March 31, 2022

Dr. Mike Hegedus
School of Engineering Science
Simon Fraser University
8888 University Dr.
Burnaby, BC

EZ MOVE COMPANY

RE: ENSC 405W/440 Final Project Proposal for EZ Table

Dear Dr. Hegedus,

The following document is the Final Project Proposal for our project, the EZ Table, developed by the EZ Move Company. EZ Table is a remote controlled motorized table for the household designed to transport items within a household and offer space to hold everyday necessities for the mobility impaired.

The purpose of this document is to provide an overview of the project scope, risks and benefits of the project and research of the market we plan to target with this project. Furthermore, this document will dive into our project plans and major milestones, the costs associated with completing the project, as well as an overview of the EZ Move Company including a summary of our teams' core skills.

EZ Move Company has five members: David Song, Sachin Momuli, Faraz Borghei, Trevor Lee, and Tommy Yang. Thank you for taking your time in reading our document. If you have any questions or concerns, please contact our Chief Communications Officer, Sachin, by email at smomuli@sfu.ca

Sincerely,

David Song
CEO
EZ Move Company

Project Proposal

EZ Table

Team

CEO - David Song
CTO - Faraz Borghei
CCO - Sachin Momuli
CFO - Tommy Yang
CIO - Trevor Lee

Contact:

Sachin Momuli - smomuli@sfu.ca

Submitted To:

Mike Hegedus, ENSC 405W
Dr. Andrew Rawicz, ENSC 440
School of Engineering Science
Simon Fraser University

Submission Date:

Mar 31st 2022

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Revision History

Date	**Version**	**Description**
Mar 31st, 2022	1.0	Final Draft (Submission)

Ⅰ. List of Figures

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1. Introduction

Recent advancements in computing technology and robotics have enabled us to explore new avenues of care for seniors and those with disabilities. A recent census done by the government of Canada shows that 83.9% of persons aged 65 and over are living alone [1]. 2.7 million Canadians over the age of 15 have some type of mobility disability, 36.5% of which use a cane, walking stick, or crutches [2]. The need for new methods of care is increasing throughout the developed world, as there is an ever growing proportion of elderly citizens as compared to those of working age [3].

EZ Move Company intends to use our EZ Table product to assist customers who struggle with mobility around their own homes. This group mainly consists of senior citizens, but also significantly includes many younger individuals who have a mobility related disability that requires them to use handheld assistance devices such as canes. While carrying objects, these people will find it difficult to use their assistance devices in conjunction. They are more likely to be unbalanced, and may sustain more injuries in the case of a fall. Between 20% and 30% of Canadian seniors fall each year, even leading to death in numerous cases [4]. Notably, these deaths due to falls have increased by about 30% in the last decade [5].

Our company aims to increase our users' safety while they carry out their daily household activities by helping them safely and easily move objects from one point to another. For example, our product may help users transport their laundry from the laundry machine to their bedroom, or bring them their daily medication without them having to traverse the entire house.

The current situation for many seniors and those with disabilities is that they rely on human carers every day, including health professionals and family members. A third of Canadians with parents 65 or older say their parents rely on them regularly for some kind of assistance [6]. We intend to provide these low mobility customers with the tools to live independently and regain freedom in their lives. These customers are people who are able to move about in some ways, but are lacking a bit of ability that currently prevents them from being able to safely and fully care for themselves without the need for human carers.

1.1 Background

It is projected that sales of service robots for domestic tasks will reach 48.6 million units by 2023 [7]. Service robots are becoming increasingly involved in people's lives in places such as restaurants, hotels, airports all over the world. Robots are even solidifying their place within households as everyday devices with the rising prevalence of robot vacuums and moppers. In a similar vein, smart home ecosystems are becoming more popular, and homes are becoming increasingly interconnected with various devices. Our product is meant to seamlessly integrate into the home, and act as an utilitarian piece of furniture that integrates concepts from these smart home devices and robots to ease the lives of our users.

2. Scope

The scope of this project includes the components and functionality of the EZ Move Table which includes the design, assembly and programming of the device.

The EZ Move Table will be able to transport various necessities around the house with the use of a wireless connection and seamless usage on a mobile device or desktop. This product is designed to assist users that still have relative mobility to place items on/off the table, however would like to minimize the action as much as possible.

The two main tasks that the EZ Move Table will be able to perform are:

1. Move in all 4 main directions (i.e. North, South, East, West)
2. Elevate the table up and down

The product is also equipped with a camera for the user to view the robots movements with low latency. This is necessary in cases where the user is not in the same room as the EZ Move Table.

The EZ Move Table is designed to be operated in single floor homes and can move from room to room within a standard home dimension.

3. Risks and Benefits

3.1 Risks

Since the EZ Table is mainly focused to be used by users on a daily basis, within a household, we need to consider possible risks that we might encounter. Some of the anticipated risks with development and production of the device are discussed below.

Mechanical Issues

EZ Table comprises various electrical and mechanical components such as a Raspberry Pi 400, battery, linear actuator, DC motors, respective drivers and other miscellaneous components. Although there is a test plan in place to thoroughly check these components, there might be unforeseen mechanical issues that the user might encounter, which we, as developers, might have overlooked.

Connectivity

The control of EZ Table is solely dependent on the wireless connectivity between the user device and the table. In a case where the wireless connectivity fails, the user will not be able to control the device remotely. However, users can physically move the device but without the access to camera feedback.

Movement

The friction between the wheels and the floor greatly affects the speed and movement of the EZ Table. EZ Table is designed while keeping in mind the regular surfaces that we find in a household. However, any obstacle or different level of the surface might restrict its movement and the user must manually remove the item in path or reposition the table on a different level.

Durability

The material chosen for the exterior housing of the EZ Table is MDF, which should resist the environment found within the walls of a household. The integration of parts and the overall housing will be robust and durable enough to survive expected day-to-day workload.

3.2 Benefits

EZ Table comes with its own unique benefits that separates it from competitors. Some of the notable benefits that EZ Table offers are as discussed below.

Convenience/Ease of Use

The design and development of the EZ table was performed keeping in mind the relatively low technical expertise of the user. We, as developers, have designed the product to make the operational interface of the EZ table as simple as possible. The EZ table has an adjustable table top which can be used to place objects on top, while reducing the strain on users' backs, if they were to carry them. This would help approach the market with any level of technical expertise, in turn increasing the consumer market.

Minimal Setup

The EZ Table requires a one time setup to connect to the home network and establish interaction with the user’s choice of device. A simple to follow instruction guide will be provided through which instructions are clearly stated in order for users to connect with the device. Once the connection is established, the user should be able to control the movement and view camera feedback from the device.

Wireless Control

Users can remotely control the movement of EZ Table via a browser based application on their choice of device. Once the user has successfully followed through the initial setup instructions guide, the browser client should be activated and should display the camera feedback from the device and enable the movement controls. These will be used by the users to interact with the device.

Health & Safety

As EZ table is aimed to be used within a household, certain safety concerns must be taken into consideration while designing the exterior and interior part of the device. We have chosen MDF as our external housing material which is known to survive any liquid spills and survive the household environment. We have also designed the exterior to be a cylindrical shape so as to minimize sharp corners that users might bump into when interacting with the table.

4. Market

In 2020, revenue from new consumer service robots reached 4.4 billion U.S. dollars, a growth of 16% from the previous year which resulted in a total of 18.5 million units sold [8]. However, considering that a vast majority of the units sold were from cleaning robots such as robot vacuums, it is still uncertain how much of this market will be receptive to an item transport robot. Industry data reveals that there are 211 companies currently developing robots for indoor environments without public traffic [9], indicating that this is a growing sector of the consumer service robot market, and may soon become a significant source of revenue once there is further development and widespread adoption.

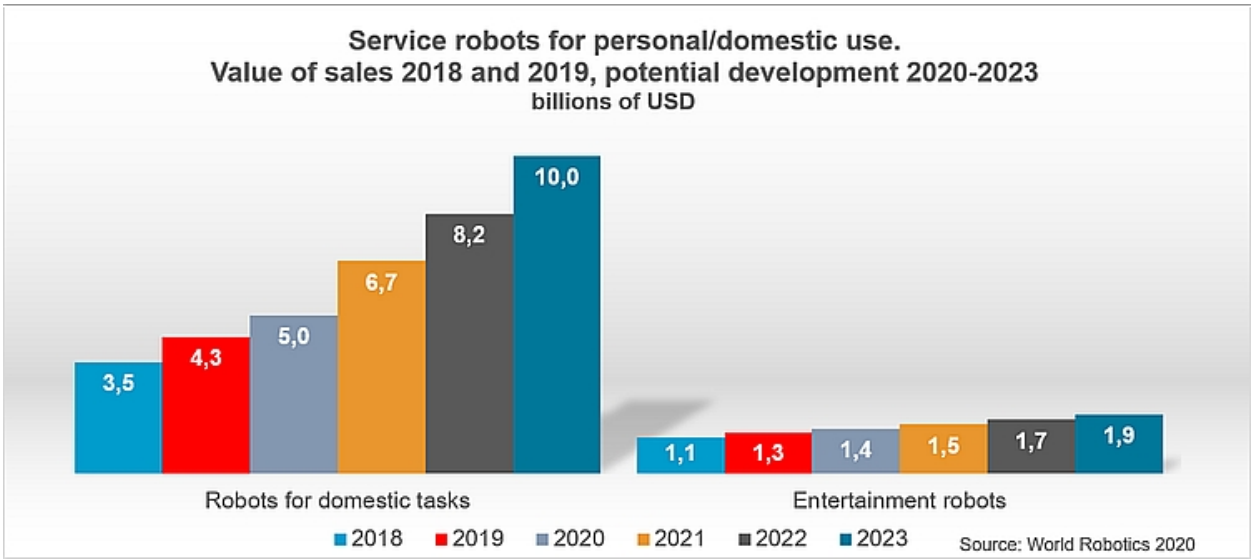

Figure 4.1: Service robot value of sales 2018 - 2023 [10]

As for our customer base, it is noteworthy that the majority of users of our product will come from the elderly, defined as those of age 65 and over. This is a quickly growing segment of Canada's population that consists of 17.2% of the population in 2018, and potentially increasing up to 29.5% of the population by 2068 [11]. With such an enormous percentage of elderly residents, the need for care of this group will undoubtedly expand accordingly. The projected decrease in the proportion of the working age population alongside the increase of the aged population [11] will create urgent demand for alternatives to human-to-human care solutions.

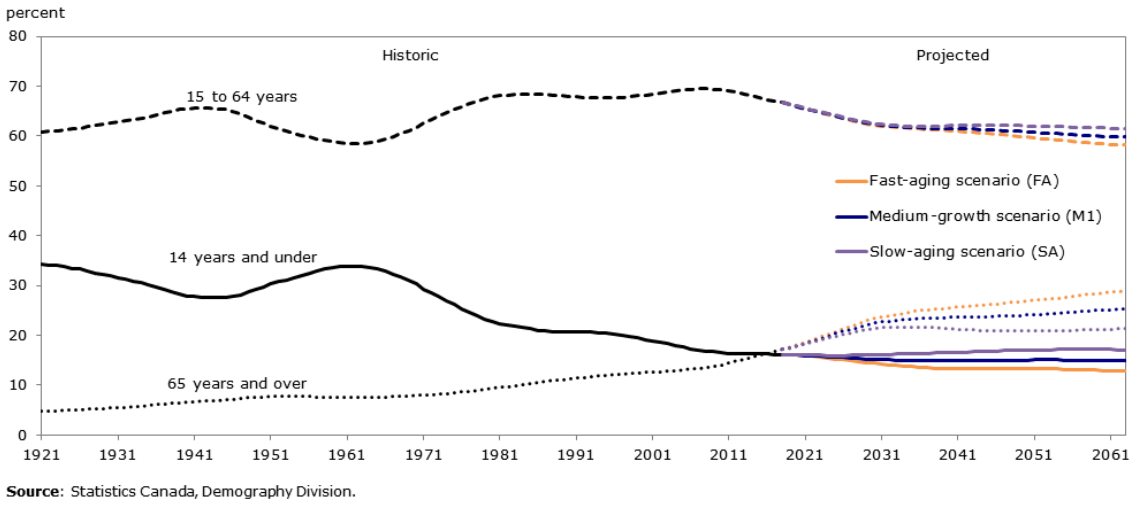

Figure 4.2: Distribution of population by age group, Canada [11]

4.1 Competition

The main competition in the market consists of two major categories: products that are currently being targeted towards business purposes, and products that are still in development for the home use consumer market.

Firstly, there are many companies that are supplying service robots to customer-facing businesses such as hotels, restaurants, and airports. As these products develop and the technologies mature, they will undoubtedly become more cost efficient and will eventually be able to be marketed directly to consumers. Some of these competitors are shown below.

Savioke “Relay”: Room deliveries to guests of hotels [12]

Figure 4.3: Savioke “Relay” [12]

Pudu “BellaBot”: Robot server for restaurants [13]

Figure 4.4: Pudu “BellaBot” [13]

The second major competitor category is home use butler robots that are currently still under development. These are still in the conceptual and prototype phases and may be years off from a product that can adequately address the consumer market, but are nonetheless being actively worked on by many companies.

Samsung “Handy”: Robot for household chores that can pick up a single object [14]

Figure 4.5: Samsung “Handy” [14]

Toyota “Gantry robot”: Ceiling-mounted home robot [15]

Figure 4.6: Toyota “Gantry robot” [15]

An analysis of our competitors reveals that they are consistently expensive, high tech solutions that rely on huge amounts of automation and artificial intelligence. However, with this increased reliance on automation, the outcome is a product which is expensive and difficult to understand for customers who are not technologically skilled. In addition, they are far too large to be conveniently used in a home setting. Our advantage over these competitors is that our robot will provide far simpler functionalities for a lower price and offer direct control to our users.

5. Project Planning

The capstone project consists of two parts which are four months in duration each. The first part of the capstone project focuses on the documentation, and user interface design, and group dynamics. It mainly involves detailed documentation in the design requirements, and specifications for the project. The first part of the capstone project will end with a working proof of concept. The second part of capstone is heavily focused on improving the work done in part one, which involves improving the working proof of concept into a prototype which is closer to production. The two parts of capstone will each have their own milestones which must be met following consecutive completion of each milestone. Project planning will allow for major processes to be detailed with their planned completion dates. It should be noted that for all major milestones, the planned due date will always be a few days ahead of the actual due date, this is so that we can catch and fix errors before milestones are due.

5.1 Proposal Draft

The proposal draft which involves defining the problem statement, and the target market was set to be due Jan 27 2022. Our team which was formed in the first week of capstone planned on getting the proposal finished by Jan 25 2022. It was important that we planned ahead in completing the proposal before the due date, this is because many project ideas were initially brought up, and finalizing our proposal early would allow us to notice any potential roadblocks. If roadblocks were identified it would allow us some time to change our proposal draft which is our first major milestone for the capstone project.

5.2 Predicted PoC Gantt Chart Timeline

The following figures display our actual timeline for completing the proof of concept of the EZ Move Table. The gantt chart is split up into three images for easier reading and formatting into the document.

TASK TITLE	START DATE	DUE DATE	DURATION
Initial Design	1/11/22	2/16/22	35
Project Selection	1/11/22	1/27/22	16
Progress Meeting #1	1/27/22	2/10/22	13
Requirement Specs Due	1/27/22	2/13/22	16
Design Complete/Review	2/13/22	2/16/22	3
Draft of Design Specifications, UI Specifications, and 440 Planning Appendix	2/13/22	3/31/22	48
UI Appendix Due	2/13/22	3/3/22	20
Design Specifcations Due	3/3/22	3/13/22	10
440 Planning Appendix Due	3/3/22	3/13/22	10
Proof of Concept	2/16/22	4/12/22	56
Parts ordering	2/16/22	3/13/22	27
Progress Meeting #2	2/16/22	3/10/22	24
Construction of Proof of Concept	3/13/22	4/12/22	29

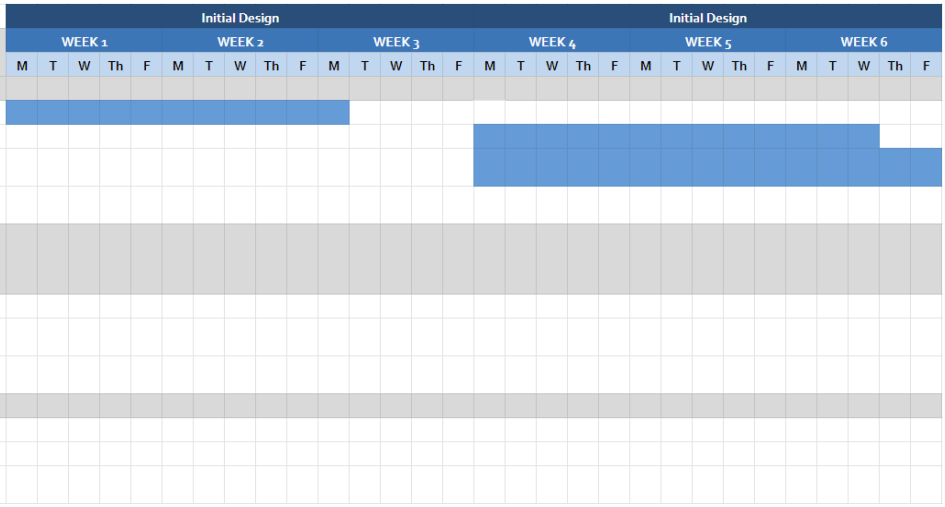

Figure 5.1: Predicted - Initial Design section of Gantt Chart

TASK TITLE	START DATE	DUE DATE	DURATION
Initial Design	1/11/22	2/16/22	35
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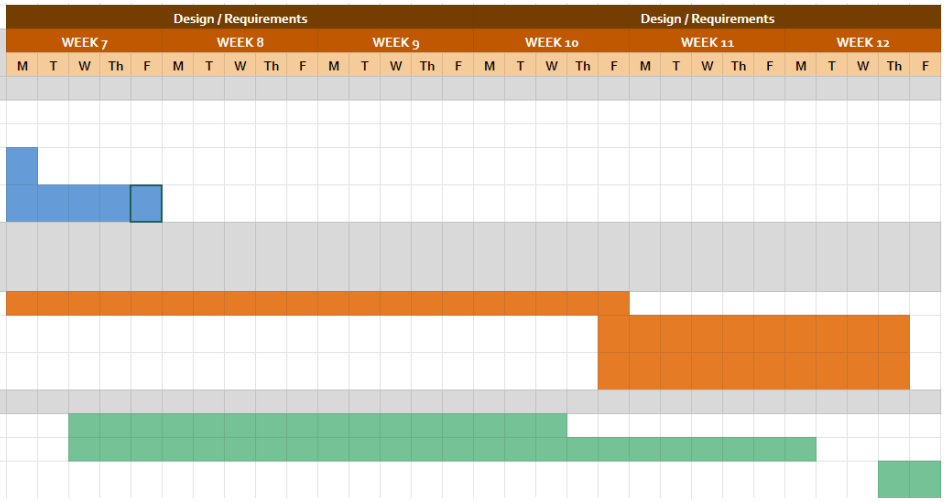

Figure 5.2: Predicted - Design / Requirements section of Gantt Chart

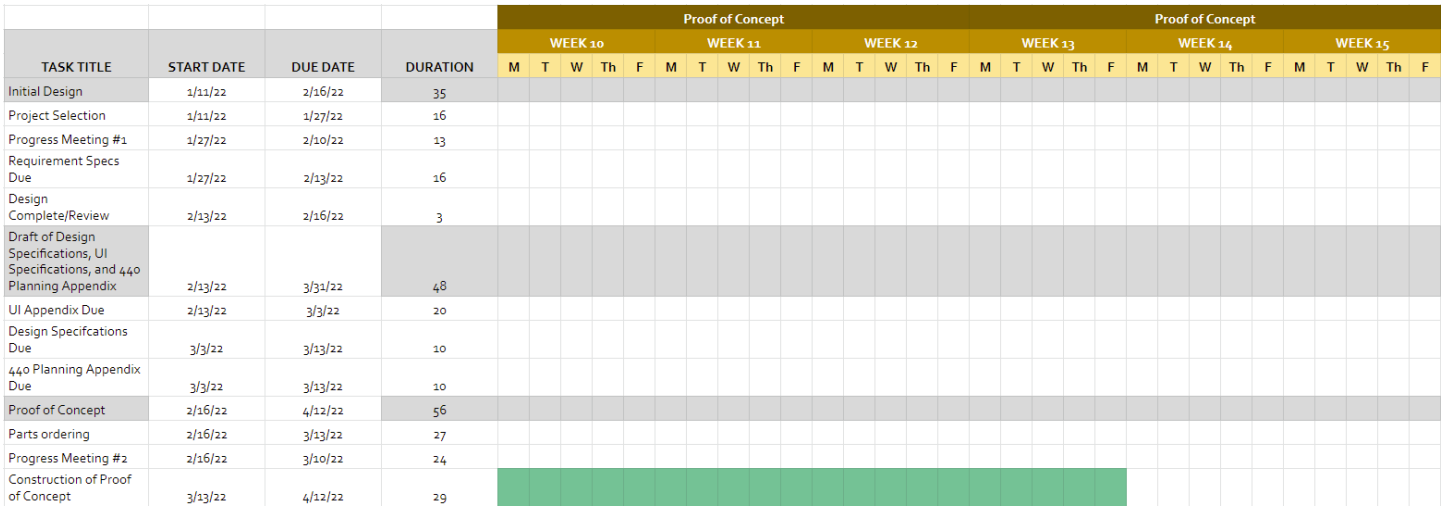

Figure 5.3: Predicted - Proof of Concept section of Gantt Chart

5.3 Actual PoC Gantt Chart Timeline

The following figures display our predicted timeline for completing the proof of concept of the EZ Move Table. The gantt chart is split up into three images for easier reading and formatting into the document.

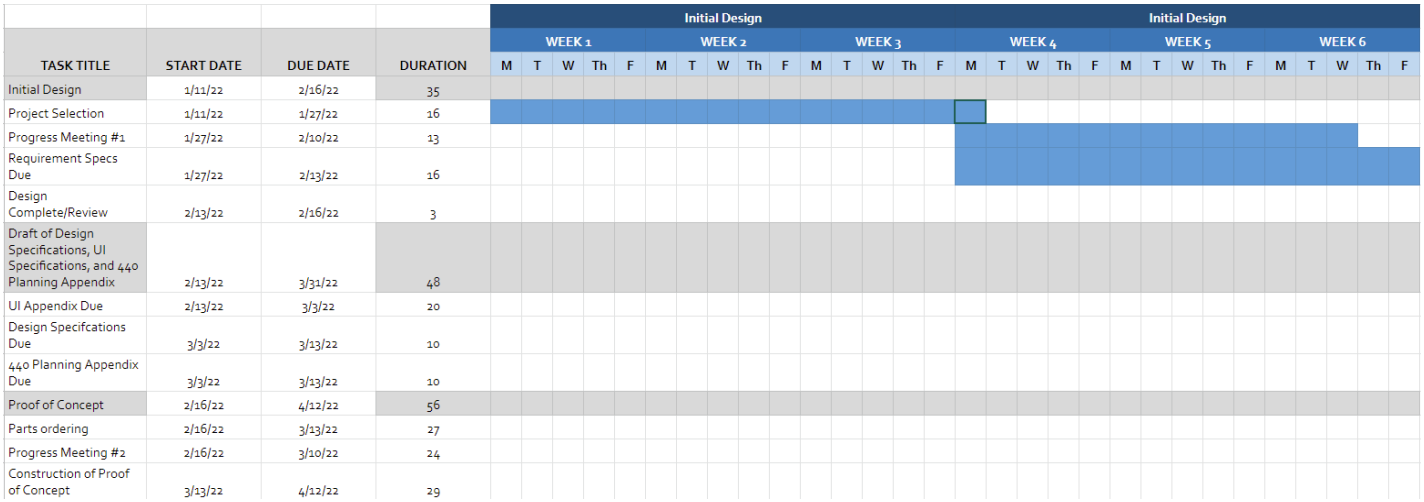

Figure 5.4: Actual - Initial Design section of Gantt Chart

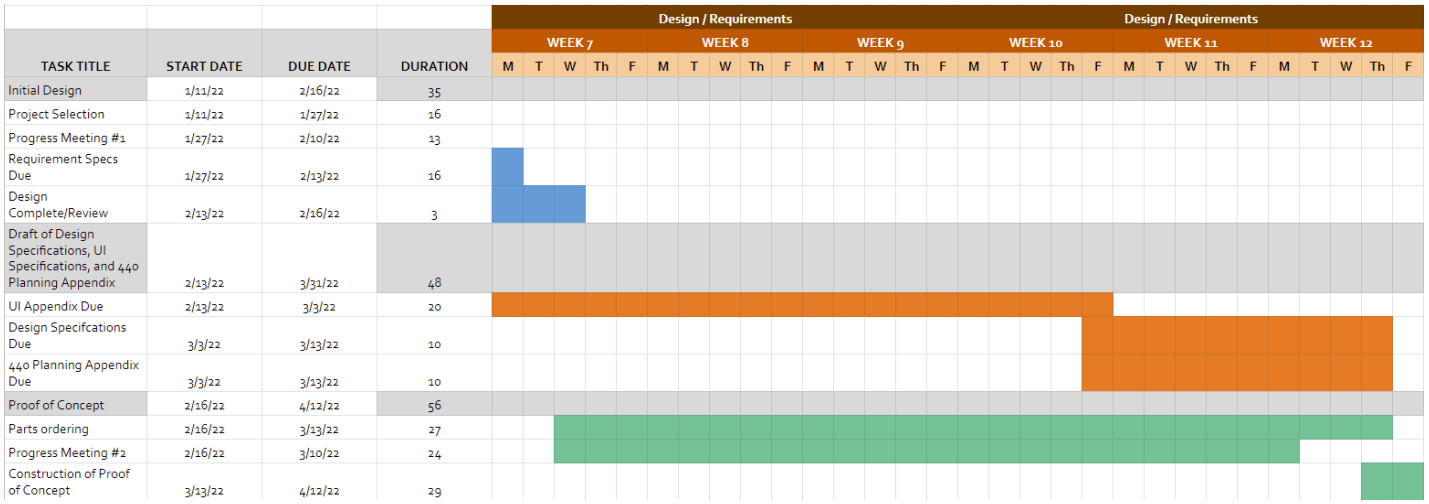

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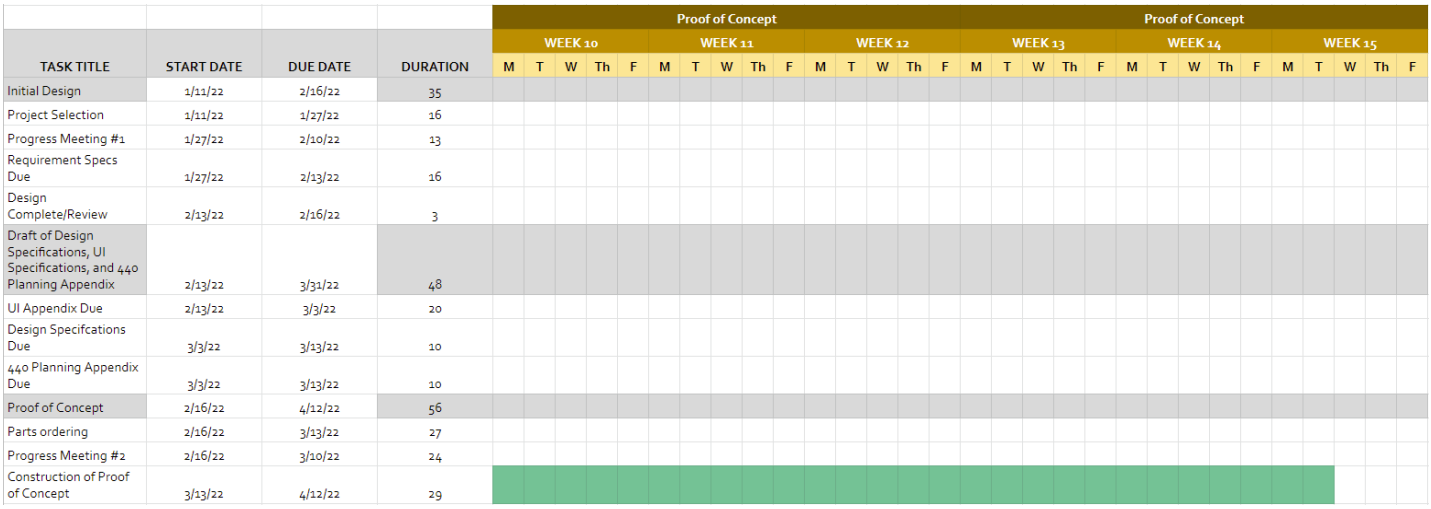
Figure 5.5: Actual - Design / Requirements section of Gantt Chart



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Construction of Proof of Concept	3/13/22	4/12/22	29

Figure 5.6: Actual - Proof of Concept section of Gantt Chart

6. Cost Considerations

6.1 Estimate of Costs for proof of concept

The EZ Table's costs for the prototype of proof of concept which is to be showcased April 12th 2022 is detailed below

Part	**Description**	**Total Cost $(CAD)**
Microcontroller	Raspberry Pi 400	120.00
Motors x2	120W Brush DC Motor High Speed	126.28
Battery	Rechargeable SLA Lead Acid	30.00
Linear Actuator	Artilife Linear Actuator	70.00
Motor Drivers x2	Cytron Motor Driver	52.51
Camera	PAPALOOK AF925 Webcam	50.00
Wheels x2	Semi Pneumatic Wheels	26.00
Wheel Hubs x2	Flange Coupling Connector	6.50
Electrical Wires	Jumper Wires	13.00
EZ Table Hardware Material	Standard Hardboard Handy Panel	43.00
Miscellaneous	Caster wheels, Brackets, Screws	30.00
Sum of all Parts		567.29

Table 6.1: Estimate of costs for the proof of concept for EZ Table

6.2 Estimate of costs for final functioning prototype

The EZ Table's cost for the final functioning product with ideal parts is detailed below

Part	**Description**	**Total Cost $(CAD)**

Microcontroller	Raspberry Pi 400	120.00
Motors x2	120W Brush DC Motor High Speed	126.28
Battery	Lithium Ion Battery	240.00
Linear Actuator	Artilife Linear Actuator	70.00
Motor Drivers x2	Cytron Motor Driver	52.51
Camera	PAPALOOK AF925 Webcam	50.00
Drive Wheels x2	Semi Pneumatic Wheels	26.00
Wheel Hubs x2	Flange Coupling Connector	6.50
Electrical Wires	Jumper Wires	13.00
EZ Table Hardware Material	Standard Hardboard Handy Panel	43.00
Miscellaneous	Caster wheels, Brackets, Screws	30.00
Sum of all parts		777.29

Table 6.2: Estimate of costs for the final functional prototype design

6.3 Potential Funding Sources

6.3.1 Engineering Science Student Endowment Fund

The Engineering Science Student Society has a fund which is awarded to projects provided that they meet certain criteria. Projects can fall into four different categories which are competition, entrepreneurial, class, and miscellaneous. We believe that the EZ Move Company can satisfy the criteria of these four categories given the working prototype of the EZ Table, and the detailed documents and business plan.

6.3.2 Wighton Development Fund

The Wighton Development Fund is awarded when a proposal is submitted to Dr Andrew H. Rawicz. The proposal is a document which details the project's purpose and scope, as well as the intended market outlook, and the budget of the project.

6.3.3 Engineering Science Student Society Parts Library

The parts library hosted by the engineering science student society has a collection of items available from previous projects. By checking the parts library, and borrowing items to use in the project, we will be able to reduce the budget towards completing the proof of concept prototype.

6.3.4 Personal Funding

Personal Funding will be funds which come out of team member's pockets at their own expense. Certain miscellaneous items which may not be covered by the above funding sources will be done so by the team members. The personal funding will be split up equally among all members.This is to ensure equal responsibility for the project, which all team members have agreed on.

7. Company Overview

Figure 7.1: Company Logo for EZ Move Company

David Song - Chief Executive Officer

David is in his sixth year of Engineering Science at Simon Fraser University, with a concentration in computer engineering. He has industry experience in various testing and product validation roles, with experience in developing, documenting, and executing manual and automated tests. David hopes to develop his skills around aspects of project design, including planning, management, and documentation.

Faraz Borghei - Chief Technical Officer

Faraz is a senior Computer Engineering student at Simon Fraser University. Faraz has some technical experience with PCBs and hardware design contributing to the Team Phantom electric race vehicle, as well as has some web development and python experience to add to the table. In his spare time, he likes to snowboard, go to the race track and play video games.

Sachin Momuli - Chief Communications Officer

Sachin is a final year Computer Engineering student at Simon Fraser University. He has co-op work experience in managing and writing automated test scripts in C++ and Tcl/Tk for hardware testing and building a cross platform desktop application. He has also worked as a research assistant, focusing on degradation of pixels in DSLR cameras over a period of time and writing formal documentations on the projects that he’s worked on. Sachin aims to widen his skills of expertise in different aspects by learning and contributing to various projects.

Tommy Yang - Chief Financial Officer

Tommy is currently a 5th year student with a specialization in Systems Engineering. He chose systems for specialization due to his interests in the mechanics, and business of engineering. This ranges from anywhere to robotics to computer-aided design and manufacture. He has experience working with small projects which usually results in a working prototype which provides valuable hands-on experience in the design of engineering. Most importantly, Tommy is very passionate about teamwork based engineering, because it allows him to learn from his peers.

Trevor Lee - Chief Information Officer

Trevor is a 6th year Electronics Engineering student at Simon Fraser University. He chose this specialization due to garnering an interest in computer hardware at a young age. He has a year's worth of co-op experience working in IT, as well as experience setting up home and small business networks as an IT contractor. Trevor aims to widen his skills working with various technologies whilst applying his skills to the current project.

8. Conclusion

Based on the market research done by our company, 83.9% of people aged 65 and over are living alone [1] and 2.7 million Canadians over the age of 15 have some type of mobility disability, 36.5% of which use a cane, walking stick, or crutches [2]. By offering our product, EZ Table to the market, we will assist individuals who are likely to struggle with picking up and moving objects. The fact that between 20%-30% of Canadian seniors fall each year, sometimes leading to death [4], and we have seen a 30% increase of these types of deaths in the last decade [5] shows us that our product can help make it both safer and easier for our customers to live independently.

The main objective of EZ Move Company is to build EZ Table as a means to reduce the strain on the back or hips of the users, while needing to move an object within a household. Although this device can be used by anyone, it is mainly focused on elderly people who are living alone and are dependent on other caretakers to move objects around in the household. EZ Table aims to solve this by providing an option to place the object on the adjustable tabletop, in order to safely transport to the destination, without the risk of toppling over.

This document includes the introduction and background to the problem EZ Table aims to solve, followed by the scope of the device. Respective risks and benefits are also discussed which are related to the development and production of EZ Table. It is then followed by the market analysis, competition and proposed planning schedule from initiation to the final product. This document also discusses the proposed cost estimations, along with potential funding sources. Brief introduction of the team members & roles, along with respective areas of expertise within EZ Move Company is also described. With the EZ Table, we hope to provide a means to reduce strain on senior individuals, who live alone and have to frequently move items around in the house.

9. References

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