RAIZEX

Comfort at Any Height

Aerial Lift for Construction

Jonathan Ulloa

Aerial Lift Solution

by

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School of Applied Technology
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Abstract

This thesis proposal investigates the safety, ergonomics, and comfort of movable aerial platforms for the perspective of the user and how they interact with them daily. Current aerial work platforms such as boom lifts and scissor lifts tend to be unstable over certain heights, as well as getting stuck in different terrains. Additionally, there have been fatalities for the user and others working around such as, falling off these machines or not using them properly and getting crushed by one. This thesis purpose is an in-depth study of human interaction with the current products that are out in the market while gathering data through a variety of ways, such as interviews with the users, observation of how they interact with the product, and surveys asking general questions about their interactions. A one-to-one scale ergonomics model is built to see how the used to examine the 5th percentile person and the 95th percentile person interact to understand the full-bodied interactions and the solution. These results were used to design the next generation of aerial work platforms. This new design helps increase the safety, ergonomics, and comfort for the user.

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Chapter 1 – Defining an Aim

This chapter will discuss the overarching problem definition that is being talked about, though this thesis project. It will investigate different approaches to gather information to learn the key elements that are hurting aerial lift operators.

1.1 Problem Definition

Construction is one of the most significant growing industries out there in the world today. It will always be a part of our daily life whether we see it or not. The people that are in this industry must work in many different conditions, areas, and machinery. One type of mechanism that is most used on the construction site is the aerial work platform (also known as a boom lift, aerial lift, and scissor lift.) “An average of 26 construction workers die each year from using aerial lifts. This is 2 to 3% of all construction deaths. On aerial lifts, the major causes are falls, electrocutions, and collapses or tip-overs (eLCOSH, 2001.) The current use of these machines is to help reach higher altitudes and in areas of difficulty that with reasonable means such as ladders or scaffolding would be hard to get to. Not to mention lifting material to work with while in the air. There are many different areas of concern for workers up in the air while working and others working around them that can and needs to be addressed. The following thesis project will propose a solution regarding safety, ergonomics, and comfort for the workers utilizing the machine.

1.2 Investigative Approach Taken

To understand the key issues surrounding the use of aerial lifts among the users. The methods that are chosen helped enhanced problem recognition and will assist in the development of a solution for the workers on the aerial lift if not the lift itself. These methods of design research are stated below and will be evaluated later in the report.

- Literature reviews
- Information searches
- Analysis of existing solutions
- User Observation
- User Interviews
- Ergonomic Studies
- Activity Breakdown analysis

Some critical questions need to be answered to the given topic for a better understanding of the difficulties that are faced daily. Such questions are:

- How can we improve the overall quality of life while using the lift?
- What would the critical features of this lift include?
- How can the safety of using the machine improve?
- How long would the typical worker spend in the air?
- What are the ergonomics needs of the user?

1.3 Background / History / Social Context

Being in the construction industry has many different jobs that one can do from masonry to building the first frame of a house, to putting up siding or stucco on the outside of a townhouse. A lot of these jobs, especially jobs that are done outdoors, are challenging to do and

grueling on the body. For these workers, any sort of equipment is essential for them to use by helping them complete a task more quickly. For jobs that require reaching high areas, the three main pieces of equipment that are used are usually ladders, scaffolding, and aerial work platforms. “In 1951, Walter E. Thornton-Trump, nicknamed Ted, invented boom lifts to make working in high places easier.” (Zitzman, 2017) This helped avoid the use of ladders and to reach areas that would be unreachable in reasonable means of a ladder. It gives the mobility of moving the machine anywhere with little setup time compared to scaffolding that would be needed to put around a whole exterior of a building to use.

“The global boom lift market is driven by growing demand for constructions across the geographies and various mega construction, particularly in regions like Asia pacific.” (MarketWatch, 2019) With the ever-growing demand for boom lifts for the construction industry, the safety of the user and others around the machine must be taken at the most seriously. Not to mention keeping the user in mind and understanding how they interact with the device on and off, and how they move it around with or without impurities of their sight.

Even though construction workers can be viewed as high school dropouts or immigrants trying to make a stable income, these are the people that are shaping the infrastructure of the future, and they must have the equipment that is best suited to their needs.

2 Research

The following chapter will outline various research methods used through this initial design development stage. It will contain user and product research in two separate sections. This research will aid in identifying core user demographics, current user practices with the machinery as well as ergonomic research.

2.1 User Research

2.1.1 User Profile

User Types

Primary User:

The primary user of this product would include the operator of the vehicle and anyone else that helps the operator in and around the machine. The operator is the main person interacting with the boom, whether it is turning the lift on or off and getting in and out of the basket of the growth itself.

Secondary User:

The secondary use of this product would include Safety Instructors. These users are the ones who have train the everyday operators and shoe them the proper ways of using the boom properly to ensure that no one gets injured. As well as the person is ordering the lift because they must know the appropriate lift to use in their situation.

Tertiary Users:

The tertiary user of this product would include repair and maintenance person who would have to repair the machines when they are always damaged or just must do maintenance on the device for it to work correctly.

Demographics:

Age and Gender: 21-45 Majority of Males

The age, “The median age of Construction laborers, is 38.2, and Male employees are generally 0.201 years younger than their Female counterparts.” (CL 2017) These numbers are also seen that “96.7% of Construction laborers are Male, making them the more common gender in the occupation.” (C 2017).

Education:

Since many different construction jobs utilize this machinery, it is hard to get a full grasp of what specific knowledge is required just to be a base construction worker. For any more specialized jobs such as an electrical engineer. In this case, higher education is needed. For the use of the boom lift, the knowledge that is required is a one-day safety training that would be set up by the moving company or the person.

Income:

“On average, employees in the Construction Industry Group make $51,097 per year. This number makes Construction the 138 highest paying Industry Group in the United States out of a total of 266 Industry Groups.” (C 2017)

Ethnicity:

"71.1% of Construction laborers are White, making that the most common race or ethnicity in the occupation. Representing 16.2% of Construction laborers, Other is the second most common race or ethnicity in this occupation." (CL 2017)

User Behaviors:

The user behavior for construction workers tends to relate to the job at hand. A typical week tends to up to 40 hours of work, if not more, depending on the situation. They try to keep a level head due to their surroundings with constant movement and noise of other workers doing other jobs. Not to mention all the dangers that they must keep in mind such making sure such as overhead wires or gaps in the floor.

User Persona:

Name: John Doe

Age: 40

Job: Beam Worker

Education: High School

Relationship: Wife and 9-year-old son

Location Toronto, ON

Main Job: Installing Metal Beams

Frequency: Five days a week

Duration: 40 hours a week

Figure 2-0-construction worker working at construction site using lifting boom machinery Retrieved September 24, 2019 from: https://www.shutterstock.com/video/clip-16402942-construction-worker-working-site-using-lifting-boom

Social/solitary: With Co-workers and clients

Income: $50,000 per year

Profile:

John Doe is a 40-year old Caucasian individual who works as a beam installer for many different job sites. The highest education that he has gotten was from high school; however, he has also got lots of training in safety and understanding how to handle big machinery on a job site properly. He has been married to his wife for 15 years.

He has taken this job since he has finished high school and has moved up in the company many different times, each increasing in pay and benefits.

User Behavior:

John enjoys spending his weekend with his family relaxing and recuperating from all the work he has done on the job site. He keeps a good relationship with his co-workers, understanding that they are there to help him, and he is there to help them, as well as trying not to get into arguments with different types of workers using the same equipment.

Relationship:

John has high respect for what he and others do on any given job site. This is because he understands the need and awareness and the dangers of working where he does. Having respect for all the equipment that must be used and keeping them well maintained for no failure to happen. Daily he always must put a harness on and use either a boom lift or

aerial work platform to reach areas that are not accessible from a ladder or scaffolding. He understands this is the only means of doing so, and it could be dangerous at times.

2.1.2 Current User Practice

Frequency:

"So far, in 2017, TSheets' data shows that construction workers are working, on average, 39.6 hours a week. This is an increase of more than one hour per employee per week compared to 2015 when the average was 38.4 hours. In 2016, the average was 39.2 hours a week per employee." (Worsfold & Simon, 2019)

"69,000 construction workers across the US worked almost 50 hours" (Worsfold &Simon, 2019)

Working five days a week

Duration:

They are working roughly 40 hours a week. The amount of time spent on the boom itself varies depending on the job. Some days it will be for a short amount of time, such as ten minutes, or they will be up in the air for most of the day. It all depends on the type of job that is being down air the time.

Social and Solitary:

"What I enjoyed most was seeing new buildings and meeting new people every day of the week." (Zemeckis)

"men are stepping through an unseen hole on a roof and falling twenty feet to a concrete slab below. I've watched men get their fingers caught in machinery and almost ripped off. I've

sliced open my skin dozens of times. I've had to drive myself to an emergency room twice." (Zemeckis)

Location:

There are many different locations for construction sites around the country. Must happen to be where there is a high development of housing.

2.1.3 Activity Mapping

Utilizing the aerial lift is left to those who are trained to do so on and off a construction site. This means using this machinery is not common knowledge, and not everyone has the experience to operate one. This portion of the report is helping the reader to understand how the operator utilizes this machine in their daily work time.

The method of this was done by observational research being conducted about the use of the aerial lift and how the user interacts and operates the machine. A report was written to show the findings of that research (details in Appendix).

User Observation:

The initial observation began by understanding the user environment that the aerial lift is stationed in. The location of the observational study was held at a construction site that was developing townhouses that were a mix between some being finished while others need more work on. The ground conditions were a mix between hard concrete and soft mud, depending on where on the job site you were standing.

The following activity map shows an aerial lift operator doing his job from turning on the lift to entering and doing work at a perceived height then exiting the elevator.

Table 1- User Observation- Photos taken by Jonathan Ulloa

Step 1: Turning Machine on		- The operator turns on the machine from control panel from the ground and re-positions basket for entry
Step 2: Getting in		- Entering the basket in this instance requires the operator to bend in an uncomfortable while holding the bar with his back
Step 3: Fall Arrest Point		- Connecting himself to the basket using a lanyard for safety measures

Step 4: Getting into position		- Begins to operate the machine to position himself to work - Foot on a pedal on the floor always to move the boom
Step 5: Working		- Brings himself within one foot from edge to do work - Varies in length depending on the job
Step 6: Bringing basket down		- Once the job is done starts to move basket back to the ground to get out

Step 7: Getting out		- Again, awkward position to get out of the basket acting like a slide going feet first - Has a chance to hit the head-on bar that goes up and down

2.1.4 Ergonomic Research

Ergonomic accommodations for the boom lift were identified during the observation are essential contact points the user makes. The current user interactions include turning on and off the boom, getting in and out of the growth, and the position the user is in a while working in the basket, these aspects suit the criteria for a full-body human interaction study.

2.1.5 Safety and Health Research

The current safety regulations that are emplaced for using boom lifts are strictly mandated, and everyone that comes into contact and uses the boom must have the proper training that is necessary to use any aerial lift such as scissor, boom, articulating booms. There are many perils for not following all the safety regulations that are in place. If any of the safety processions are not taken seriously, this may cause severe damage to the property that is being worked on, and even worse may injure people that are working around or on the lift; it may also lead to the death of some workers.

2.1.6 Interview Results

During the research phase of this thesis, two different participants took part in interviews. This exercise provided unique data that would be unattainable with extensive research over the internet in journals. As well it gave an insight into the day-in-a-life situation of the worker and what they must do daily.

These interviews were set up with the two workers; however, they were unable to meet up, so a questionnaire was sent to them to fill out their answers. The two workers are

experienced users in the construction industry who know the frustrations that other users feel with their equipment. The interviews were a transcript and can be found in the Appendix.

The information was taken, analyzed, and critical points were taken regarding the user profile.

- Safety is a major priority
- The amount of time spent on the boom lift during a job
- Having a safety checklist

2.2 Product Research

The following section will compare different aerial lifts by identifying key features, benefits, and functionality between them. The data will also be collected via benchmarking to determine the different areas that are needed for the aerial lifts.

2.2.1 Benchmarking- Benefits, and Features

Product benchmarking for an aerial lift relied heavily on to see what other companies had to offer. This is to give a clear idea to what lots of companies' focus are and what they advertise as being the best to use compared to others. The selection of 7 different aerial lifts were chosen to be examined based on each manufacturer that produces aerial lifts. Further information can be seen in the appendix.

Aerial Lifts			
1	Genie S-40	5	NIFTY LIFT SD34T 4X4
2	JLG 340AJ	6	DINOLIFT DINO 280RXT
3	SKYJACK SJ46 AJ	7	MEC 45-AJ
4	HAULOTTE HA32 CJ		

Table 2- Product Benchmark

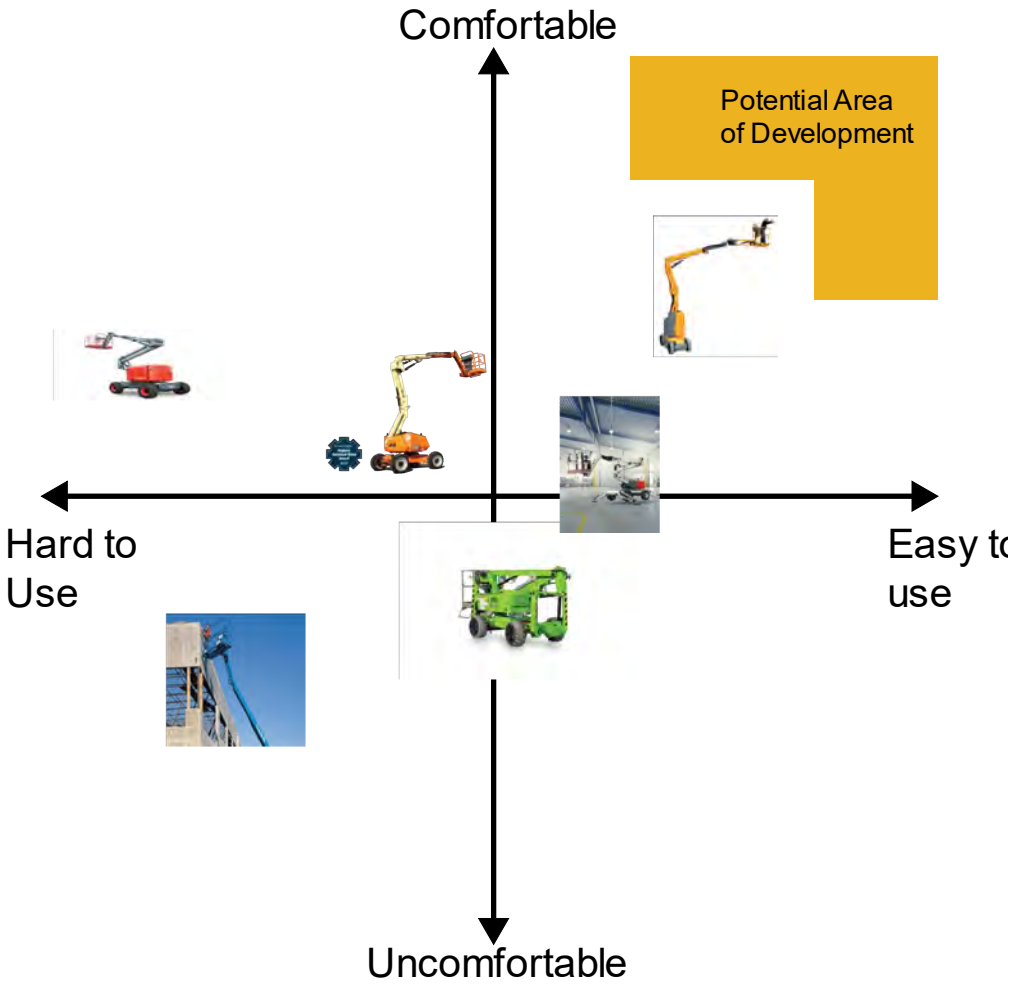


Figure 1-1 X-Y Comparison of Boom Lifts Ease of use

With modern aerial lifts being used today tend to have a standardized layout that can be easily identifiable between all models. The most significant difference between them all is the size of each lift. The lifts that were compared had the smallest arm reach for being utilized in outdoor environments.

Regarding the benefits and features of each of the lift's majority of the lift manufactures detail on how strong the engine is due to the lift capacity and moving the overall machine. They

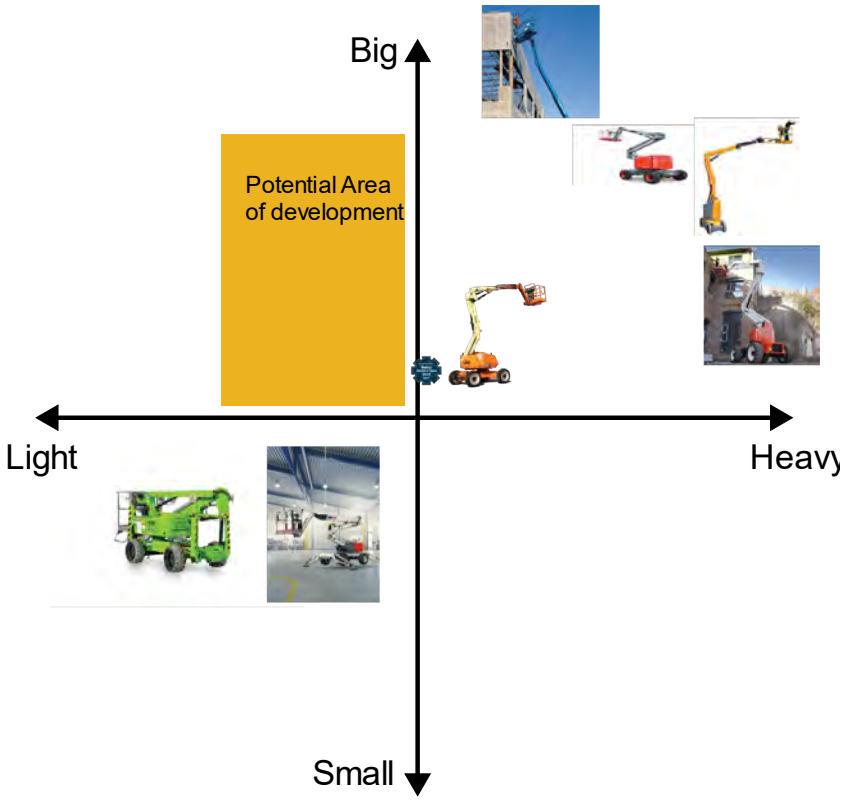


Figure 2-2 X-Y Comparison of Boom lift Sizes

all can fit one to two people in the basket with only one means of entrance, usually parallel to the controls.

2.2.2 Benchmarking- Functionality

Table 3- Detail Benchmark

Aerial Lift Name	Width and Length	Weight	Max Horizontal Reach	Max Height	Engine Type
Genie S-40	7ft 6in X 24ft 3in	12,310 lbs.	31ft 8in	46ft	Diesel
JLG 340AJ	6ft 4in X 18ft 2in	9,700 lbs.	19ft 11in	33ft	Diesel

SKYJACK SJ46 AJ	90in X 20ft 10in	13,300 lbs.	24ft 9in	52ft 3in	Diesel
HAULOTTE HA32 CJ	3ft 11in X 17ft 7in	15,578 lbs.	23ft 2in	37ft 9in	Electric
NIFTYLIFT SD34T 4X4	5ft 1in X 12ft 10in	4980 lbs.	20ft	42ft	Bi-Energy
DINOLIFT DINO 280RXT	7ft X 19ft	10595 lbs.	52ft	91ft	Diesel
SNORKEL A46JRT	7ft X 19ft	16622 lbs.	24ft	53ft	Diesel

Summary:

Overall, the comparison of products shows the range of how high and far each of these machines can reach as well show how big of a footprint each takes up. Some of these machines are smaller such as the Dinolift and Niftylift weighing the lightest out of the others, still competing in height. As in fact, what stands out the most is that most of these lifts utilize diesel as their power source, from moving the machine around to helping push the hydraulics to move the arms. The one outlier is the Niftylift that uses a combination of both.

2.2.3 Benchmarking- Aesthetics & Semantic Profile

General Aesthetics

Figure 2-4 Genie Boom Lift- Photo Taken by Jonathan Ulloa

Aesthetics and styling regarding many industrial pieces of machinery tend to lead to having a very sturdy look towards them. This being the case to help enforce that these machines can take a beating when they are out in the field. The styling in many of them is meant for easy replacement of parts when necessary, as well as creating an opening to fill in any missing fluids such as oil and hydraulic fluids. This tends to mean the boom may look very angular on the body with minimal lofts. This happens because these machines do not care about aerodynamics on the bottom because this is where the engine is usually held in.

Figure 2-3 Boom lift- Photo Taken by Jonathan Ulloa

In the past decade, there have been weight-saving materials that can help with the overall weight of the lift itself. As well the general color tends to correlate towards the different companies that own each machine; however, the color that is chosen can be seen very quickly, such as a bright blue or a bright green that can be easily identifiable from a far distance. There is always a light to indicate when the lift is in the movement to allow others to see the lift and to be aware that it may cross their path.

In each case, the most-used section of the lift part that is used and cared upon is the basket the operator will be. This is because the central location, the operator and the most time spent there; if not moving the lift from that location, they are working in that location. This

Figure 2-5 Genie Lift Bucket- Photo taken by Jonathan Ulloa

basket is always a rectangle due to its nature to go up the side of any building and getting as close as possible to any given surface. The basket is not enclosed but has bars going around the basket to provide ample areas to reach for work. As well if the basket were to be confined, it

would be pushed by wind more efficiently and create a dangerous work condition for the worker and others around the boom, if it were ever to tip over.

2.2.4 Benchmarking- Materials & Manufacturing

The type of material that usually is used for manufacturing these machines tend to be made from steel for the arms of the booms and the lifting mechanism for scissor lifts. The housing for the engine is made with plastic for ease of access when there needs to be any repairs done to the engine. The batteries are located at the bottom with a swing mechanism for easy access for reparability. The reasoning that most of the boom is made from steel is because of how durable the booms must be when they are in use in many different conditions. Each of the parts is painted with urethane to help the steel beams last longer.

2.2.5 Benchmarking- Sustainability

Boom lifts today are made to last an extended period. This is done with the help of how easy it is to access areas that may need maintenance, such as the engine, batteries, and hydraulic fluids. With this being the case, it helps to reduce the number of unwanted booms that would otherwise be thrown out or destroyed.

One of the critical factors that help the boom lift function is the engine. The engine is typically either diesel, electric, or a hybrid of both. Each of these options has its pros and cons of being used. In the industry today, the most common engine type is a hybrid of both.

The issues with diesel fuel are the carbon waste that they produce when running the boom. This is one of the significant problems that affect the boom lifts because the engine is always turning on and off any time the boom needs to be moved on the ground or just moving

the arm in any different location. However, this is one of the most common means of the engine due to its power and ability to do multiple jobs at once from moving the boom on the ground, moving the hydraulic fluids for the arms.

Batteries are another type of engine that is mainly used for indoor use only due to the no emission of any toxic fumes. With this, the cells eries have a set amount of charge until they need to be replaced, and if not disposed of properly can cause significant effects to the environment later. Another disadvantage of using the battery is required in order to charge the boom. If the cells are not fully charged or need a bit more power, you could have the possibility of not having the boom working at its full potential.

2.2.6 Interview Results

As stated earlier, the information that was gathered from interviews and data were collected and put into a list of key points:

- The wind conditions that are faced during the operation of the boom lift
- The amount of times needs to start the machine on to move it in small increments
- The fact between the doors getting rusted and the bar is easier to use
- the lift must be on a level ground to be operated
- Improvement of stability up in the air
- Protection from natural elements such as direct sunlight
- Bigger workspace to use

3 Analysis

The following chapter will analyze the precious chapter research and benchmarking phase, ultimately deriving critical design decisions. By analyzing user's needs, functionality, usability, aesthetics, and sustainability.

3.1 Needs Analysis

3.1.1 Needs/Benefits

Going through the initial information that was gathered from interviews that were done, as well as information that was collected through different online forms such as Reddit can help indicate the different areas of needs and benefits that the user may need to make their task more efficient to do. Some of these current needs are more ergonomic movement when they are interacting with the basket, whether it is getting in/out, using the controls, or working above or below the rails. It also has a critical location that can store or hold tools while in the basket so that tools do not fall out and injure someone walking by or damage the area they are working on. There are a lot of restricted movements that are taken away with the lanyard and can be tangled up with others if there is more than one person, which tends to be the case.

3.1.2 Latent Needs

Latent needs refer to the needs that are not as obvious and may be hidden behind the previous requirements, which are more prominent. These are the needs that the user may want and need without knowing that they need them.

Ergonomically, the overall design of a boom lift, it is not meant for any ease of access to being comfortable while in the basket.

3.1.3 Categorization of Needs

Wishes/wants

- Easier movement
- Area to hold tools
- More tactile controls
- More comfortable to move while in the air

Immediate Needs

- Ease of use
- More ergonomic movements
- Stabilization
- Safety of user

Latent Needs

- Ease of access
- Comfortable
- Easy to maintain

- Stylish

3.1.4 Needs Analysis Diagram

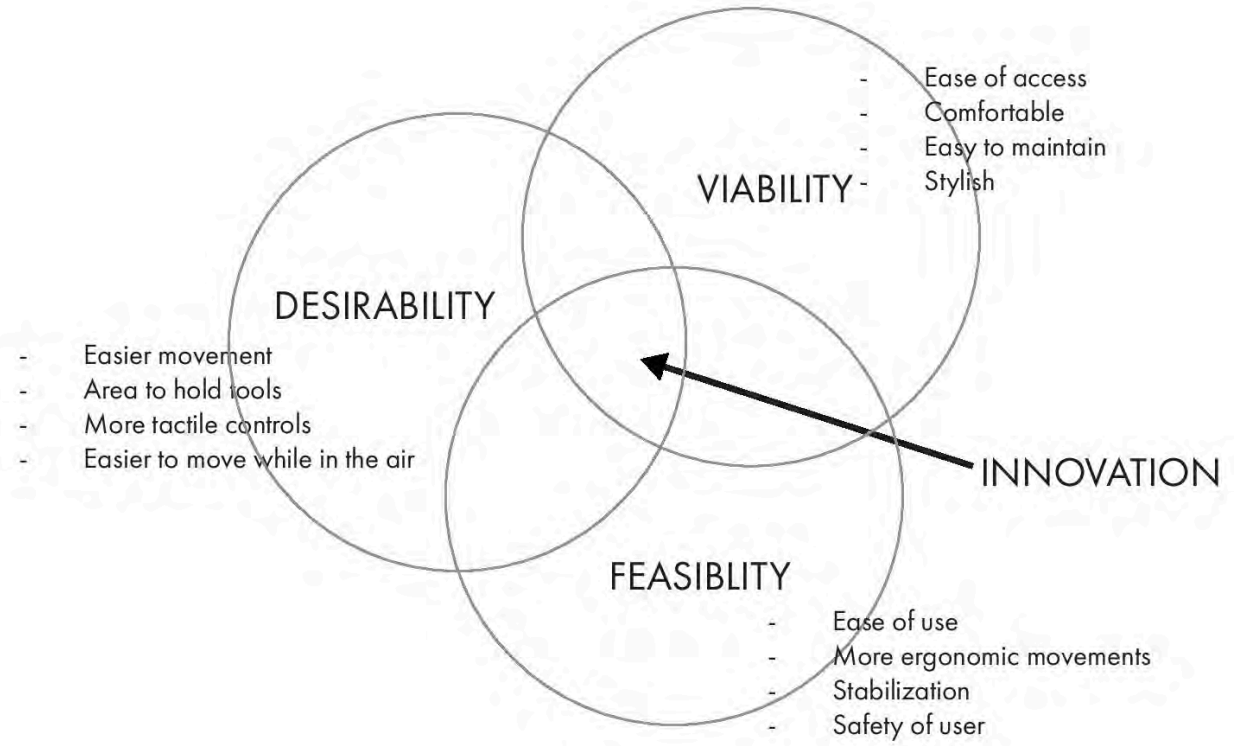


Figure 3.1.4 Needs Analysis Diagram

3.2 Functionality

3.2.1 Activity/workflow mapping

It is essential to understand how a user would operate a typical boom lift, from getting in and out to operate the controls of the lift. This whole process is gone through every time a user wants to use the boom lift. It is crucial to map out what happens in this process and what kinds of frustrations arise during each step. This section will discuss and analyze the pinch points of the activity.

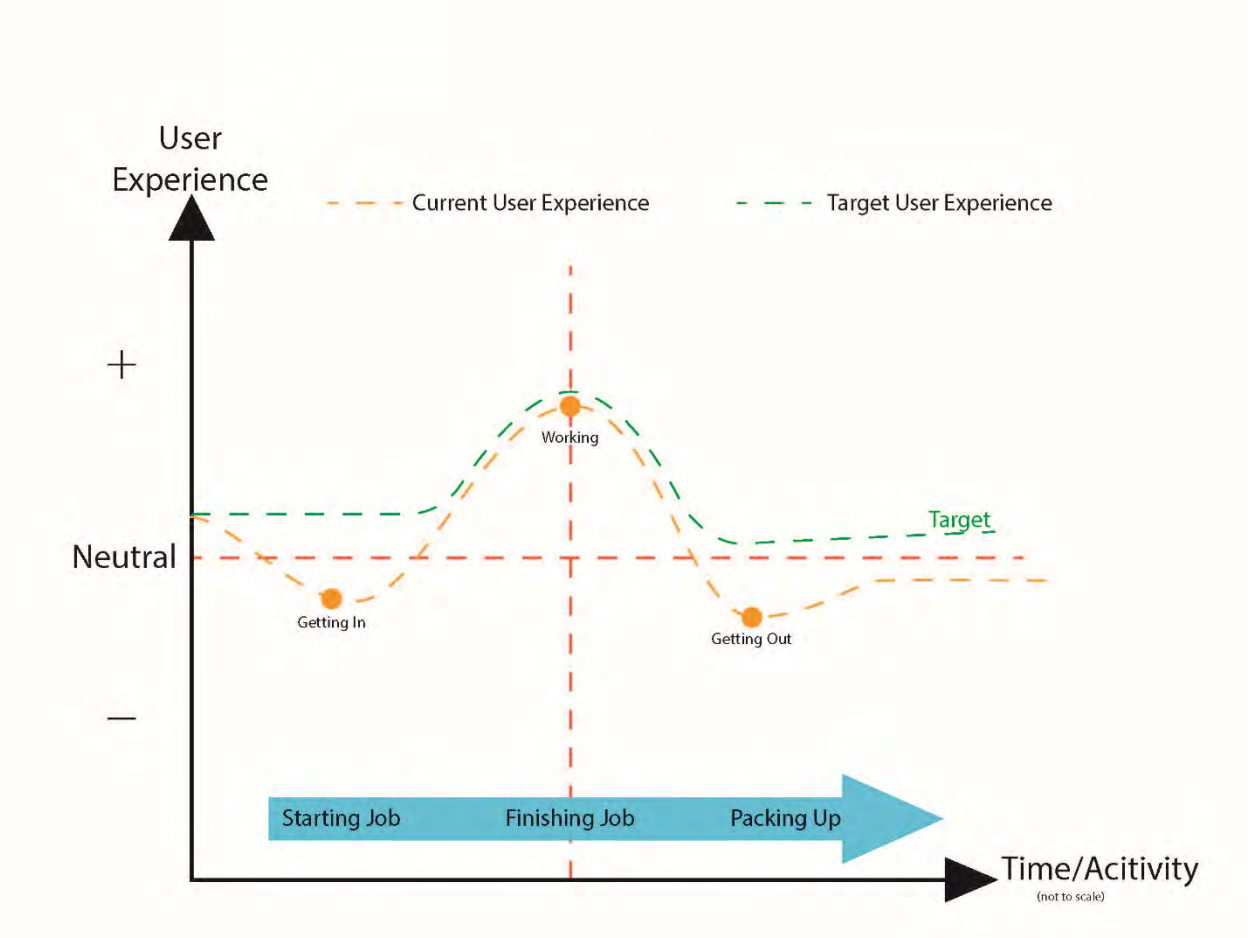
An onsite observation was done and was recorded thoroughly in section 2.1.3-Activity Mapping. This section will go in-depth into the full operation of the boom lift from the initial start of the engine until it is turned off. Further information can be found in the appendix.

Step 1: Turning Machine on	
Step 2: Getting in	
Step 3: Fall Arrest Point	
Step 4: Getting into position	
Step 5: Working	
Step 6: Bringing basket down	

Step 7: Getting out	

3.2.2 Activity Experience Mapping

Previously in section 2, the activity of a user was researched to determine how the user interacts with existing products. With this research, it helps generate a map of how the user



reacts to the different activities during operation, whether positive or negative.

Figure 3.1-User Experience Map

Key Activities	Steps	Base User Experience	Potential Improvement
Starting Job	Preparing all the tools needed Making sure all material is required and loaded safely Turn on machine Safety Harness	Many safety processions taken in the beginning as well as to get in the basket may be difficult	Easier to get in Quick and easy way to secure material Checklist of safety
Finishing Job	Going up/down the boom safely	The time it takes for the boom to move	Faster depending on the environment
Getting out	Getting out of the basket Cleaning up any mess in the basket Turning off Boom	Stressing a body to get out of the basket Cleaning Ensuring everything is okay before leaving	Easier to get out A quick way to clean A quick way to shut off

3.3 Usability and Ergonomics

An ergonomic evaluation of the human interaction and spatial constraints inside of the aerial lift basket. This area is chosen due to the amount of time that is spent. This is looking at it through “the measure of man: Human factors of design” (Dreyfuss, 2002) and by testing a 1:1 ergonomic model with male participants, to determine the most effective use of space.

Literature Review:

For an accurate representation of human ergonomics, “The measure of man: Human Factors in design” (Dreyfuss, 2002) was referenced. Measurements for the 1st percentile man and the 95th percentile man were taken to ensure the final design would be a function for all potential users regardless of size.

Methodology:

The evaluation of this task was to understand the users' interactions with the aerial lift while working and identifying key areas that can be improved upon to improve the overall quality of life for the user.

Objectives:

The goal for doing research is to have a better understanding of the human bodies' interaction with the surroundings that are made and to be a visual aid. This goes from evaluating the needs of getting into the basket itself, to understanding the critical points of contact the user will face while doing their daily tasks. This will also show three areas of the body parts to meet the requirement of full-bodied human interaction design. (Kappen, Chong, Zaccolo 2020).

Decision(s) to be made: ***FIX THIS, IS IT A LIST?***

The following interactions relevant to the significant body part areas (Kappen et al., 2018) were chosen to be further studied to obtain a better understanding of the overall experience the user may have.

Getting in of the basket at certain height levels

Displaying different hand positions on the controllers while at the same time holding done a switch attached to the floor

Bending down to attach the harness point

Description of users targeted by-product:

The target demographic that this model will be showing is between the 1st percentile man to the 95th percentile man between the ages of 18-50. “96.7% of construction workers are male” (CL, 2017).

Evaluation process:

The evaluation process consisted of designing and creating a full-scale ergonomic buck of the aerial lift basket, which made it possible to observe the following:

Observing how the user enters the basket

Observing the hand placements when controlling the lift itself

Observing the foot position that the user has

Observing how much interference the harness line may have

The buck is created following the 1st and 95th percentile data that was acquired from Dreyguss (2002).

Description of User Observation Environment Used in this Study:

For this study, a proper observational study was held where the user of the aerial lift was able to utilize the machine as if it was a typical day. This observation was carried out as a construction site.

Location and Timeframe

Date of observation(s): 17/11/19

Location of Observation(s): Construction Site

Results

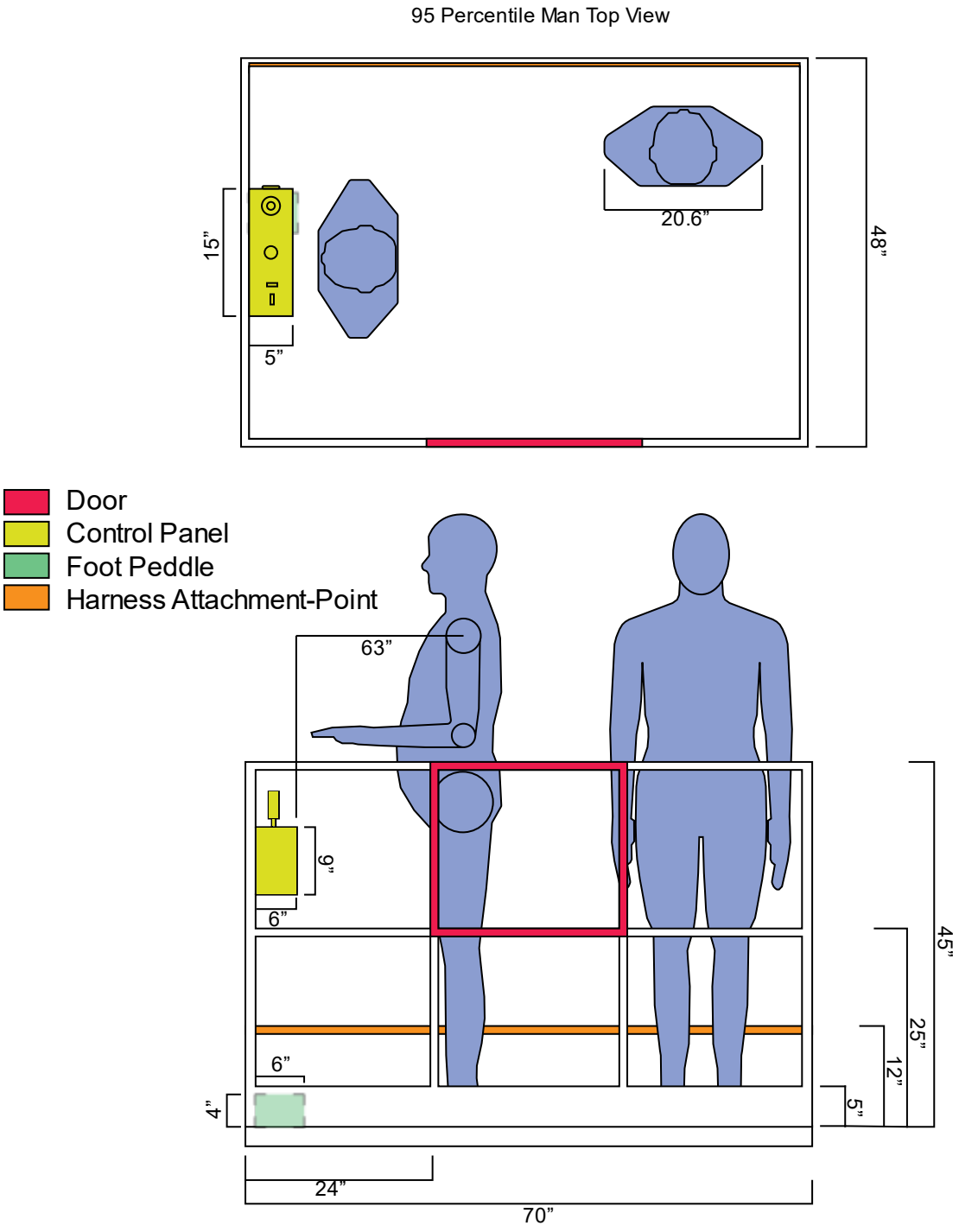


Figure 2- 95th Percentile Man

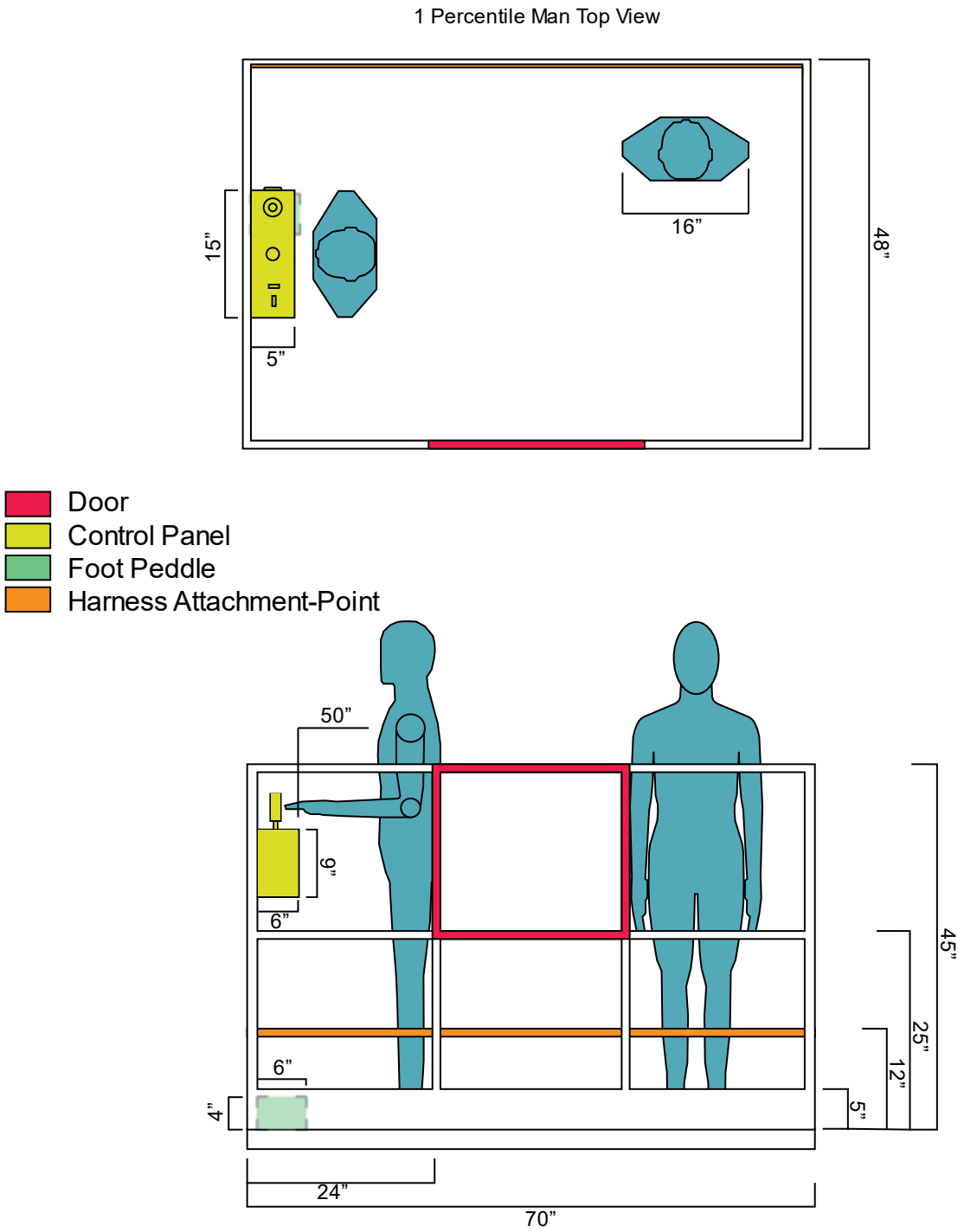


Figure 3-1st Percentile Man

Figure 3- Getting in the basket

Figure 4- Attaching harness to attachment

Figure 5- Controls to move the whole aerial lift with foot pedal

Figure 6- Using controls to move basket in the X – Y axis

Analysis:

Once the ergonomic model assembly was complete, the primary interaction between the user and the controls moving the aerial lift in any direction was studied. This is a key because the users are always interacting with these controls for moving the machine or having to hit the emergency stop button. Especially in current models, these controls either tend to be in the middle for the best possible view or crammed into a corner. Having control up above two feet ensures that the users have a comfortable time being able to grip and use the controls.

A consideration was that most of the construction workers tend to wear gloves, and this is very true when they are working in cold conditions during the winter times. Being able to grip the controls was another critical consideration. In this design, there are two main controls. In Figure 5, these controls can move the aerial lift on the ground when the basket is not in the air. The main features that control this are the foot pedal, the joystick, and the button on the joystick. The joystick would be the centerpiece to be able to move the whole machine with the ease of use and easy to grip with or without gloves. The position of the foot pedal had to be under the control box to ensure that any users in the basket would not trip over it when working on the lift. The placement of the button on the joystick is easily accessible via the index finger. This button is there to ensure that when no one is holding it down at the same time with the foot pedal that the aerial lift cannot move.

The second set of controls that are seen in Figure 6 is to control the basket moving in the X -Y axis while it is not in movement. These are switches rather than a joystick; this is for more control of the basket when going up and down and left and right. As for safety measures, there is a button on the side of the control box that activates the switches to function correctly. This is in place as safety measures just in case anyone accidentally bumps into those controls. For these

switches, they will have a tactile feel towards them, giving the user a good idea of where they are moving. As well, this portion will be regulated to how fast they are moving.

Another area that was investigated was the mode of entrance into the basket itself. The contains a five-inch barrier surrounding the floor; this is in case any tools fall and hit the floor of the basket, they do not fall out of the basket entirely. The user in Figure 3, is stepping twice that height due to fact the basket will not be entirely on the ground but somewhat elevated slightly off the ground another five inches. The user ends up putting both hands on the top of the entrance of the doorway, making three points of contact, which is the proper way of entering any vehicle that is higher than the average step (7). As well to mention, the door must be swung inwards again to bid into safety regulations that are put into place.

The attachment point for the harness is another essential consideration; this is important because it is the user's safety line in case the aerial lift ever tips over and throws out the user in it. This bar would raise a foot off the ground for easier access compared to other aerial lifts where the attachment point for the harness is located on the ground and in the corner. With having a bar, this creates ease of moving freely from one side to another without worrying about unhooking from one corner to go to the other side. As well from elevating the bar off the ground afoot, it causes less strain on the users back bending down to reach the harness point.

Limitations and Conclusion

Identifying critical human dimensions affecting the product use were as followed:

While controlling the aerial lift, they may have visual limitations

Chances of entanglement if more than one worker is using the harness bar

Some of the current ergonomic issues that are not yet resolved include the interaction with a building in front of them or even above them, determining an area for storage of tools and how accessible is to get to.

This study helps to identify crucial human interaction areas of the aerial lift in context to the basket concerning the controls, enter/exiting and, to attach to the harness point. The study also shows the range of motion of the user while in each position and evaluating the three-specific major-body parts for the thesis requirements.

3.4 Aesthetics

Due to the nature of the environment and the treatment of the equipment that happens in and around construction sites, the overall design of the aerial lift would have been heavily designed around function instead of form. The overall shape of the aerial lift would need to hold between one to three people at a time. Special attention is directed to the usability of the basket and how the interactions affect the overall work quality of the worker.

No matter what happens with the plans, the overall design must meet the safety standards that are in place currently, such as having a light and horn to indicate when the lift is moving to a different location or just the basket alone. As well should be easily identifiable from anywhere with a bright color, such as many different products that are currently in the market today.

3.5 Sustainability-Safety, health & Environment

3.5.1 Safety

In the industry of construction, safety is of the most importance for everyone working in the construction field, the environment the user is in is ever-changing from day to day. If the user cannot utilize the machine to its fullest potential, then there can be safety concerns.

Many safety measures are put into place when dealing with these types of machines, such as a harness attach point, which the users may attach themselves to the basket if, in any case, they are thrown out of the basket, they do not fall to the ground. Another safety feature is the control panel. If the worker were to bump into the controls, they could nudge the lift by moving the arm or the whole base. If this were to happen, for instance, on a boom lift and hit a bump in the ground, an elevation difference of two inches on the floor is equivalent to four feet in the air. Some of the safety procedures that are in place right now is a two-step process where the user must place their foot on a pedal on the floor and hold down specific buttons to move the boom.

Another safety feature that was implemented was the ability to auto-level out the boom so that the body is ideally 90 degrees, so there cannot be any tip-overs.

3.5.2 Health

The user of the equipment is working at high altitudes and must face different wind speeds depending on the weather. This can cause various fluctuations in temperatures depending on the wind. This can affect the overall work the user is doing by trying to be out in the air, working in a “standing position regularly can cause sore feet, swelling of the legs, varicose veins,

general muscular fatigue, low back pain, stiffness in the neck and shoulders, and other health problems" (Canadian Centre for Occupational Health, 2020).

3.5.3 Environment

The environment that aerial lift would be used in would be on different construction sites, and these tend to have various ground conditions such as mud and concrete. This affects the overall use of the machines, as well as many different elevations on the ground level that can affect the machine, meaning if they can use it in certain areas or not. These machines are used in every weather condition and stored outside, meaning that they must be resilient in all-weather types of many diffractions in the change in temperature.

3.6 Commercial Viability

3.6.1 Material and Manufacturing

The choice for the material is critical because of the safety concerns for everyone, no matter what. Current scissors and boom lifts are made mostly of steel. When lifting all the weight, there are hydraulic pumps on each machine and having plastic paneling covering the engine for the boom lift. With the construction of steel, this would ensure the most reliable possible strength of the lift. The type of engines that are used for scissor and boom lifts are typically a hybrid system of diesel, and this would be the same for the proposed design as well.

The manufacturing method for the proposed design will be like how the current boom and scissor lifts are made. They are currently all welded parts together, and with moving parts would have enough of a gap to move freely.

3.6.2 Cost

The cost for scissor and boom lifts all differ from the companies on how high they can go and as well as weight capacity. The average price of the boom lifts comes up to $61,500, as calculated from appendix F. Thus, it is estimated that the cost for the proposed design would be in the range of $60,000 to $75,000. This cost would change due to the cost of material and labor of making.

3.7 Design Brief

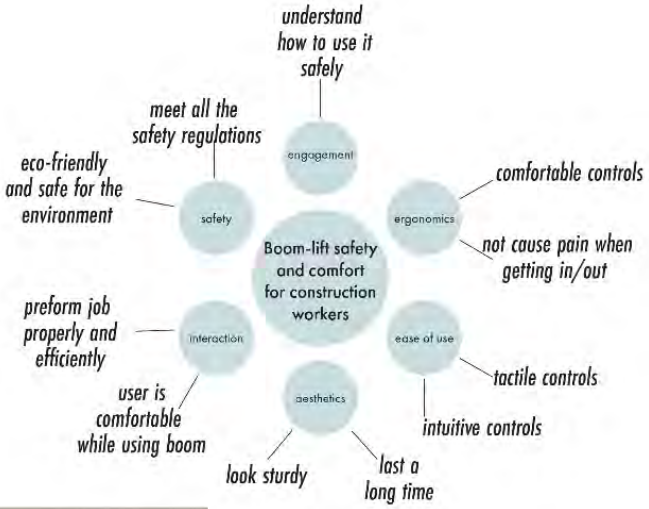
The purpose of this thesis is to develop a safer and more comfortable boom lift for any operators that are doing work outside. The following list is specific guidelines; this final thesis product will resolve:

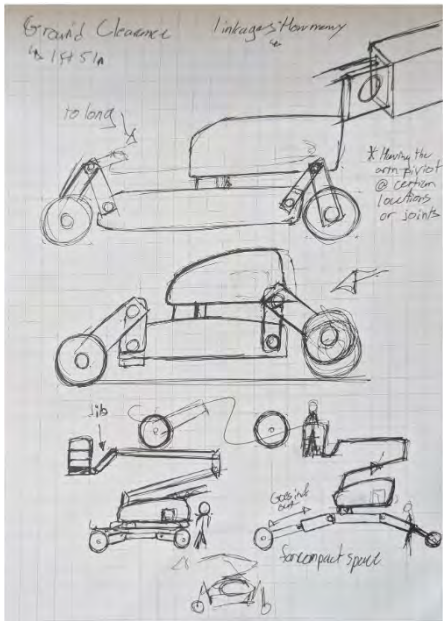
- Improved Comfort while in the basket
- Improved ergonomics of getting in/out of the basket
- Smoother interaction with the controls of the machine
- Safe for the user and surrounding users
- Sustainable Materials & power source
- Be aesthetically pleasing
- Improve safety while using the boom
- Improvements in daily tasks

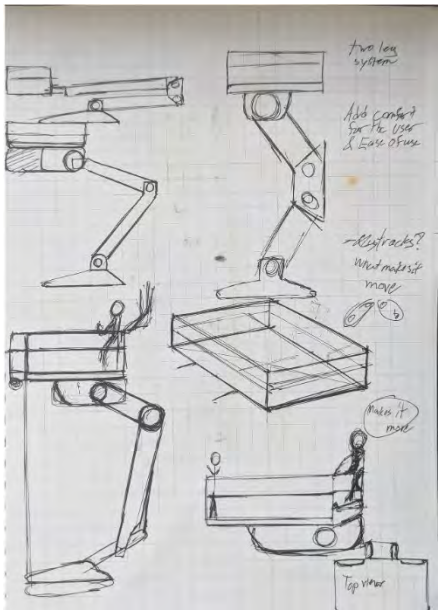
4 Design Development

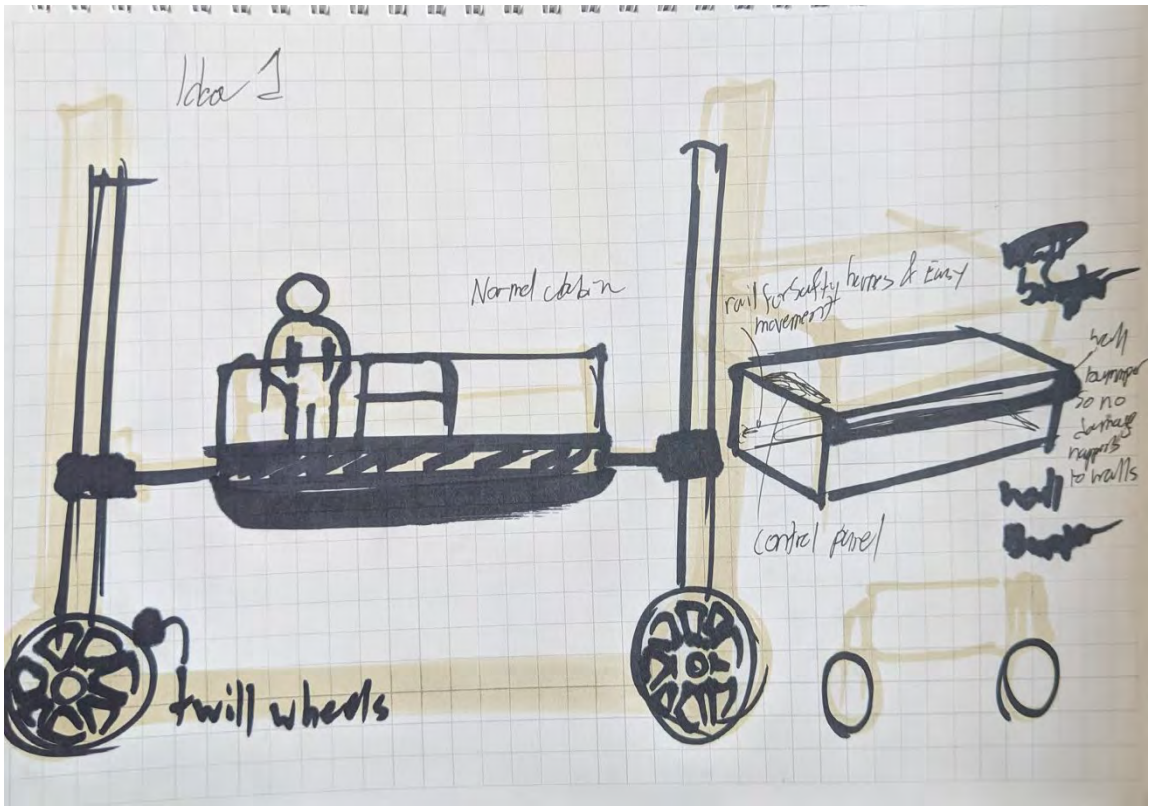
4.1 Ideation

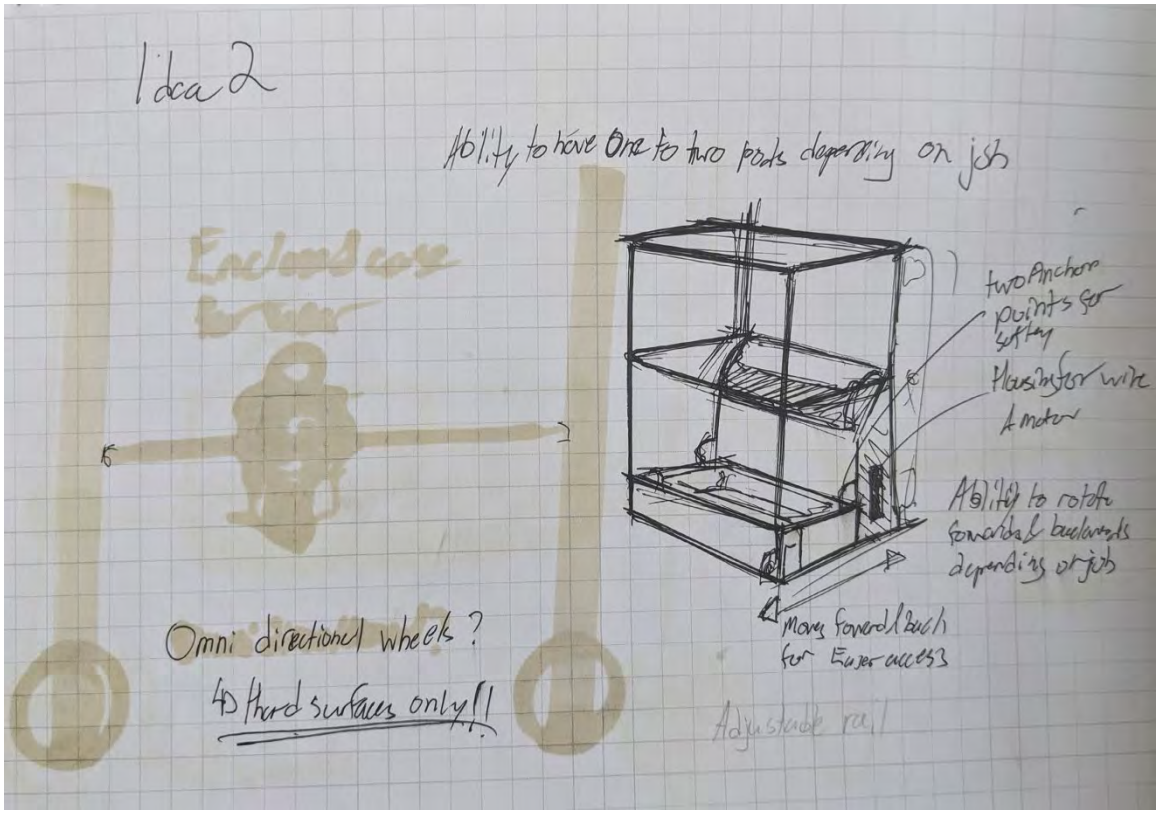
Through the whole process of the design development of the different analyses, a thesis notebook was always kept with me. This notebook was a viable tool in putting down quick notes or sketches to have a better understanding and just to have something on me, so I did not forget what the initial idea was. As well as developing key areas that will need improvements.





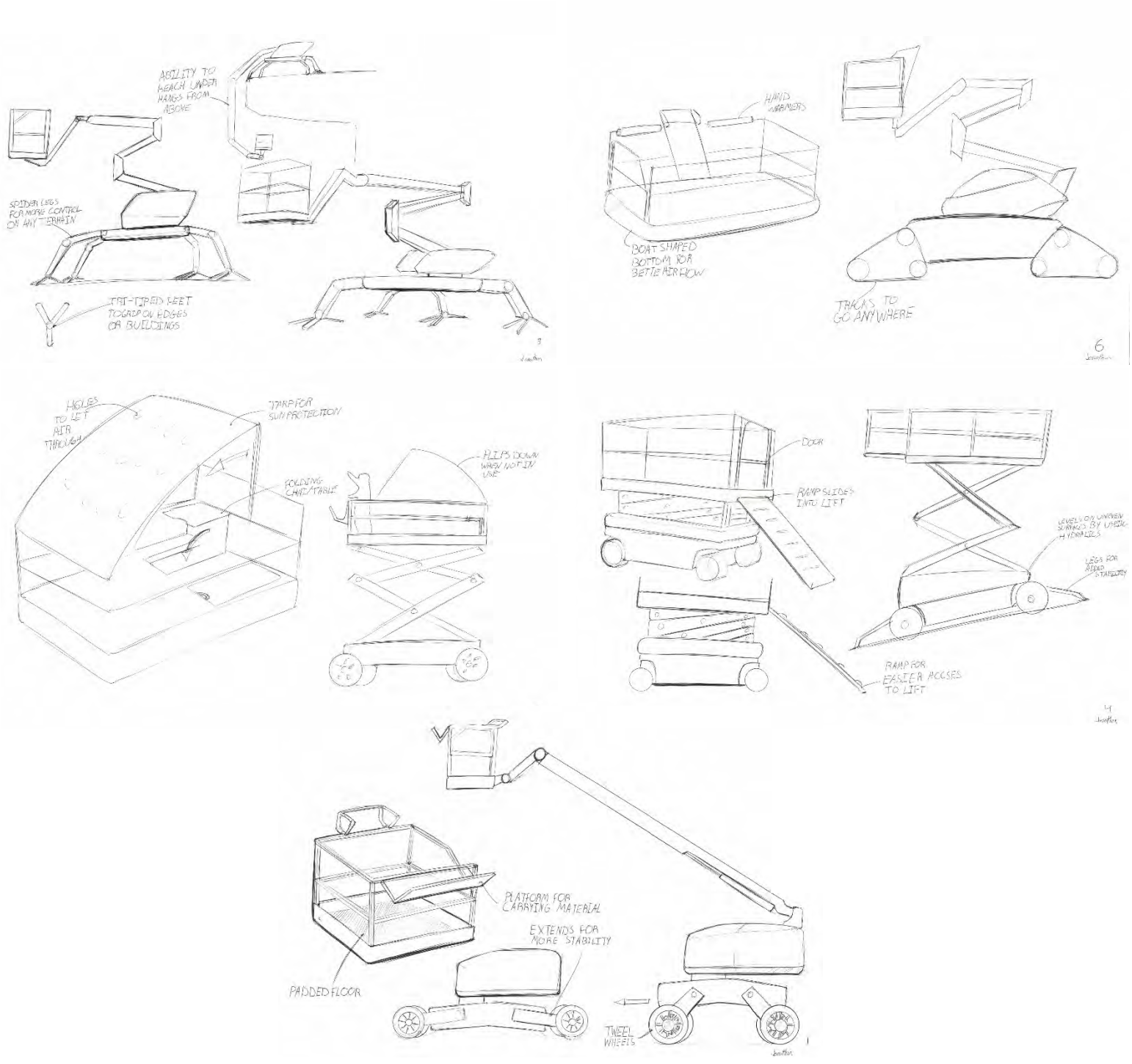



Idea 1
Normal cabin
rail for safety barriers & Easy movement
control panel
twill wheels

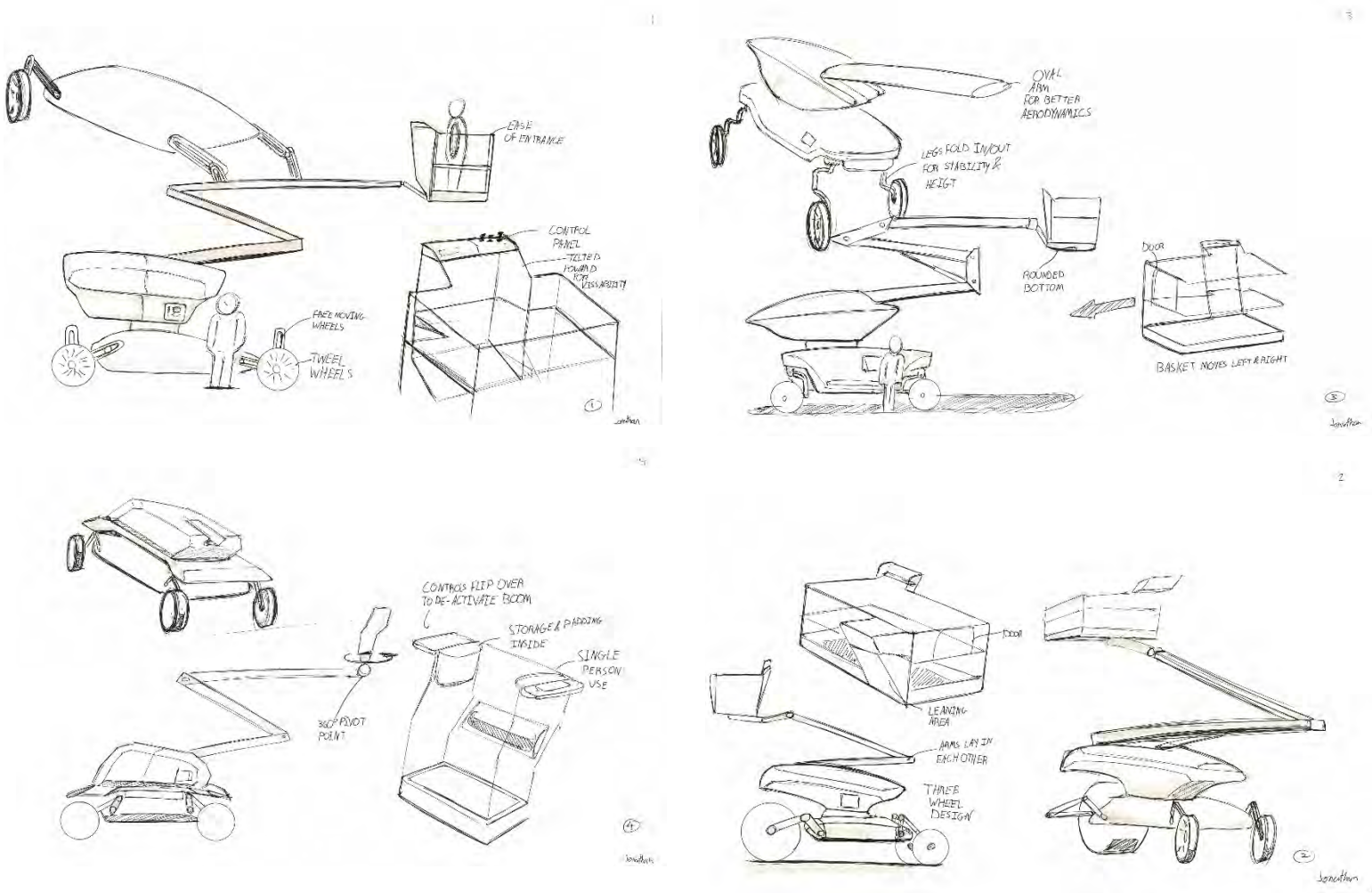

Idea 2
Ability to have One to two pods depending on job
two Anchors points for safety
Ability to rotate forwards & backwards depending on jobs
Moves forward/back for Easier access
Omni directional wheels ?
4D Hard surfaces only!!
Adjustable rail

4.2 Preliminary Concept Exploration

In the following ideation phase, two of the ideations were taken and further developed to flesh out the overall design and what components were to be used and where. From the ideation,



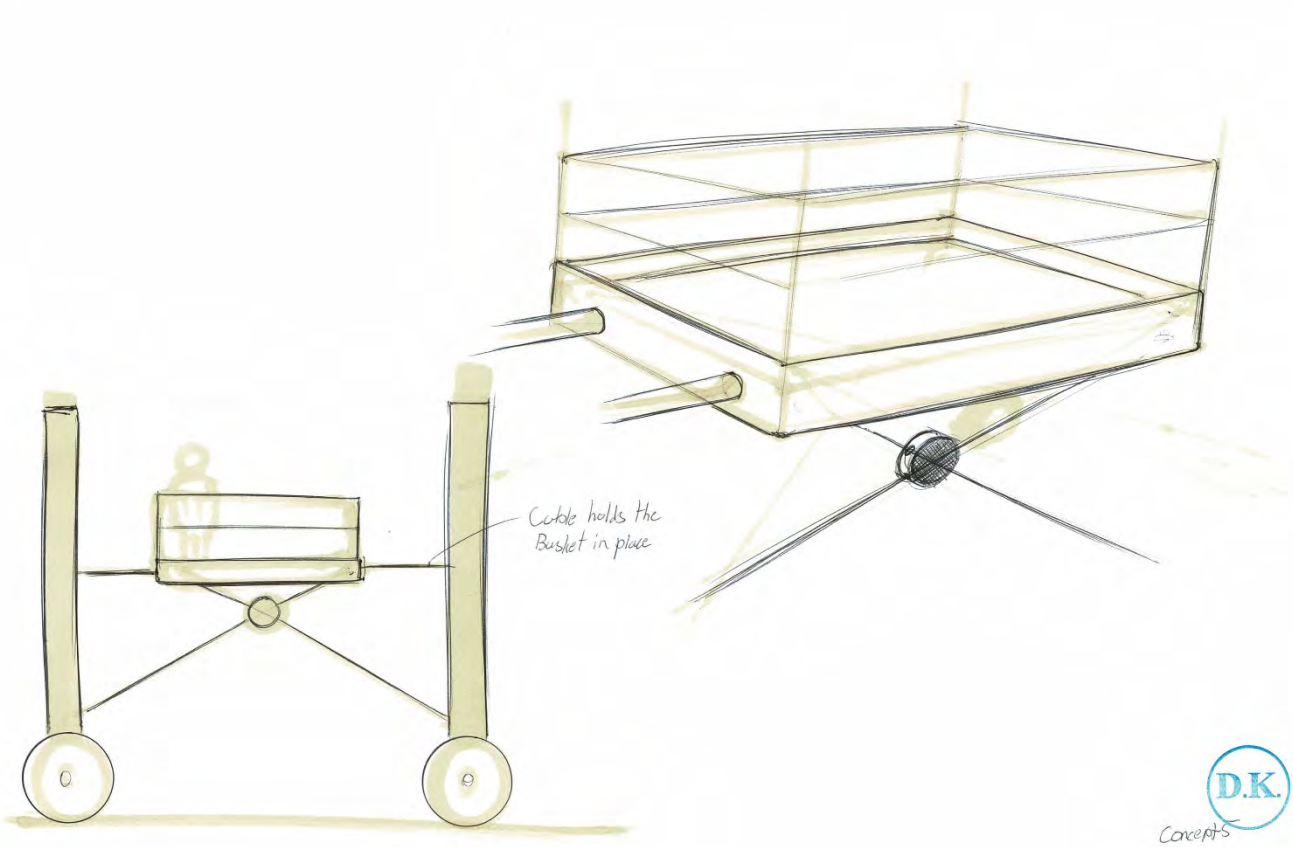
two forms of lifts where being used the boom lift, and the scissor lift. This was all done while trying to avoid re-design of both these tools that are used daily.



After doing these sketches, I tended to lean towards the idea of a combination of both scissor and boom lift. This would allow me to add all the creature comforts needed for the user while not restricting the overall moment of the machine and not impeding on the task at hand.

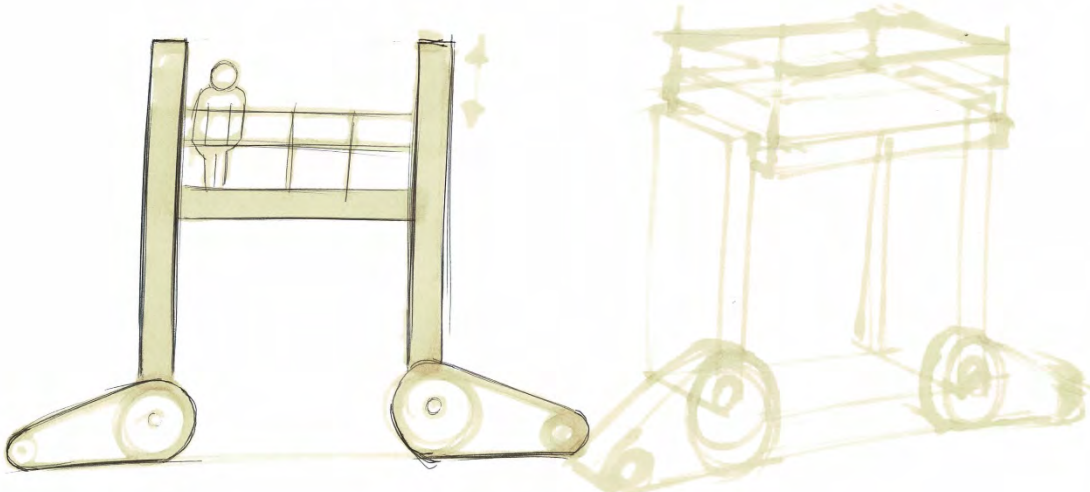
4.3 Concept Refinement

During this phase, some of the key concepts that were further developed form the previous phase. As well as trying to integrate both the boom and scissor lift seamlessly and without restraining any freedom of movement for the lift.



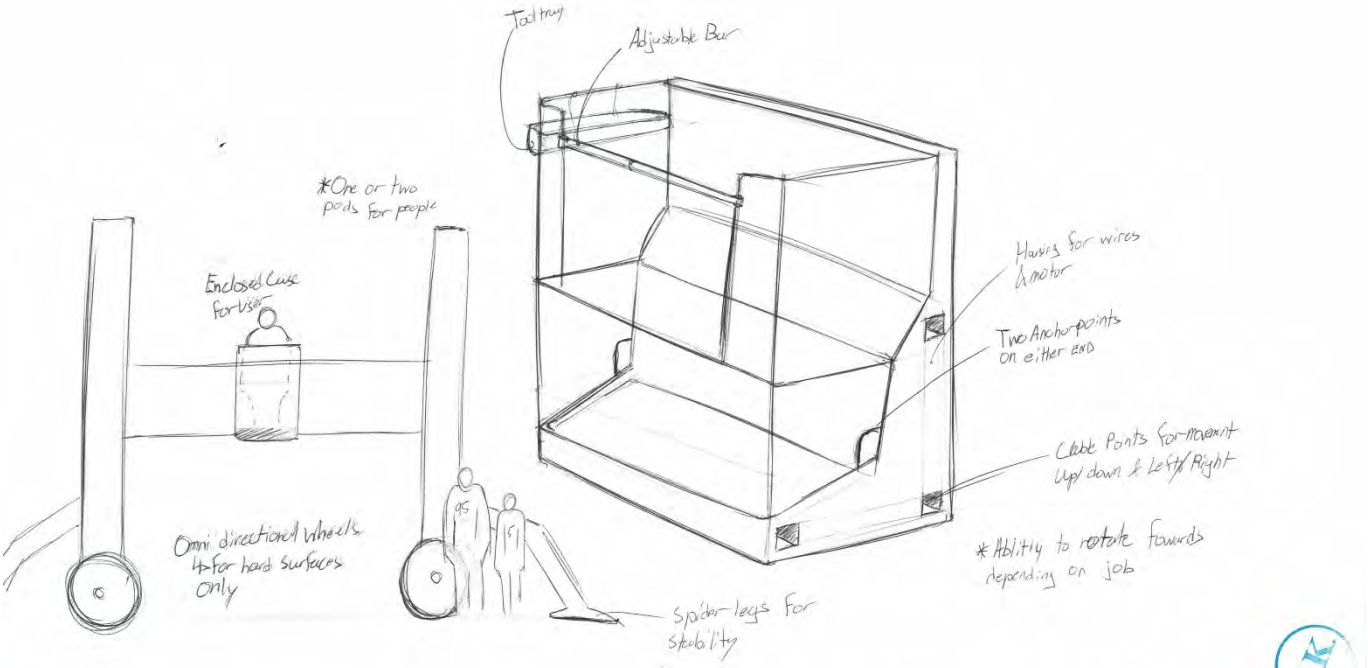
D.K.

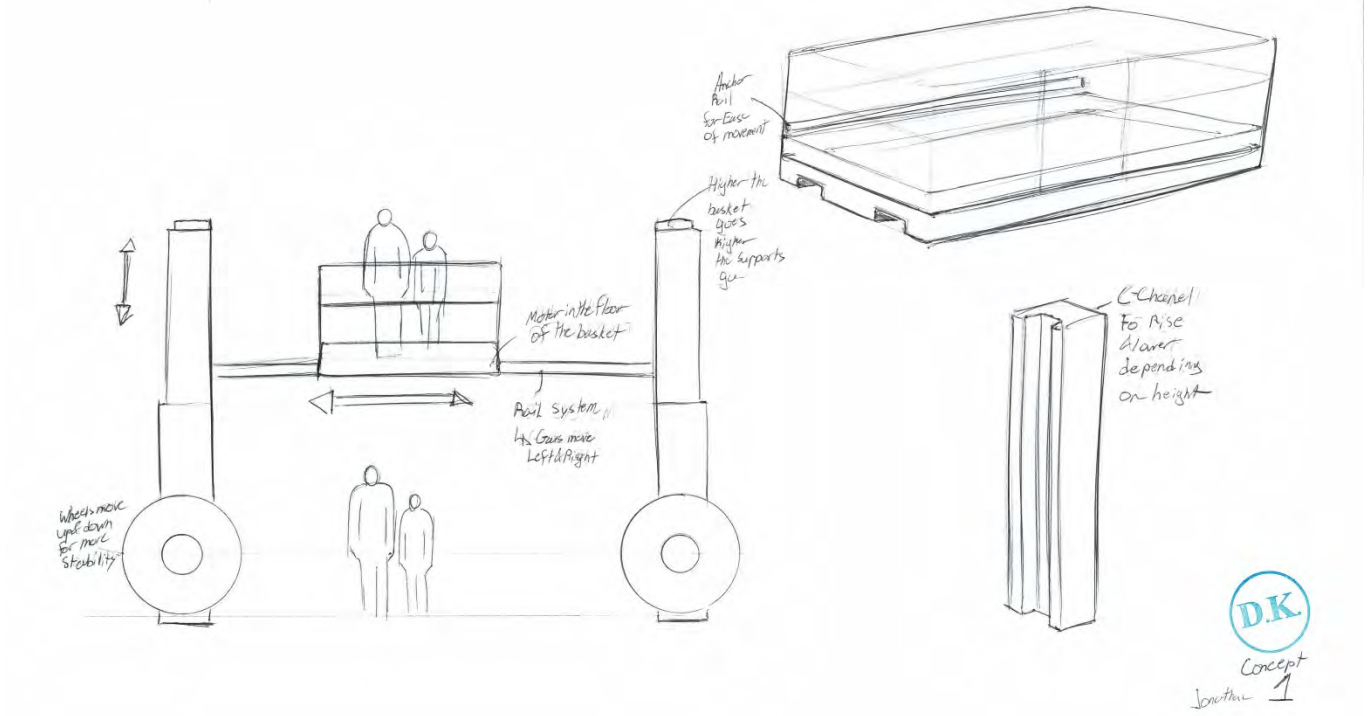
Concept 5

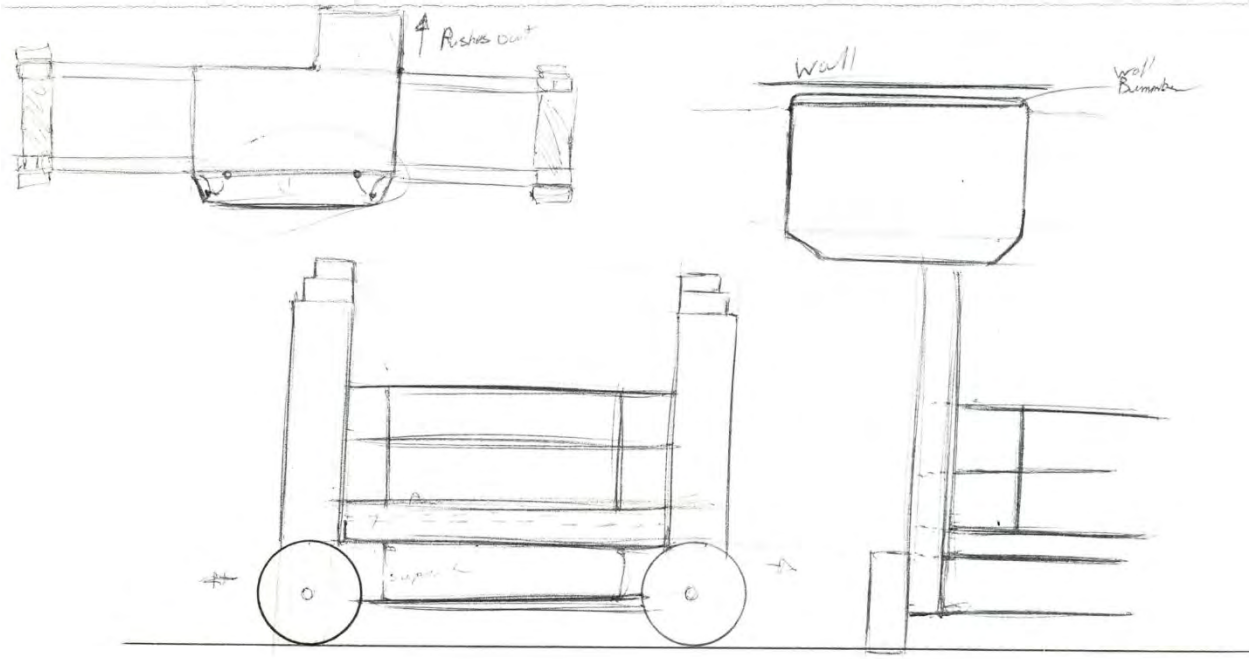


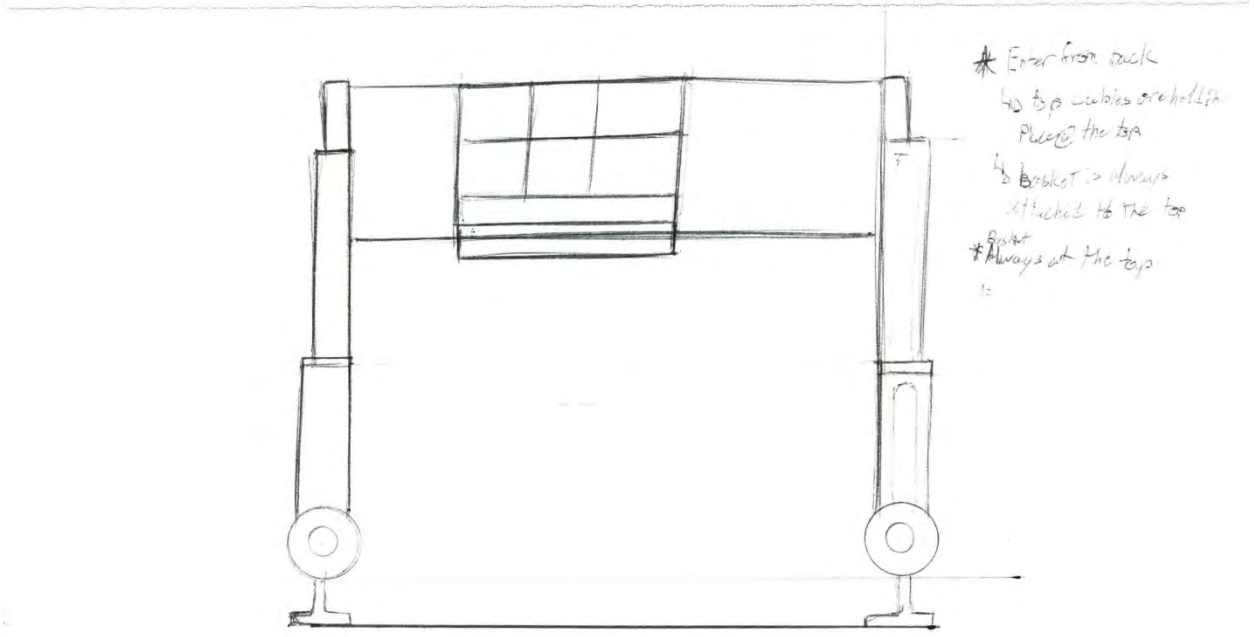
Concept 4

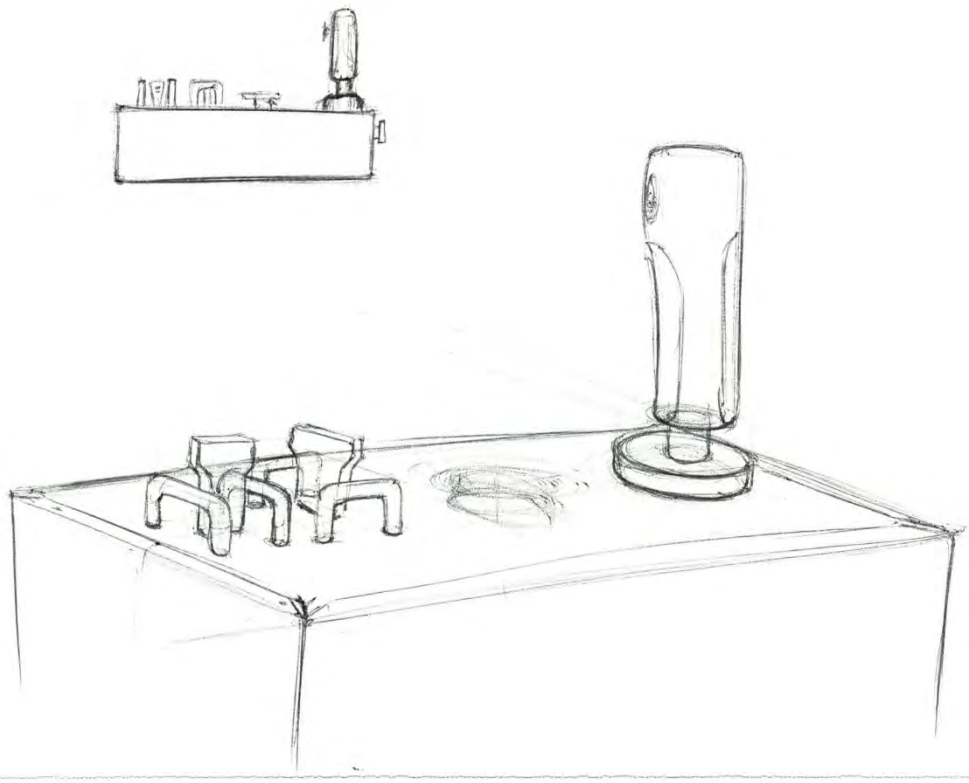
D.K.

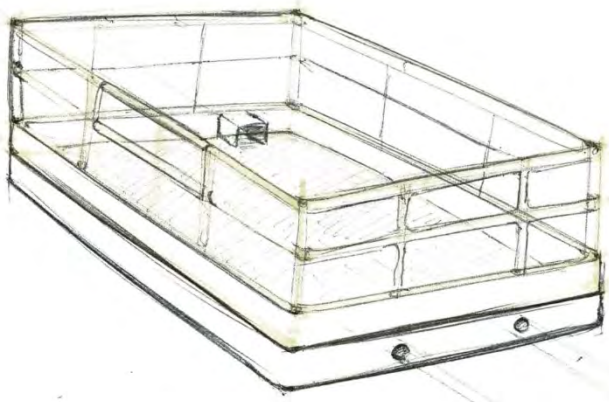

Tool tray
Adjustable Bar
*One or two pods for people
Enclosed Case for Visor
Housing for wires & motor
Two Anchor points on either end
Cable Points for movement Up/down & Left/Right
Omni directional wheels 4 for hard surfaces Only
*Ability to rotate fowards depending on job
Spider legs For Stability
Concept Jonathan 2


Anchor Rail for Ease of movement
Higher the basket goes Higher the supports go
Motor in the floor of the basket
Rail system 4 Goes more Left & Right
Wheels move up/down for more Stability
C-Channel To Rise & Lower depending on height
D.K
Concept 1
Jonathan


Pushes out
Wall
Wall Bumper


Enter from back
to top cubies are held in
Place @ the top
to basket is always
attached to the top
Always at the top

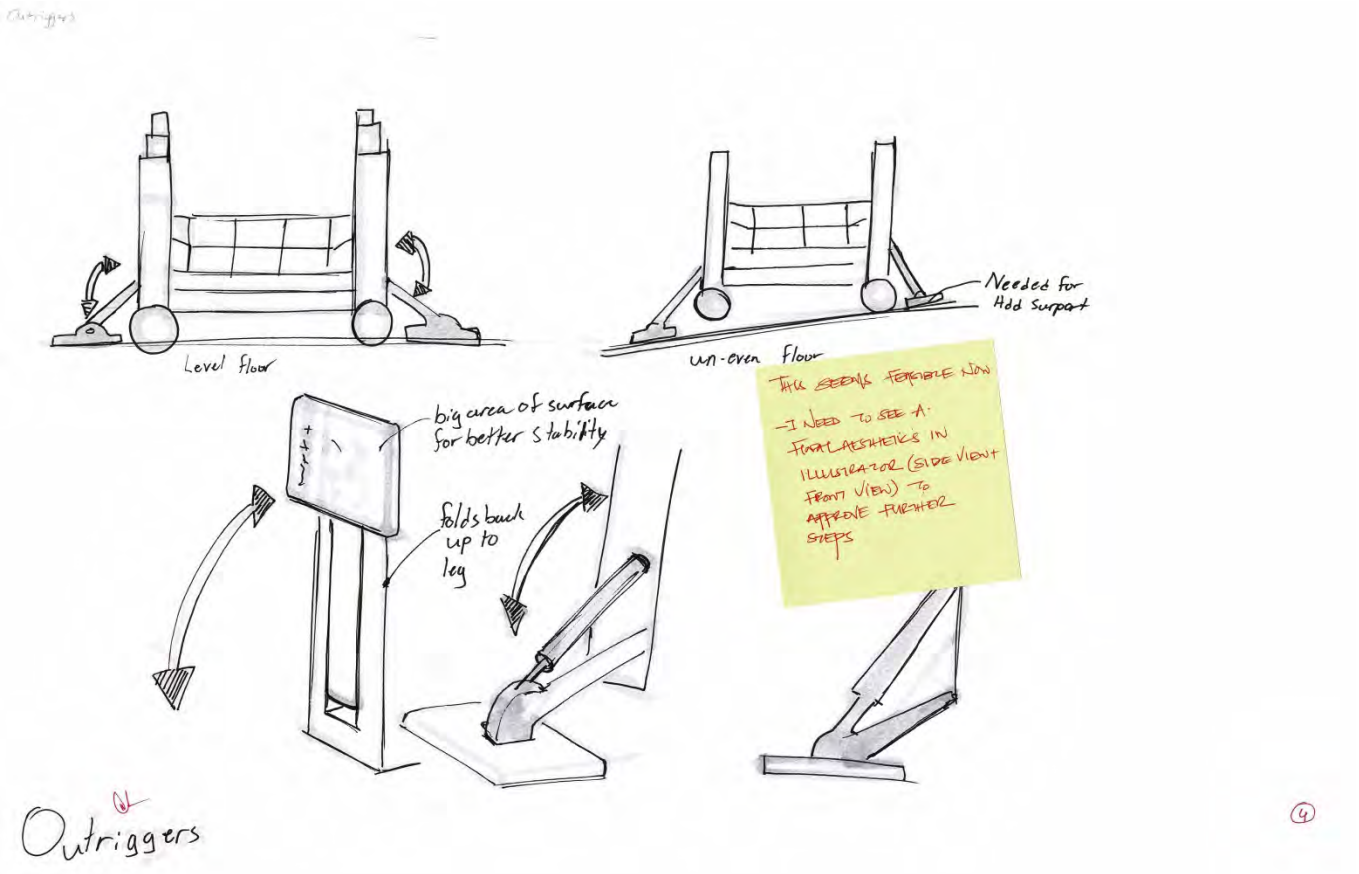


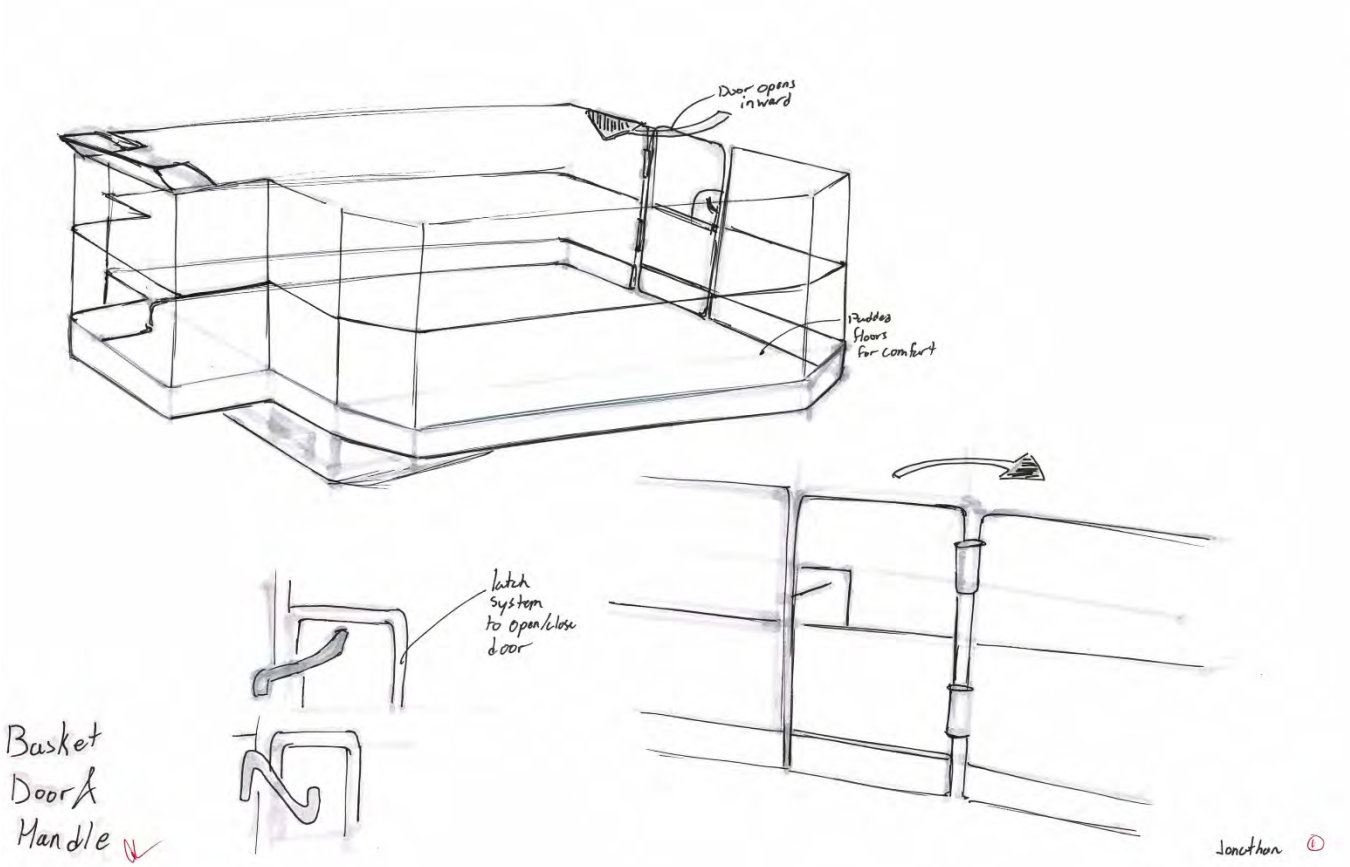


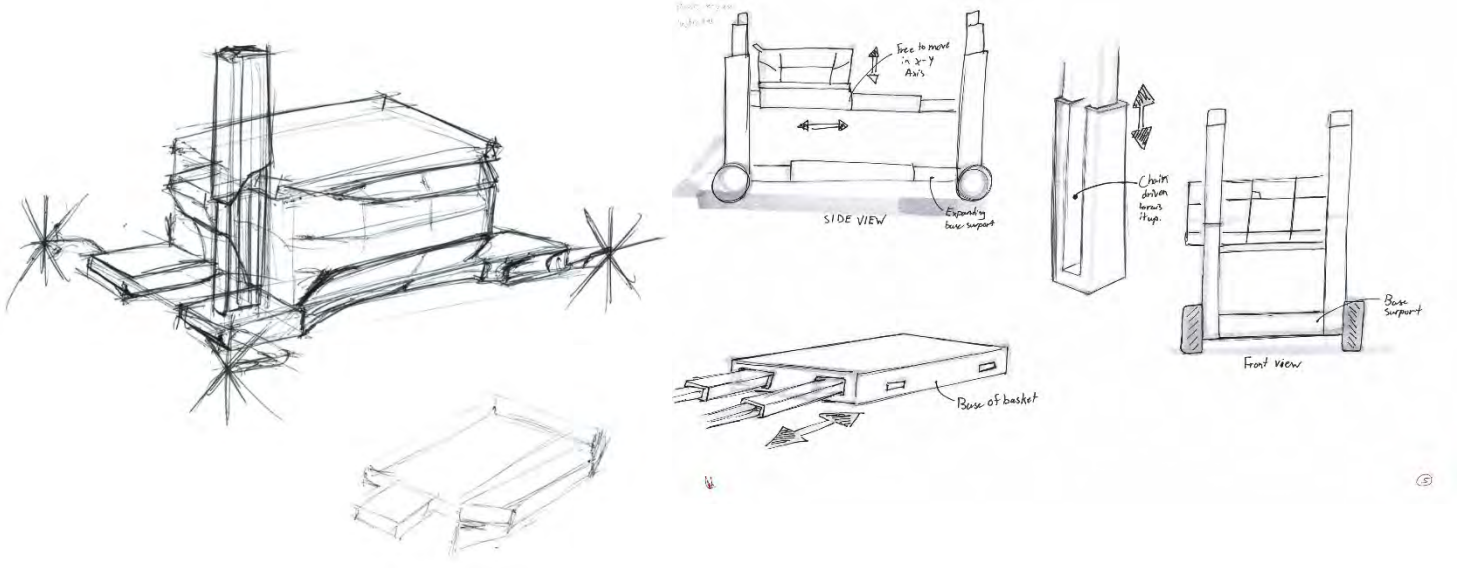
The concepts that are shown above illustrate the different ways of movement regarding how the basket moves with the user in it as well as seeing the most efficient use of space of the basket while it is in air and the general area of the control panel that can be used.

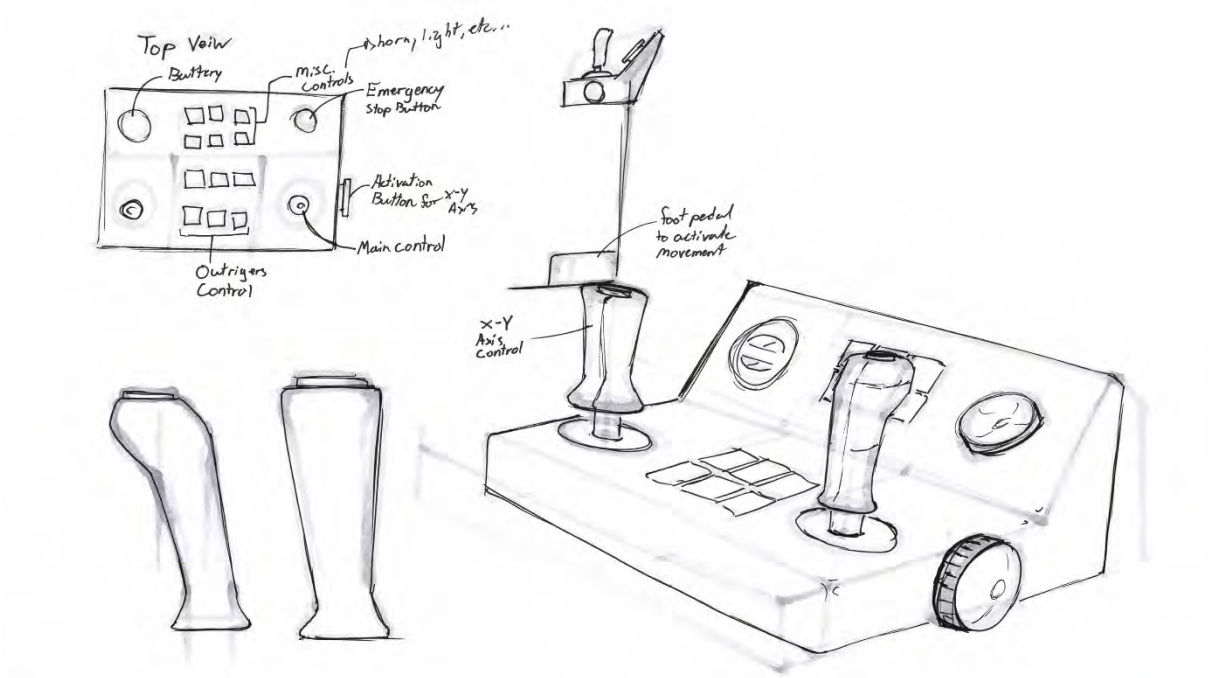
4.4 Detail Resolution

This section shows the development of the final package of the lift. It also shows more in detail aspects of the lift, such as how the door latches and how the lift can move in the X-Y axis.

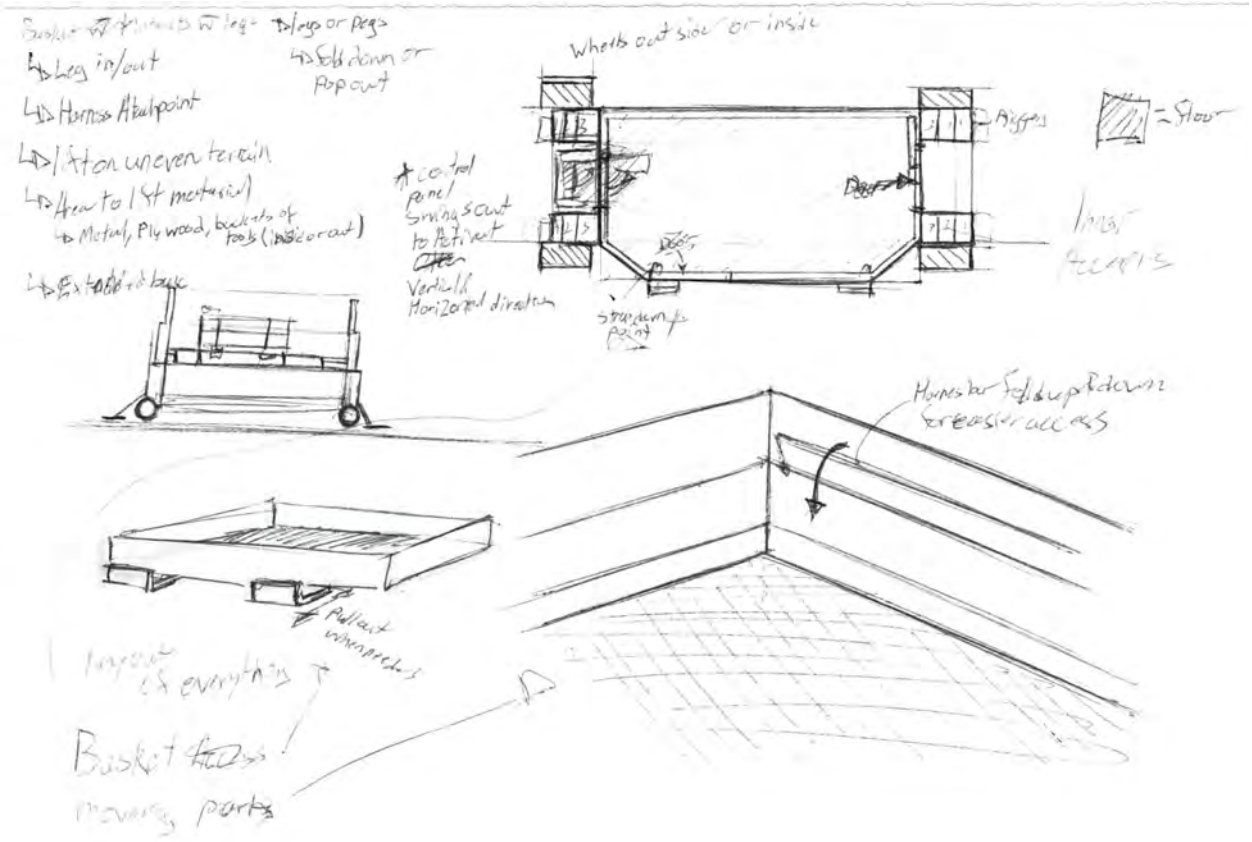


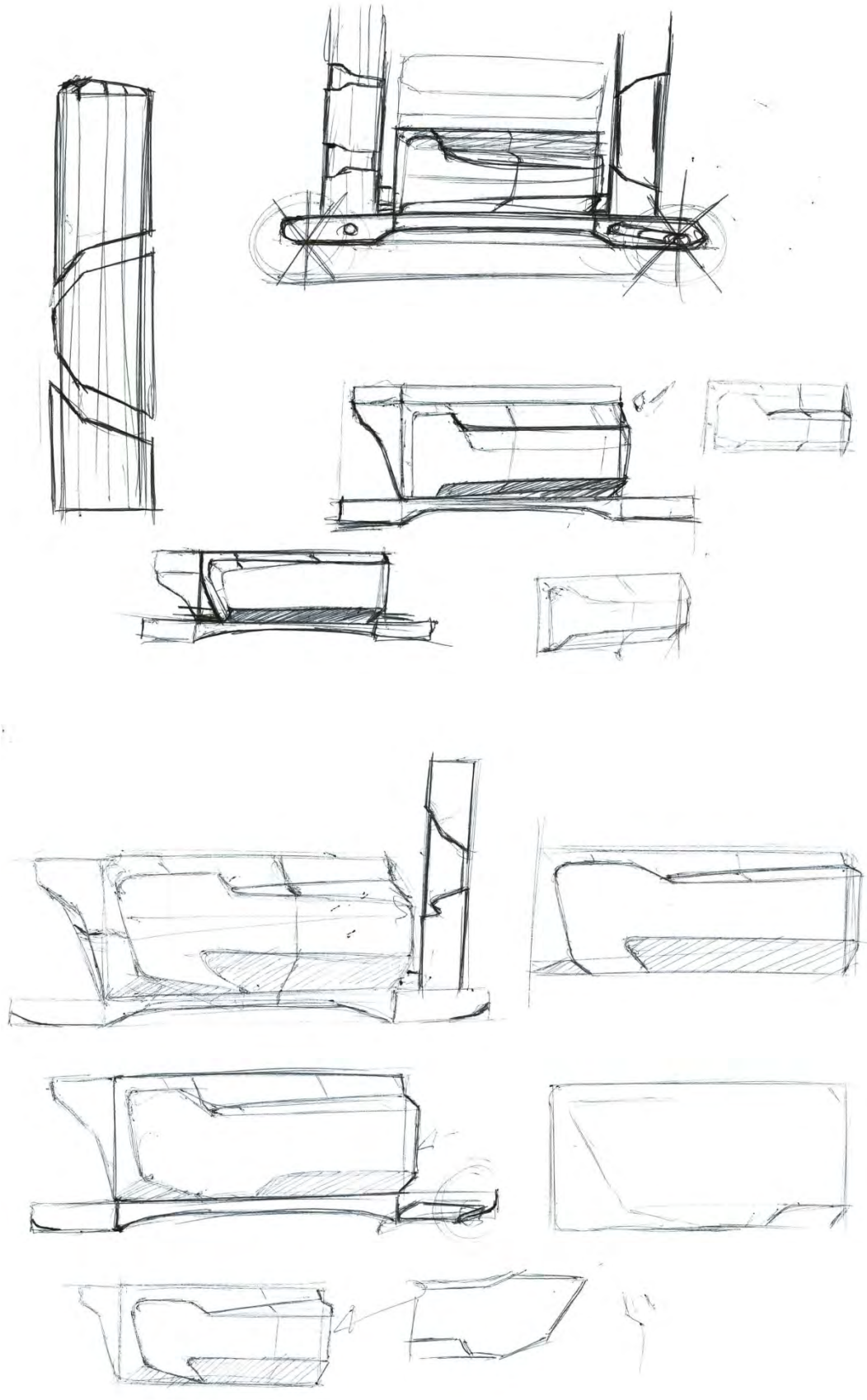

Door opens inward
Padded floors for comfort
latch system to open/close door
Basket Door & Handle
Jonathan ①


Free to move in x-y Axis
SIDE VIEW
Expanding base support
Chain down here it up.
Base Support
Front view
Base of basket
⑤



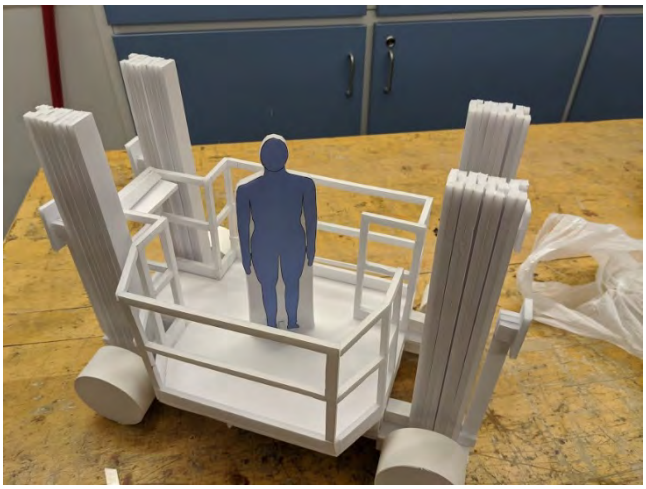
Basket Control Panel

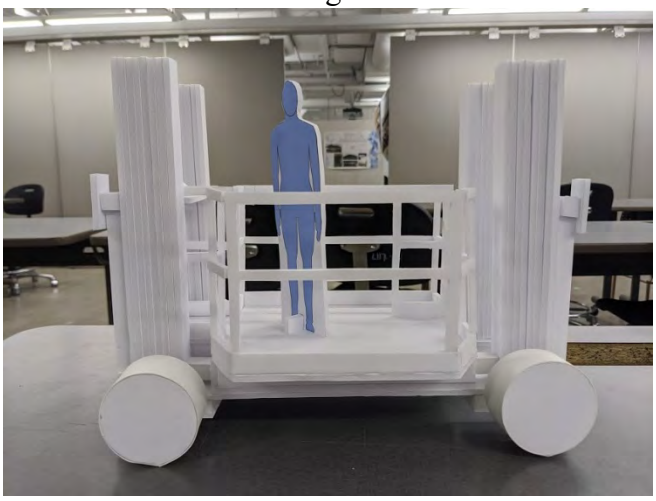


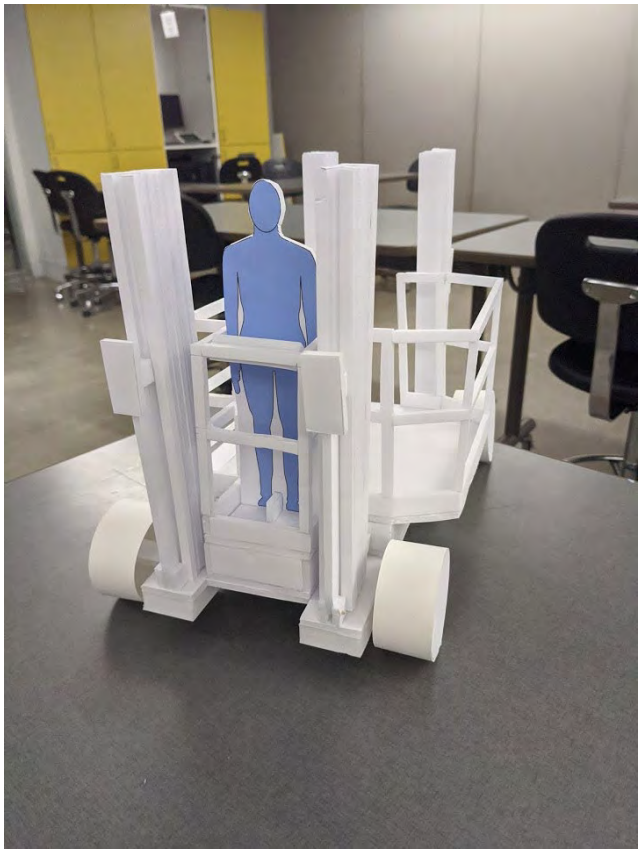


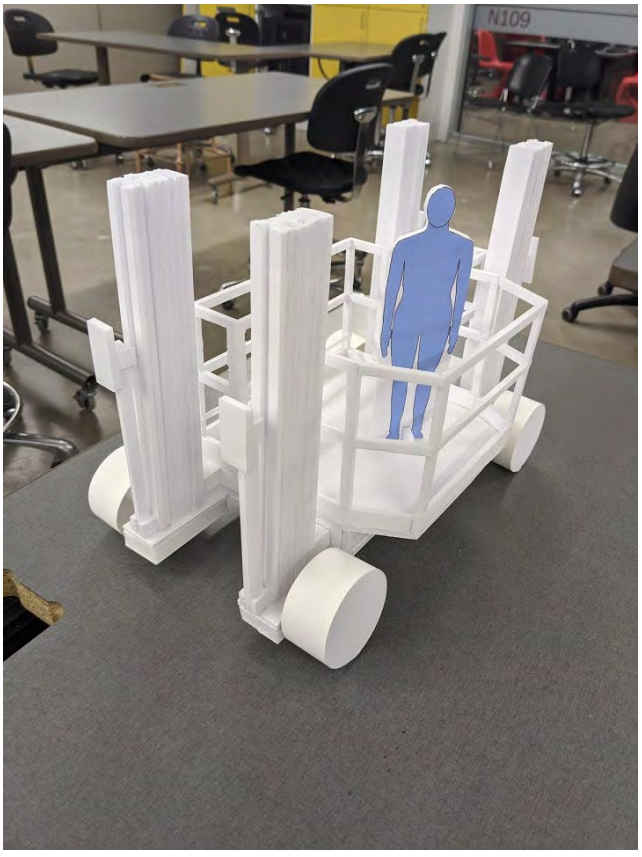
4.5 Sketch Models

To further understand the design, a quick and accurate sketch model was made using a 1:10 scale. This was done to have a better understanding of what the final design would look like to also be useful in the creation of the CAD model to establish different sizing.

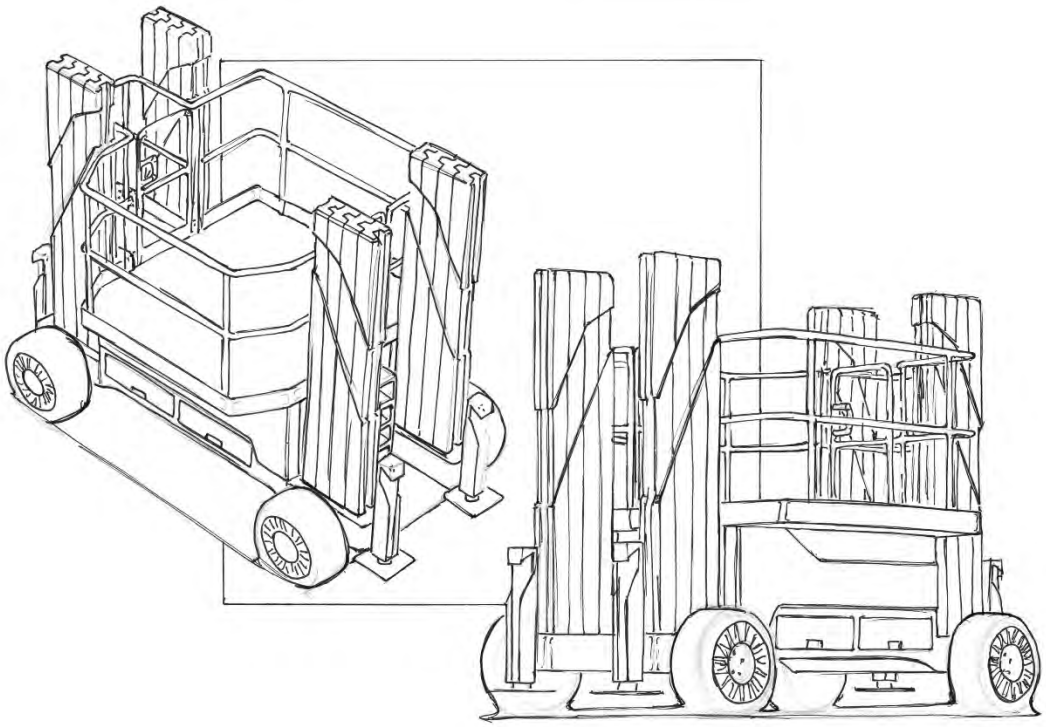






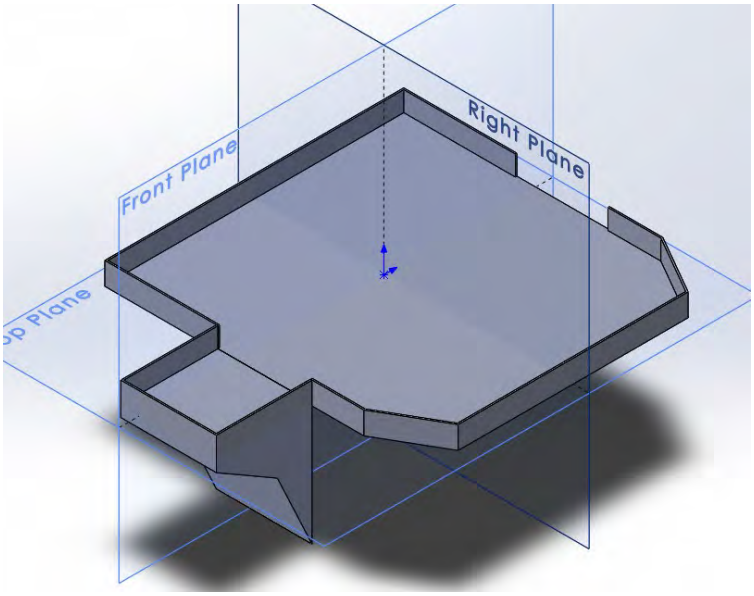


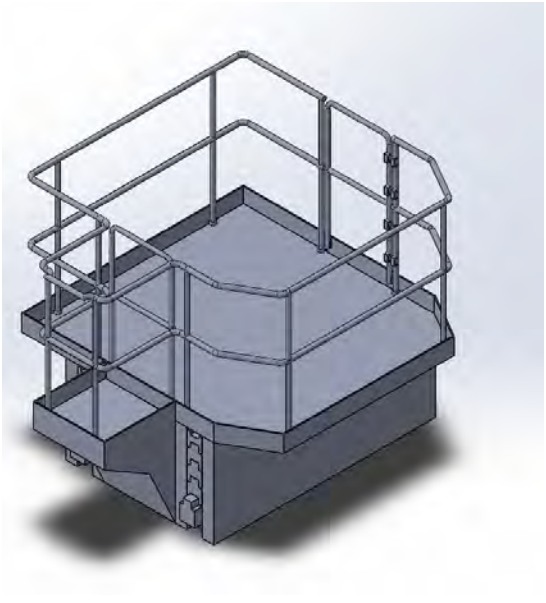
4.6 Final Design

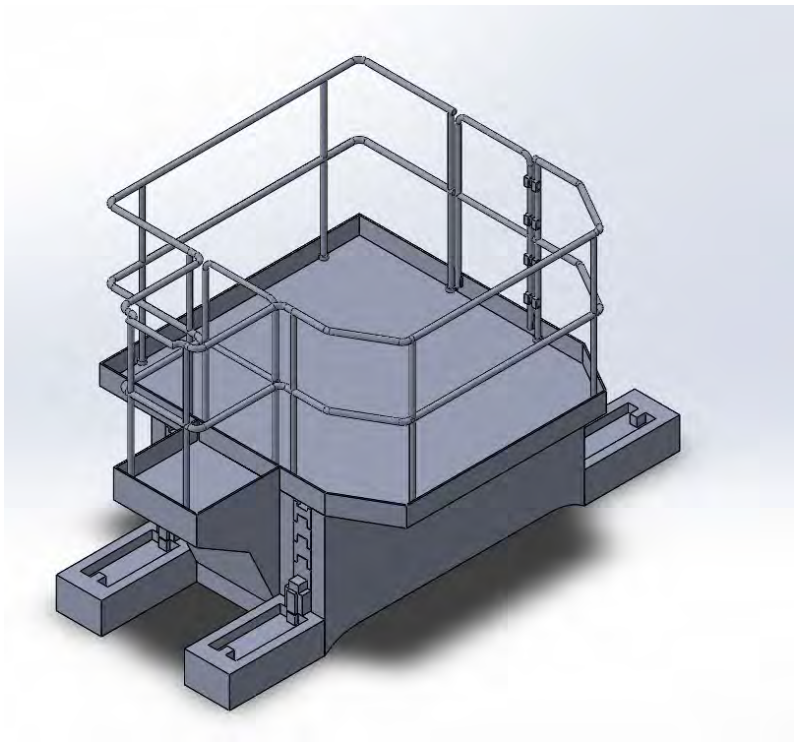


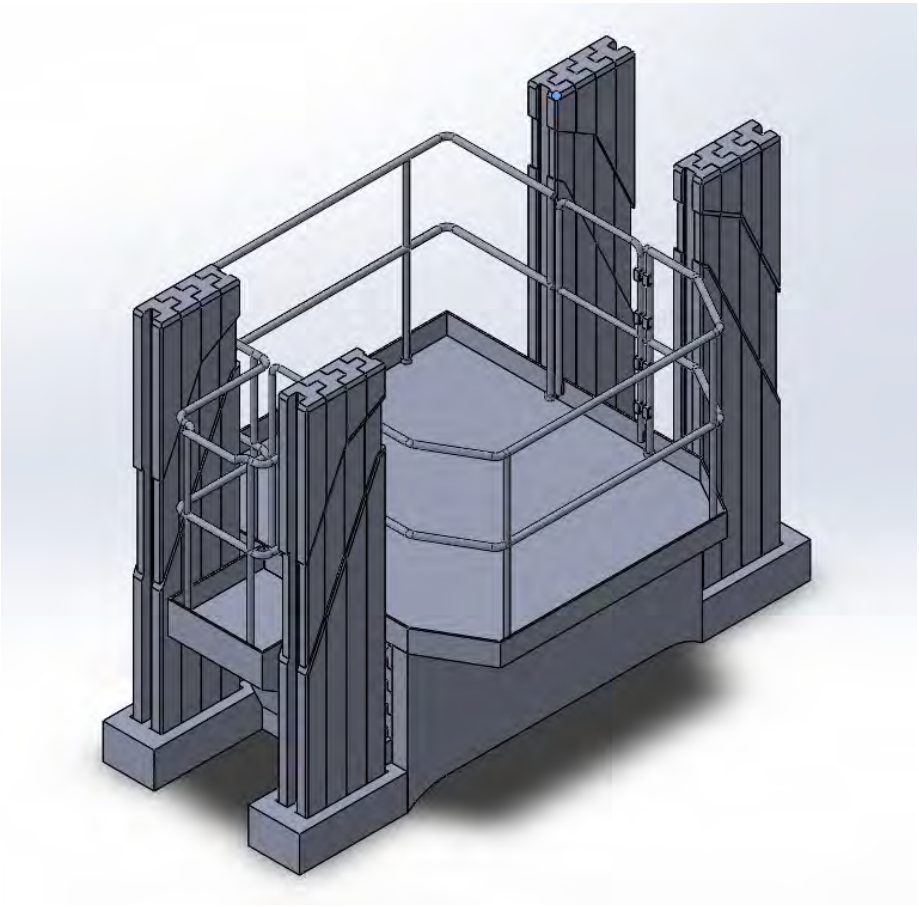
4.7 CAD Models

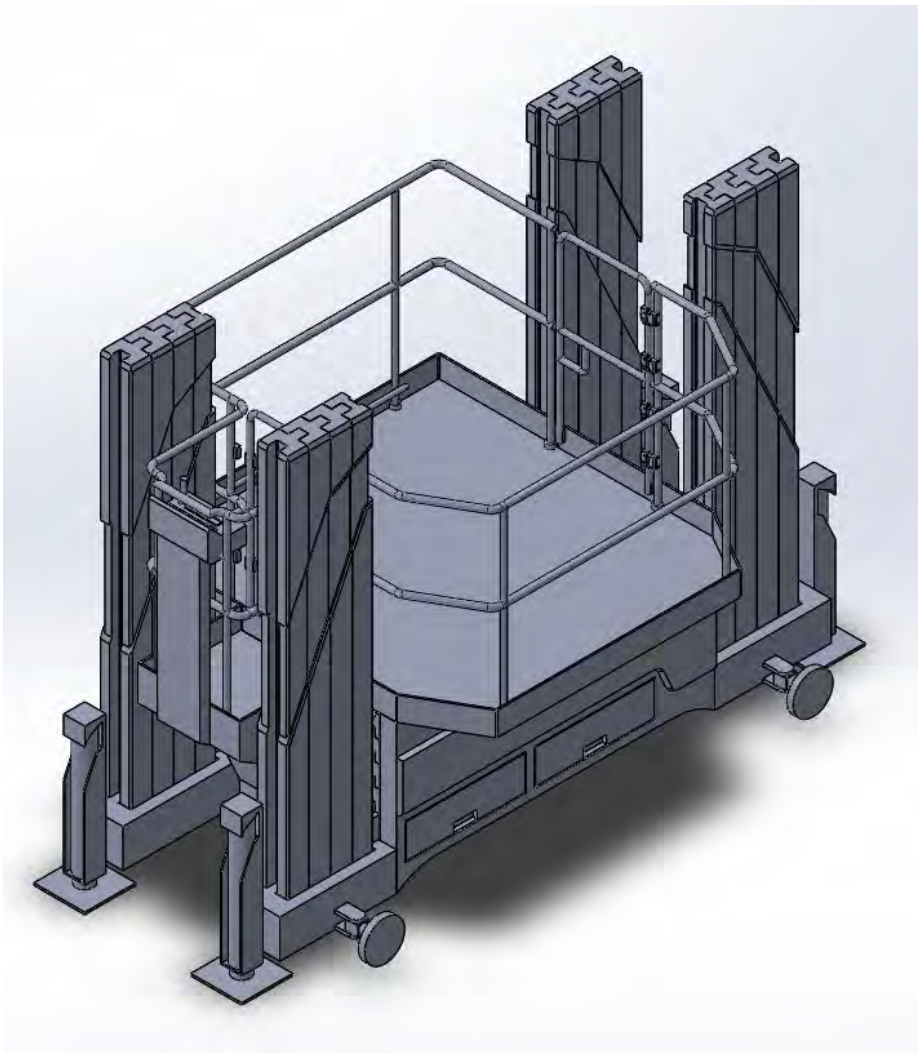
These photos display some of the work that went into creating the CAD model made in Solidworks for the final Design.

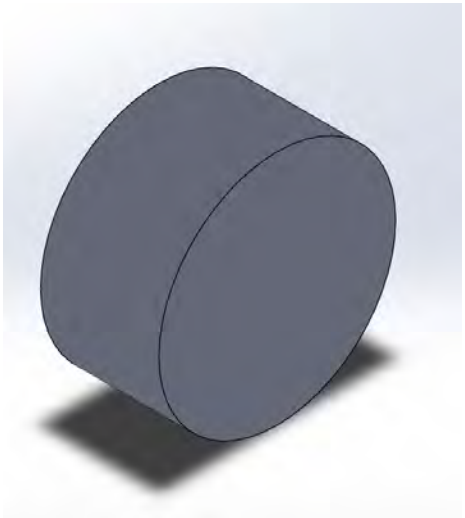


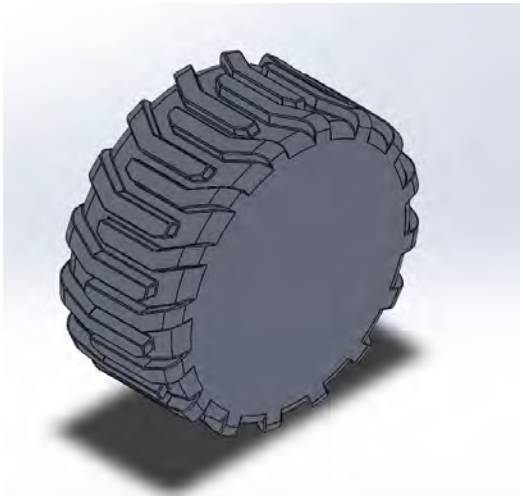




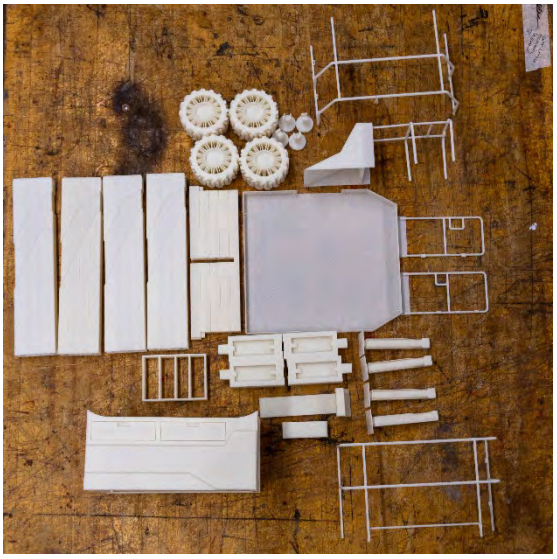


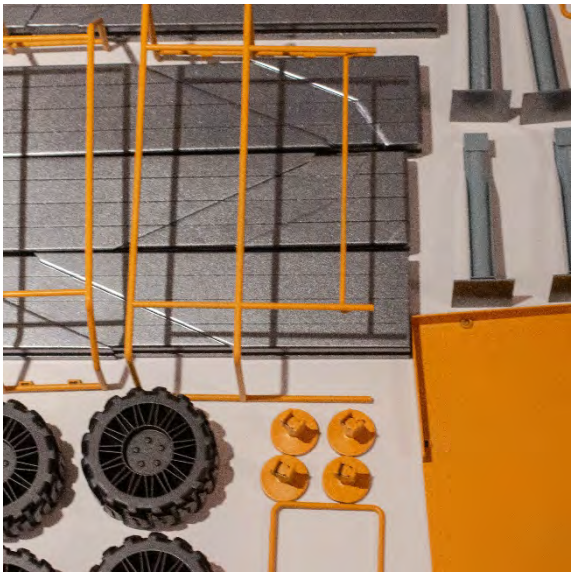


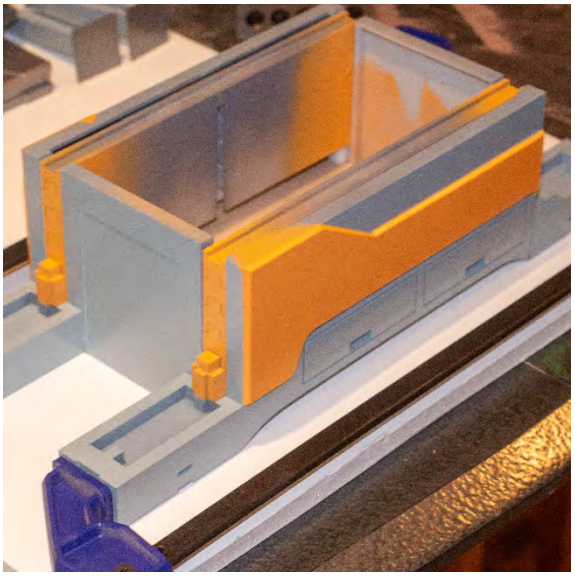


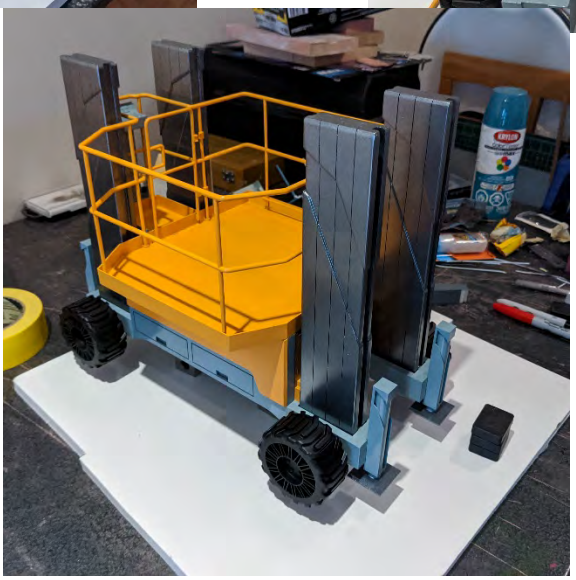


4.8 Hard Model Fabrication History









5 Final Design

5.1 Summery

5.1.1 Description

Raizex is a lift that is a human-centered design that allows the users to cover a large side area of a building by moving freely on an X – Y axis, increasing safety while in use.

5.1.2 Explanation

Current methods of working up in the air on a building would involve either using a scissor lift or a boom lift, yet there are safety issues when doing so. Such as when the user is in the scissor lift that is fully extended. There is a considerable amount of sway back and forth when you are moving from to a different location, countering the sway the user would have to bring down the basket, then move it to the next appropriate site and bring the basket back up again. The same goes for the boom lift, and there are tremendous amounts of sway when the boom is extended out with the basket and not to mention that it takes up a lot of space while in use and extended out towards any location. For the boom lift, it must indicate that they have a low capacity of workers in the basket at one time and hold a minimal amount of weight on the basket. For both machines, the controls tend to be in an uncomfortable spot, thus straining the user whenever they must use either machine.

Raizex was designed to create a safer and more comfortable work environment for the user. This is done by adding adding a combination of the scissor lift and boom lift to give the best experience as possible; by being able to move in an X – Y axis freely, it provides the user with the ability to move freely without the fear of any type of sway. It has enough workspace to

carry up any material that they may need and still have space to move freely in the basket. With it just taking up as much space as some scaffolding, it is easy to be out of the way for others to work around it. Raizex would also have airless wheels for a more comfortable ride over any rough surfaces; this would be essential when this would be on any construction site with uneven terrain. This wheel would replace the standard wheels that tend to be heavier and freeze in colder weather, as well as having an auto-leveling system that enables the whole lift to level itself on any uneven terrain that it may be working on.

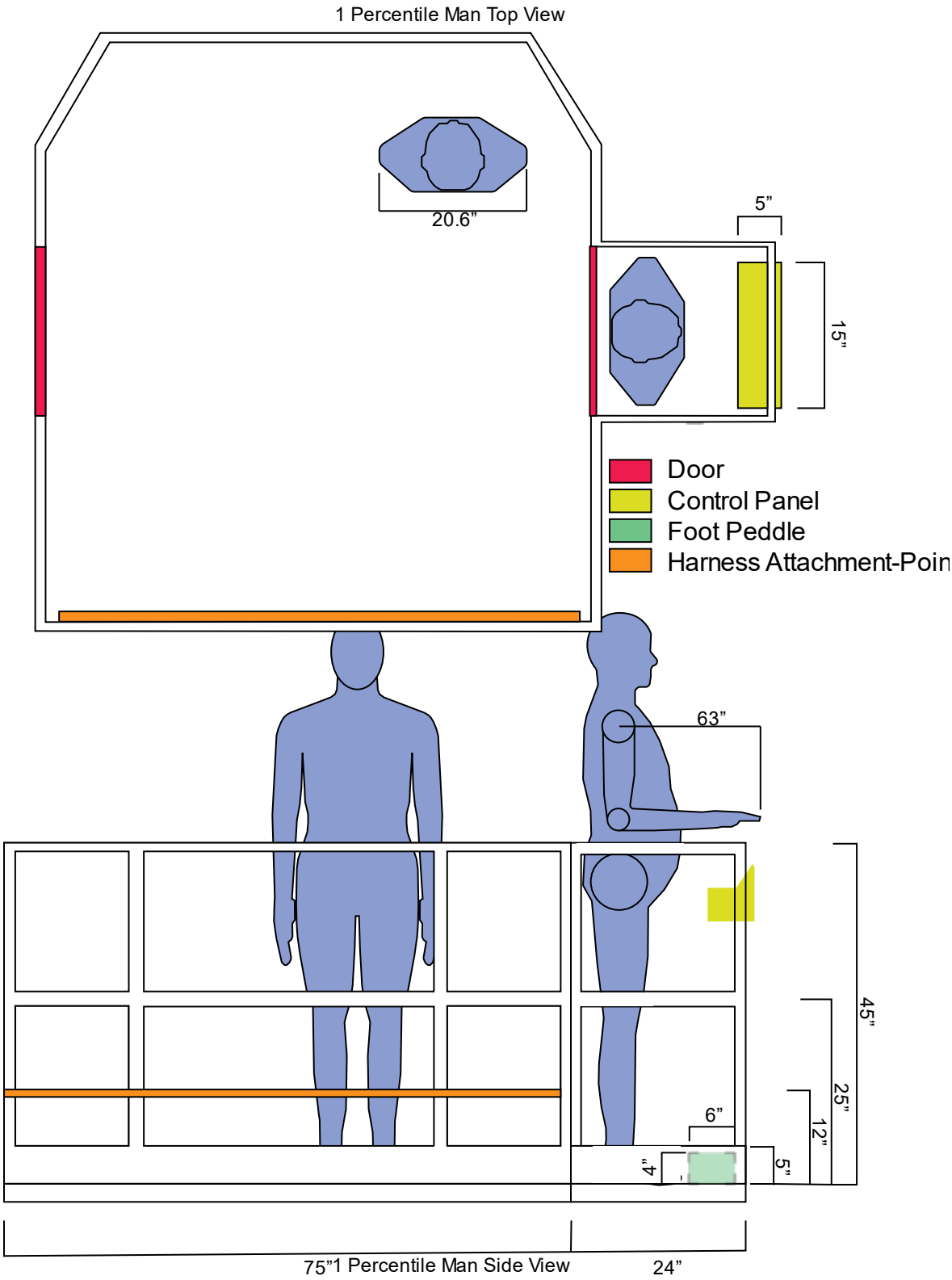
5.1.3 Benefit Statement

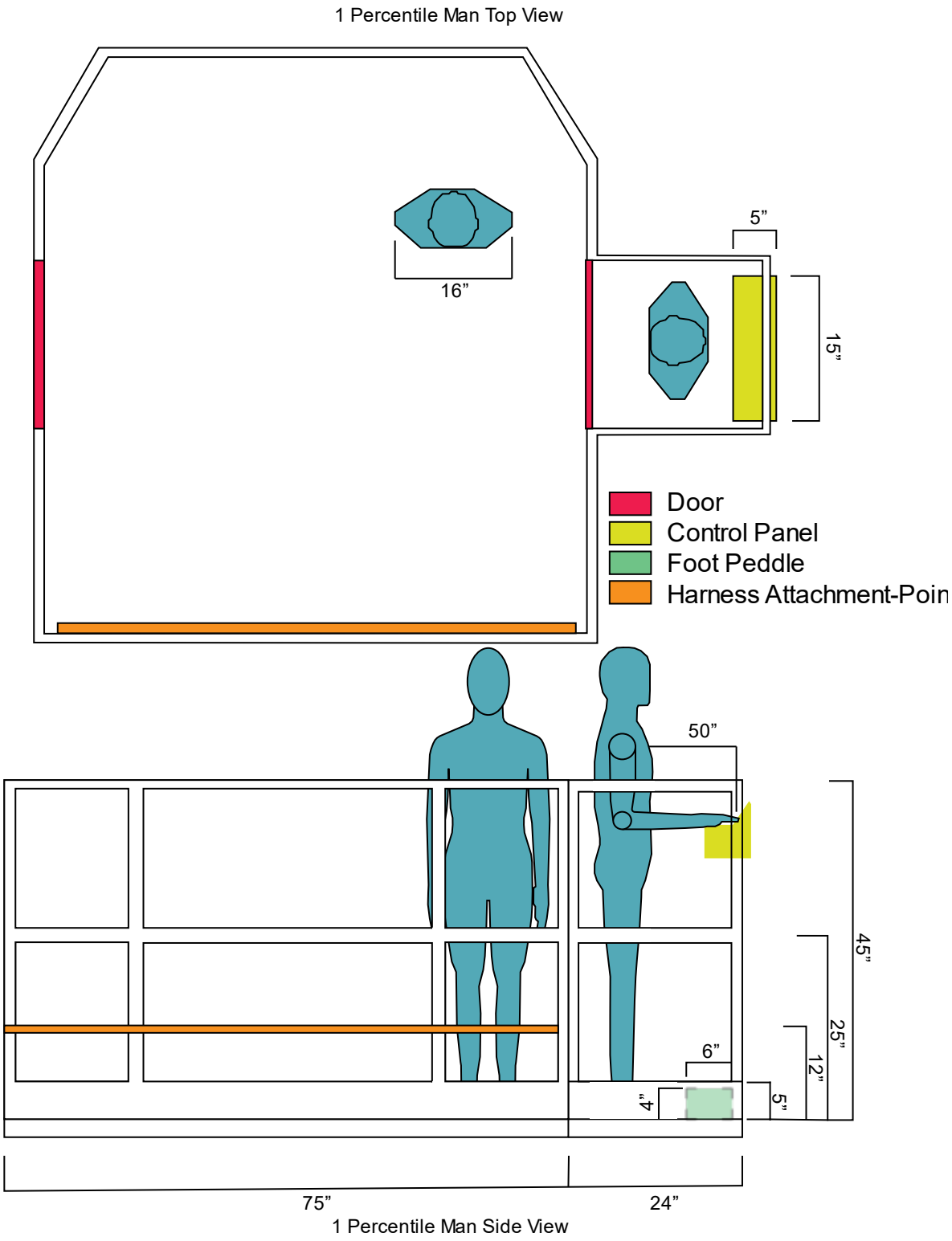
Raizex is a construction equipment that is used to work at any different heights while being the safest and comfortable as possible. By doing so, this helps with overall work experience and by minimizing any downtime.

5.2 Design Criteria Met

5.2.1 Ergonomics

In general, the Raizex is a better and more ergonomic solution for workers needing to work at any high altitude. Below is the final dimensioned layout for the Raizex that is suited for all primary and secondary users ranging from the 1st percentile male to the 95th percentile man.


1 Percentile Man Top View
20.6”
5”
15”
Door
Control Panel
Foot Peddle
Harness Attachment-Poin
63”
45”
25”
12”
6”
5”
4”
75”1 Percentile Man Side View
24”



There are other essential areas of the design that enhances the overall ergonomics experience for the user is the control center, with this being in its independent location it allows

more freedom for the workspaces as well as lower the controls to a more manageable height for all to use. It is not tucked away in a corner, and the harness attachment point has been raised off the ground a little and is extended from one side to another for more natural movement around the whole basket and avoiding any tangle harness lanyards.

5.2.2 Materials, Processes, & Technologies

Through this thesis project, the functionality of the design was given more importance than the overall manufacturing cost. Raizex would be mostly made of steel to ensure the most reliable lift capacity and the longest lifetime of the proposed design. Such components that would be made of steel would be the basket, the overall frame, and the risers that end uplifting the whole assembly. There will also be plated steel to enclose the hydraulic pumps for the outriggers to ensure their protection. The wheels are a twill base wheel that is made of rubber, thus allowing them to move on whatever surface freely. Plastic would be used on the housing of all the components under the basket, such as the motor, hydraulic tubing, and electronics.

The technology that would be in the Raizex would include the hybrid diesel engine that would power the entire lift and as well all the hydraulics that ensure the movement of the lift.

5.2.3 Manufacturing Cost Report

An estimated cost breakdown is listed down below.

Component Name	Component Cost	# of Component	Total Cost
Wheels	600	4	2400

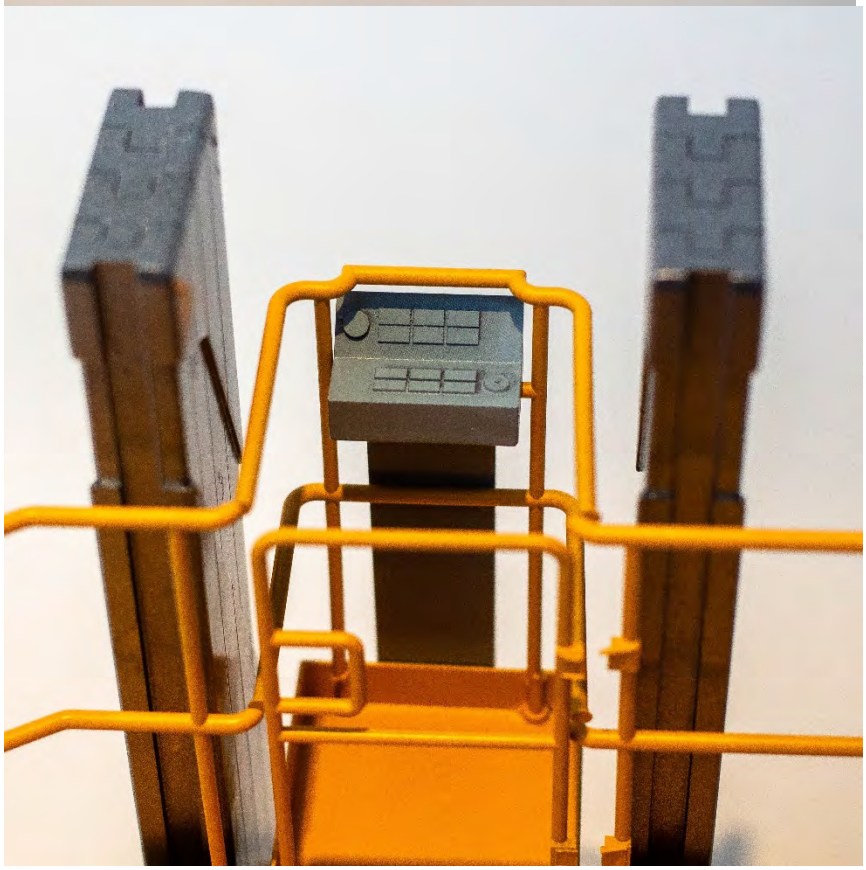
Outriggers	2,000	4	8,000
Storage Compartment	250	4	1000
Chassis	15,000	1	15000
Plastic Housing	5,000	1	5000
Basket	8,000	1	8000
Control Center	4000	1	4000
Controls	1000	1	1000
Door	50	2	100
Extenders (up/down)	1500	16	2400
Extenders (left/right)	1500	18	2700
Wheel mounts	500	4	2000
Diesel Engine	1000.00	1	10000
Electric Motor	2500	4	10000

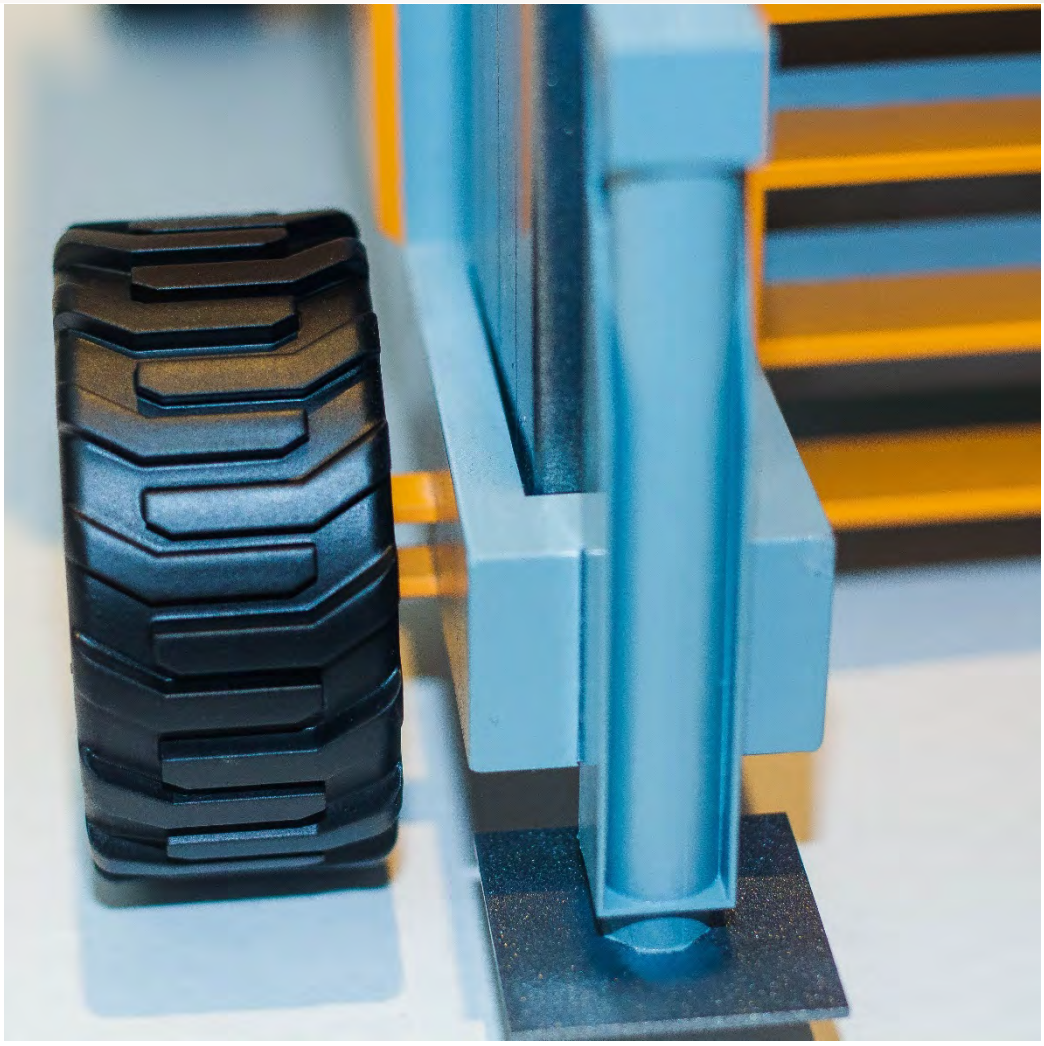
Batteries	6000	1	6000
Hydraulics (pump, tubing, cylinders)	5,000	-	5,000

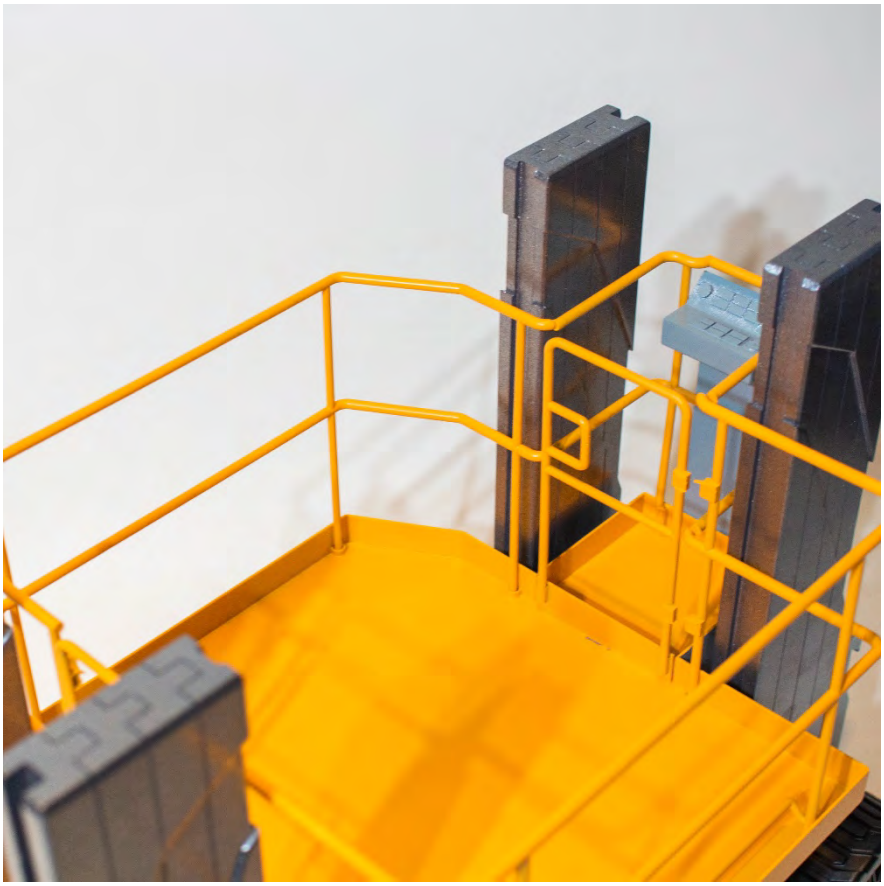
Disclaimer to the total cost of the proposed design, due to limited information on the construction of any lifts being disclosed, the price of the design could vary by a lot. With the total being $83,500, this is without any taxes or labor cost of assembling this all together.

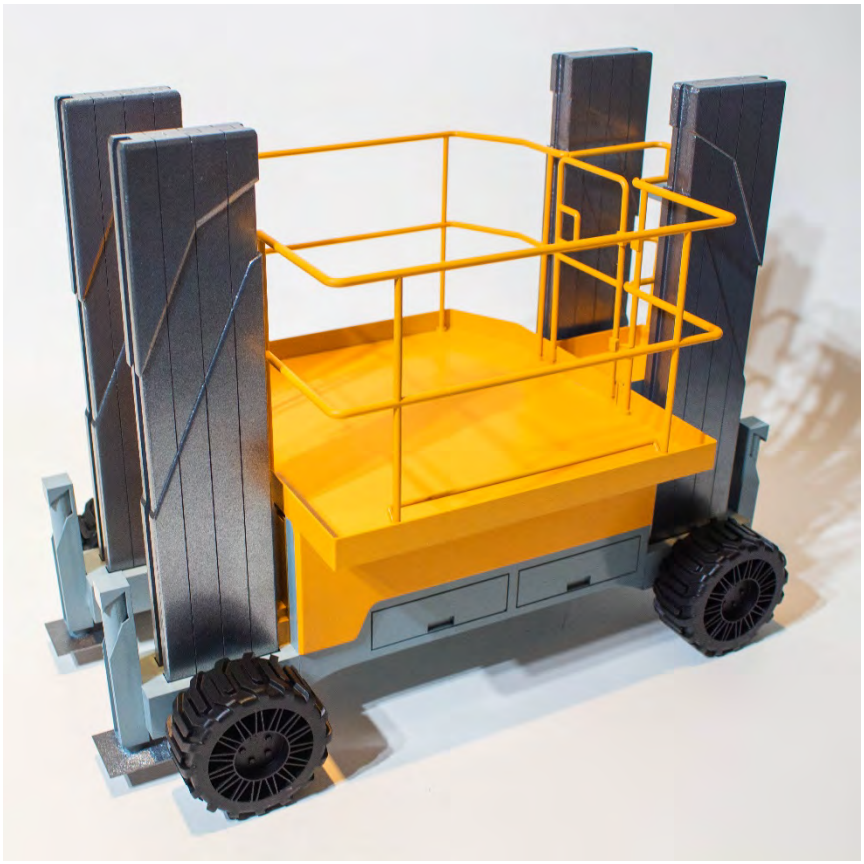
5.3 Final CAD Renderings

5.4 Hard Model Photographs

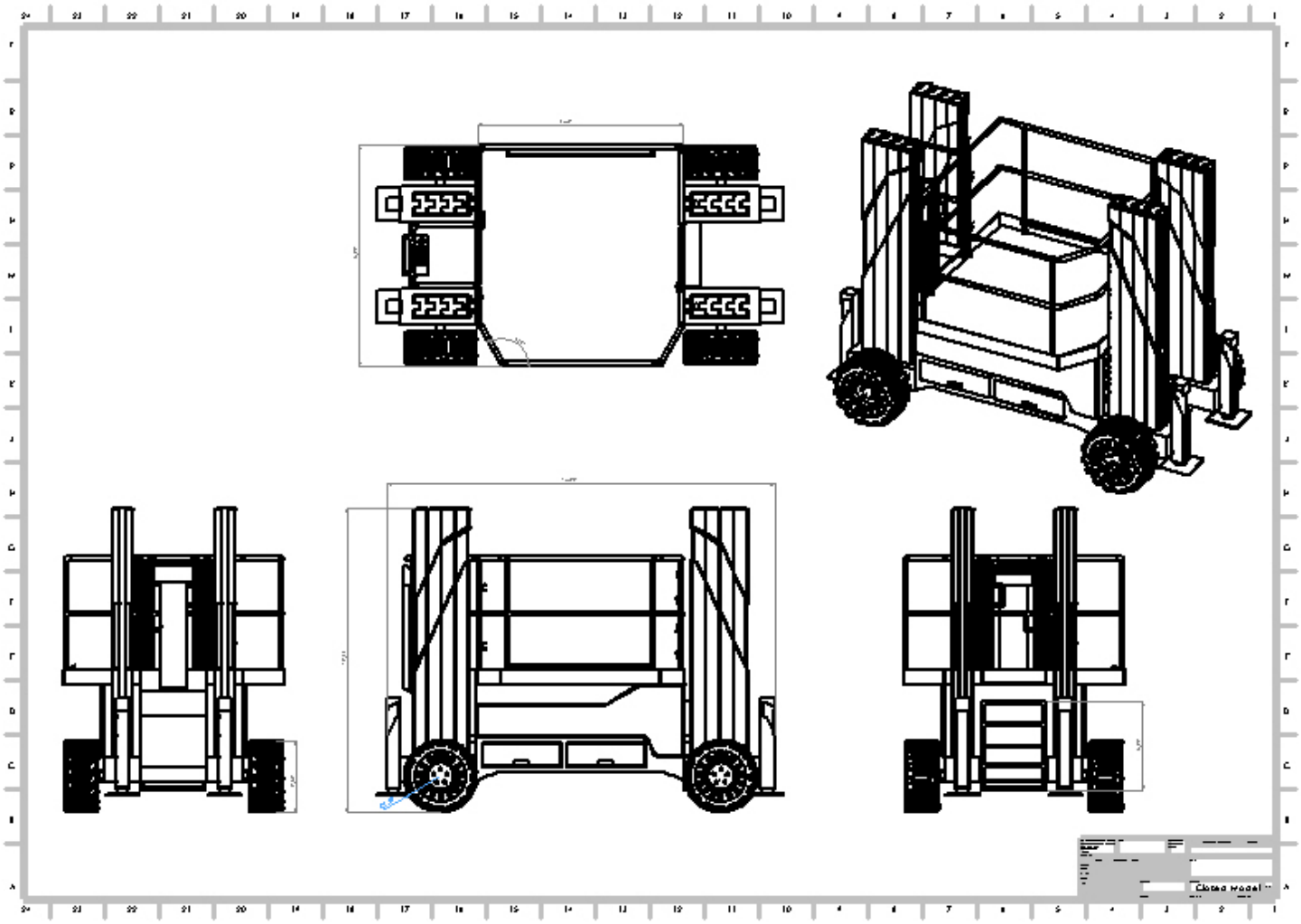








5.5 Technical Drawings



5.6 Sustainability

The final design will incorporate many sustainable aspects for the user's health, safety, and environment. Concerning the health of the user, the new model will have a more comfortable entrance for easier access to the basket. It would have a more ergonomically friendly control panel that is a comfortable position, a more natural reach for connecting the harness straps and padded floors for the duel system for the controls, and outriggers to level the of the machine on uneven grounds. Environmentally sustainable features would include highly recyclable metals such as steel. This would be working on a hybrid system for the batteries to move the entirety of

the machine and having an engine assisting the battery when needed such as to lift the basket up and down, and by driving the entire lift with independent electric motors in each wheel, with having the possibility of it being fully electric.

6 Conclusion

Raizex is an ergonomic lift that allows the users to freely move in the basket in an X-Y axis on a large surface. This improves the overall work experience with this specialized design, as well as giving the workers many different options for doing many different jobs on any job sites such as under bridges and sides of buildings.

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8 Appendices

Discovery

Literature Review

Summary of Statements-Literature 1

1. Majority of falls happen in a specific range of heights (10-20)
    a. 44-46% are from boom lifts
    b. 56-59% are from scissors lifts
2. 1991, the occupational safety and health administration (OSHA) reported that 34 fatal incidents involving 35 deaths from 1986-1992 related to bucket trucks. One-third was due to failure of equipment of the facility
3. From 1992-199 there were 339 deaths: an average of 42 a year: 51% due to falling off aerial platforms
4. Scissor lifts can reach between a height of 20 to 70 feet, reducing its stability as it gets higher
5. Extending a platform can lead to falls as well due to the small center of gravity the machine has, thus tipping it over

Summary Statements- Literature 2

1. There are many uses for an aerial lift to help in different locations. They can get to higher, more difficult areas that cannot be reached.

Interviews

Interview One

Findings/Evidence

Background

The first person I interviewed was my father, Jose Saul Ulloa. He works as a metal flashing installer on high-rises, townhouses, and everyday homes.

Date/Location/Method

I interviewed him on Sunday, October 6^{th,} at our house a few hours after he came back from work. He has been working in this industry for 25 years and has worked with many different boom lifts. The interview was recorded by audio-only.

Transcript

J= Jonathan S=Saul

J- Hi, how are you doing, how was your day?

S- I am doing well, tired from working.
J- Okay, I'll start with the first question. How would you prepare your day when working with any aerial lift?
S- First, I check the surrounding area of where I am going to be working. Then from there, I check the machine to see that it has been properly maintained from the last time I or someone else has used it. Usually, that consists of checking the motor, oil, and the hydraulic fluids on the machine and whether they must be changed.
J- What brand have you used most often, and why?
S- Usually, I don't choose the brand of lift, they are sent out by the company — however, the ones that we usually use or Genie and Skyjack.
J- How might the appearance of the lift affect the overall use of it?
S- Again, that goes back to see if there is any damage surrounding the machine. If so, I don't use it and call the rental company to bring me a new one.
J- How easy is the aerial lift able to maintain on/off the job?
S- I don't maintain the machine at all, which is usually left to the rental companies. As well, there are always safety inspections that happen every year, and that is represented as a sticker.
J- Where would the lift be stored when not in use? Are they in any position on the job site?
S- Usually, there is a designated area that is meant for the machines in a safe out of the way place. Depending on the job site, the basket may be set on the ground for storage, but the majority of the time, it is left up in the air to take up a smaller space and to stop people who aren't allowed to use it.
J- What are some of the restraints that you have while working in the lift?
S- One of the restraints that I must deal with is the Basket. I always must move the basket left and right in small increments. Thus, turning on and off the machine frequently to move me over a few feet to work
J- How does it feel to be up in the air on the lift mentally and physically?
S- I usually feel nervous when up in the air and trying to finish the job as fast as possible. When the job is done, I feel tired from standing up for a long period.
J- What are the ideal conditions to use any lift?
S- Sunny, no wind, and no rain. As well as the area surrounding the lift being flat level area, with no mud.
J- What is your average amount of time spent on the aerial lift? What would be the longest time spent on the machine for you?
S- Depending on the job, it ranges from one hour to 10, with breaks in between. The longest I've been up to would have to be 10 hours with small breaks here and there. During these breaks, I would either bring down the boom and eat lunch or take a cooler with me up on the lift and sit on that for a little bit.
J- What have been the most dangerous conditions you have used the lift in?
S- Usually, any time that I must work in windy or rainy conditions. Sometimes I must come down due to how fast the wind is blowing.
J- Where would you see improvements on the machine in use?

S- To have the ability to have the machine self-level when it is on the uneven ground since I waste a lot of time trying to level out the machines with either scrap wood or foam. Another thing that bothers me is some of the entrances to get in and out of the basket. Cause, on the one hand, the normal bar is inconvenient to use, always bending down to get in, yet I find it safer compared to the conventional door because sometimes the door can rust, and it is harder to lock it and could swing open when I am on it.
J- Thank you again for participating in my interview and giving up your time to do this with me.
S- No problem.

Interview Two

Background

The interviewee's name is Dmitry Sviridov; he is a boom lift operator for the construction company BIRD. I got in contact with him through a mutual participant. He has been this type of work for around 30 years.

Date/Location/Method

The date the "interview" was conducted was on Monday, October 7th. This was not much of an interview. Instead, it was consulted as a questionnaire due to the fact that he was busy with his job and preferred to do it this way. The questionnaire was given on Monday and picked up on Tuesday.

Transcript

J= Jonathan Ulloa D= Dmitry

J- How would you prepare your day when working with any aerial lift?

D- I always start with safety. That's my priority. I fill out a safety sheet/checklist. I make sure that the weather conditions are safe enough to use a lift, and that my surrounding area is safe as well.
J- What brand have you used most often, and why?
D- Sky-tech I've to use moist often. I've also used Genie. I used them because my company has contracts with them.
J- How might the appearance of the lift affect the overall use of it?
D- If the base is larger, it is much safer and more reliable to use. You are more flexible with it, and you can stretch it higher.
J- When selecting an aerial lift, what is the thought process behind a specific lift for a job?
D- I don't pick it myself, I use what is given to me by my company just if it fits safety requirements and the goal of the job.
J- How easy is the aerial lift able to maintain on/off the job?
D- It requires quite a bit of effort, as there are a lot of steps involved in the operation, but off the job site, it is easy to turn off and store.
J- Where would the lift be stored when not in use? Are they in any position on the job site?
D- It is stored at the job site in a safe place near the building in the lowest position.
J- What are some of the restraints that you have while working in the lift?
D- I always have a double lanyard harness on when working on the lift.

J- How does it feel to be up in the air on the lift mentally and physically?
D- Mentally- High stress because you must constantly be aware of your surroundings. I still experience stress and fright when working on the lift. Physically- you get tired faster because of the stress, I compare it to the peak of a rollercoaster, but you must work with the tools in your hands too.
J- What are the ideal conditions to use any lift?
D- No rain, partly cloudy avoiding direct sunlight.
J- What is your average amount of time spent on the aerial lift? What would be the longest time spent on the machine for you?
D- Usually, 2-3 hours. The most I have spent was 4 hours.
J- What have been the most dangerous conditions you have used the lift, and what was your reaction?
D- I used the lift at maximum height during high winds, and the lift started to swing severely. That gave me quite a scare, yet after a while, I got used to working in those conditions.
J- Where would you see improvements on the machine in use?
D- IF they could improve stability on the base of the lift, workers would be more comfortable and more productive while using the lift.

User Research

User Demographics

User Category	Description
Primary User	Construction Operator
Secondary User	Safety Instructor
Tertiary User	Mechanic

Findings.

Review Age: 21-30 Gender: Male Culture: Ethnicity- Hispanic Income: Middle Income (Inferred due to the amount of work the user must do.)	 Figure 1- Man on a scissor lift Retrieved from: https://www.chainsawjournal.com/wp-

Educational background: Unknown (due to the fact that he can be specialized or not) Motivation: To earn an income to pay taxes	content/uploads/2016/06/Genie-GS-1930-scissor-lift-aerial-lift-feature.jpg
Advertisement: Genie Age: 30-40 Gender: Male Culture: Ethnicity- Caucasian Income: Middle Income (Inferred due to the amount of work the user must do.) Educational background: Unknown (due to the fact that he can be specialized or not) Motivation: To earn an income to pay taxes	 Figure 2- Genie Product shot Retrieved from: https://www.genielift.com/images/default-source/product-images/articulated-boom-lift/z-62-40/z-6240_alt2.jpg?sfvrsn=58fedeab_13
Safety Age: 21-25 Gender: Male Culture: Ethnicity- Hispanic Income: Middle Income (Inferred due to the amount of work the user must do.) Educational background: Unknown (due to the fact that he can be specialized or not) Motivation: To earn an income to pay taxes	 Figure 3- METI Training pictures Retrieved from: http://www.metiatlantic.com/wp-content/uploads/2018/06/METI-0067-300x200-300x200.jpg

Seaspan Age: 25-50 Gender: Mixed Culture: Ethnicity-Mixed Income: Middle Income (Inferred due to the amount of work the user must do.) Educational background: Unknown (due to the fact that he can be specialized or not) Motivation: To earn an income to pay taxes	 Figure 4- Seaspan Award Retrieved from: https://www.itabc.ca/sites/default/files/success-story/20160218_134624.jpg

Gender

"96.7% of Construction laborers are Male, making them the more common gender in the occupation." (C 2017)

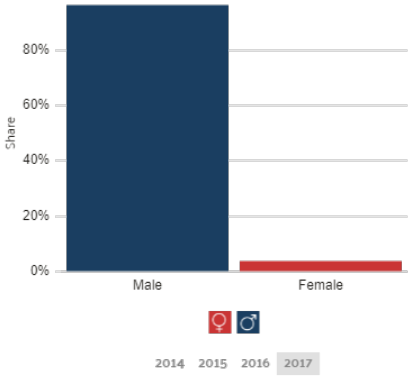
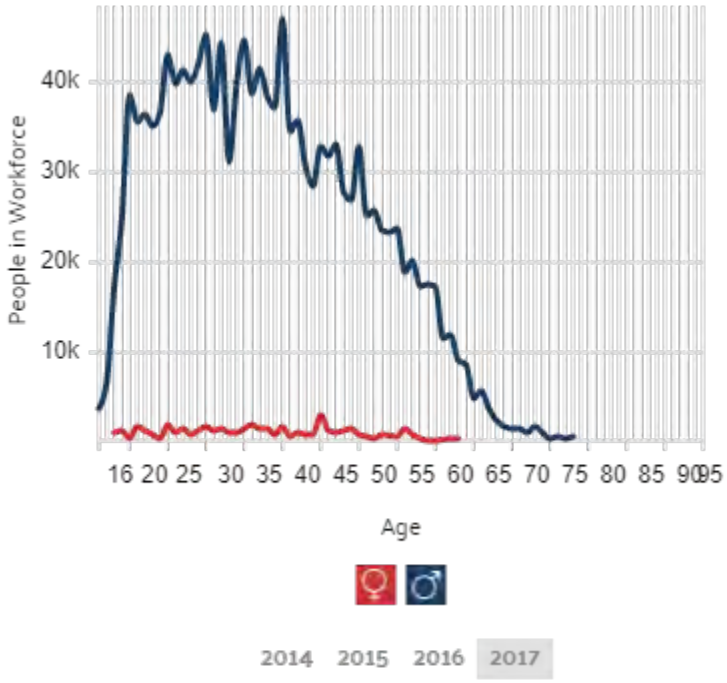


Table 1-Gender composition, US (C 2017)

Age by Gender

"The median age of Construction laborers is 38.2, and Male employees are generally 0.201 years younger than their Female counterparts." (CL 2017)



Gender	Average Age
Male	38.2
Female	38.4

Table 2- Age by Gender (CL 2017)

Ethnicity/Culture

"71.1% of Construction laborers are White, making that the most common race or ethnicity in the occupation. Representing 16.2% of Construction laborers, Other is the second most common race or ethnicity in this occupation." (CL 2017)

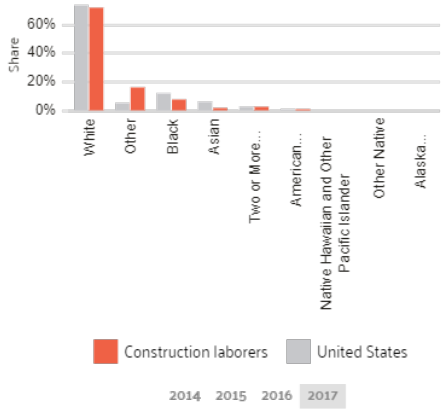
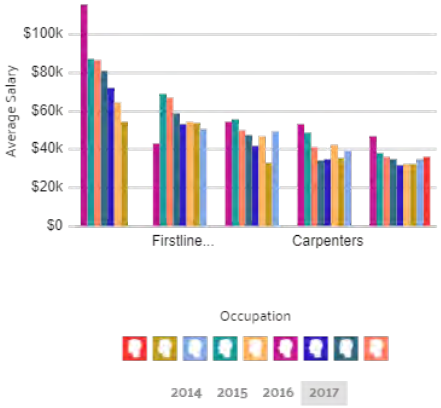


Table 3-Race & Ethnicity (CL 2017)

Education & Income

"On average, Asian employees in the Construction Industry Group earn 1.21 times more than other races and ethnicities. This chart shows the race and ethnicity-based wage disparities in the five most common occupations in the Construction Industry Group." (C 2017)



"On average, employees in the Construction Industry Group make $51,097 per year. This number makes Construction the 138 highest paying Industry Group in the United States out of a total of 266 Industry Groups." (C 2017)

Table 4-Wage by Race (C 2017)

The majority of the bachelor's Degrees that go into construction labor have a business degree. However, most people that end up in the construction field come from just having an education from high school.

Table 5- Education of Majors (CL 2017)

Summery

Primary User: Operator of Machine

Secondary User: Safety Instructor

Tertiary User: Mechanic

Demographic of Construction Workers		References
Age	21-45	https://datausa.io/profile/soc/472061
Gender	Mostly Male (~97%)	https://datausa.io/profile/soc/472061
Culture/Ethnicity	White	https://datausa.io/profile/soc/472061
Income	$51,097 is at the higher end	https://datausa.io/profile/naics/23
Education Background	Post 2ndary or Bachelors	https://datausa.io/profile/soc/472061

Overall, US construction works tend to younger, male, and white, with having an average level of income.

Age: Majority <45

Income: Minimal Income

Education: Bachelor's Degree or High School Diploma.

User Behavior

Method

Search Engine: Google

Keywords Used in Search:

Construction Worker Demographic

Construction Worker Market Research

Literature Search results:

Worsfold, S., & Simon. (2019, September 12). TSheets Data Reveals Longer Days, Hiring Squeeze for Construction Workers. Retrieved from https://blog.tsheets.com/2017/business-help/construction-industry-data

Zemeckis, J. (2018). Being A Construction Worker - The Good, The Bad, And the Ugly. Retrieved from https://www.streetdirectory.com/travel_guide/190856/careers_and_job_hunting/being_a_construction_worker___the_good_the_bad_and_the_ugly.html

Findings

Frequency

"So far, in 2017, TSheets' data shows that construction workers are working, on average, 39.6 hours a week. This is an increase of more than one hour per employee per week compared to 2015 when the average was 38.4 hours. In 2016, the average was 39.2 hours a week per employee." (Worsfold &Simon, 2019)

"69,000 construction workers across the US worked almost 50 hours" (Worsfold &Simon, 2019)

Working five days a week

Duration

Roughly working 40 hours a week.

Social and Solitary

“What I enjoyed most was seeing new buildings and meeting new people every day of the week.” (Zemeckis)

“men were stepping through an unseen hole on a roof and falling twenty feet to a concrete slab below. I've watched men get their fingers caught in machinery and almost ripped off. I've sliced open my own skin dozens of times. I've had to drive myself to an emergency room twice.” (Zemeckis)

Discussion

Use Behavior		**Comments**
Frequency	5 Days a week	
Duration	40 hrs. a week	Depending on if there is no overtime
Social or Solitary Activity	Mixed	
Level of focus/exertion	High	
Location	Construction Site	

Table 6- User Behavior

User Profile

Demographics		Use Behavior		Personality		Cognitive aspect	
Age	**21-45**	**Frequency of use**	**Five days a week**	**‘locus of control.’**	↑	**Technical Skill**	↑
Gender	**Male**	**Duration**	**40 hrs.**	**Self-efficacy**	↑	**Pre-req. content knowledge**	↑
Culture / Ethnicity	**White**	**Social/Solitary**	**Mixed**	**Changeability**	**---**		
Income	**$55000**	**Level of Focus**	**High**	**Uncertainty Avoidance**	**---**		
Educational Background	**High School**	**Location**	**Construct-ion Sites**				

Demographics:

Overall, the Canadian/US construction worker is a Caucasian male from the average age of 21-45, even going up into their 50s.

User Behaviors:

The user behavior of construction workers who do their job daily would work up to 40 hours a week for five days. This depends if or if not, they must work overtime or even the time restrictions on the job site itself. The construction worker also must be able to pay attention to their surroundings due to there being many dangers on a busy site.

Persona

Name: John Doe

Age: 40

Job: Beam Worker

Education: High School

Relationship: Wife and 9-year-old son

Location Toronto, ON

Main Job: Installing Metal Beams

Frequency: Five days a week

Duration: 40 hours a week

Social/solitary: With Co-workers and clients

Profile:

Figure 5 construction worker working at the construction site using lifting boom machinery Retrieved September 24, 2019, from https://www.shutterstock.com/video/clip-16402942-construction-worker-working-site-using-lifting-boom

John Doe is a 40-year old Caucasian individual who works as a beam installer for many different job sites. The highest education that he has gotten was from high school; however, he has also got lots of training in safety and understanding how to properly handle big machinery on a job site. John has married to his wife for 25 years.

He has taken this job since he has finished high school and has moved up in the company many different times, each increasing in pay and benefits.

User Behavior:

John enjoys spending his weekend with his family relaxing and recuperating from all the work he has done on the job site. He keeps a good relationship with his co-workers as well as understanding that they are there to help him, and he is the5re to help them, as well as trying not to get into arguments with different types of workers using the same equipment.

Relationship

John has high respect for what he and others do on any given job site. This is because he understands the need and awareness and the dangers of working where he does. Having respect for all the equipment he must use and keeping them well maintained for no failure to happen. Daily he always must put a harness on and use either a boom lift or aerial work platform to reach areas that are not accessible from a ladder or scaffolding. He understands this is the only means of doing so, and it could be dangerous at times.

User Observation

Target User:

The primary user of the machine is the worker operating the aerial lift. This is because they are the ones who are in contact with the machine the moment that the device is turned on and utilizing it to its fullest extent. This would be the primary subject in the observation. The secondary user is mechanics who would have to fix any issues that come up with the machine when they get damaged or parts are worn out.

User Environment:

The location of the observational study happened at the townhouse complex that was at its final stages of being built. The day that the observation happened was on Sunday due to safety concerns with the participant, myself, and others around because, during regular business days, the area has a high amounts of traffic from many different people trying to complete their jobs on time moving in and out of the complex. There was a mix of many different terrains, such as normal asphalt, to heavily mudded areas in different parts of the complex. A key factor that day was chosen was due to weather with low amounts of wind that day.

Preliminary Video Observation

Preliminary Scoping:

Initial scoping of the user in and around the machines happened with trying to see different videos online to get an understanding of some key areas that I can see or not see during these videos. There were a lot of videos from many different manufacturers of aerial lifts showing off their machines, such companies as Genie, JLG, and Dino lifts. These helped identify the benchmark products by seeing what is available and offered by other companies. In one instance, one of these videos made by Genie was a walk around one of their boom lifts and all the features it has (Genielnd, 2016). Another of these Company videos was from Dino Lifts by showing how a worker prepares with their machine (DinoLiftOy, 2019). A few videos were showing some accidents involving aerial lifts and what happens when they are not used properly. One such video showed two people being flung out of a boom lift as it tips over on its side (Safety trebubg online, 2019). This is one of the scarier parts of working with these huge machines that reach up to great heights.

Video Observation

The video that was used for observation was made by Dino lifts (DinoLiftOy, 2019). This video demonstrates how their machine can be used from unloading it off to a truck and into the field wherein this instance is cutting overhanging branches off trees.

Activity Mapping for Video

Key Activity 1. The worker setting up the lift

This shows how the worker can get in the boom lift as well as to where he must put his harness for fall protection. This is an area of interest because not all boom lifts have a similar means of entry, such as this boom. As well seeing that the user has put the harness in a specific location for his safety.

Key Activity 2. Moving the lift

It is easily seen that he controls this particular boom lift, and the layout of each different movement the boom has. As well as seeing how operator moves the basket while driving to get through various areas and thus creating different blind spots for him.

Key Activity 3. Setting up Outriggers

One of the most important steps is to ensure that the machine is on a leveled surface before operating. Yet, in this instance, it is a solo operator, he must get out of the basket and then go back in after adequately setting up this outrigger.

Key Activity 4. Working

While working in the air, this boom has a lot of movement in the air, yet the worker must extend himself to get the task completed.

Direct User Observation

Chronology

Step 1: Turning Machine on		The operator turns on the machine from control panel from the ground and re-positions basket for entry
Step 2: Getting in		Entering the basket in this instance requires the operator to bend in an uncomfortable way while holding the bar with his back
Step 3: Fall Arrest Point		Connecting himself to the basket using a lanyard for safety measures

Step 4: Getting into position		Begins to operate the machine to position himself to work -Foot on a pedal on the floor always to move the boom
Step 5: Working		Brings himself within one foot from edge to do work Varies in length depending on the job
Step 6: Bringing basket down		Once the job is done starts to move basket back to the ground to get out

Step 7: Getting out		Again, awkward position to get out of the basket acting like a slide going feet first Has a chance to hit the head-on bar that goes up and down

Product Research

Features and Benefits

Benefit #1: Reaching Heights

A product that Affords: Ladder

Featherlite aluminum extension ladder 24 Feet grade I

Price: CDN$ 310.00 & FREE Shipping.

Product Description

This Featherlite 24-foot aluminum extension ladder has a 250 lb. load capacity, rated Grade I. This ladder features outside slide guides, D-shape rungs fully serrated for a slip resistant surface, mar resistant rail end caps, rope and pulley, and swivel safety shoes to be used as tread down or in spike position. The Featherlite FL-2120-24 aluminum extension ladder meets or exceeds the safety standards set by ANSI, CSA, and OSHA.

D-Shaped Rungs
Mar-Resistant Rail End Caps
Swivel Safety Shoes
Rope and Pulley Included
Packaged Weight (In lbs.) 37

- **Specifications**

Brand Name	Featherlite
Colour	Silver
EAN	1000101595
Material Type	aluminum
Model Number	FL-2120-24

Benefits	Features
Tread down or in spiked position for feet	24-foot long
Sturdy Aluminum	250 lb. capacity for the ladder
Ease of use	D-shaped rings
Stability	Swivel Safety shoes
Lightweight	Rope and pulley system
	ANSI, CSA, and OSHA approved

Men's Pro Endurance HD 8 " Composite Toe Composite Plate Boots

https://www.marks.com/en/timberland-pro-mens-pro-endurance-hd-8-composite-toe-composite-plate-boots-103175.html#103175%5Bcolor%5D=DRKBRN&103175%5Bwidth%5D=WID

Price: Cad$279.99

Product Description

- From Timberland PRO, these Endurance HD eight-inch boots have CSA Grade 1 composite toes and plates. The waterproof leather boots also feature all-weather outsoles for protection on outdoor work sites. Antimicrobial linings stay fresh and lightweight insulation keeps your feet warm and comfortable. When you spend long hours on your feet, you'll appreciate the insoles in these boots which are built using anti-fatigue technology.
- WATERPROOF FULL GRAIN LEATHER UPPER
- TOE GUARD
- ANTIMICROBIAL MESH LINING
- THERMOLITE® INSULATION, 200 GR
- PU INSOLE WITH ANTI-FATIGUE TECHNOLOGY
- PU MIDSOLE
- ALL-WEATHER TPU OUTSOLE
- 8" SHAFT HEIGHT
- SAFETY FIRST
- CSA Grade 1 composite toe, composite plate. Puncture resistant
- LACE-UP STYLE

Benefits	Features
Keeps feet warm and comfortable	Composite toes and plates
Protects from outdoor worksites	Waterproof leather
Anti-Fatigue Technology	All-weather TPU outsole
	CSA Grade 1 puncture resistant

Summary: Benefit #2

Product:	**Steel toe Shoe**	
Linking Benefit:	***Comfort of worker***	
Needs – *long term*	**Needs- *short term***	**Benefits**
Comfort	soft	Pads to stand on for a long period of time so they don't get tired
Safety		Hard protection on an area that is delicate

Statement of Need *(comfort only)*

An area where the worker feels comfortable

Specific needs to be considered include:

- Comfort of the worker
- Safety of the worker
- Ease of use

Combined Statement of Need for Benefit #1 and #2

Statement of Need (*Height and comfort)*

A tool where it keeps in mind the safety and comfort of the worker as well gives the ability to go to high elevations to complete tasks

Specific needs include:

- ease of use and control
- comfort and safety for the worker
- Control of product in specific areas

Fundamental Human Needs

Linking the product benefits with fundamental human needs will utilize two models: Maslow's 'Hierarchy of Human Needs,' and 'Fundamental Human Needs' (according to the school of "Human Scale Development" and Manfred Max-Need).

The 'Fundamental Human Needs' is like Maslow's model, but with some important additional categories. For example, in the 'leisure' category, one has 'games, parties.' Games are fun and often highly addictive.

Below is a table summarizing these categories.

Need	Being *(qualities)*	Having *(things)*	Doing *(actions)*	Interacting *(settings)*
subsistence	physical and mental health	food, shelter, work	feed, clothe, rest, work	living environment, social setting
protection	care, **adaptability**, **autonomy**	social security, health systems, **work**	co-operate, **plan, take care of,** help	social environment, dwelling
affection	respect, sense of humor, generosity, sensuality	friendships, family, relationships with nature	share, take care of, make love, express emotions	privacy, intimate spaces of togetherness
understanding	critical capacity, **curiosity,** intuition	literature, teachers, policies, educational	analyze, study, meditate, investigate,	schools, families, universities, communities,
participation	receptiveness, dedication, sense of humor	responsibilities, duties, work, rights	cooperate, dissent, express opinions	associations, parties, churches, neighborhoods
leisure	imagination, tranquility, **spontaneity**	**games, parties,** peace of mind	daydream, remember, relax, have fun	landscapes, intimate spaces, places to be alone
creation	**imagination,** boldness, **inventiveness, curiosity**	abilities, skills, work, techniques	**invent, build, design, work, compose,** interpret	spaces for expression, workshops, audiences
identity	sense of belonging, self-esteem, consistency	language, religions, work, customs, values, norms	get to know oneself, grow, commit oneself	places one belongs to, everyday settings
freedom	autonomy, passion, self-esteem, open-mindedness	equal rights	dissent, choose, **run risks,** develop awareness	anywhere

Common benefits and the correlating fundamental human need

Commonly cited product benefits are the following: ***easy, efficient, convenient, comfort***
These are related to **control over one's environment**. Correlating needs are (Max-Need model):

Protection: **autonomy**, adaptability, work, planning, take care of
Freedom: **autonomy**, self-esteem

Another group of benefits is **experiential,** e.g., ***exciting, stimulating, exhilarating***
These are related to experiences. Correlating needs are (Max-Need model) are:

Leisure: **spontaneity,** games, have fun, imagination
Freedom: **autonomy**, self-esteem, risk-taking

Beauty and style are important categories not specifically addressed by either the Maslow or Max-Need models. "Beauty is the quality of being pleasing, especially to look at, or someone or something that gives great pleasure, especially when looking at it." *Wikipedia.* What is pleasing is either innate or culturally derived.

For purposes of this exercise of associating benefits with fundamental human needs, **style and beauty** will be associated with the term **aesthetics** or higher-order activities such as **self-fulfillment** and **creativity**.

Benefits and Corresponding Fundamental Human Needs

The fundamental human needs corresponding to the product benefits *(reference Product Research REPORT)* was determined and displayed in the table below. The relative strength of the relationship (strong/moderate/weak) was also indicated.

Table: Benefits and Corresponding Fundamental Human Needs

Aerial Work platform

	Benefit	***Possible Corresponding Fundamental Human Needs (FHN)***	***Relationship between Benefits and FHN***
1	Comfort	Creating a safer way of going up and down using aerial platforms	Strong
2	Style	Suitable for high abuse and damage on a job site	Moderate
3	Efficiency	Ease of mobility from one location to another regardless of the terrain	Strong
4	Ease	Using when there is either heavy equipment on-off, getting in and out	Strong

Comfort in this context enables the worker to be relaxed while going up and down the aerial lift and giving them a sense of security and not the feeling that they are in any immediate danger.

The style in this context is not as crucial regarding the type of machines that are used daily. Yet having this product look and feel robust gives the feeling to the worker of security.

Efficiency is defined as the effort required to perform at a level. This is necessary for the worker to use this product with the confidence that he/she will use this tool to its effect.

Ease in this context, is related to efficiency as well as how easy it is to train the works to use and for the works to remember all the steps required to do so.

Statement of Need

Aerial work platforms are a tool that can help any construction worker reach many new heights yet has it challenges and mastery to do so.

Control and **mastery** of the device is related to the performance of the machine (**effectiveness, ease** and **comfort)**.

Benchmarking- Features and Benefits

Method

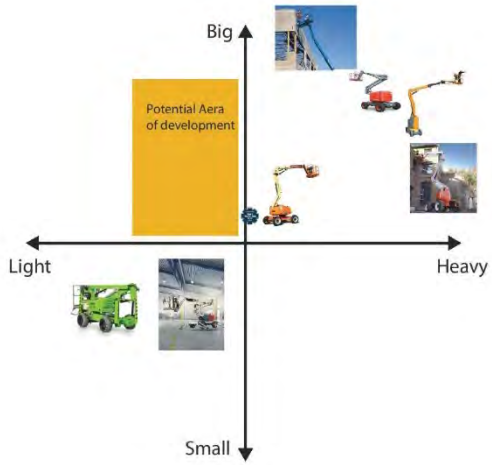
The selection of 7 different aerial lifts to be compared was based on each manufacturer that produces aerial lifts.

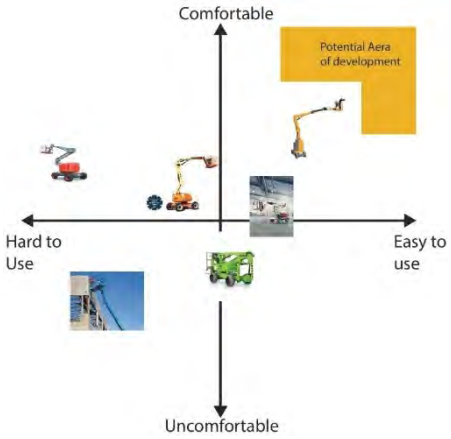
Aerial Lifts			
1	Genie S-40	5	NIFTY LIFT SD34T 4X4
2	JLG 340AJ	6	DINOLIFT DINO 280RXT
3	SKYJACK SJ46 AJ	7	MEC 45-AJ
4	HAULOTTE HA32 CJ		

These lifts were chosen given that they each are from their own company, that there would be no repeating features and benefits. As well all these companies are competitors towards each other, which helps to clearly identify what areas are key for them.

Table 4 More information in Appendix 1

Aerial Lift Name	**Width and Length**	**Weight**	**Max Horizontal Reach**	**Max Height**	**Engine Type**	**Cost (USD)**
Genie S-40	7ft 6in X 24ft 3in	12,310 lbs.	31ft 8in	46ft	Diesel	$66,950
JLG 340AJ	6ft 4in X 18ft 2in	9,700 lbs.	19ft 11in	33ft	Diesel	$64,899
SKYJACK SJ46 AJ	90in X 20ft 10in	13,300 lbs.	24ft 9in	52ft 3in	Diesel	$68,600
HAULOTTE HA32 CJ	3ft 11in X 17ft 7in	15,578 lbs.	23ft 2in	37ft 9in	Electric	u/a
NIFTYLIFT SD34T 4X4	5ft 1in X 12ft 10in	4980 lbs.	20ft	42ft	Bi-Energy	$39,900
DINOLIFT DINO 280RXT	7ft X 19ft	10595 lbs.	52ft	91ft	Diesel	u/a
SNORKEL A46JRT	7ft X 19ft	16622 lbs.	24ft	53ft	Diesel	$65,900





Benchmarking- Comparing Features and Benefits

Method

The following section will discuss and break down the features of each of these products by placing them in the X – Y graph. Images of the comparable items will be placed on the graph, and from there, a pattern would emerge and an opportunity for advancement as well.

X-Y Graphs

Conclusion

Upon finishing the two X-Y graphs that reflect on the overall size and weight of the machine, it shows that there is a potential area of improvement where the device can be lighter and can reach higher heights. This can be an area where can be expanded upon with the use of different materials and different techniques to utilize the height. As well it shows that the market is mostly towards the bigger, more massive machines that allow you to have a greater reach in any direction.

In the second X-Y graph it shows the comfort-ease of use of the different boom lift controls that are in each basket. This is important to ensure the worker does not strain themselves while operating the machine as well as to how easy it is to get the hang of using the tool, especially if it is their first time using it. After doing the graph, the controls tend to run in the hard to use but semi-comfortable, with potential improvements with ergonomics of the authorities and having a clear layout to understand what each button or switch does in a transparent manner.

Benchmarking- Key Benefits

Method

To gain a better understanding of the overall benefits and features that are needed the seven products were investigated to source key information from the marketing text. Benefits and features were gathered in a chart, shorted and sorted alphabetically. This was done to understand what the customers are most interested in.

Evidence

Benefits		
1	Movement	10
2	Automation	8

3	Ease of Use	5
4	Improved Working	5
5	Environmentally Friendly	2

Features		
1	Engine	9
2	Weight	5
3	Materials	3
4	Cost	3
5	Noise	2

Needs Analysis

Organizing Data

The following will show three key activities from the observation of the aerial lift worker as well as organize the data from above in a simple manner.

Activity 1 Getting in/out

Getting in and out of the boom can be awkward especially if it does not have a door. Due to the top bar being reliable, the only way is to lift the middle bar all the way to the top and go under it, creating an awkward position and could cause pain if getting in and out frequently.

Activity 2 Moving Boom

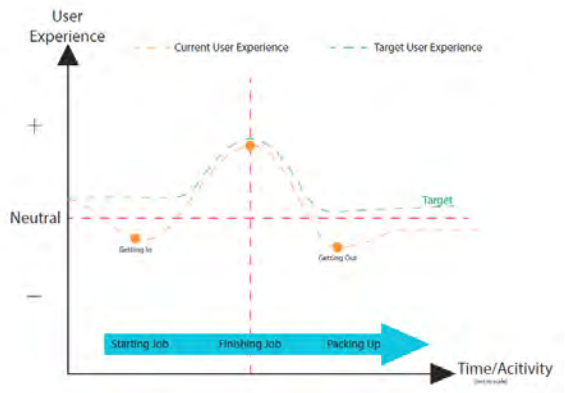
Controlling the boom can be hard due to all the different movements that the boom can do. One area of interest is that the operator must have his foot on a pedal to move the machine at all. Once his foot leaves the pedal, the boom no longer moves in any direction.

Activity 3 Working on the boom

While working on the boom, there was always a minimal distance between the basket of the boom and the working surface. This is because he does not want to get closer to the edge in fear of damaging what he is working on.

User Experience

User Experience Map



Potential User Experience Improvement

Key Activities	Steps	Base User Experience	Potential Improvement
Starting Job	Preparing all the tools needed Making sure all material is required and loaded safely Turn on machine Safety Harness	Many safety processions taken in the beginning as well as to get in the basket may be difficult	Easier to get in Quick and easy way to secure material Checklist of safety
Finishing Job	Going up/down the boom safely	The time it takes for the boom to move	Faster depending on the environment
Getting out	Getting out of the basket Cleaning up any mess in the basket Turing off Boom	Stressing a body to get out of the basket Cleaning Ensuring everything is fine before leaving	Easier to get out A quick way to clean A quick way to shut off

Cad Model

Cad model can be found in 5.3

Hard Model

Hard Model can be found in 5.4

Technical Drawings

Technical Drawings can be found in 5.5

Sustainability Report

Introduction:

This report was done to have a better understanding of what the current market has and how those current products are sustainable through the different processes of Materials and manufacturing as well as having a good idea of what these processes will have to the safety and health for the user and the environment while each of the products is in use. With that given information, the ideal usages would be used for the thesis solution.

Sustainability

Benchmarked Products

Materials & Manufacturing

The type of material that usually is used for manufacturing these machines tend to be made from steel for the arms of the booms and the lifting mechanism for scissor lifts. The housing for the engine is made with a plastic for ease of access when there need to be any repairs done to the engine. The batteries are located at the bottom with a swing mechanism for easy access for reparability. The reasoning that most of the boom is made from steel is because of how durable the booms must be when they are in use in many different conditions. Each of the parts is painted with urethane to help the steel beams last longer.

Sustainability:

Boom lifts today are made to last a long period of time. This is done with the help of how easy it is to access areas that may need maintenance, such as the engine, batteries, and hydraulic fluids. With this being the case, it helps to reduce the number of unwanted booms that would otherwise be thrown out or destroyed.

One of the critical factors that contribute the boom lift function is the engine. The engine is typically either Diesel, Electric, or a hybrid of both. Each of these options has its pros and cons of being used. In the industry today, the most common engine type is a hybrid of both.

The issues with diesel fuel are the carbon waste that they produce when running the boom. This is one of the significant problems that affect the boom lifts because the engine is always turning on and off any time the boom needs to be moved on the ground or just moving the arm in any different location. However, this is one of the most common means of the engine due to its power and ability to do multiple jobs at once from moving the boom on the ground, moving the hydraulic fluids for the arms.

Batteries are another type of engine that is mainly used for indoor use only due to the no emission of any toxic fumes. With this, the batteries have a set amount of charge until they need to be replaced, and if not disposed of properly can cause significant effects to the environment

later. Another disadvantage of using the battery is needed to charge the boom. If the batteries are not fully charged or need a bit more power, you could have the possibility of not having the boom working at its full potential.

Safety, Health & Environment

Safety:

In the industry of construction, safety is of the most importantance for everyone working in the construction field. As well the environment the user is in is ever-changing from day to day. If the user cannot utilize the machine to its fullest potential, then there can be some safety concerns.

Many safety measures are put into place when dealing with these types of machines such as a harness attach point, so that the users may attach themselves to the basket if in any case, they are thrown out of the basket, they do not fall to the ground. Another safety feature is the control panel. If the worker were to bump into the controls, they could jostle the lift by moving the arm or the whole base. If this were to happen for instance, on a boom lift and hit a bump in the ground an elevation difference of two inches on the floor is equivalent to four feet in the air. Some of the safety procedures that are in place right now is a two-step process where the user must place their foot on a pedal on the floor and hold down certain buttons to move the boom.

Another safety feature that was implemented was the ability to level out the boom so that the body is perfectly 90 degrees so there cannot be any tip-overs.

Health:

The user of the equipment is working at high altitudes and must face different wind speeds depending on the weather. This can cause different fluctuations in temperatures depending on the wind. This can affect the overall work the user is doing by trying to be out in the air. It includes also working in a “standing position regularly can cause sore feet, swelling of the legs, varicose veins, general muscular fatigue, low back pain, stiffness in the neck and shoulders, and other health problems” (Canadian Centre for Occupational Health, 2020).

Environment:

The environment that the aerial lift would be used is on different construction sites. These sites tend to have various ground conditions such as mud and concrete. This affects the overall use of the machines, as well as with the many different elevations on the ground level that can affect the machine, meaning if they can use it in certain areas or not. These machines are used in every weather condition and stored outside, meaning that they must be resilient in all weather type of many diffractions in the change in temperature.

Final Design:

The final design of this thesis project is a human center designed aerial lift that utilizes key ergonomic and safety features to enhance the overall work experience for the worker. The final design will incorporate many sustainable aspects for the user’s health, safety, and environment. Concerning the health of the user, the new design will have a more comfortable

entrance for easier access to the basket, a more ergonomically friendly control panel that is in a comfortable position, and an easier reach for connecting the harness straps and padded floors for added comfort. For the safety, it will include all the modern safety amenities including, auto shut off, duel system for the controls, and outriggers to level the of the machine on uneven grounds. Environmentally sustainable features would include highly recyclable metals such as aluminum and steel. The project would be working on a hybrid system for the batteries to move the entirety of the machine and having an engine to assist the battery when needed to lift the basket up and down, with having the possibility to be fully electronic.

Conclusion:

The research and development of sustainability have been talked about through this chapter. Regarding the initial benchmarked products by the way they are made and how they affect the environment. The process goes into the overall aspect of the safety, health, and environment that this machine does to the users and the surrounding environment. Finally, then implementing all these findings into the final design.

Topic Approval Form

Humber Institute of Technology & Advanced Learning
School of Applied Technology
Bachelor of Applied Technology – Industrial Design
Winter 2020
iDSN 4502 Senior Level Thesis Project II
Dennis L. Kappen/Catherine Chong/Sandro Zaccolo

THESIS DESIGN APPROVAL FORM

NAME
Jonathan Ulloa

TOPIC TITLE (Brand)

Aerial 1.5t

PS: Ensure that the visualization of the final design, side views and front views in Illustrator or Photoshop are required to be shown to us for securing an approval

Thesis design is approved to proceed for the following:

✓ **CAD Design Phase**

✓ **Rapid Prototyping and model building phase**

COMMENTS: -ADD A FEW DETAILS - A FEW SMALL CURVES TO ADD SOME AESTHETIC ELEMENTS
- RAPID PROTOTYPING - APPROVAL FOR RP.

Signed

Catherine Chong / Dennis L. Kappen

Topic Specific Data, papers, publications

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Jonathan Ulloa

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **3 September, 2019**