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.

Report for the Monthly period: 06/09/12 – 07/06/12 **Date Submitted:** 07/10/12

Section I. Accomplishments

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

Motive Drive Subsystem

- The main components of the yard tractor motive drive subsystem, an electric drive motor mated to an automated manual transmission, have been integrated. As shown in Figure 1, this assembly has been test-fitted into the frame rails of Tractor #1. The shifting hardware for the automated manual transmission has been calibrated and the shifting logic has gone through a "dry run" with simulated motor speed signals.

Figure 1: Motor attached to automated manual transmission, with entire assembly in Tractor #1.

Integrated Motor/Motor Control Subsystem

TransPower is in the final stages of assembling a dynamometer that will be used for final validation of the integrated motor/motor control subsystem. Motor control will be accomplished with a custom-designed inverter-charger unit (ICU), which will also be used to recharge the tractor's batteries when the tractors are plugged into the grid. Dynamometer testing of the integrated subsystem consisting of the ICU and motive drive subsystem is scheduled to begin by the week of July 16, 2012, through July 20, 2012, upon delivery to TransPower of the prototype ICU from EPC, the manufacturer of the ICU.

Energy Storage Subsystem

- TransPower has finalized the design of the Mile-Max™ module that will be the main building block for the yard tractor energy storage subsystem (ESS), and is close to finalizing the Mile-Max™

mounting strategy. An assembly of 4 modules will be mounted on each side of each tractor, with an additional 6 modules underneath the cab. Each of the 14 Mile-Max™ modules on each tractor will contain 16 large format (300 ampere-hour) lithium ion battery cells. As shown in Figure 2, two mounting plates are installed at the top of each module, each providing the electrical connections and battery management system (BMS) sensing for 8 cells. The 14 modules on each tractor will be electrically connected in two parallel strings of 7 modules, with 112 cells in each string.

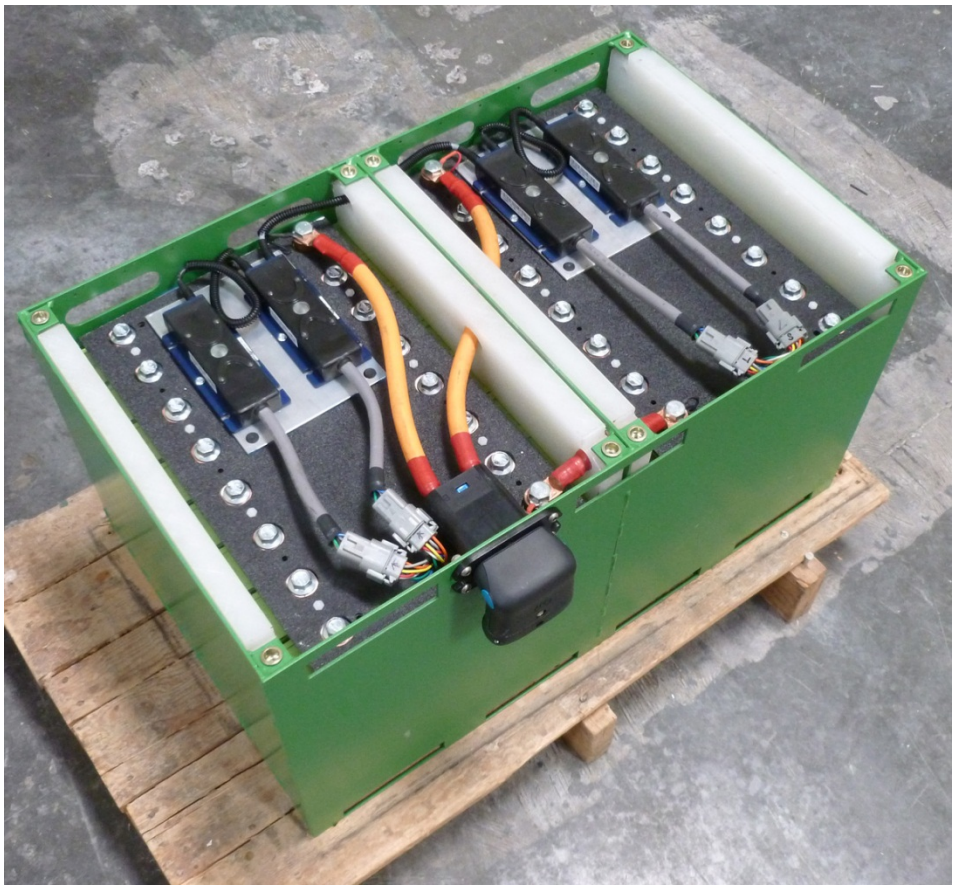

Figure 2: Fully-assembled Mile-Max™ battery module.

- The 448 battery cells required for both tractors were received during the most recent reporting period.
- The mounting structure for the six Mile-Max™ modules to be installed under the cab of Tractor #1 was fabricated and installed into the tractor (Figure 3).

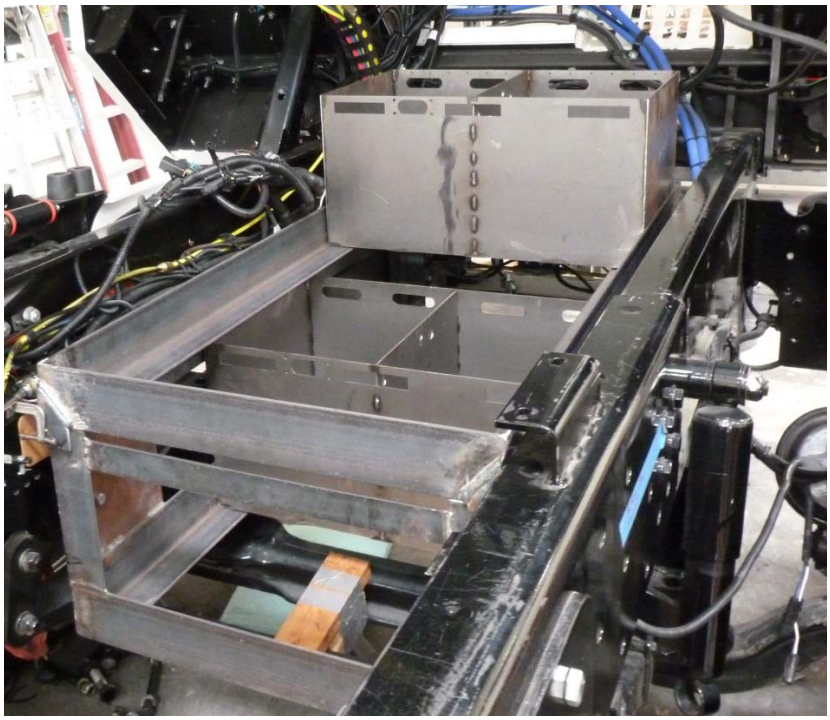

Figure 3: Under-cab mounting structure for ESS modules.

- The mounting structure for the four Mile-Max™ modules to be installed on each side of the tractors was designed, and units were built and test fitted on a Navistar on-road truck prior to fabrication and installation of the structures to be used on the two yard tractors (Figure 4).

Figure 4: Structure to support side-mounted battery modules, installed on Navistar test truck.

Power Control and Distribution Center (PCDC)

- The PCDC for Tractor 1 has been completed, including the modifications to the tractor's gauge cluster. The PCDC, shown in Figure 5, contains drive system controls and main electrical connections, and routes power in the appropriate form to the various tractor subsystems.

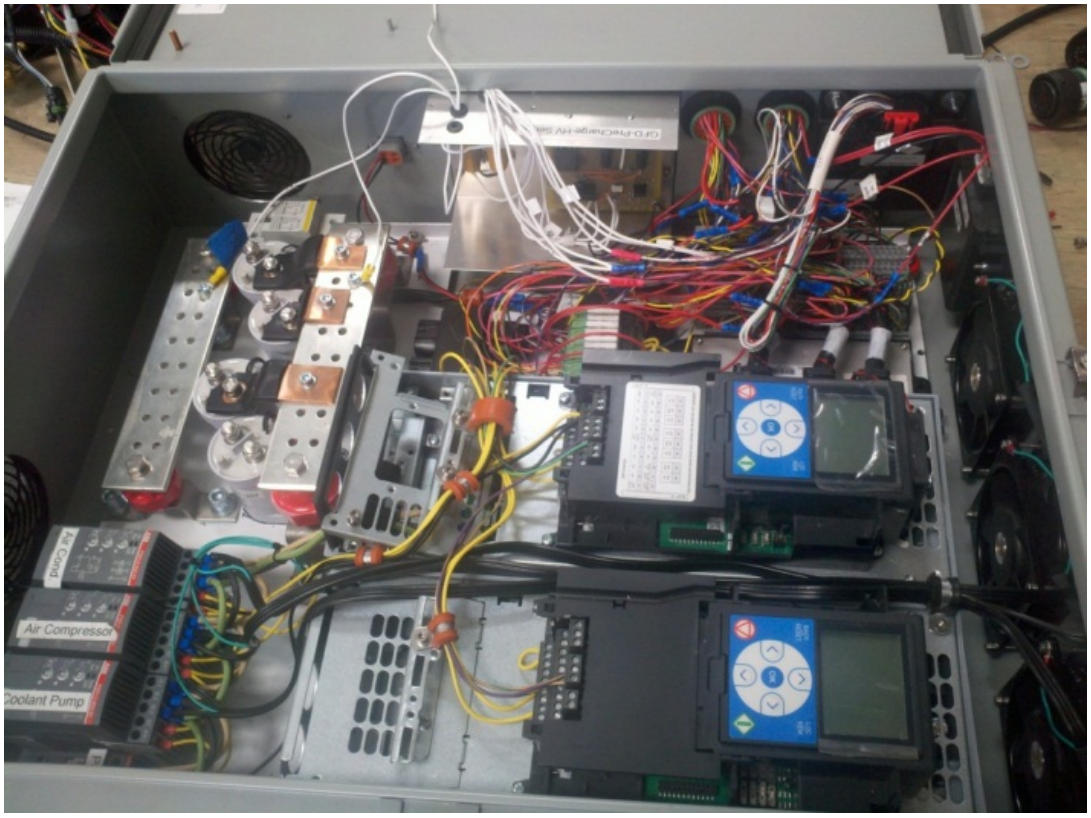

Figure 5: PCDC for Tractor #1.

- The PCDC hardware for Tractor 1 is complete, including the modifications to the tractor's gauge cluster.
- Power-up procedures have been finalized, and a 12V power-up test has been completed. All input/output (I/O) and impacted logic are verified and tested. Drive system software contains all of the necessary functionality.
- The next steps for software development will be to calibrate the software using the dynamometer as well as improve the robustness of the software by adding additional layers of fault tolerance.

Electrically-Driven Accessory Subsystem (EDAS)

- The EDAS provides electrical power to the tractor accessories, which include an air compressor for the braking system, air conditioning unit, power steering pump, and a hydraulic pump for the fifth wheel lift. The EDAS has been designed and most of its components have been installed into Tractor #1. A few components, such as the air compressor, will not be installed until after the energy storage system mounting structure is finalized to allow increased access.

Figure 2: Hydraulic pump assembly mounted to tractor

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

- All of the accomplishments listed above relate to Task 2.2.2, “Tractor 1 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) When initial efforts were made to install the center-mounted (under-cab) battery modules onto Tractor #1, it was discovered that the module structures were too tall to fit within the available space. This was due to a small error in calculating the space available between the lower frame of the chassis and the top of the cab enclosure.
b) During dynamometer testing of the first prototype ICU, some noise issues have been observed. This raised a concern that, if left unaddressed, such noise could disrupt the operations of other electronic devices on the tractors using the ICU.
c) ICU supplier EPC has reported that they are experiencing a two-week delay in receipt of the enclosures and inductors for the ICUs to be installed into the two tractors.

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

a) The options for addressing the oversized battery modules were to either expand the space available under the cab by modifying the cab structure, or trimming the height of the battery module boxes to be installed in this area.
b) Options for dealing with the noise issue included modifying the inverter or putting additional shielding on other electronic components in the drive system.
c) As there are no alternative suppliers for the ICU enclosures and the inductors are long-lead items from any supplier, there is not much TransPower or EPC can do about these latest parts delays.

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

a) The easiest remedy for the battery module size problem was to trim about one half inch of material from the bottom of each module to enable them to fit within the space under the cab. The modules were modified accordingly, thus solving the problem
b) After further analysis, it was determined that the noise issues were artifacts of the data acquisition device and not the inverter, hence the ICU is not now expected to produce sufficient noise to disrupt any other components. Nonetheless, as an added precaution, a common mode choke is being added to the ICU to reduce common mode noise.
c) The first prototype ICU, which will not be used in either tractor, will be utilized for the dynamometer testing involving the motor and automated transmission, planned for the week of July 16, 2012, to July 20, 2012. This will enable final calibration of the motor-transmission controls to be achieved without having to wait for the first tractor ICU. If the first tractor ICU is received on or around July 20, 2012, as is now expected, this will enable it to be installed into Tractor #1 during the week of July 23, 2012, to July 27, 2012. Assuming all other remaining work proceeds as planned, this would keep us on track to achieve our goals of completing Tractor #1 by the end of July 2012 and enable us to begin drive testing of this tractor during 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 August 10, 2012) include:

- Complete Tractor #1.
- Initiate drive testing of Tractor #1.
- Begin preparations for installation of the electric drive system into Tractor #2.

Achievement of these goals entails the key challenge of making all electric drive components work together for the first time. It is hoped that the extensive bench testing and dynamometer testing performed prior to final tractor commissioning will increase the likelihood that the components all work together seamlessly once installed into the first tractor.

Date: 7/10/12

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.*