ROBOTIC AGRICULTURAL DATA ACQUISITION

GROUP MAY15-27

SENIOR DESIGN II

Team Advisers

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Team Members

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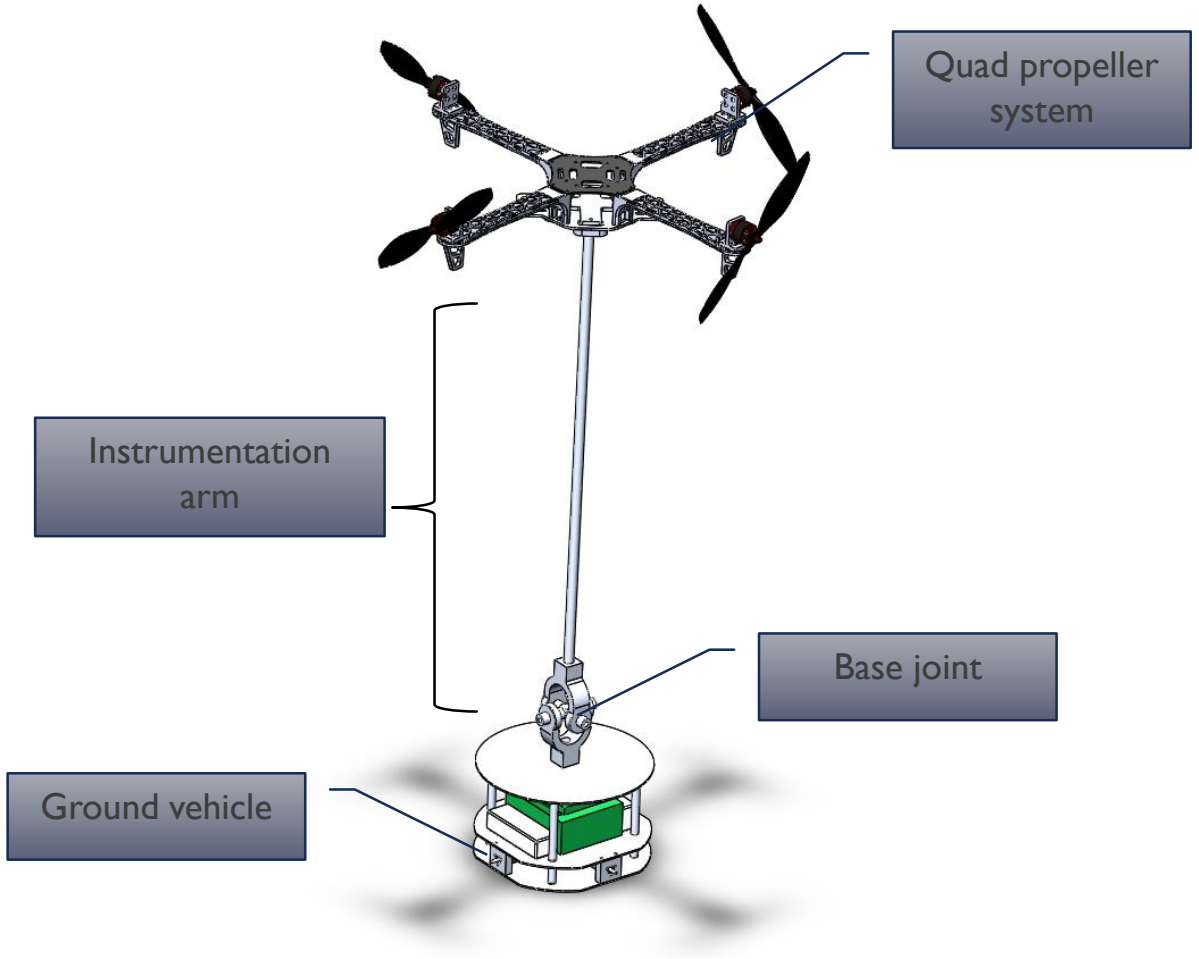
PROBLEM STATEMENT

- Agricultural experiments
  - Experimental crop fields
  - Measure growth and analyze progress
- Automation of tasks with robotics
  - Saves time, money and personnel

FINAL DESIGN

- Ground vehicle
  - On-board computation
- Instrumentation arm
  - Mounted cameras
- Quad-propeller system
  - On-board sensors



PROJECT END GOAL

- The end goal of our Senior Design project is to demonstrate a proof of concept of such a robotic system.

SIMPLIFYING DECISIONS

- Reused existing resources left over from previous senior design teams
  - Use of existing quad-rotor frame
  - Ground robot
  - Use existing camera system for sensing
  - Develop indoors on smaller scale

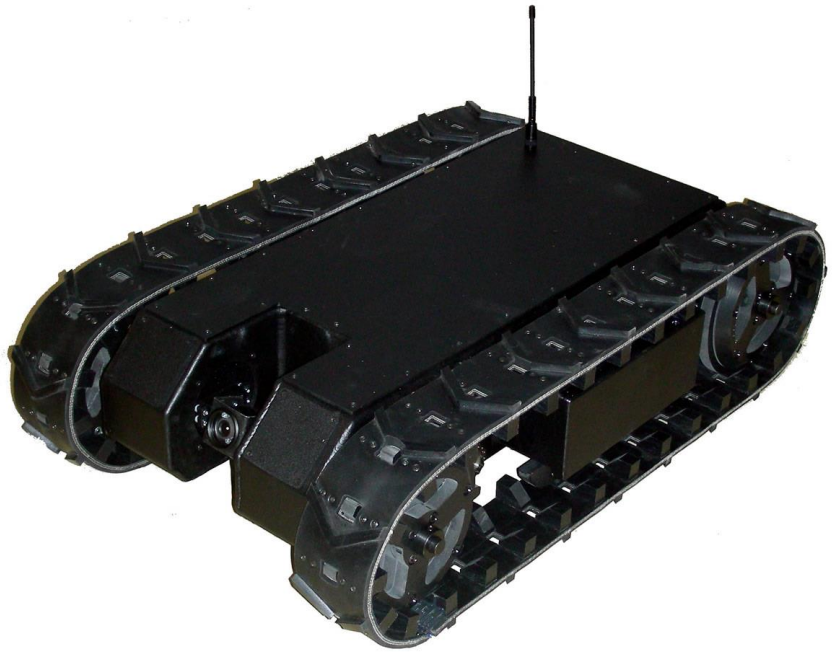
SIMPLIFYING DECISIONS

DJI Quadcopter Frame

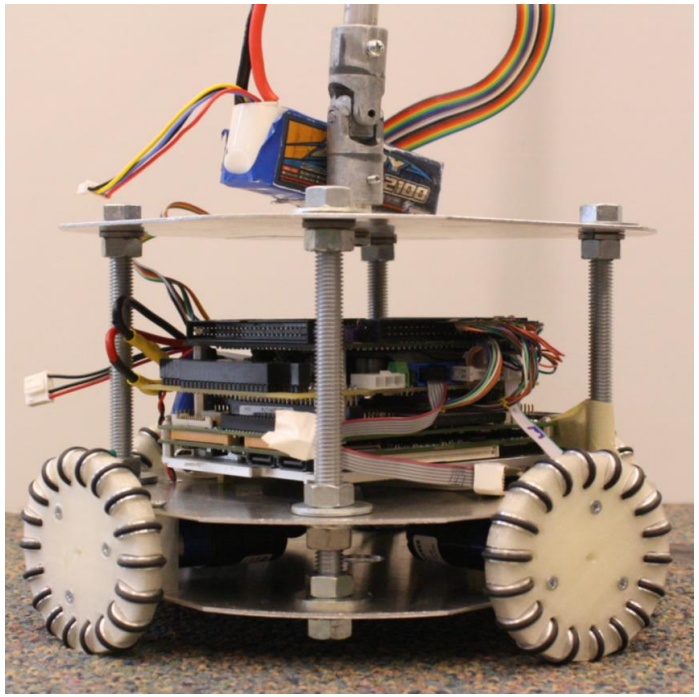
Prototype Design Modifications

SIMPLIFYING DECISIONS

Ideal Implementation

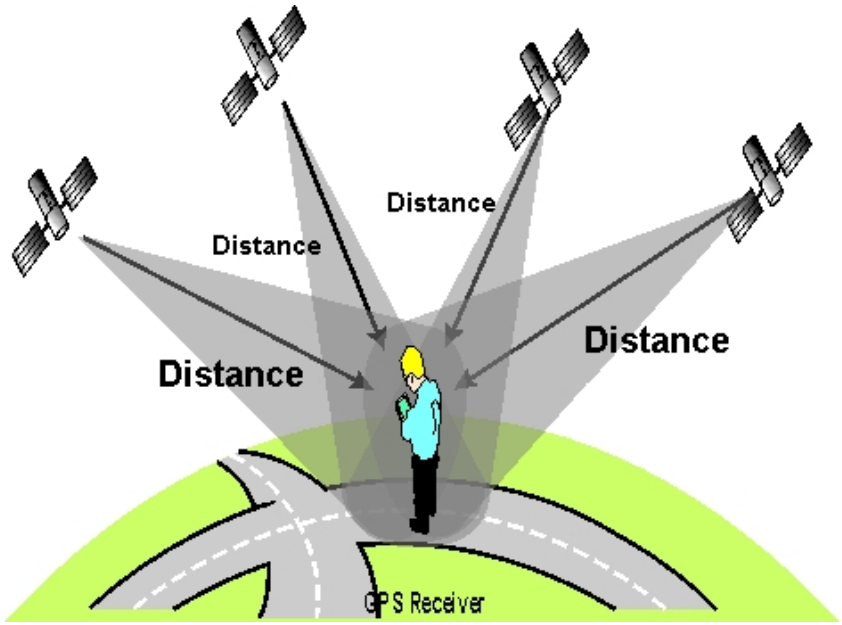


Omnidirectional Robot

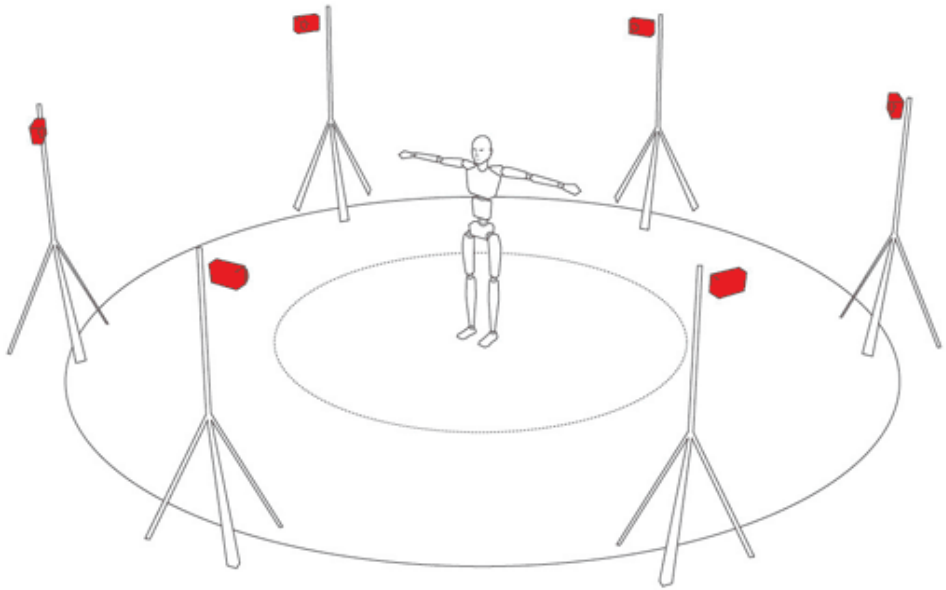


SIMPLIFYING DECISIONS

GPS System



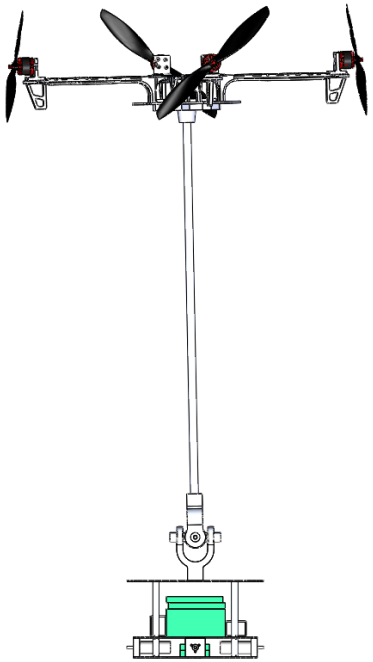
OptiTrack Camera Tracking System



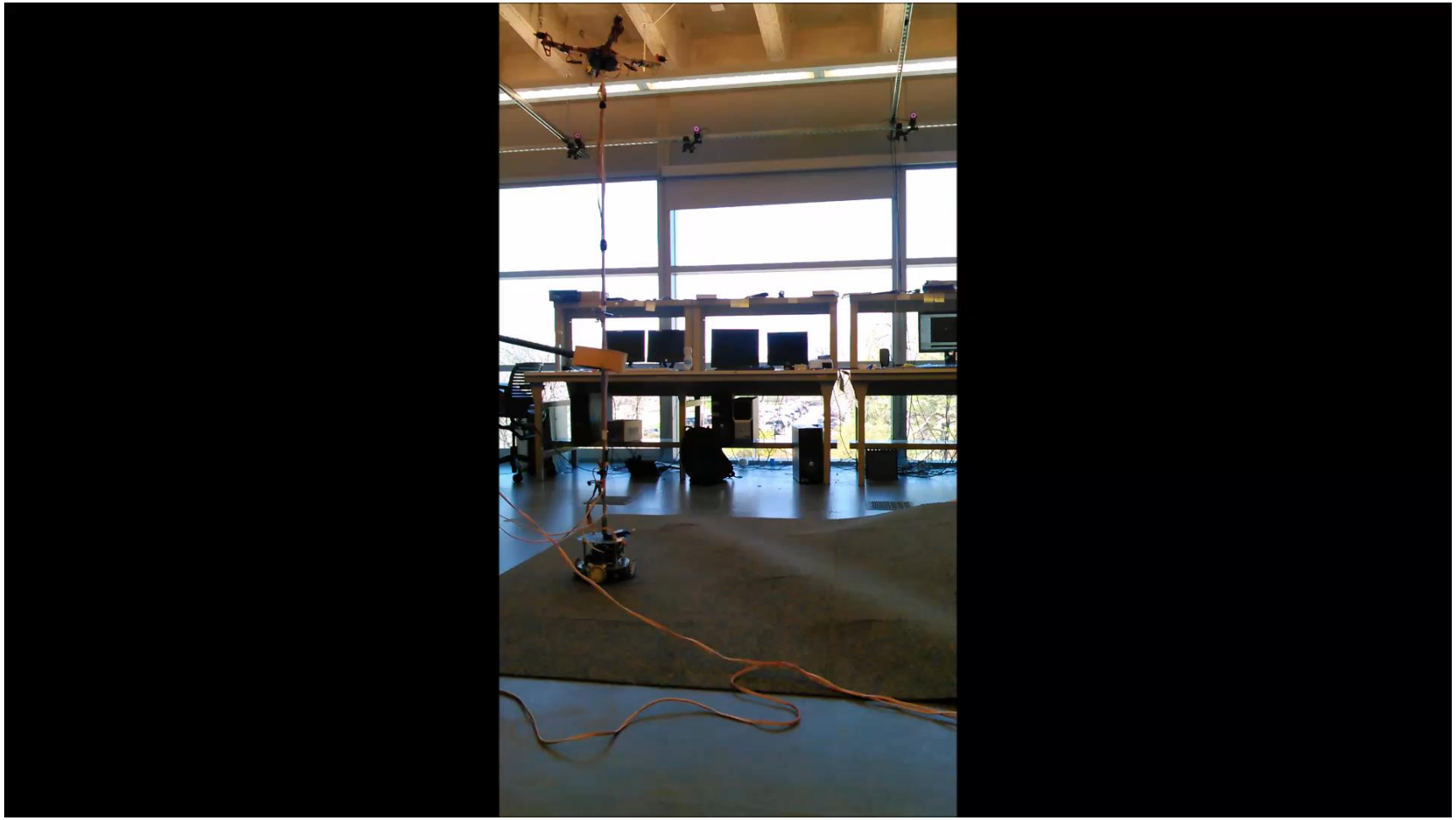
SIMPLIFYING DECISIONS

~12 ft pole

~6.5 ft pole



DEMO VIDEO



MODULES

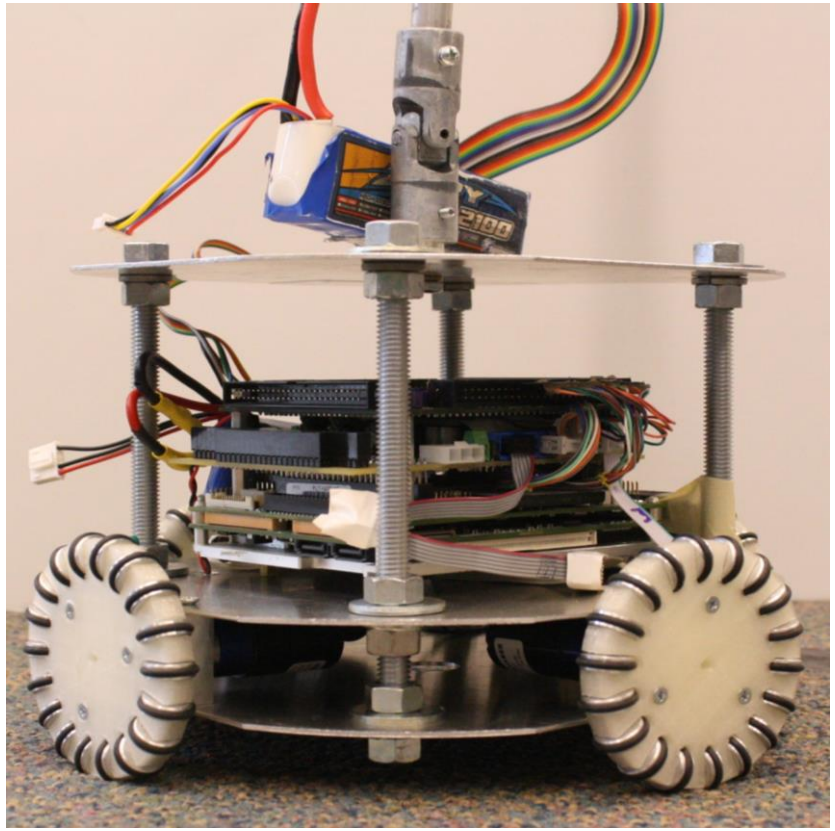
RADA, MAY15-27

MODULAR BREAKDOWN

- Ground robot
- Propeller system & instrumentation arm
- Data analysis tool
- Camera system
- Base-joint

GROUND ROBOT

- Main system design
  - Pluto PC board (Intel Atom Processor)
  - Mesa 4i68 FPGA (Spartan III)
  - Linux OS (C++ software)
- Complete system design by previous teams
  - Repurposing functionality
- Sufficient for prototype system following modifications

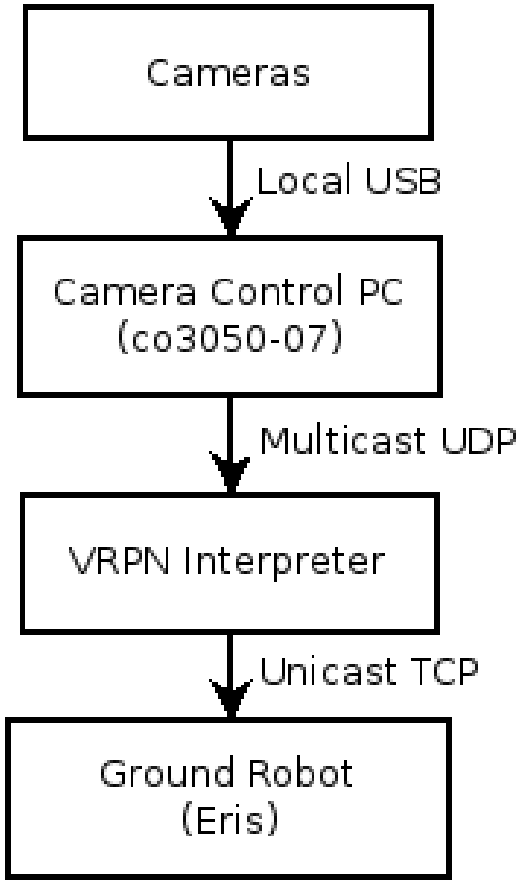


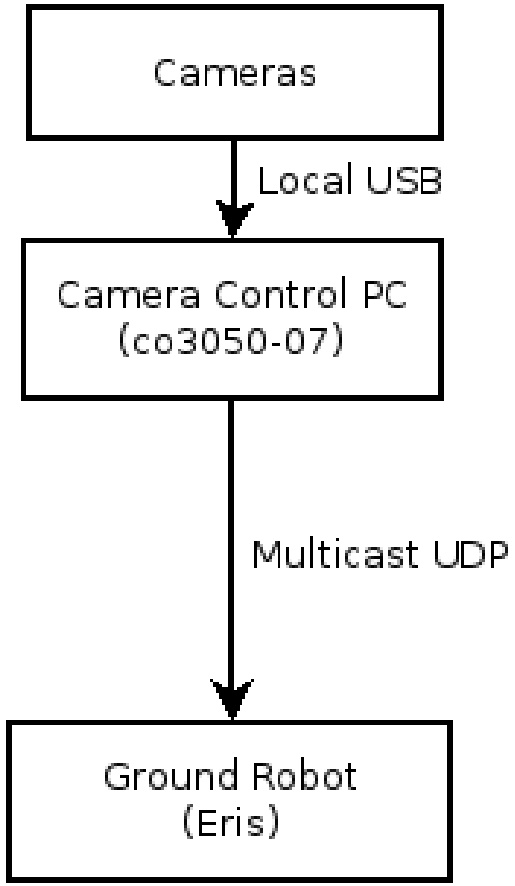
GROUND ROBOT

- Issues with adaptation
  - Unable to support new libraries
  - Non-portable development environment
  - Unable to control all new and old motors
- Solutions
  - Removal of unused modules
  - Update codebase dependencies

GROUND ROBOT

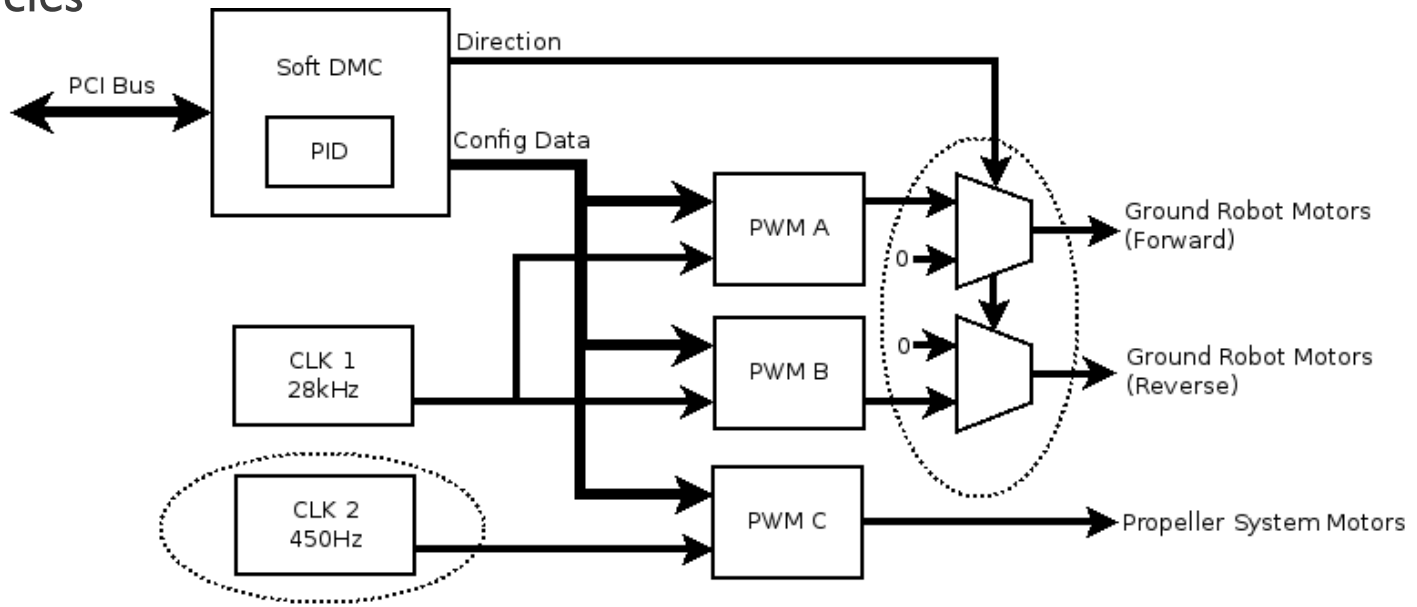
- Implementing control
  - PID controller
- Issues
  - TCP timeout
  - FPGA .bit file generation





GROUND ROBOT VHDL

- Reverse-engineered VHDL
- Modified VHDL to
  - Work with H-bridge drivers for ground robot motors
  - Allow PWMs of different frequencies

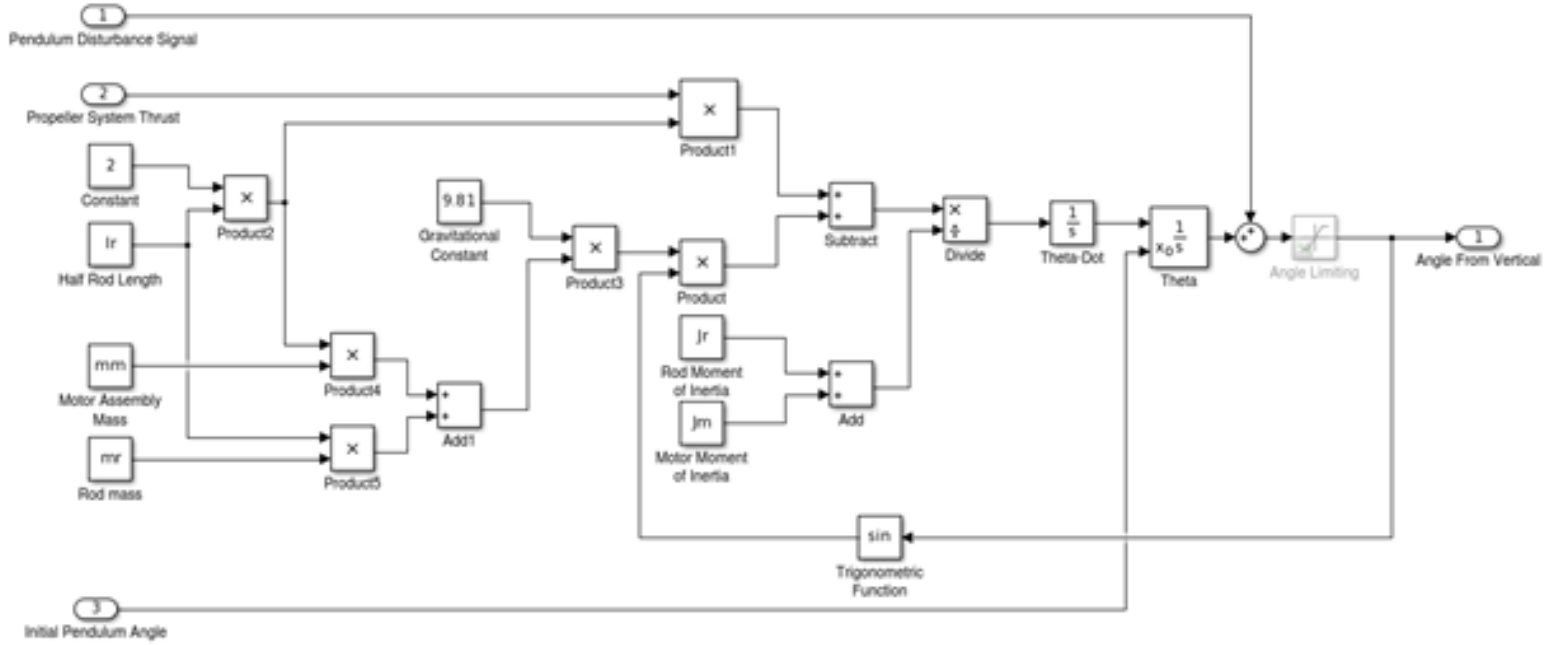


PROPELLER SYSTEM & INSTRUMENTATION ARM

- Propellers to provide thrust
- Base joint rotates in pitch and roll
- Default ESC firmware replaced with BLHeli
- All power and control supplied by ground robot

PROPELLER SYSTEM & INSTRUMENTATION ARM

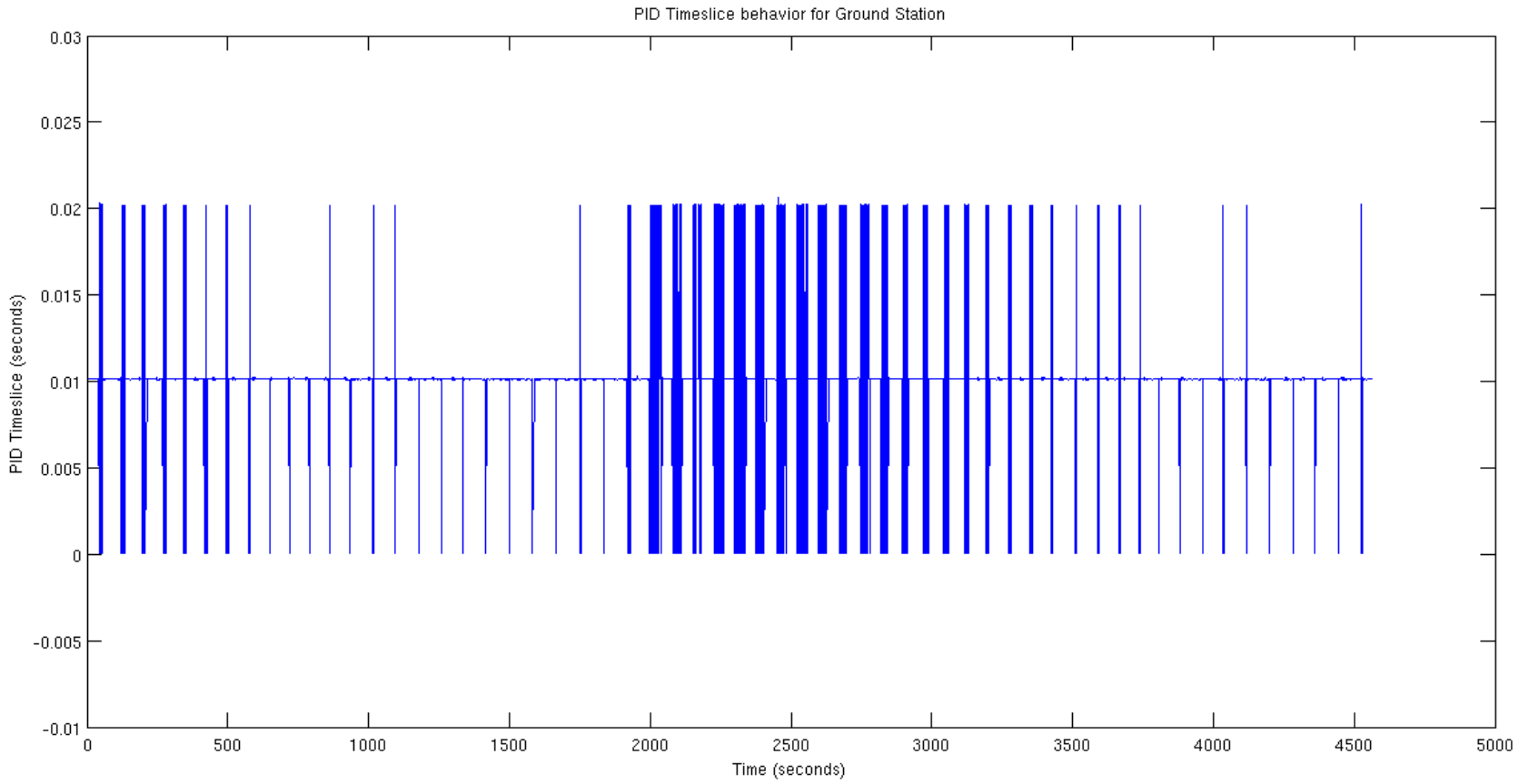
- System physics models for 1-D and 2-D movement
  - Simulation in Simulink
  - Verification against physical system



PROPELLER SYSTEM & INSTRUMENTATION ARM

- Initial Implementation
  - Used existing PID control software and RC RF link
- Issues
  - PID computation had time calculation issues
  - RF link provided significant delay to the controller
- Solution
  - Migrate control software to the ground robot platform

PROPELLER SYSTEM & INSTRUMENTATION ARM



DATA ANALYSIS TOOL

- Purpose: Debugging
- Two interfaces
  - MATLAB Command-line interface
  - MATLAB GUI interface
- MATLAB-based functions
  - Parsing
  - Data analysis

DATA ANALYSIS TOOL

- Data logging format

```
#Constants      pitch_P     pitch_I     pitch_D
#PIDValues      1900        0           409
#Constants      roll_P      roll_I      roll_D
#PIDValues      1900        0           409
#Orientation:   OptiTrack-VRPN
#Position:      OptiTrack-VRPN
#Direction:     OptiTrack-VRPN
#Communication: 6-Channel Trainer
%Time   Motor_1 Motor_2 Motor_3 Motor_4 Pitch    Pitch_err
&sec    %thrust %thrust %thrust %thrust degrees  degrees
0.000000    0   1300    1300    0   -70.274537  110.266991
```

Experiment configuration

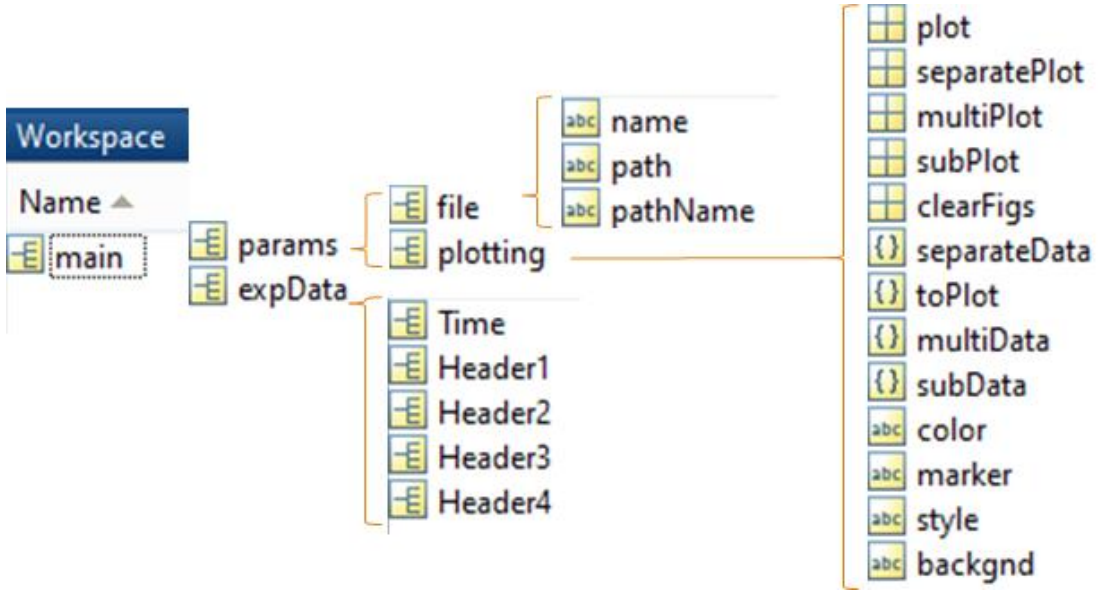
Header names

Units of headers

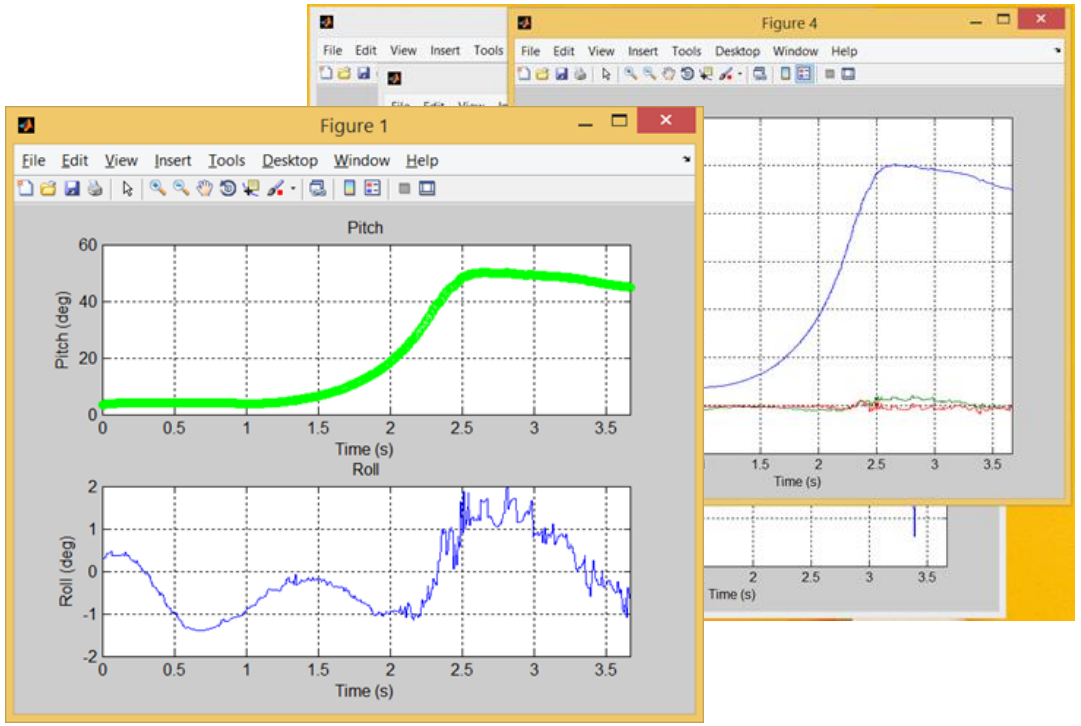
Data

DATA ANALYSIS TOOL

Output of parsing: MATLAB struct

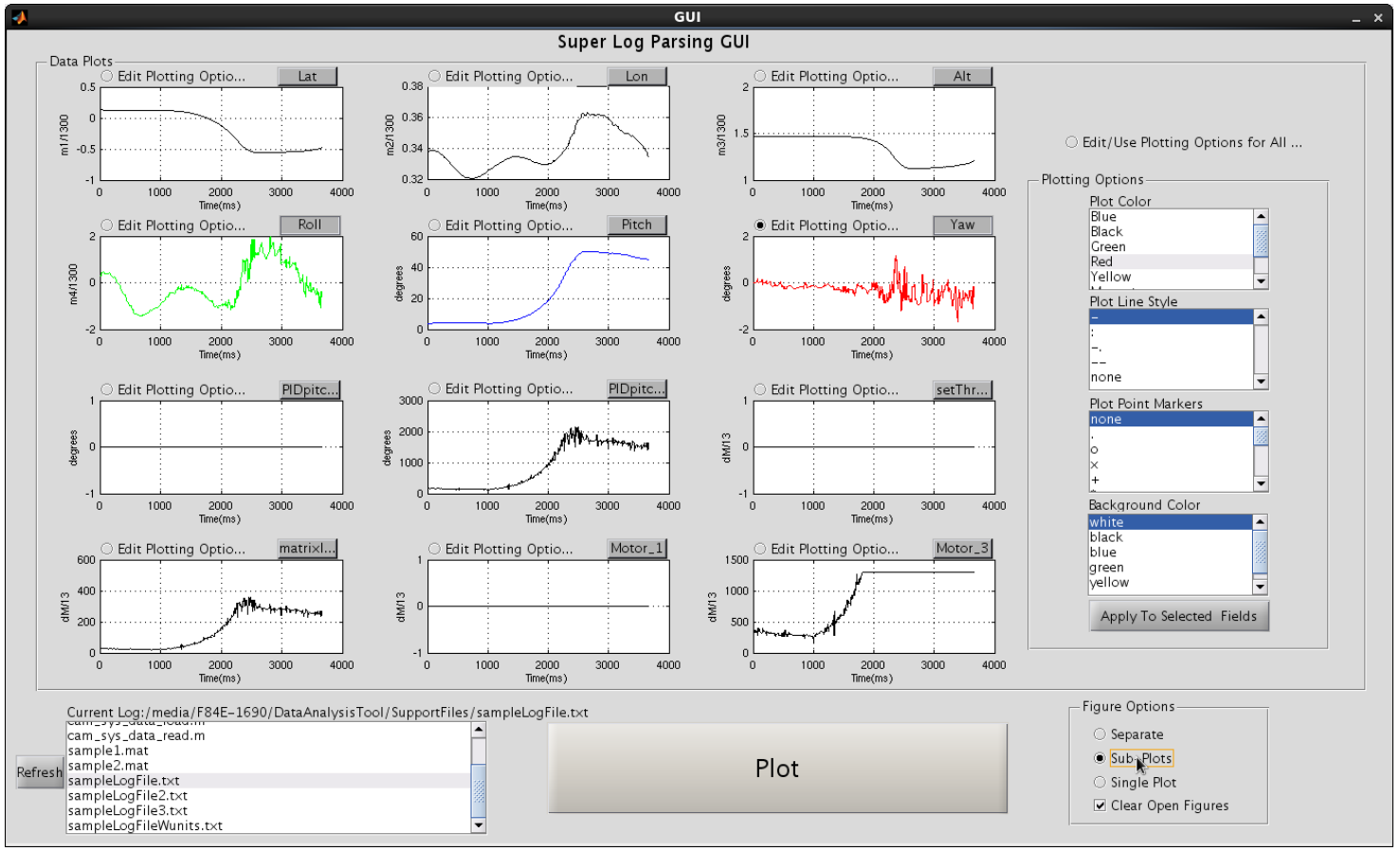


Data analysis: MATLAB functions



DATA ANALYSIS TOOL

- MATLAB-based GUI
  - User-friendly, even for non-MATLAB users
  - Uses the universal format and functions
  - Usable by future design teams

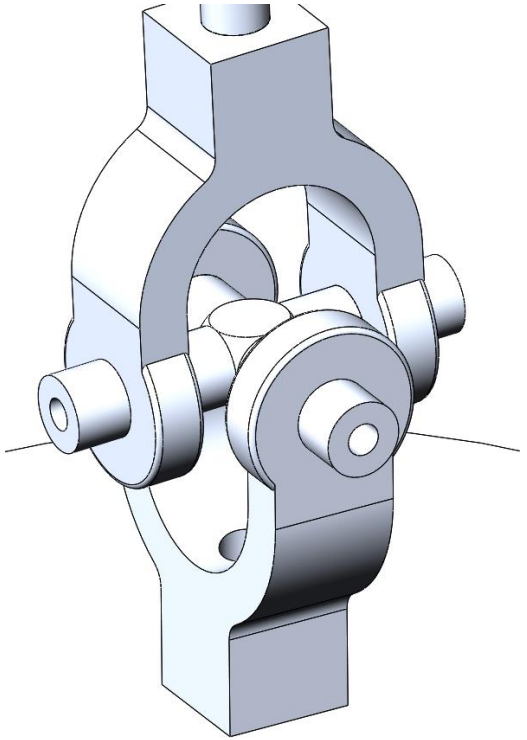


BASE JOINT

- What we want
  - No yaw rotation
  - Angle sensors integrated
  - Actuators integrated
- Why we want it
  - Additional sensing capability
  - More precise actuation

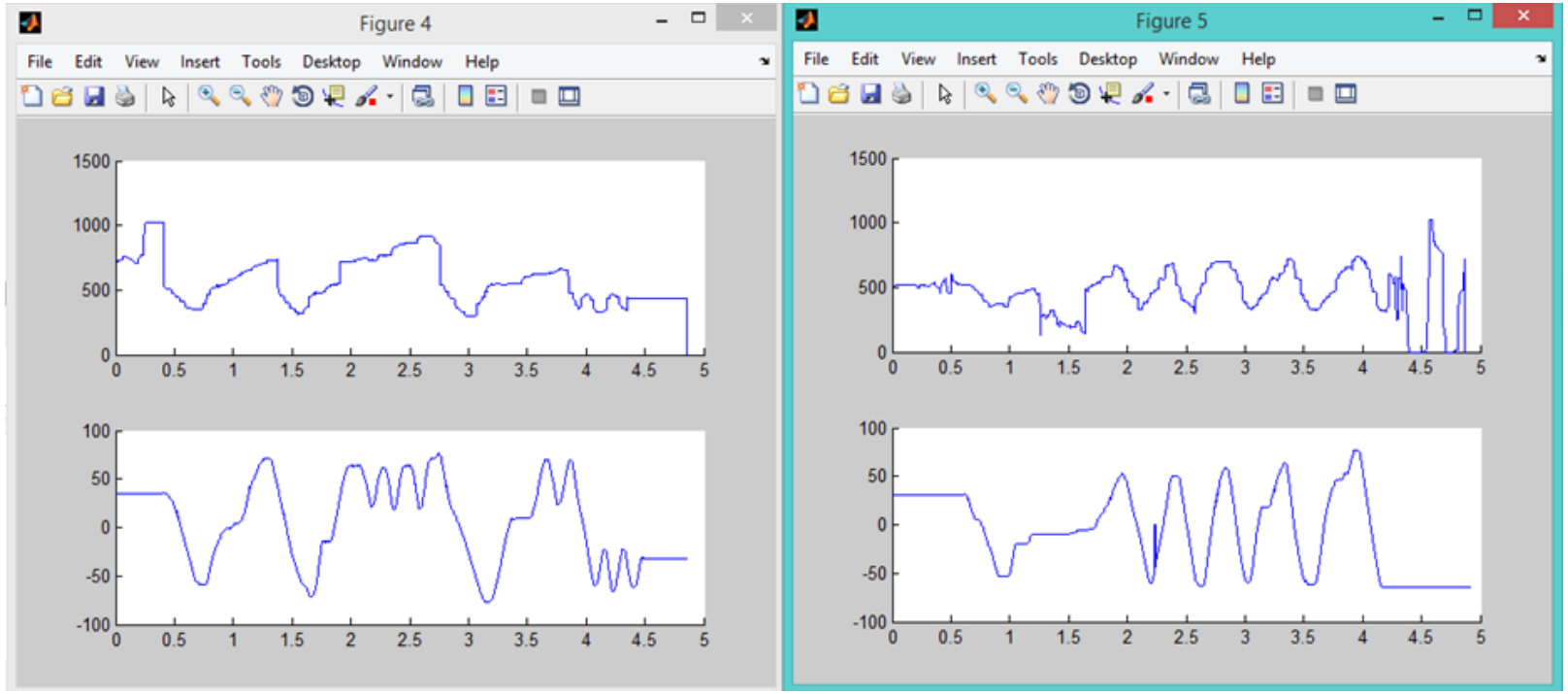
BASE JOINT

- Design
  - Current joint modified U-Joint
    - Fixable axis
  - New robot/joint design
    - Custom U-Joint



BASE JOINT

- Actuator/Sensor
  - Research possible options
    - Membrane Potentiometer
    - Hall effect
  - Run tests
  - Compare results



Membrane potentiometer (top)
VS
Camera system tracking (bottom)

TEST PLAN

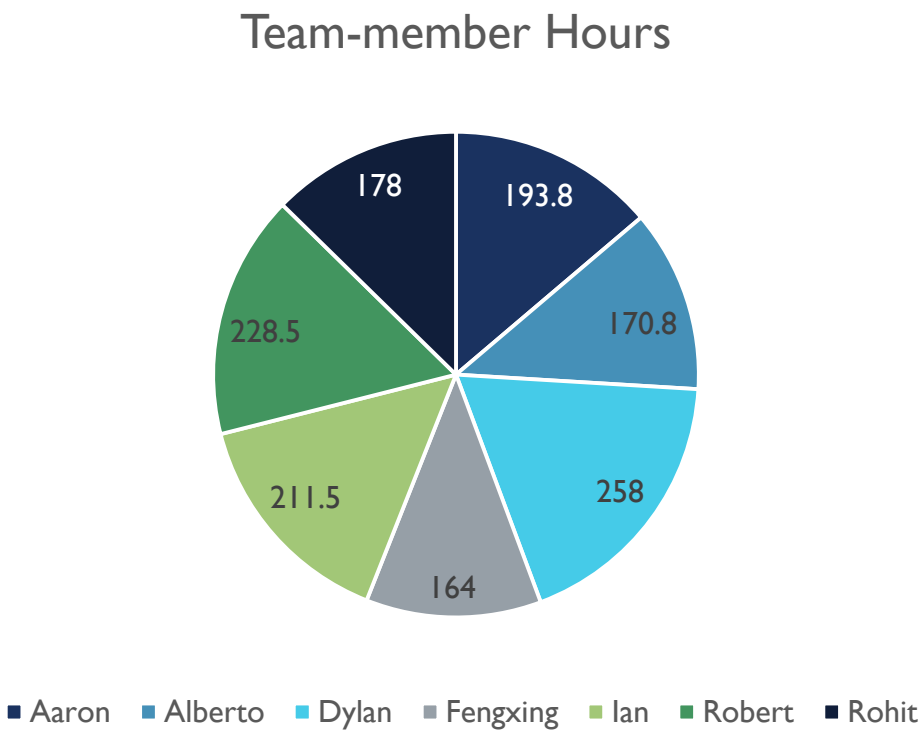
- Each system independently verified via functional testing
- Controllers tuned using logged data and plots to visualize behavior

THANK YOU!

QUESTIONS?

BACKUP SLIDES

BUDGET/RESOURCES



Total Hours = 1404.6

BUDGET/RESOURCES

- December 10-1
  - Total cost = $2695.86
- December 11-13
  - Total cost = $624
- May 2015 Team (US)
  - Total cost = $676.50