

Quarterly Progress Report

A. **SCAQMD Contract #13433** Contract Recipient: US Hybrid Corporation

B. **Project Title:** Zero Emission Cargo Transport Demonstration

Project Director: Brian Choe, SCAQMD

C. **Report Date:** January 25, 2016 **Period Covered:** 10-1-15 to 12-31-15

D. **A comparison of actual accomplishments with the goals and objectives established for the period and reasons why any established goals were not met.**

Milestone	Description	Estimated Completion Date	Date Completed
Task 1.3	Develop a test strategy and data collection with NREL	July 2015	In progress
Task 2.1	Develop a model for the demonstration vehicles and run vehicle performance of critical performance parameters	Aug 2013	Completed
Task 2.2	Design and develop the powertrain components; energy storage, management and protection system; charging interface and control; and electric-driven hydraulic, air and HVAC accessories.	Aug 2013	Completed
Task 3.1	Procure components and parts to fabricate motor, transmission, battery packs, BMS, charger, CEU, etc.	March 2015	Completed
Task 3.2	Develop a Simulink/Advisor model for traction system and components and validate the model with actual test data chassis dynamometer and on-road testing.	August 2015	Completed
Task 3.3	ABC150 or other power cycling and testing system to validate the energy and power density of battery packs.	May 2015	Completed
Task 3.4	Validate the Safety Disconnect Unit, driver command and display, and data collection systems.	May 2015	Completed
Task 4.1	Procure two class 8 drayage trucks	Oct 2014	Completed
Task 4.2	Perform test and modeling during integration period	Aug 2015	Completed
Task 4.3	Perform chassis dyno test at UCR	Aug 2015	Completed
Task 5.1	Deliver two completed demo vehicles to TTSI	March 2016	In Progress
Task 5.2	Provide Training and Documentation to TTSI	March 2016	In Progress
Task 5.3	Conduct one-month road test prior to full deployment	April 2016	In Progress
Task 5.4	Service during demonstration	Ongoing from March 2016	In Progress
Task 6.1	Install on-board data collection devices according to a data collection plan developed in conjunction with NREL and approved by SCAQMD	July 2015	Completed

Task 7.1-7.3	Design and develop two on-board 60kW 3-phase chargers	August 2015	Completed
Task 7.4	Integrate on-board chargers in vehicle	October 2015	Completed

E. Accomplished this Period:

A discussion of what was accomplished under these goals during this reporting period, including major activities, significant results, major findings or conclusions, key outcomes or other achievements.

Build, Integration, and Testing Work

In this quarter, US Hybrid finished build and integration of truck 1, and proceeded with control and drive testing. US Hybrid designed and fabricated an on-board 3-phase isolated charger rated 60kW, operating from 208V, 3-Phase compatible with EVSE charge port interface and control and integrated it into the vehicle, and proceeded with vehicle drive testing. The charger was also used during the chassis dynamometer testing at UC Riverside. US Hybrid has been test driving the truck in actual high way driving and also testing the 80,000 trailer testing for handling and hill climbing. Following is task specific achievements and achievements during the Q4 2015 period.

- 3.2 CONTRACTOR shall develop a Simulink/Advisor model for traction system and components, and validate the model with actual test data gathered from the truck performance on chassis dynamometer and on-road testing to further validate the model for system optimization. Completed and model verified with both Chassis dyno and road testing. (See the data attached)
- 4.2 During and following vehicle integration, CONTRACTOR shall perform necessary modeling and simulations as well as testing required to verify or validate subsystem or vehicle level design performance and functionality. The testing shall include, but not be limited to, dynamometer testing, durability testing, safety testing, and environmental testing. Completed.
- 4.3 CONTRACTOR shall ensure that at least one of the demonstration vehicles shall be tested on a chassis dynamometer to validate energy efficiency and range by University of California, Riverside. Completed (See Picture)
- 7.1 CONTRACTOR shall design on-board charger interface and control to meet the vehicle system and battery management system requirements. Completed
- 7.2 CONTRACTOR shall design, develop, and fabricate two on-board 60kW, 3-phase chargers and control interfaces in compliance with the EVSE electrical, mechanical, and control interface. Completed.
- 7.3 CONTRACTOR shall integrate on-board chargers in two-battery electric drayage trucks. One truck integration, testing and operation is completed and the second truck is in build process. In order to complete task 7.1 – 7.4, US Hybrid began by ordering three 20kW single-phase chargers from vendor EDN. Once the chargers arrived in mid-October, testing on the units began. The three single-phase units would then be combined to make one, 60kW 3-phase charger. US Hybrid also delivered the vehicle to UC Riverside for chassis dynamometer testing. The integrated charger is pictured below.



Figure 1. Integrated Charger

In addition to satisfying Tasks 7.1 and 7.2, US Hybrid also finished integration of the drivetrain. CAD pictures of the drivetrain are shown below:

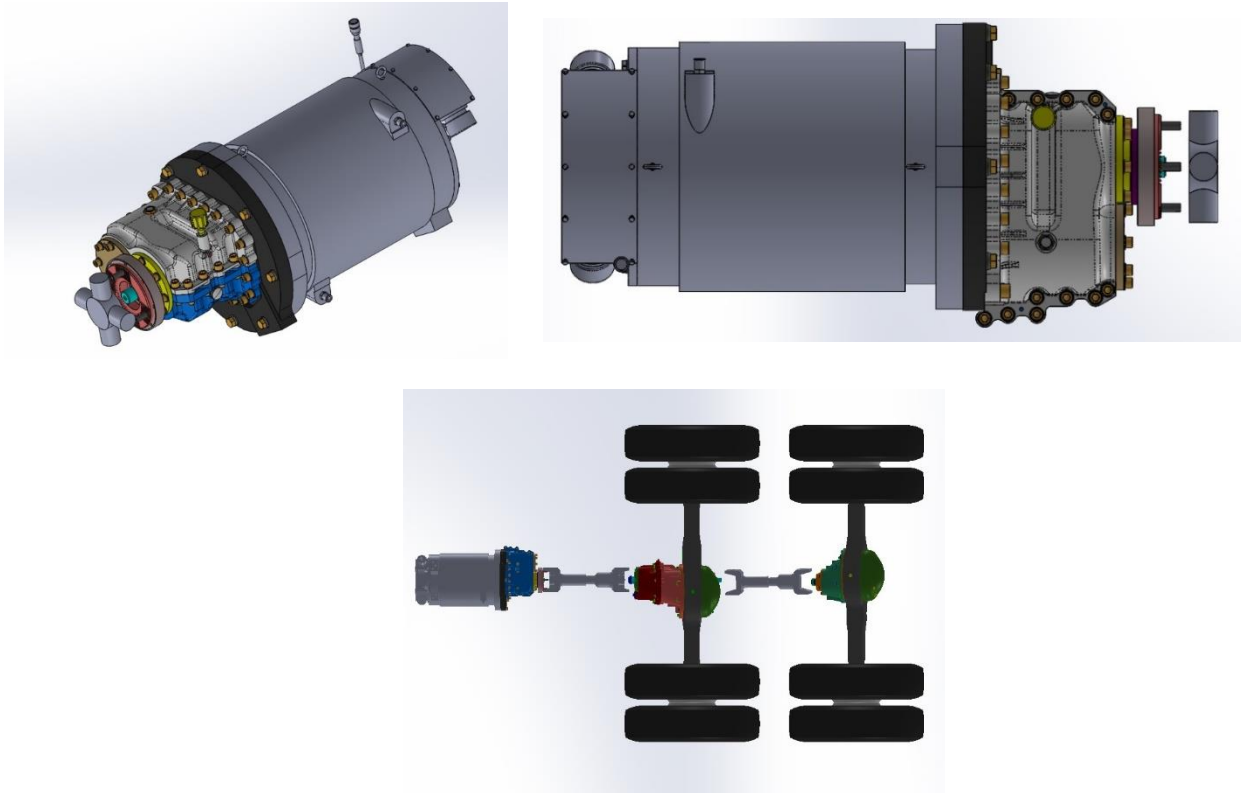


Figure 2. ZECT 1, Direct Electric powertrian (No Transmission shifting)

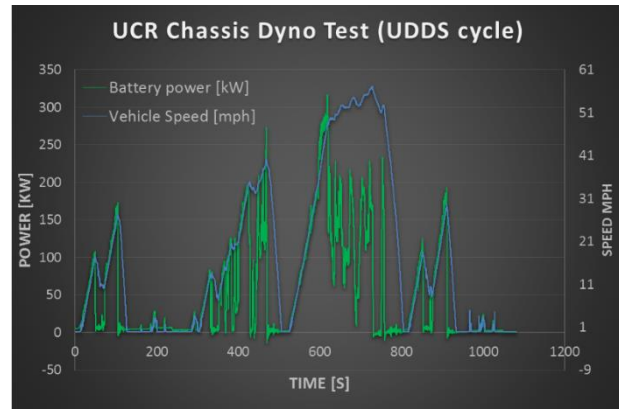


Figure 3. ZECT 1 truck testing at UCR Chassis Dyno testing

The battery reported an energy usage of 7% capacity (15.4kWh). The distance travelled was 5.1miles with energy efficiency of 3.01kWh/mile for UDDS cycle test at UC Riverside chassis dyno under 70,000 lb. GCWR. The truck range at full rated load is about 72 miles. US Hybrid confirmed the chassis dyno test data with the simulation data. The comparative performance is provided below.

US Hybrid Vehicle Specifications

Truck: International ProStar
GVWR:29484 kg (65,000 lb)
Rear Differential: 3.7:1
Tire: GOODYEAR 295/75R22.5
Wheel Radius:0.5 m

Rolling Resistance:0.009
Frontal Area:6.5 m²
Drag Coefficient: C_d=0.7

Motor: EDU320 (320kW)
Gear ratio: 2.93:1

Battery Pack:
 Lion battery: 240 kWh
 Battery Voltage = 600Vdc

Electric Vehicle

US Hybrid Proprietary & Confidential

US Hybrid ADVISOR Customized Simulation Toolbox

US Hybrid Proprietary & Confidential

US Hybrid Drive Cycle

Drive cycle test data
 File: \\Engineering\Projects\SY48 - AQMD\Demo truck\Results1_drive\drage race_street_0_last good one_mid
 Time: Mon Mar 23 17:55:14 2015

US Hybrid Proprietary & Confidential

US Hybrid Simulation Results versus Test Data

Voltage

Motor Speed

Current

Power

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Road Testing:

After completion of integration, US Hybrid conducted control and drive testing. The drive test route (2 loops) and sample plot and data summary is shown below.

1. Columbia Ave East Bound
2. Right turn at Maricopa
3. Left turn at Crenshaw
4. Merge onto I-405 South
5. Exit to Rt 91-East
6. Exit to 710-South
7. Merge back onto I-405 North
8. Exit back to Crenshaw
9. Turn back to Columbia Ave

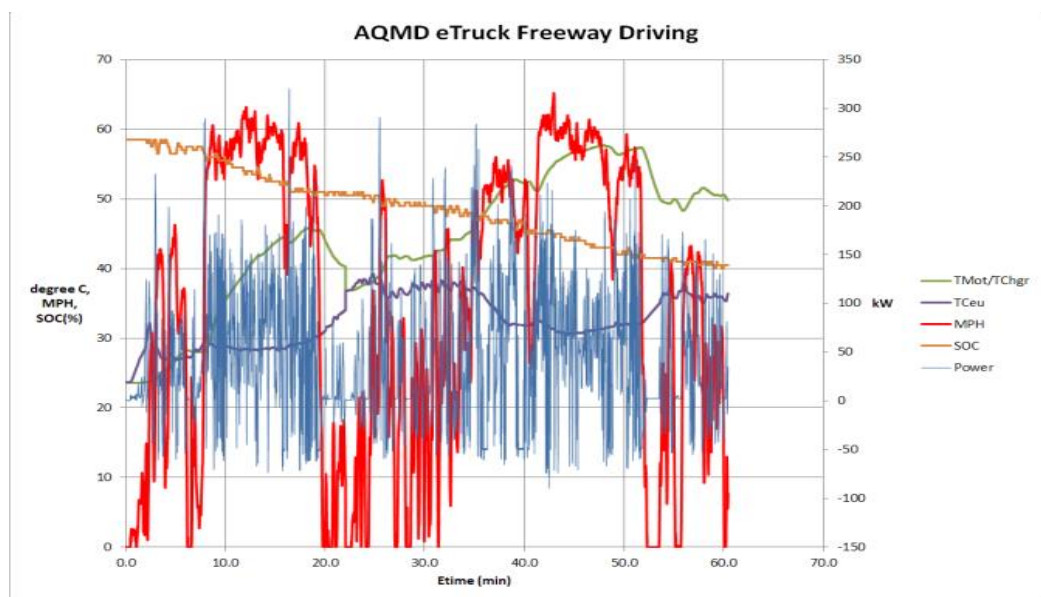
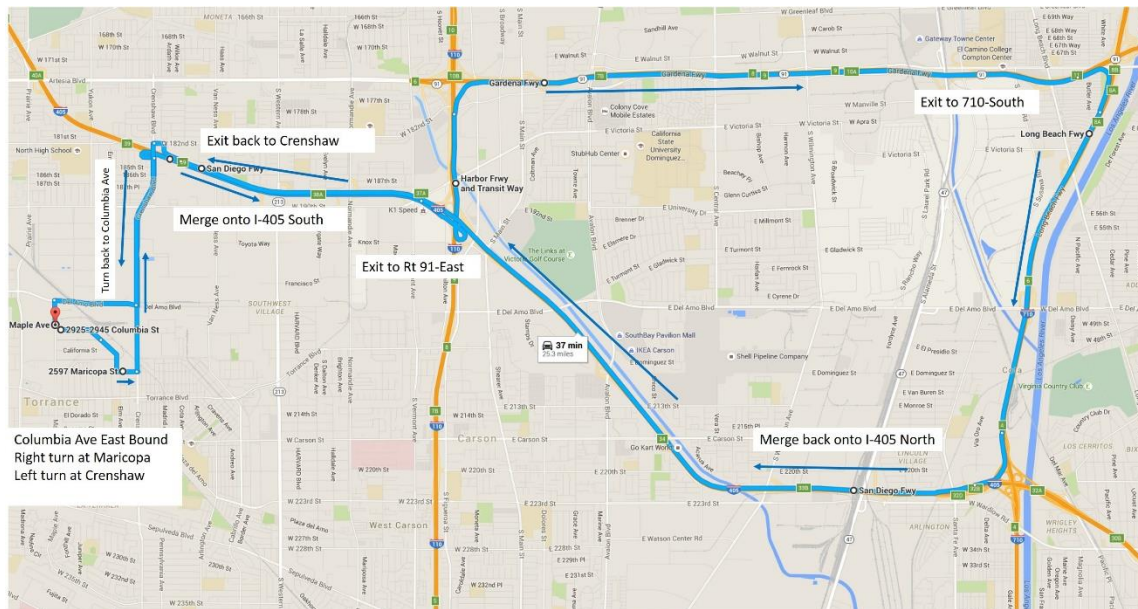


Figure 3. Drive Test Data

ZECT 1 Test Drive Summary							
<i>Test eTruck Curve Weight: 9560 + 9520 = 19,020 LBS</i>							
<i>Plus Driver & Passenger = 280 + 160 = 440 LBS</i>							
Date	Drive Cycle	SOC Begin	SOC End	SOC Net %	kWhr	miles	kWh/mi
10/6/2015	Dr 1				6.6	3.2	2.06
10/6/2015	Dr 2	48.5	43.5	5	5.6	4.3	1.30
10/6/2015	Dr 3	43.5	26.5	17	23.6	17.3	1.36
10/6/2015	Dr 4	26.5	17.5	9	13.4	10.7	1.25
10/8/2015	Dr 1	68	58.5	9.5	31.3	25.2	1.24
10/8/2015	Dr 2	58.5	49.5	9	29.7	24.8	1.20
10/8/2015	Dr 3	49.5	38	11.5	38.3	35.3	1.08
10/10/2015	Dr 1	75	54	21	46.2	35.0	1.32
10/10/2015	Dr 2	54	22	32	97.6	61.0	1.60
10/28/2015	Dr 1	58	40	18	44	35.9	1.23
10/28/2015	Dr 2	40	28	12	26.5	23.7	1.12
11/5/2015	Dr2	81	66	15	27.5	18.8	1.46
11/11/2015	DR	93	82	11	26.4	11.0	2.40
11/23/2015	DR	90	69	21	50.4	31.0	1.63
Total					467.1	337.2	1.39

Table 1. ZECT I, Test Drive and Energy Efficiency (kWh/mile) Summary.

Cost Status:

Show approved budget by budget period and actual costs incurred. Costs shall be broken out by SCAQMD share, CONTRACTOR share, and total costs.

Milestone	SCAQMD Share	Minimum Contractor Share	Total	Total Invoiced to AQMD as of 12/30/15
Task 1.3	\$17,851	\$17,851	\$35,702	\$17,851
Task 2.1 and 2.2	\$64,666	\$64,666	\$129,332	\$64,000
Task 3.1	\$387,994	\$387,995	\$775,989	\$388,660
Task 3.3 and 3.4	\$75,321	\$75,321	\$150,642	\$75,321
Task 6.1	\$32,333	\$32,333	\$64,666	\$32,333
Task 4.1	\$64,666	\$64,666	\$129,332	\$64,666
Task 4.2 and 4.3	\$29,814	\$29,814	\$59,628	\$29,814
Task 3.2	\$21,678	\$21,678	\$43,356	\$21,678
Task 5.1, 5.2 and 5.3	\$79,381	\$79,381	\$158,762	
Tasks 7.1-7.3	\$45,000	\$45,000	\$90,000	\$45,000
Task 7.4	\$30,000	\$30,000	\$60,000	\$30,000
Task 5.4 (Recurring)	\$35,073	\$60,073	\$95,146	
	\$35,073	\$60,073	\$95,146	
	\$35,073	\$60,073	\$95,146	
	\$35,073	\$60,073	\$95,146	
Final Report & Synopsis	\$29,814	\$29,814	\$59,628	
Total	\$1,018,810	\$1,043,811	\$1,987,621	\$769,323

- F. **Changes in Approach:** *Any changes in approach or aims and reasons for change. Remember significant changes to the objectives and scope require prior approval by the contracting officer.*

US Hybrid made some control modifications to ensure vehicle hill climbing capability at full 80,000 lbs. rating. Updated the truck rear axle ratio.

- G. **Problems or Delays:** *Actual or anticipated problems or delays and actions taken or planned to resolve them.*

US Hybrid is still in procurement process of components, fabrication assemblies and batteries for truck 2. Due to limited vendor supply, the delayed arrival of the batteries will delay the complete integration of truck 2. The March delivery data is still the base schedule. Also, US Hybrid is in the process of moving its Torrance integration facility. This facility change will cause some interruption in work. We are working with the present landlord and the potential new location or consolidation of the two facilities.

- H. **Absences or Changes:** Any absence or changes of key personnel or changes in consortium/teaming arrangement.

There have been no absences or changes.

- I. **Product or Technology Transfer:**

A description of any product produced or technology transfer activities accomplished during this reporting period, such as:

- I. Publications (list journal name, volume, issue); conference papers; or other public releases of results. Attach or send copies of public releases to the SCAQMD Project Officer.*
- II. Website or other Internet sites that reflect the results of this project.*
- III. Networks or collaborations fostered.*
- IV. Technologies/Techniques.*
- V. Inventions/Patent applications.*
- VI. Other products, such as data or databases, physical collections, audio or video, software or netware, models, educational aid or curricula, instruments or equipment.*

No product or technology transfer activities took place this period.

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