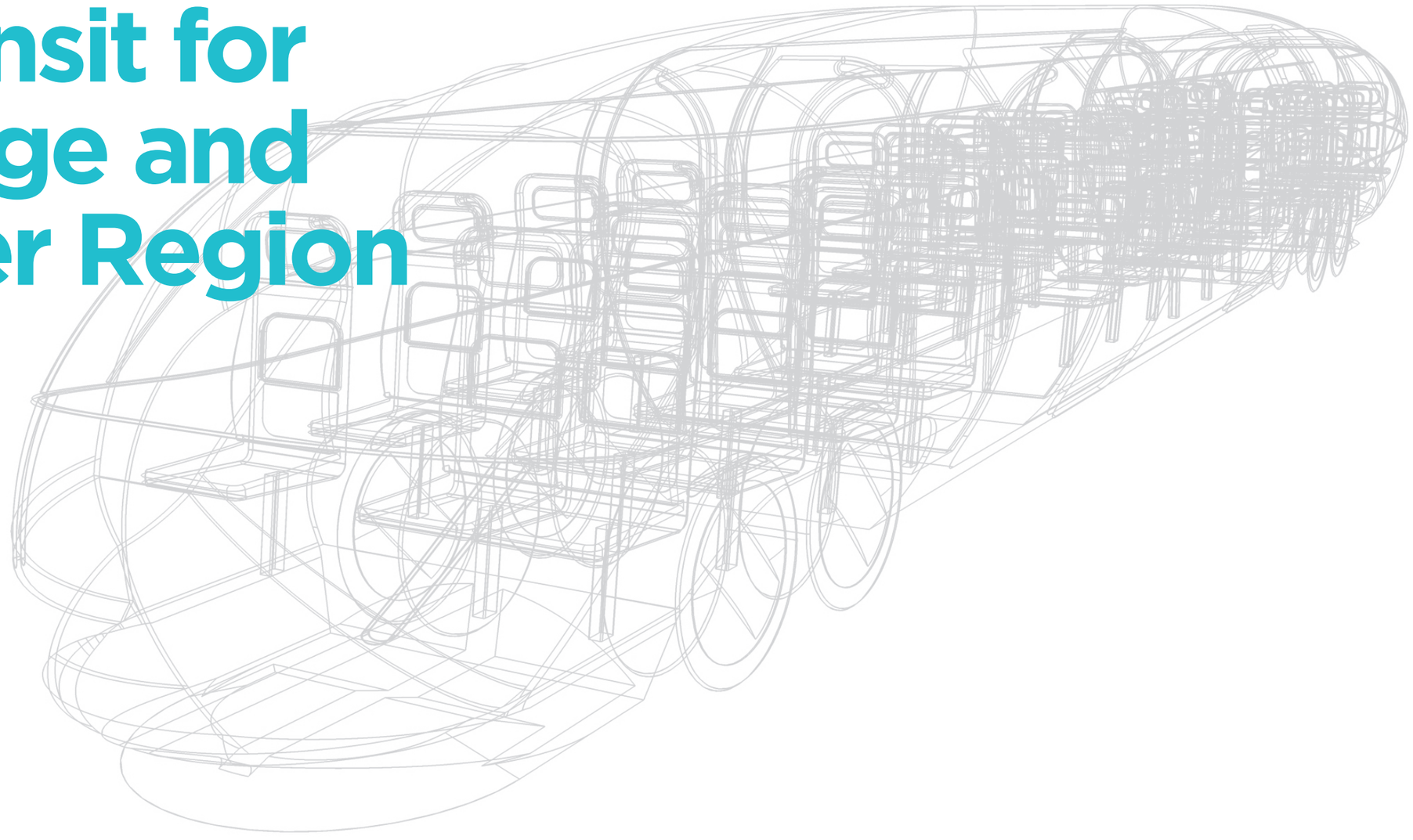
smart CAMBRIDGE

Affordable Mass Transit for Cambridge and the Wider Region



GREATER CAMBRIDGE PARTNERSHIP
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Delivering our City Deal

CAMBRIDGE AHEAD

Introduction

This document presents different options for the configuration of the Cambridge network for Affordable Very Rapid Transit (AVRT). Each option sheet shows detailed information for the selected configuration and there is also a summary sheet to aid comparison between options.

Assumptions and limitations

The data presented for each option is based on assumptions about the governing capital costs, operating costs, and vehicle and power requirements (refer to tables on the right). These costs and requirements are based on initial estimates suitable for this concept stage of work and should be taken as indicative only.

Map

Each option sheet contains a map showing the network coverage (which interchanges and lines are included) and whether tunnels are single or twin bore. Each line is labelled with either its (a) distance, (b) journey time or (c) operating frequency.

Capital costs

Typically, a large proportion of the capital cost for each option is the cost of tunnels. The total length of tunnel and whether it is single or twin bore have a significant effect on capital cost. Other significant expenses are underground interchanges and those interchanges with a Park & Ride.

Operating costs

The largest component of the operating cost is the assumed loan repayment. The operating costs excluding loan repayment are also presented in case there is a different funding method.

The vehicle, power and tyre costs are affected by the specified passenger capacity and the assumed daily hours of operation. For simplicity, the "operational hours per day" is taken to be the equivalent hours per day with the system running at peak operation.

Vehicle requirements

The maximum distances for the urban and satellite routes are governed by limits imposed on max speed and max charging power. Max speed is limited to around 120 mph and max charging rate per vehicle is limited to 400 kW.

Urban (tunnel) lines are 0-6 km in length with up to a 150 second duration including buffer time. This means that for a 6 km single bore tunnel there is a 5 minute operating frequency and for twin bore there is a 2.5 minute operating frequency.

Satellite (road) lines are 6-14 km in length, are always twin-track and have up to a 300 second duration including buffer time. This means that there is a 5 minute operating frequency or a 2.5 minute operating frequency if convoys can be set off at intervals. The assumption is that convoys *can* be set off at intervals because this improves operating frequency and reduces the number of vehicles required per line.

Power requirements

Charging rates are limited to 400 kW per vehicle. In any of the options designed for 1000 passengers per hour, there is either one vehicle at each end of the line charging for 2.5 minutes, or two vehicles at each end but with 5 minutes over which to charge. Hence each line has a power requirement of 800 kW per 1000 passengers per hour.

Journey time

The time T (in seconds) taken to travel a line of length d is:

$$T = 0.0187d + 20.6$$

This is an empirical formula derived from separate system dynamics calculations. A buffer time of T_{buffer} = 18 seconds is added to allow for vehicles entering and exiting interchanges and other delays. The journey time $T_{journey} = T + T_{buffer}$ is used to calculate the operating frequency, which also depends on whether tunnels are single or twin bore.

Typical commuter journeys

In order to try to capture the performance of each option in terms of expected journey times for a typical commuter, four different types of journey are defined (these are illustrated on the summary sheet):

- **Satellite to Centre** – a journey from one of the satellite towns to the city centre interchange
- **Satellite to Branch** – the commuter changes direction in order to reach one of the adjacent employment centres at the edge of the city
- **Cross-Town** – a journey from one edge of the city to the other
- **Satellite to Cross-Town** – a journey from one of the satellite towns to the opposite edge of the city

For a given network option, all permutations of these journeys are assessed and minimum possible, maximum possible and average (approximate) journey times are presented on the summary sheet. Additional notes:

- Minimum journey time is sum of leg journey times with a nominal 30 seconds added for switching vehicles
- Maximum journey time is minimum journey time plus sum of leg operating frequency times (assumes commuter just misses every connection).

System cost versus total distance

One way of comparing the cost of each option is to consider cost per kilometre of track, which is tabulated and plotted on the summary sheet.

Legend

Capital Costs

Lines		
Road	£2,005	/metre
Viaduct	£8,000	/metre
Single bore lined tunnel	£10,769	/metre
Twin bore lined tunnel	£19,692	/metre
Interchanges		
Interchange cost (excluding vehicle charging infrastructure)	£623,500	/line
Underground interchange cost	£16,250,000	/line
Car park cost (per Park&Ride)	£18,500,000	
Vehicles and Charging		
Vehicles	£500,000	each
Charging pad and urban connection	£1,125	/kW
Charging pad and rural connection	£1,500	/kW

Operating Costs

Loan		
Term	30	years
Rate	3%	
Staff		
Salary – manager	£45,000	/annum
Salary – controller	£30,000	/annum
Salary – interchange staff	£30,000	/annum
Vehicles		
Maintenance	£6,000	/year/vehicle
Insurance	£6,000	/year/vehicle
Vehicle life	10	years
Power		
Charging efficiency	90%	
Electricity price	£0.10	/kWh
Tyres		
Tyre life	40,000	km
Tyre cost	£500	/tyre
Number of tyres per vehicle	8	/vehicle

Vehicle and Power Requirements

vehicles per convoy		operating frequency	
		300	150
passengers per hour	1000	2	1
	2000	4	2
vehicles per line (urban, tunnel)		track (bore)	
		1	2
passengers per hour	1000	6	4
	2000	12	8
vehicles per line (satellite, road)		track	
		2	
passengers per hour	1000	6	
	2000	12	
Charging		kW	
passengers per hour	1000	800	
	2000	1600	
passengers per vehicle		42	

Summary

Option
1
2
3
4
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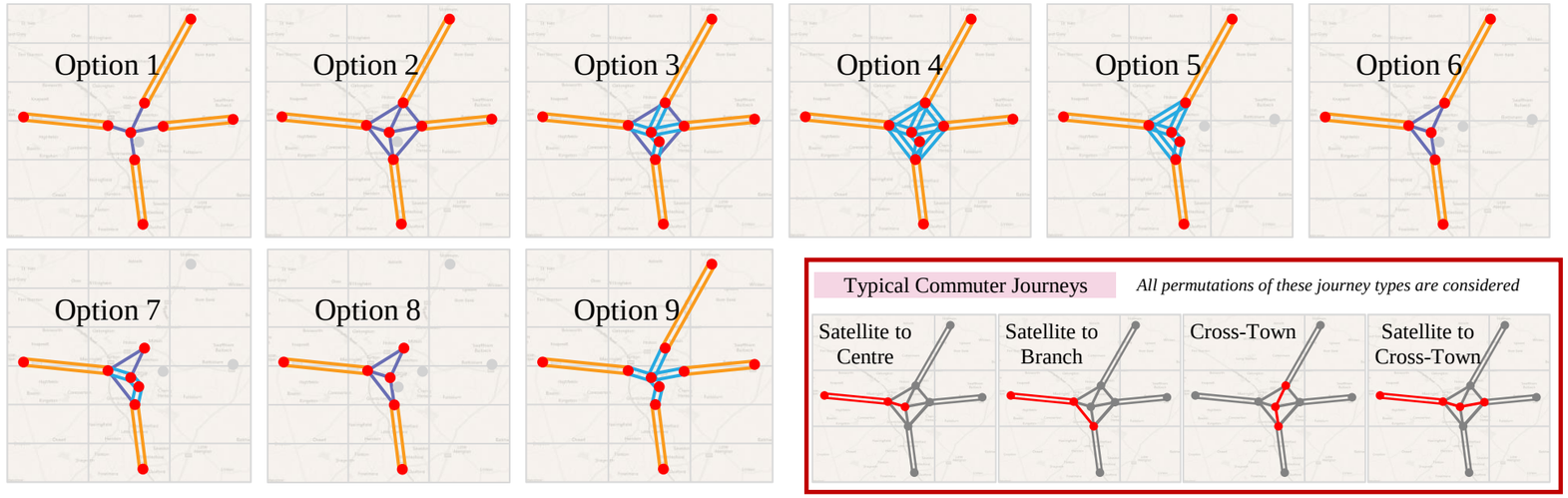
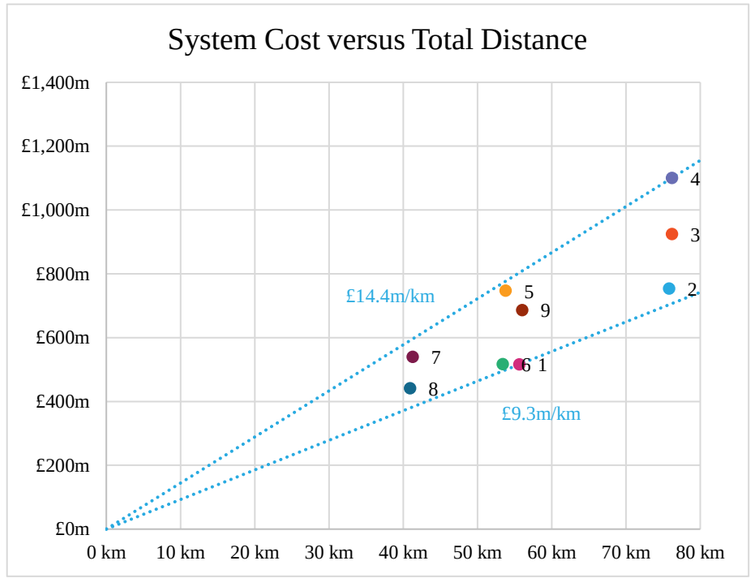
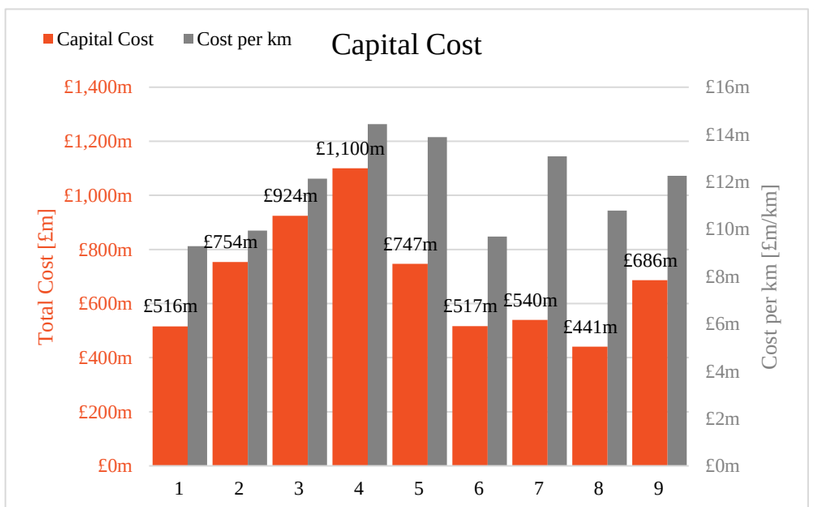
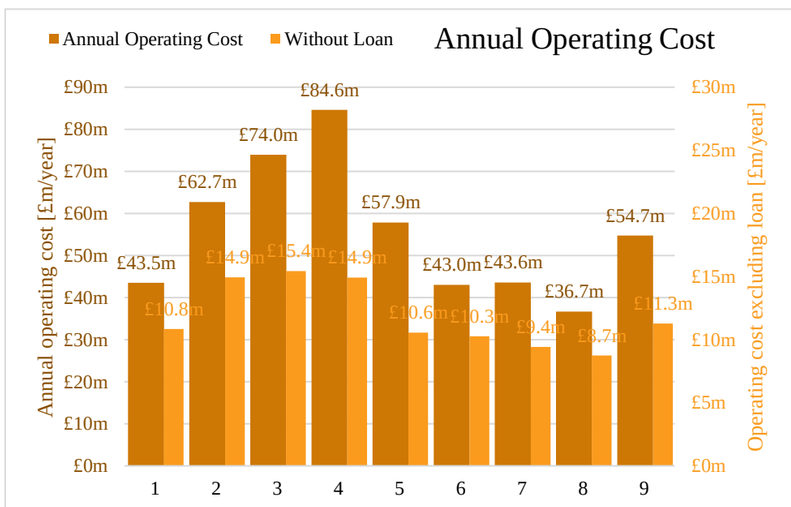
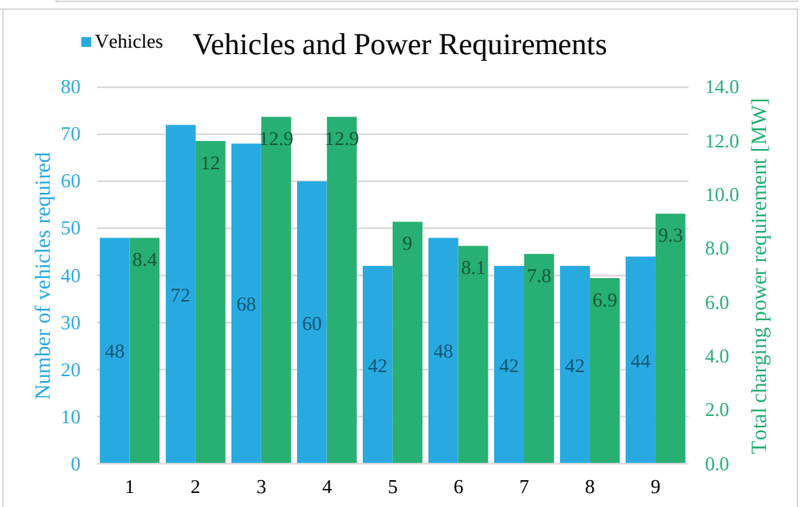
9

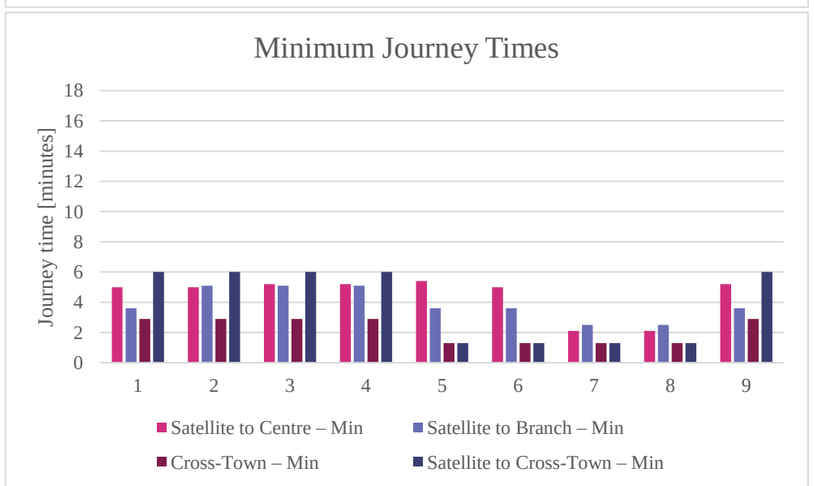


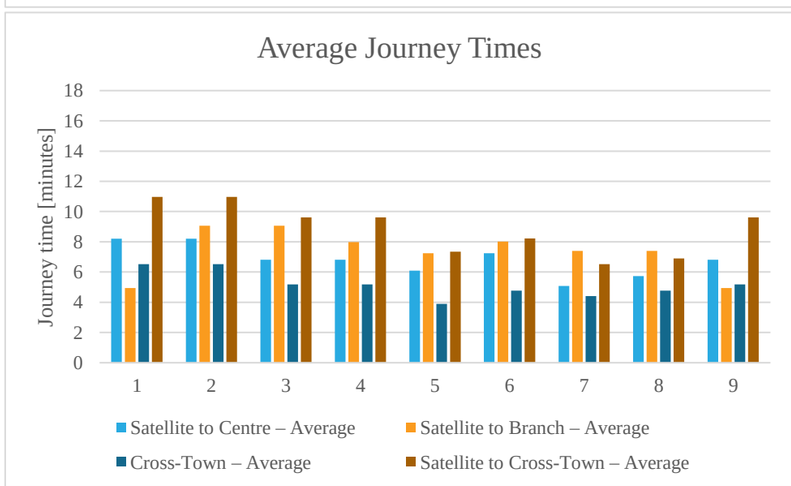


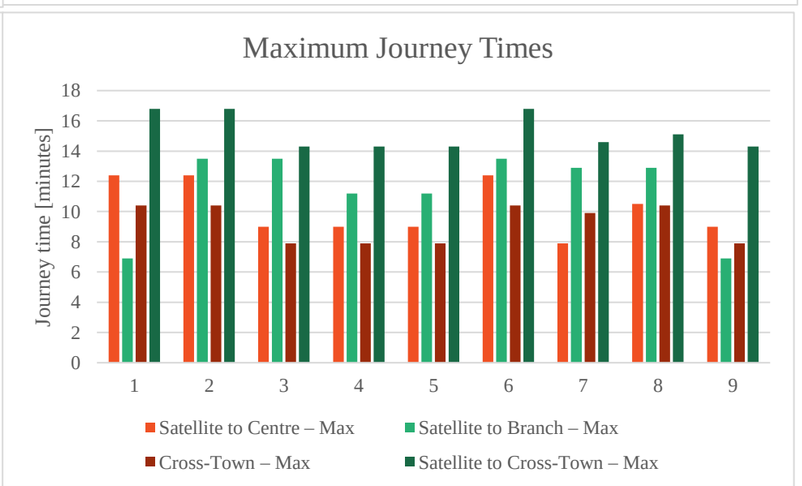






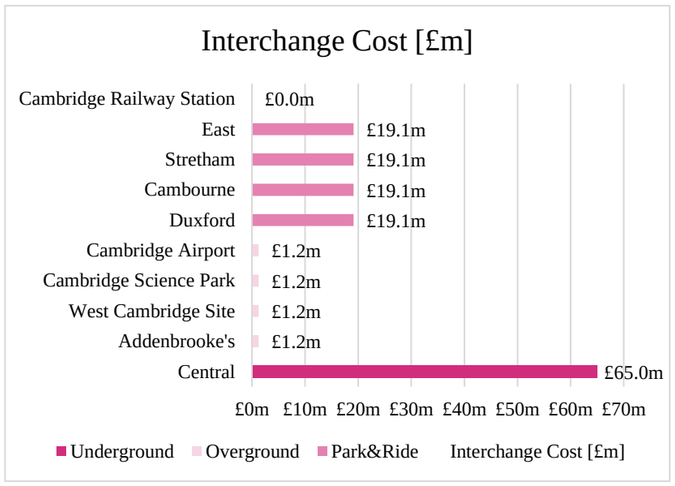






Option 1 | Star Single

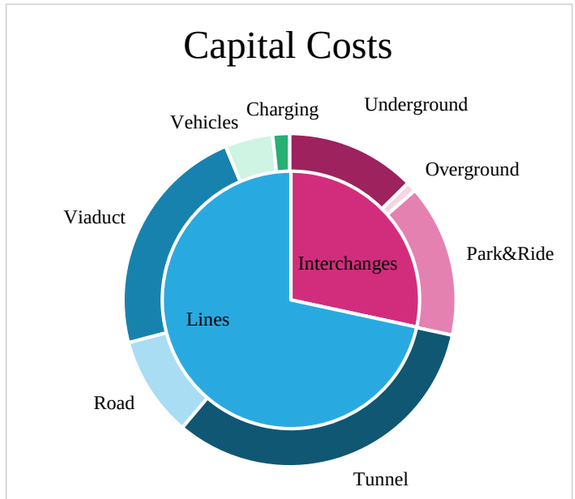
- All **star** routes, excludes **Cambridge Railway Station**
- Single bore tunnels throughout

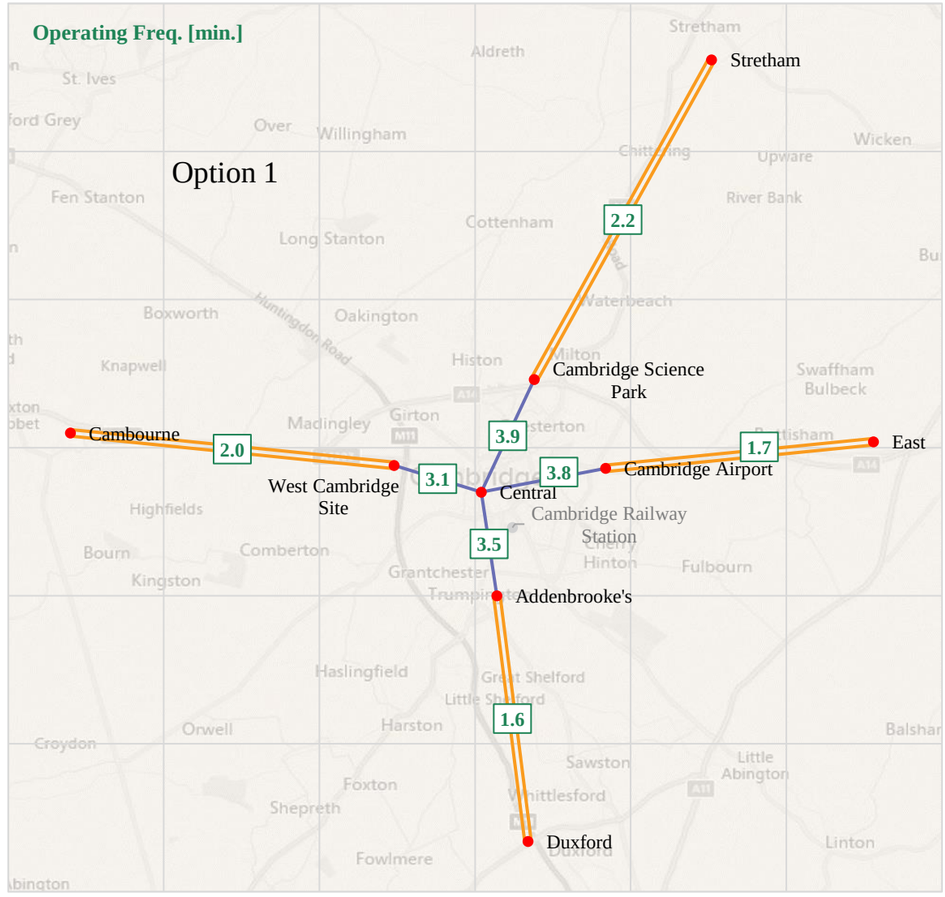


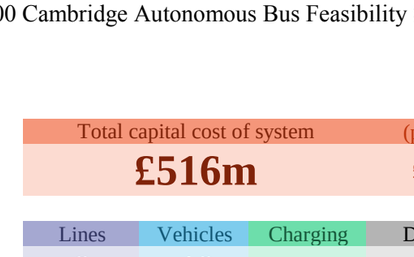
Total capital cost of system	(per km)
£516m	£9.3m

Lines	Vehicles	Charging	Distance
8	48	7.5 MW	55.6 km

Annual operating cost of system	(excluding loan)
£43.5m/year	£10.8m/year







Nodes (Interchanges)

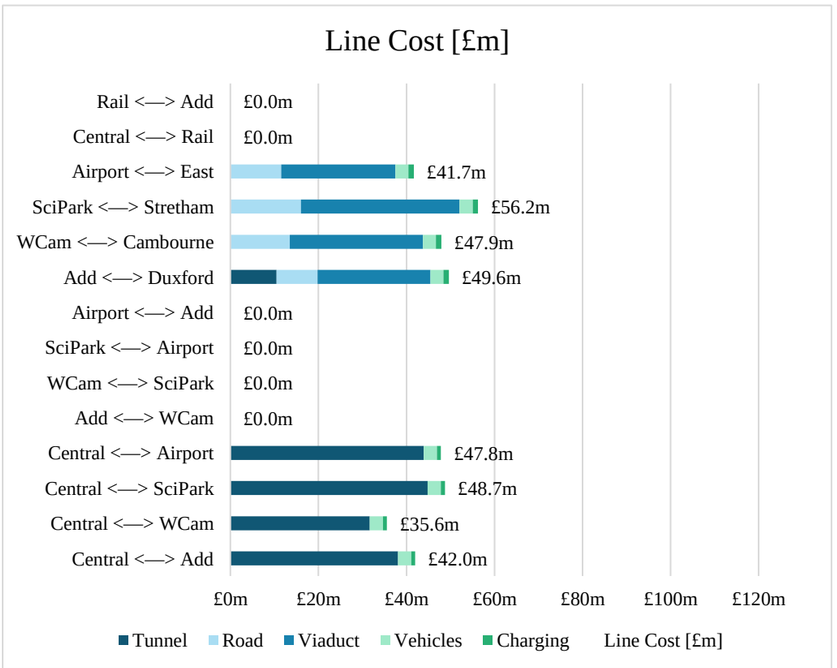
NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overground	Add	457550
3	West Cambridge Site	1	Overground	WCam	424594
4	Cambridge Science Park	1	Overground	SciPark	469623
5	Cambridge Airport	1	Overground	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	1	Park&Ride	East	578602
10	Cambridge Railway Station	0	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

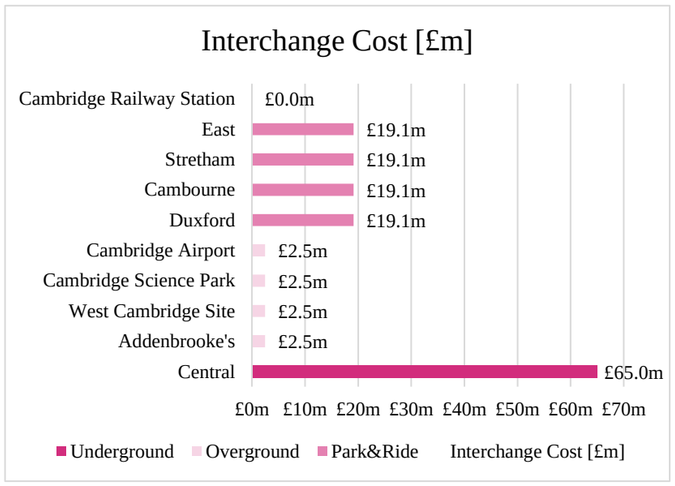
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	1	Urban	100%	0%	0%	straight	3.5	1.4	3.5
2	1	3	Central <—> WCam	1000	1	Urban	100%	0%	0%	straight	2.9	1.3	3.1
3	1	4	Central <—> SciPark	1000	1	Urban	100%	0%	0%	straight	4.2	1.6	3.9
4	1	5	Central <—> Airport	1000	1	Urban	100%	0%	0%	straight	4.1	1.6	3.8
5	2	3	Add <—> WCam	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
6	3	4	WCam <—> SciPark	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	2	Satellite	0%	64%	36%	9000	9.0	3.1	1.7
13	1	10	Central <—> Rail	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
14	10	2	Rail <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0



Option 2 | Full Single

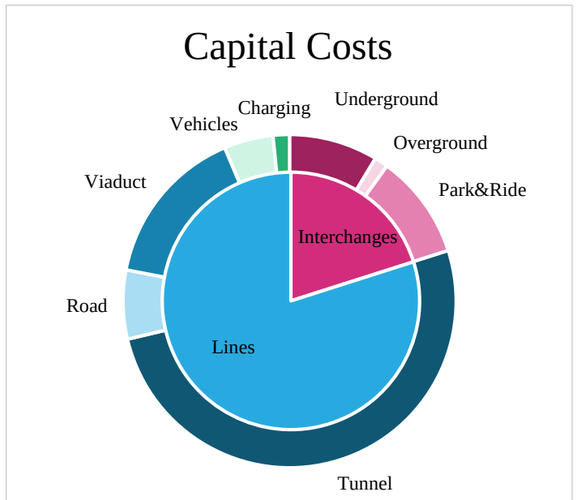
- All routes (no **Cambridge Railway Station**)
- Single bore tunnels throughout

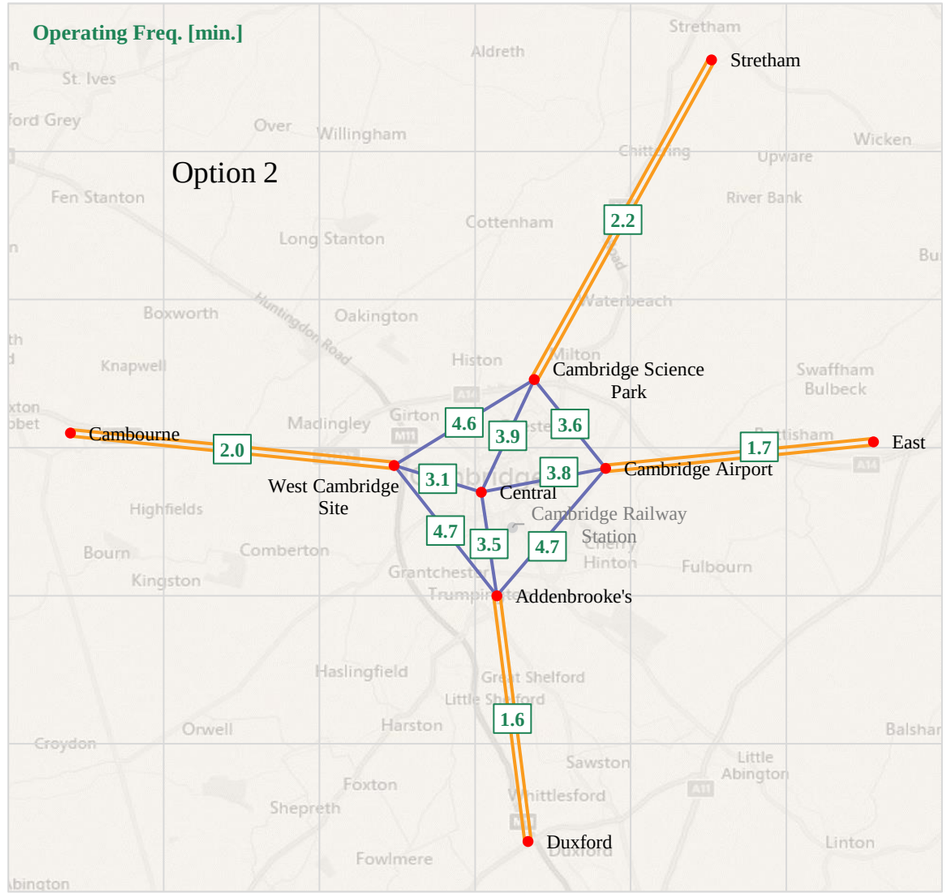


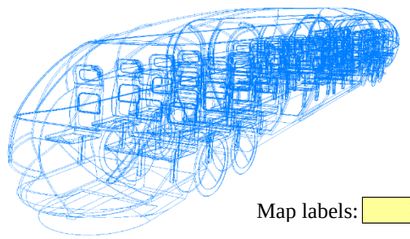
Total capital cost of system	(per km)
£754m	**£9.9m**

Lines	Vehicles	Charging	Distance
12	72	**10.7 MW**	**75.8 km**

Annual operating cost of system	(excluding loan)
£62.7m/year	**£14.9m/year**







Nodes (Interchanges)

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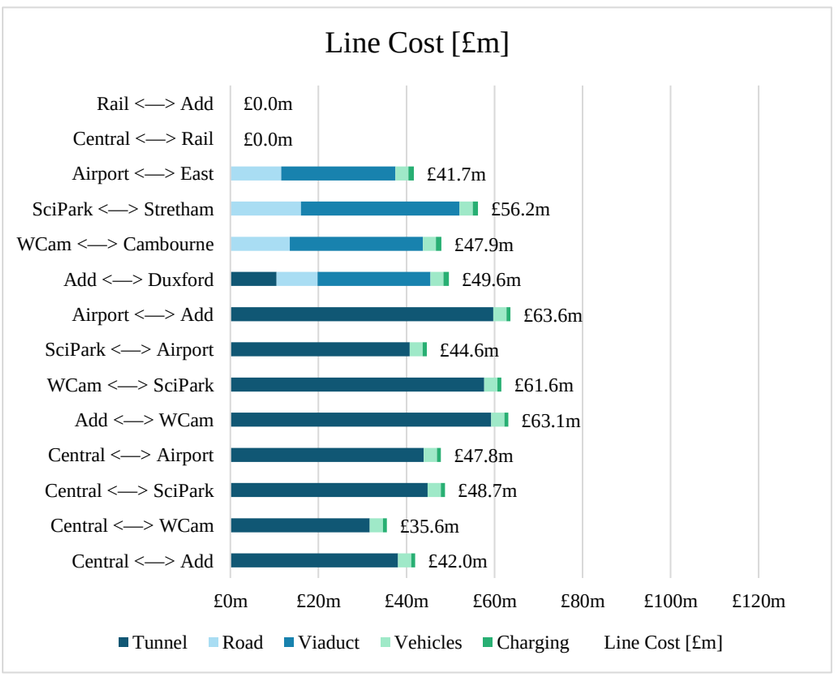
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	1	Park&Ride	East	578602
10	Cambridge Railway Station	0	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

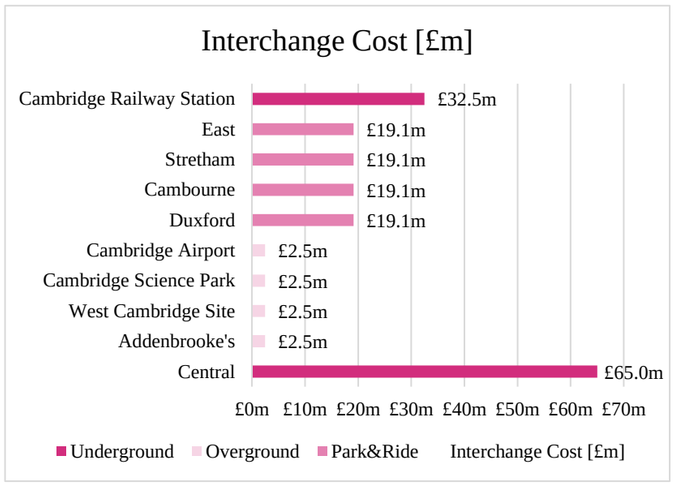
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	1	Urban	100%	0%	0%	straight	3.5	1.4	3.5
2	1	3	Central <—> WCam	1000	1	Urban	100%	0%	0%	straight	2.9	1.3	3.1
3	1	4	Central <—> SciPark	1000	1	Urban	100%	0%	0%	straight	4.2	1.6	3.9
4	1	5	Central <—> Airport	1000	1	Urban	100%	0%	0%	straight	4.1	1.6	3.8
5	2	3	Add <—> WCam	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
6	3	4	WCam <—> SciPark	1000	1	Urban	100%	0%	0%	straight	5.4	2.0	4.6
7	4	5	SciPark <—> Airport	1000	1	Urban	100%	0%	0%	straight	3.8	1.5	3.6
8	5	2	Airport <—> Add	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	2	Satellite	0%	64%	36%	9000	9.0	3.1	1.7
13	1	10	Central <—> Rail	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
14	10	2	Rail <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0



Option 3 | Twin Star, Single Ring

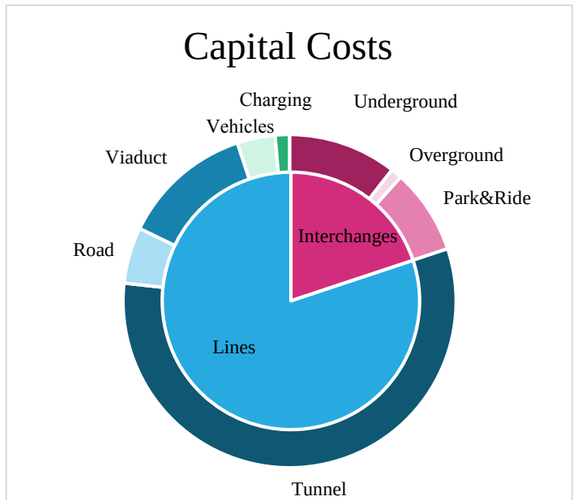
- All routes including **Cambridge Railway Station**
- Twin bore tunnels on star lines, single bore tunnels on ring lines

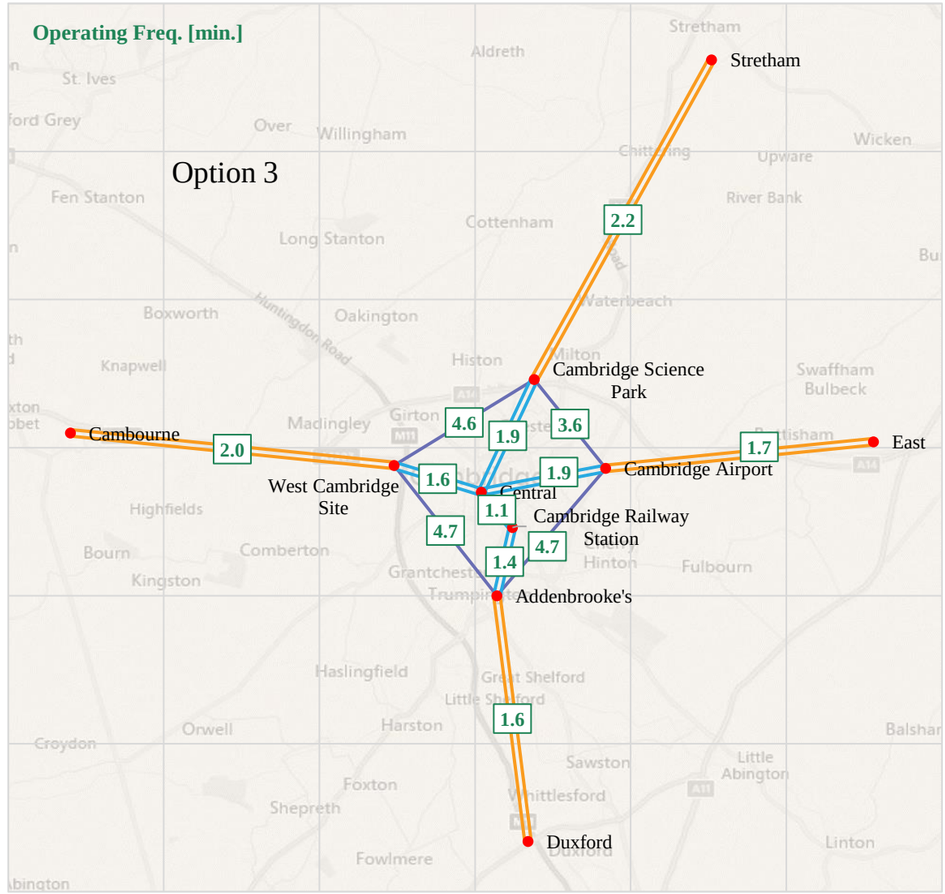


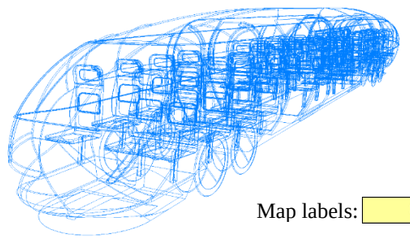
Total capital cost of system	(per km)
£924m	**£12.1m**

Lines	Vehicles	Charging	Distance
13	68	**11.5 MW**	**76.2 km**

Annual operating cost of system	(excluding loan)
£74.0m/year	**£15.4m/year**







Nodes (Interchanges)

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8	Stretham	1	Park&Ride	Stretham	526731
9	East	1	Park&Ride	East	578602
10	Cambridge Railway Station	1	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
2	1	3	Central <—> WCam	1000	2	Urban	100%	0%	0%	straight	2.9	1.3	1.6
3	1	4	Central <—> SciPark	1000	2	Urban	100%	0%	0%	straight	4.2	1.6	1.9
4	1	5	Central <—> Airport	1000	2	Urban	100%	0%	0%	straight	4.1	1.6	1.9
5	2	3	Add <—> WCam	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
6	3	4	WCam <—> SciPark	1000	1	Urban	100%	0%	0%	straight	5.4	2.0	4.6
7	4	5	SciPark <—> Airport	1000	1	Urban	100%	0%	0%	straight	3.8	1.5	3.6
8	5	2	Airport <—> Add	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
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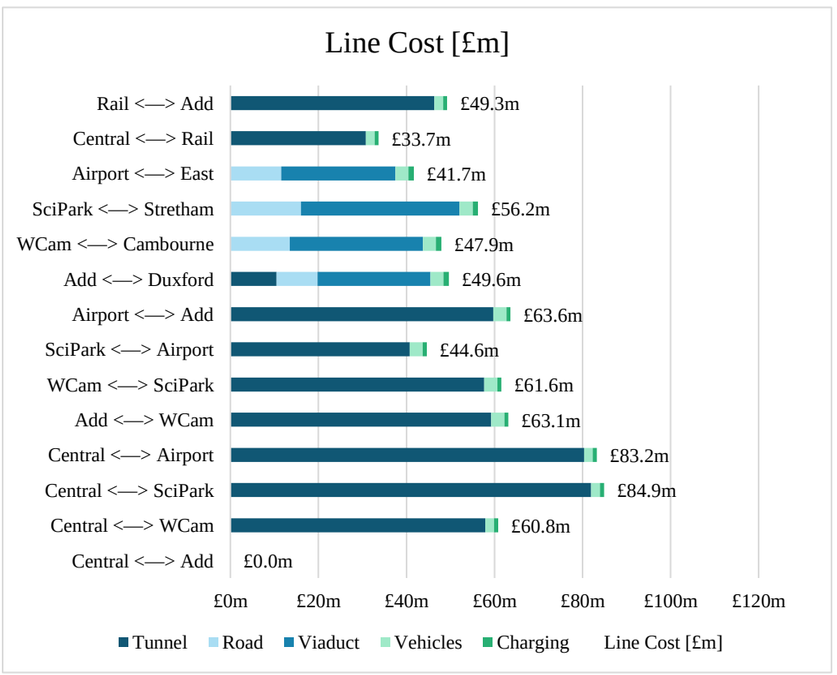
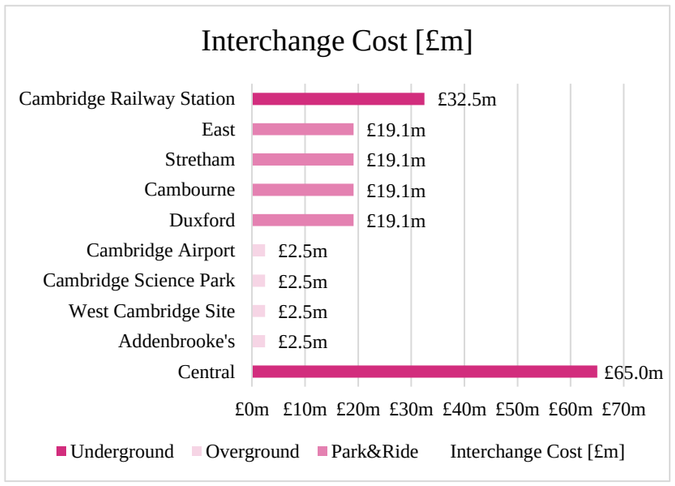
12	5	9	Airport <—> East	1000	2	Satellite	0%	64%	36%	9000	9.0	3.1	1.7
13	1	10	Central <—> Rail	1000	2	Urban	100%	0%	0%	straight	1.6	0.8	1.1
14	10	2	Rail <—> Add	1000	2	Urban	100%	0%	0%	straight	2.4	1.1	1.4



Option 4 | Full Twin

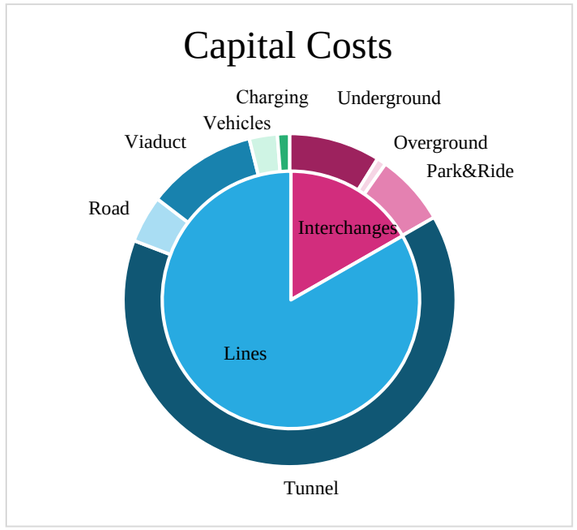
- All routes including **Cambridge Railway Station**
- Twin bore tunnels throughout

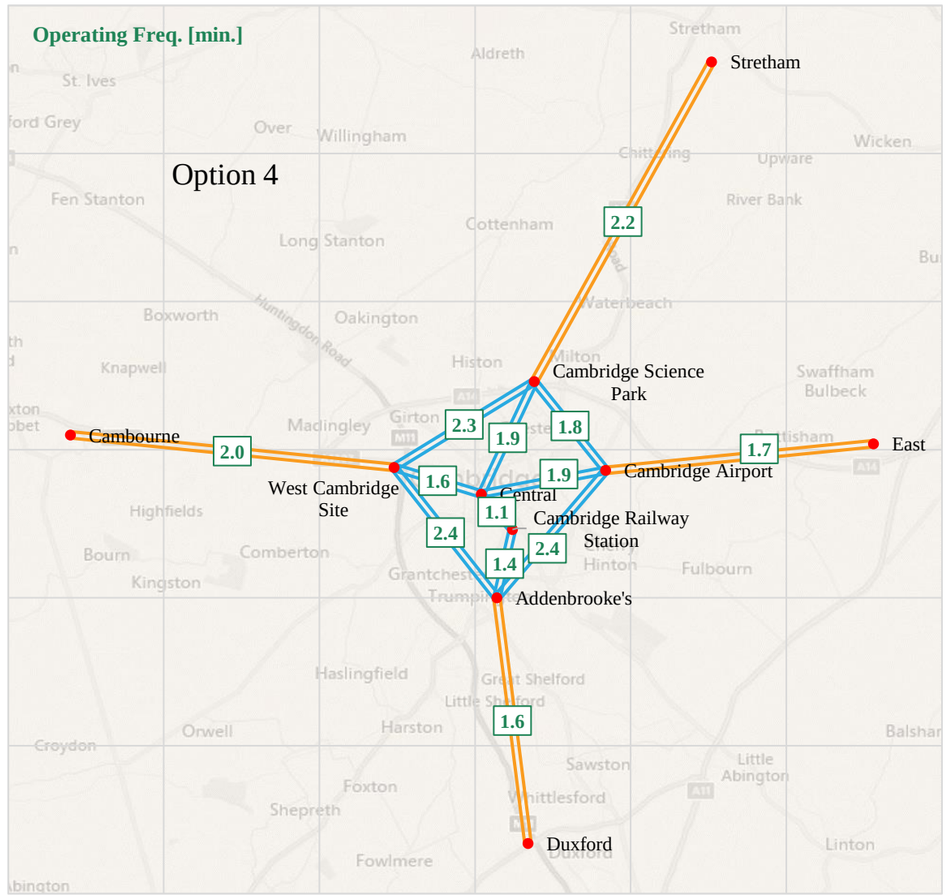


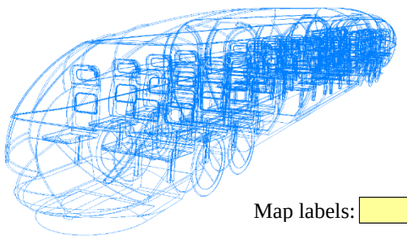
Total capital cost of system	(per km)
£1,100m	**£14.4m**

Lines	Vehicles	Charging	Distance
13	60	**11.5 MW**	**76.2 km**

Annual operating cost of system	(excluding loan)
£84.6m/year	**£14.9m/year**







Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

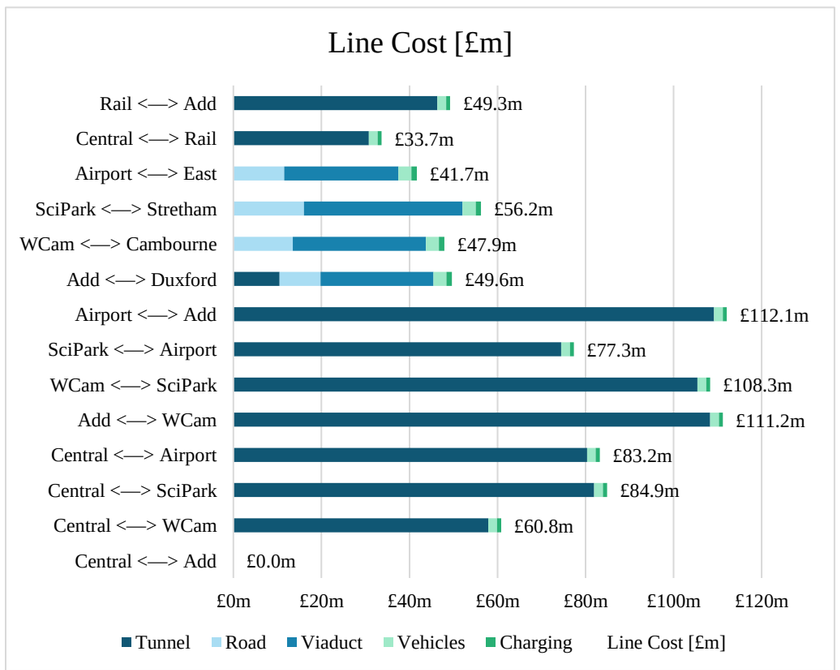
Nodes (Interchanges)

NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overground	Add	457550
3	West Cambridge Site	1	Overground	WCam	424594
4	Cambridge Science Park	1	Overground	SciPark	469623
5	Cambridge Airport	1	Overground	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	1	Park&Ride	East	578602
10	Cambridge Railway Station	1	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

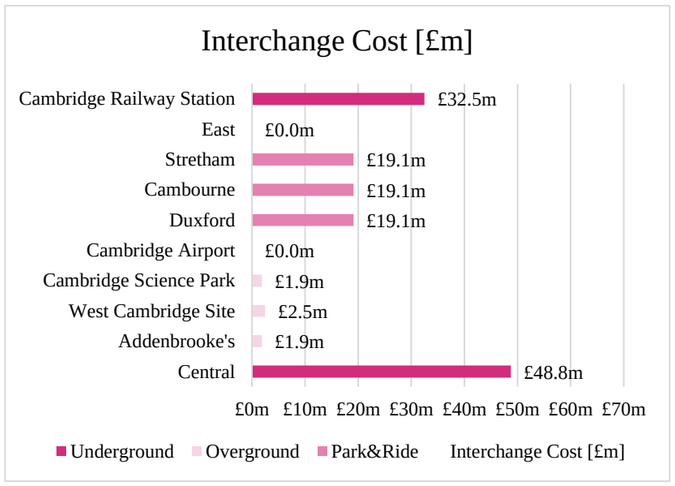
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
2	1	3	Central <—> WCam	1000	2	Urban	100%	0%	0%	straight	2.9	1.3	1.6
3	1	4	Central <—> SciPark	1000	2	Urban	100%	0%	0%	straight	4.2	1.6	1.9
4	1	5	Central <—> Airport	1000	2	Urban	100%	0%	0%	straight	4.1	1.6	1.9
5	2	3	Add <—> WCam	1000	2	Urban	100%	0%	0%	straight	5.5	2.1	2.4
6	3	4	WCam <—> SciPark	1000	2	Urban	100%	0%	0%	straight	5.4	2.0	2.3
7	4	5	SciPark <—> Airport	1000	2	Urban	100%	0%	0%	straight	3.8	1.5	1.8
8	5	2	Airport <—> Add	1000	2	Urban	100%	0%	0%	straight	5.5	2.1	2.4
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	2	Satellite	0%	64%	36%	9000	9.0	3.1	1.7
13	1	10	Central <—> Rail	1000	2	Urban	100%	0%	0%	straight	1.6	0.8	1.1
14	10	2	Rail <—> Add	1000	2	Urban	100%	0%	0%	straight	2.4	1.1	1.4



Option 5 | Twin, No East

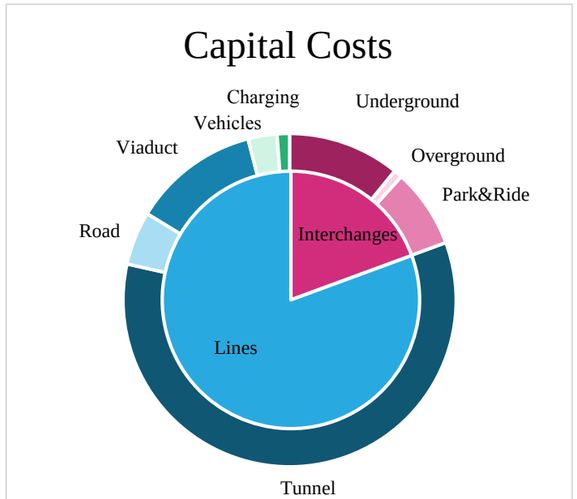
- Excludes all lines to **East** and **Cambridge Airport**; includes **Cambridge Railway Station**
- Twin bore tunnels throughout

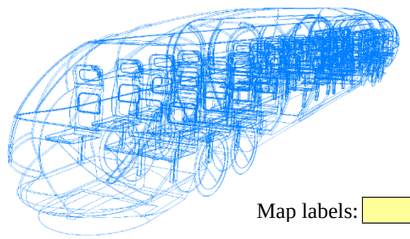


Total capital cost of system	(per km)
£747m	£13.9m

Lines	Vehicles	Charging	Distance
9	42	8.0 MW	53.8 km

Annual operating cost of system	(excluding loan)
£57.9m/year	£10.6m/year





Nodes (Interchanges)

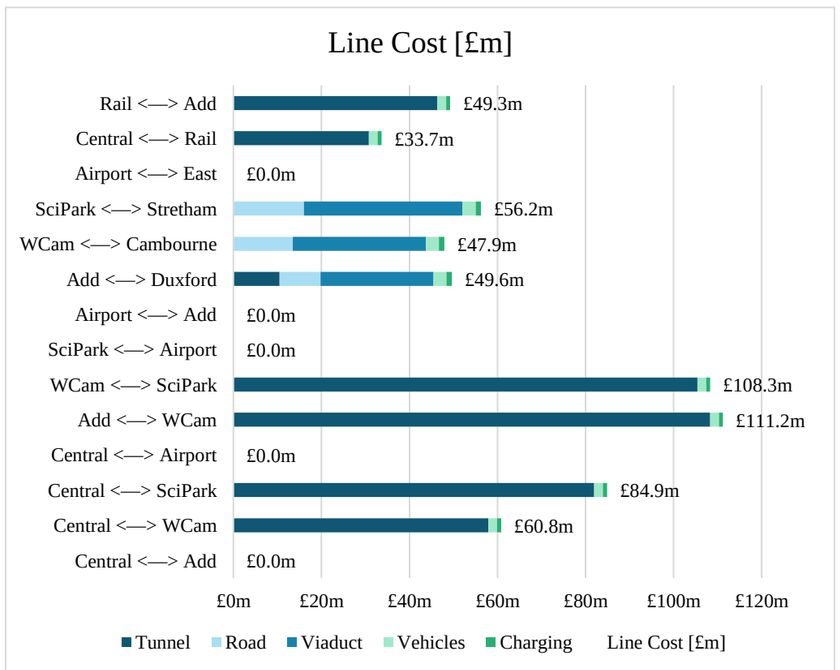
NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overground	Add	457550
3	West Cambridge Site	1	Overground	WCam	424594
4	Cambridge Science Park	1	Overground	SciPark	469623
5	Cambridge Airport	0	Overground	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	0	Park&Ride	East	578602
10	Cambridge Railway Station	1	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

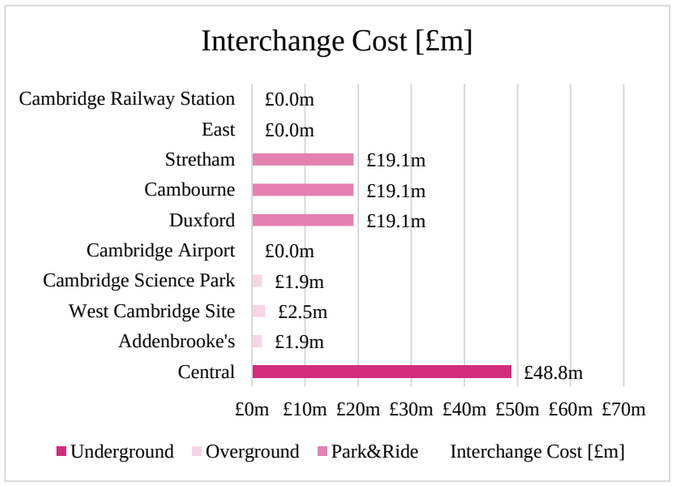
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
2	1	3	Central <—> WCam	1000	2	Urban	100%	0%	0%	straight	2.9	1.3	1.6
3	1	4	Central <—> SciPark	1000	2	Urban	100%	0%	0%	straight	4.2	1.6	1.9
4	1	5	Central <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
5	2	3	Add <—> WCam	1000	2	Urban	100%	0%	0%	straight	5.5	2.1	2.4
6	3	4	WCam <—> SciPark	1000	2	Urban	100%	0%	0%	straight	5.4	2.0	2.3
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	0	Satellite	0%	64%	36%	9000	0.0	0.0	0.0
13	1	10	Central <—> Rail	1000	2	Urban	100%	0%	0%	straight	1.6	0.8	1.1
14	10	2	Rail <—> Add	1000	2	Urban	100%	0%	0%	straight	2.4	1.1	1.4



Option 6 | Single, No East

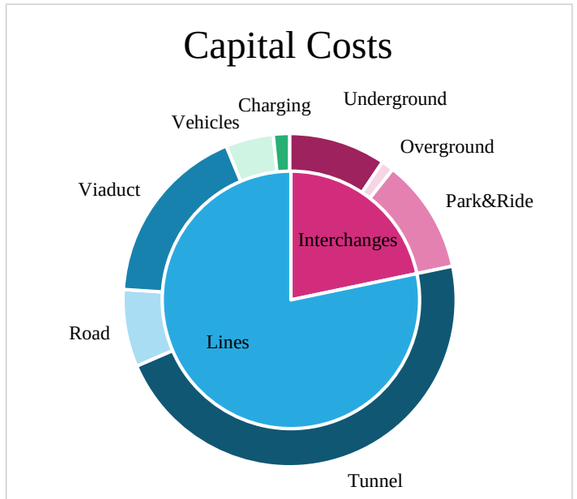
- Excludes all lines to **East** and **Cambridge Airport**; excludes **Cambridge Railway Station**
- Single bore tunnels everywhere

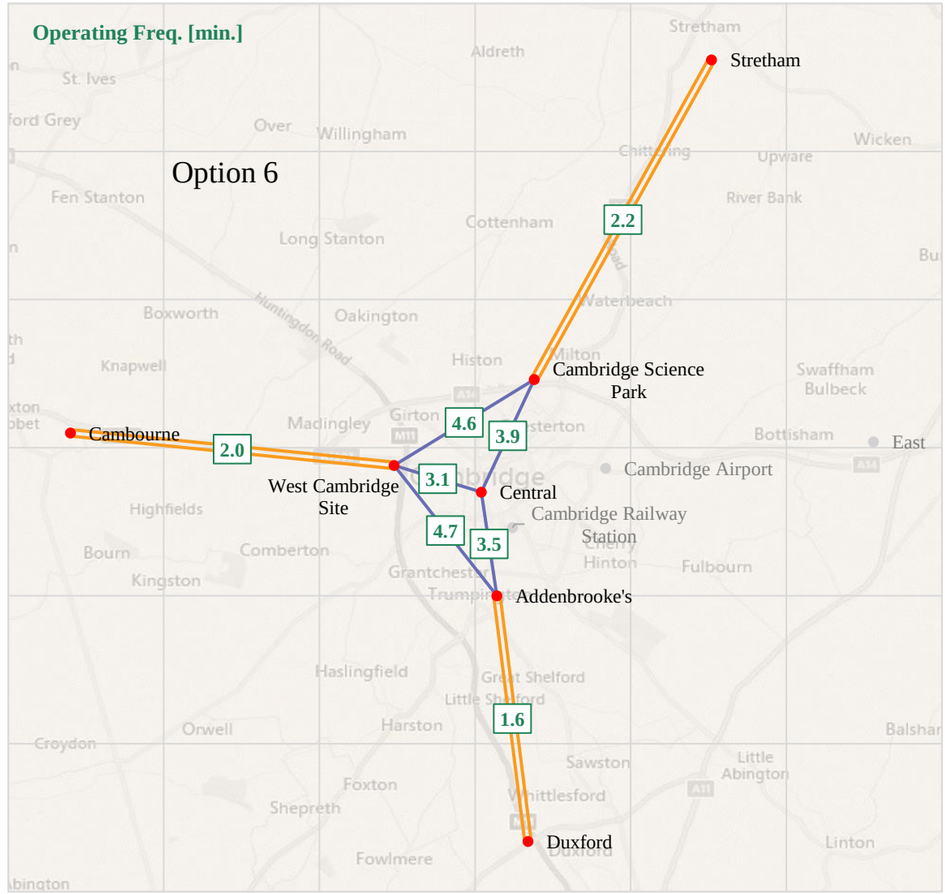


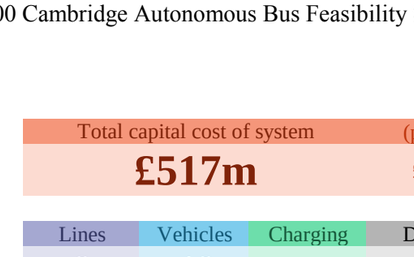
Total capital cost of system	(per km)
£517m	£9.7m

Lines	Vehicles	Charging	Distance
8	48	7.2 MW	53.4 km

Annual operating cost of system	(excluding loan)
£43.0m/year	£10.3m/year







Nodes (Interchanges)

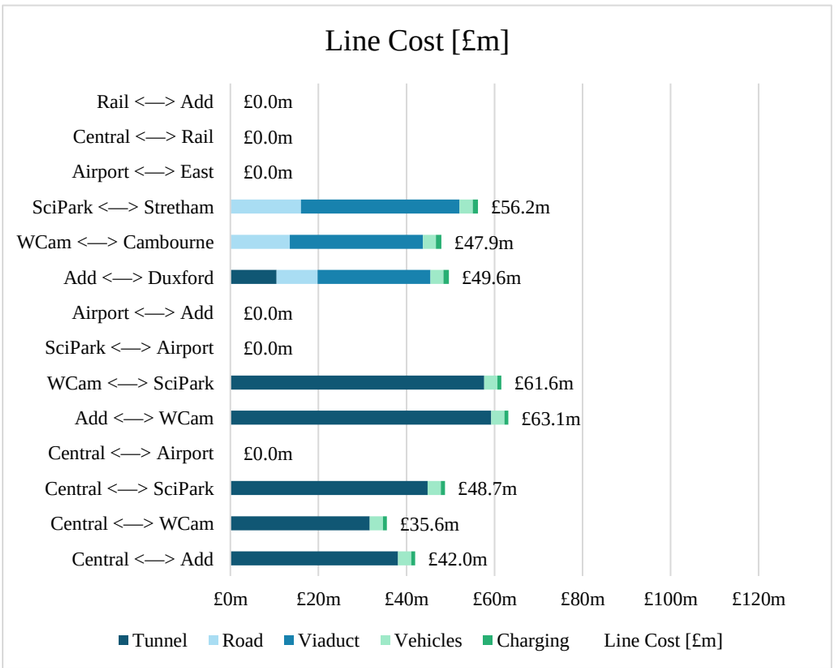
NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overground	Add	457550
3	West Cambridge Site	1	Overground	WCam	424594
4	Cambridge Science Park	1	Overground	SciPark	469623
5	Cambridge Airport	0	Overground	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	0	Park&Ride	East	578602
10	Cambridge Railway Station	0	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

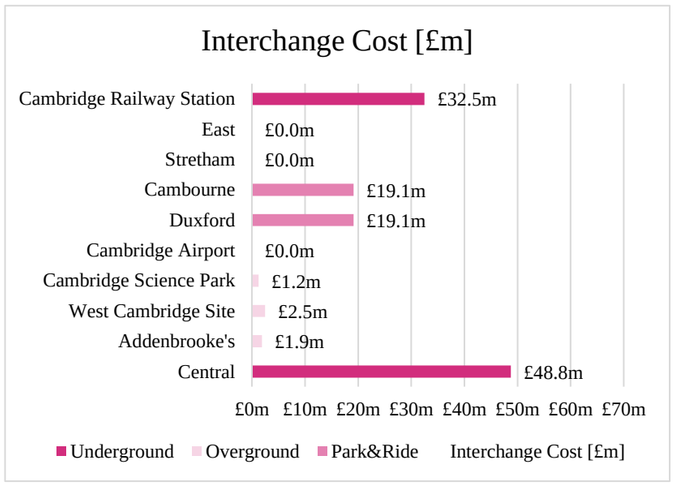
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	1	Urban	100%	0%	0%	straight	3.5	1.4	3.5
2	1	3	Central <—> WCam	1000	1	Urban	100%	0%	0%	straight	2.9	1.3	3.1
3	1	4	Central <—> SciPark	1000	1	Urban	100%	0%	0%	straight	4.2	1.6	3.9
4	1	5	Central <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
5	2	3	Add <—> WCam	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
6	3	4	WCam <—> SciPark	1000	1	Urban	100%	0%	0%	straight	5.4	2.0	4.6
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	0	Satellite	0%	64%	36%	9000	0.0	0.0	0.0
13	1	10	Central <—> Rail	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
14	10	2	Rail <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0



Option 7 | Twin Central Spine

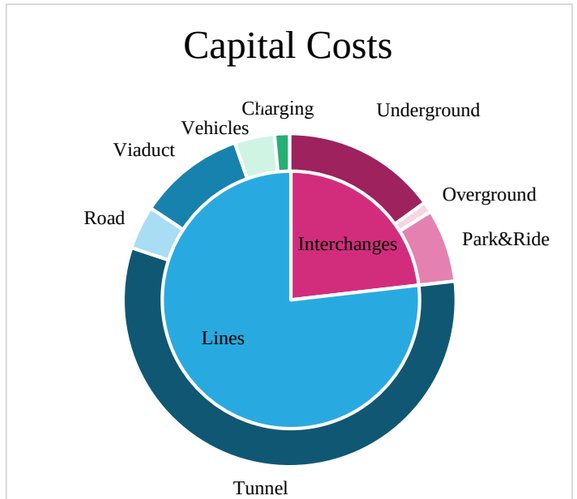
- Excludes **Stretham**, **East**, **Cambridge Airport**; includes **Cambridge Railway Station**
- Twin bore tunnels on central spine, single bore tunnels to link employment centres

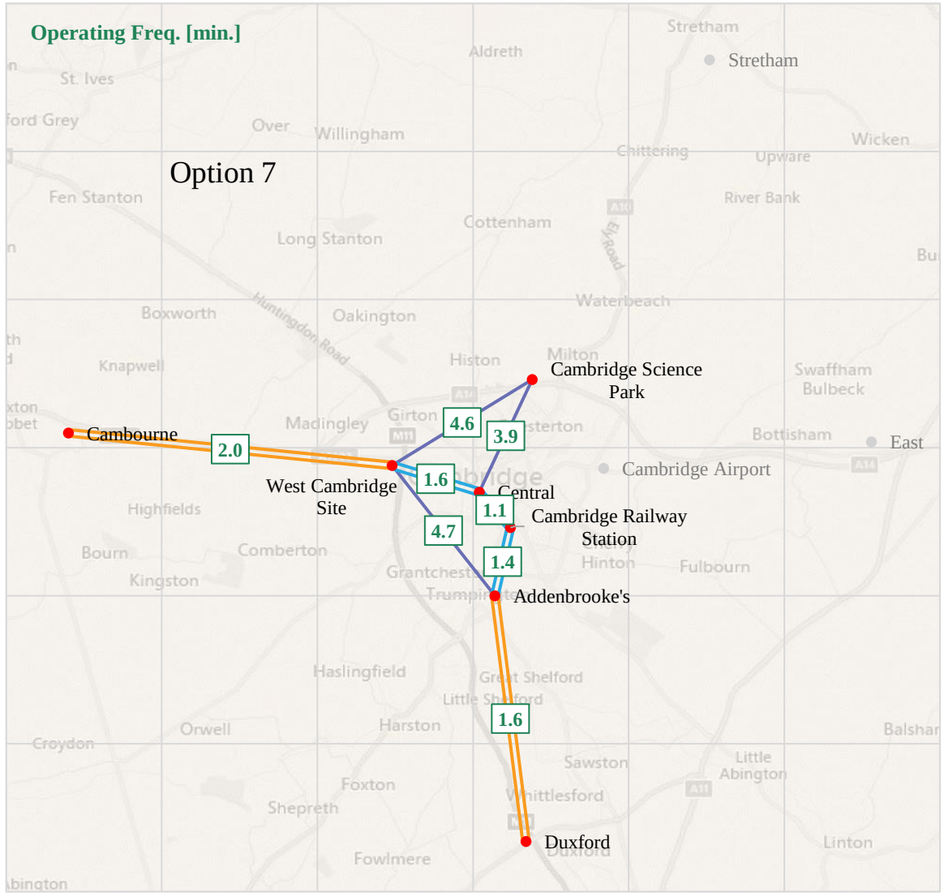


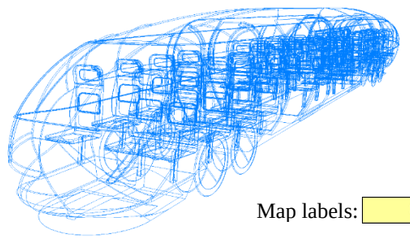
Total capital cost of system	(per km)
£540m	£13.1m

Lines	Vehicles	Charging	Distance
8	42	6.9 MW	41.3 km

Annual operating cost of system	(excluding loan)
£43.6m/year	£9.4m/year







Nodes (Interchanges)

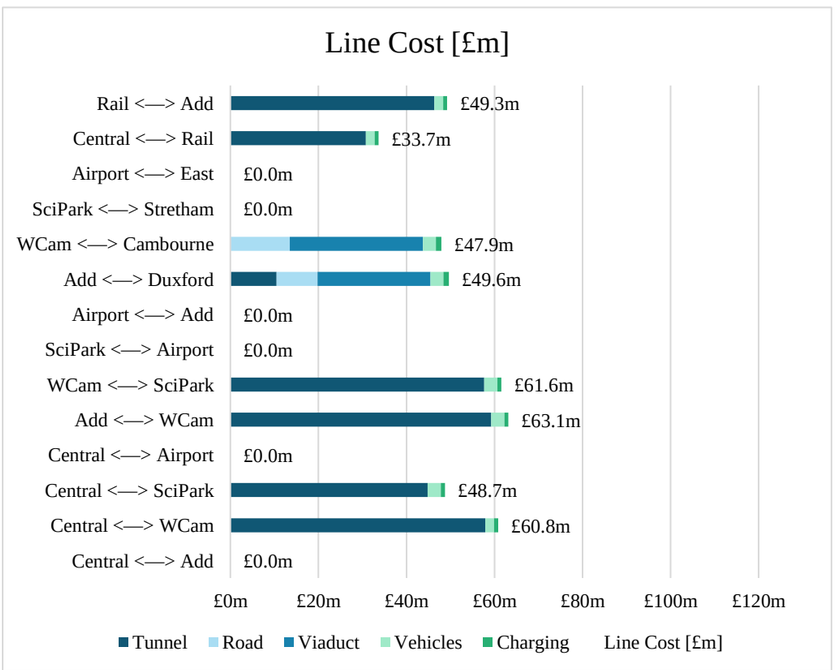
NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overgound	Add	457550
3	West Cambridge Site	1	Overgound	WCam	424594
4	Cambridge Science Park	1	Overgound	SciPark	469623
5	Cambridge Airport	0	Overgound	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	0	Park&Ride	Stretham	526731
9	East	0	Park&Ride	East	578602
10	Cambridge Railway Station	1	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

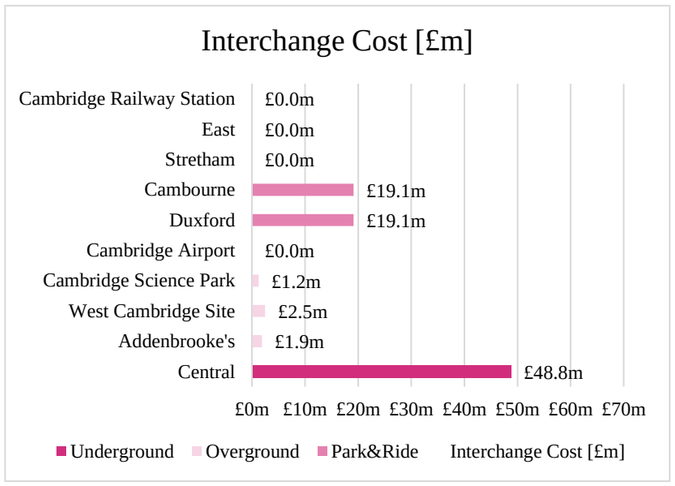
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
2	1	3	Central <—> WCam	1000	2	Urban	100%	0%	0%	straight	2.9	1.3	1.6
3	1	4	Central <—> SciPark	1000	1	Urban	100%	0%	0%	straight	4.2	1.6	3.9
4	1	5	Central <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
5	2	3	Add <—> WCam	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
6	3	4	WCam <—> SciPark	1000	1	Urban	100%	0%	0%	straight	5.4	2.0	4.6
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	0	Satellite	0%	64%	36%	12500	0.0	0.0	0.0
12	5	9	Airport <—> East	1000	0	Satellite	0%	64%	36%	9000	0.0	0.0	0.0
13	1	10	Central <—> Rail	1000	2	Urban	100%	0%	0%	straight	1.6	0.8	1.1
14	10	2	Rail <—> Add	1000	2	Urban	100%	0%	0%	straight	2.4	1.1	1.4



Option 8 | Single Central Spine

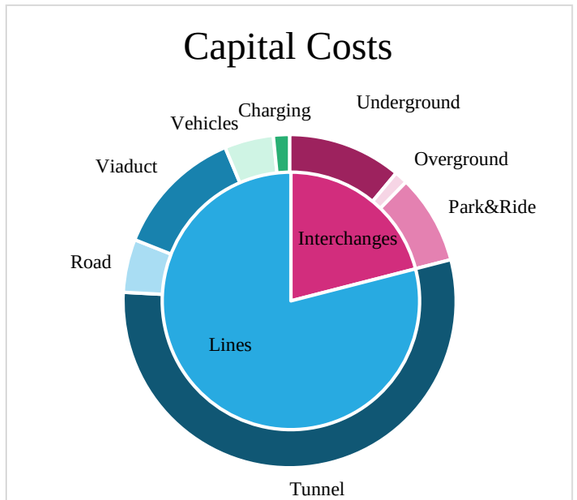
- Excludes **Stretham**, **East**, **Cambridge Airport**, **Cambridge Railway Station**
- Single bore tunnels throughout

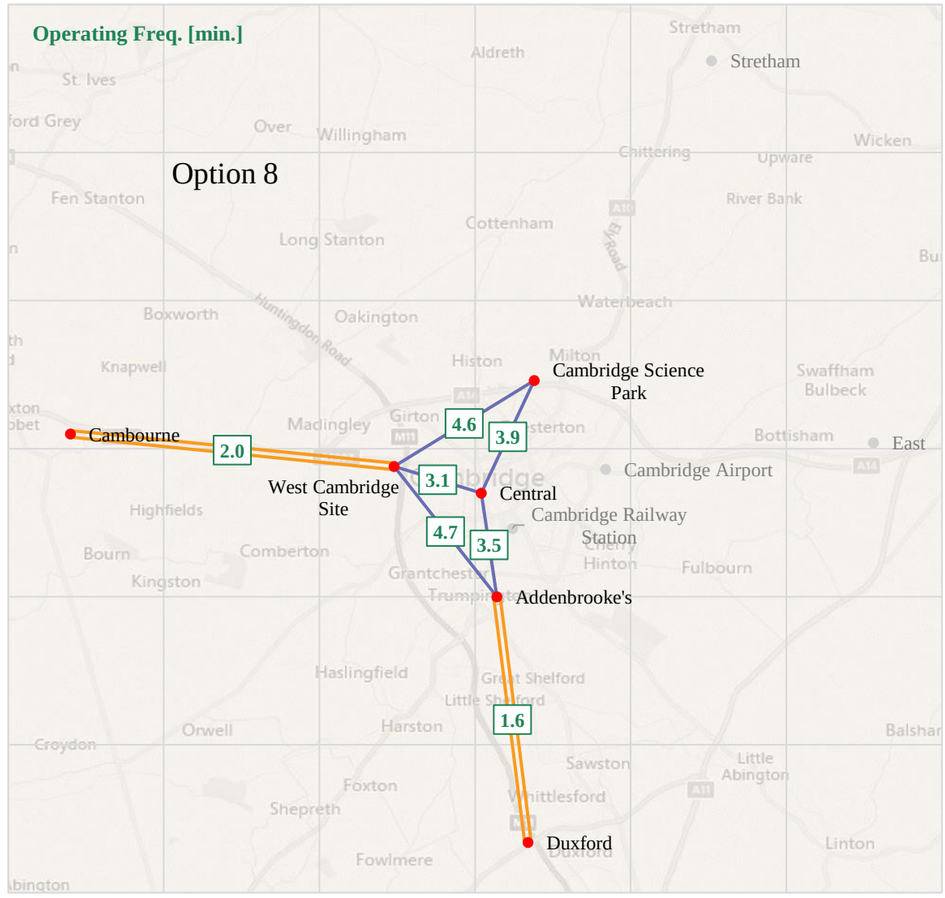


Total capital cost of system	(per km)
£441m	**£10.8m**

Lines	Vehicles	Charging	Distance
7	42	**6.1 MW**	**40.9 km**

Annual operating cost of system	(excluding loan)
£36.7m/year	**£8.7m/year**





Nodes (Interchanges)

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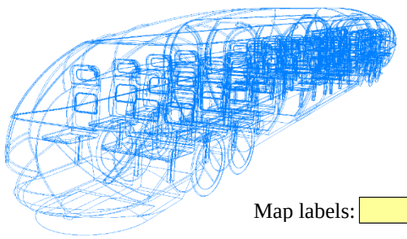
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	0	Park&Ride	Stretham	526731
9	East	0	Park&Ride	East	578602
10	Cambridge Railway Station	0	Underground	Rail	462573

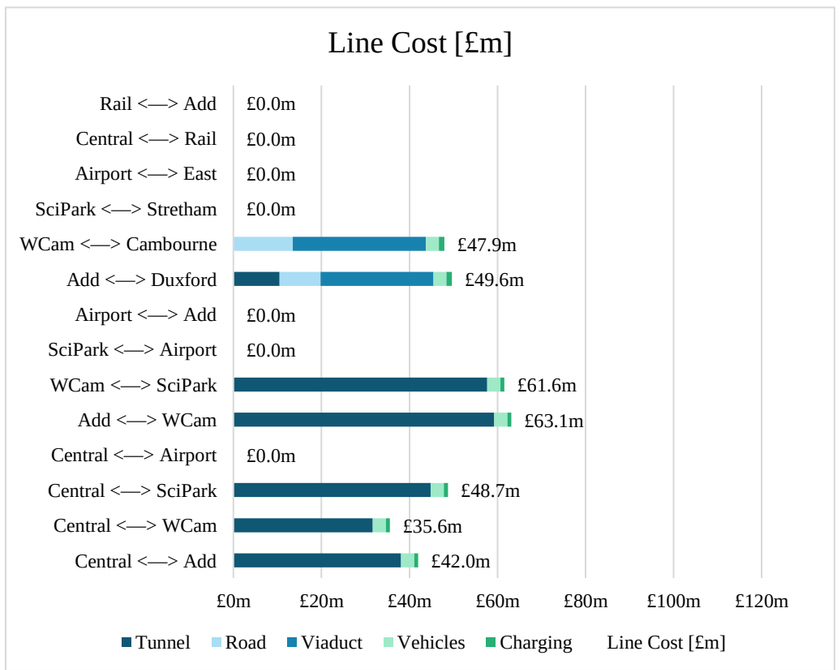
† Ordinance Survey TL (OS Landranger 154)



Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

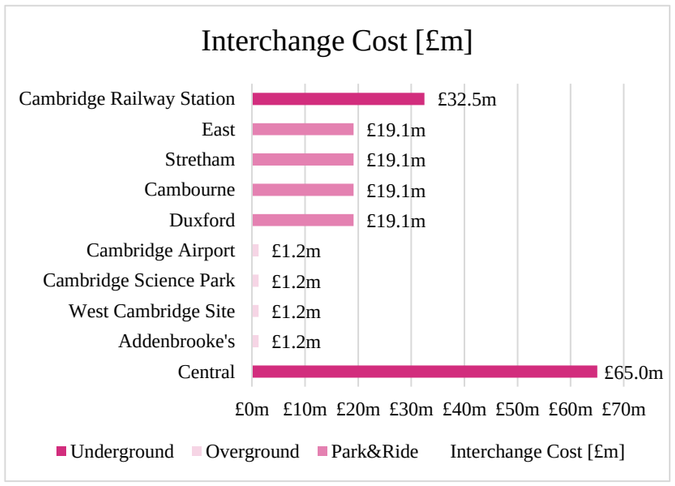
Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	1	Urban	100%	0%	0%	straight	3.5	1.4	3.5
2	1	3	Central <—> WCam	1000	1	Urban	100%	0%	0%	straight	2.9	1.3	3.1
3	1	4	Central <—> SciPark	1000	1	Urban	100%	0%	0%	straight	4.2	1.6	3.9
4	1	5	Central <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
5	2	3	Add <—> WCam	1000	1	Urban	100%	0%	0%	straight	5.5	2.1	4.7
6	3	4	WCam <—> SciPark	1000	1	Urban	100%	0%	0%	straight	5.4	2.0	4.6
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	0	Satellite	0%	64%	36%	12500	0.0	0.0	0.0
12	5	9	Airport <—> East	1000	0	Satellite	0%	64%	36%	9000	0.0	0.0	0.0
13	1	10	Central <—> Rail	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
14	10	2	Rail <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0



Option 9 | Star Twin

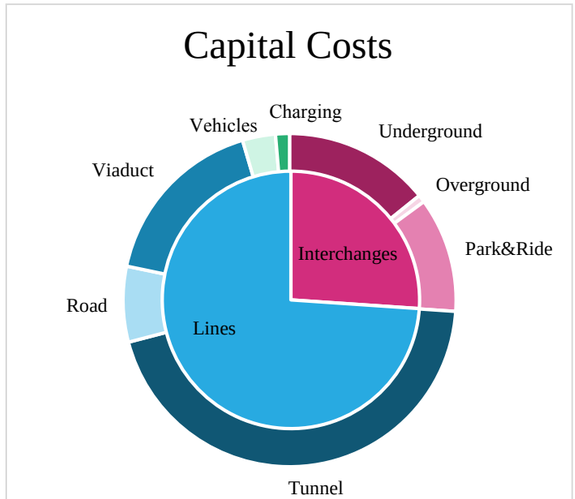
- All **star** routes including **Cambridge Railway Station**
- Twin bore tunnels throughout

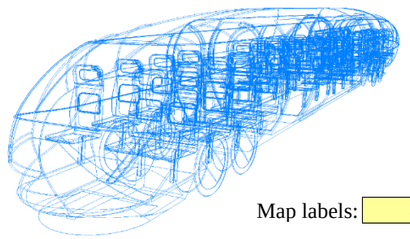


Total capital cost of system	(per km)
£686m	**£12.3m**

Lines	Vehicles	Charging	Distance
9	44	**8.3 MW**	**56.0 km**

Annual operating cost of system	(excluding loan)
£54.7m/year	**£11.3m/year**



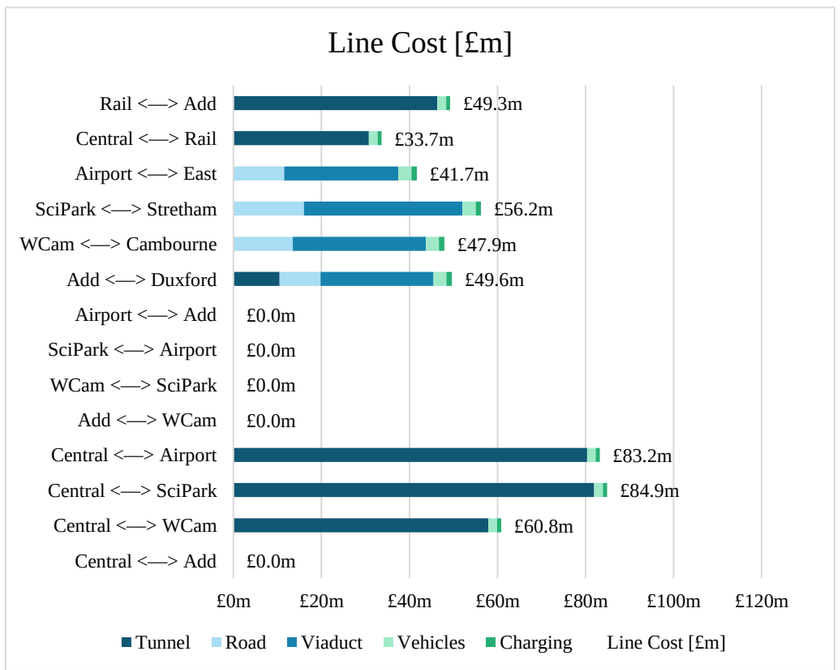


Nodes (Interchanges)

NID	Interchange	Build	Type	Abbr.	Grid † Reference
1	Central	1	Underground	Central	452585
2	Addenbrooke's	1	Overground	Add	457550
3	West Cambridge Site	1	Overground	WCam	424594
4	Cambridge Science Park	1	Overground	SciPark	469623
5	Cambridge Airport	1	Overground	Airport	492593
6	Duxford	1	Park&Ride	Duxford	467467
7	Cambourne	1	Park&Ride	Cambourne	320605
8	Stretham	1	Park&Ride	Stretham	526731
9	East	1	Park&Ride	East	578602
10	Cambridge Railway Station	1	Underground	Rail	462573

† Ordinance Survey TL (OS Landranger 154)

Capacity [h^{-1}]: 1000 Operational hours per day: 15 Map labels: Operating Freq. [min.]

Elements (Lines)

EID	N1	N2	Route name	Capacity [/h]	Track	Type	Tunnel	Road	Viaduct	Distance [m]	Distance [km]	Journey Time [min.]	Operating Freq. [min.]
1	1	2	Central <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
2	1	3	Central <—> WCam	1000	2	Urban	100%	0%	0%	straight	2.9	1.3	1.6
3	1	4	Central <—> SciPark	1000	2	Urban	100%	0%	0%	straight	4.2	1.6	1.9
4	1	5	Central <—> Airport	1000	2	Urban	100%	0%	0%	straight	4.1	1.6	1.9
5	2	3	Add <—> WCam	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
6	3	4	WCam <—> SciPark	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
7	4	5	SciPark <—> Airport	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
8	5	2	Airport <—> Add	1000	0	Urban	100%	0%	0%	straight	0.0	0.0	0.0
9	2	6	Add <—> Duxford	1000	2	Satellite	6%	52%	36%	8900	8.9	3.1	1.6
10	3	7	WCam <—> Cambourne	1000	2	Satellite	0%	64%	36%	10500	10.5	3.6	2.0
11	4	8	SciPark <—> Stretham	1000	2	Satellite	0%	64%	36%	12500	12.5	4.2	2.2
12	5	9	Airport <—> East	1000	2	Satellite	0%	64%	36%	9000	9.0	3.1	1.7
13	1	10	Central <—> Rail	1000	2	Urban	100%	0%	0%	straight	1.6	0.8	1.1
14	10	2	Rail <—> Add	1000	2	Urban	100%	0%	0%	straight	2.4	1.1	1.4