Manufacturing Status Review

DRIFT

Drone-Rover Integrated Fire Tracker

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Customer: Barbara Streiffert, Jet Propulsion Laboratory

Advisor: Dr. Jelliffe Jackson

Agenda

- Project Overview
- Mother Rover Design
- Schedule
- Budget
- Manufacturing & Status Update
  - Mother Rover Housing
  - Translational System Structure
  - Leveling System
  - Software
  - Electronics
- Conclusion

Mission Statement

Drone-Rover Integrated Fire-Tracker (DRIFT)

will develop a mother rover to secure, carry, and level an Unmanned Aerial Vehicle (UAV) for the purposes of gathering pertinent environmental data regarding locations at risk of or exposed to a wildfire.

Project Overview

Project Overview: Fire Tracker System

- As a result of climate change, wildfire seasons are becoming hotter and longer
  - This allows for a wildfire to easily ignite and rapidly spread
  - United States Forest Service is consistently increasing its budget for wildfire mitigation, rising from 16 to 50% of the Forest Service Budget since 1995[1]
- A deployable **mother rover** and **autonomous drone** provide a low cost means of long-range reconnaissance for early detection of wildfires
- These systems can assist firefighters in investigating areas sometimes impassible by ground-based methods alone

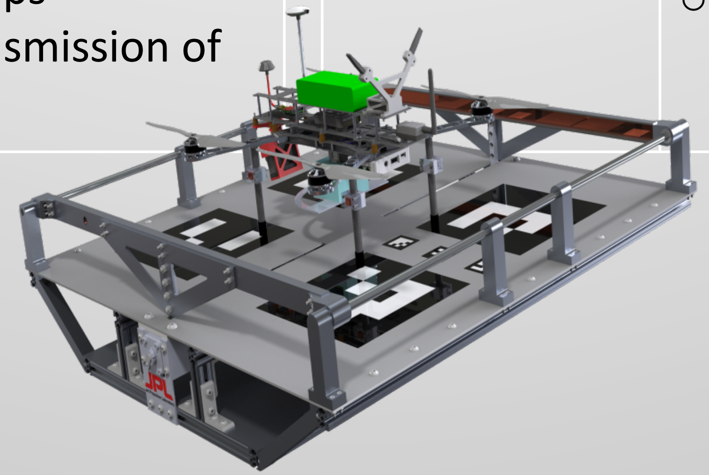
[1]The Rising Cost of Wildfire Operations: Effects on the Forest Service's Non-Fire Work." United States Department of Agriculture: Forest Service, 4 Aug. 2015.

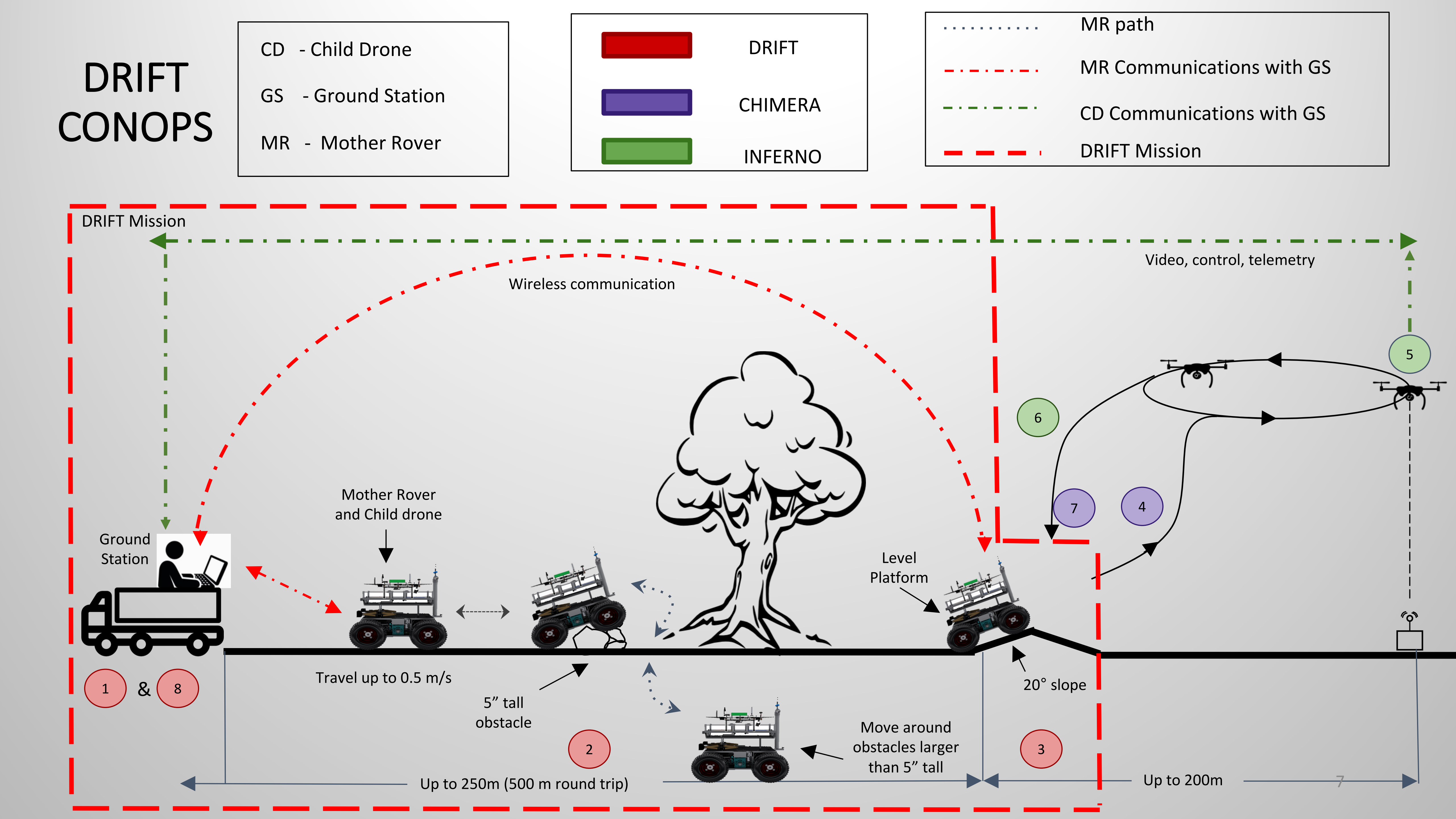
Project Heritage

DRIFT will utilize both the **INFERNO** and **CHIMERA** hardware and software shown below:

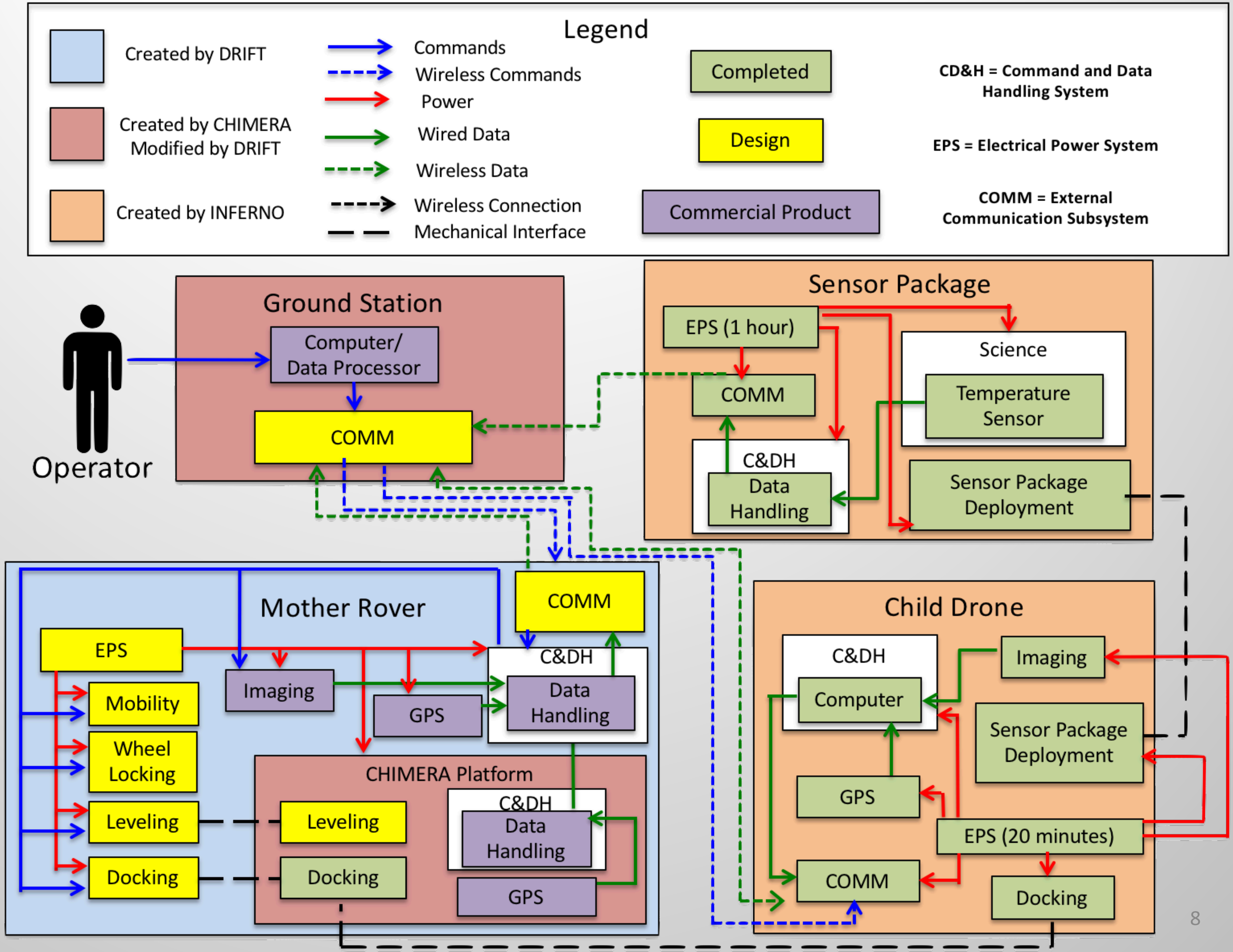
Project Name	**INFERNO** **IN**tegrated **F**light **E**nabled **R**over for **N**atural disaster **O**bservation
Timeline	2015-2016
Overview	Semi-autonomous **Child Drone** capable of transporting and deploying a temperature sensor package to a location of interest
Capabilities	○ Mission Duration: 13.5 min ○ Fully Autonomous Takeoff at inclinations < 3.5 degrees ○ 10 m/s Translational Flight ○ Video/Imaging: 720p at 30fps ○ Sensor Package: > 90% transmission of SPS data

Project Name	**CHIMERA** **CHI**ld drone deployment **ME**chanism and **R**etrieval **A**pparatus
Timeline	2016-2017
Overview	The landing, securing, and deployment system for the autonomous drone inherited from INFERNO (**Landing Platform**)
Capabilities	○ Capable of securing CD up to 200m from GS ○ Drone recharging system can charge the CDS LiPo battery upon command ○ Autonomous landing functionality utilizing image recognition upon command from ground station



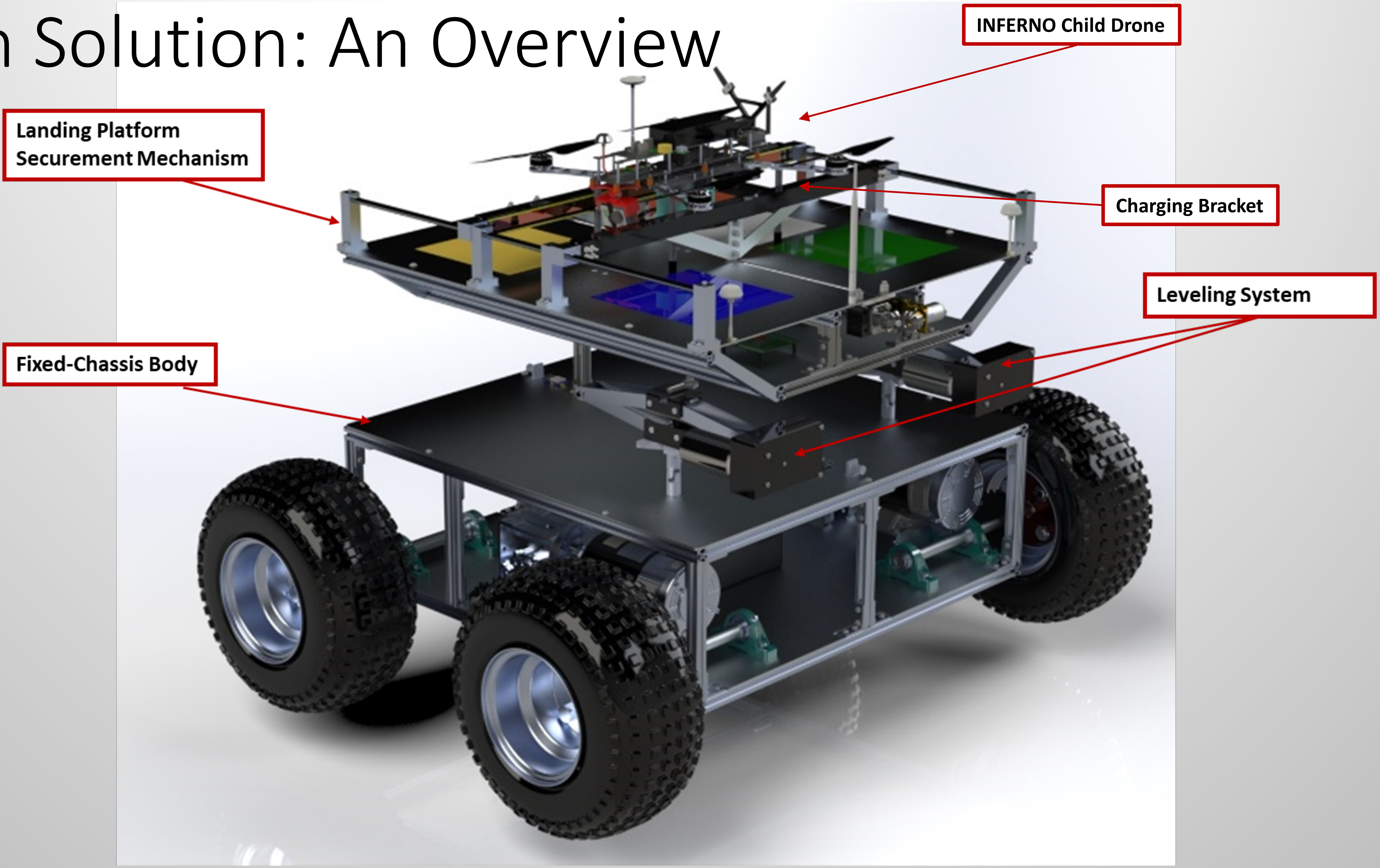

DRIFT
CONOPS
CD - Child Drone
GS - Ground Station
MR - Mother Rover
DRIFT
CHIMERA
INFERNO
MR path
MR Communications with GS
CD Communications with GS
DRIFT Mission
DRIFT Mission
Video, control, telemetry
Wireless communication
Mother Rover
and Child drone
Ground
Station
Level
Platform
1
&
8
2
3
4
5
6
7
Travel up to 0.5 m/s
5” tall
obstacle
20° slope
Move around
obstacles larger
than 5” tall
Up to 250m (500 m round trip)
Up to 200m

Functional Block Diagram



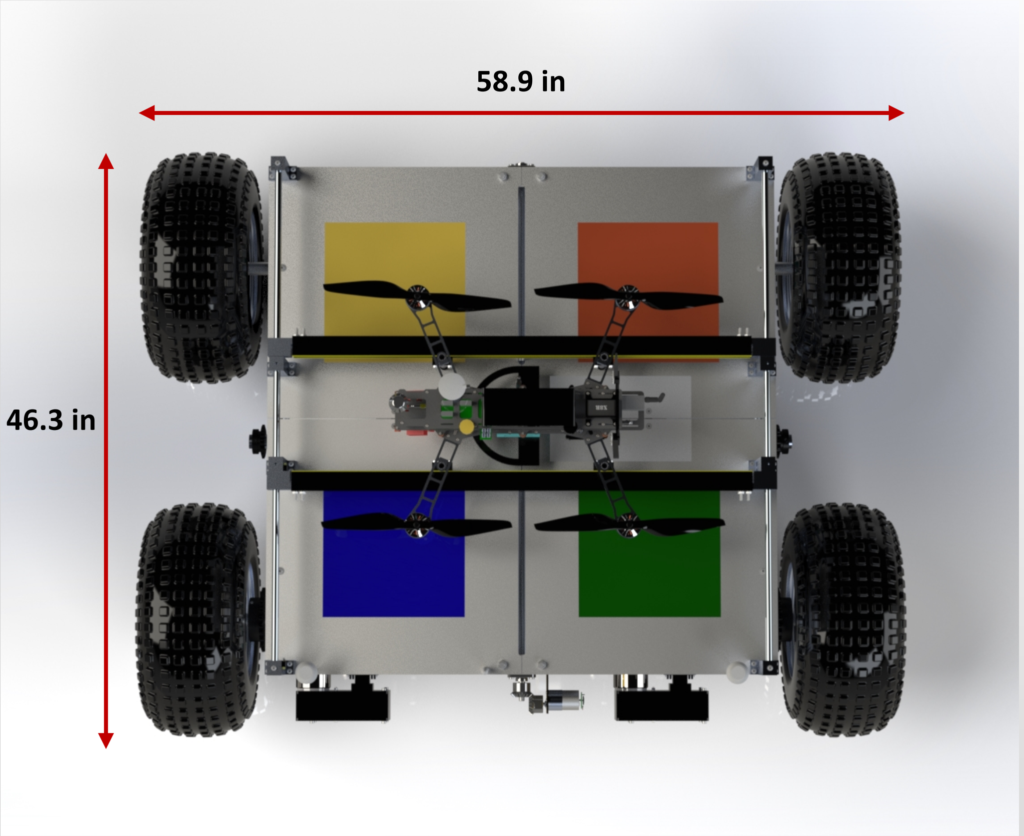
Design Solution

Design Solution: An Overview



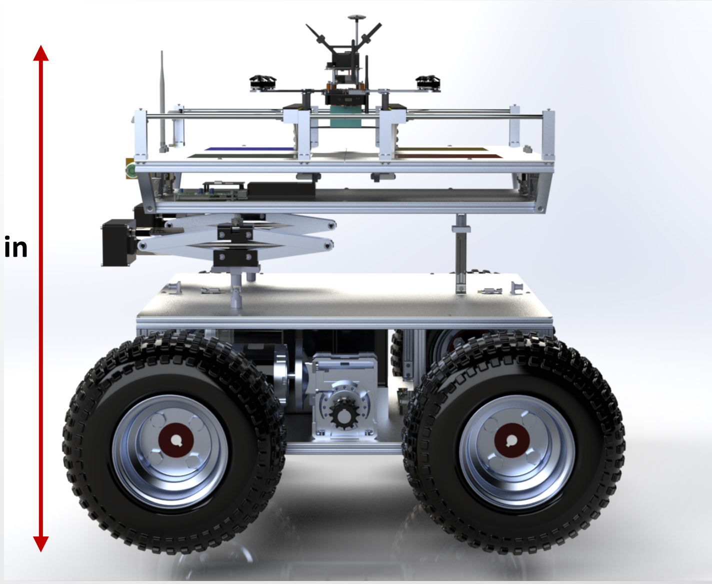
Design Solution: An Overview

Top View

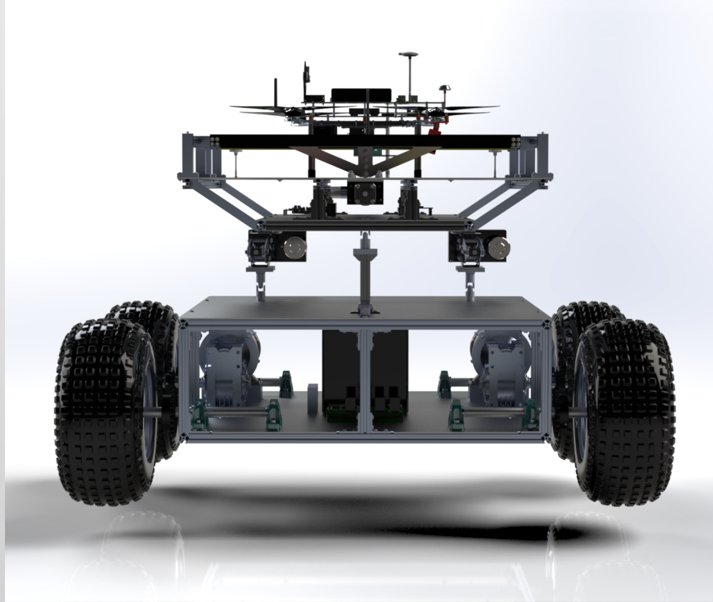


Total Weight : **393.45 lbs**

41.9 in



Side View

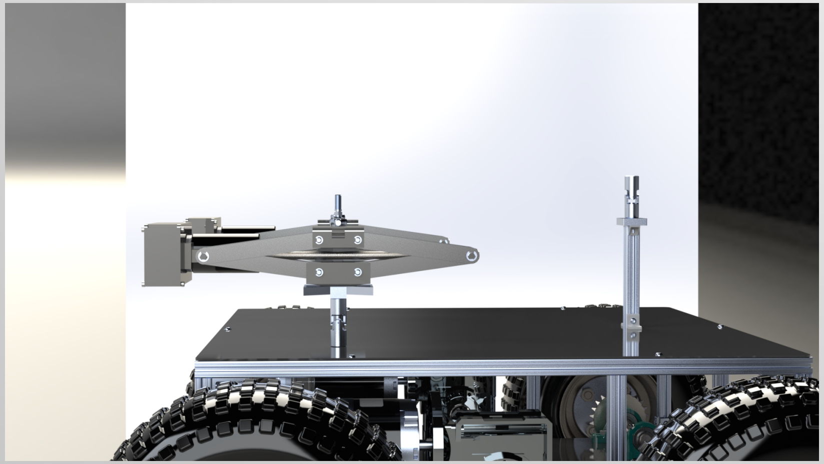


Front View

Design Modifications from CDR

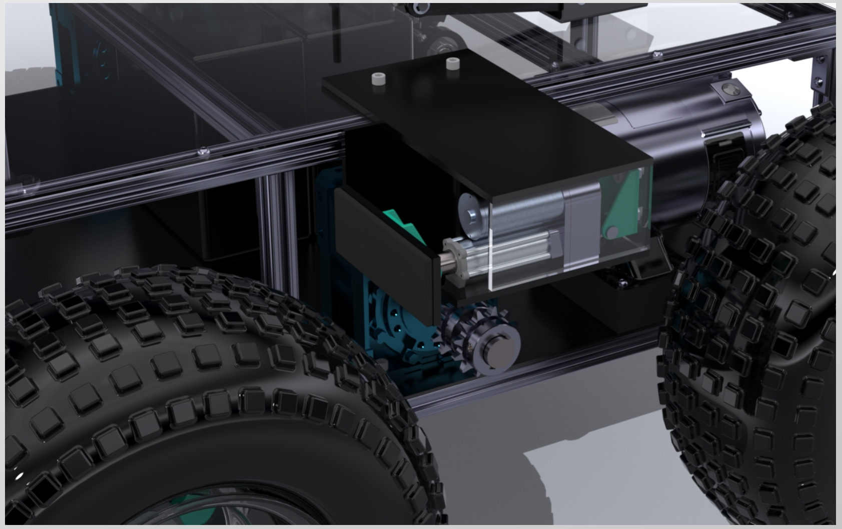
Leveling

- Previous system required **additional degree of freedom** on scissor jacks
- Accomplished through a **universal joint** beneath jacks
- Includes **custom jack base** to allow for U-joint mounting



Wheel Locking Mechanism

- **Removed** from Mother Rover System
- Test of worm-gear motors proved back driving will not occur
- Gives room in budget – saves $157.41



Critical Project Elements

- **Translational System**
  - **Fixed Chassis design** enables the mother rover to traverse rough terrain including fine dirt, small gravel, and lawn grass.
- **Leveling System**
  - Utilizes **internal leveling jack design** to level the landing platform to the required 3.5^0 necessary for the child drone to deploy and autonomously land safely.
- **Electronics and Communication**
  - Necessary for communication between Ground Station and Mother Rover
    - Commands leveling system
    - Provides live video feed for operator
    - Commands Mother Rover for Translational motion
- **$5000 Budget**
  - Currently only $163.31 margin
  - Applied for an additional $675.00 through Engineering Excellence Fund (EEF)

Levels of Success

Level 1

- MR can **traverse** over a **flat dirt path** while supporting the size and the weight of the attached LP and CD
- MR can be **driven by operator** to the desired location (and back) while operator walks alongside
- MR can **relay location** at least at 5 Hz at a **distance of 100 m** back to GS
- MR can be powered to achieve a **round trip of 100 m**

Level 2

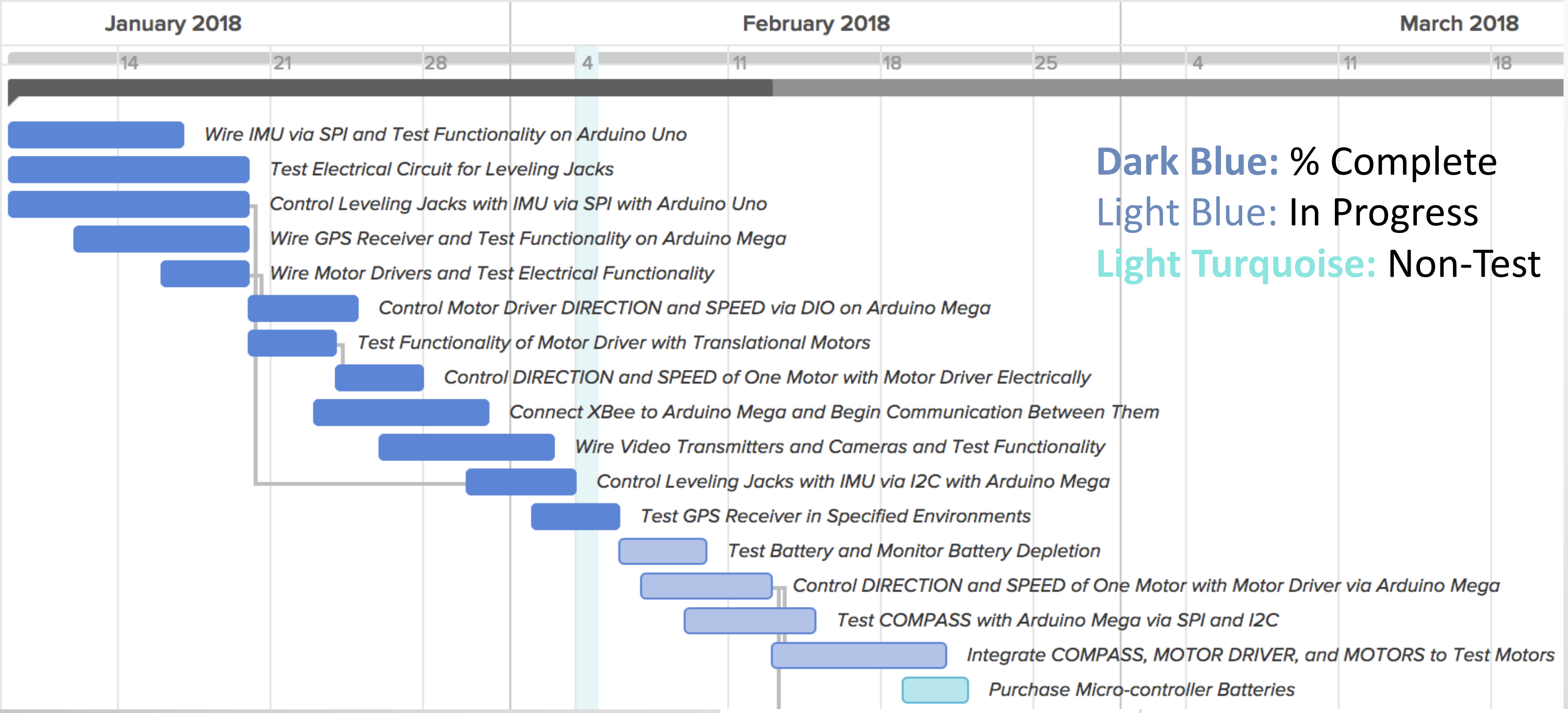
- MR can overcome **slopes** $\leq$ 10 degrees at speed up to 0.5 m/s
- MR can **traverse** a path that has obstacles less than or equal to **5 inch tall** while the CD and LP remain securely fixed to MR
- MR can **level the platform to $\mathbf{0^\circ \pm 3.5^\circ}$** for the CD to take off and land on a **10 slope**
- MR can be **driven by an operator** at GS via live video feed to desired location
- MR can **relay live video feed** and location at least at 5 Hz for a **distance of 150 m** to the GS
- MR can be powered to achieve a **round trip of 300 m**

Level 3

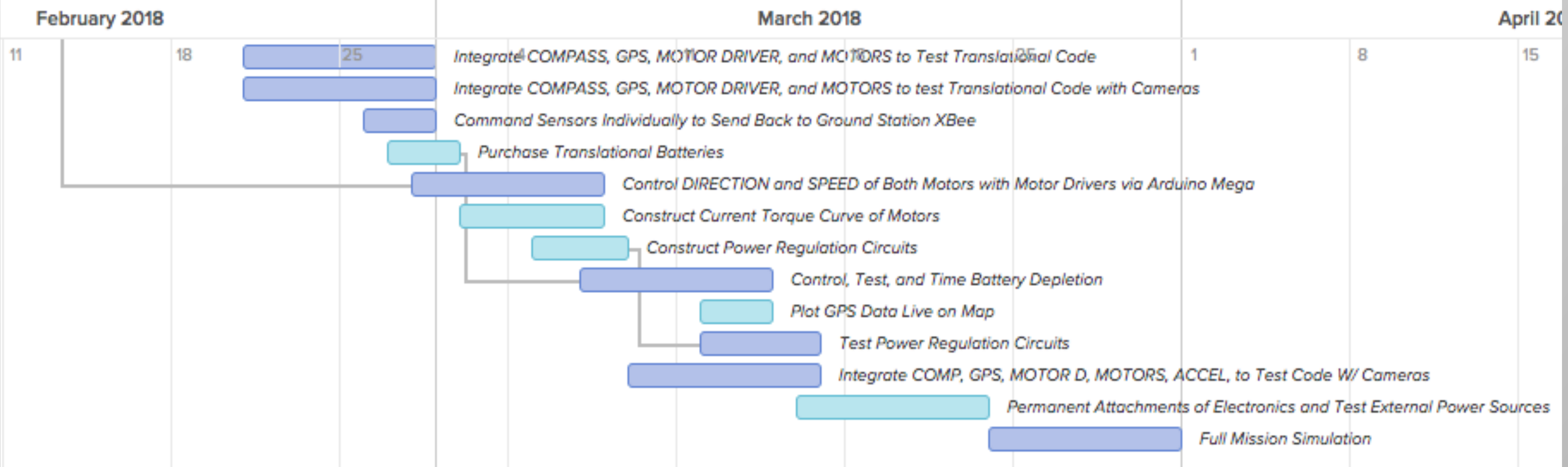
- MR can overcome **slopes $\leq$ 20 degrees** at speeds up to 0.5 m/s
- MR can maneuver around **obstacle over 5 inches tall** while the CD and LP remains securely fixed to the MR
- MR can **level the platform to $\mathbf{0^\circ \pm 3.5^\circ}$** to take off and land on a **20 degrees slope**
- MR can **relay live video feed and location** at least at 5Hz for a **distance of 250 m** to the GS
- MR can be powered to achieve **a round trip mission of 500 m**

Schedule Breakdown

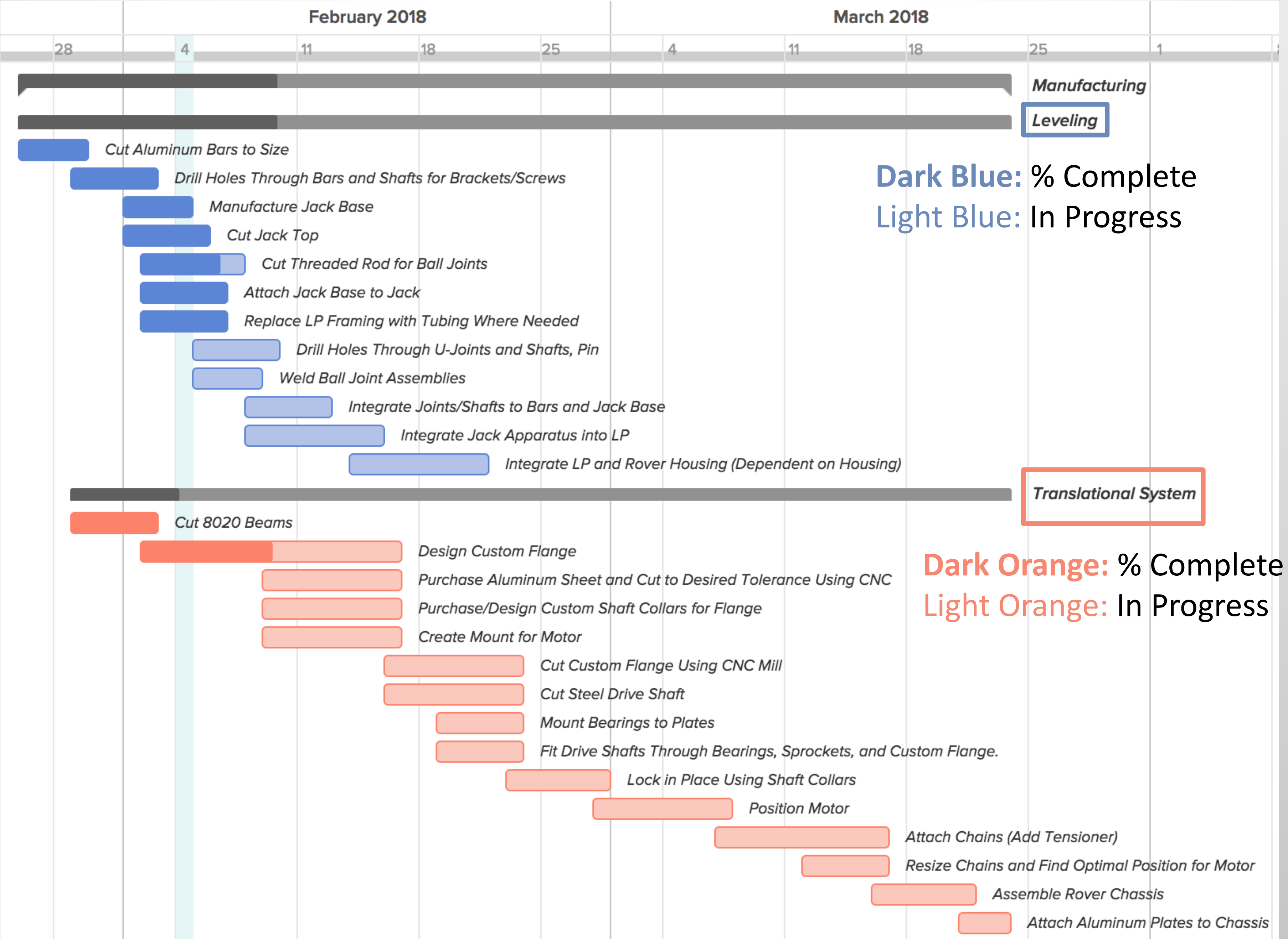
Electrical/Software Schedule



Dark Blue: % Complete
Light Blue: In Progress
Light Turquoise: Non-Test

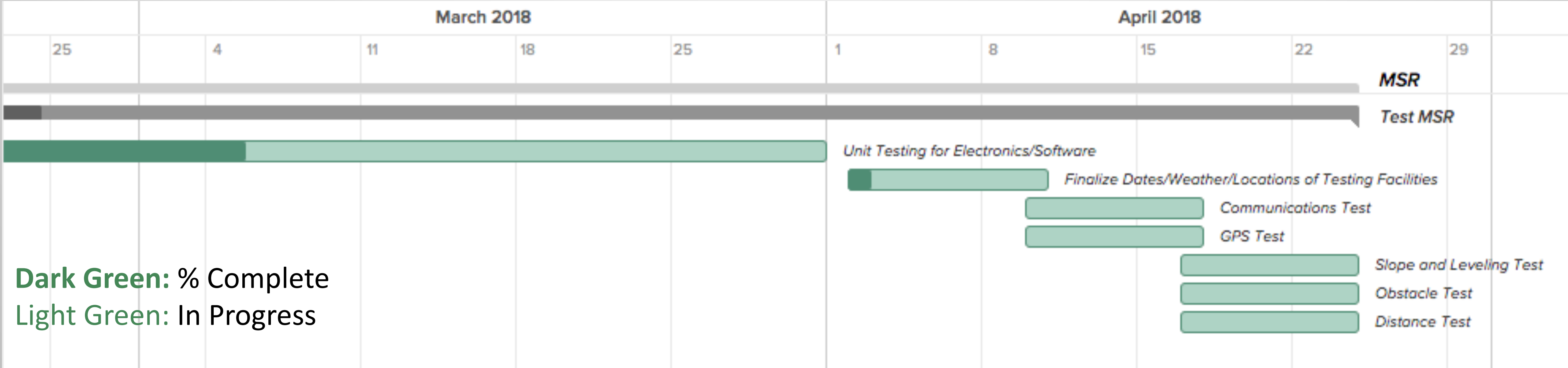


Manufacturing Schedule



Testing Schedule

- Includes **Unit Testing**
  - For Electronics/Software Components has been in progress since January 16.
  - Approximately 65% Completed
- Some Tests are **Weather Dependent**
  - Includes: Slope and Leveling, Obstacle, and Distance
  - Provided 1 Week Margin
  - Goal: Testing Completed by April 24th



Dark Green: % Complete
Light Green: In Progress

Financial Status Update

Financial Status: Subsystems Budget

What Changed?

- Leveling System
  - Additional degree of freedom
- Electronics
  - Custom PCB for leveling system
- Translational
  - Removal of Wheel Locking Mechanism
  - Unaccounted for components
- Shipping
  - Developed more accurate estimates

CDR Budget

Summary	
Subsystem	**Cost**
Administrative	$150.00
Communications	$225.94
Electronics	$438.00
Leveling	$256.48
Shipping	$241.95
Testing	$100.00
Translational	$3,104.46
Budget	**$5,000.00**
Total Cost	**$4,516.83**
Margin	**$483.17**

MSR Budget

Summary	
Subsystem	**Cost**
Administrative	$150.00
Communications	$193.59
Electronics	$525.36
Leveling	$439.08
Shipping	$370.43
Testing	$100.00
Translational	$3,058.23
Budget	**$5,000.00**
Total Cost	**$4,836.69**
Margin	**$163.31**

Financial Status: EEF Application

- Applied for additional **$675.00**
- EEF Presentation – 2/5/2018
- Notified by 3/15/2018
- Funding for:
  - indoor testing
  - additional electronics components

Summary	
Subsystem	**Cost**
Administrative	$250.00
Communications	$230.80
Electronics	$862.80
Leveling	$497.94
Shipping	$375.42
Testing	$322.23
Translational	$3,135.81
Budget	**$5,000.00**
Amount Over Budget	**$675.00**
Total Cost	**$5,675.00**

Financial Status: Major Component Procurement

Arrived (2/2/2018)

- 2 Bison Gear Motors
- 2 American Control Motor Drivers
- Rover Raw Materials
- 2 Leveling Jacks
- Arduino Mega Microcontroller
- Wheels, Tires, Bearings
- 2 Cameras

To Be Purchased

- 2 12V 55Ah Batteries
- Leveling Raw Materials
- Leveling System PCB
- Aluminum Plating
- 2 XBee Pro S3Bs
- Electronics Component Connections

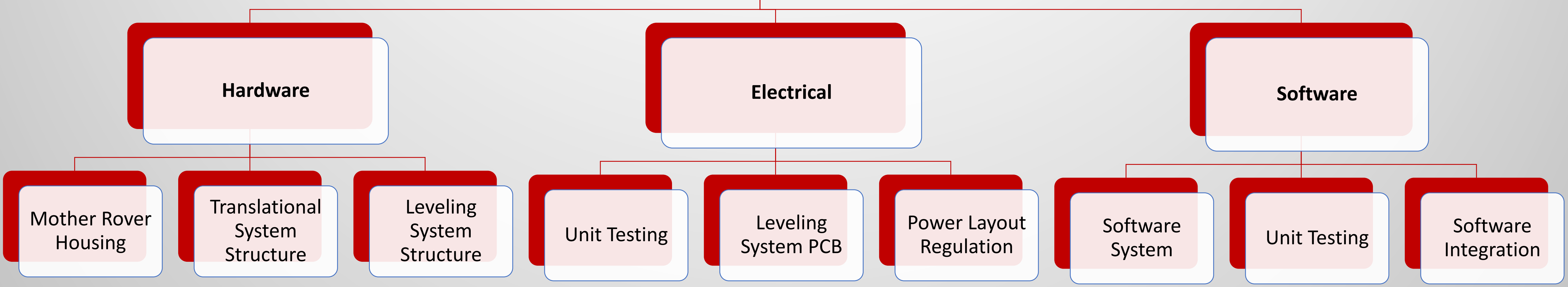
EEF (March 15)

- 2 12V 100Ah Batteries
- Full Wheel Locking Mechanism
- Indoor Testing Components
- Additional allocation to printing posters/reports

Major components to be purchased by March 7

EEF components to be purchased by March 22

Manufacturing Status Update



Hardware
Total Hours to Completion: **117 hours**

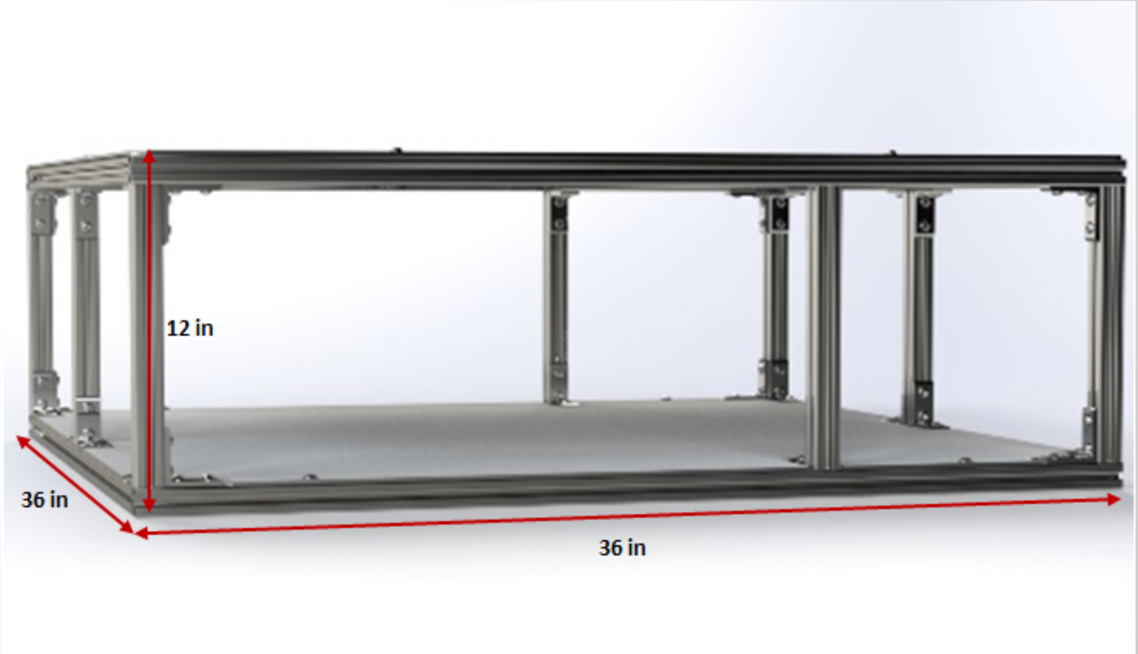
Mother Rover Housing and Translational System Structure

Functional Requirement	Description
FR1.0	The MR shall ***integrate with the attached landing platform*** such that it is permanently fixed and ***securely carries*** the CD without tipping while traversing the defined rough terrain.
FR2.0	The MR shall receive commands from the GS at a rate of 5 Hz.
FR3.0	The MR shall transmit data to the GS at a rate of 30 HZ.
FR4.0	The MR shall ***traverse 250 meters*** away from the GS to a specified GPS location over ***rough terrain*** defined by varying slopes and obstacles which require the MR to ***navigate over and around them***. The MR shall ***return to the GS*** after the mission is complete.
FR5.0	The MR shall position itself for the CD to take-off and land safely such that it is able to be secured by the MR's securement mechanism.

Mother Rover Housing

Rover Chassis

- Due date: 1/30
- Materials: 80/20 Aluminum T-Slotted Bars



Steps to complete:

1. Cut to size using horizontal band saw
2. Assemble frame using square brackets, bolts, and cut T-slotted bars

Status: Both steps 100% complete

Hours: 6/6

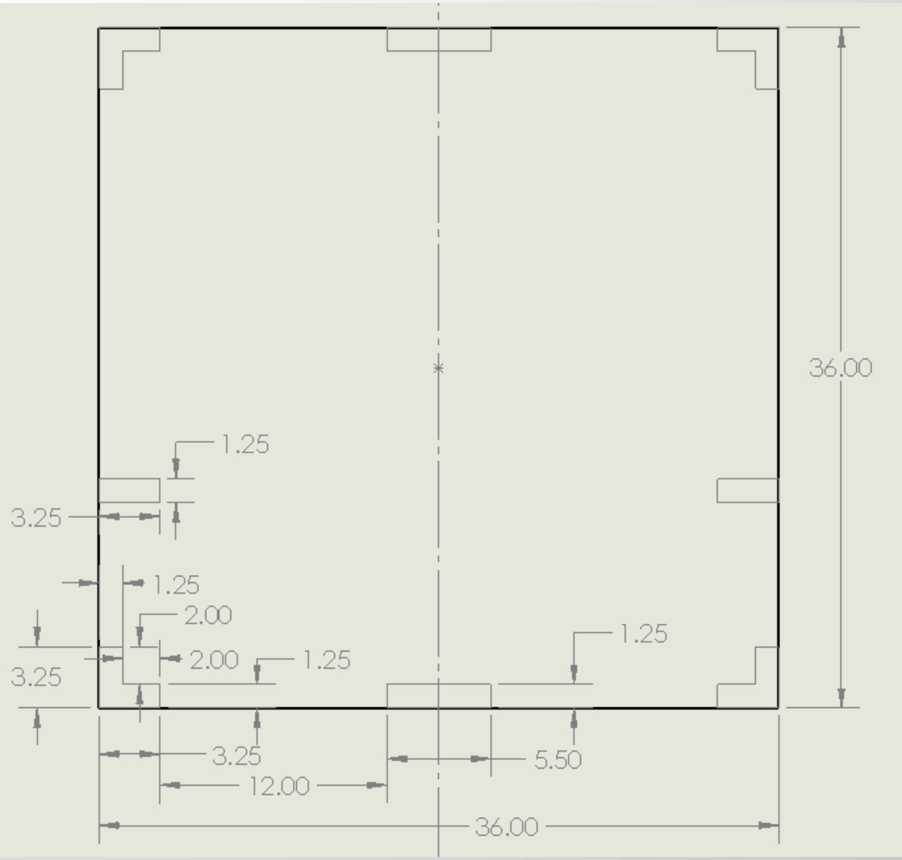
Mother Rover Housing

Rover Chassis Base Platforms

- Due date: 2/16
- Materials: Two 36”x36”x0.25” 6061 Aluminum Plates

Steps to complete:

1. Develop CNC tool path and machine using CNC mill
2. Bolt both top and bottom plates to chassis



Status: To be purchased by 2/9

Hours: 0/20

Project Overview | **Schedule** | **Budget** | **Manufacturing Status** | **Conclusion**

Translational System Structure

Drive Shafts

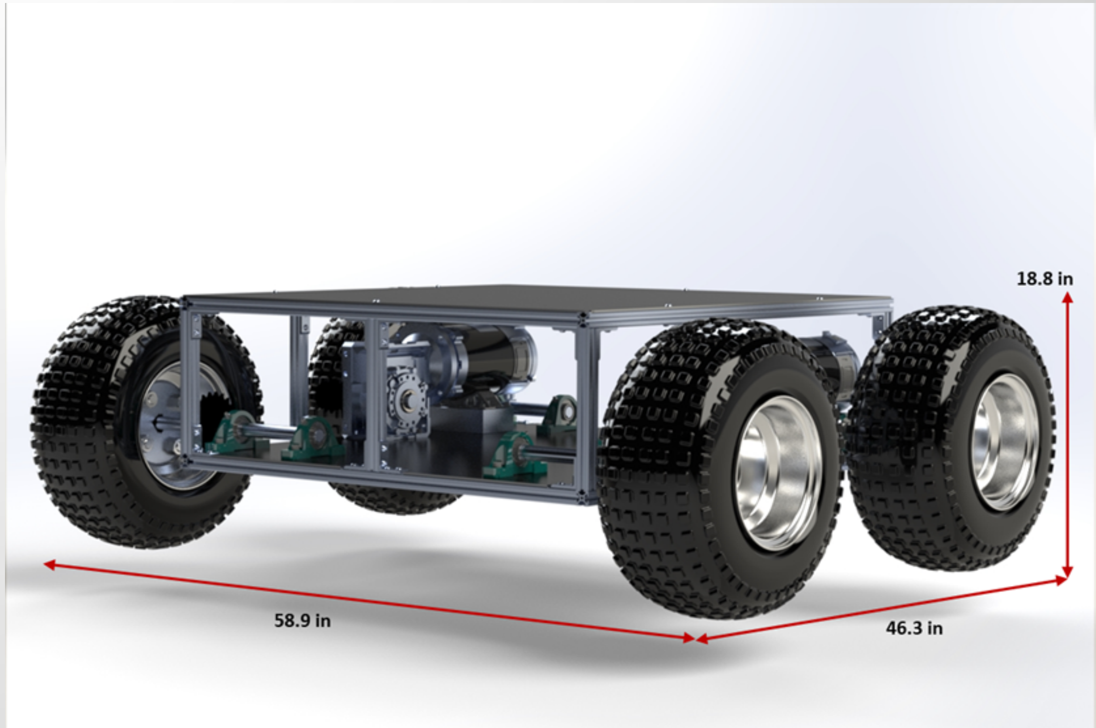
- Due Date: 2/16
- Materials: 1045 Carbon steel keyed rotary shaft

Steps to complete:

1. Cut shafts using horizontal band saw into 12” sections
2. Fit to mounted bearings with set screws
3. Integrate wheel sprockets and custom wheel hub

Status: Wheels purchased.

Hours: 0/10



Translational System Structure

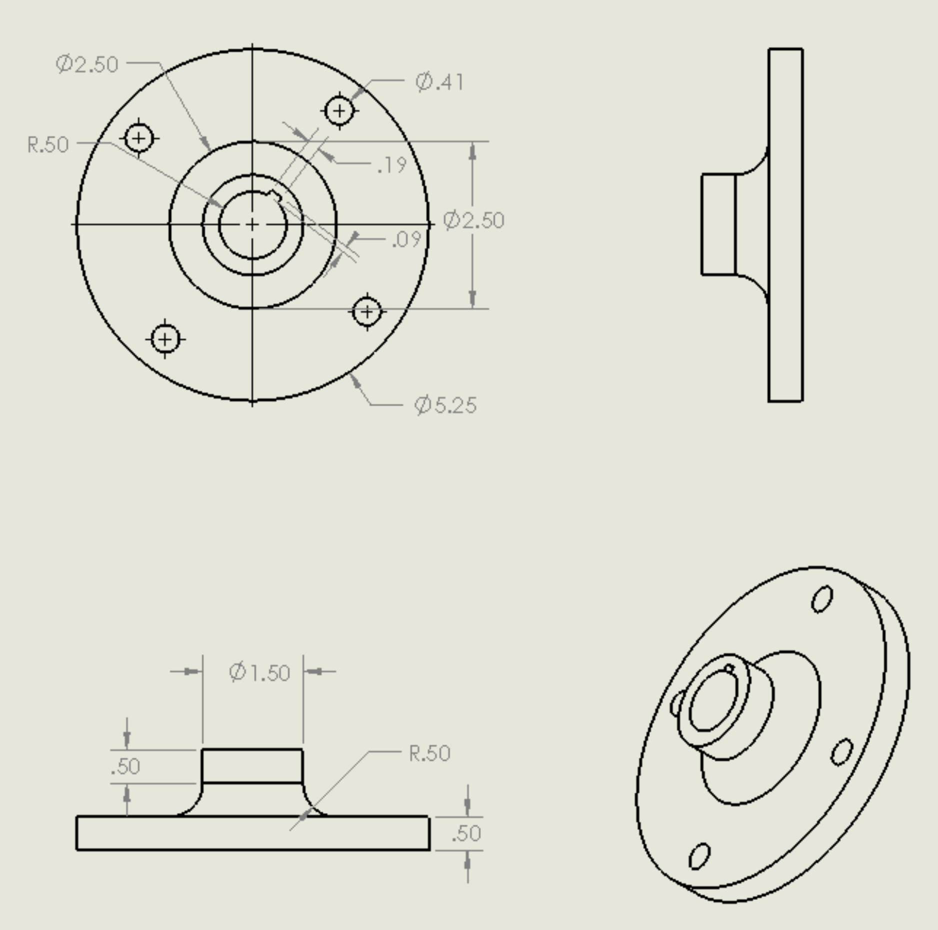
Wheel Hub

- Due date: 2/16
- Materials: 6061 Aluminum cylinder provided
  by Aerospace Machine Shop

Steps to complete:

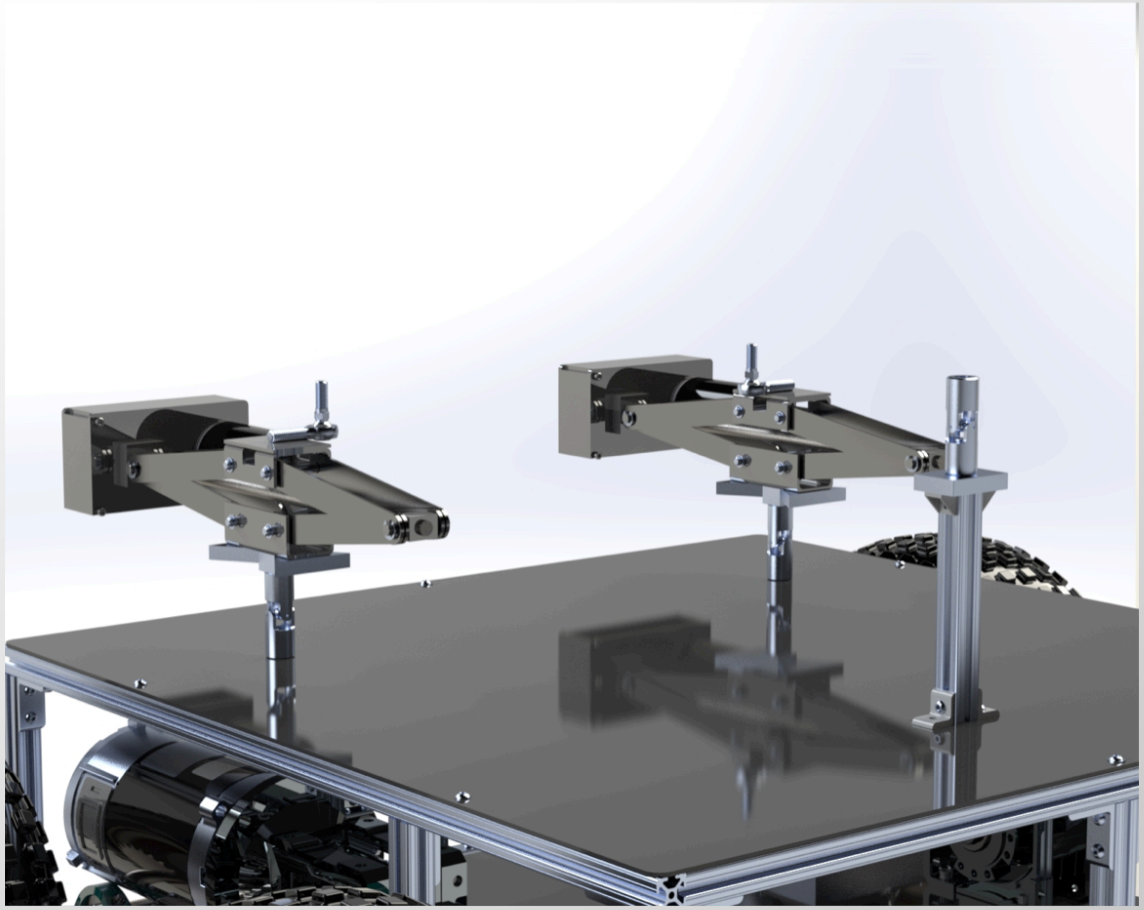
1. Cut out four sections of cylinder
2. Use CNC to cut custom flange
3. Align with wheels, fit with drive shaft and shaft collars, and bolt to wheels

Hours: 0/20



Leveling System

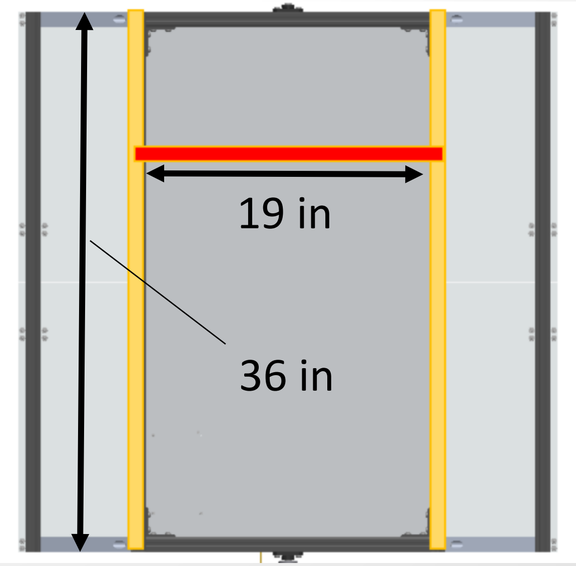
Functional Requirement	Description
FR5.0	The MR shall position itself for the CD to take-off and land safely such that it is able to be secured by the MR's securement mechanism
Design Requirement	Definition
DR5.1	The MR shall level itself within 3.5 degrees after coming to a complete stop.
DR5.2	The MR shall hold a completely stopped position a slope of 20 degrees by using a wheel locking mechanism.



Leveling System

Alterations to CHIMERA Landing Platform Structure

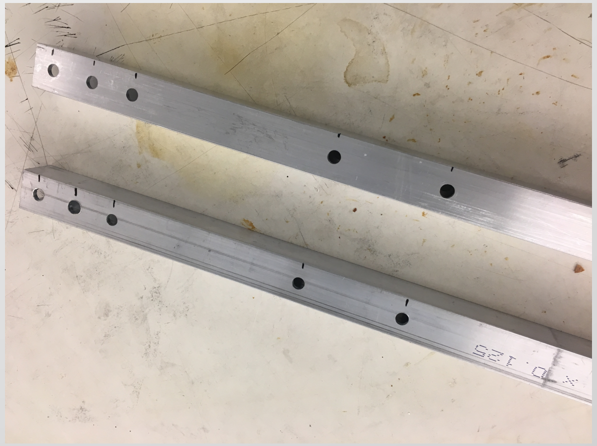
- Due Date: 2/16
- Materials: 6061 Aluminum square tubing, assorted brackets and screws



Underside of landing platform with square tubing added (red) and replacing T-slotted framing (gold)

Steps to complete:

1. Cutting of bars to size
2. Drilling holes for screws and jack mounting
3. Integration into LP



Aluminum tubing cut and drilled before integration to LP

Status: Steps 1 and 2 are 100% complete

Hours: 11/16

Leveling System

Scissor Jack Alterations and Base

- Due Date: 2/16
- Materials: 6061 Aluminum stock, scissor jacks

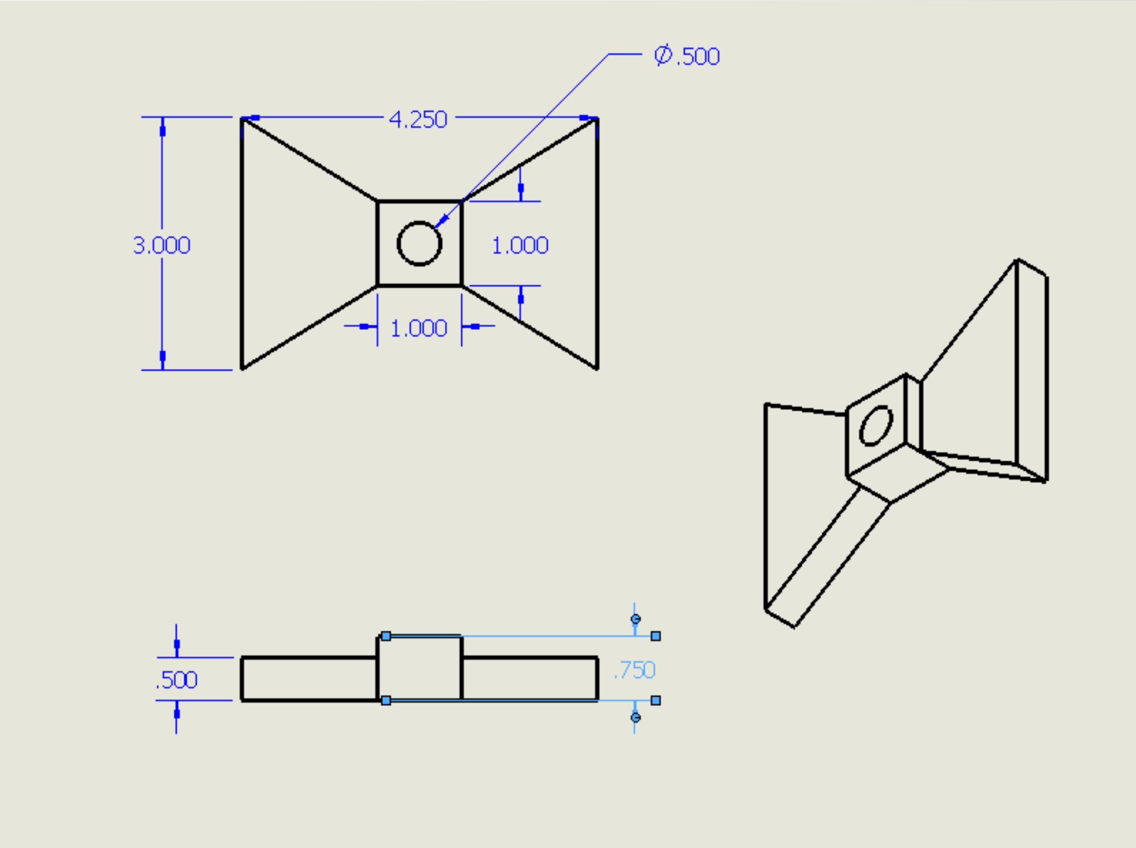
Steps to complete:

1. Mill custom jack base
2. Remove swivel pad from top of jack
3. Drill existing jack base and attach with screws

Status: Step 1 is 50% complete

Risk: Drilling and machining around delicate prototype electronics on jacks

Hours: 7/25



Leveling System

Universal Joint and shaft integration

- Due Date: 2/12
- Materials: U-joints, 0.5" diameter steel shaft, spring pins

Steps to complete:

1. Drill holes through shafts and U-joints
2. Pin shafts and joints together
3. Pin shafts into square tubing and jack bases

Status: Awaiting arrival of parts

Hours: 0/20

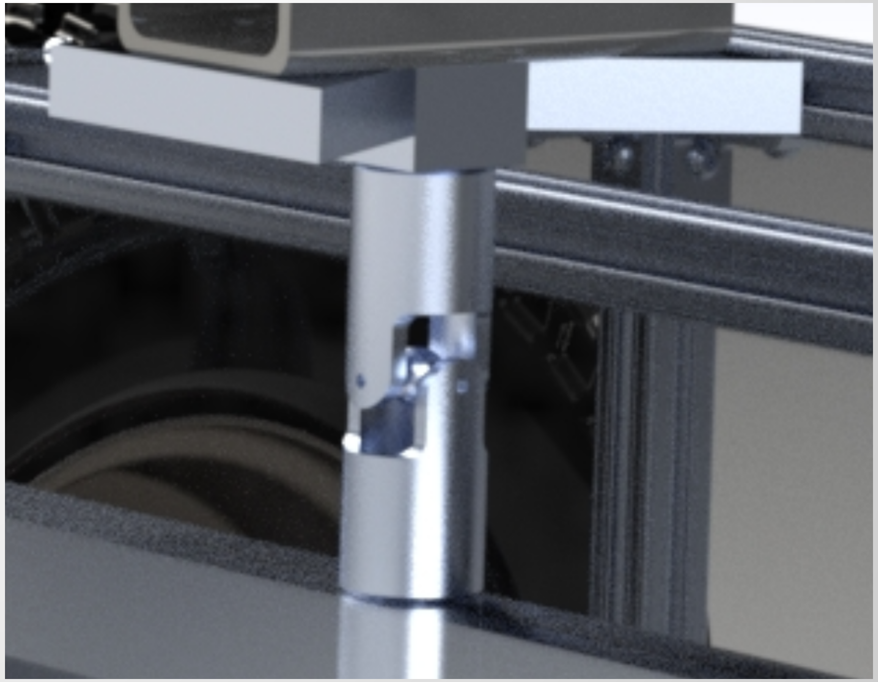


Image: U-joint integrated with rover housing and custom jack base.

Electrical

Total Hours to Completion: **132 hours**

Electrical and Software Requirements

Functional Requirement	Description
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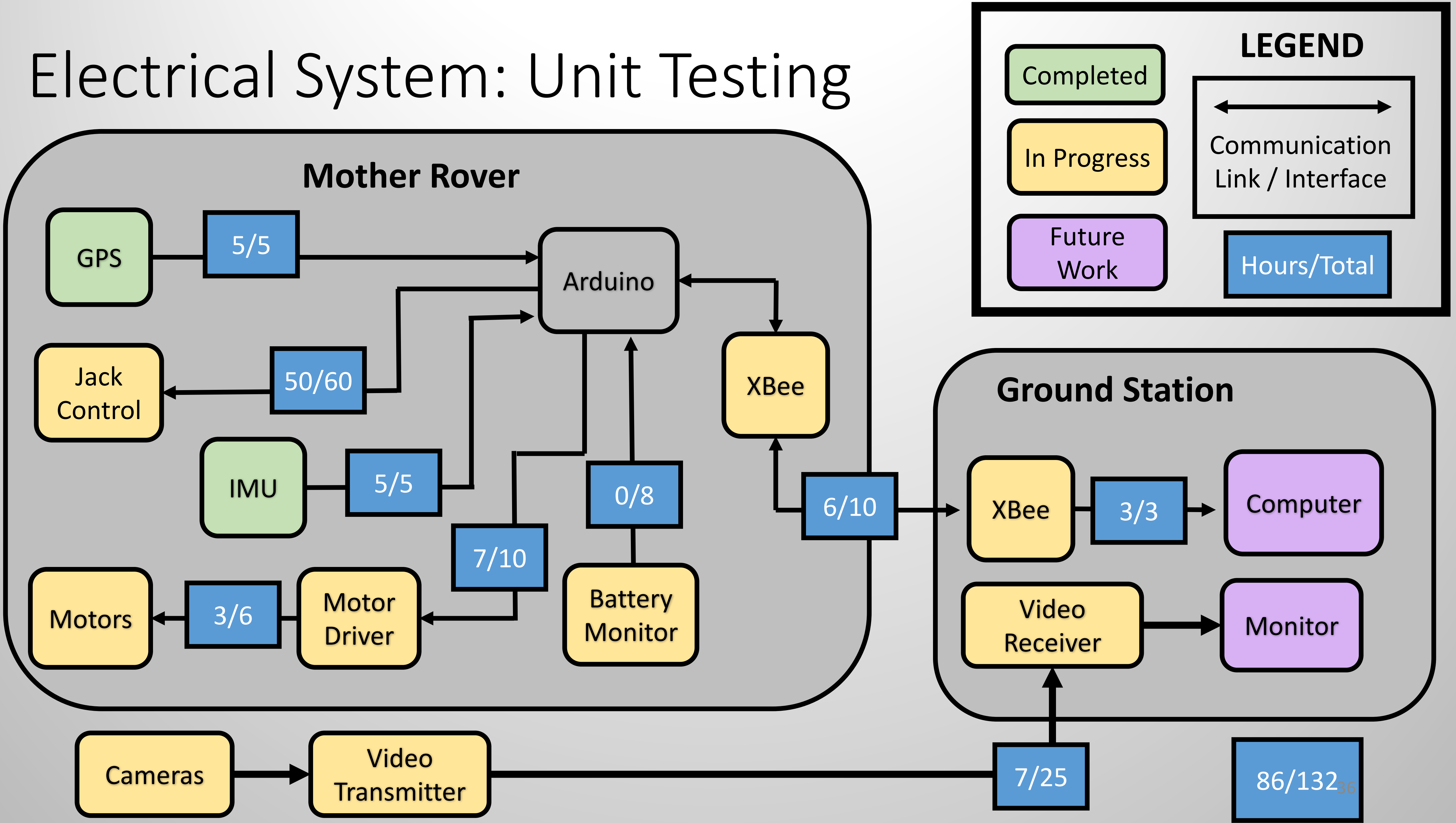
Electrical System: Unit Testing



Electronics Status Update: Leveling System PCB

Full PCB Design

Due Date: 2/10

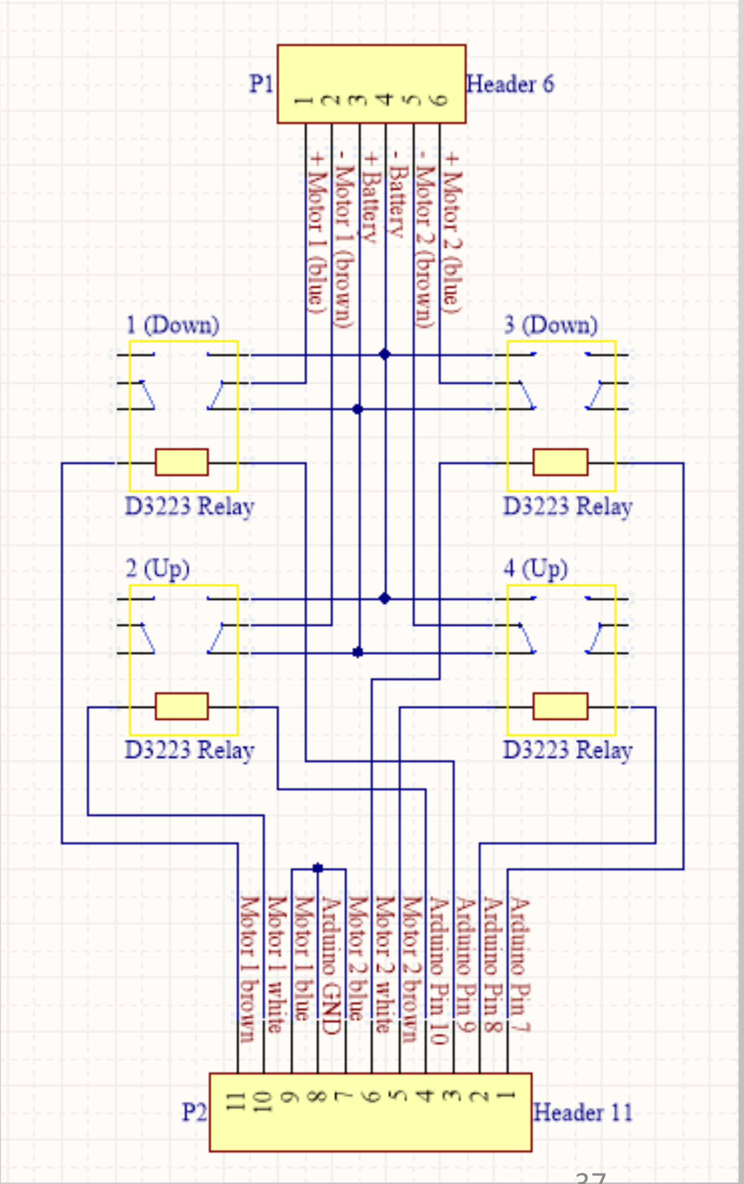
Materials:

1. SamTec connectors: MPT, MPS, IPD1, IPL1

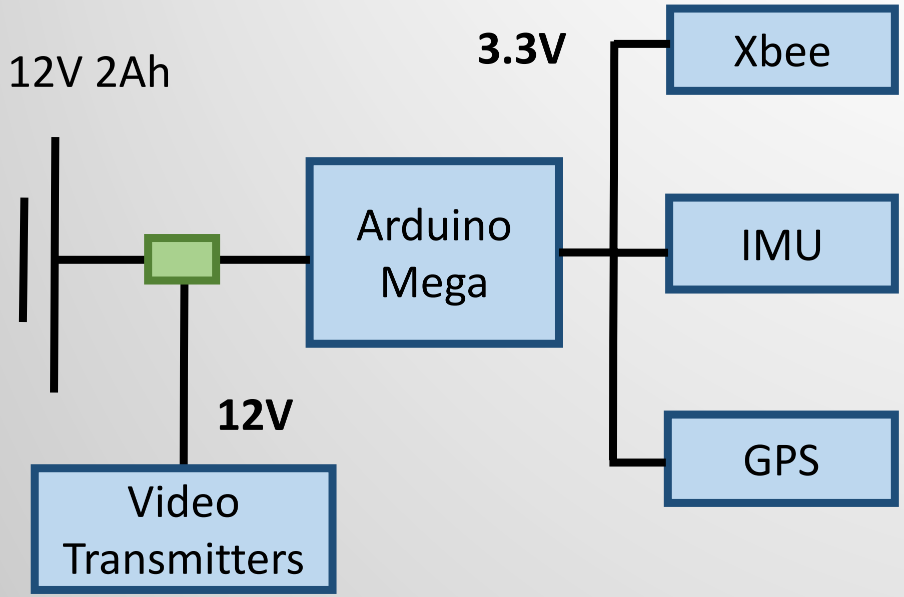
Steps to complete:

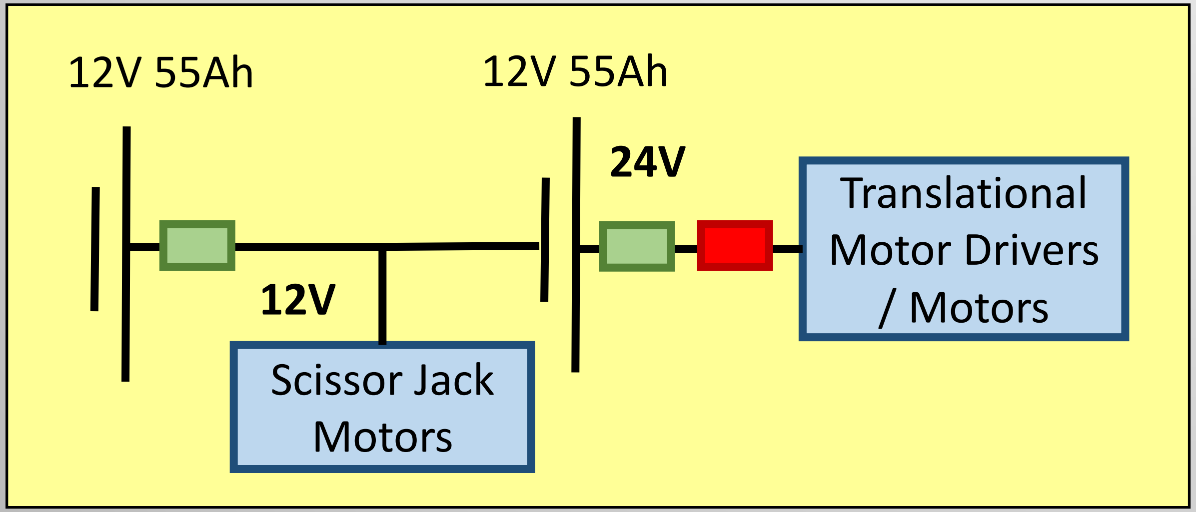
1. Receive IPL1 Footprint
2. Fill in traces for PCB design
3. Send in PCB to verify and get a quote

Status: 50% Complete, awaiting arrival of footprint to add traces to the board



Electronics Status Update: Power Layout / Regulation





Due Date – 03/16

LEGEND

60A Fuse

Voltage Regulator

Steps to Complete:

1. Purchase batteries, voltage regulators, fuses, and wire
2. Measure current draw from each component to ensure it will be supplied enough power
3. Construct power circuit and measure available voltage and current

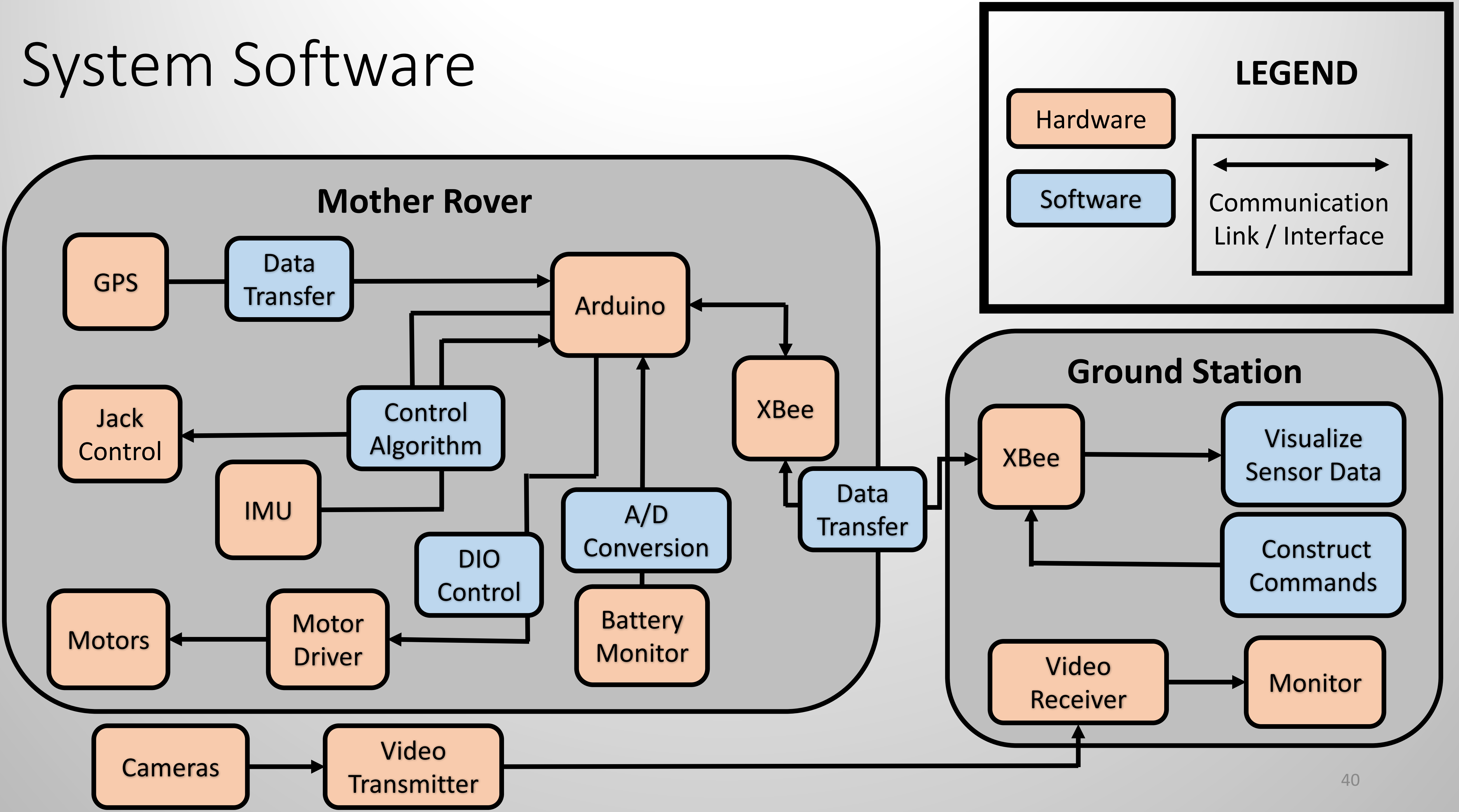
- If we don't receive EEF funding or funding sufficient to purchase 12V 100Ah batteries, we will purchase the 12V 55Ah batteries.

- In the mean time, we are using a power supply that is sufficient for unit testing, but not power testing

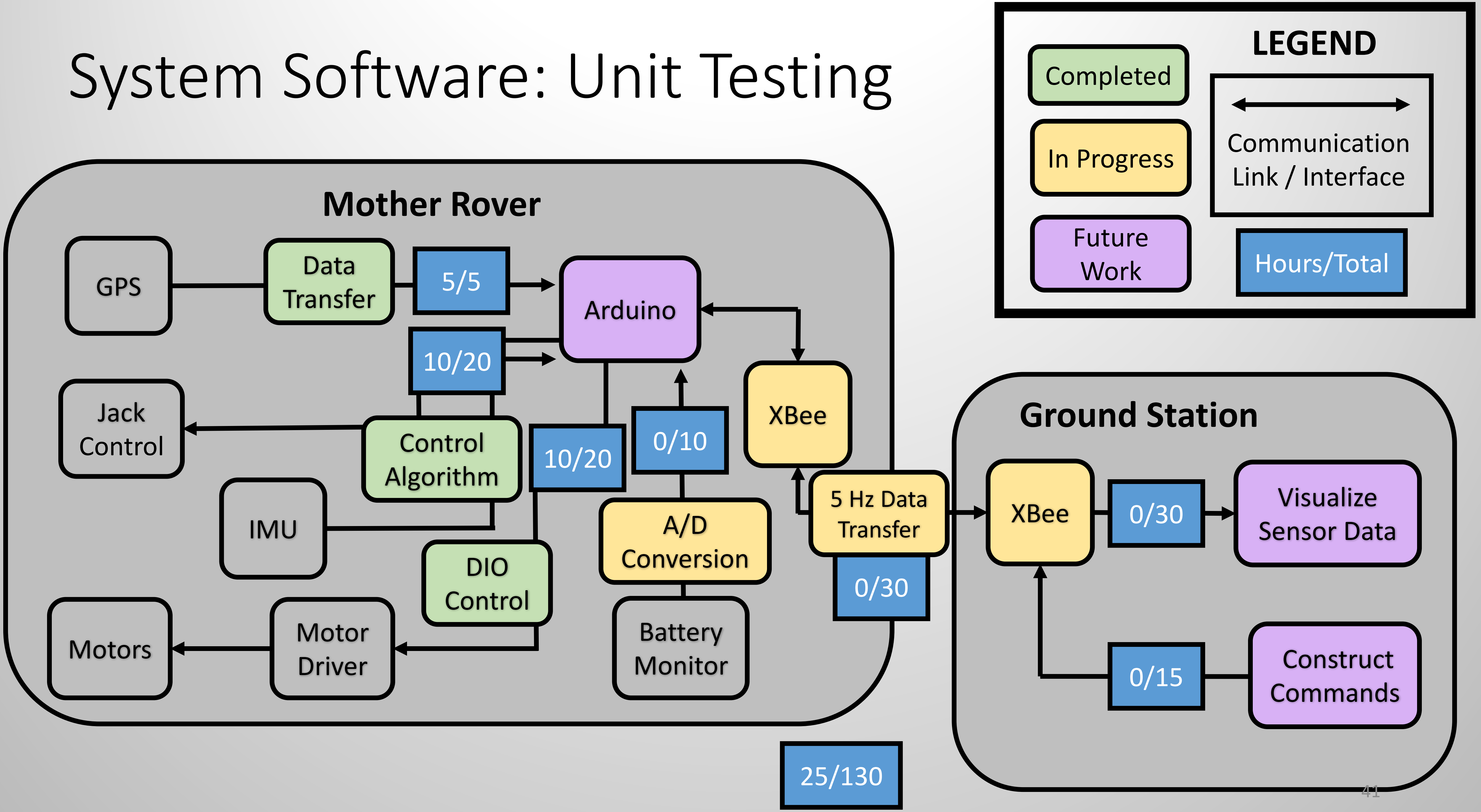
Software

Total Hours to Completion: **170 hours**

System Software



System Software: Unit Testing



Software Final Integration Flowchart

Communication Between MR and Ground Station XBees

0/15

Level the Landing Platform

0/15

Command Motors via Motor Drivers

0/10

Transmit Heading and GPS Location

MR landing platform levels with a command from the ground station

MR can drive and level the landing platform with commands from the ground station

MR can drive, transmit heading and GPS location, and level the landing platform with commands from the ground station

Time Remaining: 40 hrs

Conclusion

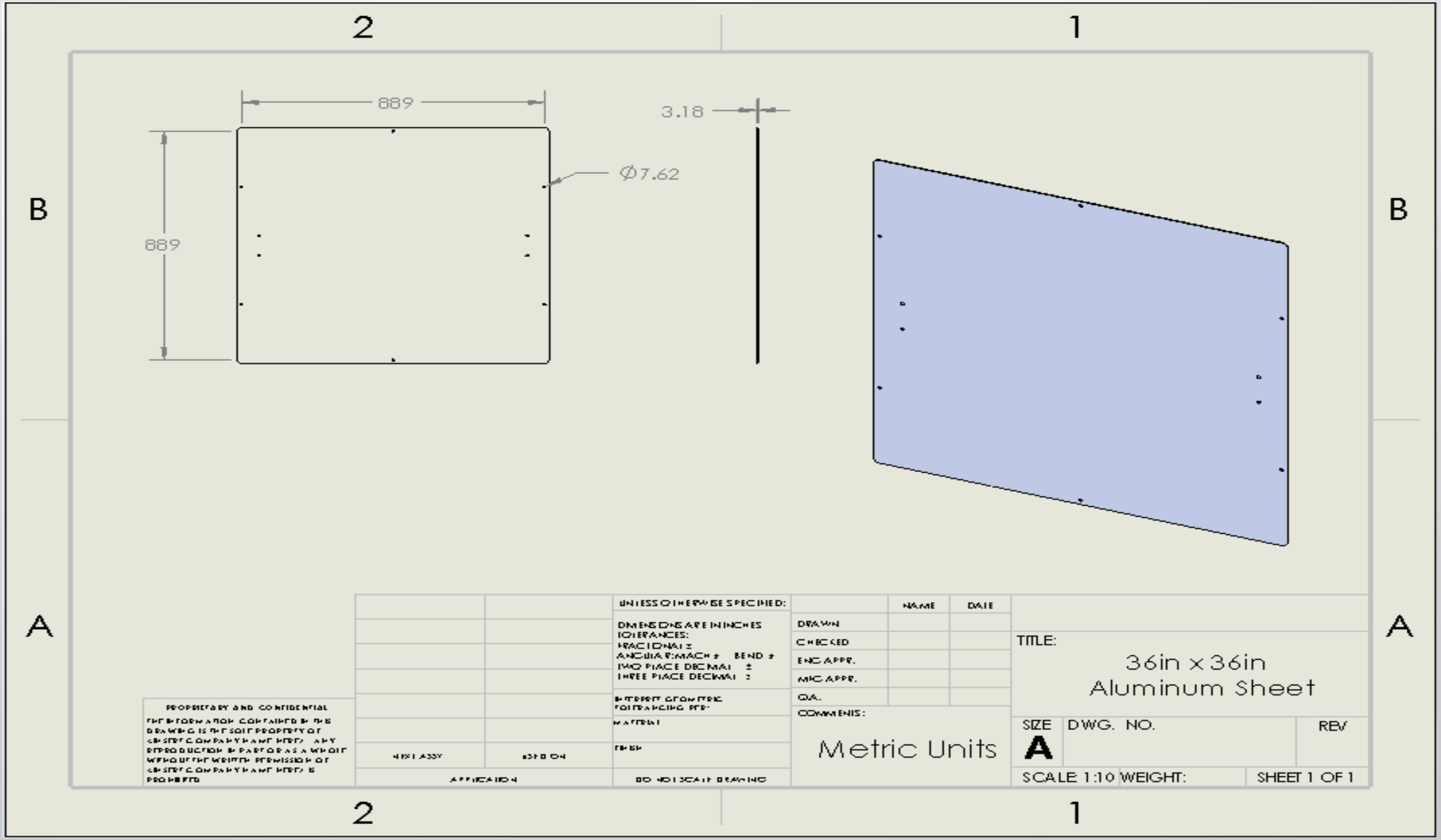
- Changes from CDR
  - Leveling System Modifications
  - No Wheel Locking Mechanism
- Schedule
  - Rover Housing Frame Complete
  - Unit Testing for Electrical/Software 65% Complete
- Budget
  - Increased projected budget from CDR
  - Applied for EEF funding
    - Completed presentation 2/5

Questions?

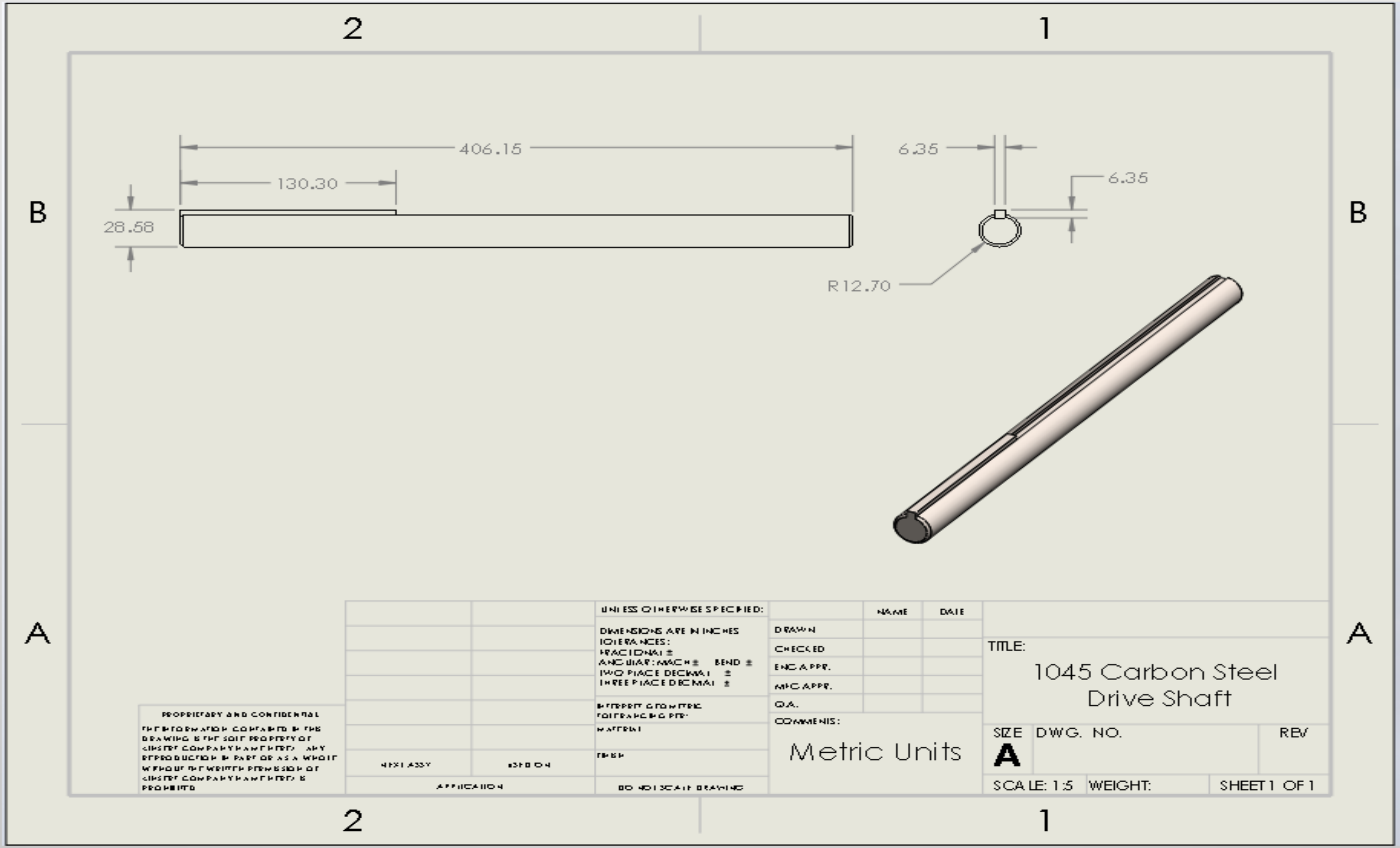
Backup Slides

Hardware

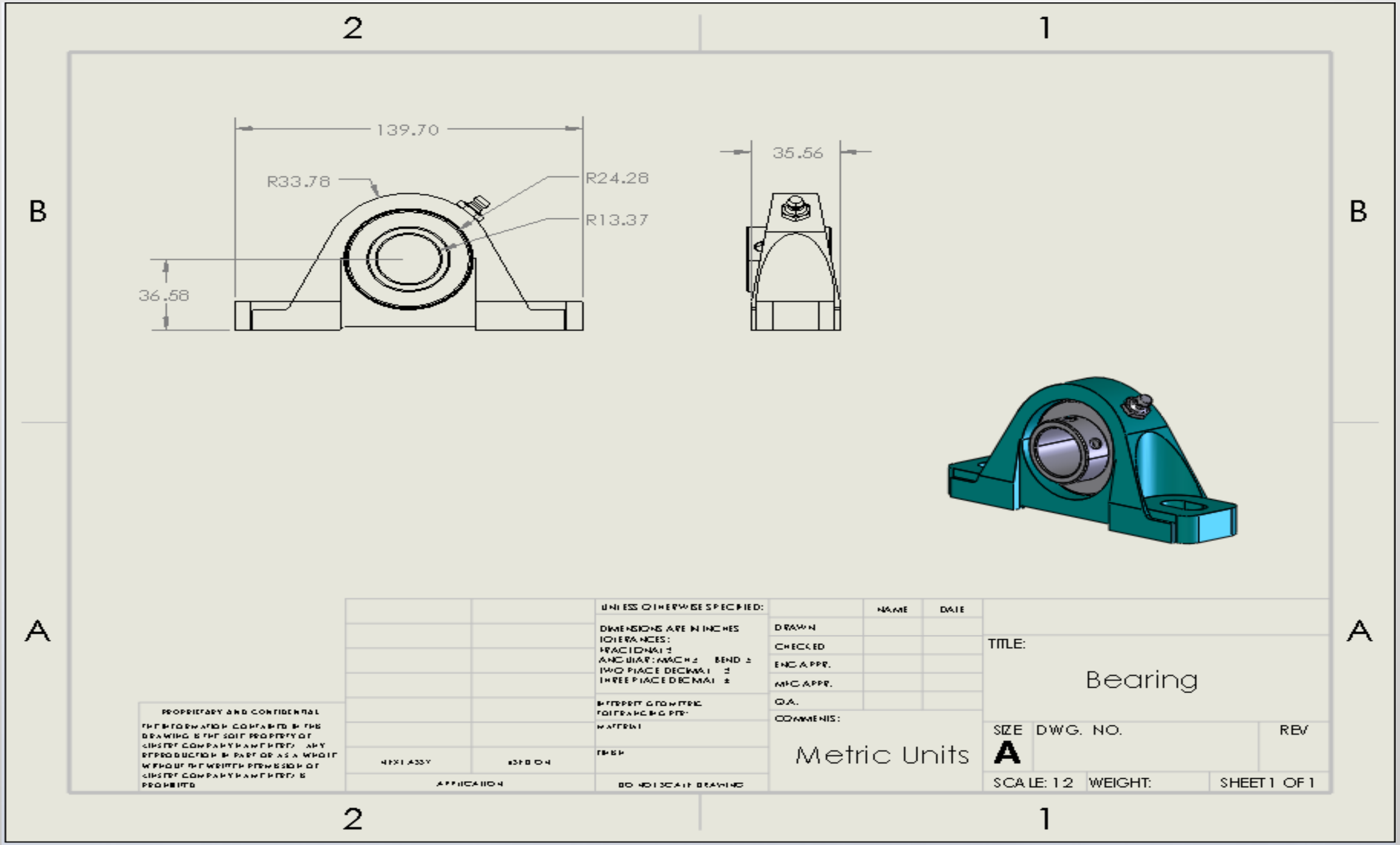
Rover Housing – Top Sheet



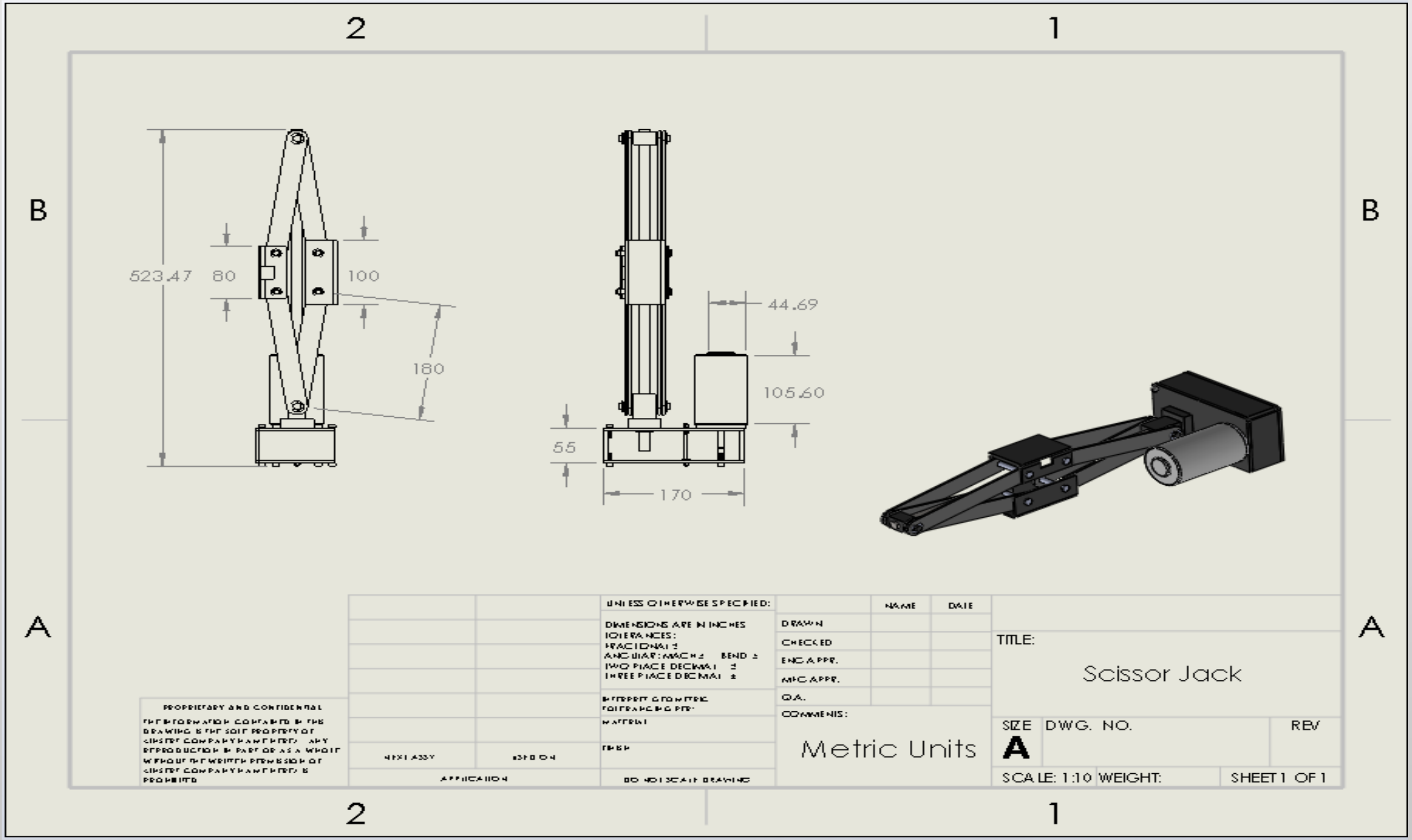
Translational System – Wheel Drive Shaft



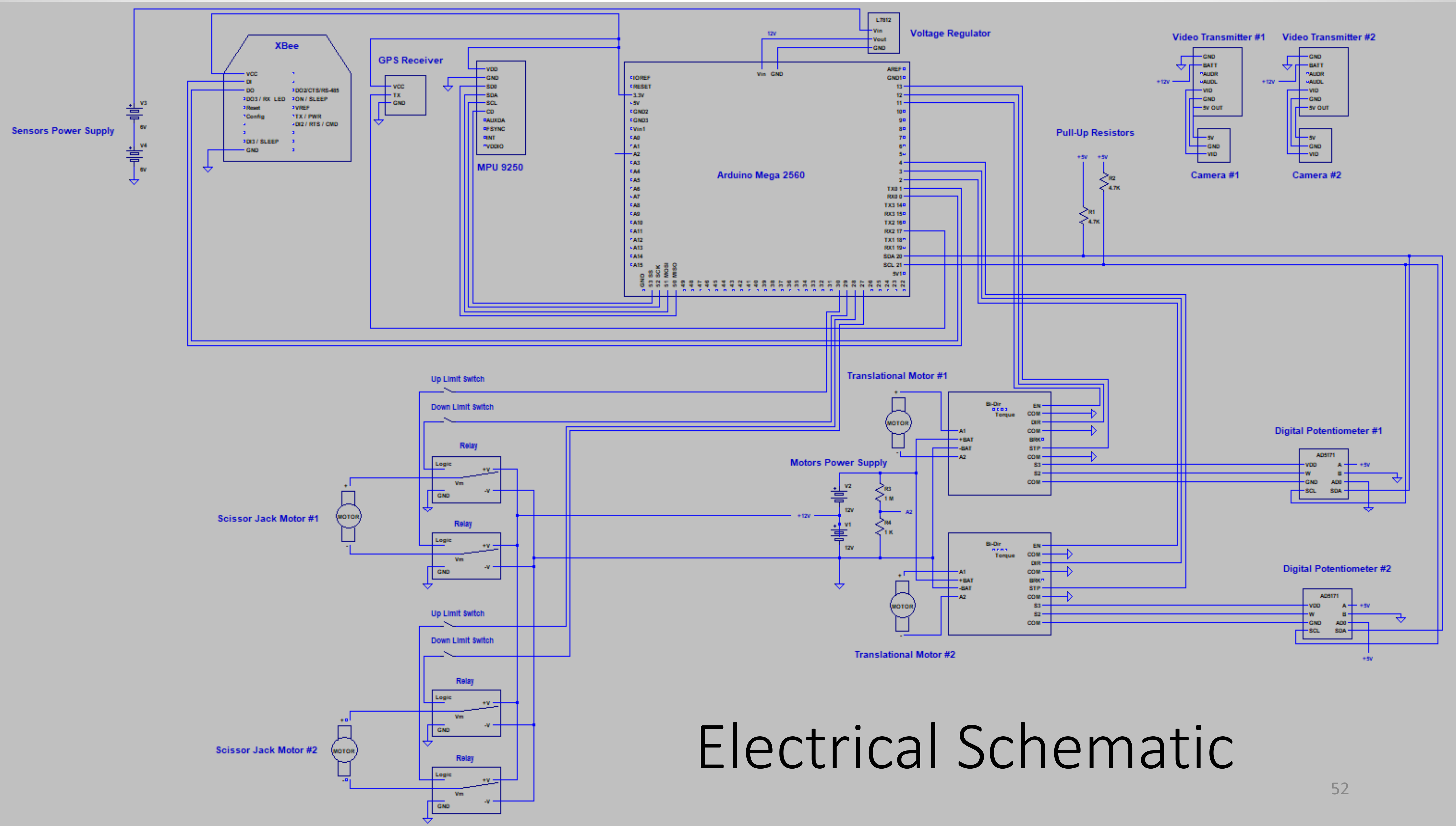
Translational System – Bearings



Leveling System – Scissor Jack

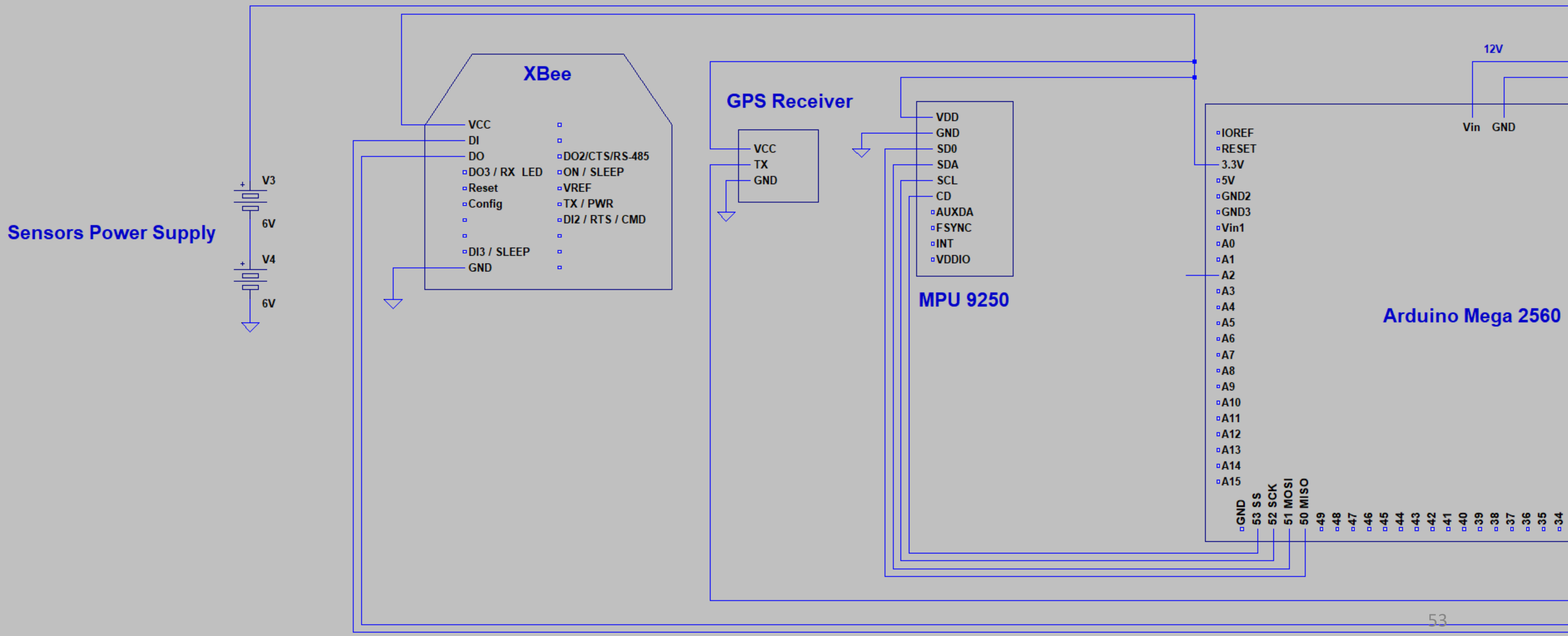


Electrical

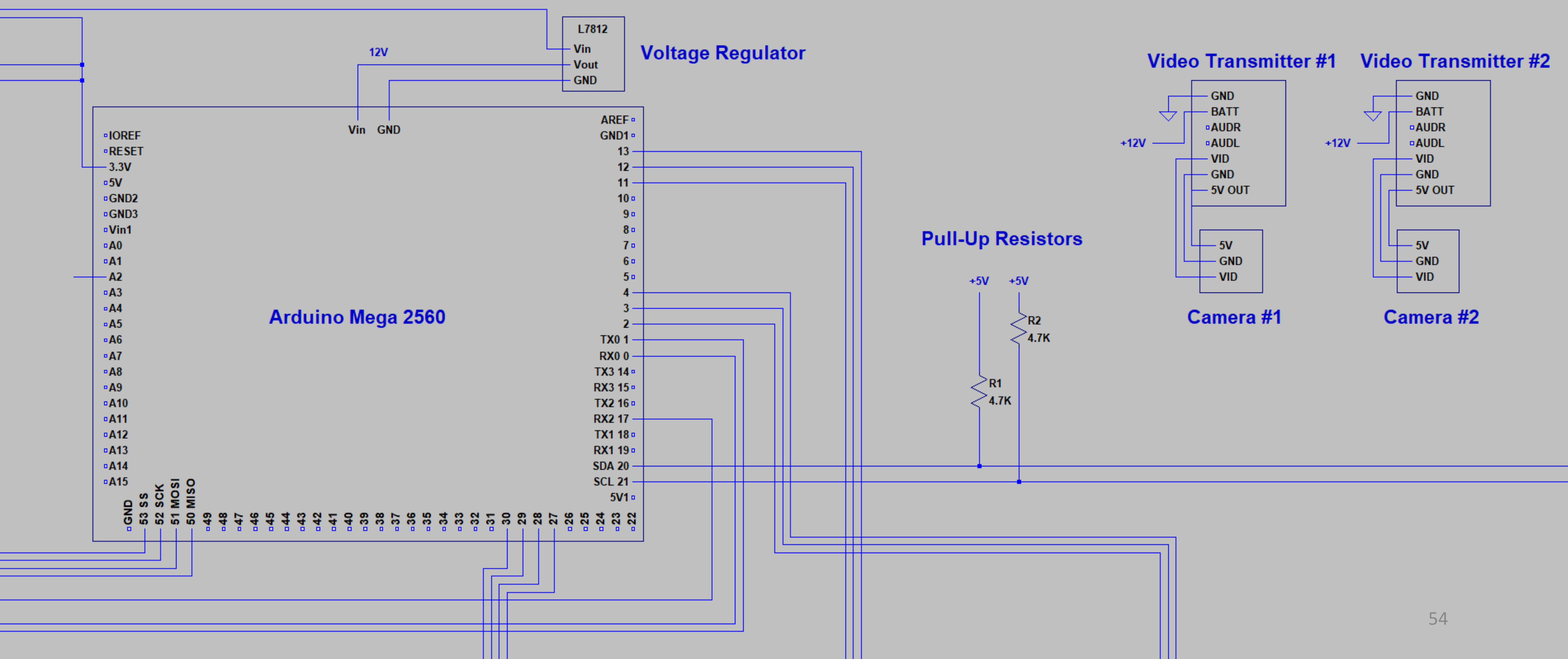


Electrical Schematic

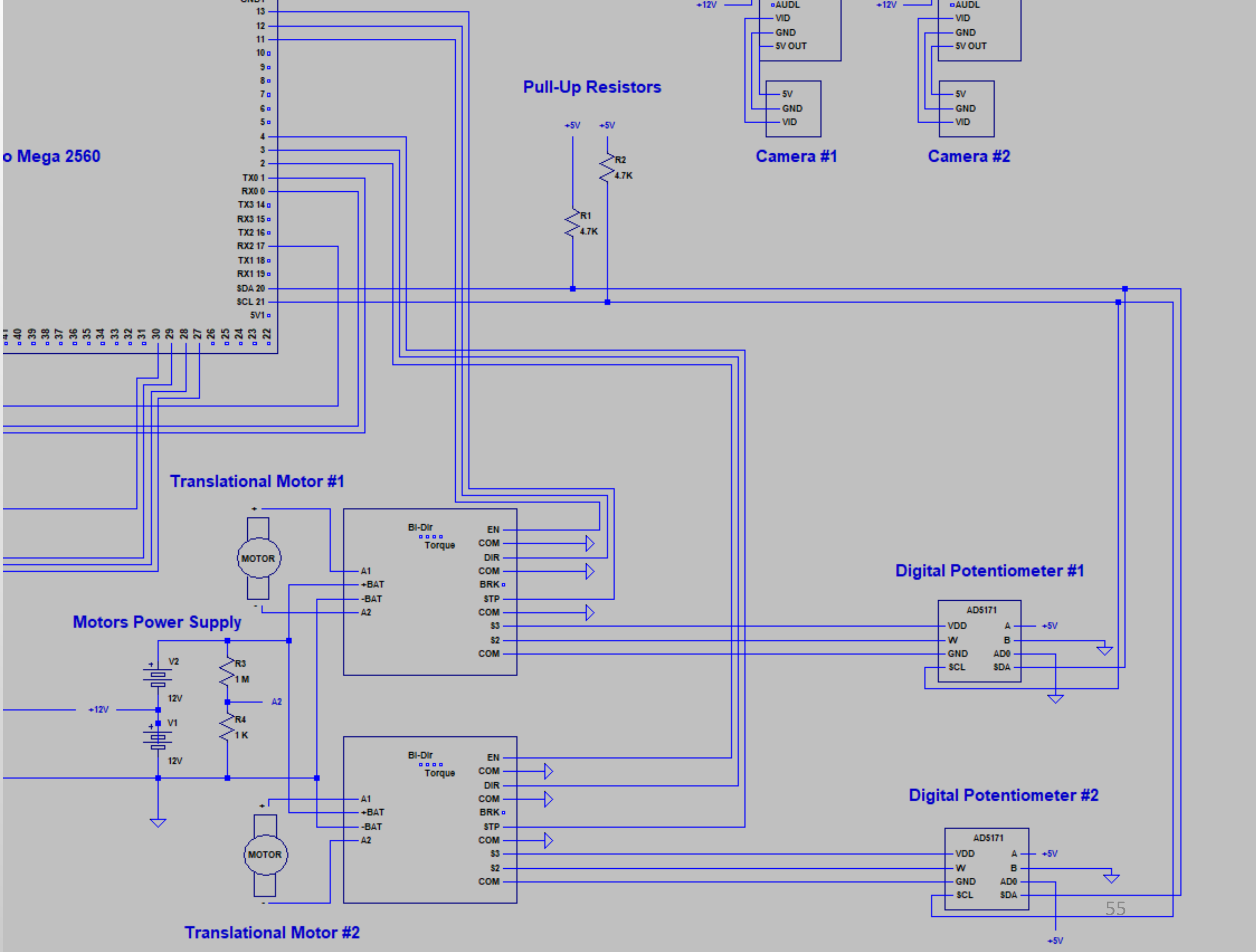
Xbee, GPS Receiver, IMU Schematic



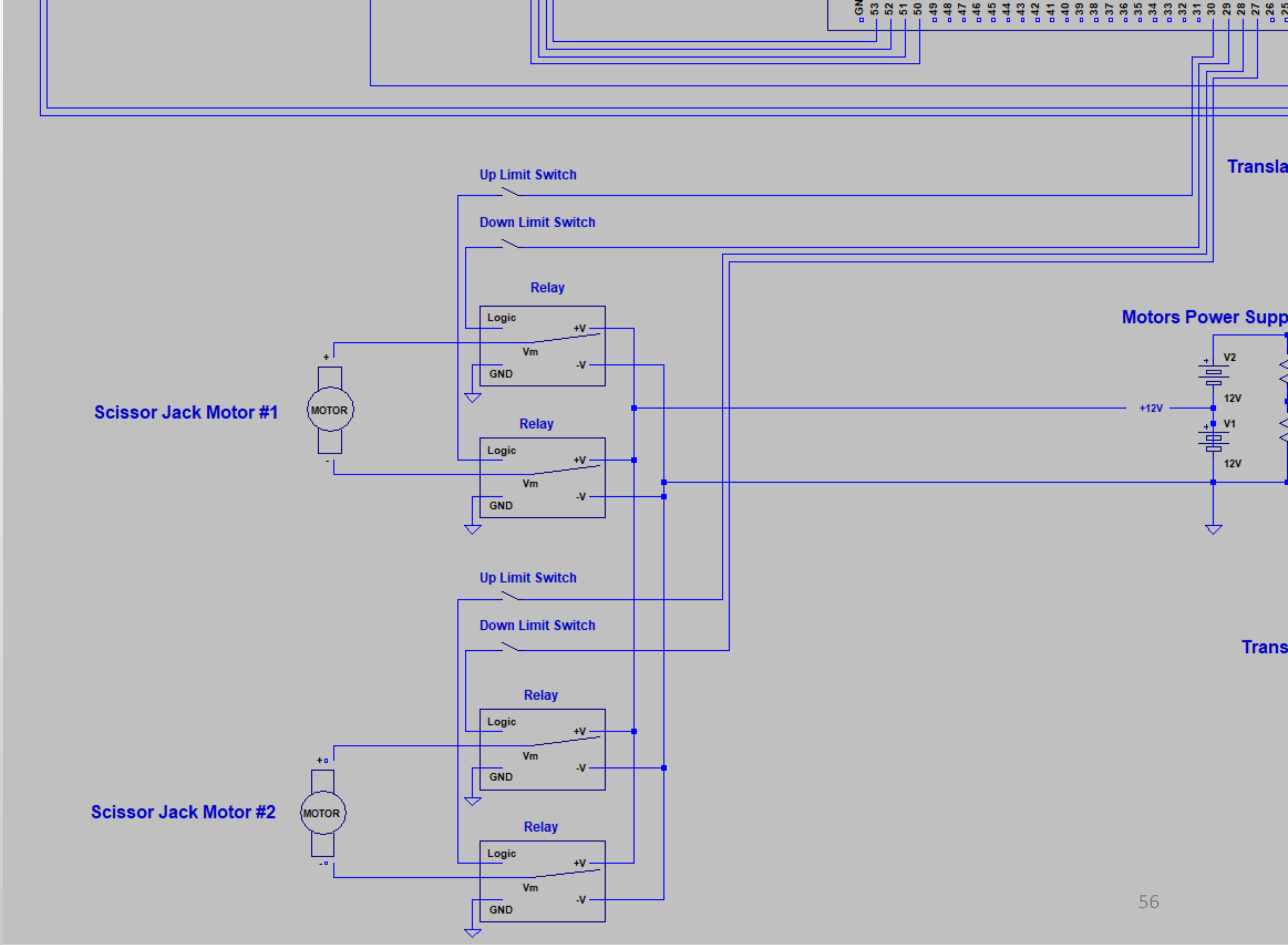
Arduino & Hazard Cameras Schematic



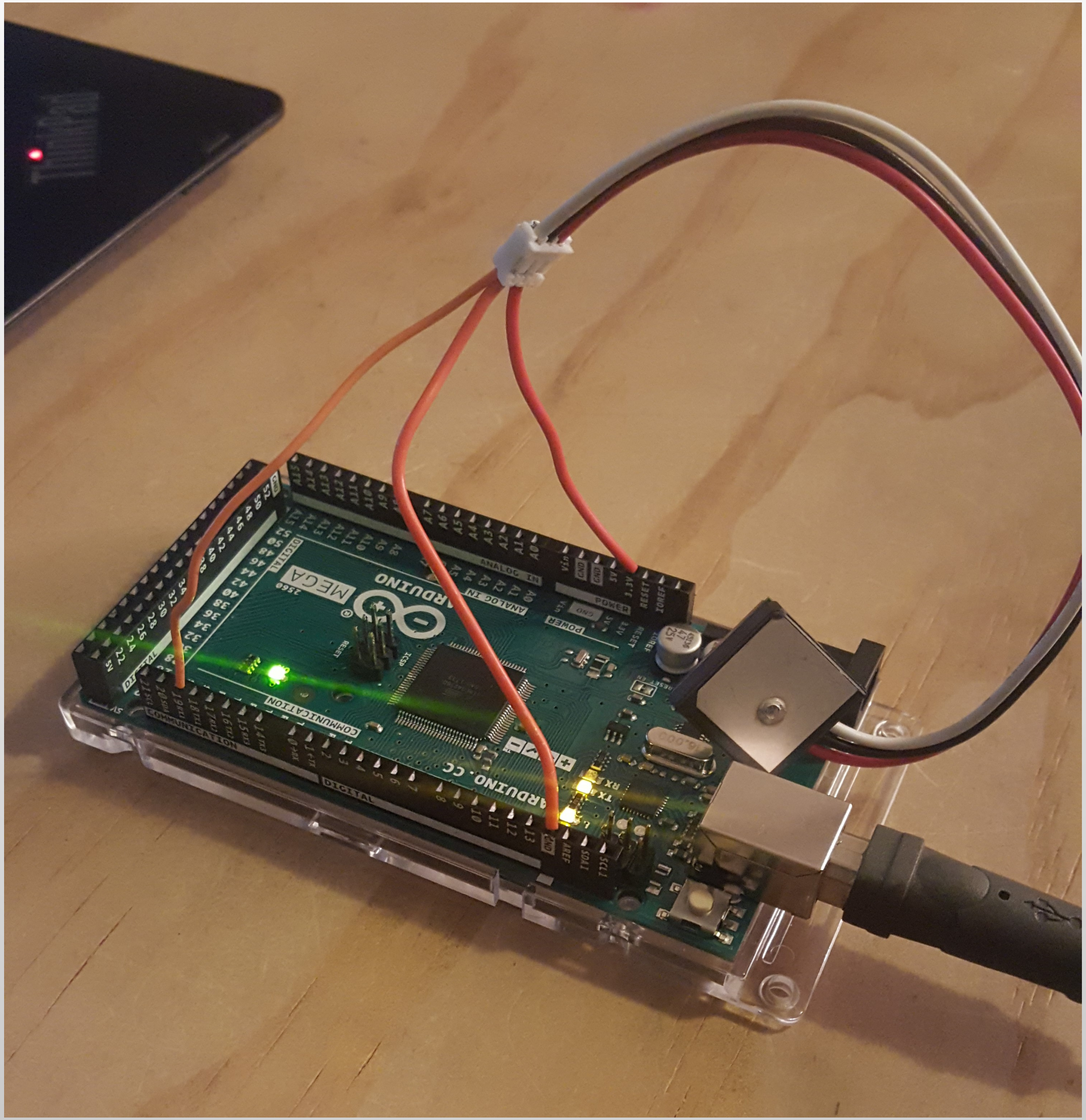
Translational Motors Schematic



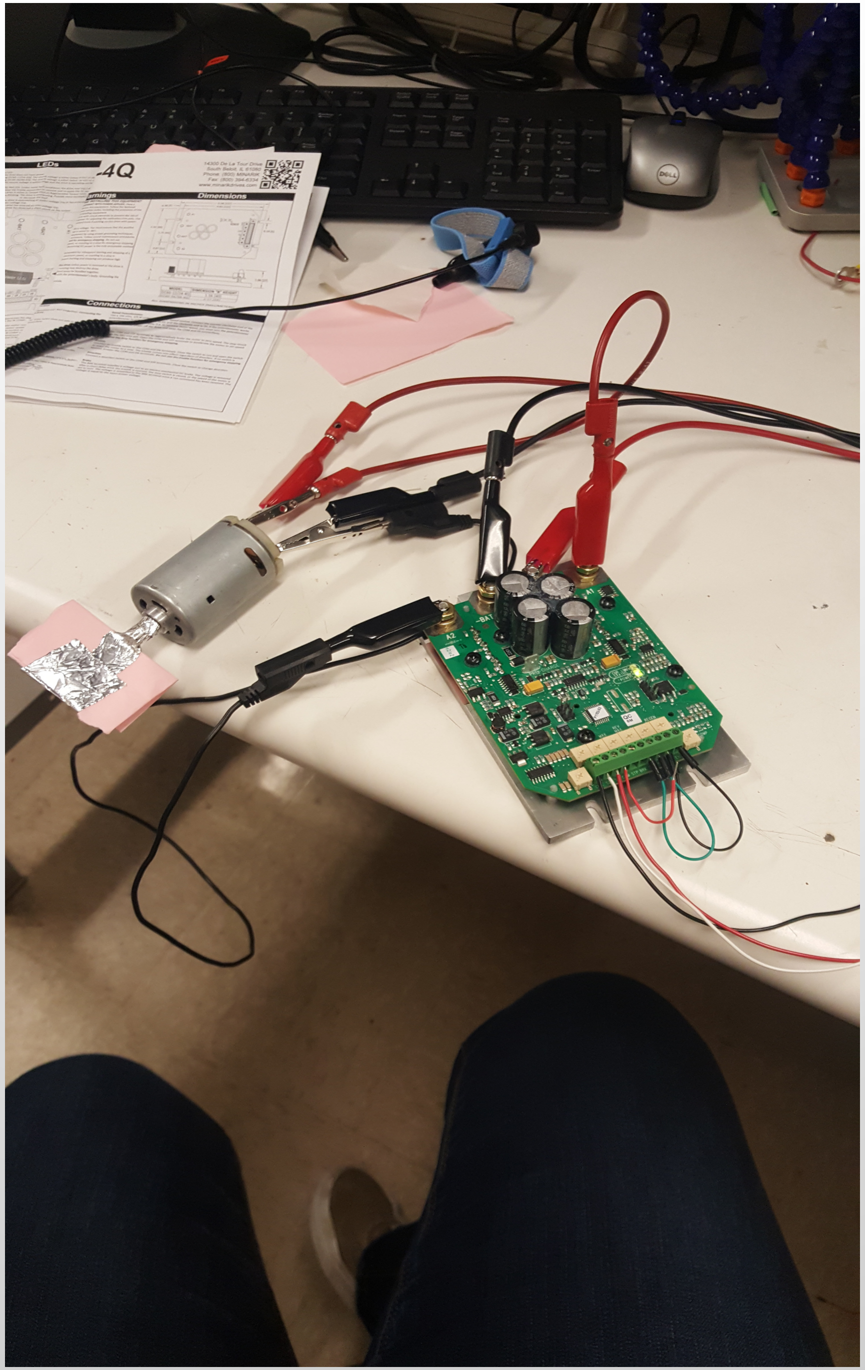
Leveling System Schematic



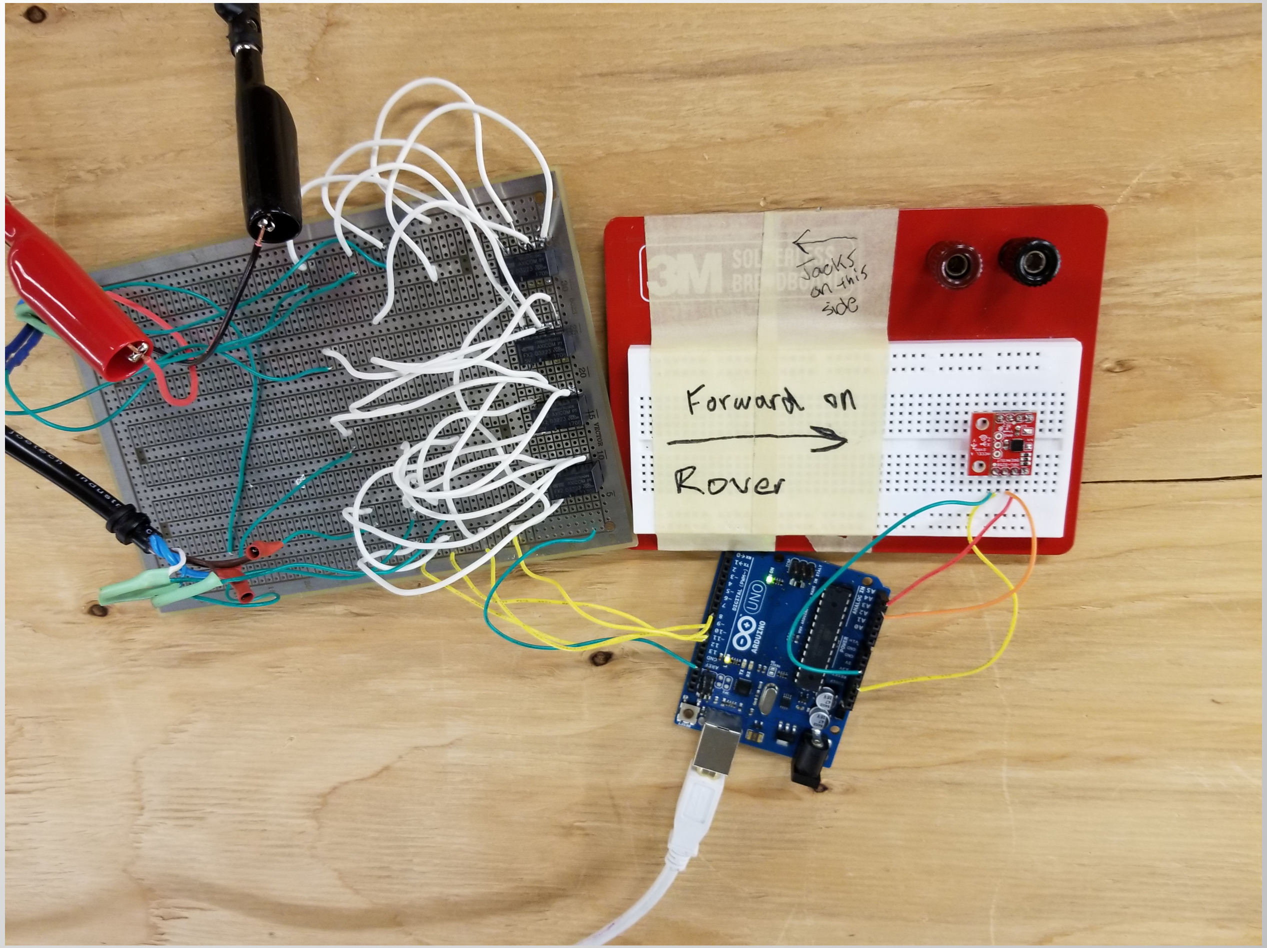
GPS



Motor Driver

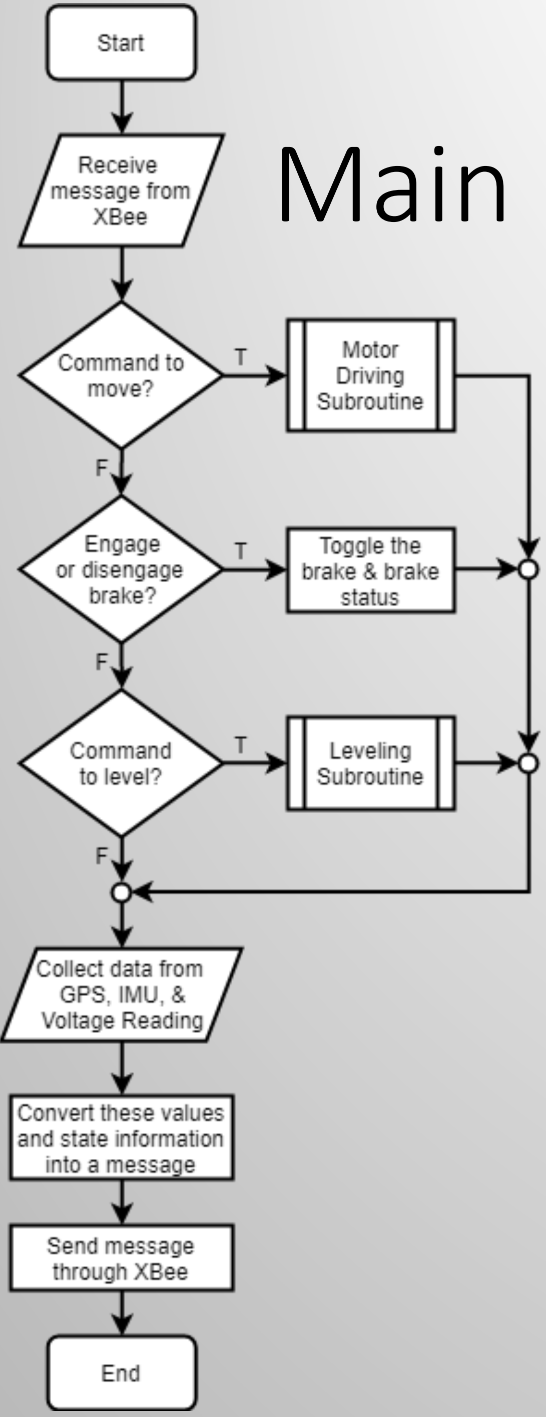


Leveling System

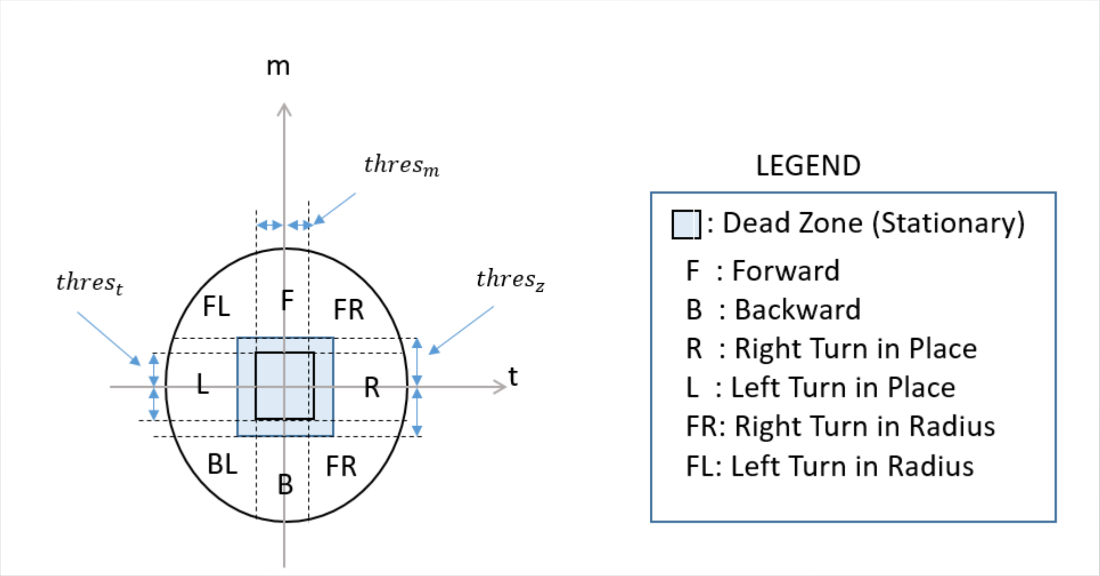


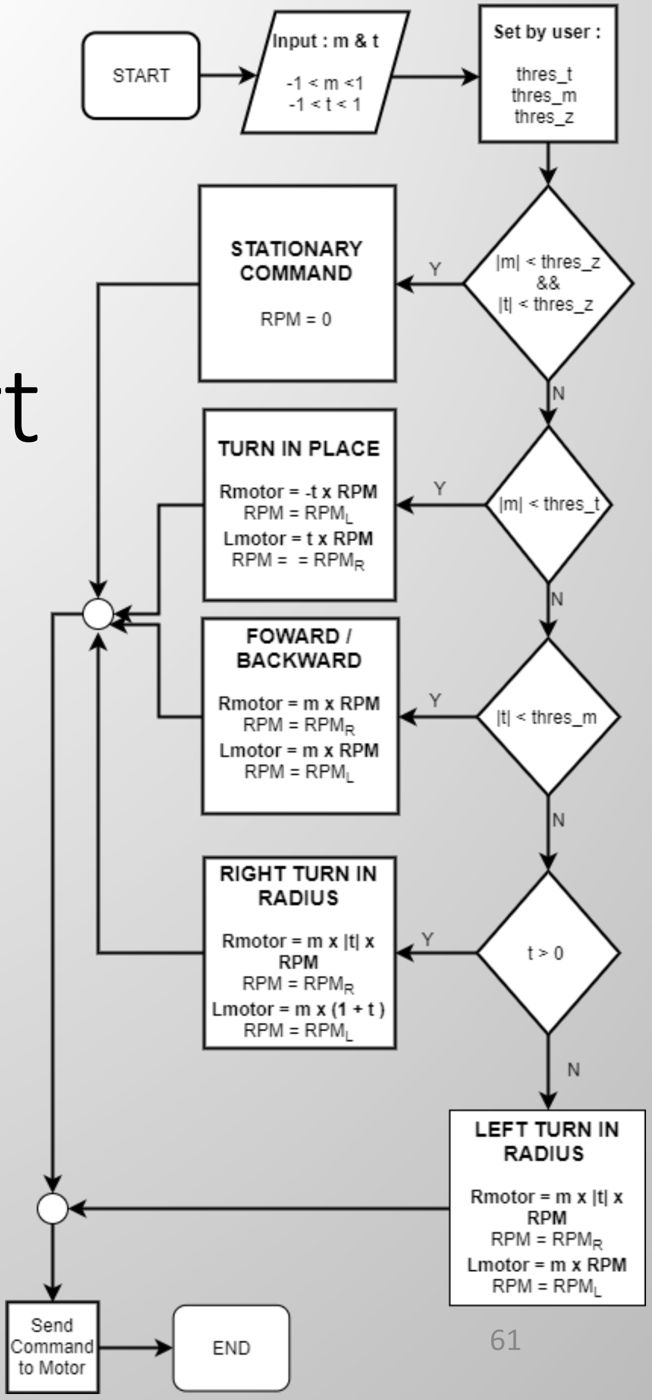
Software

Main Flowchart

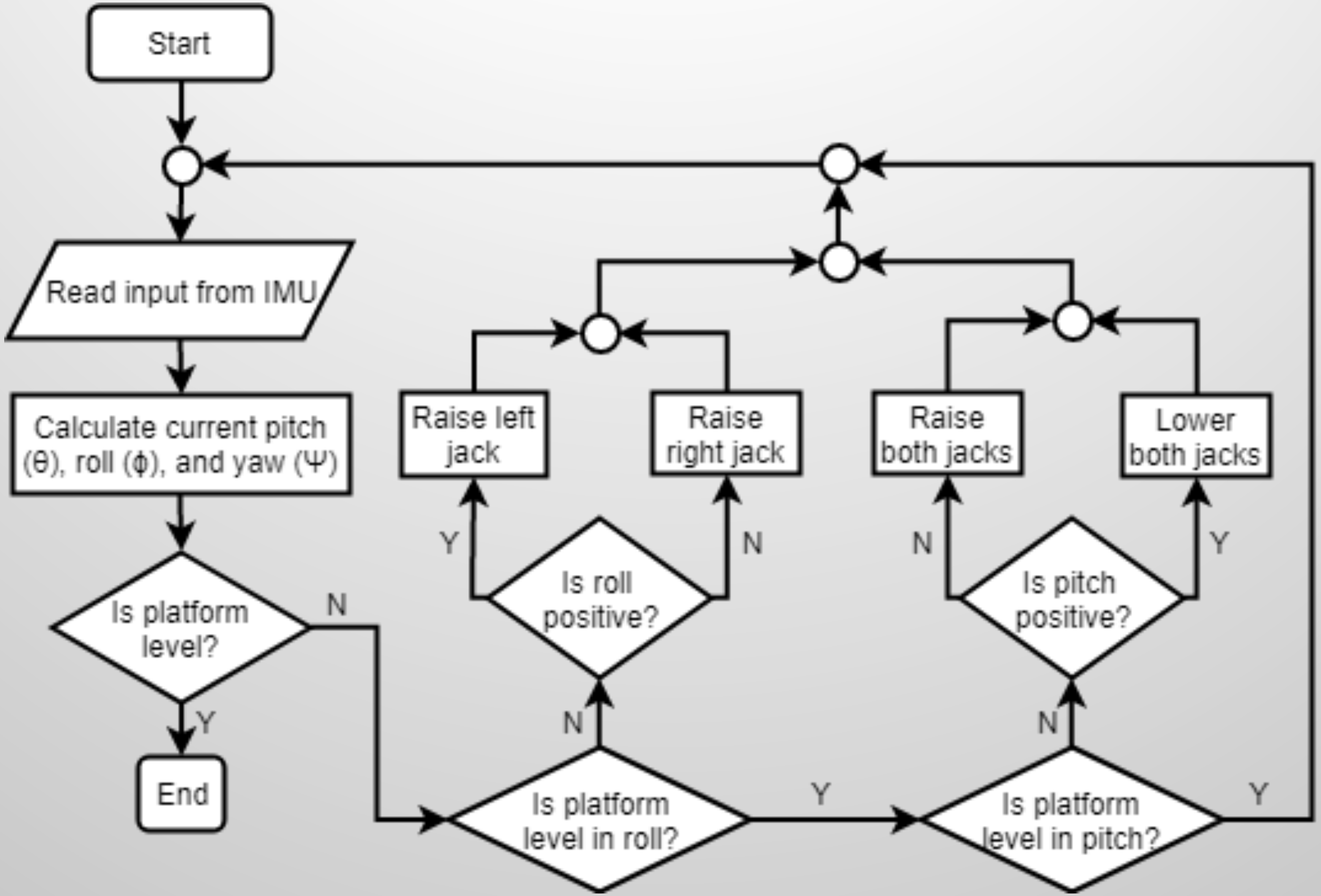


Steering Flowchart





Leveling Flowchart



Leveling System Testing

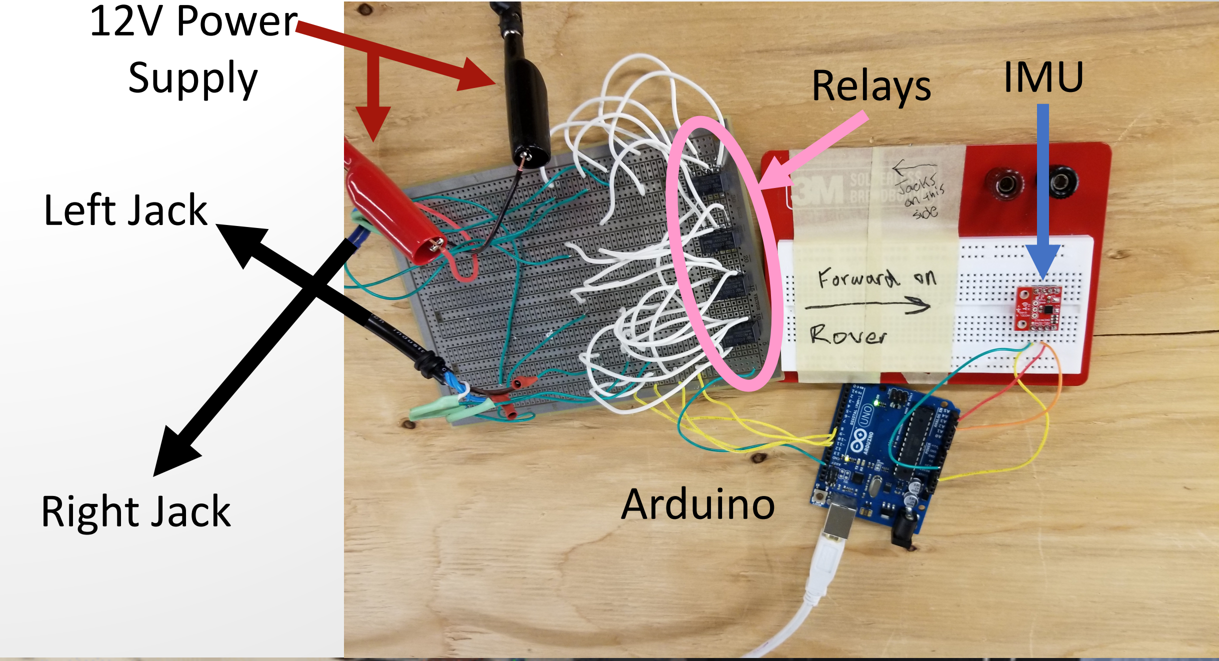
Completed Testing

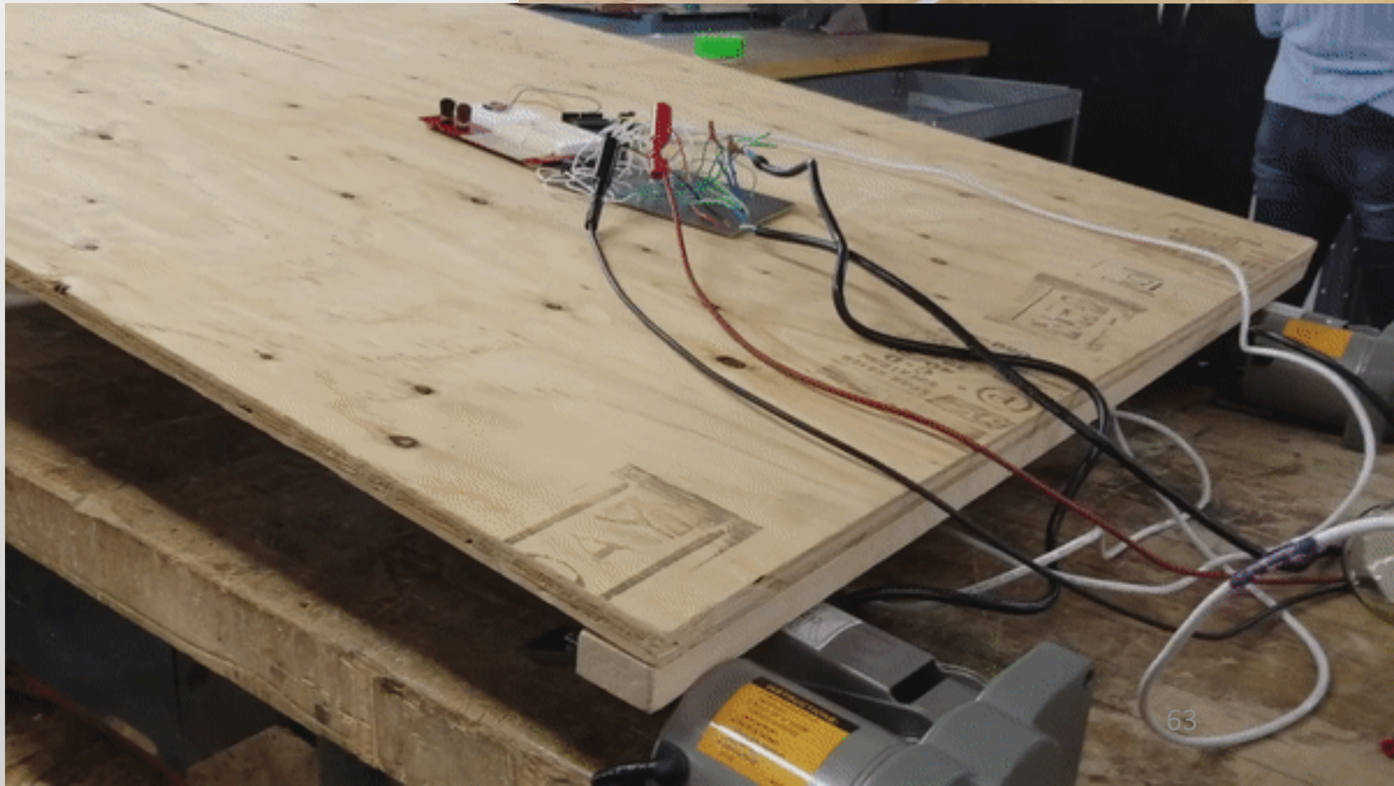
Due Date - 2/10

Steps to complete:

1. Fix wiring issues with vector board
2. Run several tests without failure
3. Shift circuit to PCB

Mostly finished, need to remedy connection issues in wiring by shifting to the PCB





Weight Budget

Subsystem	Part Name	Description	Manufacturer	Weight (lbs)	Quantity	Total Weight (lbs)
Translational	TracGard N766 TURF Bias Tire 18X9.50-8 B/4 Ply	Tires for translation, 18 x 9.50 - 8	From Walmart	7.00	4	28.00
Translational	DWT .125 Aluminum Blue Label Wheel	Wheels for translation, 8x8	motosport	3.65	4	14.60
Translational	LIN-ACT1-02	Wheel lock linear actuator, free shipping, c	Windynation	2.00	2	4.00
Translational	1370N16	Rubber pad for wheel lock	mcmaster-carr		1	0.00
Translational	GQ63-0045-RSB2S-WDE3B and GQ63-0045-LSB	gearmotors	Bison Gear & Engineering	39.12	2	78.24
Translational	DC60-12/24-4Q	Motor drivers	Minarik Drives	0.69	2	1.39
Translational	6280K895	motor sprockets	mcmaster-carr	0.54	4	2.16
Translational	6280K866	wheel sprockets	mcmaster-carr	3.28	4	13.12
Translational	UCP204-16, 1" 2-Bolt Pillow Block	mount bearings	Intech bearing inc	1.86	8	14.88
Translational	6261K175	chains	mcmaster-carr		4	0.00
Translational	1497K103	keyed shaft	mcmaster-carr	10.20	1	10.20
Translational	47065T101	10' of T-slotted bars	mcmaster-carr	4.92	4	19.68
Translational	47065T101	5' of T-slotted bars	mcmaster-carr	2.46	1	2.46
Translational	47065T239	Brackets for connecting the T-slotted bars	mcmaster-carr	0.14	36	5.04
Translational	Aluminum 6061 plate	36x36 0.25", could go away with scraps	midwest	31.77	2	63.54
Translational	Aluminum 6061 plate, brake housing	24x12, 025",	midwest	7.06	1	7.06
Translational	91274A244	Bolts for reducer, pack of 25	mcmaster-carr		1	0.00
Translational	92316A552	Bolts for motor, pack of 25	mcmaster-carr		1	0.00
Translational	5537T163	Bolts for motor, pack of 4	mcmaster-carr		1	0.00
Translational	95505A602	Nuts for Reducer, pack of 100	mcmaster-carr	1.02	1	1.02
Translational	910030A028	Nuts for motor	mcmaster-carr		4	0.00
Translational	A36 Steel plate	Plates for building the motor stand	midwest	20.40	1	20.40
Translational	SHIPPING FROM MCMASTER	MCMASTER	mcmaster-carr		0	0.00

Leveling	EJ212 Automatic Jack	Scissor Jack, 5x17x9	Buffalo Tools	8.08	2	16.16
Leveling	98957A148	Threaded rod for extending ball joint, as ne	mcmaster-carr	0.44	1	0.44
Leveling	60645K251	Ball Joint	mcmaster-carr	0.22	2	0.44
Leveling	92327A288	Bolts for base	mcmaster-carr		8	0.00
Leveling	90977A190	Coupling Nut	mcmaster-carr	0.10	3	0.30
Leveling	6443K49	Universal Joint	mcmaster-carr	0.22	3	0.66
Leveling	92383A214	Spring pin for u-joint mounting	mcmaster-carr		1	0.00
Leveling	8890K1	1 ft of steel shaft for U-joint mounting	mcmaster-carr	0.50	1	0.50
Leveling	94758A645	Flange nut for 7/16-20	mcmaster-carr		3	0.00
Leveling	6546K21	1/8 thickness aluminum 6061 square tube	mcmaster-carr	4.80	1	4.80
Leveling	90473A031	3/8 16 nuts 100 count	mcmaster-carr		1	0.00
LEVELING	other parts used for connections to joints	dont have parts, dont have exact weight		5.00	1	5.00
Communications	5.8GHz Circular Polarized Antenna Set-T and R 9(	Antennas for the video transmission feed	HobbyKing	0.15	2	0.30
Communications	ImmersionRC 5.8 GHz AUdio/Video TRansmitter	Transmitter for MR Video Feed	HobbyKing	0.11	2	0.22
Communications	SHIPPING FROM Hobby King	Hobby King	HobbyKing	0.01	0	0.00
Communications	XBP9B-XCST-002	XBee Pro S3B for MR Data Transmission	DigiKey International	0.01	2	0.02
Communications	RG58 Patch Cable SMA F to M (2 meter)	Cables to connect video antennas to	Amazon	0.07	2	0.14
Communications	2m RP-SMA extension cable	Cable to connect XBee to antenna on rove	?	0.03	1	0.03
Communications	ANT0906 900MHz antenna	900MHz 3.5dBi Omni GSM Antenna RP-SI	Eightwood	0.06	2	0.11
Communications	Thick-Wall Unthreaded PVC Pipe for Water: 48855	PVC pipe for pole	mcmaster-carr		1	0.00
Communications	Tee Connector, 2 Pipe Size Socket-Connect Femal	PVC pipe for pole, thick wall unthreaded p\	mcmaster-carr		1	0.00
Communications	XBee shield USB dongle	GS Xbee connection	SparkFun	0.03	1	0.03
Communications	U.LF to RP-SMA connection	Connection for XBees given by Trudy	Amazon	0.00	1	0.00

Electronics	SparkFun IMU Breakout - MPU-9250 SEN-137	Calculate the inclination and heading of the	SparkFun	0.00	1	0.00
Electronics	FatShark 700TVL CMOS FPV Camera V2 NTSC/F	Video Camera	HobbyKing	0.03	2	0.06
Electronics	Arduino Mega 2560 R3 DEV-11061 ROHS	Microcontroller Arduino Mega	Arduino	0.11	1	0.11
Electronics	AD5171 Digital Potentiometer	Digital Potentiometer	Mouser	0.00	2	0.00
Electronics	SparkFun Motor Driver - Dual TB6612FNG	Linear Actuator Motor Driver	SparkFun	0.00	1	0.00
Electronics	Miscellaneous			0.50	1	0.50
Electronics	GPS Receiver - GP-20U7	GPS Receiver	SparkFun	0.02	1	0.02
Electronics	Tenergy 6V 2000mAh NiMH RX Battery Packs	Battery to power Arduino and Sensors	Tenergy	0.31	2	0.63
Electronics	Tenergy Universal Smart Charger for NiMH/NiCd B	Battery Charger	Tenergy		1	0.00
Electronics	ML55-12 SLA - 12V 55 Ah	Battery to power translational system	Walmart	38.58	2	77.16
Electronics	552087807	Battery Charger	Walmart		1	0.00
Electronics	PB1107-ND relay	Relay	Digikey	0.00	6	0.00
Administrative	printing posters, paper, etc	printing	CU		1	0.00
Testing	Testbed	Testing our Rover	DRIFT		1	0.00
Shipping	Total of $400, subtracting current estimate from $4	Shipping	Drift		1	0.00
					TOTAL WEIGHT	393.43
				69.93	2	139.86
					TOTAL WEIGHT W/ 100Ah Batteries	456.13