Note: The Proposal Template used in ECE 4011 and ECE 4012, senior design, is modeled on commercial business proposals and contains elements of R&D proposals. Real-world examples of engineering proposals are not available because of the proprietary nature of the information disclosed therein. **The Project Proposal should be submitted on CANVAS (Teamname_Proposal.pdf) as well as to your team's faculty advisor and external partner (if applicable).**

Smart Mirror

ECE 4011/4012 Senior Design Project

Team Name: Myr R
Project Faculty Advisor: X. Ma
External Partner (if applicable)

Team Members Names, Majors, and Email Addresses

Jessey Sperrey, EE, jsperrey3@gatech.edu
Brennon Farmer, CmpE, bfarmer31@gatech.edu
Daniel Yue, CmpE, dyue9@gatech.edu

Submitted:

Submission Date: 04/30/2020

Table of Contents

Executive Summary

The bathroom mirror is a staple in any public or private bathroom in the world. For an everyday object to be used so frequently, how could it become more useful to the everyday user? The Smart Mirror is an upgrade to the everyday mirror to allow for even more functionality with a focus on entertainment and convenience. The mirror will feature two-way dielectric glass to allow for both common self viewing and simultaneous viewing of a display screen. The screen will allow the user to display his or her day planner, calendar and weather with the possibility of customizing the readout. Along with the display, the user will be able to play music through the speakers added to the mirror either through a smart phone or by audio jack connected straight into the mirror interface. Bluetooth is what will allow the user to customize their music and display choices. A Raspberry Pi is the device that will be the central processor for all of the aforementioned functions along with speakers and LCD display. The cost of materials for the entire product will be around $300-$400. For a successful final product, the product would be expected to seamlessly output desired information based on user input. If an event is input into Google Calendar, it will seamlessly display onto the LCD screen. The title of music played from one's smartphone will also output onto the display via bluetooth connectivity. An on-screen alarm clock will require the user to input time and it will sound when that time is passed, and user input is also required for the google maps application as the LCD will in turn calculate distance and output time of travel based on the destination given. The LCD will also display weather and current time on the main screen.

Smart Mirror 2019

1. Introduction

Smart Mirror is an affordable embedded device, which allows the user to perform the tasks of looking at one's reflection while doing various tasks. The tasks for this project include listening to music, checking daily schedules and memos, and checking the weather forecast. The device consists of a Raspberry Pi, phone application, LCD screen, dielectric glass material, LED lights, speakers, USB sound card and microphone, and a wooden casing for the mirror. The mirror will cost all-together $300-$400.

1.1 Objective

The team will design and build a Smart Mirror that enables the user to perform various daily tasks while looking in the mirror. The mirror will consist of a Raspberry Pi that will execute various applications for the end user. The applications include a music player, google drive calendar, clock, alarm clock, and weather forecast applications.. The Raspberry Pi will be connected to an LCD screen which will act as a display for the Raspberry Pi. The LCD screen will be connected to the back of an actual mirror. As a result, the user will be able to see their reflection and use the various applications of the Raspberry Pi. The LCD screen, mirror, and Raspberry Pi will be placed in a wood casing, so the complete product can be used anywhere in the home environment. Ultimately, the mentioned features will complete the main objective of providing users with entertainment and task planning while looking at their reflection in a mirror.

1.2 Motivation

Many people spend a vast amount of time in front of the mirror. According to a report from Gfk, people spend an average of 3.7 to 6.2 hours a week in front of a mirror [1]. This means 14.8 to 36.8 hours per month are used to look at a mirror. The Smart Mirror will help users make use of the idle time by providing entertainment and task planning. Some companies have developed Smart Mirrors for consumers. For example, Seura produces smart mirrors with the capability of voice control, Bluetooth, displaying a user's calendar or schedule, and playing music [2]. This product is similar to the given project but is priced at $6,999[2]. Team Myr R will develop a similar mirror but at a price around $300 to $400. In summary, the main motivation of the project is to develop a Smart Mirror that allows a user to perform important or entertaining tasks for the day (examples: checking daily schedule or calendar) during the idle time of using a mirror. However, the cost of the product will be less, and the product will be usable in any part of the home environment.

1.3 Background

There are many aspects that must be taken into consideration for the Smart Mirror. However, there are few aspects that the project relies on greatly for the success of the project's goal. The key performance aspects of the Smart Mirror include the range of phone connectivity and the time required to access and switch applications or widgets The background section will provide background information for the key components of the project and the key performance aspects of each.

1.3.1 Rasberry Pi 3 B+

The main hardware component of the Smart Mirror is the system on chip or microcontroller that will be used in its design. The system on chip and microcontroller allow the Smart Mirror to execute applications and provide the main features for the Smart Mirror (ex. Google calendar, clock, music player, etc.). The Smart Mirror for this project will use a system on chip (SOC) called the Raspberry Pi 3 B+. The Raspberry Pi 3 B+ consists of a CPU (central processing unit) which is used to execute the applications and widgets that will be displayed on the Smart Mirror. The Raspberry Pi also consists of SRAM which allows multiple applications and widgets to load at a faster rate. This allows users to switch between applications at a fast pace. The last major feature of the Raspberry Pi is the Bluetooth capabilities [3]. Bluetooth will allow other devices (such as the user's phone) to connect to the Smart Mirror. Further details of Bluetooth will be covered in the next section. The key performance aspects of application access speeds are directly tied to the Raspberry Pi.

The Raspberry is also used in another smart mirror called Magic Mirror. Magic Mirror is an open source smart mirror platform that uses the Raspberry Pi 2 and 3 [4]. The Magic Mirror project is similar to Team Myr R's project; however, Team Myr R's Smart Mirror will use the Bluetooth capabilities of the Raspberry Pi.

1.3.2 Bluetooth

Phone connectivity between the Smart Mirror and the user's phone will be supported by Bluetooth. Bluetooth is a wireless technology standard that allows devices such as computers, system on chips, and mobile phones to transmit data over a short distance using radio waves. It is used to perform many features such as: controlling wireless speakers through a phone, transferring files, or connecting to other Bluetooth devices. Approximately 10 billion devices use Bluetooth as of 2018 [5]. The standard technology of Bluetooth (Bluetooth 4.2 for Raspberry Pi 3 B+) will be used by the Smart Mirror to efficiently communicate to the user's phone [3]. The Smart Mirror's key performance aspect of phone connectivity ranges are directly affected by the Bluetooth feature of the Raspberry Pi.

1.4 Future Content

The next sections of the project proposal will touch on the project's description and goals, technical specifications design approach, project schedule, project demonstration, market analysis, current status and leadership roles. A brief description of the project's technical issues, and value statement, key concepts, and proof of concept. The technical issues of the project include the amount of memory and processing power of the Raspberry pi's RAM and CPU. The value of the product is the idea of allowing customers to use their idle time in a more efficient or entertaining way. Finally, the proof of concept will be demonstrated by creating a working prototype of the project.

2. Project Description, Customer Requirements, and Goals

2.1 Project Description and Goals

The team will design a Smart Mirror that consists of a Raspberry Pi B+, dielectric mirror, speakers and wooden case. The Raspberry Pi will be programmed with applications and widgets that the customer found important. The applications will include the calendar widget, alarm clock widget, weather forecast application, memo application, and music player application. The Raspberry Pi will also be programmed to display a user interface to the user through the LCD screen. Furthermore, the Raspberry Pi will control the speakers, display onto the LCD, and run the selected program modules.

The LCD screen will be positioned behind the dielectric glass material. This will allow the user to view their reflection and browse the various applications of the Smart mirror. All the electrical components will be positioned behind the electric glass material and the LCD screen. Next, all the components will be encased in a wooden frame to hide the electrical components and only display the dielectric glass.

2.2 Stakeholders

The stakeholders that have huge power over the project include Google, Amazon, and Raspberry Pi Foundation. Google and Amazon provide the software for voice recognition. Using their software commercially requires an agreement. If the agreement is not met, the project will not have the important feature of voice input. The Raspberry Pi is a part of the same category since the project relies heavily on the use of the Raspberry Pi. A significant change in the project would occur if the Raspberry is not available for use.

The wood, dielectric, and speaker suppliers have low interest and power over the project. The suppliers can be replaced by many other vendors. As a result, the suppliers do not cause a huge impact on the project. Now, the employees contain a high amount of power and interest for the project. The project partners directly affect the development speed and completion of the project. The group must be prioritized and constantly updated about the project. The customers have a huge interest in the project since this group decides if the project is worth buying and correctly fulfills the requirements. Figure 1. Shows the stakeholders in a 2x2 stakeholder matrix.

<u>Keep Satisfied</u> Google Amazon Raspberry Pi Foundation	<u>Manage</u> Project partners
<u>Monitor</u> Wood supplier Dielectric material supplier Speaker Suppliers USB sound card and microphone supplier	<u>Keep Informed</u> Customers

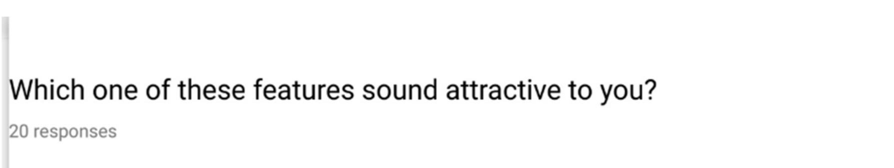
Figure 1. Stakeholder 2x2 matrix for stakeholders of the Team Myr R's Smart Mirror Project

2.3 Customer's needs

The customer needs are listed:

- Users can use Google calendar or calendar widget, weather forecast app, clock widget, and music player
- Speakers can be used to play music or listen to podcasts
- User can clearly see their own image
- The product is priced at or below $400.

The customer needs are based on a survey for the Smart Mirror Project. The survey showed which features were most important for the customers as shown in Figure 2. Team Myr R issued the survey through Reddit in which 20 users answered with their most wanted features.



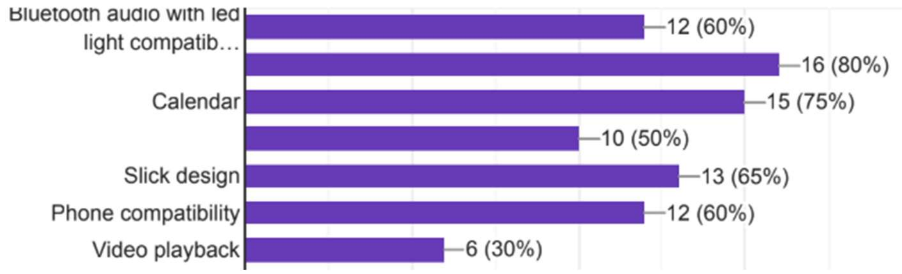


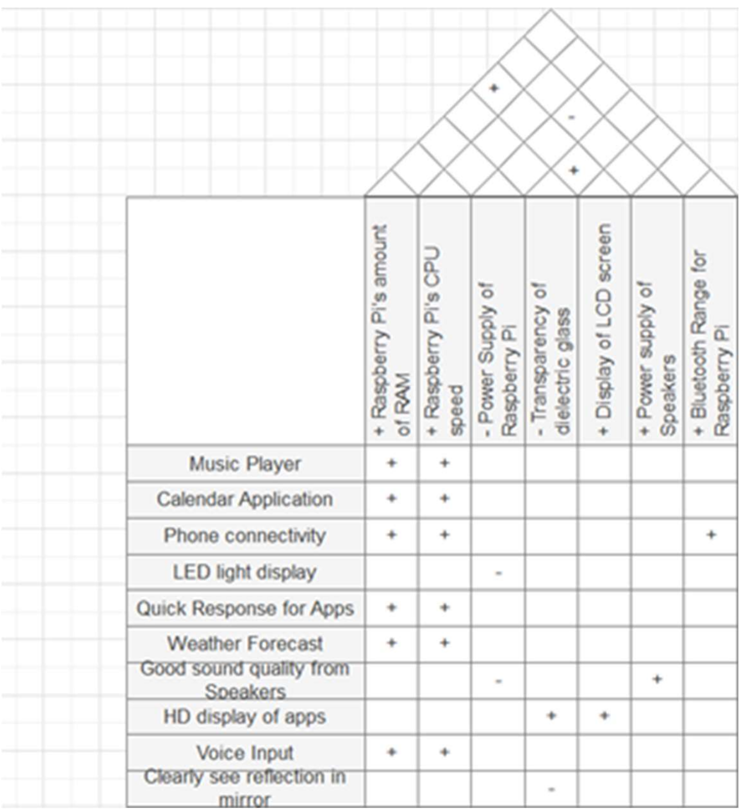
Figure 2. Reddit survey for most wanted features for Smart Mirror

The target users will be anyone who wants the capability of using their time efficiently while looking at their reflection in the mirror. The product is also targeted at customers who wishes to entertain themselves while looking in a mirror.

2.4 Performance Goals

The final design should allow a user to use the various applications mentioned in the customer needs list, but the design should slos allow the applications to have high access and switching speeds for multiple simultaneous running applications. The access and switching speeds should be no higher than one second to ensure that the end user is satisfied with the Smart Mirror's processing speed. The next function for the Smart Mirror is the speakers. The speakers should have a good sound quality.It was decided that a sensitivity of 80 decibels should be the sound quality of the speakers. The next function is a clear image from the mirror. The end user should still be able to use the Smart Mirror as an actual mirror. The dielectric glass should be at most 30% transparent for this aspect of the final design. This will allow users to view their reflection and the applications of the Smart Mirror. The next function is the voice control capabilities of the design.

QFD chart for the project is shown below:



	+ Raspberry Pi's amount of RAM	+ Raspberry Pi's CPU speed	- Power Supply of Raspberry Pi	- Transparency of dielectric glass	+ Display of LCD screen	+ Power supply of Speakers	+ Bluetooth Range for Raspberry Pi
Music Player	+	+					
Calendar Application	+	+					
Phone connectivity	+	+					+
LED light display			-				
Quick Response for Apps	+	+					
Weather Forecast	+	+					
Good sound quality from Speakers			-			+	
HD display of apps				+	+		
Voice Input	+	+					
Clearly see reflection in mirror				-			

Constraints

List of constraints

- Limited SRAM of Raspberry Pi
- Limited processing power of Raspberry Pi
- Reflectivity of dielectric glass
- Power output for Speakers based on Raspberry Pi

Three of the project's constraints stem from the Raspberry Pi. The constraints include the limited processing power and RAM.. The Raspberry Pi's CPU provides restrictions on which applications can run on the Smart machine and the loading speeds of the applications. The RAM provides restrictions on how many applications can be switched and accessed at a decent speed.If a large amount of applications are executed at the same time or a resource heavy operating system is used, the speed of switching between applications will decrease greatly.

The reflectivity of the mirror is another constraint. If the dielectric glass is highly reflective, the LCD screen will not be viewable by the user. As a result, the application will not be seen by the user. The last constraint is the power output of the Raspberry Pi. The Raspberry Pi must be able to power the LCD screen, LED lights, and the speakers for the project.The design of the project only use one power outlet to power the entire product. As a result, all electrical components must be powered by the Raspberry Pi.If the Raspberry Pi is not capable of powering the components, the usage of electrical components will be greatly restricted.

3. Technical Specifications

3.1 Mirror Enclosure

Table 1. Smart Mirror Enclosure

Outer Frame Dimensions	38” x 26” x 2”
Mirror Dimensions	3’ x 2’ x 0.12”

3.2 Hardware

Table 2. Raspberry Pi

Processor	Broadcom BCM2837B0, Cortex®-A53 (Arm®v8) 64-bit SoC @ 1.4 GHz
Communication	2.4 GHz and 5 GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
RAM	1 GB SDRAM
GPU	250MHz VideoCore IV
Memory Storage	10 GB
Input Voltage	5V/2.5A DC

Table 3. Speakers

Dimensions	W 7.7 x D 5.5 x H 5.7 (cm)
Output Power	3W per speaker
Weight	0.26 KG total

Table 4. LCD Screen

Dimensions	85 x 55 (mm)
Resolution	1024 x 600

Table 5. Dielectric Glass

Transparency	30% transparent
Dimensions	18” x 24” x 1/4"

Quality Function Deployment Chart with Specifications and Rankings

Quality Function Deployment

Project Title: Smart Mirror

Date: 11/18/19

	1: low, 5: high Customer importance rating	Functional Requirements (How) → Customer Requirements - (What) ↓	+ Raspberry Pi's RAM	+ Raspberry Pi's CPU speed	- Power Supply of Raspberry Pi	- Transparency of dielectric glass	+ Display of LCD screen	+ Power Supply of speakers	+ Bluetooth Range of Raspberry Pi	Supporting Descriptions
1	4	Music player	+	+						Music app displayed
2	5	Calendar application	+	+						Calendar app displayed
3	5	Phone connectivity	+	+					+	Connectivity for synchronization of apps
4	3	LED display			-					Light display around mirror
5	4	Quick response for Apps	+	+						Fast processing time for lesser delays
6	1	Weather Forecast	+	+						Weather app displayed
7	3	Good sound quality from speakers			-			+		Speaker quality and stability
8	3	HD display of apps				+	+			Quality LCD display
9	2	Voice input	+	+						Voice recognition software
10	4	Clearly see reflection in mirror				-				Mirror reflectiveness
		Technical Specification	1 GB SDRAM	1.4 GHz	5V/2.5A DC	30%	800 x 480	5-12 V	25 m	
		Importance rank	5	5	3	4	4	3	2	1: low, 5: high
		Difficulty to improve	4	4	3	1	2	3	1	1: very easy, 5: very difficult

Correlation:	+		-
	Positive	No correlation	Negative

4. Design Approach and Details

4.1 Design Concept Ideation, Constraints, Alternatives, and Tradeoffs

The design must both function as a mirror and as a convenient system that supplements one's experience. The system will include a music player, google maps, calendar, weather forecast, alarm clock and internet/bluetooth connectivity. To include both the system and the mirror, a mirror must be used that has enough reflectivity to see oneself, but also transparent enough to see the screen. The mirror must be large as well so that the screen can be placed on the bottom left of the mirror. This would allow for a feeling of convenience rather than taking too much space.

For the system, there are certain constraints and trade-offs that will affect the team's project decisions. The first constraint is the size of the system as the team cannot simply build a computer into the mirror. An embedded system known as the Raspberry Pi will be used, which is a basic computer that may not be able to run large excessive programs, but is portable enough to place within a mirror. While this is very beneficial to the user, it will make for more time in creating and designing such a system. Another constraint we must worry about is the cost of the system, as certain embedded systems are more expensive than others depending on the power of the CPU. Thus, cost leads to our biggest trade-off: the trade-off between how good our technology is and how resource intensive it is to run the Smart Mirror's entertainment system. Furthermore, certain chips can run more powerful programs. Depending on the amount of budget used on the CPU aspect of the Raspberry Pit, it would allow for more upgraded entertainment systems. The Smart Mirror will be capable of executing high processing power applications. Another trade-off is how much time is allocated for coding the Raspberry Pi (embedded system). Depending on the software solution the team chooses, it could require a substantial amount of time to implement. As a result, the project may be a more efficient and executable program structure, but the team may not have enough time to implement the design. The last constraint is the reflectivity of the mirror. The balance between transparency and reflectivity of the mirror must be considered grealty, since too much reflectivity would not allow the user to see the LCD display. Furthermore, too much transparency would not allow the user to see their reflection.

Smart Mirror has certain hardware – software trade offs and constraints such as the amount of RAM and processing power of the CPU in the Raspberry Pi. The CompE majors must determine how many software programs (such as online calendars, memos, music player) can run on the Raspberry Pi at a given time without using too much RAM. If the RAM is overused, the mirror responsiveness will suffer due to lower speeds of switching between applications. This result will lower user satisfaction. The CPU of the Raspberry Pi will affect how fast applications are executed. Lower processing power in the CPU will result in slower execution of applications which will have a negative impact on customer satisfaction.

The Smart Mirror project also has computing aspects. A software application must be developed so that a smartphone can connect to the mirror for the purpose of playing music and is a huge computing aspect of the project. Integrating the music player, calendar, clock, weather, and maps into the Raspberry Pi must also be completed and is a computing aspect of the project. The main idea of the computing aspects is keeping the device responsive and user-friendly, as the success of the Smart Mirror relies on the convenience and straightforward nature of integrating entertainment and reminders to an item of everyday use.

There are many interesting global factors we can consider. The first factor is the economic factor, which is that is there enough demand for our product? Most people have powerful smartphones already, do they truly need a smart mirror? Another factor that must be considered is sustainable factors. Although microcontrollers and chips are extremely cheap in the current market, we don't know if those metals will become much more rare.

4.2 Preliminary Concept Selection and Justification

The selection process of the concepts we hope to commit to will be tested via a decision-matrix. One of the key concepts the team introduced is the convenience of use. This concept is actually much more difficult than one thinks as adding things to people's lives does not always make it more convenient. However, the project is simply adding things to people's lives that they already do. Certain things include playing music when in the bathroom and internalizing one's schedule before the day begins. Known parts of the design includes a screen, apps, and a program that performs without lag. If the program is not fast, than it will lose the appeal of convenience.The countermeasure for the project include reducing the number of applications on the Smart Mirror or disabling features such as voice input.This will allow more RAM to be available on the microcontroller or system on chip, so applications will be more responsive. A design aspect we don't have yet figured out is how we will code the program, as there are many ways and solutions to code our system, yet we don't know which one would be the best one.

The project will use existing software and hardware. The existing software consists of the application software (Google Calendar and music application). The existing hardware consists of the Raspberry Pi 3 B+. Furthermore, the project will consist of GUIs for the app selection on the Smart Mirror and the phone application for connecting the user's phone to the mirror. The preliminary designs are shown in Figures 3 and 4.

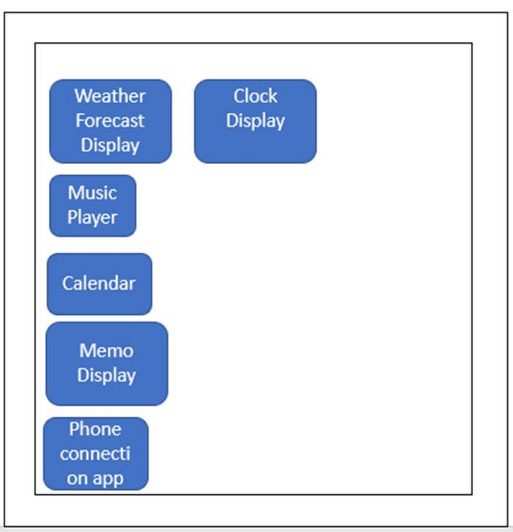


Figure 3. GUI for Smart Mirror. Displays the location of applications on Smart Mirror.

4.3 Engineering Analyses and Experiment

For prototype testing, there are three factors that must be tested. The first test is the design, and a slick design is one of the main concerns for the customers . To prove that this design works, the team will simply ask a third party if our mirror is something that would meet their standards. The next test would be a hardware test, and we must analyze our hardware's reliability. To accomplish precise testing, the team will use statistics and understand our hardware components to measure how well and how long our hardware will last. The final experiment would be checking to see how well our software will run under duress. To test that, we will run much more difficult to run programs, and see how it performs.

4.4 Codes and Standards

The most significant code we must apply to our project is that we must make sure that we deliver on what we say we would do. Secondly, we must also protect our customer, and in that way we must make sure that their information is our top priority. In terms of our design decisions, we will not have a camera so physical privacy cannot be breached, especially when understanding that this mirror is placed in the bathroom and is also connected to the internet. The functionality is built into the existing software.

The standards that influenced the design of the Smart Mirror were HDMI, Cascade Style Sheets, http, html, javascript, and Bluetooth. The interface that will be used to display the contents of the Raspberry Pi will be HDMI. HDMI is a standard for connecting devices with high definition. The team would like the Smart Mirror to display the contents of its applications (such as the calendar and memos) in the sharpest manner. The standard of HDMI was the solution to that request. Cascade Style Sheets (CSS), javascript, and HTML are markup language standards for applications. The standards will be incorporated in the production of the application used to connect a smart phone to the Smart Mirror. The UI of the application will be developed using the mentioned standards. The last standard is Bluetooth. Bluetooth is a networking standard that will allow smartphones to connect to the Smart Mirror. The team wanted a simple way to connect devices to the Smart Mirror besides using Wifi. The standard of Bluetooth influenced that design decision.

5. Project Demonstration

Prototyping our project is the most simple way of demonstrating the project. To prove that our system works we can run even more programs all at once to show that there are no performance issues. Furthermore, we can also run our project for a long period of time also to show that there are no hardware issues. Showing that the project works and that it works efficiently and for a long period of time validates the project's specifications. Because of the complications of the coronavirus and cancellation of the design expo, the plan for the demonstration has changed.

Certain components would be demonstrated for quality and responsiveness, including the LCD display and speakers. The LCD display would be shown to be bright enough for viewing from at least 3 feet. Software components like Bluetooth and speed of computing would be demonstrated for use in a real-time situation, such as selecting a song to play and going to Google Calendar. All applications and modules must run successfully, quickly, and be run using the proper user input (if needed). The actual mirror would be demonstrated to be appropriately reflective, allowing light from the LCD display to pass through, and durability. Because of the aforementioned limitations though, only the LCD with the modules all displayed on the screen will be shown.

6. Schedule, Tasks, and Milestones:

The Gnatt chart shows the team's project schedule and which must be completed prior in order to complete future tasks. The Gnatt chart is shown in Appendix A.

Gantt Chart: refer to Appendix A

The division of labor is based on the proficiencies of each of our group members.For the hardware and physical aspects of the device, including the components that are attached/implemented and the involved CAD, both Jessey and Daniel are more skilled, experienced, and agreed to take up that part of the project. This includes purchasing hardware/software goods, modelling on CAD, building the box, completing the I/O and power wiring, and the final assembly.

For the software and embedded aspects of the device, including the internal implementations of the embedded systems and LCD screen, Brennon is more experienced and agreed to take up that part of the project. This includes researching the platform, coding the main Rasperry Pi features, coding extra features, debugging the Raspberry Pi, and testing/compiling the environment.

The non-specific tasks are more easily handled as a group, including the project review, oral presentation, test for an extended period, and final presentations.

CPM Chart: refer to Appendix B

The critical path for the project is shown below.

Critical Path:

Start Project -> Final Project Proposal -> Project Oral Presentation -> List out all goods -> Research Code -> Code Raspberry Pi -> Code extra features -> Debugging/Testing -> Final Assembly -> Simulate for long extended period -> Finish Project -> Final Project Proposal Review -> Final Project Oral Presentation -> Design Expo

Risk Assessment: refer to Appendix C

The hardware tasks are expected to be moderately difficult and moderately time consuming, Putting everything together so that it fits exactly may take a lot of tuning and require the use of power tools. The software tasks are expected to take much longer, and its difficulty scales with the amount of applications implemented. The initial controller design code might be quite simple, but adding on each embedded system will take more time to research and add to the initial code. The software component may take up to twice as long, with much more room for errors.

Given the amount of time between all of our tasks, especially during the final stretch, our probability of finishing the project before the Design Expo is very high.

7. Marketing and Cost Analysis

7.1 Marketing Analysis

The Team Myr R Smart Mirror is designed to make life more convenient and simple in ways that are somewhat unexpected. There is also an added entertainment quality included in the design that adds to the end-user's benefits. The Smart Mirror design that has been chosen also allows for added system upgrades on both a component/hardware level and a software/firmware level.These functions, paired with the fact that it is cost effective are all very appealing to the current customer base.

Currently on the market there are different options for similar products. Home Depot offers a "Jovian Framless 27" x 43" LED Mirror" [10]. This mirror is readily available, it includes energy efficient LEDs and has a touch power sensor. It does not however allow for any customizable options or any types of display except for the light output and common mirror function. It is also rather expensive at approx. $374 per unit. This is considered to be on the lower end of functionality as compared to the Smart Mirror.

Rather than custom solutions to compare to the proposed Smart Mirror, there is a very similar product on the market called Savvy by Electric Mirror [11]. Savvy is a very progressive design and includes many of the same functions including bluetooth connectivity, audio output, light output, and customizable display options but it also allows for smart home connectivity as well as a complete Android 7.1 software option. While this product allows for the maximum functionality, it is anywhere from $2,000 to $6,000 in price. Our product will cost a maximum of $2,000 and will offer a majority of the functions while still allowing for future customization and upgrades to the firmware.

7.2 Cost Analysis

Project cost Analysis			
Engineering time:	$70,000 a year, $35 an hour		
	Jessey (80 hours)		$2,800
	Brennon (100 hours)		$3,500
	Khoa (100 hours)		$3,500
	Daniel (80 hours)		$2,800
		TOTAL	$12,600
Parts:	Shadow box materials/extra wiring		$180
	Raspberry Pi 3 B+		$40
	LCD		$50
	Power supply		$20
	Programmable LEDs		$30
	Speakers w/ parts		$10
		Total	$330
Total Cost to Make:	Parts		$310
	Production (build box, wire, load firmware) - 12 hours		$420
	Test time - 6 hours		$210
		Total	$940
Units sold (over 5 yrs)	unit cost		$2,000
	Units sold per year		20
	Total earnings on sold products		$40,000
All expenses:	marketing (5%)		$2,000.00
	Tool cost/maintenance (5%)		$2,000.00
	Worker Benefits (5%)		$2,000.00
			$6,000.00
	Engineering time		$12,600
	Total cost to make units sold		$18,800
			$31,400
		Total	$37,400
Final Profit			$2,600.00

The hours per engineer was determined by taking the estimated time spent on every aspect of the design process. Price per engineer was the average hourly rate of a $70,000 annual salary. Production time is the hours based off of the estimation of steps after design; this includes the steps in the frame construction, hardware and wiring steps, and the completed firmware/software loaded into the hardware. The resulting production hours were added with the price of materials per unit and the testing time required for each individual unit. This obviously differs from the cost of the first unit as the design and extended planning period is already completed. Sales on the unit were based on what would give the best chance to make a profit after paying off the design phase and overhead costs. The additional costs including marketing, tool cost and maintenance, and worker benefits were taken straight from 5% of the total earnings made from sales. The final profit was the money left from units sold after all other costs were covered. The final unit per year was 20 units minimum at $2,000 per unit.

8. Current Status

The current status of our project is that we have all our plans ready to go. Our first task we must do is to write a list of items we must purchase. We have yet to do that, but we have set out a date to start that soon.

9. Leadership Roles

<u>Jessey Sperrey</u> - Hardware (Expo Coordinator)

Manages the physical implementation of the Smart Mirror, including the actual mirror and the LCD screen, as well as other components like sound pieces. Keeps track of the events taking place during meetings, builds, and planning sessions.

<u>Brennon Farmer</u> - Software (Documentation)

Manages the internal implementation of the Smart Mirror, including the code utilized in the embedded system, displayed on the LCD, and other components like sound pieces.

Daniel Yue - Sound Systems (Webmaster)

Manages the implementation of the sound systems used, including speakers, portable music player, sound inputs utilized with voice recognition. Keeps track of the events taking place during meetings, builds, and planning sessions.

10. References

[1] N. McCarthy, "Infographic: Italians Spend The Most Time In Front Of The Mirror", Statista Infographics, 2019. [Online]. Available: https://www.statista.com/chart/4363/italians-spend-the-most-time-in-front-of-the-mirror/. [Accessed: 18- Nov- 2019].

[2] "Smart Display Mirror - Seura", *Seura.com*, 2019. [Online]. Available: https://www.seura.com/products/smart/display-mirror. [Accessed: 18- Nov- 2019].

[3] "Meet the New Raspberry Pi 3 Model B+", *Digikey.com*, 2019. [Online]. Available: https://www.digikey.com/en/maker/blogs/2018/meet-the-new-raspberry-pi-3-model-b-plus. [Accessed: 18- Nov- 2019].

[4] M. Teeuw, "MichMich/MagicMirror", GitHub, 2019. [Online]. Available: https://github.com/MichMich/MagicMirror. [Accessed: 18- Nov- 2019].

[5] "Installed base: bluetooth-enabled devices 2012-2018 | Statista", Statista, 2013. [Online]. Available: https://www.statista.com/statistics/283638/installed-base-forecast-bluetooth-enabled-devices-2012-2018/. [Accessed: 18- Nov- 2019].

[6] "Smart Speaker Lighted Mirror - Seura", Seura.com, 2019. [Online]. Available: https://www.seura.com/products/smart/speaker-lighted-mirror#overview. [Accessed: 18- Nov- 2019].

[7] J. Vanian, "This Is Amazon's Latest Effort to Get Alexa Into More Devices", Fortune, 2017. [Online]. Available: https://fortune.com/2017/08/17/amazon-alexa-devices-software-kit/. [Accessed: 18- Nov- 2019].

[8] "Conversational Actions | Google Developers", Google Developers, 2019. [Online]. Available: https://developers.google.com/assistant/conversational/overview. [Accessed: 18- Nov- 2019].

[9] C. Heukelman, "Bluetooth 5 versus Bluetooth 4.2, what’s the difference?", Semiconductorstore.com, 2017. [Online]. Available: https://www.semiconductorstore.com/blog/2017/Bluetooth-5-versus-Bluetooth-4-2-whats-the-difference/2080/. [Accessed: 18- Nov- 2019].

[10] Home Depot, "Home Depot Online Store," [Online]. Available: https://www.homedepot.com/p/OVE-Decors-Jovian-27-in-x-43-in-LED-Frameless-Single-Mirror-Jovian/206873851?mtc=Shopping-B-F_D29B-G-D29B-29_22_VANITIES-Multi-NA-NA-PLA-NA-NA-Bath_Mirrors&cm_mmc=Shopping-B-F_D29B-G-D29B-29_22_VANITIES-Multi-NA-NA-PLA-NA-NA-Ba. [Accessed 18 November 2019]

[11] Electric Mirror, "Smart Mirror - Savvy," [Online]. Available: https://www.electricmirror.com/smart-mirror-savvy/. [Accessed 18 November 2019].

[12] Digikey.com. (2019). *Raspberry Pi 3 Model B+ - Raspberry Pi | DigiKey*. [online] Available at: https://www.digikey.com/en/product-highlight/r/raspberry-pi/raspberry-pi-3-model-b?utm_adgroup=xGeneral&slid=&gclid=Cj0KCQiA2b7uBRDsARIsAEE9XpEKHTwM9OwRRhBA8o02d6ERZR9z508BjenxdQRbKRTDz4Kd6obifu8aAjJCEALw_wcB [Accessed 18 Nov. 2019].

[13] Amazon.com. (2019). *uxcell a15080600ux0275 Metal Shell Round Internal Magnet Speaker 2W 8 Ohm Pack of 4*. [online] Available at: https://www.amazon.com/Uxcell-a15080600ux0275-Internal-Magnet-Speaker/dp/B0177ABRQ6/ref=sr_1_17?crid=144ST24QJ6K8I&keywords=small+round+speakers&qid=1573935413&sprefix=small+round+speakers%2Caps%2C-1&sr=8-17 [Accessed 18 Nov. 2019].

[14] www.banggood.com. (2019). *LM386 Audio Amplifier Module 200 Times Input 10K Adjustable Resistance Module Board For Arduino from Electronics on banggood.com*. [online] Available at: https://www.banggood.com/LM386-Audio-Amplifier-Module-200-Times-Input-10K-Adjustable-Resistance-p-917571.html?gmcCountry=US&currency=USD&createTmp=1&utm_source=googleshopping&utm_medium=cpc_elc&utm_content=frank&utm_campaign=pla-mix-us-pc-0626&gclid=Cj0KCQiA2b7uBRDsARIsAEE9XpGcgl7chGjrhI1o9z2I5WGYV4qB

c3D3TswIZMXm0-Tb9ZVQjf8Kp8EaAnljEALw_wcB&cur_warehouse=CN [Accessed 18 Nov. 2019].

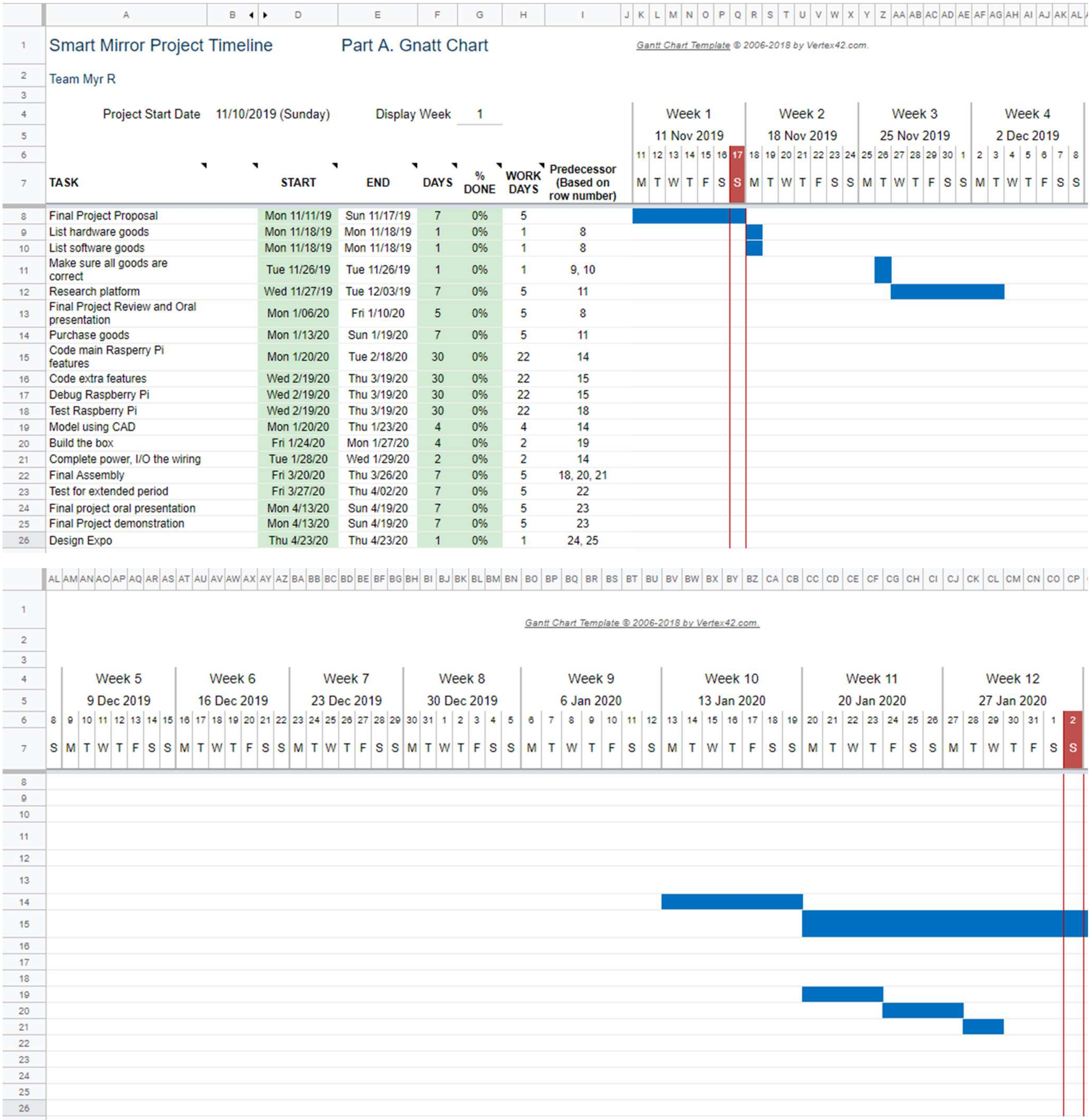
[15] Amazon.com. (2019). *24" x 36" x 0.12" Acrylic See-Through Mirror, 30% Transparent*. [online] Available at: https://www.amazon.com/dp/B01CZ35YJ6/ref=twister_B07S3S8JD6 [Accessed 18 Nov. 2019].

[16] Amazon.com. (2019). *Elecrow 5 inch Capacitive Touch Screen 800x480 TFT LCD Display HDMI*. [online] Available at: https://www.amazon.com/Elecrow-Capacitive-interface-Supports-Raspberry/dp/B07FDYXPT7/ref=sr_1_2_sspa?gclid=Cj0KCQiA2b7uBRDsARIsAEE9XpFj2gI_1Pn0BerpctSg98Q0VCJ5n2kfI_sUmnHruIrrDorPPb-piC0aAkHfEALw_wcB&hvadid=237352446621&hvdev=c&hvlocphy=1015243&hvnetw=g&hvpos=1t2&hvqmt=e&hvrand=9574843572370309111&hvtargid=aud-836718182849%3Akwd-304092504165&hydadcr=18031_9433042&keywords=lcd+screen+with+hdmi&qid=1573935890&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUFHN1U3RFVOMEk3SUMmZW5jcnlwdGVkSWQ9QTA4NDk4MzAzQ1hBTVQ3UTQzODcwJmVuY3J5cHRlZEFkSWQ9QTAwMzQwMTczMEZaTzU3WTlEOUdCJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ== [Accessed 18 Nov. 2019].

[17] Amazon.com. (2019). *ALITOVE WS2811 12V Addressable RGB LED Strip Light 16.4ft 150 LEDs Dream Color Programmable Digital LED Flexible Pixel Lights Waterproof IP65 with 3M VHB Heavy Duty Self-Adhesive Back*. [online] Available at: https://www.amazon.com/ALITOVE-Addressable-Programmable-Waterproof-Self-Adhesive/dp/B07M5KPBJM/ref=sr_1_1_sspa?keywords=programmable%2BLED%2Blights&qid=1573935100&sr=8-1-spons&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExTUNCMDFXQUpEOTlBJmVuY3J5cHRlZElkPUEwOTQxMjMxTVBYSkczSE82OUpMJmVuY3J5cHRlZEFkSWQ9QTAyNzU1MzAxR1hUUzJUQUoxR0VIJndpZGdldE5hbWU9c3BfYXR

mJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ&th=1
[Accessed 18 Nov. 2019].

Appendix A: Gantt Chart

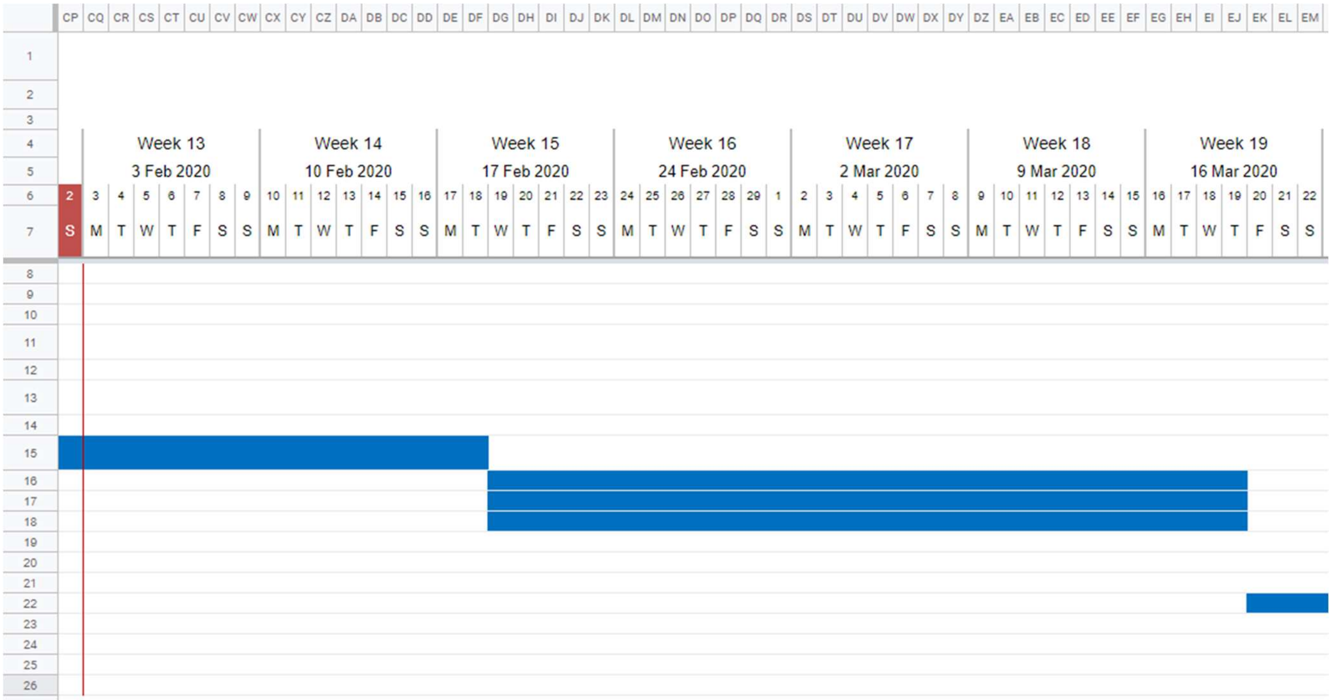


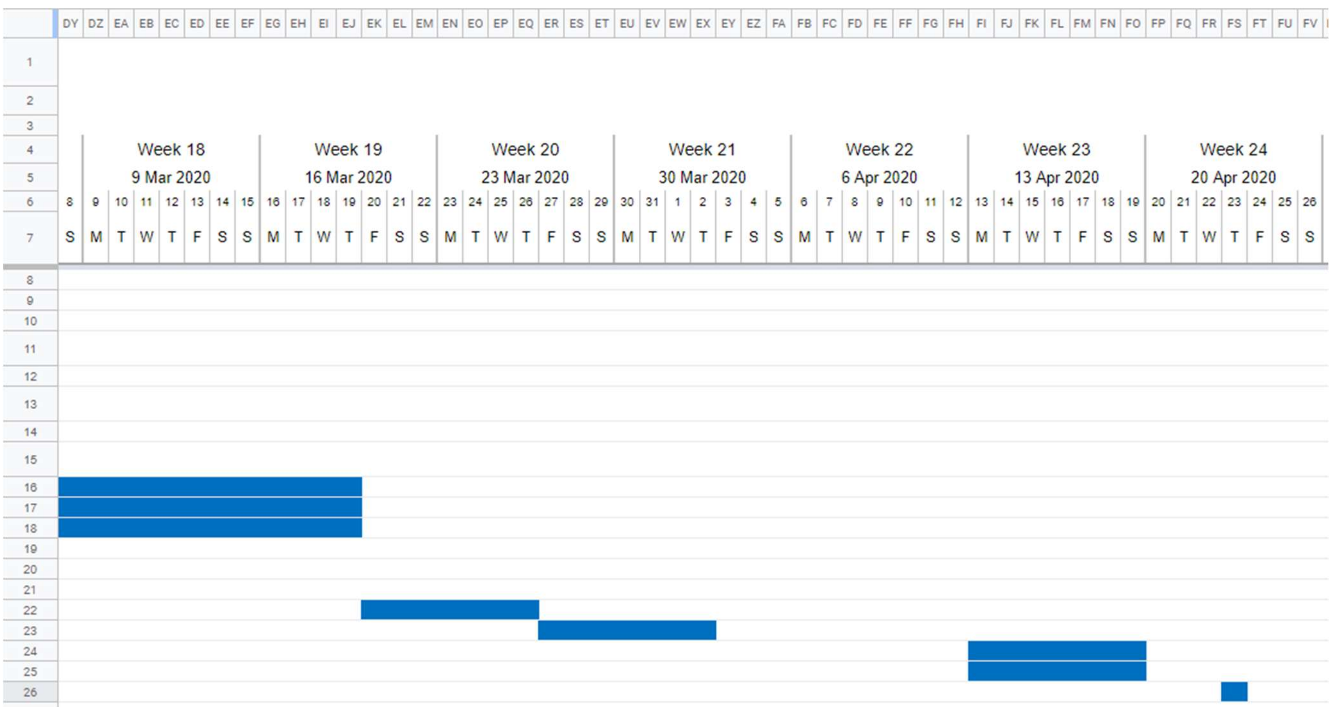
Smart Mirror Project Timeline — Part A. Gnatt Chart

Team Myr R

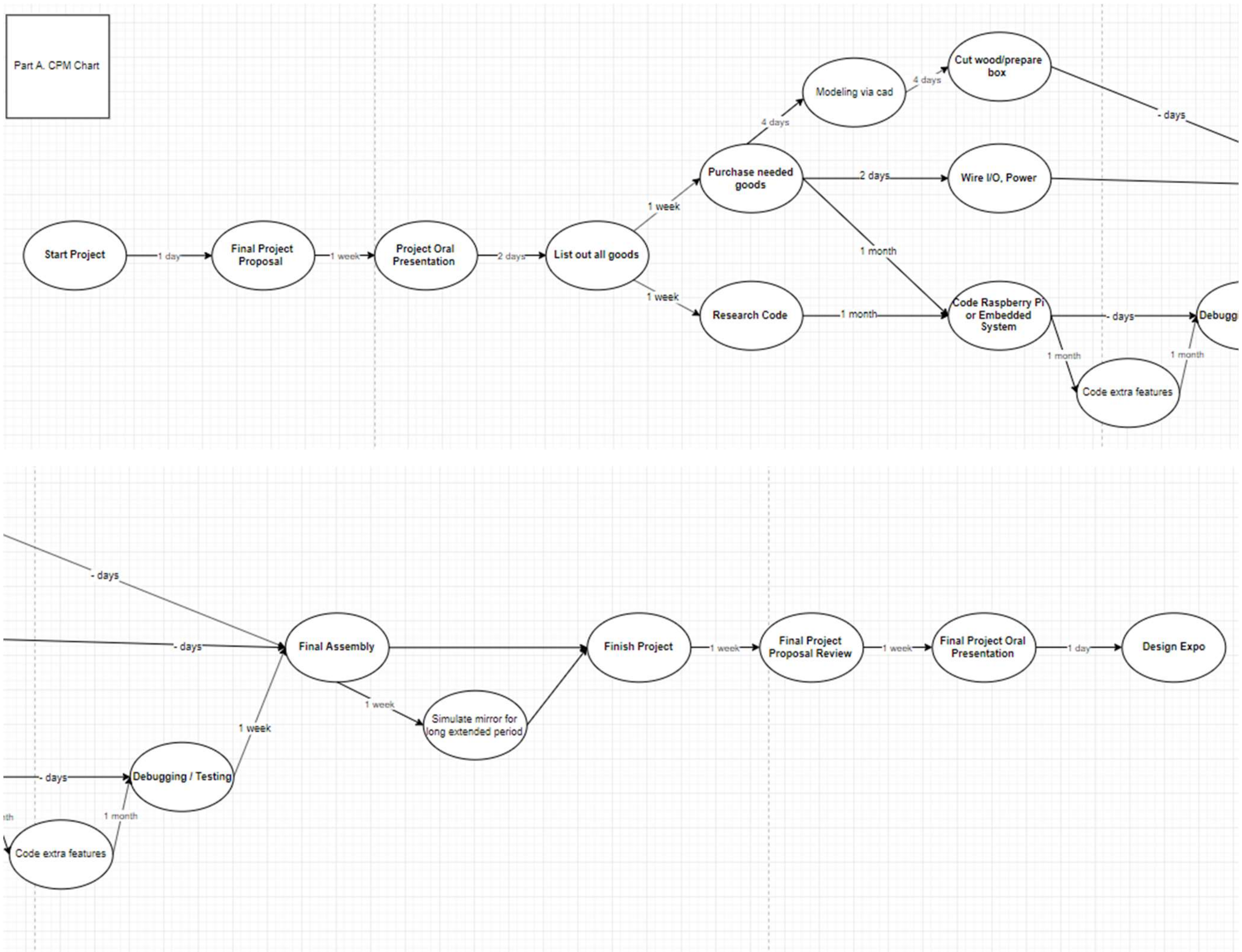
Project Start Date 11/10/2019 (Sunday) — Display Week 1

	TASK	START	END	DAYS	% DONE	WORK DAYS	Predecessor (Based on row number)
8	Final Project Proposal	Mon 11/11/19	Sun 11/17/19	7	0%	5	
9	List hardware goods	Mon 11/18/19	Mon 11/18/19	1	0%	1	8
10	List software goods	Mon 11/18/19	Mon 11/18/19	1	0%	1	8
11	Make sure all goods are correct	Tue 11/26/19	Tue 11/26/19	1	0%	1	9, 10
12	Research platform	Wed 11/27/19	Tue 12/03/19	7	0%	5	11
13	Final Project Review and Oral presentation	Mon 1/06/20	Fri 1/10/20	5	0%	5	8
14	Purchase goods	Mon 1/13/20	Sun 1/19/20	7	0%	5	11
15	Code main Rasperry Pi features	Mon 1/20/20	Tue 2/18/20	30	0%	22	14
16	Code extra features	Wed 2/19/20	Thu 3/19/20	30	0%	22	15
17	Debug Raspberry Pi	Wed 2/19/20	Thu 3/19/20	30	0%	22	15
18	Test Raspberry Pi	Wed 2/19/20	Thu 3/19/20	30	0%	22	18
19	Model using CAD	Mon 1/20/20	Thu 1/23/20	4	0%	4	14
20	Build the box	Fri 1/24/20	Mon 1/27/20	4	0%	2	19
21	Complete power, I/O the wiring	Tue 1/28/20	Wed 1/29/20	2	0%	2	14
22	Final Assembly	Fri 3/20/20	Thu 3/26/20	7	0%	5	18, 20, 21
23	Test for extended period	Fri 3/27/20	Thu 4/02/20	7	0%	5	22
24	Final project oral presentation	Mon 4/13/20	Sun 4/19/20	7	0%	5	23
25	Final Project demonstration	Mon 4/13/20	Sun 4/19/20	7	0%	5	23
26	Design Expo	Thu 4/23/20	Thu 4/23/20	1	0%	1	24, 25





Appendix B: CPM Chart



Appendix C: Risk Assessment

Task Name	Task Lead	Risk Level
Planning, Presentations, Documentation	All	Low
Technical Review Paper	All	Low
Final Project Proposal	All	Low
Parts Ordering	All	Low
PDR Presentation	All	Low
Final Project Review/Presentation	All	Medium
Final Project Demonstration	All	Medium
Final Project Report	All	Low
Hardware	JS, DY	Medium
Model using CAD	JS, DY	Medium
Build the box	JS, DY	Medium
Complete power, I/O, wiring	JS, DY	Medium
Final assembly	JS, DY	High
Software	BF, KP	High
Research Platform	BF, KP	Low
Code main Raspberry Pi features	BF, KP	Medium
Code extra features	BF, KP	High
Debug Raspberry Pi	BF, KP	High
Test Raspberry Pi	BF, KP	Medium