Electric Drive Component Manufacturing Facilities

Jon Lutz – Presenter
Luke Bokas – Principal Investigator
Organization: UQM Technologies, Inc.
Email: jlutz@uqm.com
Phone: (303) 682-4900

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USDRIVE
DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY

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The Problem

- **Component manufacturing costs are driven largely by production quantity, and to achieve high production volumes, low cost components are required**
- **Without high volume commitment from OEMs, component manufacturers are unwilling to invest in the equipment, tooling, and other supply chain costs to bring propulsion system prices down**
- **Without low cost propulsion systems, OEMs are unable to price vehicles at a level that will create consumer demand**

Project Overview

Focus Area: motors and power electronics (traction drive system)
➔ manufacturing

Objective

- This project aims to address the problem by making manufacturing investments to facilitate lower costs, and therefore, higher volumes within electrified vehicle markets

Addresses Targets

- UQM Technologies is focusing on two markets within this project by taking existing products and applying manufacturing disciplines and investments to bring costs down and volumes up
  - Automotive (100 to 135 kW)
  - Truck and Bus (150 to 220 kW)

Uniqueness and Impacts

- UQM's established technology and decades of vehicle electrification experience provide a solid foundation to apply manufacturing principles and disciplines

Description of Technology/Approach

- Apply Design for Manufacturing and Assembly (DFM/DFA) principles to existing products to create low cost electric propulsion systems that can be manufactured in volume, following Advanced Product Quality Planning (APQP) and Control Plans, creating quality products that meet SAE Standards
- Create a manufacturing facility that supports high volume component manufacturing
- Set up production lines and systems to support an initial rate of at least 20,000 units a year on a single shift
- Establish multiple suppliers for key components to minimize timing and volume delivery risks
- Design manufacturing systems that are flexible enough to adapt to evolving technologies and product variants

Accomplishments to Date

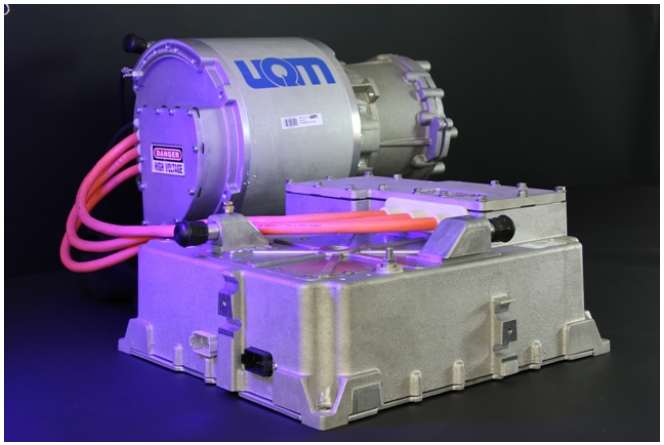
- Renovated and moved into a facility that provides the company with sufficient manufacturing space to achieve the objectives of the program
  - 13,000 square meters / 140,000 square feet
  - Facility contains all UQM operations
- Completed in July 2010

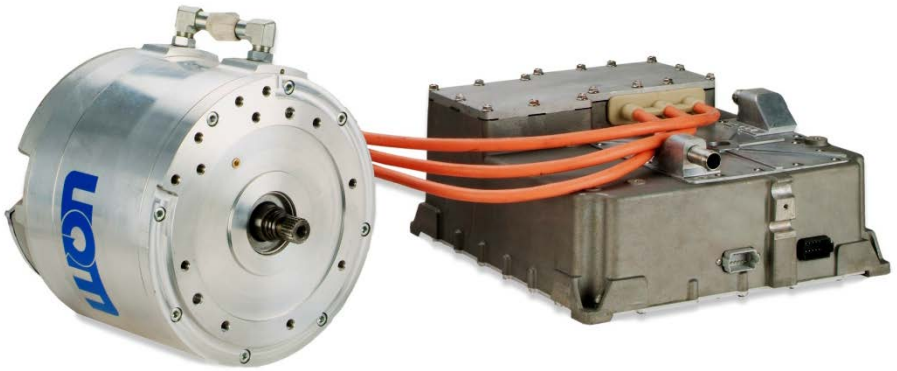
Accomplishments to Date

- Designed and implemented production lines to support the objective volumes
  - Motor Production Line
  - Controller Production Line
- Completed in June 2011, including product PPAP
- 28 new hires over the last 18 months for production assembly and related activities (e.g., manufacturing engineering, quality)

Accomplishments to Date

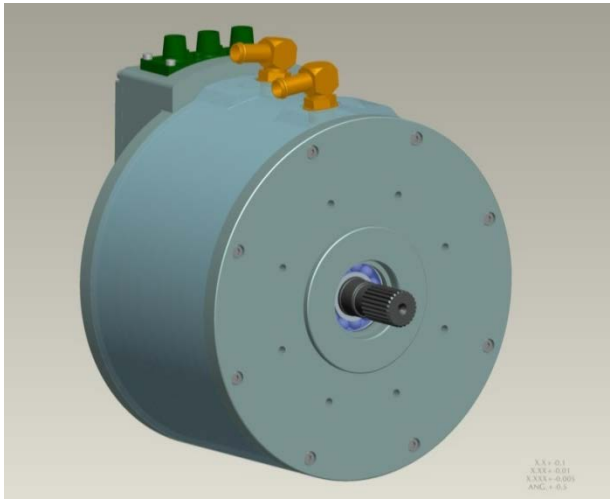
- **Completed the Production Part Approval Process (PPAP) for the automotive product (100 kW motor and controller)**
- **Design and process validation includes the following standards**
  - **Mechanical Vibration-** SAE J1455 Heavy duty truck standard — Passed
  - **Mechanical Shock-** SAE J1455 Heavy duty truck standard — Passed
  - **Humidity Cycle-** SAE J1455 Heavy duty truck standard — Passed
  - **Salt Fog-** SAE J1455 Heavy duty truck standard — Passed
  - **Thermal Cycle-** SAE J1455 Heavy duty truck standard — Passed
  - **Water Immersion-** SAE J1455 Heavy duty truck standard — Passed
  - **Liquid Contaminant Splash-** SAE J1455 Heavy duty truck standard — Passed
  - **Pressure Wash-** DIN 40 050 — Passed
  - **Electrical System Qualification-** Battery of tests based on previous experience — Passed

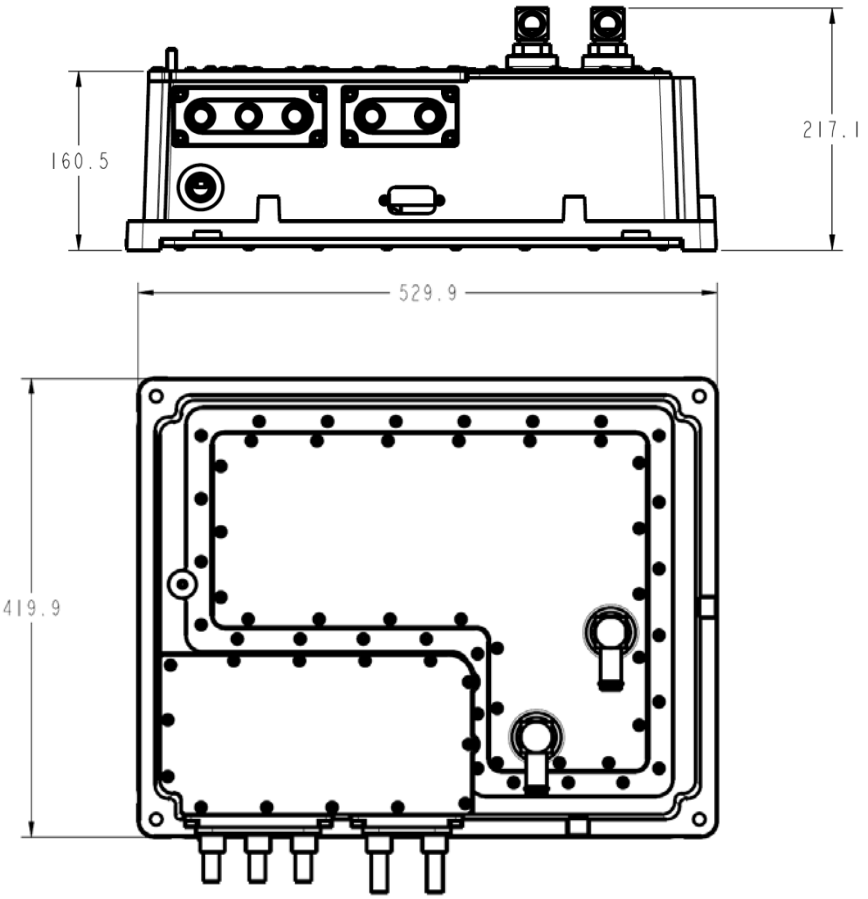




Accomplishments to Date

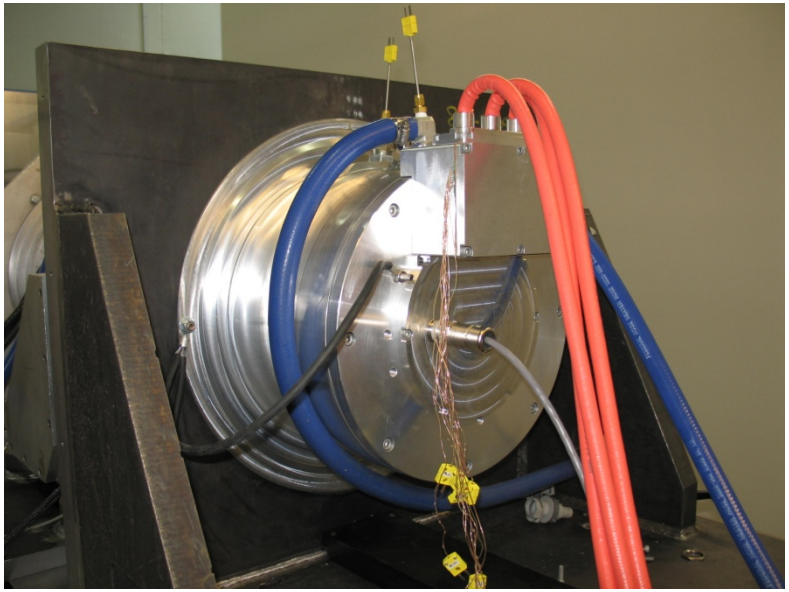
- **Initiated production work on the bus/truck product (220 kW motor and controller)**
- **Preliminary Specifications include the following:**
  - **220 kW Peak Power (295 hp)**
  - **120 kW Continuous Power (161 hp)**
  - **700 N-m Peak Torque (517 lb-ft)**
  - **6000 RPM Top Speed**
  - **360 VDC to over 700 VDC nominal**
  - **Concept units being tested**
  - **DV and PV units in 2012**





Accomplishments to Date

- Completed the prototype 220kW systems and began design validation testing
- Prototype 220 kW systems sent to key customers for early development testing



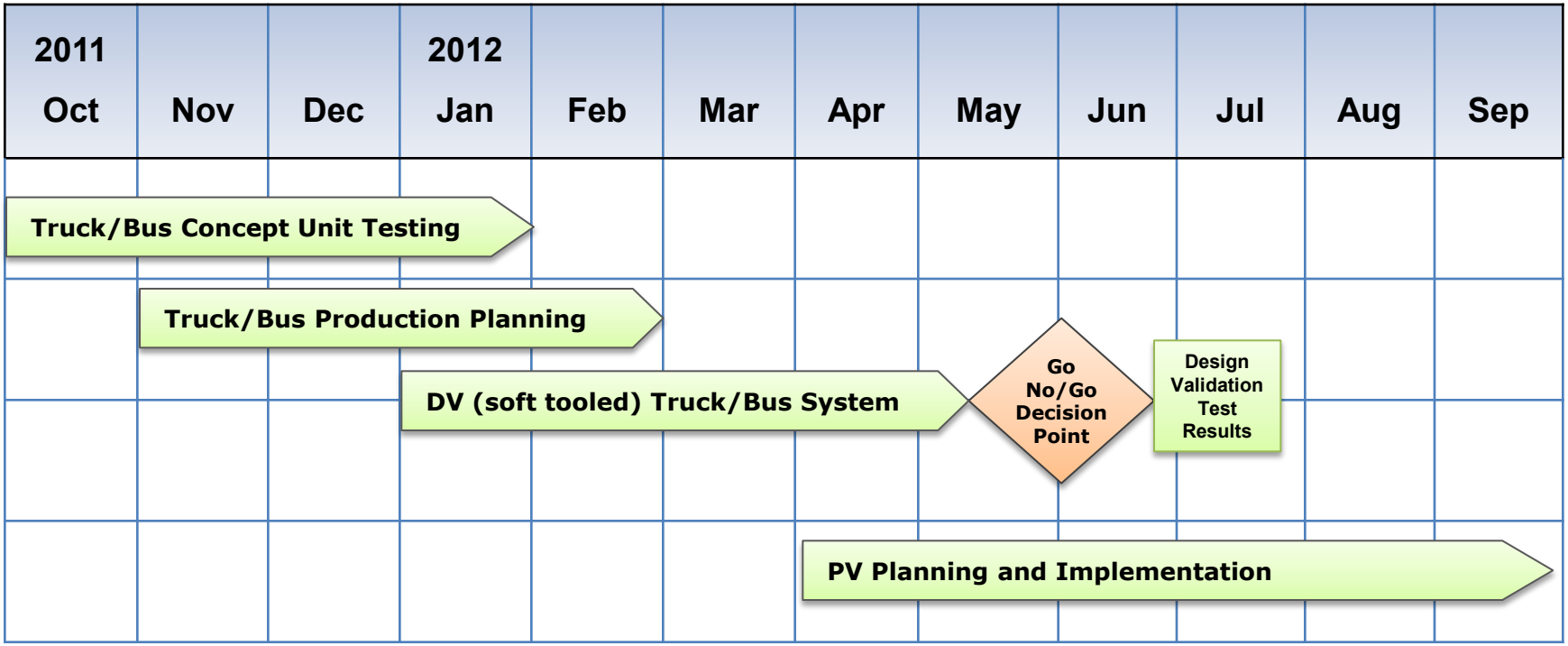
Accomplishments to Date Summary

- High volume manufacturing facility is in place
- Automotive production system is complete, manufacturing lines are running, and product is being supplied to high volume customers
- Well over a thousand production 100 kW systems built on the production line

Accomplishments to Date Summary

- Bus/Truck production system is being tested and production is planned for calendar year 2012
- No exclusivity agreements exist and these systems may be supplied to any customer with production programs
- UQM continues to plan next generation product offerings with leading edge technologies and evolving standards in mind

FY12 Approach and Challenges



Go No/Go Decision Point: Concept Unit and Design Validation Unit customers are identified and Production Line investments will be made based upon programs that support the investments

Challenges/Barriers: Truck and Bus customers are generally lagging behind automotive customers relative to production decisions and the volumes are lower. UQM is careful to launch the PV phase only when the opportunities justify the investment.

FY12 Approach Highlights

- The electrified truck and bus markets are important segments to address within the VTP Program
- Creating a production-intent system, through design validation, is an important step toward fielding these vehicles
- Analysis of the market and UQM's opportunities will be an important step before launching production lines for this system
- This is a continuing project from FY11 and no changes in the scope have occurred