Drone Disabling Device
Design Review 5

Ryan Cziko
Quentin Lewis
Dylan Macaulay
Trevor Stade
Taylor Stamm

Team 518

Team Introductions

Trevor Stade

Project Manager

Mechanical Engineering

Quentin Lewis

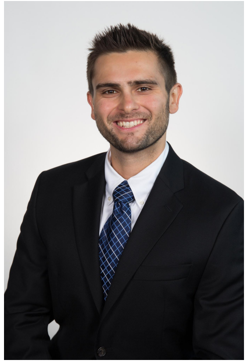
Sensor Interface Engineer

Computer Engineering

Ryan Cziko

Test Engineer

Mechanical Engineering



Taylor Stamm

Systems Integration Engineer

Electrical Engineering

Dylan Macaulay

Design Engineer

Mechanical Engineering

Sponsor and Advisor

Sponsor
Tameika Hollis
Executive at Northrop Grumman

Academic Advisor
Jonathan Clark, Ph.D.
Professor

Objective

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

Project Background

Quentin Lewis

Intended Markets

- **Primary Market:**
  - Government
  - Military operatives
  - Law Enforcement
- **Secondary Market:**
  - Contractors
  - Private security
  - Defense companies

[2]

- Device primarily used in defense and security operations
- Not intended for civilian use
- Intended target is unauthorized civilian drones

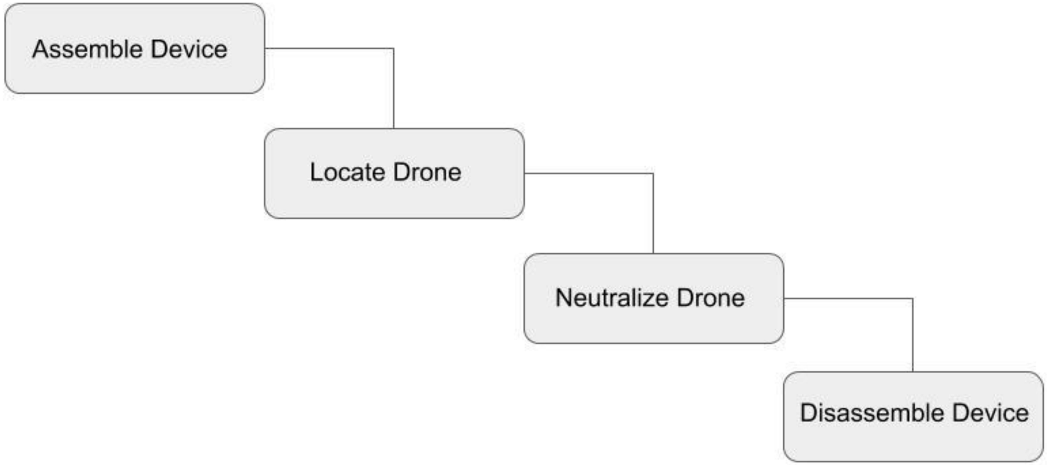
Quentin Lewis

Customer Needs

- Size of drone
  - Recreational or household drones
- Operable time
  - Device should operate until task is completed
- Device outcomes
  - Neutralize, not destroy, drone and if possible recover
- Size of device
  - Device should be portable and easily maneuverable
- Purpose of this project
  - Aid-to-hire and give better understanding of the design process

Quentin Lewis

Basic Device Function



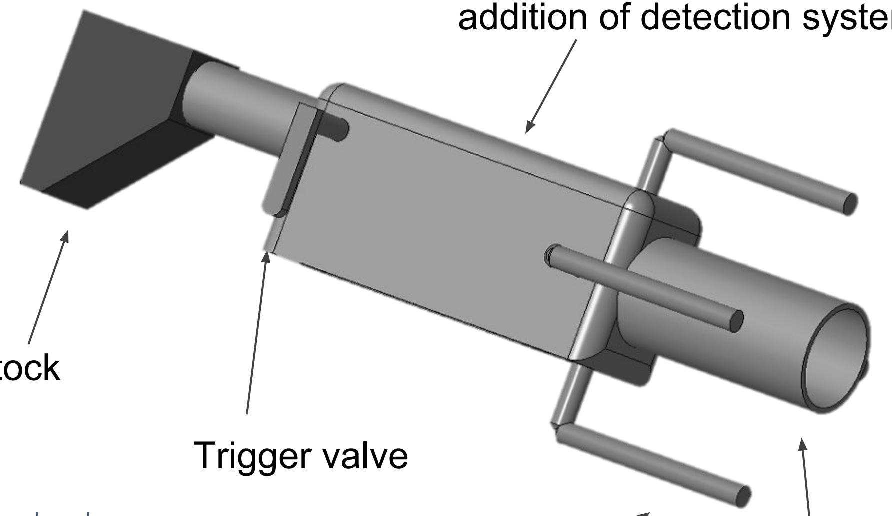
Quentin Lewis

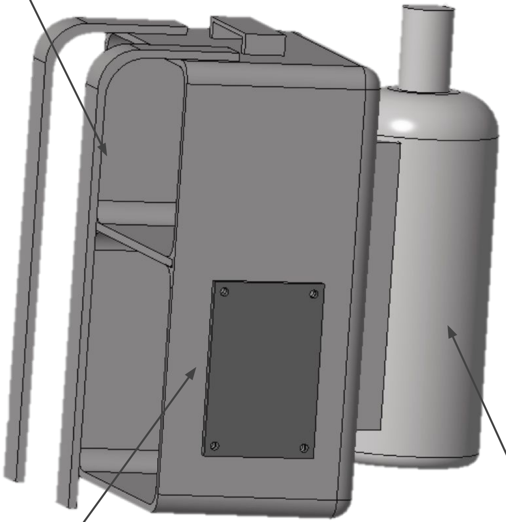
Concept Generation and Selection

- Five detailed concepts generated
  1. Paintball style marker that fires substance to disrupt communications between drone and operator.
  2. Bazooka style launcher that uses a sonar like detection system.
  3. Automated device that is floor mounted and fires net at detected drones.
  4. Mobile rifle with detection system and operator pack that fires a net powered by pressurized air or CO_2.
  5. Dart rifle that disrupts electronics on drone, uses high tech sight to manually scan airspace for drones.

Quentin Lewis

Original Proposed Design





Quentin Lewis

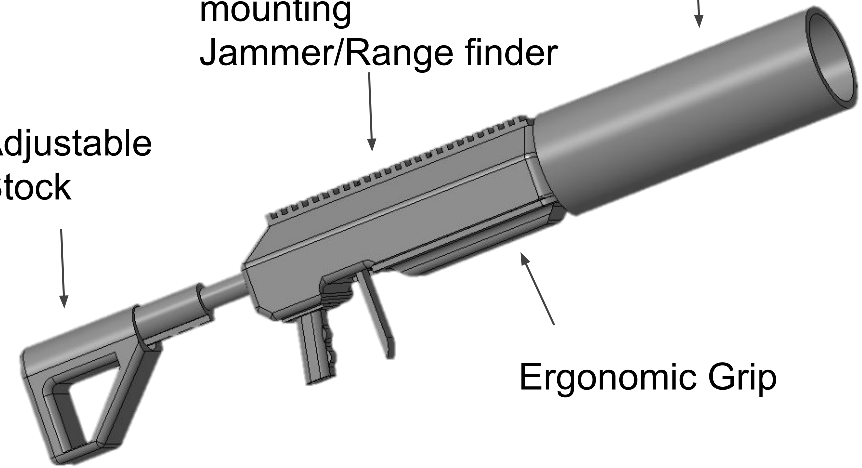
Reworked Design

Rail system for mounting Jammer/Range finder

Barrel Extension

Adjustable Stock

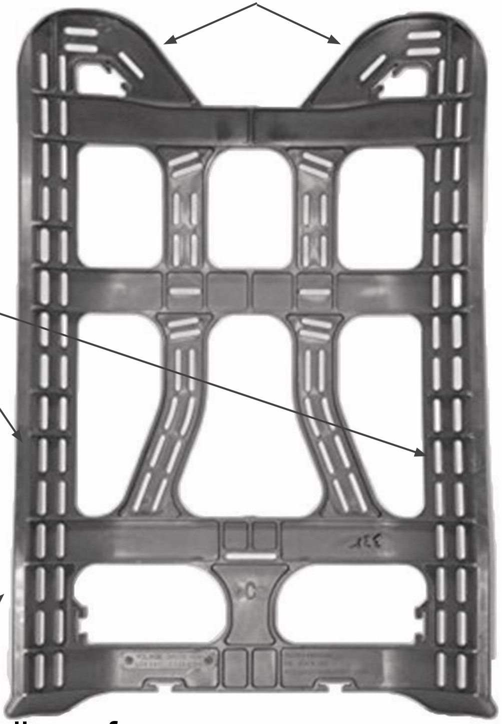
Ergonomic Grip



2 inches

Shoulder Straps Connection

Mounting point for CO_2 Tanks and brackets



Molle Webbing allows for addition of waist straps

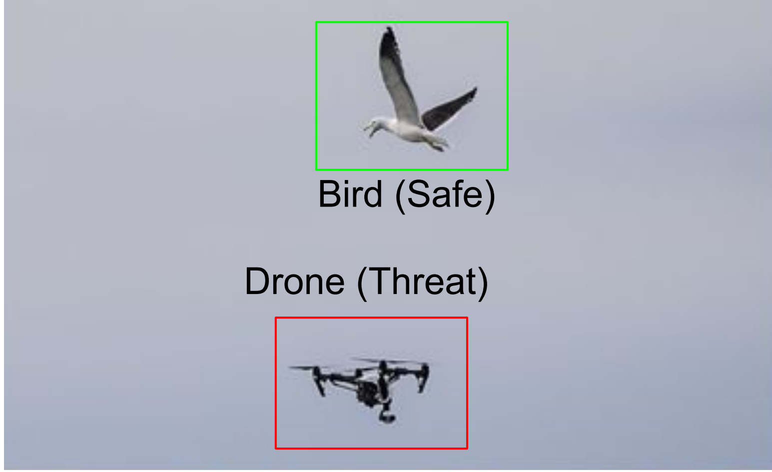
Quentin Lewis

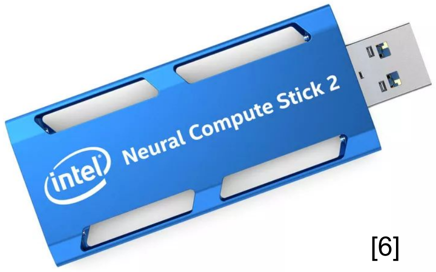
Embodiment

Dylan Macaulay

Detection System

- Raspberry Pi Model 3 B+
  - Runs the detection algorithm
  - Powers the cameras
- Intel Neural Compute Stick 2
  - Dedicated processor designed for neural networks
  - Increases processing speed by 56x
- SJCAM SJ4000 Cameras (3, mounted)
  - Provides 360° detection coverage
- 30,000 mAh USB Power Bank
  - Powers the Raspberry Pi





[6]

Dylan Macaulay

Air System

- Pro Grade 12 ounce CO_2 tank
  - Standard ⅝-18 UNF thread size
  - Seamless, high strength aluminum alloy 6061-T6
  - Service pressure of 1800 psi
- High Output Regulator
  - 4500 psi air tank regulator with output pressure of 850 psi
  - Displays amount of gas inside tank
  - Lightweight and easily rebuildable
- Heavy Duty Coiled remote line
  - Quick disconnect to easily attach and detach remote line
  - Works with up to 3000 psi of CO_2 and 4500 of HPA
  - Allows for mobility when handling device

Dylan Macaulay

Net Launcher and Backpack

Overview

Net Launcher:

- Launch net 50ft and capture a stationary drone.
- Allow easy addition of a frequency jammer.

Backpack

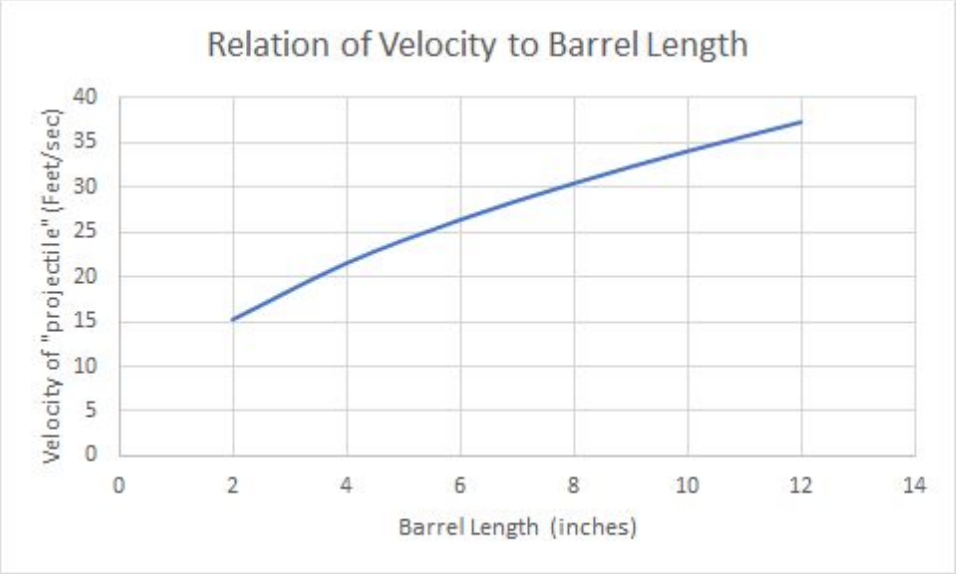
- Support detection system, compressed air, and computer components with minimal hindrance to wearer.

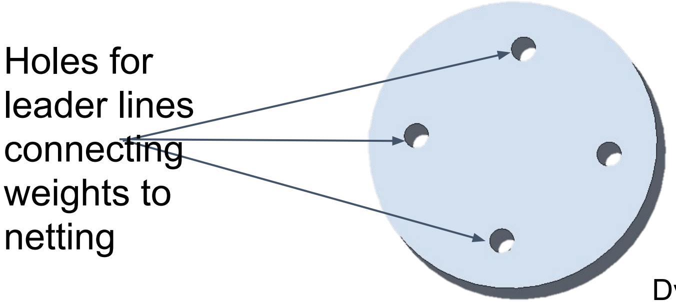
Dylan Macaulay

Net Launcher

- Addition of extended barrel
  - Extension of 8 inches or greater to increase net velocity
  - Barrel to be machined and honed here on campus

- Testing and designs for “net cap”
  - Net attached to cap that is used for launch
  - Modeled after horn of casting net





Dylan Macaulay

Backpack

- Molle II Rucksack Frame and Shoulder straps
  - Durable and built to last a lifetime
  - Frame is lightweight and molds to back for comfort
  - Shoulder straps add comfort and weight distribution
- Air tank and various pouches/packs can be attached using Molle straps

[8]

Dylan Macaulay

Future Work

- Image training for Raspberry Pi and Intel Compute Stick 2
- Assembly of pressure systems
- Testing launch of cap and comparisons of computed values
- Finalize drawings for components to be machined
- Final orders of missing parts
- Testing and adjustments to prototype

Dylan Macaulay

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] http://hyperphysics.phy-astr.gsu.edu/hbase/pber.html

[4] https://www.princeton.edu/~asmits/Bicycle_web/Bernoulli.html

[5] https://www.engineeringtoolbox.com/colebrook-equation-d_1031.html

[6] https://www.zdnet.com/article/intel-rolls-out-neural-compute-stick-2/

[7] https://becominghuman.ai/deep-learning-made-easy-with-deep-cognition-403fbe445351

[8] https://www.amazon.com/gp/product/B00CHSR1C8/ref=ppx_yo_dt_b_asin_title_o00__o00_s00?ie=UTF8&psc=1

Questions?

Backup Slides

Customer Needs Backup

Customer Needs

What is the size and type of drone to be neutralized?

- **Recreational drones that could be carrying IEDs or have cameras.**

How long does this device need to be operable for?

- **The device should be operable for the time necessary until the user powers it off.**

What is the outcome of the neutralized drone?

- **We are looking to just neutralize the drone given the time constraints, but if possible, recover the drone if it is not completely destroyed.**

Is the device expected to be autonomous?

- **No, due to time constraints it will most likely not be possible; but ideally that is what we would want.**

Is there a specific range that the device must function within?

- **100 feet in radius, 100 feet altitude. Constraints may need to be adjusted due to not being possible to meet.**

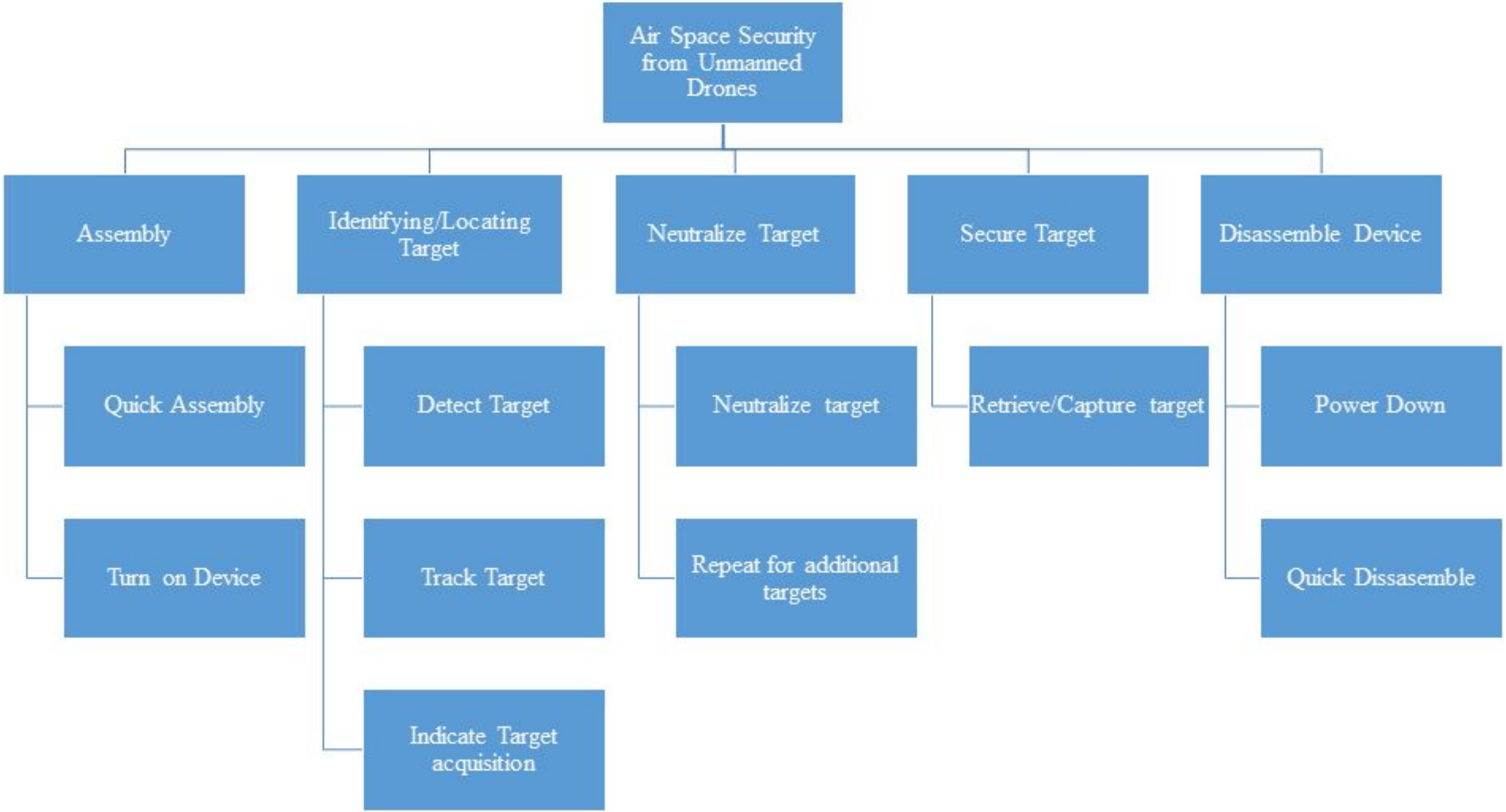
Does this device need to be portable?

- **Yes, must be able to assemble the device within 4 hours.**

What is the purpose of Northrop Grumman sponsoring this project?

- **To aid-to-hire and give students an understanding of the learning process. Northrop Grumman is not looking for a proof of concept to scale.**

Functional Decomp Backup


Air Space Security from Unmanned Drones
Assembly
Identifying/Locating Target
Neutralize Target
Secure Target
Disassemble Device
Quick Assembly
Turn on Device
Detect Target
Track Target
Indicate Target acquisition
Neutralize target
Repeat for additional targets
Retrieve/Capture target
Power Down
Quick Dissasemble

Targets Backup

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	$	2000	1500

Concept Selection Backup

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

Pugh Matrix

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

AHP

- 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

Detailed Math Backup

CO_2 Calculations

- Used Bernoulli's equation (1) twice to find the velocity of CO2 as it leaves the barrel of the gun.
  - First stage is from the tank to the nozzle
  - Second stage is from nozzle and through hose to rifle
- Problem then modeled as smooth pipe (Barrel) with turbulent flow
  - Re ≃ 151,721
  - Darcy friction factor (2) solved, *f* = 0.016569
- Velocity of net determined to be ≃ 30.414 feet/sec

$$P_1 + \frac{1}{2}\rho {V_1}^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho {V_2}^2 + \rho g h_2$$

(1) Bernoulli's equation

$$f = \frac{0.25}{\left[\log\left(\frac{\varepsilon/D}{3.7} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

(2) Colebrook-White's equation

Gas Velocity leaving Regulator

- V2 solved by subbing values into bernoulli and rearranging

$$V2 = \sqrt{2\left(\frac{P1}{\rho 1} - \frac{P2}{\rho 2}\right)}$$

- Velocity leaving nozzle of 12 OZ CO_2 tank and high output regulator at 70 deg. Fahrenheit was then found to be 34.108 ft/sec

P1	1800 psi
h1	0 inch
V1	0 ft/sec
Rho1	54.403 lb/ft³
P2	850 psi
h2	0 inch
V2 (solved)	34.108 ft/sec
Rho2	10.422 lb/ft³

Gas Velocity through hose to rifle

- V3 found by following previous method and substituting values for the gas to travel from tank to rifle

$$V3 = \sqrt{2\left(\frac{P2}{\rho 2} - \frac{P3}{\rho 3} + g * (h1 - h2) + \frac{V2}{2}\right)}$$

- Using ¼" diameter hose line and ambient temperature and pressure
- Velocity reaching rifle from hoseline at 70 degrees Fahrenheit found to be 52.356 ft/sec

P2	850 psi
h2	0 inch
V2	34.108 ft/sec
Rho2	10.422 lb/ft³
P3	14.7 psi
h3	72 inch
V3 (solved)	52.356 ft/sec
Rho3	0.075 lb/ft³

Velocity of net through barrel

- Relation of barrel length to output velocity used

$$V_{net} = \sqrt{\left(\frac{2}{m} * (Po * Vo) * \ln\left(1 + \left(\frac{A_c * L}{Vo}\right)\right) - f * L\right)}$$

- Mass of 2 lbs, output pressure of 850 psi from nozzle, cross sectional area of 28.26 inch², and a fraction factor of 0.016569 were all used
- Desired barrel length determined to be anything over 8 inches

Length (inch)	Volume (inch³)	V of net (ft/sec)
2	56.52	15.207
4	113.04	21.506
6	169.56	26.339
8	226.08	30.414
10	282.60	34.004
12	339.12	37.249

Objectives					Major Tasks	Project Completed By: April 01, 2019												Owner / Priority				
0				1	Order and test CO2 tank on current device	~	~														A	
		0		2	Test hose line		~											A				
	0			3	Interface cameras alert system with raspberry pi		~												A			A
	0			4	Create initial drone detection algorithm		~														A	
0				5	Order casting nets and size specifications		~	~													A	
	0			6	Pressure chamber calculations and manufactoring		~	~												A		
	0			7	3D print CAD models				~											A		
		0		8	Pressure equipment safety test				~									A				
		0		9	Net launch distance test				~									A				
		0		10	3D imaging test of stationary drone				~										A			
		0		11	Test trigger assembly with low pressure				~									A				
	0			12	Optimize speed and accuracy of detection algorithm					~									A			
	0			13	Assemble trigger system, air tank, hose line, and 3D prints					~										A	B	
	0			14	Assemble Rifle components						~									A	B	
		0		15	Test pressure chamber for leaks and durability						~							A				
	0			16	Combine pressure chamber and designed trigger							~								A	B	
	0			17	Implement casting net to device							~								A	B	
	0			18	Full assembly of 3D prints								~							A	B	
		0		19	Test and optimize net launch									~	~			A				
		0		20	Test optimize detection system									~	~							A
				21	Spring Break											~						
	0		0	22	Final system testing												~	A				
	0	0		23	Refine Prototype												~	A	A	A	A	A
				A	Syllabus																	
				B	ABET																	
				C	Sponors																	
				D	Documentation																	
				E	Lessons Learned																	
				F																		
					# People working on the project: 5	1	2	3	4	5	6	7	8	9	10	11	12					
Parts Ordering	ale Development	Testing	Documentation		Major Tasks / Target Dates / Objectives	7-Jan-19	14-Jan-19	21-Jan-19	28-Jan-19	4-Feb-19	11-Feb-19	18-Feb-19	25-Feb-19	4-Mar-19	11-Mar-19	18-Mar-19	25-Mar-19	Ryan Cziko	Quentin Lewis	Dylan Macaulay	Trevor Stade	Taylor Stamm

Standard Shapes

Summary Box

Text box 1

Outlined Text Box

Approved Logos

FAMU-FSU
College of
Engineering

FAMU-FSU
Engineering

FAMU-FSU
Engineering

FAMU-FSU
College of Engineering

Color Palette

PANTONE® 2299 C

2299 C
Color values:
RGB 164 210 51
HEX/HTML #A4D233
CMYK 41 0 84 0

PANTONE® 1788 C

1788 C
Color values:
RGB 238 39 55
HEX/HTML #EE2737
CMYK 0 88 82 0

COE Dk Gray

75% Black
Color values:
RGB 64 64 64
HEX/HTML
#404040
CYMK: 0 0 0 75

PANTONE® 2239 C

2239 C
Color values:
RGB 0 207 180
HEX/HTML #00CFB4
CMYK 59 0 39 0

PANTONE® 647 C

647 C
Color values:
RGB 35 97 146
HEX/HTML #236192
CMYK 96 54 5 27

COE Md Gray

50% Black
Color values:
RGB 128 128 128
HEX/HTML
#808080
CYMK: 0 0 0 50

PANTONE® 2199 C

2199 C
Color values:
RGB 0 187 220
HEX/HTML #00BBDC
CMYK 77 0 16 0

PANTONE® 7535 C

7535 C
Color values:
RGB 183 176 156
HEX/HTML #B7B09C
CMYK 10 11 23 19

COE Lt Gray

25% Black
Color values:
RGB 191 191 191
HEX/HTML #bfbfbf
CYMK: 0 0 0 25

APA Tables

Category 1	Category 2	Category 3	Category 4	Category 5
Item 1				
Item 2				
Item 3				
Item 4				

	Category 2			Category 3	
Category 1	subcategory 1	subcategory 2		subcategory 1	subcategory 2
Item 1					
Item 2					
Item 3					
Item 4					