Design Specifications for the Automatic Product Tracker

March 17, 2019

Dr. Craig Scratchley
School of Engineering
Science Simon Fraser University
8888 University Dr
Burnaby, BC, V5A 1S6

Re: ENSC 405W/440 Design Specifications for the **Automatic Product Tracker** by **Pondus Tech**

Dear Dr. Scratchley,

The attached document contains the design specifications for implementing the Automatic Product Tracker. The goal is to reduce the amount of time spent doing inventory and accurately calculating how much ingredients to purchase for buffet or grab n' go style restaurants. This will be done by tracking product data and providing suggestions based on ingredient consumption.

This document will specify our designs for the Automatic Product Tracker. The designs outlined will cover the hardware components, software components, and how the components will work together.

The group consists of five engineering students from various branches of engineering: Justin Aoki, Tahsin Alam, Paul Bologea, Kevin Corbett, and Mauricio Veloz. We believe the group as a whole has both the hardware and software experience to successfully implement the product.

Thank you for taking the time to review the design specifications. If you have any questions, please contact our Chief Communications Officer, Mauricio Veloz, by email at mveloz@sfu.ca.

Regards,
Kevin Corbett

Chief Executive Officer
Pondus Tech

Enclosed: Design Specification for Automatic Product Tracker

PONDUS TECH

Design Specification

Automatic Product Tracker

Team 10

Tahsin Alam - Chief Technical Officer
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Submitted to:

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Abstract

The Automatic Product Tracker is a scale intended for use in keeping track of inventory in fast paced environments and restaurant in order to facilitate real-time inventory monitoring as well as using product usage statistics in order to formulate efficient and effective ordering schemes.

The Automatic Product Tracker can be broken down into its 3 main systems: the scale, which measures the weight of items in real time; the processor, which reads the weight information and packages it into readable information which is also capable of sending the information out via wi-fi; and the server, which receives the incoming product data and allows users to monitor their items over days, months, and years.

This design specification document will outline our design specifications for the proof of concept stage of development. Each section provides reasoning for the design choices for each component of the Automatic Product Tracker.

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Glossary

These are a list of acronyms that will be used throughout the specification:

APT: Automatic Product Tracker
PoC: Proof of Concept (the product shown at the end of ENSC 405W)
WP: Working Prototype (the product shown at the end of ENSC 440)
FP: Finished Product (the commercial, ready-for-market product)

Introduction

With our growing population and climate change happening all over the globe, it is without a doubt that significant changes in our food production and consumption need to occur. Canada is one of the world's largest wasters of food. Over 50% of our food produced in Canada is either lost or wasted, which is a major concern at Pondus Tech.

For this reason, Pondus Tech is in the planning phase of a new product, the Automatic Product Tracker (APT). This product will be designed to keep track of inventory in fast paced environments where constant human monitoring would not otherwise be practical. A 'Grab and Go' kitchen would find this product useful as items are constantly being removed and refilled without taking inventory on a regular interval.

By using the APT device and software, we will be able to monitor usage of any particular item(s) over days, months, and years depending on use case. This will aid in day to day work if some item was being used more than usual, or over a longer term to track usage and to find the best time to restock and order more items. By doing this, we will be able to reduce shipping costs by reducing shipment sizes to be more precise as to what will be needed for that week. By having a more precise ordering system in place it will also reduce the amount of items expiring on shelves. By using our monitoring device and software it has the potential to save money for the owner and lower his/her ecological footprint.

In this document the design specifications for implementing the APT are outlined, along with the reasoning for the design choices of each component. This will include hardware design, software design, and user interface design.

General Design Specifications

The APT is a product tracking system which uses a scale with a wi-fi chip in order to relay real time statistics to a server. These statistics are easily accessible by the user via an online website, and will allow the user to keep track of products that may not be tracked by current systems. This device must be usable within a kitchen environment, as our main demographic will be a 'Grab and Go' kitchen, a kitchen where different products are used, but not necessarily kept track of every time they are used. Therefore the scale must comply with FOODSAFE BC requirements. Because this will mainly be used in kitchens, the device should also be capable of handling cold, hot and wet products. The APT scale should be able to weigh products of up to 5 kilograms, as this is around the maximum weight of a product that would be commonly used in a 'Grab and Go' kitchen. This weight requirement has been changed from the original 15kg stated in **RQ[G.PoC.4.H]** to increase the accuracy of the measurements.

The APT scale is also designed to be very intuitive for the user. The system was configured to be easily understood by any user without prior experience with our product. The simplistic design consists of two push button switches on the front of the unit and an easy to read LCD digital display. The base of the structure will house the weight sensing electronics and micro-processing unit. The push buttons on the front of the scale will be used as tare-max and tare-min options for the full and empty weight values for the product being tracked, respectively. If no tare is done on the product, the APT will have algorithms to detect these values. Together this satisfies the **RQ[G.PoC.6.H]**, **RQ[G.PoC.10.L]**, and **RQ[G.PoC.11.L]** requirements.

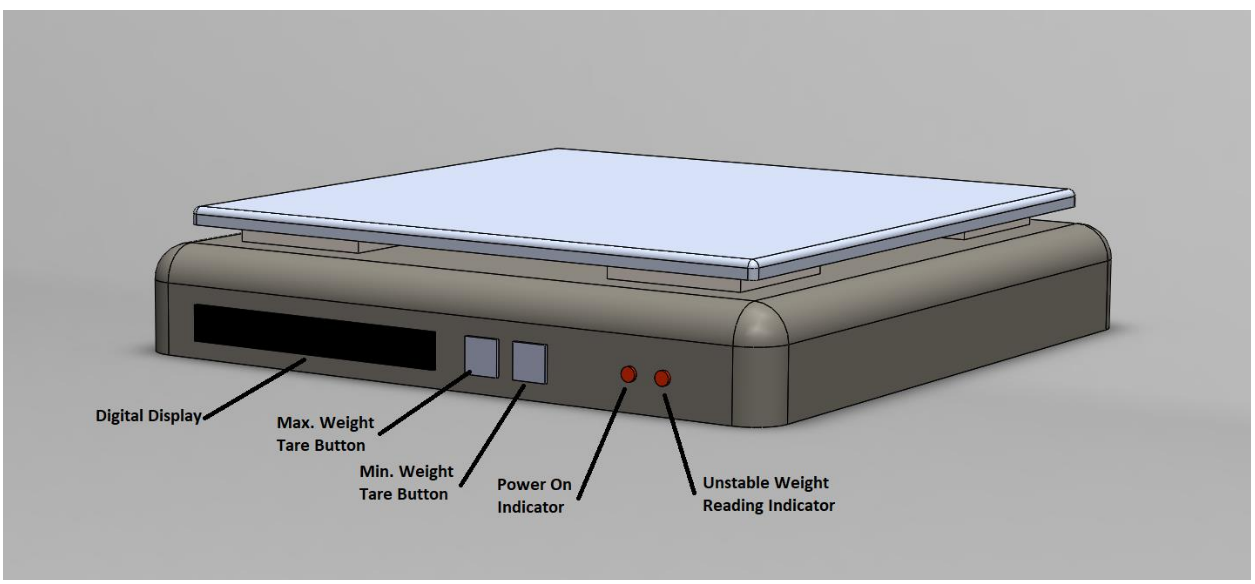

Figure 1: SolidWorks rendering of potential PoC prototype (Front View)

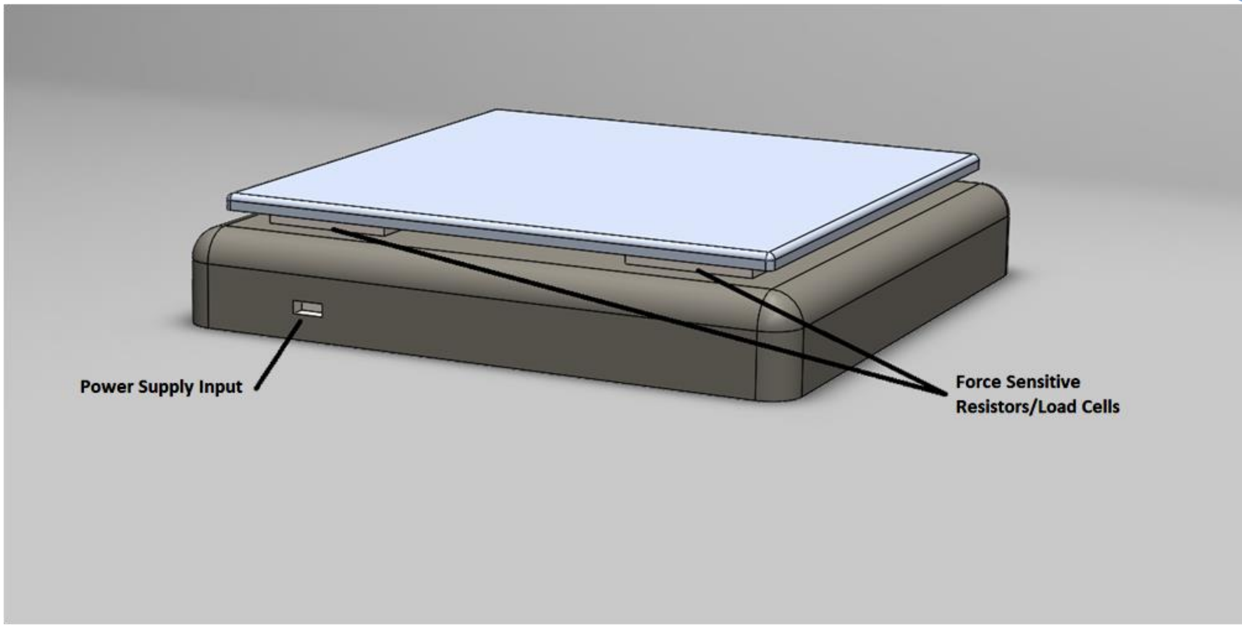

Figure 2: SolidWorks rendering of potential PoC prototype (Rear View)

Additionally, the APT system will come with an instruction manual informing the user about the logistics behind the connecting the device to the website, fulfilling the **RQ[G.PoC.9.M]** requirement. The Proof-of-Concept model will allow a user to configure a single scale, and monitor the APT statistics on our webpage. Later models will allow for the configuration of multiple devices. The physical APT scale unit will be constructed in two pieces. As shown in figures 1 and 2 above, the bottom dark grey base of the unit will be made out of wood. The weight of the wooden base allows the scale to remain stable under heavy loads, resisting bending and wobbling. The weighing platform (light blue section in figures 1 and 2) will be made from aluminum. The lightweight aluminum platform minimizes the weight on the load sensors, ensuring the most accurate measurement possible. Both the wood and aluminum materials were selected for use due to their cost efficiency, helping satisfying **RQ[G.PoC.8.M]**. The materials are also food safe for hot, cold and wet objects as well as use indoors, as listed in requirements **RQ[G.PoC.2.H]** and **RQ[G.PoC.3.H]**.

The APT scale will also be wirelessly connected to the APT server. The scale will wirelessly send data to the database server for processing and graphically displaying on the webpage. This wireless communication will be done via Wi-Fi, in order to minimize interference with any other device in its vicinity as defined in **RQ[G.PoC.7.M]**.

Electrical Design Specifications

As our main demographic for using the APT will be in a kitchen environment, the electrical design will have to be arranged such that the APT can be simply plugged in and installed wherever there is an outlet, which is common for most kitchens. The 120 Volts AC from the wall outlet will be brought down using a 120 Volts AC to 7-12 Volts DC transformer. This 7-12V DC transformer will then be used to power the Arduino Uno circuit board, which will supply a 5V DC bus to be used by the other components of the system, satisfying requirements **RQ[E.PoC.3.M]** and **RQ[E.PoC.6.M]**.

The force measuring equipment being used to calculate the weight for the APT is a set of *Uxcell Aluminum Alloy Micro Load Cell Weighing Sensors*. These load cells will be accompanied by the *HX711 Load Cell Amplifier*, in order to amplify the signal acquired from the load cells. For the Proof-of-Concept model, we will be using two of these load cells, as well as two amplifiers, in order to obtain a measurement accurate to 5 percent of an object's actual mass, up to a maximum mass of 5kg.

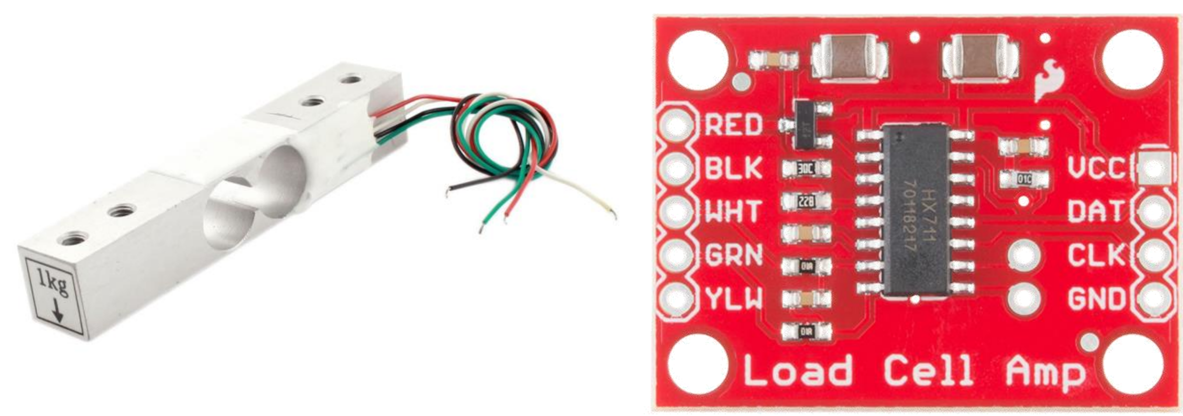

Figure 3: The Uxcell Aluminum Alloy Load Cell (Left) and HX711 Load Cell Amplifier (Right)

The load cell is installed such that the rear end (the end where the wires come out of) is fastened down onto the base structure of the APT using M5 screws, and the front end (the end with the 1kg sticker) will be secured to the base of the scale platform such that the force being applied on the load cell will be in the direction of the arrow. A strain gauge works by applying a force on the gauge in order to cause a physical deformation, which alters its electrical resistance. The load cell is designed such that it acts as though it has been separated into four resistors, two of which are variable, and two that are a fixed resistance, which are configured in a Wheatstone bridge formation, shown below.

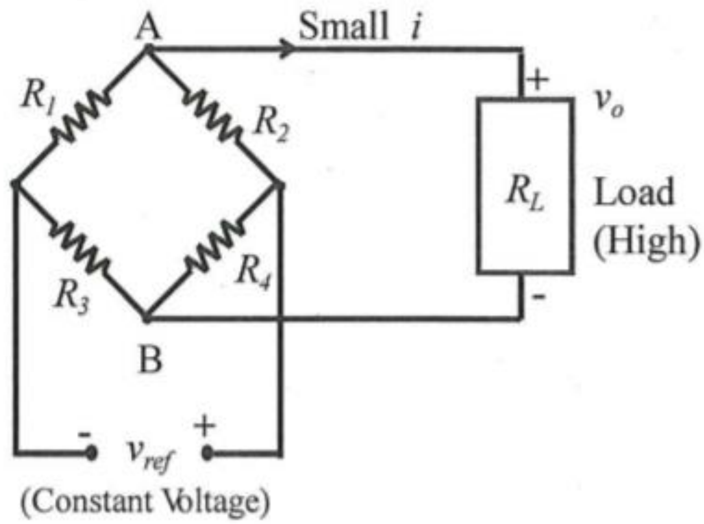

Figure 4: Wheatstone Bridge Configuration

The Wheatstone Bridge is a very useful circuit that is often used for amplifying small changes in resistance in order to achieve accurate measurements. The output voltage for this configuration can be solved as:

$$v_0 = v_{ref}\left(\frac{R_1R_4 - R_2R_3}{(R_1 + R_2)(R_3 + R_4)}\right)$$

As we can see from the equation, when there is no force applied to the strain gauge and we assume that $R_1 = R_2 = R_3 = R_4 = R$, the output voltage from the equation can be measured to be zero. However, when there is a force applied to the strain gauge, it causes a change in resistance to the active elements (variable resistors) of the strain gauge. We can then determine the change in output voltage per change in resistance to be:

$$\Delta v_0 = v_{ref}\left(\frac{R(R + \Delta R) - R(R - \Delta R)}{(2R + \Delta R)(2R - \Delta R)}\right) = v_{ref}\left(\frac{\Delta R}{2R}\right)$$

In this equation, we assume that the ΔR is much smaller than R, causing the $(\Delta R)^2$ term that should be in the denominator to be negligible. This difference in voltage, v_0, then goes through the load cell amplifier in order to create an even more accurate signal reading, so that minor noise and voltage fluctuation does not greatly affect the resulting output of the signal. Using this method, we can measure the weight of an object in the range of 0 to 5kg to within 5 percent, which satisfies requirement **RQ[E.PoC.1.H]**.

The other different electrical components that will be controlled by the Arduino Uno will be the tare button, the power-on indicator, the ready-to-measure indicator and the LCD display. The LCD display requires the usage of the analogue data pins, while the other remaining components can simply be connected to the digital input pins. The power-on indicator resolves requirement **RQ[E.PoC.4.M]** and **RQ[E.PoC.9.L]**, and our LED display will allow for the visual display of the object weight, resolving requirement **RQ[E.PoC.8.L]**. The following schematic shows the wiring of the different objects:

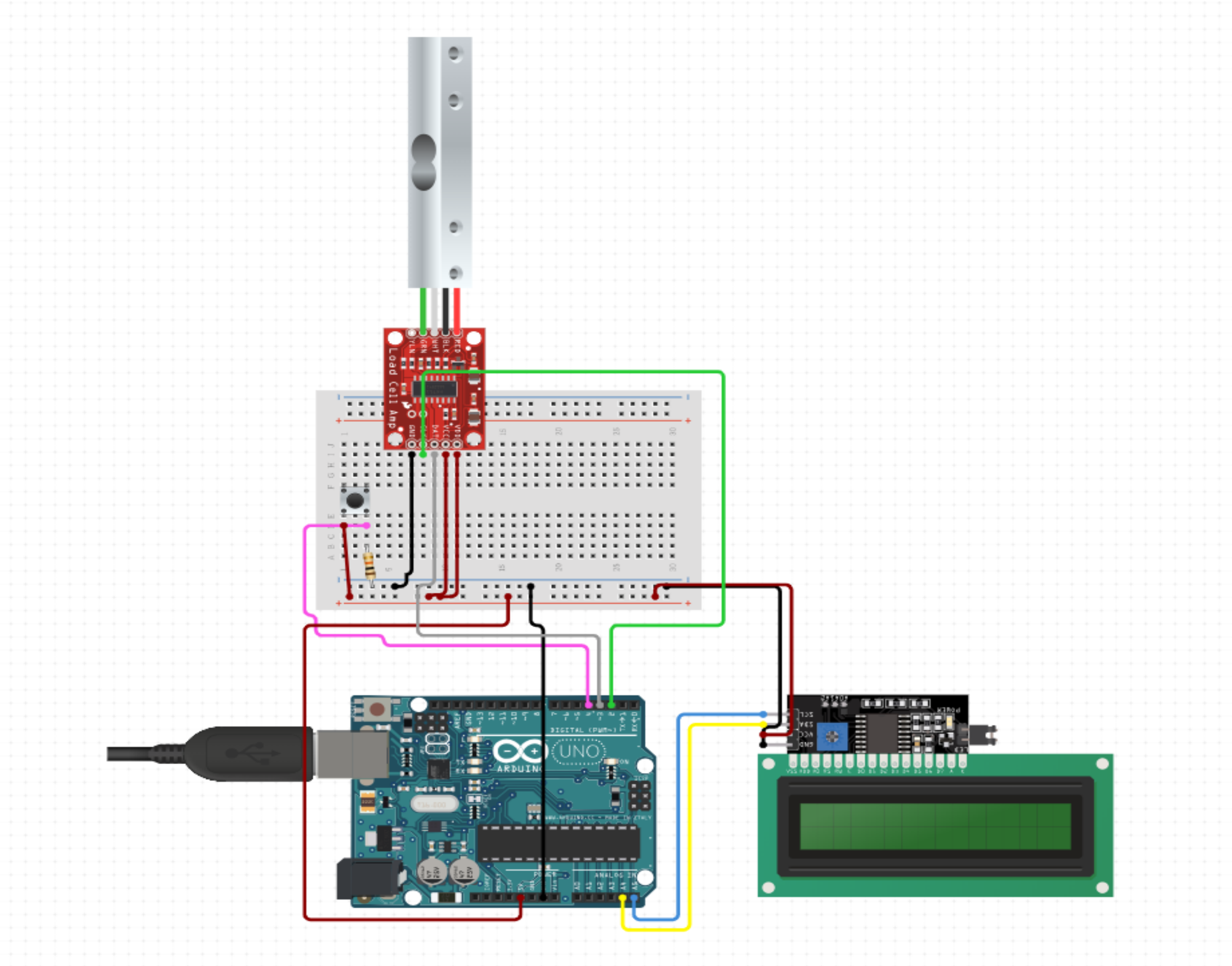

Figure 5: Wiring Diagram of the APT (made using [1])

This circuit is quite small in practice, satisfying requirement **RQ[E.PoC.7.M]**.

Microprocessor Design Specifications

For the microprocessor, we have selected to use the *Arduino Uno Wifi Rev2* due to its updated processor and Wi-Fi capabilities over its predecessors, and with its support for many peripherals that will be required for the APT to perform within our specifications.

The Arduino will be able to read the values from the load cell through and analogue to digital converter. This takes the analogue voltage reading from the load-cells' Wheatstone Bridge into a digital signal capable of being read from the Arduino. The Analog-to-Digital converter (ADC) chosen for this task was the *HX711 load cell amplifier*. In addition to the amplification properties previously described, it also has a built-in 24 bit ADC along with an op-amp for accurate readings. Each cell is capable of detecting variations of 5 grams, which is within range for **RQ[M.PoC.1.H]**.

From the load cell to the Arduino, there are errors that occur. There is a small "creep" of voltage fluctuations from the cell which is smoothened out by an intelligent smoothing algorithm on the arduino. This function discards small variations up to a certain threshold of weight change, and it also waits for the input to become stable by checking and comparing multiple data points until there is a low error. This function satisfies **RQ[M.PoC.5.M]** and **RQ[M.PoC.6.L]**.

The APT will also contain user accessible buttons for easy setting of new products. These buttons will be directly connected to digital pins of the Arduino with low power going through them. This gives the user the ability to tare the scale to compensate for a heavy container that holds products, and to register a new product on the scale. This makes the product easier to use and satisfies **RQ[M.PoC.4.M]**.

The Arduino must store the mass reading data locally, so as to prevent the data from being lost in the event of the website server failing or the Wi-Fi disconnecting. The Arduino will attempt to send this file to our web-server to be processed on each (30 seconds in the PoC) update period. The format is detailed below.

$$T_1, M_1, H, T_2, M_2, H, \ldots$$

where

T is a 32-bit unsigned integer representing the time in Unix Epoch Time (the number of seconds since January 1st, 1970). This value is obtained when the device first connects to the internet using the Network Time Protocol, and converting it to Unix Epoch Time (this amounts to a simple subtraction of the number of seconds in 70 years). This value can then be updated by examining the Arduino's internal clock, allowing the date to be known without an internet connection.

M is a floating point number representing the mass in grams of the product in the APT. This value is obtained by from the load cells (using the smoothing functions and ADC previously described).

H is a 32-bit unsigned int representing a unique product identifier. This is created during manufacture, and serves to distinguish between multiple APT devices. In function, it is similar to a MAC address used for computers and other devices.

This information is to be stored in a .csv file local to the Arduino. Every time the device takes a measurement, the 3 entries of each measurement described above are appended to the end of the file. Once this file becomes too large, instead of adding entries to the end, we start back at the beginning of the file, and start overwriting previous entries. This specification satisfies **RQ[M.PoC.2.H]**, **RQ[M.PoC.3.H]**, and **RQ[M.PoC.7.L]**, along with **RQ[M.FP.3.H]**.

Website and Server Design Specifications

Please note that the designs specified in this section of the document are a work in progress and are subject to change. The designs shown here may not be representative of the final product.

For the proof of concept design, the data received from the Arduino will be stored onto a database server. The server will attempt to read the file sent and only add data that is new. Since there will only be one APT supported during this phase, there will be no sign up or login screen to access the data. Instead, the website design will consist of a link to download a .csv file containing the data collected by the server. Setting up the website and server in this manner will satisfy **RQ[WS.PoC.1.H]** and **RQ[WS.PoC.2.H]**. Since there will be no user participation for this phase of the design, user interface was not heavily considered.

As the design moves forward to the working prototype, additional components will be added. A sign up/login screen will be added to ensure that users are not able to access data for products they do not own, satisfying **RQ[WS.WP.4.M]** and **RQ[WS.WP.5.M]**. The data will no longer be only accessible by a downloadable .csv file, instead it will be displayed in line or bar graphs depending on the date range in order to satisfy **RQ[WS.WP.1.H]**, with an option to download the data. Graphs will have drop down boxes for changing the date range displayed so that the data can be displayed in the most useful way for the user as specified by **RQ[WS.WP.6.L].** The data will be stored in such a way that it will be easy to correctly identify what data points have come from which specific scale, and also be sent in such that it can be easily sorted into chronological order. Each product will have a unique product identifier, which can be assigned to a certain profile on the website. In order to view these statistics, the website will simply request information from this unique product identifier, between a certain range of times.

The working prototype design concept is shown in Figure 6. Currently there is still some uncertainty with regards to the working prototype design as well as how the usage reports will be formatted. However due to the nature of web development changes can be dynamically made to the website with little cost as long as the data from the hardware is available.

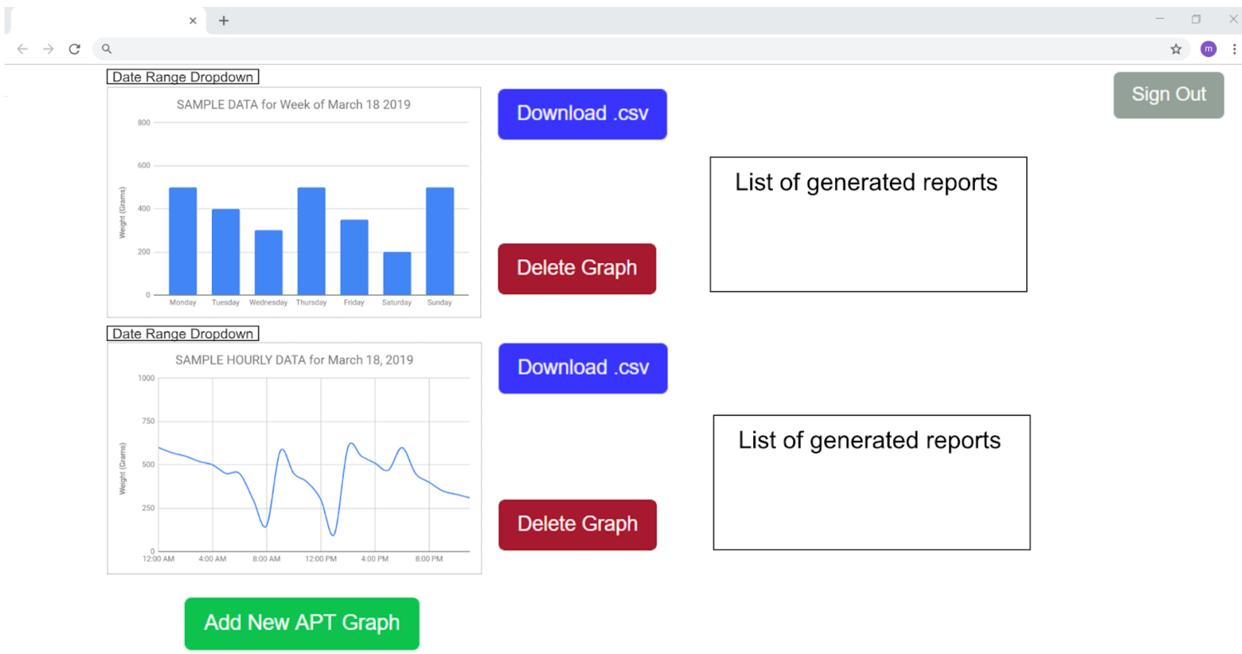

Figure 6: Current design plan for working prototype of website.

This website will be coded in such a way to support the major web browsers Edge, Firefox, and Google Chrome, satisfying **RQ[WS.PoC.3.H]**.

Safety and Sustainability Design Specifications

Throughout the process of the design of the APT, many choices have been made in order to provide safety and sustainability for the usage of the product. Due to the fact that this product will be used in a hands-on approach, it is vital that the electrical components of the APT do not exceed a high-voltage level. The amount of current required to provide lethal injuries due to electrocution is a mere 0.1 amperes. The resistance of the human body is approximately 100,000 Ohms; however with wet or broken skin, the resistance can be as low as 1,000 Ohms. Therefore, from Ohm’s Law,

$$V = IR$$

we require that the voltage level be lower than 100 Volts. The only voltage that will be higher than 100 Volts for our product will be the 120 Volts from the wall outlet, which will not be actively used during the handling of the product. There are also many security measures in place for most outlets in a kitchen environment, such as Ground Fault Circuit Interrupter (GFCI) outlets, which can detect an imbalance between incoming and outgoing current and shut down the power immediately. The remaining voltage is brought down to 7 - 12 Volts in order to power the Arduino Uno, and also a 5 Volt bus in order to power many of the other components. These voltages are safe to use, however they will still be all secured in an enclosure in order to minimize the risk of minor electrocutions. This satisfies requirement **RQ[SS.PoC.1.H]**.

The enclosure of the APT will also be in contact with food, therefore the materials selected to build the enclosure must satisfy requirement **RQ[SS.PoC.2.M]** and **RQ[G.PoC.5.H]**. The materials chosen for the PoC prototype will be wood for the base, and aluminum for the measuring plate. These materials are non-toxic and are compliant with FOODSAFE BC standards, thus satisfying the requirements. The enclosure will also be built such that it is splash-proof, and does not contain sharp edges, satisfying requirements **RQ[SS.WP.3.H]** and **RQ[SS.WP.4.M]**.

The APT may also be used in a cooled environment, and thus must be designed in to work at refrigerated temperatures in the range of 1.6℃ - 4.0℃. The parts that we are using all have operating temperatures that satisfy these conditions, therefore there should be no safety concerns relating to the operating temperature of the APT, satisfying **RQ[SS.WP.2.H]**.

The APT enclosure will be made using recycled parts from previous projects, and at the end phase of this class, the enclosure will be recycled yet again for the usage of future students. The electrical components can also be removed easily and be reused for future projects. This satisfies **RQ[SS.FP.2.M]**.

Conclusion

This document has outlined a synopsis of the Automatic Product Tracker with regards to the hardware, software, and server components. The encompassing features of this device are listed below:

Hardware
The APT contains a thin scale with a digital display capable of displaying useful weight information to the user with buttons to interact/read this data before being sent to the server. The internal control systems will be non-user accessible and therefore will contain intuitive design for users to operate the APT without issue.

Software
The APT will be able to read the scale's information, clean the signal and remove extraneous data, which will then be able to package the weight information along with time data to the server.

Server
The server will store the data and provide information to the user as the team moves forward to the prototyping stages.

With these design considerations, the APT is poised to be installed into many pre-existing kitchen and storage areas due to its ease of use, and powerful tracking capabilities which will be very useful for commercial use. With proper implementation, this product will be able to fulfill the goal at Pondus Tech, to provide a quality tracking solution for kitchens all over the country which will reduce the carbon footprint and food wastage in Canada.

Appendix I – Design Requirements

The requirements for the APT have been sorted into multiple categories to detail which part of the system they correspond to. Additionally, they have been assigned to one specific product version depending on the complexity and usefulness of the specification. The general form for requirement classification is as follows:

RQ[(Requirement Section).(Product version).(Requirement Number).(Priority Level)**]**

Requirement Section	
G	General
E	Electrical
M	Microprocessor
WS	Website and Server
SS	Safety and Sustainability

Product Version	
PoC	Proof of Concept
WP	Working Prototype
FP	Finished Product

Priority Level	
H	High
M	Medium
L	Low

Table 1: Requirement Classification Table

The specifications are shown below.

RQ[G.PoC.1.H]	The APT will consist of a weight sensor, microprocessor and visual display.
RQ[G.PoC.2.H]	The APT must be able to work indoors.
RQ[G.PoC.3.H]	The APT must be operable while handling hot, cold, and/or wet objects.
RQ[G.PoC.4.H]	The APT must be able to withstand holding a weight up to 5kg.
RQ[G.PoC.5.H]	The APT must be compliant with any and all food safe requirements.
RQ[G.PoC.6.H]	The APT must be simple to use/understand for the user.
RQ[G.PoC.7.M]	The APT must not interfere with any other wireless devices in its proximity.
RQ[G.PoC.8.M]	The APT must be under 100 dollars to manufacture.
RQ[G.PoC.9.M]	The APT must come with an instruction manual.
RQ[G.PoC.10.L]	The APT must be operable without any weight tare configurations.
RQ[G.PoC.11.L]	The APT must have Tare Max and Tare Min values to do percentage real-time tracking.
RQ[G.PoC.12.L]	The APT must have a start-up time of 10 seconds or less.

Table 2: List of General Requirements

RQ[E.PoC.1.H]	The APT must be able to receive accurate measurements from the Strain Gauge/Load Cells via signal cleaning/enhancing (accurate to 5%).
RQ[E.PoC.2.H]	The APT must be able to communicate data to the server.
RQ[E.PoC.3.M]	The APT's power supply must be able to be plugged into a 120V wall outlet.
RQ[E.PoC.4.M]	The APT must be able to visually display when the scale is on/running.
RQ[E.PoC.5.M]	The APT must be able to be powered on/off externally.
RQ[E.PoC.6.M]	The APT's controller should be able to power all other electrical components.
RQ[E.PoC.7.M]	The APT's scale and all electrical components should be able to fit into 8" x 8" x 2" physical structure.
RQ[E.PoC.8.L]	The APT must be able to visually display the current weight of the object on the digital display or serial port.
RQ[E.PoC.9.L]	The APT must have a power on/off indicator LED.
RQ[E.WP.1.H]	The APT must be compatible with multiple scales.
RQ[E.WP.2.M]	The APT must be able to tare the minimum weight of a product (The empty container that the product is kept in).
RQ[E.WP.3.M]	The APT must be able to tare the maximum weight of a product (When the container is 100 percent full of the product).
RQ[E.WP.4.M]	The APT must be able to run for extended periods of time without error.
RQ[E.WP.5.M]	The APT's Power Supply should be able to power wi-fi chip/other electrical components directly.
RQ[E.WP.6.M]	The APT must weigh the product accurately to one tenth of a gram.
RQ[E.WP.7.L]	The APT must be able to visually display when there is an unstable weight reading (weight data not being used towards average over current time period).
RQ[E.FP.1.M]	The APT's scale must have backup power supply that can run the device for 24 hours in case of loss of power.
RQ[E.FP.2.M]	The APT's scale must have internal memory that can store 48 hours worth of data in case of loss of connection to server.

Table 3: List of Electrical Requirements

RQ[M.PoC.1.H]	The microprocessor must convert load cell information into a weight within 5% error.
RQ[M.PoC.2.H]	The microprocessor must pack data into readable packets for pushing to server.
RQ[M.PoC.3.H]	The microprocessor timestamp sent packets.
RQ[M.PoC.4.M]	The microprocessor must be able to tare an empty tray.
RQ[M.PoC.5.M]	The microprocessor must discard unstable weight values.
RQ[M.PoC.6.L]	The microprocessor must use an intelligent waiting algorithm to find a stable weight.
RQ[M.PoC.7.L]	The microprocessor must push data to the server in 30 second intervals.
RQ[M.WP.1.H]	The microprocessor must have temperature load cell compensation.
RQ[M.WP.2.H]	The microprocessor must show information on a segmented display.
RQ[M.WP.3.H]	The microprocessor must be able to configure and track multiple weight trays.
RQ[M.WP.4.H]	The microprocessor must track multiple items.
RQ[M.WP.5.L]	The microprocessor must allow user to adjust frequency of data being pushed to the server.
RQ[M.WP.6.L]	The microprocessor must push error messages to the server.
RQ[M.FP.1.H]	The microprocessor must be a custom chip (not an Arduino).
RQ[M.FP.2.H]	The microprocessor must be able to detect connection loss to server.
RQ[M.FP.3.H]	The microprocessor must be able store data locally during connection loss.

Table 4: List of Microprocessor Requirements

RQ[WS.PoC.1.H]	The server must be able to accurately receive data from local device.
RQ[WS.PoC.2.H]	The website must have a downloadable .csv file containing the data collected.
RQ[WS.PoC.3.H]	The website must support Edge, Firefox, and Chrome.
RQ[WS.WP.1.H]	The website must display data for each device in a line graph and bar graph.
RQ[WS.WP.2.H]	The server must be able to distinguish between particular instances of a device.
RQ[WS.WP.3.H]	The server must be able to permanently store data.
RQ[WS.WP.4.M]	The server must have user accounts with password.
RQ[WS.WP.5.M]	The website must be able to register device(s) to an account.
RQ[WS.WP.6.L]	The website must be able to display data for different time intervals.
RQ[WS.WP.7.L]	The website must be able to remotely configure the devices.
RQ[WS.FP.1.H]	The website must be intuitive to use.
RQ[WS.FP.2.H]	The website must be able to organize individual devices into sub categories (restaurants, ingredients, etc.)
RQ[WS.FP.3.M]	The website must provide a recommendation of how much product to buy.

Table 5: List of Website and Server Requirements

RQ[SS.PoC.1.H]	The APT must run at safe, stable voltages.
RQ[SS.PoC.2.M]	The APT must not use toxic or otherwise harmful materials.
RQ[SS.WP.1.H]	The APT must use food-safe materials.
RQ[SS.WP.2.H]	The APT must be safe at low temperatures (refrigerated temperatures).
RQ[SS.WP.3.H]	The APT must be splash-proof.
RQ[SS.WP.4.M]	The APT must have no sharp edges, and its cables must be protected/shielded.
RQ[SS.FP.1.H]	The APT must be dishwasher safe.
RQ[SS.FP.2.M]	The APT must be able to be recycled.

Table 6: List of Safety and Sustainability Requirements

Appendix II – Test Plan for Proof of Concept

Scale/Load Cell Test Steps:

Test Scenario	Expected Result	Pass/Fail
Load cell can accurately determine the weight of objects on the scale.	Microcontroller can accurately (±5% of weight) determine the weight of objects of 0.1 kg, 0.25 kg, 0.5 kg, 1 kg and 5 kg.	
Comments:		

Microcontroller Test Steps:

Test Scenario	Expected Result	Pass/Fail
Microcontroller output pins provide consistent voltage to digital output pins.	Digital multimeter provides consistent (< 5% variation) voltage readings from output pins.	
Comments:		
Microcontroller analog inputs should display the correct value.	Digital multimeter value and microcontroller values are consistent (< 5% variation).	

Comments:		
Microcontroller can determine when it receives improper data from input sensors.	Removing an object and then putting the same object back on the scale within a three second period should not result in excessive data variation (< 5% variation) being received by the server.	
Comments:		
Microcontroller sends time stamped data to the server every 30 seconds.	Data values received by the server shows proper timestamp, with a data point every 30 seconds.	
Comments:		
Microcontroller needs to be able to tare an empty scale, or a container	Data values received by the server should change from the previous weight being read, to around zero (with < 5% variation)	
Comments:		
Microcontroller should be able to send data via wifi, and handle lost information	Data values received by the server will have redundancy and should have no gaps in the csv. file	
Comments:		

Server Test Steps:

Test Scenario	Expected Result	Pass/Fail
Server can properly receive data from the controller via the Wi-Fi chip.	A .csv File on the server can be viewed to check that it is receiving updated values from the Wi-Fi chip.	
Comments:		

Website Test Steps:

Test Scenario	Expected Result	Pass/Fail
Website and .csv file should be available on Firefox, Chrome and Edge.	Open the website in Firefox, Chrome and Edge, and be able to open the .csv file in all three scenarios.	
Comments:		
Test Scenario	Expected Result	Pass/Fail
Graphs must be able to be added and removed	When corresponding buttons are pressed, graphs should be added/deleted.	
Comments:		
Test Scenario	Expected Result	Pass/Fail
New accounts are able to be created	Create new account with user info and password. All data for that user is displayed after signing in.	
Comments:		
Test Scenario	Expected Result	Pass/Fail
Reports are generated based on product usage.	Report appears next to corresponding graph. Clicking on report link will provides user with statistics.	
Comments:		

User Interface Appendix

This user interface appendix will outline the basic skills required for each user to use the Automatic Product Tracker effectively, an analysis of the user interface, and a section on analytical and empirical usability testing to ensure that the best design is chosen. Engineering standards that apply to the Automatic Product Tracker will also be outlined. Please note that for the PoC, the website will be extremely minimalistic; thus many website-specific concepts pertain more to the WP or FP.

User Analysis

The user interface was designed to be simple to use and understand. However, to ensure proper use of the APT, the user requires the following skills:

Hardware	User must know how to operate a generic scale
	User must have basic experience with push buttons
	User must be familiar with visual indicators
	User must be familiar with On/Off lights

Website	User must be familiar with basic Wi-Fi functions (i.e. how to connect)
	User must have basic experience with a computer
	User must have experience with sign up and login screens
	User must be familiar with drop-down menus
	User must be familiar with graphs

Table 7: Required User Skills

Of these requirements, only the first requirements of each type are non-trivial; however, given that the APT is marketed towards restaurants, it can be safely assumed that the users would be familiar with all the necessary skills.

Technical Analysis

This analysis will cover the user interface of the APT with regards to Don Norman's *Seven Elements of UI Interaction* [2, pg 72-73]. All quotes and italicized content below come from this source unless otherwise stated.

Discoverability

It is possible to determine what actions are possible and the current state of the device.

Consider the diagrams of the APT from before:

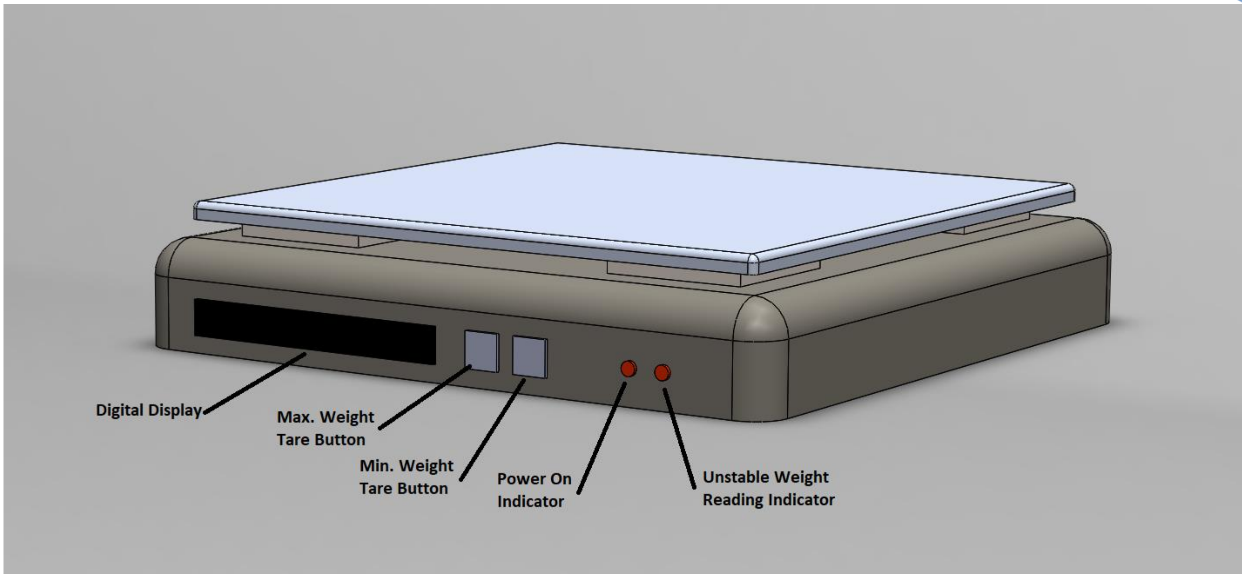

Figure 7: SolidWorks rendering of potential PoC prototype (Front View)

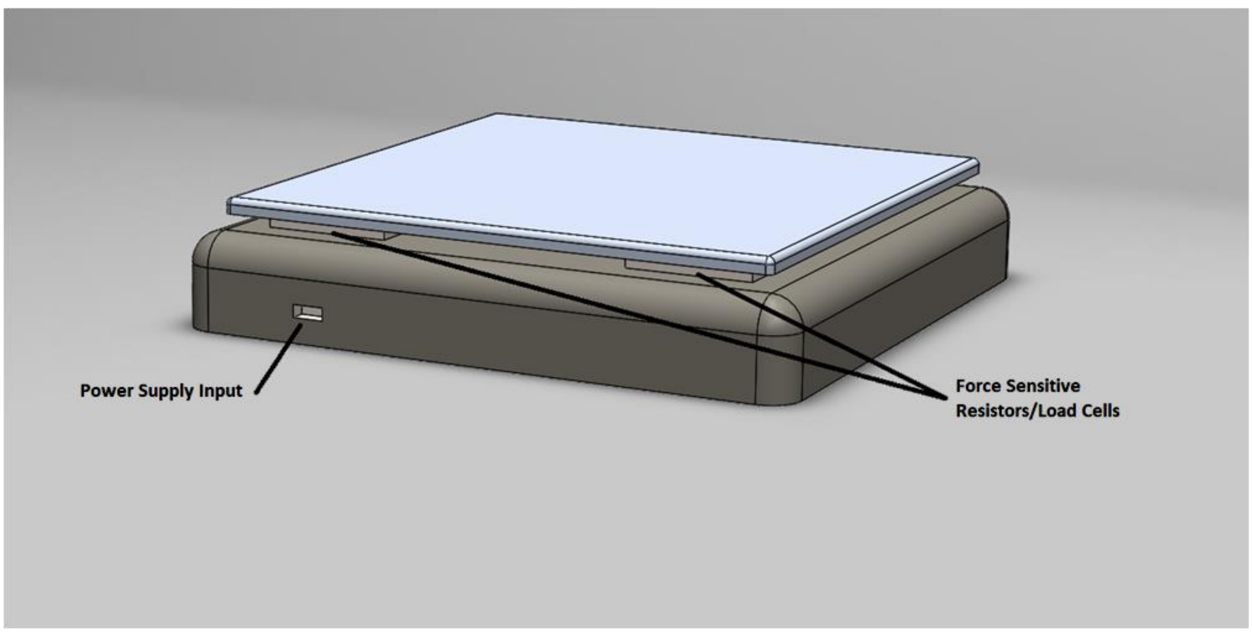

Figure 8: SolidWorks rendering of potential PoC prototype (Rear View)

From the hardware side, the scale will have very little interactive elements to limit the amount of misuse from the user, with all functions except power clearly found on the front. The only functions available from the device itself are the tare buttons (on the actual design, these will be marked as to which one is which). For the current state, there is a clear digital display and power indicator, to show that the device is operating correctly. There is also an unstable weight indicator, to show when the device is processing an unclear weight.

The website is also intentionally minimalistic, for the same reason as the hardware. Interactive elements are clearly placed near where the user will be looking, and colored differently to indicate the user can interact with them.

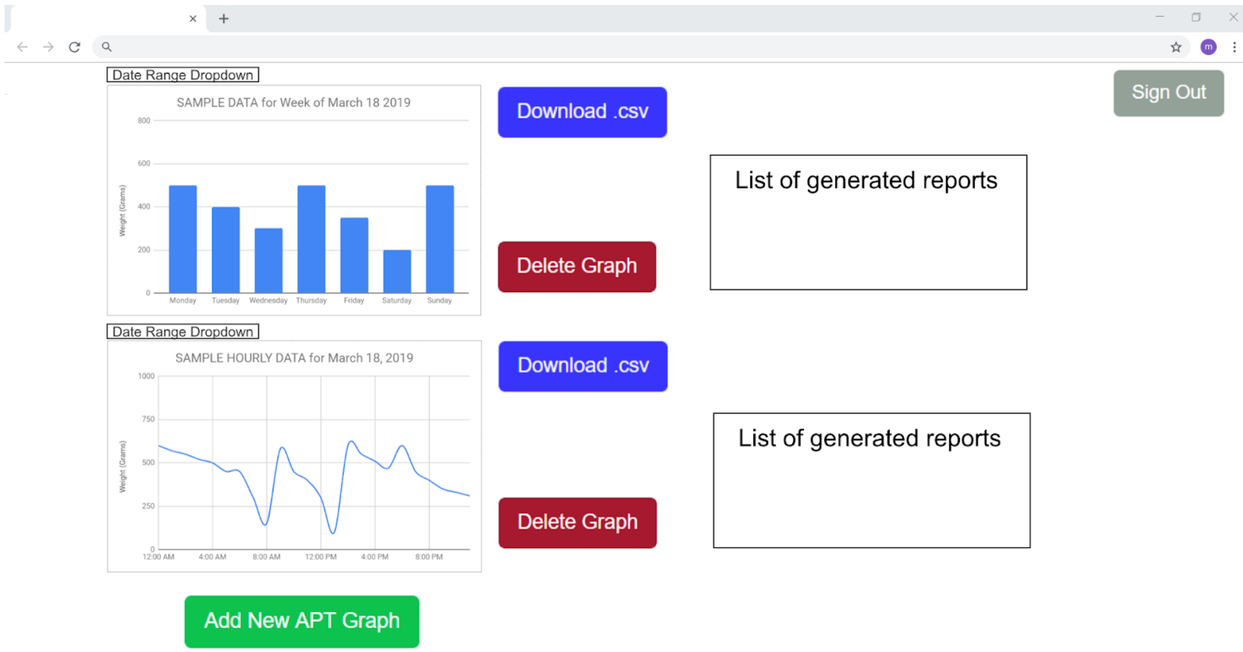

Figure 9: Current design plan for working prototype of website.

Feedback

There is full and continuous information about the results of actions and the current state of the product or service. After an action has been executed, it is easy to determine the new state.

Buttons on the scale will provide tactile feedback when pressed. Users will be able to feel the buttons press in, indicating their selections. Additionally, the LCD display will provide visual feedback when buttons are pressed.

Any buttons or sections on the website that require to be clicked will indicate when they have been pressed. When the mouse is placed over something visual feedback will be provided by having the element highlighted.

Conceptual Model

The design projects all the information needed to create a good conceptual model of the system, leading to understanding and a feeling of control. The conceptual model enhances both discoverability and evaluation of results.

The LCD display contains everything necessary to understand what the device does. The user develops a clear understanding of what the device does just from the device itself.

Affordances

The proper affordances exist to make the desired actions possible.

The LCD display contains everything necessary to understand what the device does. The user develops a clear understanding of what the device does just from the device itself.

Our product has the affordances to allow the user to measure the weight of an object, as well as to track the usage of that product over time. The hardware will allow us to measure the weight of the object, and the software is used to track the usage.

Signifiers

Effective use of signifiers ensures discoverability and that the feedback is well communicated and intelligible.

When a suggestion report is generated for a product, the website will place the report link next to the corresponding graph so that the user is well aware of which product is being reported on. We will also have button signifiers to inform the user what each button does, as well as different messages that can be read on the LCD display.

Mappings

The relationship between controls and their actions follows the principles of good mapping, enhanced as much as possible through spatial layout and temporal contiguity.

For the scale all buttons that the user will need are accessible from the front of the device and are away from any moving parts or connections. All electronics that should not be interacted with by the user will be contained inside a sealed area.

For the website all buttons that affect a particular graph will be placed close to the graph to ensure that the user knows which graph they are interacting with. Any buttons unrelated to interacting with a specific graph will be placed further away.

Constraints

Providing physical, logical, semantic, and cultural constraints guides actions and eases interpretation.

The scale will be designed so there is only one clear orientation of the device. The measuring platform will be flat and clearly defined from the base of the scale.

The website will disable buttons that would not have any effect in the current state or if they would cause the website to encounter an error.

Engineering Standards

CAN/CSA-C22.2 NO. 0-10 – General Requirements - Canadian Electrical Code, Part II

CAN/CSA-C22.2 NO. 61508-1:17 – Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems

CSA C22.1-15 PACKAGE - 2015 – Canadian Electrical Code, Part I

IEC 60529 – Degrees of Protection Provided by Enclosures (IP Codes)

IEC 61508 – Standard for Functional Safety of Electronic Safety-Related Systems

IEEE 1016 – Standard for Software Design Description

IEEE 29148 – Standard for Systems and Software Engineering Requirements

IEEE 802.11 – IEEE Standard for Implementation of Wireless Local Area Network (WLAN) Computer Connections in the 2.4GHz and 5GHz Range

IEEE 802.6 – Standards for Information Exchange between Systems

IEEE 830 – IEEE Recommended Practice for Software Requirements Specifications

UL 1026 – Standard for Household Electric Cooking and Food Serving Appliances

UL 61010-1 – Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use — Part 1: General Requirements

Table 8: List of Engineering Standards

Analytical Usability Testing

For the analytical usability testing the Pondus Tech team will perform tests on the user interface on the APT. After performing the tests if there are any issues the team will discuss on how the issues will be fixed, or if the issue is not worth fixing with regards to the cost of fixing the issue. The tests that will be performed are shown below.

Scale Test	**Pass/Fail**
Can the scale be quickly and easily tared?	
Does the LCD display quickly and accurately display the weight reading?	
Does the power display accurately work?	
Does the unstable reading indicator correctly detect and show that the reading is unstable?	

Website Tests	**Pass/Fail**
Are the graphs large enough to be seen on supported browsers and standard resolutions?	
Can the data range be clearly and quickly changed?	
Is it easy to add and remove graphs?	

Table 9: User Interface Tests for Developers

Empirical Usability Testing

For the empirical usability testing the Pondus Tech team will reach out to various users to use the APT under supervision in order to evaluate the usability of the user interface. The team will be receiving feedback from family and friends, and SFU students. Some members of the team will reach out to members of the food industry for further testing. Once the users have tested the APT the team will ask them the following series of questions to gauge the quality of the user interface:

Scale Test	Comments
How easy was it to turn on the scale the first time?	
How easy was it to set-up the scale the first time?	
Were the buttons on the scale clearly laid out?	
Was the LCD display helpful when weighing objects?	
How stable was the scale when you placed your items on the weighing platform?	
How likely are you to recommend this product?	
Is there information that could be added to the display?	

Website Test	Comments
Were the functions on the website intuitive?	
How easily were you able to add and delete a graph?	
Was the data displayed in a useful way?	
Is there any additional functionality needed?	
Was it easy to navigate and use the site?	

Table 10: User Interface Tests for Users

Conclusion

With regards to the website design the PoC was designed specifically with no user interaction in mind. Since the team was able to ping and send data from the hardware components all that would be left for the PoC is to correctly store the data. As for the working prototype, the general design of what the team thinks the website should look like has been created, and the team will use that as a guideline during the prototyping phase.

The user interface of the physical scale for the PoC prototype will allow the user to visually see the weight reading on the LCD display on the front of the enclosure, as well as have a button to tare the current weight of the scale. The usability of the PoC prototype for the physical scale is quite simple, given that the user understands the basic concepts of a scale. For future prototypes, there may be more scales in use, and therefore there will need to be updates to the interface of the LCD display, as well as possibly the addition of extra buttons with different functionalities to improve usability. Several ideas for the future design of the prototypes have been discussed and are currently being considered by the team.

References

[1] Tool for making circuit diagram. www.circuito.io

[2] D. Norman, *The Design of Everyday Things*. Philadelphia: Basic Books, 2013.

Data Sheets

Avia Semiconductor, "24-Bit Analog-to-Digital Converter (ADC) for Weigh Scales", HX711 Datasheet, Jun. 2016 [Accessed 12 Mar. 2019]

"3133 - Micro Load Cell (0-5kg)", CZL635 Datasheet, May. 2011 [Accessed 12 Mar. 2019]