

BAE SYSTEMS

▶ Z-Bus Regulation and Technology Summit

Panel 2: Fuel Cell Electric Bus – Status & Future of Technology

BAE Systems HybriDrive® Solutions - OEM Presentation

Bob Devine, 17 September, 2013

HybriDrive® Solutions Overview

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CUTTING-EDGE HYBRID TECHNOLOGY

COMMITMENT TO MARKET

DELIVERING RESULTS

Evolved from 20+ years of investment in aircraft technology

Series – Bus

THE FUTURE OF SMARTER TRANSPORTATION TODAY.

Parallel – Truck

SERVO HYBRID SYSTEMS TO YOUR TRUCK FLEET

Military

THE MOST FUEL-EFFICIENT 7.6L V8 DIESEL ENGINE (7.6L) F1000

Marine

CLEANER MARINE VESSEL POWER. SMARTER MARINE VESSEL POWER.

Systems deployed on over 11,000 vehicles worldwide

Supplying Leading OEMs

Market Leader

Hybrid Transit Bus Propulsion Providers
North America and Europe

■ BAE Systems
■ Others

Balanced Portfolio

HybriDrive Solutions 2013 Sales

Leading Provider of Hybrid Propulsion and Power Management Solutions

- 600 million miles of revenue service
- Saved 38 million gallons of diesel fuel
- Prevented the release of more than 520,000 tons of CO₂

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Electric Drive Products & Vehicle Integration Capabilities Supporting Full Electrification



AC Traction Motor
(ACTM)



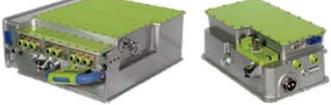
Energy Storage System (ESS)



Integration & Test Labs



Propulsion Control System (PCS)



Auxiliary Power Systems (APS)

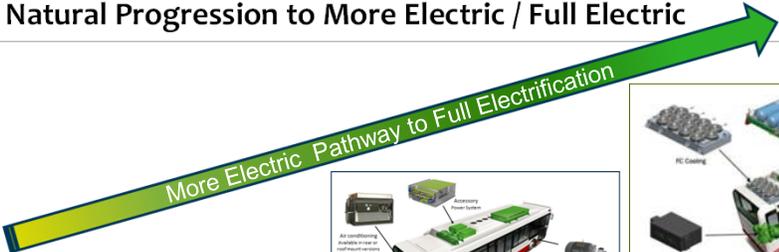
Fully Qualified Production Hardware supports ZBus

155 Engineers
50,000 sq ft of R&D
11 motor dynos
4 engine pods

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Natural Progression to More Electric / Full Electric





Conventional Series Hybrid





Electric Accessories
Electric Modes (Series-E)

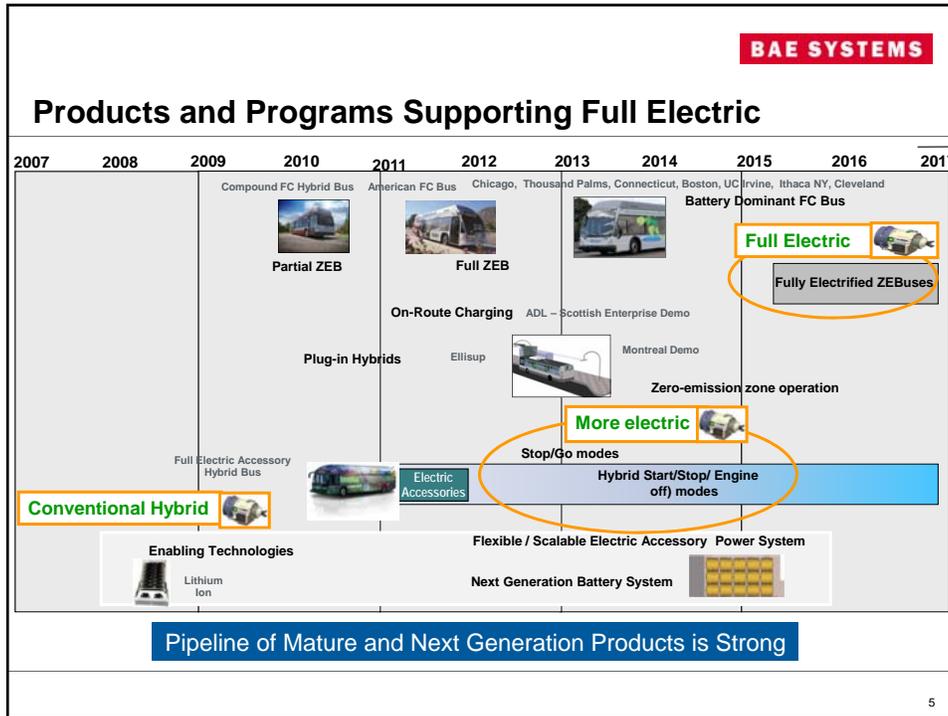




Fully Electrified ZEB



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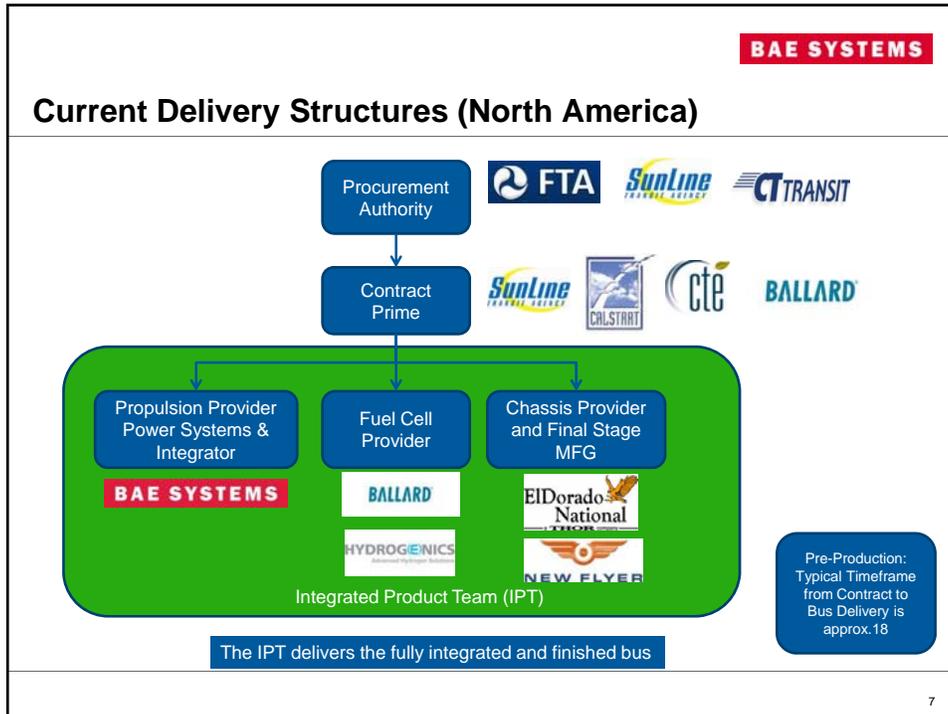
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Performance – Fulfilling the Operational Need

Parameter	Value	Comments
Gradeability	40mph/2.5%; 7mph/16%	consistent with whitebook
Acceleration	30 mph, 18 sec	consistent with whitebook
Top Speed	55 to 65 mph	dependent on gearing
Passengers	37 + Driver, 19 standees	Greater pax with weight reductions
Range	260 miles	Typical urban route driving
Fuel Economy	7+ mi/gge	Demonstrated in typical urban route driving (with accessories)
Availability	Capable of >95%	>85% demonstrated on prototype with clear pathway to >95%
Durability (hybrid and power components)	52,000 Hours, 12 Year	Batteries midlife refresh at 6 years

**The Technology is proving out!
Performance and Reliability on Track to Achieve DOE Targets for FC Bus**

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Future Technology and Performance Enhancements

- Next Generation ESS – Larger Capacity – opportunity for smaller fuel cells without significant performance impact
- Flexible / Scalable Accessory Power
 - More efficient operation of electric accessories
 - Commercialized subcomponents and sized optimally for application (lower cost)
 - Potential for high voltage gateway
- Robust Power Electronics – Continued Development
- “Balance of Platform Components – continued development by Market Leading Suppliers

Technical diagrams include:

- A grid of yellow fuel cells.
- A power electronics schematic showing a 50 kW ISG Inv, two 5.5 kW DC/DC converters, and a 12V battery.
- A photograph of a battery pack assembly.

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Game Changers

- Continued Government and Private Investment funds in order to mature enabling technologies, reduce capital cost and optimize systems / platforms.
- Lower Cost, Higher Capacity Hybrid Batteries
- Lower Cost Fuel Cells
- Lower Cost “balance of platform” systems (e.g. Hydrogen Storage)
- Vehicle OEMs or Rebuilders Must Emerge as Primes
- H2 Infrastructure/Supply – Lower cost H2
- Continuation of ZEB focus through funding, regulation, initiatives & Incentives



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