Boulder Electric Vehicle Field Validation Project 2012

Task # 2 Deliverable Report

for:

New Technology Research and Development Program

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Submitted by:

Boulder Electric Vehicle, Inc.

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Abstract/Executive Summary

Boulder Electric Vehicle (BEV) will produce, deploy and field validate 18 all electric, zero nitrogen oxide (NO_x), advanced zero emissions new vehicle 11,500 gross vehicle weight rating (GVWR) delivery trucks with a patent pending ultra-light-weight aluminum honeycomb composite vehicle frames, a top speed of 65 miles per hour (mph) and a range of 120 miles. BEV will deploy them in three metropolitan non-attainment areas in Texas for a full calendar year. FedEx and UPS will deploy and test a combined total of 9 trucks in the cities of Dallas, Houston, and San Antonio. The cities of Dallas, Galveston, and San Antonio will deploy and test three vehicles each. The validation of the top speed, range, and carrying capacity as well as the heating and cooling of the battery pack will all be validated under real world conditions and duty cycles. BEV has reduced the curb weight of a standard delivery truck from 9,000 pounds (lbs). down to near 5,000 lbs. by incorporating patent pending composite aluminum frame technology. Due to the reductions in weight, the size of the battery pack is also greatly reduced, thus lowering the cost of the vehicles and increasing economic viability. Because the ultra-light-weight aluminum honeycomb composite vehicle frames are a departure from the standard steel frame rails, field validations will greatly accelerate the market acceptance and commercialization of this new technology, thereby reducing the NO_x in Texas metropolitan non-attainment areas. The data logged and published from this field validation project will greatly accelerate the market adaptation of this zero emissions vehicle technology as well as validate the potential for great pollution reduction in Texas non-attainment cities.

Introduction/Background

There are three major issues with the performance (and therefore market acceptance) of large format electric vehicles.

- The vehicles weigh too much and therefore require very large and expensive battery packs.
- The batteries will not perform as well when it is cold (noticeable degradation of range starts at 40 degrees Fareneheit), and when the temperature goes over 102 degrees Farenheit (F) the pack starts to "bake" drastically reducing cycle life. The later issue has been greatly publicized by a major original engine manufacturer (OEM) having their range reduced in their first offering of electric cars deployed in Phoenix, Arizona.
- No one is making a commercially available electric truck that goes faster than 50 mph.

BEV has addressed all of these issues in our first prototype 11,500 lbs GVWR vehicle.

Vehicle Weight

BEV has filed patents on the ultra-lightweight composite aluminum frame which we think will be a key component in the automotive industry for making vehicles lighter while retaining strength.

Aluminum honeycomb composite is well known in the aerospace industry but has never been used in the automotive industry until now. Our primary invention is the placement of key stringers of tubing inside the honeycomb core in order to stiffen and spread out the load inside the vehicle frame and where it attaches to key suspension points. There are three primary advantages in our frame design over the typical steel frame rail truck design.

First is lightness of the vehicle. Batteries for electric vehicles have such a high cost, that a gain in the efficiency of the vehicle pays for itself through a smaller battery pack and less initial costs. On smaller vehicles such as the Nissan Leaf or the GM Volt the batteries might be 20-30% of the price of the vehicle. On larger trucks the battery pack can be fully 50% or more of the costs of materials in the manufacturing of the vehicle. Especially in the delivery market where there is a great deal of stop and go driving, the reduction in weight offers a tremendous increase in efficiency.

Second is safety. By bringing the battery pack to the center of the vehicle it protects the battery pack from accidents, thus protecting the investment in the high cost battery packs and increasing the Factor of Safety. This also places the weight of the battery pack (1,400 lbs. or over) in the center of the vehicle, increasing the stability and drivability of the vehicle.

Third is the reduced energy needed to manufacture the frame itself. Costs and energy and ease to manufacture the frame is all better than a typical steel frame rail truck. The process is vacuum bagging 6 parts instead of plasma cutting, welding and bolting 30 parts or more. Thus costs and energy to manufacture is dramatically decreased.

Battery Thermal Management System

This is different from the usual battery management system (BMS) in that the usual BMS is involved in managing the battery cells during charge and discharge in order to keep track of any over or under voltage conditions outside of normal parameters. Our battery thermal management system (BTMS) allows us to use the same heating and cooling system that we use on the cab of the truck and heat and cool the battery pack. We have spent the last 18 months in Colorado testing the system in the summer and winter. At 40 F the range of the battery pack is already being reduced without heating the pack. In minus 20 F conditions the range is reduced by 80% without heating the pack. Although it is a much more difficult parameter for a customer to quickly quantify, cooling the pack in the heat of the summer is equally important by keeping cycle life in line with manufacturer's spec. Over 102 F the pack is being baked. The cycle life can be reduced by up to 80% just by a few weeks of operations at this higher temperature. The problem is compounded by the necessary placement of the battery pack about 1 foot above the black pavement. Therefore we cool the battery pack. No one else has implemented this in electric trucks.

Highway Capable Electric Trucks

BEV's top speed is 71 mph. We are the only electric truck OEM that offers this speed. From a department of transportation legal perspective any vehicle that gets on an interstate highway *must* be capable of going at least 10 mph *less* than the posted speed limit. Since many states have speed limits of 75mph this dictates a 65mph speed. For large format electric vehicles this means either a motor/controller with a greater amount of torque and power, or a transmission. This is not hard to do, but the market dictates that this *must* be done. The only reason we can speculate as to why neither Smith nor Navistar has done this is that both of their designs were finalized in England where this is not a market driven necessity. We have also observed through our own extensive testing of our prototype truck that higher speeds will decrease range and therefore make the trucks either more expensive to produce or lower in range.

Figure 1: Production lines with first ten all electric trucks

Project Objectives/Technical Approach

The objectives for this project are:

1. Build all electric, zero-NO_x delivery trucks with a top speed of 65 mph and a range of 120 miles.
2. Demonstrate for a period of up to one year the 18 electric delivery trucks in the Dallas, Houston-Galveston, and San Antonio areas with both public and private entities, collecting data on vehicle durability and performance and customer acceptance.
3. Evaluate the durability of vehicle components and battery packs in three of the demonstration vehicles after demonstration is complete.

Tasks

The tasks for this entire project are as follows:

- Task 1: Demonstration preparation and vehicle design adjustments
- Task 2: Vehicle production
- Task 3: Vehicle deployment
- Task 4: Vehicle demonstration
- Task 5: Post-demonstration vehicle durability analysis
- Task 6: Reporting

This specific report is the report for *Task 2: Vehicle Production* and will address our methodology for building the vehicles themselves.

Task 2 – Vehicle Production

From the Grant Activities (Scope of Work):

> *"Task 2: Vehicle production*
>
> *2.2. Task Statement: The PERFORMING PARTY will build all trucks in the manner designed in Task 1 and quality test them before delivery."*

Task 2.2.1 Vehicle Builds

The following are pictures documenting the first three completed trucks.

Figure 2: City of San Antonio's first DV-500 all electric truck

Figure 3: City of Dallas' first DV-500 all electric truck

Figure 4: City of Galveston's first DV-500 all electric truck.

Task 2.2.1.1 Inventory Records

From the Grant Activities (Scope of Work):

> *"2.2.1.1. The PERFORMING PARTY will order and maintain inventory records of the various components needed for the assembly of the vehicles."*

Before receiving the signed NTP we started implementing a bar code and part numbered inventory management system. This system was specified to share information with our financial operations software. This inventory management software system takes the parts through the proper inventory management order of: purchase order, receiving, incoming inspection, part location, work order, build book, completed finished goods. The system is designed so that we could find any part at any time, that if a vendor shipped us a partial amount of the parts ordered we could track those parts not received. Each part, each location, each bill of materials, each work order generates its own bar code so that we can scan the progress of the parts, the sub-assemblies and the completed sub assembly stations as well as the finished product. We had custom inventory receiving reports programmed by the software company that fit our needs. We also had custom bill of materials reports programmed by the software company that would give us a better handle on our ongoing cash flow and cost of goods.

Task 2.2.1.2 Data Book of Options

From the Grant Activities (Scope of Work):

> *"2.2.1.2 The PERFORMING PARTY will compile an industry standard "data book" format for specifying options such as electronic mirrors, extra seats, radios or bucket trucks or standard delivery trucks. The data book will be used to coordinate the specific build-out needs of each of the demonstration partners."*

The data book was produced so as to coordinate part numbers and sub assembly part numbers with the options being offered on the specific vehicles to be delivered as part of this grant. For example, the first

round of delivery trucks that were offered with a solid bulkhead wall between the driver's compartment and the cargo compartment or a sliding door between the two compartments or just an empty space. These options each became different part numbers in the data book which in turn coordinated with a work order for that option on that truck which in turn went to purchasing for the correct amount of materials to be ordered. In turn the price of each option was able to be precisely determined so as to be able to offer these options to potential commercial customers as part of our commercialization plan.

It is extremely difficult to determine a price on a specific option, such as the above differences in doors, especially with options that may involve fifty different parts, until you actually build the first article, refine the process so that labor is minimized and quantity pricing on parts in achieved. Once that is done then the option can be priced to a commercialization partner. This specific grant has been much to our advantage in that we have been able to successfully complete this data book and pricing process on many different available options.

Task 2.2.1.3 Truck Builds

From the Grant Activities (Scope of Work):

> *"2.2.1.3 The PERFORMING PARTY will build the electric trucks to meet demonstration partners' needs as determined in Task 1."*

From our determination of fleet needs with the City fleets as well as the commercial fleets we came up with five different variations in what we needed to build for this grant in the way of field validation vehicles. The first nine vehicles built were all variations of our standard delivery van the DV-500. The city fleets all needed extra grip tape on the floor, a more comfortable jump seat and a solid bulkhead. The commercial fleet needed a remote keyless entry system on the side doors as well as the bulkhead door and the rear door. In addition they needed an orange colored seat belt and a much thinner and less comfortable jump seat. All of these needs we were able to accommodate with the end goal of changing the field demonstration partners into paying customers as part of the long range commercialization plan. The second nine vehicles produced were three flatbed models and three service body models for the city fleets as well as three trucks with basically twice the cargo capacity for the second commercial fleet partner. All of the second nine vehicles required substantial engineering. The flat beds and service bodies, although they were the same cab, axles and many parts, required extensive coordination with the vendor supplying the flat beds and service body add on parts. They also required end caps on the honeycomb deck, Swing style doors instead of sliding doors and a different rear fiberglass piece. All of these had to go through the engineering development and prototyping process. The last three field validation units for the commercial fleet that needed a larger fleet vehicle with a 1,000 cubic foot capacity basically was reengineering a new model which we are calling the DT-1000. In addition we were working with the commercial fleet and their extensive specification sheet in order to turn them into a long range customer as part of our commercialization plan.

Task 2.2.2 Vehicle Quality Testing

Task 2.2.2.1 Initial Commissioning Records

From the Grant Activities (Scope of Work):

"2.2.2.1. The PERFORMING PARTY will maintain quality control and initial commissioning records for the final assembly line production station and test drive before delivering vehicles to demonstration partners. Quality control will include tests of all systems and sub systems and a spray down in a booth that uses recycled roof rain water for the leak tests."

Final Assembly and Sub-Systems Tests

For the first three trucks we developed a single final inspection report which we would fill out at the end of the assembly process and before initial test drives. After working with this format for the first three vehicles we changed our inspection to two separate Final inspection reports, one for mechanical items and one for electrical items. Each report contains a header with the model of the vehicle, the build outs if any, the date the report was filled out and the odometer reading at the time of the report.

Both reports have several line items to be inspected. Each line item has a check box for Pass/Fail a column for notes in case of failure, a place for the employee to stamp the line item with their employee identification (ID) and a column for the date of the inspection of the line item. In theory the entire inspection should be gone through in one session, however in practice if a line item fails and must be repaired then there will be multiple dates for the inspection process.

<u>Final mechanical inspection</u>

The final mechanical inspection has major headings as follows:

- General Functionality,
- Appearance,
- New Vehicle Checks,
- Legal, and
- Vehicle Operation and Additional Checks.

Under General Functionality we have line items as follows:

- Door Locks,
- Doors Operation,
- Window Operation,
- Seat Adjustment Operation,
- Seat Belts,
- Washer Fluid,
- Brake Fluid,
- Power Steering Fluid,
- Heater Fluid,
- Mirrors, and
- Tire Pressure.

Under Appearance we have line items as follows:

- Front,
- Sides,
- Rear,
- Wheels,
- Underneath,
- Clean Cab and
- Clean.

Under New Vehicle Checks we have line items as follows:

- Coolant Level,
- Odometer Accuracy,
- Speedo Accuracy,
- Zerks Greased,
- Coolant Leaks,
- ABS Operation,
- Park Brake Adjustment,
- Backup Alarm,
- Key Sets BEV Fob,
- Remotes (optional),
- Radio Manual,
- Lug Nut Key,
- Wash-down Leak Check,
- Differential Oil (initial), and
- Differential Oil replaced after 500 test miles.

Under Legal we have line items as follows:

- Vehicle Identification Number (VIN) Tag,
- VIN Plate,
- Manufacturer’s Certificate of Origin,
- Owner’s Manual,
- Dealer’s Bill of Sale,
- Sales Tax Receipt,
- App for Title, and
- Vehicle Emissions Control Information VECI Label.

Under Vehicle Operation we have line items as follows:

- Forward,
- Reverse,
- Steering Wheel Nut Torqued,
- Steering Wheel Aligned,

- Alignment Completed,
- Power Steering,
- Parking Brake Hold Test,
- Backup Camera Alignment,
- Braking Distance Test, and
- Regenerative Braking.

Under Additional Checks we have room for items to be written in by hand. We also have room for Additional Notes.

Final electrical inspection

The final electrical inspection has major headings as follows:

- Lights,
- Main Driver Display Indicators,
- Dash Auxiliary Display,
- Dash Controls,
- High Voltage Cabinet Checks,
- Pre Charger Plug In Checks,
- Post Charger Plug In Checks, and
- Additional Checks.

Under Lights we have line items as follows:

- Rear Running Lights,
- Front Running Lights,
- High Beams,
- Low Beam Alignment,
- High Beam Alignment.
- Rear Flashers,
- Front Flashers,
- Left Turn,
- Right Turn,
- Backup Lights,
- License Plate Light,
- Rear Clearance,
- Front Clearance,
- Brake Lights,
- Dome in Cab, and
- Dash Light-Emitting Diode (LED).

Under Main Driver Display Main Indicators we have line items as follows:

- Odometer,
- Speedometer,
- Charging,
- Anti-lock Brake System (ABS),
- Drive,
- Neutral,
- Reverse,
- Park/Brake,
- Turn Flasher,
- State of Charge (SOC),
- Fuel Gage,
- Regenerative Braking, and
- Latest Software Version.

Under Dash Auxiliary Display we have line items as follows:

- Aspect Ratio,
- Service Screen,
- F Software, and
- Team Viewer Software.

Under Dash Controls we have line items as follows:

- Headlights,
- LED Dimmer,
- Wiper Speed,
- Windshield Washer,
- Shift Control,
- Heat / Air Conditioner (AC),
- Vent / Defrost,
- Fan Speed,
- Horn,
- High / Low Beam,
- Turn,
- Radio / Speaker Operation,
- Ignition Switch,
- Dome Light,
- Park Alarm w / Key Off, and
- Cab Fan (optional).

Under High Voltage Cabinet Checks we have line items as follows:

- Current Sensor Drive Disable,
- Current Sensor Charge Disable,
- New Eagle Drive Disable,
- New Eagle Charge Disable,
- DC/DC shutoff on low cell.

Under Pre Charger Plugin Checks we have line items as follows:

- Current Knob Maxed (clockwise),
- Dual in-line Package (DIP) Switches set, and
- Charger Time Arrow to 0200.

Under Post Charger Plugin Checks we have one line item: Charger Voltage Limit at 405v. Under Additional Checks we have Main Screen Video Graphics Array (VGA) Cable Zip Ties. We also have a section for additional notes.

Leak Tests

We built a special leak testing booth which will simulate a fine mist rather than a torrential pour. Fine mists will find the pinhole leaks in a windshield seal where as a full on spout of water will not. Our entire vehicles will fit in this booth so that the vehicle can be tested in one session.

The header in the leak testing sheet has the Model, VIN number, Odometer, Employee ID and Date. The potential leak areas all have Pass / Fail and notes. The areas of potential leaks to be inspected are as follows:

- Window Edges,
- Window Latches,
- Door Seals,
- Headlight Recess Under Dashboard,
- Cab Seal to Deck and Wheel Wells,
- Cab to Walls,
- Cab to Roof,
- Roof to Walls,
- Back to Roof and
- Walls.

In addition there are line drawings of the vehicle with side, front views for pin pointing potential leaks.

Figure 5: Leak Test Rig

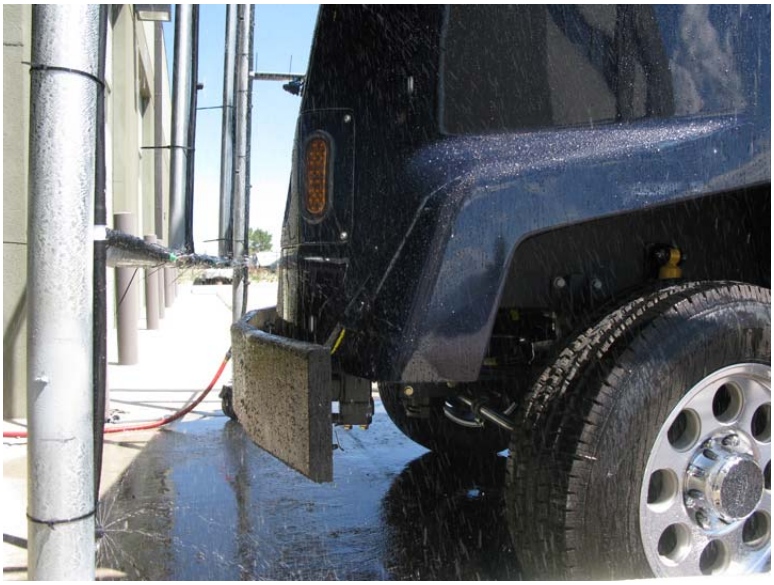

Figure 6: Leak Test Front, close up

Test Drive Results

We have developed a company policy of putting at least 500 real miles on every truck we deliver. With an average range of 120 miles this means four full charge and discharge cycles on the battery pack. We have developed a one page driver log which records pertinent information at the start and at the end of each drive cycle. The pertinent information in the header is the usual Model, VIN, Employee ID and Date. The following information is recorded at both the start and end of the drive cycle:

- SOC,
- Odometer,

- Pack Volts,
- Hi Cell Value,
- Hi Cell Temperature,
- Lo Cell Value,
- Lo Cell Temperature, and
- A section for notes.

Task 2.2.2.2 Initial Battery Full Cycle Tests

From the Grant Activities (Scope of Work):

> *"2.2.2.2. The PERFORMING PARTY will perform initial battery full cycling tests."*

Each battery pack has three separate tests at three different points in time. Each of these is designed to help detect a bad cell before the truck is delivered to the field validation partner or customer where a repair would be much more costly than if it was performed at our factory. The first test, Cell Voltage Differential, logs the voltage of each of 112 cells when the cells first go into the pack and then again after approximately one month, this gives the cells a chance to self-discharge showing any problem cells that might need to be replaced. The second test, Battery Pack Final Checklist, verifies that the interconnections between cells are correctly torqued and that the pack charges as an entire unit, any connections that are not adequate will show up in lower voltages across the interconnections. This test is performed right before the battery pack leaves the battery room to go onto the vehicle. The third and last test, Cell Cycle / Driving Log is geared to put 5 full cycles (complete charge and discharge) onto the vehicle so as to make sure the pack and the cells report range power and high and low temperatures within acceptable parameters. These tests record the Model, Date, VIN, Employee ID and Battery Pack Serial Number. This also records the serial number of the volt meter used to perform the tests.

Additional information recorded is voltage across cell blocks (or groups of eight), voltages across the battery interconnects between the cell blocks, and verification that all bolts have been properly torqued to the correct specifications. Further cycle testing is performed during real world drive conditions as specified above in Test Drive Results.

In addition the battery quality control process starts well before the battery pack leaves the battery room. Each cell is bar coded and its cell voltage is logged along with the cell's serial number when the cells arrive at our manufacturing facility, the date of arrival is also logged. The difference in each cell is then logged when the cells are assembled into a battery pack, and we try to make this shelf time for cells at least 4 weeks. If there is any substantial difference it means that particular cell has a self-discharge issue and will most likely fail in the first ten full cycles of the battery pack. Therefore we do not place that particular cell into a production battery pack.

Figure 7: Battery Pack with 112 cells, interconnects and Battery Management System, BMS.

Task 2.2.3 Schedule

From the Grant Activities (Scope of Work):

> *"2.2.3. The PERFORMING PARTY shall complete this task within 18 months of the signed Notice to Proceed Date as issued by TCEQ."*

We are delivering this task report on schedule as per amendments.

Task 2.2.4 Deliverables

From the Grant Activities (Scope of Work):

> *"2.2.4 The PERFORMING PARTY shall submit a report to the TCEQ upon completion of this task. This report will include but is not limited to the data book specifications documentation, quality control test procedure documentation including go/no go parameters, and test records for each vehicle's initial battery pack cycling."*

Data book specifications can be found in Appendix A.

Quality control test procedures can be found in Appendix B.

Initial battery pack cycling data can be found in Appendix C.

Discussion/Observations

Objectives vs. Results

The objective of Task 2 was to build 18 field validation vehicles and the result was that we succeeded. In the original grant we had specified this would be completed within 6 months of a signed notice to proceed (NTP), however we filed for two extensions so that the completion date became 18 months from a signed NTP. The main delay was due to the bankruptcy of a key vendor as explained in many previous monthly reports as well as below under "Critical Issues". The development of our quality control checklists were a direct result of ongoing issues from Vendors as well as internal build process development.

Critical issues

The key problem to overcome in going from our first two prototype vehicles into small scale production and the build of 18 vehicles as specified for Task 2 was managing the myriad of vendors so that all parts for each of the station builds were in the right place at the right time. We had a substantial delay on the first nine trucks due to a shelving vendor being two months late on delivery. However this is just the normal manufacturing problems of a new product with thousands of parts involved. This issue will take care of itself as we move into full scale production and weed out the reliable vendors vs. the ones that cannot deliver on time.

A higher level critical issue is that of the electric vehicle supply chain in general. Many companies that are producing parts for electric vehicles are either small companies that may or may not be financially stable, or even very large United State Department of Energy (DOE) funded publicly traded companies which also may be financially unstable. During execution of Task 2 both Azure Dynamics, one of our vendors, and A123, not one of our vendors, have filed for bankruptcy. Azure Dynamics' failure caused a re-engineering of our motor and controller integration on the mechanical, electrical, and internal vehicle communications levels. This in turn caused delay and added expense on the cost share side of the balance sheet. This was not just a vendor of tires, or nuts and bolts failing, but a key manufacturer of electric vehicle drive train technology.

But the problem also goes deeper than whether any given company will continue to be financially sound and a going concern. There are many products which although needed in the market place are not yet proven out to withstand the automotive environment, such as high voltage air conditioning condensers, which even though they may work and not yet demonstrate a substantial failure mode, they are not yet packaged for standard automotive protection and are not yet scaled for the size of large vehicles (trucks and busses) which will demonstrate a substantial fossil fuel, NO_x and particulate matter (PM) savings over conventional diesel and gasoline vehicles. The price of components needs to come down and the quality needs to go up. This is a typical stage for a component industry yet in its infancy. However there is a systemic problem which is that electric vehicle component engineers tend to have their backgrounds in electrical engineering and programming and not in the mechanical or quality control fields.

The quality control issue as it relates to suppliers also got to a critical point as we had to teach two separate vendors about revision levels of software and how to track that and how to supply us with the

correct revision. This is why two separate components have software revision levels in our final inspection sheets.

We would highly recommend any validation projects implement part management and quality control procedures as early as possible in the process.

Technical and commercial viability of the proposed approach

The goal of Task 2, to build 18 field validation vehicles, was technically achievable. The technical barriers become control of the supply chain and controlling our own key vendors and being able to monitor their financial stability. The barriers to commercialization now become economies of scale and managed growth. We estimate that from two prototypes to 18 test vehicles our cost of parts reduced by about 10%. We estimate that by ordering parts in 100 lots we would reduce costs another 10% and with 1,000 lots another 10% and so on. At this point we are basically producing the vehicles by hand similarly to a Rolls Royce. This will work at 250 vehicles per year but not at 25,000. But with substantial orders will come the needed tooling to increase automation and decrease labor. Even producing vehicles by hand our full price of a vehicle is below that of our competitor's costs of goods so the commercial viability is there if we receive substantial orders.

Scope for future work

A key area of interest is the development of more efficient heating systems for electric vehicles. Another key area of interest is the aerodynamic flow of the cabin heating and cooling air and increasing output by making the airflow more efficient. Another key area of interest is heated steering wheels and heated seats for large vehicles.

Intellectual Properties/Publications/Presentations

We have not filed any new IP during this project.

Summary/Conclusions

The accomplishments of Task 2 are substantial in that we were able to develop several manufacturing systems simultaneously, such as inventory management, quality control, build processes and engineering. We have also built 18 test vehicles inside of 18 months. Our test vehicles have been driven as fast as 91 miles per hour and still maintained a 100 mile range. This is a record speed for an electric cargo truck. In addition we have integrated several key customer requirements as part of the build process, thereby furthering the likelihood of commercialization.

The electric vehicle supply chain is not only immature as far as component development it is also underdeveloped as far as the needed innovations needed for cold climate operation as well as quality control. In addition electric vehicles have to compete with diesel and gas vehicles that have had 110 years

of product development. Thus vehicle performance and creature comfort expectations are substantially higher now than they were in the year 1900. That being said the progress made in the last 10 years is substantial and as economies of scale come to bear the quality and types of components will improve. We would strongly recommend component development for future work with an emphasis on highly efficient heating systems for cab and creature comfort.

Acknowledgements

We would like to thank our field validation partners at the Cities of Dallas, Galveston and San Antonio as well with FedEx Express and United Parcel Service all of whom have added greatly to our knowledge of fleet needs and commercial viability.

Contact Information

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Appendices

Appendix A: Data Book Specifications

The information in this appendix was claimed by the grantee as Proprietary and/or Confidential. To view this information please contact the New Technology Research and Development program at:

(512) 239-4950

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Appendix B: Quality Control Test Procedures

The information in this appendix was claimed by the grantee as Proprietary and/or Confidential. To view this information please contact the New Technology Research and Development program at:

(512) 239-4950

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Appendix C: Initial Battery Pack Cycling Data

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