March 31st, 2022

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

RE: ENSC 405W Final Proposal

Dear Dr. Hegedus and Dr. Rawicz,

The document accompanying this letter is DAM^3 Technologies' final proposal for NaviBot, an autonomous robot to perform in-house deliveries. We hope to create an intuitive design that will allow workers to effectively perform their basic delivery duties with ease and with little to no need for training.

This document will outline the scope of NaviBot and any associated risks and benefits, along with the potential market. In addition, the project timeline, cost considerations, and a brief introduction to the team will be presented.

NaviBot is DAM^3 Technologies' combined efforts towards developing a solution to the increased logistical workload faced by office and warehouse workers. Our project will contain applicable engineering principles our team has obtained during our time at SFU. DAM^3 Technologies aims to deliver a proof-of-concept prototype during the ENSC 405W time frame, with development continuing in ENSC 440.

If you require any further clarification or have any questions pertaining to this document, please contact DAM^3 Technologies' CCO Martin Yang at yangtaey@sfu.ca.

Sincerely,

Davis Hogg
Chief Executive Officer
DAM^3 Technologies

Final Proposal

Company 1

Davis Hogg, CEO: 301335409
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Michael Kim, COO: 301340718
Martin Yang, CCO/CFO: 301347120

March 31, 2022

Executive Summary

There comes a time in company's growth where they need to acquire a shipping and receiving handler due to the increasing size, number, and frequency of packages. This handler may initially handle the volume of packages required by the business, however as more employees join the workforce and require packages from the receiver, the busier the receiver gets. This can take their attention away from more important packages that the company acquires, and can possibly overwhelm them, eventually cascading to a delay in packages throughout the entire building.

DAM^3 Technologies strives to create innovative devices to allow users of all expertise to operate with ease, and is proud to present NaviBot, the self-driving delivery robot. NaviBot aims to assist the overwhelmed and overworked package delivery person in everyday office spaces, warehouses, manufacturing facilities, and more. With it's wide array of sensors, it can drive itself around a wide variety of floor layouts with minimal risk of collision. By remembering the layout of a building floor, NaviBot can travel between its home charging station to a room at the package handler's request. All they have to do is load the package onto NaviBot's transportation platform and press go.

The worldwide E-commerce market is continuously increasing, and the need for warehouses and package deliveries grows alongside. With this growth comes the need for low cost solutions, easily accessible for companies of all sizes. It's here that NaviBot hopes to edge out the high-cost competition with an affordable alternative.

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Glossary

Term	Description
AMR	Autonomous Mobile Robot
E-commerce	Electronic commerce
EP	Engineering Prototype
ESSS	Engineering Science Student Society
LiDAR	Light Detection and Ranging
MDDS30	Cytron Technologies SmartDriveDuo-30 MDDS30 motor controller
NaviBot	Product name
PCB	Printed Circuit Board
PoC	Proof of Concept
Rol	Reorder level formula
RPi4B	Raspberry Pi 4 Model B microcontroller
SFU	Simon Fraser University
UI	User Interface

1 Introduction

Ever since the creation of robotics, the idea of easing the burdens or risks posed to human operators has been a primary driving force. With rapid advancements being made in the past decades, robots of all forms have been made more easily accessible, and it is this idea that has inspired the creation of DAM^3 Technologies along with its flagship product, NaviBot. NaviBot is an autonomous robot that is capable of traversing within an office or warehouse space to deliver packages to their destination with the use of an intuitive touchscreen interface. This document will serve to address the risks and benefits of NaviBot, the current commercial market and potential competitors, and the cost considerations and potential funding sources.

1.1 Background

As companies grow, so do their logistics needs, and with those needs come a growth in package intake. The overhead needed to expand a company's logistical capabilities can require an extensive amount of reworking or additions to existing infrastructure. NaviBot allows companies to address their increased logistical load with minimal modification to their logistics infrastructure.

1.2 Scope

NaviBot, the smart delivery robot, aims to improve efficiency with respect to package delivery from a receiving area to other departments in office and engineering spaces. To achieve this, an initial mapping of the building layout must be generated prior to its first use, and employees overseeing this process may select and save any desired key delivery locations. During operation, a shipping and receiving handler will load small boxes or packages onto NaviBot and send them to different destinations with the use of the provided touchscreen interface. From there, NaviBot uses its array of sensors to navigate its way throughout the building and avoid obstacles. A basic system overview can be seen in Fig. 3.

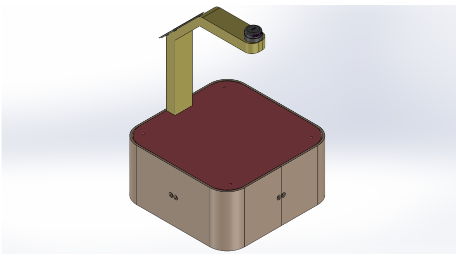

Figure 1: Front View of NaviBot

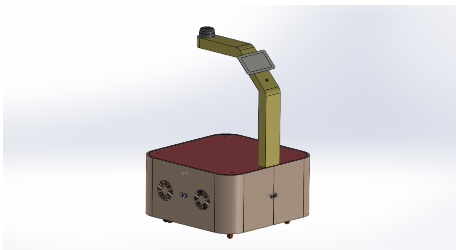

Figure 2: Back View of NaviBot

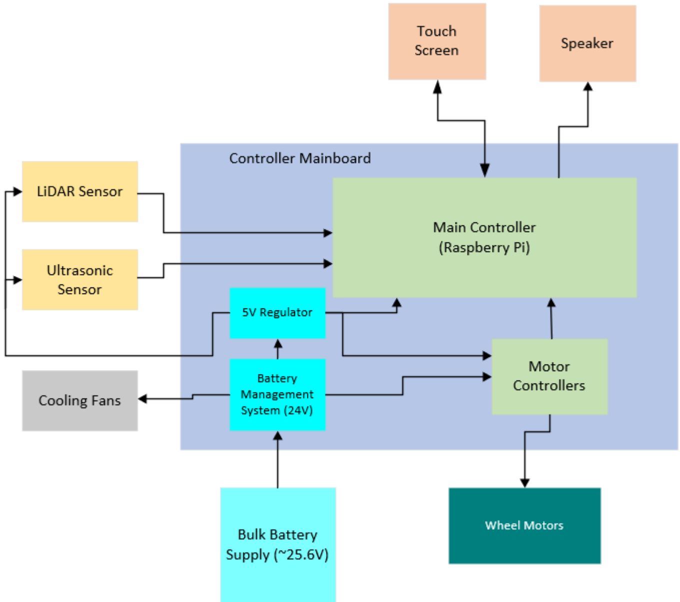

Figure 3: Block Diagram

2 Risks and Benefits

As with any new technical product, NaviBot comes with its own risks and benefits; however, as is the nature of these products, the benefits of employing NaviBot outweigh the risk and cost. Identifying these risks and benefits early in product development has allowed DAM^3 Technologies to mitigate the risks and optimize the benefits before its release to market.

2.1 Risks

2.1.1 Physical Nuisance

NaviBot's ultimate purpose in life is to deliver packages through buildings which means it may get in the way of people and vice versa. This can cause delays in package delivery, delaying important work for the business, and possibly cause annoyance amongst workers in the surrounding environment. To mitigate this risk, NaviBot has been instructed to hug the sides of walls and temporarily stop when something gets in its way.

2.1.2 Physical Hazard

With a max capacity of 25kg (55lb), NaviBot can really pull its own weight at work. However, while at max load and speed, it can pose quite a risk to the people and objects around it. If it were to strike and damage an object, the user would have to cover the cost of repair or replacement. Even worse, if it were to strike and injure a worker, it may lead to lawsuits, workers compensation, and causing harm to a worker. To minimize this risk, NaviBot uses a multitude of ultrasonic sensors surrounding its base and control arm to detect unexpected objects and stop within a safe distance.

2.1.3 Electrical Hazard

NaviBot utilizes on-board batteries to drive the motors and power the controlling and sensing equipment. There is the risk of batteries shorting and possibly catching fire. This also has the potential to cause injury, lawsuits, and workers compensation.

2.2 Benefits

2.2.1 Improved Efficiency

NaviBot aims to improve package delivery efficiency amongst the shipping and receiving department at companies. By employing NaviBot, the shipping handlers will be able to send packages to recipients inside the building without ever leaving their department allowing them to attend to other matters. This is especially useful when those recipients pester the shipping handler when they are preoccupied. All of this allows for a smoother operation for the business and reduces workload for the delivery person.

2.2.2 Reduce Manual Labour

Along with increased efficiency, manual labour is reduced. With NaviBot, the package handler will no longer need to carry or cart around cumbersome or heavy boxes around their building, but rather they will only need to load the boxes onto the shipping platform. This reduces general wear and tear on the body, therefore reducing risk of injury.

2.2.3 Low Cost

NaviBot's low price point compared to its competitors is certainly an added benefit. Even so, while sporting a seemingly high cost, the value of automating repetitive tasks is significant. As a result, the long-term gains of reduced manual labour and increased productivity will offset this.

3 Commercial

3.1 Market Analysis

The market worldwide is dominated by E-commerce currently where most products are stored, organized, and packaged across thousands of warehouses. The trend demonstrates more industries are investing into autonomous mobile robot services for material handling to increase efficiency and reduce errors and cost [1]. The current total worldwide available market size in 2020 was $2,417 billion USD and is projected to grow to $4,151 billion USD by 2028 from a survey conducted by The Insight Partners [2]. The opportunity in the American market is large, showing an average of 40 thousand units being installed between 2017 and 2020 with a revenue of $900 million USD [3, 4]. The earliest data published by the Canadian government of its robotic market size in 2015 is $201 million CAD at an annual growth of 35% [5]. The initial serviceable obtainable market targeting only 10% based on current market size and average annual growth equates to a $95 million USD market across 2,034 warehouse and storage industries [6].

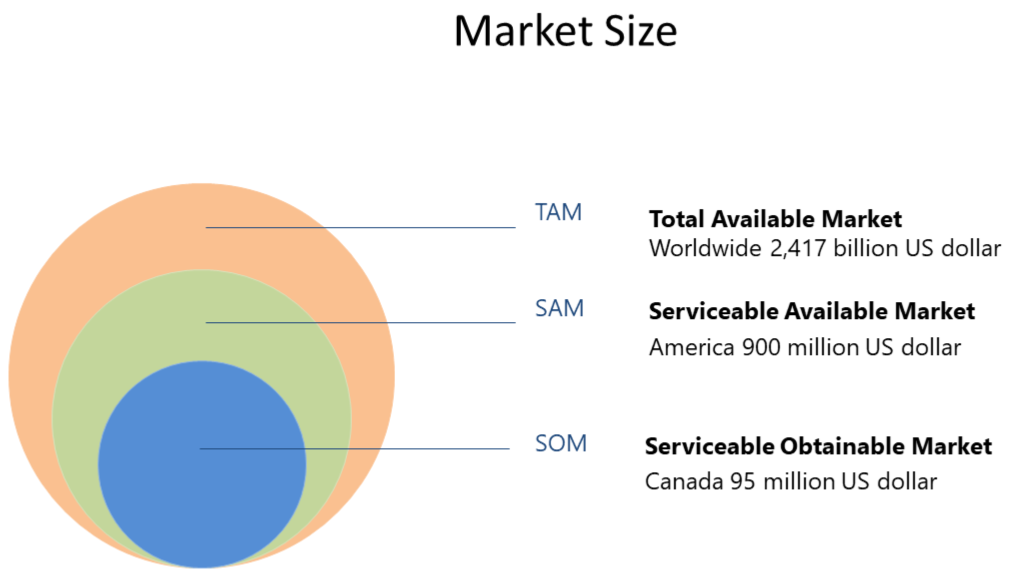

Figure 4: Autonomous Mobile Robot Market Size

3.2 Competition

In the American, market there are a variety of AMR industries producing and innovating solutions within the warehouse industry. A study on the barriers to robotics implementation across 48% of respondents cited the top 3 concerns are cost, RoI calculation, and where/how to start [7]. The advantage of NaviBot is to produce a reliable, low cost, and easy to use robot to introduce into the market. This model will outperform the competition by reducing the initial concerns expressed by the customers and appeal to new industries transforming to the autonomous business model.

3.2.1 Locus Robotics

Locus Robotics is one of the largest AMR producers in the United States, providing a multi-bot pick and delivery system. The autonomous feature is integrated with the warehouse floor plan of product location and implements a "pick path" plan. Like NaviBot, the process is not fully automated and requires an employee to place the items and confirm the action is complete [8]. Locus announced in 2021, $150 million USD in funding from investors to build upon their business ventures highlighting the potential market available within the industry [9]. The advantage DAM^3 has is the sale price of NaviBot compared to Locus at $35,000 USD or a $900 monthly subscription [10].

Figure 5: Locus Origin Model [8]

3.2.2 OTTO Motors

OTTO Motors' AMR design is very similar to that of Locus except specifically designed towards pallet lifting. It implements a robot management system based on normal traffic control, designating sections of the floor plan to high speeds traveling up to 2 meters per second and intersections for mergers to prevent collisions. The main AMR competitor is the OTTO 100 with a carrying capability of 100 kg. The edge NaviBot has is the user simplicity of navigating the robot and applying the next task at hand. Handling the concerns of how to implement robotic automation at a feasible cost compared to OTTO Motors lowest known cost at $15,000 USD per robot [11].

Figure 6: OTTO 100 Model [11]

4 Company Details

DAM^3 Technologies, named after its five founding members, was founded in 2022 with the aim to enter the internal logistics market with NaviBot, the autonomous package delivery robot. The passion of the company is depicted by its logo, representing five aspiring engineers converging upon one central idea and driving it towards success. At DAM^3 Technologies, we value a growth mindset, passion, and dedication.

4.1 Team Descriptions

Davis Hogg - Chief Executive Officer
Davis Hogg is a systems engineering student at SFU with a passion around automation. With experience in manufacturing engineering, he has gained the skills in mechanical, electrical, and software design to oversee each aspect of NaviBot's development. Along with managing this project, he also implements his skills in software and electronics to construct the motor system and assist in navigation.

Alek Srdić - Chief Hardware Officer
Alek Srdić is a systems engineering student at SFU. He has experience with a large degree of projects requiring both mechanical and electronics knowledge, and as such, is responsible for the mechanical design and development of NaviBot. Along with acting as the mechanical lead, he also advises the electronics development.

Mark Lavin - Chief Information Officer
Mark Lavin is a systems engineering student at SFU who has the necessary skills to create software and account for physical limitation of robotic implementations. His past role as project management assistant and involvement with ESSS yields the necessary experience to manage the implementation of the software development.

Michael Kim - Chief Operations Officer
Michael Kim is an electronics engineering student at SFU. He has knowledge of working with microcontrollers and system troubleshooting from his experience as a design and development engineer and looks forward to applying this knowledge towards the microcontroller configuration and electrical system design.

Martin Yang - Chief Communications Officer/Chief Financial Officer
Martin Yang is an electronics engineering student at SFU. He handles company finances and assists in the manufacturing of the physical design components of NaviBot. In his spare time. he has completed many personal projects including self assembly of an electric bike conversion kit, automotive mechanical experience, and Linux projects.

5 Project Planning

Formation of DAM^3 Technologies, along with the development of NaviBot, began early January 2022. Final PoC development and testing will be completed no later than April 12th, 2022. Development of EP will begin immediately upon final testing of PoC. A production ready EP is slated for completion by the end of August 2022.

Figures 7-9 below show a Gantt chart of DAM^3 Technologies PoC development plan.

Seen below is a brief overview of each high level project component:

- 'Documentation' involves the drafting of all necessary supporting documentation during the full PoC development of NaviBot.
- 'Project Formation' encompasses all brainstorming including the refocusing of DAM^3 Technologies' initial product idea.
- 'Component Selection & Aquirement' involves all research and selection of the various components needed for PoC development.
- 'Design and Development' includes necessary research and implementation of the main subsystems.
- 'Integration' involves the assembly of each subsystem into the NaviBot PoC.
- 'Testing' includes collection of all necessary PoC empirical data.
- 'Other' includes all miscellaneous milestones or tasks seen throughout the PoC development.

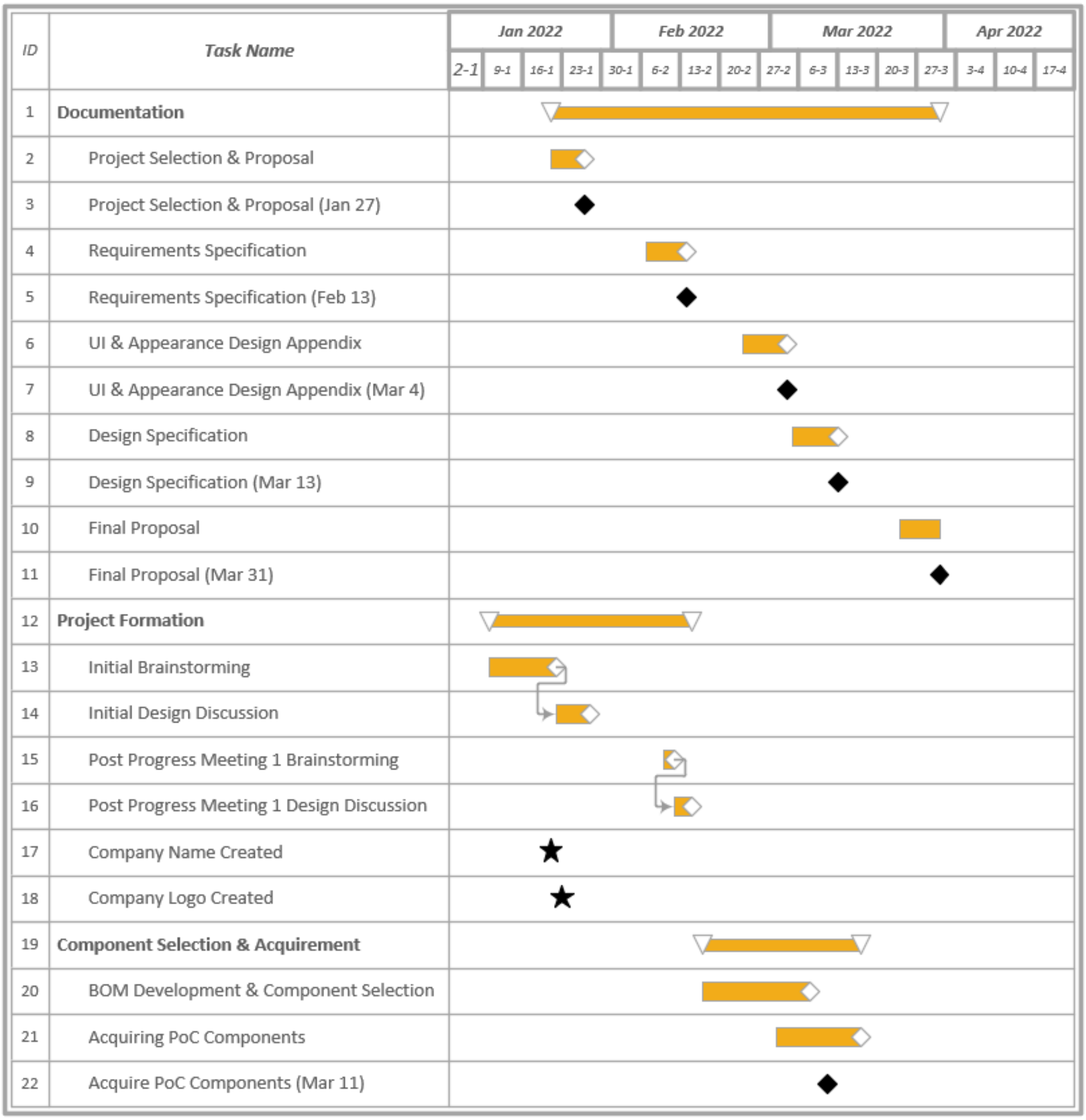

Figure 7: Proof-of-Concept (PoC) Gantt Chart 1/2

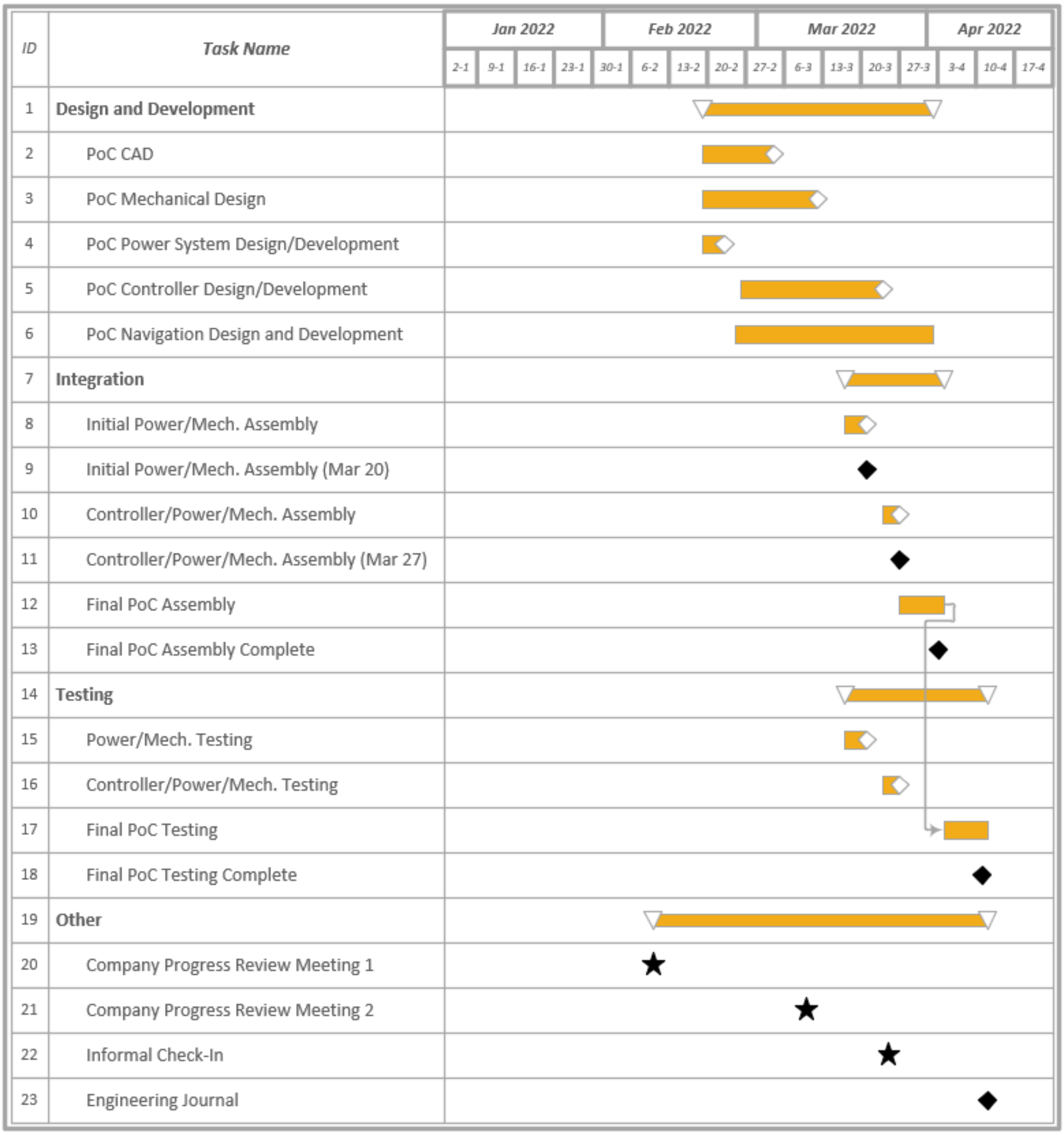

Figure 8: Proof-of-Concept (PoC) Gantt Chart 2/2

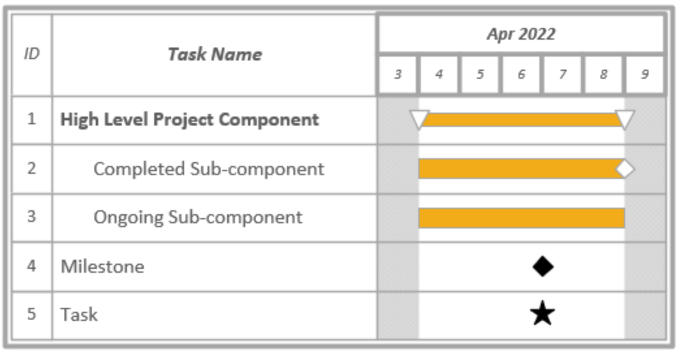

Figure 9: Gantt Chart Legend

6 Finances

6.1 Cost Analysis

A cost breakdown of each component for NaviBot's engineering prototype is summarized in Table 1 below (Prices listed in CAD).

Function	Component	Qty	Price ($/unit)	Subtotal ($)
Movement	MDDS30 7V - 35V motor controller	1	110.77	110.77
Movement	P40 350 240W DC Motor	2	98.50	197.00
Movement	2.5" Rubber Drive Wheel	2	3.48	6.95
Movement	2" Caster wheels	2	6.00	12.00
Movement	60-Tooth Pulley	4	7.25	29.00
Movement	20-Tooth Pulley	4	2.20	8.80
Movement	Assortment of Timing Belts	2	16.99	33.98
Computing	Raspberry Pi 4B	1	55.00	55.00
Computing	RPLidar A1M8 360°LiDAR	1	145.10	145.10
Computing	HC-SR04 Ultrasonic Sensor	5	2.94	14.69
Physical	Package Platform Medium Density Fibreboard	1	69.99	69.99
Physical	Assorted Nuts, Bolts, and Screws	1	10.00	10.00
Physical	UI Touch Screen	1	88.00	88.00
Power	Greenworks 24V Li-ion 4.0Ah Battery	1	79.99	79.99
Power	Greenworks 24V Battery Charger	1	38.99	38.99
Power	12-24V to 5V Buck Converter	1	21.58	21.58

Total:	$921.84

Table 1: Financial Breakdown

6.2 Funding

Due to NaviBot's heavy dependence on high standard components, secure funding is needed to allow its success without hindering development. There are several sources of funding mentioned below.

As discussed in ENSC405W, all Capstone projects are eligible for the Wighton Development Fund, courtesy of Dr. J. L. Wighton. Through this fund, a funding amount of at least $500.00 CAD towards the project with a typical upper upper limit of $5000 CAD is expected. The application will be submitted near the beginning of April 2022.

Another source of funding is through SFU's Engineering Science Student Endowment Fund. NaviBot falls under Category B (Entrepreneurial). This will supplement the required funds to acquire all the remaining parts for NaviBot. This application will be sent in the beginning of May 2022 for ENSC 440.

Sponsors from local businesses in Vancouver with large square-footage and multi-floor office spaces, such as Microsoft, could benefit greatly from NaviBot's initial autonomous delivery capabilities. The office's large horizontal distance makes NaviBot incredibly suited for delivering packages across such a space.

Lastly, if all funding options become unavailable, all five member within DAM^3 Technologies will evenly split the costs.

7 Conclusion

Automation is a continuously advancing front in both a technological and societal context, and DAM^3 Technologies is committed to delivering fully functional, automated solutions to address various industries. By alleviating repetitive delivery tasks, NaviBot's simple to use interface will allow employees to address higher priority duties. NaviBot aims to progress the adoption of consumer-focused robotics by providing the small business market with a low cost alternative.

Development is well under way towards the successful introduction of NaviBot to market. With a dedicated team and rigorous timeline to handle robot design and risks mentioned prior. DAM^3 Technologies believe in the potential impact of NaviBot and its subsequent success.

DAM^3 Technologies would like to thank Dr. Mike Hegedus, Chris Hynes, Usman Ahmed, and Ghazal Mirab for their continued support and guidance during ENSC 405W.

8 References

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