2011 DOE Vehicle Technologies Program

Electric Drive Component Manufacturing Facilities - Allison Hybrids to Serve Commercial Trucks

Project Director: Richard P. Thies, Program Director, Advanced Hybrids

Presenters: Laurie B. Tuttle, VP, Hybrid Programs

Kevin A. Rodgers, Manager, Government Liaison & Public Relations

Company: Allison Transmission, Inc.

Date: May 10, 2011

Project ID#: ARRAVT023

This presentation does not contain any proprietary, confidential, or otherwise restricted information.

Overview – Allison Transmission, Inc.

Electric Drive Component Manufacturing Facilities

Timeline

- Started on January 1, 2010
- Finishing December 31, 2013
- 32% complete as of February 28, 2011

Budget

- Total project cost is $149,000,000
  - DOE to fund $62,800,000
  - Allison funds $86,200,000
  - DOE funds received 1Q2010 through 1Q2011 = $20,025,085
  - DOE funding anticipated for 2Q-4Q2011 = $17,448,151

Barriers

- System affordability to Enduser
- Time to integrate hybrids into individual vehicle platforms
- System control optimization
- Electrical component and communication interfaces

Key Suppliers

- Delphi Electronics
  - Power electronics and energy storage system
- Remy, Inc.
  - Motor-generator

Relevance – Objectives

Electric Drive Component Manufacturing Facilities

- **Expand U.S. production capacity for the hybrid supply chain through commercializing a fuel-efficient, cost-effective, fast-to-market parallel hybrid propulsion system for commercial-duty trucks**
  - Plan to enable expansion of the U.S. hybrid supply chain
  - Plan to use existing commercial sub-components whenever possible
  - Plan to quickly establish manufacturing facilities and commercialize to begin production in December 2012
  - Plan to produce “H 3000” and “H 4000” Allison Hybrid family for commercial trucks

Relevance – Benefits

Electric Drive Component Manufacturing Facilities

- Plan to enable development of greater U.S. manufacturing capacity for, and expertise in the production of, essential hybrid technology
  - Plan to create or maintain direct jobs during course of the project
- Plan to improve fuel economy (mpg) by 25% to 35% over commercial trucks with conventional propulsion
  - Savings are dependent on vocation and duty cycle
- Plan to reduce U.S. petroleum consumption as well as greenhouse gas emissions and other air pollutants from commercial trucks

Relevance – Benefits

Plan to apply known benefits of Allison's H 40/50 EP hybrids for transit buses to commercial trucks

- Washington Metropolitan Area Transit Authority (WMATA)
  - Total fleet is 1,512 of which
  - 399 are H 40 EP-equipped
- Philadelphia has 370
- Baltimore has 169

Relevance – Benefits

Examples of commercial markets served by Allison

Current On-Highway Markets Served by Allison

School Bus / Shuttle Bus



Transit Bus



Motorhome



Truck RV



Distribution


Rugged Duty



Emergency Vehicles



Relevance – Benefits

Example Markets for Allison H 3000 and H 4000 Hybrids

Relevance – Overcoming Barriers

Electric Drive Component Manufacturing

- **Identified Barrier #1: System Affordability**
  - Plan to leverage proven, reliable, known technology
    - Both in-house and with Key Suppliers
  - Are using more than 20 years of experience with hybrids
    - Successful hybrid installations for 13 bus OEMs over past 9 years
    - Our understanding of installation cost avoidance, duty cycle specifics, brake wear savings, and fuel savings is intended to drive down overall cost of ownership

Relevance – Overcoming Barriers

Electric Drive Component Manufacturing

- **Identified Barrier #2: Time required to integrate hybrids into individual vehicle platforms**
  - Plan to leverage Allison's overall 60 years of vehicle integration expertise
  - Allison's "Process of Concurrent Engineering" is intended to drive speed into programs
  - Concurrent engineering is planned to reduce time
    - Plan to continue concurrent design work with OEM
    - Plan for joint validation between OEM, End User and Allison

Relevance – Overcoming Barriers

Electric Drive Component Manufacturing Facilities

- **Identified Barrier #3: System control optimization**
  - Allison has knowledge gained from integrating with 250 commercial vehicle OEMs
    - Managed 10,000 calibrations in CY2010
    - Able to operate behind approximately 500 combinations of engine brands, models and ratings
    - Have optimized controls for 13 OEMs of hybrid transit buses

- **Identified Barrier #4: Electrical component and communication interfaces**
  - Allison has incorporated our decades of vehicle integration and durability experience into our design and test standards in order to mitigate system interface challenges

Approach – Overall

Electric Drive Component Manufacturing Facilities

- **Hybridize existing fully-automatic Allison transmissions**
  - Plan to refurbish facility in Indianapolis, IN, for sub-assembly and test of hybridization module, assembly of module onto an existing transmission and test of the completed system
  - Plan to leverage existing Allison plant capacities and create additional capacity for annual plant capacity of 20,000 commercial-duty hybrid systems with production start December 2012
- **Plan to use many production-ready components to lower the system costs and to accelerate the speed to market**
  - Base Allison transmissions (3000 and 4000 Series) do not change
  - Base transmission controller also serves as hybrid controller
- **Create a commercial truck Allison hybrid, the value proposition for which is commercially competitive with conventional drive systems**

Approach – Uniqueness

Electric Drive Component Manufacturing Facilities

- **New Allison hybrid systems plan to incorporate**
  - State-of-the-art motor-generator, ESS and power electronics from U.S. suppliers
  - Allison's proven expertise in design, manufacture, and sale of over 4,000 hybrid propulsion systems for transit buses since October 2003
    - As of 01/01/2011 Allison estimates our hybrid system accomplishments are
      - Over 520,000,000 km in service
      - Savings of over 65,000,000 liters of diesel fuel
      - Avoidance of over 170,000 metric tons of CO_2
- **Allison may be viewed as holding a unique position as**
  - Leader in the design and manufacture of commercial-duty fully-automatic transmissions and pre-eminent supplier of commercial, heavy-duty fully-automatic transmissions to the North American medium- and heavy-duty work truck market
  - Available factory space for new hybrid family in Speedway, IN, located adjacent to conventional (base) transmission

Approach – Technical

Allison Commercial Truck Hybrid Characteristics

- Kinetic energy is the force acting on a vehicle causing its motion
- A driver slows a conventional vehicle with the service brakes or other motion-retarding device
  - As conventional vehicle slows down or comes to a stop, the energy of motion is transformed by the vehicle's braking system into heat
  - The heat is dissipated – wasting the original kinetic energy
- Allison hybrids are "kinetic energy recovery systems with regenerative braking" enabled by a motor-generator electric machine
- Existing productivity and fuel efficiency benefits of a fully-automatic Allison transmission plan to be even further improved with hybridization

Approach – Technical

Allison Commercial Truck Hybrid Characteristics

- Parallel hybrid system was chosen
  - Supplies a blend of two paths of power to assist with vehicle propulsion
    - From the conventional diesel engine, and
    - From the stored energy in the batteries
- Permanent magnet motor-generator with engine disconnect clutch is planned to be added between engine and conventional transmission
  - ***No change is required to current Allison conventional products***
  - Generator mode is used during regeneration mode when vehicle decelerates to absorb and enable vehicle energy storage in battery
  - Motor mode uses battery energy for later assisting vehicle propulsion
- Hybrid system also includes the energy storage system, inverter, DC-to-DC converter, and hybrid system controller

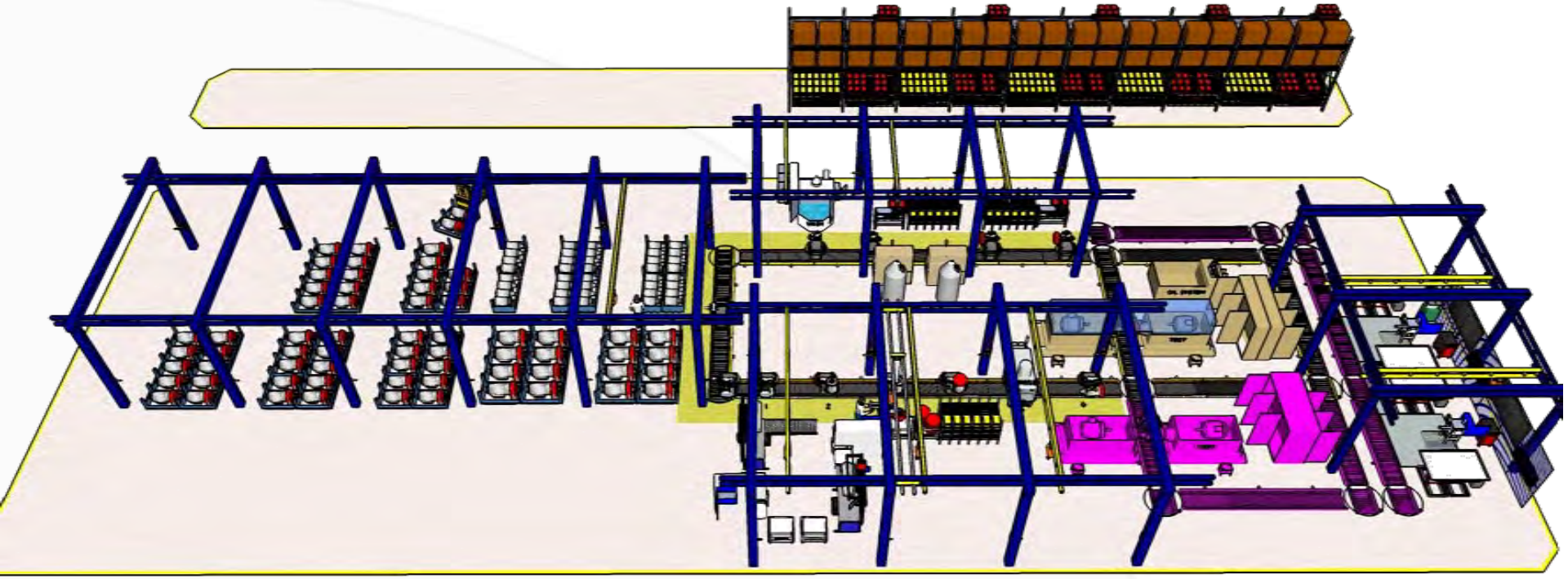
Approach – Technical

Allison Commercial Truck Hybrid Characteristics

- Energy storage system is Lithium-ion chemistry
  - Modular for flexibility in vehicle integration
- Inverter for managing the flow of power
- Optional DC-to-DC converter
- High-voltage connections for vehicle accessories
- Goal is to provide 25-35% fuel economy improvement
  - Actual “mpg” improvement has expected dependence on operating factors including vocation and duty cycle
- Hybrid System Controller
  - ***No change is required to an already-planned controller common with all Allison conventional transmissions***

Approach – Hybrid Factory

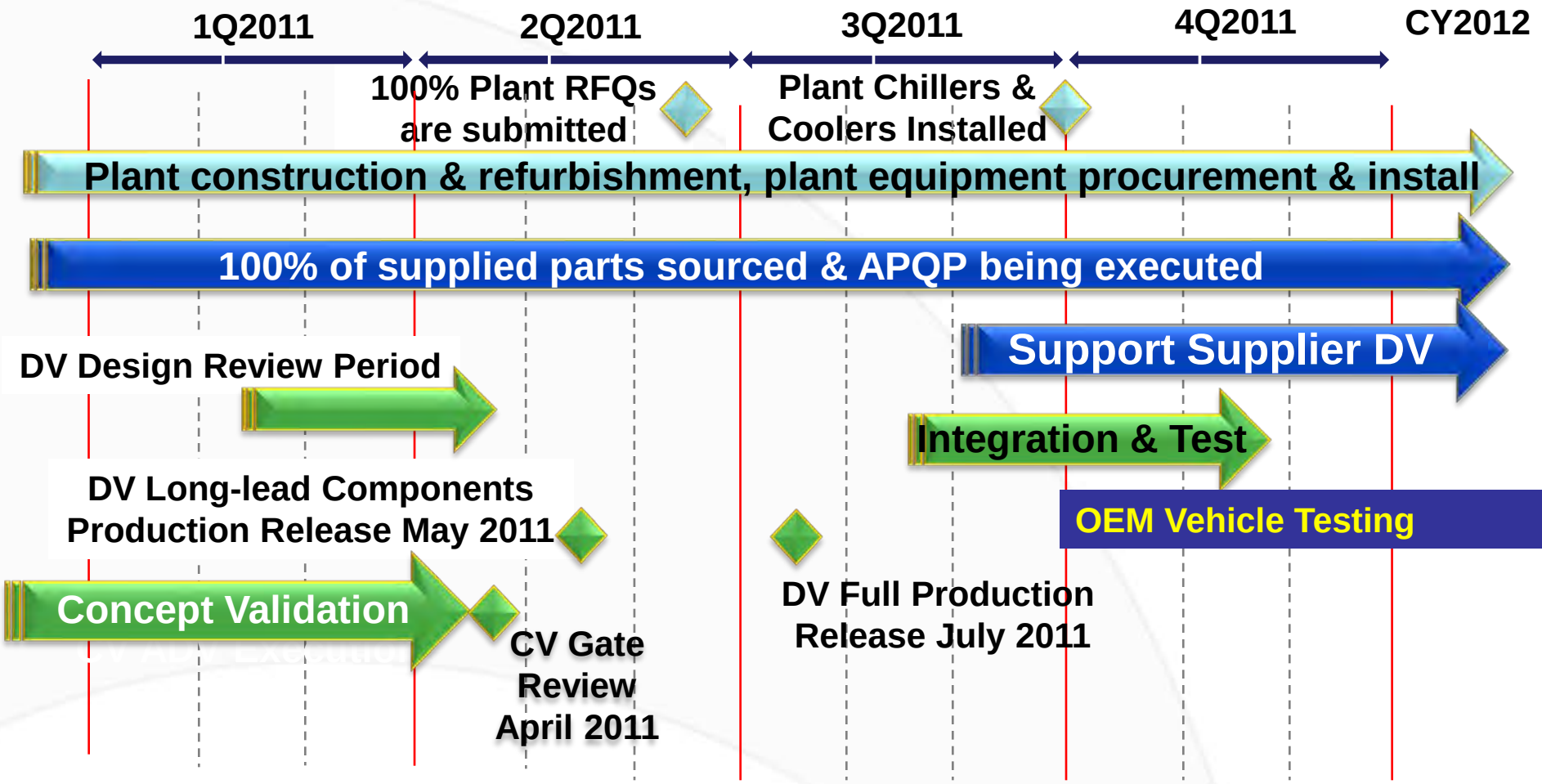
Manufacture, Assemble and Test



- Plant planned capacity of 20,000 units annually
- Hybrid input module will be assembled and tested
- Hybrid module will be assembled to base Allison transmission
- “Dress” of the combined assembly follows final test

Approach – Program Timeline in CY2011

Planned Transition from "Concept" to "Design" Validation



Technical Accomplishments and Progress

Through CY2010

- May 2009 – Concept Validation (CV) Phase began
  - Configured and scaled proven technologies to meet Customer needs
  - Selected Key Suppliers of hybrid components (Delphi and Remy)
  - Performed required analyses and design for manufacturability
  - Created the drawing sets for the product and for the factory
- August 2009 – DOE Grant awarded and under contract December 2009
- April 2010 – Concept Validation drawings released for prototype hardware
- June 2010 – CV concept hardware available
- June 2010 – Appropriations Request approved for plant capital equipment
- July 2010 – Final Assembly Manufacturing Line and Final Test RFQs sent
- September 2010 – Start of CV durability test validation
- September 2010 – 100% of long lead suppliers selected
- December 2010 – Demonstration of product in vehicle for Allison Leadership

Technical Accomplishments, Progress and Plan

Hybrid Plant Refurbishment

- **Completed through CY2010**
  - Roof replacement 100% complete per plan
  - Concrete floor replacement 100% complete per plan
  - Air handler replacement 50% complete per plan
  - Air compressors and air dryer 70% complete per plan
    - Includes plant chillers and coolers replacement
- **Plan highlights for CY2011**
  - Completion of refurbishment and painting per plan
  - Completion of equipment procurement per plan
  - Start of factory equipment installation per plan

Allison Hybrid Plant Progress

Plant Air Handler Replacement

Eight New Air Handling Units for CY2011 Installation

Allison Hybrid Plant Progress

Plant Cooling Tower #6 (Example Shown)

Technical Accomplishments and Progress

Planned activity through CY2011

- February 2011 – Non-long-lead (“other”) supplied parts bid lists completed
- April 2011 – Planned CV “Gate” Review in Allison’s Process of Concurrent Engineering
- May 2011 – Design Validation (DV) long lead drawings planned completion
- June 2011 – 100% of Plant sub-assembly lines and fabrication RFQs planned to be submitted by this date
- July 2011 – DV “other” drawings planned to be finished
- August 2011 – Quotes planned to be issued to all other suppliers
- January – September 2011 – All sources of supply planned to be selected
- January – September 2011 – Advanced Purchasing Quality Process planned start of execution for 100% of suppliers

Technical Accomplishments and Progress

Beyond FY11

- DOE Annual Merit Reviews and FY “Kickoff” Reviews CY2012 and CY2013
- Design Validation (DV) hardware available
- DV “Gate” Review to be held
- Production and Factory Validation (PV and FV) refinements
- All suppliers under contract for Delivery Schedule Agreements
- “Advanced Purchasing and Quality Process” completed and parts PPAPed
- All run-offs of equipment at machinery and equipment suppliers completed
- All machinery and equipment installed in plant and run-off
- Run-at-rate confirmations in plant and at suppliers
- PV and FV “Gate” Reviews per Allison’s Process of Concurrent Engineering
- Production builds begin in plant December 2012

Summary Slide

- **Fuel-efficient, fast-to-market hybrid propulsion system for commercial-duty trucks**
- Relevance:
  - Increased domestic manufacturing capacity for hybrids
  - Cost-efficient, affordable hybrid propulsion for Endusers
  - Jobs maintained or created during
- Approach: POCE and SAP Control
- Key Suppliers: Delphi, Remy
- Project timeline and deliverables tracking to budget and schedule
- Allison is well-prepared and in cadence with Key Suppliers for work through this Fiscal Year and next (FY 2011)

Key Suppliers

- **Delphi Electronics, Kokomo, Indiana**
  - Purchased Engineering Services
  - Power Electronics
    - Inverter
    - Converter
  - Energy Storage System
  - Transmission/Hybrid Control Module

- **Remy, Inc., Pendleton, Indiana**
  - Motor-generator
  - Hybrid module sub-assembly

Summary

Electric Drive Component Manufacturing Facilities

- **On budget and on plan to put into production a fuel-efficient, fast-to-market Allison hybrid propulsion system for commercial-duty trucks**
- **Relevance:**
  - Plan to increase domestic manufacturing capacity for hybrids
  - Plan to provide high-value hybrid system for commercial trucks
  - Maintained or created jobs during course of Project
- **Approach:**
  - Plans to refurbish existing plant, use existing base transmission and leverage known technology scaled for commercial-duty truck applications
- **Key Suppliers:** Delphi and Remy
- **Funding:**
  - Allison is well-prepared and in cadence with Key Suppliers for work through this Fiscal Year and next (FY 2012)