Solar Powered Car Camping Pull-Out Station

A Baccalaureate thesis submitted to the
Department of Mechanical and Materials Engineering
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

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April 2021

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ABSTRACT

This project was conceived since both individuals working on this are individuals who enjoy the outdoors. This idea was born from experiences and wishes of having a similar product. From there was a lot of research done regarding the components to include in the station and how the station would house those said components. After the research, calculations were made, and 3D models were made to test theoretical values. Once construction began, there were a couple of bumps along the road. First, items arrived later than anticipated. Then we had to return certain items as well, not helping with that time. Second, we had to move from using different vehicles several times. It was originally intended for a Jeep Wrangler, but due to unforeseen circumstances it was adapted for a Honda Pilot. The actual fabrication did not take too long just a day really to build due to the use of materials and tools.

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

Car Camping is starting to become a very popular hobby for many new outdoor adventurers, but unless you are driving an RV or camper you have a very limited number of supplies and space. With the growing concerns for forest fires, people are trying to move away from using fire pits and gas-powered stove tops, and instead are transitioning into using electric powered stovetops. But what happens when those electrical appliances drain one's car battery? What happens if one is camping, and they end up stranded without that many supplies. The problem is that consumers who are experiencing the outdoors with their vehicle do not always bring emergency/survival supplies, but what if by bringing one item, you can increase your chances of survival?

RESEARCH

BACKGROUND AND SCOPE OF THE PROBLEM

If you have ever gone camping/on a trip there is always a chance of needing emergency/survival gear. Not only do you need emergency gear but having solar powered utilities all combined into a station in the back of your car can be very beneficial. Having solar powered products increases efficiency, decreases battery waste and can be used when no grid connection is available (1). Nowadays you can only get solar products sold separately and not as a compact station. There are no products that combine solar safety products and camping products into one.

There are many people impacted by camping safety, but this product is geared towards people who go camping with their car in proximity. Many people who are taking a road trip or going to a music festival need compact solar powered gear located in their car. Those people will need cooking equipment, a water source and even simple charging stations in case your phone dies. According to the North American Camping Report, the sheer number of households that camped at least once grew nearly 7.2 million households since 2014 (2). Back in 2016, the average adult spent about $550 on camping gear alone, not including travel expenses. As the number of campers increases so does the possibility of accidents to happen. Not only will more lives be in danger, but with more new campers there will be more expenses on camping as well. In 2018, about one in every twenty camping households stated that they had camped for the first time.

Currently one way this problem is being addressed is by offering the user light via your car. "The utility model discloses a multi -functional open-air emergency light of camping, including lamp holder, lamp shade and light source board..." (3). This only addresses the dangers that the darkness may bring such as potential predators, but it does not address the need to heat up food, purify water, or even potentially charge any electronic devices one may have. If one quickly searches "car survival kit" the first thing that shows up are just bags filled with essentials such as sleeping bags, jugs of water, flares, etc. This is your "typical" survival bag, but we assume that the user has some sort of version of this, as this kit usually doesn't include table space, charging ports, water purification, and a stove top of some sort. For the water purification aspect, there is an interesting concept out there that purifies water via the cars heat exhaustion. ".. aims at harvesting residual heat from Internal Combustion engines to purify water." (4) Although this is a brilliant idea, what happens

when one is stranded with no gas?

Additionally, solar powered products are becoming increasingly popular due to their ease of use and environmental benefits. They are a greener way of using energy that will help you in any situation when you are without power. If you ever find yourself in an emergency/survival situation and have use of your car, you do not want to drain the battery just trying to charge your phone or running your air conditioner. Many solar powered products on the market now are just separate products. There is not a solar powered "station" aimed for survival/emergency situations. There are many solar powered stoves that were first geared towards countries without as much electricity and for disaster relief areas (5). These stoves are just the stoves themselves with nothing else. We want to create a survival "station" for the back of your car that will include a stovetop/griddle, water purification, charging station and storage all powered by solar energy.

CURRENT STATE OF THE ART

Solar Powered/Multiple Fuel Cooking Device

This device is very simple and uses solar radiation, charcoal, heating candles, gas, or electricity (6). This product uses solar reflectors to cook the food. This device is good for outdoor camping because it is very simple to use and the reflectors are a cheaper way to generate a source of heat from the sun. This product can also be used with many other "fuel alternatives when solar radiation is not available" (6). The only cons of this stove are that it is very large and must be set up at an angle where the sun will reflect off the reflectors. It also does not store any energy by using solar panels.

Solar Powered Portable Water Purifier

This portable water purification system consists of a cabinet on wheels. This cabinet is "covered with solar cells, a first inlet pipe for receiving contaminated water, a pump mounted inside said cabinet, a plurality of water filters connected together serially to perform filtration on the pumped water, an ultraviolet radiation chamber that radiates ultraviolet rays into the water being purified at the final stage and an outlet pipe for receiving and dispensing purified water." (7) The pros of this design are that it is "self-contained, highly mobile and relatively light weight" (7). The cons of this design are that it is a little too large to be added to the whole survival product. It also requires a lot more electricity which means adding more solar panels to the design.

Solar Powered Tabletop Charging Station

This tabletop device has a "base structure for stabilizing the device and for providing one or more compartments for storing items therein and/or providing a docking station or cellular phone charging station, a shade structure which contains one or more solar cells attached to an outer surface thereof, an attachment arm which connects the base and the shade structure, and various electronic components operative to convert solar energy into electricity." (8) The pro for this device is that it can charge three phones and keep them shaded with an "umbrella like" structure that has the solar panels on top (8). The "umbrella like" structure allows you to move the solar panels to get the most direct light from the sun. The only con to this design is that it is only a charging station for phone. It does not let you plug anything else in to be charged

Portable Picnic Table for Tailgate Parties

This portable table attaches to the trailer hitch of a vehicle for use at tailgate parties and camping. There are two main beams that make up this table the main beam and the mounting beam. They intersect and for a "T" shape. The mounting member as its name applies is the beam that connects directly to the vehicle hitch, while the main member holds and supports the table and the seats. The seats are attached to the main member by pivot connects at the ends of the beam. (9) The table is also connected via these pivot connections as well. These connections are constructed such that the seat and tabletop must be lifted vertically from their resting position before they can pivot outward. (9) Pros to this is that it is compact and can attach to the car itself without take space on the inside. Another pro is that it provides seats as well. Despite that, there are some cons. The first being that it is on the outside of the car. While it may not take any trunk space it will be exposed to the elements allowing it to potentially rust faster and be damaged. Additionally, the user sacrifices their trailer hitch for this table. Not allowing them to potentially connect a trailer.

Portable Utility Carrier Apparatus

This utility carrier consists of an upper frame/platform, a wheelbase, a lift system between the upper frame and wheelbase, and a squared hitch (10). The raisable and lowerable platform may house a variety of cargo, from grills, toolboxes, camping gear, etc. This allows it to be truly versatile when going camping or exploring the outdoors. The carrier connects directly to the vehicle by a receiver type hitch assembly. Although it has wheels, the wheels are not used in the transportation aspect of the carrier. This is solely transported by the vehicle and its hitch assembly. A pro to this product is that it as the versatility to be what the consumer wants it to be. There is no need to even use it for camping, as one can set it up for a tool station in a garage, but it also has the applicability to be used for camping gear, i.e. adding a grill, flat table, lantern, etc. A con though, like the product above is that it is still connected outside of the vehicle. Allowing it to be exposed to the elements and potentially rusting and being damaged.

END USER

The end user of this product would be campers/festival goers that camp with their car in proximity. This product would benefit them by providing them with solar powered camping gear and safety/survival gear in case of an emergency.

CONCLUSIONS AND SUMMARY OF RESEARCH

In conclusion, the number of new campers and the demand for more solar powered devices are increasing each year. Due to their ease of use and several benefits these devices such as solar powered battery packs and stoves are starting to be mentioned in lists for essential packing gear. But there is not really a station that includes all the following in one. The current state of the art for portable tables are all attached to the vehicles via hitches which allows the user to still maintain internal storage, but also exposes the carrier/table to the elements. By potentially have a low-profile carrier that can fit inside the trunk, we may be able to not only give the user sufficient space for their packing gear, but also increase durability of the main frame/base.

QUALITY FUNCTION DEPLOYMENT

CUSTOMER FEATURES

Affordability – The station is relatively low cost for the consumer: 5.0 Importance.
Compact – The station can be stored in a trunk without taking too much space: 4.0 Importance
Ease of Use – The station is user friendly and does not take much to learn how to operate: 3.5 Importance.
Ease of Set Up – Set up is quick and does not require much; user should be able to place in trunk and use from there: 4.0 Importance
Durability – The station can withstand the constant use and exposure to the outdoor elements: 5.0 Importance.
Lightweight – The station is relatively lightweight allowing the user to move easily: 2.0 Importance.

ENGINEERING CHARACTERISTICS

Material – The materials selected to construct the station will determine its strength, weather resistance, and weight.
Weight – Dependent on the material selection, this will allow for ease of use and movement
Tensile Strength (psi) – the resistance of a material to breaking under tension due to a pulling force
Durability – the station's ability to withstand wear, pressure, or damage, dependent on material
Water Filtration Ratio – The ration between how many debris and particles are removed compared to the volume of water
Size (in^3) – The amount of space or volume that the station takes within a car trunk
Weight Capacity – The maximum load both the table and its storage casing can hold without failure or deformation

HOUSE OF QUALITY

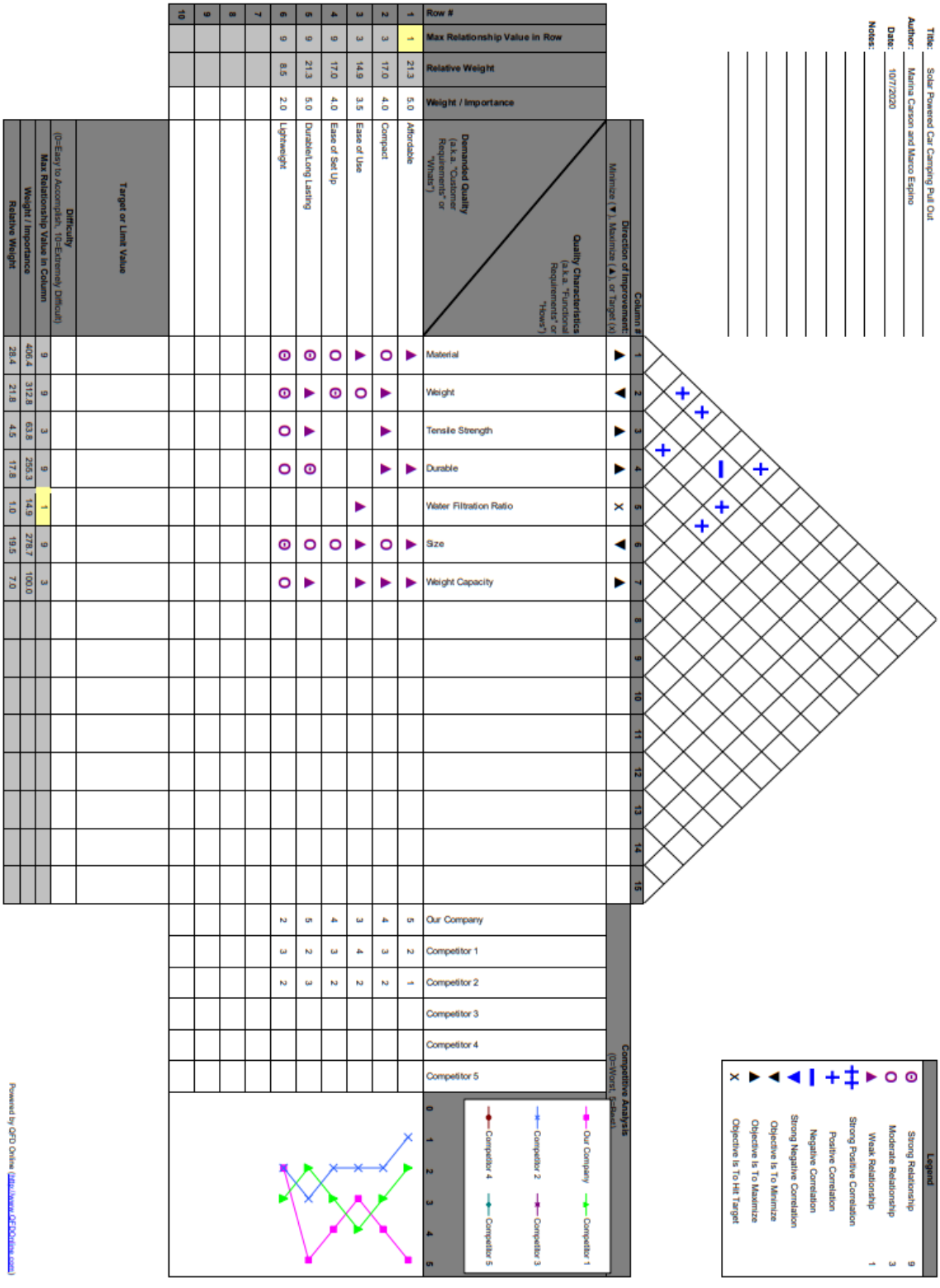

Figure 1: House of Quality

PRODUCT OBJECTIVES

- A design that takes up as little space in the trunk for other gear
- Easy to install in the vehicle and easy to operate
- Durable, giving the customer the most out of their money
- Select a material that is lightweight, allows for increase durability, and relatively cheap to buy

DESIGN

DESIGN ALTERNATIVES AND SELECTION

Housing

Concept 1: Slidable Station with Pull-out Legs

The slidable station allows the table, the portion which will house the features such as the stove top, solar panels, batteries, etc., to be stored within the base, the portion that will be sitting inside the trunk. This design allows for the base to remain stationary, meaning one can use this product and not have to move any gear on top. The legs are stored via hinges within the table, and the table slides out via rack and wheel system.

Concept 2: Foldable Station with Pull-out Legs

This design is like concept one regarding the legs and the base. The base, portion on the right, remains stationary within the trunk. When not in use the table sits on top of the base. This might cause the user to move their gear to use the station. Again, the features will be integrated with the table portion of the station. This locks via a clip that is on the side.

Concept 3: Cary Station with Lid and Pull-out Legs

This design features a simple base that also doubles as the table. The concept behind this is that once all gear is unloaded, the user essentially carries the station out of their trunk via handles on the sides. This requires the material to be light weight and strong enough as well. This design also features a lid to protect the features that will be incorporated into the table.

Criteria	Concept 1	Concept 2	Concept 3
Affordability	8	8	6
Form Factor	8	6	6
Ease of use	7	7	8
Ease of Set up	8	6	6
Durability	7	7	6
Lightweight	6	6	5
Total	44	40	37

Table 1: Design Matrix for Housing

Figure2: Concept 1

Figure 3: Concept 2

Figure 4: Concept 3

Configuration

Concept 1: Configuration

This design shows the stovetop and griddle in the right lower corner. The left lower corner shows a funnel system which will be the water filtration station. The top left corner shows where the charging station will be. The solar panels are off to the right side and they will be able to fold into the center when not in use or when being put away.

Concept 2: Configuration

Design 2 shows the charging station in the same place as design 1, but now the stovetop and griddle are in the bottom left corner. In the top right corner, there is a multi-use frame for a trash bag or to place a funnel for water filtration. The solar panels are place on a stand that can bend to reach the maximum sunlight.

Concept 3: Configuration

Design 3 shows the charging station and the stove in the same place. The multi-use frame is now placed in the front on the station. The solar panels are placed directly onto the station.

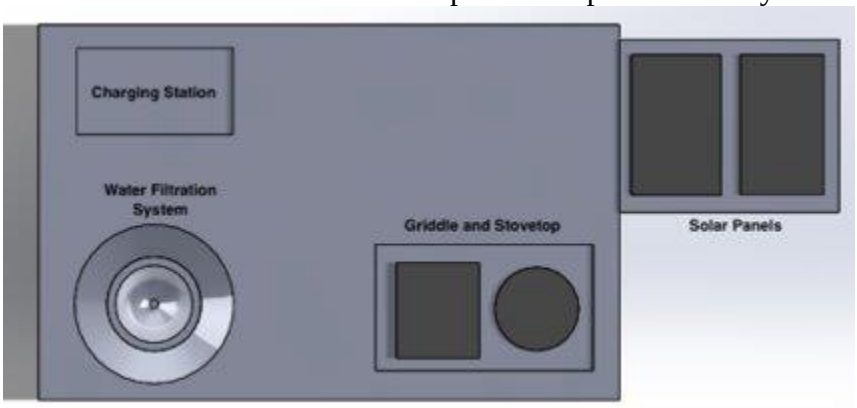

Figure 5: Concept 1

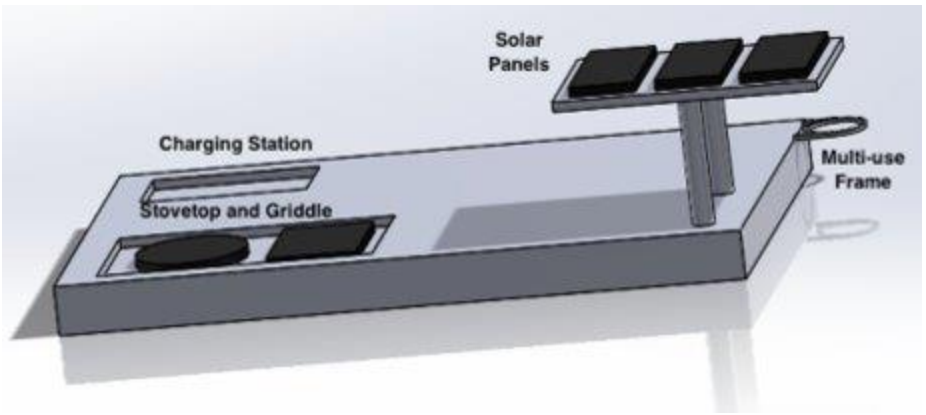

Figure 6: Concept 2

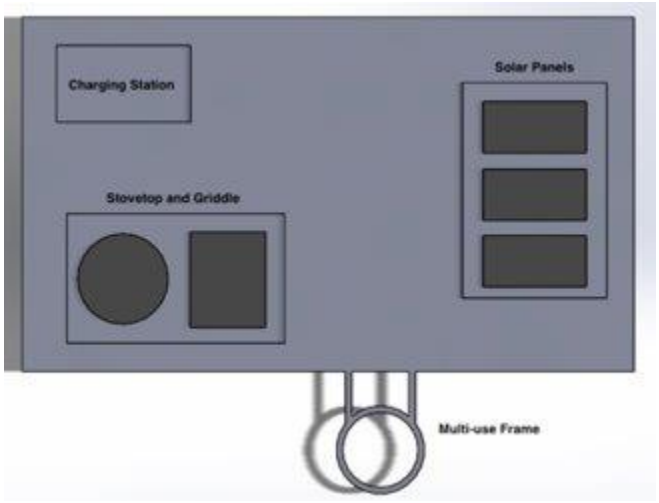

Figure 7: Concept 3

Criteria	Concept 1	Concept 2	Concept 3
Compact	8	9	8
Ease of Set up	9	8	9
Ease of use	8	9	9
Durable	7	7	6
Lightweight	8	8	8
Large Power Source	9	10	7
Total	59	61	57

Table 2: Design Matrix for Configuration

ENGINEERING CALCULATIONS

Components

$$Solar\ Panel:$$
$$Voltage = 12\ V$$
$$Watts = 300\ W$$
$$Weight = 19\ lbs$$

$$LED\ lights:$$
$$Voltage = 12\ V$$
$$Watts = 15\ W$$
$$Weight = 0.99\ lbs$$

$$Stovetop:$$
$$Voltage = 12\ V$$
$$Watts = 120\ W$$
$$Weight = 4.1\ lbs$$

Housing

$$F = 300\ lbs$$
$$Area = L * W = 48\ in * 36\ in = 1728\ in^2$$
$$\sigma = \frac{F}{A} = \frac{300}{1728} = .1736\ lb/in^2$$
$$F_{MAX} = 1150\ lbs$$
$$FoS = \frac{Max\ Strength}{Design\ Load} = \frac{1150\ lbs}{300\ lbs} = 3.83$$

$$Weight\ of\ Wood = 10\ lbs$$
$$Weight\ of\ Appliances = 30\ lbs$$
$$Total\ weight = 10 + 30 = 40\ lbs$$
$$Length\ of\ Drawer = 3.958\ ft$$
$$M_{Total} = Force * Length = 40\ lb * 3.958\ ft = 158.33\ lb * ft$$
$$M_{1,2} = \frac{M_{Total}}{2} = \frac{158.33}{2} = 79.167\ lb * ft$$
$$FoS = \frac{100\ lb * ft}{79.167\ lb * ft} = 1.26$$

Loading Conditions
Assumption: External Loading (distributed across the top of the base)
Assuming campers on average take ~150 lbs. of equipment

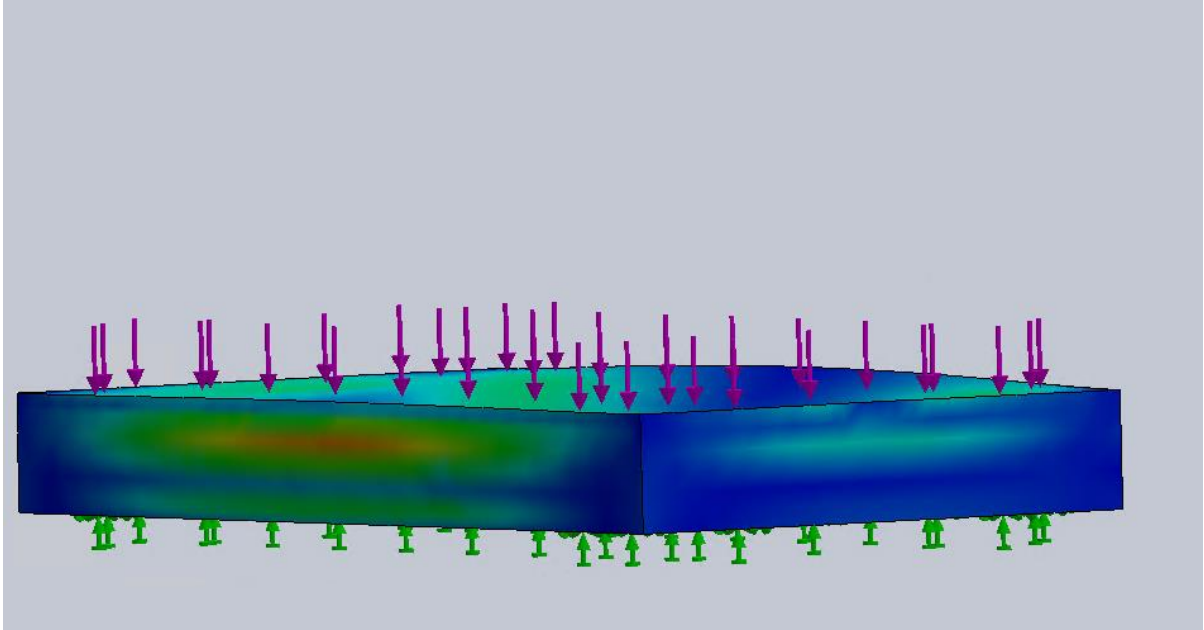

Figure 8: Stress Analysis

Material Selection
Based off stress, it was decided to choose lumber for its strength and weight
Based of the moment, it was decided to choose sliders that are rated at 100 lb*ft each

MANUFACTURING DRAWINGS

BILL OF MATERIAL

Component/Material	Price	Quantity	Total Price	Specs
Solar Panel Power Kit	139.99	1	139.99	110 W solar panel, 300 W power inverter
Stovetop	16.99	1	16.99	120 W, 4.1 lbs
Extra Charging Ports	11.99	1	11.99	4 ports, 5 V, 2.5 W
LED Lights	13.95	1	13.95	15 W, 16.4 ft
Water Filter	9.99	1	9.99	
12V 8Ah SLA Battery	19.99	1	19.99	12V, 8aH
1X4 Lumber	4.72	3	14.16	1in x 4in x 8ft
½-in Common Pine Plywood Sheathing	17.98	3	53.94	4ftx8ft
2-Pack 18-in Drawer Slide	15.98	1	15.98	28in, 100lbs cap

Table 3: Bill of Material

BUILD AND TEST

DISCUSSION OF THE MANUFACTURING PROCESSES UTILIZED

The prototype fabrication was very simple for this build. Since the material was wood there was no need for specialized tooling. The only tools used were nail gun, drill, and an electric saw.

Figure 9: Final Build

TEST PROCEDURE AND CRITERIA.

The areas that were tested from the QFD were the following: compactness, lightweight, ease of set-up/use, and durability. These were tested to be part of the housing rather than the components since the housing design has a direct impact on these criteria. To test compactness, the station was set-up to see how much storage would still be available after inserted. The lightweight test revolved around the number of people that is needed to move the station around (ideally one individual). To test set-up, we timed individuals to see how long it took them to insert the station into the car and get everything situated. Finally, durability was tested by placing items on top and slide the drawer compartment in and out.

TEST RESULTS AND FINDINGS

It was found that the station leaves a lot of space for the customer to use for other items or luggage. It was found that it only takes about seven percent of total space in a 2003 Honda Pilot trunk. Additionally, the lightweight test proved that indeed the station was lightweight only coming in at little under 27 lbs. Despite the low weight, the dimensions proved awkward to maneuver, thus it is recommended to use two individuals to move the station. This in turn affected the ease of set-up test. After seeing, the results from the lightweight test we time two individuals how long it would take them to be able to set up the station. On avg it took the couple about 36 seconds. Finally, the durability yielded positive results, but we did notice that the plywood started to bow in the center due to its long dimensions. These results are close to what the customer was looking for and it also addresses the problem statement.

The only section that could use improvement is making it a bit more compact to reduce the bowing and make it suitable for one individual rather than two.

PROJECT MANAGEMENT

BUDGET, PROPOSED/ACTUAL

Our Proposed Budget	$500			
Component/Material	Price	Quantity	Total Price	Actual
Solar Panel Power Kit	139.99	1	139.99	55.99
Stovetop	16.99	2	33.98	16.02
Extra Charging Ports	11.99	1	11.99	0
LED Lights	13.95	1	13.95	0
Water Filter	9.99	1	9.99	0
12V 8Ah SLA Battery	19.99	1	19.99	21.35
1X4 Lumber	4.72	3	14.16	12
1/2-in Common Pine Pl	17.98	3	53.94	0
2-Pack 18-in Drawer Slide	15.98	1	15.98	15.98
Total			313.97	121.34

Table 4: Proposed Budget v Actual Budget

SCHEDULE, PROPOSED /ACTUAL

Task Number	Task Name	Duration (days)	Start Date	End Date
1	SDI Formulation	53	24-Aug-20	16-Oct-20
2	Rackground research	11	24-Aug-20	4-Sep-20
3	Completed research	13	5-Sep-20	18-Sep-20
4	Complete survey	9	19-Sep-20	28-Sep-20
5	Complete HoQ	27	13-Sep-20	10-Oct-20
6	Complete Concept Drawings	27	19-Sep-20	16-Oct-20
7	SDII Design Development	50	16-Oct-20	5-Dec-20
8	Create Decison Matrix - Select a Concept	9	15-Oct-20	24-Oct-20
9	Finish Engineering Calculations	25	16-Oct-20	10-Nov-20
10	Finalize Desing/Drawing	35	16-Oct-20	20-Nov-20
11	Create Component List	29	16-Oct-20	14-Nov-20
12	Create Schedule/Budget	50	16-Oct-20	5-Dec-20
13	SDIII Manufacturing	80	11-Jan-21	4/1/2021
14	Purchase Materials	7	15-Feb-21	22-Feb-21
15	Manufacture	14	23-Feb-21	9-Mar-21
16	Build	12	10-Mar-21	22-Mar-21
17	Test Build	6	22-Mar-21	28-Mar-21
18	Tech Expo	0	1-Apr-21	1-Apr-21
19	Final Presentation			

Table 5: Schedule

SUSTAINABILITY AND MATERIAL USAGE

This project could benefit from have metal materials rather than wood. It would improve the longevity of the product. The main reason we went with standard lumber was due to cost. The lumber was used only for prototyping. Some of these items listed we were able to find around the houses or we knew others who had some extra.

CONCLUSIONS

In conclusion, the number of new campers and the demand for more solar powered devices are increasing each year. Due to their ease of use and several benefits these devices such as solar powered battery packs and stoves are starting to be mentioned in lists for essential packing gear. By potentially have a low-profile carrier that can fit inside the trunk, we may be able to not only give the user sufficient space for their packing gear, but also increase durability of the main frame/base. The product objectives that were gathered from the HoQ were all partially if not completely touched. We learned that the dimensions of the station affect the number of individuals it takes to setup. So, consideration of a housing redesign would be recommended. Another thing to consider when approaching this project was the time for delivery of our components. They took longer than expected, especially since we did not for see having to return any times. Consider this in the schedule. Overall, this prototype was successful in proving that it is possible to have a specific station like this.

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