

**Texas Commission on Environmental Quality
New Technology Research & Development (NTRD) Program
Monthly Project Status Report**

Contract Number: 582-11-13472-2019

Grantee: Transportation Power, Inc. (TransPower)

Report for the Monthly period: 09/08/12 – 10/05/12 **Date Submitted:** 10/10/12

Section I. Accomplishments

Provide a bulleted list of project accomplishments as well as a description of their importance to the project.

- Tractor #1 was drive tested during the period. While initial drive testing validated the basic functionality of the tractor, including driving during a highly successful “roll-out” event held near the Port of Los Angeles in early September 2012. However, several issues did emerge during drive testing, which are detailed in the Problems/Solutions sections below. Drive testing on Tractor #1 is not yet complete and delivery of the tractor to H-E-B in San Antonio, Texas, is being delayed by about a month to enable us to fully resolve these issues before the tractor is delivered.
- The specifications for electrical infrastructure to support charging were approved by H-E-B. H-E-B expects to complete installation during the next reporting period.
- Tractor #2 has been disassembled with all legacy diesel equipment removed



Figure 1: Disassembled tractor

- The mechanical components of Tractor #2’s energy storage system have largely been fabricated and are out for painting. This includes the mile max module enclosures and mile max module mounts.



Figure 2: Mile Max module enclosures



Figure 3: Mile Max module mounts

- The electric accessory motors for Tractor #2 have passed component level testing.



Figure 4: Electric motors after testing

- The central control module (CCM) for Tractor #2 is largely assembled.
- The Inverter-Charger Unit (ICU) for Tractor #2 has been built and is ready for installation.
- The driveline components for Tractor #2, including the motor-transmission assembly, are in the process of being assembled.

Indicate which part of the Grant Activities as defined in the grant agreement, the above accomplishments are related to:

- The first accomplishment relates to *Task 2.3.1, “The PERFORMING PARTY will conduct at least 3 weeks of drive testing of Tractor 1 in simulated and/or actual service.”*
- The second accomplishment relates to *Task 2.4.2.1, “The PERFORMING PARTY will deliver Tractors 1 and 2 to the field demonstration site, HEB’s primary distribution facility in San Antonio, Texas.”*
- The final six accomplishments relate to *Task 2.2.3, “Tractor 2 installation”*.

Section II: Problems/Solutions

Problem(s) Identified: Report anticipated or unanticipated problem(s) encountered and its effect on the progress of the project

- a) TransPower engineers discovered a software bug in the control box for the automated shifter that is causing unintended behavior. When instructed by the vehicle control software, the automated shifter is supposed to shift into neutral and await the next gear request. It was discovered that the shifter was actually shifting into a lower gear prior to shifting into neutral. This was behavior that the component manufacturer was unaware of. Traditional applications for this technology utilize a clutch for shifting, rendering them immune to this issue. TransPower's automated manual transmission, however, is clutch-less. This issue also only affects the shift between second and third gears, which is why TransPower's subsystem level testing did not catch it.
- b) The BMS in Tractor #1 was reporting anomalous voltage readings for one of the cells on the tractor. Manual inspection yielded a cell with zero voltage potential, indicating a dead cell.
- c) Initial drive testing revealed that excessive weight is being placed on the front axle of Tractor #1 and the vehicle's front tires. This is caused by the fact that space constraints required us to install several heavy components toward the front of the tractor, including six battery modules, the ICU, the CCM, and most of the electrically-driven accessories.
- d) Recharging of Tractor #1's batteries with the ICU revealed that the ICU experiences faults when charging at lower power levels. TransPower engineers have met with engineers from EPC, the company that developed and builds the ICU, to discuss this issue during the recent reporting period.

Proposed Solution(s): Report any possible solution(s) to the problem(s) that were considered/encountered

- a) Since this is an issue with the software running in the automated shifter control box, the two proposed solutions were to ask the component manufacturer to identify and fix the software bug, or alternatively to build a proprietary control system. The first solution was strongly preferred.
- b) The overall battery pack was low when the anomalous readings were first reported. It was discovered that there was an apparent miscommunication between the BMS and the control software, such that the control software failed to stop the drive system from drawing power when the lowest cell reached its low threshold voltage.
- c) The potential solutions to the weight problem include redesigning the installation to move components further back in the tractor, reducing the size or number of batteries on the tractor, or strengthening the front end of the tractor to handle the higher weight. The last of these solutions has been selected as it is viewed as the least costly and will have the least impact on vehicle performance.
- d) EPC is presently investigating reasons for ICU anomalies during low-power charging. Apparently, since the focus of their efforts during ICU testing was to validate the device's ability to support high-power charging, the issue of problems with low-level charging went unnoticed. Resolving this problem will probably require some modification to the ICU circuitry or software.

Action(s) Conducted and Results: Describe the action(s) taken to resolve the problem(s) and its effect

- a) The component manufacturer has agreed to identify the software issue and resolve it via a firmware update.

- b) The BMS component manufacturer was asked to help troubleshoot the miscommunication. The control software was modified to fix the bug. Additional testing will confirm that this issue is resolved.
- c) Strengthening of the tractor front end will consist of replacing the tractor's front axle and front tires. Fortunately the tractor manufacturer, Cargotec, has an axle with a higher rating and the tire manufacturer, Michelin, sells tires with higher weight ratings as well. Upgrading to these higher rating components will represent an unplanned expense, but can be accommodated due to reductions in costs of certain other components. The effect of these changes, along with the changes described in a) and b) above, will be to delay return of Tractor #1 to local road testing (by TransPower) for a period of about one month. Road testing is presently expected to resume between October 20, 2012, and October 30, 2012, which will push delivery of Tractor #1 to H-E-B into early November 2012 (the target date for delivery to H-E-B was October 1, 2012). Since similar upgrades will also be required for Tractor #2, road testing and delivery of the second tractor to H-E-B will also be delayed. We would like to complete road testing of Tractor #2 and deliver it to H-E-B by the end of November 2012, which would enable six full months of in-service testing of both tractors. We'll have a better idea as to whether this goal is realistic by the end of the next monthly reporting period.
- d) Various solutions to the low-power charging problem are being investigated and it is expected this issue will be resolved within the next reporting period.

Section III. Goals and Issues for Succeeding Period:

Provide a brief description of the goal(s) you hope to realize in the coming period and identify any notable challenges that can be foreseen

Goals for the next reporting period (ending November 10) include:

- Finish drive testing and drive system optimization on Tractor #1.
- Deliver Tractor #1 to H-E-B's facility in San Antonio, Texas. Along with the tractor delivery, TransPower will provide training to H-E-B vehicle operators and maintenance personnel, and will closely monitor the tractor's first few weeks of operation with on-site engineering support.
- Complete integration of Tractor #2. Our most recent target date for completion of this task was October 14, 2012, and in any event the tractor is expected to be completed and in road testing by the end of the next reporting period.
- Compile preliminary data on the performance of both tractors, including initial estimates of how many hours of tractor operation can be supported on a single battery charge and energy efficiency.

Notable challenges that can be foreseen in pursuing these objectives include resolution of the unexpected issues that arose during initial road testing of Tractor #1 (particularly the software bug related to the automated manual transmission), the tractor weight distribution issue, and the low-power charging issue. While such problems are always frustrating, they are not uncommon in research and development programs, especially on project such as this where the technologies being developed are "pushing the envelope" on multiple fronts (e.g., new transmission technologies, larger battery packs, and development of unique high-power onboard battery charging concepts.) While the delays in placing the tractors are a cause for concern, TransPower believes that the long-term benefits of taking the time to perfect all these new products easily justify these temporary setbacks.

Date: 10/10/2012

Authorized Project Representative's Signature

NOTE: *Please attach any additional information that you feel should be a part of your report or that may be required to meet the deliverable requirements for tasks completed during this reporting period.*