DATE: February 5, 2022

TO: Dr. Emin Kececi

FROM: UltraVisor-C Team

SUBJECT: Generating and Evaluating Design Criteria for the Improved UVisor

**Identifying, Quantifying, and Evaluating Design Criteria for the Improved UVisor**

The current pandemic poses a serious threat to people in high-risk environments, especially doctors and nurses. While there exist many protective measures, they are not 100% effective. Our team intends to design a prototype modeled after the UVisor, an existing prototype and faceshield that is over 99% effective against viruses. However, one missing component of the UVisor is its inability to sanitize outgoing air. This poses a safety concern for medical professionals who wish not to infect patients and other staff. The overall purpose of the UltraVisor is to improve upon the original UVisor in order to sanitize the exhaled air.

In the “Define Design Criteria” phase of the engineering design process, we clarified the objectives we wanted our modified UVisor to achieve, as well as the constraints. We first identified and created a list of the features we wanted in the UVisor (Table 1). Then we determined whether each feature was a constraint that must be met, or an objective that we would like to reach. After that, we considered our research to determine the exact quantitative values that needed to be met for each constraint, and the values that we would like to meet for each objective. We also found two of our objectives (Comfort and Audibility) to be difficult to quantify objectively. To quantify these, we created two User Defined Scales for comfort and audibility (Tables 2 and 3). Finally, we created a pairwise comparison chart, or PCC (Table 4), where we compared the importance of durability, weight, maintainability, comfort, and audibility to each other to determine which objectives were the most important to us.

For our constraints, they are divided into 3 essential factors: air sanitation, safety, and battery life. (Table 1) Sanitation includes both inhaled and exhaled air. At present, the original UVisor team has already proved 99.9% sanitation of the incoming air. As a result, our UVisor cannot have a disinfection rate less than 99.9%. Another constraint we identified was the safety of the UVisor. As a product aiming for protection, it should have 0 risk of danger for the user. For an electronic device with a UV-C light chamber, we need to eliminate the possibility of electric shock or leakage of toxic UV-C. Therefore, 0% of UV light can contact the skin, there must be 0 exposed wires, and the battery must comply with 100% of the manufacturer guidelines. Lastly, the UVisor is mainly aiming for hospital staff like doctors and nurses. Therefore, the battery life of our product must last longer than a 4-hour-long shift. We will confirm actual shift data with doctors and nurses in the future.

For our objectives, we decided that the UVisor must last longer than five years with regular use. This number was determined after clarifying it with our client, Dr. Read. There are two main replaceable items: the bulbs, which are best replaced after 2-3 years of 8 hour usage a day on top of the head, and the batteries, which will likely degrade over time. For weight, we wanted our modified UVisor to be less than or equal to 2.5 pounds, since the existing UVisor weighs 2.5 pounds, and if our modified UVisor weighed more than 2.5 pounds, it would not be a strict improvement over the original. We also wanted the UVisor to be easily maintainable, so we want the plastic and cloth materials of the device to be easily disassembled and washed in under 30 minutes once a week. For comfort, we wanted a score on the user defined scale (Table 2) greater than or equal to 4. A score of 4 or higher means that the tubes/battery/other components of the UVisor won’t get in the way of the user’s work, and there is no difficulty breathing through it. We identified our users to be doctors and people in healthcare settings, so it’s important that the UVisor doesn’t interfere with their work. Finally, for Audibility, we wanted a score on the user defined scale (Table 3) greater than or equal to 4. A score of 4 means that all the words of the person wearing the UVisor are understandable without repetition. Existing N95 masks can make it difficult to speak and communicate, so we would like the UVisor to be easier to communicate through.

Finally, for the Pairwise Comparison Chart (PCC), we evaluated the weight of each influencing objectives and ranked them from most important to least important, which is: Sanitation of exhaled air, Audibility, Weight, Comfort, Maintainability, and then Durability. We ranked sanitation of exhaled air as our first priority because that is the main goal we want to accomplish for this project. We ranked audibility as our second priority because communication in the hospital can be crucial. Whether it is talking to patients or performing a surgery, the transmission of voice must be clear either coming in or going out. The third one is weight, since wearing a heavy object on the head for a long period of time would become straining and potentially harmful to the user. The fourth one is comfort. This is considered to be relatively important because the hospital staff will need to wear them for at least 4 hours a day. The last two are maintainability and durability. Since these only affect the UVisor outside of the primary work environment, we decided to prioritize the aspects of the UVisor that affect it while it’s actively being used.

**Reflections and Takeaways From Design Criteria Generation for the Improved UVisor**

We determined our design criteria by speaking with our client, Dr. Read, who stated that the primary goal would be to sanitize exhaled air, and that our main user base would be doctors and nurses. We decided that for the UVisor to be an improvement on existing N95 masks in healthcare settings, it would need to be comfortable to wear, easy to communicate in, and also more effective in sanitizing both inhaled and exhaled air, while also being as durable, lightweight, and easily maintainable as possible. In our PCC (Table 4), we determined that audibility, comfort, and weight were the most important objectives after sanitation, since healthcare professionals work long shifts, where having a heavy object on the head for extended periods of time would be straining, where clear communication is essential.

The criteria that will likely be the most difficult to design for will be maintainability, since allowing the UVisor to be disassembled while also adding other features makes it much more complex than if we just added other features.

**Table 1: Design Criteria**

|  | **Design Criteria** | **Target Value** |
| --- | --- | --- |
| Constraints | Sanitation of inhaled air | Maintain ≥ 99% sanitation |
| Safety | 0% of UV light contacts skin, 0 exposed wires, battery complies with 100% of manufacturer guidelines |
| Battery life | Battery lasts longer than ≥ 4 hours |
| Objectives | Durability | Lasts ≥ 5 years with regular use |
| Weight | ≤ 2.5 pounds |
| Maintainability | Can be disassembled and cleaned in ≤ 30 minutes, must be cleaned ≤ 1 time/week |
| Comfort | ≥ 4 in the user defined scale\* |
| Audibility | ≥ 4 in the user defined scale\*\* |
| Sanitation of exhaled air | ≥ 99% sanitized |

**\*Table 2: User Defined Scale for Comfort**

| **Value** | **Comfortability** |
| --- | --- |
| 1 | Components are extremely inconvenient, prevent movement, and work. Difficult to breathe in. |
| 2 | Components are inconvenient and slow down work. More difficult to breathe in than an N95 mask, but still manageable. |
| 3 | Components occasionally get in the way of work but it is still manageable to work in. Feels like breathing through an N95 mask. |
| 4 | Components don’t get in the way of work but there is a minor impact on performance after prolonged use. Easier to breathe through than an N95 mask, but still feel constrained. |
| 5 | Components never get in the way of work and can be worn longer than 4 hours without negative impact on performance. No difficulty breathing. |

**\*\*Table 3: User Defined Scale for Audibility**

| **Value** | **Audibility** |
| --- | --- |
| 1 | User speech is inaudible. |
| 2 | Users need to repeat themselves every time. |
| 3 | Users need to repeat themselves frequently. |
| 4 | Users need to repeat themselves occasionally. |
| 5 | Users don’t need to repeat themselves. |

**Table 4: Pairwise Comparison Chart**

|  | Durability | Weight | Maintainability | Comfort | Audibility | Sanitation of exhaled air | Total |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Durability | - | 0 | 0 | 0 | 0 | 0 | 0 |
| Weight | 1 | - | 1 | 1 | 0 | 0 | 3 |
| Maintainability | 1 | 0 | - | 0 | 0 | 0 | 1 |
| Comfort | 1 | 0 | 1 | - | 0 | 0 | 2 |
| Audibility | 1 | 1 | 1 | 1 | - | 0 | 4 |
| Sanitation of exhaled air | 1 | 1 | 1 | 1 | 1 | - | 5 |