Innovative Technologies for Light Rail and Tram: A European reference resource

Briefing Paper 8
Additional Fuels -
Aeromovel System
September 2015


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sintropher

Sustainable transport for North-West Europe's periphery

Sintropher is a five-year €23m transnational cooperation project with the aim of enhancing local and regional transport provision to, from and withing five peripheral regions in North-West Europe.

INTERREG IVB

Investing in Opportunities

This project has received European Regional Development Funding through INTERREG IV B.

INTERREG IVB

INTERREG IVB North-West Europe is a financial instrument of the European Union's Cohesion Policy. It funds projects which support transnational cooperation.

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Report produced by University College London

Lead Partner of Sintropher project

UCL

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Background

This briefing paper is one of a series that together comprise a European reference resource for innovative technologies rail-based based systems, with particular reference to light rail and tram-based schemes in cities and regions. The approaches are also relevant, in many cases, to heavy rail and even other forms of public transport for example bus.

The resource is one of the Investments undertaken for the Sintropher project funded under the INTERREG IVB North West Europe Programme for transnational co-operation. The overall aim of Sintropher project is to develop sustainable, cost-effective solutions to improve connectivity to, from and within poorly connected regions in North-West Europe - to use innovative transport links to connect peripheral regions of NWE with the core European transport network of high-speed trains, via effective interchange hubs.

There has been a particular focus on tram-train systems which allow local trams to run on to national rail networks, pioneered in Germany, firstly in Karlsruhe and developed in Kassel, which allow urban tram systems to extend over national rail tracks to serve extensive city regions. The project has also looked at other innovative forms of tram systems such as single-track tramways, as well as high-quality transport interchanges that link such systems to major national or transnational rail or air hubs.

The project began in late 2009, with fourteen partner agencies in five EU Member States, and lead partner University College London (UCL): Valenciennes (France); the Fylde Coast (UK); West Flanders (Belgium); North Hesse (Germany); and Arnhem-Nijmegen (Netherlands).Participants included public transport operators, local authorities, regional transport agencies, and universities.

They have worked together on a series of feasibility evaluations, pilot investments and demonstration projects, as well as comparative analyses of EU best practice. The total budget is more than €23m, with funding part-financed by the EU's INTERREG IVB Programme.

A €1.5m project extension in 2014, covers follow-on work to capitalise on results from the initial project, and added a fifth objective: to test technologies for low cost transport links in different territorial contexts, plus integrated territorial corridor plans that help these links unlock wider economic and regeneration benefits; and better recognise these in business cases. This included two new partners (total now 16) and two extra demonstration regions (total now 7) in West Flanders Brugge-Zeebrugge (Belgium) and Saar-Moselle (a cross-border region France-Germany).

Innovative technologies for light rail and tram – developing opportunities

Previous results from Sintropher show that low-cost systems, such as tram-train, tram-rail, and single-track tram systems, have clear potential but there is no single "best" solution and these opportunities must be assessed and adapted to city/regional circumstances. (Sintropher Report *Connecting European regions using Innovative Transport. Investing in light rail and tram systems: technological and organisational dimensions.* See references at end.)

Additionally over the 5 years of Sintropher, there have been dramatic developments in relevant transport technologies. The most important are (a) very long-life batteries that allow electric trams and trains to operate over substantial distances "off the wire"; (b) charging devices that boost battery life by recharging at stops en route – e.g. the supercapacitator technology demonstrated at the 2010 Shanghai Expo, or the induction system employed by Bombardier in their Remove trams and buses; (c) discontinuous electrification that allows electric trains and trams to "coast" under bridges and through short tunnels where it would be impossible or prohibitively expensive to install overhead catenary.

Also, a recent Report by UK Network Rail *"Network RUS: Alternative Solutions"* (July 2013) - an input to its Route Utilisation Strategy for long-term planning of the national rail network - has reviewed these developments. This work followed a remit to think imaginatively about cost effective solutions for accommodating growth in UK passenger demand, and operating services more efficiently. The solutions which are considered in the UK context are generally over and above the conventional solutions such as types of rolling stock and 25kV AC overhead line electrification. It looked at tram-train, tram systems, battery-powered vehicles, hybrid light rail, personal rapid transit, bus rapid transit and guided bus, and electrification solutions for lightly-used routes. Its main focus is existing rail lines in the UK network, but it can also be used to consider options for new transport corridors in urban areas.

The Report's overall comment is "Whilst some of the solutions are close to an appropriate stage of development (or adaption) for introduction onto the UK rail network, others will require more attention, for example on battery technology. It is important to be aware that, by definition, a process of innovation is a process of change and that some technologies that are not listed as appropriate at present may become appropriate after further development work. It is possible that over the next 30 years there may be some significant technological developments that could reshape the market for public transport and how it is powered."

So within the project's partner regions, there has been further feasibility work to test these kinds of innovative low-cost solutions in different city/regional contexts, including new developments in technical solutions.

The European reference resource informs project partners' work, and is also intended to be of relevance to much wider audiences especially. Particular target audiences are governmental authorities and transport agencies at city, regional, national and EU levels; and transport professionals and practitioners who may be involved in the initiation and implementation of new transport links

The reference resource is a snapshot in time (September 2015) and obviously the field of technologies is developing on an ongoing basis - it is hoped to update the briefing papers periodically as necessary.

Aeromovel – Atmospheric Railway

Aeromovel trains – derived from Aerodynamic Movement Elevated – is a unique air-powered rail system inspired by 19th century "atmospheric railways". These systems capitalise on air pressure differentials running through ducts embedded in tracks to propel and brake trains. The system is unlike many other catenary-free alternatives in that no engine is required on-board rolling stock for propulsion. Aeromovel has been called the "catenary-free tram and light rail option of the developing world" and has proven itself as a viable alternative to catenary systems in this context.

Left: Jakarta Aeromovel railway, the first Aeromovel in the world. Right: Diagram of air flow creating propulsive air pressure.

Technology

Aeromovel is a modern reincarnation of 19th century atmospheric railway systems where rail cars are propelled along a track using air pressure gradients. Lightweight trains ride along rails mounted on a hollow concrete box girder that runs along the entirety of the track. The train is fitted with a square plate – the piston - that extends down into the hollow duct and forms a block between two sections of the under-track duct. Large industrial fans then either blow air into or exhaust air out of the duct forming a positive or negative pressure gradient on either side of the train. The difference in pressure acts on the square plate and causes the train to move away from the positive pressure gradient and towards the negative pressure gradient. This system has achieved operational speeds of up to 70km/h.

Attractiveness

- As there is no engine, transmission, or fuel source on the train the weight of rolling stock is reduced significantly. Ton for ton, Aeromovel trains can move up to three times more payload than conventional systems using the same amount of energy.
- With relatively few moving parts, the system requires little maintenance.
- Safety is ensured using “air cushions” which generate pockets of pressurised air between trains that prevents them from approaching one another.
- The system can be operated remotely using magnetic sensing and automated controls.
- As the trains are lighter, the supporting structures of the trains require less material and reinforcement.
- Aeromovel trains can manage relatively steep gradients and tight turns.
- Construction times are considerably faster than in traditional systems and costs are comparable.

Risks

- Traditional atmospheric railways systems tend to face significant operational problems in climates where temperature dip below zero as ice and snow can damage and block track elements.
- Hollow duct nature of track not suitable for most road elements and generally requires elevation. No Aeromovel systems have been trialled at ground level.
- Large amount of embedded carbon resulting from elevated track construction.
- Significant amount of urban intrusion from elevated track construction.

Track Record

Historically atmospheric railways have not fared well operationally, with all known networks closing by the middle of the 20th century. Since the modernisation of atmospheric railways in Aeromovel two new systems have been built and are in operation around the world: Jakarta, Indonesia and Porto Alegre, Brazil. Both Aeromovel lines are relatively short but have seen much success since their opening.

Aeromovel Case Study: Porto Alegre Tram

System Specifications:

Line	Start/End	Founded	Length	Stations	Time (min)	Operating Hours
Airport connection People Mover	Trensurb ↔ Infraero*	2013	0.814 km (0.51 mi)	2	2	06:30 AM to 11:20 PM

Rolling Stock: T'TRANS A100 developed by Coester Group, capacity of 300.

Status: Completed late 2013, two years of design and construction, part of larger investment plan ahead of 2014 world cup.

Cost: R$37.8m (USD$11.7m)

Ridership: Average 3,165 passengers per day between 01/05/2014 to 07/09/2014.

Why was the technology chosen in Porto Alegre?

"Green" and flexible system: Aeromovel boasts reduced emissions at point of use and lower urban noise pollution levels through its use of industrial fans. The "minimising relocation and dispossession" associated with the flexible engineering was also deemed a positive, allowing for the tram to operate independently of the existing roadway.

Improving Brazil's image: Aeromovel – although originally developed in Jakarta – was considered to be "100% Brazilian" and was chosen to "improve Brazil's self-esteem and image, showing that the country is able to produce an innovative and competitive solution" (Humberto Kasper, TRENSURB President). Additionally, all rolling stock parts were manufactured in Brazil.

Benefits

- Locally engineered and manufactured materials have received acclaim with Aeromovel deemed a "developing world" technological success;
- Aeromovel proven history of operation in temperate climates;
- Significantly cheaper than "traditional" elevated rail or metro options.
- Replaced "unsafe" walk between station and airport and expensive taxi rides, leading to improved public safety and reduced fares.

Drawbacks

- Project not deemed viable for other proposed extensions
- Due to large fluctuations in demand, two different vehicles with different capacities are needed for regular operations (capacity of 150/300 passengers) increasing procurement costs.

Assessment

The Porto Alegre Aeromovel is heralded as the world's "first commercial installation of an atmospheric railway technology" despite a similar system having been constructed in 1989 in Jakarta, Indonesia. Much of the positive press is associated with the bespoke design and technological implementation rather than operational characteristics. Critics question why the relatively short distance between the station and the airport (less than 1km) could not have been replaced by a rapid bus service, as road space was available for service use.

Despite these criticisms the project generated considerable prestige, proved a successful demonstration of proof of concept, and the relatively low cost of the project (~USD$10M/km of track) would make the Aeromovel a success in any developed-country context.

Future Prospects and Transnational Relevance

While there are currently no Aeromovel-style projects under development, the potential for more Aeromovel systems to be implemented in the developing world is significant. Temperate conditions are favourable to the implementation of atmospheric railways and with projects successfully running in Jakarta and Porto Alegre more interest will likely be generated in the technology as methods develop further.

Significant innovation will need to be made for the system to operate fully in climates that experience snow or below-freezing temperatures. Brazil is the most likely country to experiment further with Aeromovel as Brazilian technocrats considers the technology a “national innovation”.

Transnational relevance

The technologies and approaches and city/region case examples on the reference resource are context-specific and reflect:

- the geographical context: for example the extent of the urban or regional rail (and/or tram) network and degered of electrification or non-electrification; density of traffic; extent of urban and rural areas; and physical urban conditions such as street width, environmental conditions, historic areas.
- the technical context: the national regime of technical standards for rail or tram infrastructure, rolling-stock vehicles, rail electrification power supply.
- the regulatory context: the national regime for matters especially safety standards, CO2 emissions, environmental impact.

Some of the technical and regulatory matters are EU-wide. A Sintropher Report on the technological and organisational aspects of innovative tram-based systems looks at the desirability of greater harmonisation across Member States where different standards exist (see references).

These potential low-cost solutions now need to be tested in different regional cases in EU Member States. There are some distinct physical differences:

- rail systems in most Member States were built at lower cost than in the UK, with fewer over-bridges and more at-grade road/rail crossings, which may reduce the benefits of some technological alternatives (e.g. discontinuous electrification).
- many areas have historic towns where conservation considerations make overhead catenary undesirable, increasing the advantage of battery-based solutions.
- in many European countries, in contrast to the UK, many urban tram systems have been maintained, or even constructed in the last 20 years, making tram-train solutions more relevant.

Even though the various approaches and case examples are context-specific, their transnational relevance is strong:

- the approaches offer a stimulus and possibilities for wider thinking by cities and regions in other European countries
- some or all of the various approaches might be potentially adaptable within the particular organisational and governance regime of another country, and technical and regulatory regime. For example the Governments’ UK tram-train trial in Sheffield, Network Rail’s UK trial with battery power for trains on a non-electrified heavy rail line in East Anglia, and (in Sintropher) Province Gelderland’s feasibility studies for battery power to enable electric trains to operate on non-electrified routes in their regional network..

The reference resource should be seen from this perspective, as a means to promote knowledge transfer and learning across different NWE countries and regions.

Sources

http://www.copa2014.gov.br/en/noticia/100-national-technology-aeromovel-reaches-its-final-construction-stages-porto-alegre

https://pt.wikipedia.org/wiki/Aerom%C3%B3vel

https://en.wikipedia.org/wiki/Porto_Alegre_Metro

http://www.aeromovel.com/technology.htm

http://www.aeromovel.com/

http://www.globalrailnews.com/2013/04/17/aeromovel-vehicles-delivered-to-world-cup-host-city/

https://dspace.mit.edu/bitstream/handle/1721.1/673/151a.pdf?sequence=2

http://www.copa2014.gov.br/en/noticia/aeromovel-has-already-been-operating-24-years-indonesia-using-brazilian-technology

https://en.wikipedia.org/wiki/Atmospheric_railway

References

Network RUS - Alternative Solutions. (July 2013) Report by Network Rail, London. www.networkrail.co.uk

Connecting European regions using Innovative Transport. Investing in light rail and tram systems: technological and organisational dimensions. (September 2015) Sintropher Integration Report 1, University College London. www.sintropher.eu/publications

Further information

This paper was produced by UCL Bartlett School of Planning (Sintropher team members Charles King, Giacomo Vecia, Imogen Thompson) using desk research and expert comment. The paper reflects the views of the authors and should not be taken to be the formal view of UCL or Sintropher project

The European reference resource can be accessed on the following:

Sintropher project website

http://www.sintropher.eu/publications

POLIS website

http://www.polisnetwork.eu/sintropher or http://www.polisnetwork.eu/res/resources

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Sintropher is coordinated by

In partnership with

Co-funded by the INTERREG IVB programme for North-West Europe


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