Elk Ridge Ski Area: Poma Lift Stick

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Progress Report
Document

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Table of Contents

Sections

Figures

1.0 Introduction

The Elk Ridge Ski and Outdoor Recreation Area, located in Williams, AZ is in need of a new Poma lift stick that accommodates both skiers and snowboards equally. Our clients, Tammy Fountain and Jim Gratton, have requested that a senior capstone team from NAU help develop a new design to make the lift equally accessible for skiers and snowboarders.

The current Poma lift stick design consists of a straight pole attached to a spring mechanism which clamps onto the lift cable when removed from the pole storage area. The end of the pole is curved slightly to ensure ease of boarding and dismount. It also has a small round disc to support the riders' weight while being transported up the lift line. This is convenient for skiers whose feet are separated, but very inconvenient for snowboarders whose feet are both strapped down together. A picture of the current Poma stick can be found in Figure 1.

1.1 Needs Statement and Goal

Based on our initial conversations with our clients, the following needs statement was developed:

> "The current Poma lift stick does not accommodate skiers and snowboarders with equal support and comfort."

From this need statement, a project goal was determined. The goal of the project is to design a transportation device that provides skiers and snowboarders with equal amounts of support and comfort. To limit this goal to attainable standards, we defined the scope of the goal to be designing a device that bares equal percentages of the weight of skiers and snowboarders. Within this range, the device will also accommodate all sizes and shapes of people.

1.2 Objectives and Requirements

The objectives for this project are based on the needs and problems of our client. The chosen design must be flexible enough to accommodate people of all heights, weights, and ages because winter mountain sports attract a wide variety of people. Other main necessities of this project include: maintaining contact with the ground, obstacle clearance, and easy dismount.

Based on the above objectives, the following requirements were defined:

- The cost to manufacture the new device must cost less than the price of a new Poma lift stick purchased from Poma.
- It must take less than thirty seconds to board or dismount the lift.
- The new device must have an attachment configuration that has the exact same size and dimensions as the current attachment configuration.
- There can be zero millimeters between the bottom of a rider's ski or snowboard and the packed snow.
- The new devices must be able to vary in height by 0.5 meters to traverse obstacles under the snow (rocks, branches, etc.).
- There must be 1.5 meters of head clearance measured vertical from where a rider's weight is carried.
- The device must be able to hold a 180 kg person without deforming more than 5 mm.
- The material must have a life of at least 40 years under all loads and weather environments.

2.0 Final Design

2.1 Proposed Design

The proposed Poma stick design consists of a flattened out "U" shape connected at a 120^{o} angle to a 2.2 meter straight section which is then attached to the lift line. This length was chosen because it positions the rider at a relatively neutral distance from the ground. This means the lift assembly will be able to accommodate a wide range of riders. The "U" portion has a flat plate in the center which provides comfort for both snowboarders and skiers. This plate will allow skiers to lean back for lower back support while snowboarders lean on their hip. This outer tubing assembly will be attached to the current Poma inner pole assembly. The spring attachment system will also remain the same and can be seen in Appendix B.

In addition, this design utilizes a roller bearing mechanism to rotate the "U" portion 180^{o}. Figure 1 shows a 3D computer model of the final design.

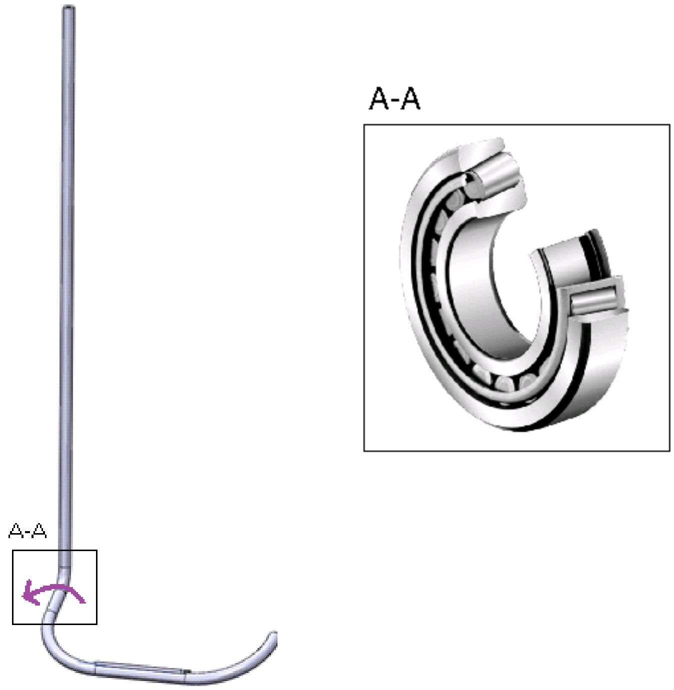


Figure 1 – Final Design

The location of the roller bearing shown above allows the design to more comfortably accommodate snowboarders of different riding orientations or riders with different dominant hands. Figure 2 shows the dimensions of the proposed design.

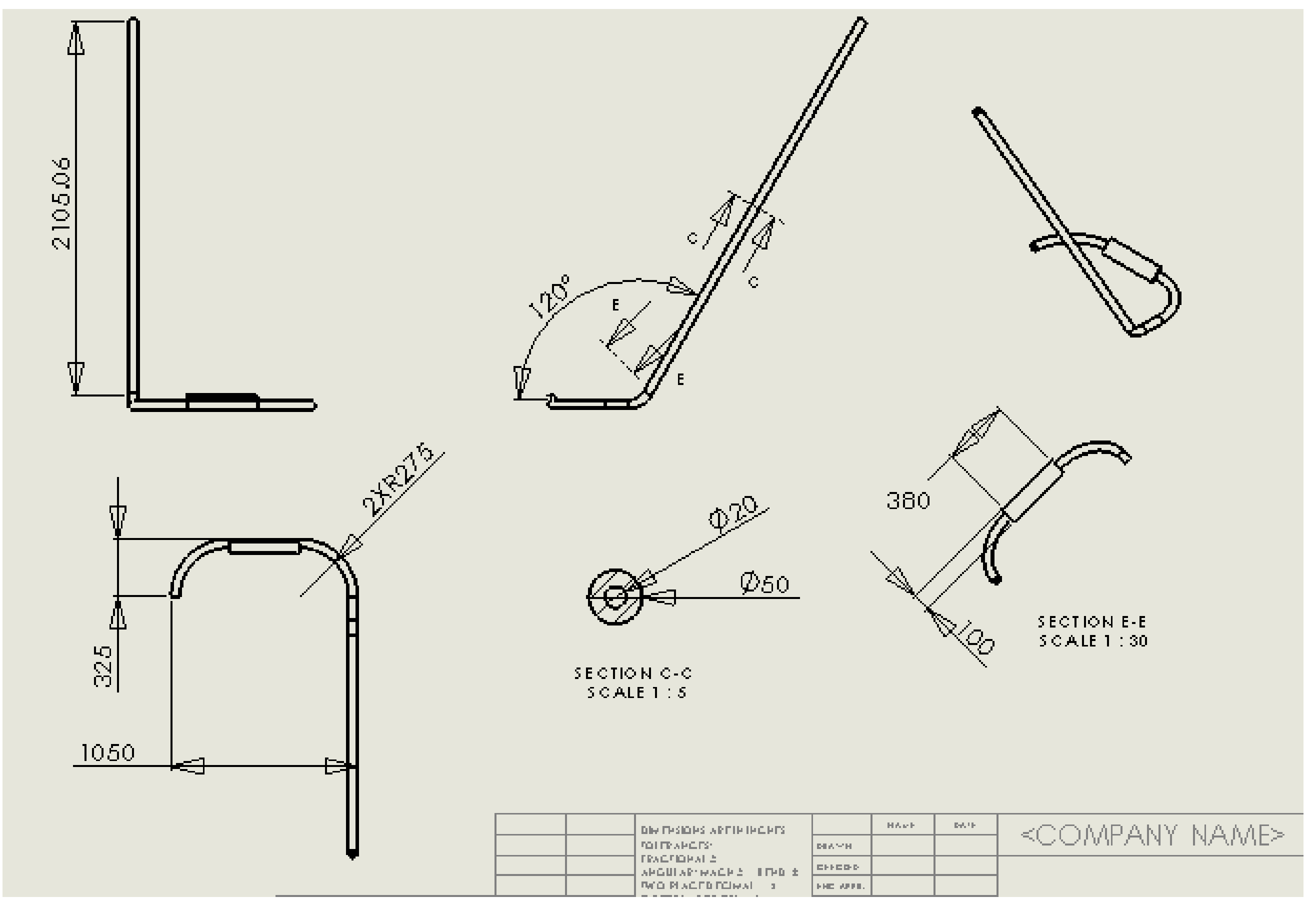


Figure 2 – Proposed Design Drawings

The pole is to be made of two continuous pieces of AISI 1030 Steel tubing. The first piece will have a 2.2 meter straight section with a 120^{o} bend at the end. At the end of this first section, a smaller pole will be press fit inside the section. This will allow a bearing to sit inside the two part assembly. The second piece will be approximately four feet long and will have two rounded bends that create the flattened "U" shape portion. The two sections will be fastened together with a spring loaded pin to limit the rotation to 180^{o}. Depending on the limitations of our machine shop, the intention is to bend the steel tubing rather than weld the pieces together. When the two main sections are created, a steel plate will be welded to the "U" portion at a 45 angle to allow riders to comfortably lean back on the pole. Cushioning with weather protection may be added to this plate to improve comfort.

2.2 Modifications

During further research into the needed components and specifications for the roller bearing assembly, several problems were encountered. The first problem was that a bearing small enough to fit inside the assembly and still withstand the stresses on the system was very difficult to find. Suitable bearings were also very expensive and had very small inner diameters which required a step down in the inner pole size that the stress concentrations were very high. Another cause for concern was the extreme weather conditions that the design will be in and the maintenance required by the proposed design. Due to the extreme cold and freezing conditions, there was a large concern of water getting inside the assembly and freezing which would cause cracking and stop the design from working safely. Gaskets were researched to reduce this possibility but most gaskets were not designed to withstand objects rotating against them regularly. A cotter pin design was considered as an alternative but the stresses induced on the pin would also have been too high for the required factors of safety. Due to these concerns, the rotating portion of this assembly was eliminated and a stationary pole design was developed. This reduces the number of moving parts within the assembly, thus reducing the risk of potential failure. Fixing the bottom of the assembly also eliminates one of the stress concentrations that the team had originally designed for.

This decision also led to the reinstatement of a handle within our design. This handle will be fixed approximately half a meter above the "U" portion and will provide added stability. The hope is that it can be placed in a position where it will be utilized by children and adults alike. The handle will be a simple straight bar so that there is less likeliness of clothing getting caught on the handle and causing people to become stuck on the lift.

The final modifications made were a change in material from AISI 1030 steel to AISI 1020 steel and a reduction in dimensions. The material change was made to enable the team to perform computerized stress modeling calculations. It is also a slightly lighter material that is easier to work with while still providing good factors of safety. The reduction in dimensions was a change in the diameters of the assembly. After careful measurement of the current Poma, it was decided to reduce the diameters to those of the current Poma. This also reduces the weight which helps reduce cost and any added stresses. Figure 3 below shows the modified design.

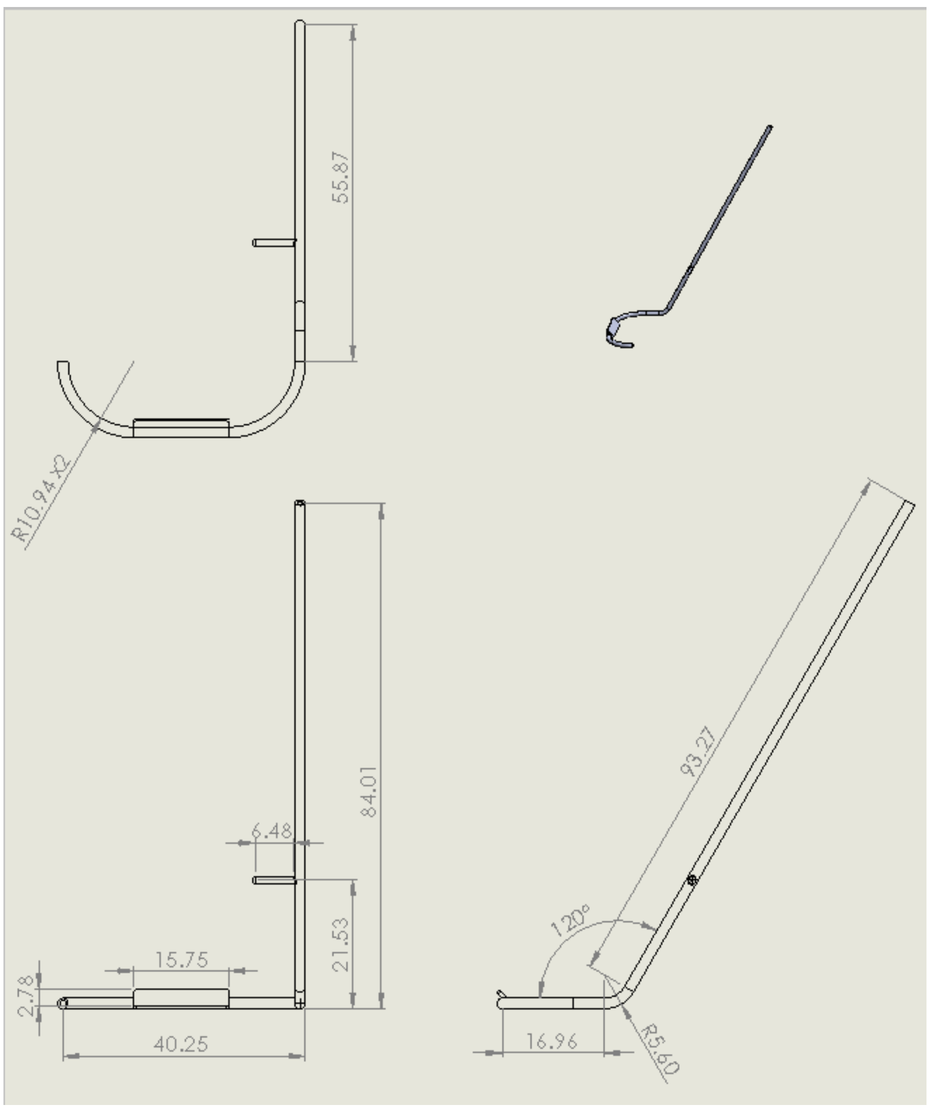


Figure 3- Modified Design Drawings

3.0 Continued Research

3.1 Material Selection

When researching suitable materials to use for our design, affordability, yield strength, and weather resistance were considered. AISI 1030 was the steel used in the initial analysis. From this steel factors of safety were found to be more than adequate. Although this particular material would work well in the given application, it was found to be rather expensive. The next step was to find a steel with similar material properties at a reduced cost. This was found in the form of ASTM A53 Schedule 40 steel piping. This Schedule 40 steel was found to have a yield strength (205 MPa) that will allow it to resist deformation in the given application. Another advantage to using Schedule 40 steel is that it is readily available for purchase at almost any local hardware/home improvement store. AISI 1030 steel on the other hand is sold per ton and typically comes in either solid round bars or in sheet metal form. We also considered Schedule 80 stainless steel, but it proved to be too thick and therefore too heavy for the design. Upon further investigation, it was found that ASTM A53 Schedule 40 piping was priced between $5 & $10 per linear foot. This equates to roughly $50-$100 for raw materials for this project. This figure is well within our monetary constraints and leaves room for fabrication costs.

It should be noted that while our pipe diameters are defined in SI units, it is very likely that the pipe bought for this project will be measured in English units. Measures will be taken to buy pipe that is close to our original specifications.

The team has also researched places where this piping material can be purchased. After speaking with the NAU machine shop manager Perry Wood and a local mechanic, we have determined a few places, locally and within the region, where the materials may be purchased. These places are Mayorga Steel and Page Steel. Caste Metal is a national supplier.

3.2 Inner Pole Disassembly

In order to be able to reuse the current inner pole assembly, the team needs to disassemble a current Poma stick. This will also help in the understanding of the inner spring assembly that allows the inner pole to extend away from the outer pole. Also, the attachments of the components must be examined. There is lubrication of the inner pole to ensure that it maintains its ability to extend. The lubrication that has been in the current Poma stick has proven efficient over the years and therefore the team will keep the same lubricant. The main component that will have to be examined is how the inner pole attaches to the outer pole. An exploded view of the pole assembly can be seen in Figure 3.

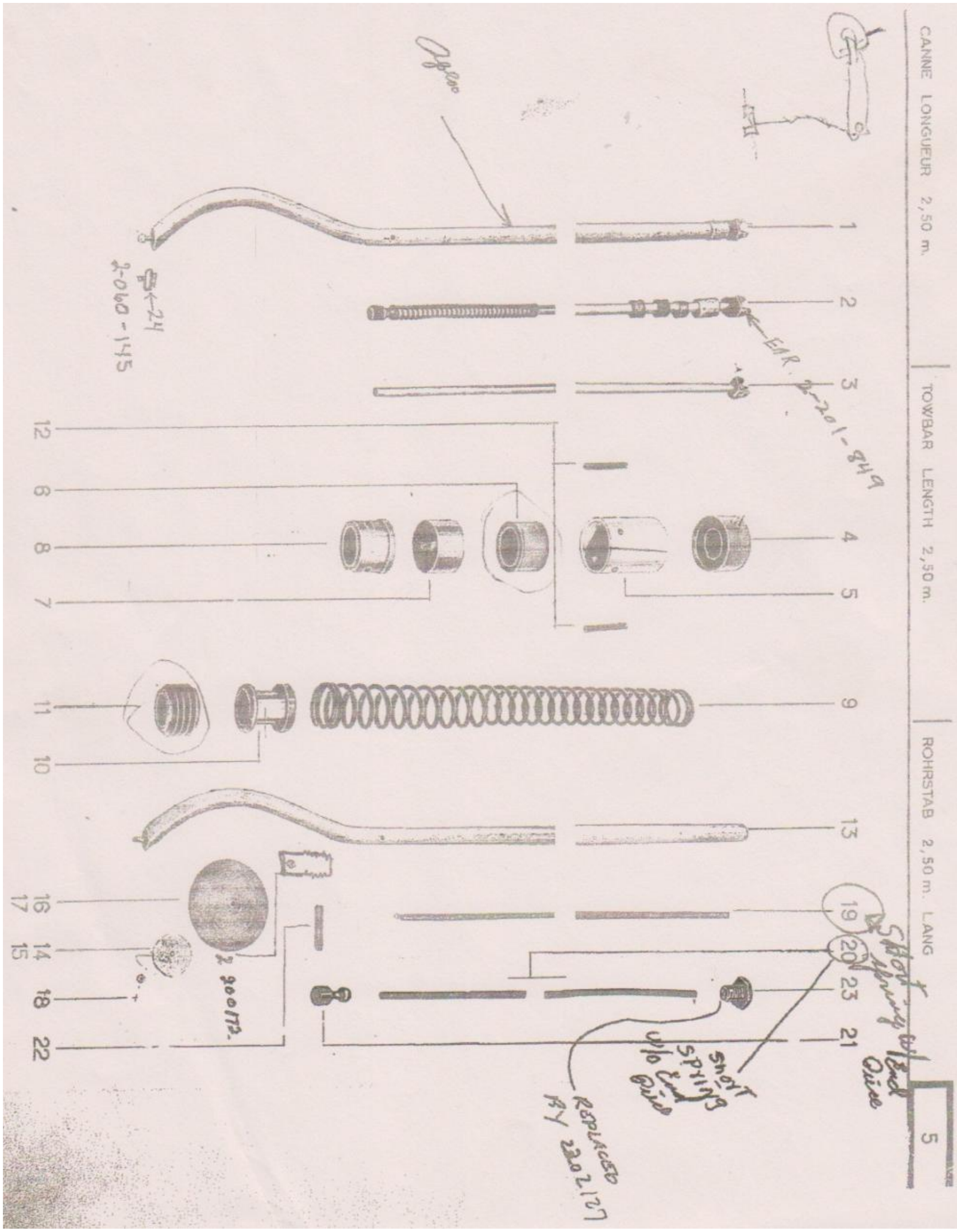


Figure 4- Current Pole Assembly

4.0 Prototyping

After material selection, the next step is to manufacture this prototype. We have spoken with our NAU machine shop as well as made contact with a local manufacturing company in town. The machine shop on campus said that although it is possible to bend the piping in the way it is designed, they do not have the necessary machinery to be able to produce this product. The machine shop did express that best process that was discussed was to bend the 90^o angles first and then the 120^o angle. We have made contact with Scott of American Spring located in East Flagstaff. He has expressed interest in our project and is willing to help with material purchase and fabrication. The process of attaching the newly design outer pole to the inner pole and spring will be determined after the team has disassembled the current Poma and evaluate the best approach.

5.0 Testing

5.1 Shop Testing

Advanced finite element modeling was conducted in SolidWorks showed that the maximum design load was significantly below the material limits. In addition, a large factor of safety was determined using a conservative analysis. Based on these calculations, it was determined that minimal shop testing is needed.

The main test needed to be done in the machine shop is to apply a reasonable load to the prototype to make sure the fabrication doesn't significantly weaken the structure. The dimensions of the prototype limit the resolution of testing that can be done. Without large machinery, it is difficult to get an accurate estimate of the loads applied and resulting deformations. The intended method of testing is to secure the outer pole assembly using weighted blocks and standing walls. A known weight will then be applied to the point where the resultant force of a rider would fall. This weight will also be applied to the areas that the pole has been machined (i.e. the bends/critical points). The known weights will likely be generated by human body forces and/or large metal objects found in the shop.

The theoretical fixed point of the analysis done is the top of the outer pole assembly. However, in practice, the true fixed point of the design is the top of the inner pole and spring assembly that attaches to the lift line. To ensure that the added weight of the new design will not reduce the safety of the assembly, the upper spring assembly will also be mechanically tested.

5.2 On Site Testing

Once the shop tests are completed and no further anticipated design alterations are required, the prototype will be taken to Elk Ridge Ski area for on-site testing. The prototype will be tested on the current Poma lift system. This will be achieved by attaching the prototype to the Poma lift line and using riders of different weights and heights. The feasibility of its use for very small riders will be tested while stationary to ensure the safety of the young rider. Riders will be questioned about the comfort of the design and its ease of use to determine if any small modifications may improve the design.

6.0 Conclusion

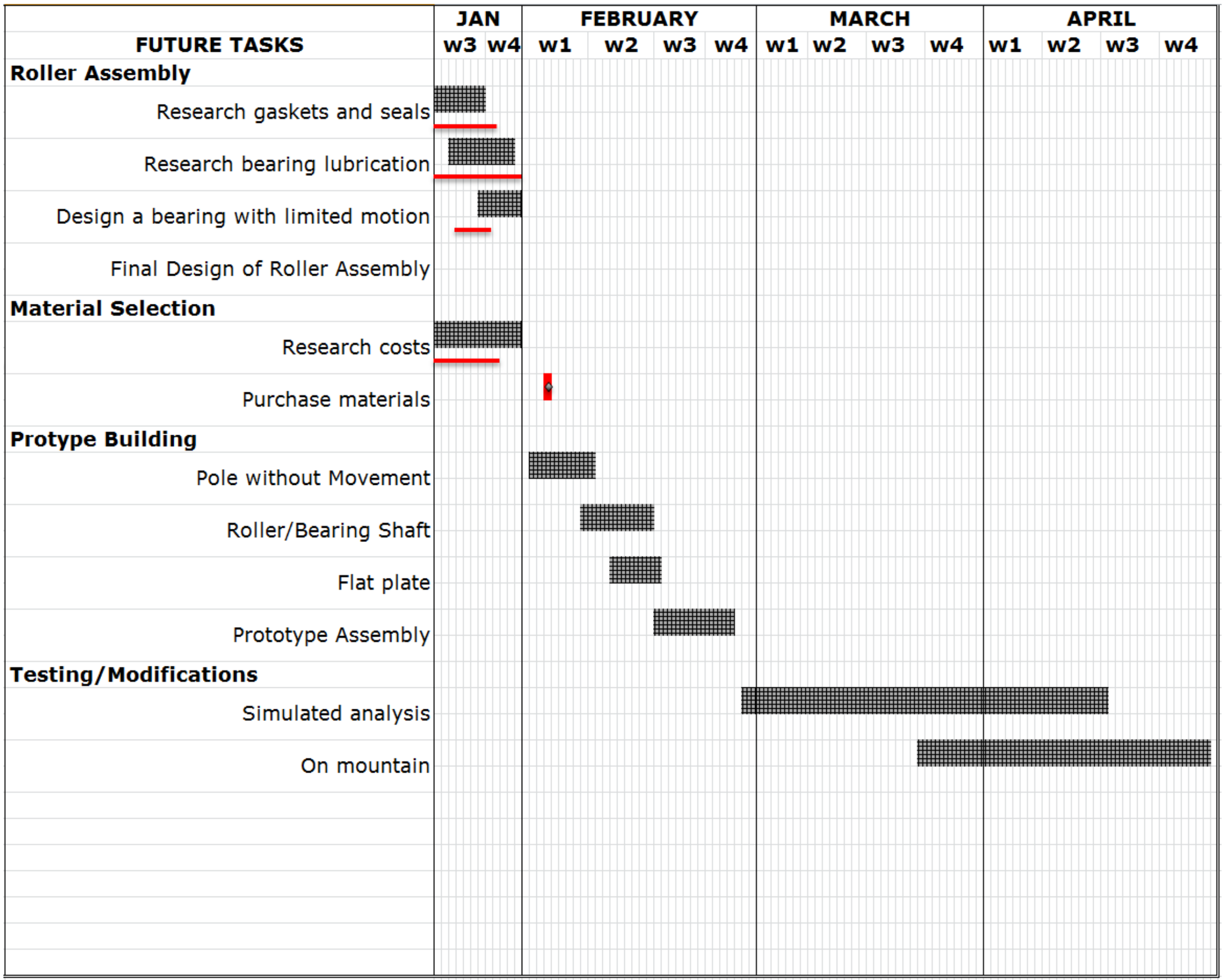
The proposed design included a pole with a “U” shaped bend that had a roller bearing to allow for 180^{o} rotation. After bearing research and considering weather conditions, it was decided that the reduction of moving parts is the best design to meet a lasting lifespan of the material. The next step in the project is to select the most appropriate material for the design and disassemble the inner pole assembly. The team has studied the assembly drawings for the inner pole assembly and will be in the shop next week to take apart the inner pole so it can be used in the newly designed outer pole. The team has researched and has selected Schedule 40 piping for the material. This material will be purchased once the design modifications have been finalized within the next couple of weeks. This is different from the previous material selection, but still meets the engineering analysis and requirements. The prototype will be manufactured locally in town due to machinery restrictions of the NAU Machine Shop. The deadline for the fabrication of the prototype is March 1. Due to large calculated factors of safety, minimal shop testing is required. The main testing will occur on site at Elk Ridge Ski Area. The testing will be on the current Poma Lift system with a variety of riders. The riders will be asked to provide feedback which will help with any adjustments needed to improve the design.

References

Heartsill, Vaughn. Personal Communication. 24 January 2013.

Wood, Perry. Personal Communication. 28 January 2013.

Appendix A: Gantt Chart



Appendix B: Current Poma