Senior Design 1

Initial Project Documentation and Group Identification

DOMINANCE: Land Mine Challenge

Department of Electrical and Computer Engineering
University of Central Florida
Dr. Lei Wei

Group 17
Corey Hogue; *Electrical Engineering*
Joey Rivera; *Electrical Engineering*
Kristopher Sipe; *Computer Engineering*
Justin Wu; *Computer Engineering*

Sponsor: Lockheed Martin
Contacts: Johnathan Tucker and Andrew Kirk

Section 2 - Project Description

The Lockheed Martin DOMINANCE Challenge calls for a stationary mine system capable of detecting, tracking, and autonomously disrupting aerial vehicles. To meet this challenge, we will employ the latest computer vision deep learning algorithms, along with fused range information, to achieve high accuracy classifications and kill capabilities. Another goal of the project will be to evaluate the deployability of deep neural networks in an embedded systems environment with candidates like Nvidia's Jetson Developer Kits. Acoustic and cybersecurity attacks will also be explored. Our mine will be equipped with a projectile netting system that utilizes robotic motor controls to aim, capture, and retrieve adversarial drones. Our goal is to create an Automatic Protection System (APS) able to intelligently decide whether a projectile should be fired based on the target classification. This system will be able to distinguish between humans, drones, and other targets of interest to correctly and safety make autonomous targeting decisions within a set range. Our focus will be on portability, autonomy, detection accuracy, and kill capabilities.

Section 3 - Requirements

This section contains the requirements for our DOMINANCE Mine project. Table 3.1 provides the section number and the corresponding requirement. Table 3.2 displays the final deliverables we shall present during our presentation.

Table 3.1 - Requirements

Section Number	Section Title	Requirements
3.1	Design	1.5 ft x 1.5 ft x 1.5 ft
3.2	Material	
3.3	Weight	Not exceed 50 pounds
3.4	Cost	Not exceed $1050
3.5	Performance Specification	
3.5.1	DOMINANCE Sight	
3.5.1.1	Mode of Operation	
3.5.1.1.1	Automatic Target Detection	
3.5.1.1.2	Automatic Target Tracking	
3.5.1.1.3	Automatic Target Recognition	
3.5.1.2	Design Requirement	
3.5.1.2.1	Detection	
3.5.1.2.1.1	Metadata Box	
3.5.1.2.1.1.1	Confidence	Collect normalized ($0 \leq x \leq 1$) confidence data
3.5.1.2.1.1.2	Range to Target	Collected in feet
3.5.1.2.1.1.3	Time of Arrival	Collected in seconds
3.5.1.2.1.2	Real Time	
3.5.1.2.1.3	Detection Speed	Detect and identify in under 2 seconds
3.5.1.2.2	Camera	4 cameras
3.5.1.2.2.1	Bit Precision	16
3.5.1.2.2.2	Field of View (FOV)	78 degrees horizontally 78 degrees vertically
3.5.1.2.2.3	Resolution	1080p resolution

Section Number	Section Title	Requirements
3.5.1.2.2.4	Wavelength	Visible light (400nm - 700nm)
3.5.1.2.2.5	Range	20 feet (Min: 60 pixels per foot of ground sampling distance)
3.5.1.2.2.6	Refresh Rate	30 frames per second
3.5.2	DOMINANCE Disruption	
3.5.2.1	Mode of Operation	
3.5.2.1.1	Auto Disruption	
3.5.2.1.2	E-Stop	
3.5.2.2	Design Requirement	
3.5.2.2.1	Blast Radius	Horizontal: 3 feet: Vertical 10 feet
3.5.2.2.2	Capacity	3 shots
3.5.2.2.3	Projectile Weight	Not exceed 5 pounds
3.5.2.2.4	Projectile Speed	Not exceed 1200 feet per second
3.5.3	DOMINANCE Design Requirement	
3.5.3.1	Stationary	
3.5.3.2	Operational Life	Minimum of 1 hour
3.5.3.3	Start and Stop	
3.5.3.4	Start-up Sequence	Within 30 seconds
3.5.3.5	Power-down Sequence	Within 30 seconds
3.5.3.6	Memory Storage	Minimum of 64 Gbs
3.5.3.7	Power Usage	Not exceed 500 Watts

Table 3.2 - Deliverables

Requirement	Deliverable
Automatic Target Tracking (ATT)	The mine shall be able to track the UAV as we move it around.
Metadata Box	We shall display the Metadata Box from out laptop
E-Stop	We shall display that the E-Stop work (Power on a and immediately stop)

3.1 Design
DOMINANCE shall meet the specified design requirements provided by our customer. It shall not exceed the maximum size of 1.5 ft. x 1.5 ft. x 1.5 ft. (L x W x H).

3.2 Material
DOMINANCE shall use materials that are readily available and allow for interchangeability.

3.3 Weight
DOMINANCE shall not exceed 50 pounds.

3.4 Cost
DOMINANCE shall stay within our customer's constraints of $700 with an additional $350 for prototyping.

3.5 Performance Specification
3.5.1 DOMINANCE Sight
DOMINANCE Sight shall be a fixed optical systems that can process color information in real time.

3.5.1.1 Mode of Operation
DOMINANCE Sight shall meet the requirement modes of operation provided by the customer.

3.5.1.1.1 Automatic Target Detection (ATD)
DOMINANCE Sight shall have auto detection (autonomously detect UAV).

3.5.1.1.2 Automatic Target Tracking (ATT)
DOMINANCE Sight shall have auto tracking (autonomously track UAV).

3.5.1.1.3 Automatic Target Recognition (ATR)
DOMINANCE Sight shall have auto recognition (autonomously classify targets).

3.5.1.2 Design Requirement
3.5.1.2.1 Detection
DOMINANCE Sight shall be able to detect and identify Unmanned Aerial Vehicles (UAVs)

3.5.1.2.1.1 Metadata Box
DOMINANCE Sight shall be able to generate a large red bounding box overlay centered on the UAV. It shall collect data as it identifies the target.

3.5.1.2.1.1.1 Confidence
The Metadata Box shall collect normalized ($0 \leq x \leq 1$) confidence data of the UAV.

3.5.1.2.1.1.2 Range To Target
The Metadata Box shall collect the range to target(in feet).

3.5.1.2.1.1.3 Time of Arrival
The Metadata Box shall collect the time of arrival(in seconds).

3.5.1.2.1.2 Real Time
DOMINANCE Sight shall be able to detect and identify the UAV in real time.

3.5.1.2.1.3 Detection Speed
DOMINANCE Sight shall detect and identify a UAV in under 2 seconds.

3.5.1.2.2 Camera
DOMINANCE Sight shall consist of 4 RGB cameras with 1080p resolution.

3.5.1.2.2.1 Bit Precision
DOMINANCE Sight shall have a bit precision of 16.

3.5.1.2.2.2 Field of View (FOV)
DOMINANCE Sight shall have a field of view of 78 degrees horizontally and 78 degrees vertically.

3.5.1.2.2.3 Resolution
DOMINANCE Sight shall have a camera resolution of 1080p.

3.5.1.2.2.4 Wavelength
DOMINANCE Sight shall operate in the visible light spectrum of 400nm - 700nm.

3.5.1.2.2.5 Range
DOMINANCE Sight shall an effective range of 20 feet with a minimum of 60 pixels per foot of ground sampling distance.

3.5.1.2.2.6 Refresh Rate
DOMINANCE Sight shall have a refresh rate of 30 frames per second.

3.5.2 DOMINANCE Disruption
DOMINANCE Disruption shall be a slewable system that has the ability to disrupt UAVs such that it falls to the ground.

3.5.2.1 Mode of Operation
DOMINANCE Disruption shall meet the requirement modes of operation provided by the customer.

3.5.2.1.1 Auto Disruption
DOMINANCE Disruption shall have auto disruption (autonomously utilize blast mechanism to disrupt UAV flight).

3.5.2.1.2 E-Stop
DOMINANCE Disruption shall be able to stop all disruption blast mechanisms.

3.5.2.2 Design Requirement

3.5.2.2.1 Blast Radius
DOMINANCE Disruption shall not exceed the maximum specified blast radius.

Horizontal	3 feet
Vertical	10 feet

3.5.2.2.2 Capacity
DOMINANCE Disruption shall be able to disrupt UAVS a minimum of three times before needing a reload.

3.5.2.2.3 Projectile Weight
DOMINANCE Disruption shall not blast a projectile exceeding 5 pounds.

3.5.2.2.4 Projectile Speed
DOMINANCE Disruption shall not blast a projectile exceeding 1200 feet per second.

3.5.3 DOMINANCE Design Requirement
3.5.3.1 Stationary
DOMINANCE shall be placed on the obstacle course and remain stationary.

3.5.3.2 Operational Life
DOMINANCE shall be able to operate for a minimum of one hour while power on.

3.5.3.3 Start and stop
DOMINANCE shall be able to be power on and power off.

3.5.3.4 Start-Up Sequence
DOMINANCE shall be able to start-up within 30 seconds. It shall be able to begin all operational modes (auto-detection, auto-tracking, and auto-disruption) on start-up.

3.5.3.5 Power-Down Sequence
DOMINANCE shall be able to power-down within 30 seconds. It shall be able to stop all operational modes (auto-detection, auto-tracking, and auto-disruption) on power-down.

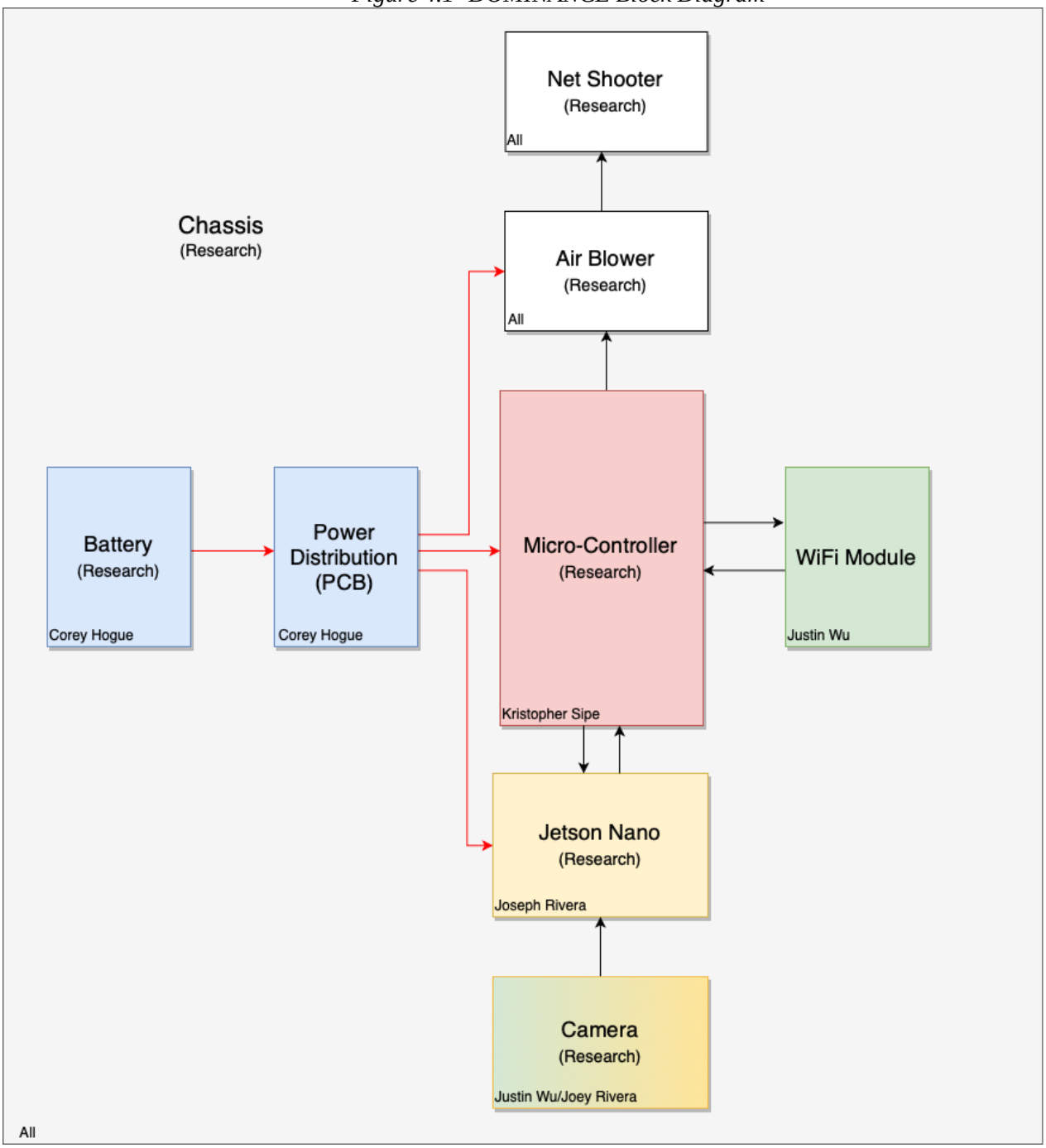
3.5.3.6 Memory Storage
DOMINANCE shall be able to hold a minimum of 64 GBs.

3.5.3.7 Power Usage
DOMINANCE shall not exceed a power usage of 500 Watts.

Section 4 - Block Diagram

This section contains a block diagram for the DOMINANCE Mine project. The block diagram represents the crucial components necessary for the DOMINANCE Mine to detect, track, and disable the UAV within the given proximity. Also provided in the diagram is a team responsibility matrix for each component along with the current state of the specific component.

Figure 4.1- DOMINANCE Block Diagram



Section 5 - Budget

This section outlines the budget for the DOMINANCE Mine Project. With our current expected budget of $694 we plan on meeting our sponsor's budget requirement of $700 w/ an additional $350 for prototyping.

Table 5.1 - Budget

Part Name	Quantity	Price
Micro-controller	1	$30
PCB Manufacturer	5	$20
Power Supply	1	$50
Servo-motor	1	$30
Wifi Module	1	$15
Disruption Device	1	$200
Jetson-nano	1	$99
Camera	4	$50 ($200)
3D Printed Chassis	1	$40
Total		$694

Section 6 - Initial Milestones

SENIOR DESIGN ONE:

Being that Senior Design One is focused on picking and planning our project that we will ultimately be building during Senior Design 2, most of our milestones will consist of documentation deadlines. More tasks will be added as the need arises, but for now the list is as follows

Table 6.1- Senior Design One Task List

Requirements / Tasks	Start Date	Completion Date
Group and Project Selection	August 26, 2019	September 9, 2019
Initial Project Document – Divide and Conquer	September 9, 2019	September 20, 2019
Initial Project Proposal	-	September 23, 2019
Updated Project Document – Divide and Conquer Revision	September 21, 2019	October 4, 2019
Senior Design Project Documentation – 60 Pages	October 5, 2019	November 1, 2019
Senior Design Project Documentation – 100 Pages	November 2, 2019	November 15, 2019
Select and Procure Components / Parts	November 2, 2019	December 2, 2019
Senior Design Project Documentation – 140 Pages (Final)	November 16, 2019	December 2, 2019
Initial Project Presentation	-	TBA

SENIOR DESIGN TWO:

Senior Design Two focuses on the building of the actual prototype and also the testing and redesigning that comes with this task. The known milestones with projected dates are as follows:

Table 6.2 – Senior Design 2 Task List

Requirements / Tasks	Start Date	Completion Date
Test Components / Parts	January 6, 2020	January 13, 2020
Assemble Initial Hardware Prototype	January 14, 2020	January 28, 2020
Design Initial Program Infrastructure	January 29, 2020	February 19, 2020
Design and Implement Advanced Firmware	February 20, 2020	TBA
Integrate Hardware and Software	TBA	TBA
Test and Redesign System	TBA	TBA
Final Project Presentation	TBA	TBA
Senior Design Project Documentation- Final Report	TBA	TBA

Section 7 - Parameters

We considered quite a few different concepts before coming to a final decision. These ranged from reasonable proposals to abstract ideas, but in the end we decided upon a project that was sponsored and we believed would be reasonable, achievable, and challenging. The matrix listing a few of our internal ideas can be seen below:

Table 7.1 – Project Selection Design Matrix

Project Idea	Practicality	Originality	Difficulty	Interest
Lockheed Martin Challenge – Land Ordinance Mine	4	2	3	3
Eye Tracking Controlled RC Vehicle	3	4	2	2
Solar Powered Electric Longboard with Bluetooth Control Interface	2	1	1	2
Sentry Drone for Home Security / Protection	4	2	3	2

ALL FACTORS ARE RATED ON A SCALE OF 1 – 4.