Ethical and Environmental Analysis

Year: 2020 **Semester:** Fall **Team:** 6 **Project:** Snow-weAR Goggles
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Assignment Evaluation:

Item	Score (0-5)	Weight	Points	Notes
Assignment-Specific Items				
Environmental Impact		x6		
Ethical Challenges		x6		
Writing-Specific Items				
Spelling and Grammar		x2		
Formatting and Citations		x1		
Figures and Graphs		x2		
Technical Writing Style		x3		
Total Score				

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

Comments:
Comments from the grader will be inserted here.

1.0 Environmental Impact Analysis

Considering the limited availability of resources in the world and the devastation that their improper use can wreak, it is important to analyze the environmental impact on any product and how it can be reduced or mitigated. With the demand for electronics still growing, the raw material extraction, manufacturing waste, product waste, and energy consumption continue to toll the environment. The main products that will be examined in this analysis are the lithium-ion battery (LIB), the printed circuit board (PCB), and the tantalum capacitors. The generation and disposal of these products are generally unsustainable. While these factors can be reduced in some areas, a sustainable life cycle for this product is unattainable.

The production of the components is resource intensive, producing an average of 5 times the waste of the electronic itself, and requiring 25 times the amount of raw materials[2].

The LIB requires 328 Wh of energy and emissions of 110 gCO2eq for every 1 Wh of storage [3]. For comparison, the production of 1 iPhone 11 emits 72 kg CO2e[4]. This apparently puts the LIB in the clear, considering that the Snow-weAR goggles' demand won't be near that of the iPhone's. However, the environmental impact of the electronics industry continues to worsen, making it clear that industry standards are not sustainable. While economically viable and completely legal, this relatively low footprint can not be dismissed as a negligible contribution to a much larger issue.

The PCB manufacturing process produces a significant amount of waste, including solder paste waste, solder dross, solvents, volatile organic compounds from soldering operations, energy, and wastewater. It also requires the sourcing of precious metals, their extraction from the Earth and shipping to manufacturing facilities yet another detrimental blow to the environment. The need for toxic substance such as lead-based solder and polymeric binder matrices further worsen the impact of PCBs.[6]

Tantalum capacitors are relatively simple to manufacture when compared with PCB's and LIB's, but were included in this analysis because of their rarity and the rarity of tantalum itself. Tantalum is mined from many locations worldwide, but currently they are most commonly sourced from Brazil and various countries in central Africa, mainly Rwanda and the Democratic Republic of the Congo (DRC). [7]

Mining can be considered in conjunction with the manufacturing process as a significant source of environmental harm. Open air mining in particular is necessary for the procurement of many metals such as tantalum, copper, and gold. These operations expose bedrock, sending harmful particles into the air and also generating a toxic liquid slurry that often seeps into the bedrock and contaminates water sources.[8] In the worst case, it can breach dirt walls to flood into rivers, polluting an entire region.

Other impacts of this product include shipping and operations. The materials to manufacture this product are sourced worldwide, often by ships that use low-grade fuel containing sulphur, further contaminating the environment [5]. Depending on how the user sources their energy, the charging of the device will consume power as well. If a skier skis 30 days in a season, using one

full charge each day at 6000 mAh per charge, then they will be consuming 500 W of energy. This is relatively negligible compared to the energy consumption of much more common activities such as the annual energy cost of an elevator in a 10 story office building, which is about 4821 kW [9].

Finally, the disposal of the product has to be considered. Due to the small scale and highly complex nature of the product, recycling electronics is incredibly challenging. The tantalum capacitor can be broken back down and reused [10]. The extraction of certain metals from PCBs is only done because it is economically advantageous and still leaves most of the PCB to waste [6]. The process is energy and resource intensive. Lithium Ion batteries can also be recycled; however, the manufacturing industries aren't economically motivated to make them easy to reuse, and smelting facilities are very energy intensive as well [11]. None of these products are naturally occurring or biodegradable, and irresponsible disposal will contaminate the environment.

The environmental outlook for this device is bleak. Considering electronics trends, this is pervasive in the industry and will continue to be, hardly making the Snow-weAR product an outlier. Small steps, however, can be taken to mitigate some of the impact. The schematic could be altered to remove the tantalum capacitors. The lithium ion battery could be swapped out for a lower storage capacity and higher recyclability. Also, the PCB could be made smaller to reduce the quantity of chemicals and metals needed to manufacture it. Finally, the lifetime of the product can be optimized. This can be done by avoiding component dependencies and by providing protective and watertight packaging.

2.0 Ethical Challenges

The IEEE code of ethics contains 10 standards that must be adhered to by all participating members of IEEE. The most important of these standards is in question for this product:

> "1. to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, to protect the privacy of others, and to disclose promptly factors that might endanger the public or the environment;"[12]

On average, about half of deaths on ski slopes are trauma induced - meaning head injury, collision with other skiers, or collision with immobile objects [13]. Introducing immediate speed feedback to the snow sports experience may lead to those with a less-developed-prefrontal cortex competing to see who can obtain the fastest speed. This could lead to even more severe speeding on the slopes and more collisions. The distraction caused by operating and observing a heads up display could lead to more crashes as well.

Both of these risks could be mitigated by displaying warning signs on the packaging, such as "don't ski distracted", or "don't ski too fast". In addition, much like radar speed signs on highways that display real-time speed, there could be an upper limit to the velocity value displayed to prevent people from exceeding it.

Additionally, the GPS on the device isn't meant for safety applications and shouldn't be used to locate avalanche victims or navigate the backcountry. Heavy duty and reliable solutions already exist for these use cases and the Snow-weAR goggles will not provide useful information in survival scenarios. It is primarily meant for in-bounds use. This information will be displayed on the packaging to prevent improper use.

Both analyses have presented unfavorable aspects of Snow-weAR goggles, but the original inspiration for the design can be considered as an ethical motivation for their creation. Academics are developing an interest in the world of action sports. In previous decades, these adventure athletes have been associated with the lower echelons of society, needlessly risking their lives and providing no benefit to the world. This perspective is shifting into an appreciative view of the accomplishments that continue to grow exponentially. Every year, people are doing things that were thought impossible by the previous generation of outdoor athletes, from skiing of larger cliffs, to kayaking higher waterfalls, to jumping off of the sides of mountains. The flow state that is achieved and almost superhuman abilities are considered to be a form of genius to some, attainable by anyone. [14] These goggles are a contribution to the members of the snow sports community, allowing them to track their performance and push their sport past the perceived limits.

3.0 Sources Cited

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