Customizing an RC Truck for Towing and Racing

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Abstract

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Customer Needs and Requirements

Our customer has requested that our team re-design and customize an RC truck that can excel in both racing and towing applications. The team has been asked to re-design many aspects of the RC truck which includes: a new polymer body with Trine school pride, two sets of rims and tires, one specialized for racing and the other for towing, a new aluminum bumper and hitch, a trailer which can attach to the hitch and carry a designated load, and new head and tail lights. The team is allowed $50 for purchasing materials but they must first obtain their materials from the Foundry and SDC if possible. All materials used must also be listed in the Bill of Materials. The team must make three design iterations for the product. Design Iteration 1 must be constructed using only laser-cut cardboard, cardstock, or foam board. It will be used to check dimensions, geometry, and tolerances. Design Iteration 2 can be made using both laser cutting and 3D printing to test the functionality of the prototype. Design Iteration 3 can use all manufacturing and assembly methods and will become the final product. All manufactured products must also be refined using secondary processing methods. All of these requirements can also be found in Table 1.

Table 1: Requirements for RC Truck

Need	Requirement	Unit of Measure	Value
1	Polymer body	Achieved	Pass/Fail
2	Trine pride	Appearance of Trine logo	Pass/Fail
3	Rims and tires for racing	Achieved	Pass/Fail
4	Rims and tires for towing	Achieved	Pass/Fail
5	Aluminum bumper and hitch	Achieved	Pass/Fail
6	Trailer which can carry designated load	Achieved	Pass/Fail
7	New head lights and tail lights	Achieved	Pass/Fail
8	Spending limit on materials	Dollars ($)	50

Justification for Requirements

The RC truck needs a new polymer body that will make it both aerodynamic and weighted evenly. Trine school spirit is required because the team consists of proud Trine students. will be tested in both a racing and a towing setting, hence the need for the two separate sets of tires and rims. The trailer and hitch, of course, are necessary to support the load that the RC truck will tow. The limit of $50 for purchasing parts makes it more difficult to produce a high-quality product and will force the team to make intelligent engineering decisions.

Global, Economic, Social, and Environmental Impacts

The impacts of this project, while relatively insignificant at first glance, are quite significant when analyzed in depth. On a global scale, this project is the first step for the team in the manufacturing and engineering design process involved with the projects the team will eventually be a part of following graduation. The project helps to teach how to create concepts and select those that best fit the needs of the customer or the constraints of the project, which is one of the more difficult parts of engineering. In addition, it teaches different manufacturing processes such as casting, welding, forging, and others that we will encounter, most likely in more automated or streamlined forms, when working in industry.

The economic impact of this project will be relatively insignificant, as all of the work will be done by the team, meaning that there will be no pay for anyone involved in the project. The only economic constraint provided for the project is a $50 budget, and most of the materials used will be provided by that school. The companies that produce the RC trucks used for the project will benefit from the sales, and companies that produce the raw materials used to produce the different replacement parts of the truck that the team fabricates will benefit from the sale of those raw materials.

The social impact of this project will be the most significant of the four categories in this section. This project will be a glimpse into the teamwork aspects that are integral to working in engineering, and it will allow the team to gain essential collaboration and teamwork skills that will allow us to thrive as engineers working in a team and collaborating with different groups within a company. The concepts of meeting deadlines, prioritizing tasks, executing them on time and with the highest quality, and delegating tasks to group members with the skills best suited for those tasks are all skills that are essential for success when working in industry as an engineer.

The environmental impact of this project will be relatively minimal. Most of the materials that will be used, such as aluminum for the trailer hitch or polymers and cardboard for the prototyping phases of the project, will be recycled from around The Foundry. There will be a significant amount of electricity dedicated to this project, between the time spent collaborating on Teams to create the report and the time spent on school computers developing CAD files for the different components of the truck, along with the electricity required to run the machines used during the manufacturing processes. Aside from the transportation of the RC truck to The Foundry for pickup, and any other items that are ordered for the project, there will be minimal transportation costs.

Design Summary (Design Iteration 1)

The overall design for the racing truck was divided into several subsystems, including the body geometry, body material, trailer hitch geometry, trailer hitch material, trailer geometry, trailer material, lighting components, racing wheels, and towing wheels. The team used selection matrices for each subsystem to choose the idea that best suits the customer needs from each subsystem. Each matrix utilized a 1-to-5 scale to score each concept, where 5 is the most practical and 1 is the least practical. The rows indicated the relevant qualities of each concept, and the columns contained the different design concepts. Each quality was given weight based on the team's perceived importance to the success of the project, and the score was multiplied by the weight percentage to obtain a weighted score for each concept. The concept for each subsystem with the highest score was chosen for the team's first design iteration. The team unanimously decided that the Trine "Power T" would be used to display school spirit. The use of subsystems allowed the team to carefully analyze each component of the truck and tailor it to fit the needs of the customer.

Concept Generation (Design Iteration 1)

For the project, the team decided to break the product up into many different subsystems which will be developed and produced separately and brought together to make the final product. The subsystems include the polymer body, an attachment with Trine school spirit, a set of tires for racing, a set of tires for towing, a bumper with a hitch, a trailer, and head lights and taillights. For each subsystem, the team created sketches of several possible designs which allow them to be easily visualized. These sketches are preliminary, meaning that they do not include dimensions or tolerances, but they aim to give a general idea of some of the concepts the team evaluated during the first design iteration.

For the RC Truck's polymer body, the team came up with three distinct designs. The first is a sleek model with a compact build and sharp edges. The second is a curvier design with a more intricate rear. The final design is a more stereotypical racecar build with a spoiler to reduce drag. Sketches of these designs are shown in figure 1.

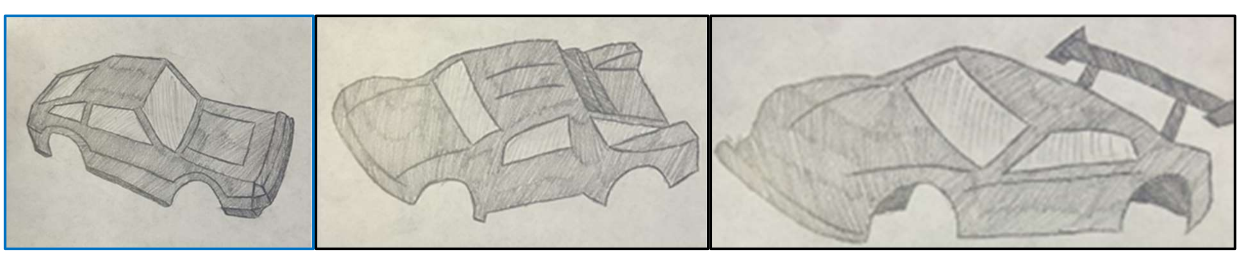


Figure 1: Polymer Body Subsystem Concept Sketches

To incorporate some Trine school spirit into the design, the team will 3D-print the Trine logo which will likely be placed somewhere on the rear end of the RC Truck to minimize the effect of the part on the truck's speed. A sketch of the Trine T is shown in figure 2.

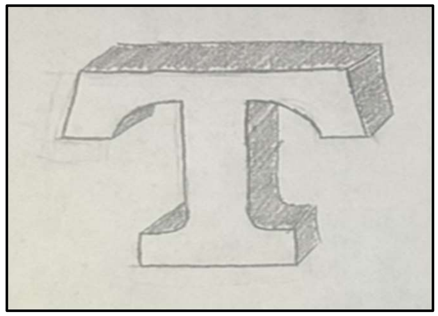


Figure 2: Trine School Spirit Subsystem Concept Sketch

For the set of racing tires, the team has narrowed it down to three similar designs. All three are wide and have minimal tread to maximize surface contact. The first design consists of a single tread through the middle of the tire with further treads branching out on either side. The second design has a more intricate tread design with several curved lines of varying lengths and a V-shape pattern. The third design has the same single tread through the middle as the first and a four-like shape repeated on each side. Sketches of these designs are shown in figure 3.

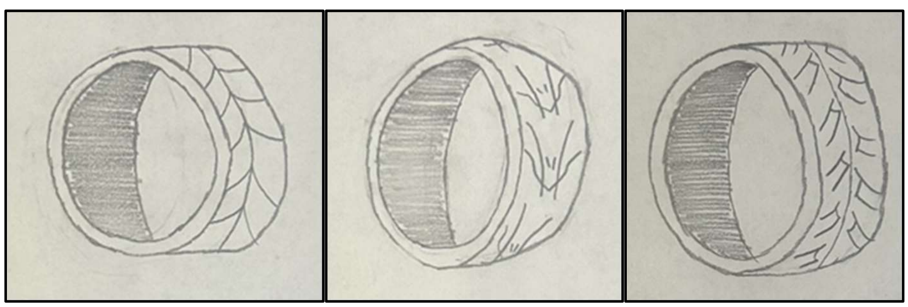


Figure 3: Racing Tire Subsystem Concept Sketches

For the set of towing tires, the team has selected three similar designs, each with some distinct different qualities that make them optimal for towing. They aim to increase friction to allow the truck to have better traction on the ground. The first design is an all-terrain style tire, which could allow for good traction and towing capabilities on the different surfaces that the truck will encounter. The second emulates a tire that would be found on a tractor or other pieces of heavy machinery, which are often designed to carry heavy objects. The third is a more traditional all-weather tire with a more aggressive tread pattern, which would allow the truck to have good traction while also not limiting it's maneuverability. It is important to note that, for both the towing and racing tires, the amount of air in the tires, and the stiffness of the material used, will play a large role in the performance of the tire in both the towing and racing tasks.

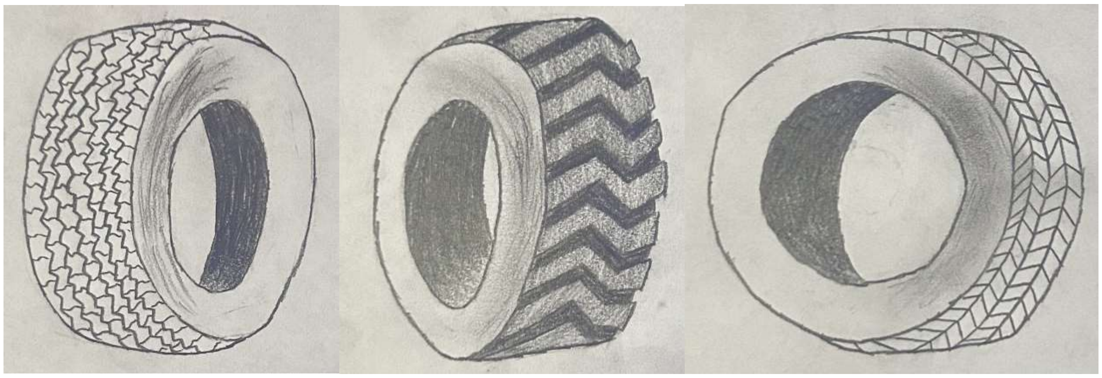


Figure 4: Towing Tires Subsystem Concept Sketches

For the set of bumpers, the team has selected 3 designs. The first design is a simple, flat aluminum bumper that is easy to manufacture. The second design is like the first but is curved to be slightly more aerodynamic and more aesthetically pleasing. The third design is a curved skeletonized bumper that trades energy absorption and protection for weight. For the hitches the team selected 3 designs, the first being a standard ball hitch. The second design is a hook hitch that contains no moving parts and is simple to manufacture. The third design has a cylinder on the bumper and the cylinder goes through a bigger cylinder with a hole and a pin is put in the top to stop the trailer from disconnecting due to bumps in the road.

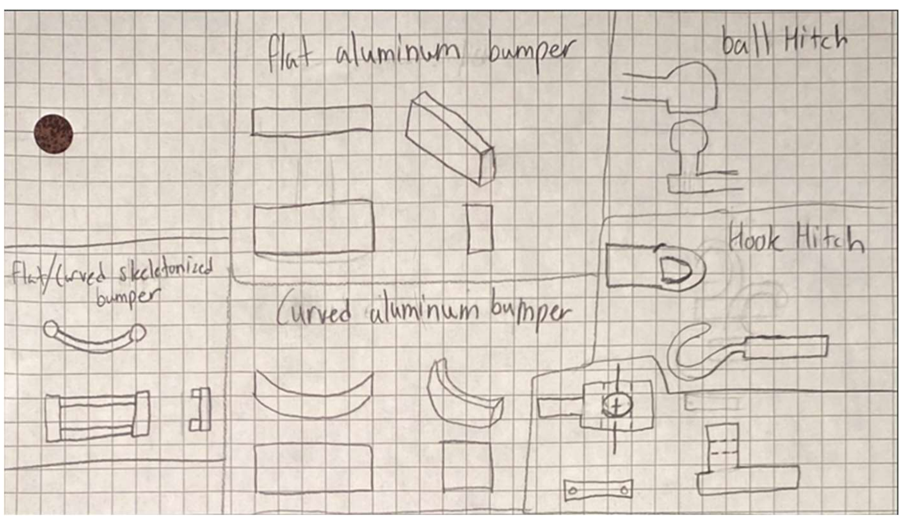


Figure 5: Bumper and Hitches subsystem concept sketches

For the set of trailers, the team selected three similar designs. The flatbed trailer is long and has a low center of mass, lightweight, and able to transport varying loads. The pickup truck bed has the "trailer" integrated into the rear of the truck. This design is easy to implement into the existing shell, at the cost of bed space and load capacity. The third design is an enclosed trailer that is potentially more aerodynamic than the flatbed trailer and can protect and contain loads better. This is at the cost of potentially not being able to haul large loads due to space constraints.

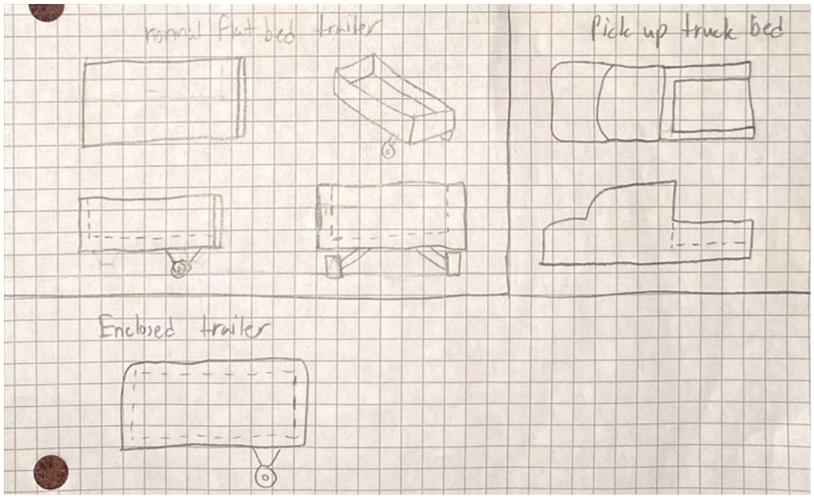


Figure 6: Trailer Subsystem Concept Sketches

For the head and taillights, the team has entertained a few distinct ideas that aim to add some aesthetic features to the truck. Since the lights are mainly a cosmetic feature, with a slight effect on the aerodynamics of the truck, these designs were selected to improve the appearance of the truck while also taking into consideration their aerodynamic properties. The first design incorporates some school spirit into the design, as both the head and taillights include a section resembling a “T”. The second design resembles that of a traditional sports car, with round headlights and a sleek taillight. The third design is a more traditional truck headlight and taillight system, with a box-like appearance.

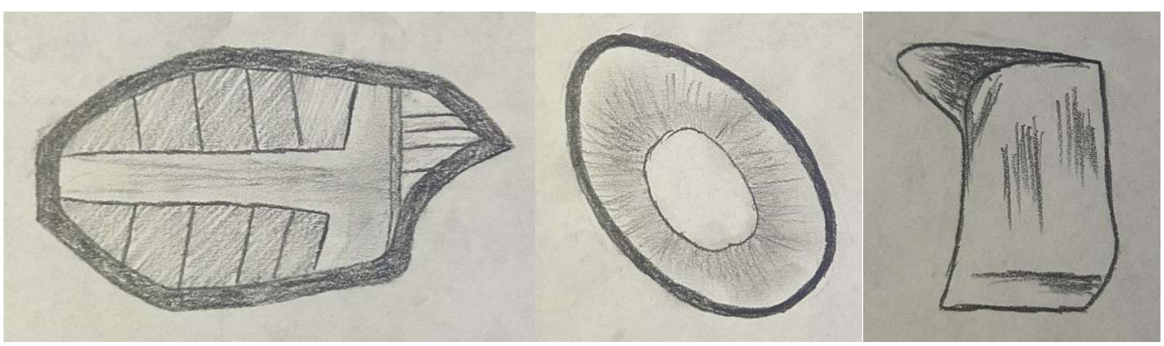


Figure 7: Headlight Subsystem Concept Sketches

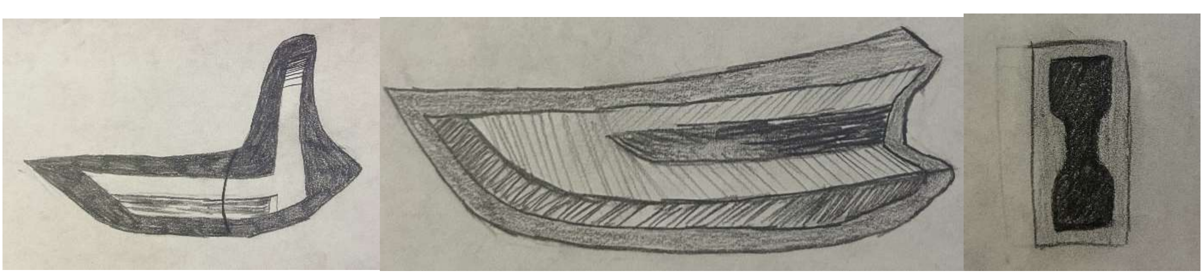
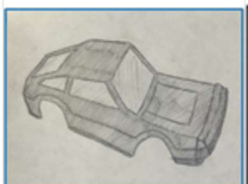
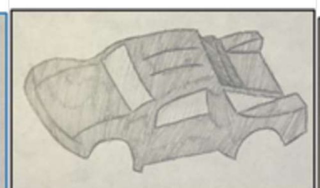


Figure 8: Taillight Subsystem Concept Sketches

Concept Selection (Design Iteration 1)

For the body geometry subsystem, the team was tasked with deciding between three sleek designs, each of which with their own unique strengths. The team judged the models based on four categories, aerodynamics, racing, towing, and feasibility. The first, aerodynamics, is how aerodynamic each model is and how they reduce drag. The third concept was the most aerodynamic due to its racecar-like build and spoiler while the first design was the least aerodynamic due to its sharp edges. The next two categories, racing and towing, are how well each model will likely perform in the actions of racing and towing. The team decided that the third design would be best suited for racing while the second design would be best suited for towing. Finally, the team judged the feasibility of each concept which was about equal for all three. The team decided to weigh racing and towing equally at 25% each, with aerodynamics weighted at 35% and feasibility at 15%. Taking these weights into account, the team chose to pursue the third design.

Table 2: Selection Matrix for Body Geometry

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Aerodynamics	35%	3	4	5
Racing	25%	4	3	5
Towing	25%	4	5	3
Feasibility	15%	4	4	4
Total	100	3.65	4	**4.35**

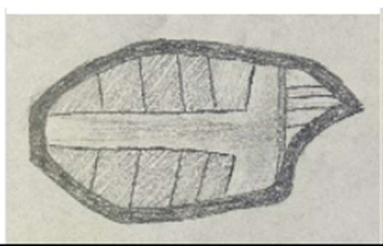
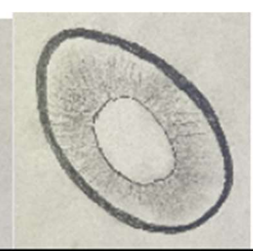
For the body material subsystem, the team decided to judge the body's material based on durability, weight, price, and ease of production, as indicated in Table 3. The durability was scored based on the material's resistance to scratches, deformation, and cracking. The weight category was scored based on the material's weight, since the truck needs a balance of strong structure and lightweight material for optimal racing conditions. The price category was scored based on ease of production, or how easily the material is to change into its final desired shape. The team decided to move forward with polycarbonate because of its good balance of all factors.

Table 3: Selection Matrix for Body Material

	Weight (%)	Polycarbonate	Nylon	Carbon Fiber
Durability	25%	4	5	3
Weight	35%	5	4	4
Price	15%	4	4	2
Ease of Production	25%	5	4	2
Total	100	**8.20**	7.20	5.90

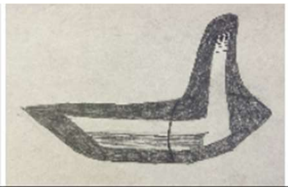
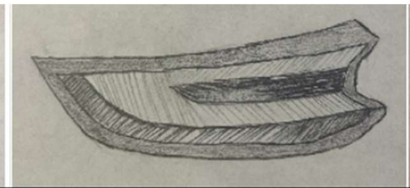
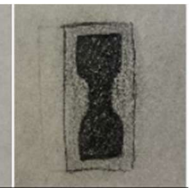
For the head and taillights subsystem, the team developed three concepts for both the headlights and taillights. The criteria used for the lights were appearance and feasibility, meaning how good they look and how logical it is to manufacture them, as indicated in Tables 4 and 5. For the headlights, the team preferred the first two concepts over the third, but the difference was made by feasibility as the first concept would be significantly more difficult to produce than the second concept. Regarding the taillights, the first two concepts certainly trump the third in terms of appearance but are far more difficult to produce than the third concept. As a result, the team decided to move forward with the third concept.

Table 4: Selection Matrix for Headlights

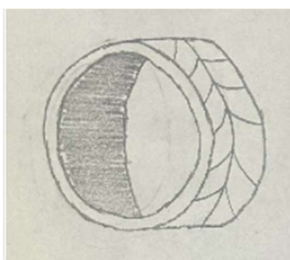
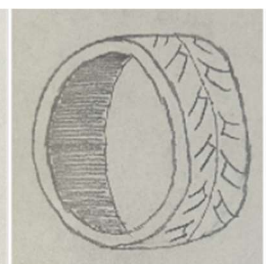

	Weight (%)	Concept 1	Concept 2	Concept 3
Appearance	40%	5	4	3
Feasibility	60%	2	5	4
Total	100	3.2	**4.6**	3.6

Table 5: Selection Matrix for Taillights

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Appearance	40%	5	5	3
Feasibility	60%	2	2	5
Total	100	3.2	3.2	**4.2**

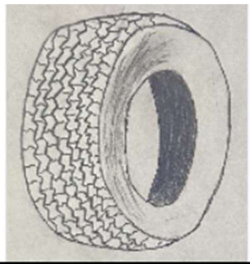
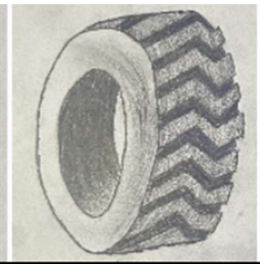
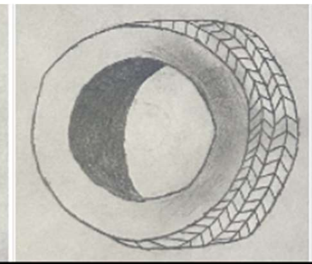
For the racing tires subsystem, the team decided to judge the models on treads and feasibility, as indicated in Table 6. The treads category is how effective the treads of each design are. For racing tires, it is ideal to have fewer and shallower treads to maximize surface contact. For this reason, along with the fact that it should be easier to produce, the first concept was chosen.

Table 6: Selection Matrix for Racing Tires

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Treads	60%	5	4	4
Feasibility	40%	5	4	4
Total	100	**5**	4	4

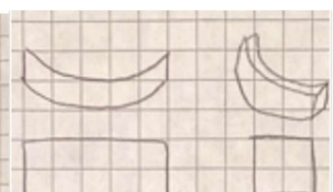
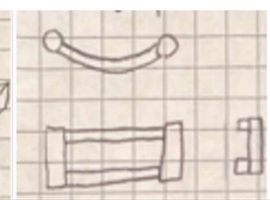
For the towing tires subsystem, the team used the same criteria as used for the racing tires subsystem. However, because the tires are designed for different applications, the treads category is slightly different. Ideal treads for towing a load are deep. Due to the vast depth of the treads on design two and its greater feasibility, the team decided to move forward with it.

Table 7: Selection Matrix for Towing Tires

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Treads	60%	4	5	4
Feasibility	40%	4	5	4
Total	100	4	**5**	4

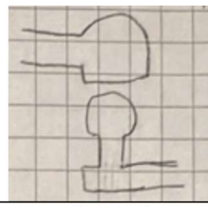
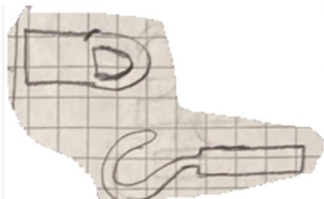
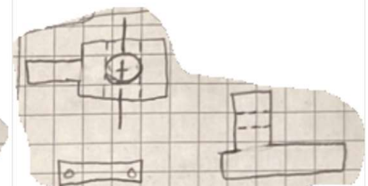
For the aluminum bumper geometry subsystem, the team decided to judge the concepts based on weight distribution, volume, and feasibility, as indicated in Table 8. The weight distribution section was judged on how much the bumper would affect the center of mass for the vehicle, which was the same for all three concepts. The volume section was judged based on how little volume it took up. The third and final was feasibility, this was judged on how easily this would be to manufacture. Feasibility was weighted the highest, so the team decided to proceed with concept number three.

Table 8: Selection Matrix for Bumper Geometry Subsystem

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Weight Distribution	30%	4	4	4
Volume	30%	4	3	5
Feasibility	40%	5	5	5
Total	100	4.4	4.1	**4.7**

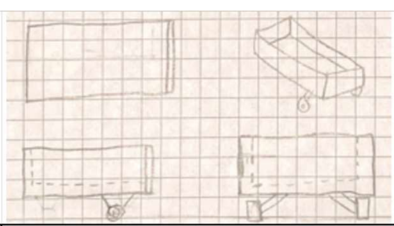
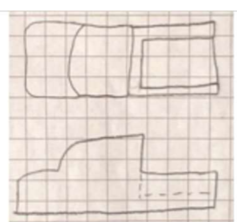
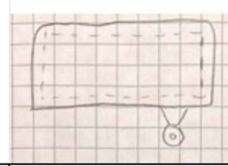
For the trailer hitch geometry subsystem, the team judged the hitch geometries based on feasibility, simplicity, and strength, as indicated in Table 9. The feasibility section was scored on how easy would it be to manufacture. Simplicity is how simple is it to attach to the truck and how easy it will be to connect to the trailer. Strength was scored based on how well each hitch would handle vibrations and stresses caused by the load on the trailer. Since strength was the most important feature of the design, the team decided to proceed with concept two due to its greater strength.

Table 9: Selection Matrix for Trailer Hitch Geometry Subsystem

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Feasibility	30%	4	5	3
Simplicity	30%	4	5	2
Strength	40%	4	5	4
Total	100%	4	**5**	3.1

For the trailer geometry subsystem, the team decided to judge the hitch geometries based on stability, feasibility, capacity, and strength, as indicated in Table 10. Stability was judged on how stable the designated load would be when moving and vibrating. Feasibility was judged on ease of manufacturing of the trailer. Capacity was judged by how large a load it could carry and strength was judged on how much weight the trailer could withstand, both of which will also be highly reliant on the material chosen. Since the capacity was the greatest factor in the design, the team decided to proceed with concept one.

Table 10: Selection Matrix for Trailer Geometry Subsystem

				
	Weight (%)	Concept 1	Concept 2	Concept 3
Stability	20%	4	3	5
Feasibility	10%	4	4	4
Capacity	40%	5	3	4
Strength	30%	4	3	4
Total	100%	**4.4**	3.1	4.2

For the trailer material subsystem, the team decided to judge the trailer material on durability, weight, price, and ease of production, as indicated in Table 11. The durability was scored based on the material's resistance to scratches, deformation, and cracking. The weight category was scored based on the material's weight. The price category was scored based on ease of production, or how easily the material is to change into its final desired shape. The team decided to move forward with aluminum because of its good balance of all factors.

Table 11: Selection Matrix for Trailer Material Subsystem

	Weight (%)	Steel	Aluminum	Carbon Fiber
Durability	25%	5	4	4
Weight	35%	2	4	5
Price	15%	5	5	2
Ease of Production	25%	4	5	2
Total	100	5.35	**7.35**	7.15