SmartWatch IOT - Computer Engineering Technology Capstone Project –

Group Members: Thomas Aziz, Baltej Bal, Jerreh Janneh

# 3.0 Methodology

## 3.1 Required Resources

### 3.1.1 Parts, Components, Materials

This project requires three sensors, one effector, one display and one development platform.

The three sensors are;

ADXL345 3-axis accelerometer – responsible for measuring acceleration forces. This sensor is an integral part of our project, offering the raw movement data that is necessary to map out user activity and facilitate the recording of data from other sensors. The ADXL345 does not require direct user contact or intervention and does not require any additional references as it measures acceleration in regards to the static force of gravity.

TMP006 IR temperature sensor – a thermopile sensor that measures the temperature of an object using infrared wave detection. This sensor is key in providing the user’s temperature data, and the data recorded will be used in our application alongside movement and pulse data to more accurately measure total user activity. Since the sensor measures using infrared waves, it requires direct line of sight to the user’s wrist, and this design requirement is reflected in the layout of the enclosure. The sensor does not, however, require direct contact with the user’s skin.

SEN-11574 pulse sensor – measures the pulse of the user using ambient light readings through the skin. This sensor will gather constant pulse data from the user at all times – allowing us to alert the user of any strange heart rate variations and to provide exercise data post-workout from data measured during strenuous user activity. The sensor requires direct contact with the user’s skin to measure heart rate, and this design requirement is also reflected in the enclosure layout.

ADS1014 12-bit ADC – an effector that converts analog signals to digital values for use in digital system. This is required for recording the data from our pulse sensor, as it is transmitted in analog format and our development platform only supports digital input.

LCD160CR – a display with resistive touch functionality that will display critical data to the user on the fly. Thanks to touchscreen functionality, the display will also allow for the user to directly interact with select watch settings without requiring their mobile phone nearby.

Raspberry Pi Zero W – a single board computer powered by the Broadcom BCM2835. Features wireless connectivity (in the form of Bluetooth and Wi-fi) which is essential for our project, and is powerful enough to handle all the sensor data we require it to. A big requirement that had to be taken into consideration for this project is physical size. Since the development platform is embedded into a wristwatch, the dimensions need to be small enough that the watch is not unwieldy. Measuring at 65mm x 30mm x 5mm, the Pi Zero W is a very good size to meet this requirement while also giving us all the further functionality we need.

### 3.1.2 Manufacturing

A custom PCB design is required to allow for all necessary sensors and effectors to connect to our development platform. The PCB will be designed using the electronic design software *Fritzing*, a tool we are familiar with – having used it in the previous semester (CENG317). All files used and exported by *Fritzing* can be found on our project repository, within the Electronics directory. The PCB should be no larger than our development platform (Raspberry Pi Zero W) – with maximum dimensions of 66.0mm x 30.5mm. Due to the TMP006 sensing temperature through infrared, it needs direct line of sight to the user’s wrist (but not direct contact), leading to having sensors on both sides of the board. This requirement introduces further complexity in regard to traces and vias, with very thin traces and small vias required to maximize the useable space on the board. In order to maintain tight tolerances in what will be an intricate board design, we will turn to a third-party vendor for printing. Our vendor of choice is one we have worked with in the previous semester – SeeedStudio. SeeedStudio offers a plethora of options in terms of key board properties (namely trace width, thickness and layer count) which are not available to us from the Humber Prototype Lab.

The enclosure will be 3D printed and has to tightly fit the development platform, the PCB and the display, as well as having loops to feed straps through. The enclosure will be designed using OpenSCAD and sliced using Cura – both software tools that have experience with from prior courses. Due to the abuse that watches typically face (bumps, scratches, side impacts), the enclosure needs to be remarkably durable and thus needs to be printed using a strong filament. Having worked with various different filaments and weighing the benefits and drawbacks of each, we have decided that we will use Polycarbonate as our filament of choice. Polycarbonate is a tough filament to print with – requiring very high temperatures across the printer’s head and print bed, and being very prone to warping, but the benefits of using this material (namely high scratch resistance, very high bump and shatter resistance, and relatively low-cost) outweigh the challenges faced in printing. As well, our vendor of choice for printing (Humber’s Idea Lab) features the Ultimaker 2+, a 3D printer that is adequate for printing with Polycarbonate and as such further reduces any drawbacks we may face while printing.

### 3.1.3 Tools and Facilities

There are a variety of software tools used in this project – namely *Fritzing, OpenSCAD* and *Cura.* Fritzing is open-source software used to design various electronic circuits. In our use case, Fritzing is essential for designing our custom PCB and exporting it into a format suitable for printing by our third-party vendor.

OpenSCAD is free software that is used to design and create solid 3D CAD objects. This will be used to design and create the enclosure for our platform prior to any 3D printing. Once design is complete, the OpenSCAD files can be exported into a format suitable for pre-print slicing. These files are then used in Cura, a free program that slices CAD designs in order to allow them to be used with 3D printers. The output of Cura is then used to physically print the case, and is thus the last software tool used for the design of physical components of our project.

Since PCB assembly is being handled by SeeedStudio, the standard tools for PCB assembly (solder, a soldering iron, various soldering accessories) are not required for this project.

All PCB printing facilities are owned and operated by SeeedStudio, and we do not have access to them in a physical sense. All services offered by SeeedStudio are accessible via their online storefront, with designs being uploaded by us, and verified and printed by facilities.

Out 3D printing facility is Humber’s Idea Lab, located at the North Campus. The Idea Lab provides access to two Ultimaker 2+ 3D printers which are suitable for our enclosure designs, and as such we do not need any external 3D printing facilities. The services offered by the Idea Lab are free to all students, with reasonable time constraints laid out by the school to ensure fairness to printer access.

### 3.1.4 Shipping, duty, taxes

Most of the required resources for this project can be purchased from Amazon and thus are exempt from duties and subject to Ontario’s standard tax rate of 13%. This includes the development platform (and all related accessories) and the majority of the sensors and effectors. Amazon’s *Amazon Prime* service offers free two-day shipping for most items, and the items required for this project are no exception. We have access to the *Prime* service and as such, there are very little shipping and duty fees associated with this project.

There are two exceptions to this – purchasing PCB printing from our vendor of choice, *SeeedStudio*, as well as acquiring the ADS1015 ADC, introduces significant shipping costs.

Printing and shipping is based out of China, and shipping is handled by DHL freight. Based on previous experience, the approximate flat cost for shipping and receiving the PCBs from SeeedStudio is 25CAD pre-duties. Once the shipment enters the country, duties and taxes are levied on the shipment, typically costing another 20CAD. Shipping time is rather quick, typically arriving in 2-3 days after dispatch. This is the only significant shipping cost associated with resources required for this project, and is not a stringent requirement given that it is not necessary (but very helpful) to have the boards printed out-of-country by a third-party vendor.

The ADS1015 ADC is not available on Amazon (through the vendor marketplace or through Amazon directly) and should be acquired through Adafruit. Adafruit offers express shipping through DHL (with similar shipping times as SeeedStudio) with a cost of roughly 20CAD for the package, plus approximately 5CAD for taxes and duties.

Assuming anything that can be purchased and acquired through Amazon (and their *Prime* service) is, the total shipping and duty cost for this project should total no more than 75CAD.

### 3.1.5 Time expenditure

The majority of the time spent on this project is working time- spent primarily on designing the custom PCB and enclosure, building the mobile application and database, and writing documentation across the project.

Designing a functional and appropriate PCB, based on prior experience, should take no more than 5-7 hours of dedicated work time. Enclosures can prove to be more difficult to design, requiring roughly 10 hours of dedicated work time, especially considering the material and dimensional constraints we face in our project. Lead time for the physical hardware of this project is high as well. Printing the PCBs takes on average 3-5 business days, as well as 2-3 days for shipping. 3D printing is also a lengthy procedure, requiring approximately 2-3 hours of printing time.

The software components of the project will also require a significant amount of working time. Building a secure and reliable database alongside a functional, well-designed application is a large undertaking, and as such does not currently have a fixed time frame for total working time. Lead time for the software components is not applicable, as there are no external requirements or influences in designing and creating the appropriate software.

Documentation is a constant in both working and lead time. Lead time is contingent on the speed in which other progress in the project is made – we cannot document steps that haven’t happened yet. As more progress on the project is made, more documentation can be written, and as such there is no fixed lead time currently. Working time is directly linked to the amount of total time required for the project – we estimate that roughly 30% of the total working time of the project will be spent documenting.