To: Sarah Oman

From: Electric Baja Capstone Team

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Subject: ERs and TPs Revamp Memo

We are the 2019-2020 senior E-Baja Team from Northern Arizona University. The team is composed of five Mechanical Engineers and four Electrical Engineers. We have been tasked with converting the 2015 NAU SAE Baja car to being fully electric. To convert the car, this requires disassembling the original car, then redesigning the car using the only the original frame. The mechanical components being redesigned are the brakes, the front suspension, rear suspension, steering and the gearbox. This process has remained the same since the beginning of the academic year. The customer and engineering requirements have not changed.

1 Customer Requirements (CRs)

Table 1: Customer Requirements and Weight

Customer Needs	Customer Weights (5 Most to 1Least)
Safety	5
SAE India E-Baja Rules / Industry Standards	5
Suspension System	5
Brake Design	5
Electric Compatible Drive Terrain	4
New Gear Box	4
Battery Mount	3
Steering	3
Fabrication	2
Cost	1

Table 1 shows our customer requirements that the team got from both the SAE Baja India and our client David Willy. The weights are rated 5 being most and 1 being the least important. The highly weighted needs are safety, following the rules, suspension system, and brake design (All weighted at 5). The least important is cost and fabrication. That is because the team is willing to do fund raising to increase our budget of $3,000 which was provided from W.L Gore. In addition, fabrication is rated at 2 out of 5 because the team is willing to do minor fabrication to the vehicle sub-systems such as steering and suspension. The team will not do major fabrication for the vehicle frame. The suspension system, brake design, electric compatible drive terrain, gear box, battery mount, and steering are all considered in the category of reliable, robust, and durable design. No customer needs have changed throughout the course of this project.

2 Engineering Requirements (ERs)

For our project, since none of the customer needs changed, there were no changes to the engineering requirements. We did realize some were more important than others but the original requirements are all still needed to meet the customer requirements. The team has noticed that the weight of the vehicle is not super important. While we are making it as light as possible still, we are designing it to be safe and weight is a bonus. The rest of the requirements are all important for having a successful car.

2.1 ER #1: Safety

2.1.1 ER #1: Factor of Safety throughout vehicle of 1.5

Safety became an engineering requirement because it was one of the higher customer needs the client expressed. A target value of a 1.5 factor of safety was chosen by the team and the client to ensure that no one will be harmed in the process of this project.

2.2 ER #2: Speed of Vehicle

2.2.1 ER #2: Travel

The speed is important, and it helps with designing the gear. The speed limit is 30mph and we need to make it with a one gear ratio because of the electric engine.

2.2.2 ER #2: No slower than 20 mph

This is the bottom line that the team needs based on averages from the SAE Baja speeds. Any lower than this and the vehicle would barely run fast enough for regulation.

2.3 ER #3 Cost

2.3.1 ER #3: Costs $2500

Cost is important and it will help team members to be aware of their decision. Team members need to maintain the cost with the given amount. Cost also can help with planning, knowing the design solution, and design quality before building it.

2.3.2 ER #3: $500 buffer zone

The team was given $3000 by W.L. Gore. Due to it being the only money we have, the client and team decided on using $2500 and leaving $500 for emergency funds. The sum is high due to the cost of some of the material that Baja vehicles take.

2.4 ER #4: Torque

2.4.1 ER #4: Pinion Gear 85 ft-lb, Drive Gear 520 lb-ft

The torque of the gearbox and motor is important in order to get the speed that we are shooting for. With this torque we have a fast acceleration and can still hit the 30 mph as we are wanting. The pinion gear is the torque that is put out by the motor but we are going to increase that by gearing the system down in order to power the car.

2.4.2 ER #4: Tolerance of 20 ft-lb for Drive Gear

This tolerance is put here in order to try to reach the top speed of 30 mph. If we have too high of a tolerance, we will have a slow car that can accelerate fast. We want a car that can move fast and accelerate fast which is why we have a tolerance. The calculations have all been done and we think we know the torque that we need but will find our for sure once we get the car running.

2.5 ER #5: Weight of Vehicle

2.5.1 ER #5: 800 lbs (Without driver)

This requirement makes it so the vehicle can go faster and accelerate at a faster rate. The heavier vehicle will slow down the car and require more torque to get moving which will decrease our top speed. This can be tested in Solidworks. We are able to get the approximate weight of the vehicle by having a relatively accurate drawing.

2.5.2 ER #5: Tolerance of 100 lbs

This tolerance is quite large for the weight. This is because the team isn't very concerned about weight. We have an extremely powerful motor for the car that we are running and are more concerned about a running car than a light car right now. The frame that we are starting with is also super heavy so it is hard to make the other supporting components light since they have to support the heavy frame.

3 Testing Procedures (TPs)

There are multiple testing procedures that will be done on the different components of the car. Each member is in charge of the testing procedure for each of their assigned parts. Most of the testing has been started on the CAD model to make sure that the design will work as well as meets the factor of safeties. More testing will be done once all the components are assembled to make sure the calculations and CAD were correct. A lot of the testing won't be done until the electronics are mounted and the motor is on. This is required to get a lot of the real world conditions.

3.1 Testing Procedure 1: Rear Suspension

3.1.1 Testing Procedure 1: Objective

For the rear suspension the test will be run after the motor is mounted. The test needs to be in a rough surface to test the durability and strength of the system. The testing is important since it is one of the main components of the vehicle where if it fails the vehicle will not function.

3.1.2 Testing Procedure 1: Resources Required

The team had already run FEA analysis on SolidWorks for the rear suspension system. The team got a factor of safety of 2.4, that is when the vehicle is traveling on max speed of 30 miles per an hour and jumping of a hill and hitting the ground. The team also did the worst-case scenario of getting an impact of the same type of vehicle. This is by setting a force of 800 lbf with considering acceleration to be 1 ft per second. The force is set to be perpendicular to the trailing arm. The factor of safety will be 3.43. Both factor of safety is within the target range of our engineering Requirements.

All team members are required to attend this testing procedures. There are no tools except for safety equipment's are required, such as first-aid kit, helmets, and straps to secure the vehicle to the trailer. The test will be done in a location where we are legal to drive the vehicle and test it. These conditions match the location of Cinder Hills off road location which is near the Flagstaff mall.

3.1.3 Testing Procedure 1: Schedule

The suspension will be finalized prior to spring break on March 13th. However, the vehicle delivery date is the week after spring break. March 27th will be when the vehicle will be shown to the capstone class meaning the 26th is the last day the team can test the suspension.

3.2 Testing Procedure 2: Brakes

The brakes are one of the most important parts of the vehicle. Without the brakes the vehicle wouldn't be able to stop which would pose an issue for the safety of the driver. Since they are critical to safety it is imperative that they work properly. All the calculations have been done and show that the brakes will work but it still needs to be tested in the real world.

3.2.1 Testing Procedure 2: Objective

The goal for the test is that all four brakes lock up when the brake pedal is pressed as hard as possible. The team will get the car moving at close to full speed then slam on the brakes. If all four brakes lock up then the brakes are good to go. Before we get the car running at those speeds we will make sure that the car can stop at slower speeds.

3.2.2 Testing Procedure 2: Resources Required

There are no resources required to run this test. All we need to do is take it outside to a dirt pad and run it on that.

3.2.3 Testing Procedure 2: Schedule

The team will be running the original brake test within 2 weeks (March 2) to make sure the brake components actually work. This is when the hubs and brakes will actually be put on the vehicle. The final "lock-up" test will be run once the motor is on and the car is running.

3.3 Testing Procedure 3: Steering Knuckle Attachment

3.3.1 Testing Procedure 3: Objective

The attachment link is a piece of steel plate that connects the steering knuckle to steering tie rods, this link assists in the turning geometry of the car. For the testing of this subsystem component, the link will be attached to the steering knuckle and assembled on the car. Once assembled on the car, the team will turn the steering wheel and monitor the wheels as they turn. The team will be monitoring and analyzing the geometry and motion of the component and how it affects the turning of the car.

3.3.2 Testing Procedure 3: Resources Required

The required resources consist of two – three team members, the steering components, front suspension components, the car, and to be tested in the shop or outside at building 47a or 98c. The team will have to assemble all the steering components and front suspension components which they are all located in building 47a and can be tested in the shop or outside on flat surface it will be either at 47a or 98c depending on car's needed location before testing.

3.3.3 Testing Procedure 3: Schedule

The attachment link will be manufactured the sixth week February 17 – 21, the attachment link part will be manufactured by LeAlan. Also during the sixth week, the front suspensions' modifications will be made to the A-arms and will modified by LeAlan. Once the front suspensions' modifications and steering attachment link are ready, it will be tested on February 21 and demonstrated in front of the client, Willy. It will be ready for hardware review 2.

3.4 Testing Procedure 4: Front Suspension

3.4.1 Testing Procedure 4: Objective

The front suspension can help with decreasing the impact load when the vehicle is off-roading which will make the load stored on the springs. The front suspension need to have a quality heim joints and bolt to avoid bending and snapping on the vehicle. Calculations has been made to make sure that the new heims and bolts will be safe and to avoid the snapping and bending on the vehicle.

3.4.2 Testing Procedure 4: Resources Required

For the front suspension, it doesn't need a lot of work. Two members are enough to test the front suspension. One will apply the load on the front suspension and the other will check if there is any bending on it. The results will be discovered by the second member. If there is no bending or sounds produced, that means that the heim joints are safe.

3.4.3 Testing Procedure 4: Schedule

The team will make a the whole bigger so it can fit the new heim joints and this will be made by week 6. The front suspension testing is very simple process. It will take 3-4 minutes to complete the test. The test should be performed prior to driving. It will give the existing status of front suspension