**Problem Statement:**

The goal of this project is to design a durable, wearable device for firefighters, first responders and members of the United States Department of Defense (DOD) that provides accurate, real-time feedback of an individual’s vitals. Since the device will be subject to harsh conditions, it should be fully operational in any condition that the target population may be exposed to. The device should be temperature, water, dust, wind, weather, shock and impact resistant, as well as be able to withstand drastic changes in environmental conditions. The form of this device should be comfortable for the user, and not impede on any daily activities that the user may perform. Along these lines, the device should be lightweight and compact for easy application. The device would relay all vital information that the sensors measure to a portable unit (PU) also referred to as a data logger. The device should be functional for an appropriate period of time before requiring a recharge from a charging dock or station.

**Standard of Care:**

Standard of care available for wearable health devices (WHD) that perform tasks related to tracking and monitoring one’s vitals can be broadly broken down into three main categories: medical-grade vital equipment, adhesive patches, and wearable smart devices. Examples within each category are as follows:

* Medical grade vital equipment
  + Caretaker - A patient monitor that uses a simple finger cuff to measure continuous beat-by-beat blood pressure (BP), heart rate (HR), and other physiological parameters
  + BiPS Medical - a wearable, wireless sensor system that records physiological information and transmits it to electronic medical records (EMRs), to rapid response systems, or to family doctors. This device monitors BP, HR, respiration rates, and blood oxygen level
  + Current Health - Wireless wearable, tracks respiration rate, Oxygen, pulse rate, skin temperature, posture, motion, and activity
* Adhesive Patches
  + Zephyr BioPatch - A lightweight, wireless device attached to a patient’s chest that provides continuous monitoring of HR, respiratory rate, activity levels, position and posture. Connects to Android phones or smartwatches to send real-time data.
  + iRhythm Technologies’s Zio patch - small patch with one lead ECG sensor that the user can stick onto their chest. Records heartbeats to provide diagnostic data
  + VitalTag - Using a single-lead electrocardiogram the device detects, monitors and wirelessly transmits BP, HR, respiration rate and other metrics such as blood oxygen levels, shock index and electrocardiogram.
* Wearable Smart Devices
  + AMON - one of the first smart devices. Monitored HR, blood oxygen saturation and skin temperature,
  + The Checkme - small medical device that measures ECG, heart rate, pulse and BP
  + Smartwatches - Many companies make their own versions of this wearable technology that connects to your smartphone. Majority of the fitness-focused ones have GPS and the ability to track exercise and heart rate, plus provide additional features similar to that of one’s phone
    - Apple - Apple Watches
    - Samsung - Samsung Galaxy Watch, Gear Sport, Gear S3
    - Fitbit - Ionic, Inspire, Versa
    - Garmin - Vivoactive, Vivosmart, Vivomove
    - Other Smart Watches - Fossil, TicWatch, Wear OS Watches

These standards of care are ineffective in providing real-time data for all vitals necessary for the first responder to monitor in that they are unable to monitor all information required.

**Concept Development:**

The device will be able to measure the following different vitals: hydration, body temperature, VO2 Max, heart rate, body fat composition, and location via GPS. Each component is listed below in more detail.

* Hydration:
  + The device will be able to measure the hydration level of an individual through contact with the skin. This hydration level can be used to assess user safety in a particular environment.
  + To measure the hydration levels, several methods could be adopted such as light, bioelectric impedance, sweat, pH and interstitial fluid.
* Body Temperature
  + The device should be able to measure the core temperature of the subject without being influenced by any external factors. This can be used to ensure that the body is in optimal condition for any necessary activity.
  + The body temperature can be measured by using bioelectric impedance, a thermosensor, or a thermistor circuit
* VO2 Max
  + The maximum amount of oxygen uptaken by an individual will be measured with this device. This will allow the individual to monitor their oxygen uptake and respiration efficiency.
  + Measuring VO2 max can be accomplished using lights or bioelectric impedance.
* Heart Rate
  + The device will be able to monitor the pulse and heart rate of an individual. This will aid in ensuring that the body will not experience any large cardiac event that could be dangerous to the individual
  + Measuring heart rate can be accomplished by using light, stretch sensors, or pressure sensors.
* Body Fat Composition
  + The device would measure body fat composition for the individual wearing the device. This can be used to relay accurate hydration data by accounting for body fat.
  + Rather than having to use special tools such as calipers or expensive machinery for air or water displacement, the device would use Bioelectrical Impedance Analysis (BIA) to provide quick and easy data results.
  + This device would not be a real-time tracking like the other vitals listed; however, the Body Fat Composition will be measured daily to track for drastic changes.
* GPS
  + The device should be able to relay the relative position of the individual to a central control unit. This will allow first responders to locate and keep track of individual responders while in the field. This can allow for a safe and efficient recovery in the event something happens to the individual.
  + The device will be able to determine its relative position using GPS satellites or other telecommunication devices.
* Blood Pressure

The device itself will come in a compact, lightweight, wearable form for easy application and high durability, without inhibiting or interfering with a user’s daily activities. Some preliminary concepts for configurations are belts, headbands, chinstraps, socks, gloves, rings, anklets/bracelets, body vests, and armbands. These configurations will allow the technology to operate and monitor the vitals of the individual without interfering with the individual's movement and activities in the field. The device will be in communication with a central hub that will process the data collected by the wearable and provide results in real-time. This will allow one person to monitor the data all active wearables are relaying from a single computer or device. These wearable devices will be reusable, and all electronic components will be able to be charged from a central dock or station.

**Timeline:**

The goal of this project is to create a wearable device for firefighters that meets all of the requirements stated above. To achieve this goal, certain procedures must be completed. Initially, focus groups with the target population (first responders and DOD staff) will be used to gain an understanding of the field, learn about what uniform and equipment is worn, and any foreseen problems that this type of device could create. These focus groups should be completed by September of 2019. Next, a series of interviews will be conducted with more in-depth questions regarding the metrics for the device itself. These metrics should be finalized by December of 2019. By February 2020, a non-functional prototype should be completed. This includes working circuits of all the sensors, calibration data, and testing against other methods of quantifying the same vitals. Finally, a finished, fully functional prototype should be completed and ready for piloting by May of 2020.