Debunking the myths around optically-guided bus (Trackless trams)

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"Various guidance technologies are further blurring the divide between bus and rail. Rubber-tyred metro systems, for instance, offer better traction and acceleration (especially at grade) on many urban rail systems. Kerb guided buses (e.g., Leeds, Adelaide O-Bahn) have been around for some time (though many would argue a gimmick only). Magnetic guidance systems have had various incarnations too, as well as optically guided buses—in Rouen, France and Castellón, Spain as examples, but recently gaining new attention through the "trackless train" marketed by China's CRRC and trialled in Zhuzhou. Do these modes operating on virtual tracks qualify as trains and is there an intention to mislead? Increasingly, there is a convergence of modes and so we are invited to ask exactly what constitutes a bus and what constitutes a train."[1]

Optically-guided bus is the latest in a long line of initiatives to repackage existing bus as premium rail-based technology. The name 'trackless trams', design of the vehicles and modest deployment cost has appealed to many, and the concept has gained traction in Australia, led by prominent individuals including Professor Peter Newman of Curtin University. Whilst we applaud the recognition for the role of upgraded bus and bus rapid transit, a certain level of dogma fuelled by more wilder claims about the technology and its potential has taken hold. Many misconceptions have been promulgated which prompts us to set out the facts and debunk the myths.

MYTH 1: OPTICALLY-GUIDED BUS IS A REVOLUTIONARY NEW TECHNOLOGY.

Optical guidance systems date back to the late 1980s[2] and have been deployed with limited commercial success since the early 2000s—we count just three applications in Rouen (Normandy, France), Castellón (Castelló, Spain) and Las Vegas (Nevada, United States). Whilst mechanically-guided bus remains the most popular—including [Adelaide O-Bahn styled] kerb-guided bus and to a more limited extent rail guidance systems—magnetic[3] and wire guidance technologies have also been trialled to deliver the same benefits including precision docking, lane assist, reduced road footprint and a better ride quality, but doing so for lower cost due to the absence of continuous physical infrastructure.

The three systems in Rouen, Castellón and Las Vegas are all based on the optical 'self-steering' guidance system developed in France by Matra under the trade name Visée, later rebranded as Optiguide upon acquisition by Siemens. The technology utilises a roof-mounted, forward-facing camera to detect a 'virtual rail' in the form of twin, white dashed lines painted on a darker road surface. The image is transmitted to an on-board computer which combined with the speed, yaw and wheel angle of the bus determines the correct path to be followed and in turn adjusts the vehicle's steering mechanism as required. In partnership with Renault, the Civis[4] concept was developed into a transport system based on Irisbus Agora articulated buses fitted with the optical guidance system.

The most extensive deployment has been on the Rouen BRT called TEOR (Transport Est-Ouest Rouennais), inaugurated in February 2001. The system has subsequently grown to three lines totalling 32 km all using the same guidance technology. The second deployment has been in Las Vegas along Las Vegas Boulevard North on the Metropolitan Area Express (MAX) BRT, which launched in 2004 but was discontinued in 2016. This system was unique in that optical guidance was used for station docking only and not general lane assist. For many years, the technology was deactivated due to poor reliability arising from the desert sun, dirt, grease and oil build-up on the road diminishing the pavement marking's contrast, despite the system stated to work even if just one-third of the stripes are visible. The third implementation (before Zhuzhou) has been in Castellón (Transporte Metropolitano de la Plana), which is an 8km trolleybus route launched in 2008.

[1]Wong, Y. Z. (2018). Is it a bus? Is it a train? Notes on modal etymology and nomenclature. Thinking Outside the Box. https://sydney.edu.au/business/news-and-events/news/2018/03/05/bus-or-train-notes-on-naming.html
[2]See pioneering work on vision-based vehicle guidance systems by Dickmanns et al. and Pomerleau
[3]Most prominent being the Phileas bus, using guidance technology from FROG (Free Ranging On Grid) Navigation Systems
[4]A derivative called Cristallis was also offered which featured a different driver seating configuration to allow driver-operated fare collection

So what is different this time round?

The present incarnation doing the rounds is admittedly a more advanced deployment of previous optical-guidance technologies. Led by Dr Feng Jianghua, the research arm of Chinese manufacturer CRRC[5] has used high speed rail technology (in particular, relating to the latest Fuxing series) to independently develop what it calls autonomous rail rapid transit or ART. The system is more akin to light rail than any of its predecessors. The vehicle dimensions are larger (2.65 m wide[6] by 3.4 m high), and can be lengthened or shortened by adding/removing sections from each consist. The vehicles are electric, using supercapacitor batteries which are mounted on the roof and charged via a collector at stations only (which feature an electric 'umbrella'). This allows the vehicles to be 100% low floor (330 mm floor height), as opposed to low entry for most diesel fleets in Australia. Note that the supercapacitor technology is not new, and has been launched in Shanghai (buses), Nanjing (light rail), Guangzhou (light rail) and Ningbo (buses) over the past decade. Despite this, 'new energy buses' in China (including Shenzhen's 16,400 strong electric fleet—the largest in the world) has not taken up this technology, relying instead on traditional lithium-ion batteries.[7]

A major advantage of the CRRC system is its multi-axle hydraulic steering technology and bogie-like wheel arrangement which is designed with less overhang thus requiring less clearance in turns. On the Zhuzhou test track (and as an example for comparison), the vehicles require just 3.83 m of swept path clearance, as compared with 5.74 m for a standard rigid bus. Each section of the 32 m vehicle is around 10.5 m long, and a minimum turning radius of 15 m is required. The cost of deployment is said to be USD 7-15 million per kilometre, as compared with USD 20-30 million for light rail and USD 70-150 million for metro. Capital costs for each vehicle is USD 2.2 million.

MYTH 2: OPTICALLY-GUIDED BUS OFFERS IMPROVED RIDE QUALITY.

This is true but to an extent only, and has as much to do with traction technology, route alignment and driver behaviour as it has with the optical-guidance variable. Ride quality is a direct result of rubber versus steel traction—think rubber-tyred metros compared with their steel counterparts. The track gauge (narrow, standard or broad) and axle loads (light or heavy) also determine the quality of ride on a railway. Another important factor is the alignment geometry. Light rail can handle only 4-6% gradients whilst rubber-tyred traction can reach 9%. A higher quality bus corridor with smoother gradients and curves will hence offer better ride quality. Pavement quality is another important factor which makes a marked difference to the ride experience.[8]

Optically-guided bus offers a much smoother ride, but this is primarily due to its advanced automation. It is true that the existing bus can be 'jerky', and this has a lot to do with buses getting more powerful (and lighter) over the years. An average bus engine generated 230 horsepower 20 years ago but today this can be up to 330 hp—important for uphill climbs but also allowing the driver (the opportunity) to accelerate quicker. One suggestion is to apply an acceleration limiter (perhaps more accurately the first derivative of acceleration or jerk limiter) in buses so as to limit the potential g-force experienced by passengers. The need for harsh braking is also an issue but linked to the level of bus priority afforded (i.e., traffic signals and traffic congestion) as well as driver training.

MYTH 3: OPTICALLY-GUIDED BUS WILL BE GAME CHANGING FOR THE PROVISION OF TRANSPORT SERVICES AND INFRASTRUCTURE.

Two issues with optical guidance technologies have not been considered in the present debate. Like the Civis, these remain proprietary technologies so there are always huge risks when locked into a single supplier. Secondly, the technology remains unproven for snow, heavy rain and fog conditions—and environmental constraints can be quite problematic as proven in the Las Vegas case. The potential success of the technology, however, is not related to whether the buses are optically-guided or not (nor linked to any of the above described characteristics, for that matter).

The modern, sleek, rail-like appearance of these vehicles certainly appeals to the cultural and biological elements within us. There is the potential for optically-guided bus to challenge the age-old adage that "buses are boring, and trains are sexy" and what we term at ITLS as choice versus blind commitment in the bus and rail debate. The challenge always is to avoid being emotionally fixated on technology, but rather choosing the appropriate mode to meet a particular transport requirement. However, the core characteristics of transport service are 'invisible' to the customer—frequency, service span, travel time and connectivity. Running on the road, right-of-way quality remains the critical defining factor. What good is a 'trackless tram' if it continues to be stuck in traffic? In car-dominated Australia, governments have struggled to reallocate road space away from inefficient private cars (averaging just 1.1 people per vehicle for journey-to-work) to spatially-efficient mass transit. Whenever bus priority is built, it usually arises from the widening of a road rather than any redesignation of existing road space.[9] As long as this mentality holds, we will struggle to improve the relativity of bus as compared with car—and this is the most important element for attracting users onto public transport.

[5]CRRC is the world's largest rolling stock manufacturer, formed by the merger of CNR and CSR in 2015

[6]Hence does not meet Australian 2.5 m width limit as specified by the NHVR

[7]Supercapacitor (or ultracapacitor) buses recharge rapidly, but store just 5% of the energy that lithium-ion batteries can, and are thus limited to around 5 km per charge plus suited only for very predictable routes with frequent stops

[8]A prominent example of how pavement quality affects the ride may be found in Melbourne's Albert Park where roads are built with high specification concrete to accommodate the Australian Grand Prix

[9]Historically, the (incorrect) argument made for LRT has been that it does not take away from road capacity, but rather adds to public transport capacity

That said, if 'trackless trams' can radically alter the political paradigm and garner the necessary support amongst the community for the sensible reallocation of road space including the provision of at-grade signal priority, then there exists a huge opportunity for the cost-effective deployment of high quality mass transit. After all, priority is the key to efficiency and urban amenity. ITLS research has shown there to be huge latent demand for public transport in the middle and outer suburbs of Australian capitals.[10] We believe this to be where the technology holds its greatest potential, and can readily be deployed along cross-town and orbital strategic corridors presently serviced by (for example) Metrobus in Sydney and SmartBus in Melbourne. Time will tell whether 'trackless trams' can shift the conversation including altering the idea of permanence and fixed infrastructure from one synonymous with rail to the pressing issues of right-of-way quality and public transport priority.

ADDITIONAL RESOURCES

- Documentary of CRRC optically-guided bus (in Chinese): https://www.youtube.com/watch?v=pTPcJYigg30
- Video footage of Rouen optically-guided bus: https://www.youtube.com/watch?v=ZrAm-1jVwf8
- Video footage of Castellón optically-guided bus: https://www.youtube.com/watch?v=4tP0s7MM5Zg

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[10] See recent work on Metrobus by Chinh Ho and social exclusion by John Stanley

The ITLS intelligent mobility and MaaS program of research is led by Professor David Hensher and Professor Emerita Corinne Mulley, with Dr Chinh Ho, Honorary Professor John Nelson and Yale Wong as key contributors. ITLS has also established accreditation and professional development opportunities for the bus and coach industry including the Certificate of Transport Management (CTM) and the Bus and Coach Operator (BOAS). For more information, please visit http://sydney.edu.au/business/itls.