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CRRC ART and TiG/m VLR Comparison

Criterion	CRRC ART "Trackless Tram"	TiG/m VLR
Basic technology	Articulated, rubber-tyred road vehicle using electronic or optical guidance	Conventional steel-wheel vehicle operating on steel rails
Proposed energy source	Hydrogen fuel cell for the Kuching system	Hydrogen, battery-electric or hybrid configuration
Infrastructure	Dedicated or shared carriageway with a specially engineered running surface and electronic guidance	Permanent rail guideway
Passenger capacity	Exact Kuching vehicle capacity requires confirmation from CRRC	MRV3: 100 passengers per vehicle; MRV4: 200 passengers per vehicle
Peak formation	Whether the proposed articulated vehicle can be routinely divided and coupled is not confirmed	Three MRV3 vehicles: 300 passengers; two MRV4 vehicles: 400 passengers
Off-peak flexibility	Potentially requires the complete articulated vehicle to operate unless CRRC confirms modular capability	Single MRV3 or MRV4 vehicle can operate when demand is lower
Capacity at 15 services per hour	Cannot yet be calculated without a confirmed vehicle capacity and formation	MRV3: 1,500 to 4,500 passengers per hour per direction; MRV4: 3,000 to 6,000
Driver requirement	Requires confirmation for the selected operating system	One driver for either a single vehicle or a coupled train
Rolling resistance	Rubber tyre on road-running surface	Steel wheel on steel rail
Tyre-wear emissions	Retains tyre-derived particulates and microplastic emissions	None
Road-wear emissions	Retains road-surface wear and resuspension associated with road operation	No road-surface wear from the vehicle-guideway interface
Brake emissions	Regenerative braking may reduce brake wear, but tyre and road-wear emissions remain	Regenerative braking can minimise reliance on friction brakes

Road infrastructure wear	Repeated guided operation concentrates loads along consistent wheel paths, creating a risk of rutting and surface deterioration	Loads are carried through the rails and engineered track structure
Infrastructure renewal	Requires maintenance and renewal of running surfaces, guidance equipment and associated highway infrastructure	Requires planned rail and track renewal, but avoids recurring tyre-path resurfacing
Vehicle renewal	Vehicle, fuel-cell or battery and guidance components require periodic renewal	Vehicles and propulsion equipment can be renewed while retaining the permanent railway
Energy efficiency	Higher rolling resistance associated with rubber-tyred operation	Lower rolling resistance from the steel-wheel and steel-rail interface
Modal-shift potential	Provides a tram-like service, but its ability to attract motorists requires supporting evidence	Permanent and clearly identifiable rail infrastructure may provide greater passenger and investor confidence
Development certainty	Route remains dependent on road-running and guidance infrastructure	Fixed rail alignment provides a permanent development and regeneration corridor
Supplier dependency	Greater reliance on CRRC's proprietary vehicle and guidance technology	Based on established railway principles with potentially wider component and engineering supply chains
Residual value	Dependent upon the condition and continuing supportability of vehicles, guidance systems and road infrastructure	Permanent rail infrastructure remains available beyond individual vehicle generations
Principal advantage	Avoids installation of conventional rails and may offer higher capacity in a long articulated vehicle	Modular capacity, lower rolling resistance, no tyre or road-wear emissions, and permanent infrastructure
Principal risk	Road deterioration, NEE, proprietary-system dependence and possible operation of an oversized vehicle off-peak	Higher initial infrastructure requirement and the need to construct a permanent railway

Internal technical correspondence identifies tyre and road dust, concentrated wear, potential rutting, lower energy efficiency and reduced development certainty as material issues when comparing CRRC ART with steel-wheel light rail.

Caen Precedent — Key Lessons

Caen provides an important cautionary precedent for any ART-style or rubber-tyred guided transit proposal.
The city adopted a rubber-tyred guided system intended to provide tram-like service without conventional rail infrastructure but later abandoned the technology and converted the corridor to a conventional standard-gauge tramway.

The key lesson is that apparent savings from avoiding steel rails can be offset by reliability problems, concentrated tyre-path wear, specialist maintenance, proprietary-system dependency and weak residual asset value.

Lower initial infrastructure cost should therefore not be treated as proof of value for money unless the whole-life renewal, operating and replacement risks are fully priced.

Implications for ART appraisal:

Whole-life cost must take precedence over opening capital cost.
Avoiding rails may transfer cost into road-surface renewal, guidance-system support, tyre replacement and earlier system replacement.
Reliability and availability risk should be priced explicitly.
A proprietary guided system that performs poorly can impose operational, reputational and passenger-service costs on the public authority.
Fixed tyre paths create renewal liability.
Guided rubber-tyred operation can concentrate loads along repeated running paths, increasing the risk of significant rutting, surface deterioration and disruptive renewal works.
Supplier dependency can weaken residual value.
If vehicles, guidance components or specialist systems become hard to support, the corridor may have limited reuse value without major reinvestment.
Standard-gauge rail creates stronger long-term optionality.
Caen's conversion to a conventional tramway reinforces the value of permanent infrastructure that can be renewed, extended and integrated with established rail supply chains.
Replacement and conversion risk should be included in appraisal.
ART-style proposals should be tested against the risk of stranded assets, premature conversion or forced reinvestment if the technology fails to deliver durable long-term performance.
Vulnerable to Vandalism.
CAEN found that antisocial elements of society could disrupt the guidance systems particularly the centre & rear sections with spray paint graffiti type paint on the road surface as stops approached.

For the present comparison, the Caen precedent supports a rigorous whole-life appraisal of ART, VLR and conventional light rail.

The test should include renewal risk, road-surface deterioration, supplier dependency, non-exhaust emissions, residual infrastructure value and the option value of a permanent standard-gauge rail asset capable of supporting future TramTrain or Multiple User Rail operation.

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Capacity Comparison

TiG/m formation	Passenger capacity	Services per hour	Capacity per hour per direction
One MRV3	100	15	1,500
Three coupled MRV3 vehicles	300	15	4,500
One MRV4	200	15	3,000
Two coupled MRV4 vehicles	400	15	6,000
CRRC ART	To be confirmed	To be confirmed	To be confirmed

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Indicative 60-Year Cost Comparison

Cost factor	CRRC ART "Trackless Tram"	TiG/m VLR	Strategic cost implication
Initial infrastructure	Road-running guideway, reinforced running surfaces, guidance equipment and associated highway works	Permanent steel-rail track and associated infrastructure	ART may appear less costly initially, but this must be tested against the required road construction standard
Vehicle configuration	Long articulated rubber-tyred vehicle; off-peak divisibility remains to be confirmed	Modular MRV3 and MRV4 vehicles that can operate singly or in coupled peak formations	VLR can more closely match vehicle capacity and operating cost to demand
Vehicle renewals	More frequent vehicle and component replacement expected	Vehicles replaced independently of the longer-lived rail infrastructure	VLR retains a higher proportion of its original infrastructure investment
Running-surface renewals	Recurring road-surface maintenance, rutting repairs, resurfacing and possible reconstruction	Planned rail, track and associated infrastructure renewals	ART carries a continuing highway-infrastructure renewal liability
Tyres and road wear	Tyre replacement and road-running wear continue throughout the asset life	No tyres or tyre-related road-surface wear	VLR avoids the recurring costs associated with the tyre-road interface
Guidance technology	Electronic or optical guidance equipment requires maintenance and periodic replacement	Physical rail provides continuous vehicle guidance	ART carries additional specialist-system renewal and obsolescence risks
Energy consumption	Higher rolling resistance from rubber tyres	Lower rolling resistance from steel wheel on steel rail	VLR is expected to require less traction energy for comparable operations
Peak and off-peak operation	If the formation cannot be divided, the full vehicle must operate during quieter periods	MRV3: 100 passengers singly or 300 coupled; MRV4: 200 singly or 400 coupled	VLR can reduce unnecessary off-peak vehicle mass and energy consumption
Non-exhaust emissions	Tyre wear, road wear and some brake wear remain	No tyre or road-wear emissions from the vehicle-track interface; regenerative braking reduces friction-brake use	ART retains environmental and health-related external costs
Supplier and technology risk	Greater reliance on a proprietary vehicle and guidance system	Wider established rail engineering and supply-chain base	VLR may offer lower long-term technology and supplier dependency
Residual asset value	Dependent on the condition of vehicles, road-running infrastructure and guidance systems	Long-life permanent rail infrastructure remains after vehicle replacement	VLR is expected to retain greater residual infrastructure value
Indicative total expenditure	Working benchmark: approximately **100%**	Working benchmark: approximately **60% of comparable ART expenditure**	VLR is provisionally estimated to require around **40% less whole-life expenditure**
Indicative 20 km saving	Higher-cost reference case	Potential saving of **£1.5 billion or more over 60 years**	Figure requires validation through a transparent corridor-specific appraisal
Network delivered per	Investment may be concentrated in fewer, higher-capacity corridors	Potential to extend services across a larger network and more communities	VLR may provide greater geographic coverage from the same funding envelope

On the assumptions presented, TiG/m VLR could require approximately 40% less total expenditure than a comparable CRRC ART system over 60 years, potentially representing savings of £1.5 billion or more for a 20 km corridor.

The principal savings would arise from lower energy use, modular peak and off-peak operation, the absence of tyres and road-running wear, fewer specialist-system renewals and the longer life and residual value of permanent rail infrastructure.

These indicative figures should be confirmed through an independently reviewed whole-life cost appraisal using equivalent capacity, service frequency, demand and price assumptions.

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HTaaS Benefits Over Appraisal Horizons

Hydrogen Trams as a Service (HTaaS) changes the appraisal of municipal VLR by treating hydrogen supply, tram operation, depot energy, municipal fleet fuelling and local waste-to-energy opportunities as a single integrated service model rather than as separate capital projects.

Because CRRC ART may also be hydrogen-powered, the appraisal compares both options on the same basis: hydrogen production, storage, refuelling, vehicle efficiency, infrastructure renewal, supplier dependency, residual asset value and wider municipal benefits.

Appraisal horizon	Municipal VLR with HTaaS	Hydrogen-powered ART	Value-for-money implication
0–10 years: mobilisation and early operation	HTaaS can reduce upfront municipal capital exposure by packaging vehicles, hydrogen supply, depot systems, maintenance and operations into a service-based structure. It can also create early opportunities to use local land, waste streams and renewable energy assets to support local hydrogen production.	ART may also benefit from hydrogen fuelling and fast refuelling, but it remains dependent on road-running surfaces, rubber tyres, optical or electronic guidance and proprietary system support.	The early comparison should test whether ART's lower apparent infrastructure cost is outweighed by VLR's lower rolling resistance, stronger asset base and wider municipal energy benefits under HTaaS.
10–30 years: renewal and service scaling	HTaaS can support staged VLR expansion, fleet renewal, municipal vehicle fuelling and energy optimisation as demand grows. The permanent rail guideway remains available while vehicles, hydrogen equipment and service contracts are refreshed.	ART may require repeated tyre replacement, road-surface renewal, guidance-system maintenance and vehicle or fuel-cell renewal while continuing to operate as a road-based guided bus system.	VLR gains value where the municipality captures long-term savings from lower energy use, modular operation, fewer tyre-road renewal liabilities and reuse of permanent rail infrastructure.
30–60 years and beyond: residual value and city-region growth	Municipal VLR with HTaaS can mature into a wider clean-energy and transport platform, supporting TramTrain, Multiple User Rail, depot energy resilience, municipal fleet decarbonisation and potential local hydrogen revenues. The rail corridor remains a durable asset after several generations of vehicles.	Hydrogen propulsion alone does not remove ART's dependence on road-running infrastructure, specialist guidance systems and supplier-specific technology. Its residual value depends on the continued supportability of vehicles, guidance equipment and road corridor condition.	Over the longer horizon, HTaaS strengthens the VLR case by adding option value, local energy resilience, common-good revenue potential and a permanent standard-gauge rail platform for future network expansion.

The key distinction is that hydrogen is an energy carrier, not a complete value-for-money answer.

If ART and VLR both use hydrogen, the decisive appraisal issues become whole-system efficiency, renewal liability, infrastructure residual value, municipal energy integration and the ability to expand into TramTrain or Multiple User Rail.

On these tests, HTaaS potentially gives municipal VLR a stronger long-term case because it links zero-emission transport to local energy production, service-based delivery, wider fleet decarbonisation and durable standard-gauge rail infrastructure.

ART cannot share track with a Multiple User Rail or TramTrain network and therefore cannot provide the same seamless, through-running journey options as standard-gauge VLR.

Technical terminology note

In UK highway engineering, **“pavement” can refer to the constructed carriageway layers**, although in everyday British usage it usually means the pedestrian footway.

The Caen experience demonstrates the risk of selecting a proprietary rubber-tyred guided system primarily on the promise of lower initial infrastructure cost.

In practice, reliability problems, concentrated tyre-path wear, specialist maintenance requirements and weak residual asset value led Caen to abandon the technology after only 15 years and replace it with a conventional standard-gauge tramway.

This supports the argument that ART-style systems should be tested through rigorous whole-life appraisal, not accepted as value for money simply because they avoid steel rails.

Main improvements

- Separates initial capital cost from 60-year renewal and operating liabilities.
- Identifies the cost consequences of ART’s tyre-road interface.
- Incorporates the TiG/m fleet’s modular operating flexibility.
- Clearly labels the 40% and £1.5 billion figures as assumptions requiring verification.

Terminology

In UK transport terminology, *pavement* refers to the pedestrian footway.

For transit infrastructure, references should normally be to **roads**, **streets**, **carriageways**, **running surfaces**, **guideways** or **highway infrastructure**, depending on the context.

Strategic Conclusion

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Value-for-Money Assessment

Based on the assumptions set out above, the ART proposal should not be treated as value for money merely because it avoids the initial installation of steel rails.

In line with public-sector appraisal practice, value for money should be assessed against clear transport and land-use objectives, using a whole-life comparison of costs, benefits, risks and uncertainties rather than a narrow capital-cost comparison.

If VLR is built to international standard gauge, it creates a permanent rail asset capable of supporting future Multiple User Rail and TramTrain operation.

This gives the public sector a more adaptable platform for city-region growth, allowing urban services to expand into surrounding settlements, airports, industrial areas and growth corridors without forcing passengers to interchange between incompatible systems.

ART may have merit as a road-based transit intervention where the strategic objectives, passenger demand, journey-time benefits, operating performance and wider economic impacts are sufficient to justify the long-term costs of specialist vehicles, guidance systems, hydrogen infrastructure and road-running surface renewal.

However, where demand is uncertain, dispersed or expected to grow in stages, a standard-gauge VLR/MUR approach may provide a stronger economic and strategic case because it combines lower lifecycle risk with greater residual infrastructure value, wider interoperability and a higher option value for future network expansion.

The proposal should therefore be tested through an independently verified appraisal comparing ART, VLR and conventional light rail on a like-for-like basis.

The appraisal should include Net Present Social Value, Benefit-Cost Ratio, Net Present Cost, cost per passenger-kilometre, cost per route-kilometre, quantified and non-monetised impacts, infrastructure and vehicle renewal cycles, energy and maintenance costs, non-exhaust emissions, land-use and regeneration benefits, supplier and delivery risk, sensitivity testing and the option value of future TramTrain or Multiple User Rail expansion.

Given that the ART system appears to have been procured and is expected to be completed in the near term, this assessment should be read as a forward-looking value-for-money and risk-management review rather than as a simple objection to the initial decision.

The key question is whether ART should become the default technology for future phases, or whether each additional corridor should be independently tested against standard-gauge VLR, conventional light rail, TramTrain and Multiple User Rail alternatives.

Completion of the first ART phase should therefore trigger transparent post-opening monitoring of reliability, road-surface wear, tyre life, hydrogen consumption, maintenance cost, passenger demand, residual asset value and supplier dependency before further network expansion is locked into the same technology.

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Overall Conclusion

This comparison assessed CRRC ART against TiG/m VLR from a whole-life value-for-money perspective.

While ART may avoid the initial installation of steel rails, it remains dependent on rubber tyres, road-running surfaces, specialist guidance systems and proprietary technology.

TiG/m VLR, by contrast, offers modular passenger capacity, lower rolling resistance, no tyre-road interface emissions and a permanent rail asset capable of supporting future Multiple User Rail and TramTrain expansion.

The central appraisal question is therefore not simply which option appears cheaper to build, but which system delivers the strongest long-term economic, environmental, operational and regeneration value over the full asset life.

CRRC ART provides a hydrogen-powered, tram-like service without conventional rails, but remains a heavy rubber-tyred road vehicle a bus, with continuing tyre wear, road-surface deterioration and associated non-exhaust emissions.

TiG/m VLR offers modular 100, 200, 300 and 400-passenger formations, enabling capacity to be matched more closely to peak and off-peak demand. Its steel-wheel-on-steel-rail interface eliminates tyre and road-wear emissions, reduces rolling resistance and creates a permanent transport asset with potentially greater residual value.

CRRC should therefore demonstrate the proposed ART vehicle's actual capacity, axle loads, divisibility, coupling arrangements, off-peak configuration, tyre life and road-renewal requirements before a fair whole-life comparison is completed

The concern is not that Kuching's political leadership has acted in bad faith, but that it may have been encouraged to view ART as a rail-equivalent solution without sufficient independent testing of its whole-life cost, infrastructure liability, residual value and long-term city-region expansion limitations.

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The future questions can be summarised into five core tests CRRC ART must satisfy:

1. **Capacity and flexibility**
   CRRC must confirm the exact passenger capacity, service frequency, and whether ART vehicles can be split, coupled or operated in shorter off-peak formations.
2. **Infrastructure liability**
   CRRC must define the required road-running surface, axle loads, wheel loads, rutting risk, renewal frequency and who pays for resurfacing or reconstruction over the full asset life.
3. **Environmental performance**
   CRRC must provide independent evidence on tyre wear, road-wear emissions, brake wear, microplastics and wider non-exhaust emissions, not just tailpipe emissions.
4. **Technology and supplier risk**
   CRRC must disclose the maintenance, replacement, failure-mode and obsolescence risks of its optical or electronic guidance system and proprietary vehicle technology.
5. **Long-term strategic value**
   CRRC must show what residual asset value remains after 30–60 years and whether ART can support future regional expansion, TramTrain operation or Multiple User Rail integration.

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Annex A

From Wikipedia, the free encyclopaedia

Autonomous rapid transit (ART)[a] is a lidar-guided[b] bi-articulated bus system intended for urban passenger transport. Developed by CRRC through CRRC Zhuzhou Institute Co Ltd, it was first unveiled in Zhuzhou, China, on 2 June 2017[4][9][10] and entered service in 2018.[4][9]

Though marketed with terms such as "digital rail" (Lingang digital rail rapid transit) and "electric road", its core design consists of a multi-section articulated vehicle guided by optical sensors rather than rails.

The body is composed of fixed compartments joined by articulated gangways, giving it a superficial resemblance to a rubber-tyred tram such as a translohr or GLT.

The naming and marketing of ART as "rail" or "rapid transit" has been met with skepticism, with critics describing the system as a gadgetbahn.

Despite the English branding as "autonomous", all ART vehicles in operation are manually speed-controlled with optical guidance assistance and are not capable of fully independent navigation.[11]

More significantly, the absence of any physical rail infrastructure undercuts its association with rail-based systems.

While the aesthetic and branding attempt to align ART with trams or light rail, the operational mechanics remain those of a bus, relying entirely on public roads and lacking grade separation.

Ultimately, ART falls within the category of bus or trolleybus technology, closely mirroring the function and form of bus rapid transit (BRT). Vehicles operating under ART are subject to the same regulations as conventional road traffic and must display license plates accordingly.

Although the system is promoted as a modern solution to urban transit, the use of terms like "train" and "rail" may overstate its capabilities.

In practice, ART functions as a guided articulated bus system, and critics argue that its key differences from traditional BRT are more cosmetic than substantive