TEAM VERSA-TOL

Midterm 1 Presentation
Conceptual Design

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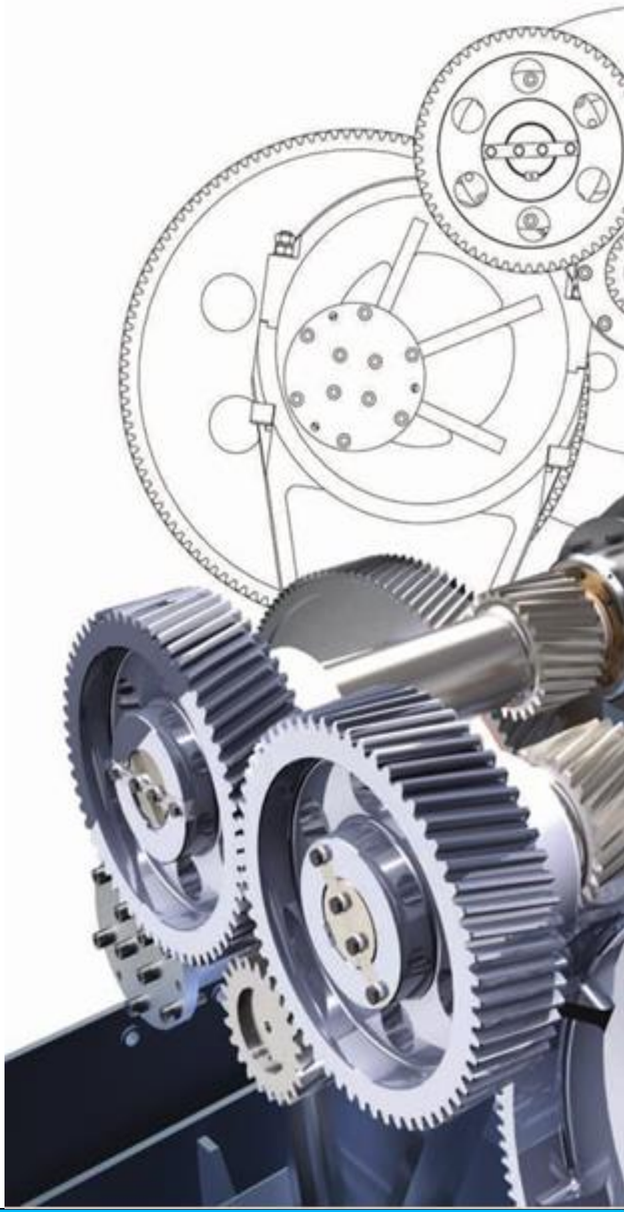
Agenda

- Background
- Constraints & Requirements
- Project Scope
- Objectives
- Design Concepts
- Concept Evaluation
- Potential Challenges
- Relevant Data
- Future Plans
- Gantt Chart



Project Overview
Background

- The Seafarer Chapter of Association for Unmanned Vehicle Systems International (AUVSI)
- Student Unmanned Aerial System (SUAS) competition
- Challenges students to design a system capable of completing a specific and independent aerial operation.
- Stimulate and foster interest in innovation and careers in the aerospace industry

Project Overview
Contraints & Requirements

- Minimum 10 Hz communication
- Less than 55 pounds
- Max airspeed of 115 mph
- Flight altitude of 100ft – 750ft
- Sense, detect, and avoid capability

House of Quality

Customer Requirements	Customer Importance Low (0) -> High (5)	Weight	Energy Needed	Thrust	Material Strength	Flight Efficiency	Controls
Direction of Improvement		↓	↑	↑	↑	↑	↑
Autonomous Flight	5					⊙	●●
Visual Feed	5	○	○				
Payload Delivery	3	⊙	⊙			○	
Obstacle Avoidance	2					○	●
Heavier-than-air Flight	5	●●	●	⊙	●	●●	
Cost	4	⊙			●		
Time of Flight	3	⊙	●●	●		●●	
VTOL Flight	4	●	●●	●	⊙	●●	●
Importance Rating Σ(Priority X Relationship)		123	122	69	79	145	92
Relative Importance		20	19	11	13	23	15
Rank Order of Engineering Characteristics Low (6) -> High (1)		2	3	6	5	1	4

Engineering Characteristics

Technical Assessment

Correlations:
- ⊕ Strong Positive
- + Positive
- ⊖ Strong Negative
- − Negative

Relationships:
- ●● Strongest= 10
- ● Strong= 7
- ⊙ Fair= 4
- ○ Weak= 1

Project Overview
Needs Assessment

Needs Statement

- "There needs to be an autonomous aerial vehicle capable of navigating waypoints, searching autonomously, and identifying targets."

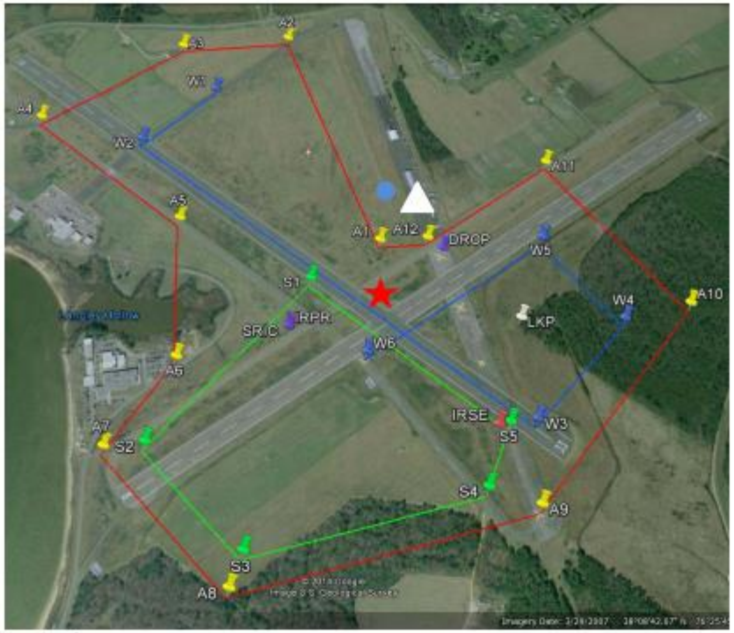
Goal Statement

- "The goal is to design an autonomous aerial vehicle able to compete in the SUAS competition and capable of vertical take-off and landing."

Project Overview
Project Scope

Design an aircraft that fulfill the customer requirements, as well as competition specifications.

- Capable of Vertical Take-Off & Landing (VTOL)
- Autonomously navigating waypoints and search large areas for targets and actionable intel



- Search Area
- No-Fly Zone
- Waypoints

Project Overview
Objectives

- Manifest and complete a VTOL vehicle design
- Purchase, gather, or manufacture components
- Integrate and test mechatronics via firmware development
- Assemble prototype and conduct benchmarking
- Test both manual control and autonomy
- Develop and test sensor package and telemetry
- Quantify and improve vehicle performance
- Compete at competition (June 15-19, 2016)

Design Concepts

- Quadcopter
- Firefly Y6
- Previous Year Design
- Skywalker Tri-copter

Design Concepts

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Figure 1 – Quadcopter[3]

Design Concepts

- Quadcopter
- Firefly Y6
- Previous Year Design
- Skywalker Tri-copter

Figure 2 - Firefly Y6[1]

Design Concepts

- Quadcopter
- Firefly Y6
- Previous Year Design
- Skywalker Tri-copter

Figure 3 - 2014 Team 8 Vehicle

Design Concepts

- Quadcopter
- Firefly Y6
- Previous Year Design
- Skywalker Tri-copter

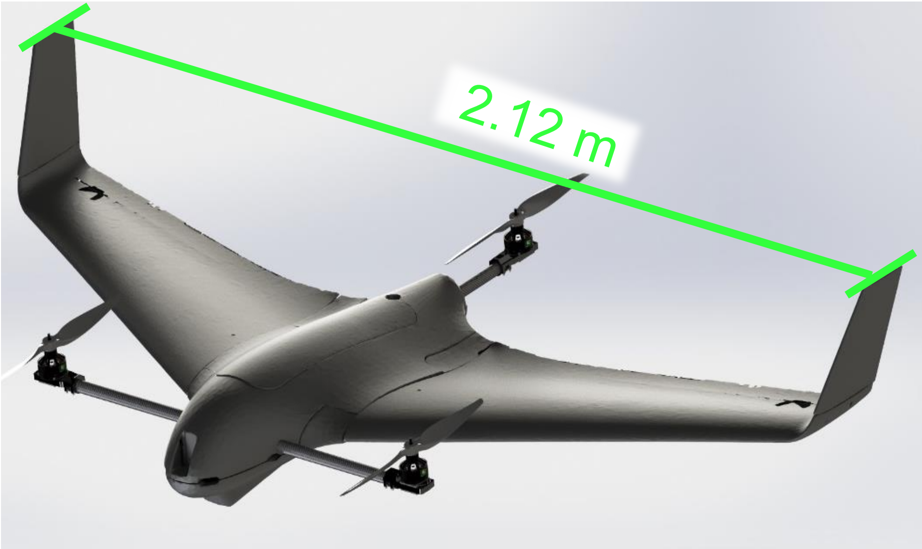


Figure 4 - Skywalker Tri-Copter

Concept Evaluation
Quadcopter

- Inefficient with horizontal flight
- 4 motors, more power consumption

Concept Evaluation
Firefly Y6

- Payload weight is low
- Expensive
- 6 motors, even more power consumption

Concept Evaluation

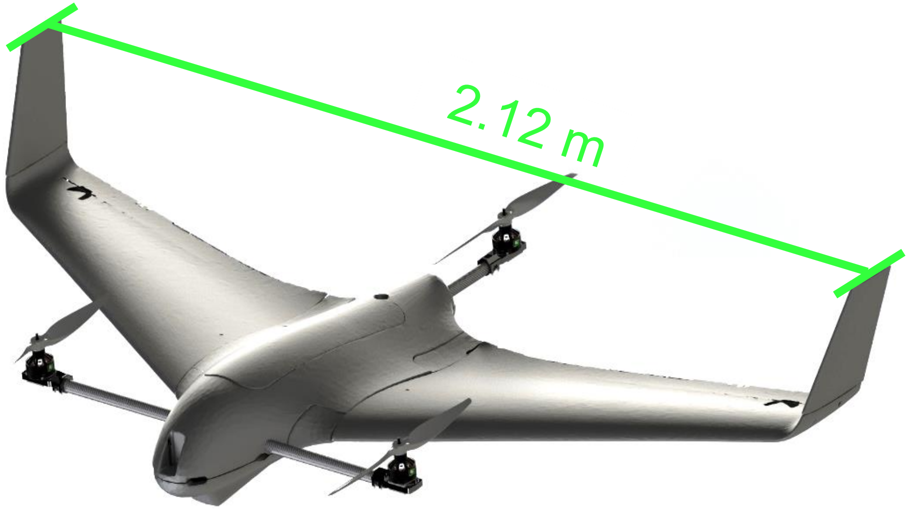
Previous Year Design

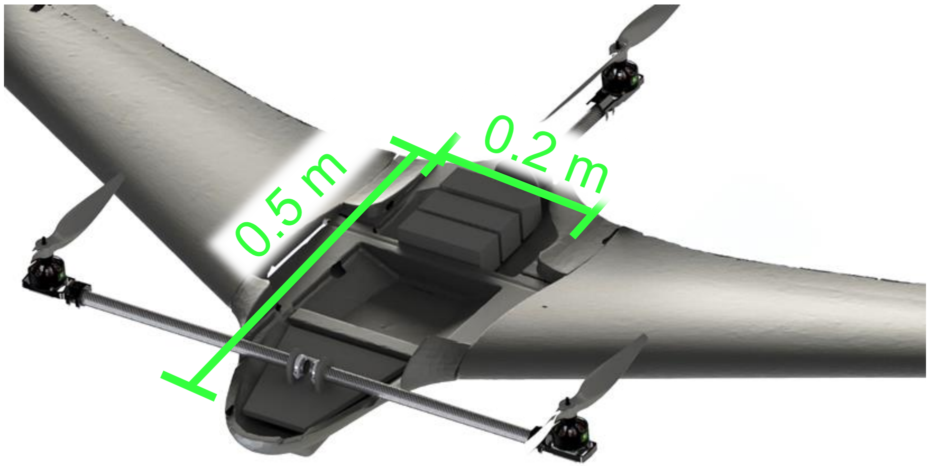
- Heavy (8,238g)
- Firmware not supported
- Difficult to repair / modify
- Unstable horizontal flight
- Relatively high power consumption

Concept Evaluation

Skywalker Tri-copter

- Lighter (5,500g)
- Proven Concept
- Durable
- Easily replaceable parts
- Large internal capacity
- Lower power consumption





Potential Challenges

- Firmware complications
- Limited references for this type of vehicle
- Autonomous flight
- Imaging software / hardware
- Competition fees

Relevant Data
Motor Spec

Component	New Design
All up weight	5500g
Number of motors	3
Thrust needed per motor	~1850g or ~65oz
Thrust (n = 2)	~3700g or ~ 131oz
Size of props	16” x 5.5”

Figure 5 – 4510/450kv Cobra Motor[4]

Relevant Data
Motor Spec

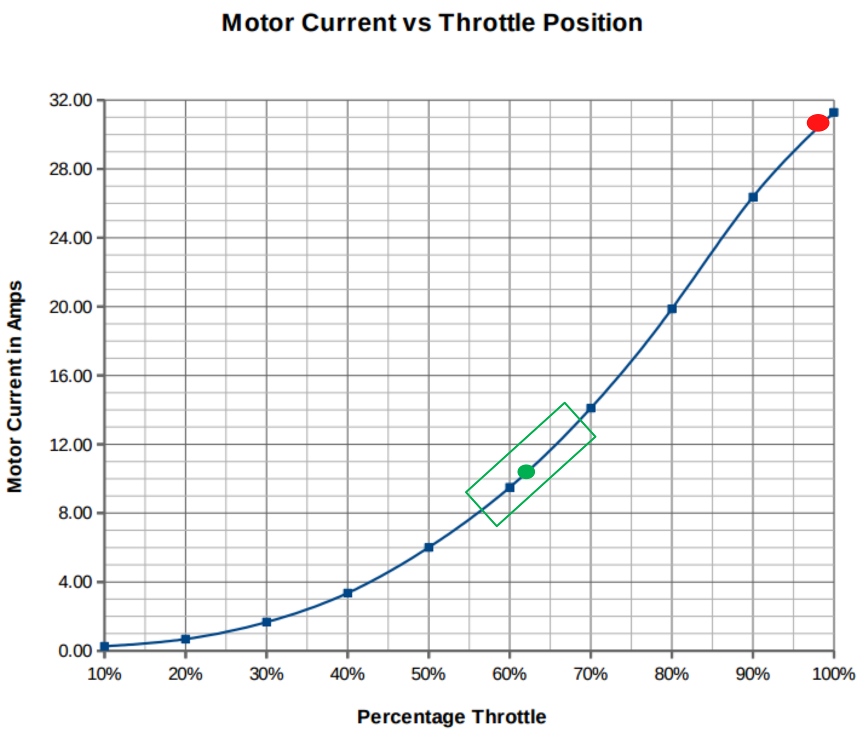


Figure 6 – Motor Current vs Throttle Position Graph

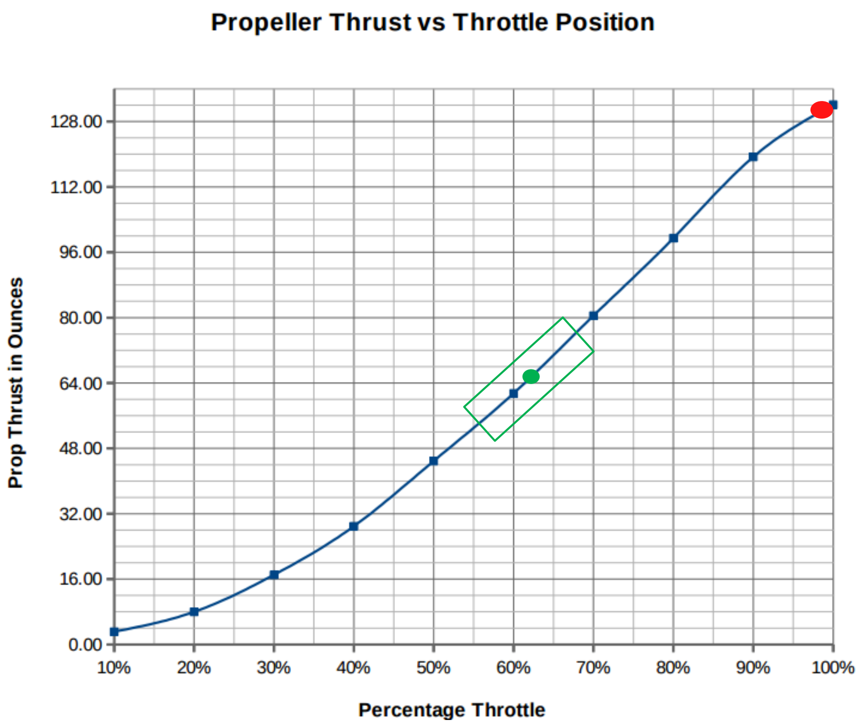


Figure 7 – Propeller Thrust vs Throttle Position Graph

- Desired weight

- Design Tolerance ($\pm 1kg$)

- Safety factor (n = 2)

Relevant Data

Prop Spec

Prop Manf.	Prop Size	Li-Po Cells	Input Voltage	Motor Amps	Input Watts	Prop RPM	Pitch Speed in MPH	Thrust Grams	Thrust Ounces	Thrust Eff. Grams/W
APC	14x5.5-MR	6	22.2	21.50	477.3	7,525	39.2	2788	98.34	5.84
APC	16x5.5-MR	6	22.2	31.29	694.6	6,915	36.0	3749	132.24	5.40
APC	18x5.5-MR	6	22.2	38.76	860.5	6,414	33.4	4468	157.60	5.19
GemFan	15x4.5-MR	6	22.2	19.73	438.0	7,638	32.5	2661	93.86	6.08
GemFan	16x4.5-MR	6	22.2	25.37	563.2	7,276	31.0	3220	113.58	5.72
RC-Timer	12x5.5-CF	6	22.2	16.44	365.0	7,874	41.0	1911	67.41	5.24
RC-Timer	13x5.5-CF	6	22.2	21.90	486.2	7,495	39.0	2417	85.26	4.97
RC-Timer	14x5.5-CF	6	22.2	29.31	650.7	7,021	36.6	2855	100.71	4.39
RC-Timer	15x5.5-CF	6	22.2	39.95	886.9	6,352	33.1	3375	119.05	3.81

Figure 9 – 4510 Cobra motor propeller comparison[6]

Propeller Chart Color Code Explanation

- (Blue) The prop is to small to get good performance from the motor. (Less than 50% power)
- (Green) The prop is sized right to get good power from the motor. (50 to 80% power)
- (Yellow) The prop can be used, but full throttle should be kept to short bursts. (80 to 100% power)

Relevant Data
Flight Time

- Better flight time (65% increase) from previous year's design

Component	Old Design	New Design
Amp Draw (100%)	38.76	31.29
Number of Motors	4	3
Total Amp Draw	155.04	93.87
Flight Time (mins) [A.3]	3.87	6.39

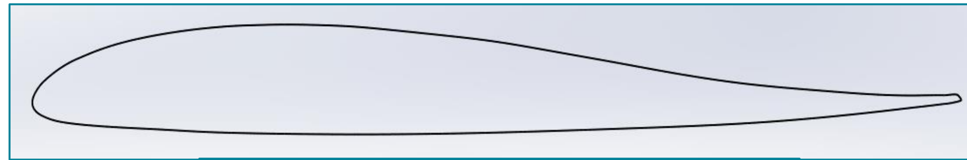
** Based on 100% thrust, 22.2 volt system, and 10,000 mAh battery

Figure 8 – Electronic Speed Controller[5]

Relevant Data

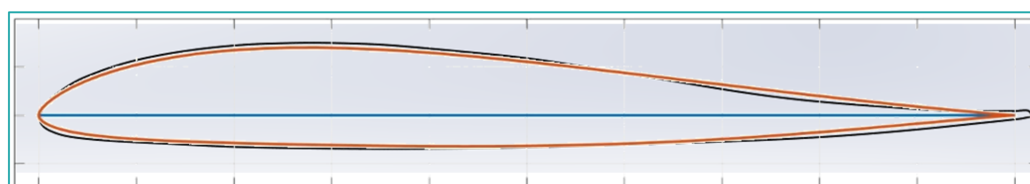
Airfoil Determination

- Airfoil needed for aerodynamic characteristics
- 2-D Sketch from 3-D model
- Tailless R/C Aircraft



Cross Section of Model

EH 2.0/10



Overlapping

Relevant Data
Lift and Drag Coefficients

- Airfoil Tools Analysis of EH 2.0/10
  - Based on Reynold's Number (200,000 Below)
  - Outputs lift and drag coefficients based on angle of attack (alpha)

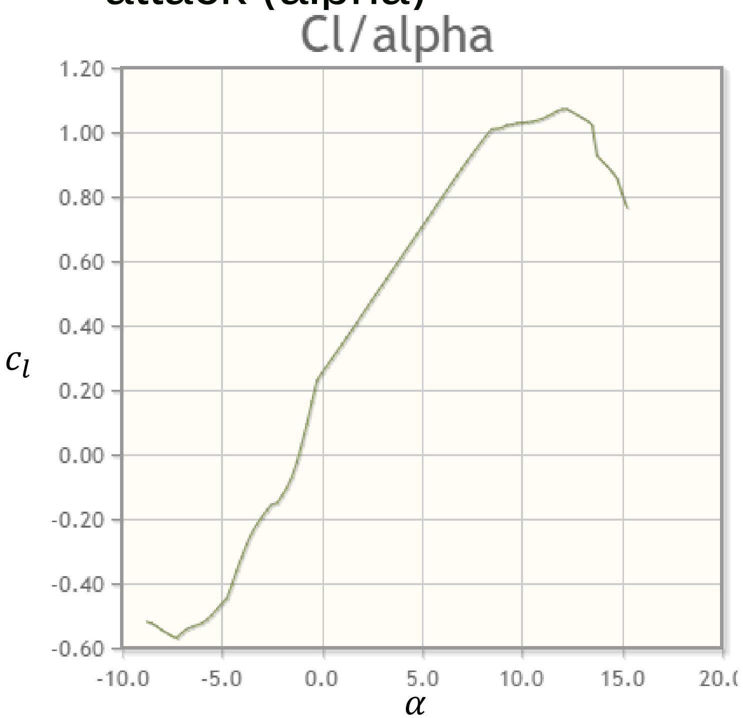


Figure 9 – Coefficient of Lift vs. Angle of Attack

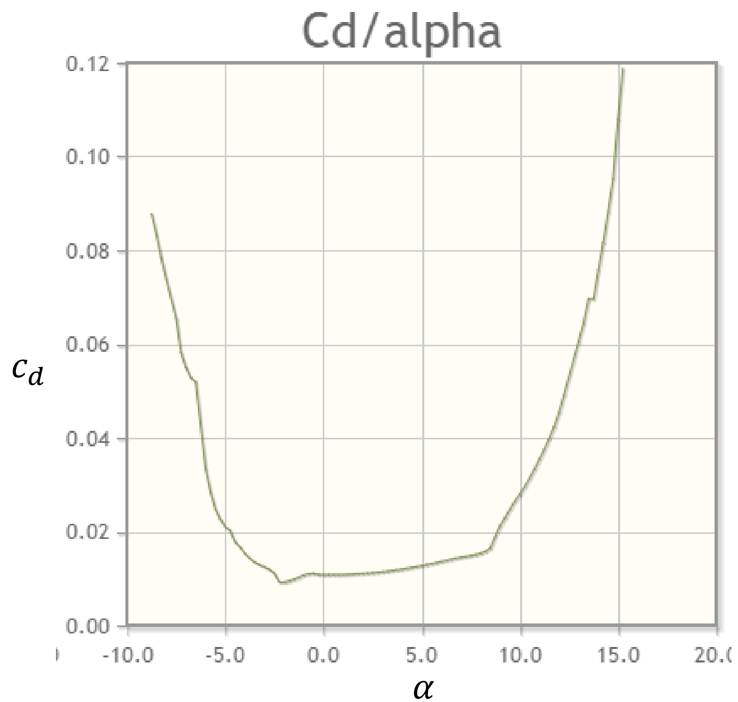


Figure 10 - Coefficient of Drag vs. Angle of Attack

Relevant Data
Lift Force

- Relationship formed from varying Reynold's Numbers (Re)
- Estimated Weight: 5500g
- Predicted Velocity: ~12.5 m/s[A.1-2]

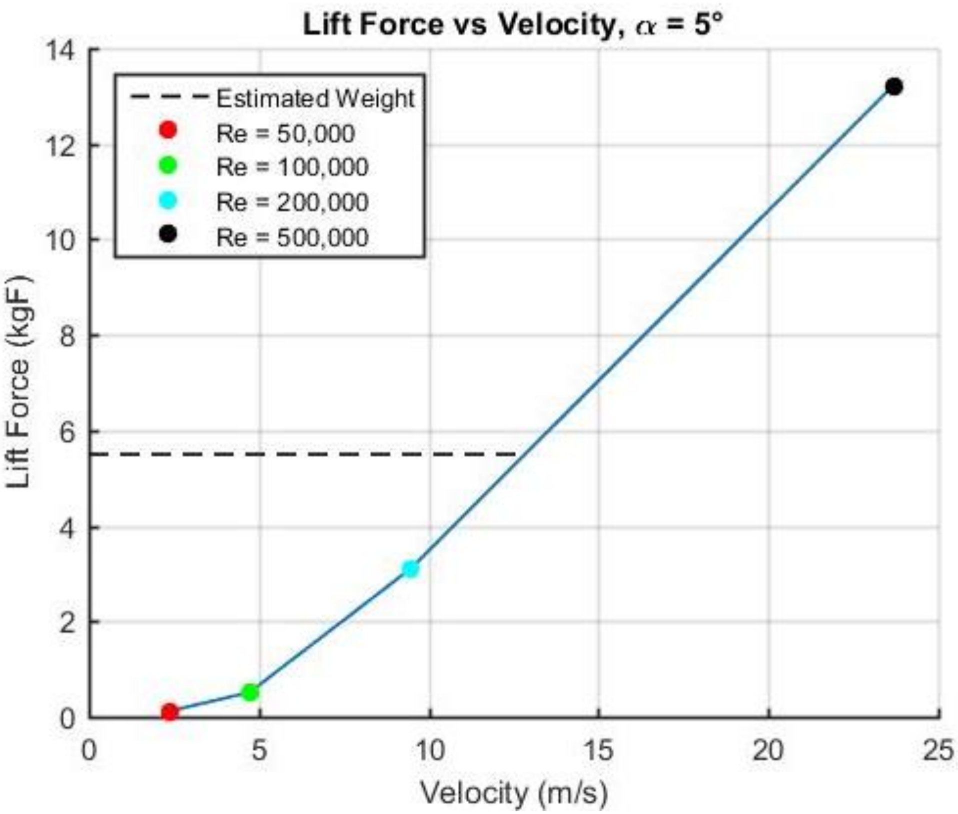


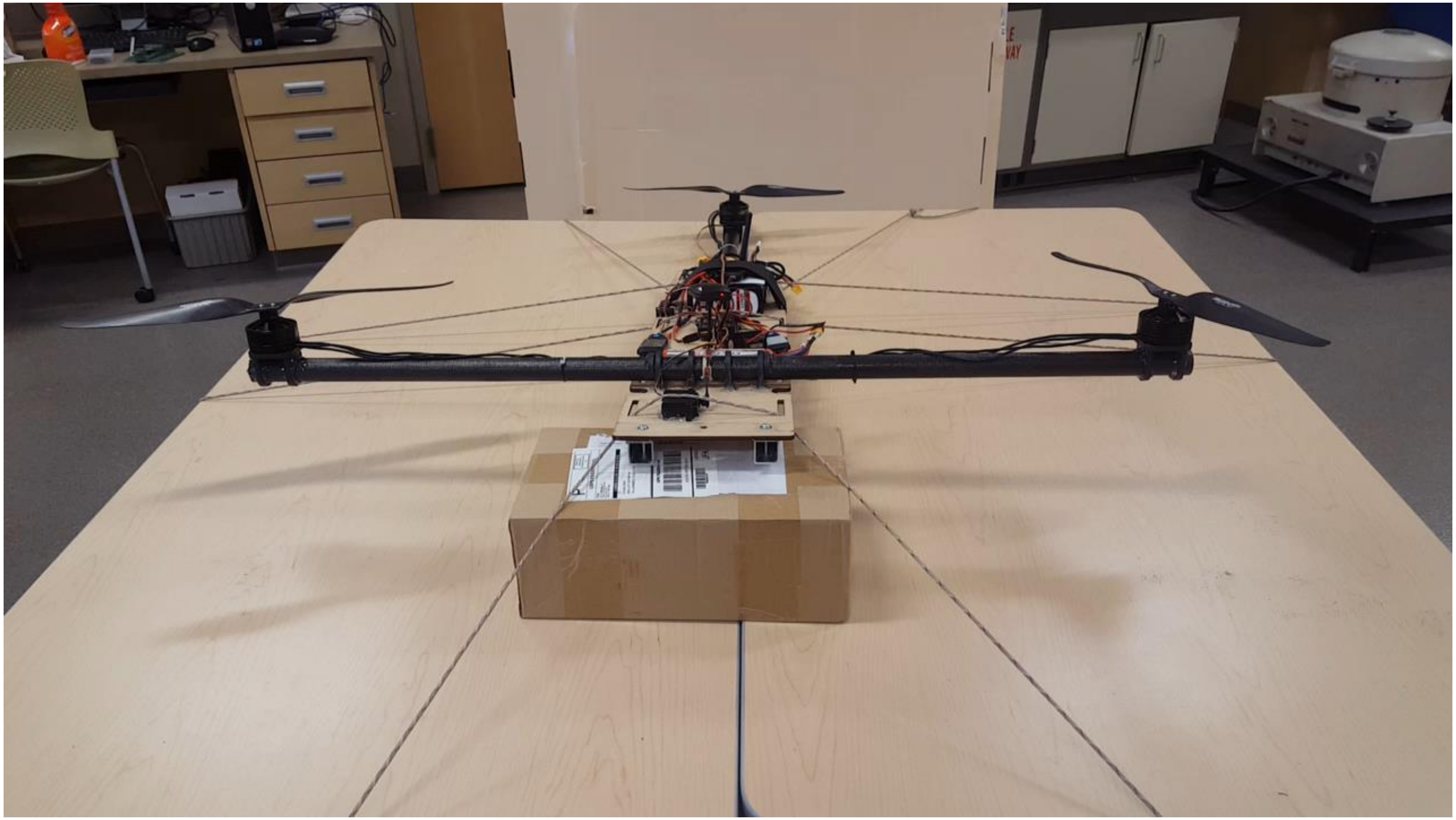
Figure 11 – Vertical Lift vs Horizontal Speed

Relevant Data
Current Firmware Code

- User-Friendly
- Open-source collaboration
- VTOL Firmware
- Diverse hardware compatibility

Figure 12 – Pixhawk Microcontroller[2]

Future Plans
Current Work



Future Plans

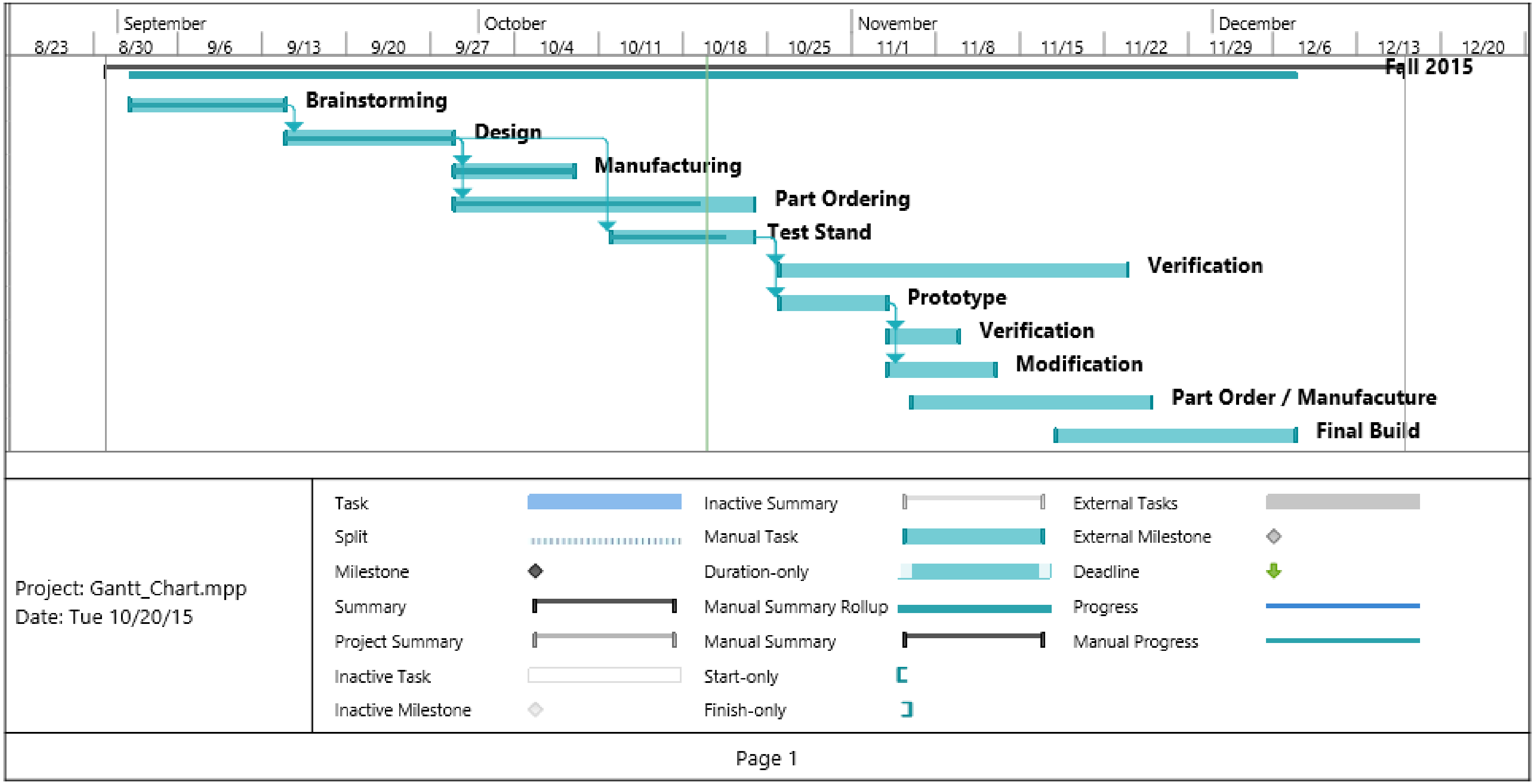
1st Semester - Vehicle

- Fully Functioning Aerial Vehicle
- Autonomous flight

2nd Semester - Competition Objectives

- Functioning sensor package
- Waypoint navigation
- Payload delivery

Gantt Chart



September
October
November
December
8/23
8/30
9/6
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10/11
10/18
10/25
11/1
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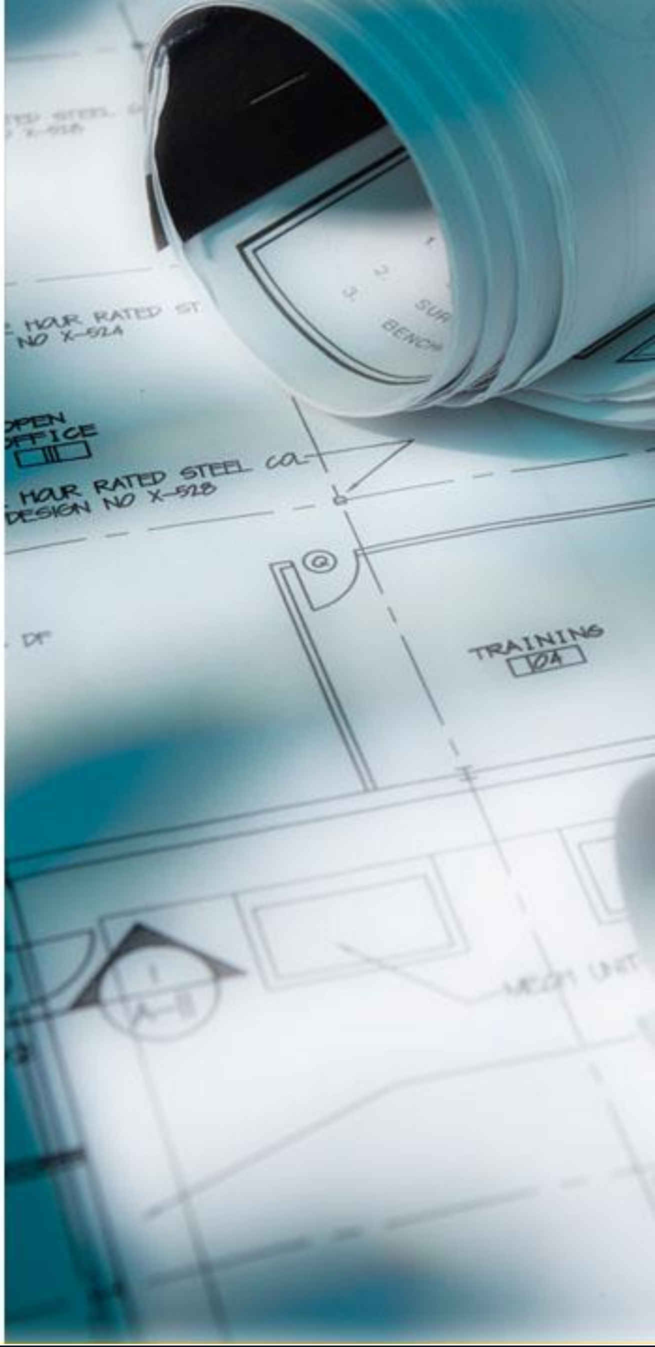
11/15
11/22
11/29
12/6
12/13
12/20
Fall 2015
Brainstorming
Design
Manufacturing
Part Ordering
Test Stand
Verification
Prototype
Verification
Modification
Part Order / Manufacuture
Final Build
Project: Gantt_Chart.mpp
Date: Tue 10/20/15
Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress
Page 1

Summary

- Tri-copter
- Flying Wing
- Tilt-Rotor
- Pixhawk Microcontroller

TEAM

VERSA-TOL



References

[1] - "FireFLY6 - Welcome to the Revolution." BirdsEyeView Aerobotics. N.p., 2015. Web. 20 Oct. 2015.

[2] - Hazelhurst, Jethro. "Pixhawk Graphic for Documentation." DIY Drones. N.p., 18 Dec. 2013. Web. 19 Oct. 2015.

[3] - Owenson, Gareth. "How to Build Your Own Quadcopter Autopilot / Flight Controller." Owenson.me. N.p., n.d. Web. 19 Oct. 2015. <http://owenson.me/build-your-own-quadcopter-autopilot/>.

[4] - "Cobra CM-4510/28 Multirotor Motor,KV=420." Cobra Motors USA. N.p., n.d. Web. 19 Oct. 2015. < http://www.cobramotorsusa.com/multirotor-4510-28.html>.

[5] - "Cobra 40A Opto Multirotor Esc" Cobra Motors USA. N.p., n.d. Web. 20 Oct. 2015 <http://www.cobramotorsusa.com/multirotoresc-40amp.html>.

[6] - "Cobra CM-4510/28 420Kv Motor Propeller Data" Innov8tive Designs. N.p., n.d. Web. 20 Oct. 2015 <http://innov8tivedesigns.com/images/specs/Cobra_CM-4510-28-420Kv_Specs.htm>.

Appendix

Reynold's Number:

$$Re = \frac{\vec{V} * L}{v} \quad [1]$$

Lift Equation:

$$F_L = C_L * \frac{\rho * \vec{V}^2}{2} * s \quad [2]$$

Flight Time:

$$Time = \frac{Battery\ Capacity}{Total\ Amperage} \quad [3]$$

Questions