11/3/2023

# Team 505: CIA Wearable Fashion Technology

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## Acknowledgement

These remarks thanks those that helped you complete your senior design project. Especially those who have sponsored the project, provided mentorship advice, and materials. 4

- Paragraph 1 thank sponsor!
- Paragraph 2 thank advisors.
- Paragraph 3 thank those that provided you materials and resources.
- Paragraph 4 thank anyone else who helped you.

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## Notation

| | |
|---|---|
| A17 | Steering Column Angle |
| A27 | Pan Angle |
| A40 | Back Angle |
| A42 | Hip Angle |
| AAA | American Automobile Association |
| AARP | American Association of Retired Persons |
| AHP | Accelerator Heel Point |
| ANOVA | Analysis of Variance |
| AOTA | American Occupational Therapy Association |
| ASA | American Society on Aging |
| BA | Back Angle |
| BOF | Ball of Foot |
| BOFRP | Ball of Foot Reference Point |
| CAD | Computer Aided Design |
| CDC | Centers for Disease Control and Prevention |
| CU-ICAR | Clemson University - International Center for Automotive Research |
| DDI | Driver Death per Involvement Ratio |
| DIT | Driver Involvement per Vehicle Mile Traveled |

Difference between the calculated and measured

| | |
|---|---|
| Difference | BOFRP to H-point |
| DRR | Death Rate Ratio |
| DRS | Driving Rehabilitation Specialist |
| EMM | Estimated Marginal Means |
| FARS | Fatality Analysis Reporting System |
| FMVSS | Federal Motor Vehicle Safety Standard |
| GES | General Estimates System |
| GHS | Greenville Health System |
| H13 | Steering Wheel Thigh Clearance |
| H17 | Wheel Center to Heel Pont |
| H30 | H-point to accelerator heel point |
| HPD | H-point Design Tool |
| HPM | H-point Machine |
| HPM-II | H-point Machine II |
| HT | H-point Travel |
| HX | H-point to Accelerator Heel Point |
| HZ | H-point to Accelerator Heel Point |
| IIHS | Insurance Institute for Highway Safety |
| L6 | BFRP to Steering Wheel Center |

## Chapter One: EML 4551C

### 1.1 Project Scope

#### 1.1.1 Project Description

The objective of this project is to design and develop a wearable technological device that uses an integrated gas detector to collect information about the wearer's surroundings when engaging in search and rescue missions.

#### 1.1.2 Key Goals

The key goal of this project is to create wearable technology that incorporates a gas sensor from another team. Additionally, our goal is to create something that benefits someone in the search and rescue field by improving operative safety and communication while in the field. By the end, the device should be a fully functional prototype.

#### 1.1.3 Market

The team's primary market would be our sponsors, the Central Intelligence Agency (CIA). Secondary markets would include disaster relief programs (American Red Cross, UNICEF, etc.), first responders (firefighters, police, paramedics, etc.), and scientists who work in potentially hazardous laboratories or environments.

#### 1.1.4 Assumptions

Within this project, our team made several assumptions dependent on our sponsor's constraints and overall project statement. The current list of assumptions include:

- The device will not exceed 40 lbs.
- The device is a prototype, only acting as proof of concept.

- The device is equipped for search and rescue scenarios.
- Wearable Technology should be connected to the companion team's gas detector.
- Should send data to either a user interface or an interface in a remote location.
- This device should be able to withstand contact with hazardous materials and gases as it will operate in harmful environments.
- The device should be able to be worn for the entirety of the search and rescue mission.
- The device itself should not put the user in danger.
- Both teams will be working under the assumption that the device will be for a specific search and rescue mission. (We will have a common scenario)

#### 1.1.5 Stakeholders

The primary stakeholders include our Central Intelligence Agency (CIA) sponsors: Franklin R., Ben W., and Tawanna D. Dr. McConomy will serve as a secondary stakeholder in that he will be assisting with general project guidance/advising, be a point of contact, and ensure the team is communicating and working with the other stakeholders adequately. Additionally, David M. of the Florida State University (FSU) Emergency Management and Homeland Security Program is serving as a secondary stakeholder, giving the team key insights into project applications and scenarios.

### 1.2 Customer Needs & Interpretation

#### 1.2.1 Customer Statements

**Is there a preference on the concept of wearable design?**

Customer Statement:

Honestly, any of these things could work but if you do a backpack make it smaller. I want to be able to wear it for years to come, have a good shelf life, light but enough power, be able to survive serious conditions, and give them a bang for their buck.

Interpretation:

It would be ideal to design something that could be pulled out of storage after years when disaster strikes. A fully functional device “out of the box” would be beneficial. A small, lightweight design is desirable so that it does not interfere with the wearer’s ability to navigate through the rubble of a fallen building, with quality and durability as the focus.

**Can the gas sensor be detached from the wearable design at any point?**

Customer Statement:

Sure, a sensor that detects bad things is useful, but you also do not want to be in the bad things. We don’t want the wearable to be the gas sensor, we want it to be its own separate project. Strike a balance between the two. The gas sensor warns the user of the wearable technology.

Interpretation:

Our interpretation is that they are leaving the decision up to our team’s discretion. Their emphasis was that our technology includes more than the gas sensor. It would be ideal to have a feature that improves the safety of the user. Whether that is a detachable gas sensor, some sort of filter, or a responsive alert, we do not know yet, but it would be beneficial if the user is able to rapidly gain information from the gas sensor/do something about their situation. We can also think about it from a different perspective that allows the wearer to plan for the danger and detach the gas sensor to deploy in the dangerous environments before they enter the environment themselves.

**Is communication among the search and rescue team more than backhauling data to headquarters?**

Customer Statement:

Yes, I think the team is more important and if anything happens the people there should be the priority.

Interpretation:

While designing our product, we will value concepts that support team-based communication over concepts that focus on data exfil as this was deemed a secondary priority. The wearer and his/ her team would benefit more from rapid team communication than communicating back to a remote location.

**What does this project need more specifically? What does the customer need?**

Customer Statement:

Up to you all how we want to implement it. We need something light but has power that can supply the technology for a long amount of time. Needs to be able to withstand terrain and time. Shelf life is especially important. They also said it should look “cool.”

Interpretation:

The product’s features outside of housing the gas sensor is left to our discretion, but our customer is interested in a product with an effective balance of comfort and durability. Our device will ideally be lightweight but also be able to power the components for long periods of time. We will also make sure that it captures the essence of the CIA while considering the practicality of the product and other features as well.

**What functional relationships are important?**

Customer Statement:

We need both communication and additional tech. From their end, it is very vague, but our focus should be on integration between the two teams and testing.

Interpretation:

Our focus is communication with the other team. We have a symbiotic relationship; our projects are connected and benefit each other. We can develop a plan for how we are going to test our device and how much time we are going to spend on this. Connectivity and functionality are huge aspects of this project for our sponsor.

**Can you help us decide what sub-systems to focus on?**

Customer Statement:

Again, from their end very vague, but we should focus on what we are good at.

Interpretation:

They want us to come up with a solution that encompasses what we have learned so far. Each of us has a different background and set of skills, so we can use that to our advantage. Our goal is to avoid scope creep and tackle what is feasible for us that provides them with a valid solution.

**Can you help us decide what this project has to do? (Action/Outcome):**

Customer Statement:

We want to burn down risk as much as possible, what has the most risk? If it was a backpack, then it might be hard to take off or the straps get in the way. Accessibility is huge. Some other risks would be if you're able to get the parts in time, are they good, how likely it is they burn out on you. They also said a basic manual of components would be super useful but not required.

Interpretation:

Eliminating risk by truly thinking about the person who needs to use this device is important. A smart plan to help us create better decisions is beneficial for us. The CIA values safety and reliability. We can implement this by reducing risk. Quality and shelf life are of utmost importance to them. We also want to create a basic manual to help improve the overall user experience.

### 1.2.2 Explanation of Results

The C.I.A. wants to develop fashion wearable technology incorporated with a gas sensor created by Team 506 which will assist in gas and hazard detection during search and rescue missions. Our team generated several questions to ask our sponsors/customers during our previously scheduled meeting via Google Meet to further specify the needs of our customers and the direction of our project. Our standing sponsor, Mr. Franklin Roberts, as well as our C.I.A. mentors provided helpful responses to our questions, to which many were stated as up to our discretion, giving our team many opportunities to make this project our own. Within their responses, the C.I.A. also provided good insight into the functions and features that give our product more application, which we will discuss further.

**Communication**

When asked "Is communication among the search and rescue team more than backhauling data to headquarters?", the C.I.A stated that communication amongst the search and rescue team would be valued greater than data transport and management. During search and rescue missions, communication is vital for the safety of those in distress but also for the team members. In the instance a fellow distress responder enters a harmful environment that requires assistance, being able to communicate to fellow team members can save both time and individual effort which both are important in these situations that are in dynamic environments.

**Lightweight & Durable**

When asked about any product requirements or other qualities our sponsors wanted implemented, two main requests were to have the item lightweight and durable. In a search and rescue mission, for example, a building collapse, at any moment an element of the surrounding environment can affect the product, so taking that into consideration, the product material needs to be able to withstand a considerable amount of force as well as chemical resistance. The weight of the product must also be considered to achieve. The sponsors stating the device needs to be lightweight tells us that we need to find the balance between the two which can be solved during multiple stages of our project such as material selection or concept generation.

## 1.3 Functional Decomposition

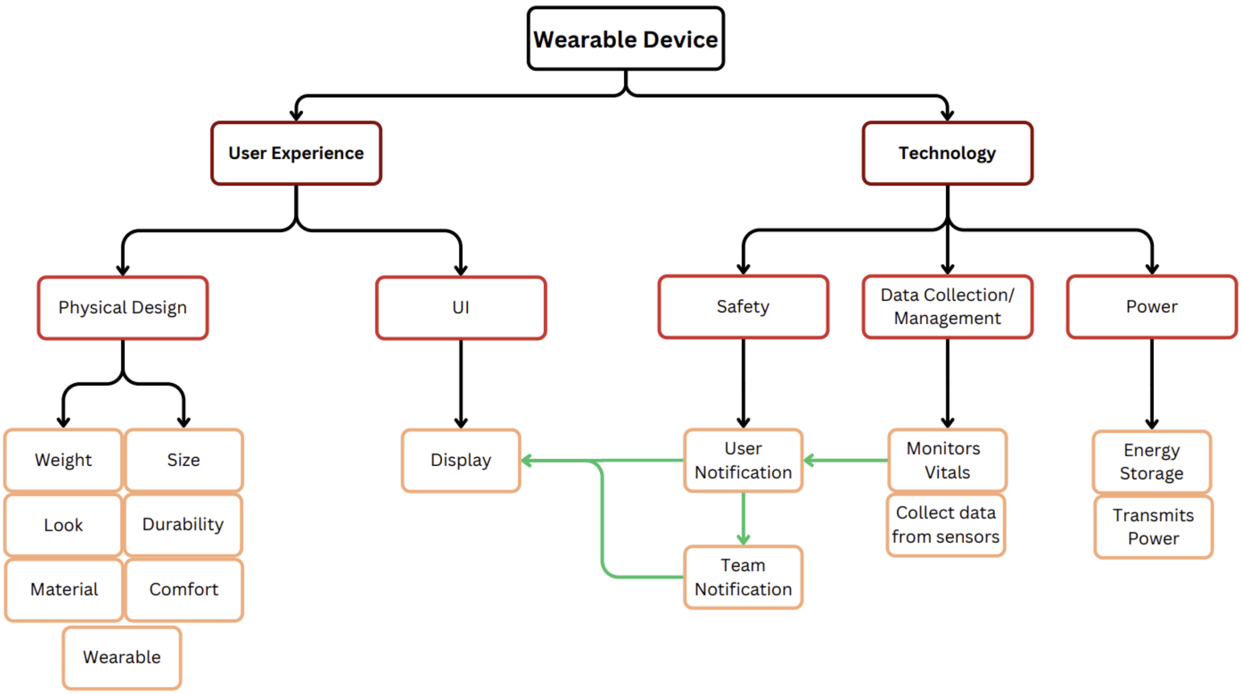
### 1.3.1 Introduction

Functional Decomposition is a technique used to simplify the complexity of a complete system by breaking it down into smaller components. This approach considers the problem statement and customer requirements and converts them into functional performance criteria for the device. These are the essential tasks that the components must accomplish for the device to be deemed successful.

### 1.3.2 Data Generation

Our approach to developing wearable technology involved identifying two main objectives: user experience and technology. We then further broke down these objectives into five primary functions of the technology. To understand how each of these functions fit into the larger picture, we divided them into fourteen different subsystems. To visualize this hierarchy, we created a branch chart, which you can see in the figure (1) below.

# Figure 1. Branch Chart




### 1.3.3 Explanation of Results

Our team focused on two main goals when creating a functional decomposition: User experience and device technology. To achieve these goals, we divided them into five main functions that our device must employ. For the User Experience branch, we considered the physical design of the product and the user interface. The physical design should be lightweight and comfortable for users to wear, while also having a clean and condensed aesthetic. It should also have a long lifespan to accommodate many users over the years. The user interface should display any relevant information gathered by the sensors to the user and surrounding team members as well.

In terms of the Technology branch, our device has four main functions: safety, data collection, management, and power supply. The technology within the device collects data from the user and connects the companion team's gas sensor, which is then transmitted to the user interface as well as the interfaces of all surrounding team members. We've also ensured that the wearable has a connected power supply that powers the user's technology and integrated gas sensor. Our goal is to have the technology endure long missions without needing to be recharged.

### 1.3.4 Connection to Systems

When it comes to wearable technology, there are five primary functions that it should serve: physical design, user interface, safety, data collection/management, and power. It's crucial that the overall look and feel of the wearable is designed with the wearer's needs in mind, while still being lightweight, useful, and fashionable. Additionally, it should be durable enough to last for multiple years with minimal maintenance.

The wearable should be able to collect data from the connected gas sensor, as well as any other vital scanners that might be connected. This data should then be sent to the user interface in the form of an alert if any vitals are out of the ordinary (such as toxic gas or a high heart rate). Finally, the wearable should be self-powered, thanks to a power bank that can power any connected technology and the gas sensor. Overall, the wearable should serve as a fashion component that monitors the user's vitals and relays any essential information to them via user interface.

### 1.3.5 Cross Reference Table

| Functional Decomposition Cross-Functional Relationship Matrix | | | | | |
|---|---|---|---|---|---|
| **Sub-Systems** | **Physical Design** | **User Interface** | **Safety** | **Data Collection/Management** | **Power** |
| **Weight** | X | | X | | |
| **Size** | X | | X | | |
| **Look** | X | | | | |
| **Durability** | X | | X | | |
| **Material** | X | | X | | |

| | | | | | |
|---|---|---|---|---|---|
| **Comfort** | **X** | | | | |
| **Wearable** | **X** | | **X** | **X** | **X** |
| **Display** | | **X** | **X** | **X** | **X** |
| **User Notification** | | **X** | **X** | **X** | |
| **Team Notification** | | **X** | **X** | **X** | |
| **Monitors Vitals** | | **X** | **X** | **X** | **X** |
| **Collect Data from Sensors** | | **X** | | **X** | |
| **Energy Storage** | **X** | **X** | **X** | | **X** |
| **Transmits** | | | | **X** | **X** |

### 1.3.6 Smart Integration

The hierarchy of the system begins with creating wearable fashion technology capable of supporting search and rescue missions. From this main objective, two main systems were generated: user experience and technology. The user experience will encompass many attributes important to the overall state of the user ranging from product weight to user interface. The technology portion covers all the electronic functions of the product and ensures that the device is both effective and energy efficient. From these main systems, several sub-systems were made to further clarify the functions of our project and assist in deciding what functions to focus on.

The priority ranks of the functions are best shown in the Functional Decomposition Cross-Functional Relationship Matrix table, shown above, as functions that are involved in more than one system will be assigned with a higher priority. The wearable function will be suited to several sub-systems; physical design, safety, data collection, and power as the concept we selected for our product will need to incorporate these sub-systems to satisfy our customer needs. Physical design also correlates with safety for many functions as when designing a product's physical attributes such as weight, size, material, and durability, therefore directly affecting the safety of the user.

Display, user notification, and team notification have several cross sub-systems relationships as they play equal roles in ensuring the product promotes communication and safety. Monitoring vitals has a significant role in assuring the rescue team they are in good condition as some gases and hazards have inconspicuous effects that can go unnoticed, and this function will operate through the sensors incorporated in the design. This function will also allow for data collection in dangerous locations to improve safety by hazard marking. Like energy storage and data transmission, this function will require an input of power to operate effectively. For our product to be effective in search and rescue missions, energy consumption and management will need to be prioritized as the technology portion of our project will become obsolete if not done properly.

### 1.3.7 Action and Outcome

The project aims to create a wearable device that can seamlessly integrate with a gas sensing device used by first responders during potentially hazardous operations. The wearable device is expected to be self-powered, comfortable, and directly connected to Team 506's gas sensor. The technology will monitor and display the vitals of the users on a user interface, in addition to any alerts produced by the gas sensor. The goal is to develop technology that can alert surrounding first responders if any hazardous gas is detected within the area or any vitals that seem out of the ordinary.

### 1.3.8 Function Resolution

At its most basic level, the device has two main categories: User Experience and Technology. The project must incorporate the sensor designed by team 506, assist in search and rescue missions, withstand harsh environments, alert emergency personnel of any hazardous contaminants in the area, and communicate with a user interface. When diving further into the 14 smaller sub-systems we see the true inner workings of the device and what it must do to perform adequately and up to standard. For example, in the safety priority function, the smallest needed action the device must do is send a notification to both the user and the team if danger is detected. It is the same instance for the power and data collection/management functions as well. To perform the data collection/management priority function the product has to monitor vitals and collect data from the sensors at minimum. Energy storage and transmitting power represent the sub-sections below the power priority rank meaning the product has to incorporate those items to meet the needs of the customer and product standard. Physical design is simple as the product must at least be a wearable device that will not cause too much strain on the user and user interface must incorporate a display to properly alert users of abnormal surroundings or vitals.

## 1.4 Target Summary

The targets for this project will serve as the goals and milestones that are set to be accomplished which will assist in the creation of the final wearable design the team is striving towards. They also assist in ensuring the project can be measured and verified to maintain proper functionality. In the Functional Decomposition section above, the final wearable product was broken down into 2 main systems being Physical design and Technology. These two systems were then broken down further into our functions: Physical Design, User Interface, Safety, Data Collection/Management and Power. These helped the team create their targets and metrics discussed below based around the subsystems of each main function to verify the design works as intended. The targets will also help further refine the final design of the product if the functions do not successfully meet their desired metric, but with further designing and device prototyping the team will be able to validate their targets as the project progresses. All targets and metrics were created with extensive research into each function and discussion with the team sponsor, the Central Intelligence Agency.

### 1.4.1 Physical Design

One of the sponsor's key customer needs is the overall physical design of the technology. Our design should prioritize fashion and comfort, allowing the user to wear it comfortably for extended periods of time. Additionally, each subsystem must relate to a physical component or aspect of the overall wearable design. Testing each function is a critical target and metric for our design. This function was also deemed to be one of the teams critical targets due to the devices nature of needing to be wearable, comfortable and durable as stated by the sponsors the CIA.

#### Weight

When creating a wearable component for search and rescuers, it is important to strike a balance between incorporating enough technology to suit the user's needs and ensuring that the device remains lightweight enough to not interfere with overall maneuverability. The target weight for the device should not exceed 25 pounds. We decided to keep this relatively high because of the differing technological components that may be added depending on the specific wearable chosen in concept selection, but we also want this to fall well within the total amount of weight a person can carry comfortably. A soldier’s average load can add up to 70 lbs and can skyrocket to as much as 120 lbs. To validate this subsystem, we will frequently weigh all components to ensure that we are meeting our assigned target.

**Size**

The device should be designed to be wearable and small enough to not cause any interference with the existing search and rescue equipment. To ensure this, we will regularly compare the size of our product with the size of the existing search and rescue equipment that is currently being used. We came up with this target to ensure our device is up to par with current industry products.

**Look**

Our sponsors have set a goal for the team that the wearable should be functional and aesthetically pleasing, while also not being too flashy or "in your face". To achieve this, we are targeting to minimize the amount of exposed electronics and wires, while ensuring that the display remains easily accessible. As part of our design process, we will regularly present our design to our sponsors to ensure that it meets their needs. This target is a little subjective, and we will base the success on the opinion of our sponsors. We have based this target off our customers' needs.

**Durability**

Our wearable technology needs to be tough enough to endure the tough conditions of a building collapse scenario. It should operate for several hours without any malfunctions, even if it collides with the surroundings. To test its durability, we will perform a series of physically demanding tests in different environments to ensure that it does not lose any functionality. We have based this target off our customers' needs.

**Material**

The material selection for our design is focused on ensuring durability without compromising user comfort. Our goal is to create a lightweight wearable that can withstand various elements and hazards that may be encountered during a search and rescue mission. To test the durability of our target material, we will expose the exterior of our wearable to different elements and hazards that may be encountered during a mission. We will also ensure that it is heat resistant. We came up with this target because we know that the user will be exposed to hazardous environments.

**Comfort**

Our goal is to create a wearable device that is both functional and comfortable for users to wear during long search and rescue missions. To ensure that our device meets both requirements, we will thoroughly test its comfort multiple times before presenting it to our sponsor. The level of comfort will be determined once all the necessary components have been installed in the device. This target was determined to ensure user satisfaction.

**Wearable**

Our technology should be designed to be worn by a user without interfering with the existing search and rescue equipment or average human maneuverability. It should be ensured that the device stays on the user's body at all times without getting loose or being too tight. To achieve this, we will constantly refer to existing equipment when expanding or modifying the shape and size of our product and test the overall feel of the design when worn. This target was based off one of the most important needs of the customer.

### 1.4.2 User Interface

A key target of the user interface is that it will accurately display gas sensor and vital data in 10 seconds or less. This will ensure that the first responders will have accurate information to make decisions on. The goal is to ensure that it is as fast as possible, but we cannot guarantee real-time monitoring at this point, so we are shooting for slightly delayed monitoring. The group consulted Team 506, and they said based on their research, that they could not guarantee an instantaneous response time from the gas sensor. We will test this by measuring the response time. The UI should also be able to be clearly operated by someone with 20/20 vision.  We came to this target based on an assumption that the operator would have 20/20 vision. We need the operate to see our user interface to effectively use it. We will test this by letting multiple people try out the device and answer some survey questions about the user interface afterwards.

**1.4.3 Safety Targets and Metrics**

A primary goal of the final design of our project is to have a device capable of keeping the user away from hazardous environments while simultaneously being unrestrictive to the movement of the user. As safety is of utmost importance in search and rescue missions, this function is deemed critical in our targets so that we prioritize the requirements needed to be met to ensure safety.  The CIA sponsor voiced the concern that the device should not exceed a certain weight limit as the user will be operating in a building collapse scenario where much of the ground, they walk on might not be structurally sound.  It was collectively decided that the weight of the device should not exceed 25 lbs. Being lightweight allows the user to either quickly evade falling debris or safely walk on damaged flooring. To validate the meeting of this weight requirement, the materials and components used in our product will be selected according to weight, size, and integration levels. With a portion of our product being gas detection, this is also attributed to the safety of not only the user but the entire search and rescue team by keeping a constant record of hazardous gases encountered to reduce exposure to possible danger. Our partnering team 506, plan to measure at least 3 gases that are commonly found within building components that could potentially be exposed to the user. As several gases can be detected by the same sensor, there are also some that vary with not only the type of sensor but the location the gas exists at as gases can differentiate in weight and lead them to occupy different spaces. The detectors selected will test for these gases in safe lab environments by intentionally releasing them in a contained space.

### 1.4.4 Data Collection/Data Management Targets and Metrics

Another goal for the final design of the project is to be able to have the device monitor and collect data from the user. This function is extremely important as it interconnects with the other functions such as safety for the user and team notification display. The final design will collect data from the connected sensors integrated into the selected concept as well as the gas detector that will be integrated into the final design by team 506.

For the collection side of the design, data will be collected and updated from the sensors every 10 seconds and will relay the information collected to the user interface for the members of the team to view. The collected data will then be stored for a maximum of an hour to not overload memory and ensure that new data has space to be stored and monitored. After the hour, the old data that was collected will be automatically erased unless the device is turned off, then the time will stop, and the previous data will be stored until the hour is up when the device is turned back on. This metric was derived by speaking with our sponsors, the Central Intelligence Agency, as one of their needs was for increased team safety and communication. The CIA also expressed wanting the team on the ground to be the first alerted if there was an issue, therefore the metrics of speed and storage for the data collection function were created with those needs in mind. The metric will be tested using a timer implemented in the code to track the amount of time passed in between information being displayed.

The other subsystem of the data management/collection function is the monitoring of vitals. The metrics for monitoring are like that of collection and storage where data will be updated and communicated to the user interface every 10 seconds. The difference between the two functions is that the vitals will be constantly monitored therefore data will be continuously read into the processor but will only be updated onto the user display unless an anomaly is detected in the surrounding environment or users' vitals i.e. a low heart rate or a toxic gas getting detected. This metric was calculated based on CIA customer needs that were mentioned in sponsor meetings but also based around how quick a human can and should be looking/ processing new data while in a search and rescue effort. An average human can process a new piece of information in about 0.1 to 0.2 seconds, but the team did not want to distract the user from their surroundings and thought a delay of 10 seconds would be beneficial so the wearer would have more time to check and comprehend the data coming in about the team and themselves.

**1.4.5 Power**

An additional goal of the final design is to have the sensor running off an external power supply. Due to the nature of search and rescue missions, the sensor may be put to extended use in potentially life-threatening environments. An external power supply would mitigate any potential risk of power loss mid-mission. The power supply will be integrated into our wearable alongside the gas sensor. Based on an average time span for search and rescue missions, the power supply will be able to supply sufficient power to the sensor for 72 hours. The time span assumes the sensor is not running continuously, instead the sensor will be assumed intermittent use.

**1.4.6 Summary and Catalog**

The assigned targets and metrics for each of the device's functions are listed in the table below. Each of these values are essential for the functionality and wearability of the final design.

All the current data is based on the key values and goals determined by the team and the sponsors but is subject to change as the concept is yet to be selected and designed.

| System | Function | Metric | Target |
|---|---|---|---|
| Weight | Weight of the entire wearable device | Force (Weight) | < 40 lb. |
| Size | Device measure in respect to user movement | Device hinderance on user movement | None |
| Durability | The strength of the device to withstand exposure to field ops. | Military standard | MIL-STD-810H |
| Material | Composition of device | Military material readiness | 10 USC 118 (b) |
| Comfort | Temperature of electrical components in contact with skin | Degrees Fahrenheit | 98.6°F |
| Wearable | How the device fits and wears on the user | User fit | Accommodates $95^{th}$ percentile |
| User Interface | Lag in displaying user data in the U.I. | Time | < 10 sec. |
| Safety | Safety features associated with the device | Military standard | MIL-STD-882B |
| Data Collection | Duration of user data collection and storage | Time | Stores data for 1 hr. then overwrites |
| Power | Duration of power supply | Time | 72 hr. |

## 1.5 Concept Generation

### 1.5.1 Introduction

Concept generation is one of the pinnacle parts of any design process. It challenges engineers to think outside the box and redefine the given problem to expand the possibilities of what they can do to solve it. The team hosted group sessions that involved brainstorming, ideation and the exploration of various ideas and possibilities to meet the specific project goals of creating a wearable technological design for the sponsor.

### 1.5.2 Concept Generation Tools

The concepts were generated by the team using a variety of differing concept-generating tools. For example, many of the concepts were created during individual and group brainstorming sessions and during these group sessions, specific tools such as crap shoot and battle of perspectives were employed to help with generating more ideas. The team began with discussing different articles of clothing that operators would consistently wear during search and rescue missions such as backpacks, vests, and helmets. Variations of these different clothes with different functionalities were drawn down to cover different applications. From there, certain concepts were selected to become high and medium-fidelity concepts based on the criteria that they adhere to many of the needs of the customer and align with the primary standards valued by the team.

### 1.5.3 Medium Fidelity Concepts

The medium fidelity concepts chosen are shown below in the table. These concepts were chosen based on the main assumption that they will perform the duties needed, such as monitoring vitals, supplying power, integrating with team 506's gas detector and being able to connect back onto the body of the user.

| **Medium Fidelity Concepts** | |
|---|---|
| **Concept Number** | **Concept Description** |

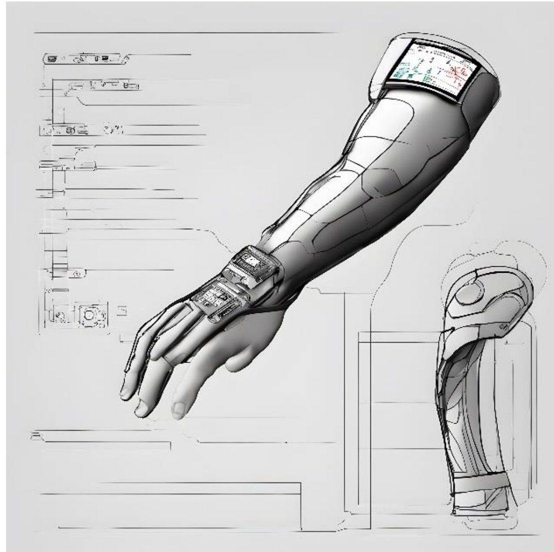
| | |
|---|---|
| 4 | Backpack + Goggle HUD |
| 81 | Vest + Gas Mask with UI on lenses |
| 74 | RC 4-Wheel Drone |
| 10 | Tech Sleeve |
| 71 | Backpack + Watch with UI |

### 1.5.4 High Fidelity Concepts

The high-fidelity concepts were chosen by the team as they fit the customer's needs and the description of the project the best in the team's opinion and are ranked the most suitable concepts. These ideas are also under the assumption that they will perform the same duties as stated in the medium fidelity concepts chosen. The high-fidelity concepts that were chosen are shown below.

| **High Fidelity Concepts** | |
|---|---|
| **Concept Number** | **Concept Description** |
| 1 | Back Brace + helmet HUD  |

| | |
|---|---|
| | Concept 1 includes a back brace-style vest integrated with a gas sensor fitted around the user's lower back. The user will also have a helmet connected to the gas sensor via connection cords that show the data readings. The helmet and vest will have several sensors on them to monitor the vitals of the user l one being a sensor near the neck to check pulse rate. The HUD display of the helmet will be connected via wires to the vital sensors and gas sensor to display all data readings for the user's safety and communication for the team operation. The length of the wires will be decided on by the consideration of neck and head movement the user will have which could lead to the system being disconnected if not set properly. The back brace will be worn either underneath the operator's coat or above it. |
| 2 | Back brace + arm sleeve UI/display |

| | |
|---|---|
| | <br>Concept 2 consists of a similar style back brace of concept 1 but instead of a helmet with a HUD display, it is replaced with an arm sleeve UI/ display. The arm sleeve will consist of a gas sensor on the back of the hand allowing for extension from the body to detect gases and a sensor around the wrist to monitor the vitals of the user such as heart rate.  Near the bicep of the arm, will be a display showing all data being gathered for the user. |
| 16 | Two strap backpack + retractable UI/display |

| | |
|---|---|
| | <br>Concept 16 will consist of a two-strap backpack with a retractable/detachable display and a gas sensor slotted in one of the sections of the backpack. The straps of the backpack will have sensors near the heart of the user to monitor their heart rate. Wires will be placed within the straps connecting the sensors and the display, which will be located on the side of the bag with a retractable cord to pull the display into the view of the user. |

### 1.5.5 Concept Generation List of All Concepts

Below is the list of all concepts generated in this step of the design process. As a group, 100 concepts were created to cover all possible solutions to providing search and rescue operators with technology capable of assisting them to safely complete their assignments and save those in distress.

| Concepts Generated | | | |
|---|---|---|---|
| 1 | Back Brace + helmet HUD | 51 | Smart Sticker |
| 2 | back brace + arm sleeve UI/display | 52 | Neck Collar with sensors |
| 3 | Suspender with utility holsters and sensors | 53 | Finger covers |
| 4 | Backpack + Goggle HUD | 54 | Ring with sensors and display |
| 5 | Bullet-proof vest | 55 | Arm brace with padding |
| 6 | Smart Color Changing Shirt | 56 | Bluetooth earpiece connected to head |
| 7 | Utility belt fitted with LEDS | 57 | Sticker sensors connected to chest |
| 8 | Safety vest with sensors | 58 | UI with compass/ clock/ battery charge/gas/ team vitals |
| 9 | Wrist Band Mount | 59 | Helmet with air filter |
| 10 | Tech Sleeve | 60 | Helmet with oxygen supply |
| 11 | Jacket and UI in Sleeve | 61 | thermal camera |
| 12 | Smart Glasses | 62 | monitoring vitals |
| 13 | Shoes | 63 | Fanny pack with sensors |
| 14 | Earrings with UI | 64 | heart rate monitor |
| 15 | Color Changing Glove | 65 | blood oxygen concentration monitor |
| 16 | two strap backpack + retractable UI/display | 66 | Armband with color changing indicator |
| 17 | Over the Shoulder Backpack | 67 | Color changing earrings |
| 18 | Wrist Band With UI | 68 | Smart watch with color indicators |
| 19 | Helmet (With Sensor Mount) | 69 | Utility shorts with integrated sensors |
| 20 | under garments with sensors | 70 | Helmet with heads-up display |
| 21 | vitals sensors that attach to neck | 71 | Backpack + Watch with UI |
| 22 | tech hat | 72 | Knee brace with sensors |
| 23 | tech hazmat suit | 73 | Utility pants integrating sensors |
| 24 | tech gloves | 74 | Backpack + RC 4-Wheel Drone |
| 25 | tech face shield | 75 | RC Quadcopter Drone |
| 26 | tech fire fighter jacket | 76 | Sensor Ball on String |
| 27 | tech exoskeleton | 77 | RC 2-Wheel Drone |
| 28 | tech arm shield | 78 | Backpack (With Drone Mount) |
| 29 | tech firearm | 79 | UI on User Phone |
| 30 | augmented reality glasses | 80 | Handheld Device with Controllable wire and a UI |
| 31 | cellphone tracker to locate people stuck | 81 | Vest + Gas Mask with UI on lense |
| 32 | tech moon shoes | 82 | Vibrating wrist band |
| 33 | teammate tracking on UI | 83 | Vibrating Body Patch |
| 34 | helmet with smart flashlight | 84 | Utility belt with retractable cord |
| 35 | projector band fitted with pulse sensor | 85 | Helmet with color changing lights |
| 36 | helmet with ear protection | 86 | Gas Mask With color changing lenses |
| 37 | Batting cap with thermal camera visor | 87 | bookbag with strap across chest lcd screen |
| 38 | Backpack fitted with o2 tank tubes | 88 | cargo pants |
| 39 | Arm sleeve with reactive material | 89 | AR Gas Mask |

| | | | |
|---|---|---|---|
| **40** | temperature sensors | **90** | modular plug ins |
| **41** | night vision goggles with thermal sensor | **91** | see through wall technology |
| **42** | LIDAR | **92** | Shoes with colored lights on them |
| **43** | AR goggles | **93** | shoulder pads that vibrate at high heartrates |
| **44** | reactive material gloves | **94** | cape made with reactive material |
| **45** | mood ring that senses heartrate | **95** | light shoes with fluorescent soles |
| **46** | brass knuckles with sensors | **96** | transparent phosphorus that reacts with lasers |
| **47** | watch with dynamic parts that move | **97** | belt that vibrates when sensors find sum |
| **48** | arm band that runners use | **98** | Chest plate connected to sensors |
| **49** | AI goggles | **99** | Retractable device that attaches to vest |
| **50** | Necklace with UI | **100** | contact lens UI |

## 1.6 Concept Selection

Concept selection is a crucial step in product development, where the team assesses and prioritizes design options that were picked from the concepts generated above. Various tools assist in this decision-making process i.e., the binary piecewise comparison chart, house of quality, multiple Pugh chart iterations to narrow down concepts, C matrices, and Analytical Hierarchy Processes. Throughout these methods, a consistency check is used to ensure the data collected is reliable and aligns with project goals. Together, these tools offer a structured approach to concept selection in the design process.

### 1.6.1 Binary Piecewise Comparison

For the binary piecewise comparison, each of the customer requirements were compared against each other. If the row was more important than the column, the cell receives a 1. If the row was less important than the column, the cell receives a 0. If the two customer requirements were the same, the cell received an x. The totals on the right were then used to find the weight factors of each of the customer requirements. The requirements were ranked from highest to lowest, with the highest being the most important and the lowest being the least important. The most important customer need is supplies sufficient power, and the least important being comfortability.

### 1.6.2 House of Quality

| Customer Requirements | Long Shelf Life | Accessability | Lightweight | Comfortable | Durable | Supplies Sufficient Power | Assists in Team Communication | Improves User Safety | Captures Essence of CIA | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Long Shelf Life | x | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 5 |
| Accessability | 0 | x | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| Lightweight | 0 | 1 | x | 1 | 0 | 0 | 0 | 0 | 1 | 3 |
| Comfortable | 0 | 0 | 0 | x | 0 | 0 | 0 | 0 | 1 | 1 |
| Durable | 0 | 1 | 1 | 1 | x | 0 | 0 | 1 | 1 | 5 |
| Supplies Sufficient Power | 1 | 1 | 1 | 1 | 1 | x | 1 | 1 | 1 | 8 |
| Assists in Team Communication | 1 | 1 | 1 | 1 | 1 | 0 | x | 1 | 1 | 7 |
| Improves User Safety | 1 | 1 | 1 | 1 | 0 | 0 | 0 | x | 1 | 5 |
| Captures Essence of CIA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | x | 0 |
| Total | 3 | 5 | 4 | 6 | 2 | 0 | 1 | 3 | 7 | |

For the house of quality, we assessed the importance of our engineering characteristics in

| | | Engineering Characteristics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Units | | Resolution | Sec | Sec | % Accurate | % Accurate | Watt/hr | Watt/s | lbs | uses/year |
| Improvement Direction | | ^ | v | v | ^ | ^ | ^ | ^ | v | ^ |
| Customer Requirements | Importance Weight Factor | Display | User Notifaction | Team Notifaction | Monitors Vitals | Collects Data From Sensors | Energy Storage | Transmits Power | Load | Maintanance |
| Long Shelf Life | 5 | | | | 3 | 3 | 3 | 3 | | 9 |
| Accessability | 2 | 9 | 1 | 1 | 1 | 3 | | | 1 | 3 |
| Lightweight | 3 | 1 | | | 1 | 1 | 3 | | 9 | |
| Comfortable | 1 | 1 | | | 1 | 1 | 3 | 1 | 9 | |
| Durable | 5 | 9 | 3 | 3 | 9 | 3 | 3 | 3 | | 9 |
| Supplies Sufficient Power | 8 | 9 | 3 | 3 | 9 | 9 | 1 | 9 | | 3 |
| Assists in Team Communication | 7 | 9 | 1 | 9 | 1 | 1 | | | | |
| Improves User Safety | 5 | 3 | 9 | 9 | 3 | 9 | | | 3 | 1 |
| Captures Essence of CIA | 0 | 3 | 1 | 1 | 1 | 1 | 1 | | 1 | |
| Raw Score (226) | | 44 | 18 | 26 | 29 | 31 | 14 | 16 | 23 | 25 |
| Relative Weight % | | 19.47 | 7.96 | 11.50 | 12.83 | 13.72 | 6.19 | 7.08 | 10.18 | 11.06 |
| Rank Order | | **1** | **7** | **4** | **3** | **2** | **9** | **8** | **6** | **5** |

each of our customer requirements, on a scale of 1-9, 9 being of utmost importance and 1 being least important. Arrows were placed above each characteristic to describe the intended improvement direction sought moving forward. Sections that are blank correspond to no relevancy between the characteristic and customer requirement as there is no potential for evaluation.

Based on the results of the chart, display and collecting data from the sensors had the highest level of importance from the engineering characteristics within each customer need with energy storage placing last based of the same standard. Concepts that prioritized these high valued characteristics, would be emphasized moving forward with selecting our final concept.

### 1.6.3 Pugh Charts

For the Pugh charts, we picked a datum (a current method used) and compared that concept against the remaining concepts. If the concept in the columns was ranked higher than the datum within the selection criteria, it received a plus. If the concept was the same as the datum, it received an 'S.' If the concept was worse than the datum, then it received a minus. In the first Pugh chart, the selected datum was a handheld gas detector to be compared to the 7 concepts which produced the conclusion that the two-strap backpack with retractable UI/display would

| | | Concepts | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Selection Criteria | Handheld Gas Detector | Backpack + Goggle HUD | Vest + Gas Mask and UI on Lense | RC 4-Wheel Drone | Tech Sleeve | Backpack + Watch with UI | Back Brace + helmet HUD | Back Brace + Arm sleeve UI/Display | Two Strap Backpack + Retractable UI/Display |
| Display | Datum | + | + | - | - | - | + | + | - |
| Collects Data from Sensors | | + | + | + | + | + | + | + | + |
| Monitors Vitals | | + | + | - | + | + | + | + | - |
| Team Notifaction | | + | + | S | + | + | + | + | + |
| Maintenance | | - | - | - | - | - | - | - | - |
| # Pluses | | 4 | 4 | 1 | 3 | 3 | 4 | 4 | 2 |
| # Minuses | | 1 | 1 | 3 | 2 | 2 | 1 | 1 | 3 |

have the least improvement from the handheld gas detector and would become the new datum moving forward.

After the first Pugh chart, we removed the handheld gas detector concept as our datum and replaced it with the two-strap backpack with a retractable UI/display. Based on the results presented in the table above, it was a 3-way tie between the last 3 concepts for having the least room for improvement from the datum. As those concepts were removed, the new datum selected was the concept with the least improvement out of the remaining 3, being the backpack plus goggle HUD.

| | Concepts | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| **Selection Critera** | Two Strap Backpack + Retractable UI/Display | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Tech Sleeve | Backpack + Watch with UI | Back Brace + Arm sleeve UI/Display |
| Display | Datum | + | + | + | - | - | - |
| Collects Data from Sensor | | S | S | S | S | S | S |
| Monitors Vitals | | - | + | + | + | + | + |
| Team Notifaction | | + | + | + | - | - | - |
| Maintenance | | - | - | - | - | - | - |
| # Pluses | | 2 | 3 | 3 | 1 | 1 | 1 |
| # Minuses | | 2 | 1 | 1 | 3 | 3 | 3 |

After the second Pough chart, we removed two strap backpacks with retractable UI/display, tech sleeve, backpack with watch with UI, and back brace with arm sleeve UI/display.  We continued this process, eliminating the worst ones after each round until there were three concepts left. We then moved forward with the remaining three concepts.

| | | Concepts | |
|---|---|---|---|
| Selection Critera | 2 | 3 | 4 |
| | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense |
| Display | Datum | + | + |
| Collects Data from Sensor | | S | S |
| Monitors Vitals | | + | S |
| Team Notifaction | | S | S |
| Maintenance | | + | S |
| # Pluses | | 3 | 1 |
| # Minuses | | 0 | 0 |

After carrying out the same process used in the first two Pugh charts, the team determined that the highest ranked concept was the back brace with helmet HUD.

### 1.6.4 C Matrix

The C Matrix, also known as the Criteria Comparison Matrix, is a tool used in the concept selection phase of product development to help the team assess how well different concepts work together as a system. In the C Matrix, each concept is listed along both the rows and columns of a matrix. The intersections between the rows and columns represent the compatibility or interaction between pairs of concepts. The team then went through the matrix and began filling out the values to show the level of compatibility between each other. It is

| Critera Comparison Matrix [C] | | | | | |
|---|---|---|---|---|---|
| Critera | Display | Collects Data from Sensors | Monitors Vitals | Team Notification | Maintenance |
| Display | 1 | 0.2 | 0.33 | 0.33 | 0.14 |
| Collects Data from Sensors | 5 | 1 | 3 | 3 | 0.33 |
| Monitors Vitals | 3 | 0.33 | 1 | 0.33 | 0.33 |
| Team Notifaction | 3 | 0.33 | 3 | 1 | 0.14 |
| Maintenance | 7 | 3 | 3 | 7 | 1 |
| Sum | 19.00 | 4.86 | 10.33 | 11.66 | 1.94 |

important to note that the spaces of qualities being compared to themselves were assigned a value of 1. For all the other comparisons either a 1,3,5, or 7 were used to make the determination.

The Normalized Criteria Comparison Matrix is a tool used in the design processes, especially in the evaluation of alternative concepts. This matrix involves assigning numerical

| Normalized Critera Comparison Matrix [NormC] | | | | | | |
|---|---|---|---|---|---|---|
| **Criteria** | Display | Collects Data from Sensors | Monitors Vitals | Team Notification | Maintenance | Criteria Weights {W} |
| Display | 0.05 | 0.04 | 0.03 | 0.03 | 0.07 | 0.05 |
| Collects Data from Sensors | 0.26 | 0.21 | 0.29 | 0.26 | 0.17 | 0.24 |
| Monitors Vitals | 0.16 | 0.07 | 0.10 | 0.03 | 0.17 | 0.10 |
| Team Notifaction | 0.16 | 0.07 | 0.29 | 0.09 | 0.07 | 0.14 |
| Maintenance | 0.37 | 0.62 | 0.29 | 0.60 | 0.51 | 0.48 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

values to criteria that are important for the defined project. These criteria are then normalized to create a common scale for comparison, allowing for a fair assessment across different factors. In the context of the C Matrix, the Normalized Criteria Comparison Matrix helps ensure a fair and consistent evaluation of compatibility factors.

### 1.6.5 Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is a method used to analytically determine which engineering characteristics are most significant. This method evaluates each characteristic against the others to comparatively determine the most important to the overall goals of the project. The AHP is used to validate the concept selection in the Pugh chart. Additionally, the AHP ensures that the criteria weights aren't biased towards any particular design. AHP tables were created for each of the nine engineering characteristics as determined by the team.

The team then took the values from the Analytical Hierarchy Process tables and put them into a Normalized Material Cost Comparison or NormC chart to create a baseline of comparison.

The normalization of values helps ensure fair comparisons when selecting a concept. This involved dividing each value in the columns of the AHP chart by its specific sum to create a common scale or baseline. These values were then added up to equal 1 at the bottom to ensure a consistent scale was used. Normalization is important as it prevents any single factor from disproportionately influencing the overall assessment. The normalized values from the NormC chart are shown below.

| Normalized Material Cost Comparison [NormC] | | | | |
|---|---|---|---|---|
| DIsplay | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Pi |
| Backpack + Goggle HUD | 0.11 | 0.14 | 0.05 | 0.10 |
| Back Brace + helmet HUD | 0.56 | 0.71 | 0.79 | 0.69 |
| Vest + Gas Mask and UI on Lense | 0.33 | 0.14 | 0.16 | 0.21 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 |

| Normalized Material Cost Comparison [NormC] | | | | |
|---|---|---|---|---|
| Collects Data from Sen | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Pi |
| Backpack + Goggle HUD | 0.14 | 0.08 | 0.09 | 0.10 |
| Back Brace + helmet HUD | 0.43 | 0.23 | 0.09 | 0.25 |
| Vest + Gas Mask and UI on Lense | 0.43 | 0.69 | 0.82 | 0.65 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 |

| Normalized Material Cost Comparison [NormC] | | | | |
|---|---|---|---|---|
| Monitors Vitals | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Pi |
| Backpack + Goggle HUD | 0.11 | 0.20 | 0.05 | 0.12 |
| Back Brace + helmet HUD | 0.33 | 0.60 | 0.71 | 0.55 |
| Vest + Gas Mask and UI on Lense | 0.56 | 0.20 | 0.24 | 0.33 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 |

| Normalized Material Cost Comparison [NormC] | | | | |
|---|---|---|---|---|
| Team Notifications | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Pi |
| Backpack + Goggle HUD | 0.11 | 0.20 | 0.05 | 0.12 |
| Back Brace + helmet HUD | 0.33 | 0.60 | 0.71 | 0.55 |
| Vest + Gas Mask and UI on Lense | 0.56 | 0.20 | 0.24 | 0.33 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 |

| Normalized Material Cost Comparison [NormC] | | | | |
|---|---|---|---|---|
| Maintenance | Backpack + Goggle HUD | Back Brace + helmet HUD | Vest + Gas Mask and UI on Lense | Pi |
| Backpack + Goggle HUD | 0.20 | 0.22 | 0.14 | 0.19 |
| Back Brace + helmet HUD | 0.60 | 0.65 | 0.71 | 0.66 |
| Vest + Gas Mask and UI on Lense | 0.20 | 0.13 | 0.14 | 0.16 |
| Sum | 1.00 | 1.00 | 1.00 | 1.00 |

In the chart above, the relative weights were determined by comparing the engineering characteristic, in the upper left corner, to the intersection of each of our top three concepts. The higher the weight assigned at the intersection of concepts, the heavier weighted the engineering characteristic is for that given concept. The relative weights add up to one laterally and vertically. From this chart the relative weights were used to calculate the alternative value through matrix multiplication to determine which idea was selected.

### 1.6.6 Final Selection

During the Analytical Hierarchy process, we narrowed down the design characteristics to the top five most important criteria. These criteria were then compared to our top three concepts to determine their ranking. The table below shows the results of this comparison.

| Concept | Alternative Value | Rank |
|---|---|---|
| Backpack + Goggle HUD | 0.1615 | 3 |
| Back Brace + helmet HUD | 0.5467 | 1 |
| Vest + Gas Mask and UI on Lense | 0.3296 | 2 |

The results show that the Back brace with a helmet HUD concept best fits the criteria that was determined in the Pugh Chart. The concept would include a flexible back brace which wouldn't restrict any of the user's movement while most of the electronic components would be stored within the back pocket of the brace itself. A single wire would run from the brace to a helmet to reduce the amount of extra weight applied to the user's head/neck. The wire would connect to a heads-up display (HUD) on the helmet visor. This design does is the best at being a comfortable wearable component while providing data and vitals to the user in the most visible way possible.

## 1.8 Spring Project Plan

# Chapter Two: EML 4552C

## 2.1 Spring Plan

### Project Plan.

### Build Plan.

**Appendices**

**Appendix A: Code of Conduct**

**Mission Statement**

To work collaboratively as a team to design and produce a device capable of both covert operations while maintaining fashionable standards to retain secrecy. The team intends to accomplish these goals and objectives by utilizing the engineering knowledge, principles, and experience accumulated throughout their undergraduate careers.

**Outside obligations (other than class)**

| Team Members | Team Responsibilities |
|---|---|
| Kartika Ahern | Theta Tau, SELB, Remote Job |
| Eliot Hamilton | Volunteer research and club affiliations |
| Malachi Johnson-Taylor | PBM Inc., potentially a part-time job |
| Patrick Molnar | Formula SAE, potentially a night job |
| Maxwell Orovitz | Student/Professor Research |

**Team Roles**

| Team Members | Team Roles |
|---|---|
| Kartika Ahern | Systems Engineer |
| Eliot Hamilton | Software Engineer & Materials Engineer |
| Malachi Johnson-Taylor | Thermal Fluids Engineer |
| Patrick Molnar | Dynamic Systems Engineer |
| Maxwell Orovitz | Design Engineer |

The following team roles were chosen by the group members according to their interests and academic strengths. Additional changes may be required after more information about the project is given. Team roles may also be subject to change at the start of the Spring Semester.

**Communication**

The primary form of communication between the team members when communicating informally should be the IMessage group chat. Otherwise, all pertinent information should be communicated on the Microsoft Teams website. When communicating with the team sponsors or Dr. McConomy, all messages should be sent via email with all group members copied onto the message chain. If an email has no response within the first 24-hour period of a team member sending an email, then a follow-up email must be sent by the original message sender. However, a follow up will also need to be sent if an email was sent by a non-team member and has no response within 72 hours (about 3 days). When meeting face-to-face, all team members should be attentive and polite to their sponsor. In addition, it is essential that all group members take notes in their team journals and log those notes within the Microsoft Teams folder. Any group member who misses a face-to-face meeting must look over other team members' notes to stay caught up with the project.

## Dress Code

When meeting informally, there will be no specific dress code. For the sponsor meetings and advising meetings (in-person or otherwise) the team will have a dress code of business casual attire. For the Virtual Design Review and Senior Design Day, the team will have a dress code of business formal attire (suit and tie). In all scenarios of the team meeting, the team should be wearing appropriate attire.

## Attendance Policy

Team members are responsible for attending the scheduled class period both days of the week. Team members have agreed upon meeting after the class period on Tuesdays and Thursdays. In addition, extra meeting times are available during the afternoons on Monday and Wednesday. If a member plans on missing a team meeting, they should alert the rest at least three hours prior to the meeting. If more than three meetings are missed by a member, that member oversees resolving the scheduling conflict at hand. If a member misses at least three meetings without notifying the team, then Dr. McConomy will be consulted for a solution. Vacation days must be agreed upon by the whole group at least 48 hours (about 2 days) prior to the assignment due date.

## Contact with Dr. McConomy

Team members will contact Dr. Mcconomy via email to reach out for a scheduled in-person appointment if required or to ask clarifying questions if no face-to-face conversation is needed. All contact emails will be sent during regular business hours of 8am-5pm Monday through Friday. All members will be CC'ed into all email communications and replies.

Contact will be made when deemed necessary by all team members with TAs added when required as well. Scenarios in which communication will be needed include but not be limited to:

- Sponsor is currently unavailable or has given no response for an extended period inhibiting the progress of the group and project.
- Problems among group members that the group has been unable to resolve even after thorough discussion.
- Any emergency project halts that will impede any further progression in either project or presentations.

## How to amend

The code of conduct above can be amended by the project group at any time with a unanimous vote. If the vote is not unanimous, then team members must communicate and resolve any issues prior to the next general team meeting. The amendment for the document must be clearly written out and signed by each team member to be passed.

## Statement of Understanding

By signing this statement, you agree to the entire document above and will uphold all that is stated above.

| Signatures | Date |
|---|---|
| | 9/18/2023 |
| | 9/18/2023 |
| Eliot H. | 9/18/2023 |
| | 9/18/2023 |
| Patrick Molnar | 9/18/2023 |

## Appendix B: Functional Decomposition

## Appendix C: Target Catalog

## Appendix B Figures and Tables (delete)

## References

**There are no sources in the current document.**