

Advancing Electric Solutions

Choose your level of electrification:
from electric accessories to zero-emission propulsion



www.hybridrive.com

BAE SYSTEMS

INSPIRED WORK

Transportation trends toward **electric**

The trend toward more electric bus solutions is growing due to their wide range of benefits. Transit authorities appreciate the fuel savings, and lower cost of operations and maintenance, while communities benefit from the reduction in harmful emissions.

To assist bus operators' transition to these more electric solutions, we provide 6 options. Consider one of our zero-emission solutions, near-zero emission solutions

(including hybrid-electric options), electric accessories for diesel and CNG powertrains, or our parallel hybrid for motor coaches.

For 20 years, we've been delivering efficient electric solutions to transit. With more than 8,000 systems operating across the globe, we'll continue to advance and develop solutions for the ever-changing transportation market.

Choose your level of **electrification**



Making a smooth transition

If you want integrate a zero-emission solution into your fleet, you are faced with many choices, including the type of charging to use, when to charge, and the type of energy storage. What matters most, however, is having the support you need to make your choice effective. That's where BAE Systems comes in. With 170 patents in electric and hybrid technology, our engineers are dedicated to advancing technology to meet the needs of transit and motor coach operators. We don't just develop the technology, though. Our core strength is systems integration, and we stand with our OEMs and operators before, during, and after the sale to ensure your success. We take pride in the fact that we offer technology management over the long term to eliminate obsolescence. Further, we understand that more often than not, technology must transition into your work process to be effective. Our series architecture enables operators to evolve to more electric systems when you're ready.



8,000 systems operating across the globe

Zero-emission options are available today

If you are ready for zero-emission solutions, you've come to the right place. Our battery electric systems and hydrogen fuel cell systems can help you achieve your emission goals. What's more, if you are currently using our hybrid electric systems, moving to a zero-emission system is simple. Our systems all use common components to help you transition seamlessly to more electric.

Series-EV: Battery Electric

Our Series-EV system is fully electric, allowing the bus to travel 100% of the time with zero emissions. Series-EV systems are currently in service in North America and Europe.

Battery options available

Accessory power system

Battery options available



Propulsion control system

Motor

Benefits:

- zero emissions 100% of the time
- fully-electric propulsion and accessories
- on-route, overnight, inductive, and conductive charging options available

How it works:

As the driver accelerates, energy moves from the energy storage system (batteries) to power the motor that drives the wheels. To increase the vehicle's efficiency during braking, the motor takes on the role of a generator and recaptures braking energy, storing it in the energy storage system for use later.



Series-H: Hydrogen Fuel Cell Electric

Our Series-H fuel cell systems are zero-emission 100% of the time – the only exhaust is pure water! As a part of the American Fuel Cell Bus team, we have successfully integrated 16 fuel cell

buses into service and have eight more on the way. These all-weather buses operate from coast to coast across the U.S.

Battery

Accessory power system

Propulsion control system

Motor



Benefits:

- zero emissions 100% of the time
- long range
- route independent
- all electric accessories

How it works:

Using our propulsion control system (PCS), electric power from our battery and the hydrogen fuel cell engine is blended to provide power to the wheels and the electrified accessories. As with Series-EV, regenerative braking maximizes vehicle efficiency. The fuel cell engine uses hydrogen to generate all of the electricity needed for the bus.



Near **zero-emission** solutions

Looking for **electric travel** but not quite ready for an all-electric solution? We have several hybrid electric system options to help you save fuel, reduce emissions, and decrease maintenance expense.

Series-ER: Electric-Range Hybrid

Like our Series-EV battery electric system, Series-E and Series-ER systems are electrically-driven systems. The electric motor drives wheels, but instead of using an external charging system to recharge the batteries, Series-E and Series-ER have

an on-board charger. Series-ER gives operators zero-emission travel where and when they need it. With our latest energy storage system, the ESS-3G-32K, operators can run in engine-off mode up to 35% of the time.

ESS-3G-32K

Accessory power system



Propulsion control system

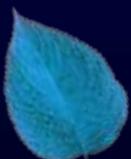
Motor/Generator

How it works:

Series-ER operates the same way as Series-E, but with a larger capacity energy storage system to achieve more engine-off time for driving or powering accessory loads during stops.

Benefits:

- up to 35% engine-off operation
- stop/start technology (engine-off at bus stops)
- ideal for travelling through tunnels and low- and no-emission areas
- no charging infrastructure required



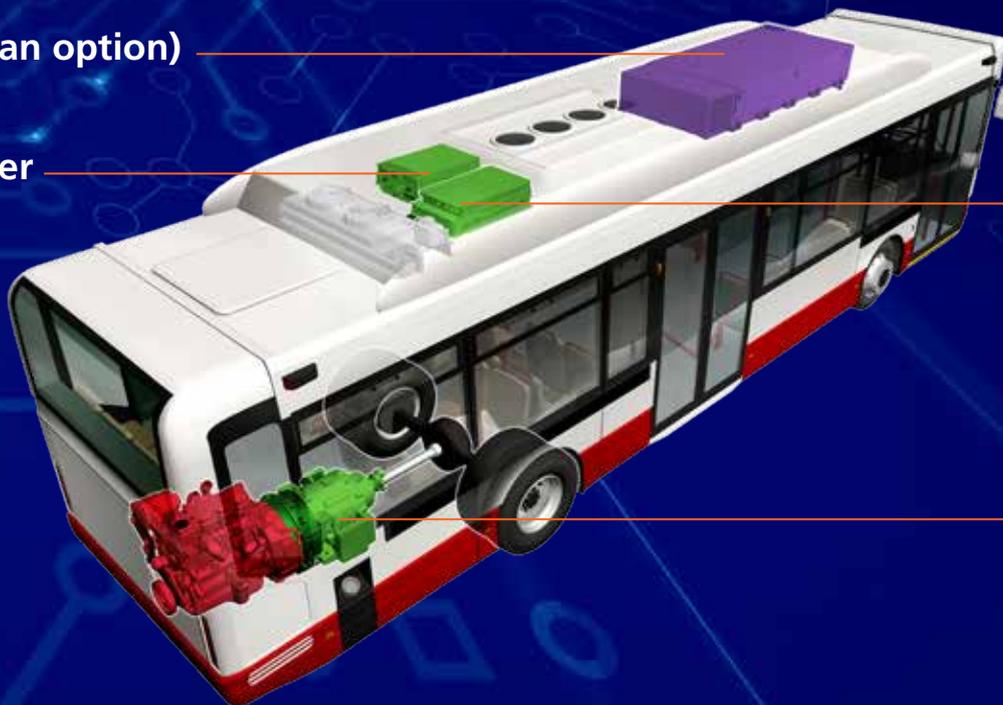
Series-E: Hybrid Electric

Series-E is a hybrid electric propulsion system capable of powering all bus accessories on electric power, allowing operators to take advantage of stop/start technology. With Series-E, the engine can shut off at stops and electric accessories (A/C, power steering,

air compressors, etc.) will continue to operate. Our hybrid systems have two energy storage units options to choose from, the ESS-3G-32K and the ESS-3G-1K. The ESS-3G-32K provides more engine-off operations whereas the ESS-3G-1K does not require a mid-life refresh.

ESS-3G-1K
(ESS-3G-32K is an option)

Accessory power system



Propulsion control system

Motor/Generator

How it works:

With Series-E, the integrated starter generator (ISG) is the prime energy source. Once the generator is turned by the engine, the generator provides power to the energy storage system (batteries) which in turn powers the electric drive motor. A secondary source of energy is realized from vehicle braking. As the driver engages the brake, energy is reclaimed and stored for use in the energy storage system to drive the wheels.

Benefits:

- up to 15% engine-off operation
- stop/start technology (engine-off at bus stops)
- no charging infrastructure required



Electric accessories for conventional powertrains (Diesel and CNG powered transit buses and motor coaches)

REAL (reduced engine accessory loads)

We've been powering electric accessories on hybrid and electric vehicles for years, but now diesel and CNG powered buses can realize the same benefits of electrification with a simple, proven system.



Accessory
power system

Generator

Benefits:

- cleaner engine compartment – only a single accessory belt drive needed for the high-voltage generator
- a single, compact electronics unit integrates all power management functionality and supplies power for all vehicle accessories
- reduces scheduled and unscheduled maintenance costs
- reduces external noise and emissions, and improves internal noise, vibration, and harshness (NVH) for riding passengers
- reduces operating costs with a fuel efficiency improvement up to 5% (duty-cycle dependent)
- eliminates hydraulic oil in the engine compartment and the associated fire potential

How it works:

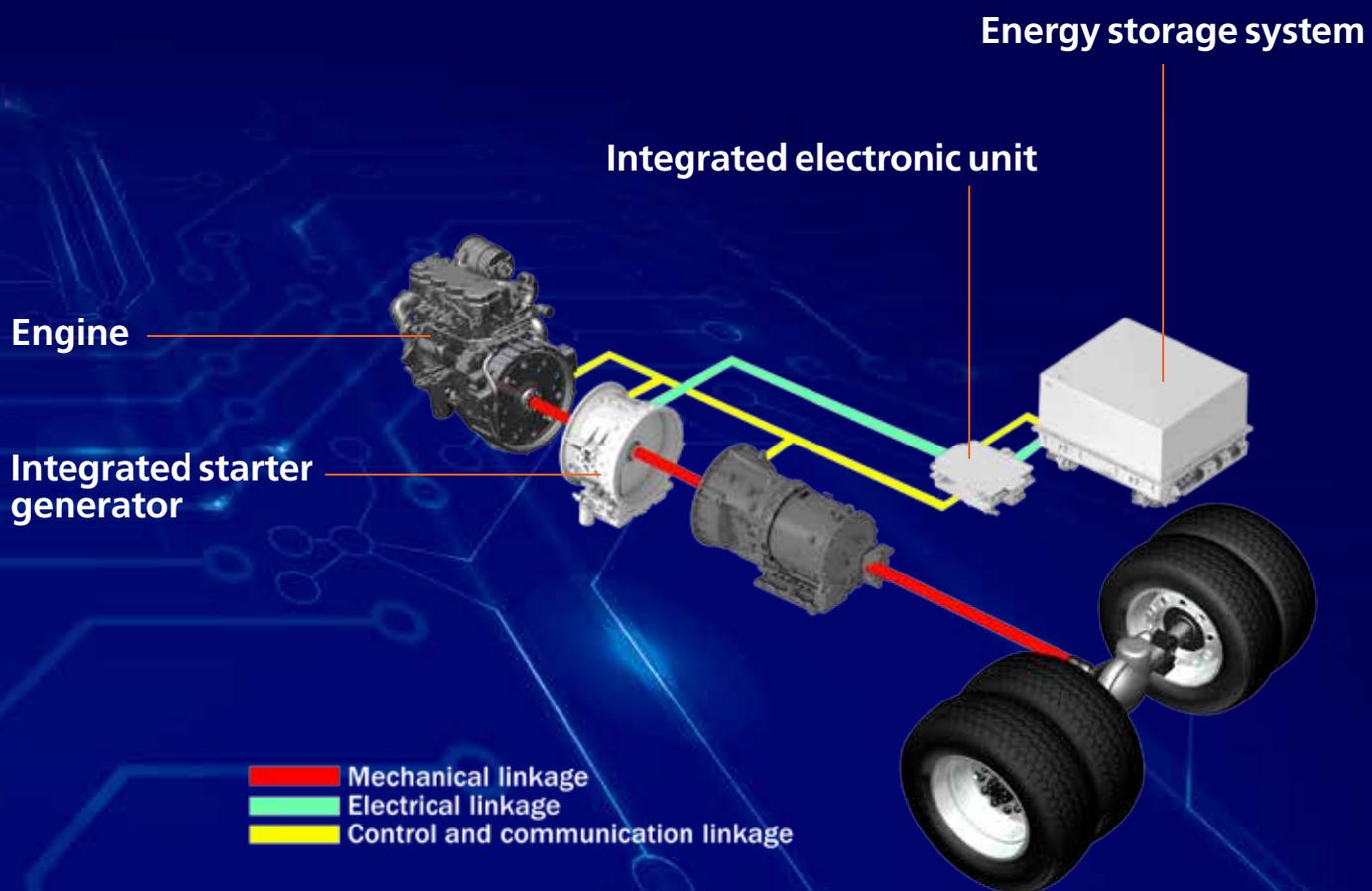
Our belt-driven, high-voltage permanent magnet generator replaces a dedicated A/C compressor and 28V hi-current alternator. Our accessory power system (APS) provides the power conversion and management to support all the accessory loads (including 208V and 230 Vac).



Parallel hybrid for motor coaches

As more and more cities pledge to decrease emissions, transit and motor coach operators are looking to adopt greener solutions to lessen their impact on the environment and save on fuel expense. Our parallel hybrid system for motor coaches provides that "green badge" that

operators are looking for to demonstrate their commitment to the environment and their destination cities. Motor coach operators will arrive and depart using clean, quiet, efficient hybrid power.



Benefits:

- reduces harmful emissions and saves fuel
- stop/start technology available
- capable of engine-off operation

How it works:

Our integrated starter generator (ISG) has both a motor and generator. The ISG takes direction from our integrated electronics unit (IEU) to blend engine and electric machine torque to provide the most efficient engine loading during acceleration events. Once the bus is up to speed and operating efficiently, electrical power is phased out. As the bus decelerates, the regenerative energy is captured through the generator and stored in the energy storage system for the next acceleration or cruise.



Advancing **electric solutions** through global market leaders

To offer transit operators maximum flexibility, BAE Systems delivers environmentally-friendly solutions and superior system integration with market-leading bus manufacturers across the globe.

Our efficient systems are available in North America with Gillig, New Flyer, Nova Bus, and El Dorado National buses, and in Europe with Alexander Dennis, Iveco Bus, and Solaris Bus & Coach buses.



Alexander Dennis



Iveco Bus



Solaris Bus and Coach



El Dorado National



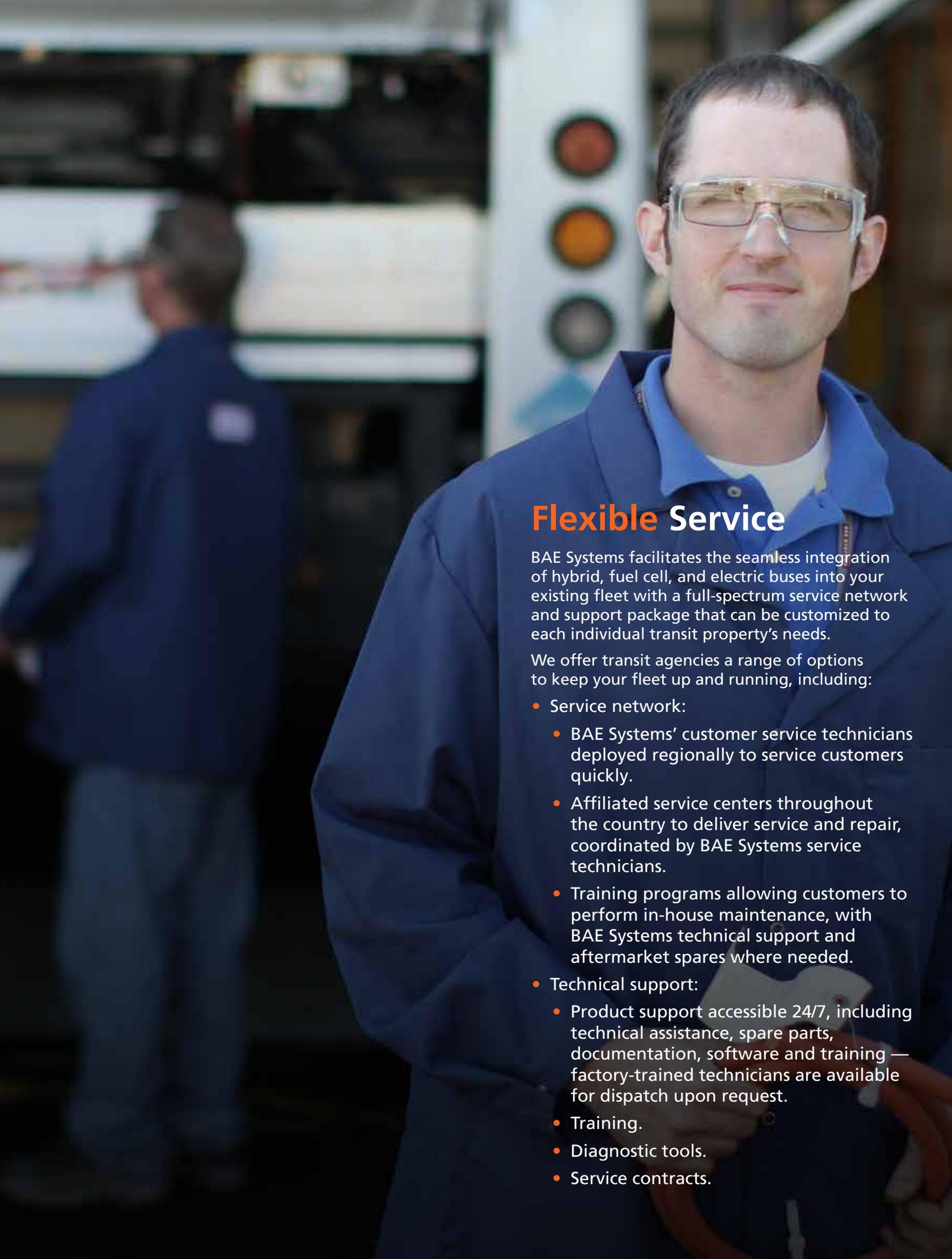
Gillig



New Flyer



Nova Bus

A man in a blue work jacket and safety glasses stands in a transit facility. In the background, another person in a blue uniform is visible, and there are traffic lights and structural elements of the facility.

Flexible Service

BAE Systems facilitates the seamless integration of hybrid, fuel cell, and electric buses into your existing fleet with a full-spectrum service network and support package that can be customized to each individual transit property's needs.

We offer transit agencies a range of options to keep your fleet up and running, including:

- Service network:
 - BAE Systems' customer service technicians deployed regionally to service customers quickly.
 - Affiliated service centers throughout the country to deliver service and repair, coordinated by BAE Systems service technicians.
 - Training programs allowing customers to perform in-house maintenance, with BAE Systems technical support and aftermarket spares where needed.
- Technical support:
 - Product support accessible 24/7, including technical assistance, spare parts, documentation, software and training — factory-trained technicians are available for dispatch upon request.
 - Training.
 - Diagnostic tools.
 - Service contracts.



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