2013 DOE Vehicle Technologies Program

Electric Drive Component Manufacturing Facilities - Allison Transmission Hybrids to Serve Commercial Vehicles

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

Presenters: Laurie B. Tuttle, Vice President, Hybrid Programs
Kevin A. Rodgers, Manager, Government Liaison & Public Policy

Company: Allison Transmission, Inc.

Date: May 14, 2013

USDRIVE
DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Project ID#: ARRAVT023

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

Allison Hybrid

Allison Transmission

Overview – Allison Transmission, Inc.

Electric Drive Component Manufacturing Facilities

Timeline

- Started on January 1, 2010
- Finishing December 31, 2013
- 78% complete as of EOCY 2012

Budget

- Total project cost is $149,000,000
  - DOE to fund $62,800,000
  - Allison funds $86,200,000
  - DOE funds received through 4Q2012 = $49.0M
  - DOE funding anticipated for 1Q-4Q2013 = $13.8M

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 vehicles**
  - 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 establish production capability to produce “H 3000” and “H 4000” Allison Hybrid family for commercial vehicles

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 vehicles 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 vehicles

Relevance – Benefits

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

- H 40/50 used by Washington Metropolitan Area Transit Authority (WMATA)
  - Total fleet is over 1,500 of which
  - ~600 are H 40/50 EP-equipped
- Philadelphia has >440
- Baltimore has >300

• Buses delivered	>5,600
• Cities worldwide	246
• U.S. states	43 of 50
• Est. accumulated miles	>553 M
• Est. gallons fuel saved	> 29 M
• Est. CO_2 eliminated	291K (metric tons)

* Data above as of January 1, 2013

Allison Hybrid

Allison Transmission.

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

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 10 years
    - Our understanding of installation cost avoidance, duty cycle specifics, brake wear savings, engine maintenance savings and fuel savings will help 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 ~360 commercial vehicle OEMs with conventional and/or hybrid transmission systems
    - 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
    - ***As of December 2012, Plant 16 is production-ready for H 3000***
- **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 vehicle 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 5,600 hybrid propulsion systems for transit buses since October 2003

- **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 Vehicle 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 "regenerative braking kinetic energy recovery systems" 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 Vehicle 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

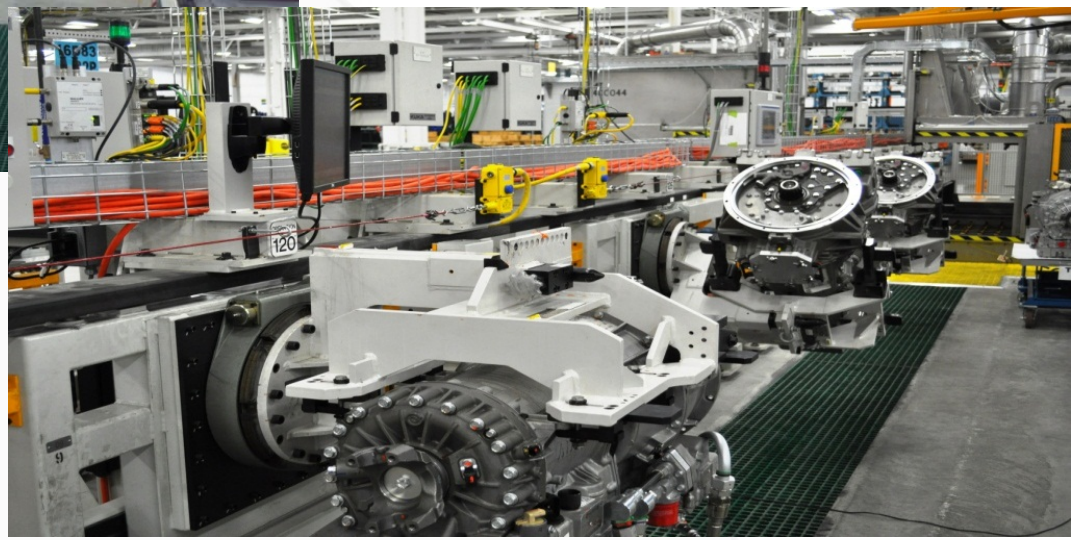
Approach – Technical

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(s)
- 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***

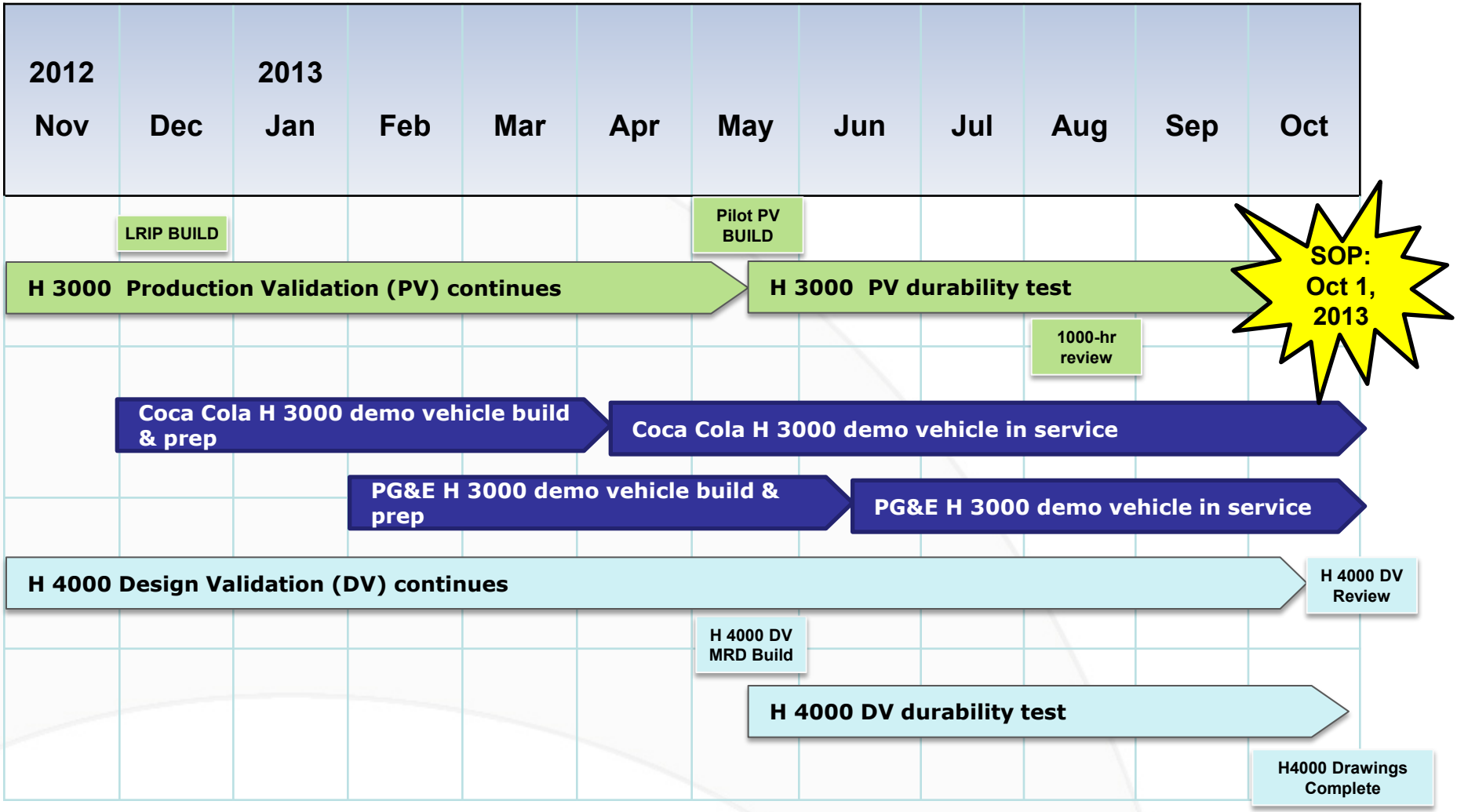
Approach – Hybrid Factory Plant 16 Indianapolis

Manufacture, Assemble and Test



Plant capacity: 20,000 units annually

Approach – Hybrid Program Timeline



Technical Accomplishments and Progress

Through Merit Review 2012

- August 2009 - DOE Grant awarded and under contract December 31, 2009
- December 2010 - Demonstration of product in vehicle for Allison Leadership
- March 2011 - Due to H 3000 success, H 4000 starts in “Design Validation” Phase
- April 2011 - Passed CV “Gate” Review in Allison’s Process of Concurrent Engineering
- July 2011 - Design Validation (DV) drawings released
- August 2011 - 100% of plant assembly, test, and fabrication RFQs submitted
- September 2011 - Source selection of purchased components complete
- December 2011 – Plant 16 Facilities work complete
- March 2012 – H 3000 Production Validation (PV) Phase begins

Technical Accomplishments and Progress

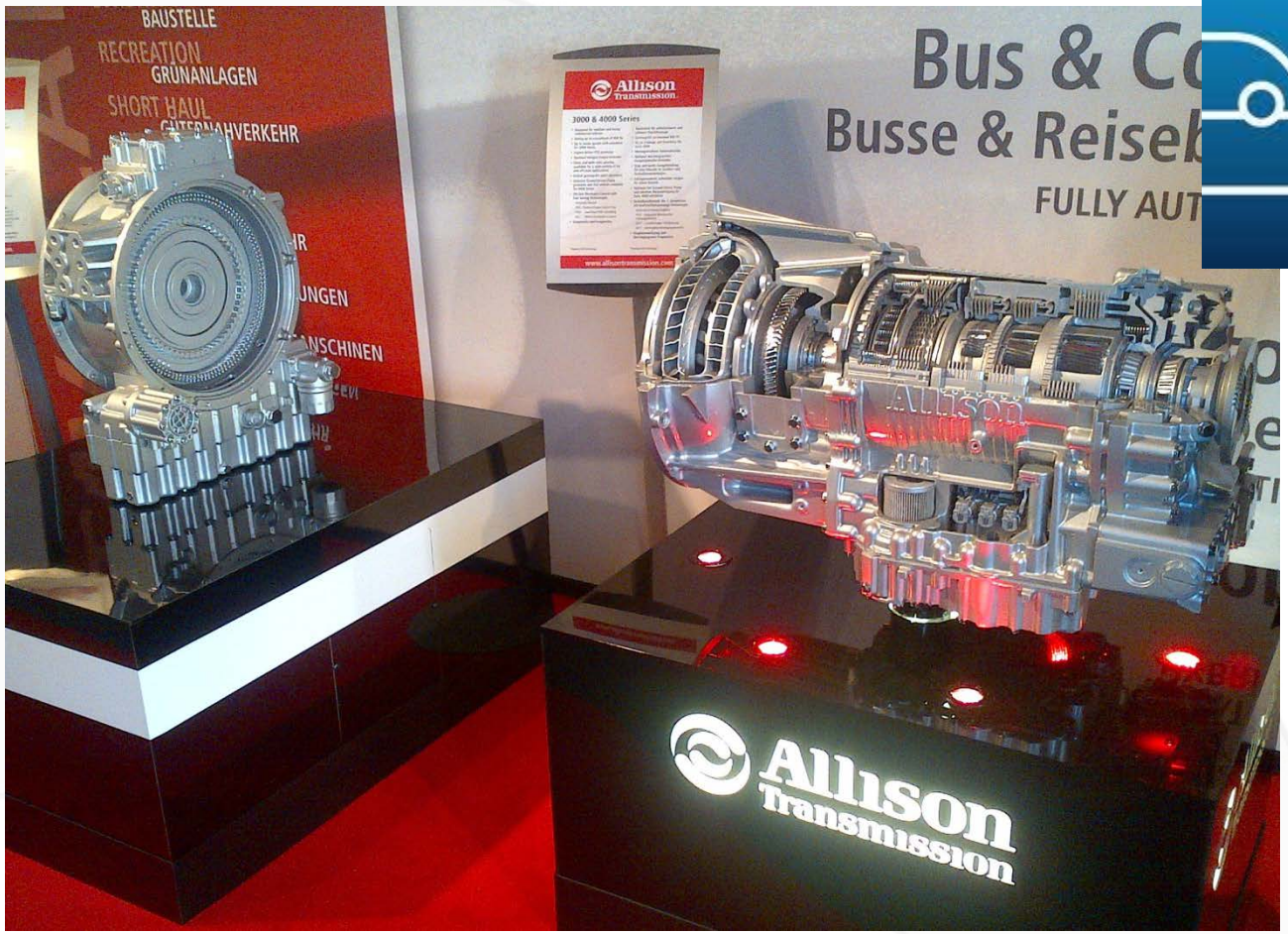
Since Merit Review 2012

- Endusers identified with whom to field H 3000 demo units & vehicles ordered
- H 3000 worldwide introduction at 2012 “IAA Commercial Vehicle Show” in Hannover, Germany (September 18–27, 2012)
- H 3000 introduction at 2013 “The Work Truck Show / Green Truck Summit” in Indianapolis (March 6-8, 2013)
- H 3000 performance and fuel economy are meeting the planned targets and timeline via simulation and Allison Transmission test vehicle assessment
- Design Validation (DV) testing and validation of Low Rate Initial Production (LRIP) H 3000 configuration
- H 3000 Calibration complete allowing “public road use” by potential end-users
- Production and Factory Validation (PV and FV) refinements for H 3000 defined
- All suppliers under contract for Delivery Schedule Agreements for H 3000
- “Advanced Purchasing and Quality Process” completed and Production Part Approval Process (PPAP) for LRIP parts for H 3000
- Run-offs of H 3000 equipment at the machinery & equipment suppliers completed
- All H 3000 machinery & equipment installed and run-off in Allison Plant 16
- H 3000 LRIP build hardware was all received for LRIP Build Event November 2012
- H 3000 LRIP test report submitted to DOE on schedule

Technical Accomplishments and Progress

H 3000 Worldside Introduction* at "IAA Commercial Vehicle Show" in Hannover, Germany (September 18 – 27, 2012)

- Press conference and press releases



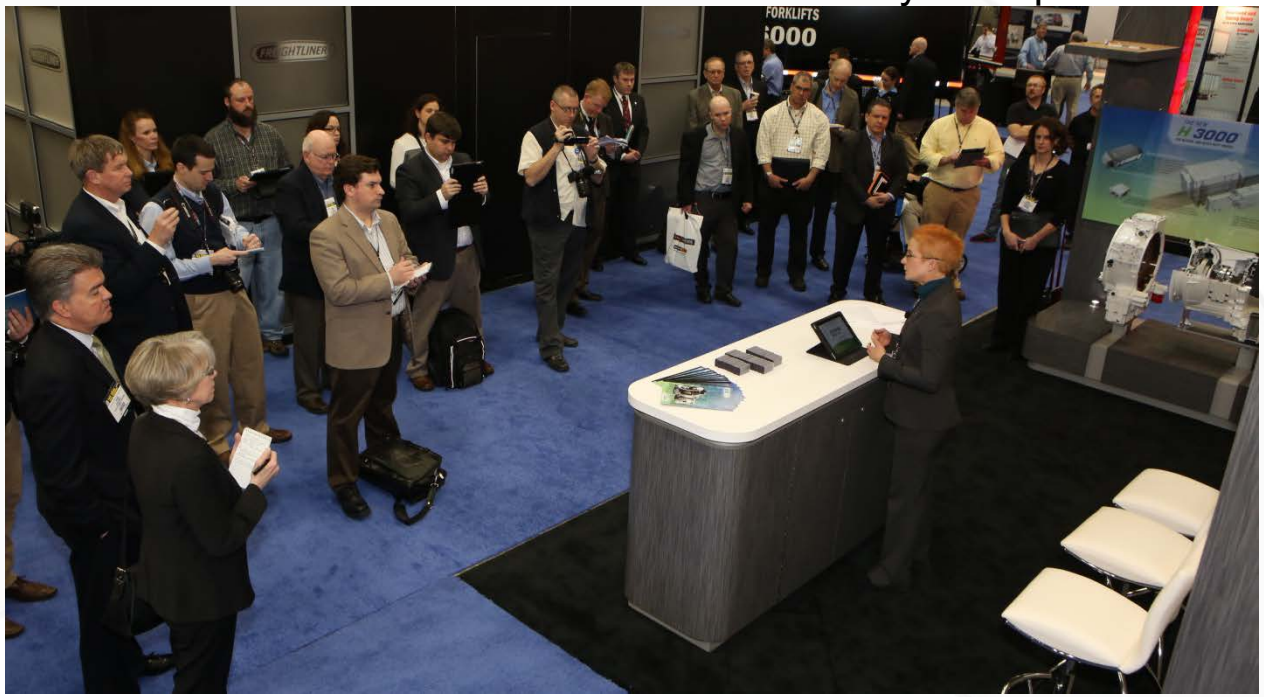
COMMERCIAL VEHICLES
DRIVING THE FUTURE
IAA
64th International Motor Show
SEPTEMBER 20-27, 2012
IN HANNOVER, GERMANY

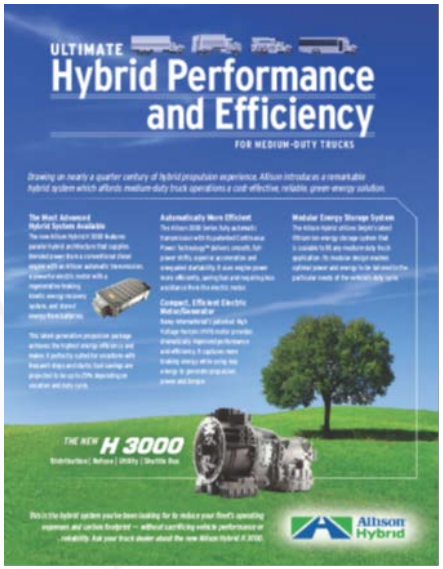
*Note:
All Marketing activity funded by Allison Transmission

Technical Accomplishments and Progress

H 3000 Introduction* at 2013 "The Work Truck Show / Green Truck Summit" in Indianapolis, IN (March 6-8, 2013)

- Press conference and press release
- Allison served as a "Green Truck Summit" co-sponsor
- Back cover ad—Green Truck Summit program
- Concurrent ads—"*Utility Fleet Professional"* and others
- Breakout session—Allison Transmission Hybrid Update



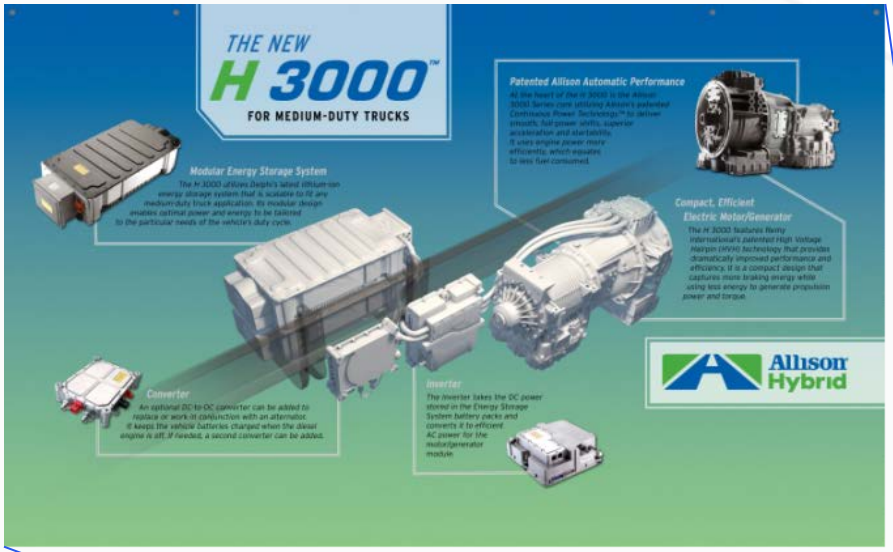


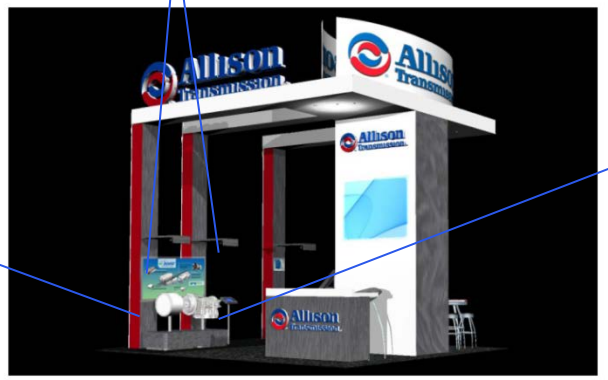
*Note: All Marketing activity funded by Allison Transmission

Technical Accomplishments and Progress

H 3000 Introduction* at 2013 NTEA's Work Truck Show / Green Truck Summit (March 6-8, 2013)

- Tradeshow booth display—new cutaway and new back panel describing new hybrid





*Note:
All Marketing activity funded by Allison Transmission

Technical Accomplishments and Progress

H 3000 Introduction* at 2013 "The Work Truck Show / Green Truck Summit" in Indianapolis (March 6-8, 2013)

Ride & Drive—H 3000 equipped shuttle bus vehicle

Static Display of H 3000-equipped Coca-Cola vehicle

*Note: All Marketing activity funded by Allison Transmission

Technical Accomplishments and Progress

21st Century Truck Partnership Visit to Plant 16 on November 8, 2012

On-site Department of Energy Low Rate Initial Production Visit To Plant 16 on November 28, 2012

Technical Accomplishments and Progress

H 3000 Low Rate Initial Production on November 28, 2013

Technical Accomplishments and Progress

Planned activity through CY2013

- DOE Annual Merit Review and FY “Kickoff” Review
- Receipt of H 3000 Production Validation (PV) hardware (MRD in May 2013)
- Production Validation / Factory Validation (PV / FV) testing and validation
- Procure H 4000-specific tooling and equipment for low-volume Plant 16 assembly and test capability
- Delivery of H 4000 Design Validation hardware (MRD in May 2013)
- Conduct H 4000 equipment runoff in Plant 16
- Conduct H 4000 DV testing and validation
- Complete H 3000 Production Calibration for Start of Production
- Complete H 4000 Design Validation Calibration
- “Gate” Reviews per Allison’s Process of Concurrent Engineering
- Continue OEM integration work
- H 3000 Planned Start of Production (October 1, 2013)

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 vehicles**
- **Relevance:**
  - Plan to increase domestic manufacturing capacity for hybrids
  - Plan to provide high-value hybrid system for commercial vehicles
  - Maintained or created jobs during course of Project
- **Approach:**
  - POCE and SAP Control
  - 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 for work through this Calendar Year 2013