Design Goals and Constraints

The Ranger EV is powered by a 312V battery pack that contains thirty-nine individual, custom 8V batteries. Ford is no longer providing support for these vehicles or batteries. Thus, replacement batteries are no longer available to the owners. The goal of this project is to create a conversion kit that allows vehicle owners to modify the existing battery pack into one that can support off the shelf batteries. The next phase of the project will be to determine modifications necessary to the case that will house and secure the new battery configuration. The final phase of the project will be the creation of the instructions, packaging details for the conversion kit, a business plan for manufacturing necessary components, and distribution of the product.

In order for our design to properly power the vehicle, we must be within the constraints that are imposed by the current battery pack. Our final design must be able to provide voltage and current to the truck at a rate equivalent to the stock battery pack. It could provide slightly less voltage and current, but this would mean that the truck and battery pack would have to weigh less to compensate, which not desirable because of the added work and cost. This means that the final design should have a net voltage of 312 V and an Amp hour rating of approximately 75 Amp-hours. Since the suspension of the truck was designed around the stock battery pack, we will have to keep the total weight and weight distribution of our design as close as possible to the stock battery pack. This is important, because the weight if the truck is directly proportional to long the truck will be able to go between charges, and by keeping the weight the same, we don’t have to worry

about changing any of the shocks or suspension. In addition, we are limited by the amount of space that is available for the battery pack underneath the truck. We would like to reuse the stock case in our design if possible, but making a new case to accommodate our design is a possibility. The final design limitation that our team faces is that we cannot exceed the project budget of three thousand dollars. A ranking of our goals and constraints can be found in Appendix B.

Design Concepts

This section of the report will include an explanation of all of the design concepts that were generated and explored by the 495 group, up to our current proposed design. Previous work on the design of an alternative battery pack was conducted during Autumn quarter of 2004 in conjunction with ME 395 at the University of Washington under Professor Joyce Smith Cooper. The focus was on designing a new battery pack that could be installed into the vehicle, using readily available batteries. The first phase of the design was selecting an off the shelf deep cycle battery. Based on an operational analysis of the existing battery pack, the 395 group determined that twenty-six Optima d31a batteries would provide the vehicle with the required 312 V and 75 Amp hours. The next phase of this conceptual design was to create a custom made battery pack that would be able to house the new batteries; the stock battery case would not be an acceptable solution due to the dimensions of the Optima batteries. The new case was designed to fit within the space available underneath the truck and to use the existing battery pack mounts present on the truck. All of the design decisions that were made by the ME 395

team were made using Dieter's Design Process. A more detailed description of the methods and results from the ME 395 project can be found at: http://students.washington.edu/njs/395home.shtml. A copy of the morphological chart used can be found in Appendix E.

Replacement of 8V batteries with other 8V batteries with existing controller

Due to the complexity of creating the custom battery pack in the conversion kit that was proposed by the ME 395 group, the initial intent was to replace the stock 8V batteries that came with the truck. This was the ideal solution because all that it would require is a set of off the shelf 8-volt batteries with similar performance specifications and dimensions to the stock batteries. In addition, this design was the least likely to require any modifications to the stock controller.

The primary goal was to find 8-volt batteries that would fit within the stock case, and the secondary goal was that the batteries have an equivalent amp hour rating as the stock batteries. The search was prioritized in this order because the design team was willing to sacrifice some of the vehicles operational time for the added convenience of using off the shelf batteries. After several hours of research, it became apparent that there were no batteries that would come close to meeting either of the search criteria that the team had settled on. The closest off the shelf battery that was found in the search process had and equivalent amp hour rating to the stock batteries but was almost double the volume of the stock battery (see appendix C for battery specifications). The team also considered the

option of having the batteries for the case custom made. After contacting Interstate Batteries, a company that makes custom battery packs, we learned that that amount of time and money that was needed to engineer a battery that met our needs was prohibitive. In addition, they did not believe they were capable of making such a battery and could not provide any recommendations for a company that might be capable of creating the desired battery.

Replacement of 8V batteries with two 4V in series with existing controller

Voltage is additive in series, which provided us with another option for replacing the stock batteries. This is where the team began with the next concept: finding 4-volt batteries that would fit our vehicles needs, i.e., batteries that would provide a sufficient amp hour rating within our size constraints. We would, however, need to double the number of battery cells in order to achieve our desired voltage. We were unable to find a 4V battery that would have an amp hour rating large enough to move the truck more than a few feet before needing a recharge (see appendix C for battery specifications). The highest amp hour rating we could find for 4V batteries was 10 AH, and at least 60 AH are needed for satisfactory operation.

Repairing the existing 8V batteries with existing controller

An alternate option for replacing the batteries is simply to repair the existing cells. BatteryMD is the official battery pack refurbishing company for Ford Ranger EVs and

services several other electric vehicle battery packs as well. For a fee of four thousand dollars, BatteryMD will exchange a customer's old battery pack with a refurbished one (the contact info for BatteryMD can be found in Appendix D). The cost includes the labor required to remove the old batter pack and replace it with a refurbished one, and a complete diagnostic inspection of the truck. Because the company was authorized to work on Ford Ranger EVs, they had, therefore, stockpiled the standard issue cells. This concept has been put on hold due to the fact that it does not offer a permanent solution to current owners of Ford Ranger EV's, as the BatteryMD has a limited quantity of stockpiled batteries. Additionally, the company is currently not authorized to sell individual cells to customers who are not authorized Ford technicians.

Replacement of 8V batteries with 12V batteries with existing controller

The concept of replacing 8-volt batteries with fewer 12-volt batteries was initially thought to be the superior design in the embodiment phase of this project, which took place in Autumn quarter's Introduction to Mechanical Design course. After discussions with members of SEVA (Seattle Electric Vehicle Association) at their monthly meeting, it was confirmed that the design should work.

However, after finding the Owner's manual, our concept was abandoned. The manual states that the battery control system performs an equalizing battery charge every three weeks. This procedure is done to ensure optimum performance of the battery pack by ensuring that each cell is equally charged. This indicates that the system will seek to

recognize thirty-nine batteries and equalize the voltage during a charge. With the conversion to the twelve-volt battery design, leads will have to be capped and abandoned. We are currently unsure how the controller will react to this configuration.

Replacement of 8V batteries with 12V batteries and a new controller

Due to the fact that the controller will try to identify 39 batteries in the case, and it is unknown how the controller will react to capped leads, a new controller would be required to convert the truck to 12-volt batteries. The 12-volt batteries provide significant improvements to the vehicle (see appendix C for battery specifications). The total weight of the battery pack is decreased by approximately 500 pounds, thus increasing the payload of the vehicle. Additionally, the batteries can be replaced individually should they fail in the future. The 495 group has selected this as the final design option.

The first phase of the design is the new battery pack. There are currently no 12-volt batteries available on the market that fit into the current battery pack. The 495 group revisited the conceptual design of the 395 group and used that battery case (see Figure 1) as the design.

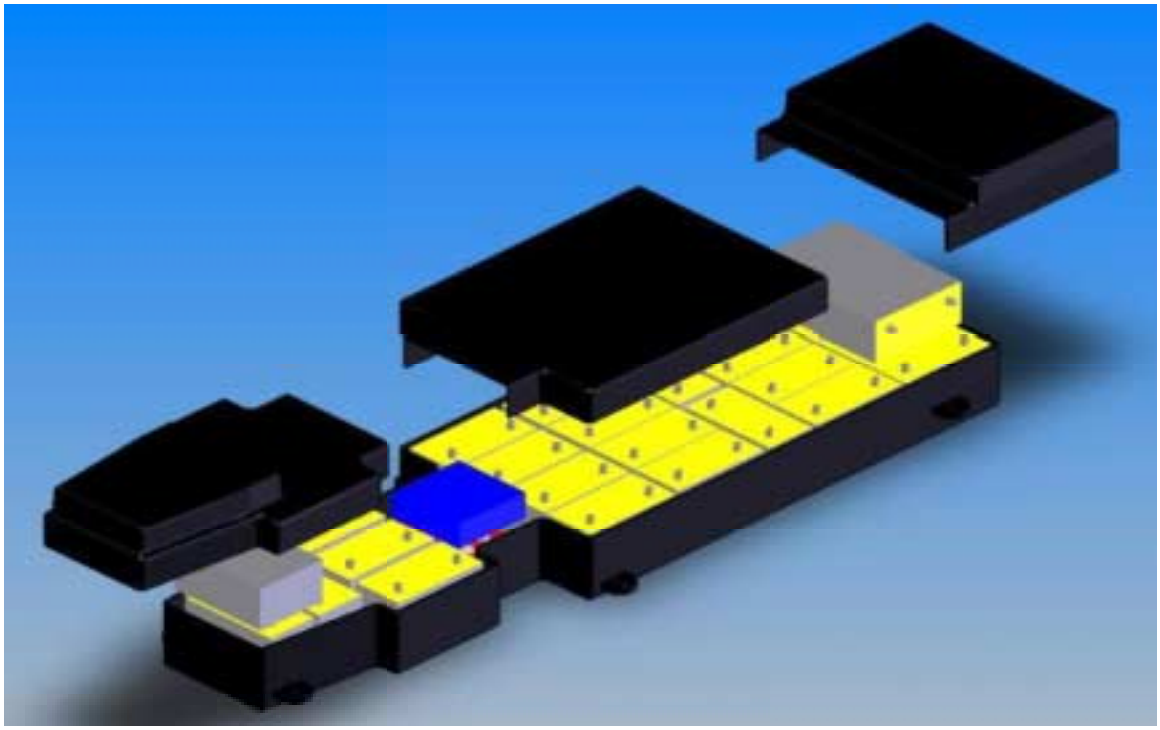

Figure 1: Conceptual design for new battery case with 12-volt batteries

The case was designed to fit in the space currently available in the truck. Further, the case utilizes the same six mounting brackets as the existing case. Therefore, no modifications to the truck frame are required.

The next phase of the design is to determine the manufacturing method for the new battery pack case. The existing case consists of two halves. The upper half is entirely molded fiberglass, while the lower portion is welded metal covered in fiberglass. The fiberglass is necessary to contain battery acid in the event of a battery rupture. This material is ideal because it does not react with the battery acid, but it is water resistant and durable. The 495 group is currently exploring options for manufacturing the new case. Finite element analysis of the case is being utilized to determine the best material based on performance and cost.

The final phase of the new battery pack design is interfacing with the truck. The 495 group has identified two options to accomplish this task. The first is a complete conversion of the Ford Ranger EV electrical system to implement the use of the battery pack. This transformation would be similar to the conversion process used in changing internal combustion vehicles to electric vehicles. This design option is being researched, but is not preferred due to the impact it would have on the vehicle. This conversion would likely result in a loss of some of the safety systems and interdependence installed by Ford. The second option is the creation of a controller for the battery pack similar to the current controller. The main difference would be that the new controller would be programmed to recognize twenty-six 12-volt batteries as opposed to thirty-nine 8-volt batteries.

Updated Timeline

Task	Date
SEVA meeting	1/11/05
Safety meeting with Russ Noe	1/11/05
Design Proposal, Safety Plan and Presentation	1/13/05
Contact information for EV maintenance	1/13/05
Possible battery choices	1/14/05
Battery choice evaluation	1/23/05
Battery selection	1/25/05
Determine battery configuration	2/1/05
Midterm report	2/10/05
Finite element analysis (FEA) of battery case	2/16/05
Determine case material from results of FEA	2/18/05
Complete budget breakdown for battery purchase	3/3/05
Complete budget breakdown and suppliers list for manufacture of the battery case	3/7/05
Determine manufacturing method for case	3/7/05
Complete website	3/14/05