February 13, 2022

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

RE: ENSC 405W/440 Requirements Specification for EZ Table

Dear Dr. Hegedus,

The following document was prepared by EZ Move Ltd. for ENSC 405W: Capstone A, and details the requirements specifications for our product, the EZ Table. The primary goal of our project is to create a remote controlled motorized table, targeted towards people with mobility impairments in order to transport and store commonly used household items. EZ Table is focused towards supporting individuals who will use the device on a daily basis in a home environment.

EZ Table will be equipped with a vertical height adjustable tabletop, which is meant to increase the reachability of the tabletop and further reduce the stress on back and hips of the user. Video feed from the camera will be relayed back to the user on a mobile application, for scenarios where the product is not under direct vision of the user.

This requirements specification document will outline all the requirements that need to be met for our proof-of-concept, engineering prototype and production versions. These include general system requirements, as well as user interactivity, hardware, and software.

Thank you for your time in reviewing our requirements specification for the EZ Table. For any further questions or concerns, please contact our designated Chief Communications Officer, Sachin at smomuli@sfu.ca.

Sincerely,

David Song
CEO
Ez Move Ltd.

Requirements Specification

EZ Table

Team

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Submitted To:

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Submission Date:

Feb 13th 2022

Abstract

The EZ Table is a robot designed by the EZ Move Ltd. which aims to assist users move daily household items from one point of the house to another, remotely. It is a system which comprises a base housing a battery, components for movement, vision and processing. The EZ Table includes a tabletop, which is height adjustable and offers a compartment for storage of day-to-day items. The EZ Table will be controlled remotely through a web browser application designed in a way which is simple and intuitive to use for the target market.

This document details the requirements specification for the EZ Table. It will first introduce the EZ Table, followed by describing why there is a need for this product, and who the target market is. Then it will go over the system overview with block diagrams to show how the hardware and software components come together.

The document will then continue to describe the requirements that the EZ Table hopes to meet over the duration of the development. It will describe the requirements in four subsections which are General system requirements, Interactive requirements, Hardware requirements, Software requirements. Then the document will go over the Safety requirements and the Sustainability of the EZ Table. It will then conclude by mentioning the Engineering Standards that EZ Table adheres to. The document aims to give the reader an understanding of the EZ table, and what it hopes to achieve. A proof of concept and the deliverables will be specified near the end of the document for the EZ Table which will be showcased on April 14th 2022.

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Revision History

Date	Version	Description
Feb 11th, 2022	1.0	Creation of Document
Feb 12th, 2022	1.1	First Draft
Feb 13th, 2022	1.2	Final Draft (Submission)

Ⅰ. List of Figures

Ⅱ. List of Tables

Glossary

The following table lists a brief explanation of some terms used in this document.

Term	**Description**
Raspberry Pi	Microcomputer selected for use in this product.
Users	Customers who will operate the robot through a user interface.
Device	A complete hardware unit of the mobile robot product.

1. Introduction

With the introduction of *EZ Move Ltd.*'s flagship mobile robot table, EZ Table, our company aims to provide users with tools and assistance so that they can live independently in their own homes. The EZ Table will give users a convenient place to store their daily necessities and a sturdy surface to place items on, available wherever and whenever through an intuitive web interface. The product consists of a base which contains components for power storage, movement, vision, and processing, and the tabletop which can be raised or lowered and offers a compartment for easy storage.

Our product provides customers with a safe and easy way to enhance their ability to care for themselves through supporting their mobility needs.

1.1 Background

In Canada and many other countries throughout the world, we are faced with a steadily growing proportion of elderly citizens and a lack of adequate care for the needs of seniors and other individuals with mobility impairments.

- 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 [1].
- Over a quarter of seniors over 65 years old in Canada live alone [2].
- Between 20% and 30% of Canadian seniors fall each year [3].

Falls can become life altering events for seniors, even leading to death in numerous cases[3]. The principal objective of our product is to minimize the amount of walking and carrying needed to be done by seniors and mobility impaired individuals, so that both their risk of injury and the effort required to go about their daily lives is reduced.

As a large component of our target market is elderly people, EZ Move Ltd. plans to develop our solution, the EZ Table, with ease of use as a priority so that users can easily and intuitively learn to operate the device.

1.2 Scope

This document will present an overview of the main requirements for the EZ Table project separated into developmental stages for proof-of-concept, prototype, and product. The document will consider the general, interactive, hardware, and software specifications required to meet EZ Move Ltd.'s objectives for the successful introduction of the EZ Table to the consumer market. The document will also consider requirement specifications in the areas of safety and sustainability, as well as regulatory and industry standards.

1.3 Intended Audience

This document is intended for the use and analysis by members of the company EZ Move Ltd. as well as instructors of the ENSC 405W and ENSC 440 courses at Simon Fraser University including Dr. Michael Hegedus, Dr. Andrew Rawicz, Dr. Craig Scratchley, and any associated teaching assistants. The intended audience consists of individuals familiar with technical writing and are typically knowledgeable in the engineering topics touched upon by these specifications.

2. System Overview

The EZ Table is a self-contained motorized table cabinet capable of being remote controlled by a user over WiFi. Capable of carrying lightweight, everyday necessities, the robot is designed for easy operation for the less technically inclined or the elderly.

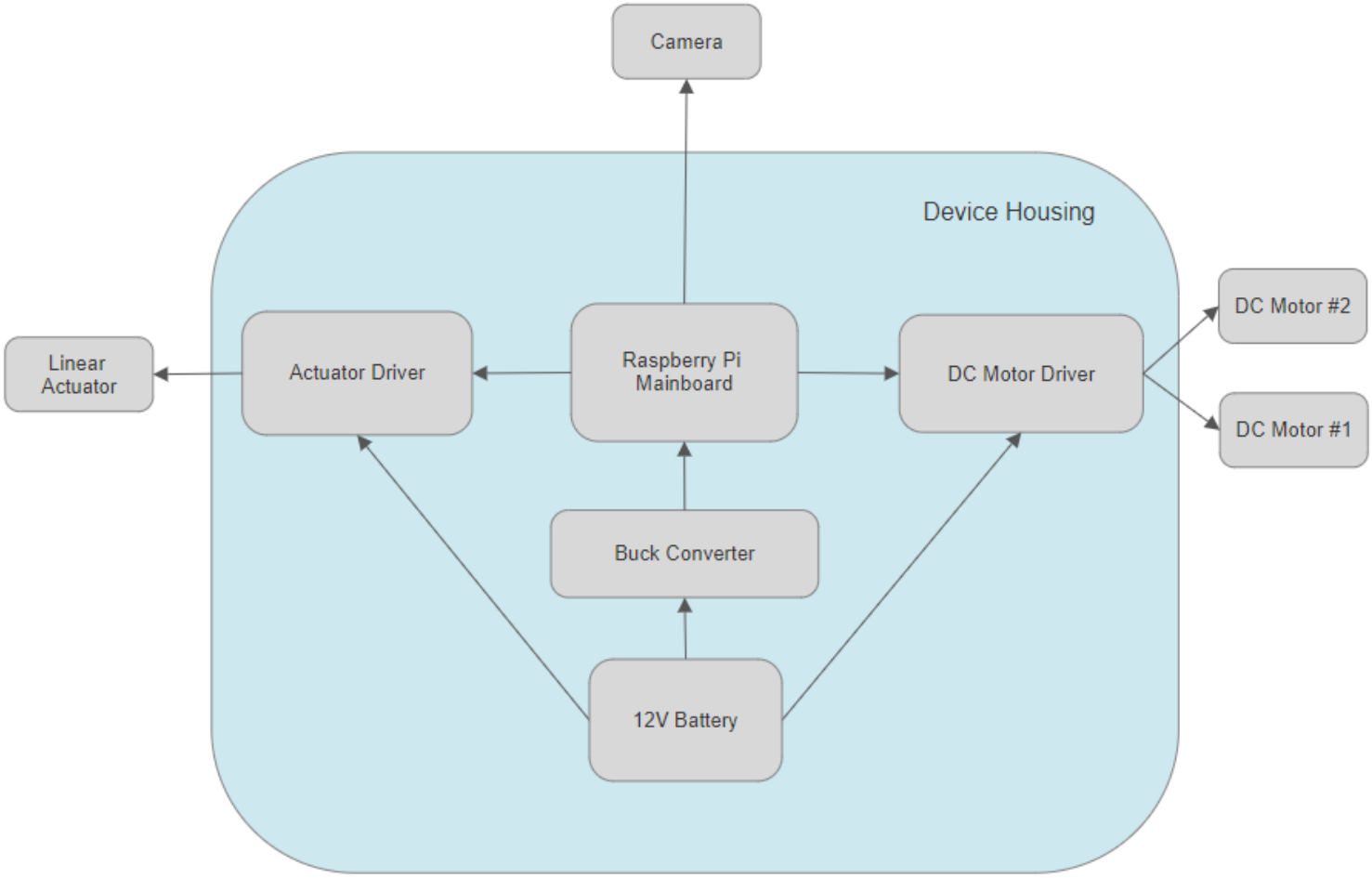

Figure 2.1 *System Overview of the EZ Table*

The diagram in *Figure 2.1* shows the block diagram for the EZ Table. The controller of choice is the Raspberry Pi, due to its increased processing power over other microcontrollers as well as the built-in WiFi functionality. Two DC motor driver circuits are used to move the robot and a camera is connected, to provide the user a live video feed. The system is powered by a rechargeable 12V battery. The system will be controlled by the user through a web-interface accessible through the local WiFi network hosted on the Raspberry Pi. This connectivity is demonstrated in *Figure 2.2.*

Figure 2.2 *Software Connectivity*

3. Requirements

This section will list the various requirements that should be met during the design and development of the EZ Table.

The labeling schema that will be used to define each requirement specification is as follows:

[Req X.Y.Z-Phase]

X - Section
Y - Subsection
Z - Requirement Number
The encoding for 'Phase' is as shown in *Table 3.1* below

Encoding	Development stage
A	Alpha (Proof-of-Concept)
B	Beta (Engineering Prototype)
C	Production Version

Table 3.1 *Development Stage encoding*

3.1 General System Requirements

The general system requirements that the EZ Table must attain for a successful project are shown in Table *3.2.*

Requirement ID	Requirement Description
Req 3.1.1-A	The system must consist of a microcontroller, battery, camera and a compatible software application.
Req 3.1.2-A	The device must fit within the average household door dimensions. (36X80 inches[4])
Req 3.1.3-A	The device must be under 3 feet high when the tabletop is lowered.
Req 3.1.4-B	The tabletop on the device must lift up to 2 feet from the minimum possible height of the device.
Req 3.1.5-C	The device must be marketed with a price lower than $800.

Req 3.1.6-B	The device must have a battery life of at least 1 hour when in active use.
Req 3.1.7-B	The device must have a battery life of at least 8 hours when idle.
Req 3.1.8-C	The device must have an option to replace tabletop of different shapes.
Req 3.1.9-A	The device must be stable at rest with 2 wheels and ball caster(s).
Req 3.1.10-A	The device must be able to operate at the speed of at least 1 m/s.
Req 3.1.11-A	The device must have a zero turning radius.

Table 3.2 *List of General System Requirements*

3.2 Interactive Requirements

The *Table 3.3* belows lists the requirements for the EZ Table for successful user interactivity. This section emphasizes the usability of the device towards the end user, including factors of practicality, accessibility, and ease of use.

Requirement ID	Requirement Description
Req 3.2.1-C	The device must not require physical supervision during operation, such that a user may control it when not in view of the device.
Req 3.2.2-B	The device must have at minimum 3000 cm^3 of storage space for items to be placed in.
Req 3.2.3-B	The device must have at minimum 500 cm^2 of surface area for items to be placed on.
Req 3.2.4-A	The device must be able to relay camera data back to the client application.
Req 3.2.5-C	The average user must be able to operate the device with less than 5 minutes of tutorial.
Req 3.2.6-C	The average user must be able to set up the device on first time use within 10 minutes.
Req 3.2.7-B	The storage space must be easily accessible.

Table 3.3 *List of Interactive Requirements*

3.3 Hardware Requirements

Table 3.4 below lists the hardware requirements for the EZ Table to function properly. In order to offer our users a sufficient and useful storage delivery solution, our device must be capable of carrying items successfully and operate in the scope of a household environment.

Requirement ID	Requirement Description
Req 3.3.1-B	The combined motors and actuator must be able to support moving and lifting a system weighing up to 50lbs.
Req 3.3.2-A	The camera on the device must have a field of view of at least 45 degrees.
Req 3.3.3-A	The wheels must be able to drive across all common household flooring without slipping.
Req 3.3.4-A	Battery should be able to power all motors, sensors, and the microcontroller at the same time.
Req 3.3.5-B	Battery must charge from 50% to 100% within 8 hours.

Table 3.4 *List of Hardware Requirements*

3.4 Software Requirements

The EZ Table features a video feed and remote control accessible through a web application. Due to this, there are several requirements pertaining to the application that will be running both on the client side, as well as the server running on our microcontroller. Base requirements for the software application are as shown in *Table 3.5* below.

Requirement ID	Requirement Description
Req 3.4.1-B	The application must be simple enough for elderly people to use without outside help.
Req 3.4.2-B	The application must connect to the device within 30 seconds.
Req 3.4.3-B	The latency between the server and client should be manageable; maximum latency at 500msp.
Req 3.4.4-B	The application should display clear and concise error messages in case of an issue or invalid user action.
Req 3.4.5-B	The server should start processing requests within 20 - 30 seconds of

	the device being turned on.
Req 3.4.6-B	The average user must be able to use the device with little to no tutorial.

Table 3.5 *List of Software Requirements*

4. Safety and Sustainability

With increasing advancements in technology, environmental concerns have also been increasing. Technological development has heightened the degree of convenience in our day-to-day tasks. However, the benefits have consumed Earth's finest materials. As a response to environmental concerns, EZ Table will follow sustainability-friendly solutions as listed below.

Requirement ID	Requirement Description
Req 4.0.1-C	Table and housing are rounded with no sharp corners.
Req 4.0.2-B	Maximum table speed is limited to prevent injury and damage to the environment.
Req 4.0.3-B	Users must not be able to operate the device when it is charging.
Req 4.0.4-B	The device must not be set in motion while the tabletop is in maximum possible height.
Req 4.0.5-C	Packaging of the device must use recyclable products.
Req 4.0.6-C	The device must use electronic components that follow standard electronic recycling processes.
Req 4.0.7-C	The housing of the components within the device must be enclosed in a recyclable plastic.
Req 4.0.8-C	The electrical components must be safely located in their respective allocated space with no movement, when the device is in motion.

Table 4.1 *List of Safety and Sustainability requirements.*

4.1 Toxic Material Avoidance

Toxic materials such as brominated flame retardants (BFRs) and polyvinyl chloride (PVC) are heavily used in making electronic devices [5]. EZ Move Ltd. will avoid the use of any such materials in production of EZ Table.

Requirement ID	Requirement Description
Req 4.1.1-C	Device must not contain any toxic materials for humans.
Req 4.1.2-C	Device must not contain any toxic materials for the environment.

Table 4.2 *Requirements for avoiding toxic materials*

5. Engineering Standards

This section will specify the engineering standards that will be met by EZ Table. Since the EZ table comprises electrical components including battery, the EZ table should adhere to following standards listed in *Table 5.1.*

Standard ID	Standard Description
CSA C22.2 NO. 0.23-15	Canadian Standards Association: General requirements for battery-powered appliances.
CSA C22.2 NO. 0:20	Canadian Standards Association: General requirements — Canadian Electrical Code, Part II.
S.C. 2010, c. 21	Canada Consumer Product Safety Act.
ISO 13482:2014	Robots and robotic devices -- Safety requirements for personal care robots.

Table 5.1 *List of Engineering Standards for Electrical Components*

The standards for wireless connectivity that EZ table should follow are as listed below in *Table 5.2*.

Standard ID	Standard Description
RSS-Gen	General Requirements for Compliance of Radio Apparatus.
CSA ISO/IEC/IEEE 8802-11:19	Wireless LAN medium access control (MAC) and physical layer (PHY) specifications.

Table 5.2 *List of Engineering Standards for Wireless Components*

6. Conclusion

This document describes the functional requirement specifications of EZ Table, that needs to be met with proof-of-concept, by May 2022 and for engineering prototype, by end of August 2022.

Ultimately, EZ Move Ltd.'s goal for the EZ Table is to be an assistive robot which can help make daily household tasks such as moving items from one point of the house to another easier for people who have trouble doing so. EZ Move Ltd. hopes that the EZ Table can achieve this by being intuitive to use, user-friendly through scientific development, and with careful consideration of the target market in mind. The company plans to achieve this by carefully considering the system, interactive, hardware, software, safety and sustainability requirements. The system requirements which are detailed in the document will come together as one whole complete system which will assist with daily household living for people with low mobility.

We truly wish that our EZ Table will be able to provide a home solution for people with low mobility when moving around the house. The company will bring forward an affordable product that has been engineered with many functional requirements and designed to be efficient, while not being intrusive in the home enviornment.

7. Appendix

7.1 Proof of Concept Deliverables

For the proof-of-concept poster presentation demo which is held on Apr 14th, 2022, EZ Move Ltd. is planning to showcase the following critical features and functionalities of EZ Table:

- Remote control of the motor movement through a web application
- The transmittal of camera feedback to the user
- Device should have no turning radius
- Device will drive across common household flooring in a controlled manner
- Motors, sensors, and the microcontroller will be powered through an onboard battery

To successfully achieve above listed features for the proof-of-concept demo, potential challenges that needs to be addressed are described below:

- Precise placement of the wheels and it's respective motors to meet the requirement of having no turning radius as well as stability in the resting/idle state
- Connectivity issues with the microcontroller and the web application
- Range of the remote control
- Delay in transmission of camera feedback from EZ Table to the user
- Compatibility between various electronic and power components

8. References

[1] Government of Canada, Statistics Canada, “The infographic highlights certain characteristics related to demographics such as sex and age, the use of AIDS and assistive devices, the need of health care services and workplace accommodations among those with a mobility disability.,” *Government of Canada, Statistics Canada*, 03-Dec-2020. [Online]. Available: https://www150.statcan.gc.ca/n1/pub/11-627-m/11-627-m2020085-eng.htm. [Accessed: 13-Feb-2022].

[2] N. Galbraith, J. Truong, and J. Tang, “This study uses the census of population and the 2017 general social survey on family to examine the characteristics of the population living alone in Canada. the demographic, socioeconomic and housing characteristics of persons who live alone are examined, as well as their conjugal history, family relationships, and well-being indicators.,” *Living alone in Canada*, 06-Mar-2019. [Online]. Available: https://www150.statcan.gc.ca/n1/pub/75-006-x/2019001/article/00003-eng.htm. [Accessed: 13-Feb-2022].

[3] Public Health Agency of Canada, “Government of Canada,” *Canada.ca*, 10-Apr-2014. [Online]. Available: https://www.canada.ca/en/public-health/services/health-promotion/aging-seniors/publications/publications-general-public/seniors-falls-canada-second-report.html#i. [Accessed: 13-Feb-2022].

[4] Window World of Southern Nevada, “Standard door width & length: Standard Door Sizes Guide,” Window World of Southern Nevada, 08-Sep-2021. [Online]. Available: https://www.windowworldsouthernnevada.com/article/standard-door-width-length-guide. [Accessed: 12-Feb-2022].

[5] “Flame retardants & PVC in electronics”, Electronics TakeBack Coalition. [Online]. Available: http://www.electronicstakeback.com/toxics-in-electronics/flame-retardants-pvc-and-electronics/. [Accessed: 13-Feb-2022].