COMPASS

*University of **CO**lorado **M**odel **P**ositioning - St**A**tic - **S**y**S**tem*

Manufacturing Status Review

3 February 2016

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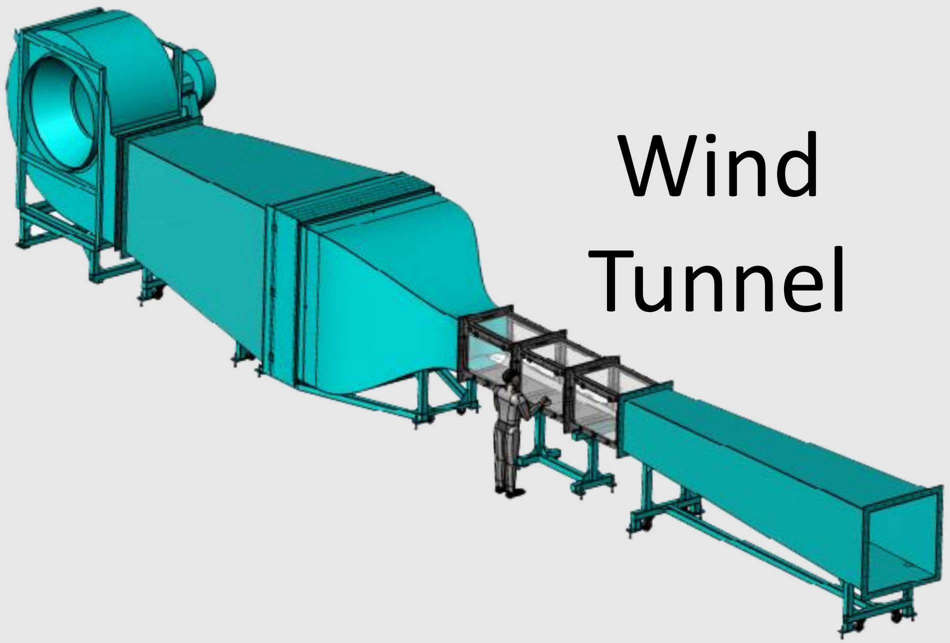
Agenda

Section	Presenter
Overview	Ryan
Schedule	Ryan
Mechanical Manufacturing	Brandon
Software Manufacturing	Anna
Electronics Manufacturing	Kyle
Budget	Ryan

Overview

Project Purpose and Objectives

Provide a model positioning system for the wind tunnel on East Campus



- **Statically position a model in 4 DoF**
- **Mobility of entire system**
- **Easily maintainable for future use**
- **Interface with current wind tunnel**
- **Failsafes within hardware and software**

Levels of Success

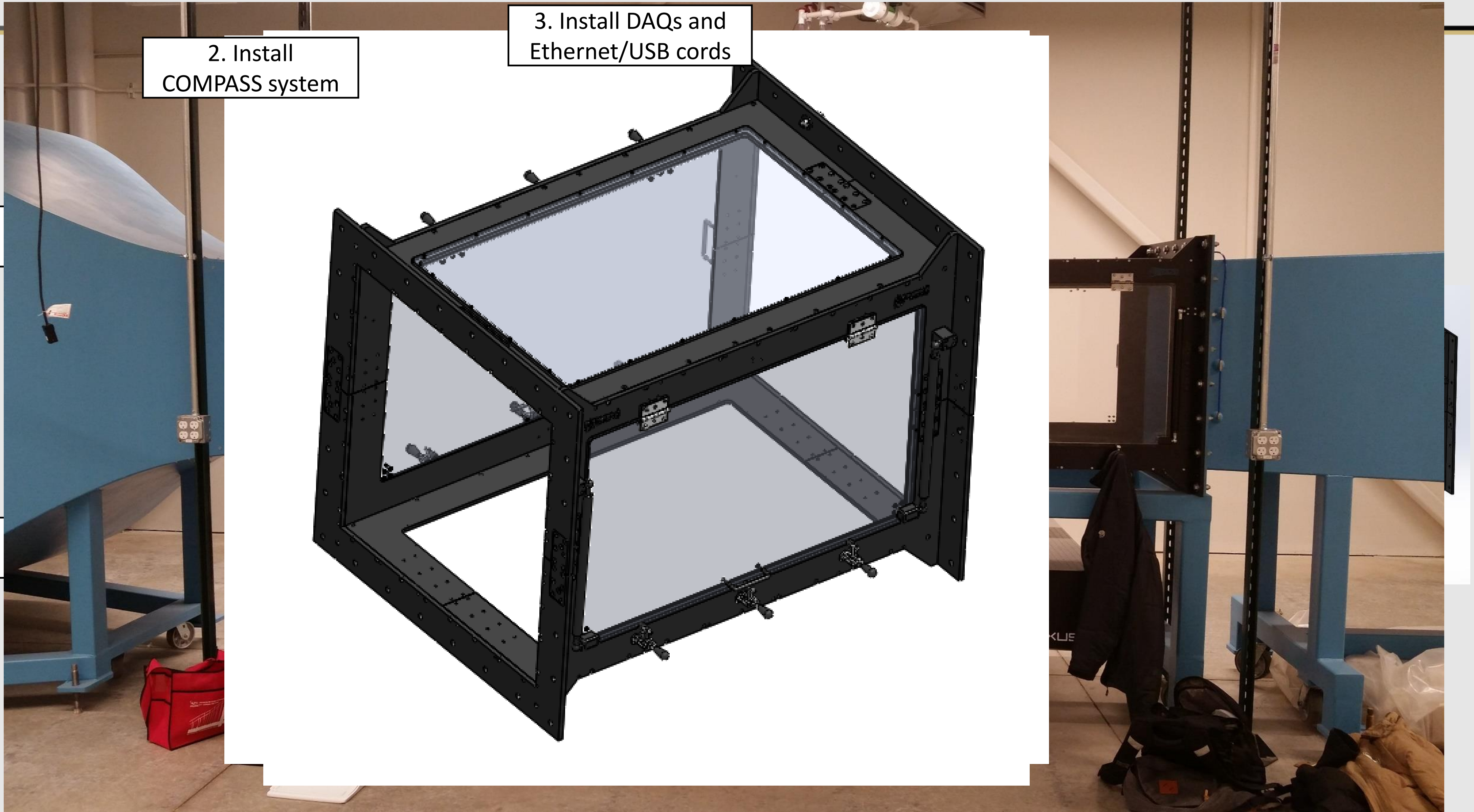
	DoF	Range	Position/Angular Accuracy	Testing Expectations
Level 1	Pitch Yaw	Pitch = ± 30° Yaw = ± 30°	Pitch = ± 0.1° Yaw = ± 0.1°	Basic verification of movement
Level 2	“ “ Roll	“ “ Roll = ± 45°	“ “ Roll = ± 0.5°	VICON w/o static load
Level 3	“ “ Plunge	“ “ Plunge = ± 10 cm	“ “ Plunge = ± 5 mm	VICON w/ static load
Level 4	“ “	“ “	“ “	In tunnel w/ aerodynamic load

Highest Level of Success Reached by:

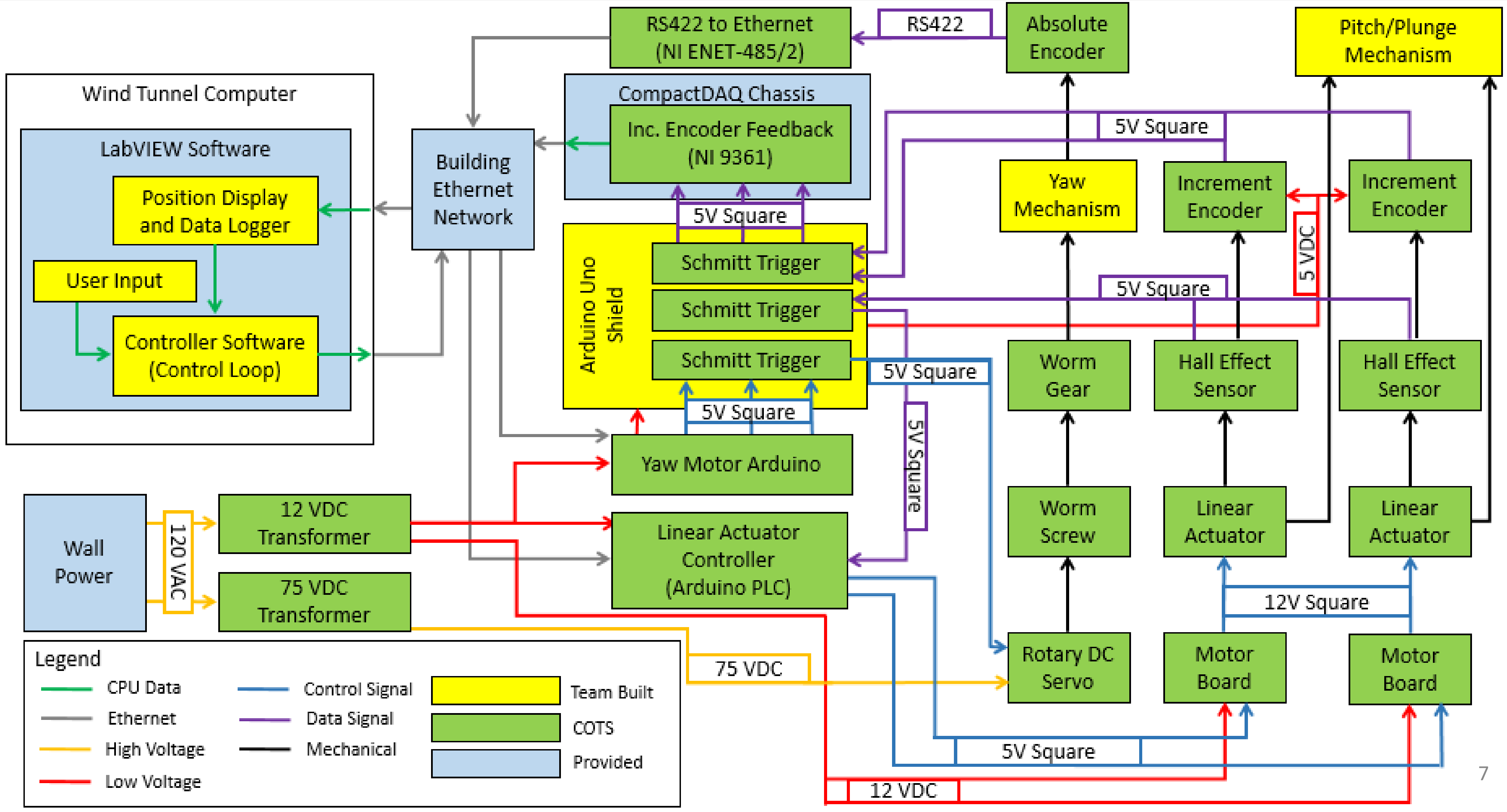
Complete by Design Symposium (Level 3)

Complete by End of Semester (Level 4)

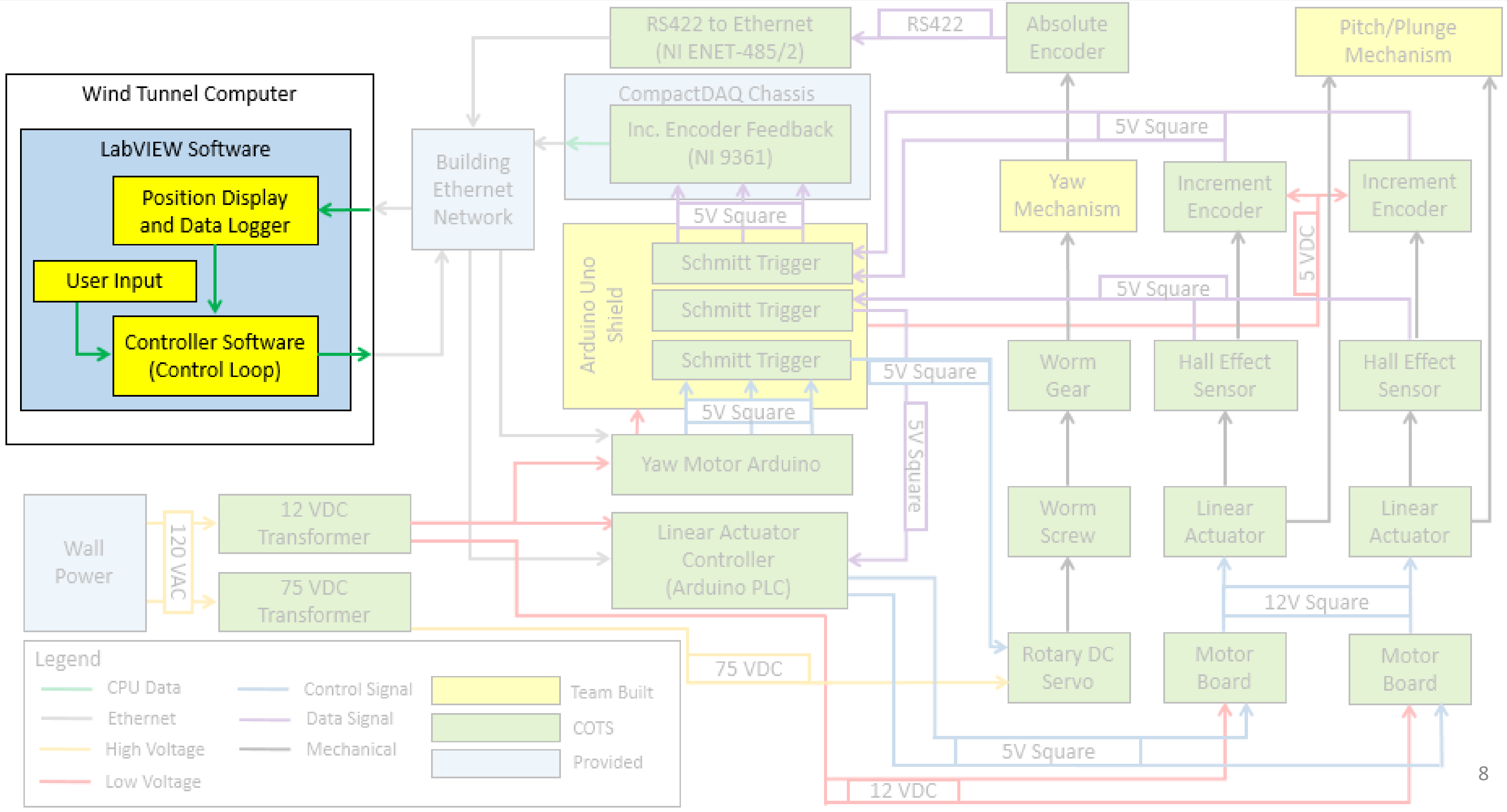
Operational CONOPS



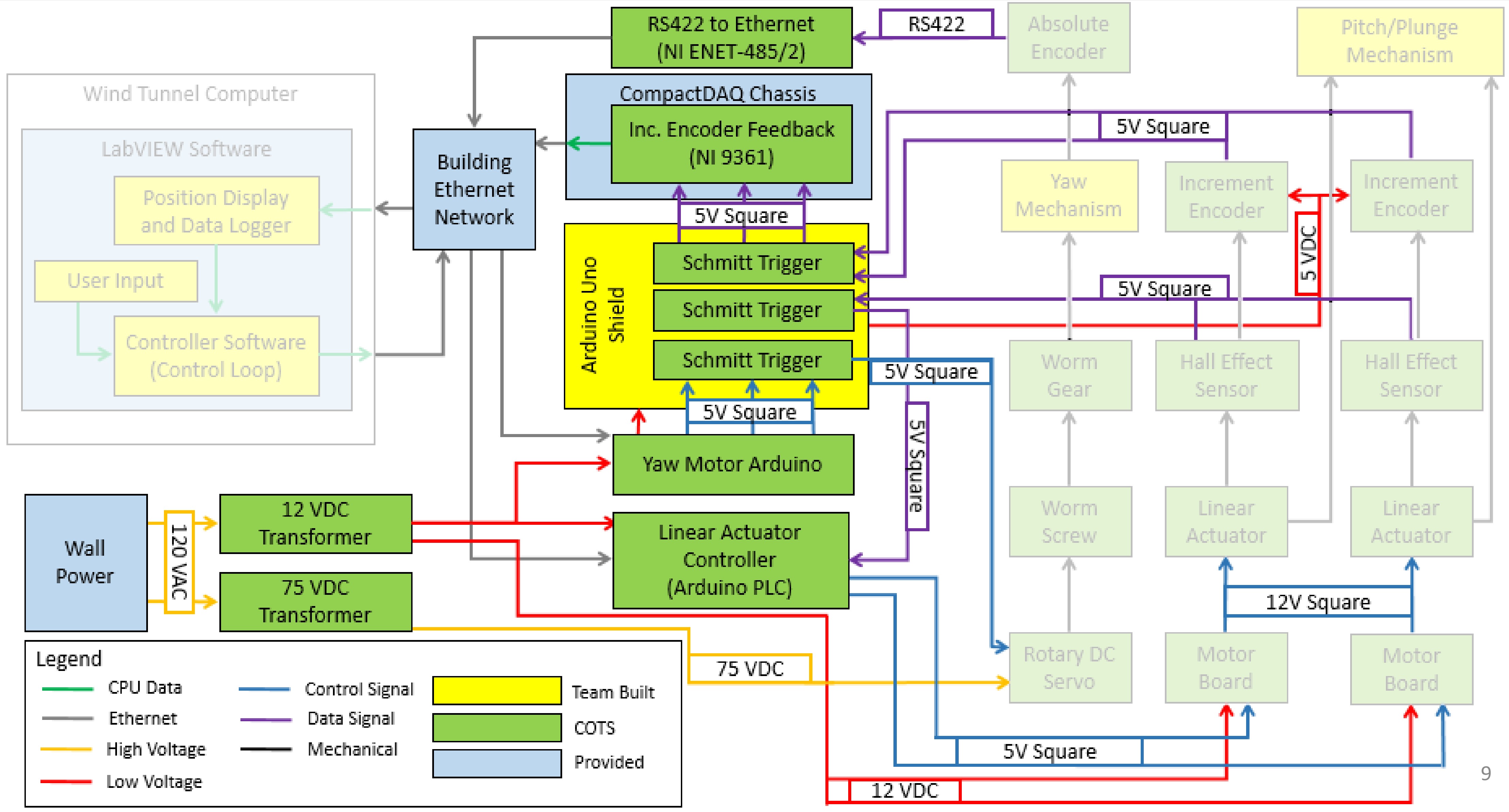
Functional Block Diagram



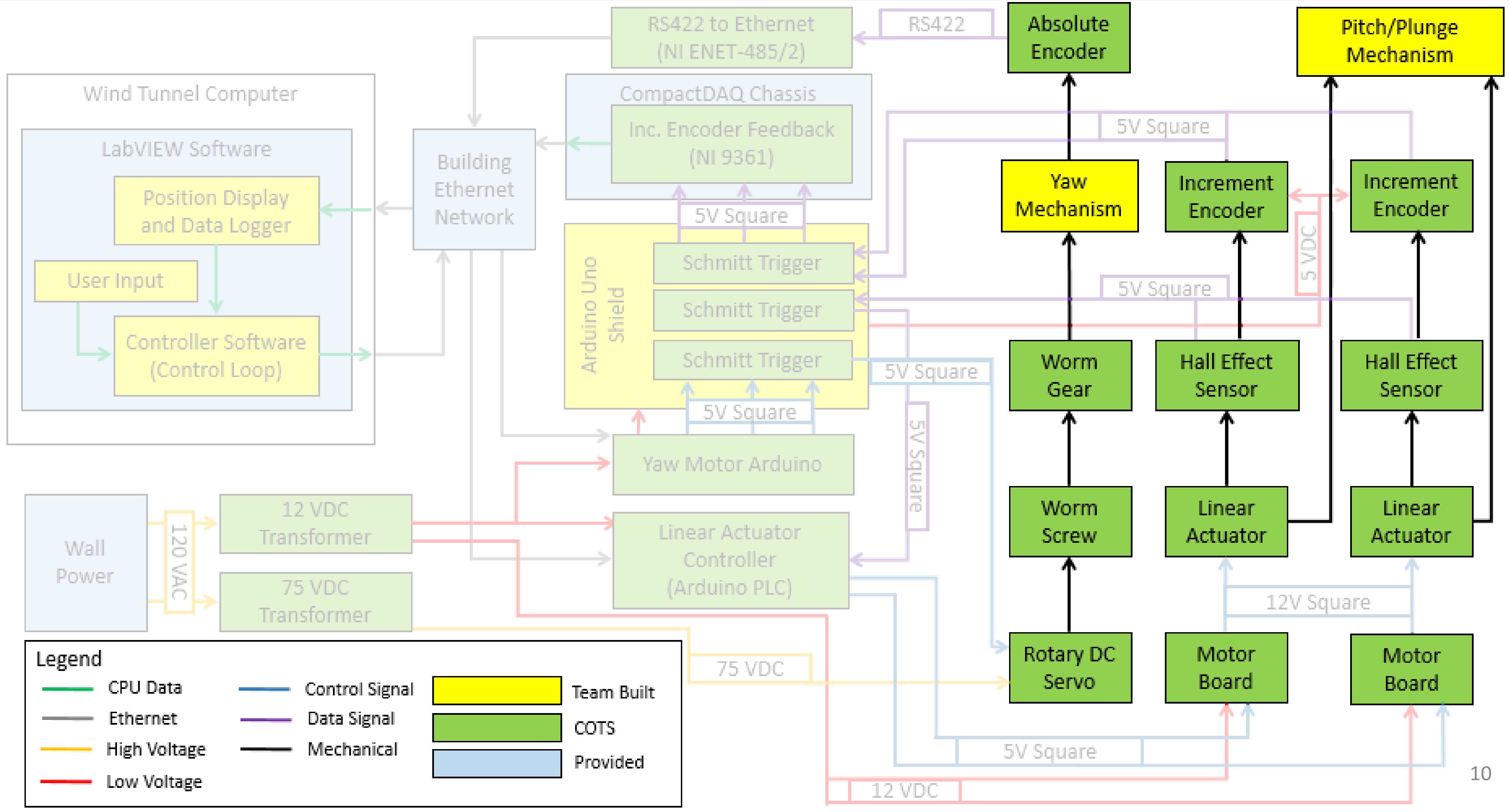
FBD - Computer/Software



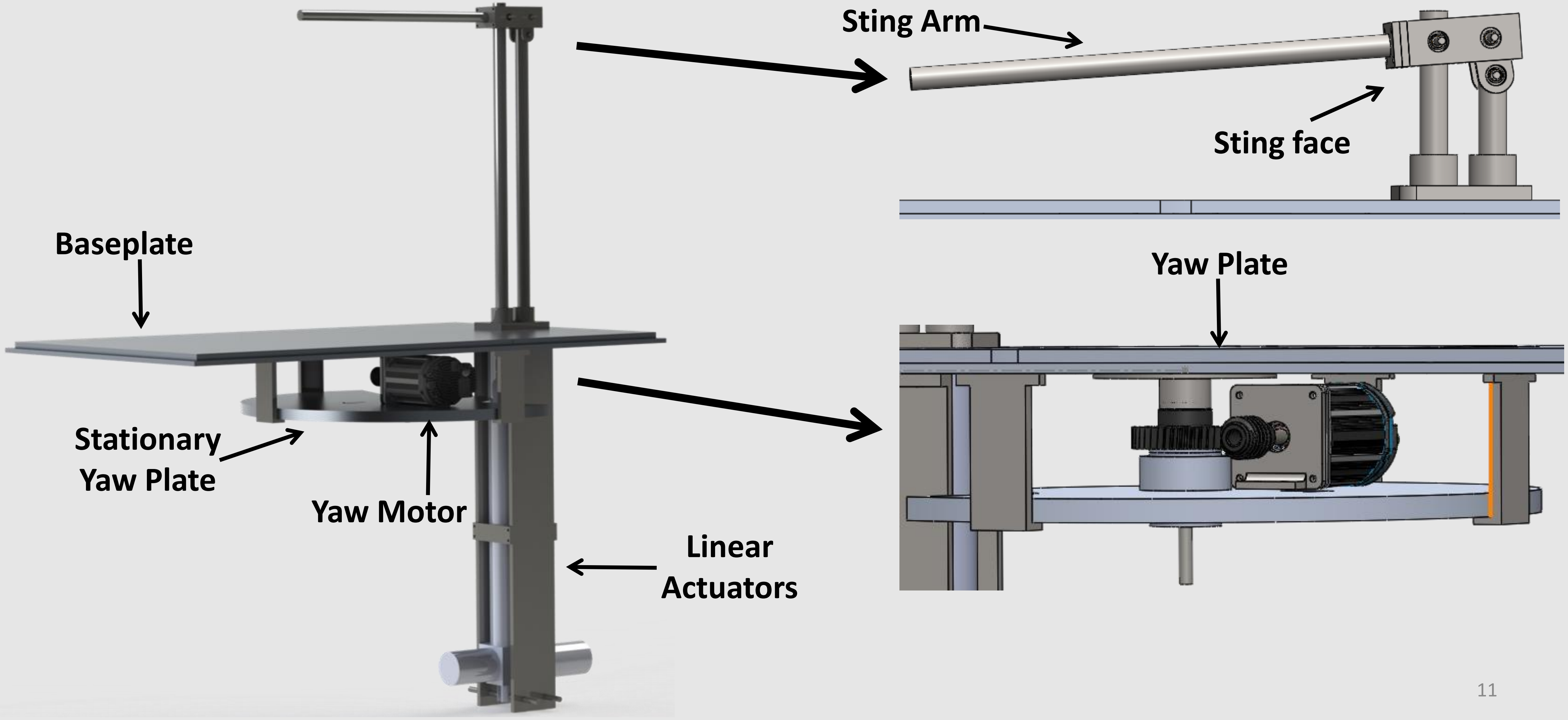
FBD - Electrical Interface



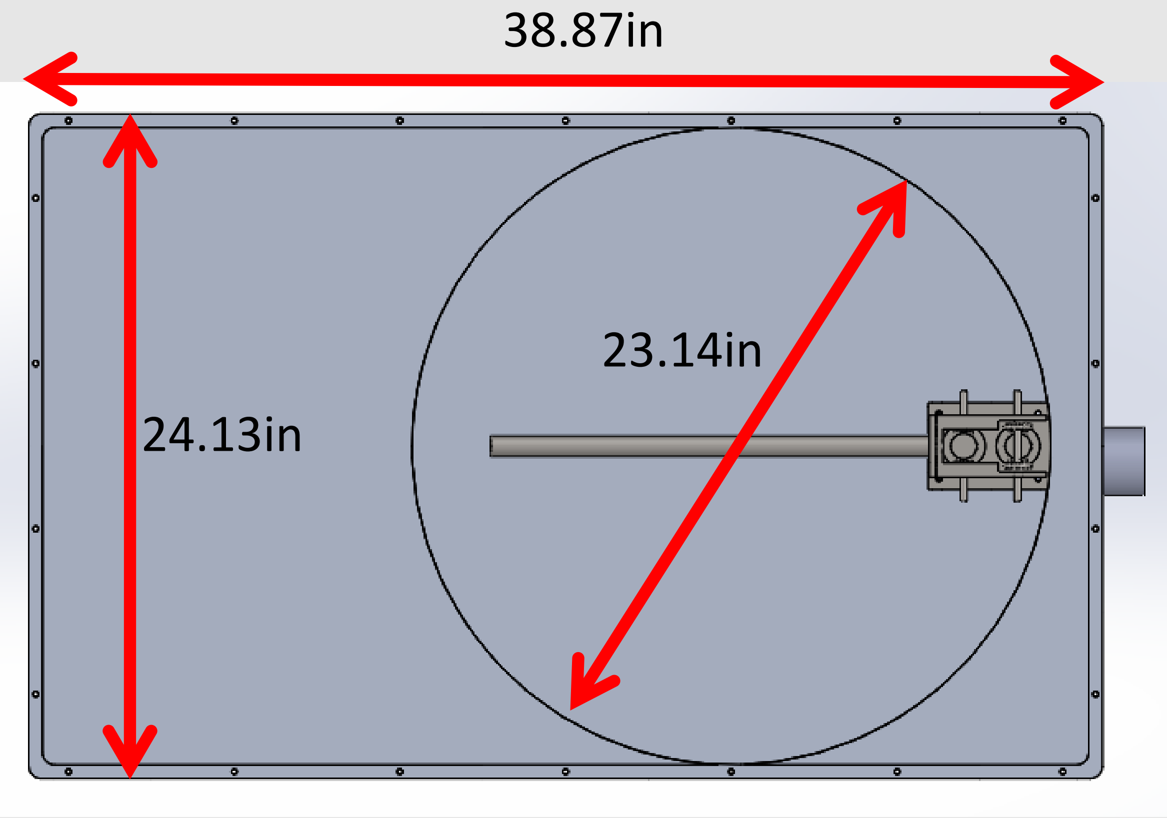
FBD - Positioning System

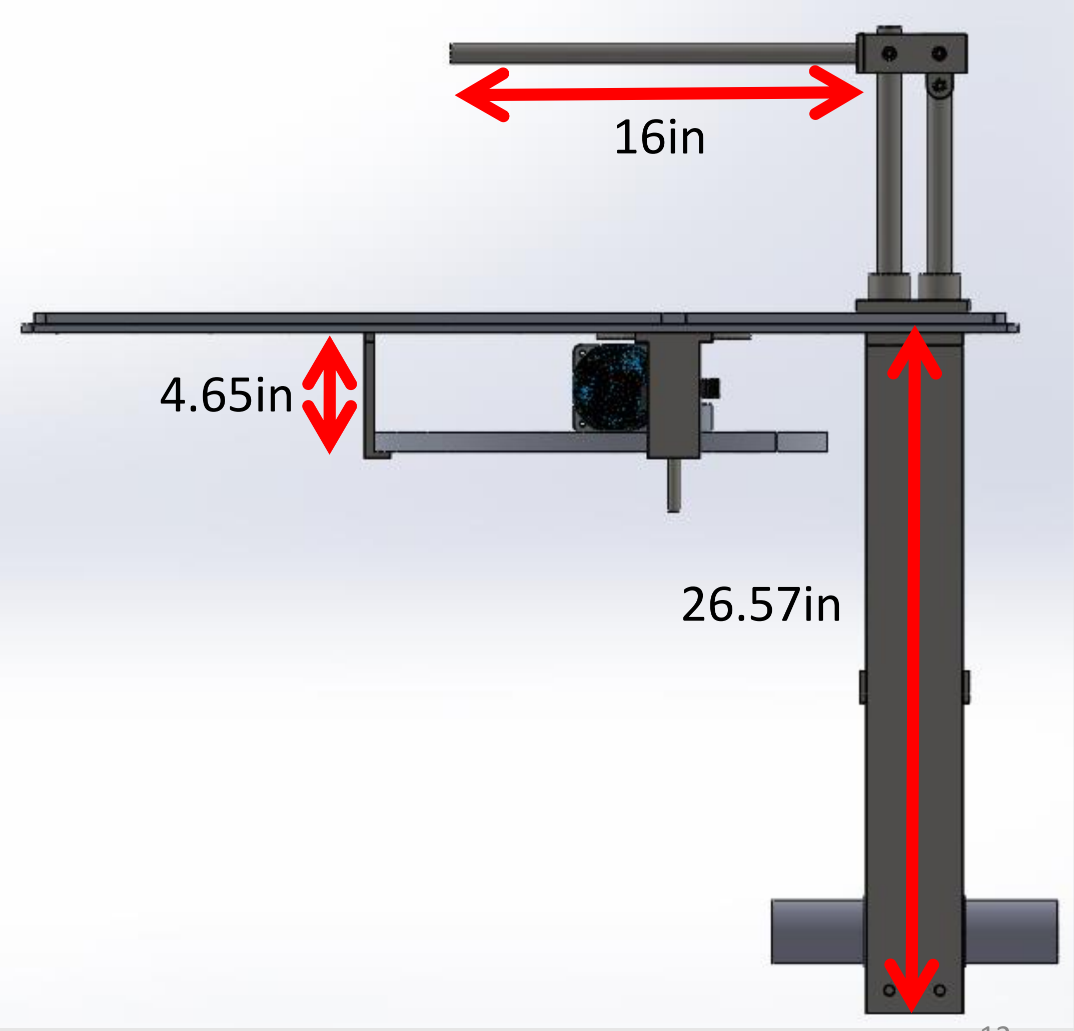


Baseline Design

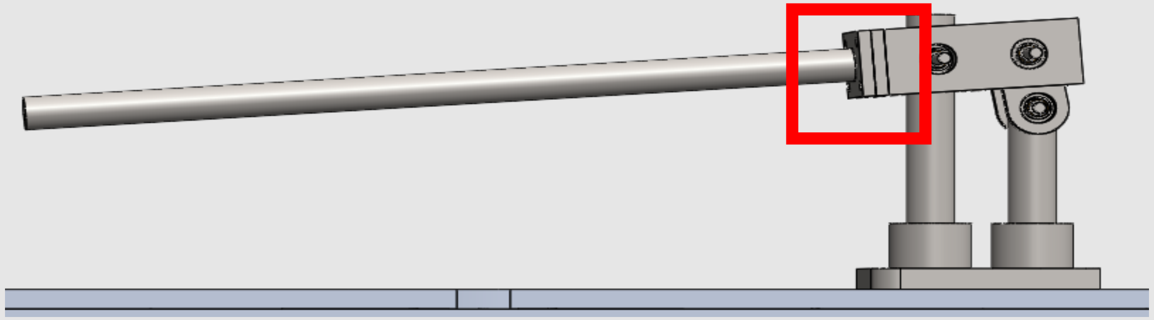


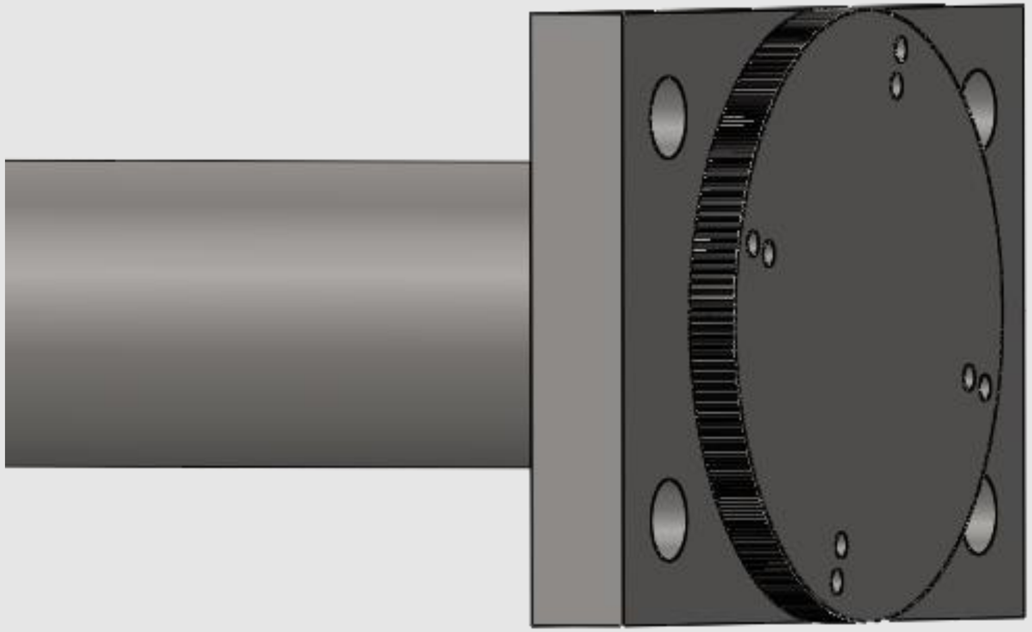
Baseline Design: Major Dimensions

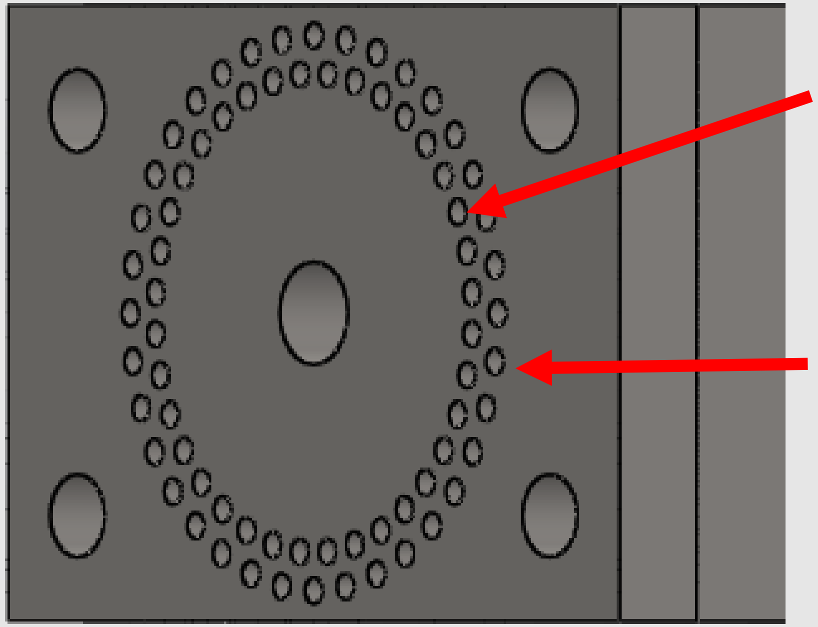




Minor Sting Design Change







Critical Project Elements

CPE.1: Manufacturing base plate
- Issues with installation in the wind tunnel if manufactured incorrectly
- Lack of funds to buy a second plate

CPE.2: Ethernet communication

CPE.2.1: Communication with Ethernet Arduinos and LabVIEW for control
- Setup of interface and establishing reliable communication

CPE.2.2: Serial to Ethernet conversion for absolute encoder
- Setup with NI components and learning the interface

CPE.3: VICON testing system
- Learning curve and usage

CPE.4: System verification within the wind tunnel while under aerodynamic load
- Feasibility and scheduling availability of testing

CPE.5: Logistical Constraints

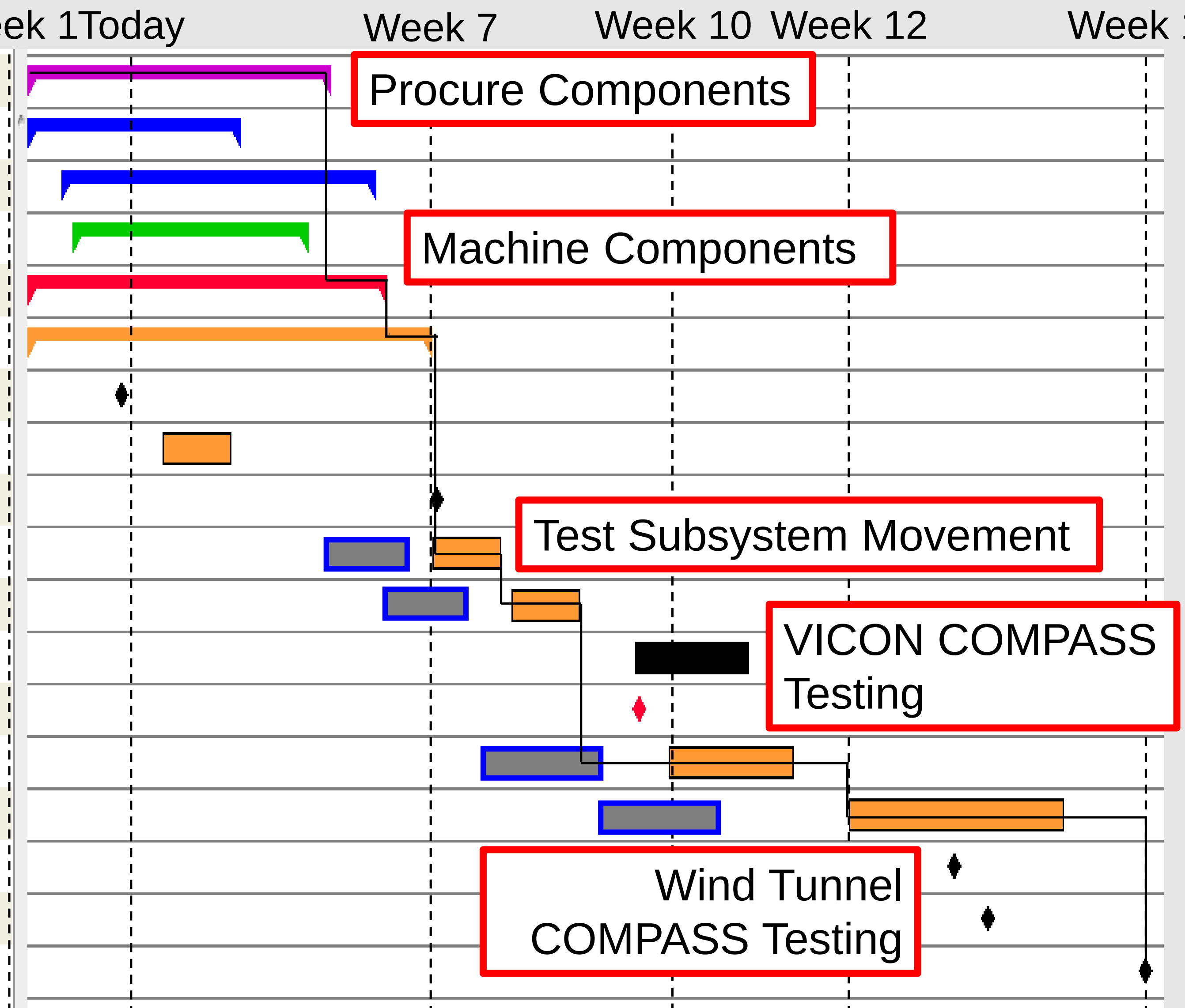
CPE.5.1: Low budget margin
- Inability to replace major procured component

CPE.5.2: Component lead time
- Puts strain on testing schedule timeline

Schedule

Project Schedule

Procured Components	12/23/15	2/19/16
LabVIEW Initializatio...	1/11/16	2/11/16
LabVIEW Positioning ...	1/27/16	2/23/16
Electronics Develop...	1/28/16	2/17/16
Manufactured Parts	1/20/16	2/24/16
Functionality Testing	1/15/16	2/28/16
MSR	2/1/16	2/1/16
VICON Tutorial/Lear...	2/5/16	2/10/16
TRR	2/29/16	2/29/16
Yaw Subsystem Mec...	2/29/16	3/5/16
Pitch/Plunge Mechan...	3/7/16	3/12/16
Spring Break	3/18/16	3/27/16
Last Day for Machining	3/18/16	3/18/16
VICON Full System T...	3/21/16	3/31/16
Integration with Wind...	4/6/16	4/24/16
Design Symposium	4/15/16	4/15/16
SFR	4/18/16	4/18/16
PFR	5/2/16	5/2/16



<u>Challenges/Changes</u>

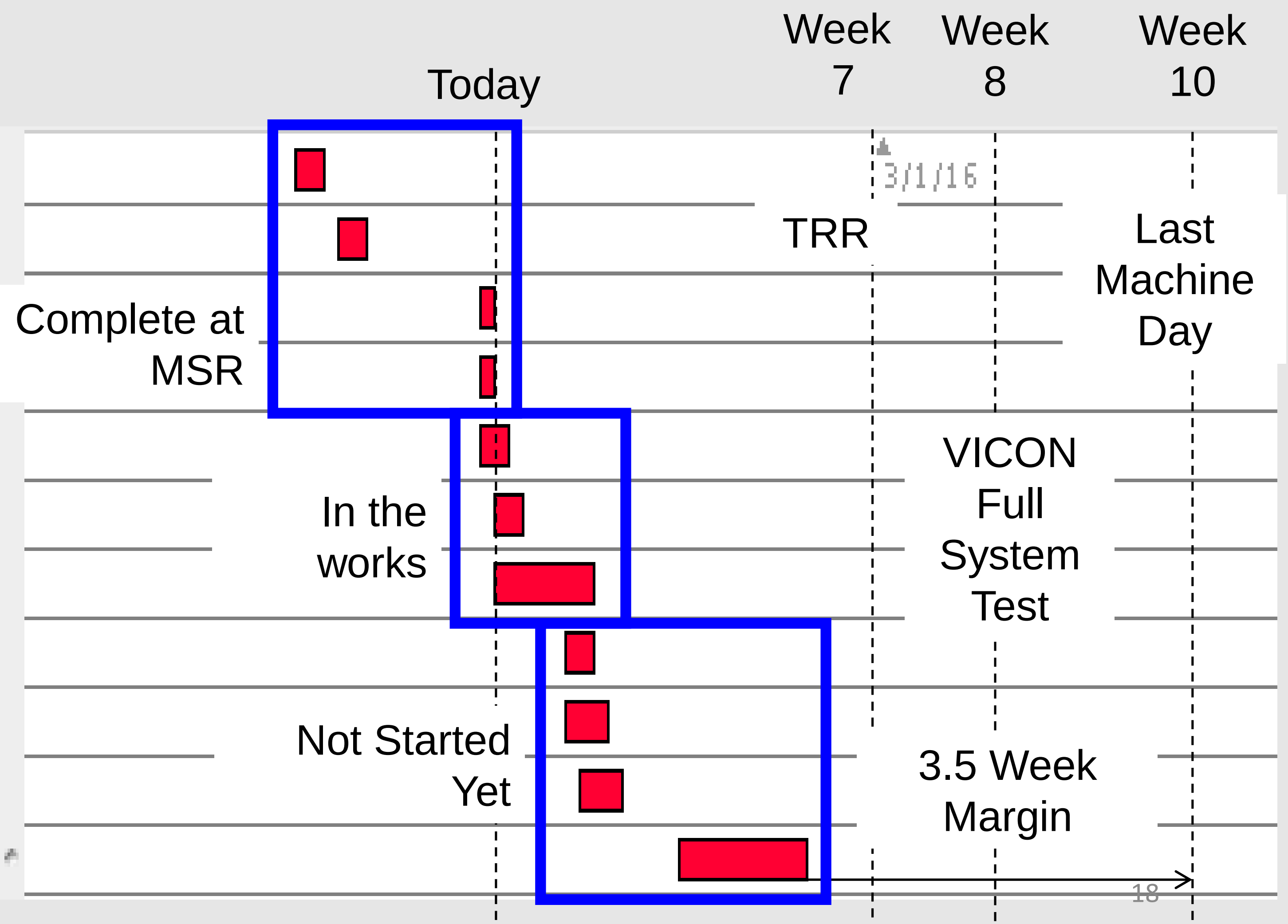
1. Longer lead times than expected
2. Changes in procured parts
3. Amount of manufacturing
4. Push back testing schedule
5. Decreased project completion margin by 2.5 weeks

= Previously Scheduled Dates

Manufacturing - Machining

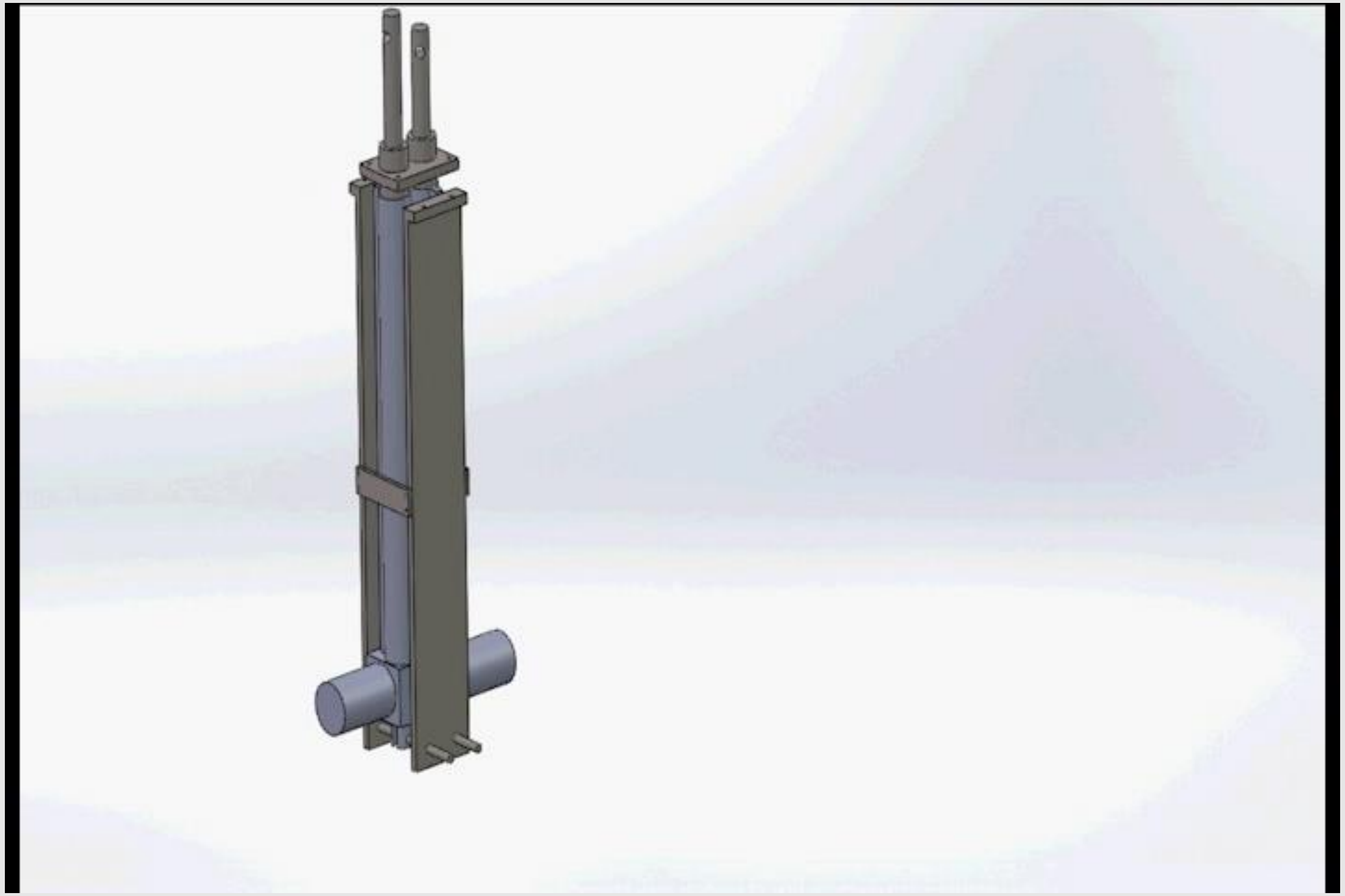
Manufacturing Schedule

Linear Bearing Mount	1/20/16	1/21/16
Sting Side Piece x2	1/23/16	1/24/16
Sting Face	2/2/16	2/2/16
Sting Cap	2/2/16	2/2/16
Sting 3rd Arm x2	2/2/16	2/3/16
Yaw Plate	2/3/16	2/4/16
Yaw Shaft Flange	2/3/16	2/9/16
Linear Collars	2/8/16	2/9/16
Linear Brackets	2/8/16	2/10/16
Yaw Brackets	2/9/16	2/11/16
Base Plate	2/16/16	2/24/16

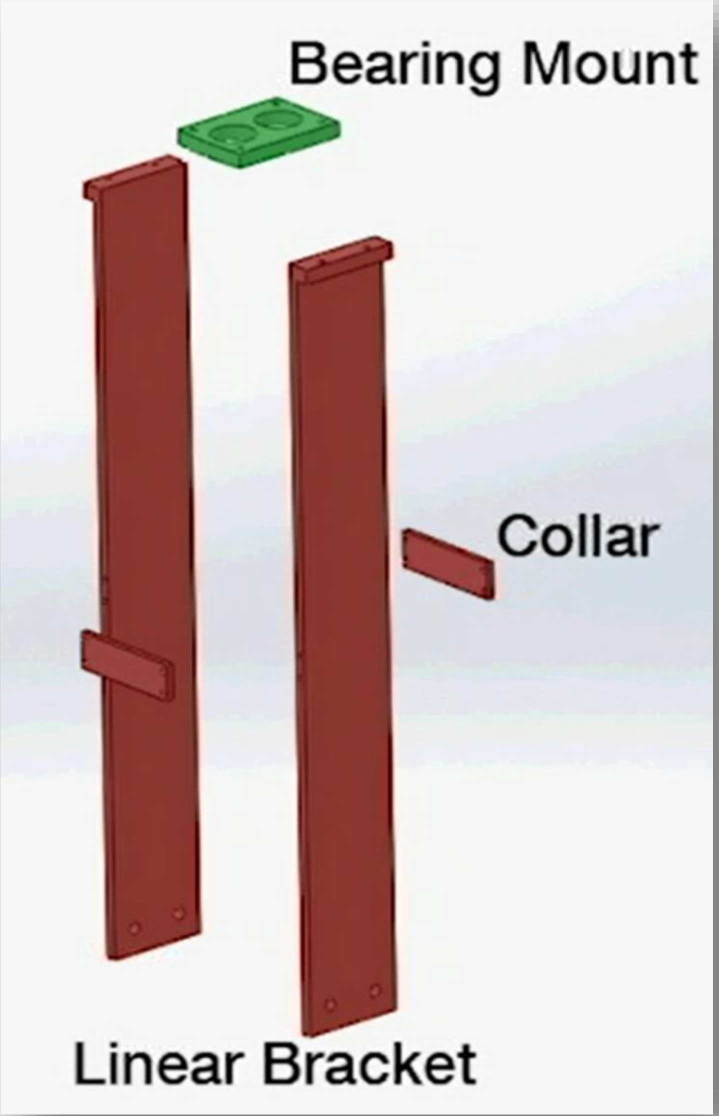


Machining: Subsystem Scope

Linear Subsystem



Linear Subsystem Scope and Status



Completed:

- Bearing Mount

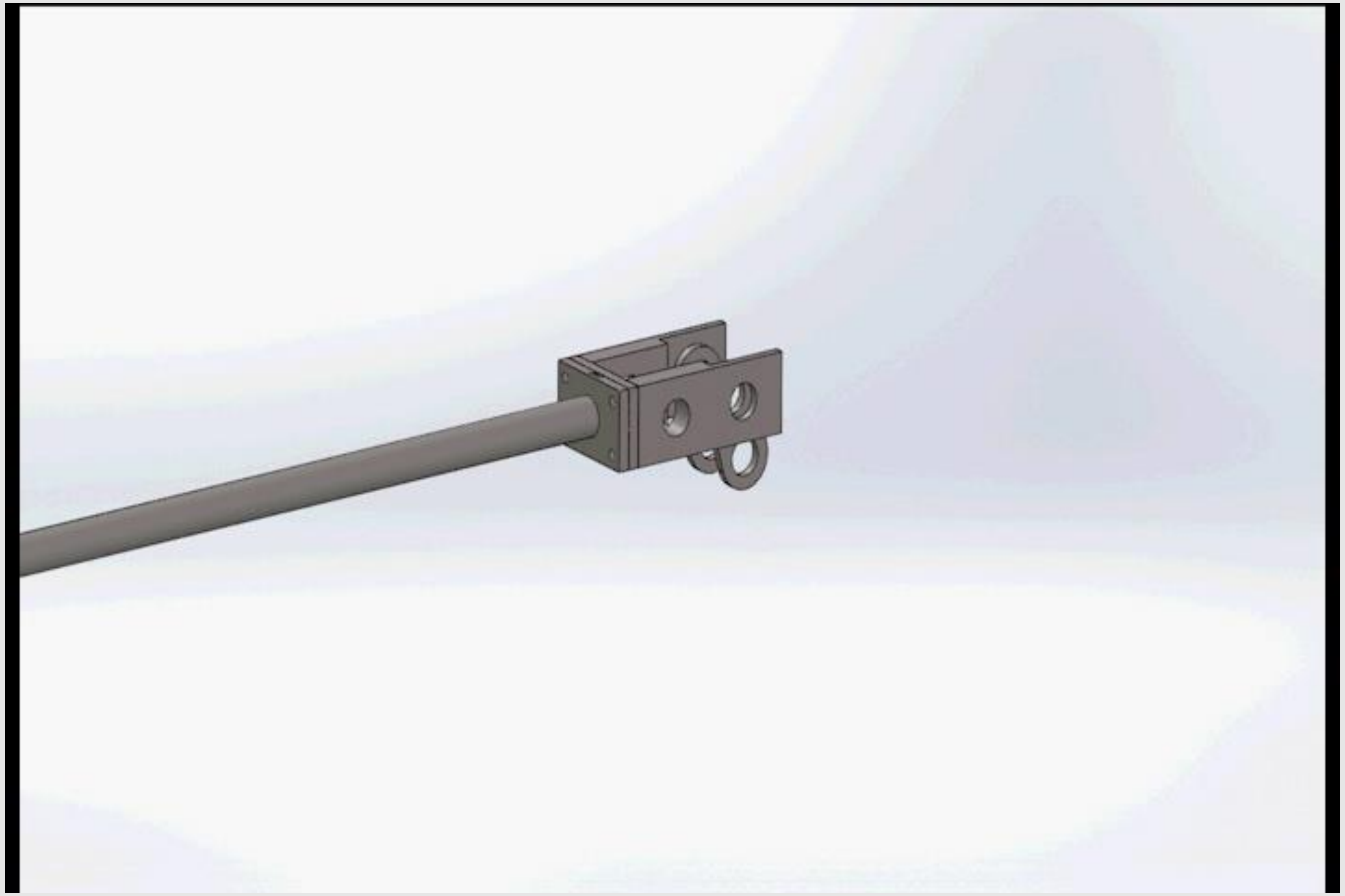
Not Complete:

- Collar (x2)
- Linear Bracket (x2)

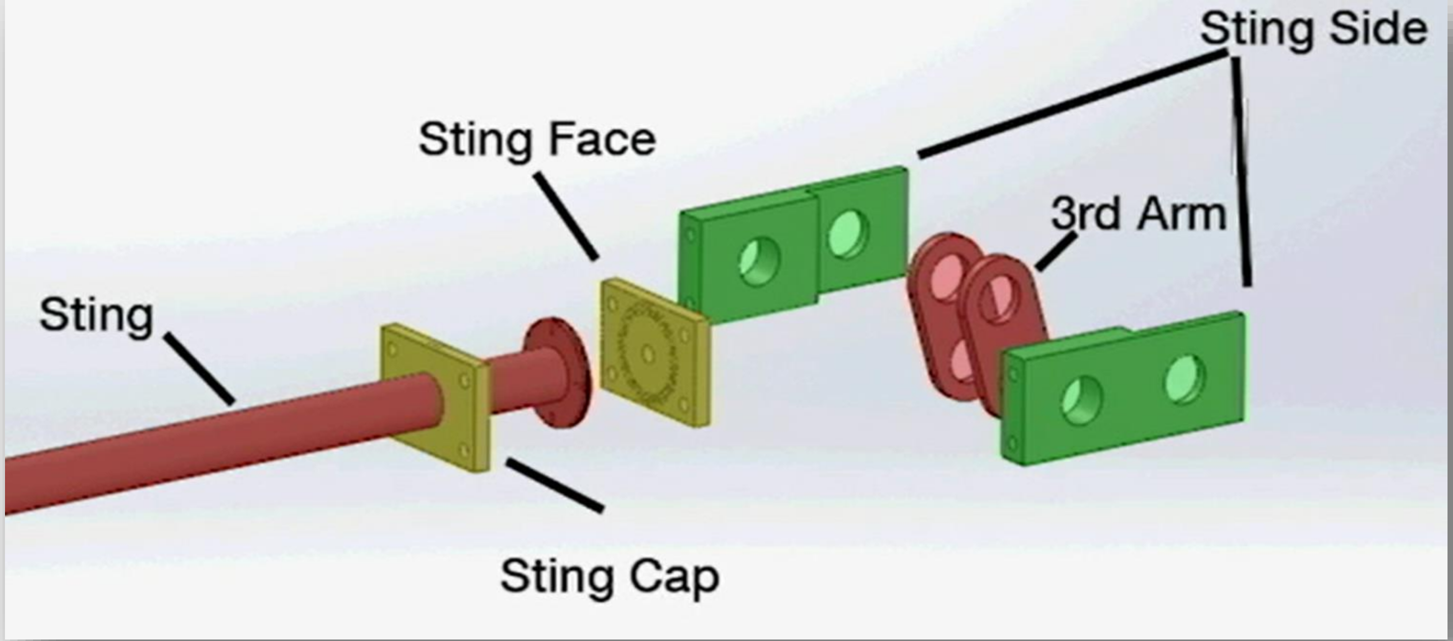
Expected Machine Time/Completion:

- Collar (x2): 4 man hours, Pending on Actuator Delivery
- Linear Bracket (x2): 4 man hours, Pending on Actuator Delivery

Sting Subsystem



Sting Subsystem Scope and Status



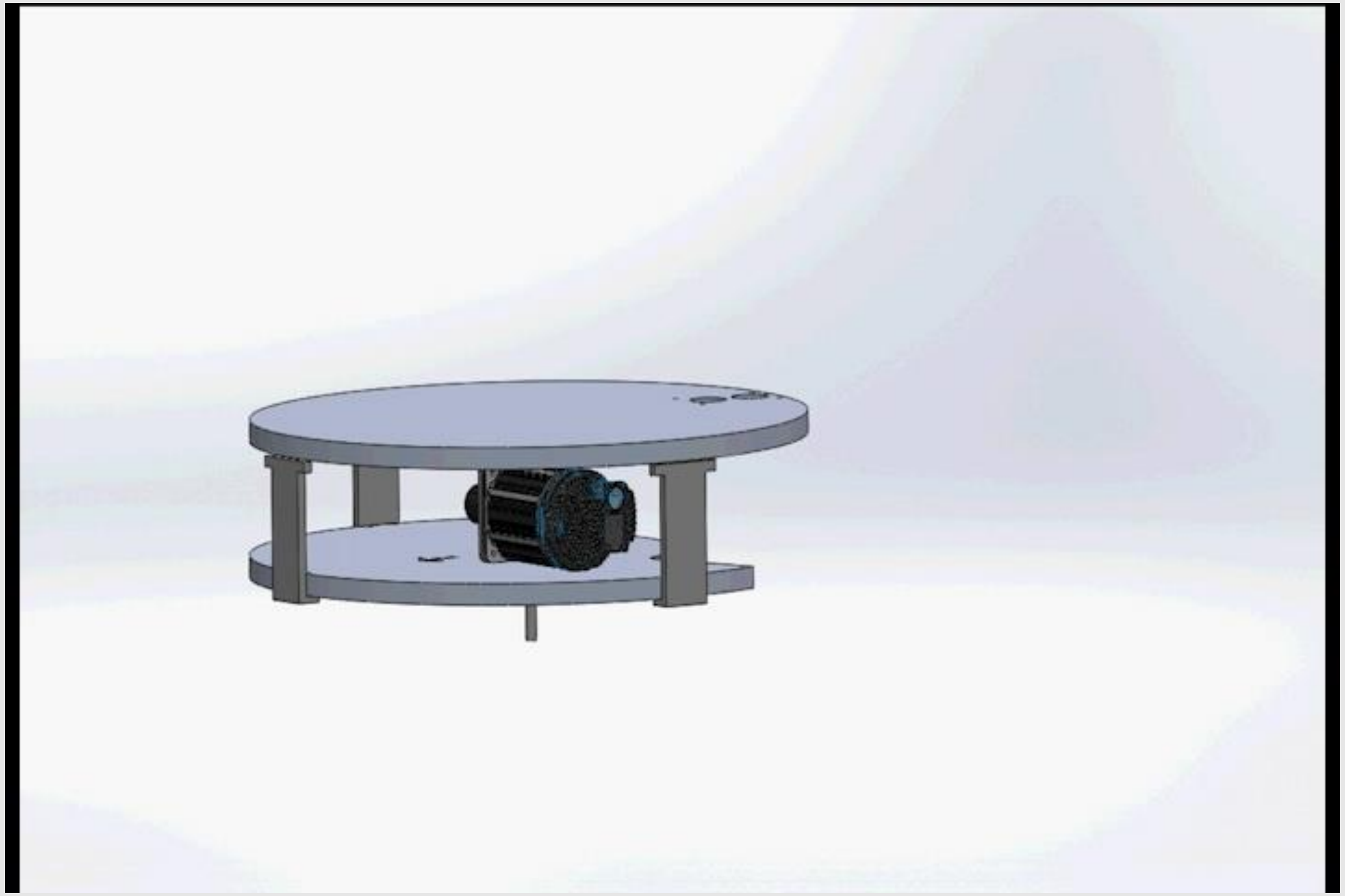
Expected Machine Time/Completion:
Sting Face: 2 man hours, Feb 2nd
Sting Cap: 1 man hour, Feb 2nd
Sting: 2 man hours, Feb 5th
3 Arm (x2): 2 man hours, Feb 3rd

Complete:
- Sting Side (x2)

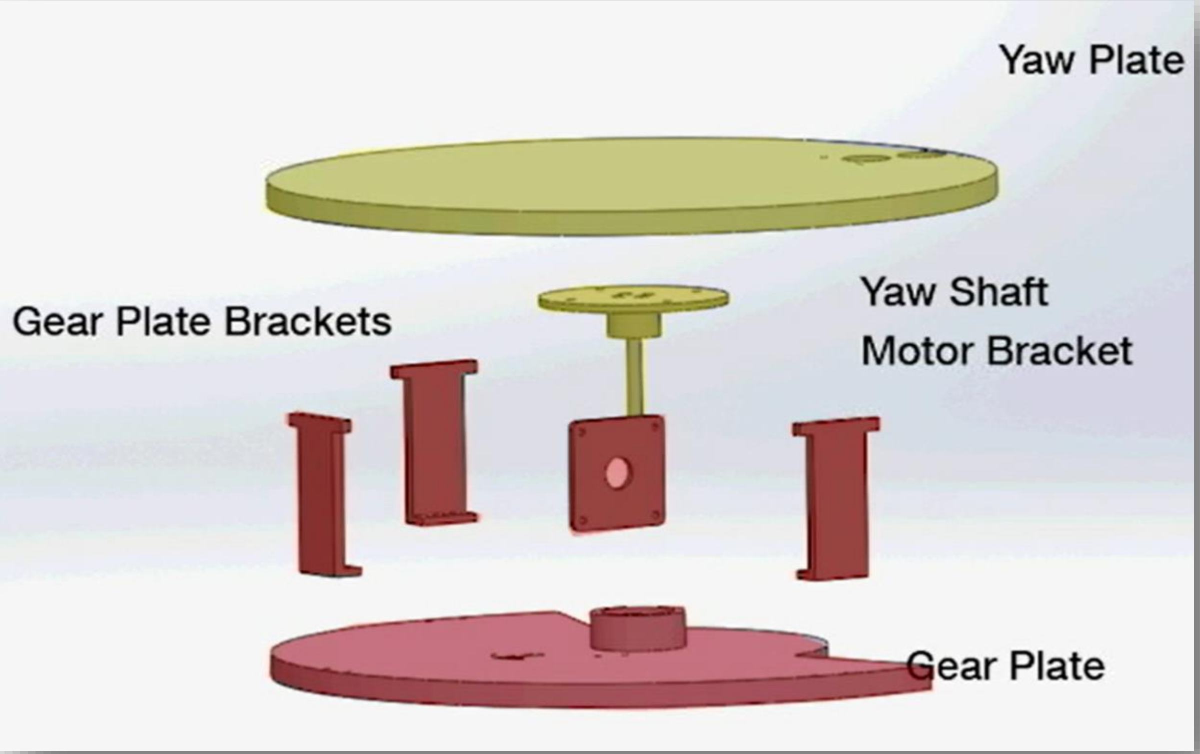
In Progress:
- Sting Face - 50% Complete
- Sting Cap - 75% Complete

Not Complete:
- Sting
- 3rd Arm (x2)

Yaw Subsystem



Yaw Subsystem Scope and Status



In Progress:
- Yaw Plate - 75% Complete
- Yaw Shaft/Motor Bracket -

Not Complete:
- Gear Plate
- Gear Plate Brackets (x4)

Expected Machine Time/Completion:
- Gear Plate w/ Base Plate: 6 man hours, Feb 24th
- Gear Plate Brackets (x4): 4 hours, Feb 11th

Manufacturing – Software/Electrical

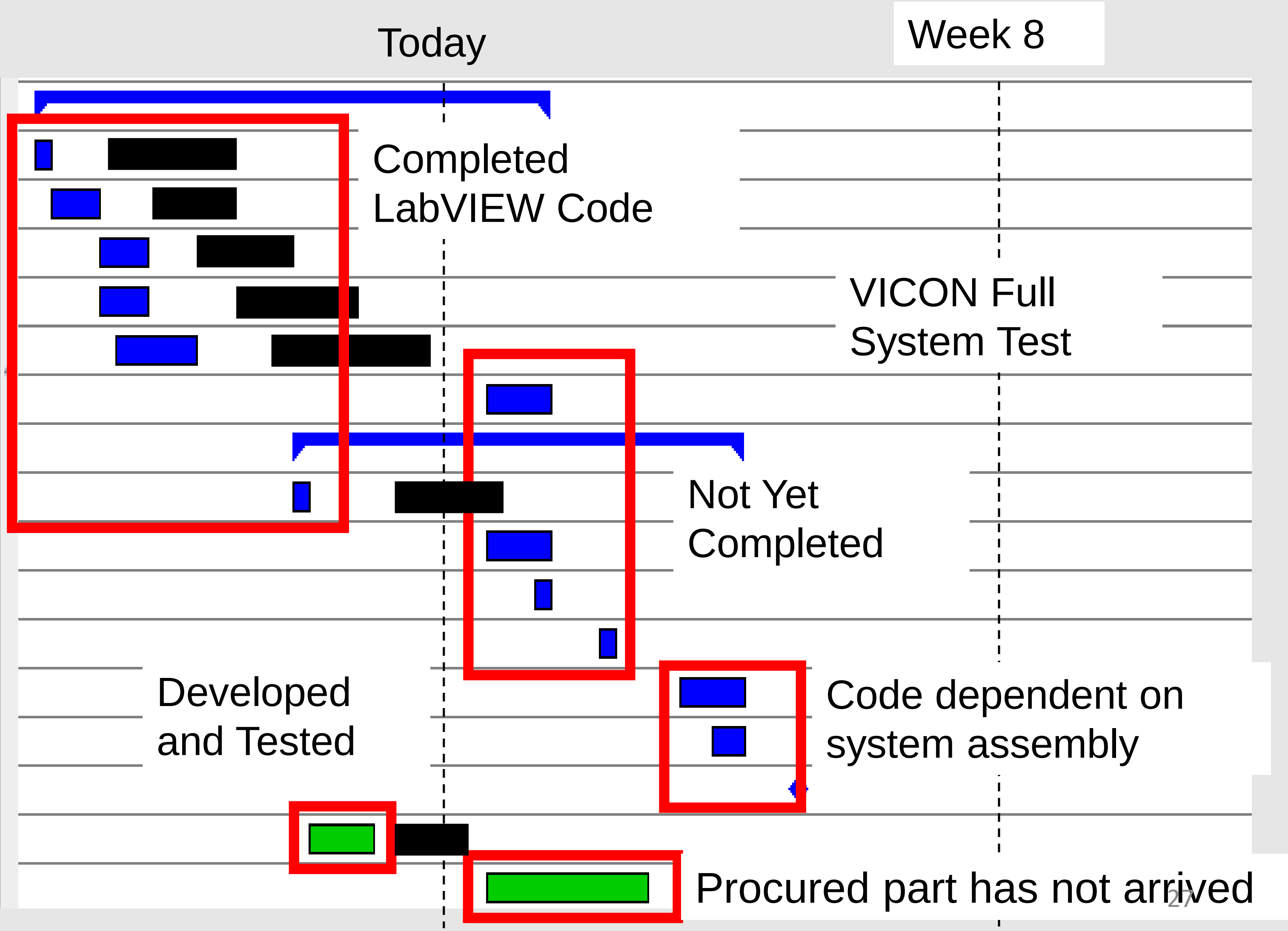
Software/Electrical Schedule

Software

LabVIEW Initializati...	1/11/16	2/11/16
User pop-up di...	1/11/16	1/11/16
Wall Display VI	1/12/16	1/14/16
Wall Check VI	1/15/16	1/17/16
Input Reader VI	1/15/16	1/17/16
File Reader VI	1/16/16	1/20/16
System Ready VI	2/8/16	2/11/16
LabVIEW Positionin...	1/27/16	2/23/16
Angle Calculatio...	1/27/16	1/27/16
Collect Position ...	2/8/16	2/11/16
Write to File VI	2/11/16	2/11/16
Format to Ardui...	2/15/16	2/15/16
Validate System...	2/20/16	2/23/16
Integrate the er...	2/22/16	2/23/16
Software Complete	2/27/16	2/27/16

Electrical

PCB Board Develop...	1/28/16	1/31/16
Linear Actuator Vali...	2/8/16	2/17/16



Software Scope

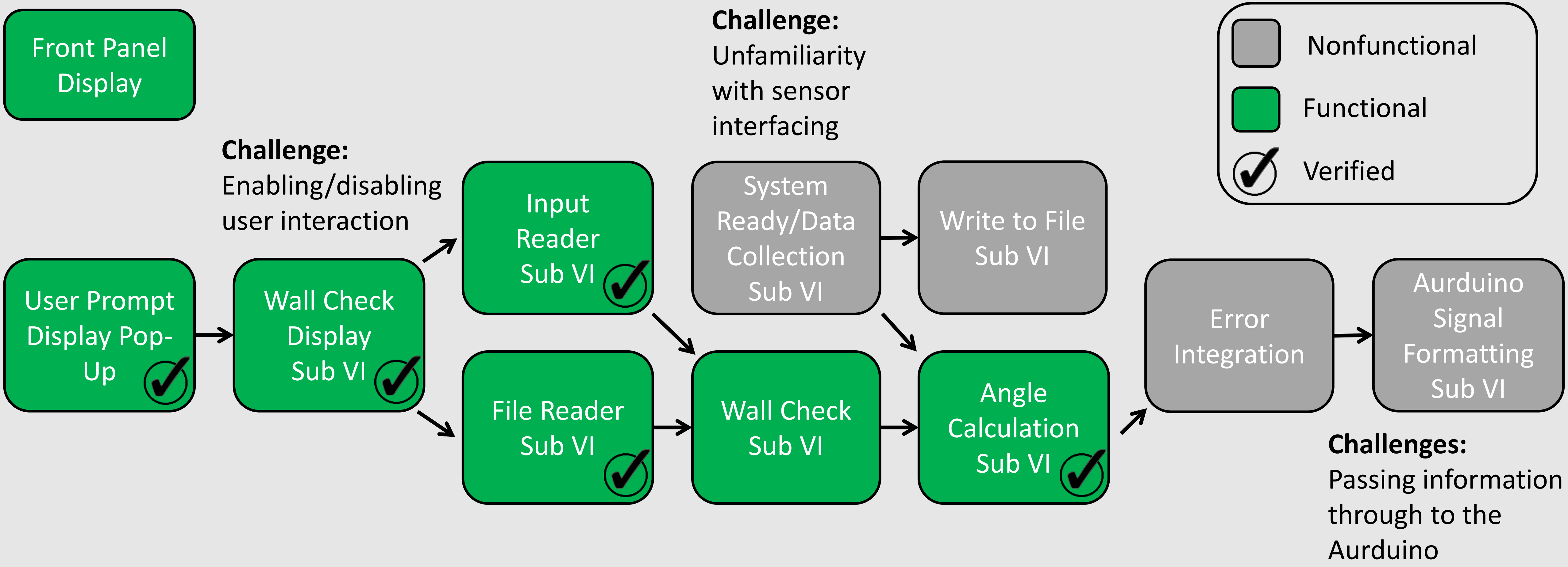
Initialization and Safety

- Allow for a variable sting length **- User Prompt**
- Read a User file - **File Reader VI**
- Allow for manual inputs **- Input Reader VI**
- Prevent damage to the system, the wind tunnel and fillets - **Wall Check VI** and **Wall Display VI**

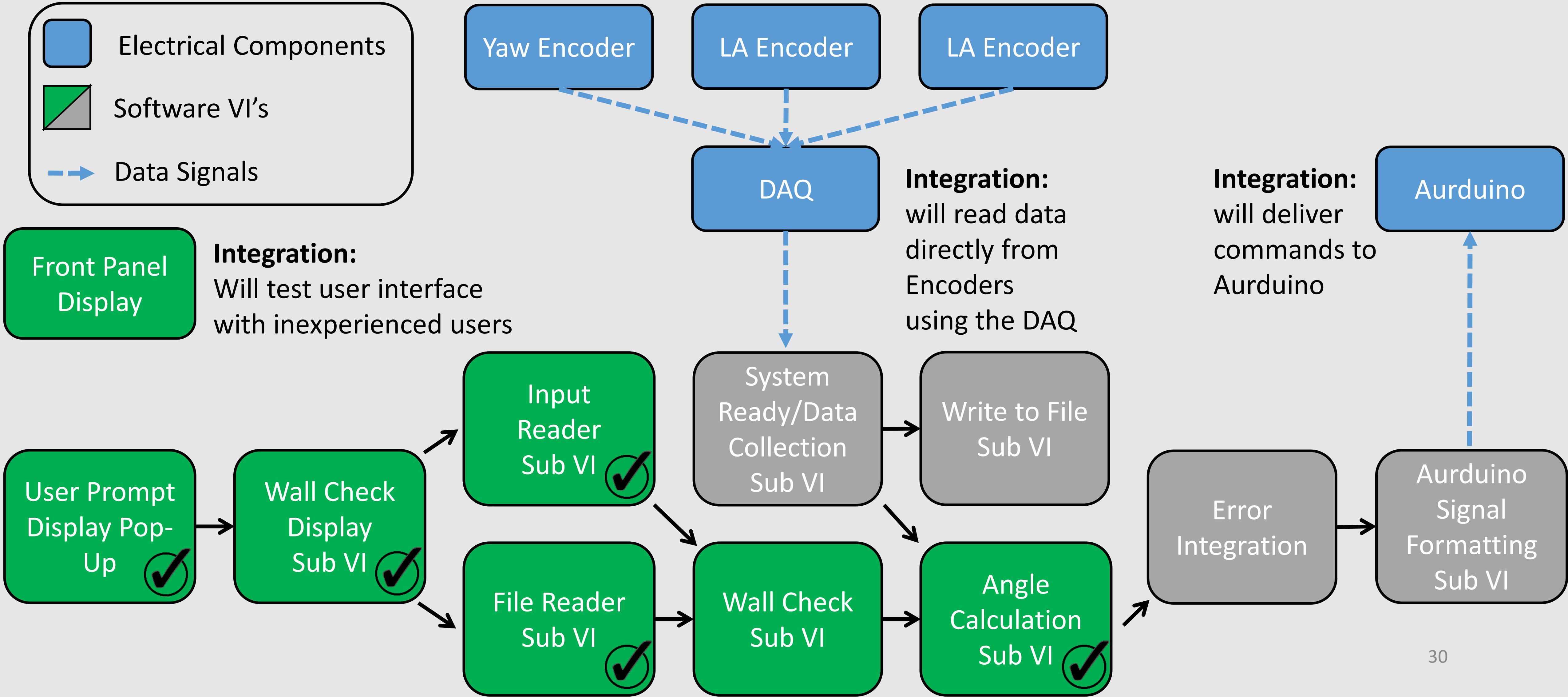
Positioning

- Format signals to the motor **- Format to DAQ VI**
- Read position from encoders **- Collect T+P VI**
- Calculate where to position the system based on attitude **- Angle Calculation VI**
- Write position to data file and allow user to save file - **Write to File VI**

Software Completion and Future Challenges



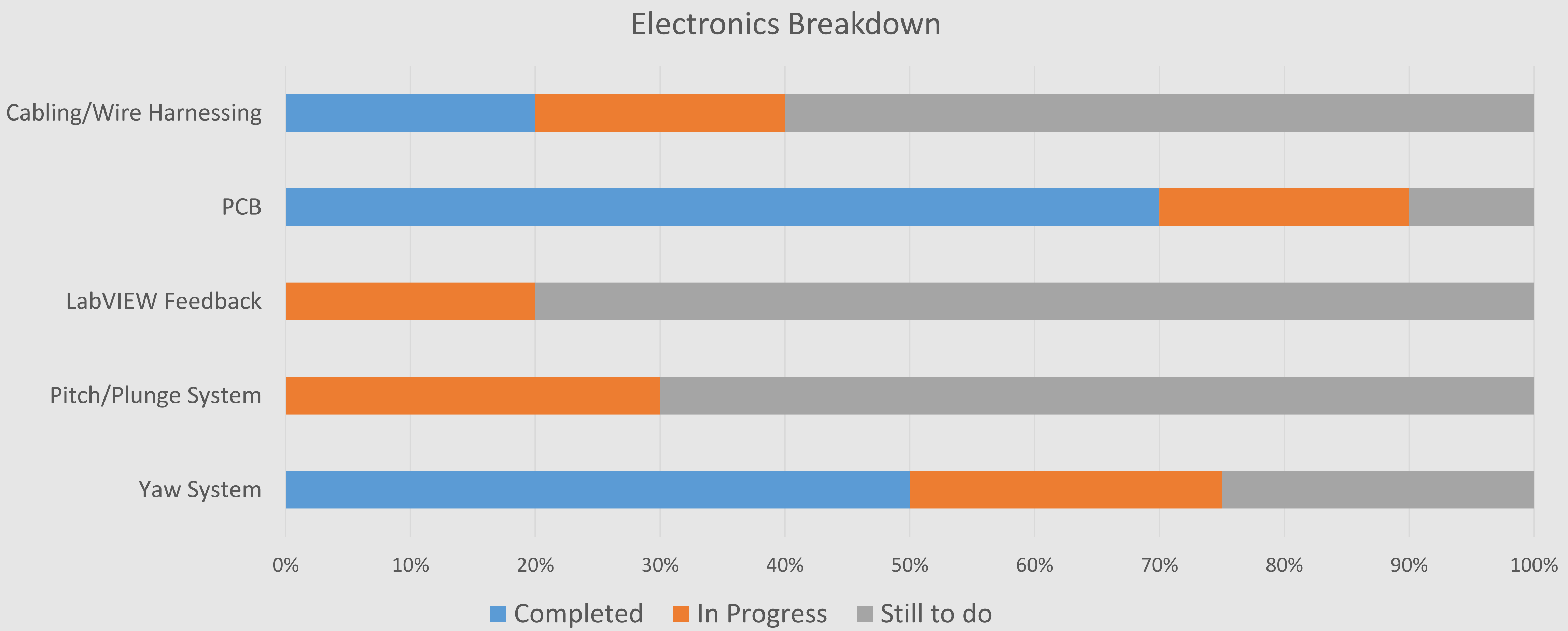
Software Integration Plan



Electronics Scope

- Precise control of motors
  - Be able to send commands from LabVIEW to motors - **Arduino**
- Electronic Motion
  - Positioning a model in pitch and plunge under load – **Linear Actuator System**
  - Positioning a model in yaw under load – **Teknic Motor System**
- Feedback to LabVIEW
  - Provide the user with real time information about position – **Incremental and Absolute Encoders**

Electronics Status Summary



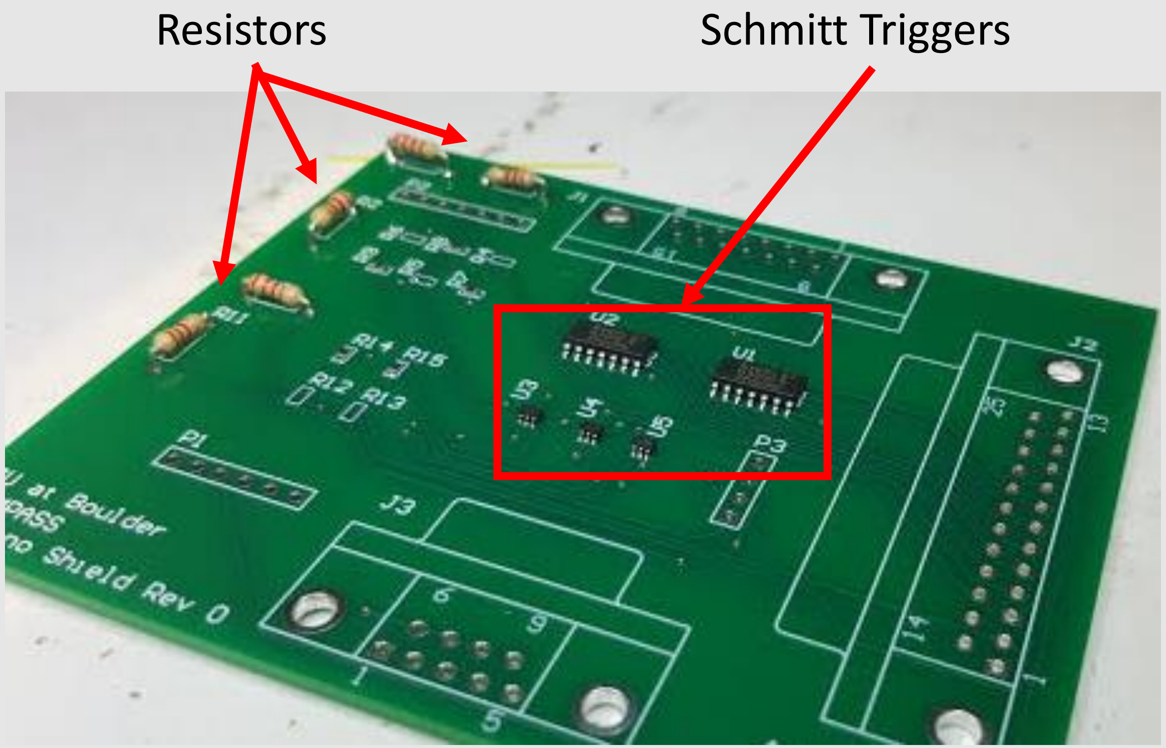
Electronics Status Summary

Completed	In Progress	Not Completed
• PCB populated • Functionality of PCB and Schmitt Triggers Tested • Yaw motor initial setup • Yaw motor internal programming • Yaw system Arduino initial code written	• PCB finalization • Yaw Arduino code and motor integration • Pitch/Plunge Arduino code (outsourced)	• Setup of Pitch/Plunge system • Setup of encoders and DAQs for LabVIEW feedback • PCB integration

- Challenges: Catching up with the schedule due to late arrival of components
- Mitigation Plan: Tutorial videos and developing a rigid plan for when components arrive
- Positive: Able to focus a lot of time on Yaw System

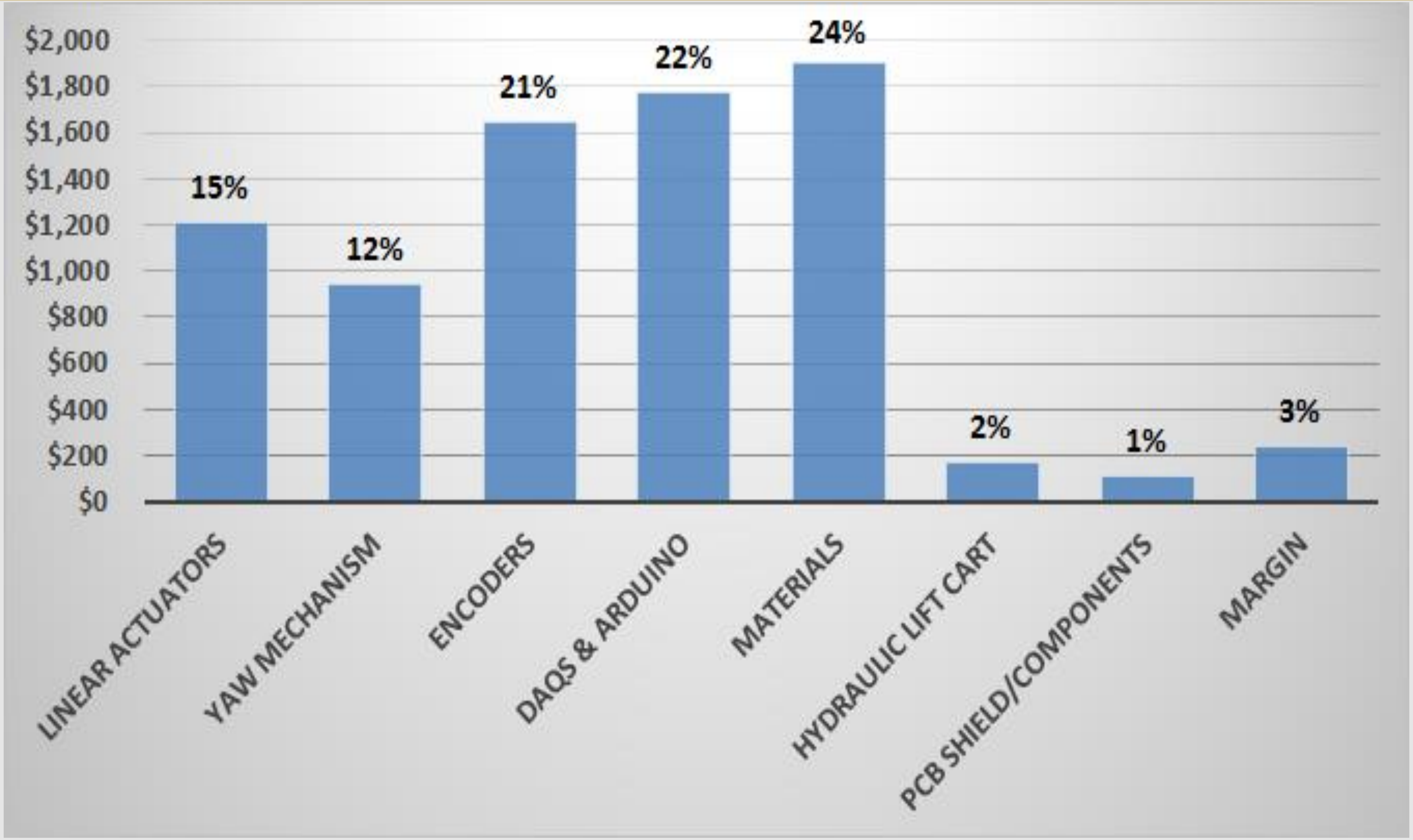
PCB Shield

- Purpose: provide signal noise reduction
  - Achieved with a combination of resistors and Schmitt triggers
  - Will force a signal high or low depending on a threshold
- Populated for testing of the Schmitt triggers
  - Confirmed functionality of board and triggers



Budget

Budget



Course Budget: $5000
EEF Addition: $3000
Total Budget: $8000
Margin: $238, 3%

Parts Price Change From CDR

Parts	Expected Price at CDR	Actual Price at MSR
Gear with baseplate	$1200	$1200
Encoders	$~1000	$1644
NI (DAQs/ENET)	$962	$1700
Yaw Motor	$730	$781
Linear Actuators	~$460	$1205
Worm Gear	Not assessed	$166
Arduino	Not assessed	$78
Hydraulic Lift Cart	Not assessed	$172
Miscellaneous Materials	Not assessed	$701
Printing	Not assessed	$200
PCD Shield/Components	Not assessed	$115
Margin	$1920	$238

Questions?

Back-up Slides

Future Work - Testing

VICON Bonita B-10

System is capable of measuring:

- **± 0.5 mm** in translation
- **± 0.5 deg** in rotation

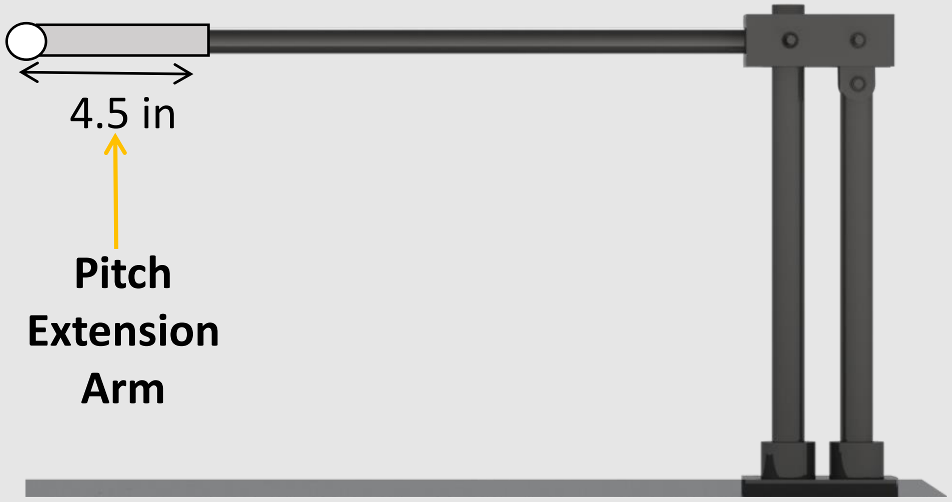
To verify COMPASS using VICON, extension arms must be implemented to reach needed displacements in pitch and yaw and roll. Angle can be solved for using displacement of nodes.

Pitch Verification Test

Main Objective: Validate **range** and **accuracy** requirements of pitch mechanism.

Requirements: ± 30° range, ± 0.1° accuracy.

Location: Idea Forge



Procedure: Connect extension arm to sting to achieve needed vertical displacement for verification in pitch using **VICON**.

Provided Displacement: 1 mm per 0.1°

VICON Accuracy	Tip Displacement
0.5 mm	1 mm

Yaw Verification Test

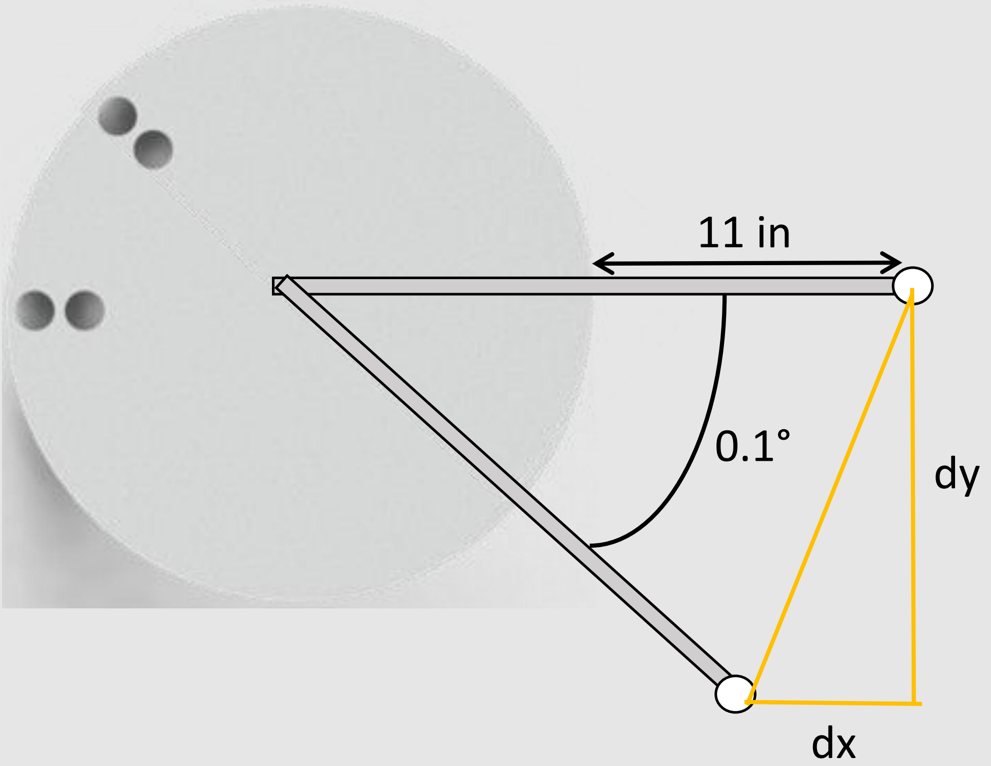
Main Objective: Validate **range** and **accuracy** requirements of yaw mechanism.

Requirements: ± 30° range, ± 0.1° accuracy.

Location: Idea Forge

Procedure: Connect extension arm to yaw plate to achieve needed horizontal displacement for verification in yaw using **VICON**.

Provided Displacement: 1 mm per 0.1°



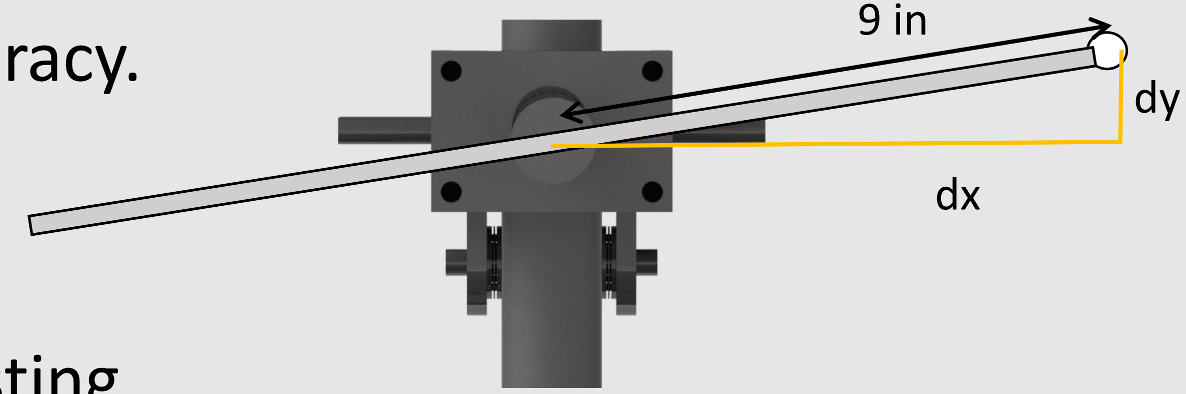
VICON Accuracy	Tip Displacement
0.5 mm	1 mm

Roll Verification Test

Main Objective: Validate **range** and **accuracy** requirements of roll mechanism.

Requirements: ± 45° range, ± 0.5° accuracy.

Location: Idea Forge



Procedure: Connect extension arm to sting to achieve needed vertical displacement for verification in roll using **VICON**. (or use VICON's 0.5° rotation accuracy)

Provided Displacement: 1 mm per 0.5°

VICON Accuracy	Tip Displacement
0.5 mm	1 mm

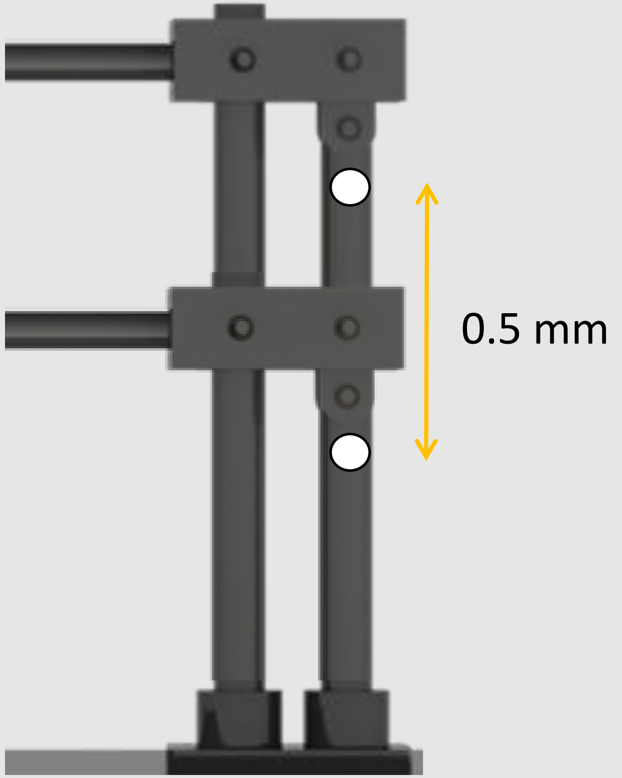
Plunge Verification Test

Main Objective: Validate **range** and **accuracy** requirements of plunge mechanism.

Requirements: ± 10 cm range, ± 0.5 mm accuracy.

Location: Idea Forge

Procedure: Connect nodes to COMPASS, command plunge to and verify plunge requirments using **VICON**.



VICON Accuracy	Tip Displacement
0.5 mm	0.5 mm

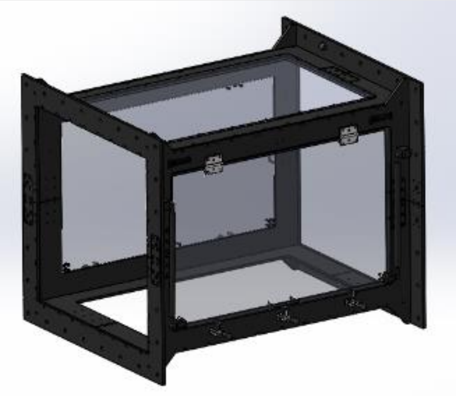
VICON Learning Curve

- Knowledge of system will take time.
  - Beginning safety brief and tutorial early February.
  - Will allow time to understand software before testing begins in March.

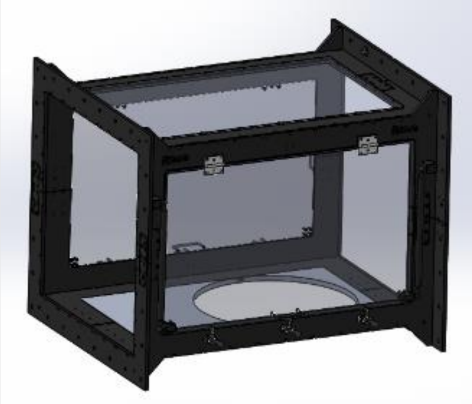
Systems Back-Up Slides

COMPASS Assembly

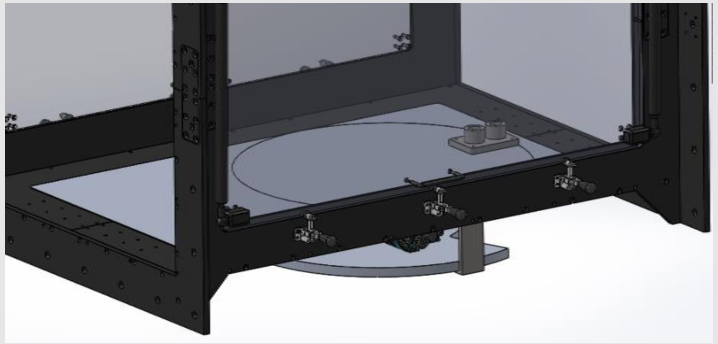
1. Remove standard bottom plate



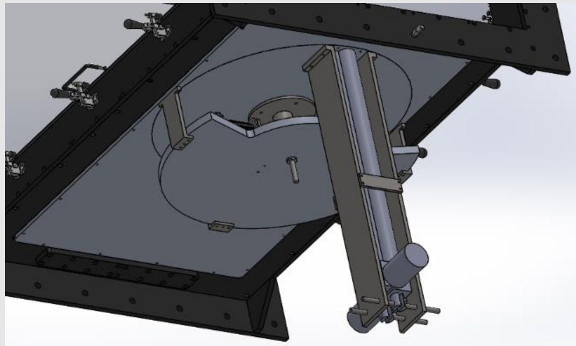
2. Install base plate

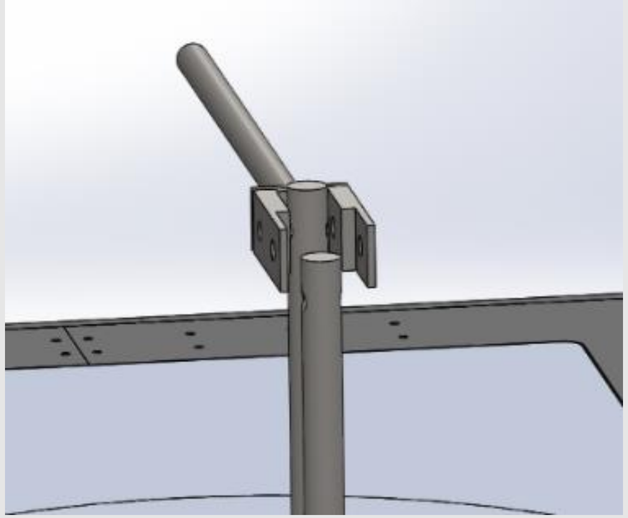


3. Install yaw mechanism with brackets

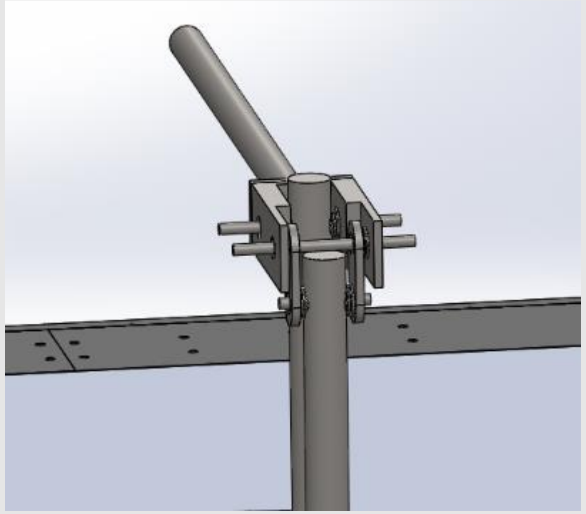


4. Install linear bearings and actuators





5. Place sting on linear actuators



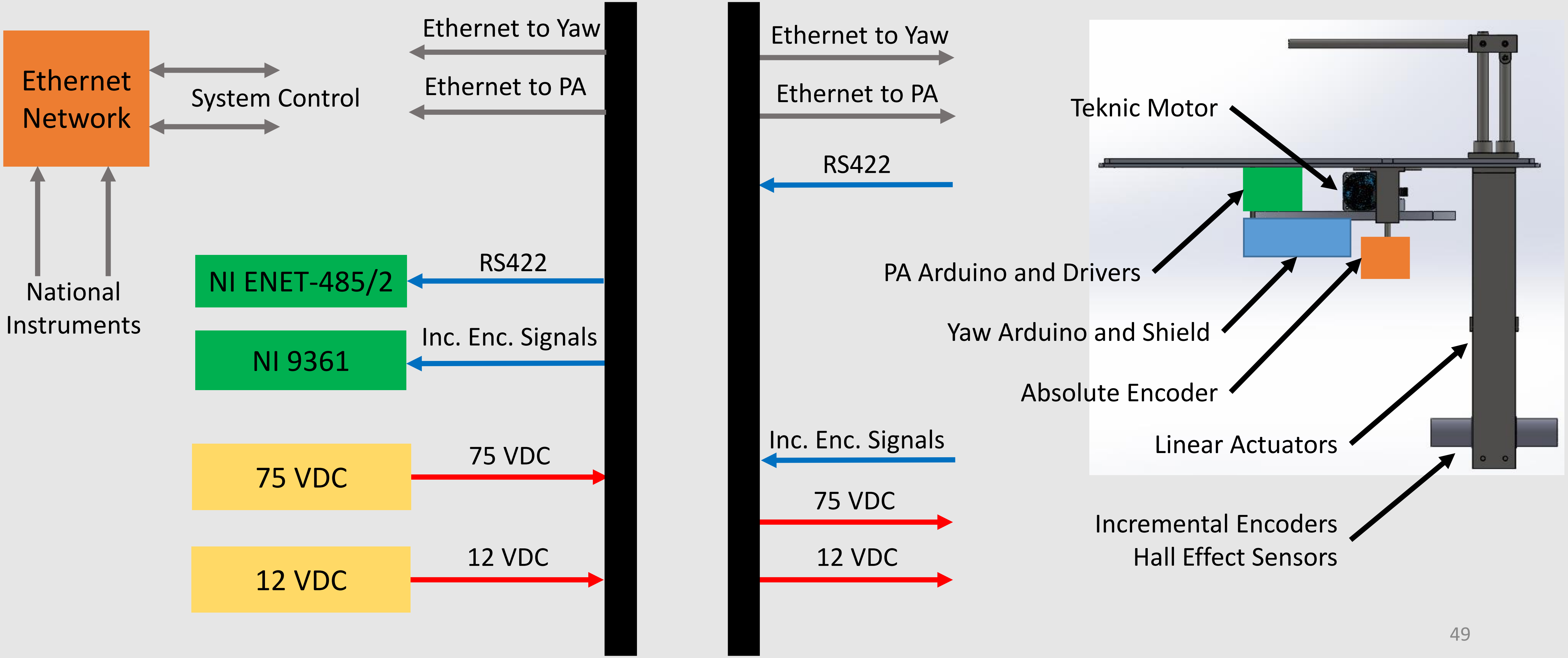
6. Install sting thrust bearings and pins

7. Move to commanded static positions

Component Placement and Interfaces

Electronic Setup Area

Test Section Area



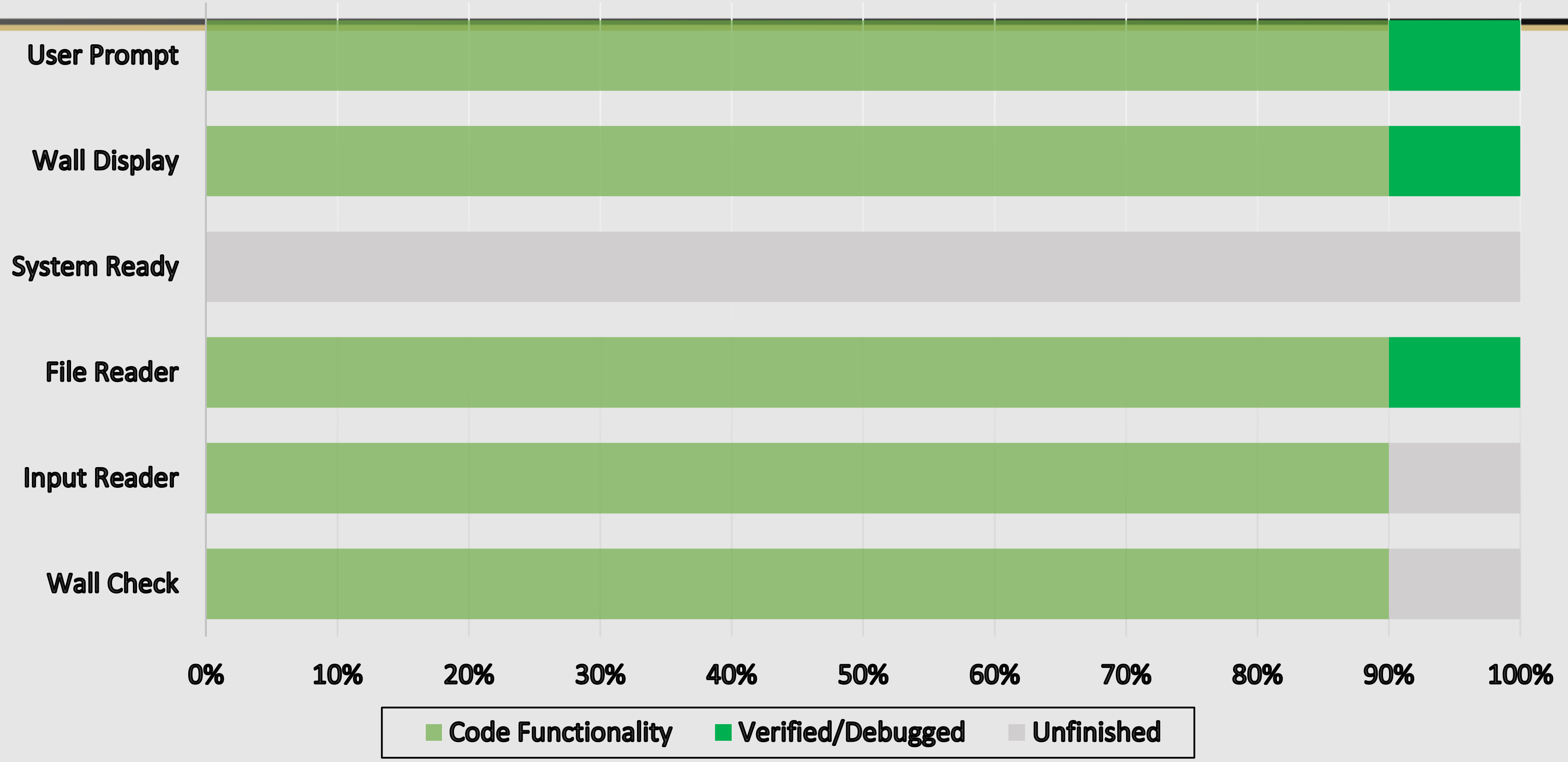
Component Connector Interfaces

Starting Location	Starting Connector Type	Terminating Location	Terminating Connector Type
LabVIEW Computer VI	Ethernet	Progressive Automations Arduino	Ethernet
LabVIEW Computer VI	Ethernet	Yaw Arduino Uno	Ethernet
Yaw Arduino Uno	Female Headers	Yaw Arduino Uno Shield	Male Headers
Yaw Arduino Uno Shield	9-Pin D-Sub	Teknic Rotary Servo Motor	8-Pin Molex
Yaw Arduino Uno Shield	15-Pin D-Sub	NI 9361 DAQ Module	Fly Leads
Yaw Arduino Uno Shield	25-Pin D-Sub	Incremental Encoders (x2)	12-Pin M23
Yaw Arduino Uno Shield	25-Pin D-Sub	Hall Effect Sensors (x2)	--------
Yaw Arduino Uno Shield	4-Pin Molex	Progressive Automations Arduino	--------
Absolute Encoder	12-Pin PCB Axial	NI ENET-485/2	9-Pin D-Sub
NI ENET-485/2	Ethernet	LabVIEW Computer VI	Ethernet
NI 9361 DAQ Module	Ethernet	LabVIEW Computer VI	Ethernet
12VDC Transformer	--------	PA Motor Drivers	--------
75VDC Transformer	2-Pin Molex	Teknic Rotary Servo Motor	4-Pin Molex

Component Signal Interfaces

Starting Location	Interface	Terminating Location
LabVIEW Computer VI	Ethernet	Progressive Automations Arduino
LabVIEW Computer VI	Ethernet	Yaw Arduino Uno
Yaw Arduino Uno	5V Digital and 5VDC	Yaw Arduino Uno Shield
Yaw Arduino Uno Shield	5V Digital	Teknic Rotary Servo Motor
Yaw Arduino Uno Shield	5V Digital	NI 9361 DAQ Module
Yaw Arduino Uno Shield	5V Digital	Incremental Encoders (x2)
Yaw Arduino Uno Shield	5V Digital	Hall Effect Sensors (x2)
Yaw Arduino Uno Shield	5V Digital	Progressive Automations Arduino
Absolute Encoder	RS422	NI ENET-485/2
NI ENET-485/2	Ethernet	LabVIEW Computer VI
NI 9361 DAQ Module	Ethernet	LabVIEW Computer VI
12VDC Transformer	12VDC	PA Motor Drivers
75VDC Transformer	75VDC	Teknic Rotary Servo Motor

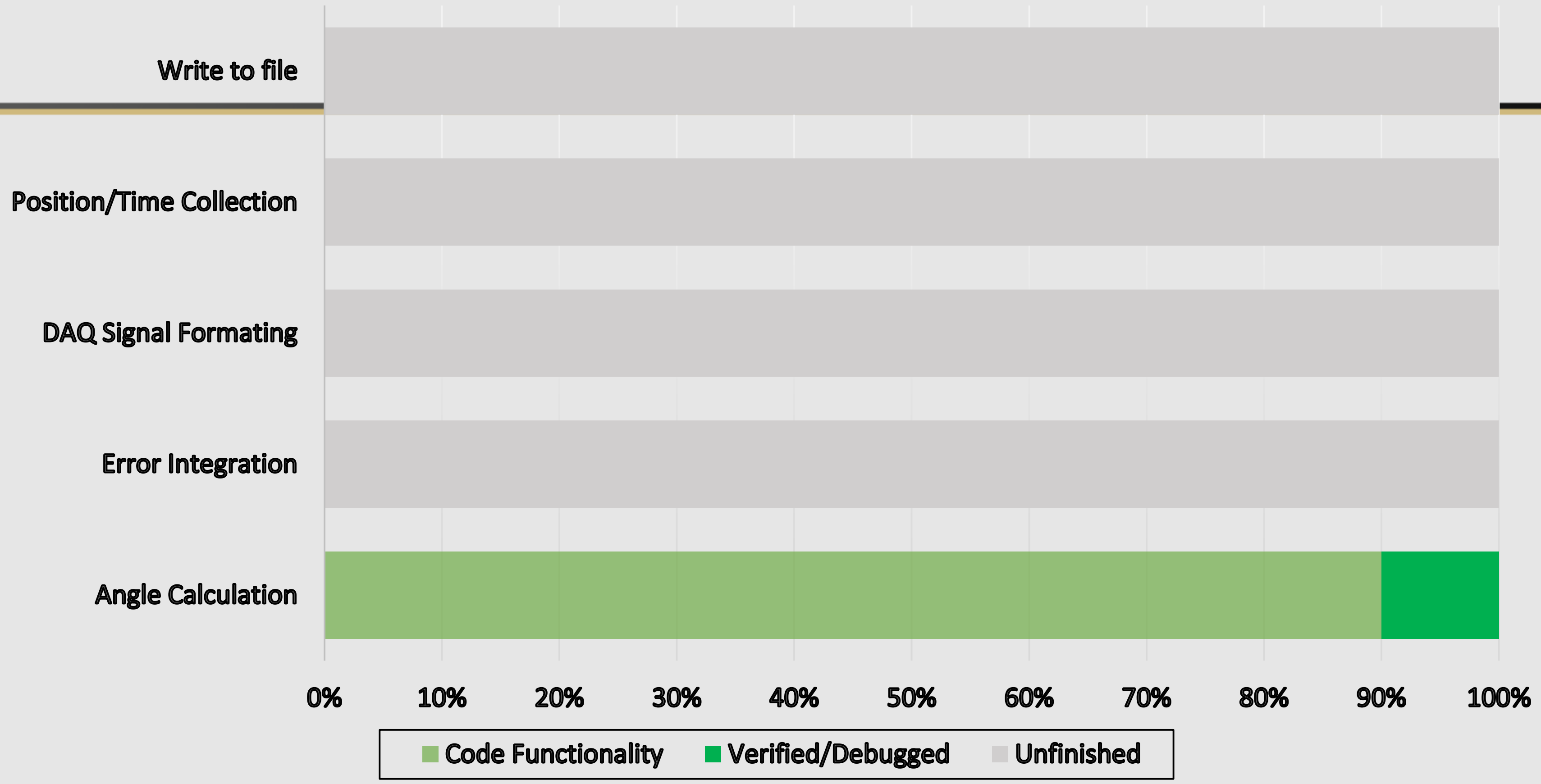
INITIALIZATION AND SAFETY SUB-VIS



Challenges:

None - this section of the code is predominantly number crunching and display windows which has proved relatively straight forward

POSITIONING SUB-VIS



Challenges:

DAQ Signal formatting - This will require a collaboration figuring out what the motors are looking for and finding a way to match it (Labview has built in Express VIs that should help)

Position and Time Collection - I have never interfaced programming and sensors (labview has many help resources)

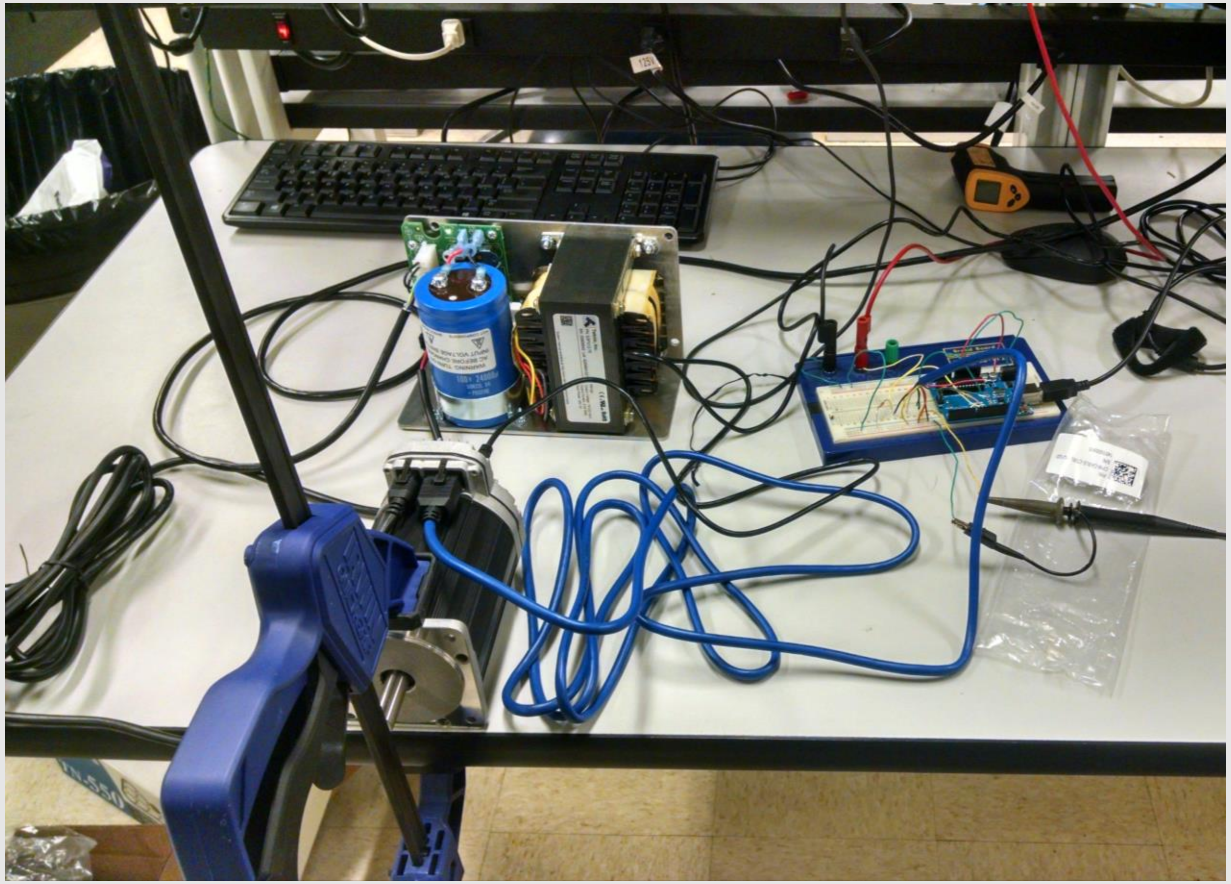
Electronics Back-Up Slides

Pitch and Plunge System

- Actuator expected arrival date February 12, incremental encoders to arrive the following week
- This puts the project behind schedule
- Plans to mitigate schedule set back
  - Learn how to set up and run actuators before they arrive
  - Tutorials provided by Progressive Automations
- Positive: Allows for yaw system focus, can finish this system

Yaw System

- Teknic motor has arrived
  - General functionality has been tested with pulse burst
  - Arduino Uno is being coded and tested with the system
  - Ethernet Arduino code in development
- Absolute Encoder has not arrived
  - Being used for outer control loop with LabVIEW



Small Margin: Budget and Schedule

- Encoder purchase was delayed
  - Absolute encoder not advertised correctly
    - Ordered encoder not capable of BiSS-C serial protocol
    - Re-ordered to available specifications
  - Dynapar did not process purchase as result
- Absolute encoder has RS422 serial output
  - Requires extra components to convert from serial to Ethernet
  - ~ $800 for ENET-485/2
- Discussing off-ramps in terms of functionality and budget

Small Margin: Off-Ramps

- Full system functionality with Ethernet network control
  - Characteristics: ENET-485/2
  - Advantages: Full functionality with Ethernet interfacing
  - Disadvantages: Small budget margin with no room for error
- Full system control at local computer, partial on Ethernet network
  - Characteristics: No conversion, absolute encoder to local computer
  - Advantages: Larger budget and schedule margin
  - Disadvantages: Only partial functionality on full Ethernet network
- Full system functionality with Ethernet network control
  - Characteristics: Serial/Ethernet converter
  - Advantages: Larger budget margin
  - Disadvantages: Possible strain on interface development

Procurement

Parts Procured
Aluminum – Baseplate/Yaw plate
Yaw Motor
Arduino
PCB Board and some Components
Worm Gear/Screw
Thrust & Radial Bearings

Parts Ordered	
Part	Estimated Delivery
Custom Linear Actuators	2/4-2/10
NI 9361 & ENET-485/2	2/10-2/12 (9361) & 1 week after ordering ENET
Encoders	2/15-2/19
Hydraulic Lift Cart	2/3-2/5
Sting Rods	2/1 & 2/8-2/10
Gear Plate Bracket Steel	2/3-2/4
PCB Components	2/3-2/5