Session 3- Emerging Advanced Heavy-Duty Technologies and Designs

February 20, 2008

ICCT/NESCCAF Workshop "Improving the Fuel Economy of Heavy Duty Fleets II"
Core Products and competencies

“Our expertise is torque distribution...”

- Experienced team with deep industry knowledge when integrating mechanical and electrical components
- Ability to design, test, and manufacture systems for real world environments
- Understanding the unique path to market for systems (creation, integration, delivery and service)

- 2007 Sales* $6.4 billion
- Located in 25 countries global with 66 manufacturing facilities
- Business covers both passenger car and commercial vehicles
- 19,000 employees globally
- Technical centers globally in North America, Europe, and Asia
We’ve targeted -
More **fuel efficient** vehicles
with lower emissions
and greater market penetration
enabled by technology that:

- makes them perform better
- makes them last longer, and
- makes them more affordable.

**...what we see for the Future**
Full BEV Zero Emission Vehicle

- 18 month white sheet development program
- Product whose technology differentiates ArvinMeritor from other electric drivetrains
- Improvements in fuel efficiency, emission and productivity derived from ArvinMeritor Drive Corner Module and the unique vehicle design from Unicell
- Successfully completed first set of fleet testing trials
Today's emerging technologies will take us from what is Feasible to what is Affordable

- GVWR 16,000 lb.
- Full BEV
- Zero emissions
- Completely flat floor, RFID controlled doors
- Rear kneels to ground level
- Clear aisle for pallet delivery
- 40’ Curb to curb turning circle
- ARM supplied Drive Train, Electrified Braking, Steering, & Suspension
Today’s Technology Baseline . . .

- **Modeling and Simulation**
  - Initial models were performance based
  - Good but not as predictable as desired
- **Energy Storage**
  - Lower voltage packs (nominal 300V) less than 10kWHRs
  - Smaller packs (less than 10kWHR)
  - Various chemistries
  - Minimal cell and thermal management
  - 500 cycles @ 70% DOD
  - Learn as you go packaging
- **Electric Traction Machines**
  - smaller machines
  - aimed at ISG or mild hybrid applications
  - limited availability of HV, High Current Semiconductors
- **Electrified Accessories**
  - solutions evolved from ‘Industrial’ technology base.
  - more opportunity than availability .....
  - targeted at removing continuously powered engine/belt driven devices.
Tomorrow we will have . . .

• Simulation
  • Right size components – neither over designed or underperforming systems – right sized = lowest cost
  • Better thermal management models where higher efficiency = minimal losses = minimal thermal management required
  • Higher confidence – predictable performance, improved efficiency, second order affects included
  • Life cycle models – reduced component stress, predictable reliability for a given environment
Tomorrow we will have . . .

• Traction Machines
  • No longer one size fits all, i.e. 60 to 300 kW = more truck architectures possible
  • Scaleable to the Vehicle and its Vocation = lower development costs
  • Integrated System (controls, cooling, gearing) = lower cost, smaller and lighter weight designs
  • Matched to the vehicle duty cycle for best efficiency
  • Extended environmental operating range
Tomorrow we will have . . .

- Energy Storage
  - Larger cells, more cost effective robust architectures
  - Larger packs from multiple suppliers allowing for better performance and longer range
  - Higher voltages and more system efficiency
  - New Chemistries – safer, longer life, > 1000 80% DOD cycles, with talk of 2000 ‘soon’.
  - More robust cell management with predictable life and reliability
  - Standardized Packaging for the Commercial Vehicle Market.
more emerging opportunities

- **Electrified Accessories**
  - Available today: Electrified Hydraulic Braking
  - Needed: Electrified cooling systems: transition from low voltage controlled pumps and fans to direct HV drive
  - Needed: Electrified Power Steering: upscale light vehicle concepts
Where the future finds us:

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<tr>
<th></th>
<th>Today</th>
<th>The Future</th>
<th>Benefits for the customer</th>
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<tbody>
<tr>
<td>Modeling &amp; Simulation</td>
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<td>Improves system performance, lowers cost and risk, shorter</td>
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<td>development time and improved efficiencies.</td>
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<td>Energy Storage (Commercial</td>
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<td>Longer range, lower life cycle costs, more reliability, safer.</td>
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<td>Vehicle Battery Packs)</td>
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<td>Traction Drives</td>
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<td>Lower weight, lower cost, better thermal management shorter</td>
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<td>Electrified Accessories</td>
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<td>Greater system architecture options allowing for higher system</td>
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Hybrid Dream Machines:

- Vehicle Performance better than traditional drive systems
- Scaleable / Modular Electric Drive Components - quicker time to market, right sized for optimized performance and lower cost.
- Packaging Flexibility – more suspension, and system architecture options, more vehicle layout options, adaptable to existing vehicle architectures
- Regenerative Braking programmable per application, with slip/traction control capabilities
- Reconfigurable / Reusable components – lower initial cost, easier to maintain
- Lower Center of Gravity and better weight distribution
- Systems optimized for the Users Operations
- Reliability equal/better than today's proven technologies
- Lower Life Cycle Costs– low risk, shorter payback timeframe