Light rail technologies have received closer attention in recent times as potential solutions to transport problems as well as providing alternatives to ‘traditional’ railway operation. In light of this, a trip run by ACoRP (Association of Community Rail Partnerships), and organised by Faber Maunsell, took eight delegates from Network Rail, the Department for Transport and Transport Scotland in December last year to Switzerland and Germany. The aim of this was to study developments in light rail and their applicability to the UK.

A major focus of this trip was ‘tram-train’. For many people, this concept is most closely associated with the city of Karlsruhe in south-west Germany, which pioneered the technology in the 1990s. Essentially it involves the ‘joining-up’ of a tram network with heavy rail so that local services sharing paths with conventional trains on the main line can travel over both systems, enabling seamless through journeys. The need to change modes is thereby eliminated: accessibility is improved and end-to-end journey times drop. In Karlsruhe’s case, the city centre, about two km from the main station, was the main attraction, and a through journey from the suburbs with dual-voltage electric trams was made possible.

Factors for success
Karlsruhe’s success has led to numerous developments and extensions, most recently conversion of the 30-km long Murgtalbahn to tram-train operation, which took only seven years from conception to completion at a cost of Euro 75 million (£50 million). The longest possible journey on the system now takes in tramways in both Karlsruhe and Heilbronn as well as main-line railway over its 150-km route from Achern to Öhringen.

But it is perhaps surprising that not more schemes modelled on this apparently thriving example have come to fruition, even in continental Europe. Those that are operational include Saarbrücken in Germany and the Rijn-Gouwe-Lijn through Leiden and Gouda in the Netherlands, with the French city of Mulhouse at the initial stages. An overview of these projects reveals that a certain number of factors typically have to come together for a scheme to work:

● a common tram and heavy rail track gauge and a suitable interface point between heavy rail and tramway;
● a relatively large but dispersed population, ideally with a strong commuting market – Karlsruhe, for instance, serves 120 communities with a total population of 1.3 million people;
● favourable urban planning and public transport characteristics – the two must be considered together;
● existing heavy rail stations some distance from the main centres they seek to serve;
● an ability to overcome the technological challenges such as providing trams with two sorts of traction equipment, signalling compatibility, and meeting the relevant safety standards;
● perhaps most importantly, the political will and funding to see the project through.

Latest developments
One city where the balance of factors has been positive, however, is the city of Kassel in central Germany, which is currently developing its own ‘RegioTram’ system, due to open in June this year. A total network of 122 km is provided with only 10 km of new track, serving an urban population of 220,000 with a further 400,000 in the surrounding area. Although the system is based on the ‘classic’ tram-train principle with dual-voltage trams running on the mainline at 15kV AC and on the city tramway at 600V DC, one very significant innovation is the introduction of diesel trams for operation over non-electrified sections of line. This extends their reach beyond conventional electrified routes to rural single-track branches and diesel freight-only lines. Specifically, these vehicles are diesel hybrids: equipped with a diesel-electric engine, they are also able to work on the city tram network at 600V DC.

Each branch will operate to a regular interval 30-minute frequency, with connecting buses at stations along the route in line with the Taktfahrplan principle of bus and rail integration. Coupled with the enhanced journey opportunities, passenger demand on the network is predicted to grow by up to 50%.

Value for money
The total cost of the whole scheme is Euro 180 million (£120 million), made up of Euro 100 million (£67 million) for infrastructure and Euro 80 million (£53 million) for new vehicles.
85% of the costs were borne by the Bundesland and federal government, with the remaining 15% contributed by the municipal authorities.

Key to the tram-train principle, and to the Kassel plan in particular, is maximum use of existing infrastructure to achieve greatest efficiencies and benefits. Diesel trams help to meet that goal by having the ability to fill in the electrification gaps as ‘go-anywhere’ vehicles, but the decision to choose them came about for three major reasons.

- Large infrastructure costs were avoided: the loading gauge in Zierenberg tunnel on the non-electrified Wolfhagen route to the west of Kassel did not allow for electrification without substantial rebuilding. This resulted in a capital cost saving of Euro 7.5million (£4.9million).
- In addition to the costs of rebuilding the tunnel, the capital spend to electrify the 30-km Wolfhagen route would have been around Euro 2million (£1.3million) per kilometre, not including ongoing operational expenditure, and unjustifiable in this case.
- Time and money would be saved in the planning process.

The above savings on the Wolfhagen route represent upwards of 35% of the total infrastructure costs of the entire project, and demonstrate, how much more expensive a fully electric system would be. Feasibility studies carried out between 2000 and 2003 focusing on whether to opt for electric-only vehicles or a mixed fleet containing diesel-hybrids. Built by Alstom, they are part of the Regio Citadis family. Both versions are visually very similar, and share many features for ease of maintenance. Crucially, performance is the same for both electric-only and diesel-hybrid vehicles – acceleration from start is 1.1ms⁻¹ in each case. A comparison of the vehicles is given in the table.

### Technical specification

Twenty-eight three-car vehicles were ordered for the project, 18 electric-only and 10 diesel hybrids. The above savings on the Wolfhagen route came about for three major reasons. Diesel trams offer the prospect of linking up the existing infrastructure to achieve greatest efficiencies and benefits. Diesel trams help to meet that goal by having the ability to fill in the electrification gaps as ‘go-anywhere’ vehicles, but the decision to choose them came about for three major reasons.

- Large infrastructure costs were avoided: the loading gauge in Zierenberg tunnel on the non-electrified Wolfhagen route to the west of Kassel did not allow for electrification without substantial rebuilding. This resulted in a capital cost saving of Euro 7.5million (£4.9million).
- In addition to the costs of rebuilding the tunnel, the capital spend to electrify the 30-km Wolfhagen route would have been around Euro 2million (£1.3million) per kilometre, not including ongoing operational expenditure, and unjustifiable in this case.
- Time and money would be saved in the planning process.

The above savings on the Wolfhagen route represent upwards of 35% of the total infrastructure costs of the entire project, and demonstrate, how much more expensive a fully electric system would be. Feasibility studies carried out between 2000 and 2003 focusing on whether to opt for electric-only vehicles or a mixed fleet containing diesel-hybrids. Built by Alstom, they are part of the Regio Citadis family. Both versions are visually very similar, and share many features for ease of maintenance. Crucially, performance is the same for both electric-only and diesel-hybrid vehicles – acceleration from start is 1.1ms⁻¹ in each case. A comparison of the vehicles is given in the table.

### Transferability / applicability to UK

As stated above, conditions for tram-train have to be right, and given the small number of tram systems in the UK, let alone other complexities in the development of a scheme, it is clear that imitating the Karlsruhe model here is a harder task. The Sunderland extension of the Tyne & Wear Metro used some tram-train principles but employed the existing electric Metro vehicles, and areas including Greater Manchester and Teesside have been looking at the use of tram-trains. It would seem that in the UK context, diesel tram technology could help broaden tram-train’s appeal, especially in increasing the affordability of light rail schemes, and where funding has been withdrawn owing to cost overruns as in the Leeds Supertram project.

Potentially they combine the speed of a railway and the accessibility of a tramway, at a much lower capital cost than electric trams.

### Joining up urban centres

First, taking advantage of a tram’s ability to penetrate the urban centre, a tramway spur from the mainline to such ‘honey pot’ sites offers the opportunity to go right to where the customers want to go and encourage modal shift with seamless journeys. If Karlsruhe has shown that through journeys work with electric vehicles, then diesel trams prove that a potential station crucially need not be sited on an electrified Network Rail line – thus opening up the entire British railway network – nor would the tramway itself require electrification.

Blackpool illustrates the potential: diesel trams offer the prospect of linking up the South Fylde line with the tramway, thereby opening up many new journey opportunities and contributing to the area’s regeneration. As no electrification would be necessary, major new infrastructure would be confined to connecting the two networks and restoring some of the double track on the railway section. There are also knock-on benefits to the local service: faster, more frequent

The diesel tram idea could be a low-cost alternative for branch lines such St Erth to St Ives, seen here. This is No 163329, which was released to traffic painted in a St Ives Bay livery and named St Ives Belle in a ceremony at St Ives. The vehicle is seen approaching Carbis Bay on its way to St Ives on the naming day, 4 December 2005.

Colin J. Marsden
Diesel trams: a new way forward?

The village of Weimar near Kassel, where light rail and heavy rail share tracks. On the left is a diesel-hybrid tram, on the right is a Stadler GTW DMU of the Kurhessen Bahn. Heribert Menzel

journeys and reduced wear and tear on the track thanks to tram running characteristics and lighter axle loads.

Again, this has been demonstrated in Kassel where the 30-km predominantly rural line to Wolfsingen has a mixture of stopping and semi-fast services, taking between 47 and 33 minutes to Kassel. Operating a diesel tram on the stopping services with its superior acceleration and braking performance has allowed five new stations to be served whilst maintaining existing end-to-end schedules. Conventional trains can then be more usefully deployed on semi-fast services.

**Challenges**

As in Kassel, electrification could be employed where it is essential, for instance in city centres and particularly sensitive areas, with diesel operation along converted local train routes or more open corridors. The same might be envisaged in Nottingham for example, with through services from Mansfield as a link at Bulwell to access the city centre. It is also conceivable that diesel trams could be used on a self-contained tramway where costs are reduced through not having to electrify from the outset. Given our acceptance of buses in city centres, why are we not ready to tolerate diesel tram operation?

Personal experience has shown a diesel tram to be perfectly acceptable; it is far quieter and has less visible emissions than any of the diesel trains operating in the UK. Queues of idling buses waiting in Manchester’s Piccadilly Gardens, London’s Oxford Street or any of the other increasingly congested UK cities underline the fact that all modes of transport are polluting. A central issue for debate, therefore, is where it is acceptable for that pollution to be produced: at the point of use as with diesel traction, or confined to a power station. Ever more sophisticated diesel engine technology and cleaner fuels such as Ultra-Low Sulphur Diesel mean that a modern diesel vehicle is coming ever closer to meeting the environmental acceptability standards of an electric.

**Operational flexibility**

The attraction of diesel trams does not merely lie in their ability to operate as urban street vehicles. With regard to rolling stock operation, in a climate where everything must be increasingly accountable, does it always make sense to run conventional trains on rural routes or a small shuttle service? Running a diesel tram over the St Erth – St Ives or Marks Tey – Sudbury branch, for example, could result in lower infrastructure operating and maintenance costs, as well as freeing up the conventional DMU for use elsewhere. A diesel tram-style service could also allow an extra service to be served, as suggested for the Tees Valley for instance (p50, last month). If more capacity is needed, several units can be coupled together (up to four can run as a ‘train’ in Kassel). Of course, the ultimate is full conversion of the line to tramway standards with simplification or even removal of signalling – driving on ‘line of sight’ – and again lowering track maintenance costs. Retaining the option of through running onto the mainline would open up many more possibilities, and also allow access to existing maintenance facilities elsewhere on the network if required.

**The future**

There are signs that the industry is looking towards an approach where operational and maintenance standards on a line are more closely dictated by its function and the type of traffic it sustains. We must be ready to accommodate this shift in focus if it secures the longer-term future of more lightly used lines and ensures they remain fit for purpose.

Community railways are a prime example of this: if a certain route with a low line speed only sees a few passenger trains a day operated by Pacers and no freight, why could this service not be provided by a diesel tram with its attendant cost savings and, from the passengers’ perspective, a more comfortable journey experience?

Diesel trams will not provide the answer in all cases, but they have clearly helped to provide new impetus to the tram-train concept as well as demonstrating their value as rail vehicles in their own right. At a time when the train-infrastructure interface comes under closer scrutiny, considerably lighter tram-type vehicles could contribute to a ‘virtuous maintenance circle’, and Network Rail’s vision for a more reliable railway. In the effort to maintain and grow rail’s attractiveness through ‘joined-up journeys’, and to ensure that each line is used as appropriately as possible, light rail technologies are likely to play an increasingly important role. Diesel trams are well placed to form part of that mix.

Following a year’s internship in Germany with DB (German Rail) and a transport planning consultancy, Charles King joined the Transportation Division of Faber Maunsell as a rail transport planner. Last year, on behalf of ACoRP, he organised the tram-train study visit to Switzerland and Germany referred to in this article.