Reducing the overheads

Do away with overhead line equipment and urban tramways become a much more attractive proposition, says SYSTRA

Tramways and light rail systems have historically sourced much of their power from overhead line equipment (OLE). However, over the last two decades, catenary-free operations have rapidly grown in popularity. They avoid the need for visually obtrusive OLE equipment in city centres, allowing historical features to remain visible to residents and visitors.

There are other advantages to catenary-free running, including reduced cost and time associated with design and approval of the system, expedited stakeholder acceptance, enhanced climate resilience, and more flexibility for rolling stock design as headroom is not limited by OLE equipment.

There are several technology options for catenary-free operation. The choice for a given tramway is influenced by the length over which catenary-free running is required and the characteristics of the section on which the catenary-free solution will be rolled out. The solutions can broadly be split into two categories: systems based on a **continuous power source** delivered through a contact line embedded in the trackbed; and vehicles equipped with **on-board energy storage** from batteries, supercapacitors and hydrogen fuel cells.

For continuous ground-level power supply systems, power is provided by physical contact or by induction. SYSTRA selected the Alstom APS supply system for the pioneering catenary free system installed in Bordeaux in 2003. This system has been extremely successful and has been adopted in other areas of France including Reims, Angers, Orleans and Tours.

APS has been adopted around the world - it was installed on the Dubai Tram which, upon opening in 2014, became the first tramway in the world to feature a ground-based power supply system along its entire length. SYSTRA managed the design of the first phase of the Dubai Tram and is in the process of undertaking preliminary design for its second and third phases, in association with AECOM.

System Engineering Manager at SYSTRA, Mathieu Melenchon reflects: "We are very proud that SYSTRA has played an instrumental part in making this innovative technology real. The challenge now is to find a way to make the costs comparable with traditional systems. This is something we are working on."

There are three principal ways of providing on-board energy storage - batteries, supercapacitors and hydrogen fuel cells. The first, battery storage, is applicable closer to home, with Midland Metro set to become the first system in the country featuring sections without OLE, and relying on battery power in carefully selected areas of the region.

Midland Metro's fleet of 21 Urbos 3 trams is currently being retrofitted by CAF with lithium-ion cells, so that OLE can be dispensed with on four planned sections of the network - including through Birmingham's central Victoria Square and in Wolverhampton City Centre.

The batteries will be fitted to the roofs of the trams and recharged by OLE on other sections of the route. Recharging is also possible through a ground-level power supply in stations.

Fitting out the entire 21-tram fleet is estimated to cost £15.5 million, and further costs will be incurred to replace the batteries once they are life-expired.

However, according to Midland Metro owner the West Midlands Combined Authority, the decision will save more than £9m in infrastructure capital costs while also protecting architecturally sensitive areas of both Wolverhampton and Birmingham. The metro system continues to provide an effective alternative to the private car, helping to ease congestion and support economic growth.

Research and development in batteries is also being supported by the automotive sector, which could help yield significant improvements such as distance between charging points and the time between upgrades and replacement.

Supercapacitors are an alternative way of providing onboard energy storage, and can be charged much more quickly than batteries. However, they have less capacity to hold charge, meaning they are more suited to lines with short distances between stations where charging points can be located.

CAF Urbos 3 trams use this technology to run on catenary-free sections of the tram networks in the Spanish cities of Zaragoza, Seville and Cadiz.

Lifecycle costs for supercapacitor systems tend to be higher, owing to the need for larger substations.

Hydrogen fuel cells produce power from hydrogen and air using electrolysis. The 'emission' from this process is pure, drinkable water, making it a non-polluting power source. An additional advantage over battery-power is the speed of charging - a few minutes (roughly the same as a petrol car) in comparison to several hours for a battery.

In addition to the onboard equipment, hydrogen refuelling stations are required and (potentially) a hydrogen production facility, which further increases overall system lifecycle costs. The lack of hydrogen distribution infrastructure makes this the most costly solution compared to classic OLE systems, but economies of scale could be achieved if a local transport authority also chose to migrate its bus fleets to hydrogen fuel cells. Furthermore, the UK commitment to achieve 'net zero' greenhouse gases by 2050 means cost is not the only factor to be considered.

Currently, across the globe, only the Chinese company Sifang is developing a hydrogen-powered tram which will have a top speed of 70kph (43.5mph) and will be able to carry 380 passengers. The tram is being designed to take three minutes to refuel and will have a range of 100km.

SYSTRA says it watches all these technology developments very carefully, which are being increasingly applied to heavy rail systems before their eventual migration to light rail.

Alstom has already introduced hydrogen trains onto regional services in Germany, while in the UK there are partnerships between the University of Birmingham and Porterbrook and between Alstom and Eversholt which are in the process of constructing standard gauge hydrogen-powered trains.

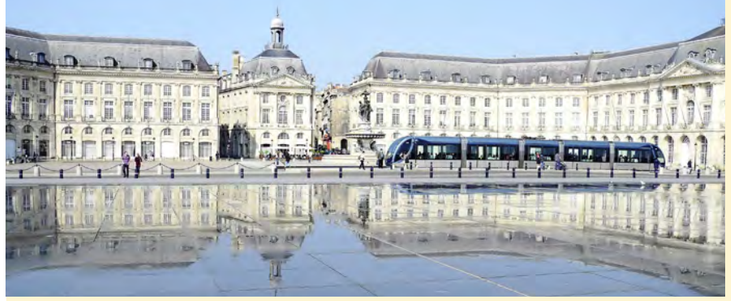
Other rolling stock owning companies and manufacturers are offering hybrid units that can operate using a combination of diesel, electrical and battery power.

Derek Small, from SYSTRA, adds: "There is no definitive answer to the catenary-free question. It comes down to careful consideration of many factors to determine which of these solutions is most appropriate - client drivers location, route, demand, environmental impact must all be considered, and you can't treat any one of them in isolation. It's a bit of a balancing act but simply looking at cost is probably the wrong thing to do for a whole transport solution. The 'net zero' greenhouse gases by 2050 emissions target is a bit of a game changer for the industry, but at SYSTRA we have been developing this technology for over a decade."

He adds: "Battery power is seen as experimental in the UK, but it has been readily available on light rail in China for the last five or six years, and we're starting to see much more of it on the heavy rail side.

"The same goes for hydrogen, which is emerging in heavy rail and looks set to make its debut in light rail in China. The more you produce, the more the costs come down, so while there are obvious cost implications for whichever system you go for, these promising technologies will help to solve many of the environmental and planning problems we face." ■

The nine-mile Dubai Tram is the first tramway in the world to feature a ground-based power supply system throughout its length. HYWELL WATERS/SYSTRA.



The 41-mile Bordeaux tramway utilises a ground-based supply system to reduce visual intrusion in the city's UNESCO Heritage Listed centre. SYSTRA.

A SYSTRA-led consortium project managed the Bordeaux tramway (Communauté Urbaine de Bordeaux) which opened in 2003, and which will carry more than 430,000 passenger per day on completion of Phase 3.

System Engineering Manager at SYSTRA Mathieu Melenchon explains: "Part of the Bordeaux system in the city centre uses APS, where electric power to the tram is supplied by a centre rail that automatically switches on and off when a tram passes over it. This prevents any risk of electrocution to pedestrians or other road users.

"This solution is most appropriate for sections of line with large distances between stations and where speeds can be considered high (greater than 50kph, or 31mph)."

Costs can be higher than classic catenary systems but the catenary-free approach offers several advantages.

"In Bordeaux, a UNESCO World Heritage-listed city, the Mayor didn't want people to see unsightly wires. He was a strong believer that a traditional system would meet with stakeholder resistance and that a catenary-free system could be more acceptable, smoothing the way for planning permission. He was right - the scheme was implemented without objection and demand in Bordeaux has exceeded all predictions.

"We can say that APS has played a key role in unlocking that market, improving the environment and helping reduce congestion whilst maintaining the historical integrity of this proud city."

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Mathieu Melenchon,
System Engineering Manager, SYSTRA