GNG2101

Design Project User and Product Manual

Craniacs B2.2:

Accessible Walker Loading Device

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December 1st 2023

University of Ottawa

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Table 1 - Acronyms

Acronym	Definition
CAD	Computer Aided Design
PPE	Personal Protective Equipment

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Table 2 - Glossary

Term	Acronym	Definition

1 Introduction

This User and Product Manual (UPM) provides the information necessary for drivers that require a walking aid to effectively use the walker loading crane and for prototype documentation. It is important to review this manual before use to ensure loading operation is performed properly and to promote user safety.

Assumptions made during the designing process include the trunk size and car model, power of any electronics, mounting, and the weight of the walker. The assumed car model was a Honda CRV with an approximate trunk size of 40x37.2x38 inches. A 12V cigarette lighter was assumed for available power, which was later determined to not be enough to power a motor that could have been included in the product. Available tie-down anchors were assumed to be available at the back of the trunk and a maximum load weight was assumed to be 30lbs.

This document outlines: an overview of the presented problem and the constructed solution, cautions and warnings, user considerations, steps to assemble and disassemble the crane, how to use the crane, definitions of each sub-system, troubleshooting and support, maintenance, documentation of product development, and recommendations for future work.

To utilize the product, users should ensure that there is a clear area around the vehicle before loading a walker into the trunk. Users should always follow weight limitations when lifting heavy loads and should not attempt to lift more than 30lbs. The base of the crane must be properly secured to the car using ratchet straps. Regular inspections and maintenance of the system is encouraged.

2 Overview

The problem at hand focuses on the obstacles some individuals with mobility limitations face when it comes to independently loading and unloading a walker to and from the trunk of a car. Many people who use walkers or other mobility devices encounter significant difficulty when they need to transport their aids into their vehicles without assistance. This problem is important because it limits their independence and restricts their ability to be self-reliant. It requires them to be dependent on others for help with handling the walker. The lack of available solutions suited to these specific needs exacerbates the issues, leaving individuals with limited options.

The fundamental needs of the user for the loader revolve around accessibility, ease of use, independence, and safety. Users requiring mobility aids seek a solution that allows them to transport their aids independently without requiring assistance. They need a product that accommodates the various weather conditions, ensuring reliability in extreme temperatures or snow. Safety is a key fundamental need. They require a product that ensures that the vehicle and walker do not get damaged when the product is in use. Easy use and simple installation are important, specifically for individuals with limited mobility. The product needs to require a low degree of mobility and is cost-effective.

Our product is differentiated from other products for several reasons. It is cost-effective, ensuring affordability without affecting quality. It is designed to protect the walker without modifying the vehicle. It can operate in various weather conditions. Also, it requires minimal mobility to use effectively. These factors combined set our product apart from other available products in the market.

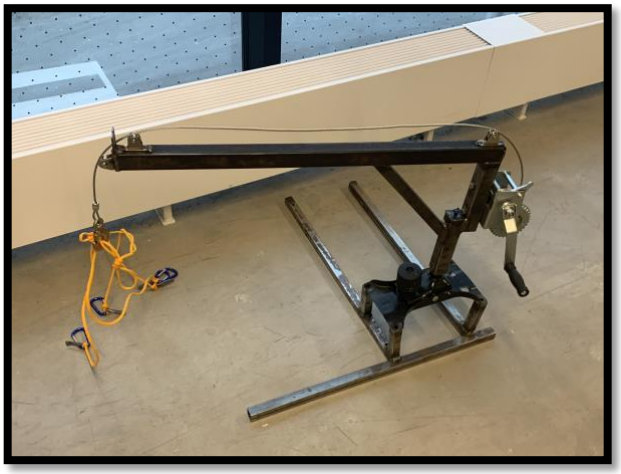

Figure 1 - Crane Assembled

The product comprises a crane-like mechanism that sits in the vehicle trunk. It consists of a base and a crane that swings out. The crane arm is equipped with hooks that are connected to rope and a pulley system. Users that extend the crane arm outside the vehicle, attaching the hooks to four points on the walker. They can lift the walker by using the crank, and then swing the crane arm and walker into the trunk smoothly.

The system is built similar to a sturdy metal frame with a specially designed crane mechanism. It does not involve complex electronic components, and it operates through a straightforward user-access mode. To use it, the user extends the crane arm outside of the trunk which is supported by the frame structure. The user attaches the hooks to the walker and lifts the walker using the hand crank. Once lifted, the user can guide the walker into the trunk using the crane arm. This is a straightforward, and simple operation that ensures ease of use without relying on complex technology. As for special conditions, the system is designed to be weather-resistant and durable.

The block diagram below shows the main focuses for the design and prototype.

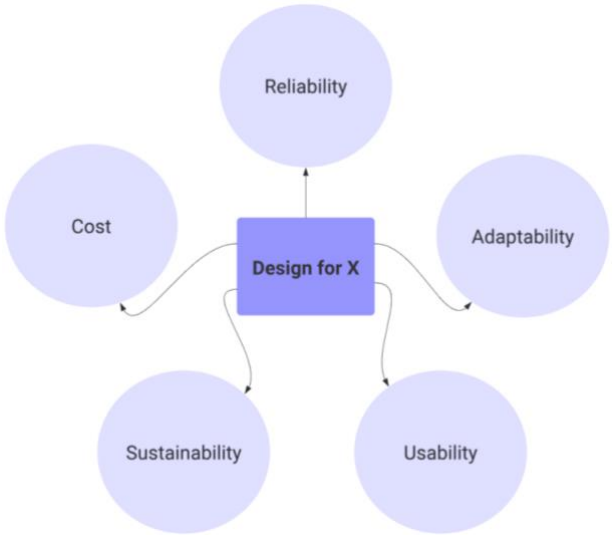

Figure 2 - Design for X

2.1 Conventions

No conventions will be used to describe user action or syntax because this is not a software product.

2.2 Cautions & Warnings

Before using the prototype, users should be aware of certain cautions and warnings:

Safety Precautions: Users should ensure the area around the vehicle is clear before operating the prototype to avoid potential accidents. The prototype should also be firmly secured to the trunk using the straps attached to the base. Also, when loading the walker in and out of the trunk you might have to guide it, so it does not hit anything.

Weight Limits: It is important to follow the weight limitations specified for the crane system. Overloading the uploader may compromise its functionality, or cause damage to the prototype.

Secure Walking Aid: Properly attach the hooks to the designated points on the walking aid. Make sure the points selected ensure that there is balance when the walking aid is being lifted. Incorrect attachment might lead to instability during transportation of lifting.

Maintenance: Regular inspections and maintenance of the prototype should be done to ensure all the components are in good working condition. Any signs of damage or wear should be addressed promptly.

Regarding waivers, if necessary, users might have to sign a liability waiver to use the prototype. The process usually involves reviewing and signing a document that outlines the risks associated with using the device and absolving the creators of any liability for accidents or damages that may occur during its use. This process might vary depending on the organization providing the prototype. Users should seek clarification from responsible parties regarding the required procedures for signing waivers before using the prototype.

3 Getting started

This prototype requires minimum setup and is not permanently attached to your vehicle, because of this, the set up and removal are extremely simple. Although, help might be needed due to the weight and size of the loader.

3.1 Configuration Considerations

There are a few tools and requirements that would be needed to be able to use and store the product. Firstly, the belt can only be used if your vehicle has anchor points behind the back seats for added support. Secondly, the vehicle has to be large enough to both accommodate the desired walker being loaded and the product. The loader was also designed based on a small SUV, any smaller car could face issues due to the trunk's size. Lastly, a flat-head screwdriver would be required to pull apart the arm from its base, for easy storage. This is not required, but highly recommended to not damage the loader.

3.2 User Access Considerations

1. This device can be used by a multitude of people. Most people who have difficulties with putting anything away in their trunk could benefit from this system. While it offers many benefits, there are specific limitations that may restrict its universal usability.To put away your walking device. Although, some level of mobility is required to be able to safely use this device: able to bend over, walk from trunk to driver seat without walking device and one hand is always free. The size of the device needs to be considered.

2. To put away bags of any sort into the trunk. The user would also require a certain mobility, such as bending down. The weight capacity of the loader also must be considered.

3. Any other object you are unable to put away into your trunk. The object must be able to fit in your trunk with the loader and not exceed a certain weight. The user must be able to bend down, able to walk to the driver's seat and have a free hand at all times.

3.2 3.3 Accessing/setting up the System

Set up procedures:

1. Open your vehicle's trunk.

2. Place the loader int o your trunk, you might need assistance for this step.

3. Depending if you use you are left-handed or right-handed, place the loader on either side of the trunk. If you are left-handed, place on the right side, and the opposite if right-handed

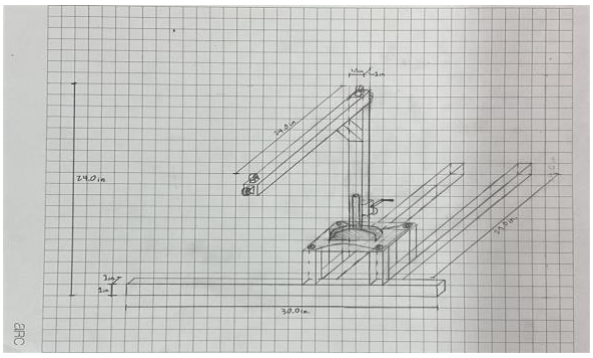

Figure 3 - left-handed walker, placed on the right side

4. Add the counterweights to the two back supports. This will prevent the loader from tipping over.

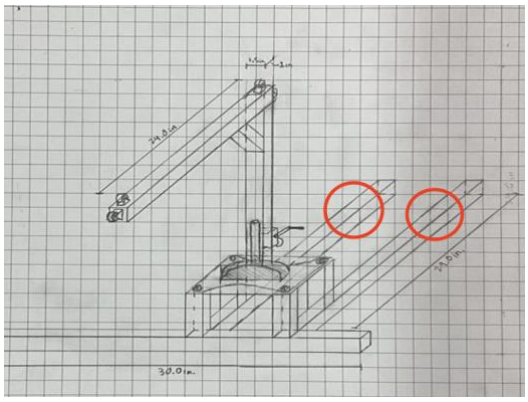

Figure 4 - place counterweights in areas shown in picture

5. Attach the belt. Hook one part to the anchor points used for car seats, then around the vertical rotating bar of the loader to the other hook of your vehicle, finally tighten the belt. This is optional but will give more support.

Figure 5 - Anchor points required for belt

The loader is now ready to be used!

3.4 System Organization & Navigation

The product can be separated into five different components: the rotating arm, the base support, the belt and lastly the counterweights.

Rotating arm:

This is the top part of the product that extends outside of the vehicle. It is also the part where you attach the objects you wish to put in your trunk with minimal effort. It has pulleys attached to it, the crank, which will have to rotate to pull objects up or down, and the cords with hooks to hook the desired object to.

Base support:

This permits the whole loader to sit upright. It consists of three metal bars welded together for strop support. It is also equipped with a mechanism that permits it to rotate the upper part of the loader, the rotating arm.

Counterweights:

Counterweights are needed to prevent the loader from tilting. Many different weights can be used depending on how much support is needed to keep the entire system upright.

Belt:

The belt is used to give extra support to the weights. Since it is placed higher, the loader, the tipping force is even more reduced. The belt only adds extra support and is not obligatory to use.

3.5 Exiting system

The exiting procedure is quite simple since the loader is not fixed to the vehicle permanently.
Exit procedures:

1. Remove the belt by losing it, then unhooking it from the vehicle.
2. Move the arm if it is in your way, and remove the counterweights, help is advised to prevent injuries.
3. You can now remove the loader from the trunk.

4 Using the System

To operate the walker loading system the following steps need to be executed in order. This ensures that the operator, as well as the vehicle and walker are always safe from injury or damage.

Loading Procedure:

1. First, the user will open the trunk of their vehicle either using a button on their key fob or a button inside of their vehicle.
2. The user will approach the open trunk of their vehicle from the right had side parallel to the bumper in relation to looking at the vehicle from behind.
3. The user will park and lock the walker so it is directly under the halfway point where the unfolded **Crane Arm** will be.
4. Supporting themselves with one hand on the open trunk the user will fold their walker into a flat position onto the ground as shown in **Figure 6**

Figure 6 - Walker Folded into a Flat Position

5. While steadying themselves on the trunk of the car with their right hand the user will rotate the **Crane Arm** from a parallel to perpendicular position in relation to the trunk of the vehicle as seen below.

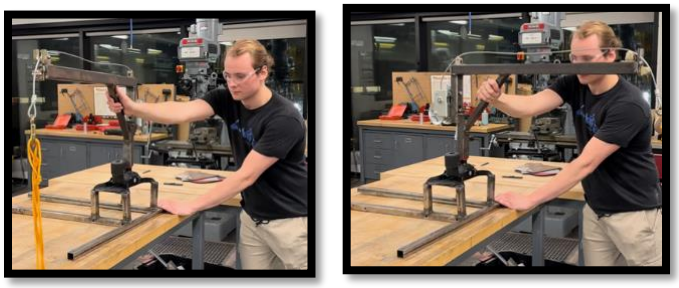

Figure 7 - Rotation of Main Arm

6. While keeping a hand on the trunk to steady themselves the user will check the **Locking Mechanism** on the **Crank** to make sure that it is in the lowering position as seen in **Figure 8**.

Figure 8 - Ensuring that the Locking Mechanism is in the Lowering Position

7. The user will then rotate the **Crank** counterclockwise shown until the **Clips** are touching the ground by the walker.

Figure 9 - Clockwise Rotation of the Crank to Lower the Clips

8. Once the **Clips** are at the correct height the user will bend down and clip each of the four to stable points on the walker as shown in Figure 10.

Figure 10 - Clips Being Connected to the Four Points on the Demonstration Walker

9. From here the user will once more switch the direction of the **Locking Mechanism** into the lifting position
10. The user will then slightly raise the walker by rotating the **Crank** clockwise and make sure it is stable as shown.

Figure 11 - Walker Slightly Lifted in a Stable Position

11. Once the walker is confirmed to be stable the user will continue to raise the walker by rotating the **Crank** clockwise until the bottom of the walker clears the trunk of the vehicle as demonstrated in Figure 12

Figure 12 - The Walker Lifted to a Height that Clears the Rear of the Vehicle

From here the user will perform the opposite operation of step 5 and rotate the **Crane Arm** back into the vehicle into the position shown in **Figure 7**.

12. The user will then change the direction on the **Locking Mechanism** and rotate the **Crank** counterclockwise and lower the walker until in is just touching the bottom of the trunk ensuring that the **Crane Arm** does not rotate causing damage while the vehicle is in motion.

13. Lastly the user will close the trunk of the vehicle using either their key fob or button inside the vehicle and make their way to the driver's seat and proceed to their destination.

Unloading Procedure:

The unloading procedure is quite like the loading procedure just in reverse. In basic terms to unload the walker from the vehicle the client will raise the walker checking if its stable, rotate it outside of the vehicle, lower it to the ground, unclip the clips, crank the clips upwards, rotate the arm back inside, and lastly fold the walker and close the trunk.

4.1 Definitions of Sub-Systems

Crane Arm: The crane arm (**Figure 13**) is a long steel-tubing structure that attaches the pulleys, crank, clips, and cable to the base of the system and allows for rotation in and out of the vehicle. This component extends past the trunk and facilitates the raising and lowering motion. Before operation it is important to make sure that the cable is correctly seated in each of the three pulleys.

Figure 13 - The Crane Arm

Crank: The crank (**Figure 14**) is what allows for the walker to be lifted or lowered. The direction is controlled by the locking mechanism as explained below. The crank contains a few different components; the crank arm is a bar and handle extending outwards that the user rotates; the cable is a thin steel rope that passes through the pulleys; the hook is where the two clip ropes are attached and the locking mechanism is explained in further detail below. The user either rotates the crank arm clockwise to raise or counterclockwise to lower the walker. Make sure to keep hands and fingers away from the exposed gears as they may become caught in the gears causing injury. Before use make sure that the cable is inside of the spool and not tangled on either side.

Figure 14 - The Crank

Locking Mechanism: The locking mechanism (Figure 15) ensures that the cable does not feed too quickly through the crank when rotating as well as changing the direction. This allows for safety in an event where the user lets go of the crank arm. In this case the locking mechanism will stop rotating when the user lets go of the crank arm and not feed any more cable through. This prevents the walker from being dropped when it is raised to any height. The locking mechanism works both for the raising and lowering application with a switch that can be flipped up or down. This is located on the top of the crank as circled in red on the figure below.

Figure 15 - The Locking Mechanism on the Crank Circled in Red

Clips: The clips (Figure 16) are what attach the lifting system to the walker. These clips are four carabiners that operate by pushing on the small lever to open the "loop". The clips are attached to two ropes that connect to the hook which extends from the crank cable. It is important to make sure that the clips are attached to stable points on the walker which will not slip and cause the walker to drop.

Figure 16 - A Clip Attached to the Rope Connecting to the Hook.

5 Troubleshooting & Support

In this section, the user can find the documented protocol for troubleshooting any issues that may be encountered during product use. The guide on how to request support has also been included in this section. Possible issues that could occur have been carefully considered through system testing.

If any issues are encountered during use, first ensure safety of users and stop operation where possible. Seek immediate help from any persons around working environment. If issue persist, contact the support team for assistance and where possible ensure system is placed in a safe position to avoid causing harm to user. Ensure to not use device when there is a reason for concern to ensure safety.

5.1 Error Messages or Behaviors

The system is of similar construct to a crane and consist of three main parts, the pulley system, the rotating arm, and the base frame. Based on these subsystems, the following are possible parts prone to issues, their causes and the possible corrective measures.

5.1.1 Spinning of Walker:

During the lifting of the walker with the pulley system, there is the possibility of spinning of the walker when at a position of the ground.

Cause: These is more likely to occur when using the system to lift lightweight walkers or items in windy weather conditions.

Corrective Action: If such situation occurs, first stop the lifting procedure, and ensure hand winch is in a secure/locked position. Next, using free hand adjust walker to correct lifting orientation. Then, standing in a safe position that allows use of body to controlling spinning, proceed with lifting procedure.

5.1.2 Detaching of Carabiners:

A less likely to occur but considerable error behavior to be considered is the detaching of the clamps used to connect walker to pulley system.

Cause: If carabiners used are not properly latched on to attachment points on the walker, the possibility of this occurring increases.

Corrective Action: In case of occurrence, first stop the lifting procedure and ensure safety of user. Assess the situation and if possible, attach the carabiner properly while leaving walker in current position. If situation does not allow for this, seek help from persons around to reattach carabiners. If no immediate assistance is available and user can stand in a safe position, resume lifting. Attempt to either lower or lift walker depending on the shortest distance to a safe position. If none of the above is possible, place system in safest position, call for support and wait while seated in car.

5.1.3 Tipping of crane

A possible error that was encountered during testing is the tipping of the crane when rotating arm is swung out of car trunk and weighted item is attached to the pulley system.

Cause: This occurs due to the imbalance of forces on the system due to the weight of the walker. The system is designed to be mounted in such a way that prevents this from occurring by the attachment of hooks to anchor points behind car seat. Hence, if it is not properly secured this likelihood of this error is increased.

Corrective Action: If this error is encountered, stop lifting procedure immediately and ensure user safety. Using free hand, support crane and seek immediate support from persons around. If no immediate help is available, seek external support by contacting family or support team. While waiting for assistance, place hand used to support body weight to vertical arm of crane. In the situation that error is caused by disconnection of mounting hooks, attempt to reattach hooks only if possible. If not the case, with supporting hand on vertical arm of crane, attempt to either lower or lift walker depending on the shortest distance to a safe position. Where above solutions are not applicable, place system in safest position, call for support and wait while seated in car.

5.1.4 Uncontrolled Rotation of Crank Handle

Another cautionary behaviour that user may encounter when using product is an uncontrolled spinning of the hand crank winch.

Cause: The hand crank winch deployed in the manufacturing of the product has a ratchet switch with three positions; upward for lifting, middle for bidirectional free rotation and downward for lowering. If left in the middle position and the user hand is not controlling the winch, the crank handle can go into uncontrolled rotation due to the weight of the walker.

Corrective Action: This error can cause injury to user, so it is important that user safety is prioritized. First, step is to maintain a safe distance from rotating handle and dropping walker. Then,

attempt to ensure safe landing of the walker as it drops to the ground by grabbing lifting cable at a safe point and using it to control the lowering of the walker. Only do this if it is safe to proceed. When, the walker is in a resting position on the ground, return ratchet switch to position for lifting. Proceed with lifting procedure.

5.2 Special Considerations

Although the maximum load capacity for the pulley system is 600lbs, it is important keep the lifted load to a maximum of 50lbs to prevent errors such as tipping of the crane. Also, do not use product if there is any cause for concern and contact team for support. To reduce the risk of failure or errors do not use system when car is parked on a hill.

Do not attempt to use product in any way other than procedure specified in this document or for any other purposes beyond the design purpose.

5.3 Maintenance

Keep Dry: To preserve strength and properties of material used, always dry product with clean dry fabric when used in rainy or snow weather conditions. This prevents corrosion and promotes product longevity.

Replacement of bearing kit: The bearings used for the product are similar to those found in office chairs gas cylinders and allow for easy replacement. If rotation of crane arm is no longer smooth, it may be a signal to replace bearing. This procedure is to be only completed by person with high mobility, hence it is important to seek assistance from family or friend where available. If not available, contact product support team. Paper towel, flat head screwdriver

Procedure:

- Before stating, ensure to have a paper towel or dry cloth, flat head screwdriver and new bearing kit.
- Retract lifting rope using hand crank winch and lock crank winch in a safe ratcheting position. Attach loose end of carabiners to the handle of the crank as shown in SEQ Figure * ARABIC 7 to prevent swinging.

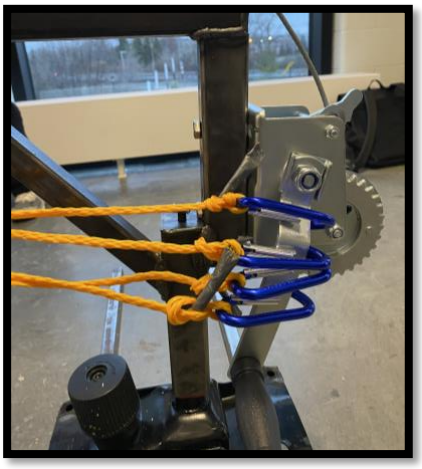

Figure 17 - Carabiner attachment during replacement of bearing

- Next, remove the clip using a flat head screwdriver to pull clip in direction shown in Figure 18.

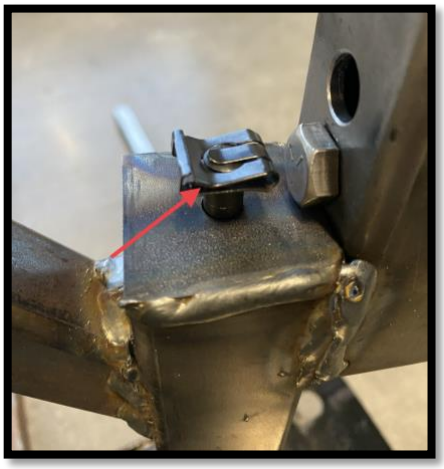

Figure 18 - Direction for removal of clip using flat head screw

- Lift the crane arm from the base rails. Do this carefully as parts such the fillers, washers, and bearings (**Error! Reference source not found.**) are likely to fall off and be misplaced.
- Remove old bearing kit (2 washers and 1 bearing) and set aside. Clean any grease or dust particles with a paper towel.

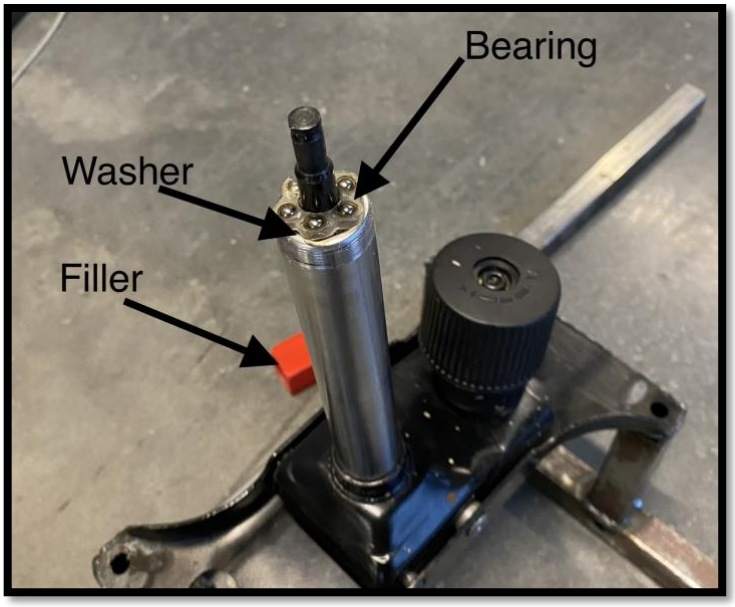

Figure 19 - Components to retain when replacing bearing kit

- Replace with new kit in the following order. Place bushing on cylinder, then follow with 1 washer. Next, place the bearing and then the last washer.
- Place the crane arm back on top of the base and reinstall clip to lock in place.

5.4 Support

For assistance from our support team, reach out to any of the members listed below via email. The support team consist of the product development personnel and are the first point of contact based on familiarity with product.

Table 3 - Support Team Contact Details

Name	**Email**
Abigail Lee	alee242@uottawa.ca
Jack Haycock	jhayc024@uottawa.ca
Kyle Mendes	kmend085@uottawa.ca
Precious Eze	peze014@uottawa.ca
Safa Diab	sdiab030@uottawa.ca
Sebastian Sardo	ssard013@uottawa.ca

Email Structure Guide:

To request support, send an email with clear description of issue to allow ensure request is directed to appropriate person. The subject of the email should be brief but informative of the specific reason for contact. The email should include detailed explanation, name, contact information, product number and receipt of purchase depending on support issue. If images or videos are available, please attach at users' discretion to improve quality of response.

It is critical to note that in case of emergency, first of point of contact would be 9-1-1, where available.

6 Product Documentation

The design of the final prototype has several key subsystems integrated together to provide product functionality. These systems include: the frame, the lifting mechanism, and the rotating base. There were several concepts iterated on for each subsystem to arrive at the current prototype.

First, three main types of materials were considered for the frame of the device: wood, aluminum, and steel. The choice of carbon steel for the frame came down to its cost-effective nature when compared to aluminum, its strong tensile and compressive strength and its ability to be welded to, which greatly simplified the building process. While wood was quickly disregarded for its questionable long-term durability during winter seasons, and its high probability for shearing under a tensile load, aluminum would have made a great light-weight substitute for steel, given the material cost could fit within budget. Additional modifications would need to be considered to accommodate aluminum, such as developing a fastening solution to replace the welds.

Figure 20 - Carbon Steel

Second, two types of power transmission were considered for the lifting mechanism: DC motors, and a manual boat winch. Initially, the design centered around DC motors for power transmission as they would draw power from the SUV's cigarette lighters or 12V standard receptacles located to the rear of the trunk. Through simple analysis, we determined that our voltage output could dip from 12V to 10.2V depending on the load, and our maximum current would only be at most 10A, delivering 120W max to the motors. In addition, the motor we intended to use initially would need to lift a 12kg (117.9N) load, which was disproven during the most optimal conditions (1cm radius), demonstrated below:

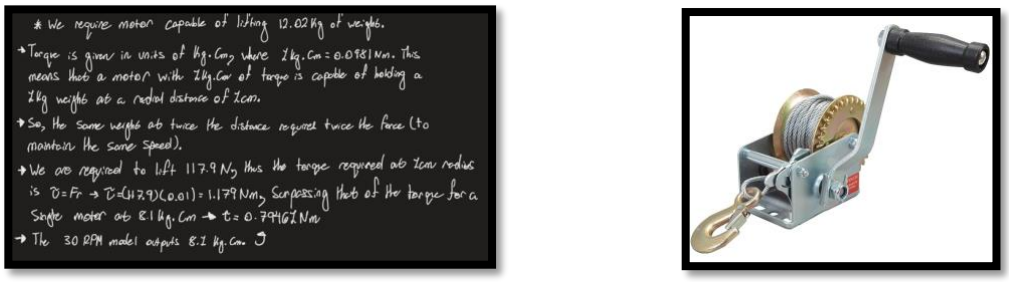

Figure 22 - Motor Calculations and Boat Winch

Since DC motors where no longer a viable option, a boat winch was chosen for the lifting mechanism. Boat winches have a wide variety of benefits over DC motors; they are reliable, work in many different weather conditions and are simple to use, making them a good fit.

Figure 23 - Office Chair

Third and finally, two concepts were also discussed for the rotation of the main arm: a "lazy suzan" bearing, and a repurposed chair swivel. The latter (chair swivel) was chosen as it provided resistance against tensile forces, which dictated many of our other decisions. The lazy suzan bearing is notorious for having poor resistance against tensile forces but excels in compressive ones, making not quite a great fit for our design. In addition, old broken-down office chairs can be repurposed and found for quite a good price on marketplace stores.

6.1 Frame

6.1.1 BOM (Bill of Materials)

Table 4 - BOM for Frame

Item	*Price/ Unit ($)*	*Quantity (#)*	*Price ($ + 0.13%)*	*Hyperlinks*
Makerstore (Brunsfield Metal)	5	1	5	Hyperlink
Steel Tubing (1.5in x 1.5in x 0.065in) for horizontal crane	10	1	10	Hyperlink
Steel Tubing (1in x 1in x 0.065in) for base (recycled)	0	0	0	
Block Pulleys	29.99	1	33.8887	Hyperlink
Metal Sheet (can utilize scrap)	0	1	0	Hyperlink
Hardware (from brunsfield)	0	0	0	
Total			48.8887	

*Note: Although prices for steel are listed at a flat rate, we used the most recent steel prices from MetalPros.com to approximate our prices.

6.1.2 Equipment list

- Mig Welder
- Steel Tickets
- Appropriate PPE (Personal Protective Equipment)
- Metal cutting Band Saw
- Deburring Tool
- Drill Press

6.1.3 Instructions

Step 0: Safety

When welding, it is important to wear the proper PPE, which include a welding mask and coat to protect against sparks and UV rays emitted from the Mig welding machine. The welding mask used was auto dimming, making it easy to go to and from welding. It is important to also establish a ground connection such that any addition current will not contact you or the device.

In addition, the band saw can be a dangerous device when not used correctly. Please refer to both you Mig welding and band saw user manuals to learn proper procedures for their usage.

Step 1: Cutting the Steel to Size

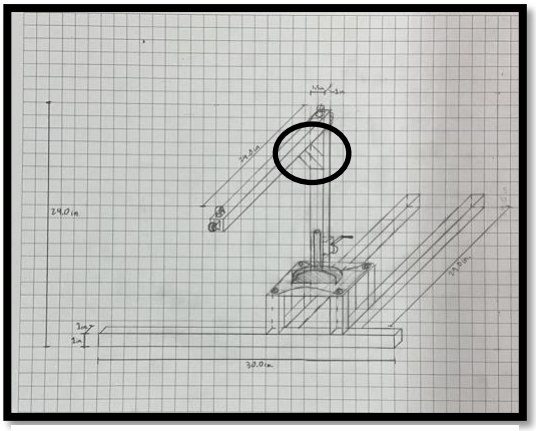

Figure 25 - Detailed Design

Based on the detailed design to the left, two pieces of steel were to be cut for the top frame from the 1.5in x 1.5in x 0.065in piece of steel, they are 24in and 11in. One piece will also be cut from the 1in x 1in x 0.065in piece, at 7in.

After the measurements have been made, the pieces can then be brought to the **band saw** to then be cut down to size. It is of note that we left a little bit of room on our pieces when cutting with the band saw.

A 45-degree cut is to be made on both sides of the 7in piece to fit in between the two previously cut pieces, highlighted by the circle

Step 2 (Optional): Deburring the Steel

Optionally, a deburring tool can be used to soften the areas where the steel had been cut before welding.

Figure 27 - Deburring tool

Step 3: Drilling:

Based on the hole distance of a given crank, two through holes are to be drilled in the vertical piece of the main arm *before* welding, as shown below:

Figure 29 - Through Holes

Step 4: Welding

When welding, we used a 17.4 for the power and 230 for wire speed. Several joints were welded for the main arm of the crane in addition to the block pulleys, which were welded to the top as shown below. In addition, several steel tickets were welded notably at the front and rear to cover any dead space or openings in the steel tubing.

Figure 30 - Welds

6.2 Lifting Mechanism

6.2.1 BOM

Table 5 - BOM for Lifting Mechanism

Item	*Price/ Unit ($)*	*Quantity (#)*	*Price ($ + 0.13%)*	*Hyperlinks*
600lbs Hand Crank	32.99	1	37.99	Hyperlink
Carabiner	11.99	1	13.5487	Hyperlink
Paracord (Had on hand)	0	0	0	
Total			51.54	

6.2.2 Instructions

Step 1:

Based on the previously drilled holes, two sets of nuts, bolts and washers can be affixed to the inside of the crank, as for our model the holes were positioned as shown in the figure to the right. Not only does this provide a non-permanent solution to mounting the crank, it also enables quick replacement if the crank is ever damaged or non-functional.

Figure 31 - Crank Mounting Holes

Step 2:

Next, two strands of paracord are to be cut to the specifications of a given walker, ensuring to take the crossed dimensions as the ropes will be crossing as the lift. The carabiners are then to be affixed to each end of the paracord strands, whether they be tied or burned to prevent slipping.

Step 3:

After step 1 and 2 are complete, the crank's steel rope can ride on the block pulleys and extend past the edge of the arm, with the paracord sitting in the claw at the end of steel rope.

6.3 Base

6.3.1 BOM

Table 6 - BOM for Base

Item	*Price/ Unit ($)*	*Quantity (#)*	*Price ($ + 0.13%)*	*Hyperlinks*
Steel Tubing (1in x 1in x 0.065in) for base (recycled)	0	0	0	
Used Office Chair (recycled) for swivel	0	1	0	
Total			0	

*Note: while our BOM total is zero dollars for this section, it would not be difficult to find these components recycled or for very cheap on online marketplaces.

6.3.2 Equipment List

- Mig Welder
- Steel Tickets
- Appropriate PPE (Personal Protective Equipment)
- Metal cutting Band Saw
- Deburring Tool
- Drill Press
- Angle Grinder
- 3D Printer

6.3.3 Instructions

Step 1: Cutting the Steel to Size

Four pieces of steel were cut to 5in in length in order to raise the base of chair swivel up, while the 3 adjacent beams were cut to 30in each. Follow the same procedure as listed above for cutting the steel tubing.

Step 2: Prep

Prior to welding the chair base to the steel base, paint had to be scrapped off so that the steel underneath could be exposed and welded to. This was accomplished by using the angle grinder to slowly remove a thick layer of black paint and smoothen the surface.

Step 3: Welding

By following a similar procedure as the one listed above, the four 5in length steel tubing beams were first welded directly to the chair base however now at a weld speed of 215, ensuring that the thinner pieces (chair base) would not be damaged. A tool (in red) was used as well to ensure that the legs would keep a 90 degree angle. The entire assembly was then placed on top of the longer 30in steel tubing beams, and welded once again.

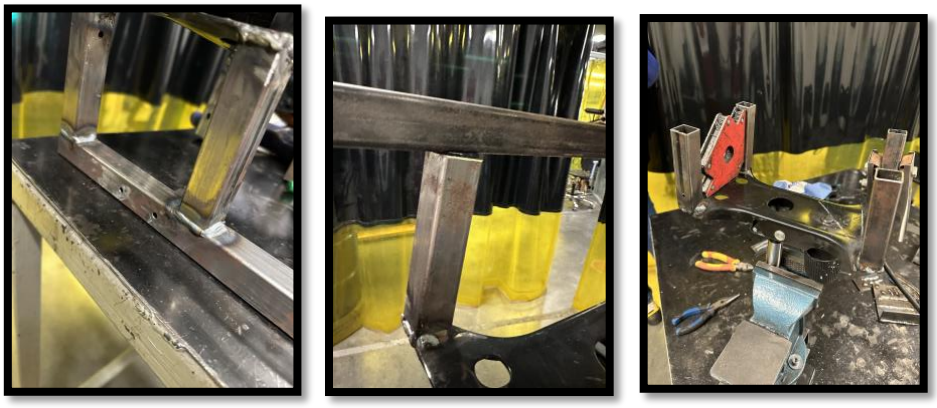

Figure 33 - Welding of the Chair Base

Step 4: 3D Printing

Finally, a spacer needed to be 3D printed in order to reduce any sway that could occur in the rotation of crane arm assembly. The bottom of the crane arm's vertical steel had room to accommodate a rectangular mold with a radius on the inside. The following piece in imperial units was extruded and printed with a 0.8mm nozzle at a height of 7in:

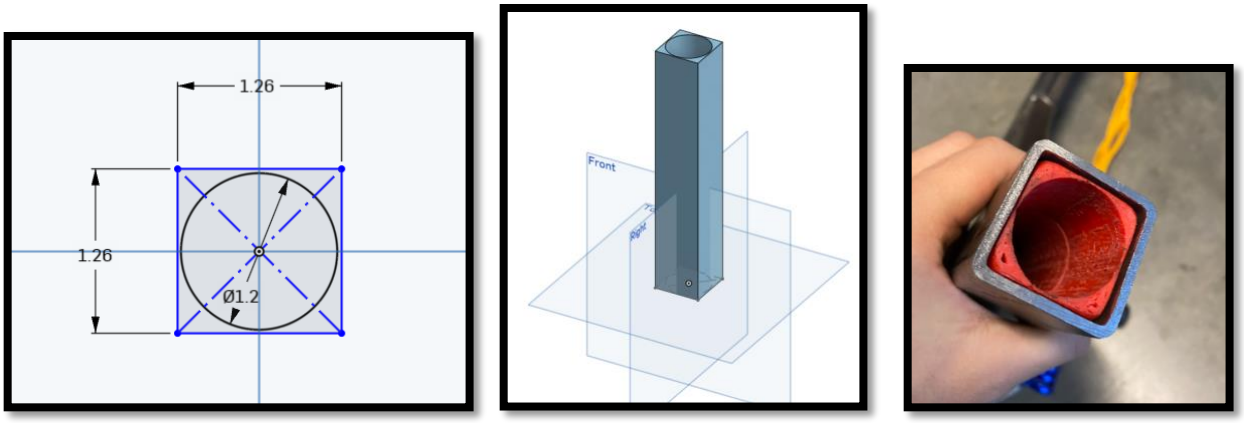

Figure 34 - 3D printed inset

Notably, the piece was quite a snug fit. So, if required the corners may need to be filed down and/or sanded to accommodate the steel tubing.

6.4 Testing & Validation

The ease of use was emphasized during the testing stage. One test was performed where the winch was screwed into a plank of wood, then the plank was clamped to the edge of a table to simulate the height of the ground to the trunk floor. A 25lb weight, similar to the weight of the walker, was on the ground and the goal of this test was to gain a better understanding of how simple it would be and how long it would take to crank the weight up and down. From this test, a time of 12 seconds was recorded for the weight to be cranked up, and 14 seconds to lower it, using two fingers on the handle and cranking at a slow to moderate speed. It was later discovered that when the direction of the winch is set to the lowering position, a weight attached could cause the handle to spin out of control if the user does not hold the handle. After welding, the strength of the welds was tested by supporting the weight of a 185lb team member who hung from the cable.

Figure 35 - Testing of Hand Crank

7 Conclusions and Recommendations for Future Work

Through the course of designing this product, there were several learning opportunities. First, it was important to learn how to apply empathy to understand users' need. Although, it could sometimes be easy to just begin concept generation, starting out by conducting interviews helps to properly satisfy client need. While trying to satisfy users' need, it was necessary to know how to compromise considering the available budget and time. Another key lesson learnt is that although all variables needed may not be known, it is acceptable to make valid assumptions that would allow project to proceed. Also, the understanding that it is acceptable to change design concept as needed is beneficial, as it helps to improve final product and maintains an open mind to new ideas. Lastly, through this project the advantage of having a simple design when working on short term projects was learnt.

Based on the current stage of the product design, some areas improvement should be considered when looking into future work. These include but are not limited to improving system mounting design, use of adjustable rails to expand adaptability to different car models and the use of a lock pin to prevent rotation of crane arm when driving. Given a few more months to continue this project, it would allow for more testing of prototypes and conducting of failure mode and effects analysis. This would also provide time to investigate cheaper but efficient materials that enable project delivery under available budget.

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APPENDICES

APPENDIX I: Design Files

This document was built based on the project deliverables and includes a summary of important information from each of them. For more details, all project documentation and design files are available on the project Makerrepo page.

Table 7 - Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Deliverables A-J	Makerrepo Project Page	Dec 10th, 2023
3D model for fillers	Makerrepo Project Page	Dec 10th, 2023
Wrike Gantt Chart		Dec 10th, 2023