Dr. Robert Dony, PhD,P.Eng.
University of Guelph
School of Engineering
50 Stone Road East
Guelph, ON, N1G2W1

Dear Dr. Robert Dony,

Thank you for providing feedback regarding the proposal. COVID-19 is a widely and rapidly spreading disease caused by a newly discovered virus known as coronavirus. Governments and health professionals are working together to defeat the virus. Currently, people are required to wear a face covering, and a routine check of their temperature and any related symptoms at the entrance of stores, clinics and other public places have been made mandatory. It was brought to the design's team's attention that the workers responsible for checking all the people entering the building are highly exposed to the virus, which puts their and other lives in greater danger. Therefore, ROBOTEX is interested in reducing the spread of COVID-19 by reducing people's exposure to the virus—hence, the front-line workers. The design team at ROBOTEX also wants to ensure that the required safety measures, including wearing a mask, regular temperature checks and the allowed number of people, are accurately done to limit the spread.

The team members sincerely appreciate your insight since it helps design a solution that can address and solve the current issue. After analyzing all the design alternatives from many perspectives, such as consumers, the design buyers and the team perspective, the best optimal solution would be to design a stand-alone device that can measure the body temperature accurately, recognize face masks and account for the number of people inside the buildings, and it also controls the entrance doors. It provides people entering the buildings or stores with hand sanitizer to ensure that everyone is safe. The design group believes that this solution will help limit the separation of COVID-19, and therefore, vast amounts of research have been done by the team to ensure the equipment used in this solution is safe and accurate. Enclosed is a detailed report of three design solutions; it contains the team's research on the components and the systems of the designs. The estimated cost of the design regarding the project activities and time spent by the team to complete them is approximately $15,360.

Altogether, ROBOTEX's goal is to stop the spread of COVID-19 through a safe and efficient approach. Your support and guidance are highly appreciated.

Sincerely,

Aarthi Christina Aruliah *Aarthi Christina Aruliah* — Layal Alzaydi

Lina Shaabo — Nasiba Alchach

Whitney Trinh — Ahmed Soomro

ENGG*3100 – Engineering and Design III - W21

Design Proposal – Automated COVID Screening Entrance Device

Robert Dony

(Group FPM-05)

Aarthi Christina Aruliah - 1069952

Layal Alzaydi - 1041786

Lina Shaabo -1053401

Nasiba Alchach - 1072028

Whitney Trinh - 1052299

University of Guelph, School of Engineering

Signature Page

In signing this report I certify that I have been an active member of the team and provided approximately equal contribution to the work. I take shared credit and responsibility for the content of this report. I understand that taking credit for work that is not my own is a form of academic misconduct and will be treated as such.

___ **Aarthi Aruliah** ____ Aarthi Christina Aruliah

Team Member One Name Team Member One Signature

____ **Layal Alzaydi** ____

Team Member Two Name Team Member Two Signature

____ **Lina Shaabo** _____ ___ ______

Team Member Three Name Team Member Three Signature

___ **Nasiba Alchach** ____ ____ _____

Team Member Four Name Team Member Four Signature

____ **Whitney Trinh** ____ ____ _____

Team Member Five Name Team Member Five Signature

___ **February 2021** ___

February 26th, 2021

Executive Summary

The recent coronavirus pandemic has been an eye-opener to the world and has brought our everyday hygienic practices to attention as the mode of transmission of this disease is through infected respiratory droplets. Different world governments have enforced many restrictions and health measures to control the spread and safeguard society. Some of the standard measures taken include wearing a mask at public places, maintaining social distance, sanitizing hands, and checking body temperature when entering. The screening test at store entrances has been assigned to essential frontline workers. Due to such exposure, this poses a threat to both these workers and the customers as well.

The scope of this problem lies in finding a safe solution that can be used in the place of a front line worker. The team of engineers at ROBOTEX have listed the main constraints of the design being the system must be able to measure temperature, detect masks and count the number of people in a safe and worry free manner. The approach to solving the problem is generating ideas through research, sketches, calculations, code implementations which can be supported by using tools like SolidWorks, Code Editors and Virtual Environments . Upon further inspection, ROBOTEX has chosen three alternative designs to compare and decide the optimal solution. The three alternatives that have been analyzed are a mobile application, the use of existing surveillance cameras, and an automated COVID screening station. These alternatives are compared to each other and are evaluated against each criteria. The team members have given importance to the accuracy of the entire system as it holds about 57% of the criteria weightage. The accuracy plays a crucial factor of this design solution as the system deals with ensuring that health measures enforced by the government are being followed. However the criteria weightage may vary, as shop owners prefer a more cost effective solution whereas customers, a quick and accessible design solution. Therefore the sensitivity analysis of the alternatives aided in choosing a preliminary design that benefits every stakeholder; in this case, ROBOTEX, shop owners and customers. From both, the decision matrix and the sensitivity matrices, it can be seen that the most suitable design solution for the proposed problem is the automated COVID screening station. Though this alternative turns out to be of a higher cost, it

proves to be the most accurate and efficient way of solving the problem as it solely would be only the technology that would monitor the screening test system and control the incoming customers.

As the time frame of the entire project design is 12 weeks with April 2nd being the deadline for finalizing the design, ROBOTEX has come up with a detailed timeline with specific goals and key milestones being met. In regards to the budget, $15,360 is the approximated labour fees cost for an estimate of 384 hours to complete the project . The technical memo is the next major deliverable, for which three weeks have been assigned as it requires in-depth calculations for proving the functionality of the chosen alternative design. This would entail the next phase for developing such a revolutionary product that will play its part in saving lives.

Table of Contents

Letter of Transmittal

Title Page

Signature Page

Executive Summary

Table of Contents

List of Tables

List of Figures

1.0 Introduction/Background ……………….…………………………………….……..10

1.1 Problem Description ……………………………………………………..……...10

1.2 Background Information and Literature Review……….…..….…..………………14

1.3 Scope of Project…………………………………………..………………...16

1.4 Constraints and Criteria…………………….………………………...……………..17

2.0 Conceptual Designs and Evaluations……………….………………………………..20

2.1 Design Process **…………………………………………………..…………….…...20**

2.2 Conceptual Design Alternatives.………………...……..…………….……..………...21

2.2.1 Design 1 - Mobile Application…………...……………..…...…..……..21

2.2.2 Design 2 - Existing Surveillance Camera…………………..…....…………22

2.2.3 Design 3 - Automated COVID Screening Station……..……..…………..…22

2.3 Design Evaluation……………………………………………………………...…25

2.3.1 Decision Matrix……………………………………..……………....26

2.3.2 Sensitivity Analysis……………………………………..…..………...32

2.4 Proposed Preliminary Design………………………………….…...……....37

3.0 Updated Work Plan and Resources………………………...……………………….…38

3.1 UPDATED TASKS AND TIMELINES……………………..….……………………….38

3.2 KEY MILESTONES AND DELIVERABLES……….……....………..…………………..40

3.3 FEE ESTIMATE FOR DESIGN AND REQUIRED DELIVERABLES……..……………….…41

4. Conclusions and Recommendations……………………….………………….……….43

5.0 References…..………………………………………………….……………….…….…44

6.0 Appendices……………………………………..……………………………………50
6.1 Appendix A: Response to Feedback……….………..……………………….....50
6.2 Appendix B: Calculations/modeling required for evaluating design alternatives….52
6.2.1 Decision Matrix Ranking……….……………..…………………….…52
6.2.2 Technical Sketch for Design - Mobile Application………….…………..56
6.2.3 Technical Sketch for Design 2 - Existing Surveillance Camera..………….57
6.2.4 Technical Sketch 1 for Design 3 - Automated COVID Screening Station….58
6.2.5 Technical Sketch 2 for Design 3 - Automated COVID Screening Station….59
6.2.6 Concept Map for Design Evaluation…………………….....................60
6.3 Appendix C: Updated Work Plan and Resources…………………………………61
6.3.1 Updated Gantt Chart……………...……………...……………………..61
6.3.2 Updated Fee estimate for design and required deliverable…………….63

List of Tables

Table 1. Constraints of the Design Solution……………………..…………………………..17

Table 2. Criteria of the Design Solution……………………………………………………18

Table 3. Design 1 Decision Matrix ………………………………………………………….25

Table 4. Design 2 Decision Matrix …………………………………………………..……..27

Table 5. Design 3 Decision Matrix……………………………………………..………...29

Table 6. Sensitivity analysis ranking according to ROBOTEX……………..………………32

Table 7. Sensitivity analysis ranking according to Retailers………….……………………34

Table 8. Sensitivity analysis ranking according to Customers…………….……………...35

Table 9. Critical Deadlines……………………………………….…………………38

Table 10. Key Milestones and Deliverables ……………………………………………….39

Table 11. Required Tools…………………………………………………………………..40

List of Figures

Figure 1. Using CCTV/IP camera for mask detection and counting…………………….……..23

1.0 Introduction/Background

The problem that the ROBOTEX company has chosen to deal with is expanded and a careful study into relatively existing solutions are presented in this section. The background surrounding the problem is given in order to further understand the alternatives that the team has come up with in the later sections of this report. The scope of the project along with the design's constraints and criteria are listed below.

1.1 Problem Description

COVID-19 is a respiratory disease that is caused by the SARS-CoV2 virus (Huang et. al, 2019). It provides flu-like symptoms to those who have it, such as having a cough, sneeze, or fever (CDC, 2020a). The main form of transmission is through respiratory particles in the form of droplets that can be released from an infected person if they talk, sneeze, or coughs (CDC, 2020b). While most tend to recover relatively well, there are still many things unknown about the virus. As the months pass, more information regarding the long term effect of COVID are becoming known. Many people report being unable to fully recover to their pre-COVID health, and in a study it was found that almost 20% of young adults who had COVID experienced prolonged symptoms such as chest pain and loss of senses like taste and smell (WHO, 2020b). In addition, as the cases rise, so do the hospitalization rates. Hospitals are often struggling to have available beds, and with a shortage of doctors and nurses, it can take days for those who have COVID or need medical care to be addressed (Abelson, 2020).

Within the last year, this disease has sent countries into a harsh lockdown, where everyone who could work from home doing so (Financial Times, 2021). However, the exception of this was for essential workers, who remained working in order to maintain the key aspects society needed to function. These included those working in lower wage areas, such as grocery stores, fast food, and more (Government of Canada, 2021). With essential workers continuing to work and interact with customers on a daily basis, this places them at a higher risk of contracting the disease. In fact, even as the months went by and screening technology became implemented, those who worked with direct customer exposure were five times more likely tobecome infected (Lan et. al, 2020). This poses a risk not just to employees, but also to the large traffic of customers they interact with daily from a health and safety perspective. Considering that in the US, 50% of these workers are unable to receive paid sick leave, along with the fact that unemployment rates have doubled since quarantine started, there are many who would still feel pressured to show up to their job even if they feel ill or anxious about the pandemic (BLS, 2018; Statistics Canada, 2020; Bhattarai, 2020). Certain protocols were recommended by the government to increase health safety, such as wearing a mask when leaving the house, as it has proven to be an effective control measure (Greenhalgh et al., 2020). While in Asian countries, such methods have been in place for years, and thus were easy to implement, other countries such as Canada and America faced difficulty adjusting to those new norms (Wong, 2020). Even then, there still poses a need to be able to develop a system that would allow customers and employees to enjoy a more safer shopping space and reduce the spread of COVID-19.

For large retail stores like Walmart, there are rules in place saying that face masks are required for entry- however, there have been contradictions to that as well. Employees have reported that though stores say this, there is no way to enforce it. Out of concern for their staff safety, stores have told employees that they should not refuse entry, or even confront a customer who comes in maskless as some become violent and hostile upon confrontation (Corkery, 2020; Meyersohn 2020; Azpiri, 2021). With around 4% of customers refusing to wear a mask, or wearing them ineffectively, concerns are raised about the efficiency of their policies, since it still exposes those inside to a higher level of risk (Haischer et al., 2020). In addition, for stores like Walmart, there is no system set up that would account for those who do have COVID from coming into the store, should they be wearing a face mask or not (Walmart, 2020). Some of the social impacts that play into the problem are that employees are experiencing an increase of anxiety and depression due to the high exposure that they’re forced to endure for their job (De Boni, 2020). It can also be linked to the high amounts of aggression and violence since the pandemic came, especially if they’re a minority (Statistics Canada, 2020). There have been a surge in xenophobic attacks towards Asians, with almost 30% of people in a survey exclaiming that they have experienced discrimination of some form since COVID came to America, with some being extremely violent (Washington State University, 2020; Yancey-Bragg, 2021). Anxieties extend to the customer as well, around 60% of people in the US have said that since the virus hit they have felt anxious going into a grocery store (C+R, 2020).

The economic impacts of COVID can be huge, especially considering pre existing losses that were experienced last March. From Statistics Canada, the following month saw a staggering amount of 110 thousand businesses closing and almost 2 million people becoming unemployed (Statistic Canada, 2021). On a global scale the amount of jobs lost exceeded the 2008 financial crisis- nearly 255 million people lost their jobs and $3.7 trillion US dollars of income was lost (International Labour Organization, 2021). Restaurants and stores in particular are struggling to find ways to adapt to the fluctuating government regulations and earn some revenue to pay off the debt that has incurred throughout the past few months. Even with government funding money, this amount isn't enough to cover for all those debts (Lourenco, 2020). Adding on, should a potential employee test positive, the Public Health Agency of Canada advises a thorough disinfection process of the store to ensure that potential transmission is minimalized (Region of Peel, n.d.). Doing so can mean closing the store for a day- which loses a day's worth of revenue. This only causes further damage for smaller, local stores who already are struggling, or for low wage employees who were already more impacted from the economic crash that COVID caused than other employees (Statistics Canada, 2020).

While there are little to no environmental impacts on this issue of regulating COVID precautions for stores, there have been growing concerns regarding the usage of masks as a result of COVID. Due to the nature of the problem, it is unsafe to reuse single use masks . Thus, many are disposed of after use, and this has created a growing concern in terms of waste. Masks are often equipped with 3 layers for optimal efficiency (Bahl et. al, 2020), however the materials used are harmful to the environment. Categorized as infectious waste, the non-biodegradable material has started to pollute oceans along with other COVID equipment such as gloves and hand sanitizer bottles (Kassam, 2020). Considering Asia alone goes through almost 17 thousand tons of medical waste per day, these masks can pose huge problems in coming future years (Sangkham, 2020).

1.2 Background Information and Literature Review

The COVID-19 outbreak placed the world into a global pandemic following the discovery of a zoonotic pneumonia virus in an elderly man in Wuhan, China. Further testing of COVID-19 (otherwise known as SARS-CoV-2) revealed it to be a highly contagious beta-coronavirus that is similar to SARS (SARS-CoV). There are 4 types of coronaviruses: alpha, beta, gamma and delta. Beta-coronaviruses are transmitted primarily through mammals, with COVID-19 originating from bats, and are considered to be more dangerous in terms of severity and fatality (Mousavizadeh & Ghasemi, 2020). To understand the virality of this virus, it is important to understand the structure of coronaviruses. Coronaviruses are single-stranded RNA viruses and contain the largest genomes in comparison to other RNA viruses. It is enclosed by nucleocapsid proteins, spike proteins, a membrane and an envelope. The spike protein in particular plays an important role in interacting with cells and the neutralization of antibodies. Once the spike protein attaches to the ACE2 protein receptor of a host, it is able to unload its viral RNA into the cell (Cevik et al., 2020). Current research is working to block the spike protein's attachment to ACE2.

Elderly, immunocompromised individuals and smokers are shown to be most affected by the virus and experience the highest mortality, whereas the majority of individuals can experience fewer symptoms, and even be asymptomatic. COVID-19 has a very high viral load and is shown to be most active in the nasopharynx -located behind the nasal cavity- and sputum-located by the mucosal glands- for at least 7 days, which allows transmission to occur through droplets released from the nasal cavity and throat. However, after the 8th day, although coronavirus RNA was still present in these areas, the virus was no longer live/infectious. Coronavirus RNA was also discovered in the stool of patients a month after transmission but was uninfectious as well (Mousavizadeh & Ghasemi, 2020). Due to the high transmission, infectivity and severity of COVID-19, appropriate measures such as wearing masks must be practiced in order to decrease transmission rates until it is eradicated.

With many forms of PPE being implemented into stores, such as mandating facial masks, sanitizing hands, and social distancing, those factors alone are difficult to facilitate especially to stores that receive heavy forms of traffic everyday. It becomes difficult to regulate what counts as an “effective” face mask since many people may wear them incorrectly, rendering the PPE useless (Haischer et al., 2020). In addition to that, there is a large percentage of people who fail to follow WHO’s recommendations for appropriate mask measures (Machida et al., 2020)

Various forms of technology have been developed to try and find more effective ways of identifying proper PPE or COVID symptoms. Some companies have looked more into models that integrate deep learning to help identify if people are wearing their masks properly. By using a set of images of masks being worn and not worn as a reference, the model is able to train itself to recognize new images with about 99% accuracy (Loey et. al, 2020). Other companies have been looking into developing methods through thermal cameras too, and while they do provide accurate results for surface temperature, the accuracy decreases when used for large groups, so finding new ways to design this is currently under development (FDA, 2021). There are also methods of looking into crowd control, in order to comply with government regulations and promote a more safe environment. For companies focusing on this aspect, such as Footfall Cam, an electronic counter is used along with screens that display the occupancy in the stores. If full capacity is exceeded, a staff member is alerted. An application is also used to show customers current occupancy and predicted wait times(FootfallCam, 2021). While this tool is effective, it fails to account for other aspects such as PPE usage or temperature that may allow those at risk to slip by undetected.

A company who has offered a potential solution to said aspect is Category 5, a Canadian business that has developed an effective screening technology that monitors temperature, proper mask usage, and more. This is done through the usage of a thermographic camera that can detect temperatures with a high accuracy, within 1-2 seconds. The pros of this technology is that it also allows group scanning, making it faster to allow entry way into and out of the store. Should a high temperature be detected, it will notify employees (Category 5, n.d.). In addition to that, another company called PredictMedix has implemented a similar screening technology. It also keeps an eye out for other COVID-like symptoms, such as coughing or a heavy breathing rate, while only requiring a bandwidth of 25 Mbps to operate (Predict Medix, n.d.) . However, the problem with these existing designs is that, unlike Footfall Cam, there are no ways of controlling whether the infected individual is allowed to enter the store or not. These current designs say that they leave it up to the business owner to determine what will happen when they are notified, and say that an employee can approach the customer and politely ask them to leave. This means direct exposure, and since they were alerted in the first place the customer has a high chance of COVID or there is a large crowd. This provides a high chance for the employee to contract the virus too.

Thus, in order to ensure that customers are wearing their masks properly, and that they are screened for COVID in a non-contact like manner, some sort of system would need to be implemented that is purely technological and autonomous. This prevents employees from being directly exposed to customers, and also allows for a safer and friendlier approach to confront those who are wearing their masks improperly. Doing so can reduce anxious feelings within employees, as well as other customers. The store can also continue operations smoothly, and these features can be used as a selling point to attract customers due to the increased level of safety provided that other stores lack. In addition, finding a method to analyze other symptoms of COVID can be another design aspect to prevent those who have it from entering the store and potentially spreading the disease even more.

1.3 Scope of Project

The problem dealt with in this project, in short, is to reduce the spread of COVID-19 in public frequented places like retail stores and grocery shops by maintaining public health measures and restrictions that are being enforced. The project aims to ensure that the checking of temperature, mask, and the number of people in a store is done effectively and efficiently without a front-line worker being exposed to all the customers entering the store. Working on this aim, this project's scope is to create an engineering solution that would help store owners operate in a safer environment and provide a sense of security to the customers by verifying that the protocol for entering the store is followed. The solution's design and specifications must be finalized before and submitted on the 2nd of April 2021. The design will include a control system with sensors that measure temperature, detect a mask, and update the count. In the case of the count reaching the allowed maximum capacity, a mechanism would create a barrier to prevent from entering.

Along with this, including a sanitization station for customers when entering would prove to be beneficial and will maintain hygiene. The design engineers at ROBOTEX aspire to optimize this process, keeping in mind the government and community safety regulations. Another main focus to apprise shoppers would be identifying a way to incorporate useful information such as the number of people currently in the store displayed on an electronic display board/screen and an app that the public can access.

There are many cases where temperature screening to detect coronavirus disease has proven ineffective as infected individuals can also either be asymptomatic or in incubation period (W.H.O., 2020). In this case it lies outside the scope of this project. Additionally, this project does not extend to ensure that people within the store are wearing their masks the entire time as it depends on the type of cameras being used within the store, angle and range of detection, and access to data. Ultimately, this project's main scope is to create a system that is automated which can be used at the entrance of stores in place of a front-line worker to reduce the risk of COVID-19 transmission.

1.4 Constraints and Criteria

The selected constraints and criteria are dedicated to protecting front-line workers, the environment, and everyone in the community. To make the device highly accessible, the team promotes the device by making it safe, accurate, and cost-effective. ***Tables 1*** and ***2*** below demonstrate the constraints and criteria of the design solution set to design a successful device that helps with the detection of COVID-19. The team also had to make certain assumptions in order to ensure a successful and effective design solution.

Table 1. Constraints of the Design Solution

#	Constraint	Explanation
1	The materials used to construct the design solution must be eco-friendly.	This helps promote the device as the design solution ensures to keep the environment safe regardless of the location.
2	The design solution must be safe and easy to use.	This helps promote the device as the design solution will require less training and will therefore be more widely used.
3	The design solution must serve as an effective alternative compared to pre-existing measures.	This implies that the device will have an outstanding face covering detection and temperature measure performance in order to compete with other alternatives in the market.
4	The design solution must serve as a worry-free alternative.	The ability to function efficiently in order to perform the tasks that front-line workers have to accomplish. This will remove the burdens that some have to carry and therefore improves the overall mental health.
5	The device must be able to use face detection.	This ensures that public health measures and restrictions are followed by everyone entering the public space.
6	The design solution must be able to count the number of people	This ensures that the maximum capacity of the store is maintained.

	entering and leaving the store.	

Table 2. Criteria of the Design Solution

#	Criteria	Explanation
1	**Minimize cost of the design.**	If the cost is unreasonable, the device will not be able to be implemented or may not be widely used regardless of its effectiveness.
2	**Maximize accuracy of mask detector.**	This ensures that the device is accessible to various stores and clinics since it is easier to carry and move around.
3	**Maximize the temperature measurement accuracy.**	This ensures that the design solution protects the front-line workers by being an effective alternative.
4	**Minimize the complexity of the assembly of the design product.**	In order to achieve satisfying results, the thermometer would need to be used correctly in order for them to be as accurate as oral and rectal thermometers.
5	**Minimize the number of components**	Complex designs are more expensive and require high maintenance.
6	**Maximize accuracy of the counter.**	False data is a concern to the government, the health professionals and everyone in the community.
7	**Maximize accessibility of the device.**	The design should allow for fast detection or multiple detections at once to allow for a smooth process and prevent any delays.

2.0 Conceptual Designs and Evaluations

The following section provides the design process in which ideas for the solution of the given problem were generated . A detailed account for each of the design solutions with their advantages and drawbacks are described. The alternatives are also evaluated based on each criteria which were determined earlier in order to choose the optimal solution.

2.1 Design Process

When solving a complex problem, the design process is highly essential in designing an achievable solution. The design process consists of a sequence of steps that must be pursued to establish an efficient result. The main steps in the design process involve defining the problem, gathering information, determining the contains and criteria, developing possible solutions and creating a decision matrix to facilitate ranking the possible solutions and choose the best solution, and finally communicating the results (Atman et al., 1999).

Defining the problem is the first and the most crucial steps in the design process. The particular problem existed as a result of the recent pandemic of COVID-19, as the front-line workers are assigned at the entrance of the stores to check if customers are following the restrictions and measures taken to prevent the transmission of the disease including wearing a mask, regular temperature check and making sure that the allowed number of customer are in the store. Thus, the situation puts the workers at a higher risk of exposure to the disease. The proposed solution is to design an efficient, accurate, and cost-effective automated device that performs all tasks done by the workers to eliminate the risk which yields to the stated constraints and criteria to solve the identified problem. Research shows that the previous solutions by Category 5 (Category 5, n.d.) and Predict Medix7 (Predict Medix, n.d.) does not detect if the customer is wearing a mask, restrict the entrance of customers who are detected for symptoms, and does not have a mobile application that displays the live capacity of the stores to minimize the waiting time of the customer outside the store. Moreover, Footfall Cam has implemented an electronic counter that is used with screens that display the occupancy in the stores. A staff member is altered when the full capacity is exceeded. A mobile application is used along with the electric counter to show customers the current occupancy and predicted wait times (FootfallCam, 2021). That being said, the tool fails to account for other aspects of the COVID measures such as Mask and temperature detection. With the Research conducted, the team was able to complete the third step of the design process and finalize the constraints and criteria. Taking on board the constraints and criteria while developing design solutions, distinct designs were developed that may lead to an achievable solution. During the brainstorming meetings throughout the period from the proposal to last week's lab with the group, different solutions were developed. Each member of the team contributed to the different steps of the design solutions by improving the main idea of the solution and giving opinions and feedback to the other ideas. The topmost three design alternatives were selected at the end of the brainstorming session in fulfilment of the criteria and the feedback from each group member. The following step is to develop decision matrices and perform sensitivity analysis on the proposed design solutions to support in the evaluation of the design alternatives. Multiple trials of improvements and re-evaluating the design will be constantly conducted as part of the design process which will lead to a feasible solution.

To ensure safety, the product needs to be approved by Health Canada under COVID-19 medical devices (Canada, 2021).

2.2 Conceptual Design Alternatives

2.2.1 Design 1 - Mobile Application

The broad scheme of the design solution is to integrate a mobile application that performs: face mask detection, temperature measure, and live capacity representation for the stores. First, customers are required to answer questions regarding COVID-19 public measures that will be prompted by a survey through the mobile application. Second, customers are required to scan their profiles for the face mask detection to be sent to the ROBOTEX server on the cloud to process the image and send back a boolean value representing the validity of the face mask coverage. A QR code will be generated if a positive feedback is returned from both assessments. The QR code is then to be scanned by the QR barcode scanning device at the store's entrance door. The counter is incremented each time the QR code is scanned to ensure the maximum capacity is not being violated. Overall, this design solution will function in a way similar to that illustrated by the sketch in **Appendix B**.

One of the advantages for this design is the use of free open source components which makes it a cost-effective alternative. Moreover, the complexity of the design is easy to assemble and accessible to a relatively large number of demographics. This promotes the device to be widely used by a variety of clients due to the simplicity of its implementation (Rafi, 2018). The design solution poses a face mask detection feature that is highly accurate, which possesses a major role in the detection and collection of COVID-19 data.

As mentioned before, a survey is being used as an alternative temperature measuring method due to the lack of hardware components that are capable of measuring the temperature on smartphones today, which results in a low accuracy for the temperature detection criteria. According to a research done by Brock University, only 257 out of 451 participants were honest about their COVID-19 symptoms and social distancing when being asked (Brock University, 2021). In addition, despite smartphones and internet access being available to most of the population, a fraction of the community that is worth to be taken into account might have limited access due to the lack of these tools (Government of Canada, 2018).

2.2.2 Design 2 - Existing Surveillance Camera

This design incorporates the use of existing closed-circuit television (CCTV) or Internet Protocol (IP) cameras of a store for mask detection and for counting the number of people. The real time feed received by the surveillance cameras at the store's entrance would be run through a software that would assess the data for masks and for the number of people entering or exiting the store. This software system would comprise of a neural network- Single Shot Multibox Detector (SSD) for object detection (face) and another neural network for a binary output classification (no mask- 0 and mask- 1) (Tryolabs, 2020). The same software would also include an object tracking algorithm which in combination with object detection can output the number of people entering or exiting the store (Rosebrock, 2020). For the measuring of body temperature, a separate thermal imaging camera would be placed at the entrance of the store. In the case of either no mask or temperature greater than the normal body temperature the store would be alerted of that particular person(s) upon which security workers may isolate these individuals for further action. In the event of the store reaching its allowed maximum capacity, the entrance doors can be monitored or even closed until the number starts to decrease again. A block diagram of how the CCTV/IP cameras would be used for counting and mask detection can be seen in ***Figure 1*** below.

The advantages to this design include the reduced cost of the design as it makes use of the existing surveillance cameras used by shop owners. The only major expense would be the thermal camera which comes to around $2,800 and with an accuracy ±0.3°C (Brick House Security, n.d.). The setting up of this design is comparatively simple as there would be only an installation of a thermal camera and the uploading of a software to a system that's connected to the surveillance cameras. Another benefit of this design is the rate of the screening process would be quicker as customers would only need to pass through the field of the cameras at the entrance/exit. For instance the thermal camera can measure upto 30 people at the same time and has a field range of 10 feet(Brick House Security, n.d.).

A major drawback for this design is that in the case of a store without an automatic entrance door, a worker must be assigned to monitor the door when the maximum capacity has been reached or when an individual is identified to have a temperature or no mask, the worker must isolate them from the store. This puts the worker's health in risk due to such exposure. Other drawbacks include that this design is for only stores that have been using CCTV/IP cameras at their entrances, and that the resolution and the visual field of the surveillance camera may vary from store to store. The resolution and field of the camera are important factors that contribute to the accuracy for counting and mask detection(Rosebrock, 2020).

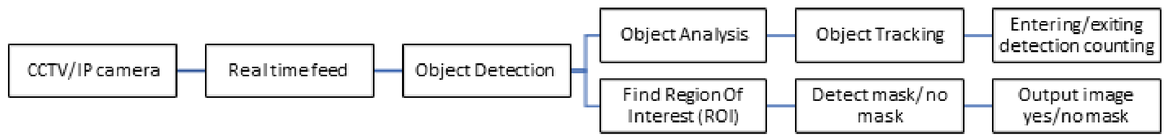


Figure 1. Using CCTV/IP camera for mask detection and counting

2.2.3 Design 3 - Automated COVID Screening Station

This design involves creating a physical device that clients can install outside of entry points. Using both a thermal and a CCTV camera, real-time detection can occur for customers. The CCTV camera is used to detect face masks and the thermal camera to measure the body temperature. Both cameras are using the AI network system, which increases their accuracy. Each camera has its own function, but the team planned on holding them together to reduce the assembly complexity. This design's thermal camera has very high accuracy, as high as ±0.3°C (BrickHouse Security, n.d.). This design aims for customers to approach the barrier and undergo a temperature check along with a mask check similar to the methods discussed in the design proposal above. Should the customer have their mask on properly and temperatures within normal ranges, the barrier will open and allow people to enter the store. However, should one of those aspects fail, a help button on the design can be called to allow them to communicate to an employee to resolve any confusion or misunderstanding. Another significant part of this device is the sensor used to count people entering and exiting the buildings or stores fixed to the ceiling (Stogdale, 2018). A screen at the front of the store or design can display the current building occupancy or potential waiting times should the store be full.

Some advantages to this design are that it provides an autonomous method for customers to be screened and that there is no need for an employee to remain near the entrance. Also, it can be implemented anywhere. There is no need to have automatic doors, nor is there a need for stores to integrate their current technology with the design. For side-by-side doors, the design can also be placed side by side with a wall of plexiglass in between. The technology is accessible to many and does not make customers go out of their way. The screen data can be expanded on too by using said data on websites or apps to allow those who want to see the estimated wait time- thus reducing crowding.

One disadvantage of the design is that it is more pricey due to the technology and size. Compared to the other alternatives, it is more difficult to ship and transport. The design also must consider various environmental factors such as lighting, weather, and wind conditions and ensure that it would still function even during said conditions. Environmental effects are larger due to the materials used. Lastly, the screening rate is low relative to design 2, and for stores with a large flow of traffic, this may delay the process and potentially inconvenience customers.

2.3 Design Evaluation

The design alternatives are evaluated on the basis of criteria and the optimal design is chosen through the implementation of decision matrix and sensitivity analysis. Using a decision matrix can help in making a complex decision in choosing a design solution and also may provide proof to defend the suggested design solution. The three alternatives which were discussed earlier are compared and evaluated in this section.

2.3.1 Design Matrix

Table 3. Design 1 Decision Matrix

#	Criteria	Ranking Weight (%)	Score (1-10)	Weighted Score (Score x Ranking Weight)	Explanation
1	**Minimize cost of the design.**	15	8	1.20	This design solution is made of components that are free open sources which highly optimize the price of the solution. In addition, the access control system is considered highly affordable in comparison to the client's financial abilities. However, the cost of the component responsible for the QR scanning with a relatively high performance approximately ranges between $350 and $600.
2	**Maximize accuracy of mask detector.**	18	8	1.44	Convolutional Neural Network (CNN), a deep learning algorithm, was used to implement the mask detection for the presented solution which resulted in a 98% accuracy.
3	**Maximize the temperature measurement accuracy.**	20	1	0.2	For the proposed design neither a thermometer nor a thermal camera is being used to measure the temperature of the customers. A survey is used as part of the proposed design to take the precautions and ask relative questions in regards to the COVID measures. The recommended component of the design solution relies

					heavily on the honesty of the customers which according to the research, only 57% of people were honest when answering COVID-19 surveys (Brock University, 2021).
4	**Minimize the complexity of the assembly of the design product.**	6.5	3	0.195	For the suggested solution, all components that make up the design solution are internally connected to control the door, transfer and update the data for the customers which implies that a professional installation is required for the assembly of the solution on the client's sites.
5	**Minimize the number of components**	6.5	8	0.52	The design solution consists of three main components: a mobile phone, a QR door access control, and sensors to help with the counter functionality of the design.
6	**Maximize accuracy of the counter.**	19	8	1.52	The design solution uses a QR scanner device that is connected to a database which will be incremented and decremented accordingly (codeREADr, n.d.). The mobile application and the database update time will have some lag which will cause an inaccuracy
7	**Maximize accessibility of the device.**	15	8	1.2	A smartphone and an internet connection is required by the customer for the face mask detection and to fill the survey. That being said the other components of the design are

					highly accessible for the customers as they will be embedded in the client's sites. However, the lack of a smartphone with an internet connection will limit the accessibility of the customer to the store (Government of Canada, 2018).
Total:				**6.275**	

Table 4. Design 2 Decision Matrix

#	Criteria	Ranking Weight (%)	Score (1-10)	Weighted Score (Score x Ranking Weight)	Explanation
1	**Minimize cost of the design.**	15	3	0.45	The design mainly relies on the CCTV/IP cameras that are used currently at the store. The only other main component to be purchased would be a wall mounted thermal image body temperature camera. The price of such a product can be approximated to around $2,800.(Brick House Security, n.d.)
2	**Maximize accuracy of mask detector.**	18	7	1.26	The mask detection software which is incorporated in this design uses an AI network and through implementation the accuracy was found to be 97%. (App Store, n.d.)

3	**Maximize the accuracy of the thermometer.**	20	9	1.8	This design alternative consists of a separate thermal body temperature camera where it uses an AI thermal imaging technology to perform with a high accuracy of ±0.3℃ upto a range of 10 feet.(Brick House Security, n.d.)
4	**Minimize the complexity of the assembly of the design product.**	6.5	4	0.26	The only component that requires installation would be the thermal camera at the entrance of the store as one of the assumptions of this proposed solution includes CCTV/IP cameras that are already in use at the store's entrance and exit doors. Also, uploading the software onto the connected computer system to incorporate the required codes for mask detection and counting may not require a professional to set it up.
5	**Minimize the number of components**	6.5	6	0.455	This design solution comprises main components such as thermal camera to measure the body temperature, CCTV/IP cameras, and a connected computer monitoring system to operate.
6	**Maximize accuracy of the counter.**	19	8	1.52	Assuming that the visual field of the camera completely covers both the entrance and exit doors, high accuracy of the number of people currently in the store is achieved through a proper balance between object

					tracking, detection and recognition.
7	**Maximize accessibility of the device.**	15	8	1.2	Inclusive of all customers as there are no additional requirements needed from them. However this design alternative restricts to stores that are already using CCTV/IP cameras at the entrance and exit doors.
Total:				**6.945**	

Table 5. Design 3 Decision Matrix

#	Criteria	Ranking Weight (%)	Score (1-10)	Weighted Score (Score x Ranking Weight)	Explanation
1	**Minimize cost of the design.**	15	2	0.3	The design solution consists of thermal and CCTV cameras, which are very accurate and fast, making them expensive. Moreover, this design has multiple functions (detect high temperature, face mask detection, automated hand sanitizer, controlling the doors, and displaying the numbers of people in the building).
2	**Maximize accuracy of mask detector.**	18	7	1.26	The software used in this design solution has a high accuracy since it utilized the AI network. By running the code, the accuracy of detecting the mask was found to be 97%.

3	**Maximize the accuracy of the thermometer.**	20	9	1.8	This design uses the most accurate thermal camera to measure people's body temperatures.This camera uses the AI network which increases its accuracy to ±0.3℃ and enables the camera to take temperature measurements for larger groups of people.
4	**Minimize the complexity of the assembly of the design product.**	6.5	9	0.59	Although this design solution has multiple components that work separately, it is designed to reduce the size and make it easy to assemble; therefore, the CCTV and the thermal cameras will be held together with the automated hand sanitizer and the door controller. All that will decrease the design assembly complexity.
5	**Minimize the number of components**	6.5	7	0.46	The main parts of this design are put together, such as the two cameras, to minimize the number of the components and reduce the size and decrease assembly complexity, making them one component.
6	**Maximize accuracy of the counter.**	19	9	1.71	This design uses a very accurate and most advanced technology in the people counting market, The Time of Flight people counting technology. This technology uses a fixed sensor to the ceiling in a small and very simple device to achieve more depth of people's vision and movement than any other counting systems such as the thermal

					methods. The sensor sends a signal out above the area to be measured then the small device will record the reflection of infrared, which bounces back to the sensor. This makes the accuracy of this design alternative very high.
7	**Maximize accessibility of the device.**	15	10	1.5	The accessibility of this design is very high as it stands alone, which means that any buildings, institutions, or stores can buy one and use it without any restrictions because all its components, such as CCTV camera, thermal camera, and door controller, are available in this design. Also, it is highly accessible by the public since it will be programmed to utilize all the checking processes without any affords from customers.
Total:				**7.62**	

2.3.2 Sensitivity Analysis

Three weighting schemes were created based on the three stakeholders identified as: the ROBOTEX team, retailers and customers priorities. A sensitivity analysis in which the weight factors were altered to help in determining the best alternative solution. ***Tables 6***, **7** and ***8*** demonstrate the results of changing the ranking weight according to the stakeholder needs. The blue highlighted cells represented an increase in the weighting and the cells highlighted in red indicate a decrease in the weighted score of that feature. The weighted score of each design alternative was calculated using the scores in section 2.3.1 With respect to the ROBOTEX team, maximizing the accuracy of the three main individual components that are responsible for: Mask detection, Temperature measure and counting the number of customers in the store have the most priorities. These criterias received a weighting of 18%, 20% and 19% respectively. The optimal alternative design based on the ROBOTEX team is the automated COVID screening station which received a total score of 7.62 points.

Table 6. Sensitivity analysis ranking according to ROBOTEX

#	Criteria	Ranking Weight (%)	Weighted Score 1^{st} Design	Weighted Score 2^{nd} Design	Weighted Score 3^{rd} Design
1	**Minimize cost of the design.**	15	1.20	0.45	0.3
2	**Maximize accuracy of mask detector.**	18	1.44	1.26	1.26
3	**Maximize the accuracy of the thermometer.**	20	0.2	1.8	1.8
4	**Minimize the complexity of the assembly of the design product.**	6.5	0.195	0.26	0.59
5	**Minimize the number of components**	6.5	0.52	0.455	0.46

6	**Maximize accuracy of the counter.**	19	1.52	1.52	1.71
7	**Maximize accessibility of the device.**	15	1.2	1.2	1.5
Total:			6.275	6.945	7.62

Retailers prioritize the criteria that minimizes the overall cost and maximize the accuracy of the design alternative, delivering a solution that is more accurate and cost effective than the existing solutions that are in the market. The weight of these criteria increased by 5% from 15% and 15% to 18% and 17% respectively. Moreover, Criteria such as the complexity of the assembly and the number of components of the device are not very important to the retailer as the accuracy and the cost since the assembly can be done by the ROBOTEX team as long as it is easy to be used by the customers which is the accessibility criteria that is important to the retailers. The weights of these criteria were decreased by 5% from 6.5% and 6.5% to 4 % and 4% respectively. The ideal design alternative in favour of retailers is the automated COVID screening station.

Table 7. Sensitivity analysis ranking according to Retailers

#	Criteria	Ranking Weight (%)	Weighted Score 1^{st} Design	Weighted Score 2^{nd} Design	Weighted Score 3^{rd} Design
1	**Minimize cost of the design.**	18	1.44	0.54	0.36

2	**Maximize accuracy of mask detector.**	18	1.44	1.26	1.26
3	**Maximize the accuracy of the thermometer.**	20	0.2	1.8	1.8
4	**Minimize the complexity of the assembly of the design product.**	4	0.12	0.16	0.36
5	**Minimize the number of components**	4	0.32	0.24	0.28
6	**Maximize accuracy of the counter.**	19	1.52	1.52	1.71
7	**Maximize accessibility of the device.**	17	1.36	1.36	1.7
Total:			6.4	6.88	7.47

Customers prioritize the criteria that maximizes the accessibility of the device and provide high accuracy measurements as they would like to produce the least effort to visit a store safely and comfortably. The weight of these criteria increased by 5.5% from 6.5% and 15% to 7% and 20% respectively. Since the main important criteria for the customer is the high accessibility and performance, therefore criteria like the complexity of the assembly and the overall cost of the device are not important to them. The weights of these criteria were decreased by 5.5% from 15% and 6.5% to 13 % and 3% respectively. The ideal design alternative in favour of the customers is the automated COVID screening station.

Table 8. Sensitivity analysis ranking according to Customers

#	Criteria	Ranking Weight (%)	Weighted Score 1^{st} Design	Weighted Score 2^{nd} Design	Weighted Score 3^{rd} Design
1	**Minimize cost of the design.**	13	1.04	0.39	0.26
2	**Maximize accuracy of mask detector.**	18	1.44	1.26	1.26
3	**Maximize the accuracy of the thermometer.**	20	0.2	1.8	1.8
4	**Minimize the complexity of the assembly of the design product.**	3	0.09	0.12	0.27

5	**Minimize the number of components**	7	0.56	0.42	0.49
6	**Maximize accuracy of the counter.**	19	1.52	1.52	1.71
7	**Maximize accessibility of the device.**	20	1.6	1.6	2.0
Total:			6.45	7.11	7.79

2.4 Proposed Preliminary Design

An overview sketch of the automated COVID-19 screening sctation can be observed in **Appendix B**. The design comprises an automated regulation of customers that enter the store, a device that would measure temperature and detect a mask accurately and another device placed at the entrance/exit doors for counting the number of people that enter or exit. From the design evaluation it can be clearly noted that this design alternative scored the total highest in regards to the listed criteria with their respective weightages. One of the main advantages of having an automated barrier system is that there would be no need of a worker to be placed at the entrance for monitoring or no need for stores to have only automatic entrance doors. Due to this, the proposed design solution can be applied to a store with any type of doors and the workers need not risk their's and the customer's health by being exposed to all the customers that enter. The store owners would only need to invest once in this system and thereby cut the costs of hiring more workers. In addition to the listed advantages of this design, having a device that uses time of flight technology for the counting of people entering and exiting the store is a strong asset. It is conveniently small, highly accurate and does not require either a proper plane of field like in the surveillance camera design solution nor does it require the customer to scan their QR code back when they exit which may prove to be a nuisance with the bags that they would be carrying on their way out. Furthermore, the data gathered from this design can easily be made available and made of use, such as the current number of people in a particular store and the estimated waiting period in the case of a busy shopping time. This data can be accessed through an app created by ROBOTEX, where it would display the count and the waiting period of a particular store that uses this system. Customers would find this beneficial as they can prepare and plan ahead for their convenient time of shopping. As all the stakeholders of this system benefit and as this design scored well out of the others in the evaluation, this design alternative proves to be the optimal solution for the proposed problem.

3.0 Updated Work Plan and Resources

The team members of ROBOTEX aim to accomplish the ultimate goal for the project. Therefore, a Gantt Chart, a reference table with the critical deadlines and a chart that outlines the project deliverables and fee estimate were constructed to outline the tasks that the team members had to accomplish. The team continues to update the work plan tools accordingly to ensure that everyone is on track.

3.1 UPDATED TASKS AND TIMELINES

The design team at ROBOTEX is aware that working with others consists of solving unexpected challenges and learning from mistakes along the way. This is why it was crucial that the team conducted coordination meetings before the start and after the completion of every task to discuss and reflect on all the unanticipated challenges that have occurred during the working process. One of the major challenges that has been identified was handling conflicts, which resulted in making the design process slower than expected at times. Since each member had their own daily tasks outside of the project, coordinating the meetings was made more difficult and at times cancelling or moving the meetings was the only solution. Therefore, the team decided to approach planning their meetings in a different way. For instance, instead of requiring everyone to be present in every single meeting coordinated, smaller meetings were conducted in between major meetings where only 2-3 members of the team attended. In order to ensure attendees managed to efficiently accomplish the tasks without the presence of the other members, the tasks were divided in a way so that they can work independently. However, to keep everyone on the team updated, the team members made sure to briefly explain what they have discussed in the major meetings by the end of every week. This gives all design members a chance to provide feedback as well as different alternatives.

Management tools were used to help the design team better plan and discuss such crucial decisions. ***Table 9*** below demonstrates how long each task should take as well as in which order they should be completed. As shown in **Appendix C**, an updated Gantt chart that clearly outlines the subtasks of each milestone has also been constructed to support and improve the project management.

Table 9. Critical Deadlines

#	Assessment	Start Date	Due Date
1	**Design Process**	18/01/2021	12/04/2021
2	**Team and Project Selection**	22/01/2021	24/01/2021
3	**Design Proposal**	24/01/2021	5/02/2021
4	**Interim Design Report**	5/02/2021	26/02/2021
5	**Technical Memo**	26/02/2021	12/03/2021
6	**Design Presentation**	12/03/2021	19/03/2021
7	**Final Design Report**	26/03/2021	02/04/2021

3.2 Key Milestones and Deliverables

The total project time frame is 12 weeks, with 6 key milestones to be finished and submitted by the due dates listed in ***Table 9*** above. ***Table 10*** below shows an estimation of the required time to complete the six deliverables. The team has successfully accomplished some of the deliverables on the assigned dates and will submit the rest within the scheduled time frame.

Table 10. Key Milestones and Deliverables

#	Deliverables	Key Milestones
		Working time per weeks
1	**Team and Project Selection**	**1**
	Start the process, form a group, and plan ideas.	
2	**Design proposal**	**2**
	Identify the problem, brainstorm to find a solution, estimate timeline, and fees.	
3	**Interim Design Report**	**2**
	Highlight the details for different solutions and explain the design based on the constraints and criteria.	
4	**Technical Memo**	**3**
	Explain in depth the calculations, and show evidence of the safety and functionality of the design	
5	**Design Presentation**	**1**
	Present the designed solution to the problem.	

6	**Final Design Report**	3
	Report the designed solution to the problem.	
	Total	**12**

3.3 FEE ESTIMATE FOR DESIGN AND REQUIRED DELIVERABLES

The total estimated hours that the team will spend are expected to be around 384 hours. The hourly wage for each team member is found to be $40 per hour for a new engineer. Based on the estimated number of hours and the hourly wage, the total working and labour fees are estimated to be $15,360.

Table 11. Required Tools

#	Tool Name	Description	Fees
1	**SolidWorks**	Used for creating a 3D model of the product and its components (CAD MicroSolutions Inc).	Available at ROBOTEX
2	**EAGLE**	It is an electronic design automation(EDA) application software used to connect electrical schematic diagrams with printed circuit boards (EAGLE: PCB design and Electrical SCHEMATIC SOFTWARE).	Available at ROBOTEX
3	**React Native Platform**	It is a mobile application framework used to develop applications that are compatible for both Android and IOS mobile applications developed by Facebook (*React native*).	Available at ROBOTEX

4	**Integrated Development Environments, Code Editors, and Virtual Environments**	IDES, Code editors, and Virtual Environments will be used to create, edit, compile and execute codes as well as creating the mobile applications.	Available at ROBOTEX
5	**Google Drive**	It is a file storage and synchronization service developed by Google. Google drive and google documents are the major platform that is used by the team for formal writings and reports.	Available at ROBOTEX
6	**Cisco Webex**	Cisco Webex is a web and a video conferencing application. It will be used extensively throughout the term of the product development by the team for brainstorming and various sessions as needed.	Available at ROBOTEX
7	**WhatsApp**	WhatsApp is a cross-platform that allows users to send text messages, voice messages, video calls and share images, documents, user locations and other content. It is the main communication platform for formal and informal conversations between group members.	Available at ROBOTEX

Although the design solution has many advantages and can limit the separation of the virus among people, there are few challenges raised in the design process. First, the cost of the design is expected to be high based on the research done by the team members on the camera's prices since this design is using special thermal cameras that have high temperature measurements accuracy about ±0.3 C. This type of cameras can range between $2,500 to $30,000 depending on their features. The only way to reduce the cost is by doing extensive research in the camera's field and find something that is accurate with a reasonable price to end up with an affordable design by big and small businesses.

Another challenge moving into the next phase of the design process is that there are many components in this device which increase the area that this device takes and raise the complexity also it makes the assembly process harder and the team goal is to find out a way to minimize the components and make them one device to solve this issue.

The team is also concerned about the time work budget as the time each member spends on this project has been increased and expected to increase more to about 384 total hours at a rate of $40 per hour for each team member. The cost alone for the work time is estimated to be $15,360 in total which will make the device price high and not affordable by the small businesses. The team's plan is to improve the time management aspect and produce more work in less time. That can be done by foxing more on each team member strength and divide the work based on that aspect.

4.0 Conclusions and Recommendations

In conclusion, the team has decided on the third alternative design solution. This decision is based on the overall evaluation of the solution from the decision matrix, which scored higher than the other two alternatives. This design is not only very accurate in measuring temperature, detecting face masks and counting the number of people entering and exiting the buildings, but it is also highly accessible by the public and easy to use which makes it beat the other two alternatives. The only negative part of this proposed design is its high cost; however, the team is working on reducing the cost and ensuring the same quality will be delivered by reducing the time work and using lower cost equipment.

The next step in the design process is the technical memo report which is going to include the calculations, problem and safety analysis. The team is planning to conduct brainstorming sessions to prepare for this step and to introduce and identify any new essential tools for the required calculations.

5.0 References

Abelson, R. (2020, Nov, 27). Covid Overload: U.S. Hospitals Are Running Out of Beds for Patients. The New York Times. https://www.nytimes.com/2020/11/27/health/covid-hospitals-overload.html

Appsstore. (n.d.). Retrieved February 27, 2021, from https://www.appsstore.ai/app-details/face-mask/?utm_source=facemaskpagelht

Azpiri, J. (2021, Feb 10). Man allegedly punched restaurant staff, bit patron after refusing to wear a mask: Victoria police. Global News. https://globalnews.ca/news/7633249/victoria-arrest-mask-restaurant/

B. (Ed.). (n.d.). 30 person thermal Image body Temperature Camera. Retrieved February 26, 2021, from https://www.brickhousesecurity.com/security-cameras/30-person-thermal-image-body-temperature-camera/?utm_source=google&utm_medium=cpc&utm_campaign=shopping

Bahl, P., Bhattacharjee, S., De Silva, C., Chughtai, A., Doolan, C. & Machlntyre. (2020). Face coverings and mask to minimize droplet dispersion and aerosolisation: a video case study. Thirax, 75(11), 1024-1025. http://dx.doi.org/10.1136/thoraxjnl-2020-215748

Bhattarai, A. (2020, April 12). *'It feels like a war zone': As more of them die, grocery workers increasingly fear showing up at work.* The Washington Post. https://www.washingtonpost.com/business/2020/04/12/grocery-worker-fear-death-coronavirus/

BLS. (2018, March). *Employee Benefits Survey.* U.S. Bureau of Labour Statistics. https://www.bls.gov/ncs/ebs/benefits/2018/ownership/civilian/table32a.htm

Brock University. (2021, February 27). People with COVID-19 often lie about symptoms and distancing, says Brock research. https://brocku.ca/brock-news/2020/08/people-with-covid-19-lie-about-symptoms-distancing-more-than-non-infected-says-brock-research/

C+R. (2020). *Changes in Grocery Shopping Habits during COVID-19.* C+R Research. https://www.crresearch.com/coronavirus-shopping-habits

Category 5. (n.d). *Thermal Imaging Camera Integration .* Category 5 COVID-19 Solutions.https://www.category5.ca/thermal-covid-19

Canada, H. (2021, January 28). Government of Canada. Retrieved February 06, 2021, from https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/medical-devices/non-contact-infrared-thermometers.htm

CDC. (2020, Dec 22). *Symptoms of coronavirus*. Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html

CDC. (2020, Oct 28). *Ways COVID-19 Spreads*. Centers for Disease Control and

Prevention.
https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html

Cevik, M., Bambord, C. G. G. & Ho, A. (2020). COVID-19 pandemic-a focused review for clinicians. *Clinical Microbiology and Infection. 26*, 842-847. https://doi.org/10.1016/j.cmi.2020.04.023

codeREADr. n.d. The Smarter Barcode Scanner App. https://www.codereadr.com/

Corkery, M. (2020, July 29). *A Wrinkle in Stores' Mask Policies: Enforcement.* The New York Times. https://www.nytimes.com/2020/07/29/business/coronavirus-masks-stores-walmart.html

COVID-19 Travel. (2020, Feb 29). *Updated WHO recommendations for international traffic in relation to COVID-19 outbreak.* World Health Organization. https://www.who.int/news-room/articles-detail/updated-who-recommendations-for-international-traffic-in-relation-to-covid-19-outbreak#:~:text=Temperature%20screening%20alone%2C%20at,tracing%20of%20incoming%20travellers.

De Boni, R. B., Balanzá-Martínez, V., Mota J. C., Cardoso, T. D. A., Ballester, P., Atienza-Carbonell, B., Bastos, F. I., Kapczinski, F. (2020). Depression, Anxiety, and Lifestyle Among Essential Workers: A Web Survey From Brazil and Spain During the COVID-19 Pandemic. *J Med Internet Res*. 22(*10*). doi: 10.2196/22835. https://www.jmir.org/2020/10/e22835

FDA. (2021, Jan 12). Thermal Imaging Systems (Infrared Thermographic Systems / Thermal Imaging Cameras). FDA. https://www.fda.gov/medical-devices/general-hospital-devices-and-supplies/thermal-imaging-systems-infrared-thermographic-systems-thermal-imaging-cameras

Financial Times. (2021, Feb 3). *Lockdowns compared: tracking governments' coronavirus responses*. Financial Times. https://ig.ft.com/coronavirus-lockdowns/

FootfallCam. (2021). Covid-19 Automated Occupancy Monitoring System for Businesses. FootfallCam.

https://www.footfallcam.com/en/Industries/Covid-19-Automated-Occupancy-Control-System

Government of Canada. (2021, Jan 15). *Guidance on Essential Services and Functions in Canada During the COVID-19 Pandemic.* Public Safety Canada. https://www.publicsafety.gc.ca/cnt/ntnl-scrt/crtcl-nfrstrctr/esf-sfe-en.aspx

Government of Canada. (2018). *Communications Monitoring Reports.* https://crtc.gc.ca/pubs/cmr2018-en.pdf

Greenhalgh T., Schmid M. B., Czypionka T., Bassler D., Gruer L. (2020). Face masks for the public during the covid-19 crisis. *BMJ. 369*. https://doi.org/10.1136/bmj.m1435

Haischer M. H., Beilfuss R., Hart M. R., Opielinski L., Wrucke D., Zirgaitis, G., Uhrich, T. D., Hunter, S. K . (2020) Who is wearing a mask? Gender-, age-, and location-related differences during the COVID-19 pandemic*. PLOS ONE* 15(*10*). https://doi.org/10.1371/journal.pone.0240785

He, X., Lau, E.H.Y., Wu, P., Deng, X., Wang, J., Hao, X., Lau, Y. C., Wong, J., Guan, Y., Tan, X., Mo, X., Chen, Y., Liao, B., Chen, W., Hu, F., Zhang, Q., Zhong, M., Wu, Y., Zhao, L., Zhan, F., Cowling, B. J., Li, F., Leung, G. M. (2020). Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat Med 26*, 672–675 . https://doi.org/10.1038/s41591-020-0869-5

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., Xiao, Y., Gao, H., Guo, L., Xie, J., Wang, G., Jiang, R., Gao, Z., Jin, Q., Wang, J., Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet (London, England)*, *395*(10223), 497–506. https://doi.org/10.1016/S0140-6736(20)30183-5

International Labour Organization. (2021, Jan 25). ILO Monitor: COVID-19 and the world of work. Seventh edition Updated estimates and analysis. International Labour Organization. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/briefingnote/wcms_767028.pdf

Kassam, A. (2020, Jun 8). 'More masks than jellyfish': coronavirus waste ends up in ocean. The Guardian.

https://www.theguardian.com/environment/2020/jun/08/more-masks-than-jellyfish-coronavirus-waste-ends-up-in-ocean

Lan F., Suharlim, C., Kales S.N., Yang, J. (2020) Association between SARS-CoV-2 infection, exposure risk and mental health among a cohort of essential retail workers in the USA. *Occupational and Environmental Medicine.* https://doi.org/10.1136/oemed-2020-106774

Loey, M., Manogaran, G., Taha, M., & Khalifa, N. (2021). A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic. Measurement : journal of the International Measurement Confederation, 167. https://doi.org/10.1016/j.measurement.2020.108288

Lourenco, D. (2020, Oct 10). Struggling restaurants unsure where to turn with new pandemic restrictions in Ont. COVID-19 hotspots. CTV News. https://www.ctvnews.ca/business/struggling-restaurants-unsure-where-to-turn-with-new-pandemic-restrictions-in-ont-covid-19-hotspots-1.5141060

Machida, M., Nakamura, I., Saito, R., Nakaya, T., Hanibuchi, T., Takamiya, T., Odagiri, Y., Fukushima, N., Kikuchi, H., Amagasa, S., Kojima, T., Watanabe, H., & Inoue, S. (2020). Incorrect Use of Face Masks during the Current COVID-19 Pandemic among the General Public in Japan. *International journal of environmental research and public health*, 17(*18*), 6484. https://doi.org/10.3390/ijerph17186484

Meyersohn, N. (2020, July 26). *Walmart and others will still serve customers who refuse to wear masks, despite new rules.* CNN Business. https://www.cnn.com/2020/07/24/business/masks-walmart-home-depot-lowes-cvs/index.html

Mousavizadeh, L. & Ghasemi, S. (2020). Genotype and phenotype of COVID-19: Their roles in pathogenesis. *Journal of Microbiology, Immunology and Infection.* https://doi.org/10.1016/j.jmii.2020.03.022

Predict Medix. (n.d). *Infectious Diseases Screening Solutions.* Predict Medix. https://predictmedix.com/infectious-disease-screening-solution/

Rafi, M. (2018, September). *The Good-Better-Best Approach to Pricing.* https://hbr.org/2018/09/the-good-better-best-approach-to-pricing

RCC. (2020). Mask or face covering requirements affecting retailers. Retail Council of Canada. https://www.retailcouncil.org/coronavirus-info-for-retailers/mask-requirements-affecting-retailers/

React native. (n.d.). Retrieved February 27, 2021, from https://reactnative.dev/

Region of Peel. (n.d). *Update on the Novel Coronavirus in Peel*. Peel Region. https://www.peelregion.ca/coronavirus/business/pdf/COVID-19-positive-case-workplace.pdf

Rosebrock, A. (2020, April 18). OpenCV people counter. Retrieved February 26, 2021, from https://www.pyimagesearch.com/2018/08/13/opencv-people-counter/

Sangkham, S. (2020). Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. Case Studies in Chemical and Environmental Engineering, 2. https://doi.org/10.1016/j.cscee.2020.100052

Statistics Canada. (2020, Oct 20). *The health impacts of COVID-19 go beyond the effects of the virus.* Statistics Canada. https://www150.statcan.gc.ca/n1/pub/11-631-x/2020004/conclusions-eng.htm

Statistics Canada. (2021, Feb 26). Experimental estimates for business openings and closures for Canada, provinces and territories, census metropolitan areas, seasonally adjusted. Statistics Canada. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3310027001&pickMembers%5B0%5D=1.1&pickMembers%5B1%5D=2.1&cubeTimeFrame.startMonth=09&cubeTimeFrame.startYear=2019&cubeTimeFrame.endMonth=09&cubeTimeFrame.endYear=2020&referencePeriods=20190901%2C20200901

Stogdale, N. (2018, July 6). What is time of flight people counting? Retrieved February 26, 2021, https://www.irisys.net/blog/what-is-time-of-flight-people-counting

Tryolabs, B. (2020, July 09). Face mask detection in street camera video streams using ai: Behind the curtain. Retrieved February 26, 2021, from https://tryolabs.com/blog/2020/07/09/face-mask-detection-in-street-camera-video-streams-using-ai-behind-the-curtain/

Walmart. (2020, Nov 23). *Important Store Info*. Walmart Co.

https://corporate.walmart.com/important-store-info

W.H.O. (2020, February 29). Updated who recommendations for international traffic in relation To COVID-19 outbreak. https://www.who.int/news-room/articles-detail/updated-who-recommendations-for-international-traffic-in-relation-to-covid-19-outbreak

WHO. (2020, Sep 9). What we know about long-term effects of COVID-19. World Health Organization. https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/update-36-long-term-symptoms.pdf?sfvrsn=5d3789a6_2#:~:text=%E2%80%A2%20Most%20people%20with%20COVID,have%20lasting%20health%20effects

Wong, B. (2020, Sep 21). Why East Asians Were Wearing Masks Long Before COVID-19. Huffington Post. https://www.huffingtonpost.ca/entry/east-asian-countries-face-masks-before-covid_l_5f63a43fc5b61845586837f4

Washington State University. (2020, Nov 2). Discrimination increases against Asian and Asian American population, affecting health. ScienceDaily. www.sciencedaily.com/releases/2020/11/201102155412.htm

Yancey-Bragg, N. (2021, Feb 24). 'Stop killing us': Attacks on Asian Americans highlight rise in hate incidents amid COVID-19. USA Today. https://www.usatoday.com/story/news/nation/2021/02/12/asian-hate-incidents-covid-19-lunar-new-year/4447037001/

6.0 Appendices

6.1 Appendix A: Response to Feedback

#	Section	Feedback	Response to Feedback and Reflections
1	**Formatting and language**	The authors refer to themselves in the first person.	To maintain the report’s objectivity, it is preferable that the authors avoid referring to themselves in first person pronouns. This implies that the results and conclusions made in this document are purely based on scientific research and calculations rather than personal feelings and/or opinions. In addition, replacing first person pronouns such as “our'' or “we” by “design team” or “team members at ROBOTEX” can make the writing of the report more technical and professional and gives the reader a sense of the engagement that the team has among themselves.
2	**Executive Summary**	The section introduces the reader to aspects that should be discussed later in the report.	Since many readers only read the executive summary, it is essential that the topics going to be discussed in the report are clearly identified. This section should not discuss detailed information in regards to the design solution or device. It should be simple, clear and rather focuses on the ‘big’ picture to keep the reader interested.
3	**Problem Description**	Missing environmental	To ensure a better comprehension and overview of the problem, the

	and Background information/literature review	effects, some citation formatting, and needs a more detailed literature review	section has been edited to include environmental effects while elaborating more on topics that were previously touched on. Within the literature review, a more in depth description discussing about the specifics of COVID-19 was also added
4	**Constraints and Criteria**	Some of the constraints and criteria for the design have been misplaced.	It is important to understand what each of the constraints and criteria imply. This section has been edited according to their definitions and therefore the constraints have been updated to outline the limiting factors for the project while the criteria outlines a set of measurable terms that help ensure the success of the project.
5	**Required information and tools**	Addition of other essential tools that are used for the project.	To better handle engineering projects, management tools along with technical tools should be used. Project management tools, such as Excel, and other communication platforms, such as WhatsApp, were used to help better plan and track the project tasks and deadlines. To show the importance of these tools to the team, a table that clearly identifies these required resources has been constructed as shown in ***Table 11*.**
6	**Gantt Chart and fee estimate for design and**	The charts inserted in the report are unclear due to	To avoid distortion, the charts have been updated accordingly. This is done by inserting the charts as tables to replace the bitmaps used

	required deliverables	inappropriate format, making it harder for the reader to read the elements.	previously in the proposal. Though the font size of the elements in the Gantt chart is much smaller than the size used in the rest of the report, using the appropriate format to represent them ensures that they are easier to read and look more professional.

6.2 Appendix B: Calculations/modelling required for the evaluation of the design alternatives

6.2.1 Decision Matrix Ranking

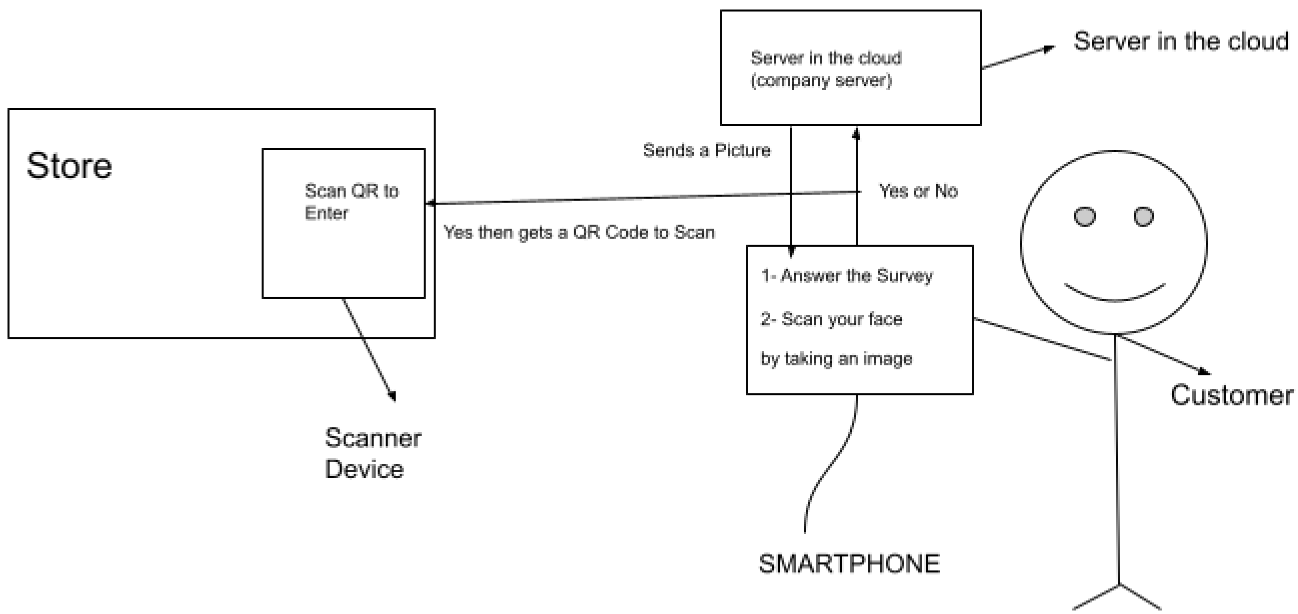
#	Criteria	Score	Justification
1	**Minimize cost of the design.**	1-3	This implies that the cost of the design solution will be greater than or equal to $2200.
		4-7	This implies that the cost of the design solution will be between $600 and $2200.
		8-10	This implies that the cost of the design solution is less than $600.
2	**Maximize accuracy of mask detector**	1-3	This implies that the accuracy of the mask detection method used in the design solution will be less than or equal to 80%.
		4-7	This implies that the accuracy of the mask detection method used in the design solution will be between 80% and 97%.

		8-10	This implies that the accuracy of the mask detection method used for the design solution will be greater than or equal to 98%.
3	**Maximize the temperature measurement accuracy.**	1-3	This implies that the accuracy of the temperature measuring method used in the design solution is +/- 1C.
		4-7	This implies that the accuracy of the temperature measuring method used in the design solution is between +/- 0.3C and +/- 1C.
		8-10	This implies that the accuracy of the temperature measuring method used in the design solution is +/- 0.3C.
4	**Minimize the complexity of the assembly of the design product.**	1-3	This implies that professional installation is required in the assembly of the design solution.
		4-7	This implies that some assistance is needed in the assembly of the design solution.
		8-10	This implies that the assembly of the design solution only requires self-installation by the client.
5	**Minimize the number of components.**	1-3	This implies that the implementation design solution requires 10 or more components.

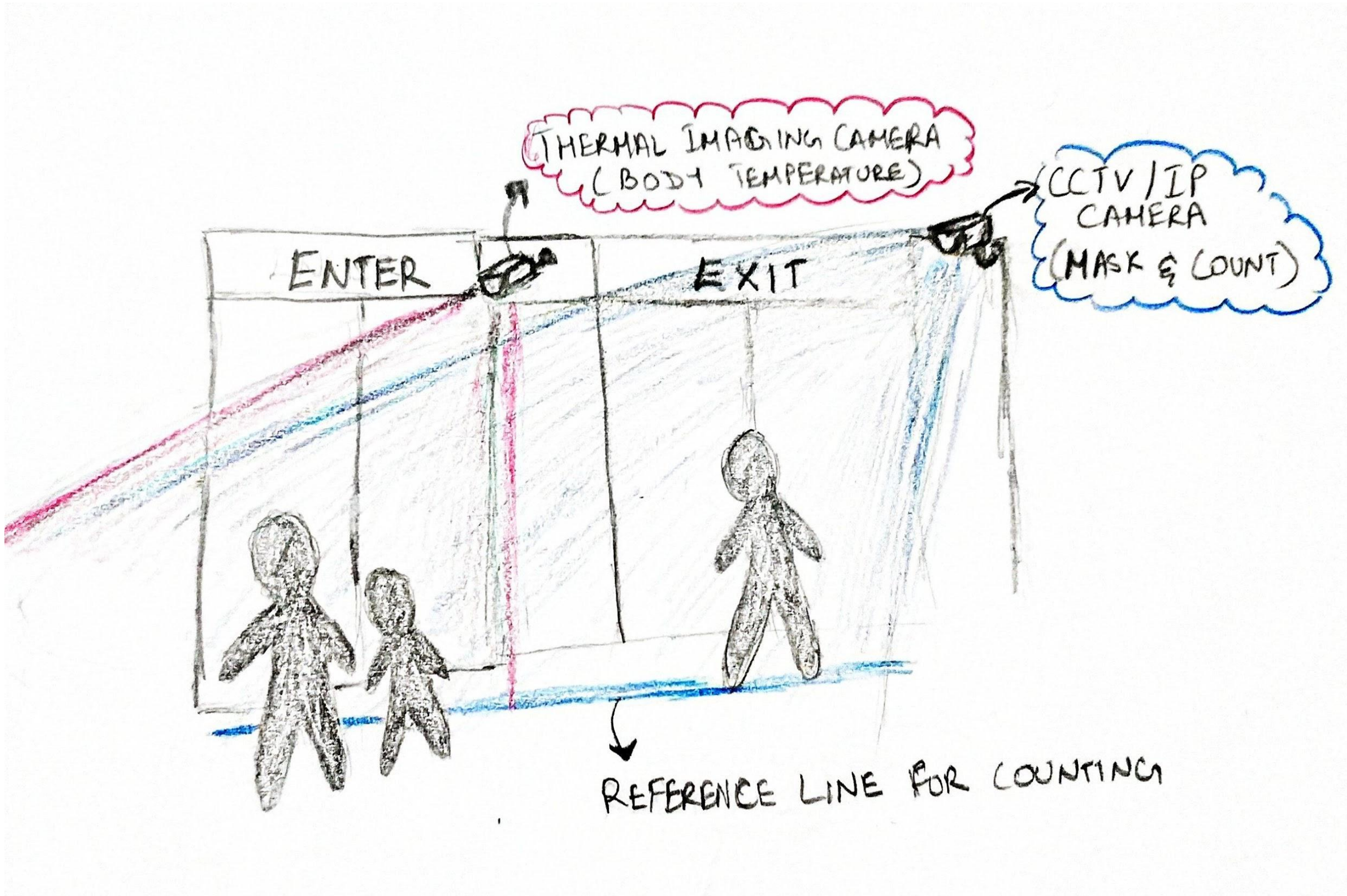
		4-7	This implies that the implementation of the design solution requires 4 to 9 components.
		8-10	This implies that the implementation of the design solution requires 1 to 3 components.
6	**Maximize accuracy of the counter.**	1-3	This implies that the accuracy of the counter is less than or equal to 30%. This means that the component of the device that is responsible for counting the number of people going in is poorly programmed in a way that does not offer accurate data collection within the system.
		4-7	This implies that the accuracy of the counter is between 30% and 90%. This means that the component of the device that is responsible for counting the number of people going in is programmed in a way that offers partially accurate data collection within the system.
		8-10	This implies that the accuracy of the counter is greater than or equal to 90%. This means that the component of the device that is responsible for counting the number of people going in is programmed in a way that ensures accurate data collection within the system.

7	**Maximize accessibility of the device.**	1-3	This implies that the design solution is not accessible to people of all demographics. The evaluation should take people of different ages and financial abilities into account, which in this case shows a low accessibility rate. Therefore, this category signifies an accessibility rate that is less than or equal 40%.
		4-7	This design solution implies that it is moderately accessible, signifying an accessibility rate that is between 40% and 80%.
		8-10	This implies that the design solution is highly accessible to people of all demographics. This means that the design solution is accessible to people of different ages/generations and different financial abilities. Therefore, this category signifies an accessibility rate that is higher than or equal to 80%.

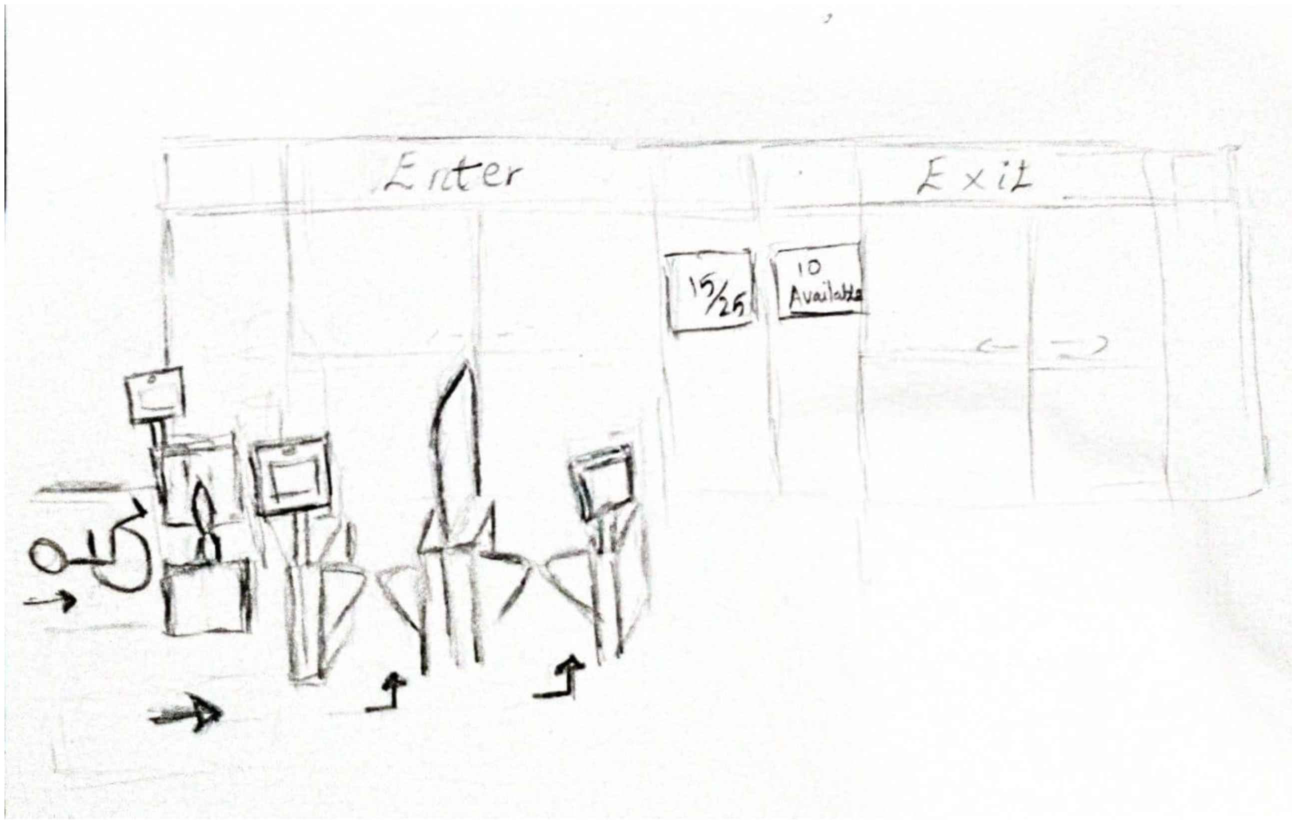
6.2.2 Technical Sketch for Design 1- Mobile Application



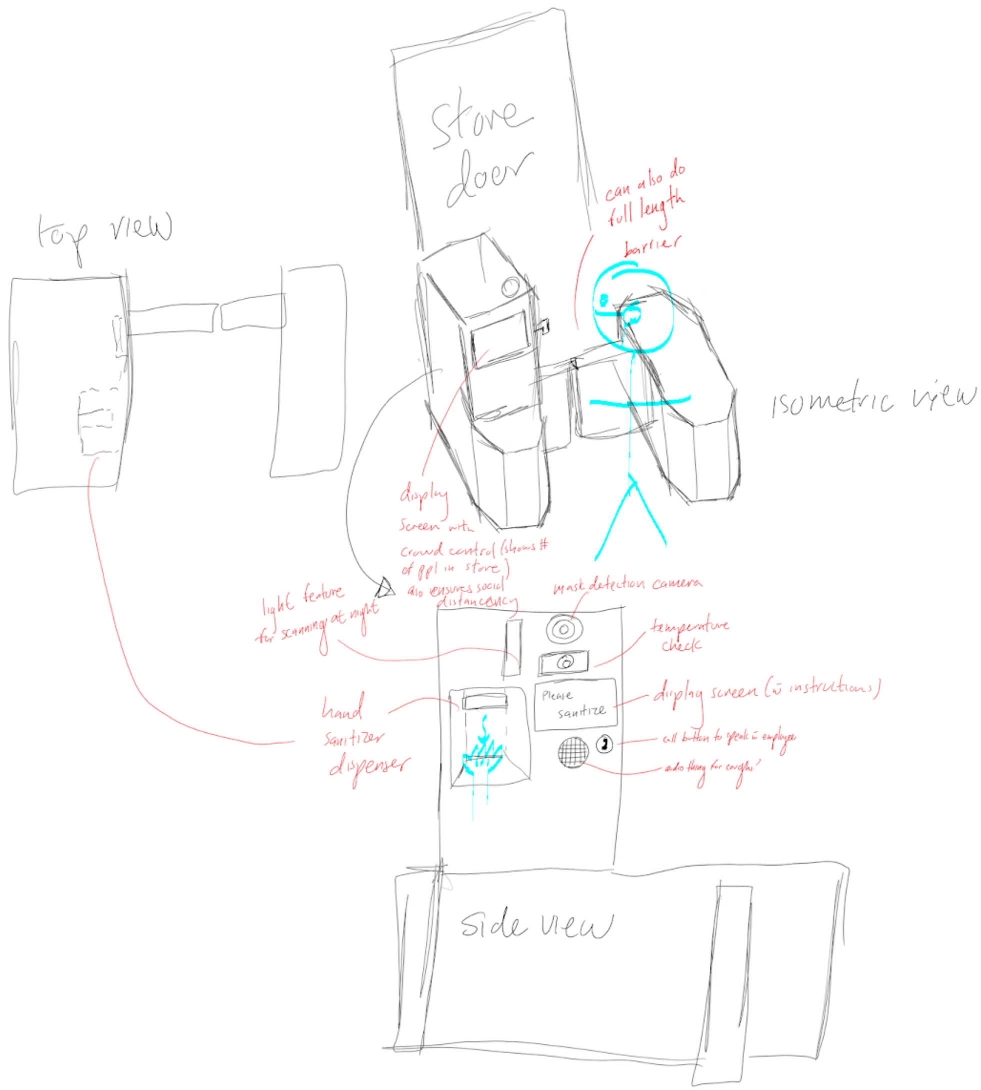
6.2.3 Technical Sketch for Design 2 - Existing Surveillance Camera



6.2.4 Technical Sketch 1 for Design 3 - Automated COVID Screening Station

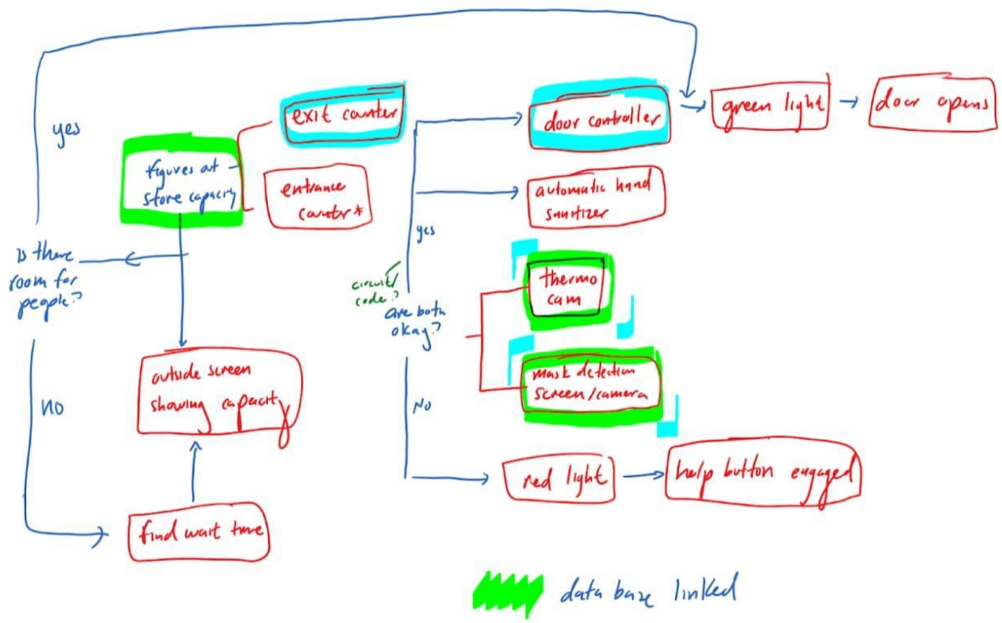


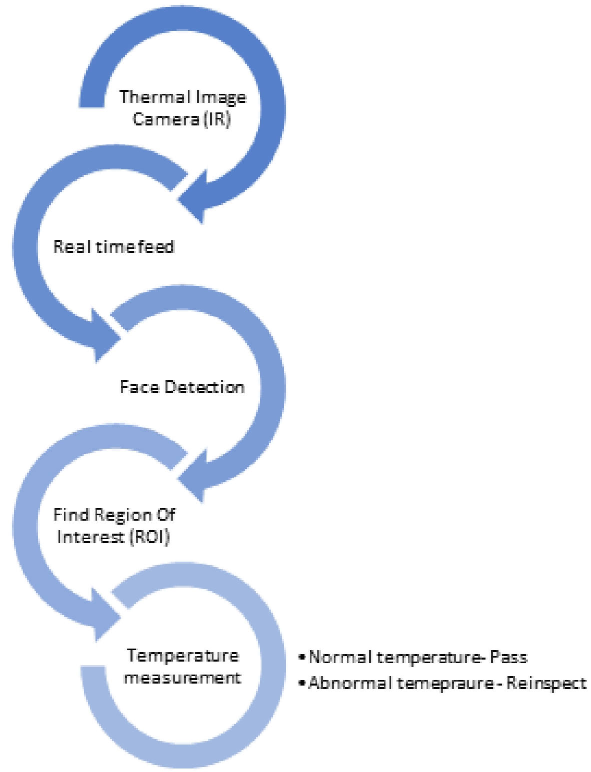
6.2.5 Technical Sketch 2 for Design 3 - Automated COVID Screening Station



top view
store door
can also do full length barrier
isometric view
display screen with crowd control (shows # of ppl in store) also ensures social distancency
light feature for scanning at night
mask detection camera
temperature check
hand sanitizer dispenser
Please sanitize
display screen (w instructions)
call button to speak w employee
audio thing for coughs'
side view

6.2.6 Concept Maps for Design Evaluation





6.3 Appendix C: Updated Work Plan and Resources

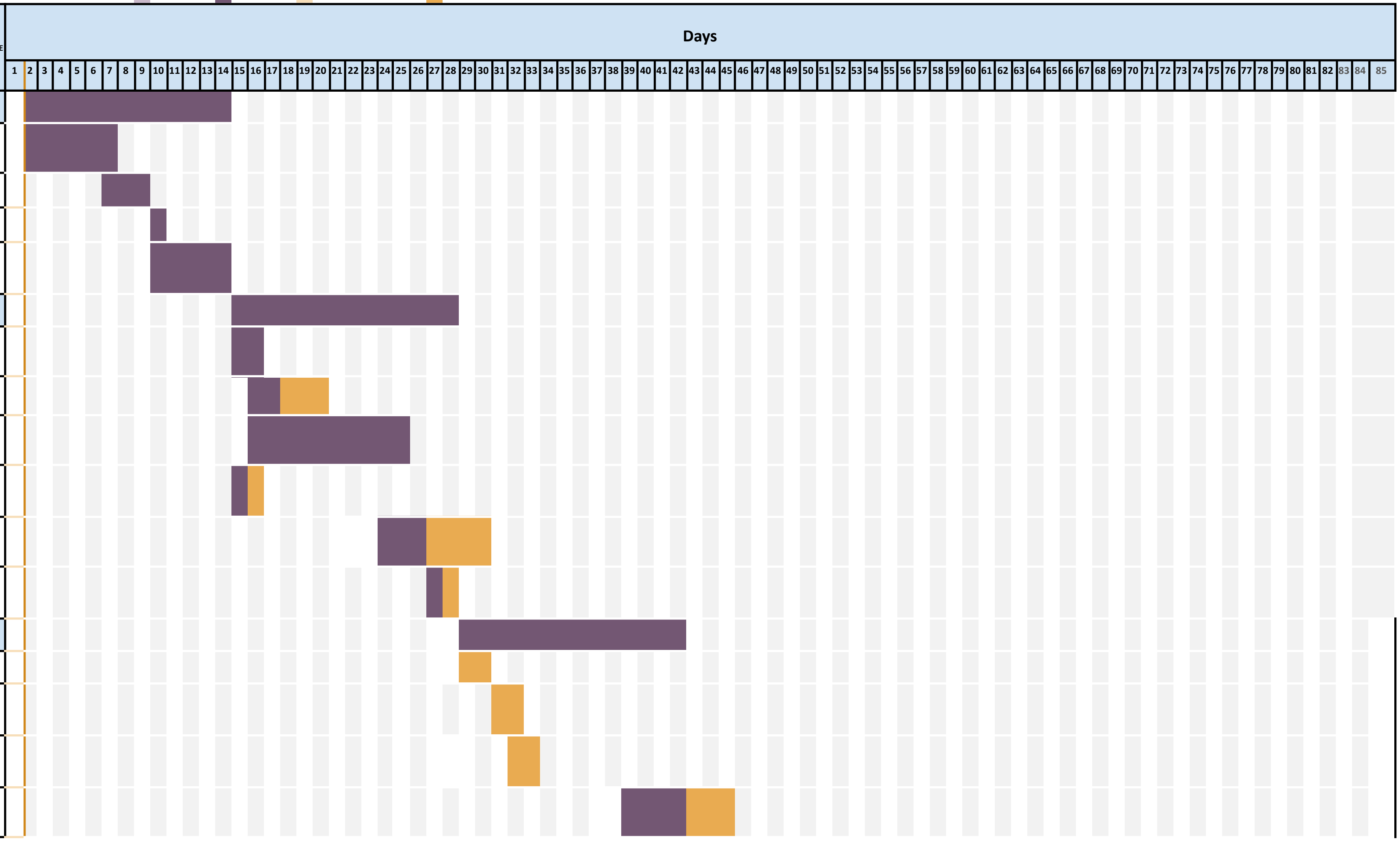
6.3.1 Updated Gantt Chart

GANTT CHART

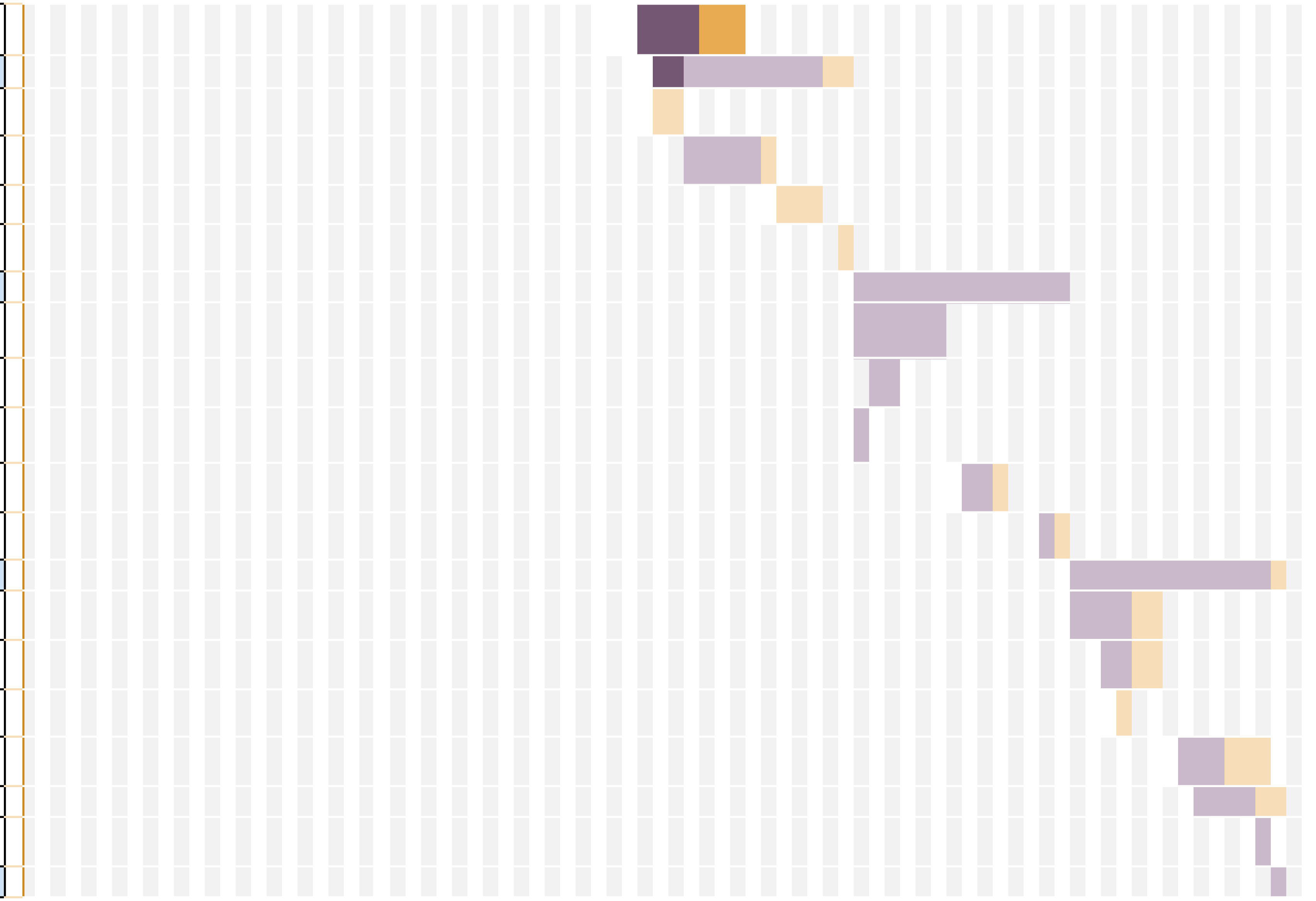
Passion. Purpose. Progress.

Plan Duration | Actual Start | % Complete | Actual (beyond plan) | % Complete (beyond plan)

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	% COMPLETE
Team/Project Selection	1	14	1	14	100%
Define individual interests	1	7	1	7	100%
Team selection	7	3	7	3	100%
Coordination Meeting	10	1	10	1	100%
Final project selection/submission	10	5	10	5	100%
Design Proposal	15	14	15	14	100%
Coordination meeting	15	2	15	2	100%
Problem Definition	16	2	16	5	100%
Research,information Gathering	15	11	16	10	100%
Divide tasks among team members	15	1	15	2	100%
Write and format the proposal	22	5	24	7	100%
Final edits/submission	27	1	27	2	100%
Interim Report	28	13	29	14	100%
Coordination Meeting	28	1	29	2	100%
Discuss, review and reflect on proposal	29	1	31	2	100%
Divide tasks among team members	28	1	32	2	100%
Write and format the proposal	37	6	39	7	100%



Final edits/submission	40	6	42	7	100%
Technical Memo	42	12	43	13	20%
Coordination Meeting	42	1	43	2	0%
Generation of the technical draft memo	45	5	45	6	0%
Review and edit	49	2	51	3	0%
Final edits and submission	53	0.5	55	1	0%
Design Presentation	56	14	56	14	0%
Coordination Meeting	56	6	56	6	0%
Discuss, review and reflect on reports	57	2	57	2	0%
Divide tasks among team members	56	1	56	1	0%
Generation of the draft presentation	62	3	63	3	0%
Final edits/submission	68	1	68	2	0%
Final Design Report	70	13	70	14	0%
Coordination Meeting	70	4	70	6	0%
Discuss, review and reflect on all reports	71	3	72	4	0%
Divide tasks among team members	72	1	73	1	0%
Finalize the design, constraints & criteria	76	4	77	6	0%
Write/format report	77	5	78	6	0%
Final review, edits and submission	82	0.2	82	1	0%
Celebrate	83	1	83	1	0%



6.3.2 Updated Fee estimate for design and required deliverables

#	Deliverable		Activity	Team members					Time (H)	Cost ($)
				Layal 40 $/H	Tina 40 $/H	Lina 40 $/H	Whitne 40 $/H	Nasiba 40 $/H		
1	Team and Project Selection									
		1.1	Group formation	0.5	0.5	0.5	0.5	0.5	2.5	100
		1.2	Coordinating meeting	0.5	0.5	0.5	0.5	0.5	2.5	100
		1.3	Determine the field of interest	0.5	0.5	0.5	0.5	0.5	2.5	100
		1.4	Problem definition and data collection	2	2	2	2	2	10	400
		1.5	Decide on the design, criteria and constraints	1.5	1.5	1.5	1.5	1.5	7.5	300
		1.6	Final selection and submission	1	1	1	1	1	5	200
			Sub.Total							1200
2	Design Proposal									
		2.1	Coordinating meeting	0.5	0.5	0.5	0.5	0.5	2.5	100
		2.2	Gather more information about the design	2	1	1	1	1	6	240
		2.3	Review the process with more research	1	1	1	1	1	5	200
		2.4	Discuss and write the proposal	2	2	2	2	2	10	400
		2.5	Final review and submission	0.5	0.5	0.5	1	0.5	3	120

			Sub.Total							**1060**
3	**Interim Design Report**									
		3.1	**Coordinating meeting**	3	3	3	3	3	15	600
		3.2	**Initial ideas about each section of the report**	2.5	2.5	2.5	2.5	2.5	12.5	500
		3.3	**Discuss and edit the draft report**	4	4	4	4	4	20	800
		3.4	**Writr, edit and format the report**	3	3	3	3	3	15	600
		3.5	**Final review and submission**	3	3	3	3	3	15	600
			Sub.Total							**3100**
4	**Technical Memo**									
		4.1	**Coordinating meeting**	3	3	3	3	3	15	600
		4.2	**Create the first Memo draft**	2	2	2	2	2	10	400
		4.3	**Review the process**	3	3	3	3	3	15	600
		4.4	**Write, edit and demonstrate the required format**	4	4	4	4	4	20	800
		4.5	**Final review and submission**	3	3	3	3	3	15	600
			Sub.Total							**3000**
5	**Design Presentation**									
		5.1	**Coordinating meeting**	2	2	2	2	2	10	400
		5.2	**Edit, review and format draft presentation**	3	3	3	3	3	15	600

		5.3	Add pictures, diagrams and videos	3	3	3	3	3	15	600
		5.4	Record the presentation	3	3	3	3	3	15	600
		5.5	Final revision and submission	2	2	2	2	2	10	400
			Sub.Total							**2600**
6 Final Design Report										
		6.1	Coordination meeting	3	3	3	3	3	15	600
		6.2	General draft report	5	5	5	5	5	25	1000
		6.3	Write, edit and format the report	4	4	4	4	4	20	800
		6.4	Review and edit the final report	5	5	5	5	5	25	1000
		6.5	Final revision and submission	5	5	5	5	5	25	1000
			Sub. Total							**4400**
			Grand Total						**384**	**15360**