

GNG2101

Design Project Progress Update

Walker Loading B2.2

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List of Acronyms and Glossary

Table 1. Acronyms

Acronym	Definition
BMC	Business Model Canvas
BOM	Bill of Materials

Table 2. Glossary

Term	Acronym	Definition

1 Introduction

The document at hand outlines the comprehensive plan and approach taken by our team for the design and development of a device capable of effortlessly lifting and lowering heavy items, such as a walker, in and out of the trunk of a car. For this project, it is necessary to gain an understanding of user experience aspects as well as considerations for vehicle adaptability, weatherproofing, usability, and cost. Our goal is to create a versatile solution that minimizes any potential damage to the car, is user-friendly, and adaptable to different car models.

Assumptions:

In the context of this project, we assume that:

1. The primary user base consists of individuals with limited user mobility who use walkers for assistance.
2. The device is capable of lifting and lowering heavy items in and out of a variety of car trunks without causing any damage to the vehicle.
3. The device can withstand various weather conditions and function as designed.
4. Installation and maintenance, if any, should be straightforward and easy for the user to perform.
5. The device should aim for universality, being adaptable to different car makes and models.

This deliverable structure starts by providing an overview of the project and its goals, outlining the assumptions made for the project and describing the document's structure and purpose. It contains the selected Business Model Canvas and DFX. For this deliverable the document states and explains our value proposition, discusses the BMC, market analysis, revenue streams, etc. Also, highlighted are the core assumptions made in the BMC, a sustainability report that analyzes the pros and cons of the project's social, environmental, and economic impacts and a selection of five Design for X (DFX) principles and how they will be integrated into the project.

Purpose and Scope:

The purpose of this document is to provide an overview of our project to design a walker loading system for car trunks. Our scope encompasses the entire project cycle, from defining objectives to design, testing, and usability considerations. The goal is to create a system that

improves the quality of life for individuals with accessibility limitations, ensuring their ability to transport walkers or heavy items with ease and independence while accommodating various car models.

2 Business Model Canvas and DFX

2.1 Business model and sustainability report

Value proposition:

Providing the ability to overcome limitations with loading heavy items into the car trunk. Our product's main goal is to give people with accessibility limitations the opportunity load/unload the trunk of the car without relying on the assistance of someone else.

2.1.1 Business model Canvas:

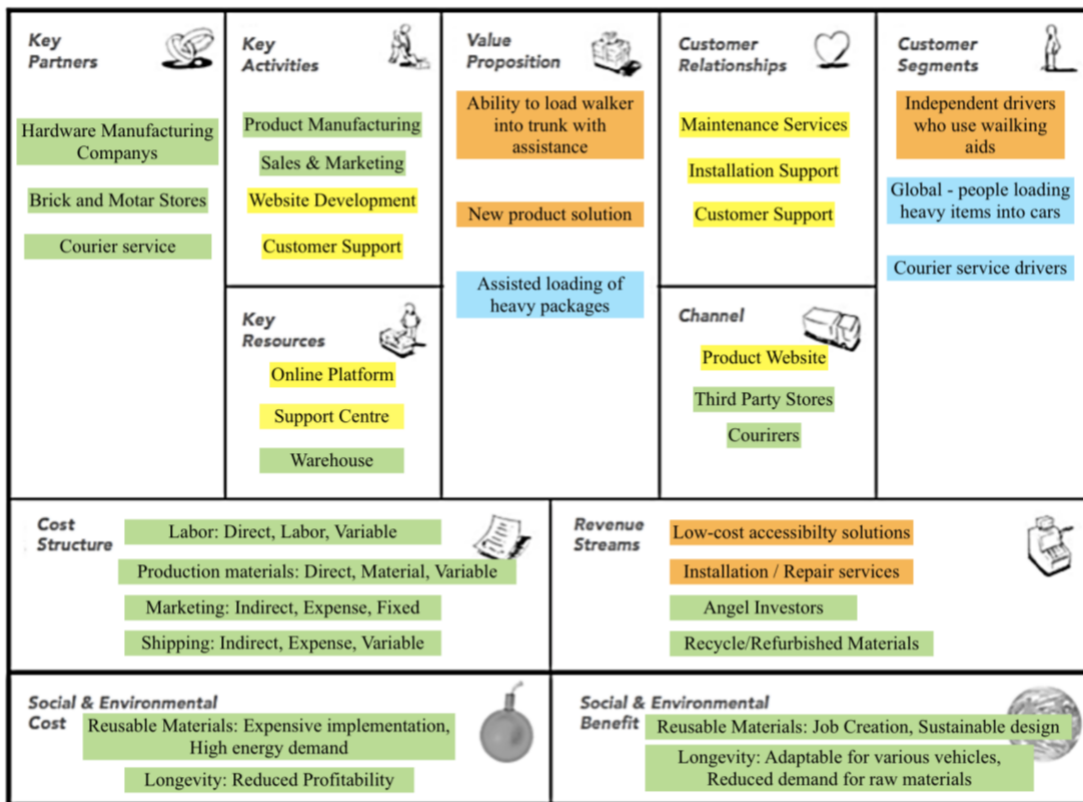


Figure 1 - Business Model Canvas

Value Proposition:

The value proposition addresses the main goal and a common problem that individuals with accessibility issues face. When people with walkers need to drive alone, they often have problems with lifting their walkers into the trunk. The product offers a solution to loading and unloading the walker without the assistance of someone else and this will allow user to have the ability to drive without requiring someone to assist them with loading the walker. The target audience are people who struggle with lifting their walkers into the trunk without assistance. Currently there are not many options available to help with the loading and unloading of walkers. Hence, the product will fill the gap in the market and give people a better option to resolve this limitation. A lack of alternative solutions means that customers who face this problem have limited options making them more likely to purchase this product. In addition to loading walkers, it could also assist with the loading and unloading of heavy items into the trunk. It's versatility enhances potential by allowing it to load other items into the trunk besides walkers and this attribute will make the product more appealing to other audiences both with and without mobility limitations.

Customer Segments:

The primary customers are independent drivers who use a walking aid. The intended goal of the product is to help people load and unload their walker from the trunk. They are the ones who we are creating the product for. However, since the product is versatile, it could be adapted and used in different situations. It could be adapted to help people with loading heavy items into their trunk or assist courier service drivers with their jobs.

Customer Relations:

To develop strong customer relationships, we would offer repairs, provide installation assistance, and customer support. Including these three vital factors will help develop strong customer relations with loyalty and trust. Providing repairs will ensure that the products' quality is upheld, and satisfy customers as they would be able to extend the lifespan of their product. Providing installation assistance would guarantee that our product is properly secure and safe to use while allowing customers to easily integrate the product into their vehicles, minimizing any

potential installation errors. This is important for troubleshooting issues, addressing any questions, and providing real time assistance. Given that the target audience are people with accessibility limitations, having readily available support ensures that customers can receive immediate help.

Channels:

There are 4 main ways that we will deliver the product. The first way is through shipping our products. Using courier service partnership, we would be able to ship the loaders to customers. We will also have loaders in developed stores that we partner with. People will be able to physically view and buy the loaders inside Brick-and-Mortar stores. Using an online platform, customers will be able to view specific details, purchase the walker loader online and have it shipped to their homes.

Key Partners:

Partnerships with brick-and-mortar stores would involve agreements with physical stores that would sell our walker loader. The device is designed to aid individuals with physical limitations by loading their walkers into the trunk. Having our product displayed in a physical store would allow potential customers to test out our product to see if it would be able to assist them. Only having our product online would limit the number of customers we would attract. We would also be able to increase the visibility of our product and utilize existing store relationships. Majority of businesses require manufacturers to function. Since we would need to build many walker loaders, manufacturers would ensure the same quality and specifications are upheld while our product is being built. Having manufacturers would ensure that our product is being built with minimal cost, efficiency, and quality. Developing a relationship with manufacturers can also guarantee that we are able to meet demand. We plan on having a website for our product and having a courier service would allow us to ship our product efficiently to our customers. Having a relationship with a courier service is vital because it would allow us to save money as we ship more products. Advertisers would help with the marketing of the product. They would develop and execute various promotional campaigns to increase the products' visibility. Effective marketing is vital to the product by helping us reach the target audience and build brand recognition. The target audience is people who struggle with loading and unloading their walkers from the trunk without assistance.

Key Activities:

Having an online platform is essential to the survival of a business. Having an online platform would allow us to sell the product directly to our clients, provide information about the walker loader, and provide support to customers. An online platform would provide a more convenient and accessible option for customers to view our product remotely and access important information regarding the product. The online platform would also allow us to expand the audience and gain attention. Maintenance of our product is important because it will ensure that the product is working correctly, and any defects will be resolved quickly. By providing maintenance on the product, it would guarantee customer satisfaction and ensure the products' quality is upheld. Regular maintenance would also extend the lifespan of the product, which would lead to stronger customer relationships. Extending the lifespan of the product benefits the environment because we would not need to make as many loaders. Sales and marketing would involve the promotion of our product, generating revenue, and gaining customers. An effective sales and marketing campaign is important to gain product awareness. Marketing activities will allow us to target our intended audience and build strong customer relationships. Customer support involves addressing customer issues, providing technical support, handling customer feedback, and ensuring customer satisfaction. Excellent customer support is important when building loyalty and trust between our business and our clients. Customer support would allow us to resolve issues quicker, thus keeping our customers happy.

Key Resources:

Some of the key resources that we will use are an online platform, a warehouse, a HR department, and a customer support call center. An online platform is crucial to the success of our business. It will allow us to sell our product online, provide customers with important details about the product, and assist customers with any questions they have. A warehouse is important because we would use the warehouse to build, store, and ship the products. Having a warehouse will also allow us to store all the materials required for building the loader. The HR department will help us manage the business by hiring employees and finding suitable managers to manage the business. HR will also ensure that the safety protocols are being followed, and the department will properly

train employees to be for effective in the work force. Finally, having a customer support call center is important to address all our customers' needs and questions. Customer support is important because it will allow for seamless communication between our business and our customers. Plus, we would be able to help our customers in real-time if they are having problems with the product.

Cost Structure:

There are 4 main costs that would be involved in our business. The costs are labor, materials, marketing, and shipping. labor is a direct cost because it directly relates to the production of our product. It is a labor cost and would be variable because the salaries would vary based on production levels. Materials is the next cost which would be direct since it is a part of production. It is a material cost and would be variable since it depends on production levels. Marketing is indirect because it does not directly relate to production. It is an expense that is fixed because it does not change based on production levels. Shipping is indirect because it relates to the distribution of the product. It is an expense that is variable because it depends on how many walk loaders we ship.

Revenue Streams:

There are many ways that we could generate our revenue streams. The first way would be to lower our manufacturing cost then price the product a bit higher than the manufacturing cost. This would be how we price the product, and the product sales would be a major revenue stream. There are also other fees that we would implement to make money. Some of the fees would include installation and repair service fees. We could also use angel investors to finance our company in the beginning.

Core Assumptions:

One of our main core assumptions is the type of customers. Currently our primary customers are independent drivers who use walking aids, people loading heavy items, and courier service drivers. The assumption is feasible because there are not many products currently that target loading and unloading walkers from the trunk. There is a clear need for our product among people who use

walking aids. However, more research would need to be done regarding whether our other target audiences would integrate this product into their lives.

Market demand is another core assumption that we have made. Our assumption is that there is a significant demand for our product. This assumption is probably feasible since there are people who struggle with loading heavy items into the trunk. Although there are people who struggle with this problem, we cannot be sure whether there would be a high demand for this product. Some people might not want to purchase this product and store it in their trunk.

Adding to our list of core assumptions is profitability. Our assumption for profitability is that we would make enough revenue from our product and services to stay profitable. This is feasible if we have proper financial planning and adequate streams of revenue. There would need to constantly be marketing campaigns to ensure that we sell enough products and have visibility. However, we cannot know for sure if people will purchase our products and services.

Another assumption we made is that we will have a dedicated customer support call center. This is feasible and completely possible; however, it will require vast amounts of planning and logistics. It would take a lot of resources and training to make the support center a success and have it function effectively. Throughout our business canvas model, we state how the support center would be an important part of the business. The support center would complete a variety of tasks such as providing real-time help and addressing any concerns. For the support center to accomplish these tasks the workers would need a thorough knowledge of the product. This might be hard to accomplish if they do not have the right educational background.

2.1.2 Sustainability Report:

In the past, environmental concern was not strongly considered when developing a product. Generally speaking, it requires a significant amount of resources, time and money, ultimately impacting the company's profit. But there is a way to conserve positive net profit and become environmentally conscious: through the lens of sustainability. A sustainable business must consider the "triple bottom line", a balance of the environment, society and economy. In other words, a successfully sustainable business must focus attention on the planet, people and its

profit. As such, our most significant impacts are detailed under groupings of *Recyclable Materials* and *Product Longevity*.

1. Recyclable Materials (RM):

As a company or as an engineer, one should be responsible for their product and its life-cycle, accounting for what will happen at the end of the product’s life. It is evident that many companies only consider their profit when choosing their product’s materials.

Table 3 - Environmental Impacts (RM)

Positive	Negative
<p>The most predominant benefit is that recyclable materials can produce new products. Although self-explanatory, the reuse of “old” materials can drastically diminish the quantity of virgin materials that the company consumes. This could decrease involvement in creating new waste products sent to landfills, which in turn generate green gas emission as mentioned by the government of Canada Department of Environment and Climate Change (Government of Canada, 2023). For example, Apple Inc. estimates that nearly 20% of all materials used on Apple phones in 2021 was recycled, and that 59 – 100% of products shipped with aluminum enclosures was recycled aluminum. (Apple Newsroom, 2022).</p>	<p>More often than not, products consist of a variety of different plastics in an effort to reduce manufacturing cost-per-unit. However, recycling plastics is an extremely expensive endeavor. Due to the nature of plastics, each has a slightly different composition which requires that each piece be exhaustingly sorted. The process requires lots of energy to generate heat that melts the plastics down. Also, in the case of some plastics, less than pleasurable gasses are expelled into the air. Though from an economical perspective plastics are low-cost, ethically and economically the recycling process does not provide a valid solution.</p>
<p>When materials are sustainably sourced, not only do they respect guidelines for the workers, but also environmental regulations. Sourcing raw materials from these suppliers can reduce the impact generated on the environment and ensure the clients get the best materials. When sourcing materials that are sustainable, the</p>	<p>While recycling is always a good idea. It does have a few negative points. Recycling requires a lot of energy. From transportation, separation, cleaning and sent to new factories. Not only that, but many chemicals and metals leach into the surrounding environment where the recycling is taking place.</p>

Table 4 - Economic Impacts (RM)

Positive	Negative
<p>When designing a product at a certain consumer price point, there are likely to be customers who fit below the target price and cannot afford to purchase the product. Thus, claiming and refurbishing our previously owned products at a discount opens up the possibility of more people getting to use the product. The discounted price incentivizes buying refurbished as: “consumers are willing to pay approximately 16% less for a remanufactured camera than for a new one” (Harms and Linton, 893, 2016). Having a lower environmental impact is also a by-product that may attract customers who are “eco-friendly”. To those who bring their old products back to us, credit can be distributed, incentivizing them to recycle and continue to purchase from us.</p>	<p>As a business committed to recycling and proper disposal of waste, it is clear that on top of all our regular business expenses (warehouse rent, machinery, salary, etc.) we must consider infrastructure for recyclability. Several factors play into the cost for an in-house recycling facility; however, it is estimated that to fully equip a recycling facility in the United States would cost upwards of 20 million dollars (ICTSD). While our recycling facility would not amount to the same level as a general-purpose facility, there would remain an incredible initial cost to start recycling.</p>

Table 5 - Social Impacts (RM)

Positive
<p>While our company would need to overcome the initial cost of starting a recycling platform, it would create job opportunities in the surrounding area. It is estimated that “recycling creates on average nine times more jobs than trash”, where the EPA’s 2020 Recycling Economic Information Report states that recycling and reuse accounted for 681 000 jobs in the United States (Eco Cycle, 2022). The benefit to creating jobs in a possibly low-income area is that it would inject the neighborhood with income and infrastructure, with the potential to grow.</p>

2. Product Longevity (PL):

Almost every customer investing in some product would request longevity. For example, household appliances come at a usually high consumer price point, and with that the customers expect 10, 20 or even 50 years of use, and possibly retain their functionality in a new house after a

move. It is clear however that products are not always “made-to-last” as it can negatively impact profits.

Table 6 - Social Impacts (PL)

Positive
Creating a product that is made to last much longer than others on the market will incentivize people to buy a product and transition it between vehicles when needed. Typically, people transition between cars every 2-10 years, thus having a product that will endure a decade worth of abuse creates a positive reputation for our company, and a customer that will surely come back.
When we source our sustainable materials ethically, we are ensuring that the workers are paid fairly and no kids are working. We are also making sure that the workers are not around harmful chemicals.
We can create more jobs when recycling. While recycling does take quite a few steps, each step is conducted by people. This would mean creating more jobs not only nationally but even in other parts of the world.

Table 7 - Economic Impacts (PL)

Positive	Negative
Having one product for a long duration of time, wearing the product down, means the product will likely require repairs at some point in the product's lifespan. For our company to create a repair service for older models means we can continue to receive profit off the same sale. The repair service would have to be offered at a premium, but considering our business model centers around longevity, the customer is likely to pay for repairs.	While ethically creating one “do-it-all” product is beneficial from a societal standpoint as you build a fundamental customer relationship, and environmentally less product will be made to counteract less demand, ultimately hurting profits.
Normally, when companies think of ethically sourcing and sustainability, we believe the costs of production are higher, but if done right, we can reduce costs in the long term. We could decrease these costs by up to 16% while boosting brand value by up to 30%, as mentioned by World Economic Forum (2015).	

2.2 Design for X

Design for Adaptability:

In the client interview, the client had highlighted the value of being able to adapt the solution to different car models and to address this, design for adaptability is selected as a vital element to consider. The device will be designed to be adaptable with the intention of allowing the user to be able to implement the product when switching to a different car. This is an ideal concept that would be accounted for when generating solutions and is related to the client's statement. Additionally, taking into account that the client has recently purchased a new walker, the device would also need to accommodate such situations. In terms of implementing this to design a universal solution, the device would fit into different vehicles and be useful for different walkers.

Design for Reliability:

With the understanding that this project aims to offer accessibility solutions, another vital element that the solution would focus on is the design for reliability. The main requirement of reliability that would be incorporated into the design of the loading system includes function, performance, lifespan and environment. The user will be driving around without assistance and needs to be able to make use of the preferred solution independently. To this end, the device is to be dependable, secure and consistently in good performance. Also, the loading system would operate normally in different weather conditions and would not cause any damage to the car during use. The system would be designed to require minimal planned maintenance during its lifespan. Ensuring reliability would involve defining and collecting metrics that reflect the key indicators of the system's behavior and performance. This will be done in the next stage of this project.

Design for Usability:

Usability in the design of the loading system will be defined as a measure that assesses how easily the user can use it effectively and satisfactorily to lift the walker in and lower it out of the

trunk of a car. An important criterion to satisfy usability is that the use of the device is easy to understand and learn. It also has to be memorable, which implies that it will be easy to remember how to make use of the loading system. The design process would ensure efficient use when performing the loading task, account for possible errors during use, and how to recover from them. Additionally, user satisfaction is another criterion that would ensure that the device is easy to use. To test this design element, it would be beneficial to have the user make use of a prototype which would allow observation of successes and difficulties faced. The user has specific limitations that need to be considered for them to be able to use the device.

Design for Sustainability:

The design stage is the most influential in determining how a product will affect the environment, so it is necessary to review how the loading system will be built that promotes sustainability. Evaluating the lifecycle of the device through its raw materials, manufacture, distribution, usage, maintenance, and disposal would help reduce most of the negative impacts it could have on the environment. Selecting sustainable materials such as recycled materials for the components of the loading system would help reduce carbon footprint. The system could also be designed to be improvised for other uses or to meet the needs of consumers beyond the initial user it was designed for. Additionally, use of modular design would promote sustainability as it allows design with components as modules that can be used in multiple products. Modules are predesigned components with a specific function and the advantages of this include cheaper and easier manufacturing, assembly, replacement, repair and disposal.

Design for Cost:

The client is seeking an affordable solution and to meet their needs the fifth element selected to guide the design of the loading system is the design for cost. For this project the expected cost is estimated at \$100, hence it is essential that the design technique controls the cost of the device development and manufacturing. By considering the overall cost of the product and lower engineering costs of the product from the initial stages of design, unnecessary costs can be prevented.

3 Problem Definition, Concept Development, and Project Plan

3.1 Problem definition

Problem Statement: Design a weatherproof, safe, durable and adaptable system to lift a walker in and lower it out of the trunk of a vehicle. It is to be used independently by an individual who uses a walking aid without causing damage to the car or to the walker.

Mobility limitations prevent some people from loading and unloading heavy items to and from the trunk. The solution could be a device that secures to the trunk which automatically loads and unloads the items.

Known Variables: Budget, Weather requirements, General car type, User mobility.

Unknown Variables: Car dimensions, Product placement (exterior/interior).

Table 8 - Customer Needs

#	Need	Imp	
1	The loading system	operates normally in various weather conditions	5
2	The loading system	is adaptable to different vehicle types	3
3	The loading system	can lift various folded walker models	1
4	The loading system	preserves the quality of the car	4
5	The loading system	is easy to install	3
6	The loading system	is affordable and within budget	3
7	The loading system	lasts a long time	5
8	The loading system	is safe to operate	5
9	The loading system	allows for easy maintenance	3
10	The loading system	does not take up all the trunk's capacity	2
11	The loading system	preserves quality of the walker	5
12	The loading system	does not require a high degree of mobility to operate	5

*Rating used: 1-5 (1 being worst, 5 being best)

Table 9 - Interpreted Metrics

Metric #	Need #	Metric	Unit
1	6	Price (CAD)	\$
2	2,10	Dimensions: Length x Width x Height	in
3	4,11	Exterior Storage of Walker	Y/N
4	2	Exterior-Mounted Device	Y/N
5	12	Degree of Mobility Required	level
6	3,8	Load capacity	lbs
7	1,7	Material	list
8	9	Degree of Recyclability (of Materials)	level
9	8	Weight of Unit	lbs
10	5	Ease of Use	level
	5,9	Tool for installation	list

Table 10 - Benchmark on Metrics: Competitive Products

Metric #	Need #	Metric	Imp	Unit	Exterior Hitch Carrier	Hitch-Mounted Lift	Trunk-Mounted Arm/ Hoist	Ramp
		Company	-	-	Steady Carriers	Viking Solutions	MillerCare	Ganggend
1	6	Price (CAD)		\$	399.00	355.99	Unknown (Requires a Quote)	159.99
2	10	Dimensions Length x Width x Height		in	Length from hitch 12 x 19 - 26	60 x 36.5 x 52	N/A (Inquired)	36 (closed position) – 60 (open position) x 7.4
3	4,11	Exterior Storage of Walker		Y/N	Yes	No	No	No
4	2	Exterior-Mounted Device		Y/N	Yes	Yes	No	Only in Use
5	12	Degree of Mobility Required		level	High	Moderate	Low	High
6	8	Load Capacity		lbs	Unknown	300	176.4 – 220.5	600
7	1,7	Materials		list	Steel Tubing and Stainless-Steel Hardware	Steel Tubing and Stainless-Steel Hardware	Unknown	Aluminum Alloy with plastic non-slip portions
8	9	Degree of Recyclability (of Materials)		level	High	High	N/A	Moderate
9	8	Weight of Unit		lbs	< 9	54	Unknown	12.71
10	5	Ease of Use		level	Moderately Easy	Moderately Easy	Easy	Easy

*All product’s images and specifications are listed below:

Benchmarking:

Product 1: Steady Rollator Carrier – Single – SRC-30



Figure 2 - Exterior Hitch Carrier

Mounting occurs as rear wheels fit into mount, then fold up. Requires front to back folding walker. Attaches to hitch, and due to the materials generally speaking can support the weight of many different walkers. But requires high degree of mobility.

Product 2: Swivelift – Hitch Mounted Games Swivel Lift



Figure 3 - Hitch Mounted Lift

Although not directly related to accessibility, serves similar purpose. Walker would rest on the platform and raise up to comfortable level. Not listed but looks like steel tubing and stainless-steel hardware. Lifting mechanism is a winch, thus may require a moderate degree of strength and mobility.

Product 3: Millercare Autochair Car Boot Hoist



Figure 4 - Trunk Mounted Arm Hoist

Product 4: Wheelchair Ramps for Steps 3 to 5 ft, Adjustable Aluminum Ramp 2 pack



Figure 5 - Wheelchair Ramp

The ADA (American with Disabilities Act) provides a guideline on ramp slope for occupied and unoccupied wheelchairs. We only require that of the unoccupied ramp, which states that the recommended slope be for every 3 in vertical rise there is a 1 ft of ramp (approx. 14.5 degrees). Retractable design, allowing it to slide into a trunk for storage. In addition, boasts non-slip tracks.

Table 11 - Marginal and Ideal values

Metric		Unit	Marginal Value	Ideal Value
1	Price (CAD)	\$	159.99 < x < 399.99	200.00 < x
2	Dimensions inside vehicle: LxWxH	in	36 x 7.4 x H	< 37.8 x 43.3 x 35.4 (Dimensions of Trunk)
3	Exterior Storage of Walker	Y/N	N/A	N/A
4	Exterior-Mounted Device	Y/N	N/A	N/A
5	Degree of Mobility Required	level	Low < x < High	Low
6	Load capacity	lbs	176.4 < x < 600	26.5 (weight of walker) <
7	Material	list	N/A	N/A
8	Degree of Recyclability (of Materials)	level	Moderate < x < High	High
9	Weight of Unit	lbs	9 < x < 54	9 < x < 54
10	Ease of Use	level	Easy < x < Moderately Easy	Easy

Table 12 - Final Target Specifications

Metric		Unit	Value
1	Price (CAD)	\$	200
2	Dimensions: Length x Width x Height	in	< 37.8 x 43.3 x 35.4
3	Exterior Storage of Walker	Y/N	No
4	Exterior-Mounted Device	Y/N	No
5	Degree of Mobility Required	level	Low
6	Load capacity	lbs	26.5 <
7	Material	list	N/A
8	Degree of Recyclability (of Materials)	level	High

9	Weight of Unit	lbs	16
10	Ease of Use	level	Easy

3.2 Concept development

Concept 1

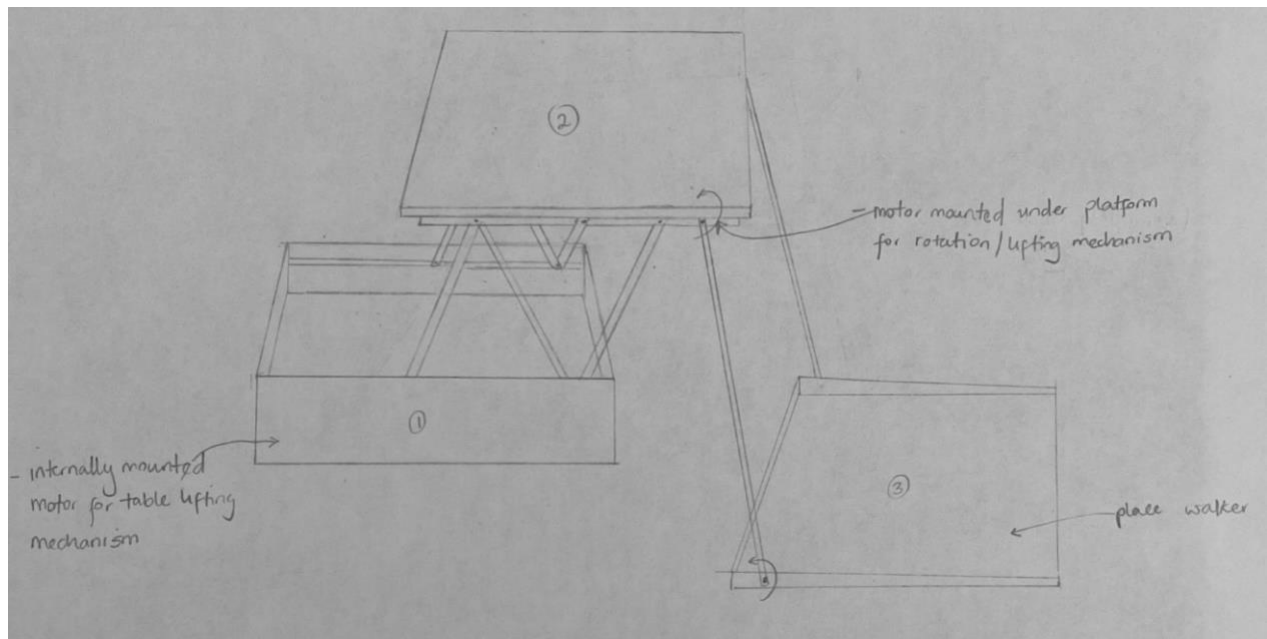


Figure 6 - Walker Loading System Concept 1

Subsystem 1: Power

System would require 2-4 actuators with each pair having equal capacity and power requirements. Power supply for the system would ideally be from the car system, however there may be need for extra power supply.

Advantages:

- Makes use of vehicle power system

Limitations:

- High power requirement for 3 actuators that can handle the target load capacity.

- High-cost requirement.
- May require additional power supply to power actuators

Subsystem 2: Lifting mechanism

Platform 2 is raised and pushed outward using a similar mechanism to that of a lift top hinge. The links from platform 2 to 3 is then rotated to bring platform 3 to the ground while keeping it constantly in a horizontal position. After walker is folded on platform 3, the reverse motion of the links from platform 2 to 3 lifts and places platform 3 on top of platform 2. Lastly, the links between platform 1 and 2 is lower to bring the walker currently placed on platform 3 to a stable position from the base of the trunk.

Advantages:

- Easy to use with 2 automated controls for each subsystem

Limitations:

- Requires estimations to accurately decipher actuator and link mechanism requirements that allow the platform 3 remain horizontal during the lifting process

Subsystem 3: Mounting

Platform 1 is attached to the base of the vehicle

Advantages:

- Parts can be designed using sustainable materials.
- Does not cause damage to vehicle and walker.
- Preserves storage capacity of trunk as items can be placed in platform 1.

Limitations:

- Dimension limitation to adapt design to vehicle trunk.
- Securing the platform to the base of the trunk may require vehicle modifications

Concept 2:

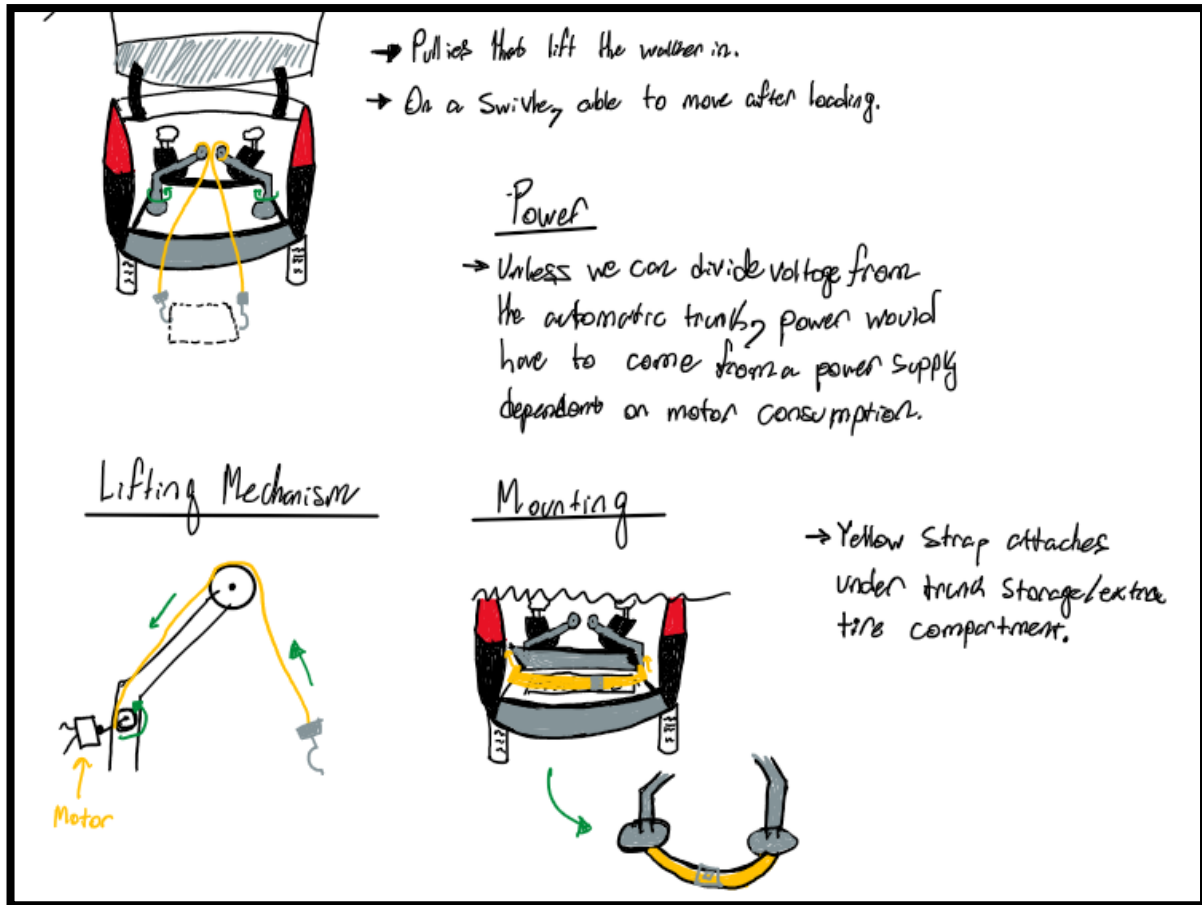


Figure 7 - Walker Loading System Concept 2

Subsystem 1: Power

Power of the system will be handled by either a splitter cable separating the trunks power into two sources or a cable coming from the vehicles centre-console 12V outlet.

Advantage:

- Very general solution, allowing adaptability for many vehicles.

Limitations:

- A long cable may have to be run from the centre console, disturbing passengers of the vehicle.

- Power may only come from a 12V outlet, restricting power.
- Splitting the trunk power may result in more battery usage if the car's alternator is not running.

Subsystem 2: Lifting Mechanism

Lifting will be done through a set of pulleys, each on a swivel being able to move out of the way when not in use and extend past to the car's trunk to reduce damage to the fender. Each pulley will be powered by a motor in the base connected to a wheel that will rotate clockwise and counterclockwise to lift and lower respectively.

Advantages:

- Due to having two pulleys, the less powerful and power-hungry motors are required, reducing power consumption and dispersing the load by a factor of $\frac{1}{2}$.
- Pulleys on a swivel, enabling small footprint when not in use (retracted).
- Almost entirely automated lifting.

Limitations:

- Must use with caution as heavy objects may have the tendency to swing.
- Load capacity is average as all the translation occurs in the y-axis only.
- Moderate easy of use, but the user would be required to bend and attach hooks.

Subsystem 3: Mounting

Mounting of the devices is done by a strap that slides underneath the spare tire/ extra storage compartment.

Advantages:

- Can be easily removed and adapted to a new vehicle. No permanent modifications.
- Mounted inside the vehicle, not directly impacted by the elements, reducing maintenance.

Limitations:

- May cause inconvenience if spare tire/ storage compartment is accessed often.
- May move/ slide if object is on the limit of its load capacity.

Subsystem 2: Lifting Mechanism

The walker will be loaded and unloaded using a motor which has rope or some type of strong material. The rope would be attached to the motor on one side and have a hook attached to the other side. The motor would rotate clockwise and counterclockwise to lift and lower the walker. The motor would be attached to the back of the plank.

Advantages:

- The ramp would not use too much trunk space.
- It is a simple design, so it would be easy to maintain.

Limitations:

- To unload the walker the user would have to pull the walker out of the trunk a bit. Once the walker is out enough the motor would rotate slowly to unload the walker.
- There would be a weight limit.

Subsystem 3: Mounting

The ramps would be attached to a large plank. The plank would be latched onto the hooks in the trunk which would hold the loader in place.

Advantages:

- The loader would not be permanent, so it could be used in different cars.
- When the loader is not being used it would use minimal space and it would be quick to remove.

Limitations:

- The loader would only function in cars with a SUV trunk style.
- Since it is not permanently fixed there would be a weight limit for the loader.

Decision matrix:

Selected Criteria	Weight	Concept 1	Concept 2	Concept 3
Ease of use	0.20	4	2	3
Cost	0.05	3	3	5
dimensions	0.10	2	2	1
Load capacity	0.10	6	4	4
Degree of Mobility Required	0.15	6	3	2
Lifespan	0.10	4	2	3
Maintenance requirements	0.10	3	5	4
Safety	0.20	5	4	4
Total	1.0	4.35	3.10	3.15
Rank		1	3	2

Table 3.6 – Decision Matrix

*Rating 1-6 (1 being worst, 6 being best)

Global Concept – Concept 1:

First, the user adjusts the walker onto the lower platform. Then, the walker is secured to the lower plank to prevent it from rolling off. Next, the user clicks a button so that the lower platform goes on top of the second platform. Lastly, the second platform will go on top of the third platform. The user can then close the trunk of the car. Advantages and limitations of the global concept have been highlighted earlier in concept 1

This concept was chosen since it is the safest and easiest model for the user. This concept requires minimal to no effort to put the loader in the trunk. The chosen concept can also lift the most weight since the links are made of metal and the system is sturdy, unlike the pulley system and the ramp. The chosen concept would also last the longest of the 3. The ramp only has two support points that hold all the weight of the loader. Thus, would break over a short period of time. The pulley system would quickly become weak as the rope gets used and dirtied by the outside weather.

3.3 Project plan

<https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=WXuwVV0jveAYzau1nl22VWIT3Aex3knJ%7CIE2DSNZVHA2DELSTGIYA>

4 Conclusions

The project involves the design of a walker loading system and the document highlights the different stages that lead to the final product. It commenced with identifying the project objectives, scope, and assumptions as well as the selection and development of a suitable Business Model Canvas. The selected business model canvas used the triple bottom line format and this required a sustainability report which was also completed in the first deliverable. The inclusion of sustainability considerations highlights a commitment to environmental and societal impacts. This approach not only fills a market gap but also aligns with broader sustainability goals, positioning the product for long-term success and societal influence.

This second deliverable is a modification of the first to include the next stage which involves problem definition and concept development. Based on the target specifications generated using the identified customer needs, various concepts were generated and screened to result in three main concepts. These main concepts were then evaluated on a design matrix to result in the selection of a final concept. The next stage would involve using customer feedback to modify concept and create a detailed design with a Bill of Materials (BOM).

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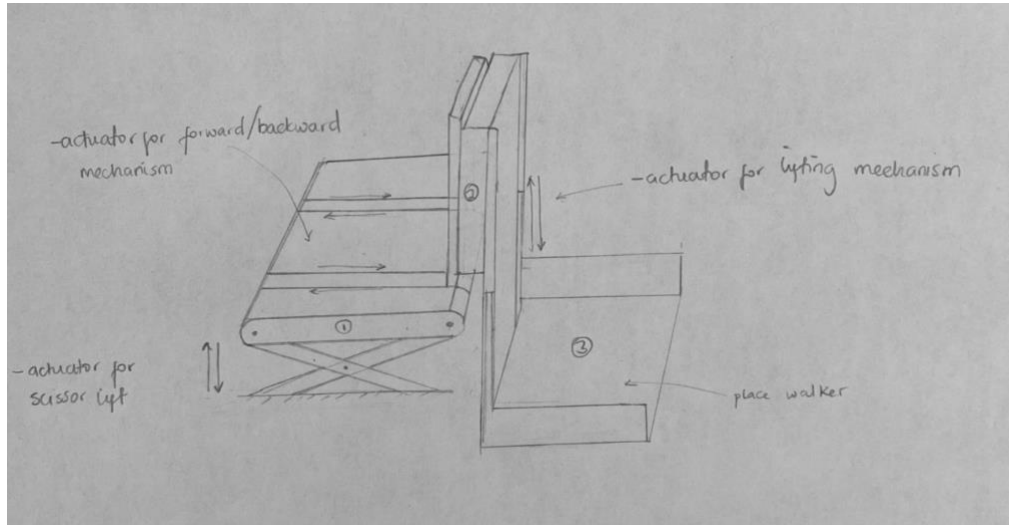
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APPENDIX

Brainstorming Concept screened out:



Platform 1 is raised, using a scissor lift system, to allow platform 2 and 3 move forward without interference from the base of the trunk. Conveyor mechanism pushes forward platform 2 and platform 3 is lowered to the ground using a modified forklift mechanism. After walker is placed on platform 3, the modified forklift mechanism is lifted to be at the same level with platform 2. Then the conveyor mechanism pulls platform 2 and 3 into the trunk with the walker loaded on 3. Lastly, the scissor lift is lowered and platform 1 is returned to a balanced position from the base of the trunk.