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: 01/05/13 – 02/08/13 **Date Submitted:** 02/11/13

Section I. Accomplishments

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

- Continued road testing of Tractor #1 built confidence in our automated manual transmission (AMT). We have fine-tuned the AMT to provide smooth automatic shifting between high and low gears, and have initiated efforts to enable three-gear shifting.
- Sealing of all battery modules on both tractors was completed. As discussed in last month's report, noticeable amounts of dust and debris built up on the battery cells in Tractor #1 during its first few months of durability testing. At the same time, battery temperature readings remained constant, providing confidence that we could alleviate the contamination problem – and achieve a higher degree of waterproofing – by sealing the battery modules. Figure 1 is a close-up view of one of the battery modules installed on Tractor #2, showing how fabric and silicone were used to seal the openings and crevices around the module.

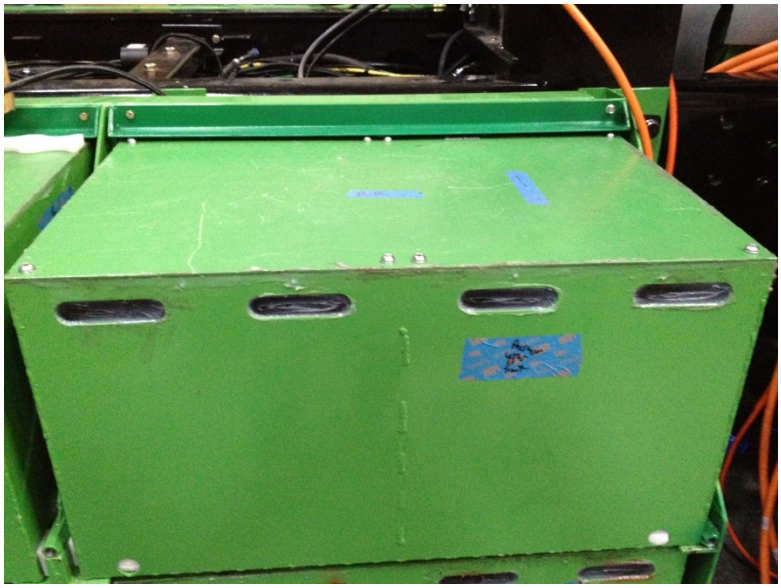

Figure 1. Close-up of a battery module showing sealing of openings.

As further precautions against battery debris or water damage, we wrapped a plastic blanket around the battery modules in the interior of the tractors and installed heavy-duty aluminum enclosures around the battery modules mounted on both sides of the tractors. Figure 2 shows the aluminum enclosures surrounding the side-mounted battery modules on Tractor #1.

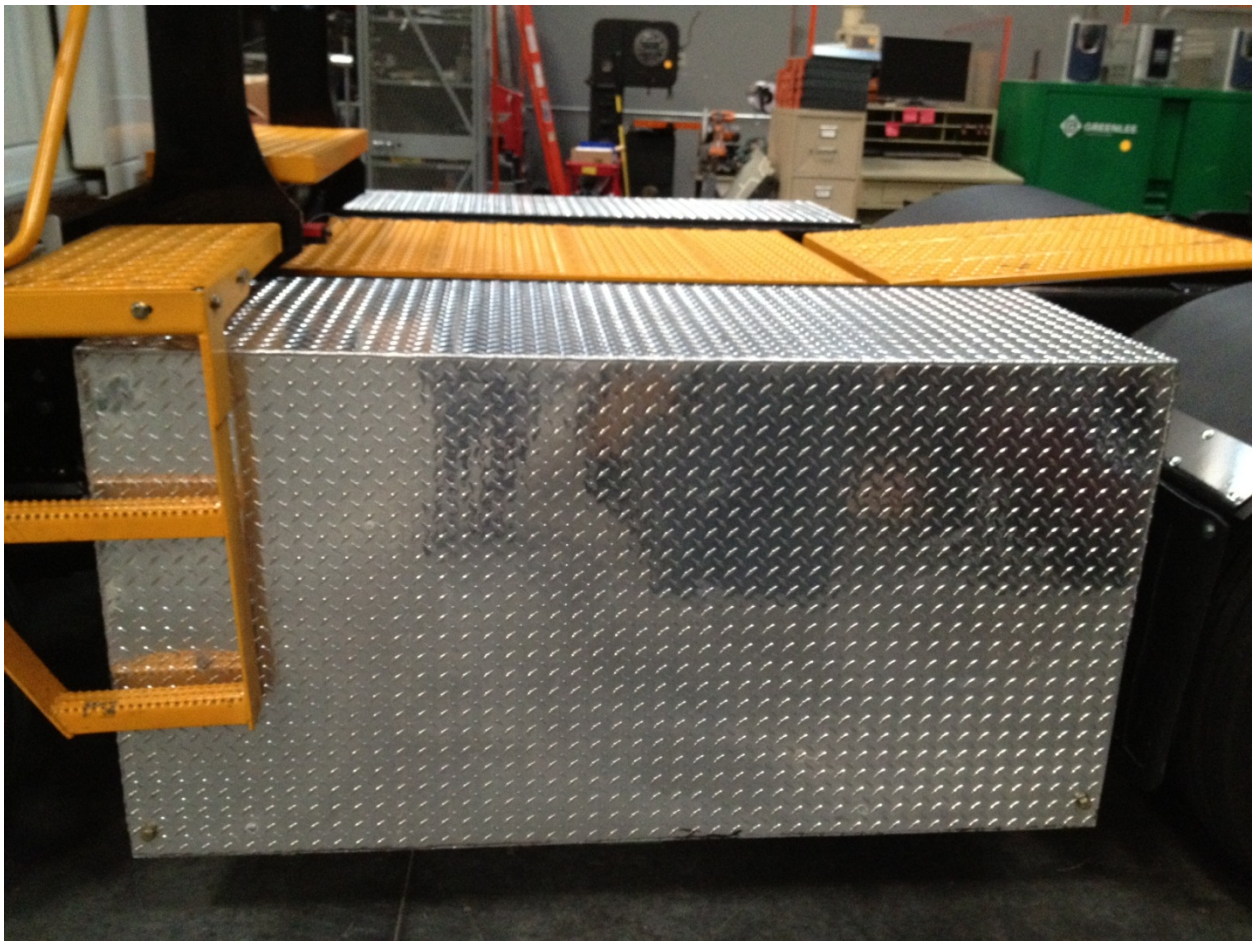

Figure 2: Aluminum enclosures installed to protect side-mounted battery modules on Tractor #1.

Tractor #1 was sent to Southern California Edison (SCE) for a week of road testing in the vicinity of SCE's facility in Pomona, California. During this testing, the tractor was subjected to heavier loads and higher speeds than it experienced during any previous testing at TransPower's Poway facilities. This testing disclosed an unanticipated problem with the design of TransPower's electrically-driven accessory subsystem that is triggered by high power demands. This problem and our proposed solution are discussed in Section II. Figure 3 is a photo of Tractor #1 during its testing near SCE's Pomona facilities. Despite this problem, some drive testing was successfully performed, and drivers reported that the tractor was significantly smoother and faster than conventional tractors, and also faster than other electric tractors that had been tested previously.

Figure 3: Tractor #1 during durability testing near Southern California Edison's Pomona facility.

- A grant modification request to allow more time for durability testing was approved.
- On February 7, TransPower was informed by the San Joaquin Valley Air Pollution Control District in California that it had been selected to build an electric yard tractor similar to those built on this project, which will be demonstrated by IKEA at its distribution center in Lebec, California.

Indicate which part of the Grant Activities as defined in the grant agreement, the above accomplishments are related to:
The first four of the accomplishments described above relate to *Task 2.3.1, "The PERFORMING PARTY will conduct at least 3 months of drive testing of Tractor 1 in simulated and/or actual service."*

- The first accomplishment relates specifically to and to *Task 2.3.1.2, "The PERFORMING PARTY will optimize the drive system to maximize energy efficiency while meeting performance requirements and maintaining driver comfort."*
- The second, third, and fourth accomplishments relate specifically to and to *Task 2.3.1.3, "The PERFORMING PARTY will identify problems likely to occur in operational service during durability testing of Tractor 1 and implement any changes to the electric drive system deemed necessary to assure reliable operation of the tractors once they are placed in actual field service."*
- The fifth and sixth accomplishments related to contract administration and commercialization of technologies resulting from the project; the latter provides the first concrete evidence that TCEQ funding for this project is beginning to have a broader impact on the industry.

Section II: Problems/Solutions

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

a) Removal, cleaning, sealing, and replacement of the battery modules on Tractor #2 delayed the completion of commissioning of this vehicle by more than a month. At the time of last month's report, this delay was reported to be about three weeks, but upon reinstallation of the battery modules it was discovered that the battery management system had been rewired incorrectly. Due to the newness and complexity of the battery management system, it took an additional week or two to resolve these problems. Commissioning of Tractor #2 was further delayed by the discovery of a minor problem with a circuit board in its inverter-charger unit.

b) As discussed in Section I, testing of Tractor #1 under higher power levels than previously experienced disclosed a problem with the electrically-driven accessory subsystem. When tested by Southern California Edison drivers under high power loads, Tractor #1 intermittently ceased to function due to a fault in this subsystem. An investigation of the problem revealed that the "soft starters" used to start up the air compressor for the braking system and the air conditioning were creating electrical problems with the variable frequency drive (VFD) that regulates power to these devices. By creating current spikes that were causing the VFD to shut down, the soft starters were in effect causing the exact problem they were designed to prevent.

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

- The battery management system problem discovered during sealing and replacement of the Tractor #2 batteries was solved by recreating the battery management system configuration used in Tractor #1 and improving its documentation to reduce the likelihood that future systems are wired improperly. The inverter-charger unit problem discovered during Tractor #2 commissioning was solved by replacing the faulty board, and in future inverter-charger units this board will be subjected to additional testing to avoid such problems, which was determined to be an "infant mortality" issue.
- Potential solutions to the accessory problem included finding a different VFD that can operate with soft starters, eliminating the soft starters and running the brake air compressor and air conditioning compressor all the time, or eliminating the soft starters and using the VFD to turn them on and off without soft starters.

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

- The solutions to the battery management system and inverter problems discovered on Tractor #2 are discussed above. The effect of these problems, as addressed previously, has been to delay commissioning of Tractor #2. Our hope is to complete commissioning of this tractor and begin its durability testing within the next week, so field testing of the tractor (along with Tractor #1) can begin in early March.
    a) The accessory problem in Tractor #1 is in the process of being solved through the last of the methods described above, i.e., using a separate VFD to operate the braking air compressor and air conditioning system, and utilizing contactors to turn these systems on and off when required. This was determined to be preferable to seeking an alternative VFD product compatible with the soft starters, which would have been costly and might have required a significant redesign of the accessory subsystem, or running these accessories all the time, which would consume more power and reduce tractor energy efficiency and operating range. The effects of this change will be a slight increase in the cost of each tractor to accommodate an additional VFD, along with a further delay in commissioning of Tractor #2, whose central control module must now be redesigned to accommodate this design change. The central control module for Tractor #1 was going to be replaced with a more refined version during durability testing of Tractor #2 anyway, so the accessory change can be incorporated into the new Tractor #1 control module without much additional delay. Some additional drive testing of Tractor #1 will be required before it is considered ready to deliver to HEB in San Antonio, Texas.

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 March 8, 2013) include:

- Complete redesign of accessory subsystem and installation of updated design into Tractor #1 and Tractor #2.
- Complete commissioning of Tractor #2 and at least two weeks of durability testing of this tractor.
- Complete the replacement of the central control module on Tractor #1 and perform a day or two of additional durability testing to reconfirm this tractor's functionality.
- Deliver both tractors to HEB or, at minimum, be in the final preparations for delivering them to HEB within the month of March 2013.

The only notable challenge remaining is to validate the functionality of the new approach to turning the air compressor and air conditioning compressor on and off. This may require a bit of trial and error, but is not seen as a significant risk factor. This is actually an example of the type of problem that most likely would have come up during later field testing of the tractors at HEB, but the opportunity to test Tractor #1 with Southern California Edison in effect enabled us to perform some valuable field testing closer to TransPower's headquarters. While this is further delaying the long-awaited arrival of the tractors in Texas, it also further solidifies the drive system design and increases the likelihood that the tractors will operate reliably once they are delivered to Texas – a milestone now expected to occur during the first half of March 2013.

Date: 2/11/2013

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.*