March 31, 2022

Dr. Michael Hegedus
School of Engineering
Simon Fraser University
8888 University Drive
British Columbia, V5A 1S6

RE: ENSC 405/440 Design Final Proposal for Snack Bot O7

Dear Dr. Hegedus,

This proposal document for SnackBot O7 was prepared by Robo Snacks Company 7 for our Capstone (ENSC 405/440) courses.

The goal of our company is to autonomously deliver snacks to conference rooms, networking events and presentations happening on university campuses and offices before an event begins. Snack Bot O7 is targeted towards catering services that deliver to such events and locations.

The attached company proposal document will describe a high level overview of the company which includes risks and benefits associated with the product, target market, competition and general company information. Lastly it would give details regarding the cost involved in making this project feasible (cost consideration) and the planning involved in the project.

Thank you in advance for taking your time to review this proposal. If you have any questions regarding the proposal, please email us at skd24@sfu.ca or ikomolaf@sfu.ca.

Sincerely,

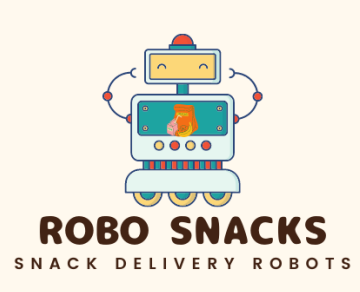
Sirpreet Kaur Dhillon & Emmanuel Komolafe
Co-CEOs
Robo Snacks Company 7 (RSC-7)

Snack Bot O7

Project Proposal

Presented by:

Robo Snacks Company 7



Company No. 7

Date: March 31st, 2022

Authors (Team Members)		**Roles / Affiliations**
Full Name	**Email**	
Favour Amah-Nnachi	famahnna@sfu.ca	Firmware Lead
Sirpreet Kaur Dhillon	skd24@sfu.ca	Automation Team, and Structure Team
Emmanuel Komolafe	ikomolaf@sfu.ca	Systems Lead, and Automation Team
Veronica Lund	vlund@sfu.ca	Automation Team
Robert Smyczynski	rsmyczyn@sfu.ca	Electronics, and Structure Lead
Eddie Zheng	eza7@sfu.ca	Automation Lead

Executive Summary

Catering services like The Lazy Gourmet [1], SFU Catering Services, H.A.V.E., Tayybeh, and Carved & Crafted often get booked to cater for events ranging from business meetings to large conferences in offices and university campuses. They get orders for fresh foods as well as snacks repetitively from venues that host meetings and conferences on a regular basis.

Carrying and delivering snacks is a task which can be automated since snacks are non-perishable goods. The prototype for Snack Bot O7 aims to automate the task of receiving orders and delivering snacks to a set location during off hours.

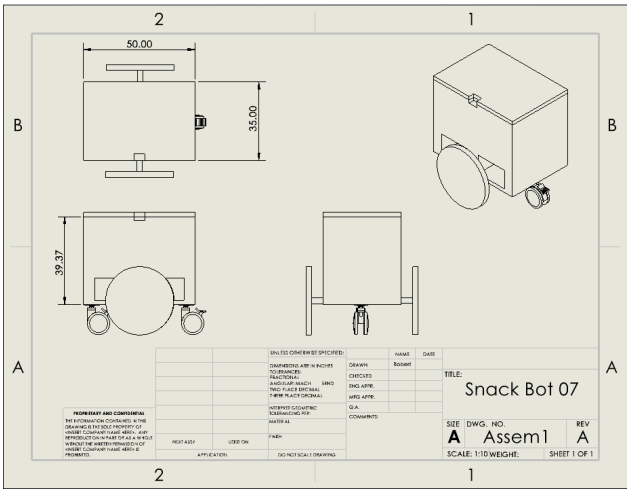


Figure 1: Schematic of Snack Bot O7's structure

Figure 1 shows the CAD diagram of the structure of Snack Bot O7. The chassis has two driving wheels controlled by a microcontroller and two castor wheels. The snacks container is waterproof and has the capacity to hold 10 pounds worth of snacks. These snacks include water bottles, coke cans, juice boxes and potato chips.

Proof-of-concept (PoC) prototype will include the fully functional and tested movement system. The movement for this stage is controlled by a remote controller.

For the final prototype, RSC7 will be targeting indoor localization, perception through LiDAR and decision making using Raspberry Pi 4 microcontroller.

The testing phase for PoC and final prototype stage will include intensive functional and system testing.

Table of Contents

List of Figures

List of Tables

Glossary

PoC: Proof-of-concept

User: People attending the event where the catering services or Snack Bot O7 is delivering snacks

Customers: Catering services

ROS NAV: Robot Operating System Navigation Stack

1. Introduction

There is no doubt that the emerging fields of artificial intelligence and autonomous robots have proven to have a major impact on our lives. Robo Snacks Company 7 (RSC-7) is a company that was established with the primary intentions of helping catering and vending services deliver snacks and drinks to their customers with the use of autonomous robots. These services are in high demand so they are well suited to use our device to serve their existing customers better. With the use of the robot, there would be no need to set up additional static vending machines or send people directly to deliver the snacks.

The company consists of six great minds who have skills in different areas of engineering and technology. This is vital given that the project integrates various aspects of engineering such as software/programming, electrical, structural and so on, so a diverse team would contribute immensely to the development of the project. The first of this kind of robot to be invented by us is called the Snack Bot 07. The scope of delivery of the robot would be conference and meeting rooms on university campuses.

Snack Bot 07 delivers the snacks and drinks to conferences and meeting rooms by navigating from a predetermined location to a specific room location where attendees of the conferences have access to the refreshments at their convenience. Because of the fact that humans can change motion at random and at will, the robot would be more efficient in delivering snacks if it does not navigate around humans. Hence, the delivery times would be very early in the mornings, during off hours, or just before the guests arrive for their meetings.

The purpose of this proposal is to provide a high level overview of our product, the risks and benefits associated with its development, an investigation of the market and market size, the competitors, the general company and product information, the project planning which includes the estimated time to complete each phase of the project, and finally the estimated cost of funding the project.

2. Scope

The scope of this project comprises the planning, design, programming, assembly and testing of the Snack Bot 07 robot, all of which contribute to the successful development of the project. Before delivery, the robot is stocked with non-perishable snacks and bottled drinks to cater at the event. The robot's objective is to deliver snacks to users in meeting rooms in a safe and effective way to guarantee excellent catering services for the customers. The Snack Bot O7 would utilize the integration of LIDAR (Light Detection and Radiation) technology, ROS NAV(Robot Operating System), an arduino board and a Raspberry PI 4 to enhance automation. Some of the requirements of the robot includes:

- Robot must be able to navigate in the forward, backward, left and right directions
- Robot must be able to navigate to delivery rooms independently
- Robot must return back to its base location independently after delivering snacks
- Robot must go on standby mode upon arrival to its destination
- Robot must be able to detect objects in its way and avoid collision with them

Snack bot 07 would have two wheels at its side and two casters (one in front and one at the back). The part of the robot where snacks and drinks are stored would be about 39.37cm in height, 50cm in length and 35cm in width as shown in figure 1 above. With these dimensions Snack bot 07 has enough space to house the snacks for a single delivery. The Raspberry Pi, LIDAR and other parts of the system would be in the chassis, separate from the layer where snacks are housed. Figure 2 below shows how signals are sent and received between the different systems that make up the robot and figure 3 shows the workflow cycle of the robot's operation during its active hours.

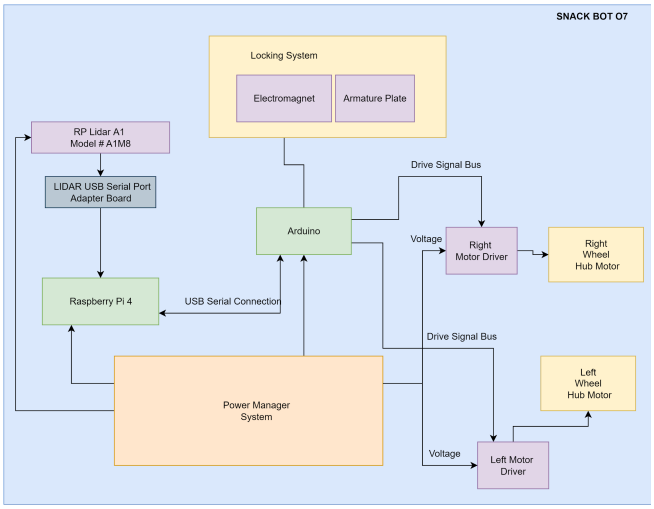


Figure 2: System Block Diagram for Snack Bot O7

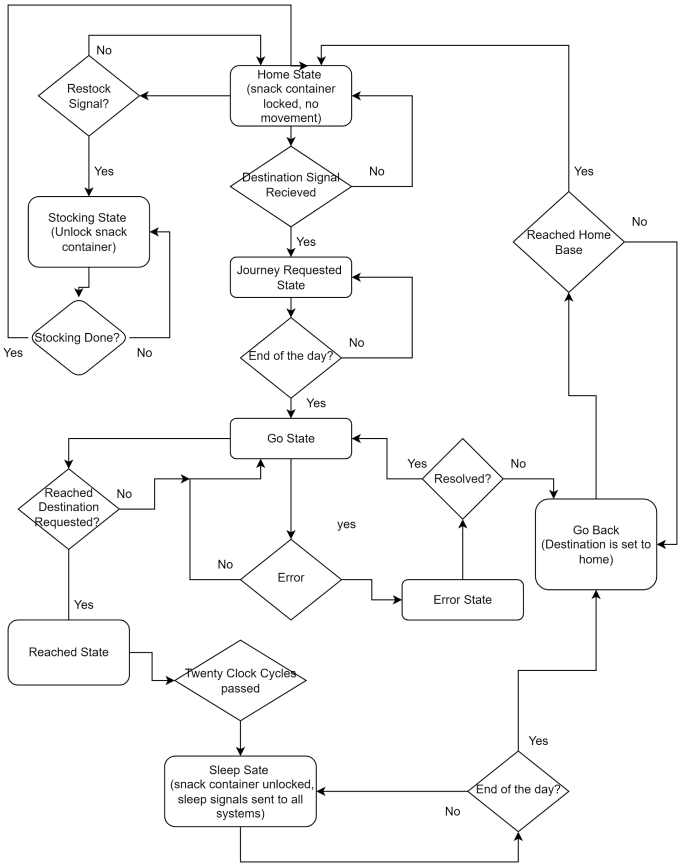


Figure 3: Flowchart

3. Potential Risks and Benefit

3.1. Risks

Regardless of how well a project has been carefully planned, the project may encounter unexpected issues. The following are the identified list of problems that may occur as well as the actions that will be taken to mitigate risks that can be can't be avoided or prevent risks that can be avoided:

1. **Costs**: Going over the initial budget due to unrealistic expectations or lack of proper budgeting during the project planning. To mitigate this risk, a detailed list of elements required for the production of the robot was created to help anticipate project needs. Also, purchasing these elements at an affordable rate.
2. **Time Crunch:** Running out of time to complete the robot with all of its requirements at the expected time due to dependencies and delayed timelines. Time crunch may lead to low performance, where the robot does not perform as expected. To mitigate this risk, earlier deadlines are made to allow for enough wiggle room.
3. **Lack of Clarity:** Understanding requirements and dependencies well ahead of time.
4. **Limited Resources:** Due to COVID-19 manufacturers are experiencing delays in production, which may affect delivery times and stock availability. We are experiencing the shortage impact in allocating resources such as RPLiDAR. And limited resource information about ROS2 as it is the newer version of ROS(robots operating system).

3.2. Benefits

1. Alleviate Strenuous tasks: The robot is able to handle carrying heavy loads of snacks and prevent accidents.
2. Performs Repetitive tasks.
3. Reduced labor costs: The robot is able to be productive under minimal supervision.
4. Automating delivery may improve safety, reliability and efficiency.

4. Market/Competition/Research Rationale

4.1. Market Analysis

The autonomous robot market is expected to grow by an astonishing 18.7% by 2028, with current projections estimating a total market of $8.7 billion globally [6]. In their report on the global autonomous mobile robot industry published in October 2020, Verified Market Research segmented the market into 4 categories: Goods-to-Person Picking Robots, Self-Driving Forklifts, Autonomous Inventory of Robots, and Unmanned Aerial Vehicles (UAVs) [6]. The Snack Bot 07 most closely relates to Goods-to-Person Picking Robots. These are robots that are tasked with fulfilling customer orders by utilizing internal storage and automatically transporting the stored goods directly to the operator, or in the case of Snack Bot 07, to the customers. In a report by Grandview Research published in January 2021, they also identified Goods-to-Person Picking Robots as a major market segment and reported that this segment accounted for over 50% of a total $1.9 billion in global revenue in 2019[5]. This demonstrates that Snack Bot 07 is well positioned for the coming years in a rapidly growing market.

4.2. Competition

Despite rapid growth, the current market size of autonomous delivery robots is still small compared to more traditional delivery mediums. Focusing on purely food delivery for a moment, three of the largest competitors include UberEats, Doordash, and Skip the Dishes. In 2019, the same year that the entire autonomous robot market garnered $1.9 billion in revenue, Uber Eats reported annual revenue of $1.9 billion[7], Doordash $850 million[8], and Skip the Dishes $415 million[9]. These services, however, focus primarily on delivery to fixed addresses. Snack Bot manages to distinguish itself from these competitors through its niche market of serving catering companies that deliver to conferences and meetings on campuses. Delivery services to these locations are currently limited, however there are new players emerging in this area as well.

Starship Technologies is a new tech startup founded in 2014, focusing on “last mile” delivery robots that operate primarily on university campuses. According to Kona Equity their annual revenue is $19 million[10]. Customers of Starship Technologies’ delivery service use a smartphone app to place an order with a restaurant on campus, and a robot delivers the food. Kiwibot is another new company that offers a very similar service. Customers place an order for food, an employee then picks up multiple orders and places them in a Kiwibot unit, which then delivers to the customer. Again in this case, Snack Bot 07 manages to distinguish itself by focusing on delivering to conferences and meetings.

5. Company Details

Robo Snacks Company 7 was created on January 15th 2022 and aims to automate food and snack delivering tasks and services.

5.1. Meet the Team

Sirpreet Kaur Dhillon

Sirpreet K. Dhillon
skd24@sfu.ca
Chief Executive Officer

Final year Computer Engineering student who is enthusiastic about software development and software architecture design.

Currently serving the SFU Women in Engineering Design team as the Machine Learning lead, Sirpreet developed an interest in machine learning during her last co-op as a Data QA for FAISAL Lab.

Outside of engineering, she enjoys sketching faces, natural patterns and landscapes. If you ask her nicely, she can sketch a cartoon version of you in 5 minutes or under.

Emmanuel Komolafe

Emmanuel Komolafe
ikomolaf@sfu.ca
Chief Executive Officer

Emmanuel is a final year Systems Engineering student at Simon Fraser University with interests in hardware and software integration. As a systems engineering student he has gotten exposed to diverse areas of engineering including electrical, mechanical and software so he has a background in all three areas.

He worked as a systems engineer co-op student for Health tech connex which was a great experience and opportunity. He was the pioneer of a major project there which is a device that produces simulated EEG signals when triggered. This device was used for the V&V testing of the company's EEG device called the nuerocatch.

Having worked as a systems engineer and gained experience in hardware software integration, he would play a major role in this project since robotics involves integrating hardware and software together.

Outside of engineering he enjoys watching soccer, exercising at the gym and spending time reading the Bible.

Favour Amah-Nnachi

Favour is a final year Computer Engineering student at Simon Fraser University with interests in user interface and software development. Favour has experience from an 8 month internship as a QA & Automation Engineer at 4Refuel and a 4 month internship as a Junior QA Analyst at PNI Digital Media.

Having worked as a test engineer, she brings diverse views on software testing and aims to use her knowledge and skills in debugging the robotic system.

In her free time, she enjoys reading, baking and walking.

Favour Amah-Nnachi
famahnna@sfu.ca
Firmware Lead

Veronica Lund

Veronica is a final year Computer Engineering major at Simon Fraser University. She has accumulated a total of 24 months of industrial internship experience, working for 8 months at Ascenti as a front-end developer, and 16 months at 4Refuel as an Android Developer.

Outside of school and work, her primary interest is music, playing and recording electric guitar and bass guitar, as well as playing local gigs in Vancouver.

Veronica Lund
vlund@sfu.ca
Software Lead

Robert Smyczynski

Currently a fifth year Electronics Engineering student whose main interests are VLSI development and IC design.

Robert recently worked as an Electrical Engineer at Kardium for his last co-op, where his main focus was on PCB design and development for the Globe PF system to treat atrial fibrillation.

In his free time, he enjoys watching scary movies on Netflix.

Robert Smyczynski
rsmyczyn@sfu.ca
Structure Lead

Eddie Zheng

Final year Computer Engineering student who is enthusiastic about software development.

Eddie has worked at Gravit-e Technologies as a QA engineer and 1010Tires and Realtor.com as a software engineer.

In his free time, he enjoys walking and walking more.

Eddie Zheng
eza7@sfu.ca
Automation Lead

6. Project Planning

Project planning for Snack bot O7 is divided into four major processes, which are:

1. Project Definition and Research,
2. Work Breakdown structure (WBS),
3. Division of Work to teams / individuals,
4. Deadline Allocation, and
5. Cost breakdown (see cost consideration section of this document)

This division in project planning is based on Ching-Seh Wu and Dick B. Simmons's paper on "Software Project Planning Associate (SPPA): A Knowledge-Based Approach for Dynamic Software Project Planning and Tracking" [x] and Adrienne Watt's book on 'Project Management'.

There are five major milestones defined and the project is planned and each subsystem is designed around it. These milestones are listed under and also marked in the gantt chart in figure 5:

1. Scope Decision
2. Acquiring Physical Components
3. System Integration
4. Functional Testing
5. PoC Testing

The following figure (figure 4) shows the progress of the project in the current state. The percentages are an approximate measure of the progress and does not include details on the progress of a particular sub-system.

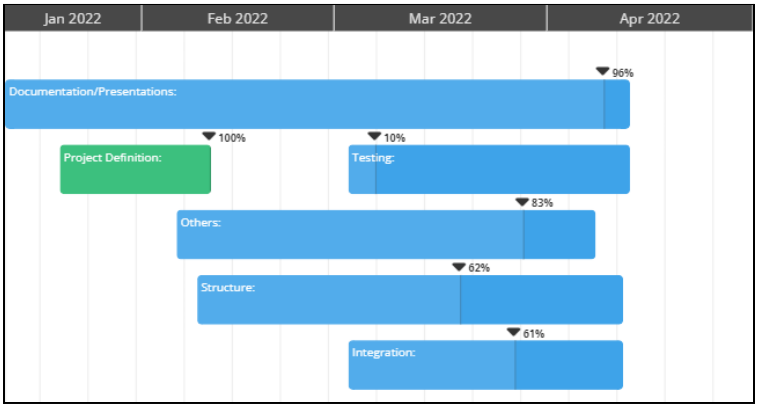


Figure 4: Project Timeline with Progress Tracker

The division in tasks based on a time framework can be seen in the following gantt chart:

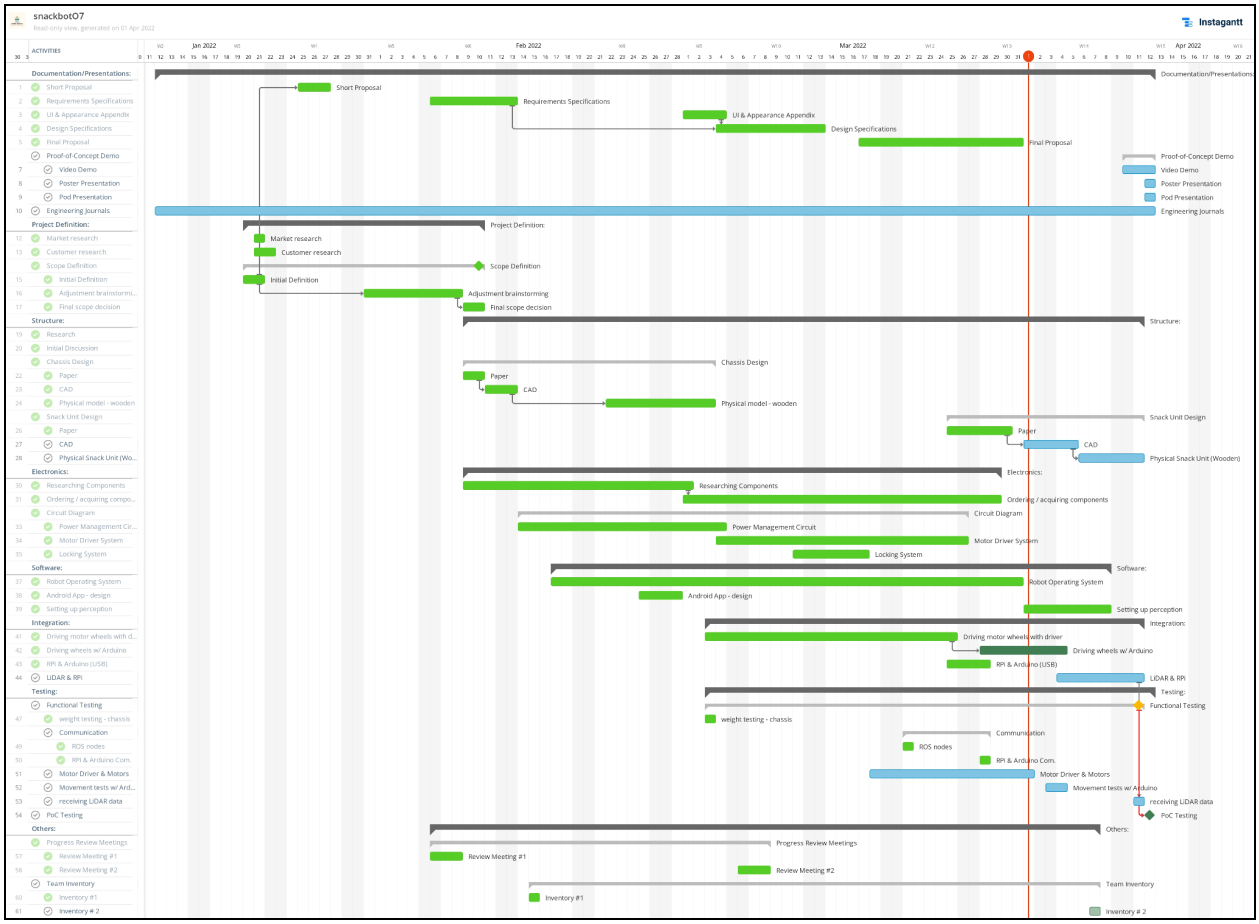


Figure 5: Gantt Chart for Snack Bot O7 Project Management and Planning

7. Cost Consideration

The breakdown for our cost and hypothetical cost on the prototype of the snackbot prototype is summarized in Table. For our project to become successful, we will require funding from Wighton Engineering Development Fund. The funding is available to students based on a competitive basis. We will need to submit a project proposal at the end of the semester to get compensated. Currently, our prototype cost around $264.38 because our team members used some of their own resources. Production wise, the SnackBot will cost around $549.97. For our target market, the cost of around $549.97 could cut back hours required to pay employees.

Function	Component	Quantity	Our Price for Prototype	Production Cost	Source for prototype
Electronics	RP LiDar A1	1	$128.54 (+ shipping)	$99	[1]
	Brushless Hall Motor Controllers	2	$31.47	$31.47	[2]
	Wheels + motors	2	Salvaged from hoverboard ($100)	2 x $42.22 = 84.44	[3]
	Battery	1	Salvaged from hoverboard($ 100)	$31.22	[4]
	Arduino Uno	1	Supplied by Eddie	$33.33	[5]
	Raspberry Pi 4	1	Borrowed from	$72.95	[6]
	Controller	1	Using keyboard	Controlled by app	x
Structure	Wooden Structure (Top wood, bottom wood, 2 side woods)	X	Supplied by Robert	3 x $18.74=$56. 32	[7]
	Mounts	2	Salvaged from hoverboard($	$10	[8]

			100)		
	Container	1	Supplied by Robert	$60.59	[7]
Miscellaneous	Wire connectors	X	Supplied by Veronica	$17.99	[9]
	Waterproof paint	1	$4.37	$20.97	[10]
Total			$264.38	$549.97	

Table 1: Cost breakdown of Snack Bot 07

8. Conclusion

Snack Bot 07 is a new player in an emerging market that has limited commercial development. As a curiosity driven project, Robo Snacks is keen on developing a robot that will push past current technological boundaries and build a strong foundation in autonomous industries.

To accomplish this goal, Robo Snacks is developing a four wheeled robot that will be able to hold up to fifteen pounds of snacks and drinks. Raspberry Pi 4 and Arduino will be the brain that will control the motors. With the incorporation of LIDAR, the Snack Bot 07 will be able to navigate autonomously to meeting rooms. A storage hold will be used to separate the food from the electronics and will have an electronic lock to prevent theft. Combining these elements into one, Robo Snacks is confident that a well-developed product will be brought to market.

A rigorous timeline will be followed to meet certain expectations on time and to build a suitable project by the end of Capstone. Companies will be able to use our product to reduce their labor costs, increase profit margins, and productivity. The project was built to minimize prototype costs while also using the best materials available. For this reason, we believe that Snack Bot 07 will be able to have a longer lifespan and have a lower production cost. Also, Robo Snacks is aware of the risks associated with developing a new project and will mitigate them as much as possible.

We would like to thank Dr. Mike Hegedus, Dr. Andrew Rawicz, and the TA's for their continuous insight and support into our project. The next stages of Capstone will prove to be a difficult task that will be overcomed with a mixture of planning, effort, and excitement.

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