Medical GPS Unit 4ctive Response Duty
(M-GU4RD)

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Summary

Every day, millions of members of military and first-responders report for duty. These distinguished men and women put the welfare of the people first by putting themselves at the forefront of danger. Military men, police officers, firefighters, and EMTs establish order amongst the chaos and ensure the survival of the everyday citizen. Through gunfire, flames, and even death these first-responders endure knowing their days may be numbered. With all the dangers and hazards these people face, it is important to provide them with anything and everything necessary to raise their chances of survival and those who are rescued by them. Ensuring the well-being of these brave professionals should be of utmost priority.

The "Golden Hour" is often used to describe the hour after receiving a traumatic injury in which one would need medical attention. During this time it is important to rescue and stabilize the injured in order to increase their survivability. If medical treatment is not given, the injured will be under extreme stress. This can include massive blood loss, internal rupturing, and loss of consciousness. Once this hour is up, medical treatment may be impossible and injuries sustained may affect a person's life forever if they are not already dead.

The goal of this project is to construct a device to reduce casualties and monitor those who may be under extreme trauma or stress. This applies especially to those during the "Golden Hour". The device made by the team will be used primarily for military and first-responders so that they can be constantly monitored from the outside. This will ensure that everyone going into the field is fully accounted for and later safely extracted from impending dangers.

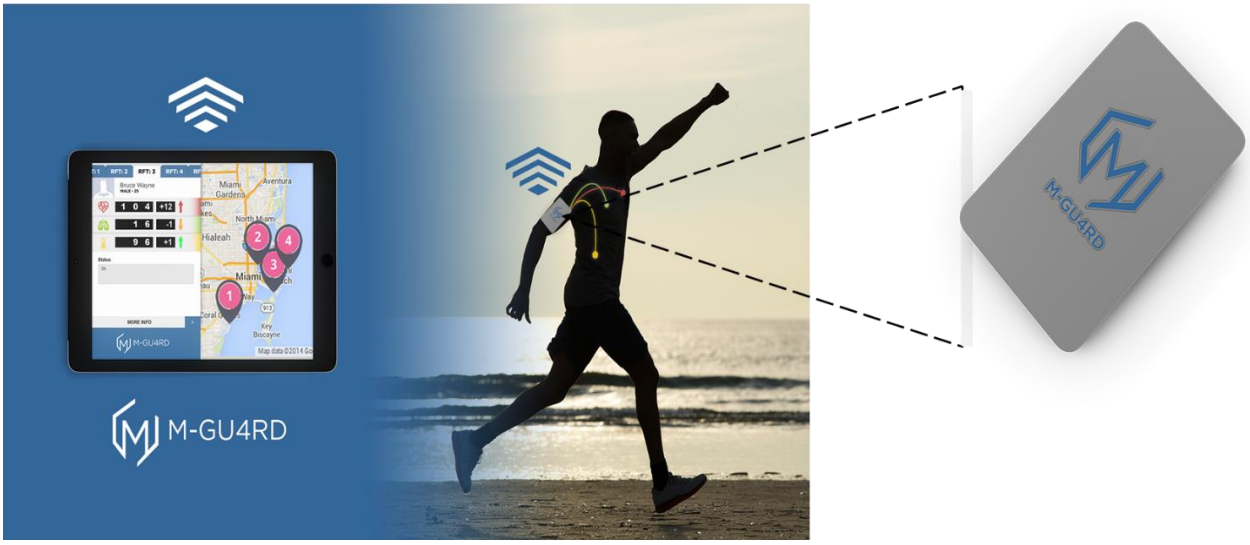
The device, codenamed M-GU4RD, consists of two devices. One is the M-GU4RD itself which will be formed to the body via a vest or band. The other is a peripheral device or display. The display houses an application that can be connected to several M-GU4RDs and displays vitals, location, and other pertinent information of the person using it. The M-GU4RD device attached to the body has several electrodes to detect heart-rate, respiratory rate, and body temperature with an accompanying GPS to monitor the user's location. This design is meant to be the barebones version of the M-GU4RD as the ideal version would be customizable and even specific to each profession. Future developments can include gas sensors and the addition of other biometric sensors.

In terms of hardware, the M-GU4RD prototype will be constructed using a basic microcontroller (Atmega2560) integrated with biometric sensors and a GPS unit. All sensors and units are directly compatible with the MCUs/MPUs and will be attached seamlessly to them. A PCB will be made to distribute power to all electronic devices as needed. The peripheral device that displays information will house a GUI constructed by the team that can be accessed via an app.

While similar devices to the M-GU4RD exist in some capacity or another, the team hopes to design a more intensive and comprehensive device. The current devices under development, especially in the medical field exist as large machines focused on monitoring patients. With advancements in technology, even select applications on smart watches can monitor certain vitals and obtain GPS location. Perhaps the closest designs to the M-GU4RD itself is the many fitness/trainer watches and body wear technology that help monitor vitals and other information to keep track of health and progress. These devices are more for commercial and public use for the everyday citizen. With

this comes many constraints and standards that must be met for commercial sale. This can inhibit the overall performance and quality of the device. For the M-GU4RD the team wants to place value on multipurpose use and customization for those in professional careers, accuracy, an ergonomic fit, and affordability. The large problem with direct competitors to the M-GU4RD is the fact that their devices are astoundingly expensive and inflexible to a point where using their technology becomes more of a liability. That is why currently you do not see many police officers or firefighters wearing any form of monitoring device. The M-GU4RD will address this issue and keep these men safe.

Project Description



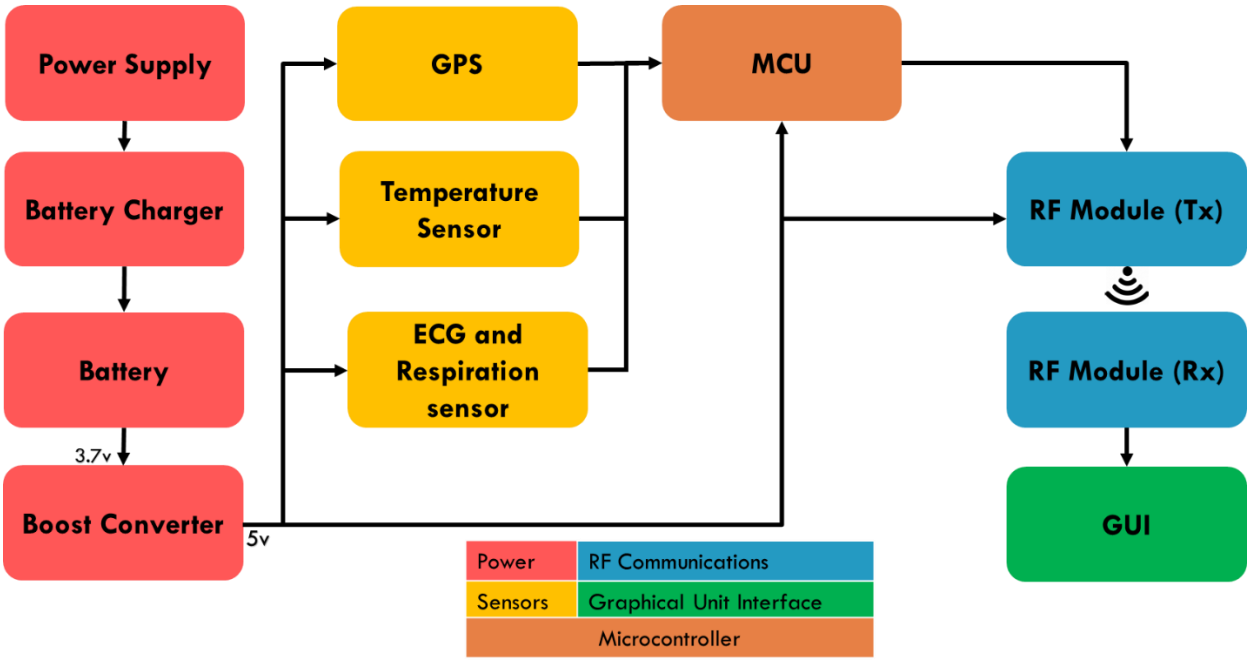
In order to monitor first responders when they are out in the field and ensure they are safe our team is designing a device that reports/shares vitals and other pertinent information amongst those involved. Ideally this device would be ergonomic in design as to not be intrusive to the user. It would also include an interactive display capable of showing the location of squad members and their status. With this design we can incorporate non-verbal communication using the touchscreen to mark hazards, draw paths of approach, etcetera. While this is the ideal design it is not the most practical. Firefighters and military personnel have similar technology available to them already, but these devices are incredibly expensive and because of the price they see very little use. Our focus is to create a more innovative device one that is more compact, affordable, and overall very efficient.

To compete with present devices our device will not include a display. Instead, all vitals and info will report to a leading official. A GPS unit will be used to track first responders and there will be a multipurpose button that can be used as a panic/help button. All this information will report to a central computer with software that monitors everyone involved. This technology should be used in tandem with some form of communication so that the official receiving this information can call shots and provide support. Vitals will primarily focus on heart rate and oxygen percentage, but depending on the devices use more vitals can be added with various attachments to fit the need of the user.

As stated prior, this kind of device has several applications useful for military officials, firefighters, medical practitioners, and law enforcement. While our team intends to create a device that can cater to all these professions with various attachments our design will focus strictly on the basics of recording vitals and sending other pertinent information.

Functional Block Diagram

The following diagram describes behavior of the system while going through the multiple subsystem.



Functional Requirements

- The M-GU4RD shall take the following vitals: Respiratory rate, Heart Rate and Temperature
- The M-GU4RD shall provide an accurate geographical location of the user
- The Graphical Unit Interface (GUI) shall display the sensor data
- The M-GU4RD shall have a transmission range of at least 50 meters
- The M-GU4RD shall be smaller than 20x20x15 cm
- The M-GU4RD shall weight less than 7.5 pounds
- The M-GU4RD shall be able to operate for a minimum of 2 hours

Component Selection

After careful consideration and review of all the components and based on our table comparisons, we proceeded to order the main components that will be used for the design and implementation of the M-GU4RD.

- Biometric Sensors:
    - Heart-rate (ADS1292R ECG/Respiration Shield)
    - Respiration-rate (ADS1292R ECG/Respiration Shield)
    - Body temperature (DS18B20 Digital Temperature Sensor)
- Other Components:
    - MCU (AtMega2560 processor)
    - GPS with altimeter (NEO-6M GPS Module)
    - RF module (APC-220 Wireless Transceiver)
    - Battery (3.7V Weltool LiPo)

Hardware Design

The finalized technological design for the M-GU4RD will consist of two separate devices:

- The actual M-GU4RD device that is worn on the body
- A receiving device that holds the GUI

The M-GU4RD will be strapped to the body of the first responder to improve accuracy of the ECG sensors, which will be attached to the user's upper-body. While all electrodes will be attached to the user's upper-body the microcontroller and microprocessor can be attached either to a belt or sling that fits to the bodies form. Our prototype will be developed using the Arduino microcontroller. The Arduino will be the main hub for all the major sensors as it already includes an analog-to-digital converter. This includes additional sensors and the GPS device. Wireless communication between the M-GU4RD and an overseeing device will be done via a transmitter to an application. In addition, a printable circuit board (PCB) will be used as our power control unit (PCU). This will be designed in order to properly distribute power to all sensors and devices.

The M-GU4RD will transmit all information to a secondary device that displays and translates all relevant information onto a display. The graphical user interface (GUI) shown on the touchscreen device will simplify all the sensor information so that an overseer can monitor all units in the stressful situations they may be in. From here an outsider can check the various vitals and GPS information and execute orders.

When deciding on the main components to the M-GU4RD, the first device to be selected is the microcontroller (MCU). This is the case because everything revolves around these devices as they are the main control of the system and everything must be connected to them. In a sense, no exterior device or sensor can be decided on until a central control is established as they must be compatible with the MCU/MPU. The Arduino was selected as they it is widely supported in hardware and software, inexpensive, and customizable. A problem prior to selecting these devices was whether a medical development board should be used instead. This idea was rejected as it did not allow for

as much flexibility and uniqueness in design. This gives the team more options and the ability to make additions to the original M-GU4RD design.

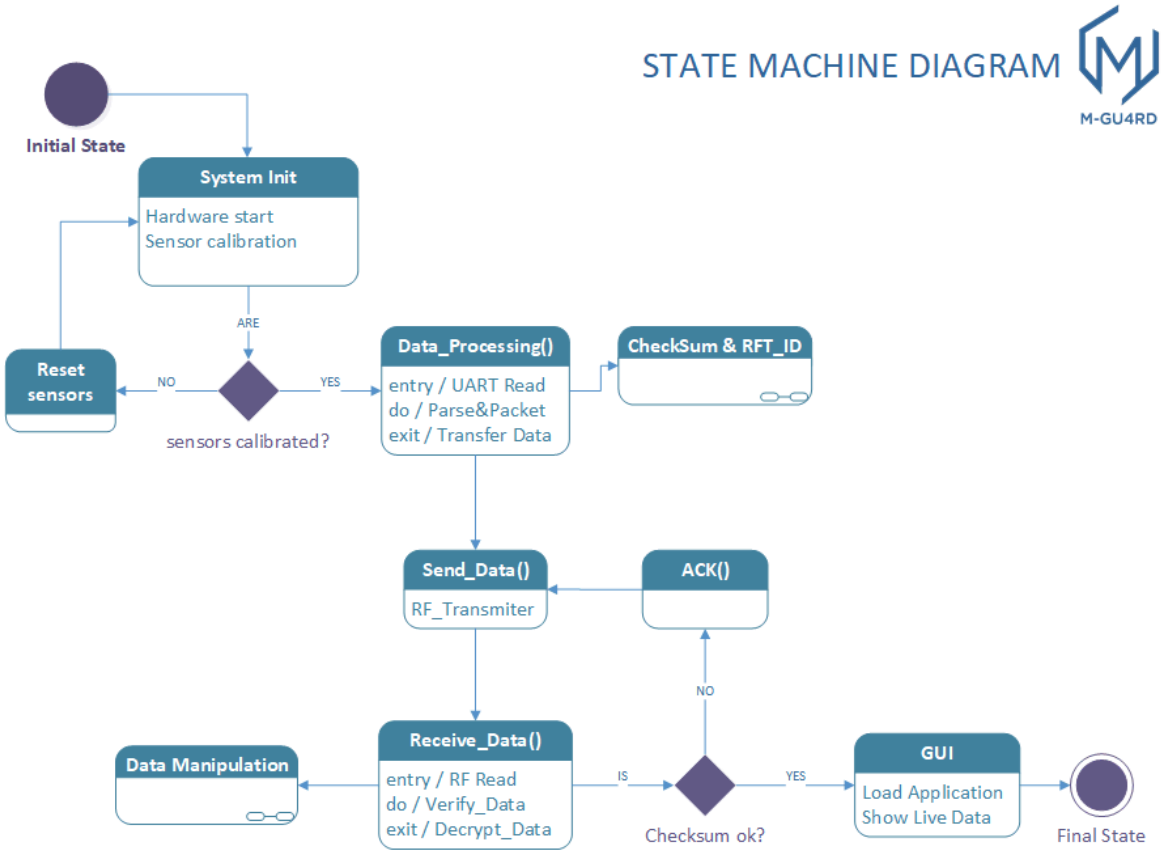
After arriving at a consensus on the brains of the M-GU4RD the team selected biometric sensors that were compatible with the Arduino. There were many options but only a few met the standards the team wanted in the device. These standards being accuracy, durability, and additional features. In the case of finding a capable ECG sensor it was found that some chips did not measure both heart rate and respiratory rate. So, our search was narrowed to a device that could. This came into account in selecting the ADS1292R ECG/Respiration Shield for Arduino as our ECG device and sensor. To get the last vital necessary for the M-GU4RD, body temperature, the team only had a few reliable options. So, the team selected the DS18B20 as it was cheap, durable, and simplistic in design.

As for location tracking, the NEO-6M GPS unit was selected. The primary reason the team selected this device is because it is compatible with both Arduino and Raspberry Pi and it also includes an antenna. This provides some flexibility as the GPS can be mounted on both devices and its antenna can be used or not depending on the receiver and transmitter combination the team decides to use. In addition the NEO-6M GPS unit is just as accurate as the other more expensive choices so quality is not sacrificed in constructing the M-GU4RD. There is also a unique function that this GPS provides in that it contains a third axis that can be used to monitor height which eliminates the need for an altimeter. This can then be used in order to detect floor location when a first-responder is located inside a building.

Software Design

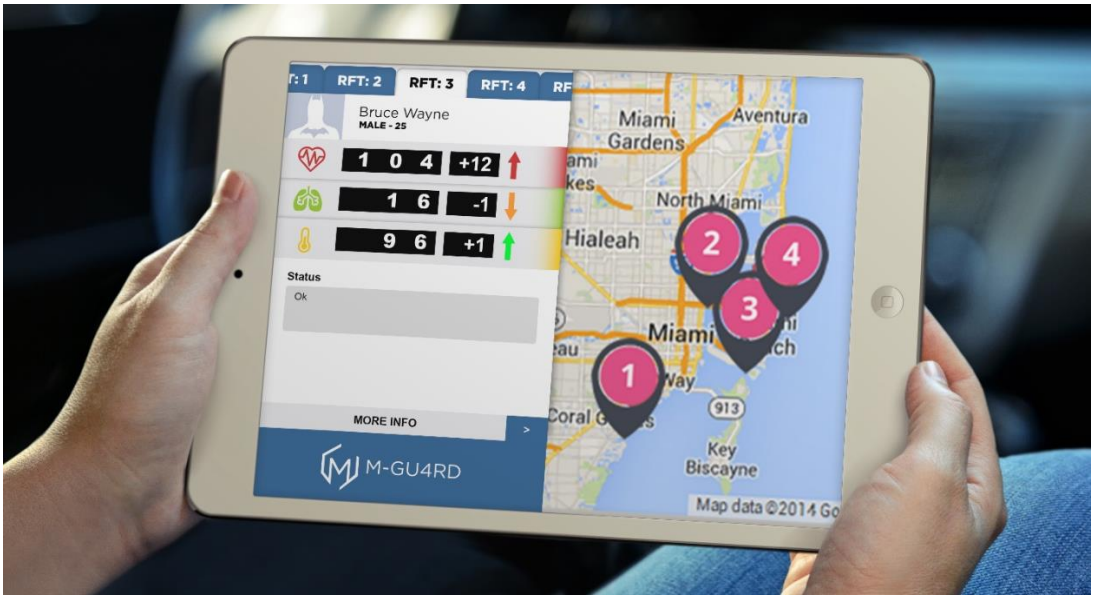
There will be multiple code languages implemented in this system. The programming language utilized to code the Microcontroller unit (MCU) is C/C++ while utilizing the libraries and data provided by the sensors. The Graphical Unit Interface (GUI) utilizes Java as the programming language, this GUI will be launched initially with an Android Platform. Part of the future development for the M-GU4RD includes development for IOS and Microsoft. In order to the MCU and GUI to communicate C/C++ will be utilized. The Geographical Interface will utilize Java as the programming language.

The following state diagram describes the system behavior and logic for the M-GU4RD. Part of the software development includes a test to see if sensors are calibrated. If not, the M-GU4RD will reset these sensors until obtain the desired calibration. Another part of this diagram describes the “Checksum test” this will assure that the data display in the Graphical Unit Interface is correct and ready to be display.



Graphical User Interface (GUI)

One of the biggest features and advantages of this design is to create a simple, easy to read Graphical Unit Interface. The display must be clear and easy to understand in order to be utilized by people who might not be have an intense training in this field. The goal is to make this design a very user-friendly design.



Our design is very technical and will incorporate a microcontroller with various sensors to interpret and send data to an outside device. Although a lot of this design will focus on the hardware, the graphical user interface is vital in accurately and effectively representing the information provided. The GUI will be dynamic and will constantly update and adapt to changes in location and health patterns in order to keep the user updated.

At the forefront of the GUI will be a dynamic map of the surrounding environment and the GPS locations of every squad member wearing an M-GU4RD. This display can be adjusted to show marked locations, a unit's range of view, and even a squad member calling for help. To the side of this display will be the vitals of the selected M-GU4RD user. These users can be cycled through to focus on one singular unit. The primary vitals displayed will be heart rate, respiratory rate, and body temperature. These vitals provide the most information as slight variation in these numbers can signal distress. Next to these numbers will be an arrow pointing in the upward or downward direction. Alongside these arrows will be a number that represents the deviation of that specific vital compared to their resting average. If their vitals go up an up arrow will display with a positive number. If their vitals go down a down arrow will display with a negative number. The purpose of these numbers and arrows is to simplify the results so the user of the GUI can understand everyone's status. In addition to these simplified measurements, sound and color alterations will signify issues in vitals. Green will signify a healthy status, yellow will serve as a warning, and red will trigger a noise meaning the user is distressed.

To accurately track the vitals of an M-GU4RD user there is important information to note. The heart rate, in beats per minute, should be within 60-100. The respiratory rate should be within 12-20 breaths per minute where hitting greater than 25 and lower than 12 is considered abnormal. Body temperature in degrees Fahrenheit has an average of 98.6, but can be anywhere between 97.8 and 99.1. At 95 and below is when hypothermia is taking into account. All these averages will be displayed in green whereas slight variations will be displayed as yellow. In the case of severe changes in vitals red will be used.

	Green (Good)	Yellow (Warning)	Red (Danger)
Heart-Rate	Users resting number	Fluctuations between 60-100 bpm	Outside yellow range
Body Temperature	Users resting number	Fluctuations between 97.8-99.1 degrees	Outside yellow range
Respiratory Rate	Users resting number	Fluctuations between 12-20 bpm	Outside yellow range

Cost of Manufacturing

Component	Unit Cost
3.7V Weltool Lipo Battery 2600mAh	$7.59
5V 3A AC Wall Adapter	$10.05
AtMega2560 Chip	$12.20
NEO-6M GPS Module	$15.66
ADS1292R ECG/Respiration Shield	$46.73
DS18B20 Digital Temperature Sensor	$2.32
APC220 RF Module	$24.58
PCB	$18.33
18650 Battery Holder	$2.60
TPS61230A 5V Boost Converter	$2.03
MCP73832T Battery Management Chip	$0.57
Resistors/Capacitors etc.	$14.52
TOTAL UNIT COST	**$157.18**

Conclusion

The M-GU4RD is a revolutionary device providing scope to first-responder tools and mechanisms. This device allows for constant monitoring of those facing dangerous and traumatic situations. The everyday heroes: firemen, police officers, and emergency response deserve protection. Risking their lives for the greater good whether it be fires, enemy combatants, and deathly illness. That is why this device is so important. It's about protecting those who rescue others so that everyone can be safe and healthy. Reducing the amount of unwarranted deaths by monitoring their location and vitals saves lives.

Many of these first-responders are also dealing with trauma at home. After a tough day of work these brave men and women have seen it all. The injuries, the death, it takes a toll. This can result in death in the following hours. Many first-responders keep fighting even after the action due to PTSD, internal injuries that may go unchecked, and heart-attacks overnight. Some even result to suicide. The M-GU4RD doubles as a safety precaution to monitor people over the next 24-hours after an emergency engagement. This device is very flexible and can adjust and address multiple issues. Including saving those within the "Golden Hour".

In final analysis, the M-GU4RD project is a device meant to monitor the vitals and location of first responders for safety reasons. The device is designed to measure heart rate, respiratory rate, body temperature, and position and send this data to someone who can monitor the individual. The design uses sensors to measure this data and a microprocessor arranges the data cohesively. This packet of information is transmitted using a RF module to a receiver that can be plugged into any Windows laptop or tablet. The information can be displayed on the Windows application.

This project thus far focused on what major components were to be used as well as the testing of said components and design. All of the major sensors and devices were tested individually to prove functionality and accuracy. After testing was complete, all the sensors demonstrated successful results to utilize them for the final product. Further testing will take place to combine all of the components together and to test PCB designs. If time permits, the group will work on additional features including altitude sensing and gas detection.