1.5 Concept Generation

Concept generation is an integral part of the design process that challenges students to think creatively. Considering the project's limitations and targets, our team brainstormed one hundred different ideas. From there we determined our high and medium fidelity concepts. The full list of ideas can be found in Appendix D: Concept Generation

1.5.1 Medium Fidelity Concepts

Concept 1 – Combustible Gas (CG) with O2 sensor, SBC, LiPo battery on a vest (#29)

All computational and sensing components will be placed on a vest, display will

be mounted as decided by team 505. Using a vest allows for a larger battery and less obstruction of the user's range of motion than limb-mounted options. Mass will also be maintained close to the user's natural center of gravity.

Concept 2 - CG with O2 sensor, Microcontroller, LiPo battery in a boot (#42)

The components would be fitted into a boot giving us more space than a shoe would and would use a micro controller since an SBC would be unnecessary. It would then communicate with team 505's display in order to give necessary information from the sensors. The integration from the boots will also allow for an alarm to go off when gas concentration gets too high, this will specifically have an O2 sensor that would also test for air quality so the user will know when they need to get out of the building. Similar to other concepts there will be a LiPo battery in use, this helps with weight and the portability of the battery, it also ensures the battery will be powerful enough.

Concept 3 - CG with O2 sensor, SBC, LiPo battery on a removable clip (#66)

All sensing gas sensors feature a single board computing (SBC) which would have a lot of flexibility on how we can code the gas sensor. The design would fit on the waist which can clip on and off of belt loops or belt buckles and be very lightweight and portable. This board would also be able to communicate with the display and other functions with team 505 and be integrable. The battery would be somewhat heavy because it is a LiPo battery but would be powerful enough to have lasting hours on the sensor.

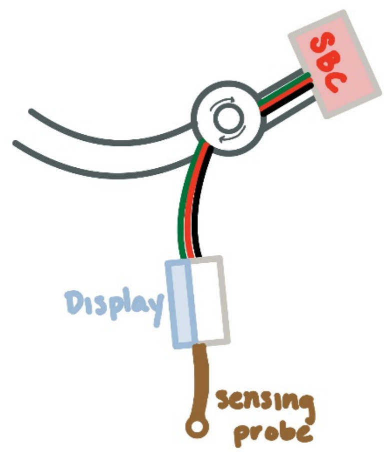

Figure 3: Concept 3

Concept 4 – CG with O2 sensor, Microcontroller, LiPo battery in a watch (#73)

Sensing vitals and gas sensor will be placed on the band of the watch. The display will be the face of the watch and be digital. Team 505 would create the display and the vitals of the user. We will create the interface of the gas sensor and the LiPo battery with the watch. The watch will also create a noise when detecting gas to notify user.

Concept 5 - CG with O2 sensor, Microcontroller, LiPo battery on a hat (#75)

Mounting a combustible gas sensor on a hat would prove advantageous, given that the gases it detects are predominantly located in the upper regions of the atmosphere. Moreover, placing the O2 sensor in close proximity to the face is crucial for accurately assessing the breathability levels in the surroundings. Opting for a microcontroller offers cost-effectiveness, lower power consumption, and ensures the device remains lightweight. Nevertheless, this is a medium fidelity as it imposes constraints on processing power and networking capabilities. Lastly, it introduces additional weight to the head, which is not ideal.

1.5.2 High Fidelity Concepts

Concept 6 - CG with O2 sensor, SBC, LiPo battery inside waist pack (#70)

All sensing, computing, and power components are held in a pack worn on the user's waist. This could integrate with tool belts already worn by search and rescue operators, adding little weight or restrictions on mobility.

Concept 7 – Isolated computer and battery that can be easily connected to multiple wearable configurations (#60)

Because many concepts will involve using the same general electrical hardware, a modular design will be created to connect a computer and battery pack to a range of wearable components. This will allow search and rescue operators to tailor their gas sensor experience to whatever platform suits them best. This idea was generated by considering the open nature of the project and the broad requirements of the sponsor.

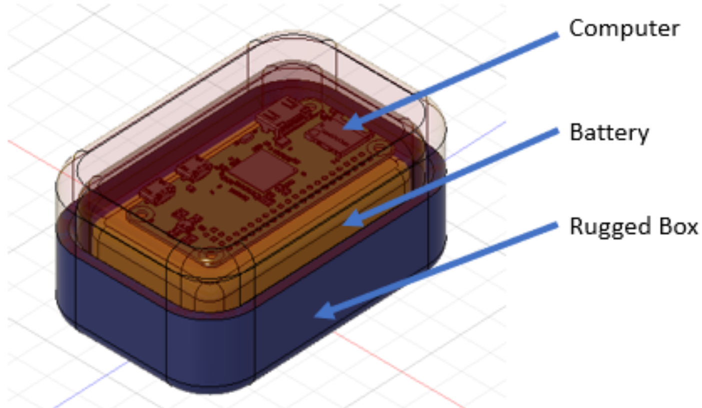

Figure 4: Concept 7

Concept 8 – Analog sensing for each desired gas detection chemicals will be placed on the inner arm (#12)

Rather than using a complex computational system to detect gases, an analog system can be used to detect gases. Different gases will react differently with other chemicals to change color, which can be taken advantage of to make clear gasses present in the air. A fluid reserve will be kept ensuring enough to allow a use time of over 18 hours. The user will be given a switch/bulb to press to release the chemical onto a test area that is exposed to the environment.

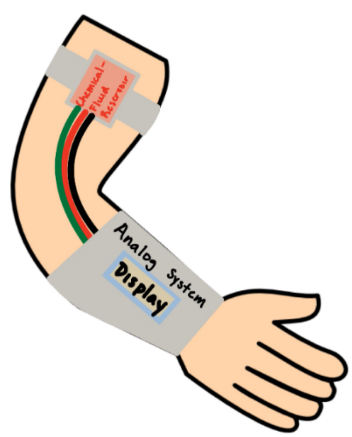

Figure 5: Concept 8

1.5.3 Concept Generation Tools

To help reach one hundred concepts we utilized a variety of different concept generation tools: crap-shoot, anti-problem, forced analogy, and a morphological chart.

Using crap-shooting, concepts were developed by naming existing articles of clothing that a search and rescue operator would be wearing, then determining if a gas sensor could be integrated into that article of clothing. This resulted in concepts such as integrating sensors into a helmet, arm sleeve, boot, and more. Using these concepts, we were able to better determine the expected size of our computational package, and where on the body a package of this nature would cause the least disruption to range of motion and mobility.

Using a morphological chart was helpful for determining the type of computational components to be used. There are many options for computers, sensors, power supplies, and mounting locations that needed to be considered, and a morphological chart provided useful insight. It was determined that using a microcontroller will limit our ability to store and process large amounts of data, so it was decided that an SBC will be necessary. Many sensor types exist, but the options within our price range that can interface with an SBC are more limited. It was decided that it would be best to decide on specific sensor types and products once a concept has been selected, as most have a comparable form factor.

Using anti-problem to generate ideas allowed us to see potential problems and generate ideas that would fix them. An example would be to ask ourselves, “How do we create a gas sensor to fail at detecting gas?” some answers to that would be to create a sensor that is easily blocked or a sensor that is affected by pressure or temperature. Considering these challenges resulted in the team coming up with different ideas that would fix certain problems that may arise when in our chosen scenario. Most of the questions that were asked during the anti-problem generation had to do with safety, meaning that this generation method was good for generating ideas with safety in mind.

Using forced analogy was helpful to come up with unique ideas that may not have been thought of without it. Forced analogy is the process of finding parallels between two unrelated concepts to spark ideas for other concepts. Some of the ideas on their own may not be the most likely design choices but components of the ideas would be good to incorporate into a final design. This helped us because instead of looking at these somewhat unrelated ideas we took them and found ways that they could be connected and that helped us to come up with other unique ideas.

Using these simplifying assumptions, our concept selection was narrowed to form factors that could house an SBC and appropriately sized battery (approximately 5000mah @ 5V) without hindering the user. Based on these new constraints, concepts were further generated to meet them, now focusing on where the sensors will be located. Most of the gases that will be detected are lighter than air, so there is a bias to higher mounting of the sensors relative to the user.