

Cambridge Rapid Mass Transit Options Appraisal

'Cambridgeshire **Autonomous Metro**' (**CAM**): The Proposition

Greater Cambridge Partnership
Cambridgeshire and Peterborough Combined Authority

January 2018

Overview

- The case for rapid mass transit
- Option Development and Sifting Process
- Description of shortlisted options:
 - LRT, AVRT, Cambridgeshire Autonomous Metro
- Recommendations:
 - Preferred option
 - Option development
 - Funding mechanisms
 - Delivery

The Case for Mass Transit

January 2018

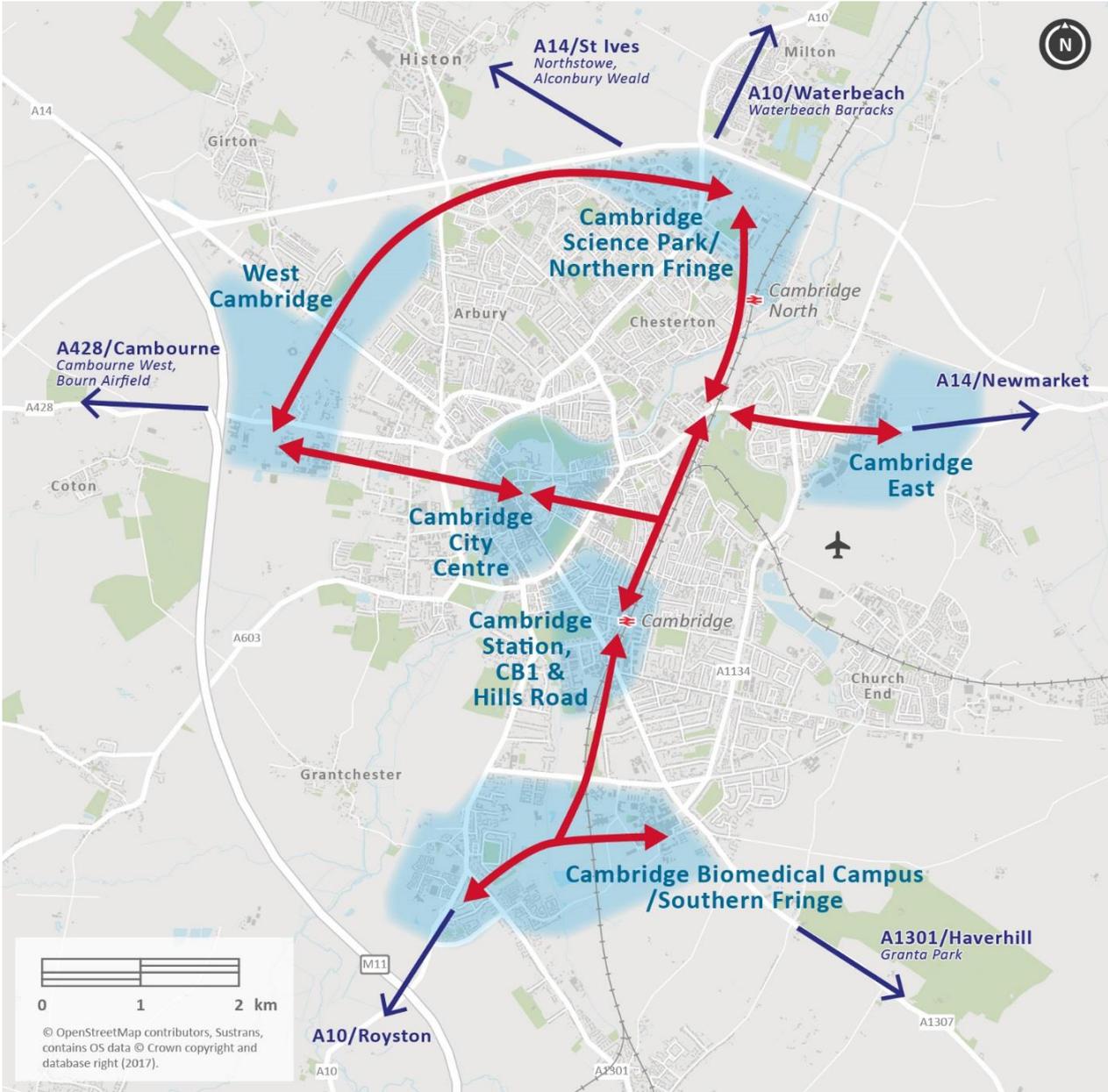
What is required?

Cambridge requires a transit network which:

- Delivers **high quality, high frequency, reliable** services, attractive to car users:
 - World-leading user experience, with fully-segregated infrastructure, dedicated stops and real time information
- Delivers **maximum connectivity**, network coverage and reliable journey times:
 - Directly linking all key destinations and corridors to one another
 - Minimising the need to interchange
- Provides **sufficient capacity for growth**, and to support Transit Oriented Development:
 - A maximum capacity through City Centre core of 15,000 - 20,000 people per hour each direction
- Is **flexible to adapt** for the future:
 - Responsive to technological advances as they develop and become commercially available
 - Providing capacity for growth, with a network that can be developed incrementally enabling operation to be scaled to support and accommodate future growth
 - Planned for autonomous operation, but can accommodate driver-operated services in the short term
- Utilises **emerging technology**, including connected and autonomous vehicles:
 - Huge opportunity for Cambridge to be a 'city of firsts' in developing a high quality, high capacity automated mass transit system.
- **Must represent value for money, be affordable and deliverable.**

Network of connectivity

Connects all key destinations and development sites to one other and to radial corridors



Options Assessment Process

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Long list of options considered

- Rail Based Metro
- Rubber Tyred Metro (VAL)
- Light Rail Transit/Tram (LRT)
- Ultra Light Rail
- Affordable Very Rapid Transit (AVRT)
- Bus Rapid Transit (BRT)
- Kerb Guided Bus
- Cambridgeshire Autonomous Metro (CAM)
- Monorail
- Personal Rapid Transit
- Cable Car

Options shortlisted based on providing a capacity commensurate with Cambridge's demand:

LRT

AVRT

CAM

Shortlist subject to more detailed assessment

Shortlisted Options

- Option developed around concept of:
 - City focused network – with P&R, feeder services
 - Regional network – direct linkages to satellite centres and market towns
 - All options include tunnelling within city centre

Option	Description - Infrastructure	Service coverage	Capital Cost (indicative)
LRT City Network	<ul style="list-style-type: none"> • 42km new infrastructure • Based on Cambridge Connect proposals 	<ul style="list-style-type: none"> • 42km network • Corridors served via P&R, bus feeders 	£2.8bn
LRT Regional Network	<ul style="list-style-type: none"> • 90km new infrastructure • Based on Cambridge Connect proposals 	<ul style="list-style-type: none"> • 90km network • Direct service to hinterland locations 	£4.5bn
AVRT City Network	<ul style="list-style-type: none"> • 15km new infrastructure • Based on John Miles' proposal • Single or twin bore 	<ul style="list-style-type: none"> • 15km network • Corridors served via P&R, bus feeders 	£1.1 - £1.7bn
AVRT Regional Network	<ul style="list-style-type: none"> • 56km new infrastructure • Based on John Miles' proposal • Twin-bore to provide required capacity 	<ul style="list-style-type: none"> • 56km network • Direct service to hinterland locations 	£2.1bn
Cambridgeshire Autonomous Metro (CAM)	<ul style="list-style-type: none"> • 42km new infrastructure, of which: <ul style="list-style-type: none"> • 16km new segregated infrastructure in Cambridge (inc. tunnel) • 25km of planned / proposed segregated links under City Deal • Flexible services, so could serve regional network 	<ul style="list-style-type: none"> • Support services across full regional network (i.e. 90km +) • Direct service to hinterland locations 	£1.5 - £1.7bn

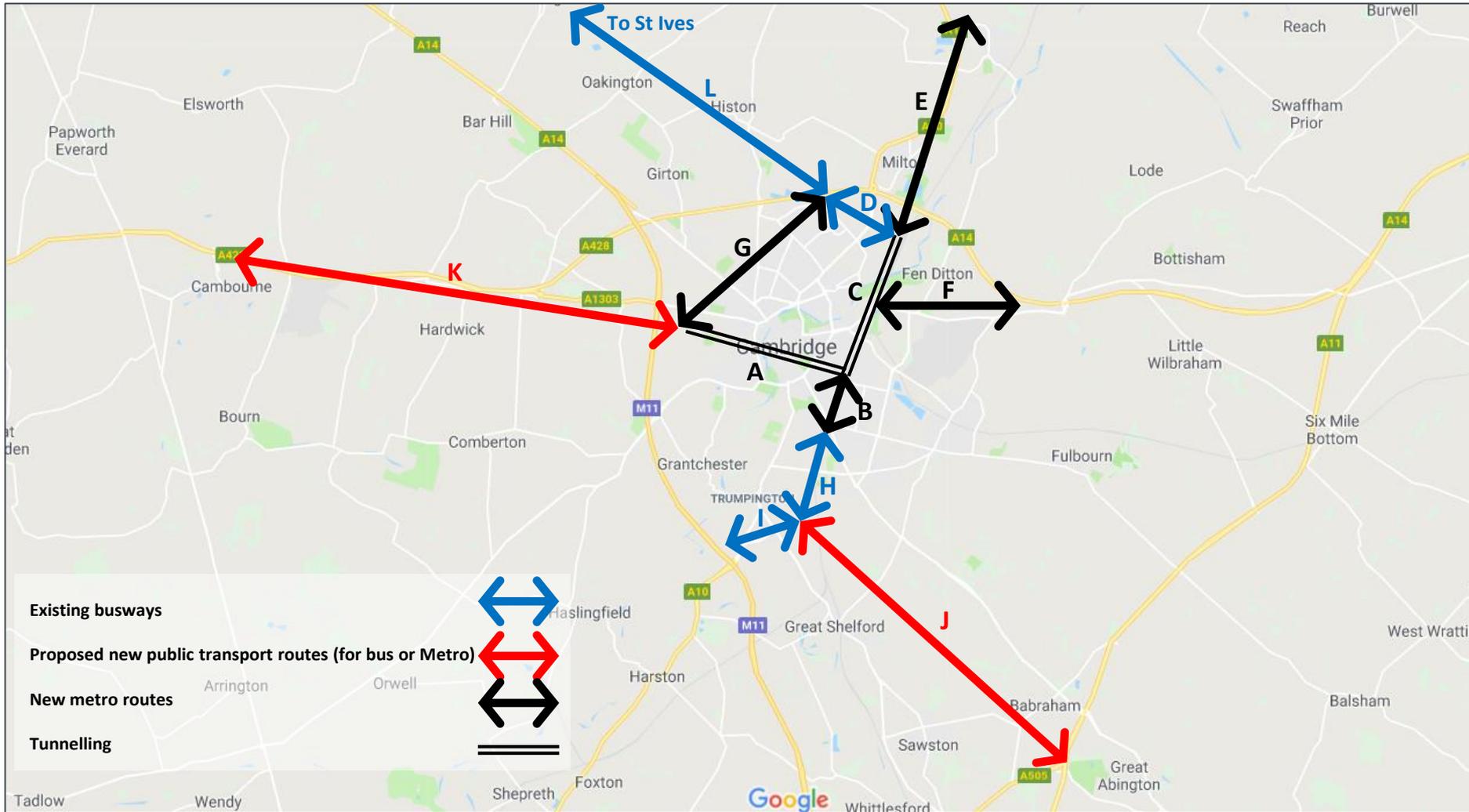
Option Definition: Cambridgeshire Autonomous Metro

Cambridgeshire Area Metro / Cambridgeshire Autonomous Metro = **CAM**

CAM combines the use of existing and planned segregated infrastructure with a short City Centre tunnel to deliver maximum connectivity throughout Cambridge and its hinterland

- Short length of tunnelling in the City Centre (3-4km), where physical constraints are greatest, connecting West Cambridge to east end of Mill Road
- Segregated link between Cambridge Biomedical Campus, Cambridge Station and Cambridge North linking to City Centre and:
 - Existing segregated alignments to St Ives / Huntingdon and Trumpington
 - Delivery of segregated mass transit infrastructure linking to Cambourne and Waterbeach
 - New links towards Cambridge East / Airport and Haverhill
 - Connects to existing and proposed park and ride sites
- Serves the wider network beyond Greater Cambridge
- Ability for the network to expand incrementally, in line with housing growth, or as sufficient demand is established to justify dedicated infrastructure.

CAM: Network Schematic (infrastructure)



CAM: Indicative vehicle and features

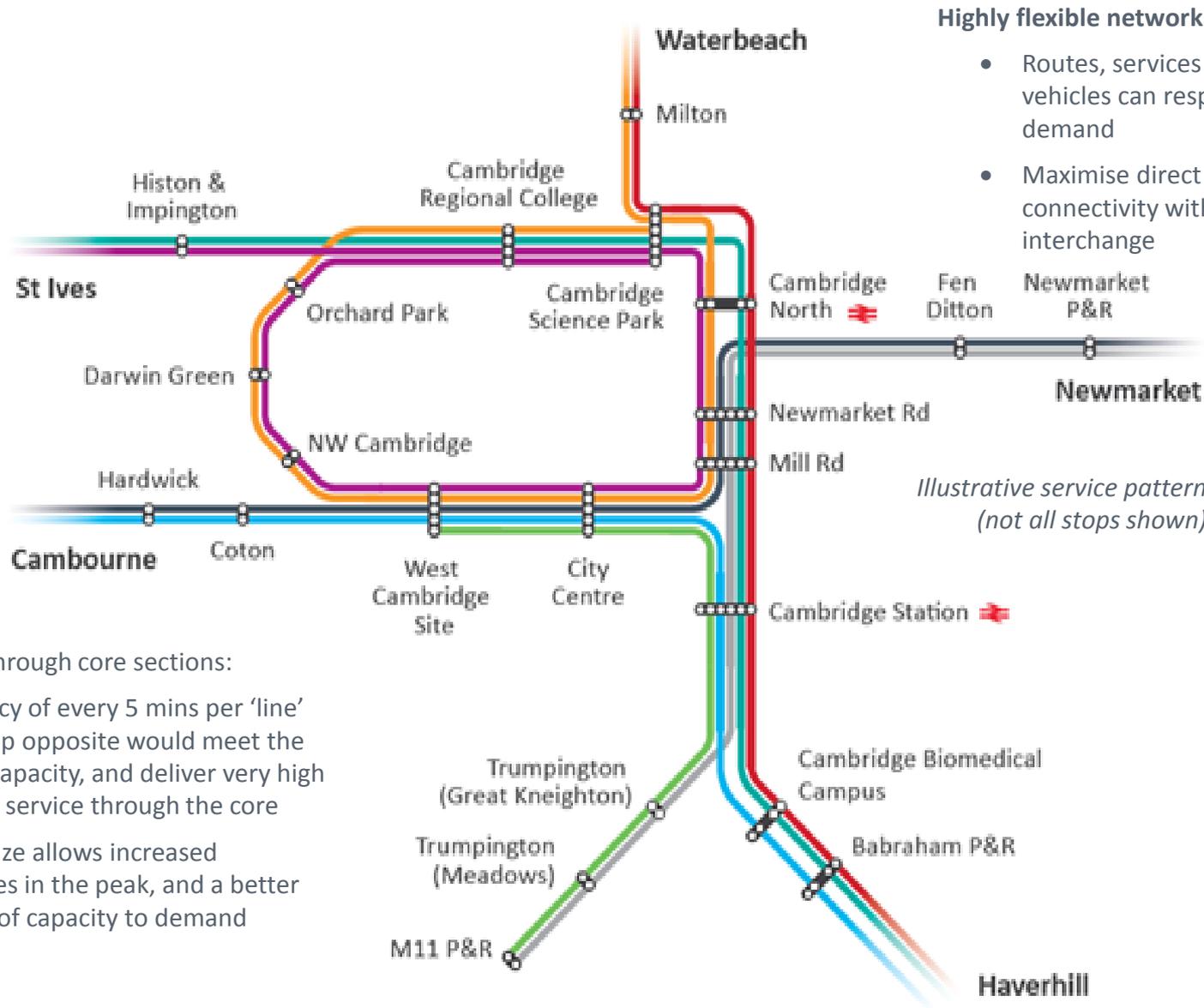


- High capacity and frequency
 - Capacity to support future growth in Cambridge
 - Reduced headways and fleet optimisation
- Electric vehicles
 - Battery operated and charge-at-stop
- Proven technology
 - Already operating elsewhere
- Autonomous capable
 - Can operate with a driver initially until autonomous technology matures
 - Automation using on-board sensors
 - No requirement for rails or physical guidance
 - Platooning of vehicles
- Branding
 - Centrepiece of a Cambridge transport 'brand' integrated with other modes.

CAM: The vision



CAM: Operational Concept



High frequency through core sections:

- A frequency of every 5 mins per 'line' on the map opposite would meet the required capacity, and deliver very high frequency service through the core
- Vehicles size allows increased frequencies in the peak, and a better matching of capacity to demand

Options Assessment of Shortlist

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Strategic Assessment

- Strategic Assessment Framework developed - key assessment criteria:
 - Transport capacity benefits and demand potential -> ability to fulfil Mass Transit Objectives
 - Costs
 - Feasibility
 - Value for money - which option represents best VfM, and requirement to meet eligibility for funding?
 - Affordability - whether ongoing subsidy required?

Transport Outputs / Benefits: Assessment

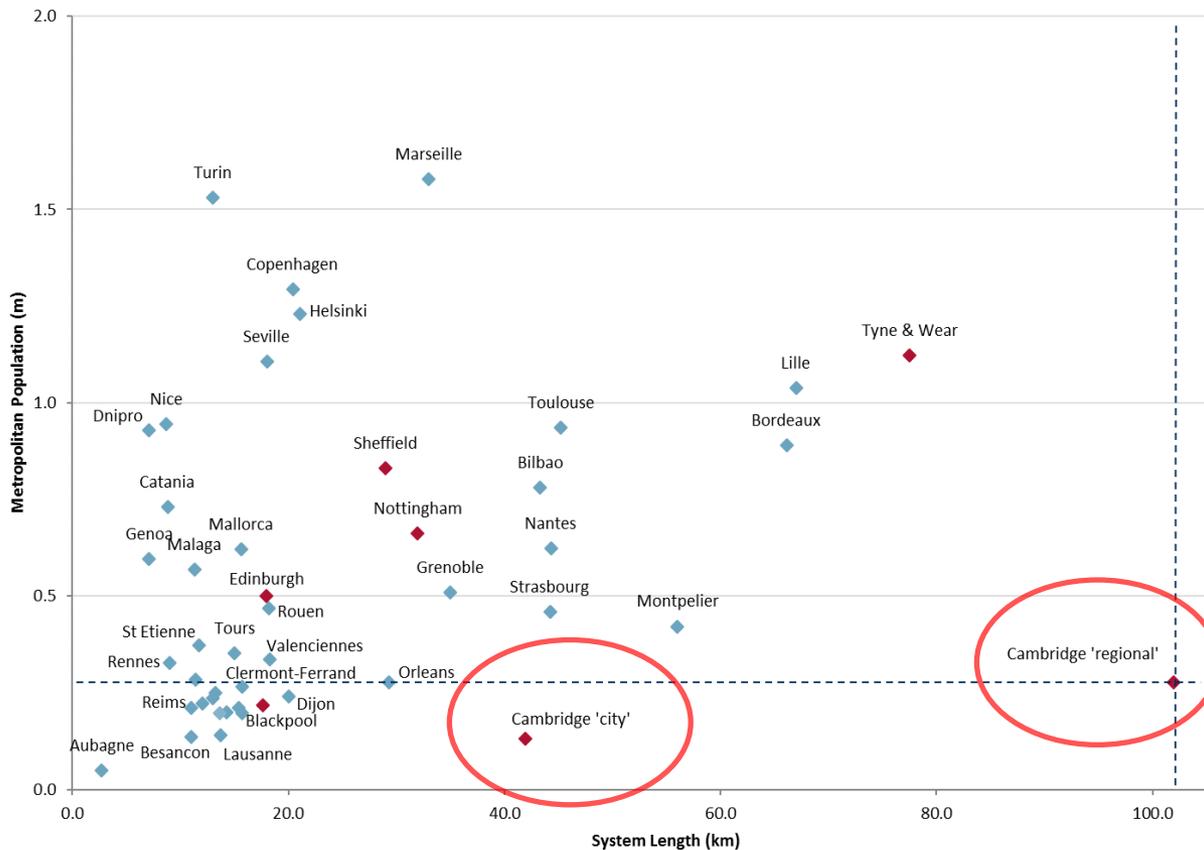
	LRT - City	LRT – Regional Network	AVRT - City	AVRT - Regional	CAM	Comment
Network coverage	✓✓	✓✓✓	✓	✓✓	✓✓✓✓	<ul style="list-style-type: none"> • CAM offers widest potential service coverage, across all radial corridors. • LRT city network provides good coverage, but only within the city area. • LRT regional network would serve radial corridors, but not those to the north (e.g. Huntingdon / Waterbeach), where interchange would be required with existing / proposed bus services. • AVRT would serve four radial corridors. • AVRT city network coverage is more limited than other options.
Route flexibility	✓	✓	✓	✓	✓✓✓	<ul style="list-style-type: none"> • CAM provides for greater route flexibility through its ability to operate on existing segregated and on-street infrastructure. • LRT and AVRT networks could be developed incrementally, but network expansion would incur significant capital costs and higher deliverability risk than the more limited infrastructure required for CAM. In absence of bespoke fixed infrastructure bus feeder services could link to LRT and AVRT hubs.
Frequency	✓	✓	✓✓✓	✓✓✓	✓✓	<ul style="list-style-type: none"> • All options would operate at an attractive service level: <ul style="list-style-type: none"> • AVRT would operate at highest frequency of options to serve expected demand, as the vehicle capacity is lower. • Higher capacity of LRT means that fewer vehicles per hour likely to operate compared to CAM.
Journey time / reliability (in-vehicle)	✓✓	✓✓	✓✓✓✓	✓✓✓✓	✓✓	<p>All options would provide attractive journey times, due to segregation of key sections of route from general traffic.</p> <ul style="list-style-type: none"> • AVRT is fully segregated and would have a faster in-vehicle time. • LRT and CAM would both offer significant journey time savings over current provision.
Interchange (minimised)	✓✓	✓✓✓	✓	✓	✓✓✓✓	<p>Interchange is unattractive from a user perspective.</p> <ul style="list-style-type: none"> • CAM would provide the greatest opportunity for direct services, to and across the city, both due to a more expansive network and smaller vehicle sizes. • LRT would provide direct access to the city centre and for some cross-city movements. The LRT city network would require interchange from 'feeder' corridors. • AVRT involved potentially multiple interchanges for some movements (any that are not directly between the two stations at either end of each tunnel)
Accessibility (no. stops served)	✓✓	✓✓	✓	✓	✓✓	<ul style="list-style-type: none"> • AVRT offers poor overall direct accessibility (i.e. without interchange), and the network comprises only one city centre station and four on the city periphery. • Other options provide for good levels of accessibility.
Quality	✓✓✓	✓✓✓	✓✓	✓✓	✓✓✓	<ul style="list-style-type: none"> • LRT would, likely, offer a more attractive ride quality than the other modes. • CAM would provide a higher quality offer than existing bus provision, through a higher quality vehicle, stops and information provision. • AVRT quality is uncertain – it would operate at very high speed and this may compromise passenger comfort.

Transport Outputs / Benefits: Interpretation

- **LRT would deliver significant transport benefits across range of criteria.**
 - High quality
 - Frequency likely to be lower, but would provide an attractive frequency (every 10 mins)
 - Requirement for interchange (for City Network) and inability to provide route flexibility can be mitigated through the provision of complementary services and infrastructure, such as bus feeders and P&R sites.
- **AVRT would be less attractive to users overall than LRT**
 - Provides the fastest in-vehicle journey times and high-frequency
 - Counterbalanced by the requirement for interchange for many movements, and the relatively poor direct accessibility (fewer stops) than other options.
- **CAM performs well against full range of key transport benefit areas**
 - Segregated and high frequency service, combined with wide route coverage, flexibility and accessibility (maximising overall connectivity)
 - It performs as well, or better than, LRT across the range of attributes considered.
- **Implications for demand:**
 - LRT and CAM have the potential to deliver greater benefits, and therefore attract more demand, than AVRT, along a comparable route alignment. We would expect that both LRT and CAM would attract a similar proportion of current and future demand along any given corridor, assuming they serve the same key destinations.

Demand Potential: Benchmarking of Mass Transit / LRT

- Benchmarking of a potential Cambridge Mass Transit system against international and UK comparators. **The focus of this is on LRT and tram systems, to assess whether Cambridge and the wider area is likely to provide (now or in the future) the critical mass of demand to support such a network (and justify its costs).**



- Analysis suggests:
 - Cambridge 'city' and 'regional' networks are outliers and will not have critical mass to support rail-based mass transit.
 - Specific VfM issues will undermine case for LRT in 'city network' context: limited journey time benefits but high cost
 - Regional network, even under a Transit-Oriented Development scenario would not support LRT.
- As a point of comparison, the Tyne & Wear Metro 80km network serves dense conurbation of c. 1.1m people, with a large established public transport market and comparatively low rates of car ownership / use, and of cycling.
 - T&W requires ongoing subsidy.

Deliverability: Risk Based Assessment

	LRT - City	LRT - Regional	AVRT - City	AVRT - Regional	CAM	Comment
Technical Feasibility	Yellow	Yellow	Yellow	Yellow	Yellow	<ul style="list-style-type: none"> There are technical issues for all options, but there are no 'feasibility showstoppers' at this stage. The key issue is not feasibility, but the acceptability of solutions in relation to tunnelling and underground stations.
Technology	Green	Green	Red	Red	Green	<ul style="list-style-type: none"> Both LRT and CAM use existing technologies, and do not present significant feasibility risks, although technical challenges remain regarding tunnelling under historic Cambridge. LRT is a proven technology, in use in the UK and abroad. CAM could use, as a starting point, technology already available in the market (e.g. VanHool ExquiCity), and does not rely on bespoke solution. AVRT is a bespoke proposition, using new technology in untested settings, and hence technological risks (and technology interface risks) are correspondingly higher.
Value for Money	Red	Red	Red	Red	Yellow	<ul style="list-style-type: none"> There are significant risks over whether LRT or AVRT (both 'city' and 'regional') have the potential to deliver a VfM solution based on current WebTAG guidance and funding sources. CAM represents the most likely option to achieve VfM, although due to the high cost of tunnelling a VfM case is still subject to further analysis.
Affordability	Yellow	Red	Yellow	Red	Green	<ul style="list-style-type: none"> Both LRT & AVRT 'regional' networks are expected to require a significant ongoing subsidy, due to the low levels of transit demand relative to other regions with LRT networks. Flexibility in service planning and vehicle capacity of CAM means that services can better match transport demand to capacity, and are likely to achieve an operating surplus. While the AVRT and LRT 'city' networks may require operating subsidies, this is uncertain and therefore medium risk.
Powers / consents / legislation	Yellow	Yellow	Yellow	Yellow	Yellow	<ul style="list-style-type: none"> All options would require powers, and are likely to receive objections. New consents would be required for all options, both for the new technology required for AVRT and the underground running for LRT/CAM. It is not possible to make a detailed, comparative assessment at this stage,

- VfM risk is considered a potential showstopper for LRT and AVRT.
- Regional networks for LRT and AVRT would be unaffordable in terms of ongoing subsidy.
 - CAM unlikely to require ongoing subsidy.
- AVRT - additional risks related to technology.
- CAM - complex project, but no showstopper risks.

Summary of Options Assessment

Feature	LRT	AVRT	CAM	Benefits of CAM
Connectivity	✓✓	✓	✓✓✓	<ul style="list-style-type: none"> Delivers maximum connectivity within Cambridge, to major 'city fringe' employment centres, satellite centres and market towns
Capacity	✓✓✓	✓✓	✓✓✓	<ul style="list-style-type: none"> Provides capacity and coverage to support growth
Quality	✓✓✓	✓✓	✓✓✓	<ul style="list-style-type: none"> Segregated routes and high-quality vehicles will benefit passengers and encourage significant modal-shift from car
Flexible and scalable	✓	✓	✓✓✓	<ul style="list-style-type: none"> Can be planned on basis of automated vehicles, and systems allowing for platooning (capacity) and network management (system optimisation and efficiency) Concept allows flexible operation to support growth over time Operation efficiency through optimising service levels and demand / capacity by corridor, time-period etc.
Value for Money	X	X	✓✓	<ul style="list-style-type: none"> Most cost-effective means of delivering connectivity, quality and capacity outputs, by making best use of existing and planned infrastructure and taking advantage of opportunities from rapidly advancing technology Most likely meet criteria for, and secure, Government funding contribution
Affordable	X	?	✓✓	<ul style="list-style-type: none"> Likely to deliver an operational surplus i.e. not require ongoing subsidy
Deliverable	✓	X	✓✓	<ul style="list-style-type: none"> Elements of proposition can be implemented within next 5 years Delivery of full concept would be quicker than for other options considered

Conclusion of Option Assessment

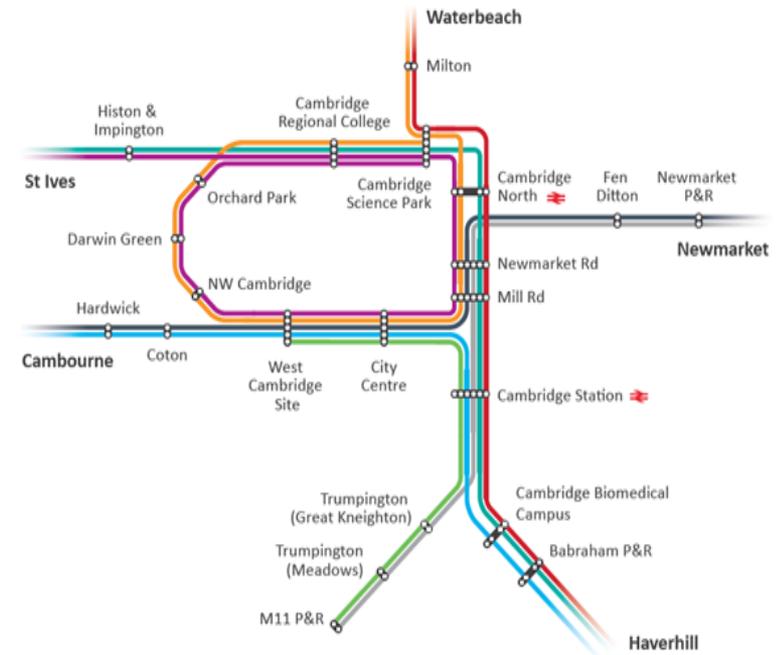
- **CAM offers the potential to deliver the equivalent capacity, quality and coverage as LRT**, in order to support wider outcomes related to housing growth, jobs, GVA
- It could deliver **similar benefits at approximately 1/3 of the overall cost of LRT**, hence better VfM and affordability
- CAM would deliver greater coverage, connectivity and accessibility than AVRT, better meeting the requirements of a Mass Transit system for greater Cambridge. Provides greater demand and benefit potential at similar or lower cost.
- The CAM concept utilises emerging technology, including connected, autonomous / driverless vehicles
 - a great opportunity for Cambridge to be a 'city of firsts' in developing a **high quality, high capacity, world-class automated mass transit system**
- **It could deliver transit-oriented development**, and utilise a range of local funding mechanisms, including **land value capture**, which could support delivery of scheme.

Recommendations

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Development of CAM

- **Development of proposition:**
 - Vehicles and technology
 - Infrastructure, routes, services, hubs
- **Phased development of network:**
 - Utilise existing and proposed segregated alignments
 - Tunnel > step change connectivity and reliability delivering full segregation within the city
 - Future segregation and priority measures can be implemented across wider network (aligned with growth, congestion) are to ensure quality of services
- **Autonomous, connected, driverless:**
 - Could operate on segregated sections within 5 years
 - Full roll out as regulation permits driverless operations on general road network
 - Infrastructure can support high-quality vehicles and services in interim.



Operations

- CAM would be developed as ‘private’ infrastructure, owned and managed by the Combined Authority
 - CA would have control over quality and service aspects, but could be operated by a third party
- CAM would be fully integrated with other public transport modes and first/last mile solutions - creating one transport ‘brand’ for Cambridgeshire, and a familiarity and ease of use for passengers similar to TfL and TfGM
- Subject to further analysis, the proposed solution will be viable and is unlikely to require a public subsidy to operate
- Operating costs are dependent on the routes and service patterns adopted. These are flexible:
 - Over time - scale up to accommodate planned growth / growth in demand
 - Between regional corridors and destinations
 - Peak vs. inter-peak (driverless operation better enables this)
 - Allows for mix of vehicle lengths (higher / lower capacity)

Funding mechanisms

CAM could be funded through a combination of:

- **Existing mechanisms:**

- Community Infrastructure Levy
- Business Rate Supplement
- Council Tax Precept
- Local tax retention
- Workplace parking levy or dynamic charging regime
- Highways England Contribution
- Direct contributions

- **Innovative funding:**

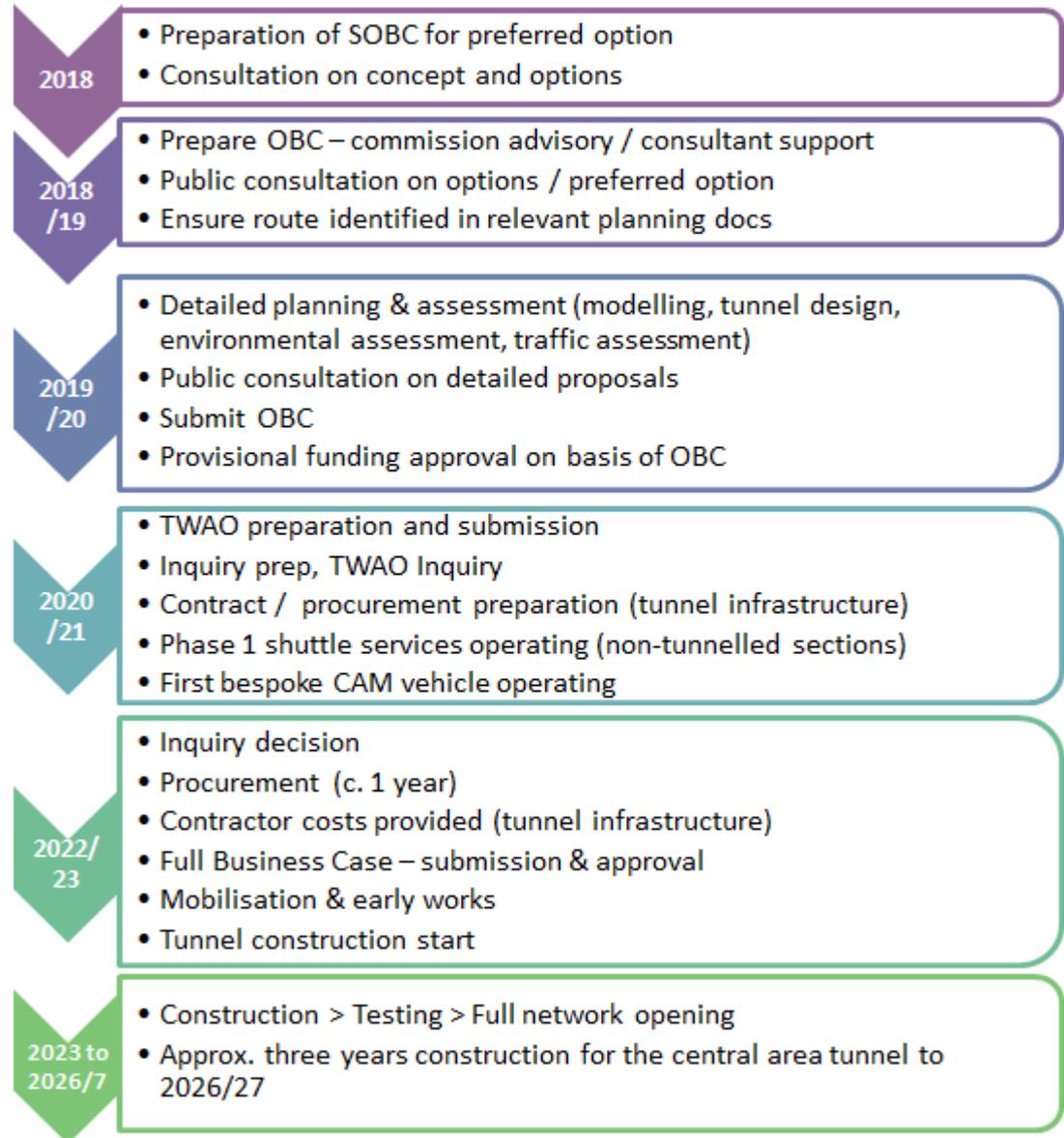
- More flexible approaches to existing land-value capture mechanisms, as proposed by National Infrastructure Commission in November 2017, including:
 - a city-regional CIL and/or pooling of Section 106 agreements
 - ability to forward-fund infrastructure by borrowing against future receipts
- Wholly new land-value capture mechanisms, which fully address the “*significant weaknesses*” of current mechanisms identified by the National Infrastructure Commission, if developed through primary legislation

- **Central Government funding** through existing funding streams

- E.g. Large Local Major Schemes (DfT), Housing Infrastructure Fund (DCLG)

Delivery timescales

- **Phase 1 in early 2021:**
 - Bespoke CAM vehicles delivered to Cambridge
 - Adaptation of guideway for autonomous operation
 - Initial shuttle service operating between Biomedical Campus and Cambridge Station
- **Through services via tunnel in 2026/27**



Thank you

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