

# Truck Trailer Scraper

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## **ABSTRACT**

Snow and ice accumulation on truck trailers has been an issue for some time now. This accumulation can lead to weight limit violations and fines, decrease fuel efficiency, dislodge during transit potentially harming vehicle components and or fellow motorists, and can also lead to citations. Many states are making it mandatory to clean truck trailers from snow or ice before transport. Industry has provided many solutions, all of which are stationary and not readily available. Therefore, there was a need for a portable solution.

Because of this, research, surveys, and interviews with trucking companies and possible customers were done to determine what characteristics a portable design would need to include and be designed for. It would need to be safe, fast, easy to operate, and affordable. The design needed to be light weight, durable, and versatile to allow for operation in extreme conditions. It also needed to be small and easy to store.

Concepts were developed in order to ascertain the best possible design. These concepts were analyzed utilizing various engineering design tools. From this, the concept delivering the best overall characteristics was chosen. The final concept was designed, analyzed, and tested with those characteristics in mind.

The final product provided a cheaper alternative to industry options and keeps trucking companies less liable for any injuries related to snow and ice accumulation. It leads to less weight limit violations, increased fuel efficiency, and could potentially pay for itself. The design can also be used for different applications like the snow removal from school busses, UPS, USPS, and FedEx trucks. It can also be used to clean house roofs during times of heavy snow fall.

## INTRODUCTION

### *BACKGROUND*

Safety is a pressing concern throughout the trucking industry. There are many hazards on the road that might cause truck related accidents; one of which is ice and snow accumulation. This becomes a bigger concern in regions that experience significant snowfall in the winter. Snow and ice that has accumulated on top of the trailer could dislodge during transit potentially harming vehicle components and or fellow motorists on the road. Besides being a dangerous hazard, snow accumulation can increase the weight of the vehicle possibly leading to a weight limit violation and fine. In an Interview with Mike LaCalameto, the general manager at OptiVia Logistics he said that fuel, downtime, and safety are the most important things in the trucking industry. (1) . The increase in weight from snow and ice would decrease the trucks fuel efficiency. This brings up the issue of snow removal from the top of truck trailers.

### *SNOW AND ICE REMOVAL CHALLENGES*

The easiest and cheapest way to remove snow and ice would be to have drivers simply climb up on top of the trailer and use a broom or shovel to clear it. The potential for slips, falls and even death far outweigh any potential benefits. Any company that allows this procedure leaves themselves liable for any injuries incurred during removal. According to the American Transportation Research Institute (2) many states are making it mandatory to clean truck trailers from snow or that are issuing citations to drivers with heavy snow accumulation before transport. These states include Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, Georgia, Iowa, Michigan, Nebraska, New Hampshire, and Washington D.C. There are more and more states and other countries trying to stop the dangers of snow accumulation. Though there are other options, most are costly and are fixed so there is limited accessibility on the road. These will be discussed later in the report.

The focus of this design project is to design a mechanism that allows the removal of ice and snow from the tops of truck trailers while on the road. This mechanism will eliminate the possibility of injury to any person clearing a tractor trailer and also prevent injury to any motorists traveling near the truck. It will provide a much cheaper alternative to all other options available in the industry and could potentially pay for itself in fuel cost savings, less weight limit violations, lowered insurance premiums, and it will keep trucking companies less liable for any injuries related to snow and ice accumulation.

***MANUAL CLEANING BY TRUCK DRIVER***

Drivers are certainly one of the lowest cost options for the removal of snow and ice. The truckers simply climb up on top of the trailer and use a broom or shovel.

The downside is that the tops of the trailers were not designed to withstand the weight of a person. Furthermore, this procedure is very hazardous. The potential for slips, falls and even death far outweigh any potential benefits. Agencies that are responsible for and that regulate worker safety would not allow this as an appropriate approach. Any company that allows this leave themselves liable for any injuries incurred during removal.

***SNOW SCRAPER***

A snow scraper is an assembly that uses a blade device that can be raised or lowered to accommodate varying heights of trailers. The device is mounted on an H-type frame. The driver can pull the trailer up to the snow scraper, raise or lower it based in the height of the trailer, and drive through. The blade will scrape the snow from top of trailer. The blade is sometimes tilted or shaped like a “v” to push snow to the side of trailer rather than behind it. Figure 1 (3) below shows the use of a scraper system.



**Figure 1 – Scraper Systems**

It is a quick (under 1 minute) and easy process but has some definite cons. The process may not always remove all of the ice or snow and the snow or ice removed may cause a build-up in the area in which it falls. The snow scraper is fixed so there is limited accessibility on the road. It is limited to flat surfaces and is also costly at \$15,000 - \$18,000 per scraper.

### ***SNOW BRUSHER***

Snow brushes use a similar frame as the snow scraper. Instead of a blade, a high speed rotating brush is used. Figure 2 (4) shows a DuraSweeper system.



**Figure 2 – DuraSweeper**

Unlike the snow scraper, build-up of piles of snow removed from the trailers is minimized. It is a fast process (1 to 5 minutes) and can be used in a variety of vehicle types. The snow brusher is fixed so there is limited accessibility on the road. The process may not always remove all of the ice or snow and it is also costly at \$12,000 to \$15,000 per scraper.

### ***HEATED TRAILER ROOF TOPS***

In an article called, “Heated trailer roofs coming to Canada?” James Menzies of Truck News says a company in the UK has a solution to snow and ice accumulation. (10) The idea came from William Tudor, president of Erythros Technologies International. Using solar panels, energy is collected and stored in small lithium batteries. The energy is then used to heat the top of the trailer to prevent snow or ice from forming on the trailer.

The system would employ a temperature control system meaning that when the temperature drops below 32°F the system turns on when the temperature is above 32°F it turns off. It will keep snow and ice off the trailer. The system is attached to the trailer which provides greater accessibility than the alternatives. It is estimated to weigh 78 lbs and cost around \$300 per trailer. It is a great idea but is not yet available. Also, battery life is short at about 24 hrs between charges.

***SNOW THROWER***

Snow throwers use a similar frame as that of the snow scraper and snow brusher. Though, instead of a blade or brush, three tines rotate and throw the snow or ice from the trailer.

Figure 3 (5) shows the YETI snow thrower system.



**Figure 3 - YETI Snow Thrower**

Snow throwers remove snow and ice well and operate quickly at 2 minutes per trailer. Build-up of snow removed from the trailers is minimized. The snow scraper is fixed so there is limited accessibility on the road. It is limited to flat surfaces and is also costly at about \$70,000 per scraper.



***TRUCK WASH FACILITIES***

Truck wash facilities can be used remove snow and ice from the top of a trailer. In an interview with Denny Merk of RAM Freight Nationwide, Inc. he says that all of his drivers get their trailers cleaned at a truck wash if it ever becomes necessary. (7) It costs them \$75 on average per trailer. Figure 5 (8) below shows a typical truck washing facility.



**Figure 4 – Blue Beacon Truck Wash Facility**

Though these facilities are fairly wide spread, snow and ice may not be completely washed off. Furthermore, these facilities are fixed so there may limited accessibility on the road depending on the truck route. Also, the driver is responsible for the cost associated with the wash. These costs range from \$30 to \$75 and are typically not covered by the carrier.

***THIRD PARTY CONTRACTORS***

A trucker or trucking company can hire an independent snow removal contractor. They are on call to remove snow from trailer tops as needed. Trucks can be reached by contractors at any location as shown in Figure 4 (6) below.



**Figure 5 – Trailer on the Road**

There are some definite pros to this alternative. You can have the snow removed as needed and since contractors have the ability to travel, the trailer can be cleaned anywhere. Though, in the trucking industry, time is money. It takes, on average, 30 minutes to clear a trailer and contractor travel time may add to the delay. If several trailers need to be cleared, the time delay is even greater. There is also a liability issue if a contractor gets injured during snow removal. The price to clean one trailer can range from \$50 to \$150 depending on the accumulation.

***SNOW AND ICE REMOVAL PLATFORMS AND CATWALKS***

Platforms and Catwalks provide easy access to the top of the trailer. Truckers pull up parallel to the platforms or catwalks, climb on, attach a safety harness to prevent falling, and manually clean the trailer. Figure 6 (9) shows a platform that can be used to clear snow or ice from a trailer.



**Figure 6 - Carbis Platform**

These platforms or catwalks provide an easy solution to snow removal though drivers may not be able to remove all snow and ice. These platforms and catwalks are fixed so there is limited accessibility on the road. Furthermore, there is a liability issue if a trucker gets injured during snow removal. Also, these are expensive and priced from \$9,500 to \$18,000.

***DRIVER SLAM ON BRAKES WHILE IN A PARKING LOT OR TRUCK YARD***

An alternative solution would be to simply slam on brakes while in a parking lot or truck yard. This is done in the hopes of dislodging accumulated ice and snow.

Though there are no costs associated with this method and it can be done anywhere, there are definite cons. If the ice or snow is bonded to the trailer, it may not dislodge. This method may also be damaging to the vehicle because falling snow or ice could potentially make it to the tractor and dent or scratch it. It may be damaging to the braking system as well. This would typically need to be done before leaving the facility or on the road. Both of these are times when the trailers have cargo in them providing possible damage to the cargo.

## CUSTOMER FEEDBACK, FEATURES, AND OBJECTIVES

### *SURVEY FEEDBACK*

A survey was produced and sent out to 25 potential product customers including, but not limited to, truck drivers, engineers, and upper management at 7 major trucking companies. The survey was used to gauge the importance of a wide range of product features such as durability, ease of installation, size, cost, etc. The first half of the survey focused on features and customer importance. They were asked to rate the importance of these features on a scale from 1-5 with 5 being the most important. Twenty of the twenty five surveys sent were returned and analyzed to determine the most and least important features in the product. These averages are shown in Table 1 below. (See **Appendix B** for full survey and customer results).

Feature Surveyed	Average Customer Results
Safe	4.5
Light Weight	4.15
Easy to Operate	4.1
Operates Quickly	3.9
Easy to Install	3.65
Reliable	3.6
Durable	3.5
Easy to Store	3.4
Small in Size	3.25

**Table 1 – Customer Survey Analysis**

The results of this survey show that safety of truckers is the most important, followed by light weight and easy to operate. Design concepts will address these desirable features as the voice of the customer.

**OBJECTIVES**

This list of product objectives includes engineering characteristics that describe how the features will be obtained or measured to ensure that the goal of the project was met. The list below ranks the features in order of rated importance from greatest to least. The percentages in the parentheses describe the analyzed weighted importance of each feature. The weighted importance was arrived at using a Quality Function Deployment (QFD). A QFD is used to accumulate and quantify survey results and designer options and to link the importance of the customer features to the design decisions. Below each feature is followed by the method or objective that will be used for the prototype design.

**Safe (15%)**

- Will prevent ice or snow from falling within 3 ft of the operator
- Attachment to the trailer will keep the system attached at all times until the operator removes it
- System to slow down the moving scraper so that it doesn't fall off the trailer
- Safety guards covering moving parts

**Easy to Operate (13%)**

- Hand crank system that produces the work needed to move the scraper across the trailer
- Reverse capability

**Operates Quickly (13%)**

- Will completely clean the trailer in under 4 minutes

**Easy to Install (11%)**

- No tools necessary
- One person install
- Installed in under 1 minute
- Replaceable blade

**Light Weight (10%)**

- Light enough to be carried and handled by an average size and strength male

**Durable (10%)**

- Structure of design will withstand impact force of being dropped from 12 ft.
- Rust resistant metals will be used
- Ductile and lightweight metal used for the base of the system
- Scraper blade will withstand temperatures from -30F to 130F
- System will operate in and withstand all weather conditions in temperatures from -30F to 130F

**Reliable (10%)**

- Will have an operating life of 40 years based on 30 average uses per year

**Small in Size (10%)**

- Will fit in to a volume of 4 ft x 1.5 ft x 2 ft

**Easy to Store (8%)**

- Will fit in the cab or attach to the outside of the trailer

***ENGINEERING CHARACTERISTICS***

The features listed on the previous page were followed by the method or objective that will be used for the prototype design. These are listed below. The relative importance percentages describe how important the characteristics are relative to the weighted features. They were arrived at using the Quality Function Deployment (QFD) described above.

<b>Engineering Characteristics</b>	<b>Relative Importance</b>
Ductile and lightweight metal	12%
Withstand impact force 12 ft drop	10%
Withstand temperatures from -30F to 130F	10%
Reverse capability	9%
Volume of 4 ft x 1.5 ft x 2 ft	9%
Storage in the cab or attachment to trailer	8%
No tools necessary	7%
One person install	7%
> 3 ft between operator and fall of debris	7%
Clean the trailer in under 4 minutes	7%
Hand crank system that produces work	7%
Rust resistant metals	3%
Operating life of 40 years	3%
Safety guards covering moving parts	2%

## CONCEPT GENERATION AND SELECTION

The first concept involved a complete assembly that would be attached to the trailer at all times. This assembly consisted of a blade assembly that would remain attached to two guide rails on the side of the trailer. The blade assembly incorporated an angle to allow for snow to fall to the sides of the trailer while also eliminating the buildup of stresses on the system. A belt drive would then be installed on the front and back of the trailer. This belt drive consists of a winch, pulley, and belt. The winch would be attached to the front end and the pulley would be attached to the back. The belt would go through the winch then to the blade and finally to the pulley. The operator would crank the pulley causing the blade to move along the length of the trailer. When the process is completed, the blade would rest on the front side of the trailer in between the trailer and the tractor. This is all shown in Figures 7-9 below.

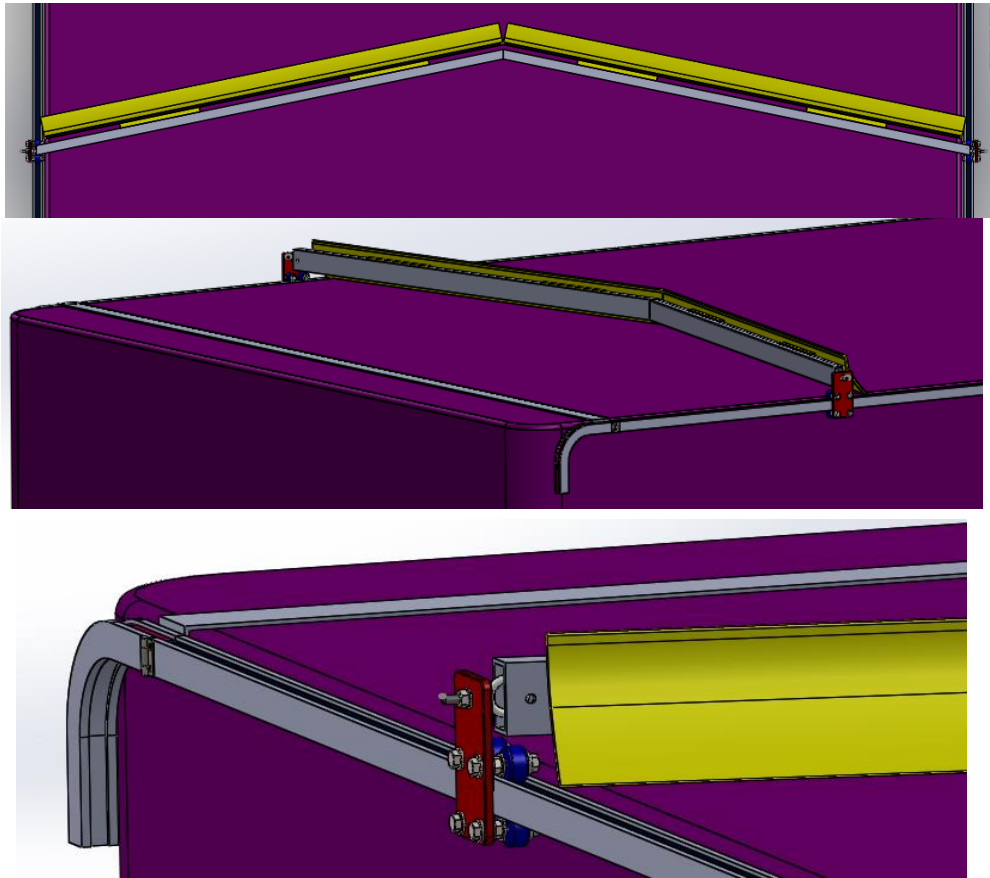
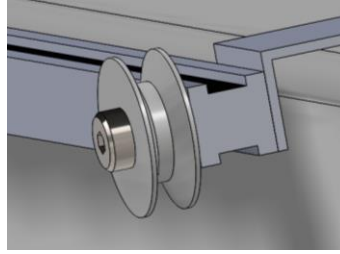
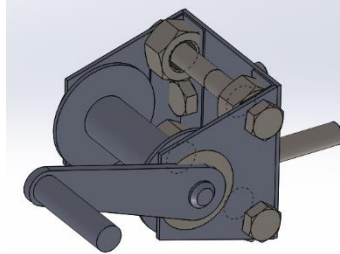


Figure 7 – First Concept Views

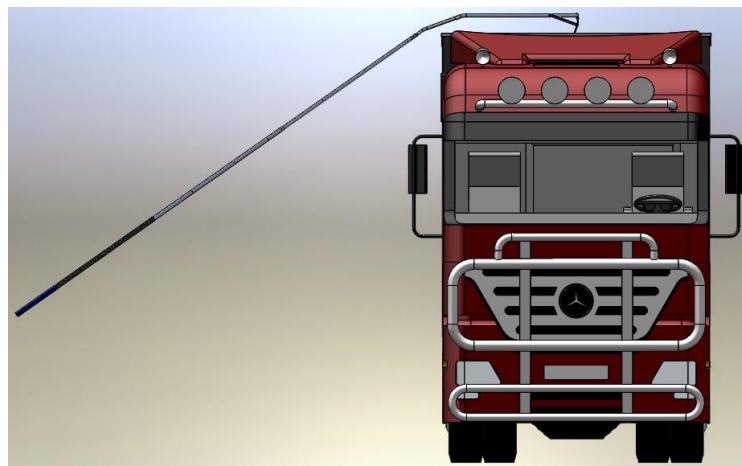


**Figure 8 – First Concept Pulley**



**Figure 9 – First Concept Winch**

The second concept, shown in Figure 10 below, involves a telescoping tube assembly along with a blade attachment. The tube assembly consists of three oval tubes nested within each other and two push button joints allowing for fast and easy extension and retraction. The oval tubing also increases bending resistance. The telescopic tubing is followed by the tube shown in Figure 11. This tube is used to connect the telescopic tubing to the blade assembly. It is formed to fit in the cross section of the oval tubing and has a bend incorporated to help decrease the bending moment incurred by pulling and reaction forces. Finally, the blade assembly, shown in Figure 12, is attached using a button clip. This assembly consists of an aluminum tube connected to a blade using nuts and bolts. The assembly is reinforced with two braces to help increase the strength of the blade under load. The tube also includes a bend to help decrease the bending moment incurred by the pulling and reaction forces.

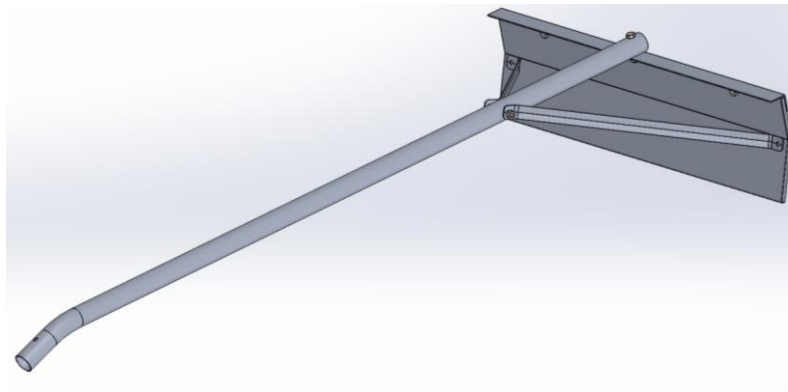


**Figure 10 – Second Concept**





**Figure 11 – Second Concept Center Tube**



**Figure 12 - Second Concept Blade Assembly**

The first concept did not meet many of the engineering characteristics. The forecasted budget was roughly \$2500 and considering the surveys and interviews, it was obvious that this design's cost would not be feasible in a trucking market. The design was bulky and could not be installed by one person. It was heavy, large, and in turn, difficult to store. Through continued research, I found that trailers vary in lengths meaning that this design would not be applicable for all trailers. With these facts in mind, concept two was chosen for a prototype. This concept allowed for fast and easy assembly and disassembly. It is easy to install and easy to store. The aluminum materials chosen can withstand extremely cold temperatures and also resist corrosion. The complete assembly is lightweight, durable, and easy to handle. This concept also allowed for use in other applications.

## CALCULATIONS

Every snowfall is different and because of this fact, snow does not always have the same properties. As the snow piles up, it compresses under its own weight causing its density to change. Temperature also plays a role. If the temperature is hovering around the freezing point, part of the snow will begin to melt causing the formation of wet snow. Therefore, calculations were done using different snow densities. Various snow densities are shown in Table 2 (11) below. These are shown as a reference.

Typical densities of snow and ice (kg/m³)	
New snow (immediately after falling)	50-70
Damp new snow	100-200
Settled snow	200-300
Depth hoar	100-300
Wind packed snow	350-400
Firn	400-830
Very wet snow and Firn	700-800
Glacier ice	830-917

**Table 2 – Snow Density Reference**

The density and temperature of snow also effects the coefficient of friction between the snow and the material that it will be moving across. Because of this, calculations were done using different coefficients of friction. Various coefficients of friction are shown in Table 3 (12) below. These are shown as a reference.

Bibliographic Entry	Result (w/surrounding text)	Standardized Result
Raymond A. Serway, & Jerry S. Faughn. <i>College Physics Sixth Edition</i> . Pacific Grove: Thomson Learning Inc, 2003: 102.	Materials in Contact      Static Friction      Kinetic Friction Waxed Wood on Wet Snow      0.14      0.1	0.14 (static) 0.1 (kinetic)
Johnson, Clifford V. Friction. Microsoft Encarta Online Encyclopedia 2007.	Materials in Contact      Static Friction      Kinetic Friction Waxed Ski on Snow      0.1      0.05	0.1 (static) 0.05 (kinetic)
Tadeusz, Burakowski and Tadeusz, Wierzchn. <i>Surface Engineering of Metals: Principles, Practices, Technologies</i> . CRC Press, 1999: 143.	"The Coefficient of friction for snow or ice is only 0.03 because due to local very high pressure the temperature of water -ice phase transformation is lowered and a layer of water is created. At low temperatures (-40 C and lower) the layer of water is not formed and the coefficient of friction rises to a value normal for two sliding solid surfaces, i.e., 0.7 to 1.2".	
Baker, J.S. <i>Traffic Accident Investigation Manual</i> . Evanston: Northwestern University, 1975: 210.	Materials in contact      Wet Snow Rubber on Wet Snow      0.30-0.60	0.30-0.60
Gleason, J. Andrew. <a href="#">Preliminary results of snow surface friction coefficient measurements</a> . International Snow Science Workshop. Penticton, BC, 2002.	"A coefficient of dry static friction was calculated for each snow type. Coefficients ranged from 0.53â€"1.76. Some of these coefficients were compared to shear strength numbers derived from shear frame measurements on the previous surface layer 24 hours after new snow fell on the surface."	
		0.53â€"1.76 (static)

**Table 3 – Snow Coefficients of Friction Reference**

These factors, as well as volumes, were taken in to account to calculate the force needed to remove said amount of snow. These results are shown in Tables 4-7 below.

3" thick snow with a $\mu k$ of 0.3 and various densities.					
D	Density of snow		200 kg/m <sup>3</sup>	500 kg/m <sup>3</sup>	1000 kg/m <sup>3</sup>
V	Volume of snow	L*W*H	0.06 m <sup>3</sup>		
m	Mass of snow	Density*Volume	11 Kg	28 Kg	56 Kg
W	Weight of snow	mass*gravity	109 N	273 N	547 N
Ff	Frictional Force	$\mu k * N$	33 N	82 N	164 N
Fs	Snow reaction force Fs	Sum Fx -> = m(aG) = -Fs + Ff	31 N	76 N	153 N
Snow Properties and Assumptions					
The force needed to move heavy, packed snow with a density of 1000 kg/m <sup>3</sup> is 153 N.			Length	Width	Height
			1.22 m	0.6 m	0.076 m
			V (velocity)	t (time)	a (acceleration)
			0.5 m/s	2.44 s	0.205 m/s <sup>2</sup>
			Gravity	$\mu k$	
			9.81 m/s <sup>2</sup>	0.3	

Table 4 – Snow Removal Force First Case

6" thick snow with a $\mu k$ of 0.3 and various densities.					
D	Density		200 kg/m <sup>3</sup>	500 kg/m <sup>3</sup>	1000 kg/m <sup>3</sup>
V	Volume of snow	L*W*H	0.11 m <sup>3</sup>		
m	mass	Density*Volume	22 Kg	56 Kg	111 Kg
W	Weight	mass*gravity	219 N	547 N	1093 N
Ff	Frictional Force	$\mu k * N$	66 N	164 N	328 N
Fs	Snow reaction force Fs	Sum Fx -> = m(aG) = -Fs + Ff	61 N	153 N	305 N
Snow Properties and Assumptions					
The force needed to move heavy, packed snow with a density of 1000 kg/m <sup>3</sup> is 305 N			Length	Width	Height
			1.22 m	0.6 m	0.152 m
			V (velocity)	t (time)	a (acceleration)
			0.5 m/s	2.44 s	0.205 m/s <sup>2</sup>
			Gravity	$\mu k$	
			9.81 m/s <sup>2</sup>	0.3	

Table 5 - Snow Removal Force Second Case

3" thick snow with a Mk of 0.7 and various densities.					
D	Density		200 kg/m <sup>3</sup>	500 kg/m <sup>3</sup>	1000 kg/m <sup>3</sup>
V	Volume of snow	L*W*H	0.06 m <sup>3</sup>		
m	mass	Density*Volume	11 Kg	28 Kg	56 Kg
W	Weight	mass*gravity	109 N	273 N	547 N
Ff	Frictional Force	$\mu k * N$	77 N	191 N	383 N
Fs	Snow reaction force Fs	Sum Fx -> = m(aG) = -Fs + Ff	74 N	186 N	371 N
Snow Properties and Assumptions					
The force needed to move heavy, packed snow with a density of 1000 kg/m <sup>3</sup> is 371 N			Length	Width	Height
			1.22 m	0.6 m	0.076 m
			V (velocity)	t (time)	a (acceleration)
			0.5 m/s	2.44 s	0.205 m/s <sup>2</sup>
			Gravity	$\mu k$	
			9.81 m/s <sup>2</sup>	0.7	

Table 6 - Snow Removal Force Third Case

6" thick snow with a $\mu k$ of 0.7 and various densities.					
D	Density		200 kg/m <sup>3</sup>	500 kg/m <sup>3</sup>	1000 kg/m <sup>3</sup>
V	Volume of snow	L*W*H	0.11 m <sup>3</sup>		
m	mass	Density*Volume	22 kg	56 kg	111 kg
W	Weight	mass*gravity	219 N	547 N	1093 N
Ff	Frictional Force	$\mu k * N$	153 N	383 N	765 N
Fs	Snow reaction force Fs	Sum Fx -> = m(aG) = -Fs + Ff	148 N	371 N	742 N
Snow Properties and Assumptions					
The force needed to move heavy, packed snow with a density of 1000 kg/m <sup>3</sup> is 742 N.			Length	Width	Height
			1.22 m	0.6 m	0.152 m
If snow is 6" thick and has a high density with a high friction factor, the area of snow removed per stroke will need to be lowered. Starting removal at .610 m instead of 1.22 m			V (velocity)	t (time)	a (acceleration)
will suffice. The force needed will then be 370 N.			0.5 m/s	2.44 s	0.205 m/s <sup>2</sup>
			Gravity	$\mu k$	
			9.81 m/s <sup>2</sup>	0.7	

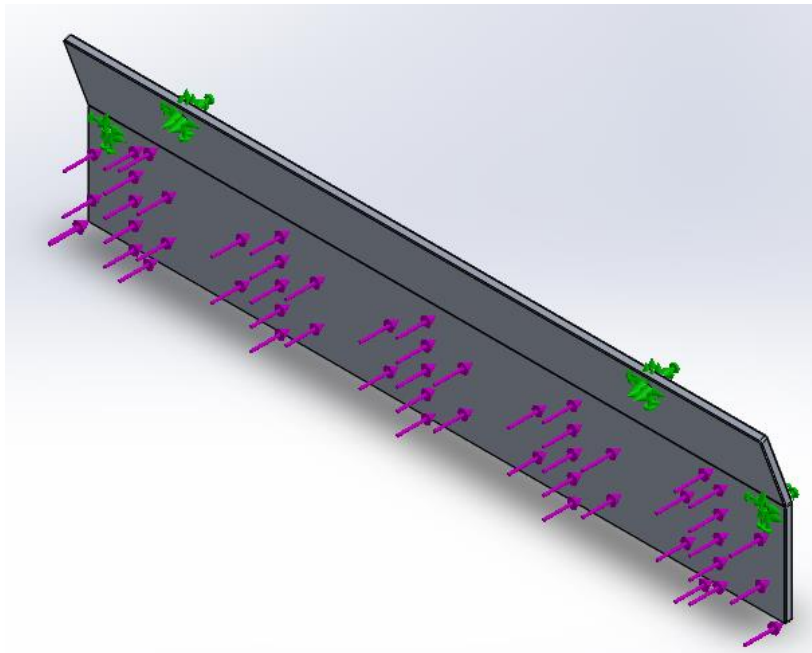
Table 7 - Snow Removal Force Fourth Case

Human strength characteristics also needed to be taken in to account. Since these characteristics range from person to person, different values for applied pulling forces needed to be analyzed. Calculations were done to show the reaction force from the blade to the snow created by exerting different pulling forces on the handle. The results are shown in Table 8.

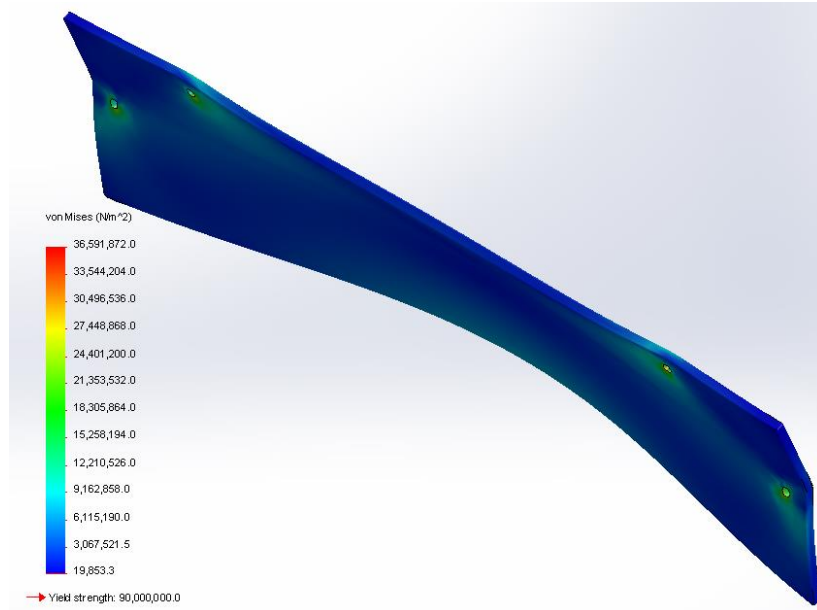
Reaction Force on Blade with Various Pulling Forces			English Units	50 lbs	75 lbs	100 lbs
Fp	Assumed Human Pulling Forces			222 N	334 N	445 N
Fsx	Snow Reaction Force in x	sum Fsx ->	$F_{px} + F_{sx} = 0$	38 N	58 N	77 N
Fsy	Snow Reaction Force in y	sum Fsy -^	$F_{py} + F_{sy} = 0$	270 N	406 N	541 N
Fs	Horizontal Vector Magnitude	Pythagorean Theorm	$\sqrt{F_{sx}^2 + F_{sy}^2}$	272 N	410 N	546 N
A person exerting a pulling force of 445 N (100 lbs) will cause a reaction force of 546 N on the blade.						
The force needed to remove 6" of snow with a high coefficient of friction and high density is roughly 371 N;						
A 75 lbs pulling force creates a reaction of 410 N which is enough to remove the snow.						

**Table 8 – Blade Reaction Forces**

To test the blade under extreme loads, SolidWorks SimulationXpress Simulation Wizard was used. The analysis included a distributed load of 371 N acting on the blade while 4 holes were fixed. This is shown in Figure 13 below. The material of the blade is 5052-0 Aluminum. This aluminum has a yield strength of 90000 kPa. After the SolidWorks simulation, the factor of safety came out to be 2.5 which is well within a safe range. The stress study is shown in Figure 14.



**Figure 13 – Stress Study**



**Figure 14 – Stress Study Results**

## SCHEDULE AND BUDGET

The major milestones of this design project are shown in Table 9 below. These milestones include research/data collection/analysis, followed by design, and finally fabrication/testing. The table shows what months were used to achieve said milestones.

	September	October	November	December	January	February	March	April
Research, Data Collection, and Analysis								
Design								
Fabrication and Testing								

**Table 9 - Schedule**

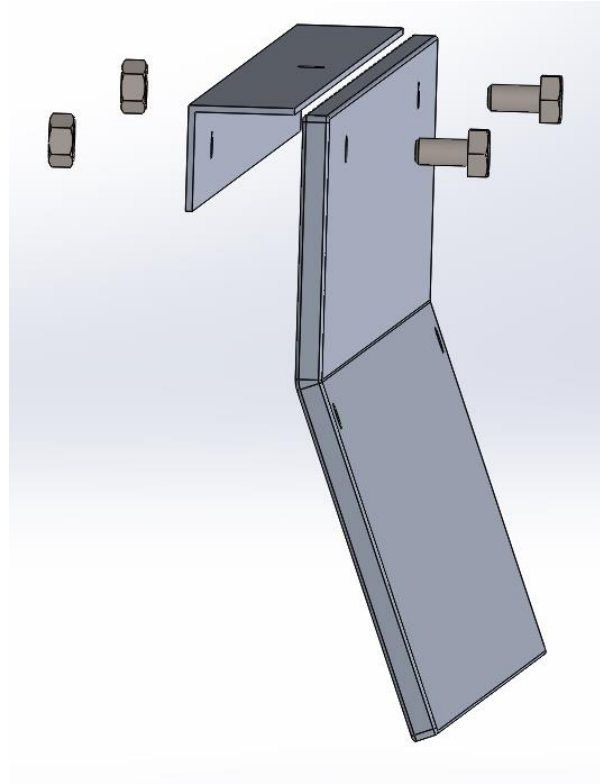
The forecasted and actual budget is shown in Table 10 below. The actual cost turned out to be roughly 30% of the forecasted cost. This was accomplished by completing all machining processes in workshops provided by UC. Also, purchased parts such as the telescopic tubing assembly aided in cost savings.

Project Budget		
Materials/Components/Labor	Forecasted	Actual
Aluminum Blade	\$ 80.00	\$ 45.00
Telescopic Tubing	\$ 150.00	\$ 50.00
Aluminum Tubing	\$ 30.00	\$ 20.00
Machining	\$ 100.00	\$ -
Telescoping Buttons	\$ 10.00	\$ 3.00
Rubber Edge Guards	\$ 15.00	\$ 3.00
Nuts/Bolts	\$ 5.00	\$ 3.00
Misc.	\$ 78.00	\$ 15.00
Total	\$ 468.00	\$ 139.00

**Table 10 – Project Budget**

## DESIGN, ASSEMBLY, AND MANUFACTURING

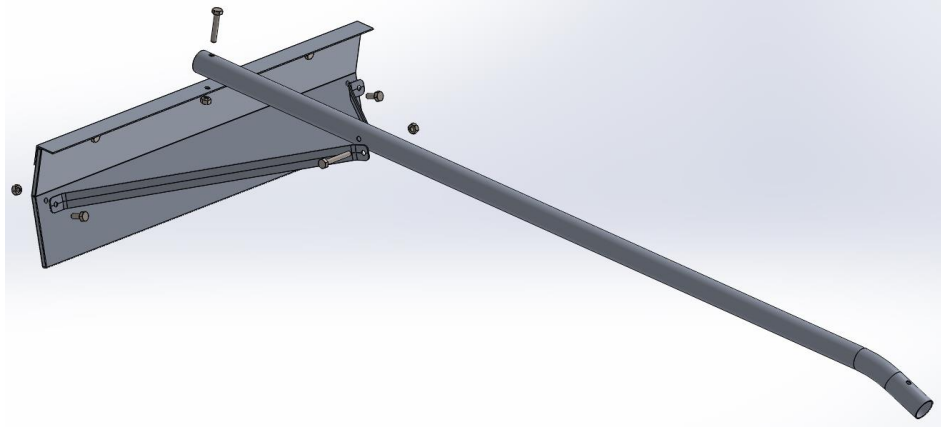
Figure 15 below shows Blade Assembly 1. This assembly consists of a blade, an angle bracket, and nuts/bolts. The blade was cut to size and machined with four holes. Two of these holes are used to attach the angle bracket to the blade. The other two are used to attach braces from the following assembly. The blade also includes an angle which was achieved using a sheet metal bender. The bracket was machined with three holes. Two of these are aligned with holes on the blade and are used for attachment. The other hole is used to attach an aluminum tube shown in the next assembly. All of these attachments are made using nuts and bolts.



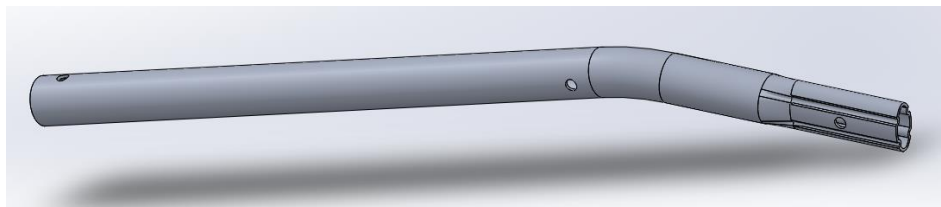
**Figure 15 - Blade Assembly 1**

Figure 16 below shows Blade Assembly 2. This assembly consists of Blade Assembly 1, two aluminum braces, an aluminum tube, and nuts/bolts. The braces were cut from sheet metal, drilled, and bent. Each brace includes a hole on each end. These holes are used for attachment to Blade Assembly 1 and the aluminum tube. The braces were bent to allow for angled placement and attachment. Finally the aluminum tube was fabricated. This tube was cut to size, drilled with three thru holes, and bent using a tube bender. One hole is used for attachment to Blade Assembly 1. The second hole is used to attach the braces. The third and final hole is used to attach the Center Tube shown in Figure 17. Blade Assembly 1, the braces and the aluminum tube are attached using nuts and bolts.



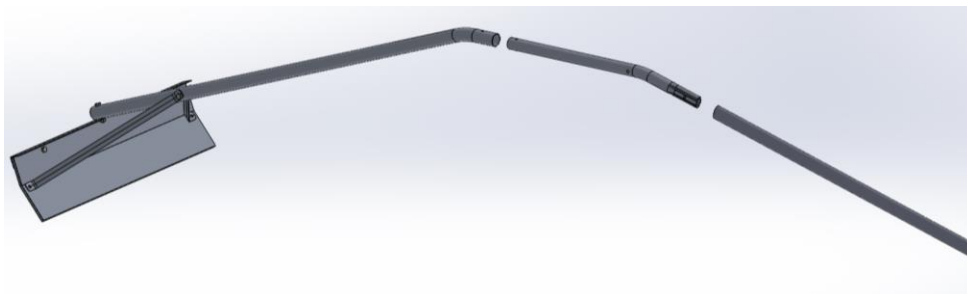


**Figure 16 - Blade Assembly 2**



**Figure 17 – Center Tube**

Figure 16 below shows the complete assembly. The Center Tube is attached to Blade Assembly 2 and the telescopic tubing using push button clips. These clips allow for easy assembly and disassembly.



**Figure 18 – Truck Trailer Scraper**

## TESTING

The goal; of testing was to use a material with properties similar to that of snow. This substance also needed to provide a reaction force on the blade equal to the worst case snow scenario. Since snow is not readily available, wet mulch was used. The properties of the mulch used are shown in Table 11 below.

Mulch Properties		
Length	Width	Height
1.22 m	0.601 m	0.114 m
V (velocity)	t (time)	a (acceleration)
0.5 m/s	2.44 s	0.205 m/s <sup>2</sup>
Gravity	$\mu_k$	
9.81 m/s <sup>2</sup>	0.85	

**Table 11 – Mulch Properties**

Using wet mulch with the properties shown above, a reaction force was calculated to be 341 N. This reaction force is near the required 371 N reaction force developed in the worst case snow scenario. The calculations for this force are shown in tables 12 below.

4.5" thick wet mulch with a $\mu_k$ of .85			
D	Density		500 kg/m <sup>3</sup>
V	Volume of mulch	$L*W*H$	0.08 m <sup>3</sup>
m	mass	Density*Volume	42 kg
W	Weight	mass*gravity	411 N
Ff	Frictional Force	$\mu_k * N$	349 N
Fm	Mulch reaction force Fm	Sum Fx -> = $m(aG) = -Fm + Ff$	341 N

**Table 12 – Mulch Testing Analysis**

Figure 19 below shows the scraper in use.



**Figure 19 – Testing in Progress**

Before and after pictures are shown in Figure 20 below.



**Figure 20 – Before and After Testing**

## **CONCLUSION**

Utilizing various engineering design tools. A product was developed for use in the trucking industry. This design is safe, fast, easy to operate, and affordable. It's designed for strength and durability with lightweight aluminum and temperature resistant plastics. These materials allow for operation in extreme conditions. The telescoping design makes it sleek and collapsible for easy storage. It is versatile allowing for use for different applications like the snow removal from school busses, UPS, USPS, and FedEx trucks. It can also be used to clean house roofs during times of heavy snow fall.


The final product provided a cheaper alternative to industry options and keeps trucking companies less liable for any injuries related to snow and ice accumulation. It leads to less weight limit violations, increased fuel efficiency, and could potentially pay for itself. The design

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## APPENDIX A - RESEARCH

Scraper Systems		<div>http://www.scraperystems.com/ 09/05/13</div>	Not Portable
<div></div>			
<p>Equipment designed for fast, efficient, low-maintenance operation in the harshest of winter conditions.</p> <p>Scraper Systems patented designs (Patent #5802654 and Patents Pending) incorporate heavy, extreme duty materials and components with few moving parts that require little to no maintenance. The result is a reliable machine.</p> <ul style="list-style-type: none"><li>• 12 in. wide flange steel beams for frame main columns</li><li>• 8 in. rectangular steel tubing for frame top beam</li><li>• Heavy steel reinforcing and bracing throughout 3/16 in. steel plate reinforced plow blade, framed by 8 in. rectangular tubing</li><li>• 1 in. thick x 6 in. rubber plow wiper blade</li><li>• Harrington SNER electric chain hoist built for extreme duty applications that require single phase power; 60 minute, H4 duty rated motor; maintenance friendly features include a unique chain guide, hinged control panel, sealed housing and durable load sheave</li><li>• NEMA 4 water-tight, dust-tight electrical enclosures</li><li>• Grade 8 high tensile bolts used throughout</li><li>• 3-step durable all-weather painting process:<ol style="list-style-type: none"><li>1. Steel grit blast chamber surface cleaning</li><li>2. High quality, rust-prohibitive alkyd primer</li><li>3. High gloss, high solids, machinery grade enamel premium finish coat</li></ol></li></ul>			Heavy
			Needs technical Installation
			Expensive \$ Waiting on Response
<p>Other Benefits</p> <ul style="list-style-type: none"><li>• Reduce fleet idle time.</li><li>• Reduce labor costs.</li><li>• Prevent injuries to employees, OSHA violations &amp; workers compensation claims.</li><li>• Reduce fuel costs.</li><li>• Reduce equipment damage.</li><li>• Eliminate violations &amp; fines to drivers.</li><li>• Reduce risks &amp; liability to motorists.</li><li>• Protect your brand from negative publicity.</li></ul>			

## DuraSweeper



<http://www.durasweeper.com/09/05/13>

<http://www.jejendomsservice.dk/index.php/durasweeper.ht>

DURASWEEPER uses state of the art technology to remove snow from the rooftops of all types of commercial vehicles, buses, flatbeds, straight jobs and delivery trucks without damaging the integrity of the vehicles roof.

DURASWEEPER utilizes a thirty-two inch poly wafer brush twelve foot in length. The brush, mounted to the two uprights and angled at a precise degree, is raised hydraulically to a height slightly higher than that of the vehicle. As the vehicle passes under the spinning brush, the patented flicking action removes the snow quickly and easily without damaging the roof.

The DuraSweeper is so versatile that it can be used year round! Not only can it clean snow but it can clean debris from the decks of wood based flat beds. Stones, gravel, glass, plastic, metal shavings are easily removed by the high speed brush, without having to send an employee up to sweep and possibly injure themselves!

Many northeastern states have begun to pass legislation addressing the situation of Flying Snow. Presently Pennsylvania, New Jersey, Massachusetts, Maine, New York and Connecticut have laws in place mandating the removal of snow and from all vehicle rooftops with fines ranging from \$250.00 to \$1,500.00 not to mention the liability and subsequent litigation if someone gets hurt or killed from flying snow! It will certainly reduce your company's liability and possibly insurance premiums! Keep your companies image, reputation and concern for safety a top priority.

The machine uses a brush constructed of replaceable airport tarmac-grade polypropylene bristle cartridges that rotate at 200 RPMs to gently but effectively remove snow that has accumulated on the affected area. The rotary brush can be raised or lowered hydraulically to clean surface areas situated at a height ranging between 0.6 m to 5.4 m off the ground, thus making the DuraSweeper ideal for effortlessly removing snow from almost any type of vehicle, regardless of the intricacy of its surface area. This product is comes with 1 year manufactures warranty that covers all of its parts, excluding the rotary brush. DuraSweeper unit weight a total of 1.428kg, overall width at base 4.6m, overall height 6.3m, etc. The DuraSweeper uses a 30 horsepower motor connected to a 480 3-phase electrical supply running 60 amps. DuraSweeper is used at one permanent location with the base of the unit being anchored to a concrete pad. A proven and effective turnkey installation is provided. This product is comes with 1 year manufactures warranty that covers all of its parts, excluding the rotary brush. DuraSweeper unit weight a total of 1.428kg, overall width at base 4.6m, overall height 6.3m, etc. The DuraSweeper uses a 30 horsepower motor connected to a 480 3-phase electrical supply running 60 amps. DuraSweeper is used at one permanent location with the base of the unit being anchored to a concrete pad. Effective turnkey installation is provided.

Not Portable.

Permanent

Expensive

\$ Waiting on response.



## Hummell Services llc.



<http://trailertopsnowremoval.com/services>

Provide a complete service of on-site and emergency roadside removal of snow and ice from Box Truck and Tractor Trailers both Van and Flatbed. Mechanical machines leave crumbs which could still refreeze and dislodge. Manual service clears 100% of snow and ice. Serving Central and Southern New Jersey and South Eastern Pennsylvania

As snow accumulates on van and flatbed trucks, so do fuel costs, liability risks and headaches. If a piece of ice falls from a vehicle and causes injury or property damage, car drivers face fines between \$200 and \$1,000, while truck drivers could be fined \$500 to \$1,500. N.J.C.39:4-77.1 makes drivers responsible for making “all reasonable efforts to remove accumulated ice or snow” from the hood, trunk and roof of the motor vehicle, truck cab, trailer or intermodal freight container. We also do emergency Roadside removal of snow!

Snow removed as needed

Cleaned anywhere  
Not Portable

30 minutes to clear a trailer and contractor travel time may add to the delay.

Heavy

Liability issue if a contractor gets injured during snow removal. Needs technical Installation

\$50 to \$150 depending on the accumulation.

## YETI Snow Thrower



<http://www.yetiledeneigeur.com/deneigeur-demonstration.php>

Thanks to its proximity sensors, the YETI automatically adjusts to the vehicle's size and shape. It expels snow and ice far from the snow removal corridor, thus allowing multiple cleaning cycles, with limited accumulation on the ground, and without any interruption between each trailer. No residue, no ice sheets left behind, the YETI offers a completely snowless roof each trip, regardless of the quantity or density of the snowpack. The driver simply needs to position the vehicle under the machine, press a button, and the machine starts automatically. The self-supporting head **adjusts to any trailer**. As the vehicle advances, snow is expelled by the YETI to a location up to 20 feet away. The YETI system allows removing the snow off of a trailer **in less than two minutes**, allowing companies to avoid using personnel assigned to other tasks, and having them climb onto the trailers' roofs. This method is dangerous, tedious, and incurs excessive costs, since this operation can take up to half an hour per trailer. You must also keep in mind that manual snow removal must be done while observing health and occupational safety laws. Article 2.9.1 stipulates "that a worker cannot go over three meters in height to carry out his functions without a guardrail or being tied. However, a worker who removes snow off of a trailer must be tied using a harness, even if he is located on a conventional snow removal ramp. In addition, there may be repercussions on CSST premiums. An employee who falls off of a trailer's roof can suffer serious injuries or even die, and consequently incur major costs to the company." By removing the snow off of the trailers before they leave, the truck drivers will not impede visibility for the vehicles they share the road with.

It is important to note that article 498 of the "code de la sécurité routière" (Road safety code) stipulates that all drivers are prohibited from letting any material become detached from the vehicle that they are driving. Should the case arise, a fine is given to the driver and the transport company. However, the violation is much more serious if the accumulated ice and/or snow causes an accident; then, the driver of the vehicle at fault can be found guilty of criminal negligence causing death. These charges are very serious and can lead to hefty fines. In addition, the insurance company, as well as the Commission des transports du Québec (Quebec Transport Commission) are given the police report, which taints the driver's record.

Remove snow and ice well

Operates quickly 2 minutes

Fixed so there is limited accessibility on the road

Limited to flat surfaces

Costly at about \$70,000

### **Adjusts to any trailer**

Quantity or density of the snowpack doesn't matter

YETI automatically adjusts to the vehicle's size and shape

Expels snow and ice far from the snow removal corridor

## Blue Beacon Truck Wash



<http://www.bluebeacon.com/>

Facilities are fairly wide spread

Snow and ice may not be completely washed off.

Facilities are fixed so there may limited accessibility on the road

The driver is responsible for the cost associated with the wash.

Costs range from \$30 to \$75 and are typically not covered by the carrier.

Blue Beacon owns and operates over 100 truck wash locations across the US and Canada. Each location is open 24 hours a day, 7 days a week for your convenience. At Blue Beacon, we pride ourselves in serving your truck washing, RV washing and trailer washout needs in a friendly and courteous manner. We appreciate your business and want you to be satisfied.

Located at the country's finest travel plazas, Blue Beacon Truck Washes are conveniently located and provide easy access for even the biggest rigs. With over 100 - 24hr locations and growing, and more than 40 years of experience, Blue Beacon Truck Washes is the most recognized and trusted truck washing service in the nation.

You can count on us to consistently deliver a high quality wash in the shortest amount of time possible. Our prices are among the lowest in the industry, and we accept most credit cards and checks.

### Tractor Only

Conventional	\$40.50
Tractor when washed with any trailer or washout	\$33.50

### Tractor/Trailer

Tractor/Van Trailer	\$63.50
Tractor/Flat Trailer	\$55.00
Tractor/Small Tanker	\$65.00
Tractor/Large Tanker	\$70.50

### Trailer Only

Van Trailer Only	\$30.00
Flat Trailer Only	\$21.50
Small Tanker Only	\$31.50
Large Tanker Only	\$37.00

### Protectant

Tractor	\$4.00	\$8.00
Trailer	\$6.00	\$12.00

<p>Heated trailer roofs coming to Canada?</p> <p>UK company says it has solution to snow and ice accumulation</p> <p><b>By James Menzies TORONTO, Ont. 2008-04-01</b></p> <p>Climbing atop a trailer to remove snow and ice is a workplace hazard, and strongly discouraged by workers' compensation agencies in Canada. But on the other hand, police are inclined to ticket a driver for failing to remove the wintry debris.</p> <p>There appears to be a potential solution out there. William Tudor, president of Erythros Technologies International contacted <i>Truck West</i> after reading a blog entry on trucknews.com about trailer-top snow and ice accumulation.</p> <p>His company has developed a roof-top system that prevents snow and ice from collecting in the first place. It consists of a series of panels (10 would be required for a 53-ft. van trailer) which capture solar energy and store it in small, watch-sized lithium batteries. When the temperature drops below 35 F (2 C), the system turns on and warms the panels to 45-50 F (7-10 C) to prevent snow and ice from accumulating. When the temperature is above 2 C, the system hibernates.</p> <p>It works on untethered trailers as well as those that are attached to power units, Tudor told <i>Truck West</i> in a recent interview from the U. K.</p> <p>"You don't have to worry about turning it on," explained Tudor, who learned all about the dangers of snow and ice accumulation while working as a truck driver in the US. "These trailers sit in the yard and it's not sticking, so they're ready to go which is a major plus for drivers and trucking companies. They don't have to worry about trailer turnaround and drivers getting citations."</p> <p>The company has been in talks with Liberty Linehaul to begin testing the system here in Canada next winter. Currently, the largest obstacles to bringing the system to market are the manufacturing cost and life-expectancy, Tudor admits. The company is aiming to design a system that will last more than 10 years and it is seeking suppliers that can help drive down the manufacturing cost.</p> <p>By the time the system is rolled out, Tudor said it should cost no more than \$300 per trailer.</p> <p>The entire system weighs about 78 lbs - significantly less than a rooftop full of snow and ice. When the sun isn't out, the heating coils are powered by the batteries which last for up to 24 hours before needing to be recharged by the solar panels. Tudor said the batteries are designed specifically to perform in extremely cold weather.</p>	<p>Has not been produced and is not in use</p> <p>Will keep snow and ice off the trailer</p> <p>Attached to the trailer which provides greater accessibility than the alternatives</p> <p>Renewable source of energy</p> <p>Weigh 78 lbs</p> <p>Battery life is short at about 24 hrs between charges.</p> <p>\$300 per trailer.</p> <div data-bbox="1096 1129 1443 1339"> <p><a href="http://www.trucknews.com/news/heated-trailer-roofs-coming-to-canada/1000221965/">http://www.trucknews.com/news/heated-trailer-roofs-coming-to-canada/1000221965/</a></p> </div>
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Interview with Denny Merk of RAM Freight RAM Nationwide, Inc.  
240 Northbend Road Cincinnati, OH 9-16-13

Large trucking facility.  
\$75 to clean a truck at a truck stop.  
Truckers might not do the extra work so the less labor the better.  
Must be a fast process because time lost is money lost.  
Simplicity is a plus.  
Want to keep the integrity of the trailer.  
Definitely not permanent.  
No maintenance and minimal moving parts.  
Fuel, downtime, and safety are all important.

Interview with Mike LaCalameto, GM at OptiVia Logistics 513-967-0896  
3574 East Kemper Rd. Cincinnati, Ohio 9-12-13

Large trucking facility.  
Very interested in the idea.  
Gave me contacts in UPS and RAM  
The faster the better.  
Permanent may be ok.  
Snow or ice shouldn't fall near operator.  
No maintenance.  
Fuel, downtime, and safety are all important.  
Advised me to get a patent quickly.  
Shouldn't be too expensive.

## APPENDIX B – SURVEY

### SEMI TRUCK TRAILER PORTABLE SCRAPER CUSTOMER SURVEY

The cleaning of truck trailers in the trucking industry today is difficult and dangerous. The development of this scraper will give truckers the ability to clean their trailers from ice, snow, and other debris. This scraper will keep truckers safe, keep fellow motorists out of harm's way, and leave your company less liable. The features listed below will be incorporated in to the design.

**How important is each feature to you for the design of semi truck trailer portable scraper?**

**Please circle the appropriate answer. 1 = low importance 5 = high importance**

							<b>Avg</b>
Durable	1(0)	2(2)	3(9)	4(6)	5(3)	N/A (0)	3.5
Light Weight	1(0)	2(0)	3(4)	4(9)	5(7)	N/A (0)	4.15
Easy to Install	1(0)	2(0)	3(8)	4(11)	5(1)	N/A (0)	3.65
Safe	1(0)	2(0)	3(1)	4(8)	5(11)	N/A (0)	4.5
Easy to Operate	1(0)	2(0)	3(5)	4(8)	5(7)	N/A (0)	4.1
Reliable	1(0)	2(0)	3(10)	4(8)	5(2)	N/A (0)	3.6
Easy to Store	1(0)	2(3)	3(8)	4(7)	5(2)	N/A (0)	3.4
Operates Quickly	1(0)	2(0)	3(6)	4(10)	5(4)	N/A (0)	3.9
Small in Size	1(0)	2(4)	3(7)	4(9)	5(0)	N/A (0)	3.25

**How much would you be willing to spend for this product?**

\$50-\$100(2)    \$100-\$200(4)    \$200-\$500(6)    \$500-\$1000(5)    \$1000-\$2000(3)

**Thank you for your time.**

## APPENDIX C – QFD

Mazen Shteivi Truck Trailer Scraper 9 = Strong 3 = Moderate 1 = Weak`	No tools necessary	One person install	> 3 ft between operator and fall of debris	Safety guards covering moving parts	Hand crank system that produces work	Reverse capability	Storage in the cab or attachment to trailer	Withstand impact force 12 ft drop	Rust resistant metals	Ductile and lightweight metal	Withstand temperatures from -30F to 130F	Operating life of 40 years	Clean the trailer in under 4 minutes	Volume of 4 ft x 1.5 ft x 2 ft	Customer importance	Planned Satisfaction	Improvement ratio	Modified Importance	Relative weight	Relative weight %
Durable								9	3	9	9	3			3.5	3	0.9	3.0	0.10	10%
Light Weight										9					4.15	3	0.7	3.0	0.10	10%
Easy to Install	9	9					3								3.65	3.5	1.0	3.5	0.11	11%
Safe			9	3											4.5	4.5	1.0	4.5	0.15	15%
Easy to Operate	1	1			9	9									4.1	4	1.0	4.0	0.13	13%
Reliable								9	3	3	9	3			3.6	3	0.8	3.0	0.10	10%
Easy to Store							9							9	3.4	2.5	0.7	2.5	0.08	8%
Operates Quickly						3							9		3.9	4	1.0	4.0	0.13	13%
Small in Size							3							9	3.25	3	0.9	3.0	0.10	10%
Abs. importance	1.16	1.16	1.33	0.44	1.18	1.57	1.38	1.77	0.59	2.07	1.77	0.59	1.18	1.62	17.8			30.5	1.0	1.0
Rel. importance	0.07	0.07	0.07	0.02	0.07	0.09	0.08	0.10	0.03	0.12	0.10	0.03	0.07	0.09	1.0					

## **APPENDIX D – PRODUCT OBJECTIVES**

Below each feature is followed by the method or objective that will be used for the prototype design. The following is a list of product objectives and how they will be obtained or measured to ensure that the goal of the project was met.

### **Safe (15%)**

- Will prevent ice or snow from falling within 3 ft of the operator
- Attachment to the trailer will keep the system attached at all times until the operator removes it
- System to slow down the moving scraper so that it doesn't fall off the trailer
- Safety guards covering moving parts

### **Easy to Operate (13%)**

- Hand crank system that produces the work needed to move the scraper across the trailer
- Reverse capability

### **Operates Quickly (13%)**

- Will completely clean the trailer in under 4 minutes

### **Easy to Install (11%)**

- No tools necessary
- One person install
- Installed in under 1 minute
- Replaceable blade

### **Light Weight (10%)**

- Light enough to be carried and handled by an average size and strength male

### **Durable (10%)**

- Structure of design will withstand impact force of being dropped from 12 ft.
- Rust resistant metals will be used
- Ductile and lightweight metal used for the base of the system
- Scraper blade will withstand temperatures from -30F to 130F
- System will operate in and withstand all weather conditions in temperatures from -30F to 130F

### **Reliable (10%)**

- Will have an operating life of 40 years based on 30 average uses per year

### **Small in Size (10%)**

- Will fit in to a volume of 4 ft x 1.5 ft x 2 ft

### **Easy to Store (8%)**

- Will fit in the cab or attach to the outside of the trailer



## APPENDIX E – SCHEDULE

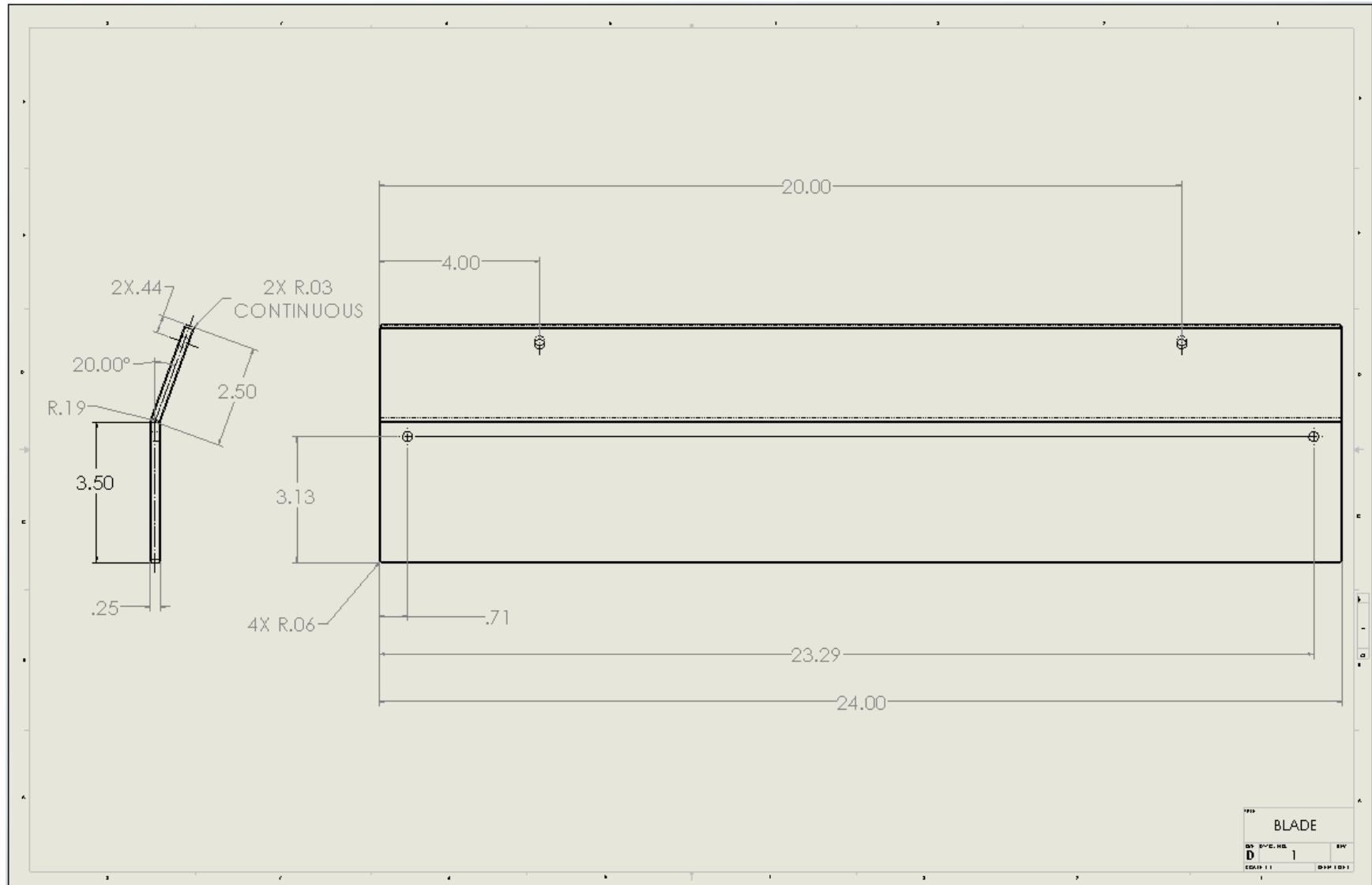
Mazen Shteiri Truck Trailer Scraper	Sep 29 - Oct 5	Oct 6 - 12	Oct 13 - 19	Oct 20 - 26	Oct 27 - Nov 2	Nov 3 - Nov 9	Nov 10 - 16	Nov 17 - 23	Nov 24 - 30	Dec 1 - 7	Dec 8 - 14	Dec 15 - 21	Dec 22 - 28	Dec 29 - Jan 4	Jan 5 - Jan 11	Jan 12 - 18	Jan 19 - 25	Jan 26 - Feb 1	Feb 2 - 8	Feb 9 - 15	Feb 16 - 22	Feb 23 - Mar 1	Mar 2 - 8	Mar 9 - 15	Mar 16 - 22	Mar 23 - 29	Mar 30 - Apr 5	Apr 6 - 12	Apr 13 - 19	Apr 20 - 26
<b>TASKS</b>																														
Content review (advisor)			17																											
Proof of Design Agree (advisor)			24																											
Concepts/Selection (advisor)				31																										
3D Model - (Blade and Frame)				31																										
3D Model - (Hand Crank System)					6																									
3D Model - (Folding/Storage Mechanism)						18																								
Design Calculations								2																						
Design Freeze									9																					
Bill of Materials														6																
Shop Drawing															13															
Order Parts																20														
Oral Report																	27													
Report Due																		3												
Fabrication																			17											
Assembly																				24										
Testing																					3									
Modification																						7								
Final Testing																							10							
Advisor Demonstration																									27					
Expo																										3				
Oral Report																											7			
Project Report for Review																												14		
Project Pdf Due																													21	

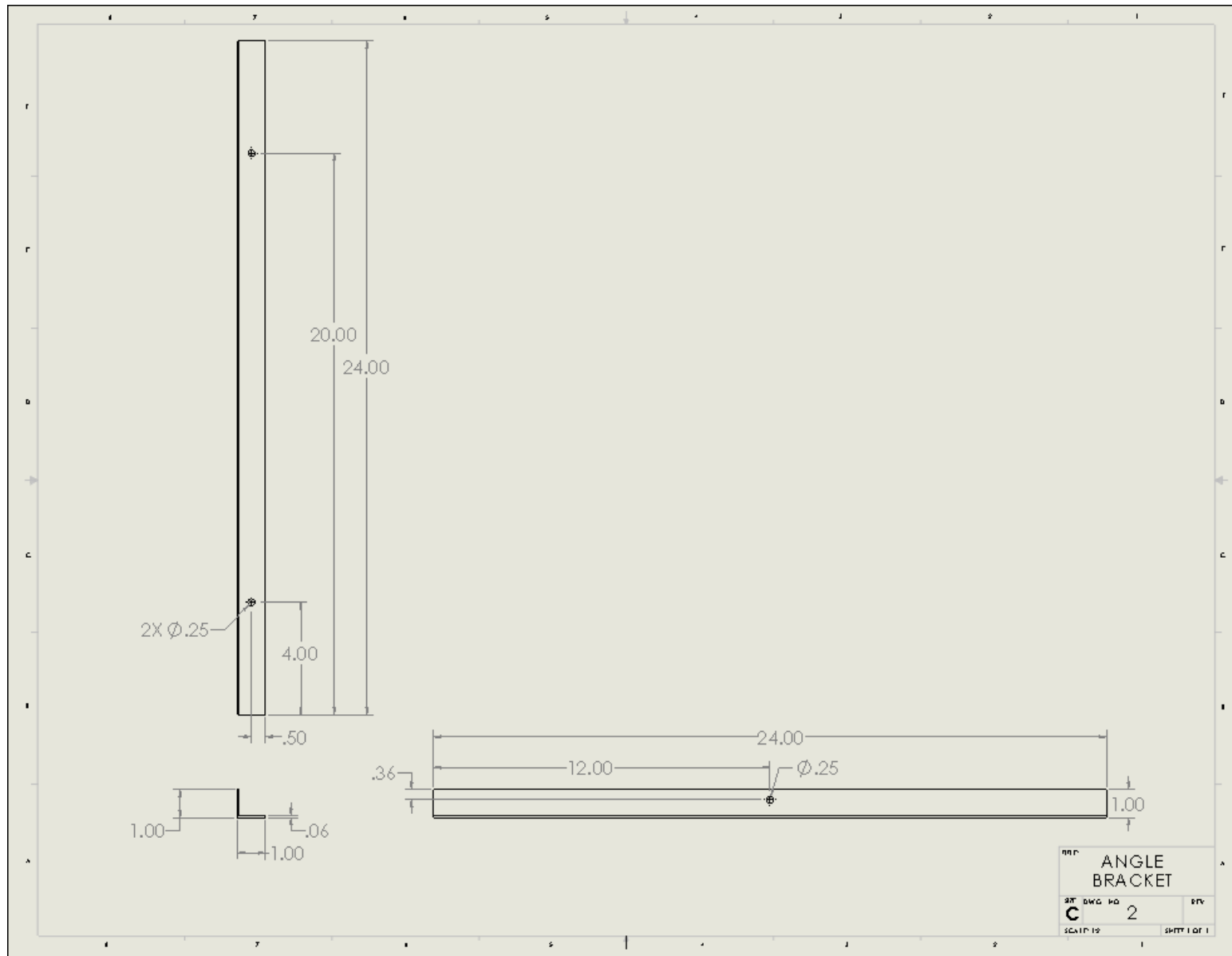
## APPENDIX F – BUDGET

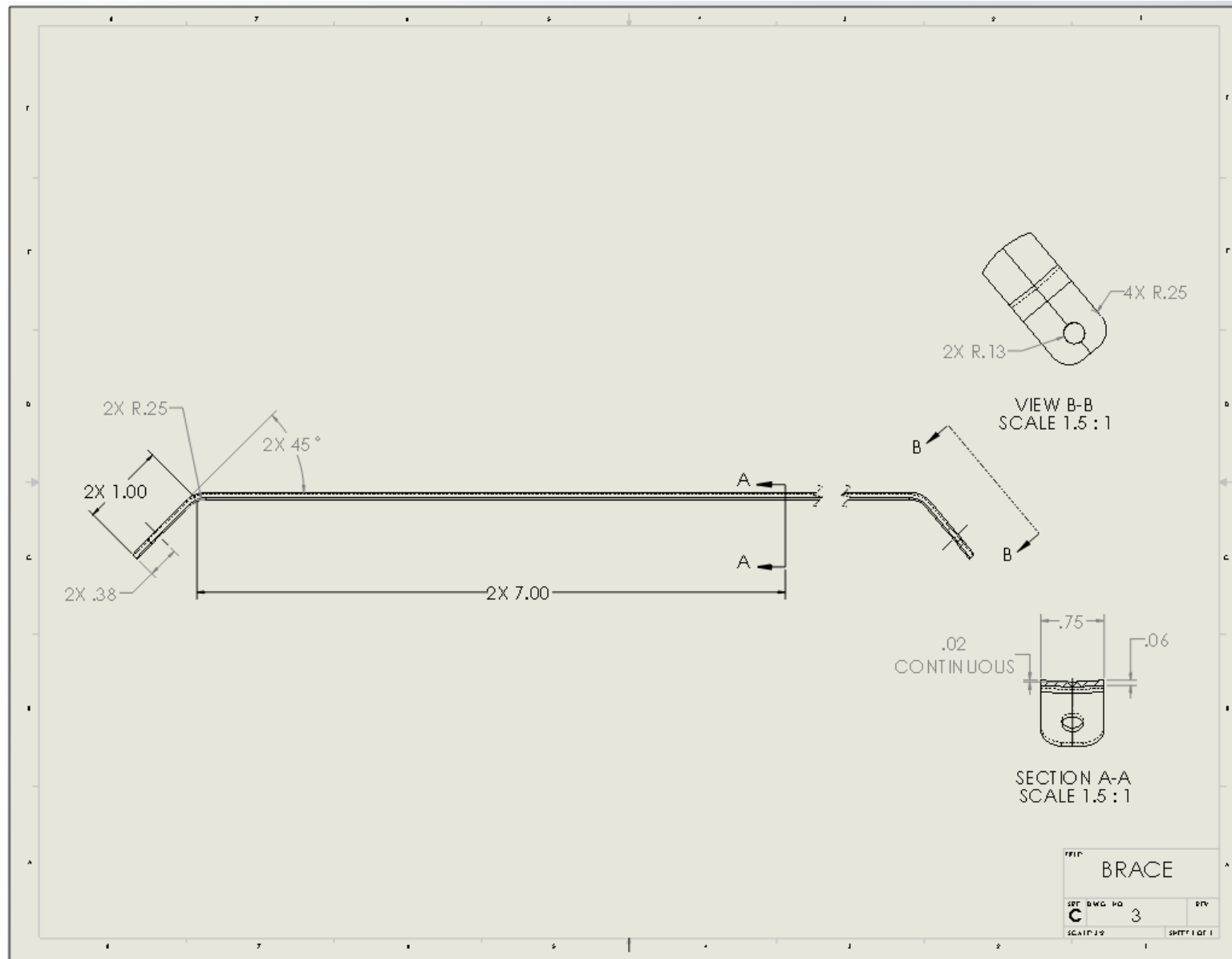
Project Budget		
Materials/Components/Labor	Forecasted	Actual
Aluminum Blade	\$ 80.00	\$ 45.00
Telescopic Tubing	\$ 150.00	\$ 50.00
Aluminum Tubing	\$ 30.00	\$ 20.00
Machining	\$ 100.00	\$ -
Telescoping Buttons	\$ 10.00	\$ 3.00
Rubber Edge Guards	\$ 15.00	\$ 3.00
Nuts/Bolts	\$ 5.00	\$ 3.00
Misc.	\$ 78.00	\$ 15.00
Total	\$ 468.00	\$ 139.00

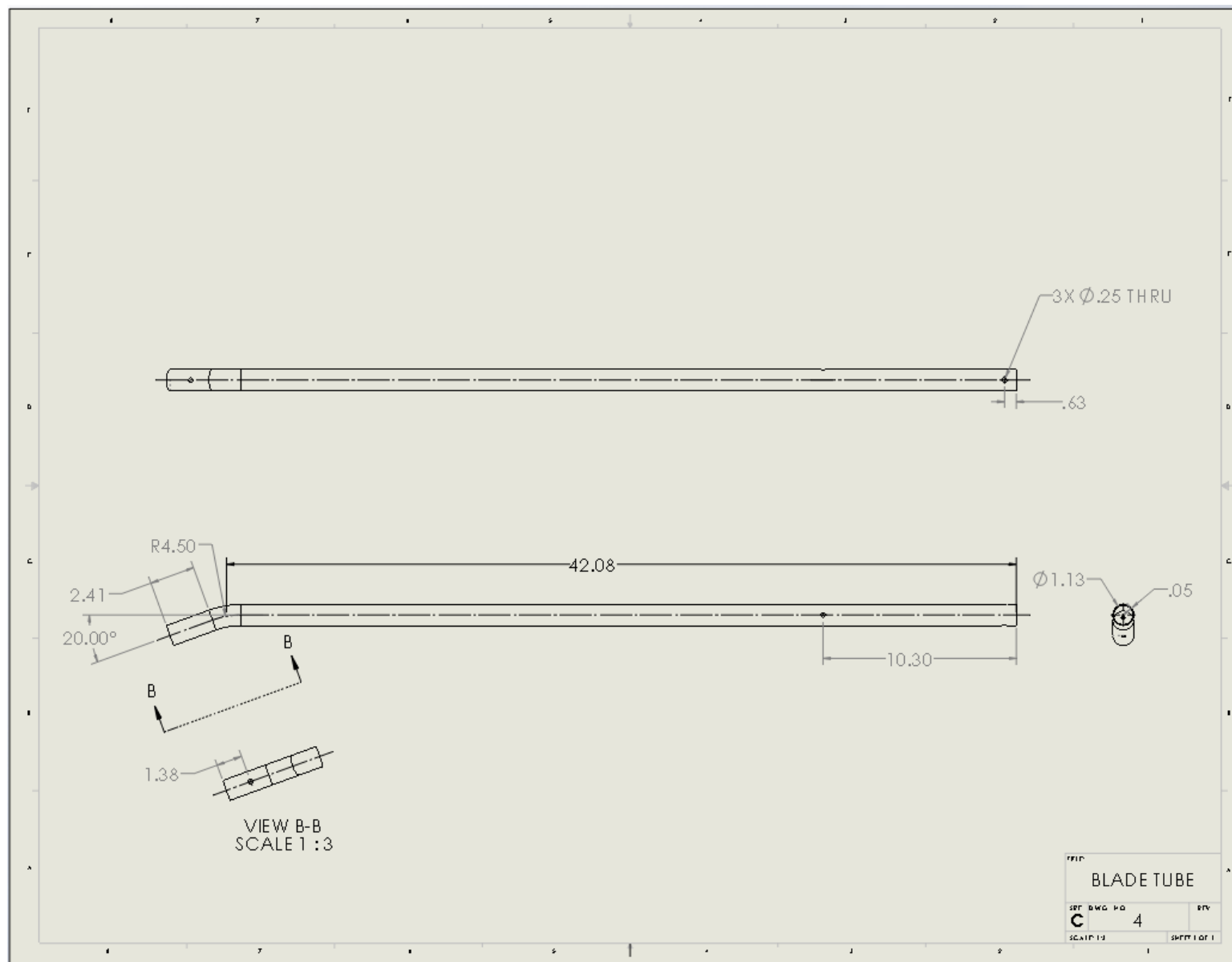


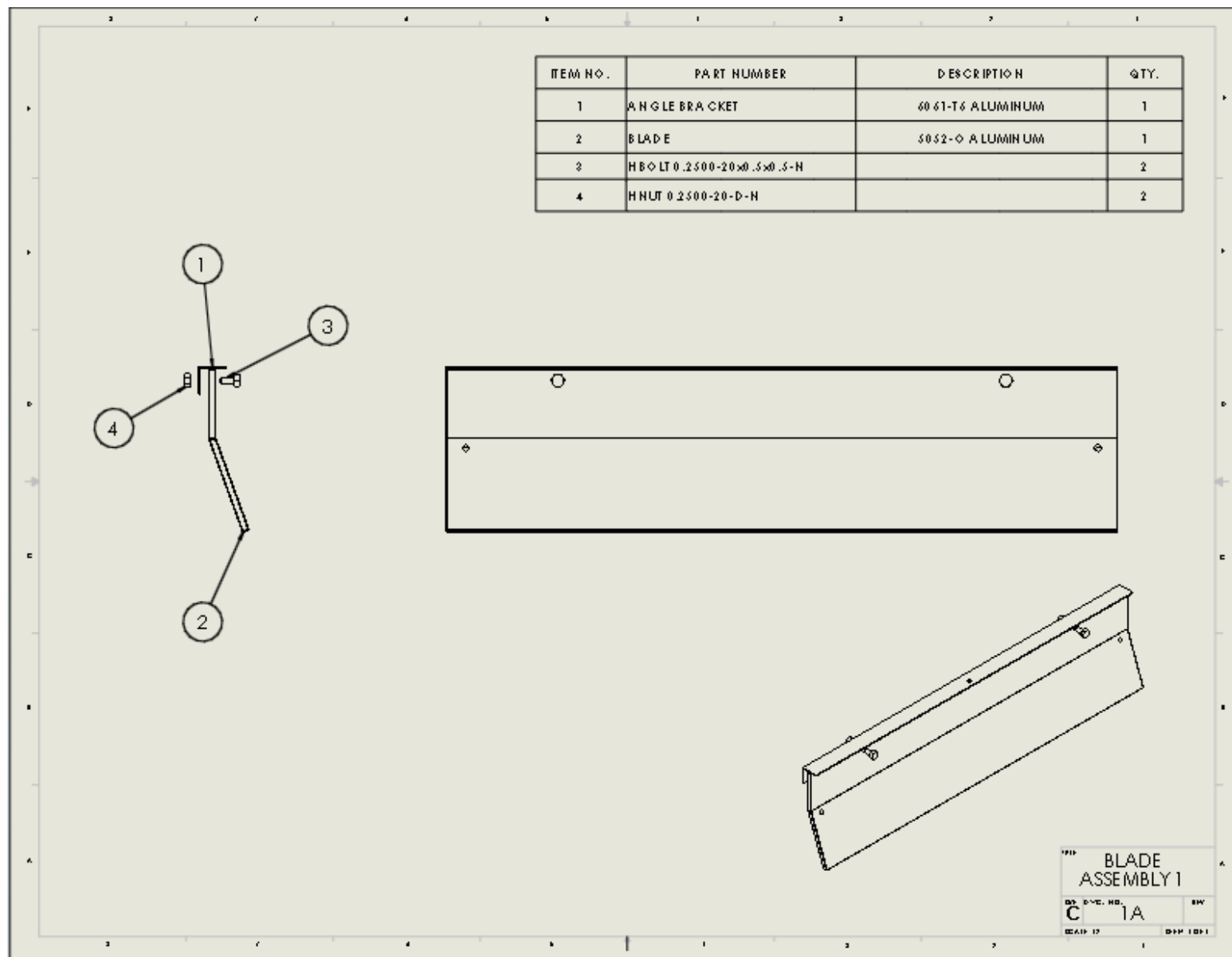
## APPENDIX F – ASSEMBLY AND DETAIL DRAWINGS



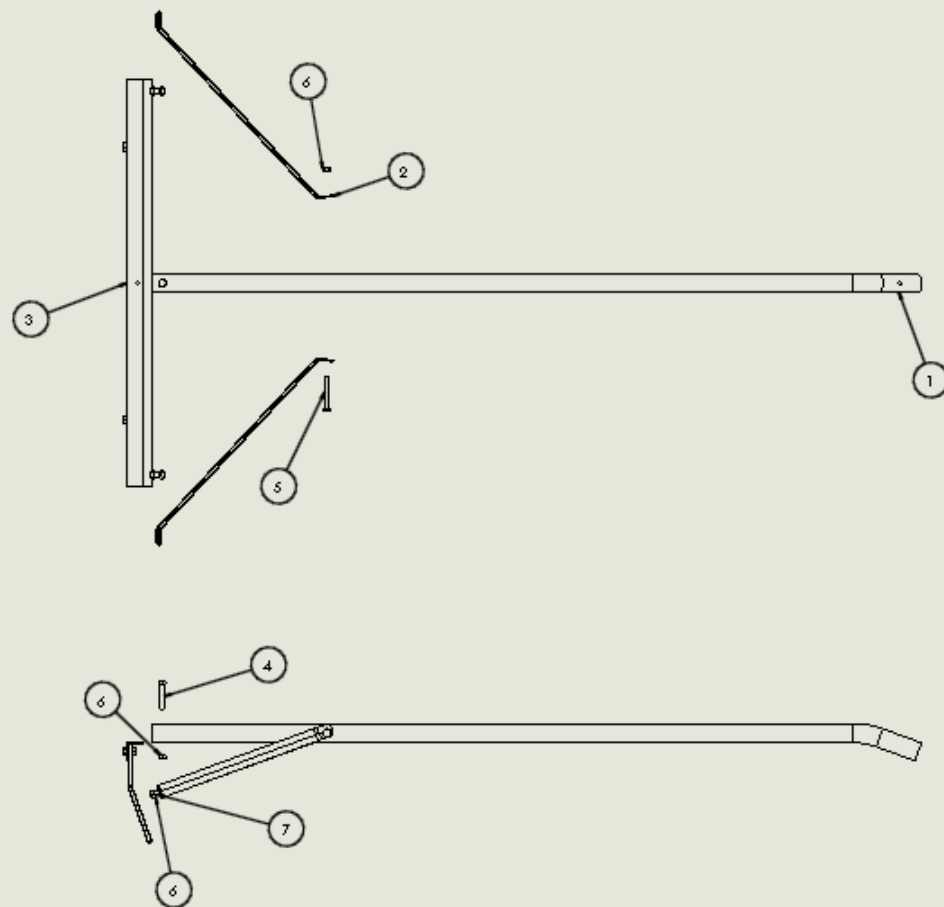




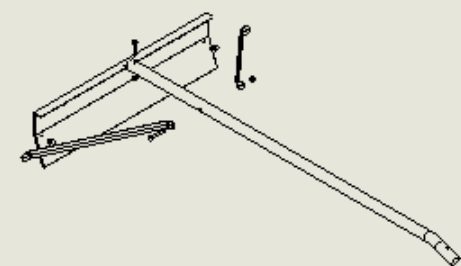






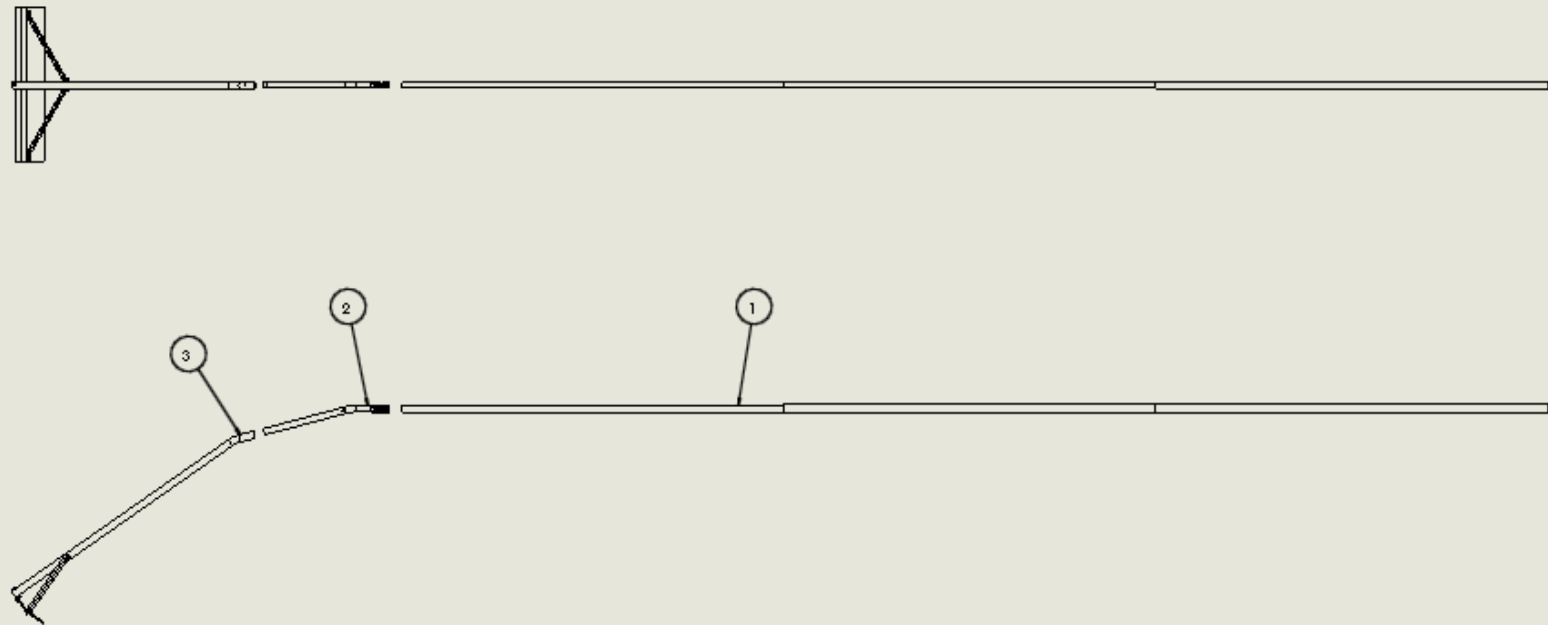


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	BLADE TUBE	SDS1-16 ALUMINUM	1
2	BRACE	SDS1-16 ALUMINUM	2
3	BLADE ASSEMBLY 1		1
4	WRENCH D2500-20N SDS75-N		1
5	WRENCH D2500-20N SDS75-N		1
6	WRENCH D2500-20N		1
7	WRENCH D2500-20N SDS75-N		2



BLADE  
ASSEMBLY 2

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	TRUE TEMPER	TELESCOPIC TUBING	1
2	CENTER TUBE	6061 T-6 ALUMINUM	1
3	BLADE ASSY 2		1



TRUCK TRAILER  
SCRAPER  
REV. 10  
D 10

APPENDIX G – PURCHASED COMPONENTS



PRODUCT OVERVIEW

The Telescoping Roof Rake is the most innovative roof rake in years. The push-button, telescoping design make it sleek and collapsible for easy storage. This snow roof rake can help prevent structural and water damage to your home that can result from heavy snow left on your home's roof. It's designed for strength and durability with lightweight aluminum and temperature resistant plastics. The handle enables a very long reach and it's easier and safer to use than climbing up on your roof with a snow shovel.

- Ships unassembled
- Aluminum handle extends to 17 ft.
- Non-slip handle treatment for control
- End grip helps hand placement
- 24 in. wide poly blade

[Return To](#)

SPECIFICATIONS

Assembled Depth (in.)	6.5 in	Assembled Height (in.)	86 in
Assembled Width (in.)	24 in	Garden Center Tool Type	Roof Rake
Handle length (in.)	86	Head Height (in.)	6
Head Material	Poly	Manufacturer Warranty	None
Product Weight (lb.)	4.88	Rake Width (in.)	24
Returnable	90-Day		

True Temper 17 ft. Telescoping Roof Rake

Model # 193055510 Internet # 202943651 Store SKU # 486611

★★★★★ (58) [Write a Review](#)

\$46.97 / each



**AIRPARTS, INC**  
2400 Merriam Lane  
Kansas City, KS 66106 USA

Telephone: 913-831-1780

## Invoice 93916

**Customer SHTMAZ**

**Bill To:**

Mazen Shteivi  
1 Hidden Hills Ct  
Fairfield, OH 45014

**Ship To:**

Mazen Shteivi  
1 Hidden Hills Ct  
Fairfield, OH 45014

Date		Ship Via		F.O.B.		Terms	
03/27/14		U P S		ORIGIN		MASTERCARD	
Purchase Order Number			Order Date	Salesperson		Our Order Number	
VERBAL			03/27/14	PAM			
Quantity		Item Number	Description	Tax	Unit Price	Amount	
Req.	Ship						
6		6 11/8.058T6	1 1/8 x.058 6061T6 TUBE (CUT 4' & 2' pcs)	N	3.55	21.30	
1		1 SHIP	SHIPPING	N	14.69	14.69	
						NonTaxable Subtotal	35.99
						Taxable Subtotal	0.00
						Tax	0.00
						Total Invoice	35.99
						Paid/Applied	35.99
						Pay Disc. Applied	0.00
						Balance Inv.	0.00

Customer Original

Page 1



## Crown Bolt 1 in. x 36 in. Aluminum Angle Bar with 1/16 in. Thick

Model # 41950 Internet # 202183481 Store SKU # 470983

★★★★★ (1) [Write a Review](#) +

**\$5.37** / each

**7 in Stock at Crescent Springs #2324**

**Aisle 14 Bay 017**

[\(change pick up store\)](#)

## Button Clip - Stainless Steel - Fits Inside Tube Diameters - 0.50 to 0.75 - Button Diameter 0.24 inch (1139-SS)

### More Info...

Button diameter = 0.24" - Fits tubes with inner diameter 0.5" - 0.875"

### Quick Stats & Add to Cart

SKU	Finish	Inside Diameter (in.)	Outside Diameter (in.)	Wall (in.)	Weight (lbs./ft.)	Length (in.)
1139-SS	Stainless Steel	0.5	0.75	0.25	0.006	1.44

Pricing  
1 to 10 \$1.89  
11 to 999 \$1.57

1 [Add](#)

## APPENDIX H – BILL OF MATERIALS

Bill of Materials				
Item	Description	Quantity	Price Each	Total
True Temper Telescopic Tubing		1	\$ 46.97	\$ 46.97
Blade		1	\$ 40.00	\$ 40.00
Blade Bracket		1	\$ 5.37	\$ 5.37
Blade Tube		1	\$ 35.99	\$ 35.99
Brace		2	\$ -	\$ -
Button Clips		2	\$ 1.89	\$ 3.78
1/4 X 1 1/2 Bolt	HBOLT 0.2500-20x1.5x0.75-N	2	\$ 0.17	\$ 0.34
1/4 X 1/2 Bolt	HBOLT 0.2500-20x0.5x0.5-N	4	\$ 0.11	\$ 0.44
1/4 Nut	HNUT 0.2500-20-D-N	6	\$ 0.15	\$ 0.90
1/4 Washer	FW .25	6	\$ 0.15	\$ 0.90
			Total =	\$ 134.69