HybriDrive PROPULSION SYSTEMS

BAE SYSTEMS
INSPIRED WORK

Advanced Clean Transit Technology Symposium

Advanced technology availability and outlook

BAE Systems

February 8th, 2016


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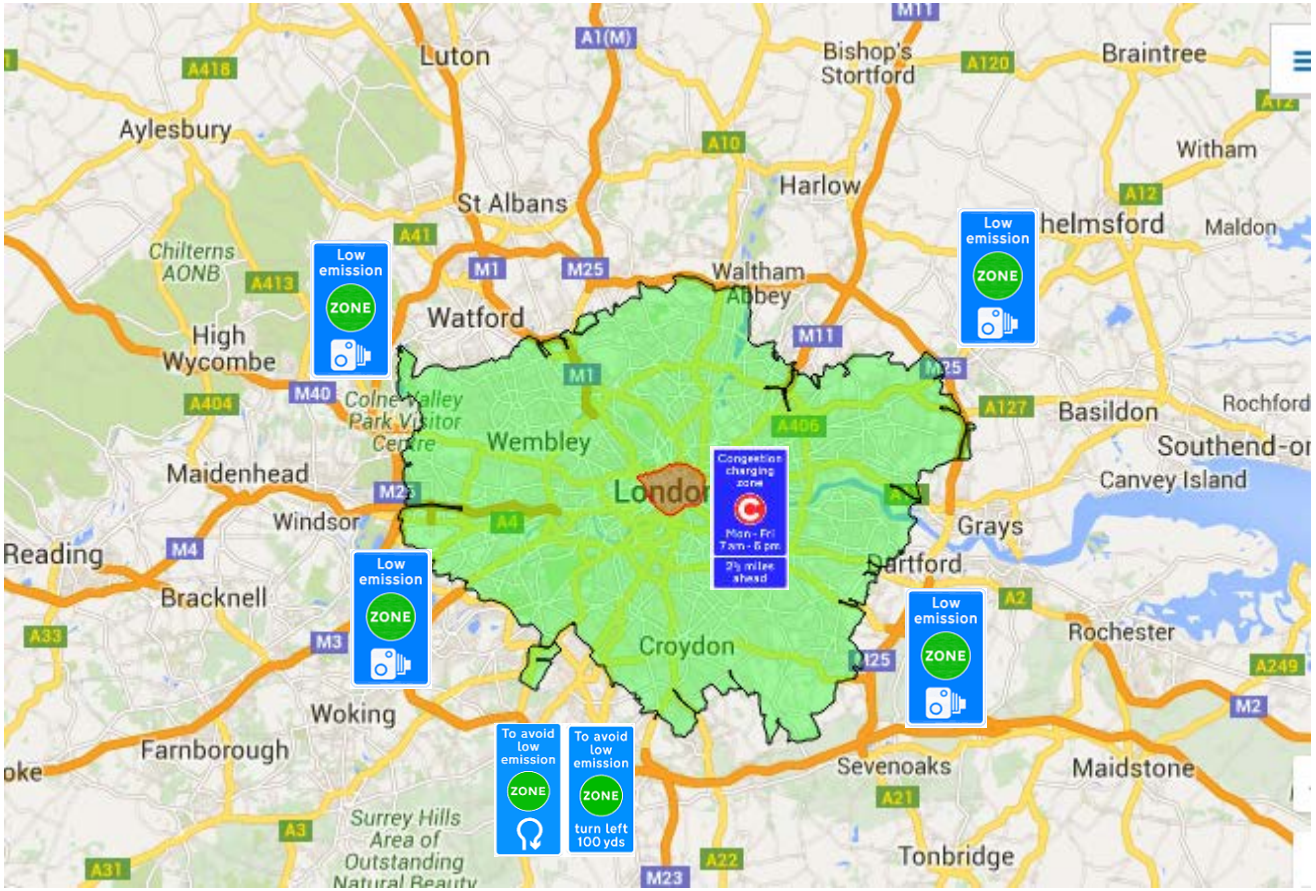
Trends shaping urban mobility



Emission and congestion zones with fares and penalties restrict traffic and cut pollution

Urban planners are leading efforts to clean up cities

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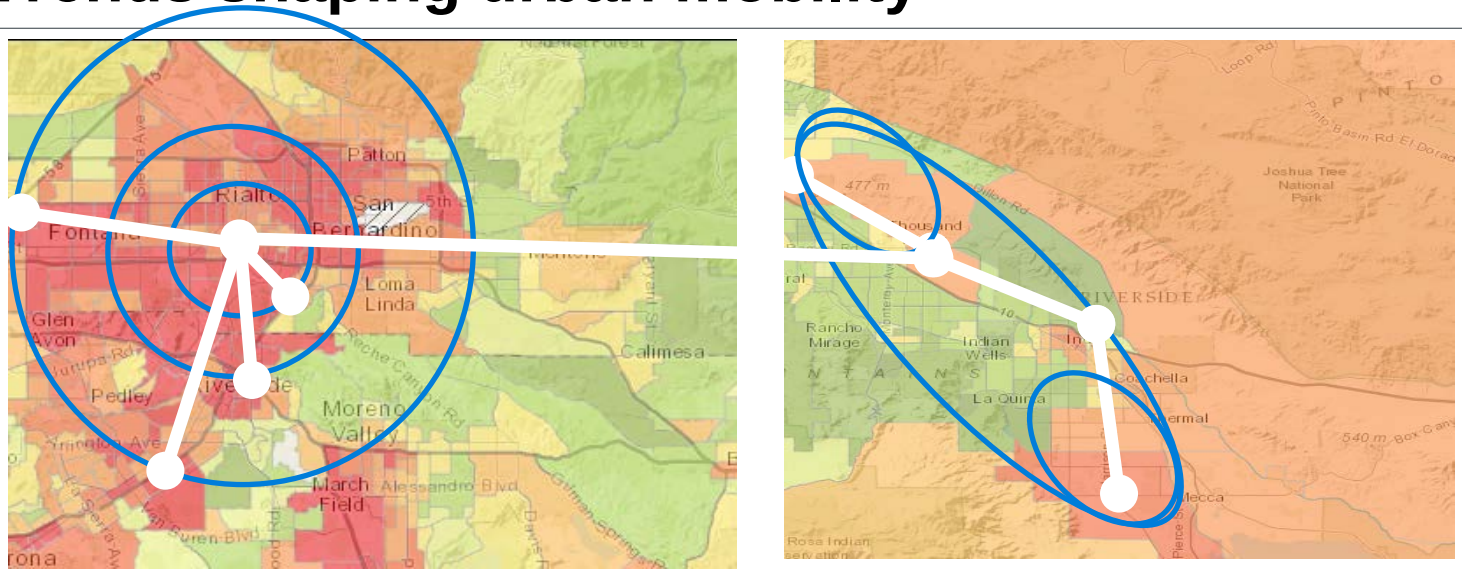
Trends shaping urban mobility



Map Excerpt from CalEnviroscreen2.0

Full electric: 100% electric, zero emissions; specific routes

Electric hybrid: Larger ESS, charging optional, 40-80% engine off capability

Hybrid intercity: "Today's hybrid", . 20-30% fuel econ benefit or Hydrogen Fuel Cell providing long range and zero emissions

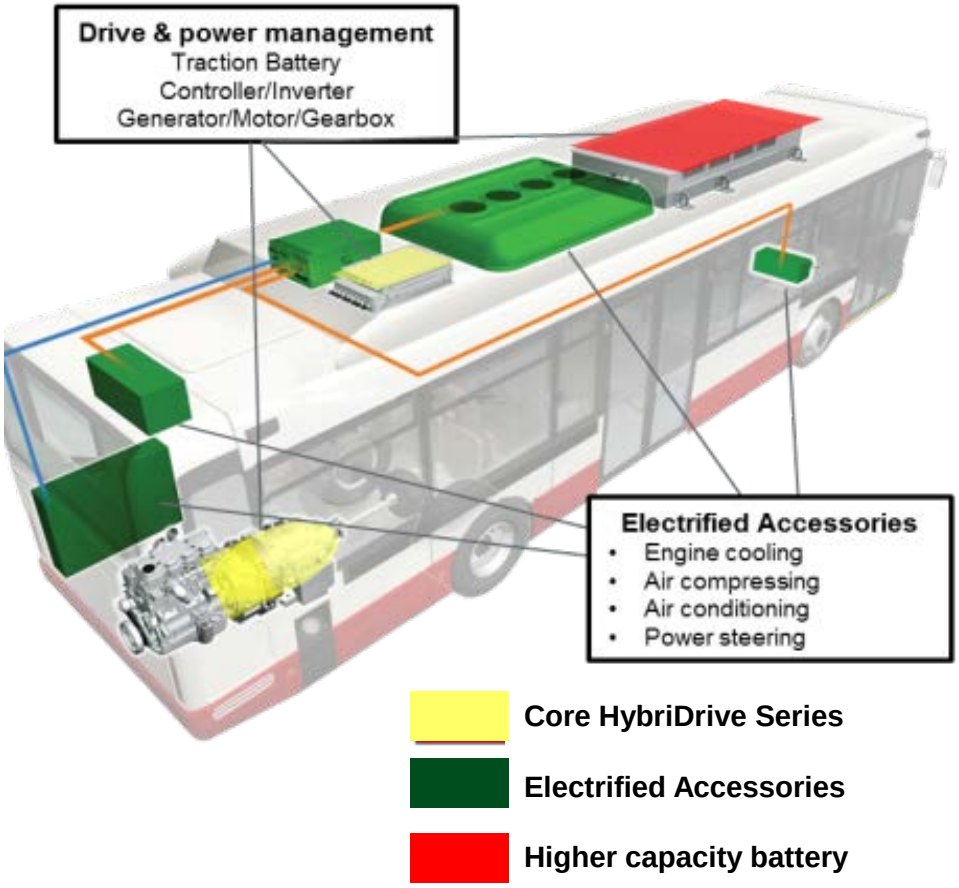
Low Emission Coach: high power engine-based; higher speed and longer range

A range of technology options that work together is evolving

BAE Systems' 'More' Electric Hybrid Bus

A plug-free, "part-time" all-electric transit bus

- HybriDrive Series-E with engine stop/start
- No charging infrastructure, no range limitations
- Future Trend toward:
  - Larger energy storage system
  - Up to 50 miles of zero emission transit each day
  - ~ 40% of revenue service time w/ engine off
  - GPS-fenced and depot mode EV transit
  - Zero emission bus stops
  - Plug-in option available
- Leverages proven HybriDrive Series system



An electric hybrid with larger ESS and more engine off capability

BAE Systems' Contribution - Zero Emission Transit Bus

ELLISUP

All-Electric Battery Bus

- Demonstrations with leading OEMs
- In-route, wireless inductive charging
- Charging options: catenary (Ellisup) or overnight plug in charge
- Full zero emission operation

ZeEUS Project (virtual electric)

Hydrogen Fuel Cell Bus

- Leading fuel cell bus integrator in North America
- Active fleets with significant revenue service miles
- Altoona testing scheduled
- Leveraging experience into zero emission truck applications

Built on HybriDrive Series backbone

Multiple Pathways for Low and Zero Emissions

Technology	Example	Features/ Benefits	Best Use
Hybrid bus featuring Engine Stop / Start – in production Extended Range Engine Off Hybrid Bus – rev. svc. demo		Larger Battery (than typical hybrid), Geo Fenced Route independence No charging infrastructure needed Long Op Range	Provides Zero Emissions WHEN and WHERE ZE is needed. Typical ZE operation is typically a few miles (through a designated ZE zone) a dozen or more times per day
Virtual Electric Bus – rev. svc. demo (Hybrid with large battery and inductive charge)		Larger Battery, Good All Electr. Range Geo Fenced Engine off Opportunity Charge (inductive) Long Op Range, High % ZE operation	Extended ZE range – simpler charging infrastructure – full performance
ZE Fuel Cell Fuel Cell Bus – deployment		Hydrogen Fuel Cell Powered Route Independence Long Op Range	All Zero Emission Full Performance
Battery Electric – Opportunity Charge - demo	OEM to Announce	All Electric, Battery Powered Lower Cost ZE Bus Inductive Charge	Prescribed Route – Circulator Unlimited On-route operation Limited Off Route Electric Range
Electric Bus - demo		All Electric bus – Leading European OEM,	Urban Duty Cycle

HybriDrive Propulsion Systems: Current and Future

- High degree of Power & Propulsion system maturity - evolving
- Used on over 5,000 buses across 8 OEMs, 80+ transit agencies both in US and Europe
- Altoona tested and proven
  - American FC bus: Altoona testing starting 1Q2016
    HVIP Eligibility forecast Mid April
- OBD approval for Low Emission Solutions – benefits translate to zero
- Low Emission Hybrid (including engine start/stop) TRL9
- American FC Bus TRL 9
- Electric Bus Demonstrations – TRL 7
- Support and service – in place for all systems
- Training – in place for all systems

Wide range of mature solutions to best fit Transit Agency's needs

Thank You!

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