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Augmented Reality Accessory for Firearm Target Practice
Project Plan

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Background

Problem Statement

Often, when training with a firearm without help, it can be difficult to analyze one's individual technique, especially when the only feedback available is how many holes are in the target after a round of shooting. The target cannot provide information about shots that missed. Our solution will provide a shooter with this missing information. The product will consist of a hardware device, as well as a software application targeted at Android mobile platform. The device will attach to a firearm via a standard picatinny rail mount and will snap a picture every time the weapon is fired. The image is then transmitted via Bluetooth to the user's mobile device, where it is processed. After processing completes, the mobile application will display an image of the target with the estimated locations of the bullets highlighted. The shooter obtains immediate feedback, allowing corrective actions to be taken promptly.

Concept Sketches

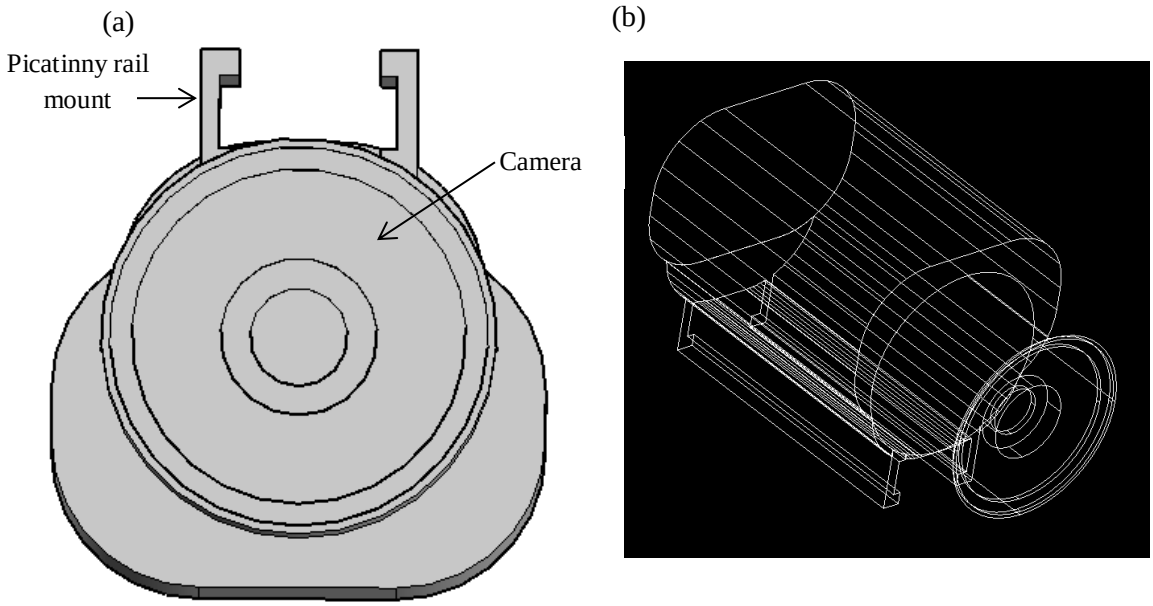

FIGURE 1 - DEVICE CONCEPT SKETCH. (A) DEPICTS THE FRONT OF THE DEVICE. (B) SHOWS A WIREFRAME IMAGE OF THE DEVICE FROM AN ANGLE.

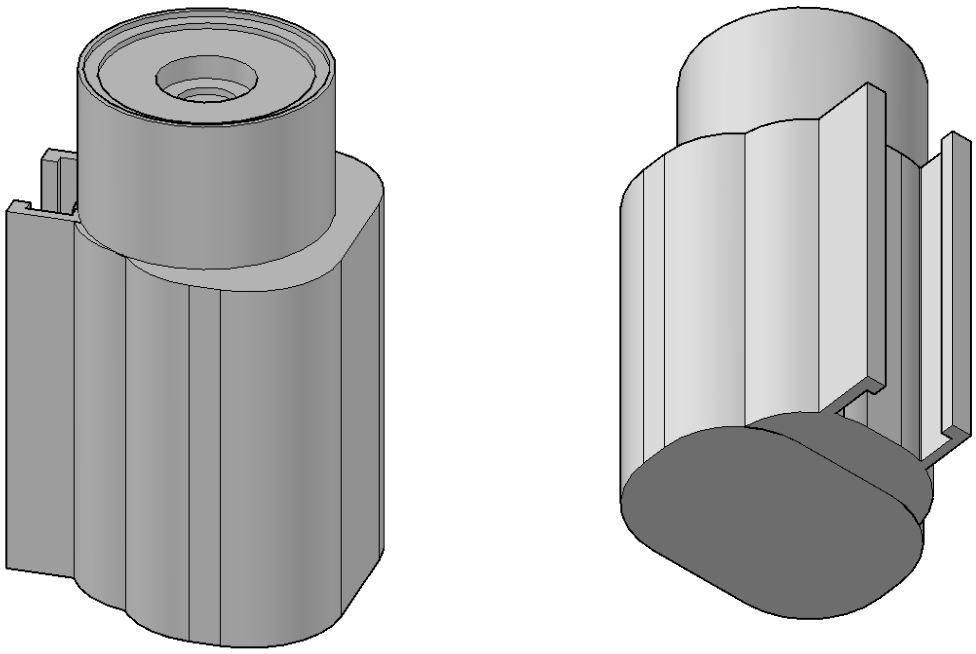

FIGURE 2 - SIDE VIEWS OF THE DEVICE

System Overview

System Description

Firearm Attachment

The firearm attachment is a battery-powered device that uses an accelerometer to detect sudden changes in acceleration. Before detecting a rapid acceleration, the camera is collecting image data which is collected by the microcontroller and sent via Bluetooth to the user's mobile device. Once a sudden acceleration is detected, the accelerometer signals the microcontroller, which then marks the last valid data with a special packet, and stops data collection from the camera. Any remaining data in the outgoing buffer is transmitted before sending the special packet. After a certain delay, the system returns to the ready state, which means the system begins collecting image data and transmits it to the user's mobile device.

Mobile Device

The application on the user's mobile device collects the transmitted image data, reassembling it into an image, until it receives the special packet signaling a rapid acceleration. Once it reads the packet, it processes the new image, and compares it with a baseline image taking during the calibration phase. Once the delta between the images is computed, the application calculates an estimation of where the shot went, and marks the location on the baseline image. The image with markings is displayed to the user. The application saves the shot history, allowing the user to display previous sessions.

System Block Diagram

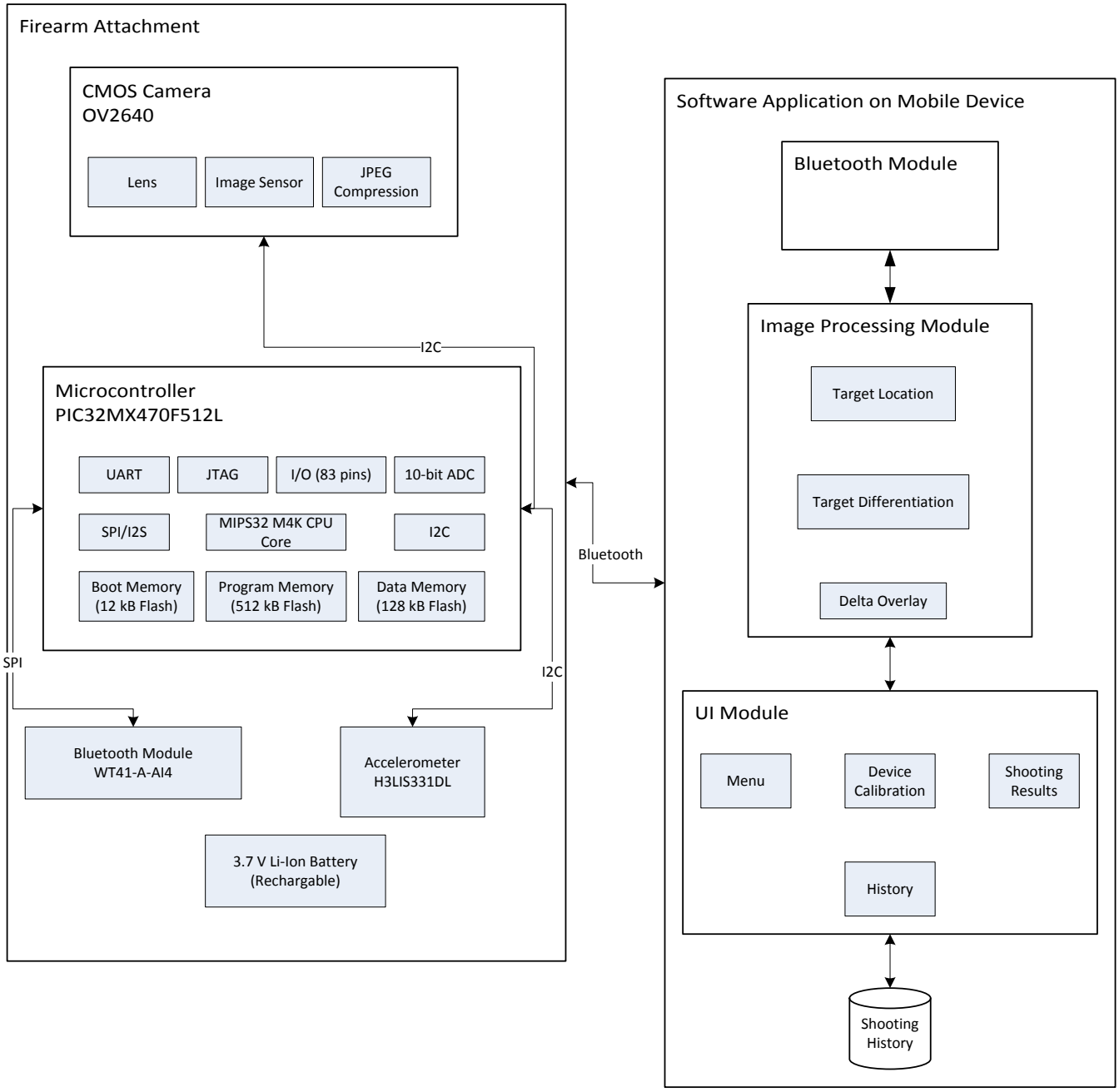

FIGURE 3 – SYSTEM BLOCK DIAGRAM

Operating Environment

The firearm attachment will operate in an outdoor environment. This means it will be subject to the elements such as wind, dust, heat, cold, and varied forms of precipitation. Additionally, the firearm attachment will be exposed to extreme changes in acceleration during the firing sequence, and potentially gunpowder residues and other byproducts from the discharge of the weapon.

User Interface Description

Physical Device

1. The device shall have a simple on/off switch.
2. The device shall have a battery compartment which allows the user access to the battery.

Android Application

The mobile application is where most of the user interaction takes place. Users can tell the application when to begin recording data and when to stop recording data. Once the begin signal is sent, the mounted device will send continuous image data line by line or several lines at a time to the smartphone via Bluetooth. Once the mounted device detects a shot has been fired, it temporarily stops sending image data. The application will then take the whole image and compare it to a base image of the target. Using image processing techniques, it will identify points of similarity and match the two pictures together by rotating or translating as necessary. The offset between the two images will allow the application to accurately place each shot on the base image of the target. Users will be able to view each target individually and identify each shot fired. They are able to cycle between the targets fired at (if there are multiple) by pressing the "Prev" and "Next" buttons on the screen. The option of saving the image to view at a later time is available. There will also be a settings menu in which users can specify the type of firearm and ammunition they are using, as well as some other helpful data such as where the device is mounted.

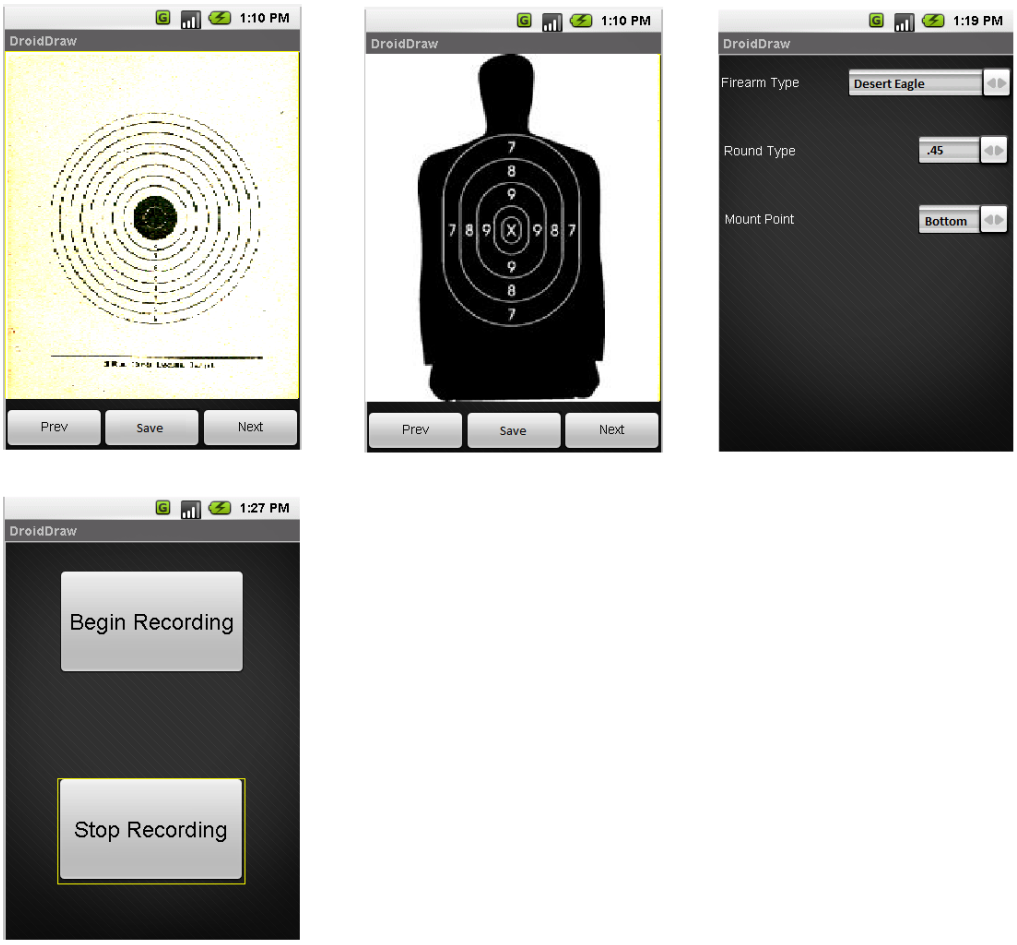

FIGURE 4 – THE ANDROID APPLICATION USER INTERFACE

Functional Requirements

Functional requirements are operations and activities that a system should perform in order to meet the specific demand that is placed on the product. The functional requirements for this device have been listed below:

1. The device must connect to a mobile phone via Bluetooth.
   1.1. Bluetooth is a short-range radio protocol in the ISM band from 2400 – 2480 MHz.
2. The device must be able to be calibrated (zeroed).
   2.1. It is important for the user to be able to calibrate the mounted device to properly align with the target in order to achieve optimal results. This is important because there is no restriction on mounting the device on top of the barrel of the firearm, underneath the barrel of the firearm, or on the side of the barrel of the firearm.
3. Device must mount on a picatinny rail compliant with MIL-STD-1913.
4. The application software must be compatible with both Android devices.
5. The application software must apply image processing techniques to the images received from the device and display the results to the user in an appropriate manner.
6. The system must have an operational range from 3-50 yards.

7. Device must be able to correctly operate when attached to the firearm on the top of the barrel, on either side of the barrel, and underneath the barrel.

Non-functional Requirements

1. Device fabrication cost shall be no more than $60.00 (US).
2. Device shall be able to withstand forces associated with the normal operation of firearms.
3. Device shall be water resistant.
4. Device shall be powered by a 3.7V power source.
5. Device shall not exceed the dimensions 3.0” (L) x 1.0” (W) x 1.5” (H)
6. Device shall not exceed a weight of 4 ounces.
   6.1. The device must be as light as possible in order to reduce the impact on the ballistics properties of the unmodified firearm.

Market & Literature Survey

Similar Products:

Tachyon OPS HD GunCam:

This device is a 720p video/still camera that mounts on several types of small-caliber arms via a picatinny rail mount. Its battery life is approximately 4 hours of continuous video. Video is recorded to a removable Micro-SD card. The battery is recharged via a Micro-USB port. Retail price ranges from $200-$230.

http://www.tachyoninc.com/guncam.php

FIGURE 5

Shooting Lab from Recreational Software, Inc

Shooting Lab is a software suite made by RSI that tracks all sorts of shooting data. It compares interior and exterior ballistics profiles of a variety of different ammo calibers. It also allows users to input images

of their actual targets for analysis. The data can be saved, which allows shooting progress to be tracked. Runs on Windows. Retail price is $99.00.
http://www.shootingsoftware.com/ballistics.htm

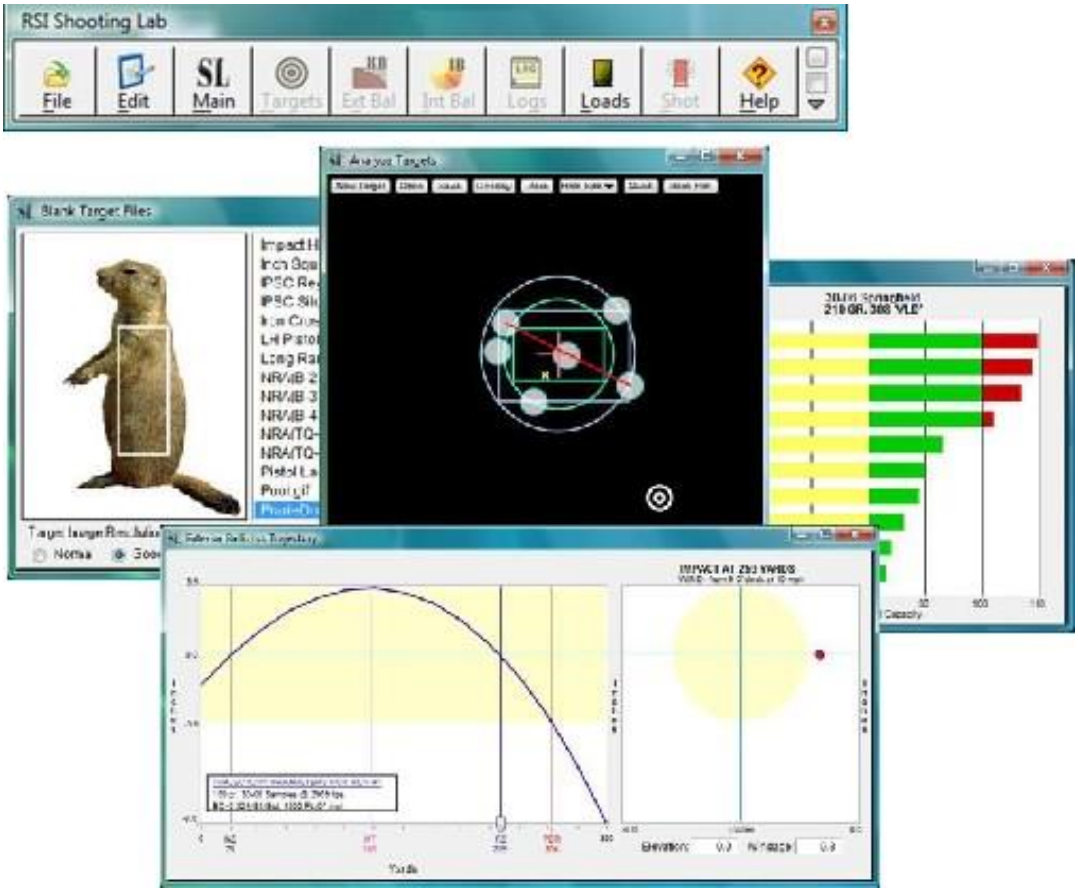

FIGURE 6

Camera Options:

Samsung Galaxy S4 Back Camera:

Pros:

- Higher resolution than cheaper option, 13MP, could be easier to use/software support found online.

Cons:

- Still moderately expensive, possible copyright infringement.

Main Points:

- $25.20
- 13MP
- In price range
- Possibly easier to use with software
- http://dx.com/p/repair-part-replacement-back-camera-module-for-samsung-galaxy-s4-i9500-230034?gclid=CMjdlMGgx7kCFSJqMgod6k8Asw

Toshiba TCM8240MD

Pros:

- Onboard JPEG compression.
- Breakout board included.
- Reasonable resolution.
- Cheap.

Cons:

- Product was recently retired and is no longer available.

OmniVision OV2640 CameraChip™

Pros:

- Onboard JPEG compression.
- Breakout board included.
- Reasonable resolution.
- Reasonable price.
- Product is available.

Cons:

- Slightly more expensive.

Main Points:

- $22.90
- 2 MP
- Onboard image compression.
- Sub-windowing capabilities.
- http://www.techtoys.com.hk/Components/OmniVision%20Cameras/OV%20CMOS%20Camera%20Modules.htm

Deliverables

At the end of the project in May 2014, we will have delivered the following items:

1. A Project Plan describing the system from a high level.
2. A Design Document detailing the technical specifications of the product.
3. A website containing all of our documentation and progress.
4. A prototype of the product. The prototype should be fully functional or else prove that the concept is infeasible.
5. An Android application that communicates with the product.
6. CAD schematic files for the device body.
7. PCB schematic files for device fabrication.

Work Plan

Work Breakdown Structure

Fall 2013

Android Development– Bluetooth

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Android Development – Image Processing

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Android Development – Test Platform

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Hardware Development and Test

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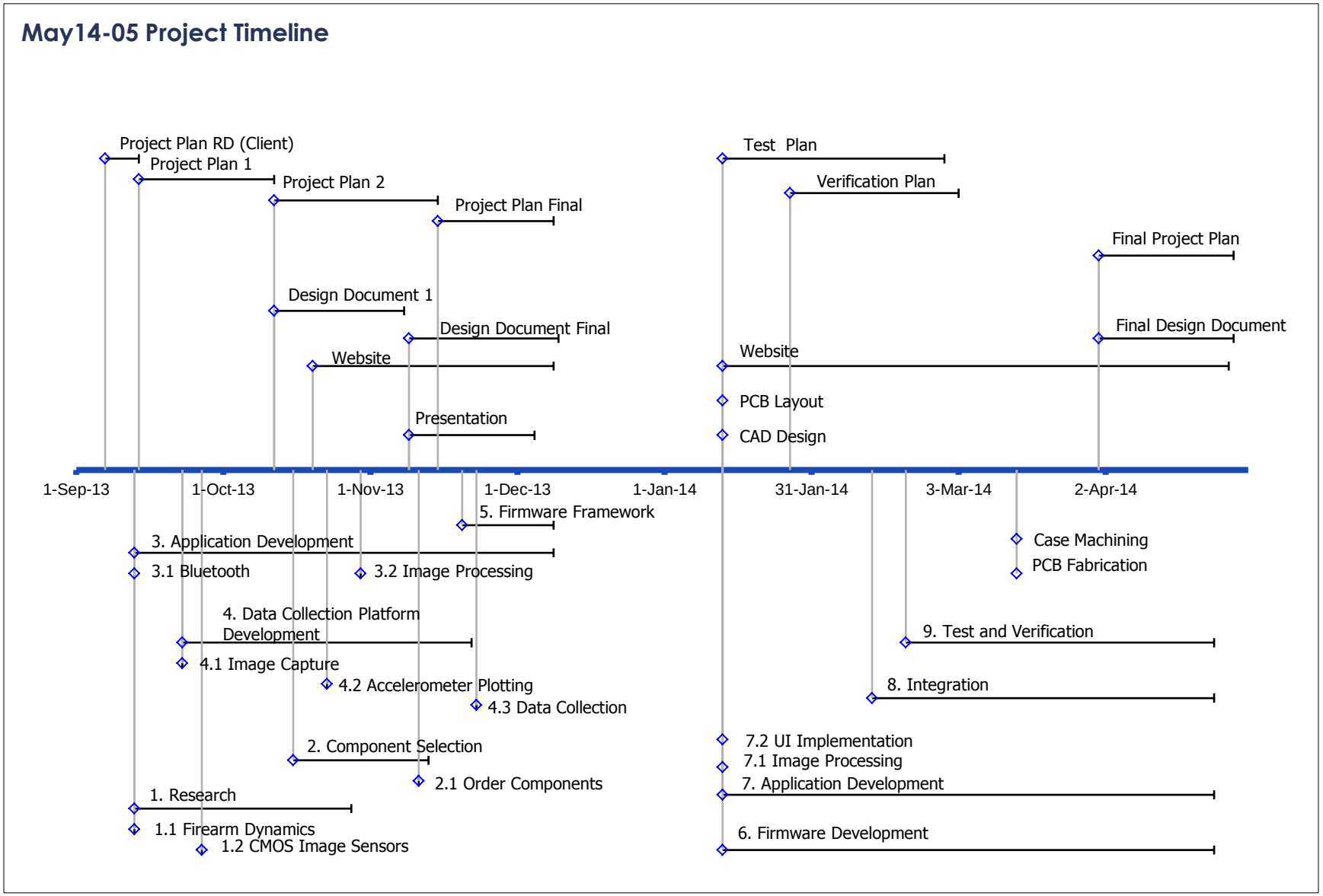
Dan Roggow

Firmware Development

Dan Roggow
Alec Jahnke
Brock Mills

Project Schedule



Risks

Camera

1. The response time of the camera is critical. If it cannot capture an image quickly enough after the trigger is pulled, then this device is infeasible.
2. The size of the camera must be small enough to not significantly alter the profile of the weapon (e.g. should fit into the dimensions of a typical scope for a particular weapon).
3. The quality of the captured image is important. If the camera cannot capture images with adequate resolution and minimal blurring, our application will not be able to accurately analyze the image.
4. For any camera containing more than 1 megapixels, the camera should support some type of onboard image compression or allow the ability to sub-index the image sensor array in order to reduce the required amount of onboard storage in the device, as well as reduced the transmission time of an image.
5. The selected camera must meet all these requirements at a reasonable price for our product to be feasible.

Accelerometer

1. The accelerometer must be able to handle the g-forces sustained in the normal operation of a variety of firearms.

Bluetooth

1. The Bluetooth module must be able to transmit data at a fast enough rate so that no image data is lost. Additionally, the rate must be sufficient so that users do not have to wait more than a second to transmit an image from the device to the mobile device.

Microcontroller

1. The microcontroller must have enough of the proper I/O ports to handle the peripherals in the system.
2. The microcontroller must have enough program memory in order to store the device firmware code.
3. The microcontroller must have a response time fast enough to process events generated from the sensors in the system in order to capture the required data.

Battery

1. The battery must provide adequate voltage for the components of the system.
2. The battery must contain enough charge to provide an acceptable amount of use time.
3. The battery will most likely be the heaviest part of the system, but it cannot affect the operation of the firearm. Battery weight must be balanced with the power requirements of the system.