July 30th, 2023

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

RE: ENSC 405W Final Proposal for Roll Technology

Dear Dr. Hegedus,

Roll Technology has prepared this final proposal document for ENSC 405W/440 in regards to our product Chairable. The aim is to create a modular product that acts as an attachment to convert a generic office chair into a motorized one.

Chairable is a modular office chair attachment specifically designed with a spherical wheel mechanism to facilitate powered movement. After attachment, the user can sit and move the chair in any direction around using simple controls at low speeds. This would allow the user to enhance their workplace environment by making it more fun and accessible.

The document includes our overall scope which consists of the risks, benefits, market and fellow competition for our project. In addition the main processes and goals of the project are shown in a gantt chart. The cost considerations are then listed out in a table specifying the cost of each part. This is followed by a company overview introducing the background, work experience and interest of each team member.

Should you have any questions or require additional information please do not hesitate to contact our Chief Communication Officer, Divyam Sharma, via email (divyams@sfu.ca) or via phone (+1 236-512 4989). We will be more than happy to address any concerns or provide any clarification you may require.

Sincerely,

Kaj Grant-Mathiasen
Chief Executive Officer
Roll Technology

ENCLOSED: Final Proposal for Chairable

Company #13

Final Proposal:
Chairable

Partners:
Kaj Grant-Mathiasen - CEO
Kate Wang - CFO
Amrit Mangat - COO
Colin Buchko - CTO
Divyam Sharma - CCO

Contact:
Divyam Sharma
divyams@sfu.ca

Submitted to:
Dr. Mike Hegedus
Dr. Shervin Jannesar
School of Engineering Science
Simon Fraser University

Issue Date:
July 30th, 2023

Abstract

This document outlines the final proposal for Chairable, Roll Technology's product that is currently in development which will enable an office chair to be motorized. The final proposal will contain information regarding the scope, market, project planning, cost considerations as well as risks and benefits. At the end of the document there will be a section introducing each of the team members involved in building Chairable.

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Glossary

Terminology	Definition
Microcontroller	A compact computer on an integrated circuit which is dedicated to perform a specific function
Omni-wheel	Wheel that can move in all direction while facing all directions
PWM	Pulse Width Modulation
RF	Radio Frequency
LiPoly	Lithium Polymer

1 Introduction

Chairable is a product for individuals looking to change up their everyday work environment with a fun and accessible solution. Chairable combines a battery powered spherical wheel system, a strategically placed footstand and an intuitive user interface into an attachment for an everyday office chair. Users will remain comfortably seated on the chair while they navigate Chairable with a simple user interface. Chairable is designed to add onto the existing abilities of office chairs in addition to it being modular, compact and cost effective. It will also have the benefit of maneuvering in a variety of work environments, taking into account different spaces and floor surfaces.

2 Background

One of the founders' fathers suggested the idea of a mobile chair as he found standing up repeatedly from his office chair to be frustrating and physically straining. Furthemore, the idea of a motorized office chair could allow individuals to add some excitement to their daily work routine, sparking some joy throughout their day. It can also provide an alternative to using bulky mobility aids that are not suitable to navigate in a tight office environment.

Sitting down for a long time can result in the work routine being boring and monotonous. People tend to decorate their immediate surroundings to personalize their desk space to make it more exciting. They bring in houseplants, vibrant decorations, and desk gadgets to liven up their space and make it more engaging [1]. In search of a disruption to their repetitive routine and environment, people will find Chairable to be a refreshing change in their daily work life with a fun and interesting way to travel around the office.

Additionally, individuals with mobility disabilities or those who require a mobility aid are more often affected by challenges in the workplace [2]. Wheelchair and power chair users claimed that they were feeling sore and uncomfortable while performing their delegated tasks [3]. Furthermore, it is worth noting that approximately 288,000 Canadians rely on some form of mobile aid, emphasizing the widespread need for accessible solutions [4]. Chairable provides an alternative by being maneuverable and compact enough to fit under a desk, addressing some of the problems faced by traditional mobility aids in an office environment.

3 Scope

The scope of capstone is to make a project with a proof of concept by the first term and a working prototype by the end of the second term. The proof of concept should show that the team is able to create a product solving the most difficult challenges, with our goal being to enable Chairable to move an office chair without any load on the chair. In the second term, the goal is to improve upon this by moving an office chair with a load on top of it while also transforming the product into a near production-quality item with an improved appearance. The proof of concept should have the following:

- Ability to have rotational movement
- Ability to move the chair forward and backwards
- Ability to remain stable during movement
- Maintain near constant traction on the floor surface

The prototype should have the following:

- Ability to move a chair with a person on top
- Ability to move in all directions while being stable
- Attachment will have a frame around it
- All electronics will be enclosed together
- Battery life that will provide a full day of use without recharging

The figure below provides a high level overview of Chairable, defining how the motors and controllers will work together.

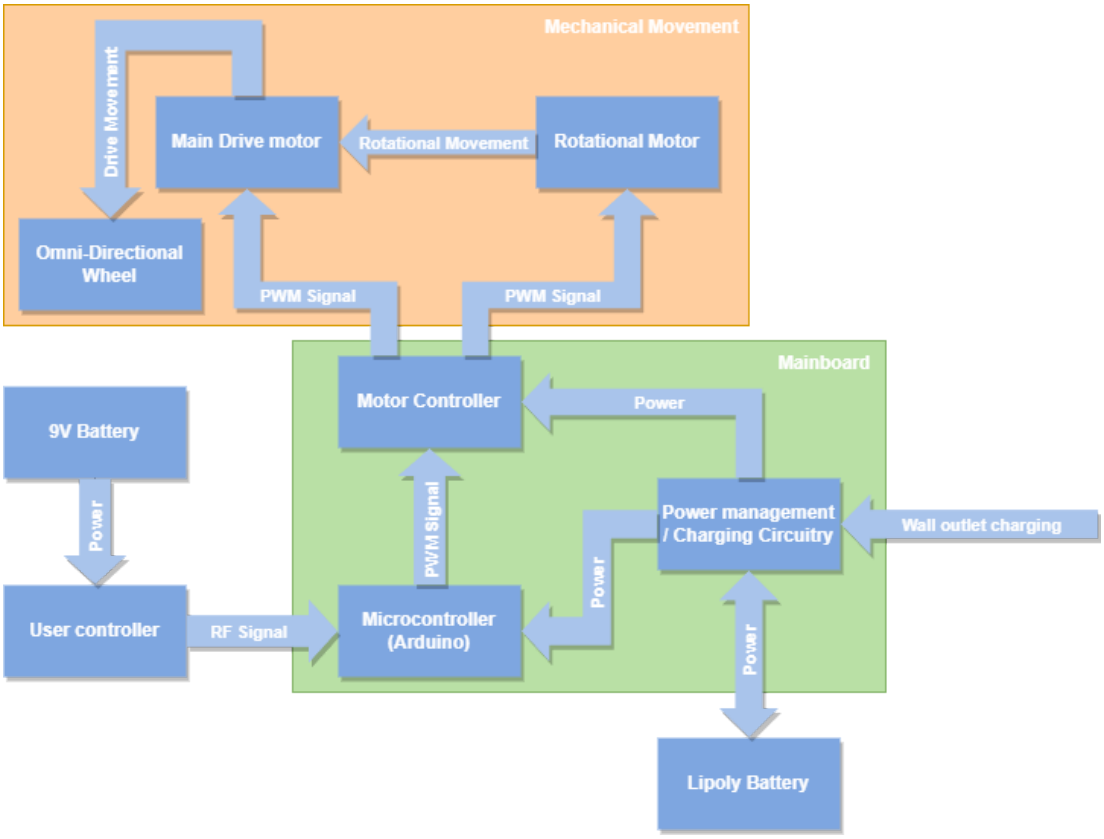


Figure 1: *Chairable system block diagram*

The figure below provides a potential 3D model of Chairable when it is attached to an office chair.

Figure 2: *Overview of Chairable with controller attached to a office chair*

4 Risks and Benefits

This following section discusses the various risks and benefits that relate to society and business aspects.

4.1 Risks

Like any product, Chairable does come with certain associated risks. However, these risks are carefully researched and managed to ensure minimal impact, even though they have low probability and severity. Nevertheless, it is important to acknowledge their existence, and they are outlined below.

4.1.1 Hesitance in Adoption

One risk that we are prepared for is the potential slow adoption of our product. As a unique and cool tech gadget, Chairable is the first in its application. Our future goals are focused on minimizing costs to make the product as affordable as possible, which can sway even the most adamant users to justify the investment. While Chairable also offers a similar yet distinct application compared to standard mobility aids, users may not be in a rush to replace their existing aids. However, once they see the product in action, we are confident they will recognize its benefits and be willing to choose Chairable over conventional mobility aids.

4.1.2 Mechanical Issues

Chairable is a mechanical-focused product utilizing 2 motors and 2 microcontrollers, among other mechanical and hardware components. Although these components have been tested and researched on their durability, there is still a possibility of wear and need for replacement over time. Even though all parts and the product itself will be thoroughly tested before production, the mechanical nature of Chairable introduces several potential risk points.

4.1.3 Obstacle Collision

Due to safety reasons, Chairable will be limited to slow speeds, but there is still a chance of collisions. The user may not always spot obstacles, especially when moving in a direction they are not facing. While the components will be encased for protection, there is still a minor risk of damage to the product and the user getting hurt if they are not careful.

4.2 Benefits

Chairable's advantages extend to both societal and business perspectives, asserting its position as a positive contribution to society and a potentially successful product. These benefits outweigh all potential risks, justifying the development of this device.

4.2.1 Limited Competition

Chairable is unique in the market as it will be the only product to motorize an office chair, resulting in no direct competitors. Although some projects based on an omni-wheel design may have been conceptualized, they have not made it to the production stage or been specifically applied to a use case like Chairable. Roll Technology is determined to dive into this blue market and make some waves.

4.2.2 Expanded Market

While we have designed Chairable to be a fun addition to office spaces, this device can also be a practical solution for users with mobility disabilities, making movement in the office space more accessible. Furthermore, the wheel technology that we are developing can be extended to numerous other use cases, adaptable to most applications that use smaller wheels or castors. This technology opens up possibilities for increasing maneuverability on various terrains, potentially allowing devices like strollers or shopping carts to benefit from the use of an omni-wheel design [5]. In addition, its popularity has increased in the last few years amongst robotic enthusiasts due to its versatile ability to navigate on different terrains in all directions [6].

4.2.3 Accessibility

Since users with mobility disabilities can utilize Chairable in office spaces, we hope to reduce barriers of entry to office-based jobs for such individuals. This solution may be especially beneficial for employers who may be reluctant or hesitant to implement accommodations like

widening hallways or changing desks. Additionally, for users experiencing discomfort from repetitive getting up and sitting, Chairable offers a minimally intrusive solution within the workspace. The user can seamlessly incorporate Chairable into their workspace without making any special changes beyond what would have been present with their normal chair. Ultimately, we aim to make both home offices and office setups accessible for everyone, creating an inclusive and accommodating environment.

4.2.4 Affordability

One of Chairable's primary goals is to create an affordable and accessible product for all potential users. Unlike typical power chairs or other motor attachments that are prohibitively expensive and inaccessible to most users, Chairable will establish itself as a lower-cost option without compromising on quality or customer satisfaction. Our team aims to provide a superior and affordable alternative for all users through Chairable.

4.2.5 Increased Maneuverability

Current products that offer similar usage to Chairable in office settings, such as power chairs and wheelchair attachments, all suffer from the constraints of limited space in offices. Chairable offers an advantage in maneuverability as it is attached to existing office chairs without significant protrusion beyond the base of the chair, ensuring that its maneuverability remains very similar to the chair's original state without the attachment. The device can move around the user's office exactly as if done manually, but now with the movements of a joystick.

5 Market

Since Chairable is primarily designed as a fun product with opportunity to expand into mobility aid, the market isn't highly specific. Chairable appeals to anyone who spends time in an office environment. This demographic constitutes a subsection of the 19-70 age group, which includes over 26 million people in Canada alone [7]. Among them, we specifically target individuals seeking a fun and enjoyable addition to their office chair, providing an entertaining mode of transport within their corporate or academic spaces.

Our secondary market concerns individuals facing difficulties walking or moving within an office environment. Addressing limited mobility and accessibility in office environments for low-income individuals is crucial for inclusivity and equal opportunities as an estimated 288,800 Canadians aged 15 or older use some form of wheeled mobility devices [8]. Additionally, stigmatization with current mobility scooter solutions discourage a significant portion of potential users from fully utilizing them [9]. Our proposed solution would address this issue by providing an alternative that can be subtly integrated into an existing office chair. This solution enables people with mobility impairments to participate fully and independently in the workplace, enhancing their productivity and well-being. This project is unique in its ability to be retrofitted to various chair models while simultaneously remaining affordable compared to other options

6 Competition

Currently, there are no direct competitors for Chairable, as there is no existing attachment to motorize an office chair using an omni-directional wheel. Despite its intended purpose as a fun addition to the office environment, aimed at reducing repetitive standing and sitting, the lack of direct competition requires the identification of competitors from adjacent markets, primarily power wheelchairs and wheelchair automation attachments. Although there are many existing power wheelchairs, commonly known as power chairs, they fail to provide the advantages of Chairable. Power chairs, and wheelchairs in general, are unsuitable for various office environments due to their size, limited maneuverability, and inability to fit under desks. Furthermore, power chairs are quite expensive, with most options well over $1,000. Some popular options, along with their prices, are listed in table below [10].

Company/Brand	**Device**	**Starting Price**
Pride Mobility Products Corporation	Jazzy Passport Carbon	$4,600
Shoprider	UL8WSLA Axis	$2,995
Comfygo Mobility	Lightweight Electric Wheelchair	$1,600

Table 1: *Popular Power Chairs along with Prices* [11]

Additionally, there are indirect competitors in the field of wheelchair automation attachments. Even though Chairable does not directly attach to wheelchairs, these competitor attachments can be considered as a form of chair automation in office spaces for wheelchair users, similar to the goals that Chairable also aims to fulfill. These attachments can be affixed to existing wheelchairs, either at the back or front depending on the device, enabling control of the wheelchair's movement using a joystick or some other hand-operated controller. Medical1st can be identified as a competitor in this market, offering the Wheelchair Hook-up Trolley. This device, shown in figure 3, attaches to the back of the wheelchair and is controlled by a joystick. However, it comes with a price tag of $3000 and requires specific wheelchairs for connection [12].The second type of device that can be identified is electric handcycles. Among the various options available, the most popular one is the FireFly 2.5 by Rio Mobility, as shown in figure 4, which is priced at approximately $3,600 [13]. The main drawback of this type of attachment is that it connects to the front of the wheelchair. In an office scenario, the user must detach it to fit under a desk and then reattach it when needing to move. This process can be inconvenient and, for individuals with mobility disabilities, possibly challenging to do independently.

Figure 3: *Medical1st Wheelchair HookUp Trolley* [12]

Figure 4: *FireFly 2.5 by Rio Mobility* [13]

7 Project Planning

The project, as mentioned before, is done in 2 phases/semesters. The first phase, as depicted in the Gantt chart in section 7.1, involves creating the proof of concept and documentation, which was done throughout ENSC 405W. The second phase, in which we will create a final prototype, will be planned out at the start of ENSC 440 with the according deadlines.

The internal milestones we had set were based on what we recognized as the 3 major steps, all with their own sub-tasks. The first task was to create the motor system and controller which would allow us to finalize the overall design of the system. Using this, we could start creating the frame for the device and figure out the clamp attachment mechanism. Once completed, we could move onto integration and further testing.

7.1 Gantt Chart

The Gantt Chart below displays the timeline until the proof of concept demo. The time taken/alloted for each task is shown with blue bars and the milestones are shown with black diamonds. Most tasks were completed on schedule, as predicted, but the two-tone blue bars, along with their milestone indicators right below, show instances where completion was behind schedule. Conversely, blue bars that are shorter than the milestone directly after them show instances where we were ahead of schedule.

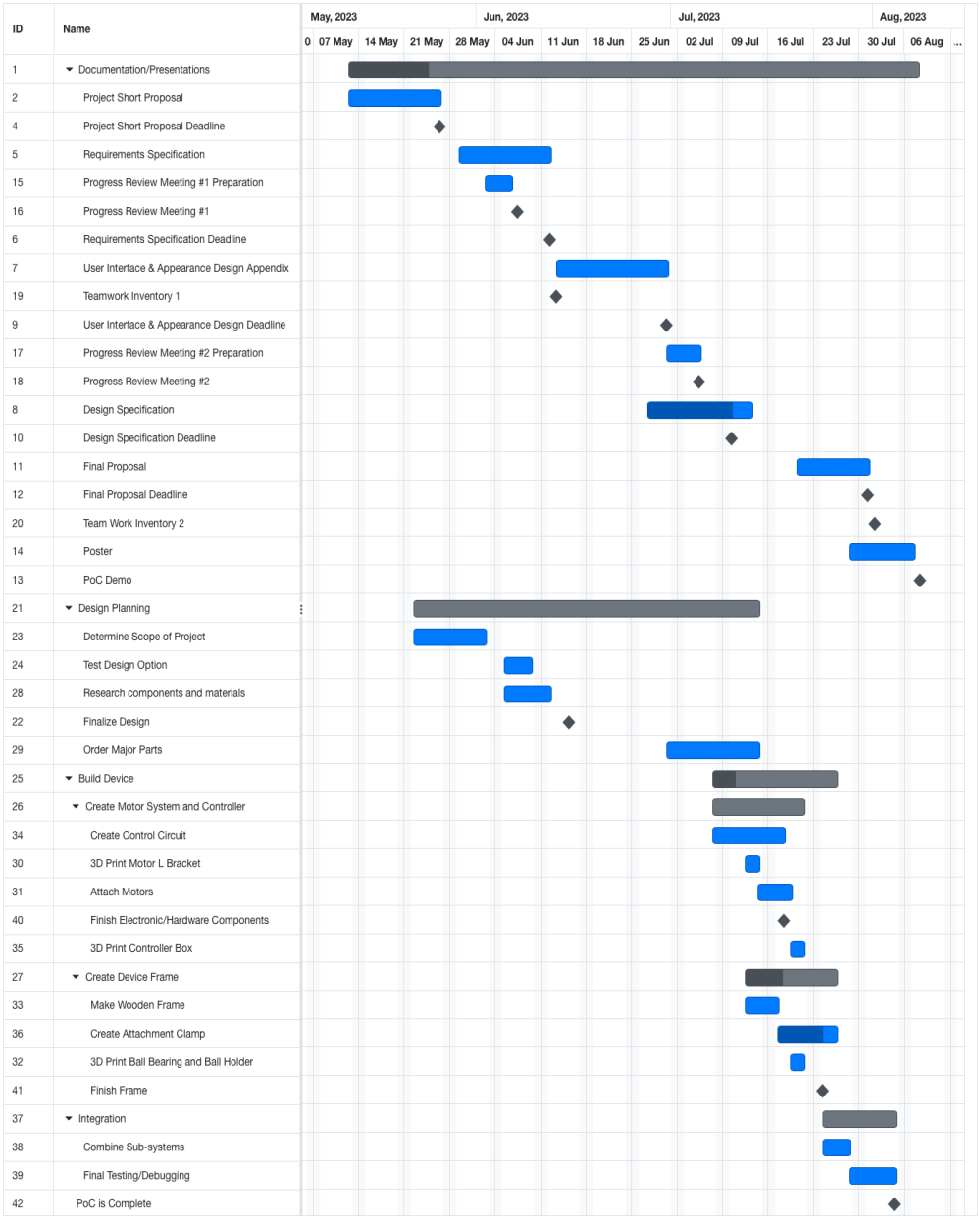


Figure 5: *Gantt Chart*

8 Cost Considerations

As discussed in the benefits section of this document, one of the benefits of Chairable is that it will be significantly more affordable than its indirect competitors. Since these parts were bought individually and often with timing/delivery constraints, we are confident in the ability to substantially reduce these costs for a production product.

This following section documents the cost estimations for the main components of Chairable and discusses the available funds to partially cover those costs.

8.1 Cost Estimations

The following table lists out the costs of parts used in Chairable:

Part	Description	Total Cost (CAD)
Main Driver Motor (SK3 - 6364-190KV) [14]	Main driving motor	$120.70
Rotational Motor (JGB37-545) [15]	Motor used to rotate the driving motor	$20.00
5000mAh LiPo Battery [16]	Main battery for the motor-wheel system	$88.15
6 Cell LiPo Charger [17]	Battery charger	$50.17
Arduino Uno Microcontroller [18]	Controllers for both the motor-wheel system and for the remote controller	$60.00
DC-DC Step Down Converter (LM2596) [19]	Voltage converter for the microcontroller	$10.00
DC Motor Controller (L298N) [20]	Controller circuit for the rotational motor	$10.00
6S Bidirectional ESC [21]	Controller circuit for the driving motor	$30.00
RF Module (nRF24L01) [22]	Wireless communication modules	$5.00
Emergency off switch [23]	Switch to stop motor-wheel system	$20.00
RGB LEDs [24]	LEDs to indicate status	$1.00

	on controller	
30A Fuse with case [25]	Protective Fuse for motor-wheel system	$12.00
PS2 Joystick Module [26]	Joystick module on controller	$1.00
9V Alkaline Battery [27]	Battery for controller	$3.00
Controller on/off switch [28]	On/Off switch for controller	$0.50
Plastic Ball (Wheel) [29]	Spherical wheel	$21.00
Rubber Wheel [30]	Wheel attached to main driving motor	$8.29
Impact Clamp with Standard Stud [31]	Clamp to attach device to office chair	$36.78
3D Printing Materials	PLA Type materials used for prototyping	$80.00
Total Cost		$577.59

Table 2: *Cost of Parts*

8.2 Potential funding sources

This section talks about the potential funding sources that are available to cover all or part of the project cost.

8.2.1 Engineering Science Student Endowment Fund (ESSEF)

The Engineering Science Student Endowment Fund (ESSEF) is a fund provided by the Engineering Science Student Society (ESSS) at SFU. The category our project qualifies for is in Category B (Entrepreneurial) and the application for this fund can be submitted during the Fall 2023 semester which is next semester [32].

8.2.2 Wighton Development Fund

The Wighton Development Fund is a fund established by Dr. John Wighton to make student projects more applicable to society and potentially increase the amount of startups that result from the project creation. The fund covers student made engineering projects with the intention to become a product. Projects that have a useful application specifically for disadvantaged minorities will be given higher consideration when compared to other types of projects [33].

8.2.3 Institute of Electrical and Electronics Engineers (IEEE) Student Project Funding

The Institute of Electrical and Electronics Engineers (IEEE) also provides several funds for student led projects and for student conferences. The different funding available for student projects are provided by the IEEE lasers and Electro-Optics Society, the IEEE Canadian Foundation, the IEEE Student Enterprise Award and the Darrel Chong Student Activity Award [34].

8.2.4 Personal Funding

If the two funding sources above cannot cover all the expenses for the project, then the team will cover the costs from their own savings. The maximum amount each team member will cover will equate to roughly $200.

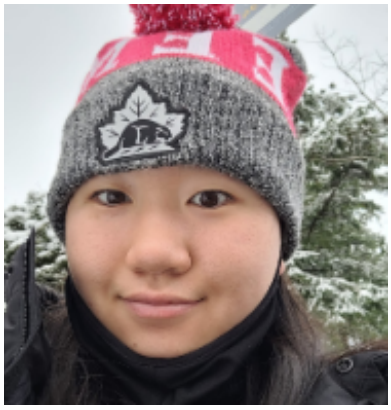
9 Company Details

Roll Technology's Chairable device, a cutting-edge attachment for office chairs, has been ingeniously designed to empower users with a seamless and dynamic way to move around their workspace. Utilizing a state-of-the-art spherical wheel system, powered by an efficient battery and motor, Chairable brings affordability, user-friendliness, and a touch of entertainment to the standard office setting. Founded on May 12th, 2023, by five innovative students, Roll Technology is committed to revolutionizing how we interact with our office space, making it a more enjoyable and productive experience for all users.

9.1 Meet the Team

Kaj Grant-Mathiasen
kgrantma@sfu.ca
Chief Executive Officer

Kaj is a 5th year Computer Engineering student with an interest in digital logic and full stack development. Previously, Kaj worked as an agile developer at SAP, helping to develop their HANA Cloud software systems. Kaj is passionate about working closely with hardware and software in the process of efficiently and harmoniously combining them. Kaj has extensive experience working with arduino and RC hobby systems which can be directly applied to motor control systems.

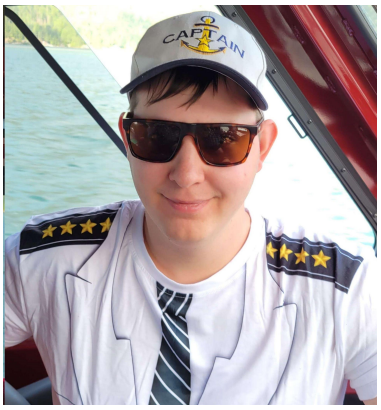


Kate Wang
kwa85@sfu.ca
Chief Financial Officer

Kate is a 5th year Biomedical Engineering student with an interest in the function of the human body. Kate has previously worked as a junior electronics engineer at Epic Semiconductors, as research assistant in Dr. Bonnie Gray's lab at SFU and as a junior hardware engineer at Damon Motorcycles. She likes the idea of integrating innovative technology with medical knowledge to save lives. Kate has experience in designing, debugging and reworking electronic circuits and PCBs. She will use her skills to help refine the electronic circuit and to design the PCB.

Amrit Mangat
asm18@sfu.ca
Chief Operating Officer

Currently in his 5th year as a Computer Engineering student, Amrit has interests in full stack development and web architecture. He previously worked as a technical specialist for CAADU (Crime Analytics Advisory and Development Unit) at the Vancouver Police Department, helping improve their existing architecture and automate several technical processes. Amrit will contribute his knowledge and experience with software and hardware to ensure the sub-systems, such as the motor control, operate correctly.



Colin Buchko
cbuchko@sfu.ca
Chief Technology Officer

Colin is a 5th year systems engineering student with an interest in robots and automation. Colin previously worked as a researcher at Ballard Power Systems as well as an automation contractor for Yoggu!. Colins passions lie in integrating hardware, software, and electronics to build smoothly combined technological systems. He will use his knowledge of system integration to ensure all components work together efficiently.

Divyam Sharma
divyams@sfu.ca
Chief Communication Officer

Divyam is a 5th year computer engineering student at SFU. He has previously worked at Andes Technology as a Design Verification Engineer. He is passionate about writing embedded software for microcontrollers. He has worked with RF modules, Arduinos, and hobby motors. He also has some experience working with solidworks. He will use these skills to assist with the electronics, software and mechanical aspects of the project. He will mainly be working with Kaj to help out on the circuit and software aspects. Additionally, he will be helping Colin with the mechanical side of the project.

10 Conclusion

Chairable is an innovative and unique product that aims to motorize an office chair using an omni-wheel system. It is a one-of-a-kind product with no similar competition in the market. This puts Chairable in a unique position as a product in development before being available to consumers.

The primary market for Chairable are individuals who would like add some enjoyment, fun and some change in their daily routines. Many individuals dislike it when they experience boredom and monotonousness constantly. As a result, having an exciting experience throughout the day can provide a break for their mental state and allow them to increase productivity and gain clarity.

Despite not fitting into an existing specific market, Chairable maintains the advantage of having no direct competitors for this unique product. One of the risks that Chairable may encounter is that the consumer base is hesitant to purchase the product since it has no predecessor. With that being said, Chairable provides an alternative with additional benefits to its indirect competitors, power chairs and wheelchair automation attachments. These existing products are bulky, have low maneuverability and can be expensive for the average individual to afford. Chairable is able to solve these issues by being compact, accessible and affordable. Even with the lack of an established market, it is clear that the benefits of Chairable outweigh the risks.

Another benefit Chairable offers is its omni-wheel technology that can be applicable in other fields. Existing products, like strollers and shopping carts, can benefit from the omni-wheel system by gaining enhanced maneuverability and functionality. Omni-wheel systems are also gaining popularity in robotics because of their ability to navigate in any direction regardless of the direction they are facing. By gaining interest and popularity, Roll Technology hopes to expand their technology to multiple fields with applications in different products.

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