H2@Airports Workshop

Together we can save much more than fuel.

gettozero.com

Bob Hess

Systems Engineering Manager

BAE SYSTEMS

BAE Systems – Surface Solutions

Our Mission

- Deliver propulsion and power management performance
- Provide market and customers with innovative electrification products & solutions
- Advance vehicle mobility, efficiency and capability in the transit, military, marine and rail markets.

Who are we:

- Leading provider of power & propulsion solutions
- Over 12,000 systems operating worldwide
- Significant IP portfolio; 300+ patents world-wide; $500M invested in products & capabilities
- 24/7 product support

Leading provider of power and propulsion systems for commercial and military applications

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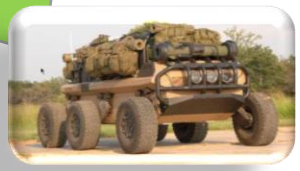
BAE Systems – Airborne Solutions

Highly Reliable & Safety Certified Vehicle Management & Engine Control Systems

Hybrid Electric Propulsion / Electric Accessories, Leading-Edge Control & Power Management Solutions for Heavy Duty Ground Platforms



Power Management & Propulsion for Advanced Tactical & Combat Ground Vehicles

Power Management & Propulsion for Maritime Applications

Power, Energy and Propulsion Management & Autonomy for Aerospace applications

Integration of 30+ years of Controls, Energy, Power & Propulsion experience, investments and evolution

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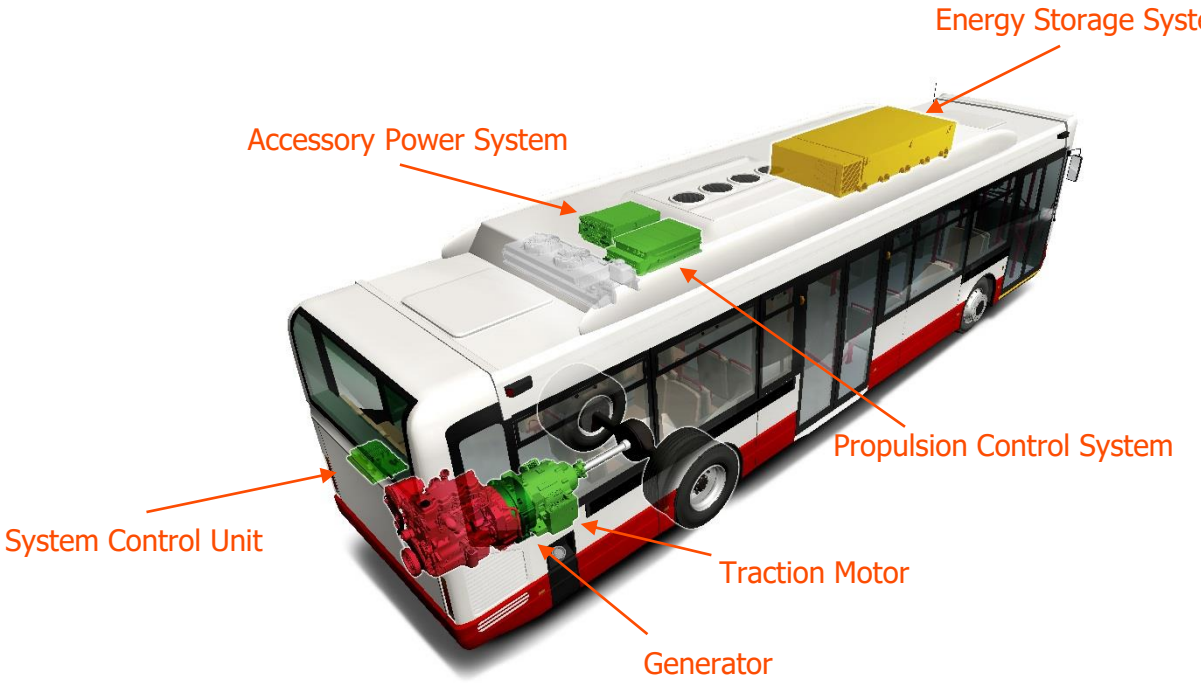
What Do We Provide?

- We use the same proven technology that has been installed in over 12,000 buses and trucks operating worldwide.
- Leverage what has been done and build on what is successful.



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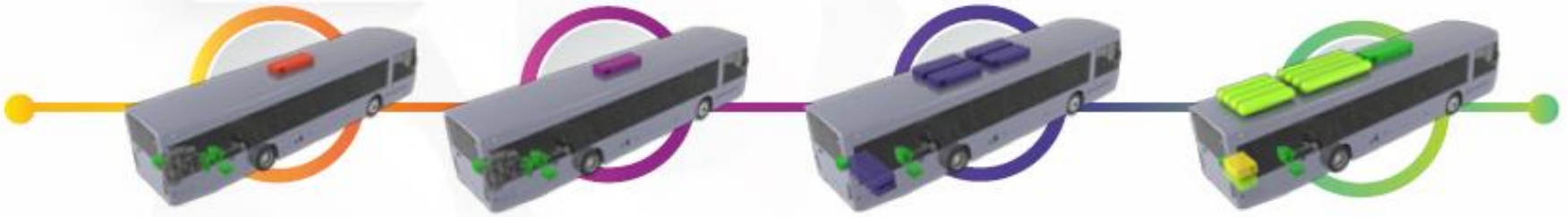
Modular Electric Propulsion Technology Solutions



Series-E: Electric Hybrid

Cost-effective first step to zero emissions:

- Electric drive today
- No mechanical link between the engine and the wheels
- Electric powered bus accessories
- Lowest TCO (total cost of ownership)

Series-ER: Electric Range Hybrid

Low-risk path to full electric:

- Electric drive today
- No mechanical link between the engine and the wheels
- Zero emission zones created with electric range
- Optional plug-in capability

Series-EV: Battery Electric

High-efficiency, zero emission, battery electric:

- Adding more passengers and less battery to travel farther
- Modular scalable electronics
- Custom configured for less weight and higher efficiency

Series-H: Fuel Cell Electric

Zero emission solution:

- Hydrogen is sole fuel source
- Produces only pure water in the exhaust
- 300+ mile range

20 Years of Technology Advancement
Pb Acid > Ultracapacitor > Li Ion > Fuel Cell
Si MOSFET > SiC MOSFET
Advanced Machine Control / Scalable / Modular

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Path to Zero Emissions

Zero emissions solutions

Series-EV: Battery Electric System

Series-H: Hydrogen Fuel Cell System

Using the same components as our leading electric hybrid system, we deliver and integrate all-electric solutions that get transit to zero emissions.

Low emission solutions

Series-ER: Electric Range Hybrid System

Series-E: Electric Hybrid System

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American Fuel Cell Electric Bus Commercialization

American Fuel Cell Bus Partners:
El Dorado National – Bus Manufacturer
BAE Systems – Power & Propulsion, Lead Integrator
Ballard Power Systems – Fuel Cell

Mass Transportation Authority (MTA)
Flint, Michigan
1 Vehicle in service

Massachuesetts Bay Transit Authority
Boston, MA
1 vehicle delivered & demonstrated

Orange Country Transit Authority
Orange County, CA
1 Vehicle in service

SunLine Transit
Thousand Palms, California
10 Vehicles in service

Stark Area Regional Transit
Stark County, Ohio
7 Vehicles in service
5 More in plan

University of Calif., Irvine
Irvine, California
1 Vehicle in service

- Altoona tested
- HVIP eligible

MADE IN USA

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Challenges

- H2 generation, delivery, storage and use are all key challenges
  - Standards, safety protocols, training, etc.
- *But….*
- Also need to look at how we integrate with other types of electrified solutions
  - Can H2 support energy needs for battery-electric aircraft?
    - Example, deliver power to recharge 150+ kWh battery pack.
- How do we deliver energy to remote locations, small airstrips?
  - Where it is impractical to build grid or H2 infrastructure, can we provide fuel cell / hybrid genset?
  - Can ground support equipment support multiple uses?

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Applications at the Airport

- Classes of vehicles:
  - Busses
  - Airport Tugs and Pushback Trucks
  - De-icing Equipment
  - Security Vehicles
  - Firefighting Equipment
  - Snow Removal Equipment
- Designs can be adapted to act as hybrid gensets
  - Do we understand use cases?
  - What are the charging standards? Voltage levels?

Capacity TJ9000
Ballard 85 kW FCveloCity-HD fuel cell modules; BAE Systems HDS200 HybriDrive propulsion system

Airport Tugs and Pushback Trucks

Demonstrated Electric Propulsion / Power Export Over 10 Years Ago…

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Final Thought…

As we move towards a zero emission future, the first step is to select solutions capable of wide scale application adoption, whether H_2 electric hybrid, battery electric or H_2 fuel cell.

It's a journey, we'll get to zero together.

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Thank you

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