Manufacturing Status Review

Presenters: Nicholas Carvo, Zachary Donovan, Jeremiah Lane, Aubrey McKelvy

Additional Team Members: Greg Clements, Thad Gleason, Everett Hale, Logan Thompson, Anna Tiberi, Tyler Faye, Austin Abraham

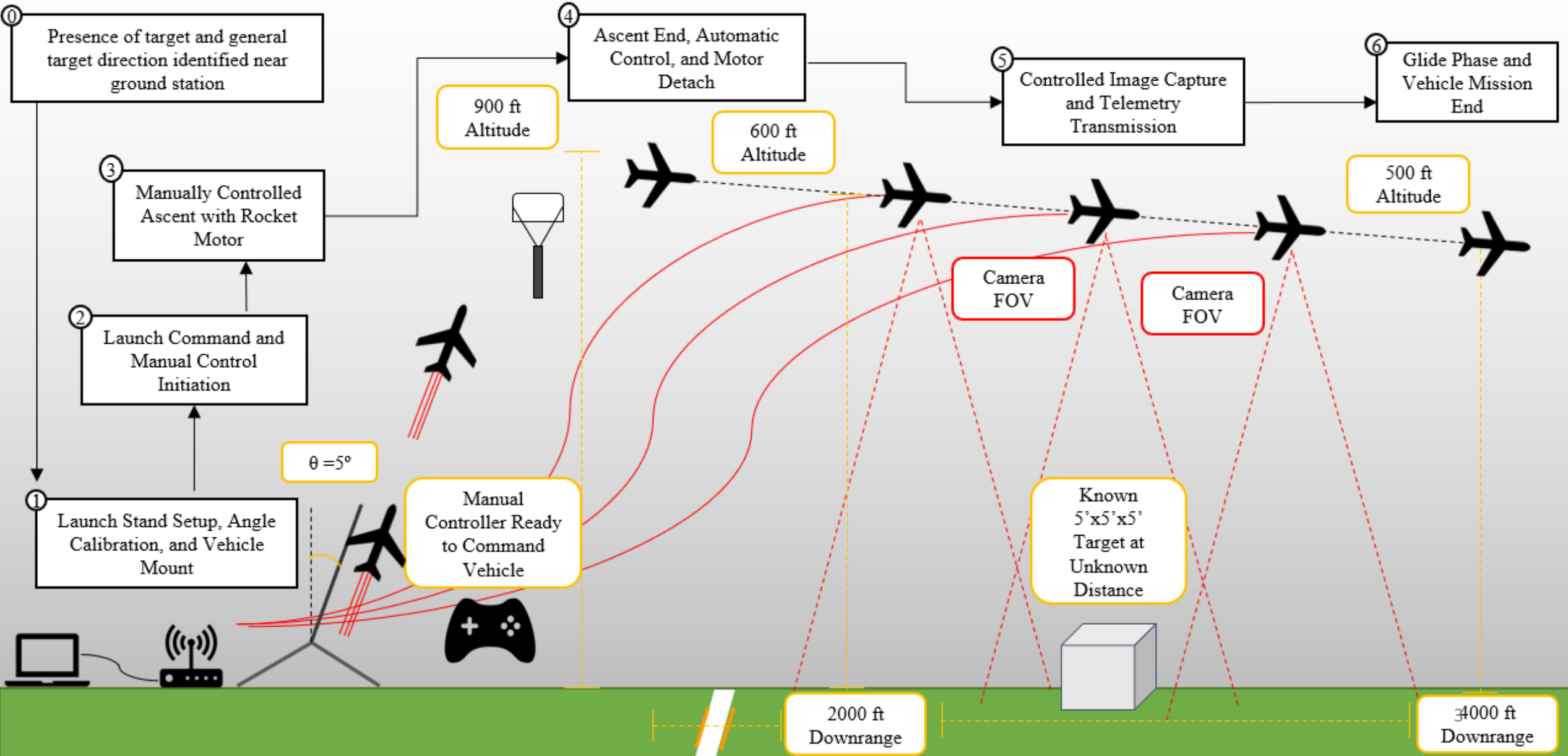
Customer: Lockheed Martin

Advisor: Dr. Dennis Akos

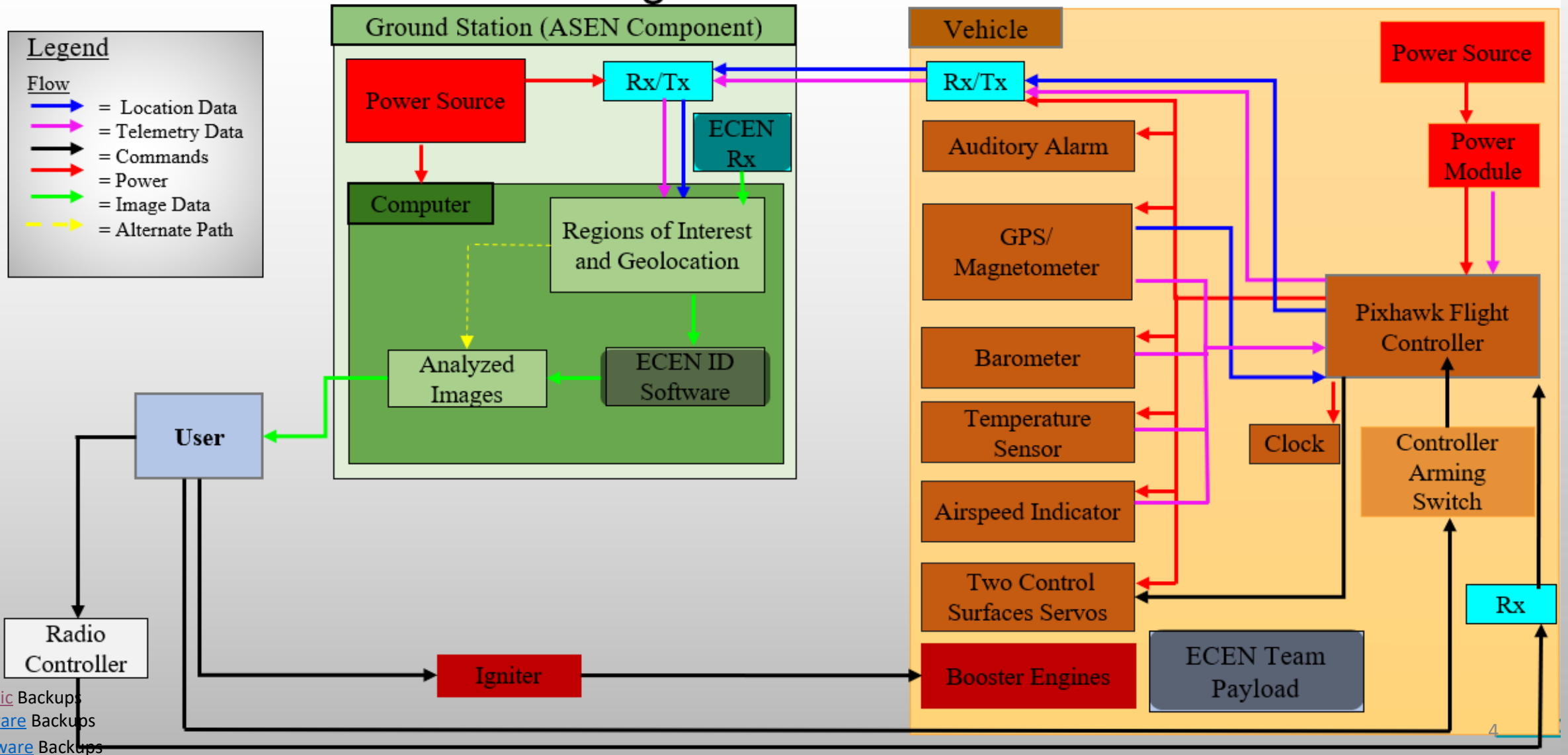
Overview

RAPTR CONOPs

Objective: Image and locate target within area of interest

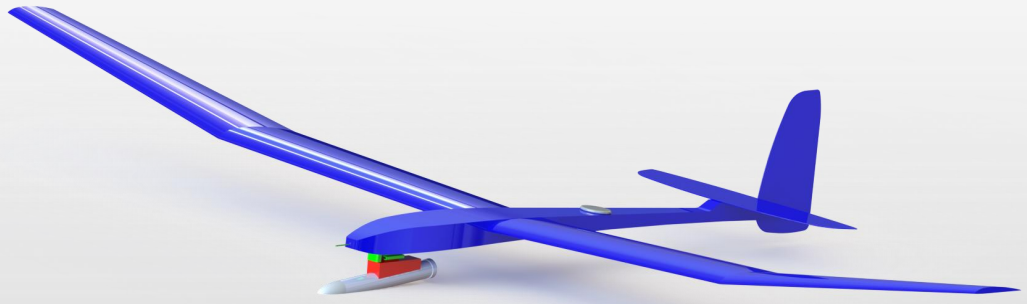


RAPTR Functional Block Diagram



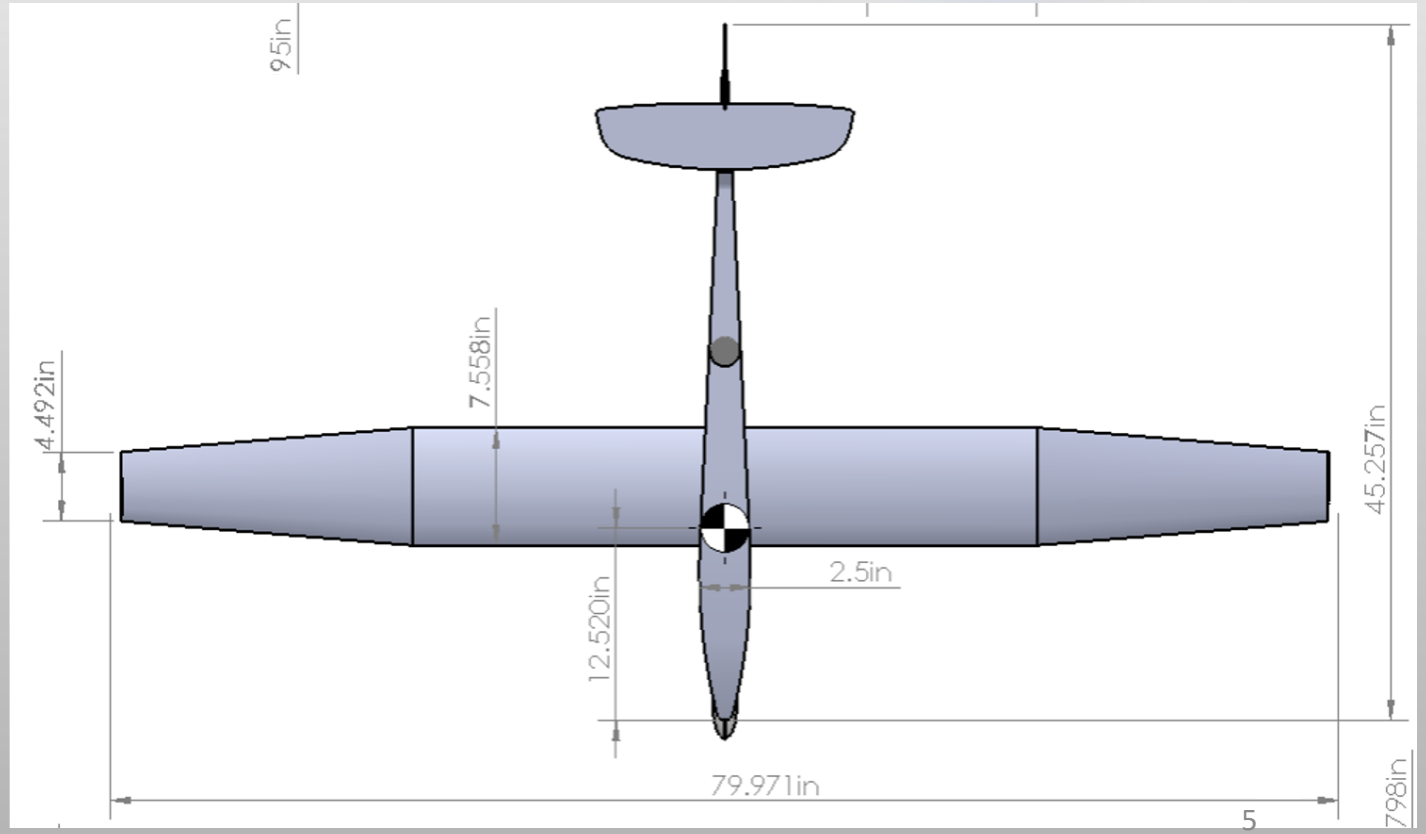
Electric Backups
Software Backups
Hardware Backups

Baseline Design



- Modified Hyperflight AndREaS
- Pixhawk GNC
- H42 Rocket Motor

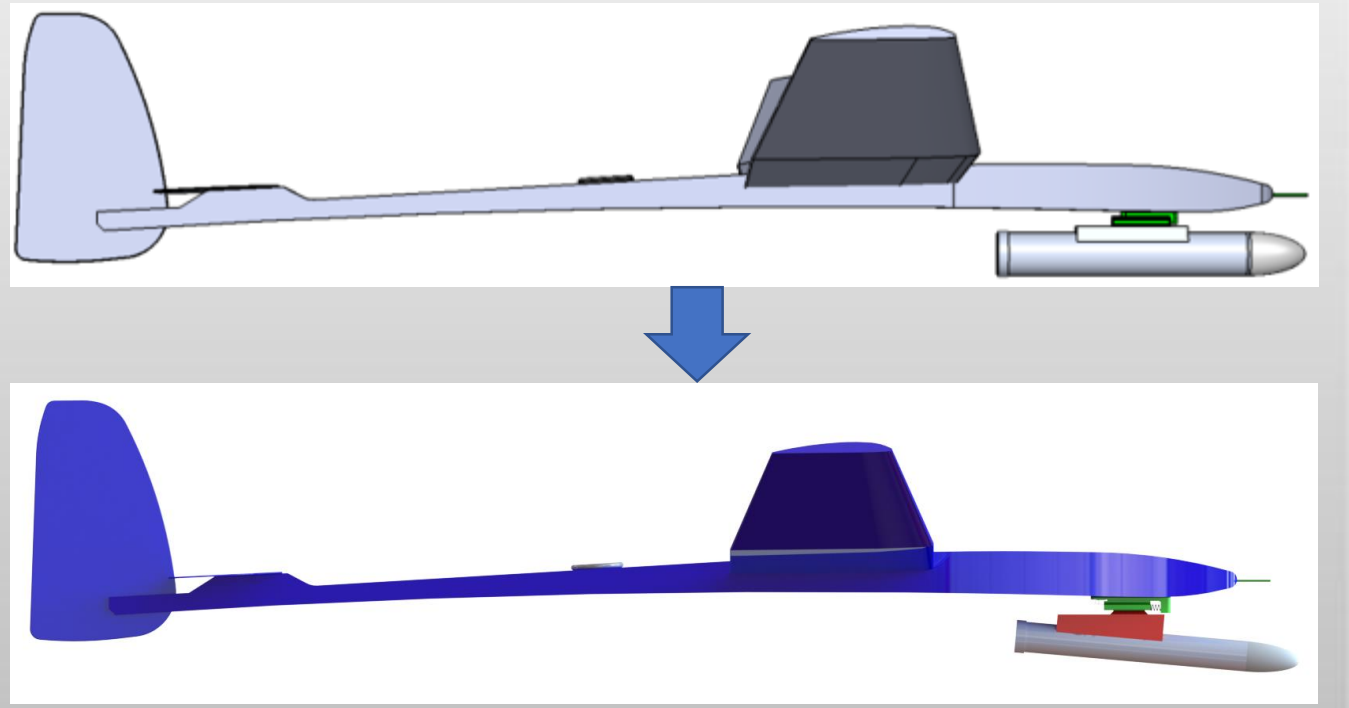
Item(s)	Mass [lb]
Airframe	1.14
Motor and Mount	1.2
Electronics	0.48
Payload	1.10
Total	3.92



Electric Backups
Software Backups
Hardware Backups

Changes from CDR

- Motor Change from I55 to H42
- Motor Angled
- Added Heat Shielding
- Spring added to Engine Mount



Electric Backups
Software Backups
Hardware Backups

CPE Review

Aerial Vehicle Design
Vehicle and Payload Integration
Vehicle Electronics
Transmission and Reception
FAA compliance
Target Recognition/GeoLocation Software
Propulsion System
Control

Modified Fuselage/Vehicle Construction

Level 1	Level 2	Level 3
Accommodate Pixhawk	Accommodate Payload Volume	Integrate Payload

Electronics Integration/Pixhawk Programming

Level 1	Level 2	Level 3
Integration	Independent Functionality	Integrated Functionality

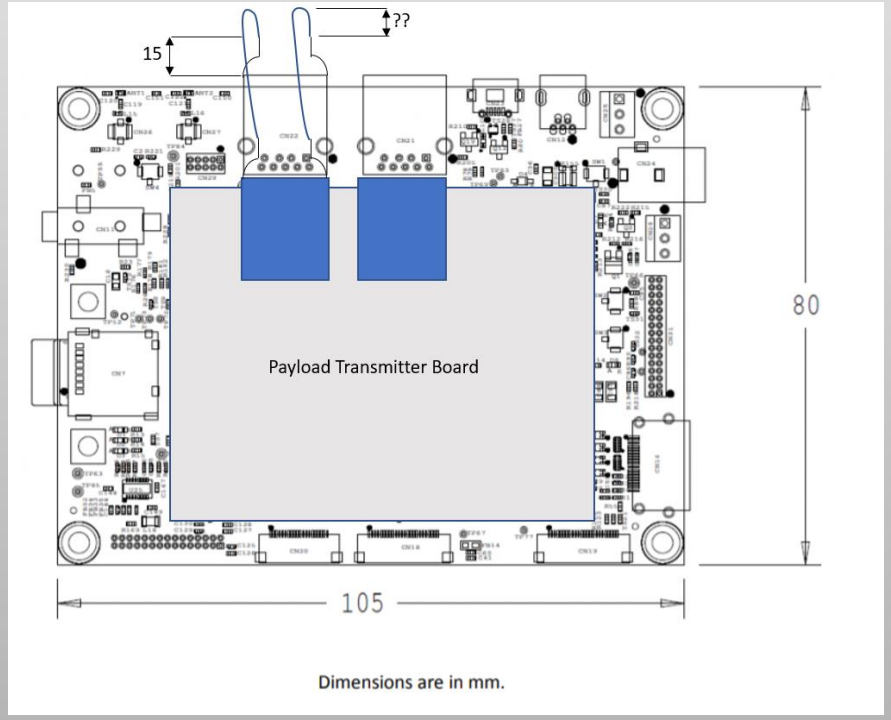
Ground Station Software Functionality

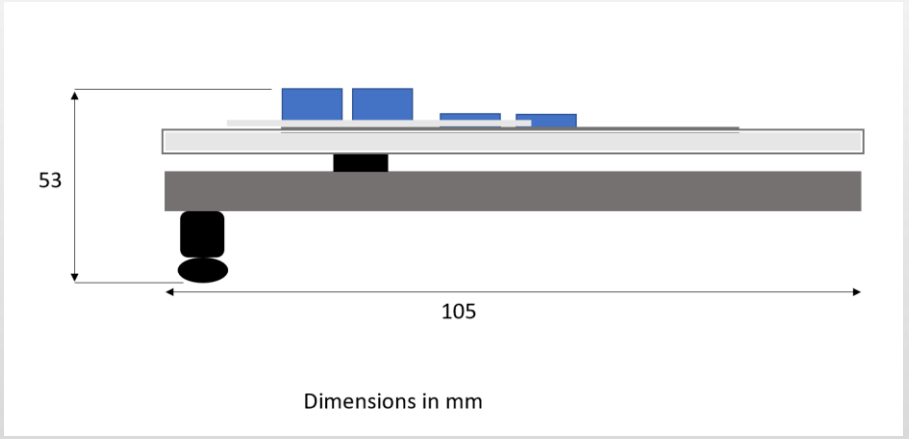
Level 1	Level 2	Level 3
Large Example Target Detection & Geolocation Functionality	Independent Small Target Detection & Geolocation Accuracy (Within 150 ft)	Detection & Geoloaction Integration & Functionality with Telemetry and Payload Image Data

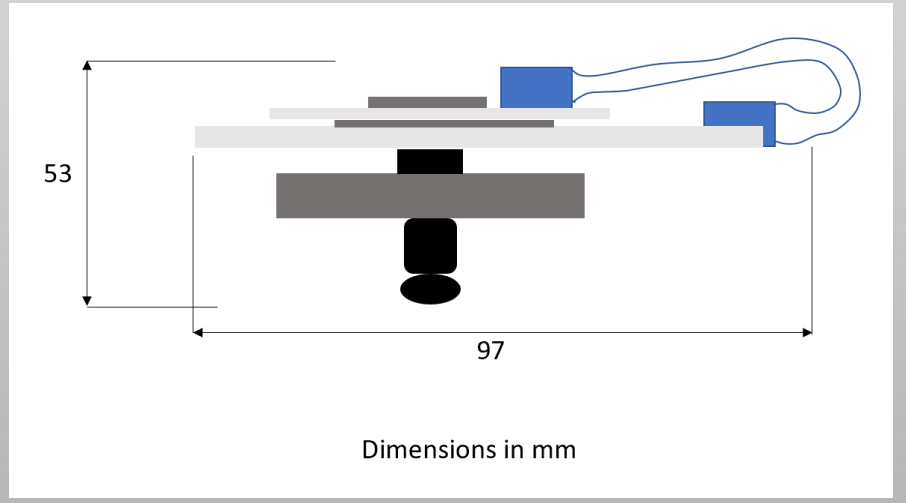
Electric Backups
Software Backups
Hardware Backups

Payload Team Status

- Imaging payload with attached board stack
- Currently too large for payload volume



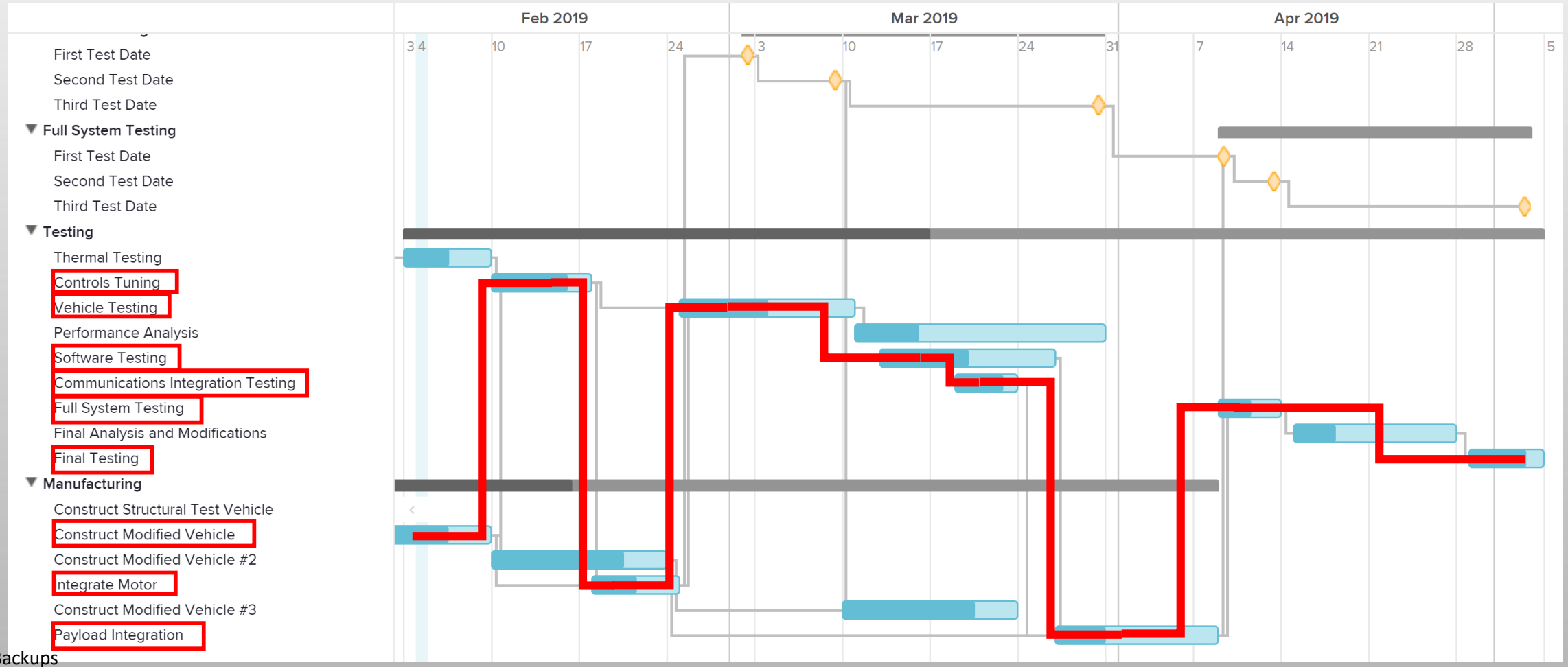




Electric Backups
Software Backups
Hardware Backups

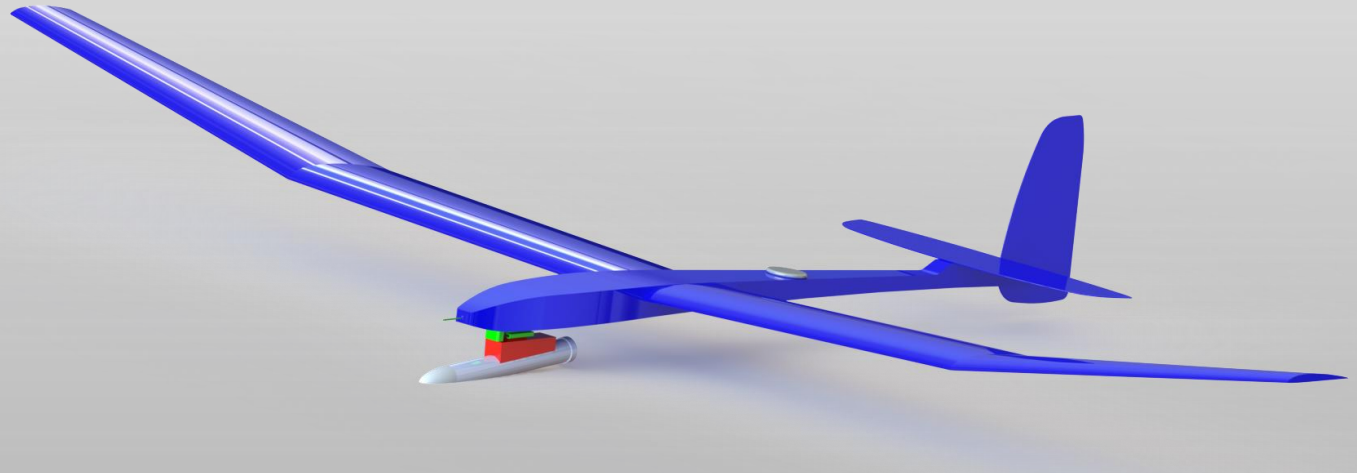
Schedule Update

Spring Gannt



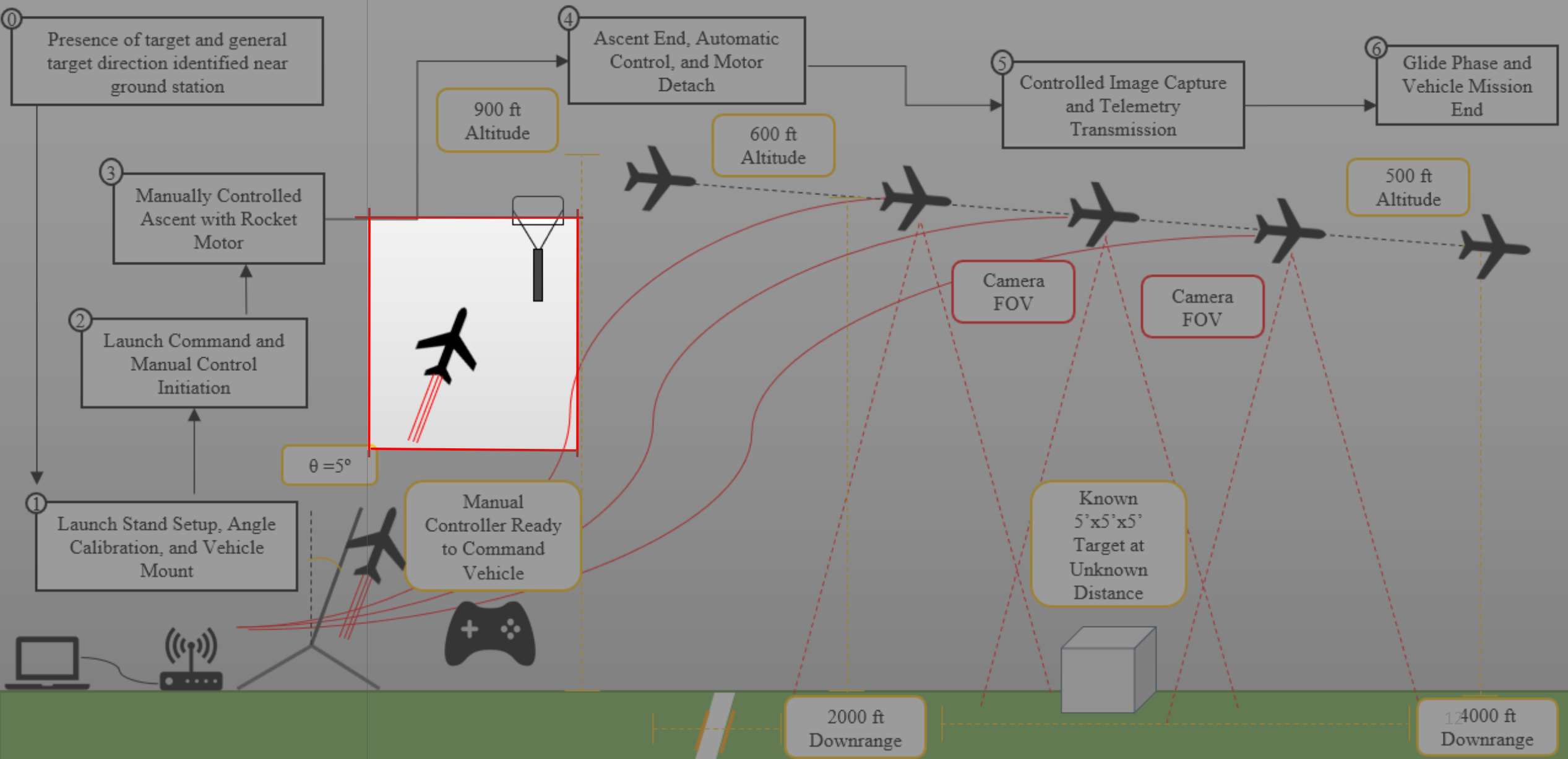
Electric Backups
Software Backups
Hardware Backups

Manufacturing Status



RAPTR CONOPs

Objective: Image and locate target within area of interest



Mechanical Status

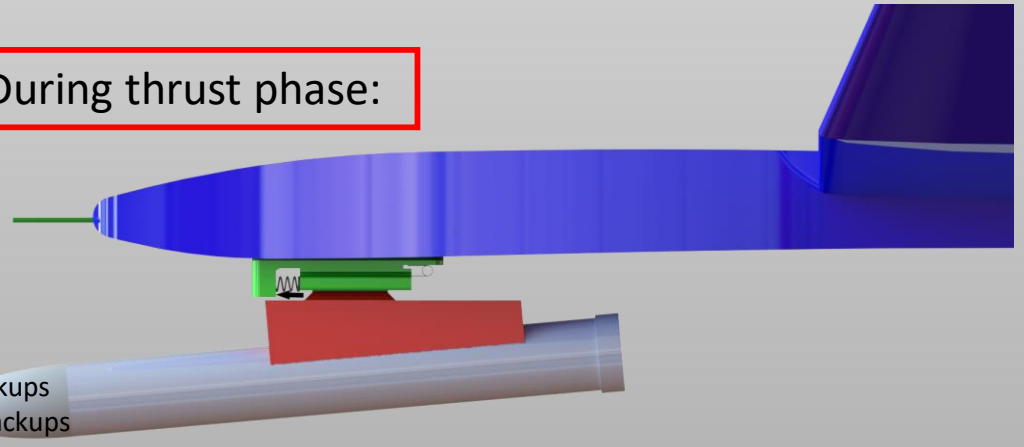
- Increased fuselage width from 1.325" to 2.625"
- Custom bulkheads and mounting boards
- Modifying top and bottom coverings
- Adding access points for electronics
- Approximately 25-35 hours to complete a glider

Electric Backups
Software Backups
Hardware Backups

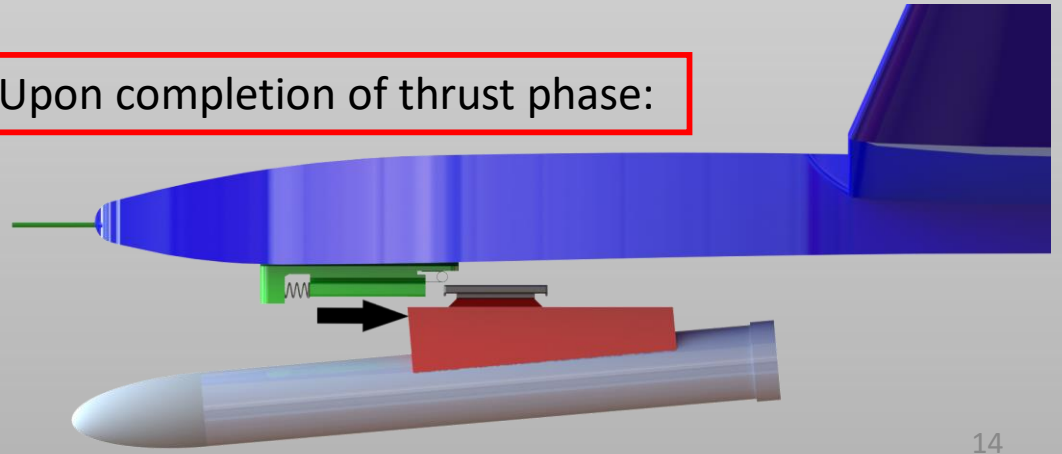
Mechanical Status

- Canted motor 5 degrees
  - Aluminum parts: reduce thermal impact & increase durability (8 hours)
  - Plastic parts: lower weight & quicker manufacturing (2.5 hours)
- Added spring to ensure separation
  - Verified timing and force using dynamics models
- Manufacturing to be started

During thrust phase:



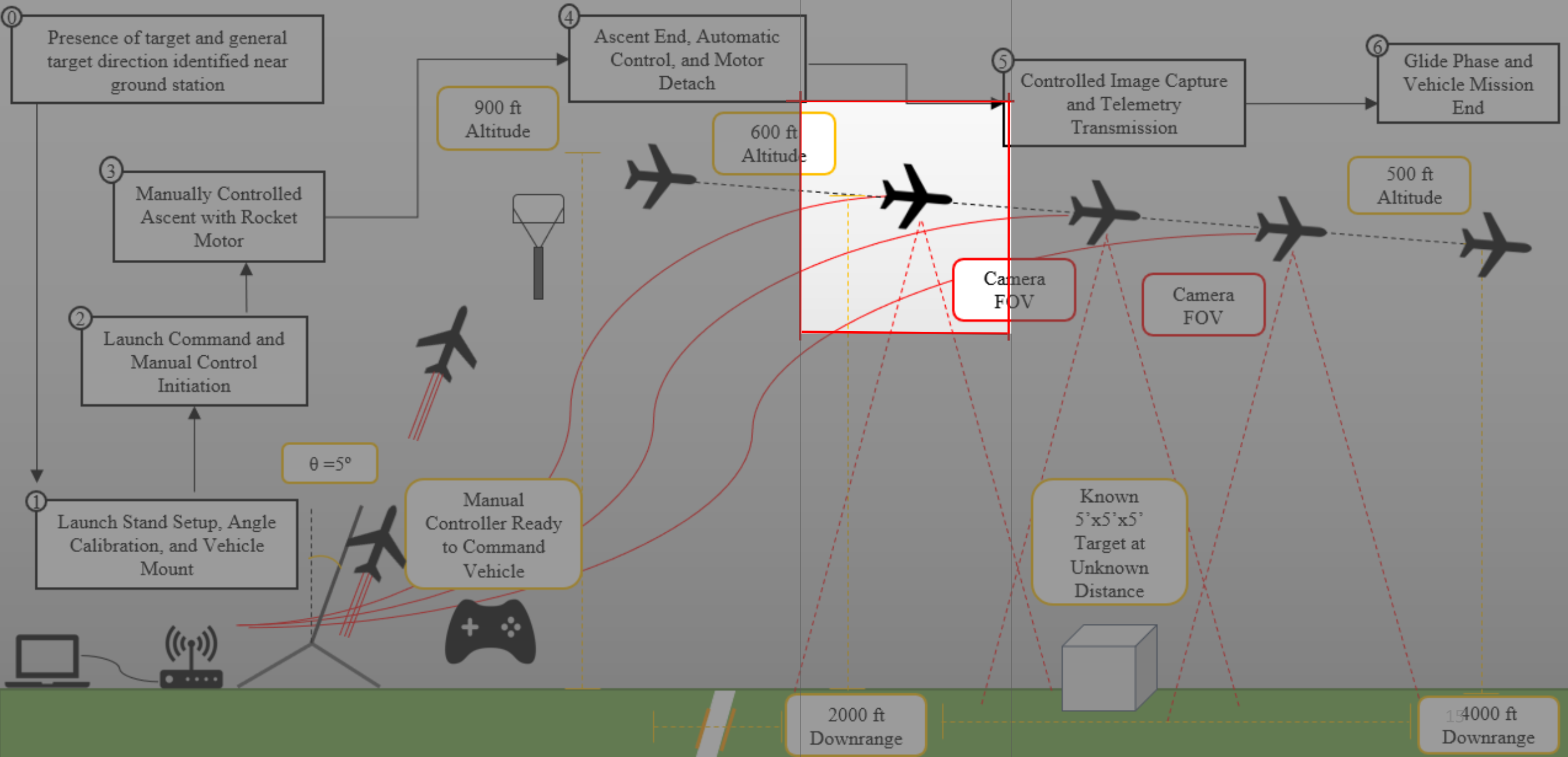
Upon completion of thrust phase:



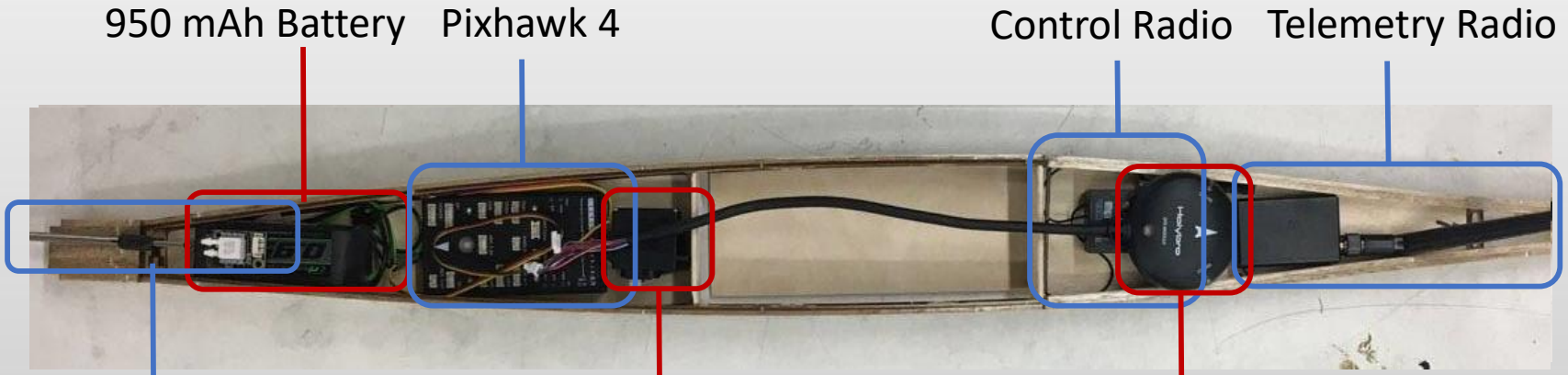
Electric Backups
Software Backups
Hardware Backups

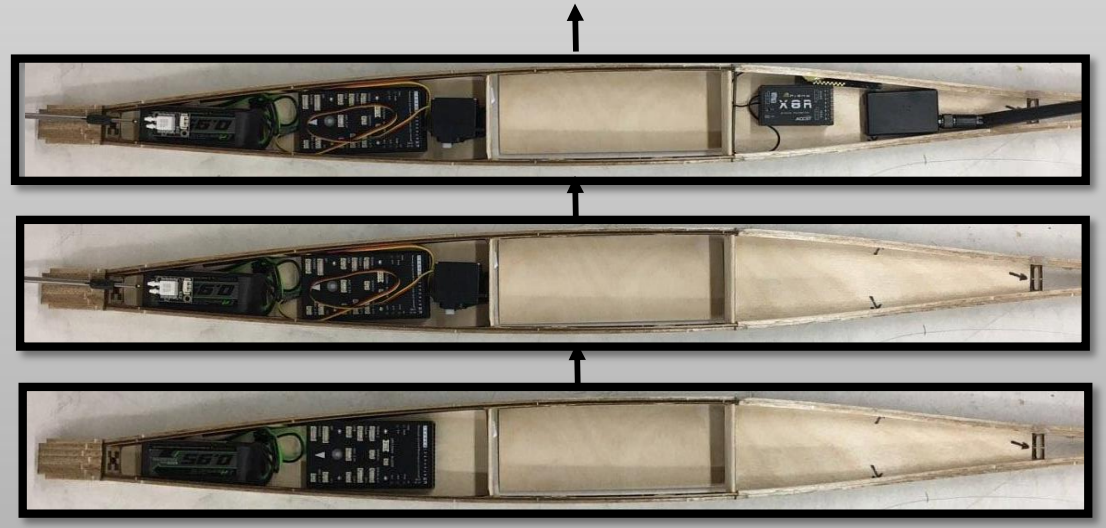
RAPTR CONOPs

Objective: Image and locate target within area of interest



Electronics Integration





Control and Telemetry Radio

+

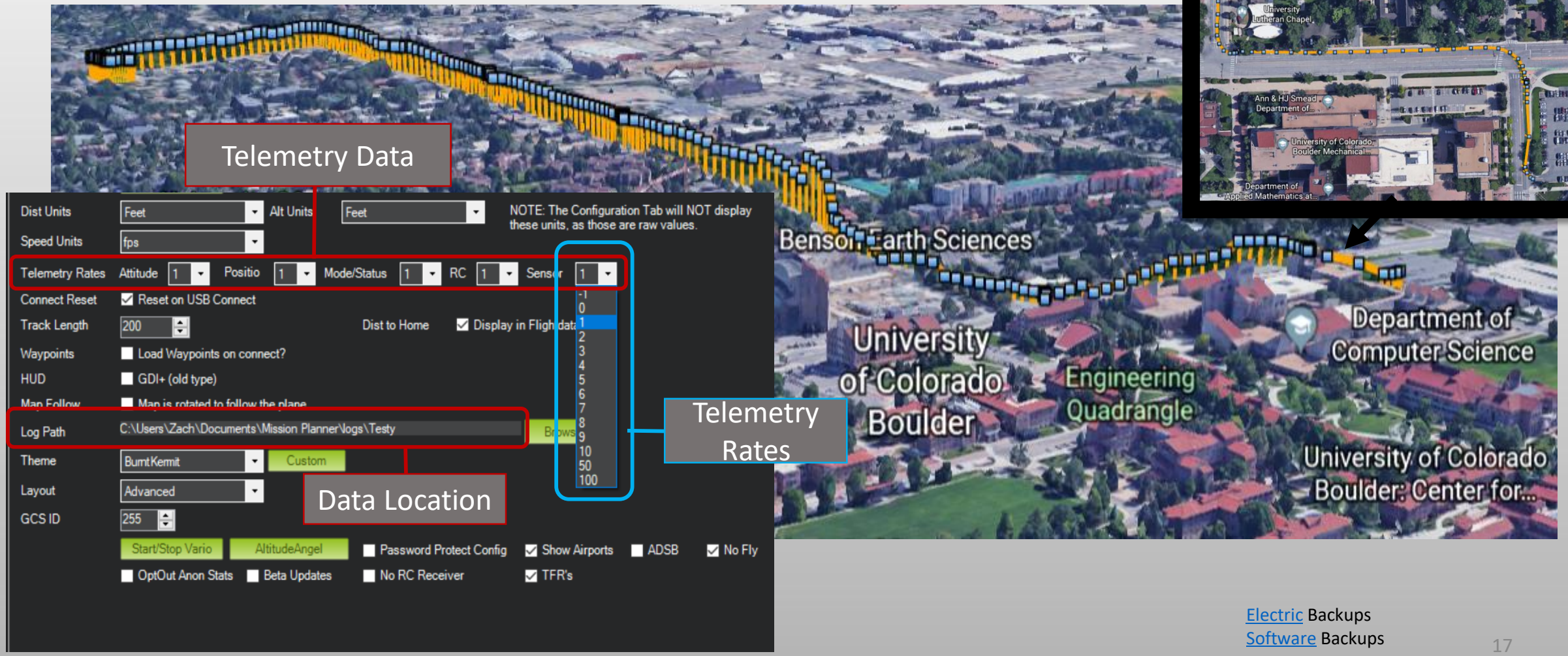
Airspeed Indicator and Servos

+

Battery and Pixhawk

Electric Backups
Software Backups
Hardware Backups

Pixhawk Software



[Electric](#) Backups
[Software](#) Backups
[Hardware](#) Backups

Pixhawk Software and Integration

Electronics Integration

Task	Hours Completed	Difficulty
Component Weight and Balance	4/5 hours	
Component Layout in Fuselage	2/3 hours	
Power Module Modification	2/4 hours	
Wiring Routing in EE Payload	0.5/3 hours	
Component Securement	1/6 hours	
Total	**9.5/21**	

Pixhawk Software

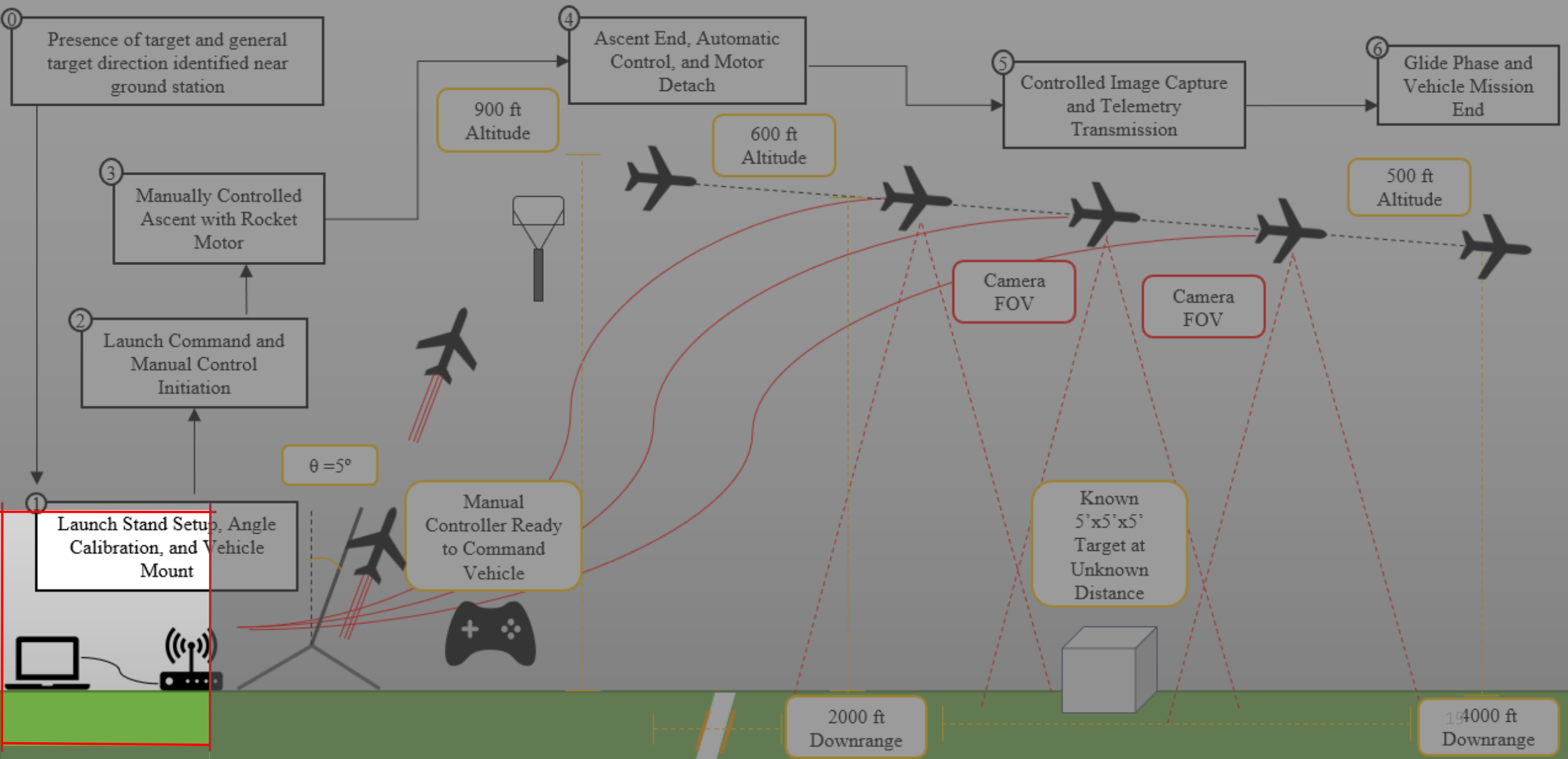
Task	Hours Completed	Difficulty
Gain Tuning	20/25 hours	
Pixhawk Software Integration	5/20 hours	
Waypoint Determination	3/8 hours	
Telemetry/Image Integration	2/7 hours	
Total	**30/60**	

Electric Backups
Software Backups
Hardware Backups

Easy | Medium | Hard

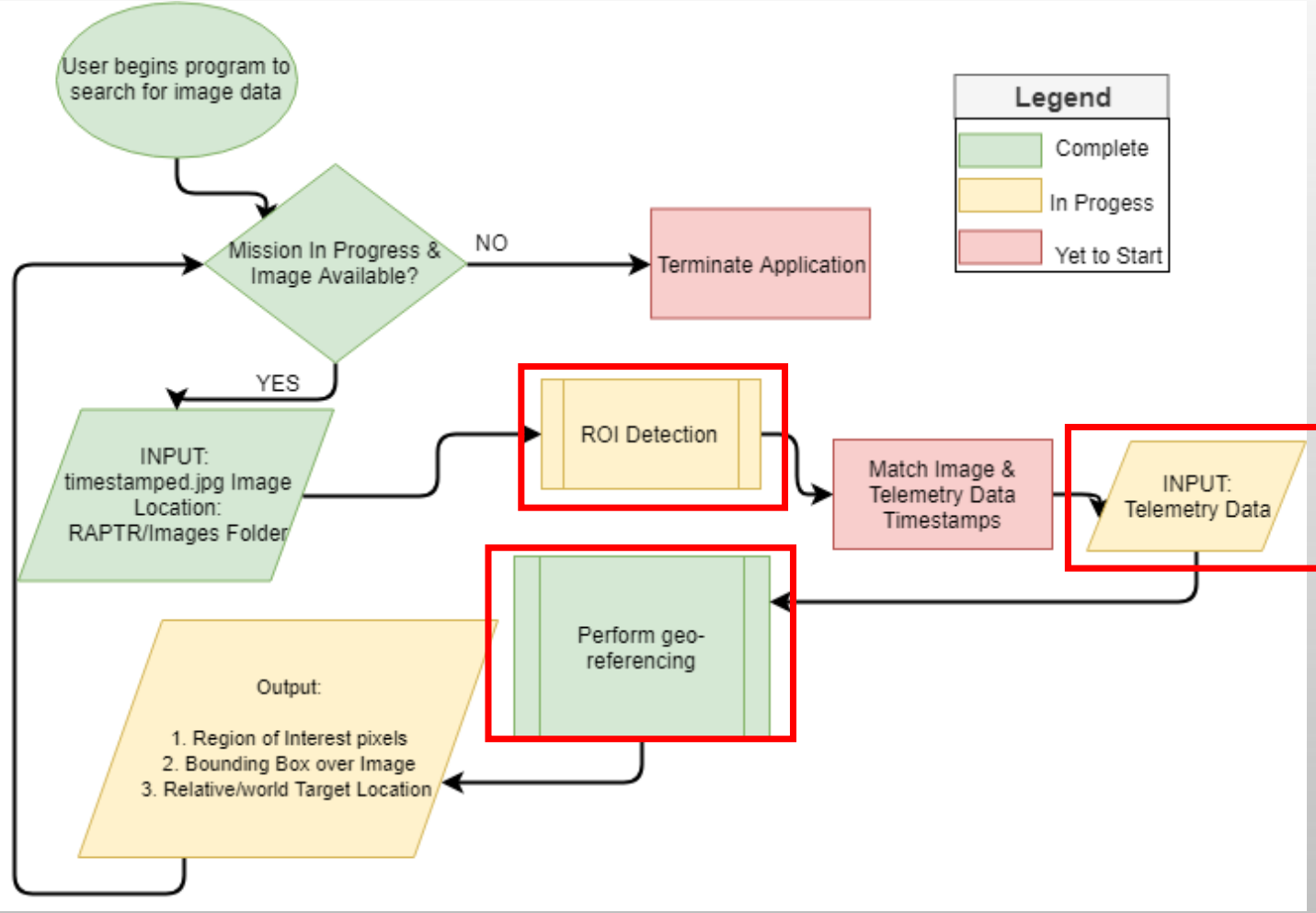
RAPTR CONOPs

Objective: Image and locate target within area of interest



Software Structure

Purpose	Determine ROI & geolocate within 150 ft of true location
Inputs	• 0.25 Hz .jpg Image • 50 Hz Telemetry Data
Outputs	• Full image (.jpg) • Pixel Indices for each ROI (.mat) • Geodetic & Relative Coordinates (.mat)

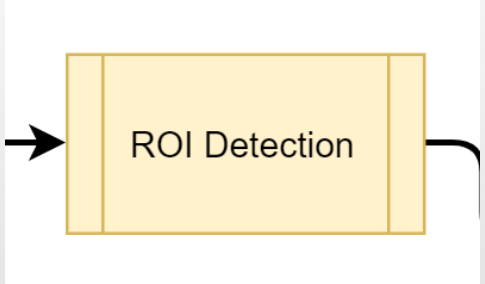


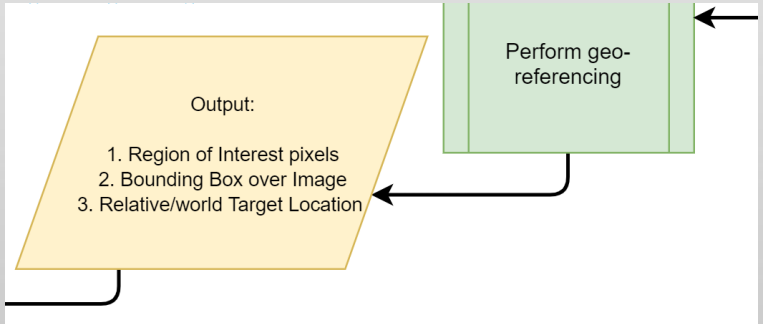
Electric Backups
Software Backups
Hardware Backups

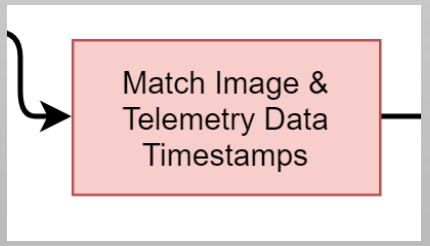
Ground Software Milestones & Progress

Major Milestones:

	Status:	
➢ Simple T-test sliding window		10/10 hrs
➢ Geolocation algorithm		15/15 hrs
➢ Saliency map generation		10/20 hrs
➢ Image thresholding for determining number of ROIs		3/10 hrs
➢ Validation using quadcopter tests		3/25 hrs
➢ Image/Telemetry timestamp matching		0/3 hrs







Electric Backups
Software Backups
Hardware Backups

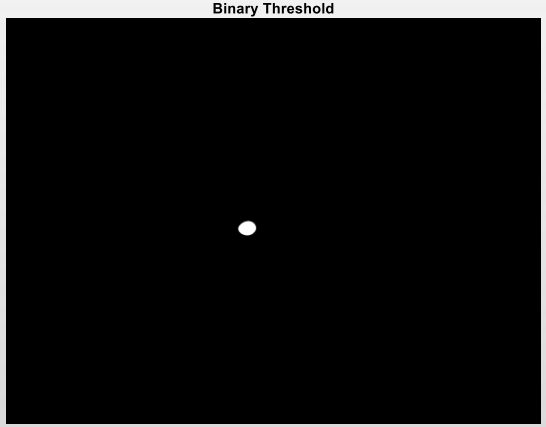
Electric Backups
Software Backups
Hardware Backups

Software Outputs

Region of Interest Detection

.jpg Image

Saliency Map



Binary Thresholding

Bounding Box Over ROI

Geolocation

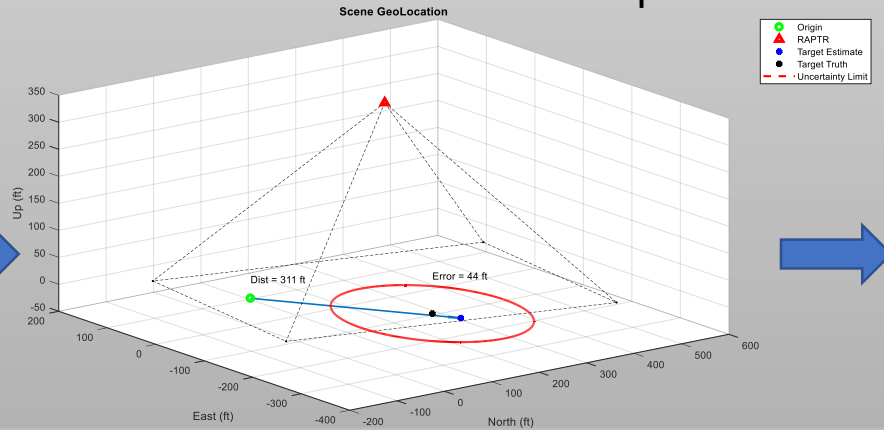
Telemetry/GPS Data & ROI Pixel indices

ATT

92336x10 double

	1	2	3	4	5	6	7	8	9	10
1	293	2.7958e+09	0	-0.3300	0	0.0300	0	298.4700	0	0
2	671	2.7958e+09	0	-0.3400	0	0.0300	0	298.4700	0	0
3	1070	2.7959e+09	0	-0.3400	0	0.0400	0	298.4700	0	0
4	1255	2.7959e+09	0	-0.3400	0	0.0300	0	298.4600	0	0
5	1282	2.7960e+09	0	-0.3400	0	0.0300	0	298.4600	0	0
6	1313	2.7960e+09	0	-0.3500	0	0.0300	0	298.4600	0	0
7	1341	2.7960e+09	0	-0.3500	0	0.0200	0	298.4600	0	0
8	1373	2.7961e+09	0	-0.3500	0	0.0300	0	298.4600	0	0
9	1404	2.7961e+09	0	-0.3500	0	0.0200	0	298.4700	0	0
10	1431	2.7962e+09	0	-0.3500	0	0.0200	0	298.4600	0	0
11	1462	2.7962e+09	0	-0.3500	0	0.0200	0	298.4600	0	0
12	1490	2.7962e+09	0	-0.3400	0	0.0200	0	298.4600	0	0
13	1521	2.7963e+09	0	-0.3500	0	0.0200	0	298.4700	0	0
14	1552	2.7963e+09	0	-0.3500	0	0.0200	0	298.4600	0	0

ROI Geolocation & Scene Map



Geodetic & Relative Coordinate Output

Latitude	**40.02709 deg**
Longitude	-105.28656 deg
Distance	311 ft

Budget Update

Budget Update

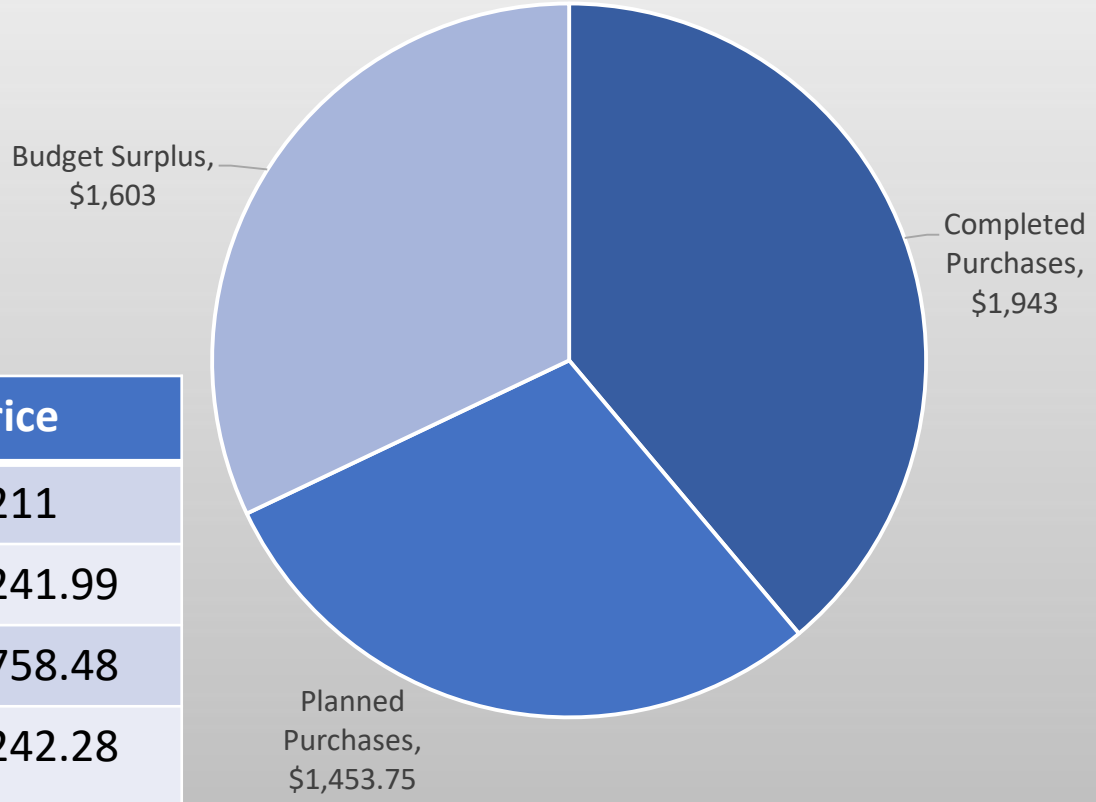
- All parts procured for first launch
- Budget accounts for 3 launches
  - Cost of additional launch: ~$1032

Completed Purchases

Item	Price
Pixhawk 4 (x2)	$468.82
AndREaS Glider (x3)	$813.88
Manufacturing Supplies	$232.53
Electronics for One Glider	$379.24
Thermal Tape	$48.90
Total:	**$1943.37**

Planned Purchases

Item	Price
Pixhawk 4 (x1)	$211
AndREaS Glider (x1)	$241.99
Electronics for Two Gliders	$758.48
Rocket Motors and Supplies for 3 Launches	$242.28
Total:	**$1453.75**



Electric Backups
Software Backups
Hardware Backups

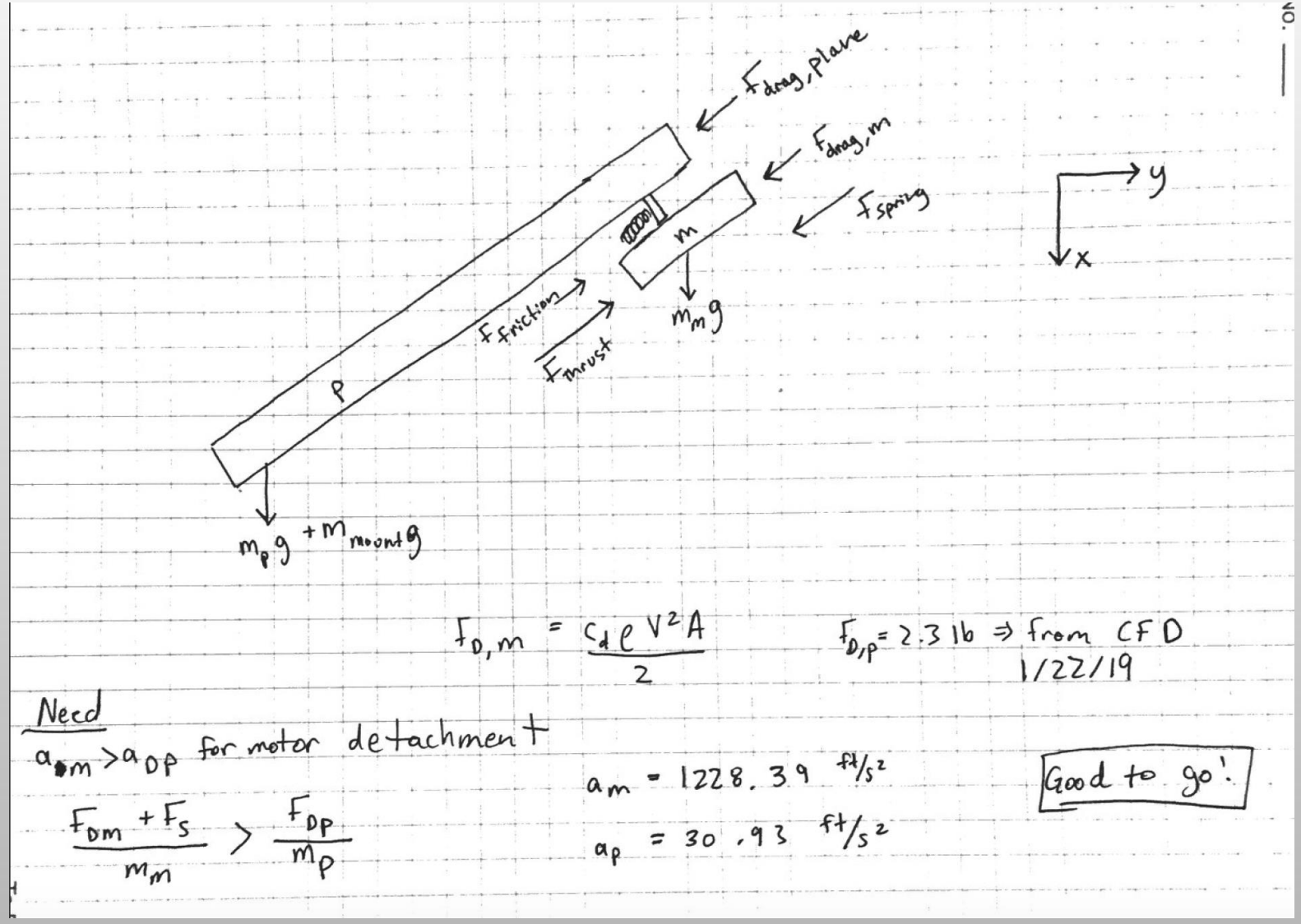
Final Questions?

Backup Slides

Price Calculation of Single Launch

Part Name	Relevant Subteam	Part Number	Cost (USD)	Quanitity	Tax per Unit (USD)	Source	Total Cost (USD)
Pixhawk 4 and GPS Module	Electronics	20064	$ 211.00	1	$ -	https://shop.holybro.com/pix	$ 211.00
Digital Airspeed Sensor	Electronics	SENAIR02KIT	$ 64.59	1	$ -	http://store.jdrones.com/digit	$ 64.59
FrSky X8R Receiver	Electronics	236000056-0	$ 34.99	1	$ -	https://www.amazon.com/FrS	$ 34.99
HKPilot Transceiver Telemetry Radio Set V2 (915Mhz)	Electronics	N/A	$ 45.00	1	$ -	https://www.amazon.com/YK	$ 45.00
Telemetry Cable	Electronics	N/A	$ 19.99	1	$ -	https://www.amazon.com/YK	$ 19.99
Servo - HiTec HS-82MG	Electronics	HS-82MG	$ 19.99	2	$ -	https://www.towerhobbies.co	$ 39.98
Turnigy Graphene Panther 950mAh Battery	Electronics	9067000367-0	$ 12.24	1	$ -	https://hobbyking.com/en_us	$ 12.24
Voltage Regulator	Electronics	NCP1117ST50T3G	$ 0.54	6	$ -	https://www.digikey.com/proc	$ 3.24
Diode	Electronics	DMV1500MFD	$ 1.57	6	$ -	https://www.digikey.com/proc	$ 9.42
Printed Circuit Board (per 10)	Electronics	N/A	$ 15.00	1	$ -	https://jlcpcb.com/	$ 15.00
						Electronics Total:	$ 455.45
38MM FIBERGLASS OGIVE 4:1 NOSE CONE	Propulsion	20265	$ 24.94	1	$ -	https://www.apogeerockets.c	$ 24.94
Parachute: 12" Plastic Chute	Propulsion	29121	$ 7.49	1	$ -	https://www.apogeerockets.c	$ 7.49
Engine (H-32)	Propulsion	N/A	$ 35.00	1	$ -	http://www.moto-joe.com/ind	$ 35.00
29mm Cesaroni 4 grain casing	Propulsion	CTI P38-3G	$ 34.82	1	$ -	https://www.apogeerockets.c	$ 34.82
						Propulsion Total:	$ 102.25
Hyperflight Andreas	Structures	N/A	$ 137.73	1	$ 27.55	https://www.hyperflight.co.uk	$ 165.28
Oracover Oralight	Structures	N/A	$ 19.48	3	$ 3.90	https://www.hyperflight.co.uk	$ 70.13
Carbon Rod	Structures	N/A	$ 5.48	1	$ 1.10	https://www.hyperflight.co.uk	$ 6.58
Low-Profile Sleeve Bearing Carriage	Structures	6723K11	$ 6.26	1	$ -	https://www.mcmaster.com/6	$ 6.26
27 mm Wide Guide Rail for Low-Profile Sleeve Bearing Carriage	Structures	6723K2	$ 15.00	1	$ -	https://www.mcmaster.com/6	$ 15.00
						Structures Total:	$ 263.24
						Total Without Shipping:	$ 820.94
						Shipping Estimates (~25%)	$ 205.24
						True Total:	$ 1,026.18

Motor Ditch


$F_{drag,plate}$
$F_{drag,m}$
F_{spring}
$F_{friction}$
F_{thrust}
$m_m g$
$m_p g + m_{mount} g$
P
m
y
x
$F_{D,m} = \frac{C_d \rho V^2 A}{2}$
$F_{D,p} = 2.316$ ⇒ from CFD 1/22/19
Need
$a_m > a_{DP}$ for motor detachment
$\frac{F_{Dm} + F_s}{m_m} > \frac{F_{DP}}{m_p}$
$a_m = 1228.39$ ft/s²
$a_p = 30.93$ ft/s²
Good to go!

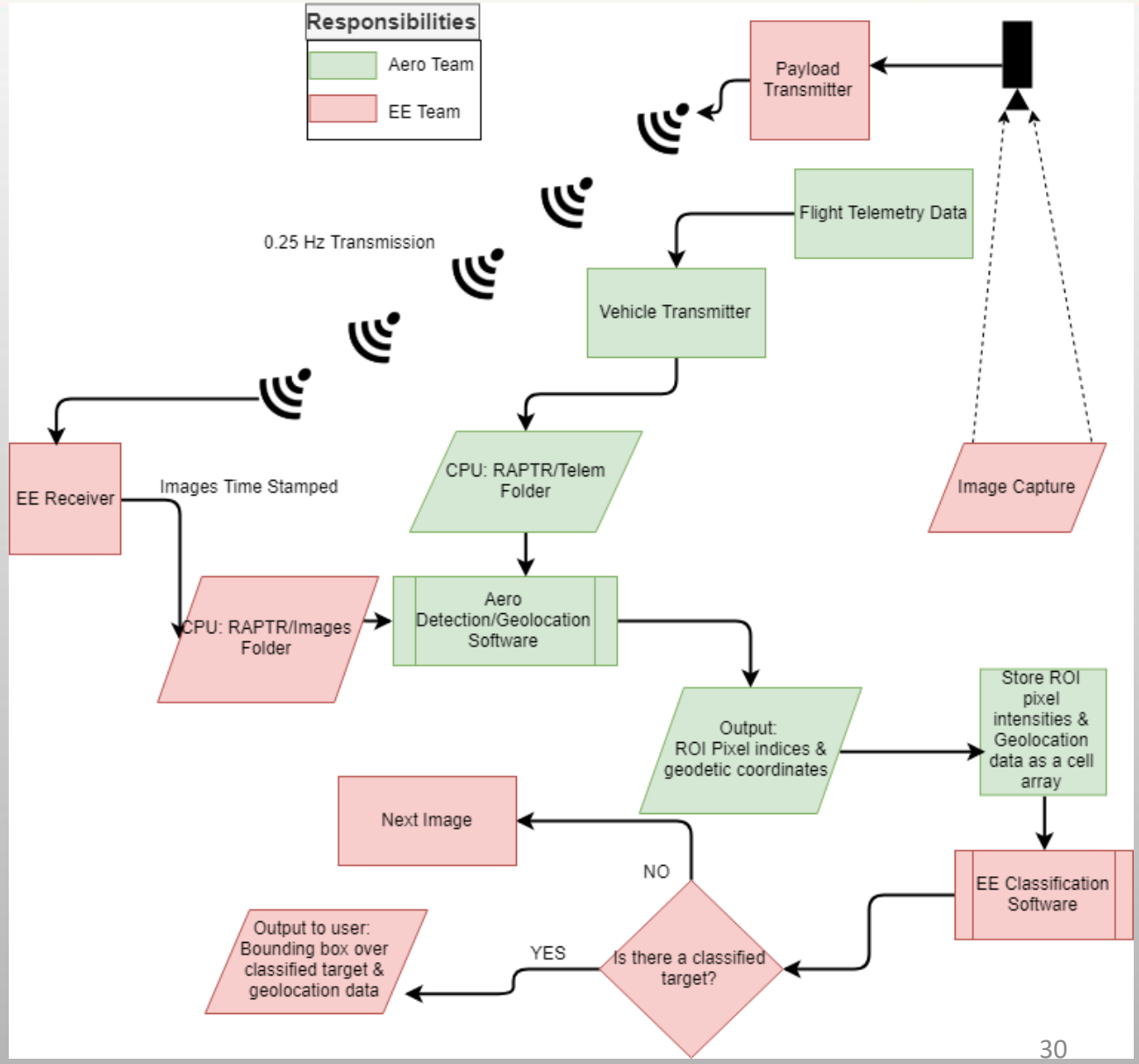
Mission Planner Waypoint Generation

Image & Telemetry Data Flow

Aero & EE team computing language:

MATLAB

Overview
Schedule
Hardware Status
Electrical Status
Software Status
Budget



Detection & Geolocation Software Status

- Purpose:
  - Determine potential regions of interest (ROI) from .jpg images taken by the payload
  - Geolocate potential ROIs in geodetic coordinates to within 150 ft of true location

Software Element	Work Already Done	Work/Tests to Do	Work hour Estimation
ROI Detection	• Sliding Window T-test & edge detection algorithm • Saliency map looking at highest contrast locations	• Computational time reduction • False alarm rate optimization • Validation w/ test images	30 hrs
ROI Geolocation	• Full coordinate transformation derivation • Preliminary validation of requirements using quad drone	• Payload camera calibration • Validation through quad drone tests	10 hrs w/ testing

Computational Time Estimates

Language: MATLAB

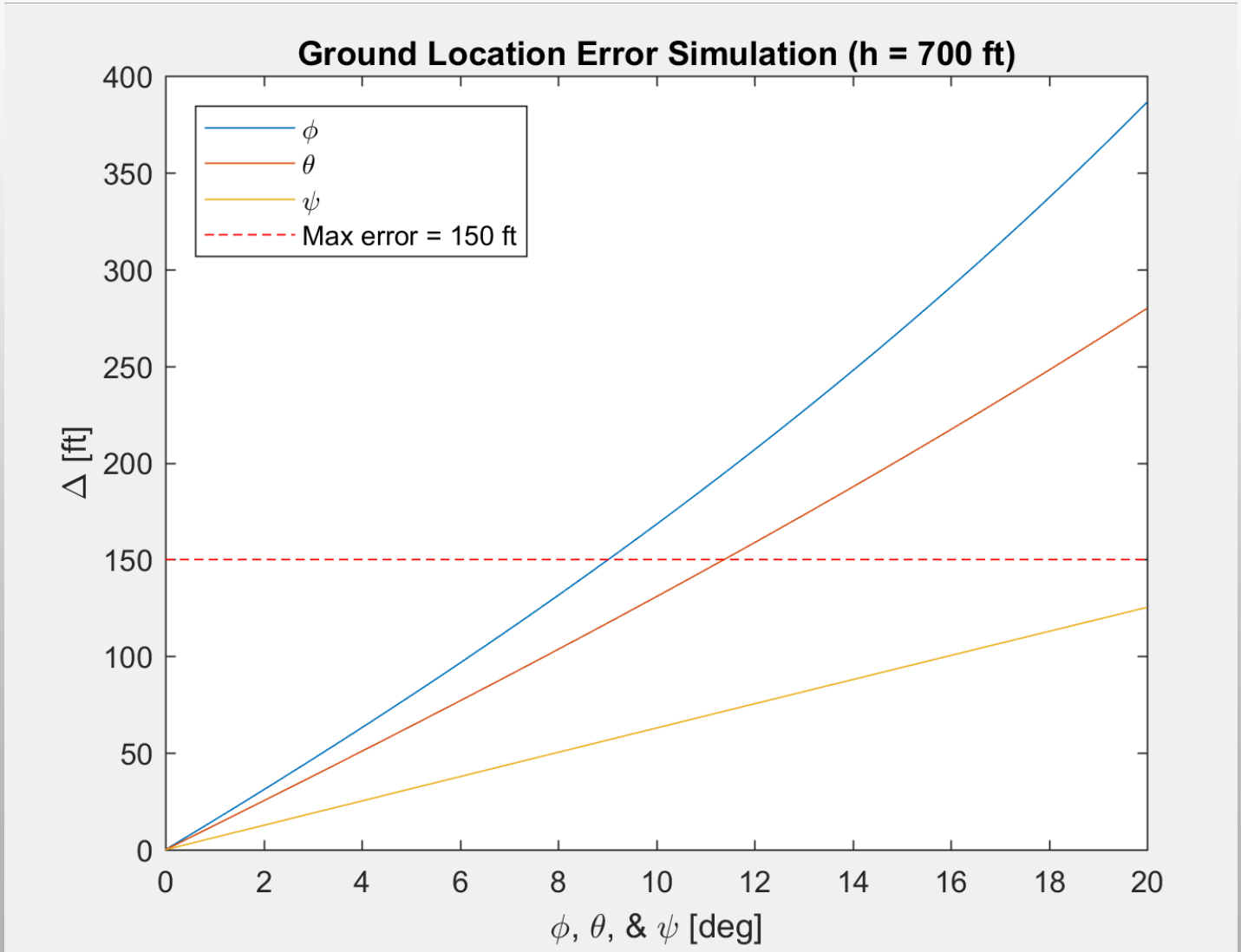
Machine: intel core i5 with 2 cores

Software Element	Current Time Estimate
ROI Detection	• 5 s for saliency map • 15-40 s for sliding window • < 1 s for all else • TOTAL: 15-40 s • IDEAL: < 5 s
ROI Geolocation	• < 1 s for algorithm & plotting • 1-5 s for telemetry data matching • TOTAL: 1-5 s • IDEAL: 1-2 s

Current EE Team Software Tasks

- Convert current Python code to MATLAB for easier integration
- Finalize classification algorithm using aero team test images
- Determine time complexity per image of algorithm
- Program payload controller to timestamp images and place into CPU folder
- Develop plan to convert aero and EE team software into .exe application
- Create User Interface to start program & display targets

Attitude Error with Payload & Algorithm Simulation



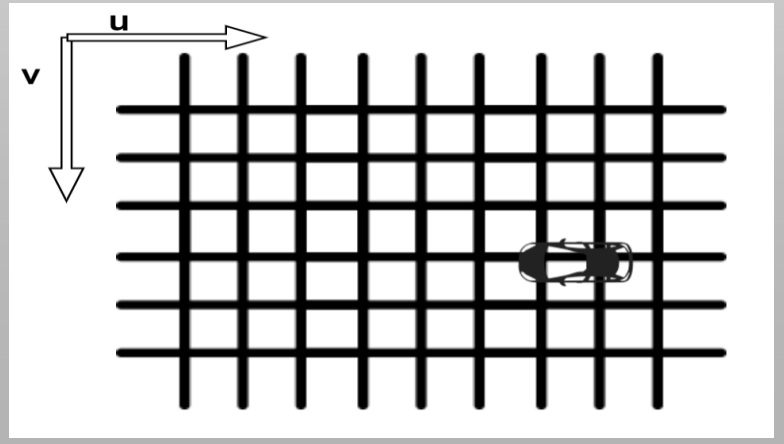
- Max pitch, roll uncertainty of 8-10 degrees
- Attitude uncertainty much less than max allowable value
- EE Payload specs compatible with requirements

Overview
Schedule
Hardware Stat
Electrical Statu
Software Statu
Budget

Pixel to World Transformation

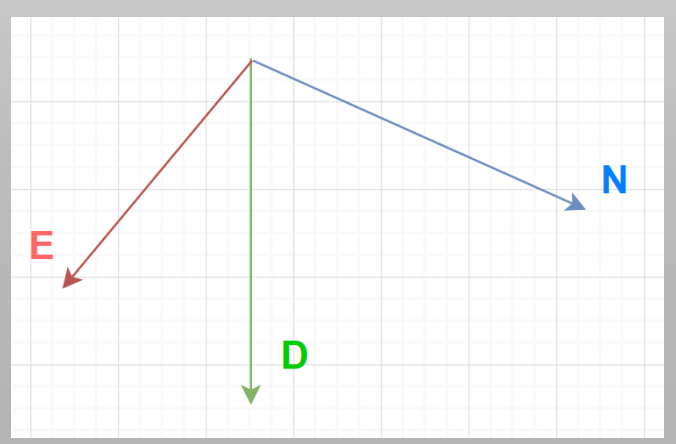
Knowns: Pixels and altitude

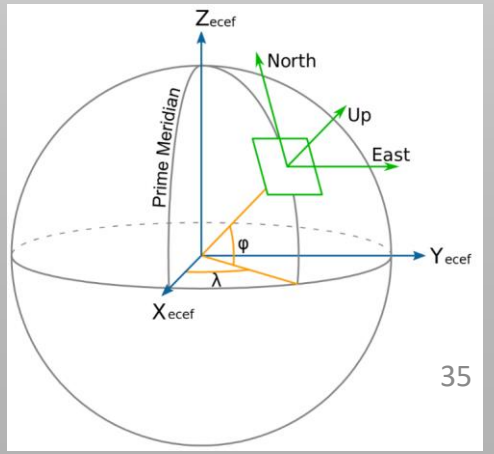
$$\begin{bmatrix} u \\ v \\ R\ (\text{range}) \end{bmatrix}$$



Unknown: World Coordinates

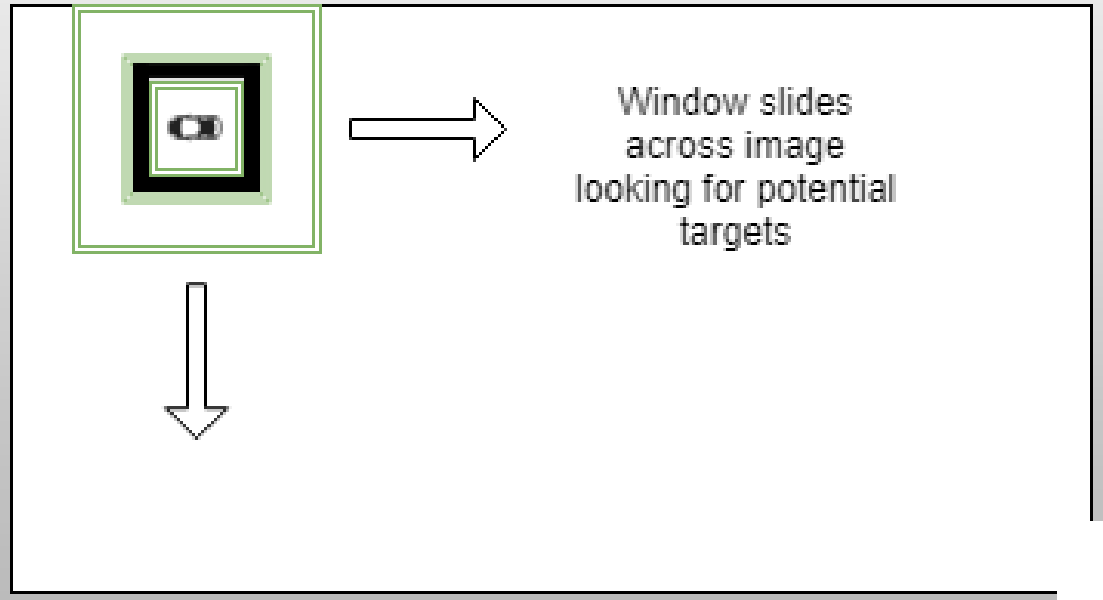
$$\begin{bmatrix} N\ (\text{north}) \\ E\ (\text{east}) \\ D\ (\text{down}) \end{bmatrix}$$





Software: Sliding Window

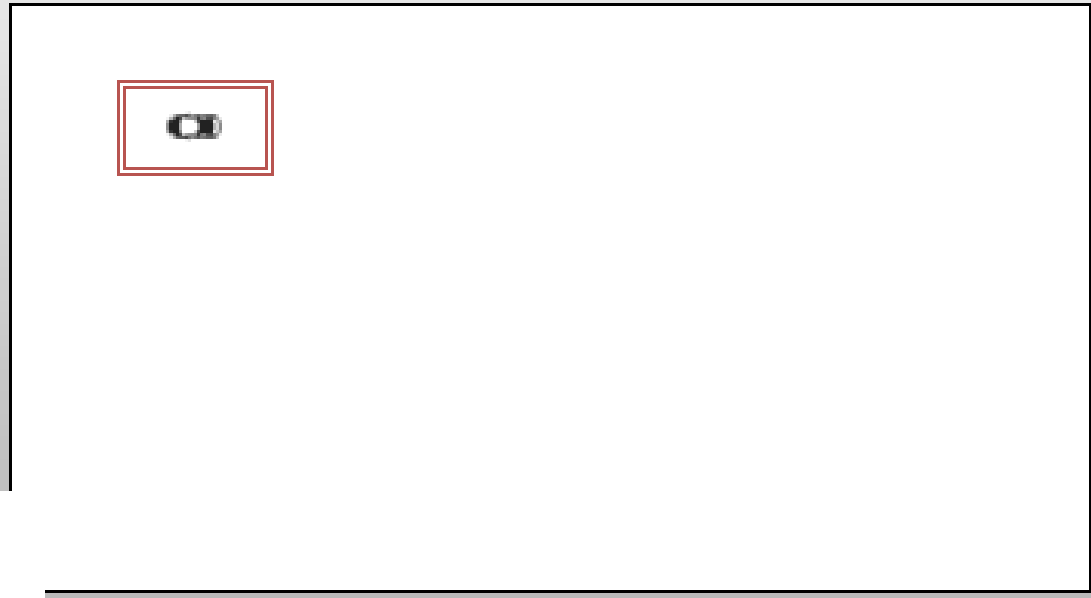
Compare statistics between windows using T-test:



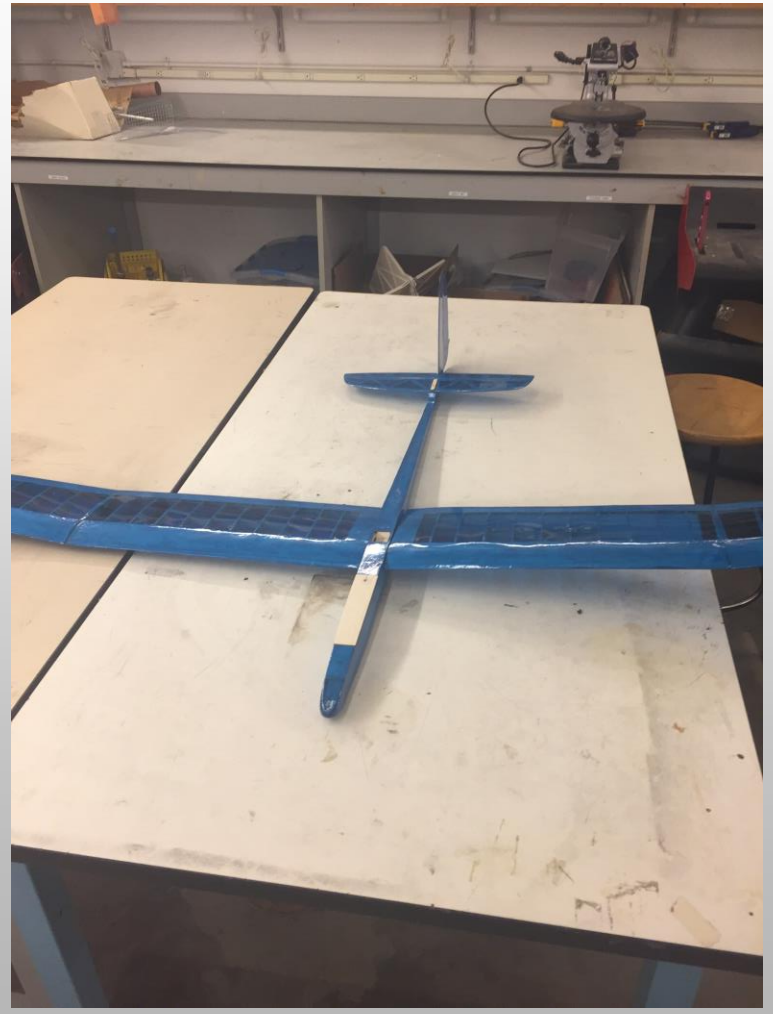
$$T = \frac{|\overline{X_1} - \overline{X_2}|}{\sqrt{s_1^2 + s_2^2}}$$

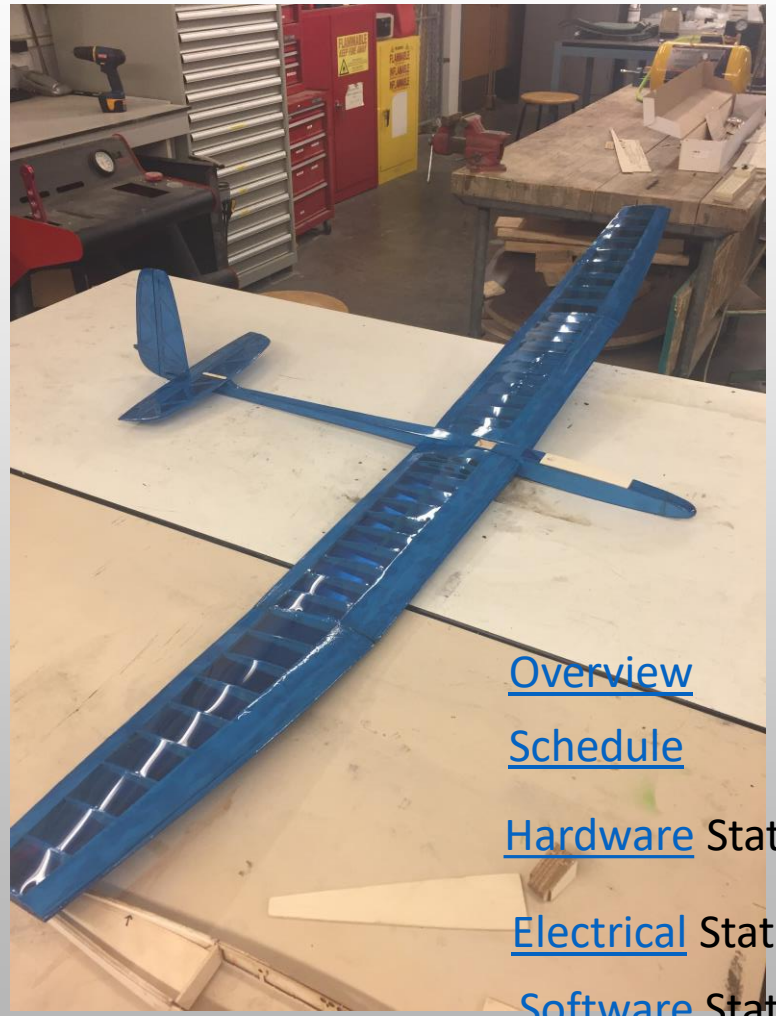
$\bar{X} = mean, s = \text{variance}$

Highlight regions of interest for classification and geolocation

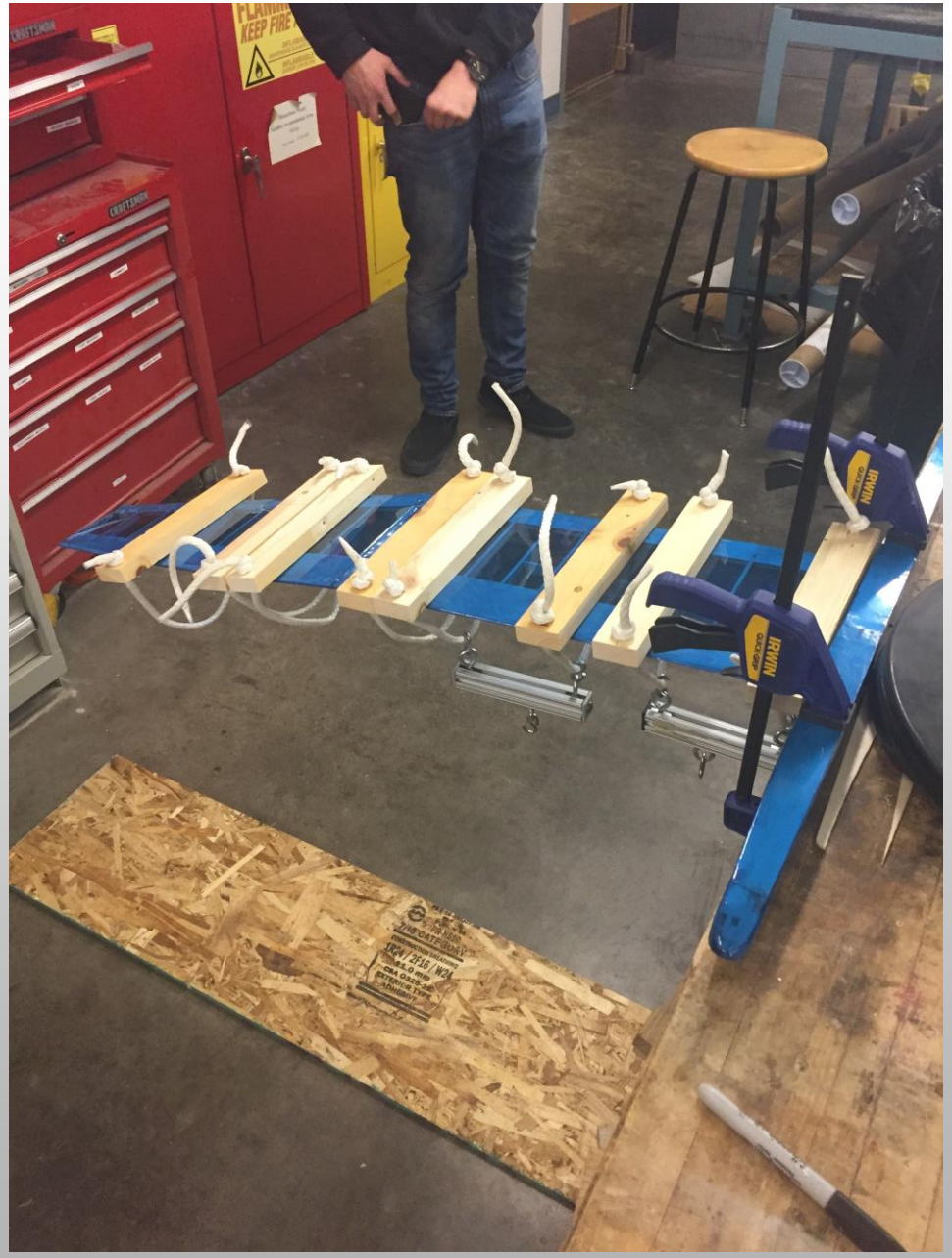


Whiffle Test Photos





Overview
Schedule
Hardware Status
Electrical Status
Software Status
Budget


IRWIN
IRWIN