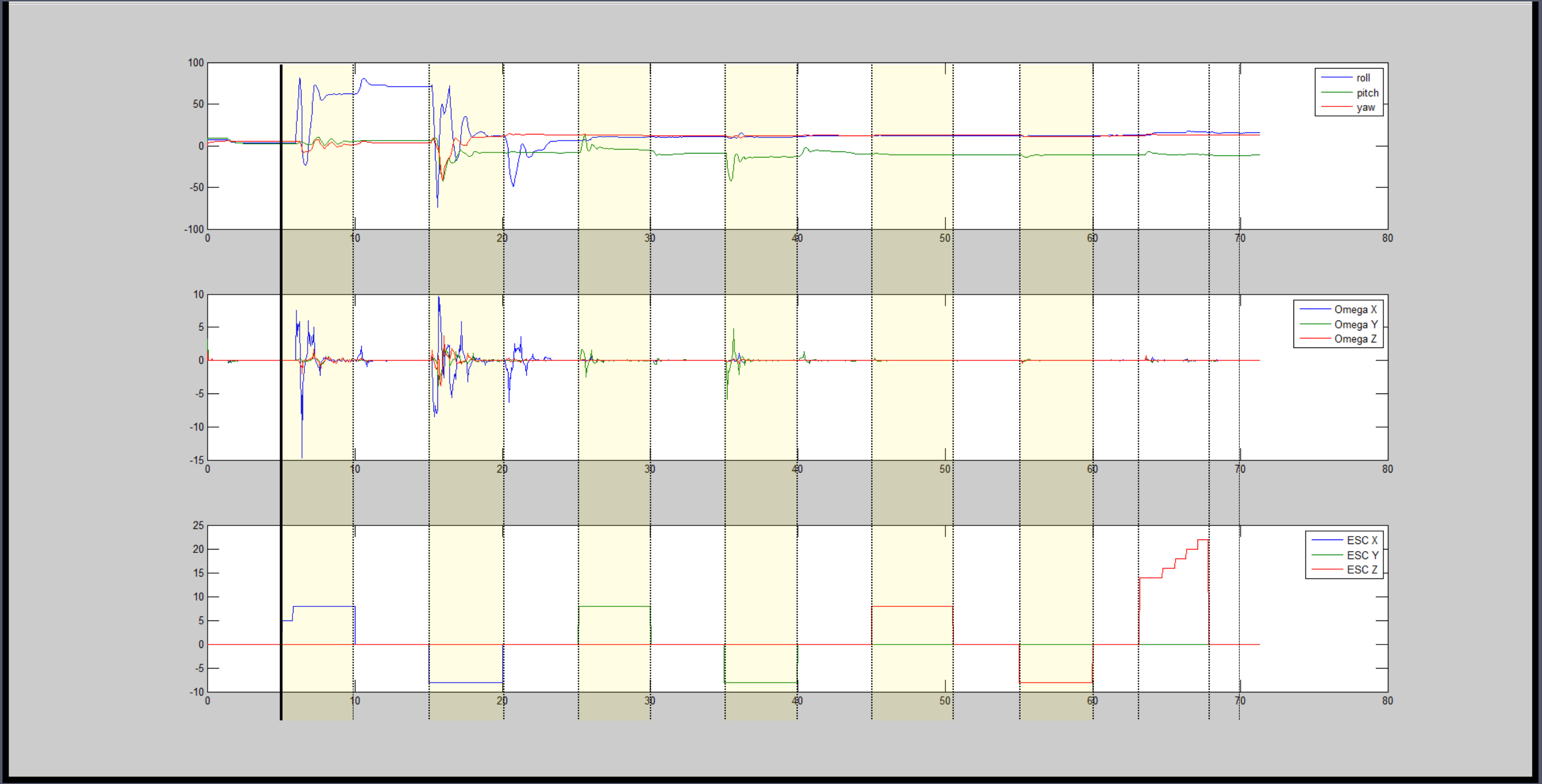
Static Test: Angle Measurement



Functional Test

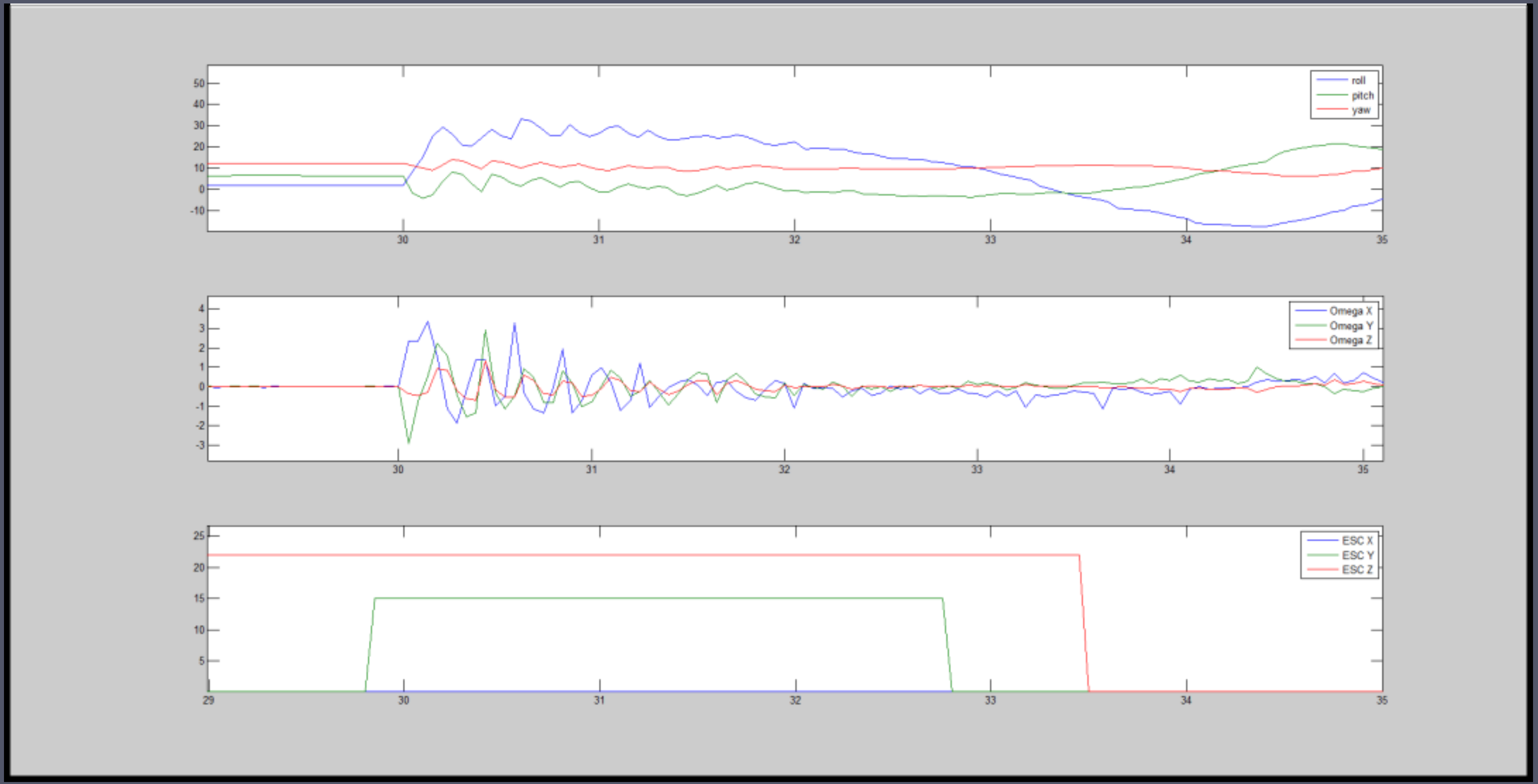
Test & Evaluation

Dynamic Test: Reaction Wheels



Functional Test

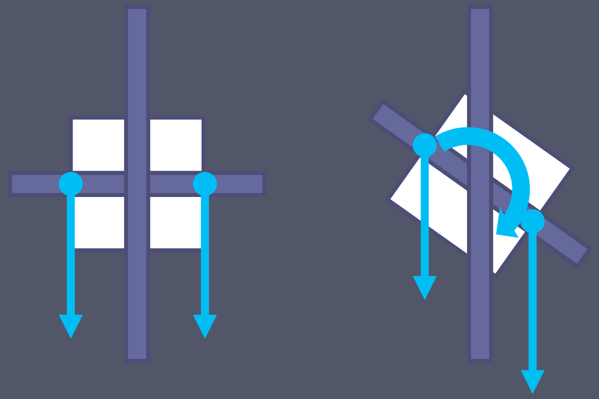
Dynamic Test: Gyroscopic Phenomenon with Reaction Wheels



Evaluation

Design & Component Selection Evaluation

1. Gyroscopic Mechanism
2. Gravity Gradient
3. Bearing Lock



Encountered Problem

1. Wireless Communication → Wired Communication
2. Cubesat Model Weight Distribution
3. Friction in the bearing lock
4. Wheel Balancing
5. Motors are stuttering in High RPM

Conclusion

1. the **simulation platform** that is intended to simulate the dynamic performance of a cubesat and to observe the capability of ADCS that is being used **has successfully been developed at early stage**.

2. **Cubesat Dynamic Design Tool** that has been built to support the design process of the Cubesat.

3. The simulation platform has been **tested and evaluated**, to be improved for further research.

Future Works

1. Hardware components have to be machined and/or processed in more proper way (balance, weight distribution, accuracy).

2. Component selection has to be reconsidered based on its performance.

3. A system to simulate perturbation in the outer space is also can be added.

References

Hutasuhut, H. M., “Early Development of Spacecraft Dynamic Simulator”, Undergraduate Theses, Aeronautics and Astronautics Dept, Institut Teknologi Bandung, Indonesia, 2011.

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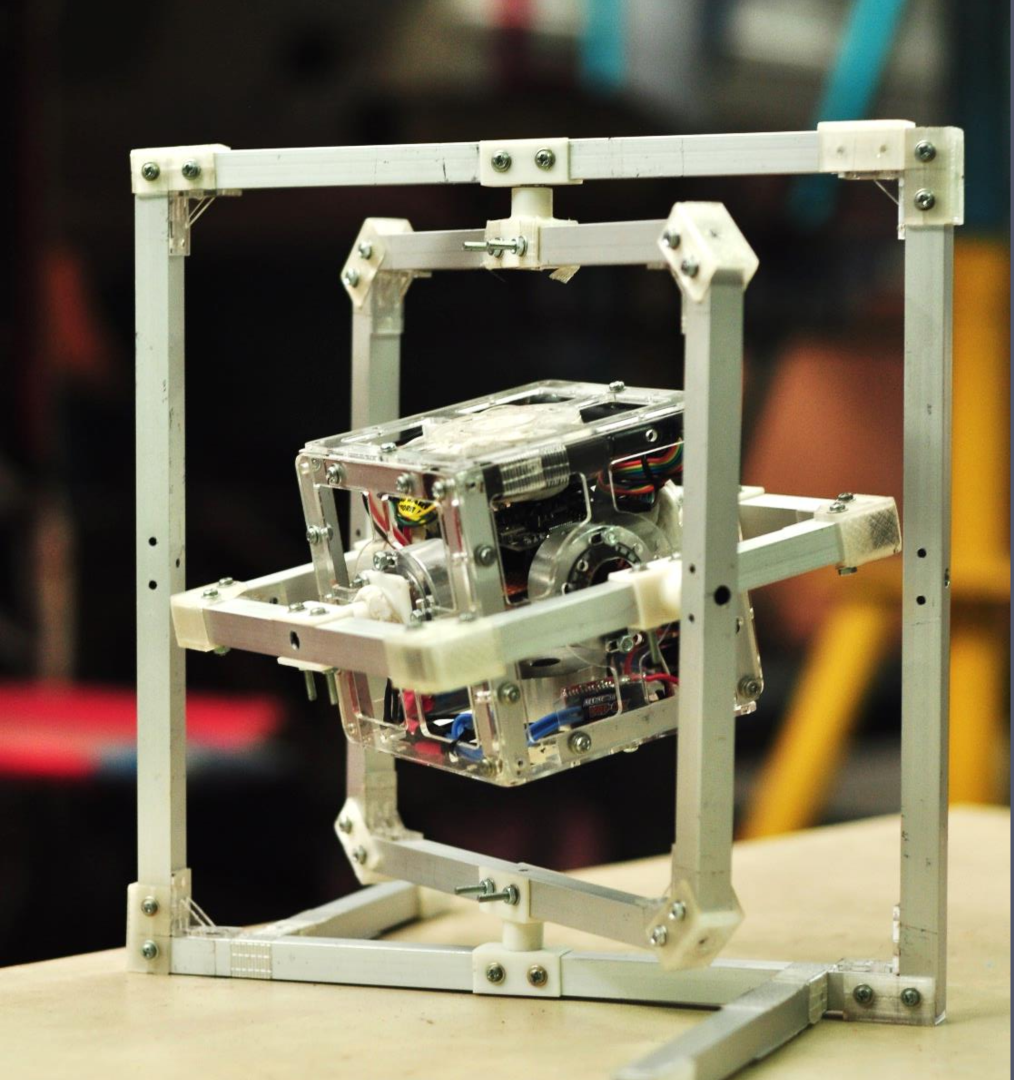

Thank you