Construction of Frame and Roof

Once the needed materials were purchased, the frame was ready to be built. It was agreed upon to first construct the frame because this is essentially the base of the design. The measurements of the frame were taken from the schematic in Figure 7-3 and reduced by 1/5 to provide the dimensions for our scaled down frame. Our frame was approximately 5 feet long, 1.6 feet high, and 1.7 feet width. Steel square tubing at 1.2 inches per side was used to construct the frame. These pieces were cut and welded together to form the frame. The process of constructing the frame was as follows: 1) Cut the pieces into the desired lengths, 2) Weld the pieces together, and 3) Grind the welds to create a smooth surface. Figures 8-1 through 8-3 show this process.

Figure 8-1: Welding the Frame Together

Figure 8-2: Grinding the Welds

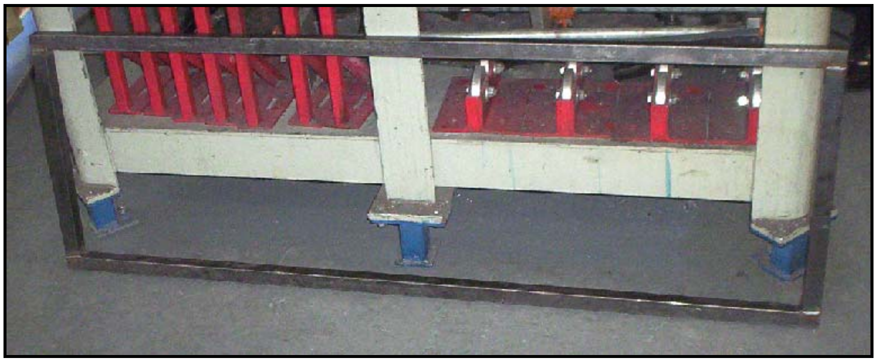

Figure 8-3: One of the Completed Sides of the Frame

Once the frame was completed, the roof of the simulator was our next project. The dimensions of the roof were taken from the schematic in Figure 7-3 and scaled down just as the frame was. The dimensions of the roof are 5 feet long, 1.5 feet high and 0.25 inches thick. The most important dimension of the roof is the weight, which is actually 500 pounds, so for our scale model it will need to be 100 pounds. The material of the actual roof could not be used because it is a special composite that Lockheed Martin has specially designed. Our first idea was steel, but the problem with using steel is that it has a lower density than the composite material used. A piece of black iron steel at the dimensions needed was only 50 pounds. Since the weight is our main concern, we decided to double the thickness of the roof to 0.5 inches so it weighed 100 pounds. We originally purchased a piece of black iron steel at quarter thickness, so all we did was buy an exact replica and welded the two pieces together. This gave us a roof that was 1.5 high, 5 feet long and 0.5 inches thick, but with a weight of approximately 100 pounds. The actual roof is connected the main trailer support beam by a hinge. We looked into several different types of hinges and settled on simple door hinges. We welded 4 door hinges to the frame and to the roof to connect the two pieces. Figure 8-4 shows a picture of the final roof and frame structure.

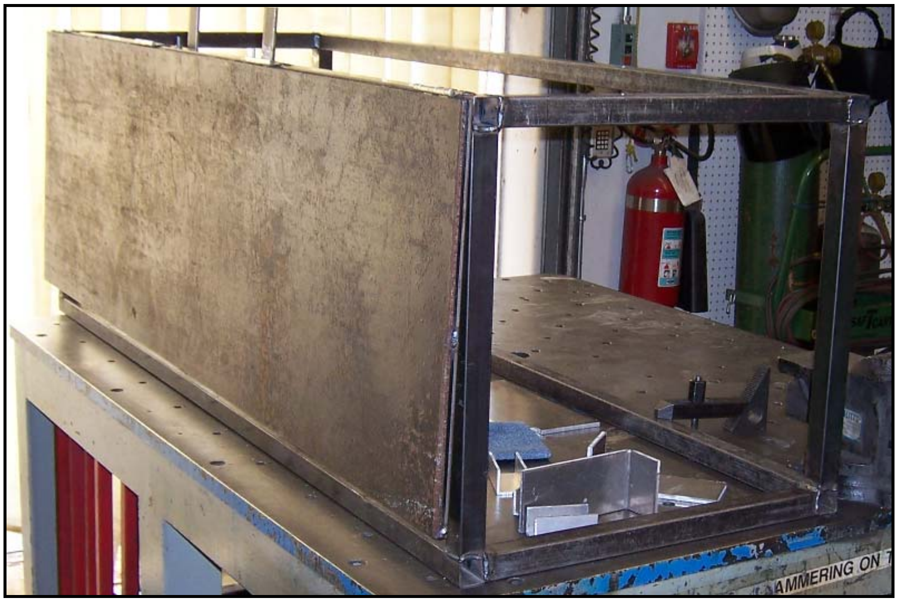

Figure 8-4: Frame and Roof Structure

8.2 Pneumatic Cylinder

The pneumatic cylinder was purchased from McMaster Carr. Figure 8-5 shows a picture of the pneumatic cylinder and Figure 8-6 shows a schematic of it.


Figure 8-5: Pneumatic Cylinder

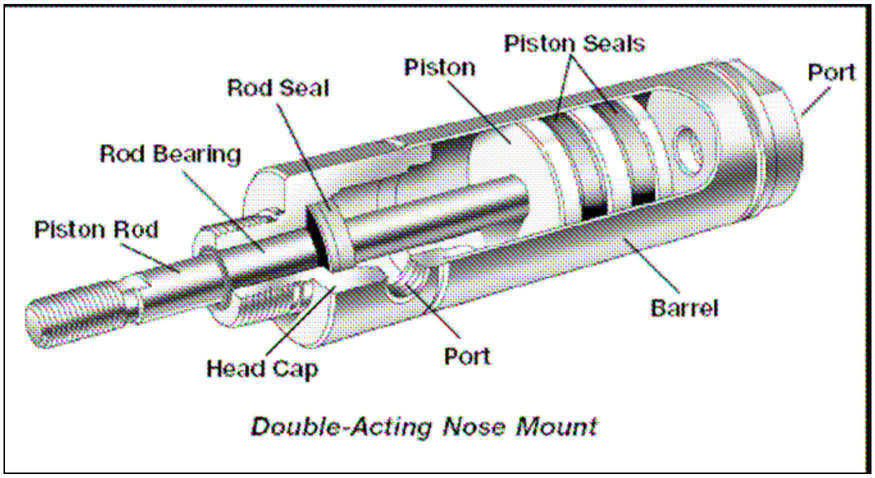

Figure 8-6: Schematic of Pneumatic Cylinder

The important dimensions of the cylinder selected can be seen in Table 8-1.

Stroke	8 in
Bore	2 in
Total Retracted Length	13.5 in
Weight	6 pounds
Port and Piston Rod	¼ inch threads
Maximum Pressure	250 psi
Force Exerted at 130 psi	400 lbf

Table 8-1: Important Cylinder Information

The important information to get out of Table 8-1 is that the stroke length is 8 in and the force exerted at 130 psi is 400 lbf. The stroke length is important because the minimum stroke required, which was calculated on page C-16, is 35 inches. When scaled down, the stroke should be 7 inches, but we went to 8 just to be safe. The compressor that was purchased has a maximum pressure of 130 psi, so that is why it is important to know how much force is exerted at 250 psi.

8.3 Construction of Support Beams

As mentioned earlier, three different support beams will be tested to determine the best one. The consensus of the group is that Support Option 3 will be the best however we want to look at different types. The support beams that will connect the cylinder to the trailer's main support beam and the connection of the piston arm to the roof will be discussed in the following sections. All of the support beams will be made out of aluminum because we want the weight of these to be as minimal as possible.

8.3.1 Support Option 1

This support beam was the most difficult to manufacture. The reason for this is because it needed to be fabricated at a 30-degree angle. Figure 8-7 shows a picture of this support beam. It is a very basic design consisting of two ¼ inch aluminum plates welded together at a 30-degree angle. A block was wedged in between the two plates to ensure that the angle would remain at 30. Two rectangular pieces were cut out of a ¼ inch aluminum plate to create the support posts, which were welded onto the 30-degree support. One support post was vertical and one was angular. The support posts were welded to an elbow bracket, which connected the whole piece to the trailer's main support beam. Two screws were used to connect this piece; one in the vertical direction and one in the horizontal direction. Figure 8-8 shows it connected to the main support beam

Figure 8-7: 30-Degree Support

Figure 8-8: 30-Degree Support Connected to Main Support Beam

The cylinder was bolted to the bottom of these supports with the help of a foot bracket. Figure 8-9 shows a picture of the cylinder bolted to a foot bracket. Bolts were now used to connect the foot bracket to the support beam. This setup kept the cylinder at a 30-degree angle as the roof swung open. The piston arm, which had a wheel screwed on the end, had a free connection to the roof. This allowed the wheel to freely move up and down the surface of the roof.

Figure 8-9: Cylinder Connected to Foot Bracket

8.3.2 Support Option 2

Our second option is different from the first, in that, it will allow the cylinder to rotate and the piston arm to remain stationary. An L-bracket support will be used to connect the main support beam to the cylinder. This beam will be made out of aluminum to reduce weight and a rough version can be seen in Figure 8-10.

Figure 8-10: L-Bracket Support

This support will be bolted to the main support beam with two screws; one in the vertical direction and one in the horizontal direction. This bracket will be connected to the cylinder by a hinge. This will allow the cylinder to rotate freely as the roof swings open. The hinge will be bolted to the foot bracket, which will be bolted to the cylinder. Figure 8-11 shows a picture of the cylinder and hinge setup.

Figure 8-11: Cylinder and Hinge Setup

Another hinge will be connected to the roof to provide a connection for the piston arm. The piston arm will be screwed into a nut, which will be welded onto this second hinge. Figure 8-12 shows a picture of the entire L-bracket support system.

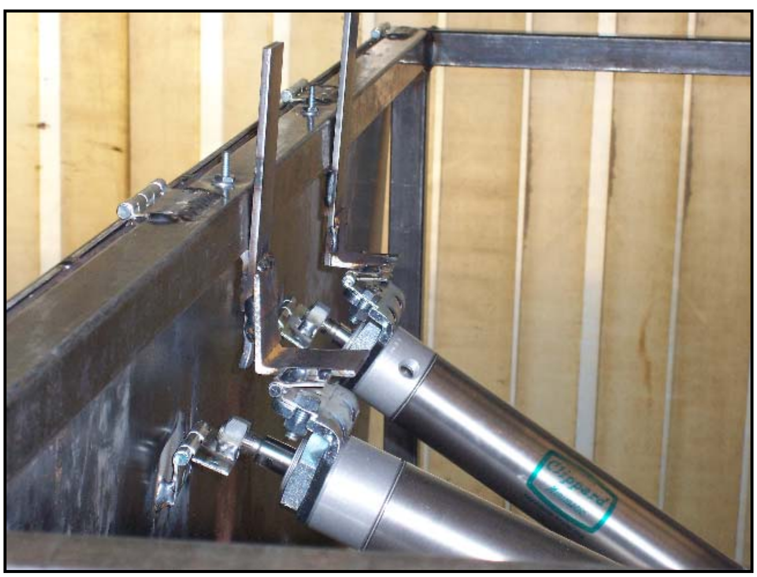

Figure 8-12: Final Setup of Support Option 2

8.3.3 Support Option 3

Our third option differs from the first two, in that the cylinders will not start at a 30-degree angle. The cylinder will actually be angled slightly down. A horizontal L-bracket will be used to connect the cylinder to the main support beam. As in Support Option 2, the cylinder will be bolted to the foot bracket, which will be bolted to the hinge. The hinge will be bolted to the horizontal L-bracket. This setup can be seen in Figure 8-13. Two vertical screws will bolt the horizontal L-bracket to the trailer's main support beam.

Figure 8-13: Horizontal L-Bracket Support

The connection of the piston arm to the roof is also unique from the first two options. A triangular piece of steel will be connected to the roof. Figure 8-14 shows this piece welded to the roof. This triangular piece will act as a lever arm and will increase the mechanical advantage of the piston arm.

Figure 8-14: Triangular Connector Attached to the Roof

A clevis rod will be screwed on the piston arm (Figure 8-15), and pin connected to the triangular connector (Figure 8-16). The clevis rod will allow the piston to rotate as the roof swings open. Figure 8-17 shows a picture of the entire setup.

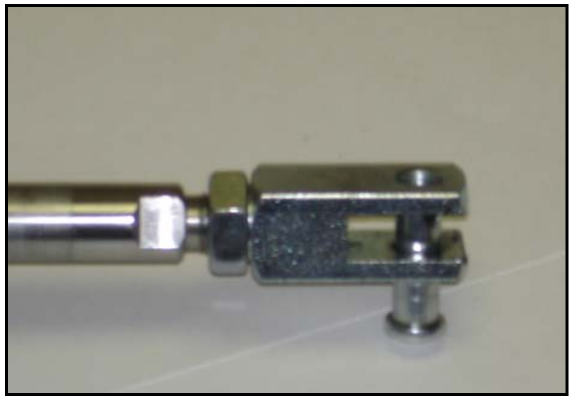

Figure 8-15: Clevis Rod Connected to Piston Arm

Figure 8-16: Clevis Rod Connected to Triangular Connector

Figure 8-17: Final Setup of Support Option 3

8.4 Air Connections

Once the cylinders are attached to the trailer, hose connections are needed to provide the air pressure. A Husky compressor was purchased at Home Depot that has a maximum pressure of 130 psi and a 6-gallon tank (Figure 8-18). This provides us with more than enough pressure and enough air to keep the compressor turned off during test runs. Since we will have 2 cylinders running off of one compressor, a splitter will be needed to distribute the air (Figure 8-19).

Figure 8-18: Compressor

Figure 8-19: Air Splitter

Three hose connections will be needed; two to connect the hose to the cylinders and one to connect the hose to the compressor. We decided to go with quick connect hose connections (Figure 8-20). These are beneficial because we won't have to screw/unscrew the connectors every time we want to install/uninstall the cylinders.

Figure 8-20: Quick Connect Hose Connectors

The quick connect hose connectors will connect to the cylinders by a hose fitting (Figure 8-21). These are not normal hose fittings however. These fittings are safety fittings. They act as a one-way damping valve. The air can pass through in one direction unscathed, but is dampen when it tries to pass through the other direction. This occurs because a small ball bearing, located inside of the fitting, is "pushed" out of the way when the air is moving from the female side to the male side and "clogs" up the hole when the air tries moving in the opposite direction. In our design, these fittings will allow the air through unscathed when the roof is lifting and dampen the air when it is closing. This will add to safety of the design because if there is a sudden loss of pressure, i.e., a hose is punctured or the compressor is damaged, the roof will slowly fall to its initial position instead of slam down as it currently does. A 90-degree fitting allows the hose to come into the cylinder from any direction. Figure 8-22 shows the entire hose setup.

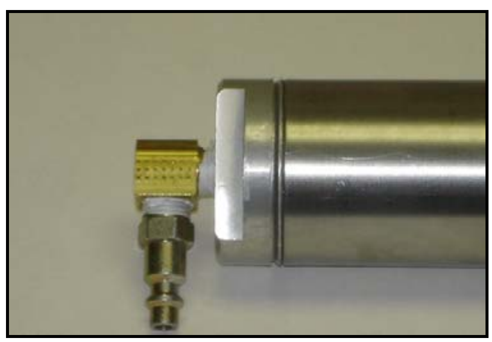

Figure 8-21: Safety Hose Fittings

Figure 8-22: Final Hose Setup

8.5 Quick Release Ball Pins

One of the main goals of this design is to decrease the number of personnel setting up and tearing down the roof of the trailer. To expedite this process, quick connect ball pins (Figure 8-23) will be used. These pins will be used instead of bolts because they will reduce most of the setup and teardown time of screwing in bolts. These pins are safety pins, in that they have a cone that protects the push button from inadvertently being pushed. To make this setup possible, two small steel rods (Figure 8-24) will be needed to “act” as bolts for the horizontal L-bracket to connect to. The ball pins will then be inserted underneath the horizontal L-bracket to support them. Another ball pin will be used to connect the clevis rod to the triangular piece. The final setup can be seen in Figure 8-25.

Figure 8-23: Quick Release Ball Pins

Figure 8-24: Steel Rod Setup

Figure 8-25: Final Quick Release Setup

8.6 Cost Analysis

Table 8-2 shows the cost analysis of the final design. This does not account for material not used, but only for the material that will be used in the final design. The total amount spend was $766.53, which is well below our budget of $2,000.

Part	Company	Cost ($)	
Steel Tubing	McMaster Carr	$18.69 (x7)	
¼ in. Steel Plate	Kelly's Steel	$130.00	
Hinges	Home Depot	$3.50 (x2)	
Pneumatic Cylinder	McMaster Carr	$68.78 (x2)	
Cylinder Foot Brackets	McMaster Carr	$5.35 (x2)	
Clevis Rods	McMaster Carr	$4.47 (x2)	
Air Tank	Home Depot	$130	
Roof Support	Kelly's Steel	$10.00	
Cylinder Support: Rod	Tallahassee Welding	$1.00	
Cylinder Support: Beam	Metal Fabrication	$20.00	
¼ in. Quick Release Pin	McMaster Carr	31.50 (x2)	
3/8 in. Quick Release Pin	McMaster Carr	$31.50 (x2)	
Balsa Wood	Home Depot	$30.00	
Safety Tube Connector	Capital Rubber	$9.50	
Spray Paint	Home Depot	$15.00	**$766.53**

Table 8-2: Final Cost Analysis