Penta Solutions

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31st March 2022

Dr. Mike Hegedus
School of Engineering Science
Simon Fraser University
8888 University Drive,
Burnaby, BC V5A 1S6

Re: ENSC 405/440 Capstone Project: Braillingo Project Proposal

Dear Dr. Hegedus,

On behalf of Penta Solutions Ltd, I am pleased to submit a formal project proposal for our product Braillingo. Braillingo's team consists of 5 enthusiastic engineers from different fields of engineering: Kunal Gossain (Electronics), Angelique Caballa (Systems), Korcan Uyanik (Computer), Anastasia Shpak (Computer) and Zhejun Dai (Electronics).Braillingo as a product is meant to be an assisting tool for the visually impaired to comprehend today's text based world.

Braillingo's main aim is to use an optical device to capture text, use a single-board computer to perform character recognition and provide the user with the information extracted in the form of a Braille cell. Feedback will be provided to the user using an audio output device for better performance and notification to the client.

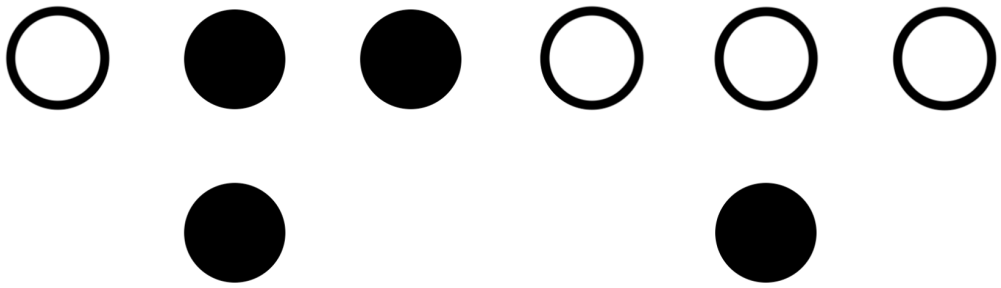
This document will help better describe overall system design, the cost, the constraints and the complexities associated with the project.The document also re-examines and presents the predicted project timeline

Thank you for your time and consideration on reviewing this document. Please feel free to email me with any questions regarding the documentor the project.

Sincerely,

Anastasiia Shpak
(Chief Communications Officer)

Penta Solutions



Design Specification: Braillingo

Submitted to: Dr. Mike Hegedus

Submission Date: 13th March 2022

Company #5

Anastasiia Shpak	Chief Communication Officer
Angelique Caballa	Chief Administrative Officer
Zhejun Dai	Chief Financial Officer
Korcan Uyanik	Chief Product Officer
Kunal Gossain	Chief Executive Officer

Executive Summary

According to WHO's official statistics, at least 1 billion people are suffering from moderate or severe distance vision impairment or blindness. This makes their quality of life not to standard as they get isolated, and have difficulty in reading or grasping knowledge from physical text. Therefore there is a need for a device that helps visually impaired people analyze and interpret text sources. Our product, Braillingo, is one of the solutions designed for such a problem. Braillingo acts as a bridge in connecting the text source aspect of the world to visually impaired people for easy understanding.

Braillingo as a product aims to automatically scan the text using an image capture device, which manipulates text into digital signals in the processing unit, and convert signals into mechanical movement on the braille module. The device is designed to be portable and functioning in all light conditions, with users having flexibility on their reading procedure and speed. This provides flexibility and opportunities for the user to use physical text based sources with ease such as books and documents. Braillingo can also be used as a teaching and learning device in schools to teach beginner students on how to read and interpret braille. Though most projects are associated with some sort of possible risk, Braillingo carries a fair share of its own risks. Some of the major risks are as such:availability of braille modules, accuracy of text detection and processing risk. The document belows goes in full detail regarding the risk and benefits of our product.

The expected cost for designing, testing and integrating multiple parts of Braillingo is 1840.81 $. This makes the product slightly cheaper and more affordable than the market competitors. There are many advantages of learning braille for visually impaired people, one of the major one being it helps with employment as the statistics show that 90% of the visually impaired people employed were able to read braille and help create more employment opportunities and positions in the workforce for the visually impaired people.

Penta Solution is made up of 5 highly motivated and knowledgeable Engineering students with excellent hardware, software and systematic aspects experience, and we have the passion to help people to boost their life qualities. We plan and look forward to continuing work on this project in the following 4 months refining and optimizing different and crucial aspects according to the users comfortability and design standards for construction of braille devices.

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Glossary

Term	Definition
Braille	Braille is a system of raised dots that can be read with the fingers by people who are blind or who have low vision.
Actuator	A mechanical part responsible for movement by converting energy
Single-board computer	A complete computer built on a single circuit board, with microprocessor(s), memory, input/output (I/O) and other features required of a functional computer.
Matrix	Rectangular array with entities in the rows and columns. Typically is described as an mxn where m is the number of rows and n is the number of columns.

Table 1 - Glossary

1. Introduction

Today at least 252,000 people in British Columbia have sight loss [1]. This condition has a drastic effect on many aspects of life and one of them is the ability to read books or any text on a paper. Current technologies to ease the access to text for visually impaired people have many disadvantages such as limited number of input sources and dependency on a visual person. As a result, only 10% of blind people are literate [2]. This is an extremely low percentage that shows a need for a better solution. Therefore, Penta Solutions is introducing a new way to access printed text with a hope to increase the life quality of people with sight loss.

Description of proposed solution first requires an introduction to the way blind people read. One of the most common ways to represent text non-visually is a tactile language called Braille. It represents each letter of the alphabet as a combination of raised dots that a person can touch with their fingertips and perceive the information. Today Braille can be displayed in a variety of ways. It can be printed on a special Braille paper that can hold the shape of the dots. Digital text such as e-books, pdfs and web pages can be accessed using refreshable braille display devices. However, these solutions do not help in case there is a text already present and written on a paper.

Penta Solutions is developing a device called Braillingo, that will convert printed text into Braille. It would mimic the ability of a visual person to independently get information by using an image to Braille conversion system. By sliding the device along the text, the user can capture the image that will be translated and outputted in a refreshable display with rising dots. Development of Braillingo is done with a hope to make lives of people with sight loss easier and give them access to more opportunities.

2. Scope

The problem of helping visually impaired people to read has existed for a long time and people came up with many potential solutions to the problem. Refreshable Braille displays are the most successful attempts. They allow the user to read text from the Internet and downloaded files. Another way of receiving text information is by transferring digital text into an audio file and listening to it. Both of them share the same problem: text has to be in a digital form. Any printed text remains out of reach and would require the help of a visual person to read. There is no device in mass production that would allow people with sight loss to access physical text. The goal of Penta Solutions is to fill the gap of missing technology and provide an easy to use and accessible device that will allow visually impaired people to read printed text such as books or magazines.

There are a few basic functions in Braillingo that are designed to be intuitive and easy to use without the help of a visual person. Figure 2.1.1 below shows the design of Braillingo Penta Solutions is aiming for. First, the image of text is captured with a camera at the bottom of the device. Users will be able to slide the device along the text they desire to read. Braillingo will automatically capture images and create a complete view of the text that will be translated to Braille. After that the captured text will be outputted in the refreshable Braille display with multiple Braille cells. Each cell represents one letter in the English alphabet. Users will be able to go along the text by pressing forward and backward buttons. Each button can be identified by a Braille marker that would tell the user its functionality. Device would also give audio feedback signals at each step to let the user know about the state of the device. Penta Solutions are also aiming to make the device portable, so that it can be used in different locations and be more convenient for the user. Therefore, Braillingo contains a battery that can be charged.

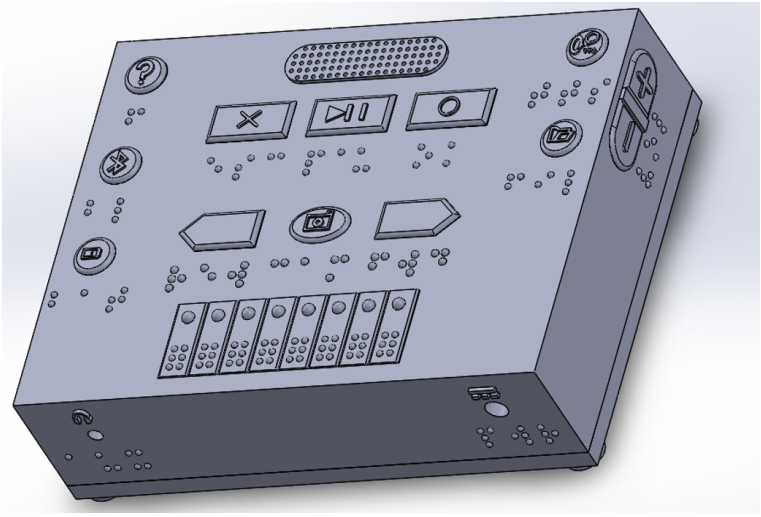

Figure 2.1.1 - Design of Braillingo.

Braillingo is made for everyone who wishes to read in Braille. The main target audience are people with partial and full loss of vision. The device is easy to use and safe. By analyzing similar products such as refreshable Braille displays for pdf books, Penta Solution identified that Braillingo can be used from a very young age and can help children to learn how to read. Children before the age of 9 should be supervised by adults [3]. User requirements for Braillingo include knowledge of Braille and ability to hold the device and press buttons.

3. Risks and Benefits

As most of the projects come with some sort of risk associated with it ,Braillingo has its fair share of risk and benefits accompanied with it. Some of the small but important risks associated with this project can be such as delay or asynchronous pin actuation in relation to the

text,heating up of the device after some time of use or failing of the portable battery to provide backup power to the system.The following are the main risks and benefits associated with Braillingo.

3.1 Business Risks

Availability of affordable and readily available Braille units/modules.
The cost that incurs on purchasing a refreshable braille from the market costs roughly 3000$.This makes braille module parts such as piezoelectric actuators to be sold in bulk and usually sold to manufacturing companies hence making the retail purchase uneconomical.Apart from the cost that involves a braille module or a braille cell, the availability of such cells are rare as not many company manufacture these.The other complexity that comes with the Braille cell/module for Braillingo occurs when designing the braille cell from scratch using the piezoelectric actuators and meeting and maintaining the braille standards such as the spacing between the braille pins and the stroke length from the braille pins.This poses as major risk as without actuation aspect of the braille pins the user will not be able to use the device.

Position of Image capturing device and image processing risk
Another potential risk associated with Braillingo is position and the ability given to the user to be able to capture pictures accurately to extract text from them easily. Since the intended user of the device is a visually impared person , the position of the camera (image capturing device) plays a vital role and hence the position of the camera should be static/ stationary. The other risk related to image processing is related to stitching of images to check where the end of the last picture was on text basis and where should the newly taken pictures text be considered from. This is a major risk and has to be handled in a proper manner as it can lead to repetition of text hence giving output on the braille display or can lead to false positives where there is no text but the system detects, extracts and displays wrong text to the user.

System integration.
Braillingo as a product has multiple subsystems and those subsystems contain multiple parts such as camera module, braille module control,rechargeable battery and speakers. All these parts are to be integrated by the use of a data processor which is raspberry pi. This imposes multiple challenges as testing and validating each part and subsystem to function as per design and to perform tasks accurately with minimum errors and need to be addressed, accounted for and handled so as to de-risk the project.

Timeline Risks
The timeline risks associated with braillingo are associated with shipping and arrival of parts from different stores as it is a multiple part project . The delays of parts arrival make it difficult to work and make any meaningful progress for the project. Also the choice of the parts have to be economical so as to make the overall project economical and need to be taken into consideration.Another timeline risk that can occur is challenges with the expertise in programming of the hardware and software. The timeline risk is crucial to the overall development of the project as it helps anticipate possible time related risks in the project and hence these risks need to be taken into account so as to create enough time for proper execution and fulfillment of the project.

3.2 Society Risks

A potential society and environmental risk associated with Brailling arises from pollution from recycling of electrical components. Also battery leakages can be part of hazardous problems when it comes to our product.

3.3 Benefits

Braillingo as a product enables easy information sharing between physical mediums of information such as books and visually impared people.This technology / device aims to improve quality of life and has multiple benefits as a product to the user. The following are the main benefits of braillingo.

Output flexibility
Braillingo provides two output methods to its user, firstly using the refreshable braille display and the second is using audio feedback in case the user doesn't want to use the refreshable display. It gives the user the flexibility to use a physical book or preloaded e-book to use.

Portability
Braillingo comes with a rechargeable, backup battery making the device portable and hence gives the user the flexibility to move around with the product. The power from the backup battery into the device is expected to be functional for 5 hours and it is expected to be an uninterrupted power supply.

Cost effective
Penta Solution aims at making brailling a cost effective product compared to the market price and hence is taking the necessary step while purchasing part.The aim is to make the device affordable for the user.

Learning tool
Brailling can be used by braille instructors as learning and teaching devices at special schools, hence assisting beginner students to easily understand and be able to read braille.

4. Market and Competition

4.1 Target Market

The target market for Braillingo is those who are severely visually impaired and blind. In particular, those who are able to read and understand Braille. As of 2019, Canadian Braille organizations do not have statistics on Braille literacy and reading; however as of 2019, in the United States, approximately 10% of those visually impaired know how to read Braille [4]. This is largely due to the availability of audio books and voice control as a replacement for reading [1]. Though the number of visually impaired that know how to read Braille is a small percentage, Braille literacy is key in employment for visually impaired [5], which is one of the many reasons Braille organizations all over the world advocate for visually impaired learning Braille. As is shown in Figure 4.1.1 below – out of 100 blind people, 30% are employed and within the 30% who are employed, 90% are literate in Braille. Because the vast majority of blind people that are employed know how to read Braille, it can be said that Braille literacy allows more employment opportunities for blind people.

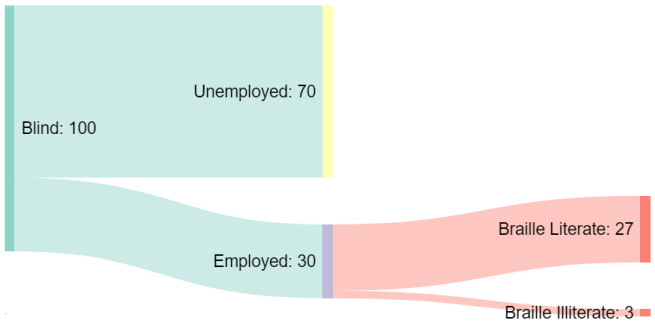

Figure 4.1.1 - Ratios associated with employment of blind people. Data taken from [5]

In general, failing to pursue education will lessen employment opportunities. In addition, as displayed in Figure 4.1.2 below, the majority (60%) of blind students drop school. This is likely because of the small 10% Braille literacy.

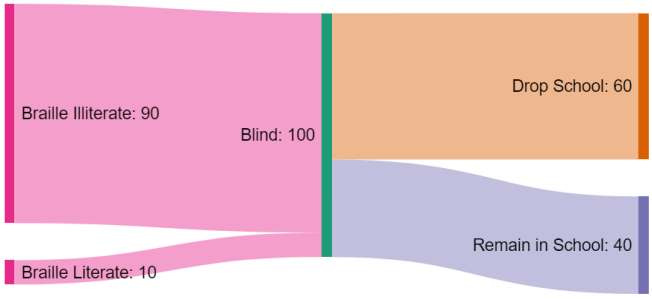

Figure 4.1.2 Ratios associated with education of blind people. Data taken from [5]

Should more visually impaired people learn Braille, a larger market size for Braillingo can be achieved. Exact numbers of those visually impaired and blind are displayed below provincially, federally, and world-wide:

British Columbia	**252 thousand**	with sight loss	5.12% of 4.924 million
Canada	**1.5 million**	with sight loss	4.10% of 36.55 million
	5.59 million	**at risk** for sight loss	15.29% of 36.55 million
World	**49.1 million**	blind	1.06% of 7.79 billion
	33.6 million	severely visually impaired	

Table 4.1.1 - Number and percentage of those with sight loss, severe visual impairment, and blindness in British Columbia, Canada and the World. Data taken from [6, 7].

Marketing locally, with the assumption that 10% of Visually Impaired people know how to read Braille, it can be assumed that 10% of the Canadian Visually Impaired population, 150 thousand, are potential customers for Braillingo.

For other countries, the number of people with blindness and percentage of the population are displayed in the table below:

Country	Population	Blindness	Blindness %
India	1,422M	9.2M	0.65
China	1,426M	8.9M	0.62
Indonesia	265M	3.7M	1.40
Russia	146M	0.6M	0.41
Brazil	217M	1.8M	0.83
Bangladesh	161M	0.9M	0.56
Pakistan	226M	1.8M	0.80
Nigeria	226M	1.3M	0.58
USA	331M	0.6M	0.18
Mexico	132M	0.5M	0.38

Table 4.1.2 - Top 10 Countries with highest number of people with blindness. Data taken from [8]

Marketing internationally, with the assumption that 10% of Visually Impaired people know how to read Braille, it can be assumed that 10% of the World Visually Impaired population, 8.27 million, are potential customers for Braillingo.

4.2 Competition and Current Solutions

Solutions for visually impaired to read text mainly consist of refreshable Braille displays. To help the visually impaired to read non-Braille hardcopy books, people have worked on projects to design a refreshable Braille display that scans text on a hardcopy book then displays the text in Braille. A notable example is a Braille display designed by a team of six students from MIT, which allows up to 6 cells to be displayed i.e. 6 characters from the scanned text [9]. In addition, two students from MVJ College of Engineering also worked on a similar project called “bBook” which they are hoping to add voice control functionality to [10]. These solutions however are not presently accessible to the public, mass-produced, nor the spacing between dots adhere to the spacing of actuator pins from each other and other cells should adhere to Braille Authority of North America’s Standards for Braille Signage. [11] Furthermore, most solutions presently being sold in the market only output Braille translated from inputted digital text such as on pdfs, ebooks, webpages, and applications. Regardless, a form of a Braille display will be integrated into our project.

Braille displays vary in features such as number of Braille cells, input keys, compatible devices, mode of communication, portability, size, and retail price. There are a number of Braille displays that are compatible with Apple products such as the iPad, iPhone and iTouch; examples of these are HIMs, HandyTech, HumanWare, and Baum [12]. HumanWare designed Braillliant BI 20X and 40X which are 20-cell and 40-cell refreshable Braille displays that connect to a compatible device via Bluetooth or USB. For the user to navigate through the screen text, several buttons are used for user input. The 20-cell and 40-cell version retail for $2,099.00 US and $3,499.00 US respectively [13, 14]. There are many devices similar to HumanWare's in terms of number of Braille cells, input keys, and mode of communication such as the Orbit Reader 20 and 40 produced Orbit Research. Just like aforementioned HumanWare products, Orbit Research's products increase in retail value the more Braille cells are integrated; however, the Orbit Research's 40-cell and 20-cell displays retail for far cheaper compared to HumanWare at $1,499.00 US and $649.00 US [15, 16].

5. Company Details

5.1 Penta Solutions Name and Logo

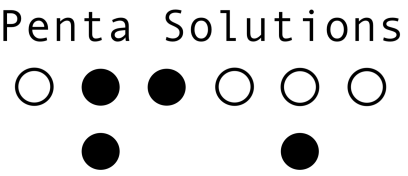

Figure 5.1.1 - Penta Solutions Logo

Penta Solutions' naming format was done to adhere to British Columbia's business naming standard of *[Name] [Type of Business]* [15~]. The name "penta" is a prefix meaning "five". Penta Solutions has five founding members that self-assigned themselves as the 5th company for Simon Fraser University's 8-month senior Engineering Science design courses ENSC 405W, Capstone A: Project Design, Management, and Documentation; and ENSC 440, Capstone B: Engineering Design Project. In addition, "solutions" is to indicate the type of business: in Penta Solutions' case, it is to engineer Braille solutions for the visually impaired.

The logo was based on the Braille characters for lowercase A, K, C, K, and A, ⠁⠅⠉⠅⠁, which are the initials of the five founding members' English names: Anastasiia, Korcan, Chloe, Kunal, and Angelique. Lowercase was chosen to minimize the Braille characters as capitalization is indicated by another Braille character prior to the letter to be capitalized. Penta Solutions chose this arrangement and spacing specifically because it resembles a bridge as they aim to create a

“bridge” for visually impaired to read physical text. The shaded dots were chosen out of purely aesthetic reasons to create contrast in colour.

5.2 Braillingo Product Name

“Braillingo” is a combination of the word “Braille” and the suffix “-ingo”. *Braille* is the tactile writing system whose characters the product will display. The suffix “-ingo” on the other hand is a suffix meaning “a holder or sheath for something”, indicating that the product will “hold” i.e. have and display Braille characters. The name “Braillingo” might be interpreted as a portmanteau of “Braille” and “Lingo” however this is incorrect as Braille is not a language i.e. lingo; it is a writing system.

5.3 Penta Solutions Team

Kunal Gossain – Chief Executive Officer (CEO)
Kunal is a 5th year Electronics Engineering student at Simon Fraser University. He performs the role of the Chief Executive Officer at Penta Solution, responsible for making major decisions regarding the functionality and managing the development of the company’s short and long term strategy.His previous co-op at Sierra Wireless’ Software team , personal projects and academic background provide the skills that can assist the Hardware team in designing, troubleshooting and simulating Braillingo’s hardware requirement.

Anastasiia Shpak – Chief Communications Officer (COO)
Anastasiia is a 5th year Computer Engineering student at Simon Fraser University. She is a member of Penta Solution’s Chief Communications Officer Product Officer, and responsible for maintaining communication between Penta Solutions and the SFU Engineering Science instructional team. Her co-op experience in SFU research FAISAL team gave her an opportunity to develop image processing and deep learning skills that will assist in the design and development of software of the final product.

Zhejun (Chloe) Dai – Chief Financial Officer (CFO)
Zhejun is a 5th year Electronics Engineering student at Simon Fraser University. She performs the role of the Chief Financial Officer at Penta Solution, responsible for paying for necessary materials and equipments.Her previous co-op at Microchip’s Hardware team as product engineer , personal projects and academic background provide the skills that can assist the Hardware team in designing, troubleshooting, sanity checking and simulating Braillingo’s hardware requirement.

Angelique Caballa – Chief Administrative Officer (CAO)
Angelique is a 5th year Systems Engineering student at Simon Fraser University. She is Penta Solution’s Chief Administrative Officer, responsible for organizing meetings and ensuring day-to-day operations are performed. With her expertise and engineering co-op experience

working in Sierra Wireless' hardware team and Verathon Medical's electrical engineering team, she will aid in designing, troubleshooting, and testing Braillingo's electrical components and systems. She also has experience in mechanical design, some knowledge in software programming and deep learning. For Braillingo's mechanical components, she will be able to create Solidworks models to 3D print to create its physical User Interface and housing. In addition, she can provide support for programming and testing Braillingo's OCR software.

Korcan Uyanik – Chief Product Officer (CPO)
Korcan is a 5th year Computer Engineering student at Simon Fraser University. He is a member of Penta Solution's as a Chief Product Officer, and responsible for bringing the product strategy to align with the business strategy and to deploy that throughout the organization. He has worked in NETGEAR to design firmware for wireless modems and hotspots. He also did machine learning research in SFU. This provides skills to troubleshoot and design Braillingo's as both of these sides are core parts of the product.

6. Project Planning

Penta Solutions has designed a Gantt Chart to keep track of the progress and milestones for the project and plan to adhere to it to maximum level to increase success chances for the project. For the following term, Penta Solutions plans to slightly increase meeting days to two days and make the work model hybrid (Thursdays(In person meeting) and Sundays (Virtual meetings)). We plan to implement the Agile Development model so as to maximize efficiency at the beginning of the semester and have enough time to troubleshoot,safely system integrate and have the final product ready for demo.

The following tasks are outlined on the Gantt Chart on Figure 6.1.

Documentation
- Project Selection
- Requirements Specification
- User Interface Appendix
- Design Specification
- Proposal
- Project Poster Presentation and Demo
- User Manual
- Engineering Journals

Hardware Development
- Research for Braille Actuators and Electrical Components

- Experiment with Intermittent Solenoid Actuators
- Experiment with Controlling Solenoid Actuators with Motor Drivers
- Testing of Continuous Solenoid Actuators and Motor Drivers
- Electrical Circuit Design (Engineering Prototype)
- Testing of Braille Modules and Boost Converter
- Battery and Charging Testing
- Design of Camera/Device Sliding Mechanism
- Case Design and Button Design
- 3D Printing of Case Design and Button Covers
- Integration of all Hardware Components Together (Engineering Prototype)

Software Development

- Research of Optical Character Recognition
- Text Recognition Software (AI)
- Image Processing
- Implementation of Braille Translation System (Level 1)
- Mapping of Text to Physical Braille (Proof of Concept, Solenoids)
- Programming of UI Buttons (Proof of Concept)
- Mapping of Text Physical Braille (Engineering Prototype, Braille Modules)
- Programming of UI Buttons (Engineering Prototype)
- Input File Reading Software (ebook, pdf, txt)
- Implementation of Braille Translation System (Level 2)
- Stitching of Pictures
- Optimization of Software Performance

System Integration

- Integration of Hardware and Software Components (Proof of Concept)
- Testing and Debugging (Proof-of-Concept)
- Integration of Hardware and Software Components (Engineering Prototype)
- Testing and Debugging (Engineering Prototype)

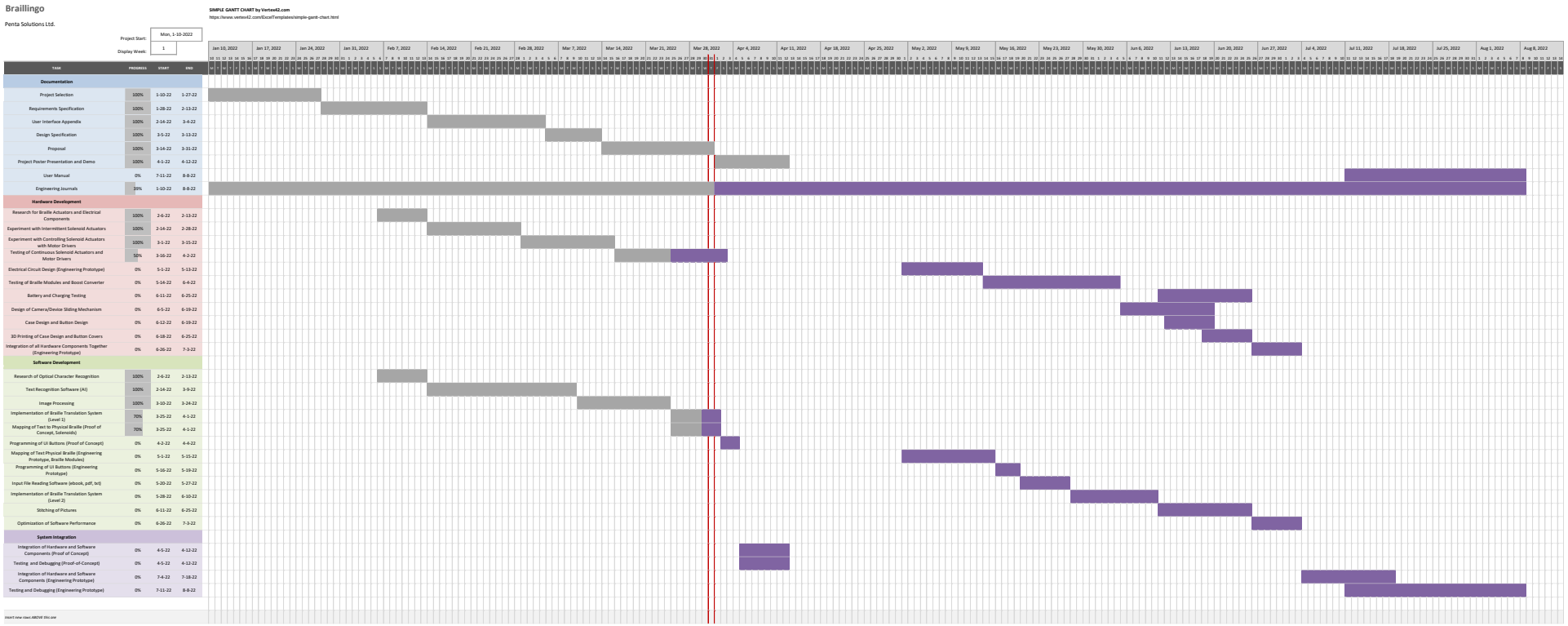

Figure 6.1 – Gantt Chart for Braillingo by Penta Solutions Ltd.

7. Cost Considerations

An initial costs list is shown in the table below. Prices are in CAD. Note: %30 contingency “cost” has been added as mechanical parts can fail and there could be upgrades to existing systems.

Item	Vendor	Quantity	Price/piece	Total (CAD)
Solenoids*	DigiKey	12	13.42	201.3
Motor Driver IC*	DigiKey	8	7.99	63.92
Camera	Pishop	1	13.49	13.49
Raspberry Pi 4 (4GB)+wires	Pishop	1	187.76	187
Braille Module	Johnson Matthey	2	335.10	670.20
Power adapter	DigiKey	1	44.22	44
Power Converters	DigiKey	3	40	120
Barrel Jack connector	DigiKey	1	3.99	3.99
Speaker	Robotshop	1	10	10
Y-audio splitter	Amazon	1	5.22	5.22
Buttons	DigiKey	15	0.538	8.07
Battery	Digikey	1	32.99	32.99
Recharging Module	Digikey	1	55.83	55.83
Subtotal				**1416.01**
+30% contingency				**1840.813**
Total				**1840.813**

*Proof-of-Concept Braille Actuators

Table 7.1 - Cost Calculations for Braillingo

Funding will be received from the Wighton fund and Engineering Science Student Endowment Fund (ESSEF), with any extra finances required from our own company.

8. Conclusion

The main objective of this project is to bridge the gap between physical text based sources like books and the visually impaired user .Brailingo aims to provide this feature to its users so as to improve the quality of their lives . We aim to make the product affordable , portable and output flexible so as to comply with the users needs .The design team will also make sure that it meets the standard for braille devices.Apart from the advantage of translating physical text into braille, our device can be used as a learning and teaching tool for beginner braille learning students. Our team is excited and looks forward to bring this device into reality by adhering to the set timeline for the project while minimizing risks and making the device cost effective

9. References

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