Remote Escalation/De-Escalation and Surveillance System (REDSS)

ECE4011 Senior Design Project

Team Pew^3
Dr. Mick West
Harris Corporation

Michael Bossi (michaelb@gatech.edu)
Joshua Dixon (josh.dixon@outlook.com)
Gyu Cheol Lim (gclim@gatech.edu)
Seong Ho Yeon (shyeon568@gatech.edu)
Satoshi Yuki (syuki1021@gatech.edu)

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Executive Summary

Current military operations frequently target hostile personnel at night in otherwise neutral or friendly areas. This environment requires soldiers to positively announce the presence of military forces to any local inhabitants which approach their positions, a process which invariably reveals the soldier's position, increasing the threat to both the soldier and local inhabitant by increasing tension. The environment also demands assault forces audibly instruct building occupants to exit the building before entry, and confirm hostile intent before firing upon targets with rifles or aircraft. These actions place military personnel at increased risk and reduce combat effectiveness. The Remote Escalation/De-escalation and Surveillance System (REDSS) will reduce this threat by removing the source of visual and audible cues from the soldier and placing it on a robot located several meters away, and will serve as a surveillance system to detect and confirm hostile intent in otherwise obscured areas. REDSS is a lightweight, cargo pocket portable stationary robot which will be thrown or dropped into a position, and will deploy white light to disorient targets designated by IR lasers, announce audible cues to building occupants, and serve as a remote surveillance camera. Operators will control REDSS in an "Eyes Up" configuration by using rifle-mounted IR lasers to designate targets and a simple rifle-mounted remote for basic control, and an Android application for advanced control and video streaming. The expected outcome of the design is a mechanically limited by electronically fully functional REDSS prototype. Initial construction will cost at least $275.

Remote Escalation/De-Escalation and Surveillance System (REDSS)

1. Introduction

The Remote Escalation/De-escalation and Surveillance System (REDSS) is a cargo pocket sized stationary robot which tracks an infrared laser and deploys a white light under command to disorient personnel approaching military positions, and can serve as a remote video surveillance system and general intelligence collection platform. Team Pew^3 requests an initial sum of $275 to begin construction of the prototype.

1.1 Objective

REDSS will serve to increase safety and margin for error in combat environments for both unarmed civilians and armed military forces, reducing the threat to soldiers and thereby increasing the tolerance for civilian actions near military operations. REDSS will accomplish this through four operational modes:

A. REDSS will reduce tension in precision nighttime combat missions in civilian areas by removing the source of visible light and audio cues from the soldier and placing it on a remote robot. In this mode, REDSS will de-escalate a potentially hostile situation by announcing the presence of military forces without revealing the position of the soldiers.

B. REDSS will function as part of an escalation of force procedure, allowing military forces to give instructions while remaining behind cover. REDSS will be thrown near a target building and remotely controlled to relay audible instructions to building occupants, and will provide a video feed enabling operators to visually inspect personnel departing the building to confirm or deny the presence of weapons.

C. REDSS will be placed in areas which could provide tactical advantages to enemy forces, and will serve as a remote surveillance camera.
D. REDSS will integrate with third-party sensors through an Application Program Interface (API), allowing intelligence collection systems to use the REDSS platform for communication and as a data source.

REDSS will differ from traditional robots by using an "Eyes Up" control concept. REDSS will track coded infrared (IR) lasers for aiming guidance at night, will provide visual feedback to operators using an IR laser mounted on the robot, and will use a rifle-mounted remote for basic instructions. These innovations will reduce operator distraction and maintain combat effectiveness. REDSS will use a mobile app on an Android device for advanced functionality.

1.2 Motivation

The primary motivation is to provide an additional means for military forces to control potentially dangerous encounters without compromising their own safety, thereby increasing the tolerance for civilian actions before lethal force becomes necessary. Current escalation and de-escalation tools, such as the GLAREMOUT laser dazzler, reveal the operator's position when used and increase tension [1]. Other tools, such as the BAGL, require limited air support resources [2]. REDSS strikes a balance between the safety cost when using man-portable devices, and the monetary cost of vehicle-mounted devices.

The secondary motivation is to increase situational awareness through video surveillance and support for intelligence collection equipment. Current portable remote surveillance such as the SKYCOP surveillance trailer are not man-portable, and cannot be used in highly-mobile infantry operations [3].

1.3 Background

Although there are no current products that match the REDSS functionality, each component within REDSS has a counterpart in the current market. In some areas of the United States, police officers wear portable cameras which document the execution of their duties. The cameras, such as the Axon Body 2, are ruggedized to survive drops and impact, contain Wi-Fi connectivity for remote activation and streaming, and have 12 hours of battery endurance [4]. While these cameras don't serve the exact same functionality as REDSS, they are designed with similar constraints and suggest the feasibility of the technological goals. Laser detection and tracking is used to provide targeting guidance to weapons, and to provide control inputs to computers in the civilian market. Military weapons systems use coded laser signals to improve noise tolerance and prevent spoofing, while civilian systems use simple brightness thresholds and movement detection to track lasers [5], [6]. The military systems use purpose-built electronic hardware for laser detection, specifically focal plane arrays and state machines for code detection, while civilian systems use commercially available CCD cameras paired with traditional processors [6], [7].

2. Project Description and Goals

The REDSS consists of two distinct segments; the user segment and the REDSS robot segment. The system view from the operator perspective is shown in Figure 1. The operator interacts with the system through a physical hardware remote mounted on a rifle, which will use an IR laser to identify targets for the REDSS robot, and provide basic functionality such as directional control and white light activation using buttons. Advanced functionality is controlled through the Android application. The robot segment contains a camera for both surveillance and laser-tracking, a white light dazzler to disorient approaching personnel, a speaker for audible warnings, and all the necessary hardware to enable the previously described devices.

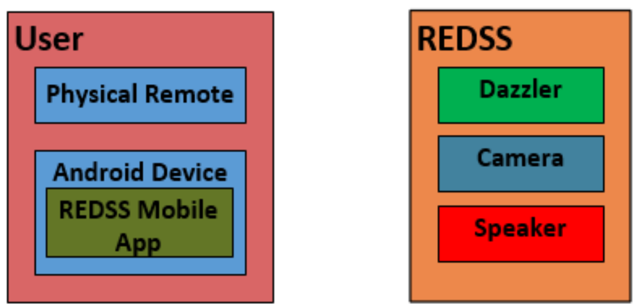

Figure 1. REDSS block diagram from the user perspective

The system's goals are as follows:

- Track an IR laser to aim a white light dazzler at a target.
- Announce audible warnings at a volume sufficient to penetrate walls.
- Fit in a cargo pocket.
- Operate for a minimum of 5 hours when in a laser tracking mode.
- Operate for a minimum of 8 hours as a surveillance camera.
- Reduce operator distraction through remote design, motion detection, and visual feedback mechanisms.
- Survive being thrown.

3. Technical Specifications

The REDSS overall performance requirements are shown in Table 1. Specific specifications for the processing unit and peripheral components are shown in Table 2 and Table 3. As REDSS is intended for military use, all electronic hardware must be military-grade. The system will use two IR lasers, one on the remote control and one for the robot to provide visual feedback to the operator. The lasers will be power limited up to 5mW for safety.

TABLE 1. SYSTEM SPECIFICATIONS

Feature	Specification
Dimension	< 17.8 × 19 × 10.1 cm^3 (Cargo pocket)
Weight	500 g - 1 kg
Operating Endurance	> 5 hours (Laser tracking mode) > 8hours (Surveillance mode)
Impact Endurance	> Survive drop from 3.2 m
Aiming Accuracy	< 0.5 Degrees
Target Distance	> 50 m
Rotational Speed	> 40 Degrees per Second
Speaker Range	> 25 m
Camera Height	> 16 cm
Interface	Android Mobile App with Video Stream

TABLE 2. PROCESSOR SPECIFICATIONS

Feature	Specification
Calculation of motor angle	< 15 ms
Communication	WIFI (802.11n)
Image Refresh Rate	> 60 fps
Image resolution	480p – 1080p
Audio Capability	Required
Location	GPS

TABLE 3. PERIPHERALS SPECIFICATIONS

Peripherals	Feature	Specification
Camera	Angular Resolution	< 0.4 degrees
	Detectable wavelength	Visible light, Infrared light
Pan Motor	Angular velocity	60 - 120 degrees/sec
	Active range	0 - 360 degrees
Tilt Motor	Angular velocity	20 - 60 degrees/sec
	Active range	10 - 170 degrees
Pan/Tilt Module	Maximum payload weight	300 g
IR Laser	Wavelength	850 – 900 nm
	Power	< 5 mW
	Weight	< 50 g
Dazzler	Diameter	5 – 10 cm
	Intensity	500 lumen
	Weight	< 100 g

4. Design Approach and Details

4.1 Design Approach

Mechanical Design

The REDSS robot segment will be entirely self-contained, and will support a camera, dazzler, and confirmation laser at a height sufficient to reduce terrain interference. A concept drawing of the REDSS robot segment is shown as Figure 2. The primary emplacement method for REDSS is being thrown by an operator, and it must therefore be mechanically rugged and self-righting, while still meeting size and camera height specifications. In order to achieve these goals, REDSS will unfold from a stowed to a deployed position. The stowed and deployed positions are shown in Figure 3. An approximate scale drawing is shown in Figure 4.

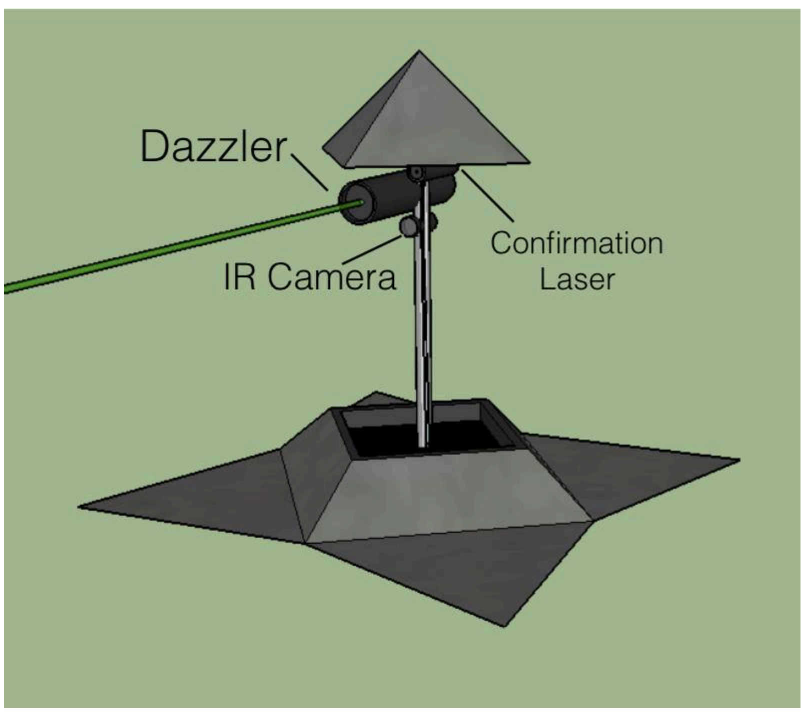

Figure 2. Graphic of deployed REDSS system.

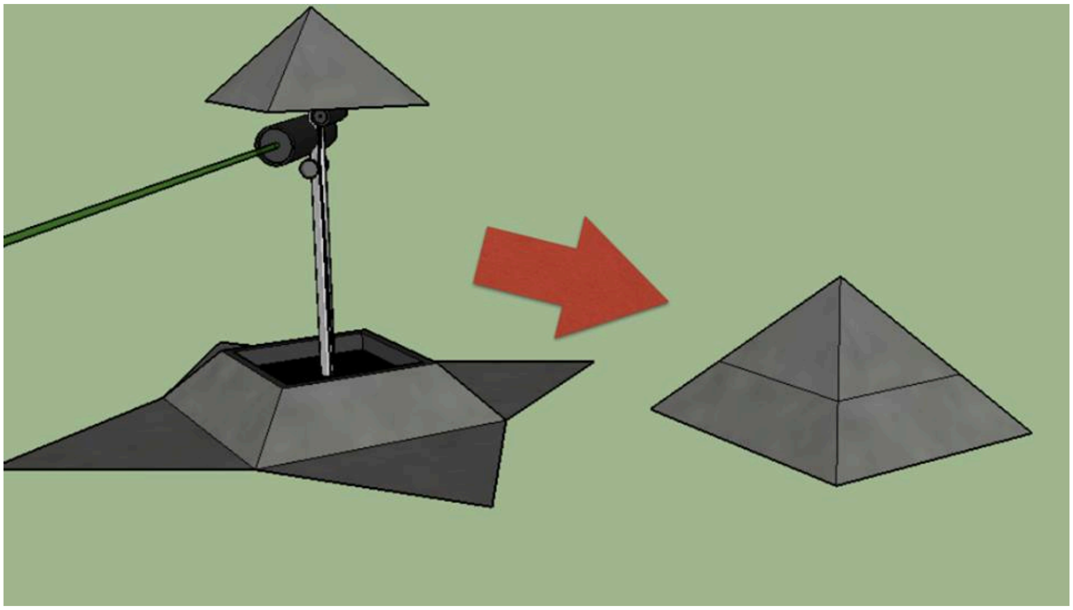

Figure 3. Graphic of REDSS system deployed and collapsed.

Figure 4. Graphic of approximate size of REDSS compared to an average adult male.

Electronics

As described previously, the REDSS consists of user and robot segments. The overall system architecture is shown in Figure 5. The primary processing unit, the Raspberry Pi 3B, is not well suited for hardware control. To overcome this challenge, the robot uses a front-seat/back-seat architecture, assigning any hardware control tasks to an Arduino microcontroller while the Raspberry Pi handles higher-level functions.

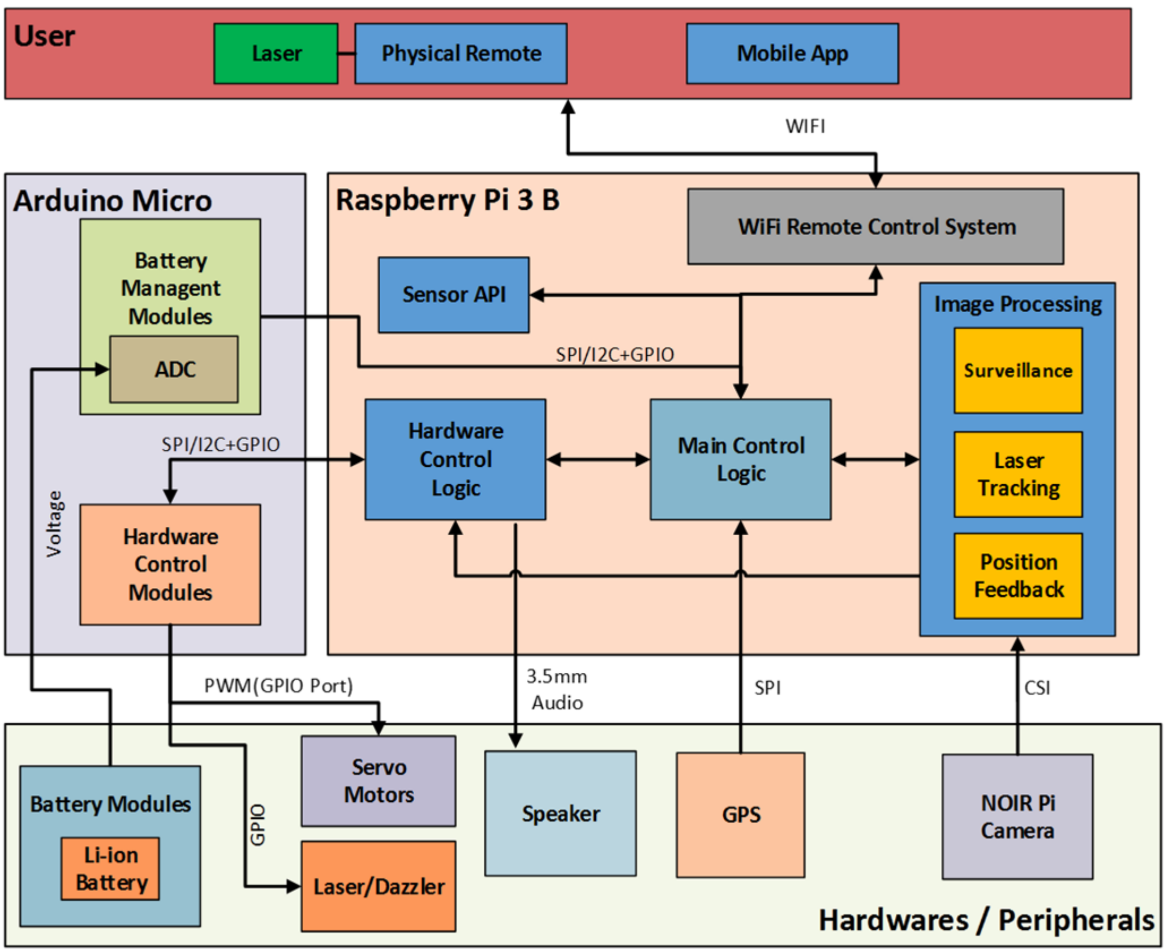

Figure 5. Detailed block diagram of the REDSS architecture.

Image Processing

The REDSS will use the camera to track a laser, provide a video feed to the user, alarm on motion detection, and provide feedback to the motors. Image processing will be provided by the Raspberry Pi 3 GPU and OpenCV software. Laser detection and tracking will use a pulse detection algorithm, which increases resistance to noise and outperforms intensity detection algorithms [1], [2].

User Interface

The operator will interact with the REDSS through an "Eyes Up" hardware remote, and through a more complex Android mobile application. Both remotes will communicate to the robot segment using standard Wi-Fi.

The hardware remote consists of a coded IR laser and buttons. The operator will designate a target using the IR laser, and the robot segment will detect and track the laser, ultimately pointing the dazzler at the target. The REDSS will confirm aim by activating an IR laser on the robot. When commanded, the REDSS will deploy the dazzler at the target. Minor aim corrections will be made using the remote's buttons. A concept drawing of the remote attached to a rifle is shown in Figure 6, while the operational mode is illustrated in Figure 7.

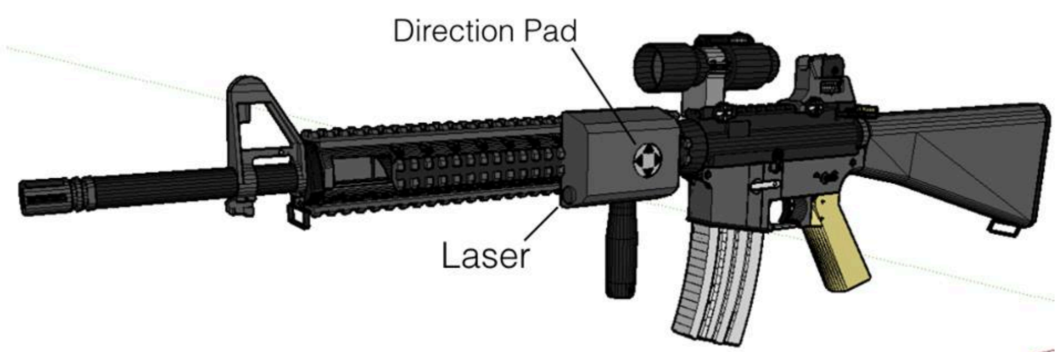

Figure 6. Graphic of Rifle with REDSS remote control system.

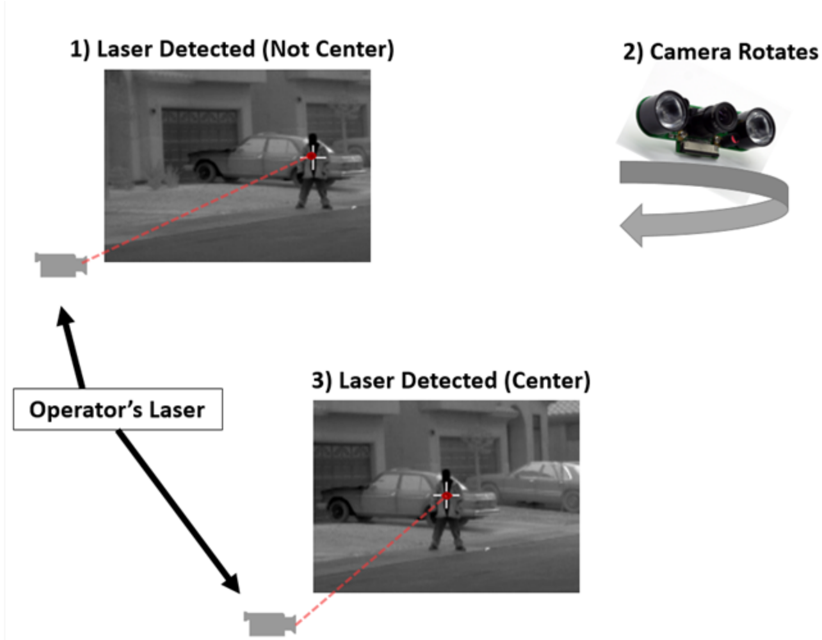

Figure 7. Concept of laser-tracking operation. The operator designates the target with an IR laser, which REDSS then tracks and uses for aim.

The mobile application provides access to the video stream, recorded audible warnings, and control of the surveillance mode. Figure 8 shows the video feed, used for both surveillance and escalation of force procedures. Figure 9 illustrates the audio warning menu, where the operator can select and play a recorded phrase in the local language. The mobile application is targeted toward generic Android devices to ensure compatibility with products such as the Harris RF-3590-RT Ruggedized Tablet [8]. The user interface is deliberately simple, which should reduce training requirements and reduce operator errors.

Figure 8. Video feed display on the REDSS mobile application.

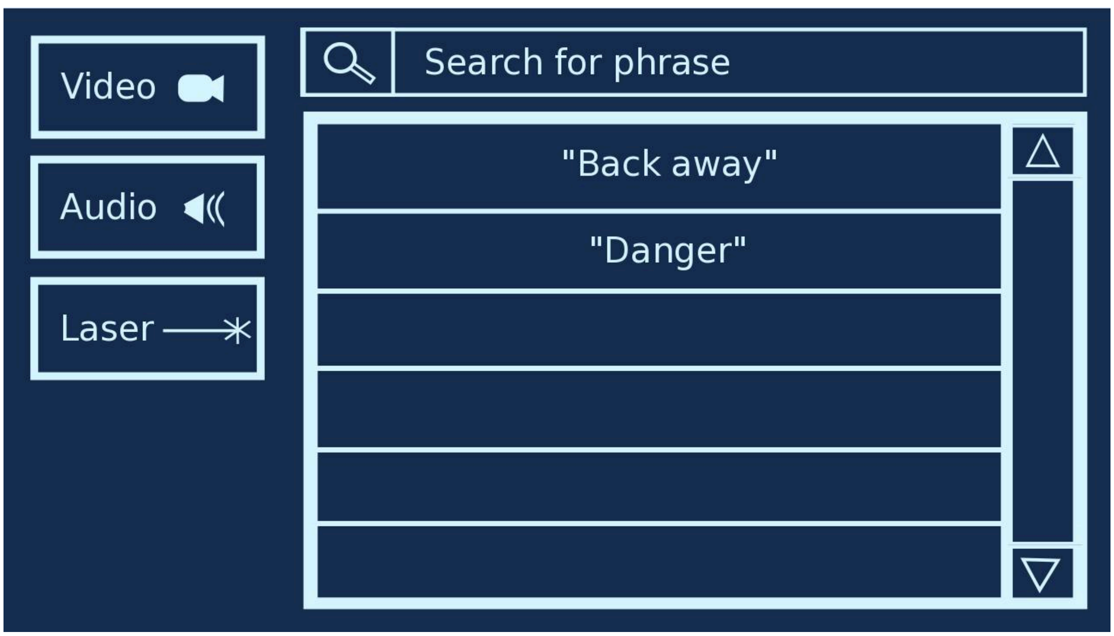

Figure 9. Audible warning selection on the REDSS mobile application.

4.2 Codes and Standards

Raspberry Pi 3

- Open source hardware and software design developed by the Raspberry Pi Foundation with a large open source community
- Low-cost hardware as the foundation for a computer running the Raspbian operating system based on Debian
- Containing the Broadcom BCM2837 64bit ARMv7 Quad Core Processor powered Single Board Computer running at 1.2GHz
- GPU of Broadcom VideoCore IV
- 4 USB ports, 40 GPIO pins, which provide I^2C and SPI functionality
- 5V device with 3.3V outputs

Arduino Micro

- Features USART (Universal synchronous and Asynchronous Serial Receiver and Transmitter), I^2C, and SPI
- Based on ATmega32U4 board
- Allowing 20 digital input/outputs (7 PWM outputs), 12 analog inputs, and USB connection
- Compiled by C/C++
- Large open source community

I^2C (Inter-Integrated Circuit)

- Low-cost network to interconnect peripheral devices
- Master-slave relationship of Raspberry pi and Arduino Micro
- Conflict-free connection of varied devices [9]
- 100kbps in standard and 400kbps in fast mode [10]

SPI (Serial Peripheral Interface)

- 4-wire serial bus to allow for short distance communication, including two input signals, one output, and a "chip select" signal [11]
- Communication to GPS

GPS

- System to report position to operator for alarm protocol or tamper-evident features
- Built around MTK3339 chipset to track up to 22 satellites on 66 channels with receiver sensitivity of -165dBm [12]

Wi-Fi

- Built-in Broadcom BCM43438 module in Raspberry Pi 3
- 2.4GHz 802.11n wireless LAN [13]

CSI (Camera Serial Interface)

- Low power 2.5 Gbps, 15-pin, processor to Pi NoIR camera interface

4.3 Constraints, Alternatives, and Tradeoffs

The most significant constraints for the REDSS are size, weight, power, and image processing capability. Hardware was selected to meet system technical requirements as well as ease the prototyping process.

The main processing unit needs a powerful image processing capability, low power requirement, and peripheral connectivity. The two most capable commercial options available were the TI Beaglebone and the Raspberry Pi. The Raspberry Pi has less capable IO mechanisms compared to the Beaglebone, but contains a Graphics Processing Unit and native support for high-speed camera interfaces in the form of Camera Serial Interface (CSI). The insufficient IO of the Raspberry Pi can be augmented by a Front-seat/Back-seat architecture with a microcontroller. There are four Raspberry Pi models available which contain a GPU and the CSI interface. Table 4 shows the decision process, which ultimately chose the Raspberry Pi 3B. Processor margin is defined as computing power beyond what the robot is expected to require, and serves as a safety net in the even OpenCV cannot be optimized for the GPU.

TABLE 4 DECISION MATRIX FOR THE RASPBERRY PI MODELS

Features	RPi 1A+	RPi 1B+	RPi 2B	RPi 3B
Power Consumption	**4**	3	1	2
Processor Speed Margin	1	1	3	**4**
GPU Capability	1	1	1	**4**
Memory Size	1	2	**4**	**4**
Price	**4**	3	2	3
Total	**11**	**10**	**11**	**17**

Hardware control is handled by the "Front-seat" microcontroller. The Arduino Micro was chosen due to its low power consumption and large user community. A weighted decision matrix is shown in Table 5.

TABLE 5 DECISION MATRIX FOR MCU WITH EXTRA WEIGHT ON SIZE AND USER COMMUNITY

Features	Arduino Micro	Arduino UNO	MBED	TI MSP430 Launchpad
Power Consumption	3	3	1	**4**
Size	**8**	4	6	4
User Community Support	**6**	6	2	4
Price	3	2	1	**4**
Total	**20**	**15**	**10**	**16**

REDSS has strict endurance requirements so expected battery life was computed with the selected hardware and is summarized in Table 6. The total duration REDSS will last in different modes is shown in Table 7.

TABLE 6 POWER CONSUMPTIONS FOR THE COMPONENTS

Components	Surveillance Mode Power Consumption	Laser Tracking Mode Power Consumption
Raspberry Pi 3B	2.75 W	3.3 W
Pan Servo Motor	1.125 W	1.25 W
Tilt Servo Motor	1.125 W	1.5 W
Camera	1.2 W	1.2 W
Total	6.2 W	7.25 W

TABLE 7 DURATION OF POWER IN DIFFERENT MODES

Battery	Surveillance Mode Operation Hours	Laser Tracking Mode Operation Hours
55Wh Li-ion Battery	8.9 hours	7.6 hours

5. Schedule, Tasks, and Milestones

The estimated timeline for the project is attached as a GANTT chart in Appendix A and B. Major milestones are the proposal presentation at the end of August and the senior design expo at the beginning of the December. Development and testing will be continuously executed between those two milestones.

Table 8 contains a breakdown of significant tasks, assigned engineers, and risk level. Image processing is the riskiest task due to the team inexperience and processing requirements, and will be reduced by assigning two engineers and purchasing hardware with sufficient processor margin.

TABLE 8 TASK DIVISION AND RISK LEVELS

Task Name	Task Lead	Risk Level
Documentation and Presentations	All (Lead by Mike)	Low
User Interface Design/Implementation	Josh	High
Hardware Integration	Gyucheol, Mike, Satoshi, Seong Ho	Medium
API Software Integration	Josh, Mike	Medium
Image Processing	Gyucheol, Mike	Highest
Peripherals (Motors, Laser, Dazzler) Controls	Satoshi, Seong Ho	Medium
GPS Processing	Mike, Seong Ho	Low

6. Project Demonstration

REDSS will be built as a functional “Flat Robot”, with all of the hardware integrated into a deployed position and will not contract to the stowed state. A non-functional stowed position will be produced to demonstrate the collapsible concept. To ensure all operational modes are presented, the demonstration will be divided into a live and a recorded demo.

6.1 Live Demonstration

REDSS is meant to track lasers at night, in areas free of powerful illumination. Therefore, it may not be able to track eye-safe lasers in a well-lit environment, especially if the light sources are incandescent or halogen.

If the demo environment is conducive to laser tracking REDSS will track an eye-safe IR laser on a notional target, and deploy its dazzler.

The camera feed, mobile app control, and physical remote control will be demonstrated regardless of ambient light conditions. REDSS will rotate and deploy its dazzler as commanded, and provide a video feed to the mobile device. Audible warnings will be played in English, Korean, and Japanese.

6.2 Video Demonstration

Former Army Rangers will film a simulated combat environment, using REDSS in all of its operational modes. The video and still images will be displayed at the Senior Design Expo. The API will be integrated with a microcontroller-based audio direction finding system, and a video will be made of the system locating the source of a tone in real time.

7. Marketing and Cost Analysis

7.1 Marketing Analysis

The target market is the government, specifically for military personnel in combat environments. Although no products with identical functionality exist, the surveillance function of the system is comparable to a standard surveillance system. A commercial surveillance system with wireless communication and video feed can cost approximately $200, while advanced designs with recording capabilities cost nearly $500 [14]. Similarly, a motion tracking security light that follows movement in a 220 degree cone costs roughly $100 without a camera and $200 with a camera installed [15]. A surveillance trailer can cost upwards of $42,000 [16]. Though there are several products available that fulfill parts of the proposed device, none have the combined functionality or a laser tracking capability which creates a unique market for the proposed product.

7.2 Cost Analysis

The total cost materials for developing a prototype REDSS system is approximately $272.03 as shown in TABLE 9 below. Although the pan tilt mechanism is rather costly, in order to complete the project in a timely manner a pan tilt system will be purchased instead of designed.

TABLE 9 EQUIPMENT COSTS

Part	Number	Cost Each	Cost Total
Raspberry Pi 3	1	$39.95	$39.95
Arduino Micro	1	$24.95	$24.95
Pan tilt system	1	$45.99	$45.99
Sailwinch Servo (SW5513-4MA)	1	$12.20	$12.20
Servo (HS-485HB)	1	$16.99	$16.99
NOIR Camera	1	$29.95	$29.95
Li-ion Battery (5.2 AH)	1	$34.80	$34.80
1/8" x 12" x 12" aluminum sheet metal	1	$28.56	$28.56
Surface Mount Hinge	8	$4.83	$38.64
Stainless Steel Hex Nut pack 100	1	$3.83	$3.83
Stainless Steel Flat Head Phillips Machine Screw	1	$5.80	$5.80
IR Laser Diode	2	$36.12	$72.24
LED Torch	1	$35.00	$35.00
Parts Total			**$272.03**

The development costs were estimated using the average annual pay of Electrical Engineers as $57,030 [17]. This converts to roughly $30 an hour which was used to estimate development costs. The total labor cost is $17,280.00 and is summarized in TABLE 10 below.

TABLE 10 COST ANALYSIS OF LABOR

Project Component	Labor Hours	Labor cost
User interface	160	$4,800.00
Pan tilt control mechanism	144	$4,320.00
Battery monitoring	40	$1,200.00
Image processing	128	$3,840.00
Mechanical construction	56	$1,680.00
Documentation	48	$1,440.00
Labor Total	**576**	**$17,280.00**
Parts Total		**$272.03**
Grand Total		**$17,552.03**

Several assumptions are made in the production calculation: the components of the REDSS device can be obtained with a 20% discount due to bulk ordering and custom manufacturing, labor costs remain consistent, fringe costs are 30% of total labor, overhead costs are 120% of the total material and labor costs, and sales costs are only 3% due to a highly focused market. With those assumptions the REDSS can be sold for approximately $562.19 earning a $35 profit per unit if 5000 units are sold. Details are shown in TABLE 11 below.

TABLE 11 PRICE PER UNIT BREAKDOWN

Parts 20% discount	$1,088,120.00
Labor	$17,280.00
Fringe	$5,184.00
Subtotal	**$1,110,584.00**
Overhead	$1,443,759.20
Production Total	$2,554,343.20
Sales	$76,630.30
Amortized Development Costs	$5,000.00
Profit	175000
Total Production, Sales and Profit	$2,810,973.50
Selling Price	$562.19

Since the REDSS device will be used in a military setting, a more ruggedized version will need to be developed to meet environmental demands. When comparing ruggedized laptop and tablet devices, ruggedized versions cost roughly 300% the cost of an equivalent non ruggedized unit [15], [18]. Using those estimates a ruggedized version could be developed and sold for $1,593.30 if maintaining a $35 profit per unit.

8. Current Status

As of April 15th 2016 all of the REDSS top level design parameters have been identified, and a detailed block diagram has been built. Detailed designs within each block are ongoing, exact parts are selected and have been analyzed to ensure they meet system requirements, and development can begin as soon as parts become available.

9. References

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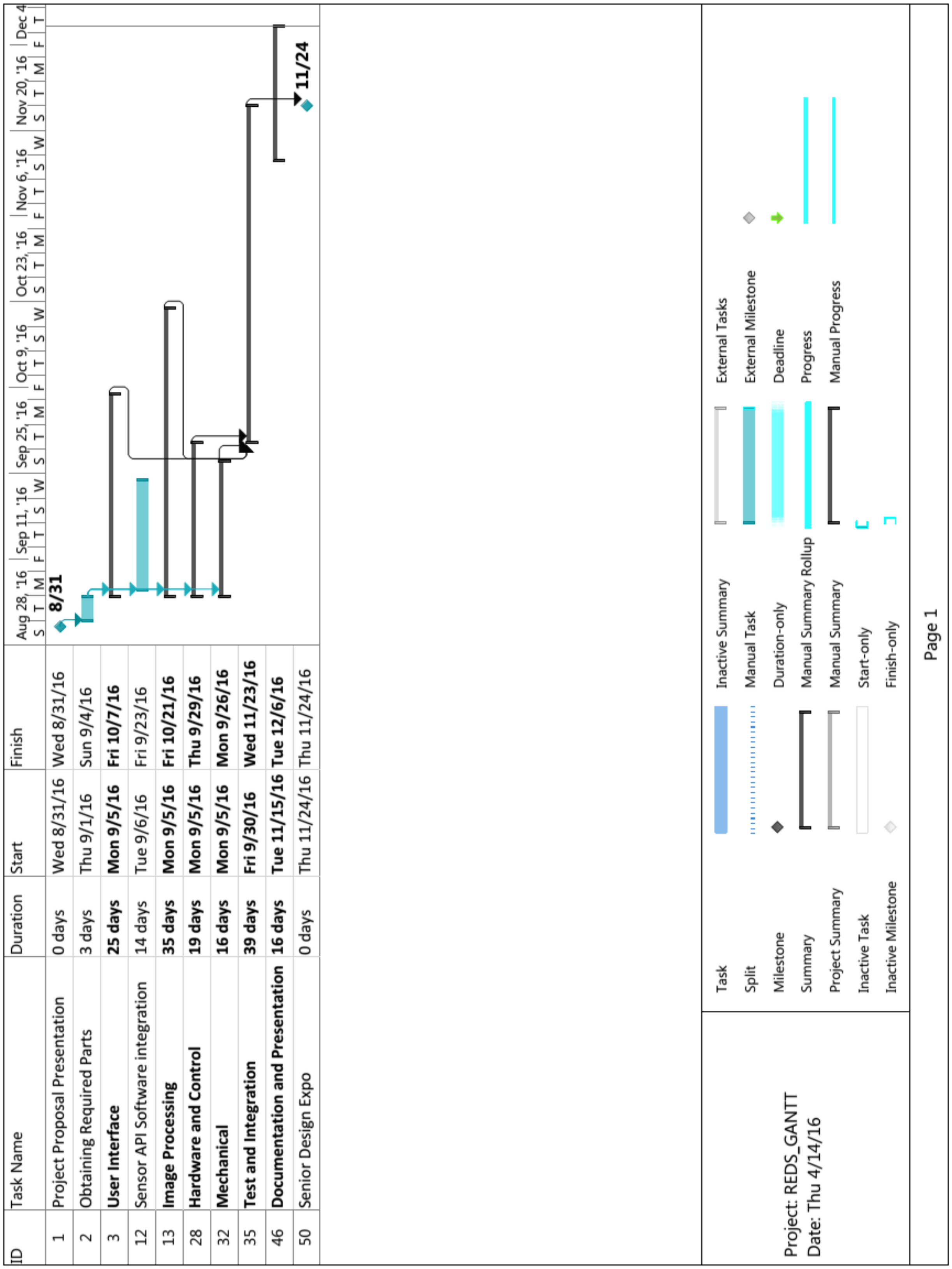
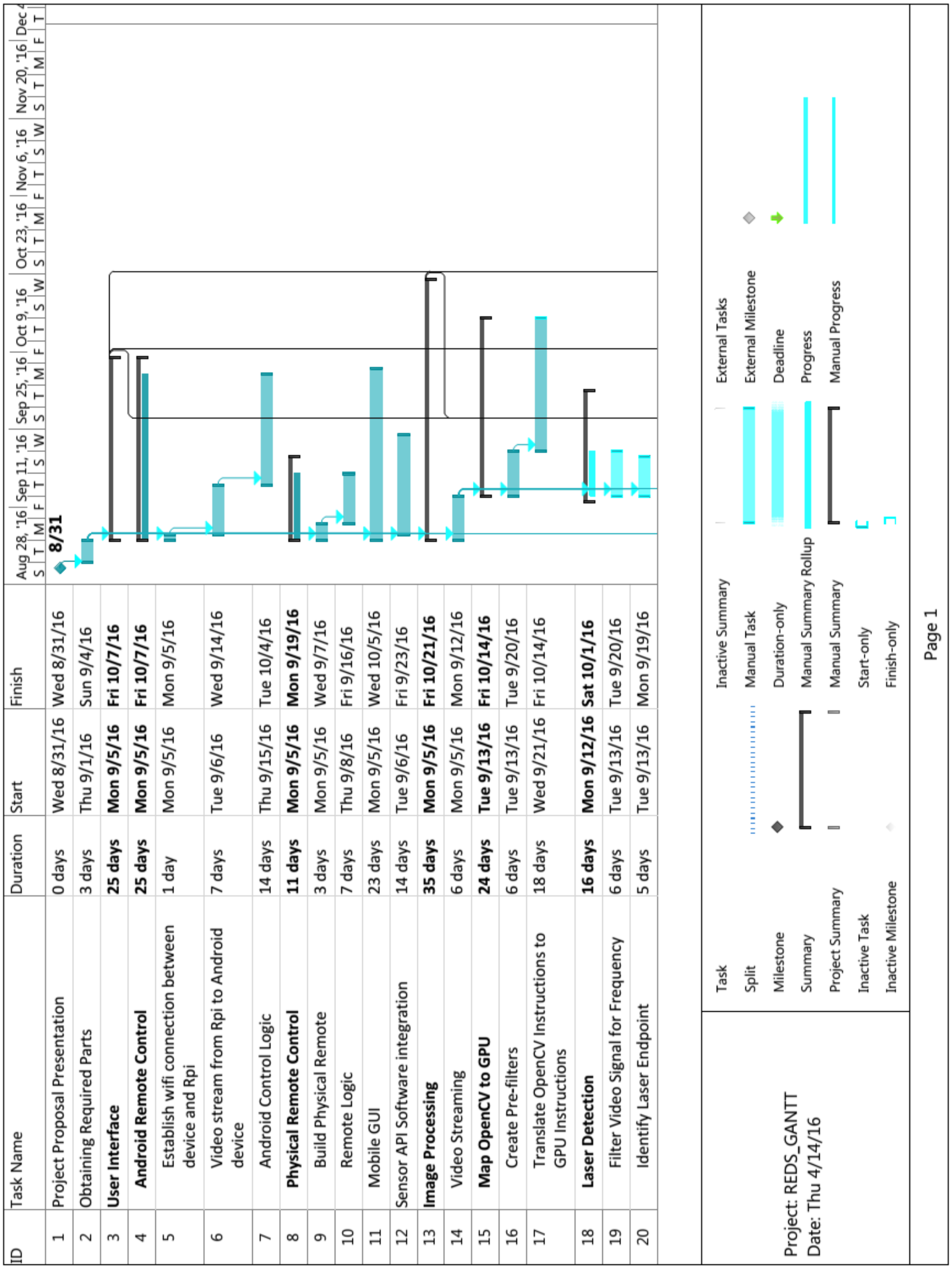
Appendix A. Compressed GANTT Chart

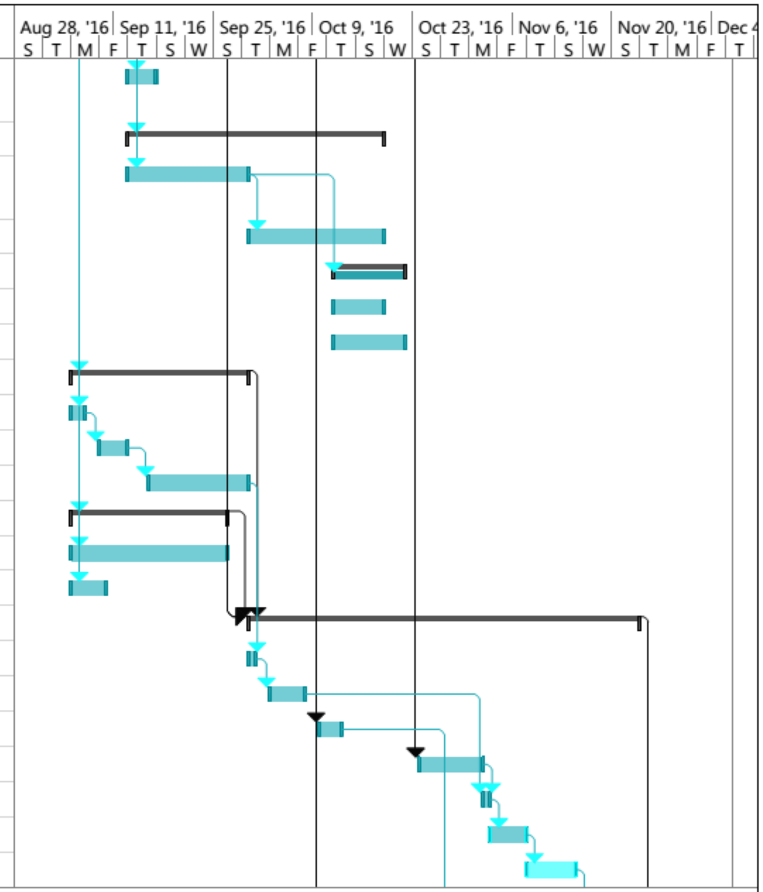


Appendix B. Comprehensive GANTT Chart



ID	Task Name	Duration	Start	Finish
1	Project Proposal Presentation	0 days	Wed 8/31/16	Wed 8/31/16
2	Obtaining Required Parts	3 days	Thu 9/1/16	Sun 9/4/16
3	**User Interface**	**25 days**	**Mon 9/5/16**	**Fri 10/7/16**
4	**Android Remote Control**	**25 days**	**Mon 9/5/16**	**Fri 10/7/16**
5	Establish wifi connection between device and Rpi	1 day	Mon 9/5/16	Mon 9/5/16
6	Video stream from Rpi to Android device	7 days	Tue 9/6/16	Wed 9/14/16
7	Android Control Logic	14 days	Thu 9/15/16	Tue 10/4/16
8	**Physical Remote Control**	**11 days**	**Mon 9/5/16**	**Mon 9/19/16**
9	Build Physical Remote	3 days	Mon 9/5/16	Wed 9/7/16
10	Remote Logic	7 days	Thu 9/8/16	Fri 9/16/16
11	Mobile GUI	23 days	Mon 9/5/16	Wed 10/5/16
12	Sensor API Software integration	14 days	Tue 9/6/16	Fri 9/23/16
13	**Image Processing**	**35 days**	**Mon 9/5/16**	**Fri 10/21/16**
14	Video Streaming	6 days	Mon 9/5/16	Mon 9/12/16
15	**Map OpenCV to GPU**	**24 days**	**Tue 9/13/16**	**Fri 10/14/16**
16	Create Pre-filters	6 days	Tue 9/13/16	Tue 9/20/16
17	Translate OpenCV Instructions to GPU Instructions	18 days	Wed 9/21/16	Fri 10/14/16
18	**Laser Detection**	**16 days**	**Mon 9/12/16**	**Sat 10/1/16**
19	Filter Video Signal for Frequency	6 days	Tue 9/13/16	Tue 9/20/16
20	Identify Laser Endpoint	5 days	Tue 9/13/16	Mon 9/19/16

ID	Task Name	Duration	Start	Finish
21	Translate Laser Position into Coordinates	4 days	Tue 9/13/16	Fri 9/16/16
22	**Surveillance Alarm/Motion Detection**	**26 days**	**Tue 9/13/16**	**Tue 10/18/16**
23	Coherent Change Detection Algorithm	13 days	Tue 9/13/16	Thu 9/29/16
24	Determine Power Optimum Strategy	13 days	Fri 9/30/16	Tue 10/18/16
25	**Movement Feedback**	**8 days**	**Wed 10/12/16**	**Fri 10/21/16**
26	Create Disparity Map Function	5 days	Wed 10/12/16	Tue 10/18/16
27	Track Image Changes	8 days	Wed 10/12/16	Fri 10/21/16
28	**Hardware and Control**	**19 days**	**Mon 9/5/16**	**Thu 9/29/16**
29	Configure sail-wynch and servo motors	2 days	Mon 9/5/16	Tue 9/6/16
30	Assemble pan tilt actuator module	2 days	Fri 9/9/16	Mon 9/12/16
31	Build Arduino PWM Control Scheme	10 days	Fri 9/16/16	Thu 9/29/16
32	**Mechanical**	**16 days**	**Mon 9/5/16**	**Mon 9/26/16**
33	Flat Robot (Functional)	16 days	Mon 9/5/16	Mon 9/26/16
34	Folded Robot (Non-Functional)	5 days	Mon 9/5/16	Fri 9/9/16
35	**Test and Integration**	**39 days**	**Fri 9/30/16**	**Wed 11/23/16**
36	Integrate Arduino with Pan/Tilt Motors	1 day	Fri 9/30/16	Fri 9/30/16
37	Test Motor functionality	5 days	Mon 10/3/16	Fri 10/7/16
38	Test Rpi WIFI	3 days	Mon 10/10/16	Wed 10/12/16
39	Test Rpi Image Processing Functionality	7 days	Mon 10/24/16	Tue 11/1/16
40	Integrate Rpi and Arduino	1 day	Wed 11/2/16	Wed 11/2/16
41	Test Rpi and Arduino Communication	3 days	Thu 11/3/16	Mon 11/7/16
42	Test Motor Feedback	5 days	Tue 11/8/16	Mon 11/14/16



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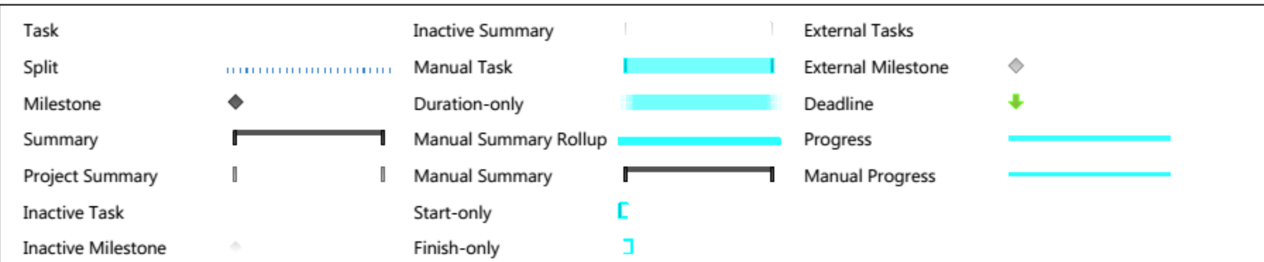

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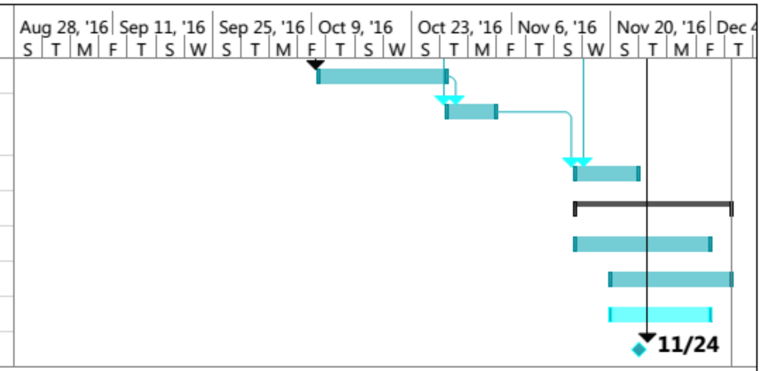
ID	Task Name	Duration	Start	Finish
43	Test User Interface	14 days	Mon 10/10/16	Thu 10/27/16
44	Test User Interface and Rpi Communication	5 days	Fri 10/28/16	Thu 11/3/16
45	Test Integrated Functionality	7 days	Tue 11/15/16	Wed 11/23/16
46	**Documentation and Presentation**	**16 days**	**Tue 11/15/16**	**Tue 12/6/16**
47	Technical Documents	15 days	Tue 11/15/16	Sat 12/3/16
48	Demonstration	13 days	Sun 11/20/16	Tue 12/6/16
49	Presentation	12 days	Sun 11/20/16	Sat 12/3/16
50	Senior Design Expo	0 days	Thu 11/24/16	Thu 11/24/16



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Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

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