NORTHROP GRUMMAN

Drone Disabling Device Virtual Design Review 2

Ryan Cziko
Quentin Lewis
Dylan Macaulay
Trevor Stade
Taylor Stamm

Team 518

Team Introduction

Trevor Stade

Project Manager

Mechanical Engineering

Quentin Lewis

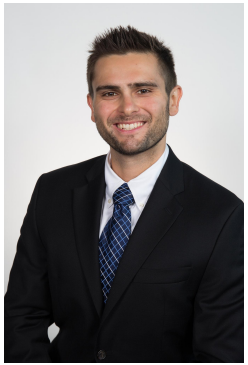
Sensor Interface Engineer

Computer Engineering

Ryan Cziko

Test Engineer

Mechanical Engineering



Taylor Stamm

Systems Integration Engineer

Electrical Engineering

Dylan Macaulay

Design Engineer

Mechanical Engineering

Objective

[2]

Develop a device to secure specified air space from unmanned flight vehicles. There needs to be an improvement upon functionality, size, and overall use.

Quentin Lewis

Key Goals

[3]

- Develop wider-frequency band signal jamming of the drone
- Improve speed and accuracy of drone-detecting functionality
- Reduce size of drone disabling apparatus to the size of a rifle
- Increase range of device functionality to a 50 ft dome
- Adhere to all safety, legal, and environmental regulations

Targets

Quentin Lewis

Targets

Target Values						
Target No.	Need	Metric	Importance	Units	Marginal Value	Ideal Value
1	2, 10	Assembly & Disassembly Time	5	min	60	5
2	10	Weight of Device	5	lbs	30	10
3	4,5,10	Disabling Range	3	ft3	30	50
4	10	Target Acquisition Speed	4	s	20	5
5	10	Battery Life	3	h	2	3
6	3,5,10	Frequencies Jammed	3	GHz	2.4	2.4 and 5
7	2,10	Device reload speed	1	min	5	2
8	10	Target max drone wingspan	3	in	25	30
9	10	Target max drone Weight	3	lbs	4	6
10	1-9	Project Cost	5	$	5000	2500

Quentin Lewis

Highlighted Device Targets

Metric	Marginal Value	Ideal Value	Units
Assembly & Disassembly Time	60	5	Minutes
Weight of Device	30	10	Lbs
Project Cost	5000	2500	$
Target Acquisition Speed	20	5	Seconds

Quentin Lewis

Concept Generation

Quentin Lewis

Detection

- 3D Imaging
- Infrared
- Sound
- Electromagnetic Signature
- Sonar

→

- 3D Imaging
- Infrared

→

Quentin Lewis

3D Imaging

- Uses cameras and algorithms to recognize distinct features of the drone

Pros

- Fast recognition speed
- Highly accurate when well-trained

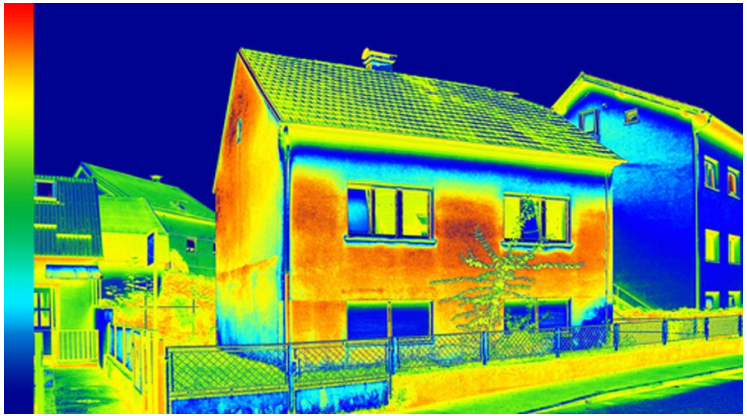
Cons

- Ineffective in non-ideal lighting conditions
- Accuracy is dependent on camera quality

Quentin Lewis

Infrared

- Uses thermal infrared imaging to detect heat signatures



Pro

- Can detect drones in low visibility conditions

Cons

- Also detects birds/flying insects
- Much more expensive than standard cameras

Quentin Lewis

Drone Capture

- Net
- Hook
- Counter-Drone Towing
- Magnet
- Hacking
- Projectile

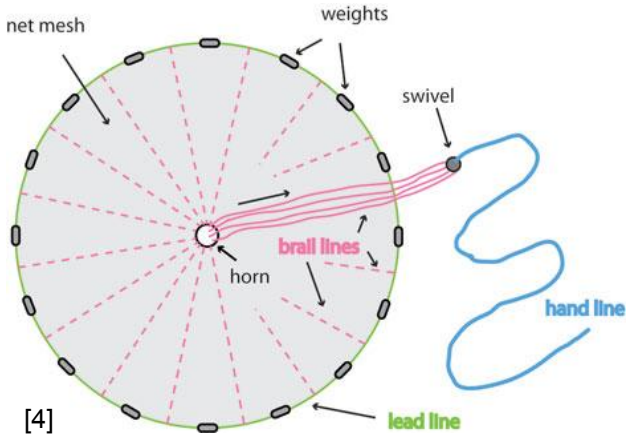
→

- Net
- Projectile

Quentin Lewis

Net

- Fired from launcher
- Driven by propulsion
- Tangles blades of drone
  - Poly Dacron
  - Nylon



[4]

Pros

- Large surface area, allowing room for human error
- Multiple disabling factors (weights, tangling)

Cons

- Difficult to launch long distances
- Firing multiple shots is slow

Quentin Lewis

Projectile

- Fired from launcher or “rifle”
- Can be small or large
- Driven by propulsion
- Hits body or blade of drone

[5]

Pros

- Fast-moving
- Long range

Cons

- May be difficult to hit drones due to small size
- High probability of destroying drones

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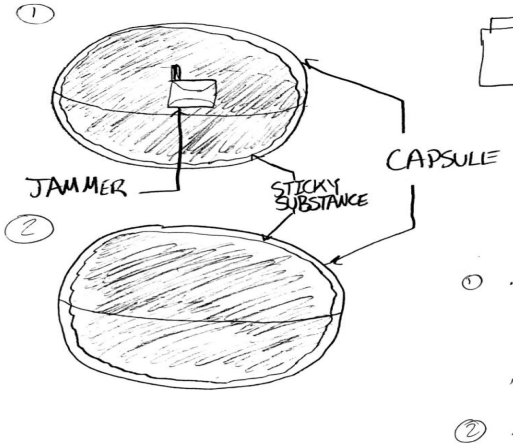
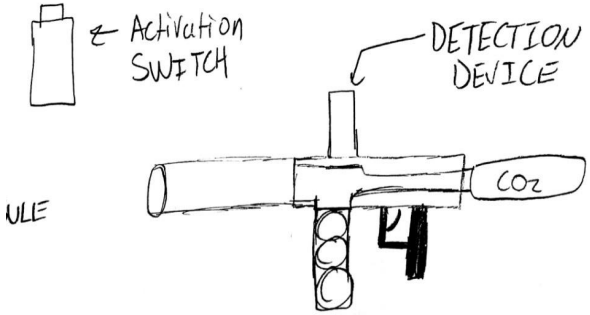
Concept #1

- Modeled after classic paintball gun
- Activation switch for jamming
- CO2 tank allows for additional projectiles fired

- Small project fired
- Must hit target in order to disrupt frequencies





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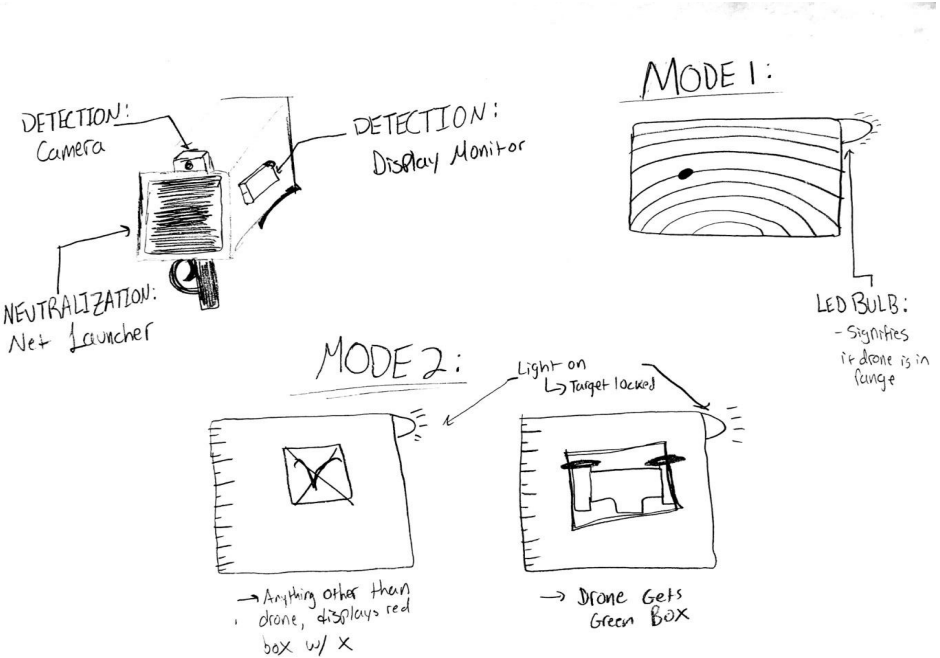
Concept #2

- Ideal use of detection system
- High mobility
- LED notification

- Integration of compressed air makes device large and bulky
- Computer systems exposed to elements

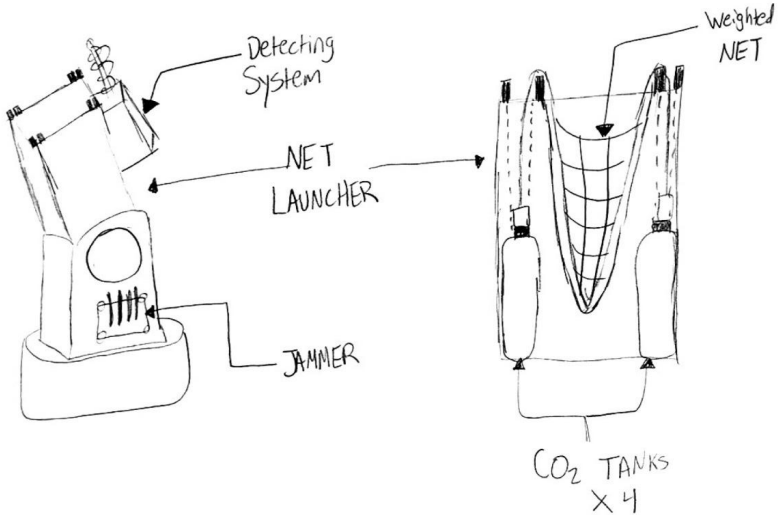


Dylan Macaulay

Concept #3

- High powered
- Wide range of Coverage
- All in one device

- Low mobility
- Uses four separate air systems

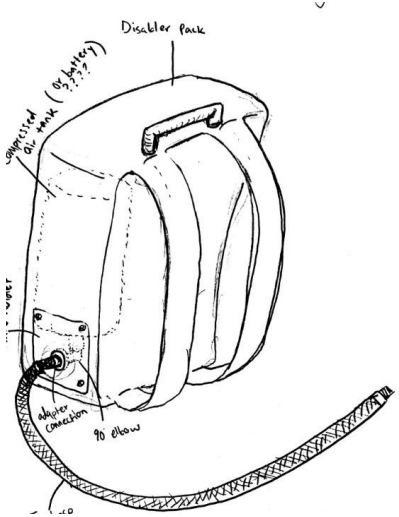


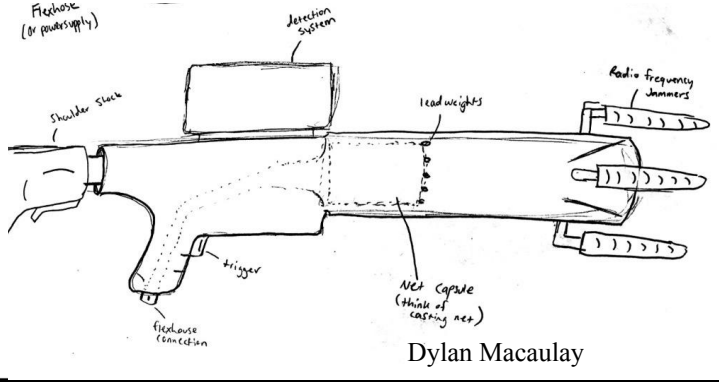
Dylan Macaulay

Concept #4

- Compressed air/CO2
- Concept can use most detection systems
- High mobility
- Can include jamming system to device

- One shot with net/Limited to tank capacity
- Pack including tank/power sources can weigh





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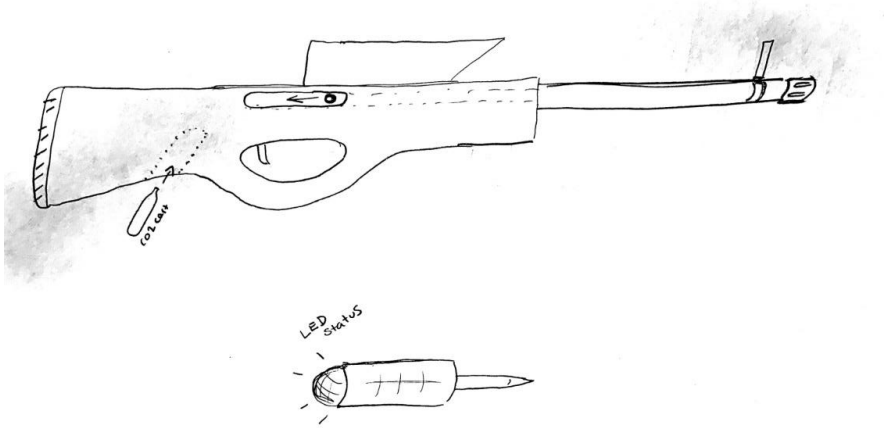
Concept #5

- CO_2/High powered spring
- Quick assembly/disassembly process
- High mobility

- Small projectile fired
- Concept relies on outside jamming for interference
- Low chance of drone neutralization



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Concept Selection

Dylan Macaulay

HOQ

- Importance for customer requirements was determined through pairwise comparison
- Improvement direction for our design evaluated for each engineering characteristic
- Correlation of customer requirements and engineering characteristics shown
- From HOQ, top engineering characteristics selected

		Engineering Characteristics									
Improvement Direction		↓	↓	↑	↓	↑	↑	↓	↑	↑	↓
Units		Mins	lbs	Ft	Sec	Hr	Ghz	Sec	in	lbs	$
Customer Requirements	**Importance**	Assembly/Disassembly Time	Weight of Device	Disabling Range	Target Acquisition Speed	Battery Life	Frequencies Jammed	Device Reload Speed	Target Max Drone Wingspan	Target max drone weight	Project Cost
Automatic Detection System	**6**		3		9	9			9		9
Device reach	**4**		3	9		1		3	1		1
Neutralization of Drone (undamaged)	**5**			9	9	3	9		3	3	
Device Safety	**5**		3								1
Retrieval of Drone	**2**			1					3	9	
Device Mobility	**3**		9								
Length of Operation	**2**			1		9	9				3
Ease of use	**1**	9	3					9			
Raw Score		9	75	85	99	91	63	21	79	33	69
Relative Weight %		1%	12%	14%	16%	15%	10%	3%	13%	5%	11%
Rank Order		10	5	3	1	2	7	9	4	8	6

Dylan Macaulay

Pugh Matrix

- DroneShield DroneGun used for Datum [6][7]
- New Pugh matrix made with Concept 5 as Datum
- Top selection criteria then used to further analyze Concepts 2, 4, and 5

Selection Criteria	DroneGun	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Target Acquisition Speed	Datum	S	-	-	S	-
Battery Life		+	+	S	+	+
Disabling Range		-	-	-	-	-
Target Max Drone Wingspan		S	S	S	S	S
Weight of Device		+	-	+	-	+
Frequencies Jammed		S	S	S	S	S
# pluses		2	1	1	1	2
# minuses		1	3	2	2	2

Selection Criteria	Concept 5	1	2	3	4
Target Acquisition Speed	Datum	S	+	-	+
Battery Life		-	-	-	+
Disabling Range		-	S	-	+
Target Max Drone Wingspan		S	S	S	S
Weight of Device		S	-	-	-
Frequencies Jammed		+	+	+	S
# pluses		1	2	1	3
# minuses		2	2	4	1

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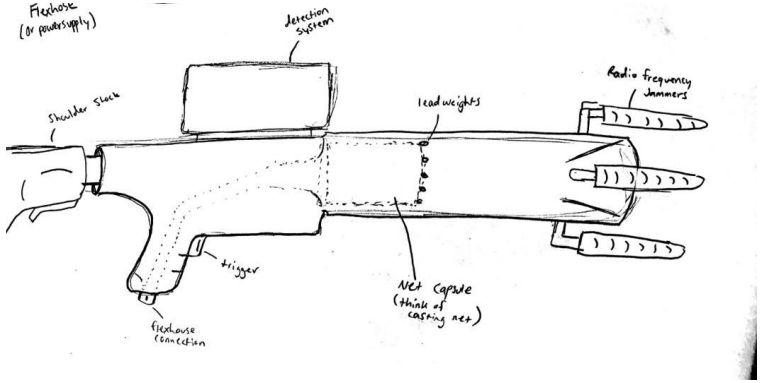
AHP Summarized

- Through the Analytical Hierarchy Process (AHP) Concept 4 was selected
- AHP was done for each criteria and each concept
- Final rating matrix shows Concept 4 with highest Alternative Value



Developement of Candidate set of Criteria weights {W} for Drone Disabling Device			
Criteria Comparison Matrix [C]			
	Disabling Range	Weight of Device	Battery Life
Disabling Range	1	0.3333333333	0.2
Weight of Device	3	1	0.3333333333
Battery Life	5	3	1
Sum	9	4.333333333	1.533333333

Final Rating Matrix				
Selection Criteria	**Disabling Range**	**Weight of Device**	**Battery Life**	**Alternative Value**
Concept 2	0.607001694	0.7513804714	0.2594645115	0.3319
Concept 4	0.08965430705	0.1679461279	0.06543515311	0.3473
Concept 5	0.303343999	0.08067340067	0.6751003354	0.3076

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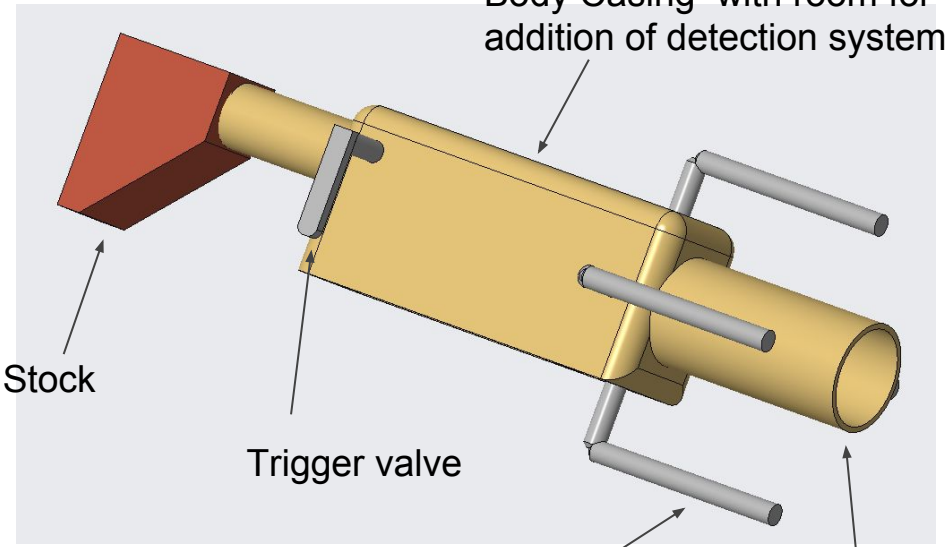
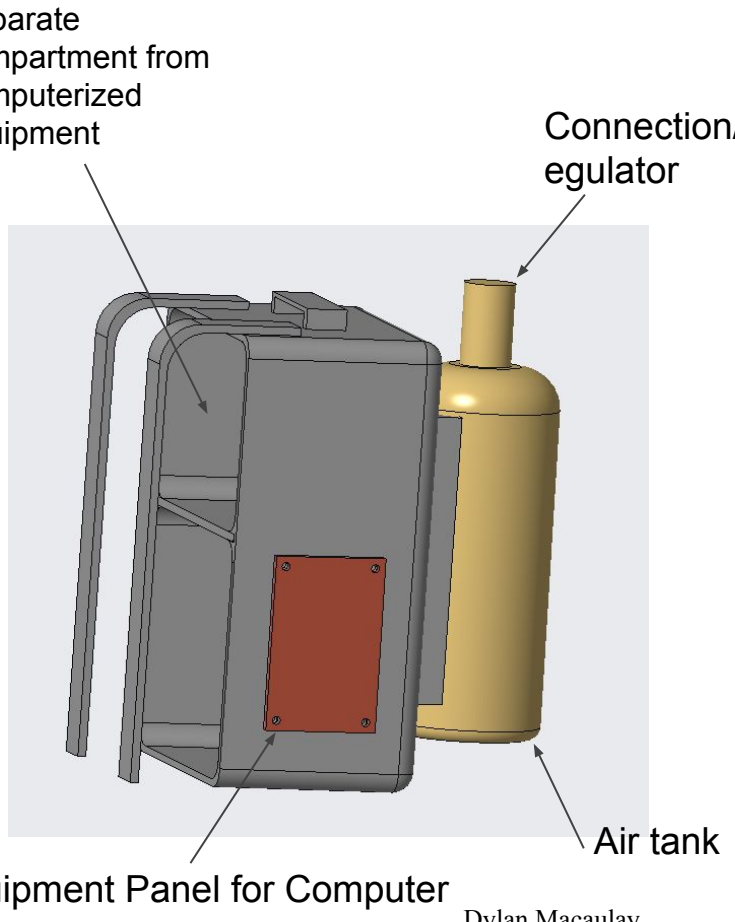
Concept Selection





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Summary

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Summary

- Progress since last design review
  - Developed targets for proposed design
  - Narrowed down large list of concepts to five feasible designs
  - Through HOQ and Pugh matrix five concepts narrowed to three
  - Analytical Hierarchy Process (AHP) showed best choice for concept
  - Concept 4 chosen and model designs created
  - Bill of Materials started for selected design

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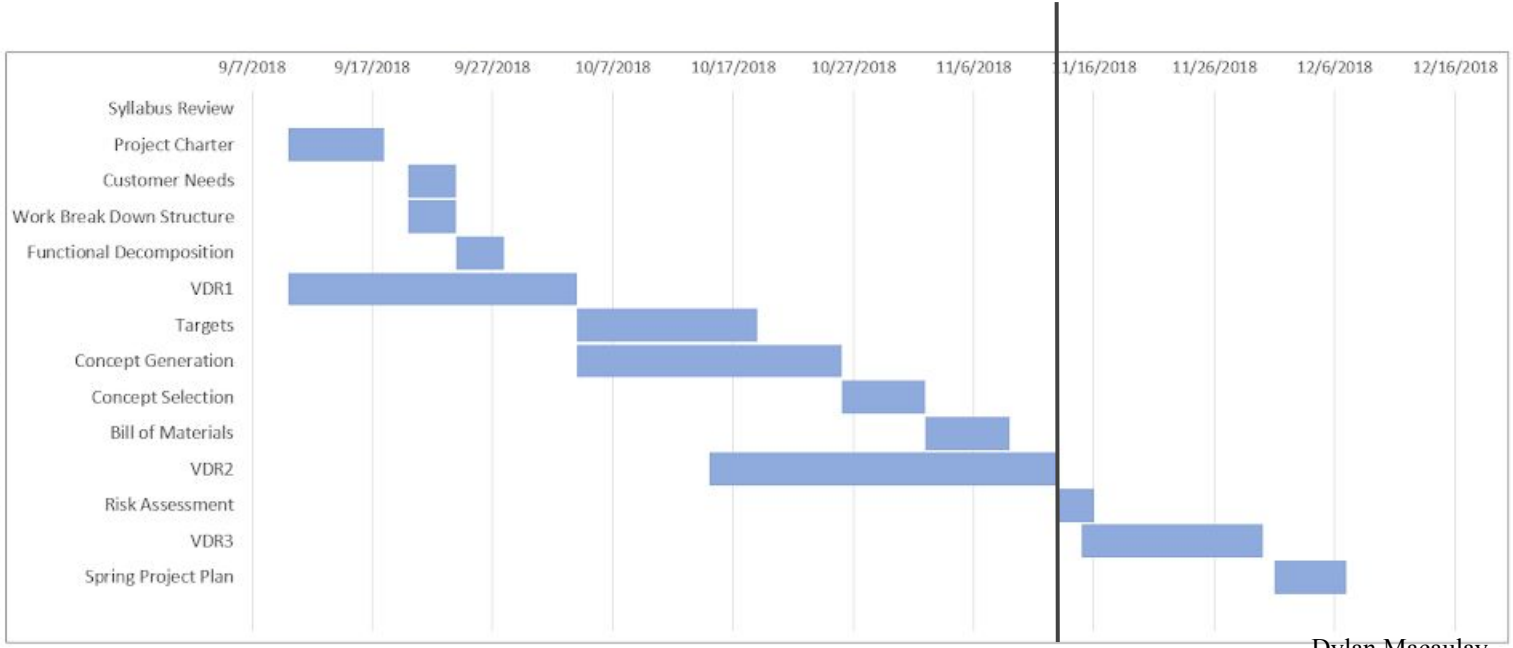
Project Status

- Current overall project status ~ 15%

Current Fall Status ~ 78.56%



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Future Plans

- Risk assessment before finalizing first round of orders
- Main bulk of orders before christmas break
- Start prototype early spring
- Order parts in relation to design adjustments
- Refine prototype for showing

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References

[1] SDT13. (2018) - Senior Design Team 13 year 2018; Concept prototype of drone disabling device. [digital Image]. Retrieved from https://ww2.eng.famu.fsu.edu/me/senior_design/2018/team13/docs_pdfs/Design_Review2.pdf

[2] NA. (2018, January 23). - Mavic Air for limitless exploration. [digital Image]. Retrieved from https://forum.dji.com/thread-130833-1-1.html

[3] https://dronelife.com/wp-content/uploads/2016/05/ANTIDRONE-SYMBOL-232x300.jpg

[4] https://theadventureedge.com/best-cast-net-buyers-guide/

[5] http://www.nelsonpaint.com/pellet-mark.html

[6] https://www.droneshield.com/dronegun-tactical/

[7] http://www.dronesglobe.com/news/dronegun-tactical-droneshield/

Questions?

Targets

Target Values						
Target No.	Need	Metric	Importance	Units	Marginal Value	Ideal Value
1	2, 10	Assembly & Disassembly Time	5	min	60	5
2	10	Weight of Device	5	lbs	30	10
3	4,5,10	Disabling Range	3	ft3	30	50
4	10	Target Acquisition Speed	4	s	20	5
5	10	Battery Life	3	h	2	3
6	3,5,10	Frequencies Jammed	3	GHz	2.4	2.4 and 5
7	2,10	Device reload speed	1	min	5	2
8	10	Target max drone wingspan	3	in	25	30
9	10	Target max drone Weight	3	lbs	4	6
10	1-9	Project Cost	5	$	5000	2500

Concept generation

Jamming:

1) RF - 2.4 GHz
2) RF - 5 GHz
3) Bluetooth
4) Infrared
5) Cellular
6) GPS
7) EMP
8) Faraday Cage
9) Satellite
10) Ultrasonic

Detection:

1) 3D Image
2) Infrared
3) Sound
4) Electromagnetic Signature
5) Heat Signature
6) Radar
7) Sonar
8) Eye Sight
9) Laser
10) Velocity Sensing
11) Neural Network
12) Detect Spinning Blades
13) Temperature Gradient Between “Object” and Air

Projection Ideas:

1) Compressed Air
2) Combustion
3) Electromagnetic Force
4) Throwing
5) Spring Launched
6) Hydraulic
7) Slingshot
8) Catapult
9) Motor
10) Counter-Drone Deployed

Protecting Impact of Hostile Drone

1) Cushioned Net
2) Predict Landing of Drone
3) Controls Take-Over
4) Parachute Net
5) Cushioned surface on ground
6) Net Becomes Parachute

Concept generation

Capture:

1) Net
2) Hook
3) Counter-Drone Towing
4) Magnet
5) Take Over Controls

Net Design:

1) Mesh (Plastic)
2) Rope
3) Twine
4) Spider Web
5) Metal (signal jamming effect)
6) Ceramic
7) Cloth
8) Magnetic
9) Rubber
10) Semi-Conductive

Net Counter-Weight for Projection:

1) Four Small Weight "Clover"- Projection
2) One Larger Weight Center-Projection
3) Evenly Weighted Net
4) Magnetized Net Edges

Size Reduction:

1) Disposable Compressed Air
2) Handheld Net Launcher
3) Counter-Drone Net Deploying
4) Lithium-Ion Battery
5) Solar Powered
6) Hand-Cranked Pressure Building

Importance Factors

	1	2	3	4	5	6	7	8	Total
1. Automatic Detection System	-	1	1	0	1	1	1	1	**6**
2. Device reach	0	-	1	0	1	0	1	1	**4**
3. Neutralization of Drone (undamaged)	0	0	-	1	1	1	1	1	**5**
4. Device Safety	1	1	0	-	1	0	1	1	**5**
5. Retrieval of Drone	0	0	0	0	-	0	1	1	**2**
6. Device Mobility	0	1	0	1	1	-	0	0	**3**
7. Length of Operation	0	0	0	0	0	1	-	1	**2**
8. Ease of use	0	0	0	0	0	1	0	-	**1**
Total	**1**	**3**	**2**	**2**	**5**	**4**	**5**	**6**	**8-1=7**