Essex Highways

North Essex Rapid Transit Study

Document Control Sheet

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Acknowledgements

It has hoped that this study gives certainty to proceed to design and develop a unified rapid transit system across North Essex which is integrated with major transport schemes and the creation of garden communities. In carrying out the study thanks must go to the NEGG transport working group which has provided clarity over the vision for North Essex and helped to ensure this study links to previous studies and investigated the right options to move the concept of rapid transit forward.

Thanks must also be expressed to the numerous people who have contributed to the research, analysis and report in one form or another. In particular, the public transport planning advice provided by John Hawthorne, Lucy Prismall and Dermot Hanney; the model development and forecasting work by Tiago Martins, Theofili Apostola and Mel Tobias; the contributions to route choices and innovation by Anirban Pal and Stelios Rodoulis; and the overview provided by Jonathan Whittaker and Hermann Maier.

Executive summary

The North Essex rapid transit study presents a case for taking forward the planning of a rapid transit system across North Essex as a keystone of integrated and sustainable transport. Rapid transit emerges as a missing piece of the North Essex transport system which will meet the need for those journeys that suit neither local bus and train for which car is often viewed as the only alternative.

A well-designed system will help to meet the transport demand arising from new residential and employment growth across the North Essex districts of Braintree, Colchester and Tendring, and surrounding districts. In particular, rapid transit will be able to connect the new garden communities to the existing centres of Braintree and Colchester. In so doing, rapid transit will contribute to the mitigation of congestion and environmental problems. It will also contribute to liveability, health and well-being, and unlocking diverse economic growth in the area.

This study draws together previous and partial investigations into rapid transit which have complemented development planning studies. The study aims to provide the wherewithal from which the planning, design and implementation of a rapid transit system can begin. Particular care has been taken to balance a strategic plan for rapid transit with realistic financial assumptions and opportunities for synergies and efficiencies with existing major transport schemes.

This though is only a step in the planning of a rapid transit system. And there are still many interdependent options which need to be worked through including the choice of rapid transit mode, route choice, degree of segregation from existing traffic and location of interchanges. For example, the A120 and A12 schemes in the Braintree, Chelmsford and Colchester triangle present opportunities for a fully integrated transport corridor once route choices are finalised. This in turn will influence the rapid transit route into Braintree and how a system connects to Marks Tey. The study also recognises the need for rapid transit interchanges to facilitate onward travel by other active and sustainable transport modes. Hence there is an inextricable link with the Essex Cycling Strategy and public transport operations and improvement plans with rail and bus companies; and with expansion of park and ride.

Consideration has also been given to forthcoming changes in technology. It is argued that predictions of on-demand personal travel and autonomous vehicles

making more efficient use of finite road space alongside more energy efficient electric vehicles do not replace the need for rapid transit. Rather technology advances are the opportunity to create a higher quality personalised experience of public transport. Technology advances can support ticketing and information systems; energy efficiency and resilience; accessibility to rapid transit hubs; and, in time, driverless systems will create efficiencies and enable more frequent rapid transit services to be run at off-peak times.

Based on projected demand the study establishes that a sound business case could be formed to back the creation of a rapid transit scheme. This relies on projected growth across the area including building up the garden communities until 2051. A bus rapid transit (BRT) and guided BRT have high and medium benefit to cost ratios, respectively. And while a system based entirely on light rail transit (LRT) has a lower benefit to cost ratio, a case for considering LRT on busier sections such as in Colchester could be justified from an economic perspective. It is noted that any decision on which mode of rapid transit to use should be influenced by other factors such as contribution to the regional economy and sustainable development.

In addition, as part of subsequent planning an implementation plan will be required. This should decide between incremental implementation which would grow the rapid transit system in stages co-ordinated with developments; or creation of the infrastructure upfront with service levels changing to meet increasing demand from developments. The former choice is likely to develop rapid transit subsystems serving Braintree and Colchester earlier on the Local Plan period and connect the subsystems to create a unified system only in later years. However, if funded permitted, the backbone of the infrastructure could be created earlier on as in the latter choice, which could enable economies of scale with any A12 and A120 construction schemes and provide a rapid transit service to support the first stages of developments.

The financial case will also be dependent on the operating model chosen. This should consider the widest possible case of franchising models and a local authority run service; and whether adequate powers are in place to control the operation of the system and co-ordinate information, scheduling and ticketing with other operators in North Essex and adjoining areas, akin to a passenger transport executive.

While it is hoped some people will read the entire report, the chapters can largely be read independently and used to inform the next stages of planning.

- Chapter 1 provides a brief introduction to previous studies and explains the purpose of the report;
- Chapter 2 explains how rapid transit corridors have been identified based on assumptions for growth across North Essex and surrounding districts;
- Chapter 3 grounds the vision for a rapid transit system by setting the aspirations for service level and quality which will drive changes in travel choice;
- Chapter 4 provides examples on a range of rapid transit schemes from the UK and continental Europe which will inform choices across the broad modes of bus rapid transit (BRT), guided BRT, light rapid transit and tram-trains;
- Chapter 5 sets out the route choices for each of the main corridors in order to inform the next design stages. It shows how the sections are integrally connected to choices made on major schemes such as the A12 and A120, but also design choices with the garden community sites. This chapter also includes a section on innovation and smart technologies in order to future proof any investment;
- Chapter 6 explains how a transport model has been developed in order to help to assess and appraise rapid transit options. The transport model is a tool that is expected to be developed further should plans for rapid transit be taken forward in order to support choices and full business cases in future steps;
- Chapter 7 provides a strategic economic, financial and management appraisal. It provides evidence that a rapid transit system could be viable and practicable. It also identifies wider qualitative benefits that would inform decision and sets out the options for the first parts of the system co-ordinated with the 2017-2033 Local Plans.
- Chapter 8 provides a conclusion which suggests possible next steps.

1 Introduction

This study has been commissioned to draw together previous proposals and studies on rapid transit options in order to inform decisions on how and in what form rapid transit can contribute to integrated and sustainable transport across North Essex. Rapid transit could link together existing centres in Colchester, Braintree, Tendring, Chelmsford and Uttlesford, so supporting liveability, environmental and economic objectives. In particular, rapid transit could help to sustainably meet travel demand associated with development growth in the next Local Plan period to 2033 and continued growth beyond the period that has been identified in the three North Essex garden communities. The North Essex garden communities are:

- Tendring Colchester Borders
- Colchester Braintree Borders
- West of Braintree

The east Colchester rapid transit study (Jacobs, 2017) examined the case for a rapid transit system focussed on serving the proposed Tendring Colchester Borders garden community and the University of Essex campus plus a park and ride site for demand from east of Colchester. The study identified a number of route and technology options linking these places with Colchester station and Colchester town centre.

The option of utilising the rail network to create a rapid transit network linking the Colchester Braintree Borders garden community and developments in Colchester and Braintree was then investigated in a tram-train study (Jacobs, 2017). Broadly this found limited potential to utilise the mainline or the branchlines to Braintree and Sudbury. However, there was potential within east Colchester to use the line towards Hythe which was consistent with the previous east Colchester study.

Meanwhile other studies have investigated options for garden communities in North Essex (e.g. Aecom, 2016). The principles of such research have informed the emerging Development Planning Documents for the garden communities proposed at Tendring Colchester Borders, Colchester Braintree Borders and West of Braintree. While these developments grow to 2500 homes each by 2033 they continue to grow up to and past 2050/51.

Complementary research on economic growth and unlocking the economic potential of North Essex was also carried out, which recognised the potential for economic and employment growth in the area (Cambridge Economics and

SQW, 2017). In broad terms employment growth is centred around Harwich, Colchester, Chelmsford and, possibly, Stansted along with an expectation that new business will locate at garden community sites.

The draft development planning documents also explain how garden community developments are being guided by design principles, which have been adapted from the Town and Country Planning Association principles for garden towns. This set an ambition for integrated and sustainable transport. This is reflected in the Movement and Access Study for garden communities which has proposed ambitious targets for travel public transport and active modes (Jacobs, 2017).

Against this backdrop of achieving sustainable residential and employment growth alongside tangible improvements in quality of life, ECC has commissioned the North Essex rapid transit study in order to establish if it is an appropriate transport measure to be pursued as part of a transport strategy.

In order to meet this overarching objective, the study proceeds in stages to:

- Establish key corridors of movement which a rapid transit system would serve (Chapter 2);
- Establish the vision and service level criteria which would be required for a rapid transit system in order match aspirations (Chapter 3);
- Identify a long list of possible rapid transit options which could meet the criteria by drawing on examples and evidence elsewhere (Chapter 4);
- Consider details of route choice and innovation trends, which identify design challenges and whether rapid transit is future proofed (Chapter 5);
- Forecast demand for a rapid transit system and to develop a transport model which can be used to assess benefits (Chapter 6); and
- Conduct an appraisal of options using the output from the model but also giving consideration to non-quantifiable aspects (Chapter 7).

Hence, by consideration of quantitative and qualitative criteria the study is able to proceed to a conclusion on whether or not rapid transit is an appropriate measure to pursue.

2 Corridors of movement

2.1 Understanding demand

2.1.1 Background

Future transport demand in North Essex including the three garden communities will comprise:

- Existing demand to and from existing communities
- Growth in demand to and from existing communities
- New demand to and from garden communities
- New demand to and from other new developments in North Essex

The corridors considered in this report have initially been determined based on forecasts for new demand to and from the garden communities and existing communities. However, since overall future demand on the identified corridors will be influenced by each of the above elements consideration has also been given to future developments, a number of which are close to the identified corridors.

2.1.2 North Essex garden communities

Demand data for the AM peak hour (0800-0900) has been obtained for each of the three garden communities from the previous Movement and Access Study (Jacobs, 2017). This is broken down by origin for arriving trips and destination for departing trips.

For each garden community we have ranked destinations for departing trips in order to identify the top four flows. As a cross-check we have also ranked the 2011 Census journey to work data for areas which correspond with the planned locations for the garden communities.

Table 2-1: West of Braintree - top four flows

West of Braintree	NGCS forecast 2032	Census 2011
Braintree	36.3%	35.4%
Uttlesford	20.0%	14.0%
London	12.2%	12.8%
Chelmsford	11.0%	10.2%

Table 2-2: Colchester Braintree Borders - top four flows

Colchester Braintree Borders	NGCS forecast 2032	Census 2011
Colchester	47.6%	42.8%
Braintree	11.6%	12.0%
London	11.1%	11.7%
Chelmsford	6.1%	5.5%

Table 2-3: Tendring Colchester Borders - top four flows

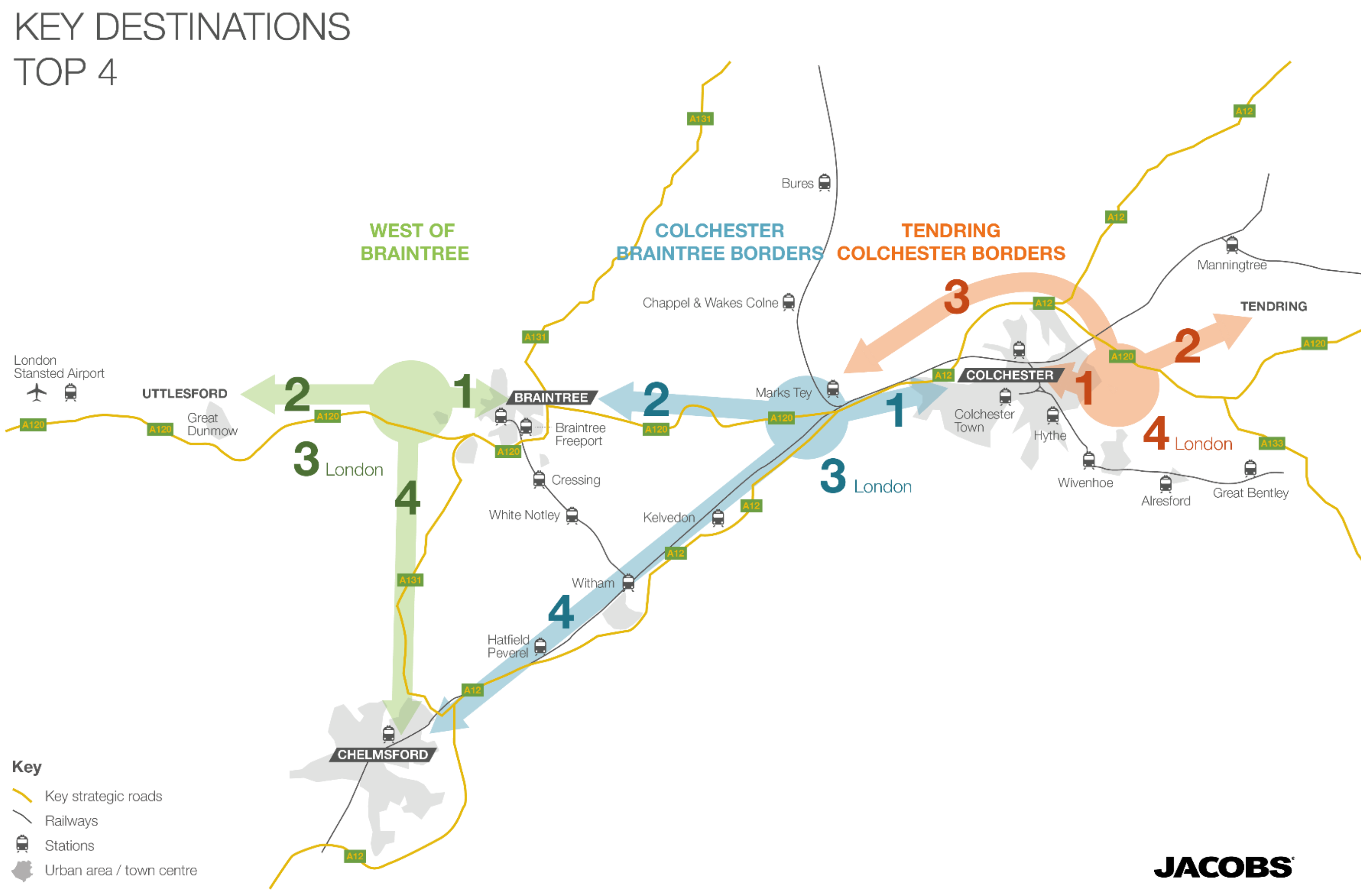
Tendring Colchester Borders	NGCS forecast 2032	Census 2011
Colchester	60.8%	45.6%
Tendring	8.4%	15.1%
West Tey	8.3%	1.2%
London	7.1%	9.6%

Key points from these tables are that:

- The top four flows typically account for 70-80% of the total demand;
- For each of the garden communities, London is ranked in the top four; and
- Colchester Braintree Borders is expected to expand as an employment location by 2032 and generate significant flows across Colchester.

The relationship between these flows is presented in the figure below.

Figure 2-1: Demand from garden communities



2.1.3 Wider developments

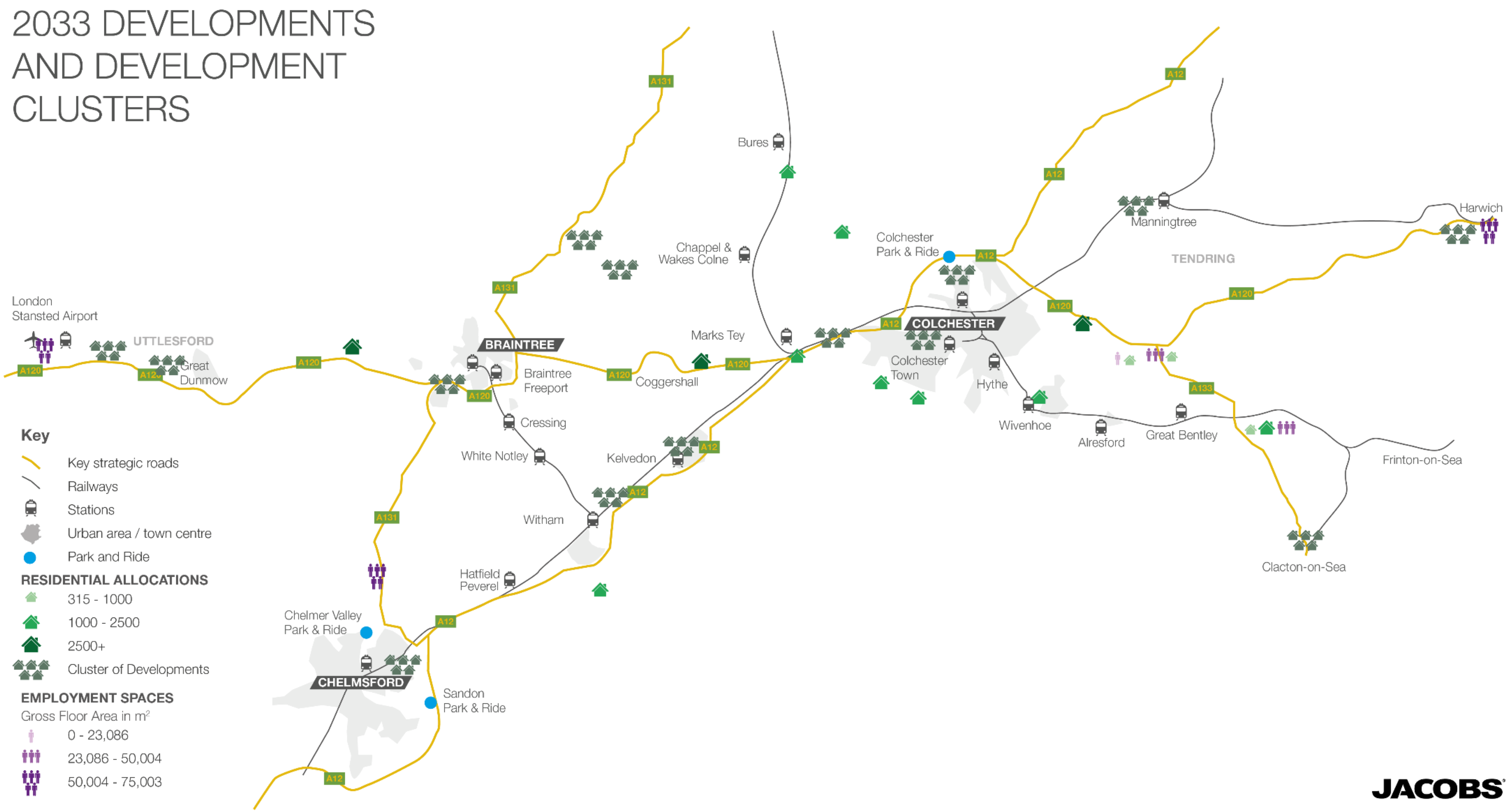
In addition to the plans for the garden communities, a number of other new developments are planned in North Essex and adjacent districts, which could influence flow patterns to and from the garden communities, but also increase demand for public transport.

In Uttlesford an additional garden community is planned at Easton Park close to Great Dunmow and employment at Stansted airport is set to grow. Meanwhile significant employment development is expected in North Chelmsford alongside approximately 10,000 new homes in Chelmsford District.

Within the North Essex districts notable development clusters are found at Braintree, Coggeshall and Witham. Meanwhile significant development plans are emerging for Colchester including expansion of the University as an employment centre.

The figure below shows the location of all developments identified in the emerging Local Plans. Further information on the quantum of these developments is given in Chapter 6.3 which informs the analysis of demand for rapid transit services. This chapter, in contrast, is focussed on identifying the patterns for demand.

Figure 2-2: Wider developments



2.1.4 Centres of attraction

Based on the “top four” analysis, key existing centres of attraction which should be served by the emerging rapid transit corridors are:

- Colchester
- Braintree
- Chelmsford
- London

Of these Colchester, Braintree and Chelmsford are considered within the main study area. In addition, there are key links:

- With Uttlesford to the west of the study area extending to Stansted
- With Tendring to the east of the study area

2.2 Considerations and challenges

2.2.1 Background

The focus of this study is the identification of significant interurban movements and thus the development of transit corridors linking the garden communities and the key centres of attraction. It is intended that the services provided on the corridors are reasonably fast and with relatively few stops or stations. Wherever possible this should be achieved through the use of infrastructure which is at least segregated from general traffic and, preferably, dedicated to the chosen mode or modes.

The planning of the transit corridors will take into account key locations for employment, education, healthcare and retail activity; however, the corridors will not necessarily provide direct services to all parts of the garden communities or the existing urban centres. The emerging corridors are not intended to offer a complete solution for local transport demand within each garden community.

It is therefore important that the transit corridors and the services operated are designed to link into local feeder and distribution services at key interchanges both within the garden communities and the existing urban centres of attraction.

2.2.2 How corridors serve garden communities

It is important that the corridors serve the “community centre” of each of the garden communities, as this will also be a focal point for local services and the origin or destination of many trips.

However, access to these centres should be on infrastructure which is at least segregated from general traffic and, preferably, dedicated to the chosen mode or modes. Depending on modes chosen for local services, these could potentially also use the transit corridor for part of their route, provided this does not impede the operation of the rapid transit services.

The central stops or stations should offer high-quality interchange with local services, cycling and walking. Ideally, the corridor should act as a spine for the development of the garden community, with local neighbourhood centres designed around stops on the transit corridor, which also act as interchange points with feeder services. This will require transport planning to be integrated with development planning.

2.2.3 How corridors serve existing conurbations

Serving existing conurbations presents greater challenges, including:

- Identification of key locations to be served
- Identification of optimal routes through the conurbations

Table 2-4: Challenges in serving existing conurbations

Existing conurbation	Challenges in identification of key locations	Challenges in identification of optimal routes
Braintree	Two rail stations- one central, and one on A120 bypass Bus station in separate location from rail station	Historic town centre with narrow streets and semi-pedestrianised market square Main east-west road through town (B1256) runs to north of town centre Rail line runs to south of town centre, with section west of station now converted to cycle/walking route
Chelmsford	Main hospital to north of town Proposed new rail station at Beaulieu Park	Historic town centre with narrow streets
Colchester	Key employment, health and education facilities on periphery of city centre University of Essex campus approx. 3km south-east of city centre On-street bus station in town centre, but already congested Three rail stations. Main station approx. 1km north of city centre. Town station closer to town centre but not on main line Hythe closest to University (approx. 1.5 km) and Tendring Colchester Borders Garden Community, but only hourly local service	Historic town centre with narrow streets. Peak hour congestion. Poor quality road links eastwards from city centre
Marks Tey	Rail station to east of majority of current and proposed development	Current A12 corridor and A120 junction cause severance between station, current shopping parade and residential development

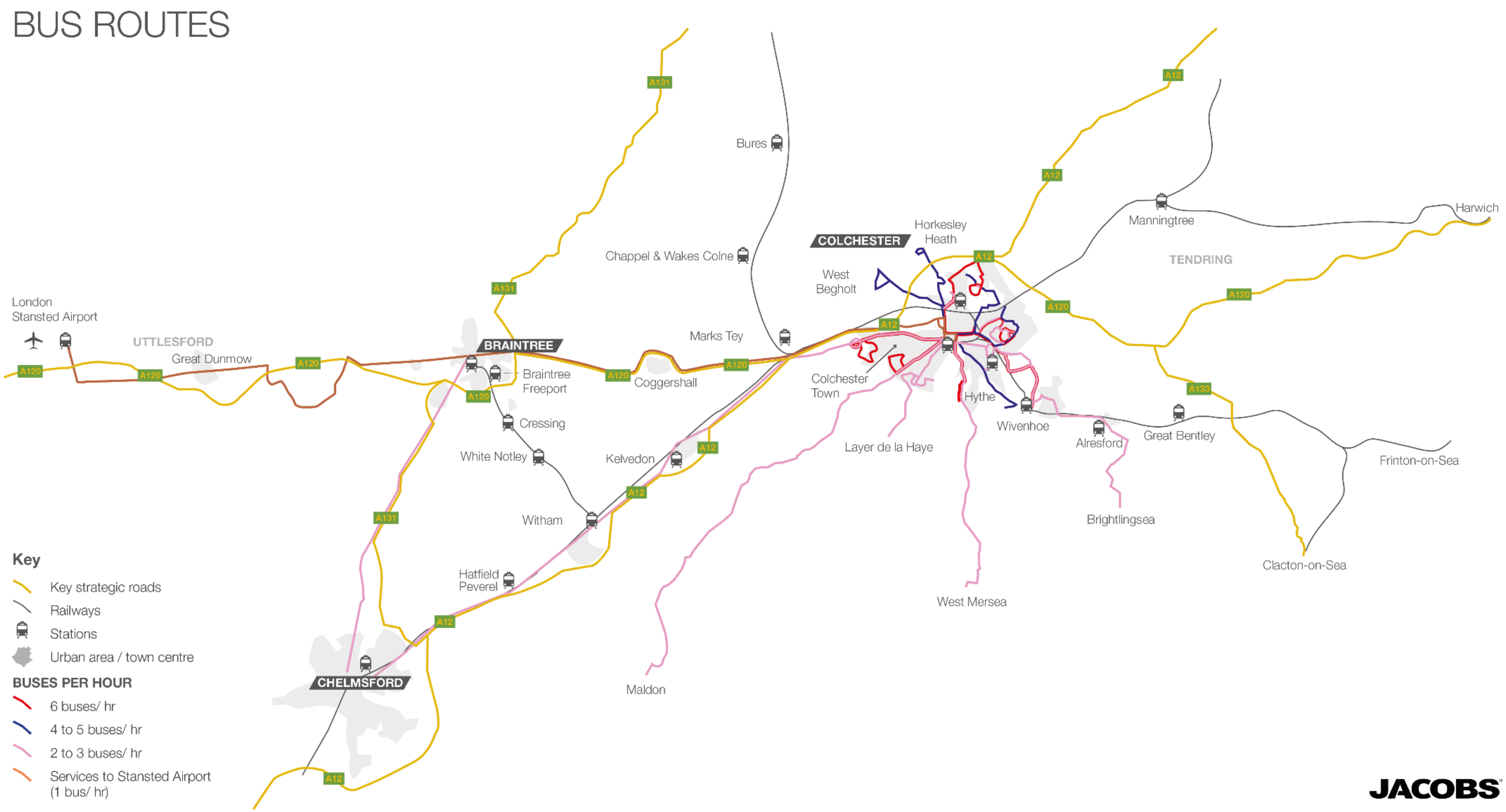
2.2.4 How corridors interact with current and planned transport facilities

Existing bus network

Nearly all towns and villages in North Essex are served by a bus. This can be seen in Figure 6-2 in a later chapter of the report, which shows the extent of the public transport (bus and train) network used in the transport model.

However, once bus services providing a frequency of less than two buses per hour are removed, the extent of coverage is far more limited. This is shown in the figure overleaf. Note the figure also shows the bus service between Colchester and Stansted even though this offers a service of once per hour.

Figure 2-3: Bus services



Existing rail network – including impact on any capacity issues

The study area is served by the Great Eastern Main Line (GEML) linking London with Ipswich via Chelmsford and Colchester, together with branches to Braintree, Sudbury, Colchester Town and Clacton. The key infrastructure characteristics are shown in Table 2-5

Table 2-5: Rail infrastructure characteristics

Section	Capacity	Electrified
Chelmsford - Colchester	Double track loops at Witham where fast services can overtake stopping servies	Yes
Witham – Braintree	Single track no passing loops	Yes
Marks Tey – Sudbury	Single track no passing loops	No
Colchester – Colchester Town	Double track	Yes
Colchester Town - Clacton	Double track	Yes

The line between Chelmsford and Colchester is served by a mixture of fast, semi-fast and stopping passenger services, plus freight. The mixture of stopping patterns and operational speeds together with the requirement to ensure paths are available for freight trains, limits capacity to introduce additional services or station calls.

The loops at Witham are used during peak hours to enable fast services to overtake stopping services.

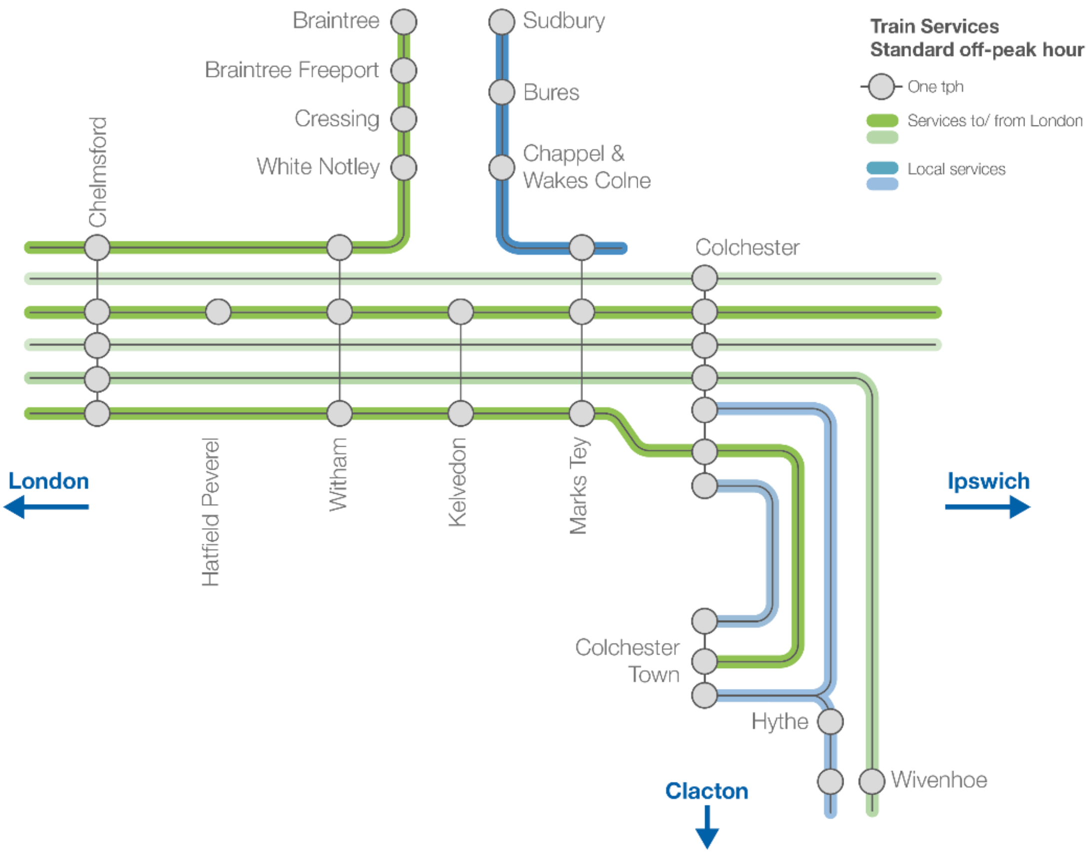
The Braintree and Sudbury branches are both single track with no passing places. This effectively limits capacity to a basic service of one train per hour, with slightly shorter intervals between services in the peaks.

Colchester Town station has a single platform, but the branch is double track. The Clacton branch is also double track.

All regular passenger services are operated by electric trains, except the Sudbury branch which is operated by diesel trains. The new train fleet, planned for introduction from 2019, includes bi-mode units (diesel and electric) and it is understood that these may be used on the Sudbury branch with services extended to Colchester or Colchester Town.

The current off-peak service pattern is shown in Figure 2-4.

Figure 2-4: Rail services



Service frequencies are increased during the peaks, as shown in Table 2-6.

Table 2-6: Off peak and peak service frequencies

Key station	Off-peak (trains per hour)		Peak (trains per hour)	
	London	Local	London	Local
Chelmsford	5	-	9	-
Hatfield Peverel	1	-	3	-
Witham	3	-	8	-
Braintree	1	-	Every 45 mins	-
Kelvedon	2	-	5	-
Sudbury	-	1	-	1
Marks Tey	2	1	4	1
Colchester	5	2	9	1
Colchester Town	1	2	2	1
Hythe	-	1	1	1
Wivenhoe	1	1	1	1

Peak based on departures from Liverpool Street 1700-1759 plus indicative local services.
Some colour coding based on combined service levels where local services provide additional connections.

Overall, the high peak train service frequency is double the basic off-peak service, however to maximise use of line capacity there is greater variation in stopping patterns.

Park and ride sites

Previous work on schemes for East Colchester included links to the existing park and ride site on the A12 north of Colchester, and a proposed site on the A133 adjacent to the Tendring Colchester Borders garden community.

These sites are considered in the context of their potential to add demand, and therefore influence service levels on the emerging rapid transit corridors

2.3 Transport integration opportunities and co-ordination

2.3.1 A12 and A120 road schemes

Highways England proposes to widen the A12 between junction 19 (Chelmsford) and junction 25 (A120 interchange) with possible start date of 2020-21.

Four options were presented for consultation. All the options link into the existing interchanges 19 and 25, and include widening of some or all of the existing alignment. However, in three of the options either or both of the following sections of new alignment are proposed:

- New alignment past Rivenhall End
- New alignment between Feering and Marks Tey

A new alignment between Feering and Marks Tey could potentially allow better integration of the A12 into the masterplan for the Colchester Braintree Borders garden community, and enable the existing A12 alignment to be repurposed to better serve the garden community. The consultation period is now closed; however, the project team is continuing with further investigations, and has extended the options selection assessment, with an expected announcement of the preferred route in winter 2017/18.

Figure 2-5: A12 route options 1 and 2

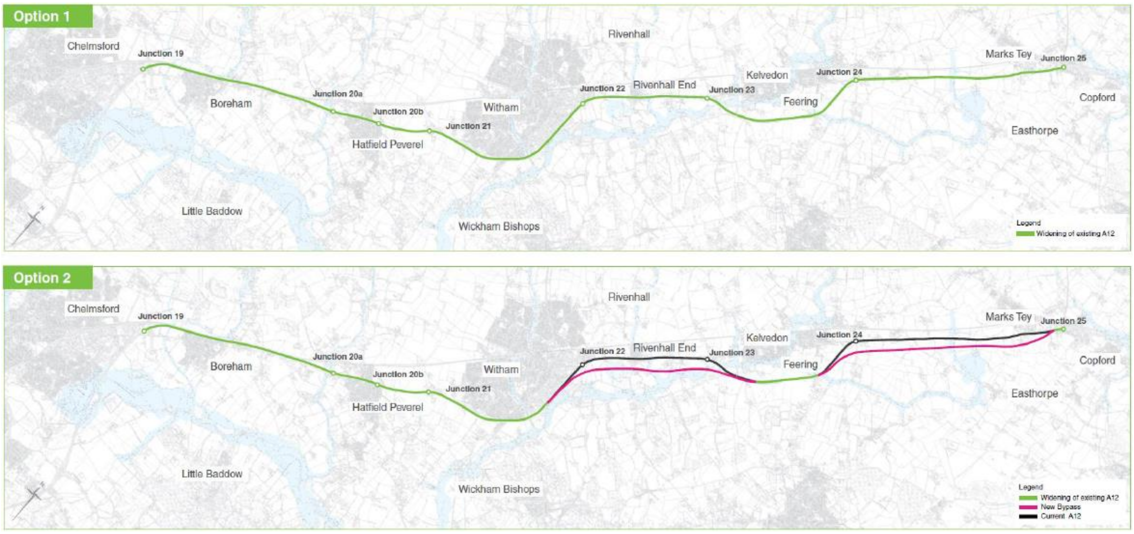
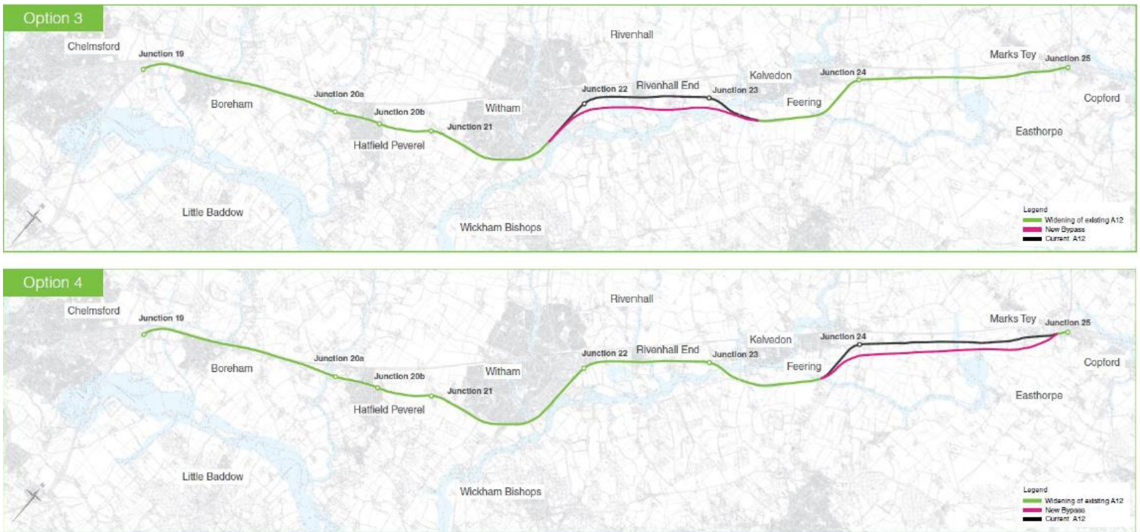
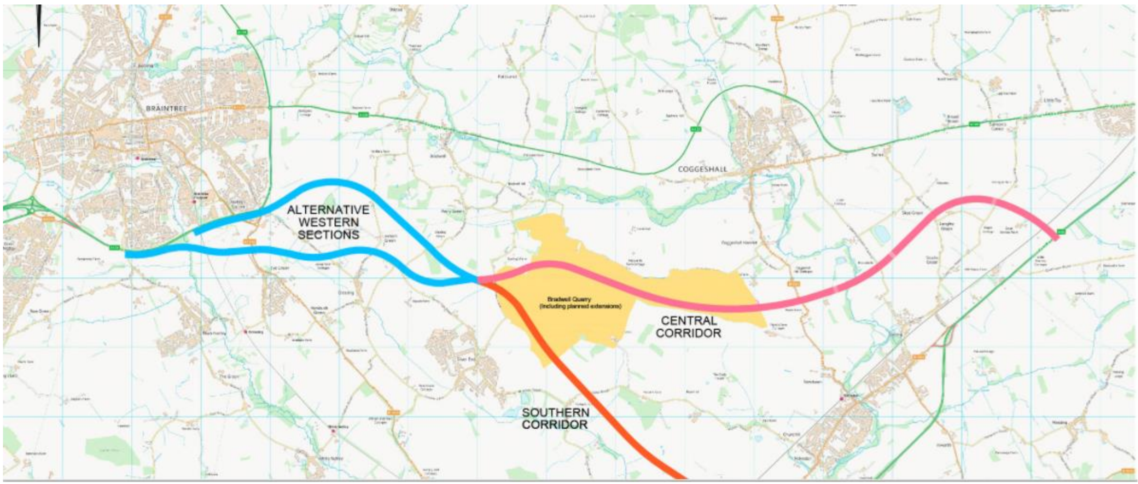


Figure 2-6: A12 route options 3 and 4



Although the A120 is a trunk road operated by Highways England, the Government asked Essex County Council to lead on the feasibility study in order to determine the best way forward. A total of four options are proposed for improvement of the A120 between Braintree and the A12. The two western sub options connect into the existing A120 Braintree bypass; continuing along either a southern corridor joining the A12 at the intersection south-east of Kelvedon, or a central corridor joining the A12 at a new intersection between Feering and Marks Tey.

Figure 2-7: A120 route options



The development of a new road corridor between Braintree and the A12 offers the possibility of designing segregated or dedicated alignments for rapid transit, either alongside the new road or as part of repurposing the existing A120.

In combination, the A12 and A120 proposals offer significant possibilities for the development of a rapid transit system.

2.3.2 Rail schemes and constraints

Greater Anglia is introducing a new timetable, promising more frequent and reliable services. However, capacity constraints on the Great Eastern Main Line mean that achieving shorter journey times between London, Ipswich and Norwich, will potentially reduce spare capacity for additional services or station calls south of Colchester.

Greater Anglia has also placed orders for new rolling stock to replace existing vehicles. The new fleet, planned for introduction from 2019, includes more vehicles than currently in service, offering the potential to increase capacity by lengthening trains, in addition to introducing additional services. It also includes bi-mode units (diesel and electric), which it is understood may be used on the Sudbury branch with services extended to Colchester or Colchester Town.

Services on the Braintree branch are limited by the singe track, and it is not currently possible to operate more frequently than every 45 minutes during the peaks. The addition of a passing loop and alterations to the track layout at Witham could potentially enable a half-hourly service to be operated, however it is unlikely that more than one train per hour could be extended to London, due to capacity constraints on the Great Eastern Main Line.

A new station is proposed at Beaulieu Park, northeast of Chelmsford. The service pattern has yet to be agreed, but it is likely that there would be consequential changes to the pattern of services and station calls on the line through to Colchester, especially if the new station provided the opportunity for terminating services.

2.3.3 Stansted Airport

Stansted Airport is currently served by rail services to London (4 tph) and via Cambridge (1 to 2 tph), also bus services to destinations including Great Dunmow, Braintree, Chelmsford and Colchester. The introduction of additional rail services is constrained by the single-track tunnel under the runway, which inhibits operation more than 6 tph, therefore any capacity improvements would require additional or reconfigured rolling stock.

2.3.4 Other opportunities

The rail line between Witham and Braintree originally continued onwards to Great Dunmow and Bishop’s Stortford. Much of the trackbed is now part of the National Cycle Network, and the solum has been taken over by the B1256 at

Great Dunmow and severed by the M11 and industrial development on the outskirts of Bishops Stortford.

2.4 Rapid transit corridors

Based on the key destinations and centres of attraction we have identified three types of corridor and six corridors as shown in the following tables.

Table 2-7: Corridor characteristics

Type	Characteristics
Interurban	Corridors linking garden communities and key local centres of attraction within North Essex
External links	Corridors linking garden communities with significant centres of attraction adjacent to the main study area, namely Chelmsford and Stansted
London commuter	Links between garden communities and commuter railheads These are Colchester, Marks Tey, Braintree, Witham, Chelmsford, Stansted and Beaulieu Park (if developed)

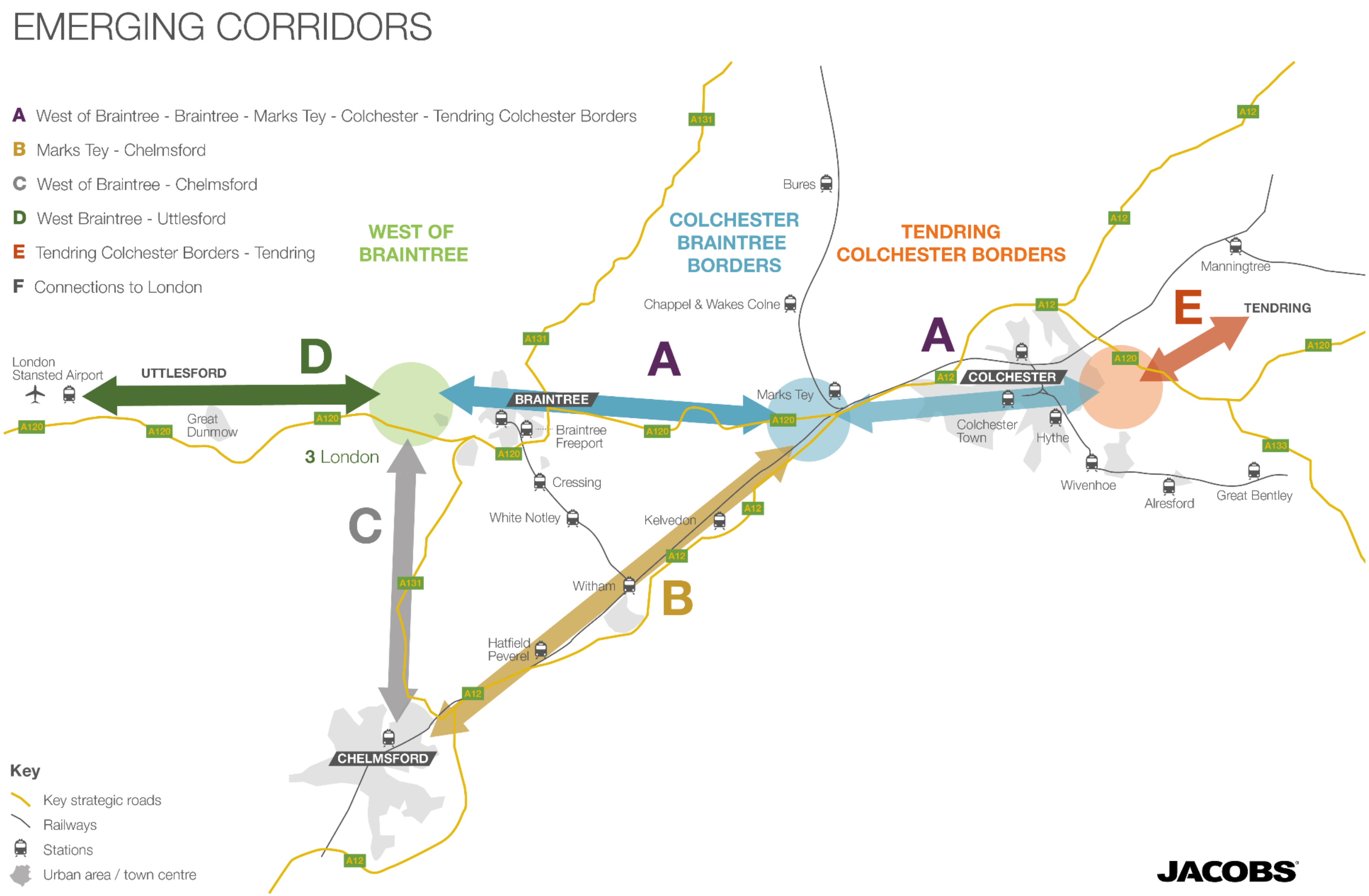
Table 2-8: Corridors

	Type	Communities served
A	Inter -urban	**West of Braintree** – Braintree – **Colchester Braintree Borders** – Colchester – **Tendring Colchester Borders**
B	Inter -urban	**Colchester Braintree Borders** - Chelmsford
C	Inter -urban	**West of Braintree** - Chelmsford
D	External links	**West of Braintree** – Uttlesford
E	External links	**Tendring Colchester Borders** - Tendring
F	London commuter	**Garden communities** - London

Corridors A-E are shown in the figure below. Corridor F is a virtual sub-group of flows which can potentially be accommodated within some or all the physical corridors A-E. In particular, the corridors may be designed to influence the use of specific railheads by commuters from each of the garden communities.

In terms of assessing the feasibility of a rapid transit system for North Essex, the modelling and appraisal chapters focus on a system created around corridors A, C and D, which are the main flows. It was considered that rapid transit could not, in the first instance, compete against the mainline rail route on corridor B. Meanwhile, corridor E represents numerous connections to Tendring some of which can be undertaken by rail. Hence corridor E could not simply be coded for a strategic options assessment. It was, nevertheless, considered sufficient for the assessment of a rapid transit to base the system on corridors A, C and D.

Figure 2-8: Emerging corridors



3 Understanding the local vision

3.1 Background

In the previous chapter a number of possible corridors which could form a rapid transit system were identified. This chapter presents a local vision for a rapid transit system across North Essex. This vision provides the detail which informs how we select between options. Hence the vision informs subsequent chapters which identify relevant rapid transit examples and service configuration scenarios.

Figure 3-1: Word cloud for DPD sections on integrated and sustainable transport

The vision has been derived from the draft Development Planning Documents (DPDs) for the three North Essex garden communities, which are at the time of writing, being consulted on publicly. These documents present a refined view of the options and ideas developed in technical studies and masterplans introduced in Chapter 1.

The draft DPDs each have sections on plans for integrated and sustainable transport at the garden communities. Figure 3-1 shows a word cloud in order to illustrate the emphasis placed on certain aspects of a transport system in these documents. In the word cloud it can be seen that the sustainable connection of garden communities comes across strongly in terms of the frequency of words used. Notable also is mention of 'new', 'rapid' and 'public'.

In addition, the vision has been informed and tested with the NEGC transport working group, with whom the consultant team met four times during the course of the study.

3.2 Objectives

3.2.1 For whom and what purpose is a rapid transit network proposed

The rapid transit system aims to connect the largest and most significant new and existing centres across North Essex. These include centres of residential communities but also those of education, retail and business. It is considered that the new garden communities will be significant residential communities but also, potentially, economic centres when fully grown post-2050. Over the draft Local Plan period up to 2033, growth in and around existing centres including Braintree, Colchester and Chelmsford will be greater than in the garden communities; hence this provides an equivalent opportunity.

The rapid transit system aims to provide a practical alternative to travelling by private car. This desire to provide an alternative is driven by congestion, environmental and health concerns as evidenced in the opportunities and challenges identified in the shared strategic section of the North Essex Authorities' draft Local Plans (BDC, CBC and TDC, 2017).

Recent Local Plan transport studies in Braintree and Colchester identified how existing congestion hotspots will worsen with forecast levels of development. However, there are decreasing opportunities for increasing capacity on the road network within existing centres such as Colchester and Braintree. While opportunities are being taken to increase capacity on strategic routes such as the A120 and A12, this does not present a solution to accessing centres.

Meanwhile concerns over protecting and enhancing the environment alongside promoting opportunities for healthy lifestyles have driven a sustainable development approach, in line with wider ECC and central government policies. Reflecting these challenges, NEGC have adapted the Town and County Planning Association garden city principles for sustainable development. Rapid transit, in many respects, can be interpreted as a manifestation of these principles across North Essex.

3.2.2 Aspirations for mode share

The NEGC Movement and Access Study (Jacobs, 2017) proposed that the new garden communities aspire to a 40:30:30 modal split across all journeys in favour of active modes defined as walking and cycling.

Active Modes	Rapid Transit	Private Car
40%	30%	30%

Modal Split Targets for all journeys (weighted average).

However, such a split is distorted by short journeys within the garden communities which can be feasibly walked or cycled. For journeys within the hinterland of communities to populous destinations potentially served by a new rapid transit system the ambition is to achieve an equal modal split between rapid transit and private car use of around 40% each.

Active Modes	Rapid Transit	Private Car
24%	38%	38%

Consequently, the aspiration is to achieve an equality of opportunity in the choice between public transport and private car travel, which should result in an equal share of trips between rapid transit and private car.

3.2.3 Aspirations for presence and visibility

Currently, for local journeys in Colchester which is one of the most densely populated parts of North Essex, public transport accounts for 10% of journeys (based on journey to work data from the 2011 Census). Hence to achieve a 40% share of journeys on a rapid transit system will take a sea-change shift in travel behaviour.

It is considered that the rapid transit system must be perceived as a radically different alternative to the bus. While parts of the UK such as London and Brighton have achieved significant increases in bus share over the last twenty years, the context of these examples is different to North Essex.

When new residents move to the garden communities, it is a prime opportunity to change travel behaviour. In order for this to occur rapid transit needs to have a high level of presence and visibility. This will be assisted by clearly fitting rapid transit into the range of public transport options on offer.

Within North Essex longer journeys across the three districts or to destinations such as London are suited to rail while short journeys can be undertaken by bus. However, rapid transit suits mid-length journeys, assuming onward connections are available.

3.2.4 Aspirations for quality

In using rapid transit to alter the perception of public transport, the quality of the offer is going to be an important factor. This will be driven by a number of subjective factors such as look and feel, journey experience and ease of use.

These can be influenced by consideration of:

- Supporting work and relaxation (tables, power sockets and refreshments for longer journeys)
- Journey information
- Ease of payment and ticket systems
- Reliability in terms of journey times (using segregated routes to avoid congestion)

Hence in selecting rapid transit options, it is considered appropriate to draw on examples that have demonstrated they can meet such criteria. And in terms of appraising options consideration needs to be given to the cost of ensuring such quality of service is deliverable.

3.2.5 Aspirations for level of service

Assuming the rapid transit system connects the key community and economic centres and is perceived as high quality, it still needs to meet a level of service in terms of frequency, journey time and capacity in order to be considered as a practicable alternative to the private car.

While these factors will evolve as a system is designed it is proposed that we consider aiming for:

- At least four services per hour
- Equivalent generalised cost between rapid transit and car
- Sufficient services to accommodate forecast public transport demand
- Flexibility to expand to meet additional demand

Another aspect of level of service is network resilience so the rapid transit system can operate even though there might be breakage somewhere in the system.

These aspirations are explored further in the subsequent chapters by drawing on findings from rapid transit systems elsewhere and in exploring options for North Essex using a transport model.

3.3 Other drivers and considerations

3.3.1 Background

A number of other factors are likely to influence the choice of rapid transit system. In broad terms these address wider sustainability issues; affordability and value for money; and opportunities arising from smart technologies.

3.3.2 Sustainability

The NEGC have created a series of charter principles which cover the socio-economic and environmental aspects of sustainable design. While rapid transport fits with the principle of integrated and sustainable transport, it must heed and support the other principles. Hence consideration should be given to how the rapid transit system supports:

- Green infrastructure – which could be indicated by opportunity for supporting green links, sustainable drainage schemes, noise minimisation;
- Employment opportunities – recognising how a rapid transit system can strengthen the local economy by attracting higher skilled jobs to the area but also tourism;
- Living environment – which could include the consideration of severance issues and how rapid transit hubs could be used as a catalyst with high quality public realm to reinforce centres of community.

In addition, energy efficiency and the type of energy used to power a rapid transit system could be a consideration.

3.3.3 Affordability and value for money

While it is hoped that the rapid transit system meets all the above requirements, there are financial limitations which should be considered. While upfront investment in capital can be expected if it is backed by a sufficiently robust business case, it would be expected that a system would have sufficient demand to cover its operating and maintenance costs net of any dowry.

However, given concerns over inequalities, fare levels should be set at an accessible level. In terms of this study, this can be reflected by using standard fare level assumptions with the economic appraisal. Therefore the more expensive systems, such as trams, will only be financially attractive if they can attract extra demand to offset increased costs or receive a capital subsidy.

3.3.4 Innovation and smart technology

The draft garden community Development Planning Documents recognise the role that digital technology can contribute to liveability. While smart living does not have to include a technological solution, it is recognised that digital technologies often play a supporting role. In addition, Essex County Council is exploring ways such innovations can support outcomes across the county.

In the context of the rapid transit system smart technology could be used do improve the user experience such as through seamless ticketing and information systems; and contribute to efficiency and resilience through energy optimisation and route optimisation. In time, driverless trams could be introduced which could further drive down costs.

Within the transport sector, there has been a trend away from car ownership and towards on-demand transport services such as Uber and cycle hire. There are also moves towards introducing non-petrol and autonomous vehicles. However, these innovations do not radically alter the pattern of demand or the need for mass transit solutions.

Hence this report considers a role for innovation and smart technology to improve the user experience, the efficiency of the system and access to and from rapid transit interchanges.

4 Rapid transit choices

4.1 Modes and characteristics

4.1.1 Modes considered

This section compares six possible modes which could potentially be used to operate rapid transit services. The characteristics of these modes are compared and contrasted in the subsequent subsections. The modes under consideration are:

- Bus
- Bus rapid transit (BRT)
- Guided bus rapid transit (GBRT)
- Tram (LRT)
- Tram-train
- Rail

4.1.2 Service type

There are four main service types, with characteristics as shown in Table 4-1.

Table 4-1: Service type characteristics

Service type	Characteristics
Local transit	Typical distance between stops in urban areas of ~400m
Urban mass transit	Typical distance between stops in urban areas of ~1km
Semi-Express	Mix of express links between urban centres with additional stops (~1km spacing) within the urban centres
Express	Single stop in urban centre, express links in between

The range of rapid transit options under consideration cover all service types, however, no one rapid transit option covers all the service types as shown in Table 4-2. As indicated in the previous chapter, a rapid transit system for North Essex fills a gap between local bus-based transit and express services provided by rail and coaches.

Table 4-2: Rapid transit modes by service type

	Local transit	Urban mass transit	Semi -express	Express
Bus	✓		✓	✓
BRT		✓	✓	
GBRT		✓	✓	
Tram/LRT		✓	✓	
Tram-train			✓	
Rail				✓

4.1.3 Infrastructure and guidance

There are three main categories of infrastructure used by rapid transit modes as summarised in Table 4-3

Table 4-3: Infrastructure characteristics

Segregation	Infrastructure type	Characteristics
Unsegregated	**Shared**	Infrastructure open for use by several modes with no specific priority for any particular mode
Segregated	**Reserved**	Separate identification or demarcation of infrastructure space for specific modes or categories of user
	Dedicated	Specially provided infrastructure for exclusive use of specified mode

In the case of rapid transit modes, the choice of infrastructure type is often determined by whether the transit system is retrofitted into an existing transport system or is part of a new construction where space can be set aside. Within these types of infrastructure there are two main types of guidance system shown in Table 4-4.

Table 4-4: Guidance systems

Guidance system	Characteristics
Non-guided	Vehicles are steered by driver who determines path followed
Guided	Specially designed infrastructure which enables suitably equipped vehicles to follow a precisely defined path

Depending on the type of guideway used, it is possible to configure vehicles which can follow a guideway where available, but they can also be steered by the driver on sections where there is no guideway provided, for example guided buses. Guidance offers four significant benefits to public transport modes as described in Table 4-5.

Table 4-5: Benefits of guidance systems

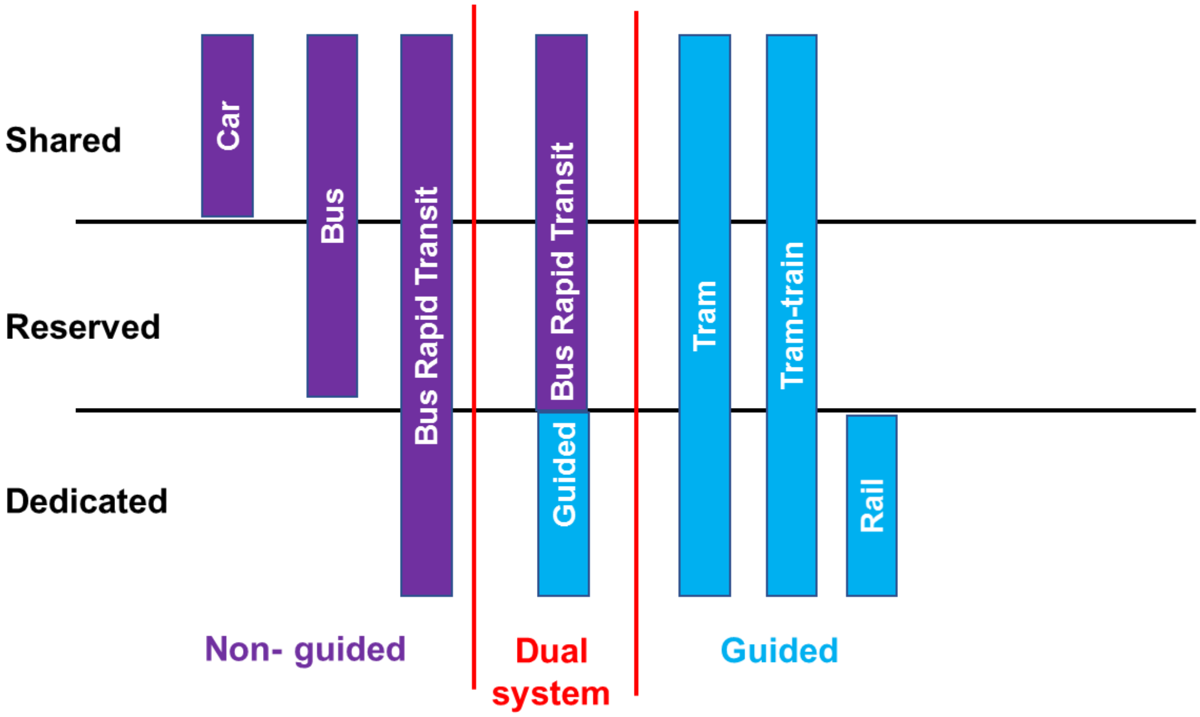
Benefit of guidance	Benefits
Capability	Guided vehicles can operate within a smaller spatial envelope such as tunnels and narrow trackways. They can also operate through restricted clearances at higher speeds than unguided vehicles.
Capacity	Guided vehicles can be longer than unguided vehicles, enabling higher capacity per vehicle.
Exclusivity	Depending on their design, the presence of guideways can deter use by other vehicle types.
Presence	Guideways are present and visible to potential transport users all times, and offer reassurance that services are available.

However, certain types of guideway, for example those requiring safety fencing or protruding above the road surface, can increase severance, especially if designated crossing points are required for pedestrians and other soft modes. The relationship between the modes under consideration in this study and infrastructure and guidance systems is shown in Figure 4-1.

Fully guided modes (tram, tram-train and rail) require the necessary guidance to be in place for the full length of all routes in the network, including access to stabling and maintenance facilities. This also constrains flexibility to extend or alter routes as services can only commence when all the necessary infrastructure is in place.

A significant advantage of guided buses is that they can also operate on sections of route without guideways, offering greater flexibility to extend or alter routes served. However, it should be recognised that tram tracks can be flush with road surfaces, so it is possible to run trams on shared infrastructure. The physical presence of tram lines also means that trams are more easily operated than buses in semi-pedestrianised settings.

Figure 4-1: Use of infrastructure and guidance by different modes



The following sections build on the characteristics identified above and provide sets of examples for each of the rapid transit modes under consideration.

4.2 Bus

The conventional bus is one of the more common and well established modes. Conventional buses typically operate on either shared or reserved infrastructure using a non-guided system. Conventional buses typically operate local transit services, though they also provide some semi-express services. The perception of the conventional bus has improved over the years, with new bus fleets now offering comfortable seating, Wi-Fi and USB charging points.

Example 1 - Oxford

Oxford offers a high quality bus system which is operated by various bus operators including Oxford Bus Company, Stagecoach, Arriva and Thames Travel. Buses cater for journeys within the city, as well as further afield to places such as Aylesbury, Reading and London (including major airports).

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

Some operators offer semi-express services which only stop at key stops, for example the U1X which runs between Oxford Brookes University's Wheatley, and Harcourt Hill Campuses.

Oxford has four park and ride sites which are strategically located nearby Oxford's ring road in the north, east, south and west. Services operate in a north to south and east to west movement, with the aim of reducing car use in the city centre.

Generally, buses in Oxford run on shared infrastructure within close proximity to the city centre, and also benefit from priority within the city centre itself. Reserved infrastructure is more frequent outside of the central area of Oxford, with various bus lanes offering the opportunity for more reliable journey times during peak periods.

Buses in Oxford run on an unguided system and therefore do not offer any of the benefits listed in Table 4-5.

Figure 4-2: Image of conventional bus in Oxford[1]

Example 2 – Reading

Reading also offers a high quality bus service which caters for the wider Reading area. Some bus routes offer a 24 hour, 7 days a week service which offers more flexibility to passengers. The majority of Reading Buses' services are local transit, with a few bus routes operating an urban mass transit service.

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

1 https://upload.wikimedia.org/wikipedia/commons/6/67/Oxford_Bus_Company_224_on_Route_X3%2C_Oxford_Station_%2815576900125%29.jpg

The type of infrastructure used in Reading is predominantly shared use infrastructure which reduces the attractiveness of bus travel as buses are subject to the queues experienced by other modes including car users. This congestion and delay on certain sections of Reading's network impacts on the journey times and reliability for a number of services.

Reading has the highest use of PlusBus tickets indicating the importance for train passengers to be able to interchange directly to buses to continue their journeys. Some of the main train to bus flows are to access the University of Reading and three major business parks: Green Park, Reading International Business Park and Thames Valley Park. There is also extensive use by children from outside Reading of buses from the station to schools within Reading[2]. As noted within Reading's Local Transport Plan, there are plans to introduce a mass rapid transit system in conjunction with new park and ride sites.

Similar to the Oxford example, buses run on an unguided system.

Figure 4-3: Image of conventional bus in Reading[3]

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[2] http://www.reading.gov.uk/media/2421/Local-Transport-Plan-2011-26/pdf/Local_Transport_Plan_2011-26.pdf
[3] https://greenerjourneys.com/wp-content/uploads/2015/08/15039263273_c7a2ff9314_o-1-1024x768.jpg

4.3 Bus rapid transit (BRT)

Bus rapid transit systems typically run on reserved or dedicated infrastructure, and in some cases some sections may run on shared infrastructure. Bus rapid transit is typically used for urban mass transit within conurbations, and semi-express inter-urban and commuter services.

Example 1 – Runcorn Unguided Busway

The purpose of this scheme was to provide a high-quality and accessible bus system by offering a local transit service which made buses competitive with private cars for local trips. The scheme has initiated a 16% shift from public transport to BRT and a 75% shift from car to BRT (on surveyed routes).

Service Type	**Local**	Urban mass transit	Semi-Express
Infrastructure Type	**Shared**	Reserved	**Dedicated**
Guidance	**Unguided**		Guided

The Runcorn scheme opened in 1971 and operates on a segregated busway which is dedicated for buses only on an unguided system. This particular scheme was built before development; the North Essex scheme is likely to follow this notion and be built prior to or at the same time as residential development.

Figure 4-4: Image of Runcorn BRT scheme[4]

Example 2 - Zuidtangent, Amsterdam

The Zuidtangent BRT system offers a direct route between Amsterdam Zuidoost, Schiphol Airport and Haarlem Central Station. Buses operate on a frequent basis at every 6 minutes during the day with the end to end trip taking approximately 60-70 minutes.

Service Type	Local	Urban mass transit	**Semi-Express**
Infrastructure Type	**Shared**	**Reserved**	**Dedicated**
Guidance	**Unguided**		Guided

[4] https://farm9.staticflickr.com/8539/8698427128_919fe9c302_b.jpg

The scheme incorporates both dedicated (37km) and unsegregated sections of busway running on an unguided system. Between Schiphol and Amsterdam Zuidoost, buses run mainly on public roads, including motorways, with some unreserved sections. Some sections of the route are also used by local buses, with off-line stops to enable express buses to overtake.

Since 2011, the service has been marketed as an integral part of the R-net (Randstad-net) system which includes bus, BRT, tram and metro services. The system includes a dedicated tunnel under the runway to access Schiphol airport, and has been designed for possible future upgrade to light rapid transit or tram operation.

Figure 4-5: Zuidtangent BRT – Amsterdam (Source: BRTdata)

Example 3 – Kent (Thameside) Fastrack

The purpose of the Kent (Thameside) Fastrack scheme is to provide a fast, reliable, efficient transport across Kent Thameside. Services run up to every 10 minutes offering a local transit service for local journeys from new and existing developments around Dartford, Bluewater, Ebbsfleet and Gravesend. It also provides links to Ebbsfleet International station and Bluewater shopping centre.

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

The Fastrack scheme runs on a combination of shared and reserved infrastructure on an unguided system as illustrated in Figure 4-6 below.

Figure 4-6: Image of Fastrack route[5]

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[5] http://www.go-fastrack.co.uk/wp-content/uploads/2014/06/fastrack-route-map.pdf

Dedicated Fastrack services are operated by Arriva, However, from December 2017, the section of London Buses route 96 between Dartford and Bluewater has been diverted to run on the Fastrack route. It previously ran non-stop on the public road network, but now additionally serves Darent Valley Hospital with no increase in overall journey time.

Figure 4-7: Kent (Thameside) Fastrack scheme[6]

Example 4 – East London Transit

East London Transit (ELT) is a network of services developed by Transport for London to meet the existing and anticipated demand for public transport in East London caused by the Thames Gateway redevelopment. Although originally conceived as a bus rapid transit system, it has limited segregation from other traffic and is operated as part of the London Buses network. The original East London Transit opened in phases between 2010 and 2013, since when it has been further developed and extended.

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[6] http://www.go-fastrack.co.uk/wp-content/uploads/2014/04/The-Bridge-1024x509.jpg?1512086410070

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

There are currently three routes, which combine on the core section between Barking town centre and the Thames View Estate. Most of the routes run on unsegregated roads, with segregated sections in Barking Town centre and short segregated sections within the existing Thames View Estate. Longer segregated sections are being provided on extensions to serve new development into Barking Riverside, however there is no bus priority or segregation at the signalised junction at Movers Way/River Road where the main access road from Barking into Barking Riverside crosses the A13.

Figure 4-8: East London Transit Scheme[7]

Much of the system has been developed by extending, upgrading and renumbering several pre-existing bus routes which served the Thames View

[7] http://www.ukbusawards.org.uk/content/images/stories/2010-SLImages/INF-ELTransit.gif

estate. Improvements include, higher frequency, longer hours of operation, new rolling stock, and new links to the station at Dagenham Dock. When the system opened, the buses carried a special livery. More recently, the introduction of new Routemasters resulted initially in operation with unbranded buses, with displaced ELT branded buses transferred to other routes

Routes EL1 and EL2 operate through areas of Barking Riverside which have yet to be developed. In particular, route EL1 has recently been extended to run every six minutes to serve a new school campus, and is also intended to attract demand as the surrounding area is built out.

Construction of an extension of the London Overground to Barking Riverside is expected to begin in early 2018, with train services starting during 2021. It is anticipated that the local bus network will then be reconfigured to serve the new station.

4.4 Guided bus rapid transit (GBRT)

A GBRT system is considered as a midway offer between conventional bus and tram systems in terms of achieving a similar speed, capacity and design. The differing factors between a BRT system and GBRT system are guidance, land uptake and speed. A GBRT system typically runs on dedicated infrastructure (guideways) and hence tends to be more reliable and faster than conventional buses.

Example 1 – Cambridgeshire Guided Busway

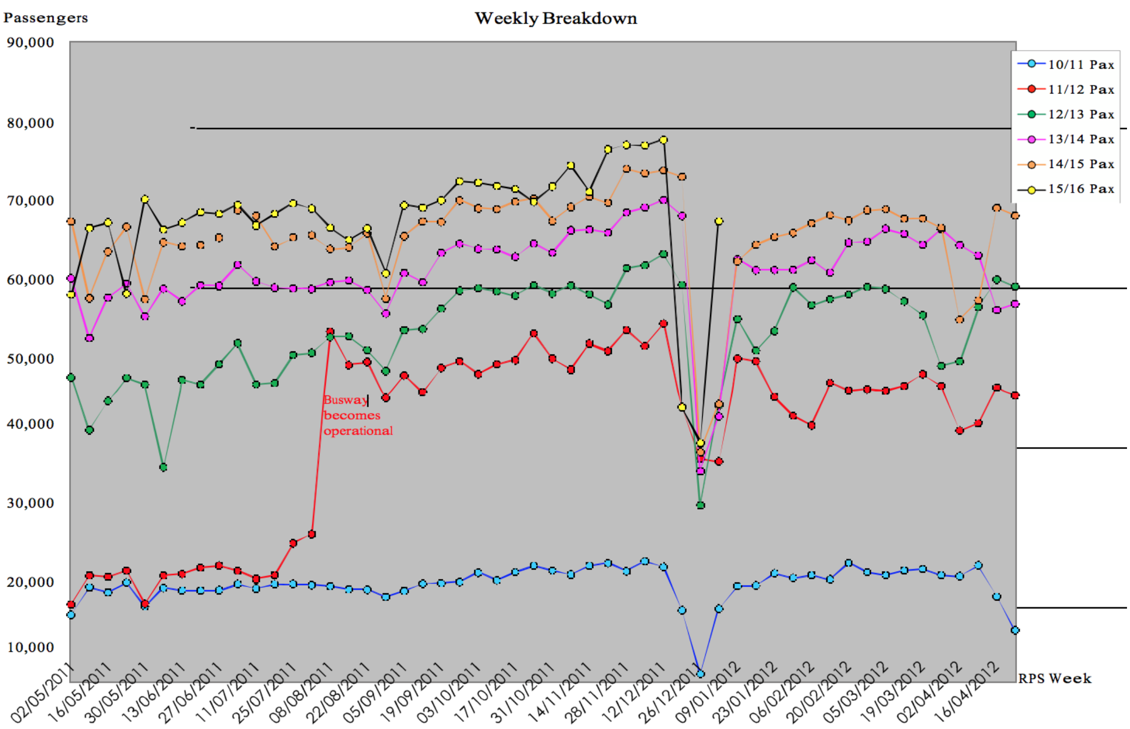
The Cambridgeshire GBRT system offers a semi-express service between Huntingdon, St Ives and Cambridge (including the rail stations and Addenbrooks Hospital). It also serves 4 park and ride sites (St Ives, Longstanton, Trumpington and Madingley Road). However, this unintentionally encourages drivers to travel to each of these park and ride sites using the car. With this in mind, the potential mode shift away from the car is likely to be limited.

This scheme predominantly operates on dedicated infrastructure, which allows speeds of up to 56mph to be reached. However, sections of the busways are not dedicated, instead there are some reserved sections for buses and taxis which are located in the historical city centre.

<table>
<tr><th>Service Type</th><th colspan="2">Local</th><th colspan="2">Urban mass transit</th><th colspan="2">Semi-Express</th></tr>
<tr><td>Infrastructure Type</td><td colspan="2">Shared</td><td colspan="2">Reserved</td><td colspan="2">Dedicated</td></tr>
<tr><td>Guidance</td><td colspan="3">Unguided</td><td colspan="3">Guided</td></tr>
</table>

The system demonstrates how a disused railway line can be utilised as a guideway for buses. The scheme which opened in 2011 has seen increasing patronage on a year by year basis as illustrated in Figure 4-6 which provides a weekly breakdown of passenger numbers for Stagecoach East.

Figure 4-9: Weekly passenger breakdown for Stagecoach East (source: Stagecoach East)



The busway operates on a guided system for the majority of the route. Which as identified earlier in Table 4-5, offers capability, capacity, exclusivity and presence.

Figure 4-10: Cambridgeshire Guided Busway (Source: Prismall, 2016)

Example 2 – Bristol MetroBus

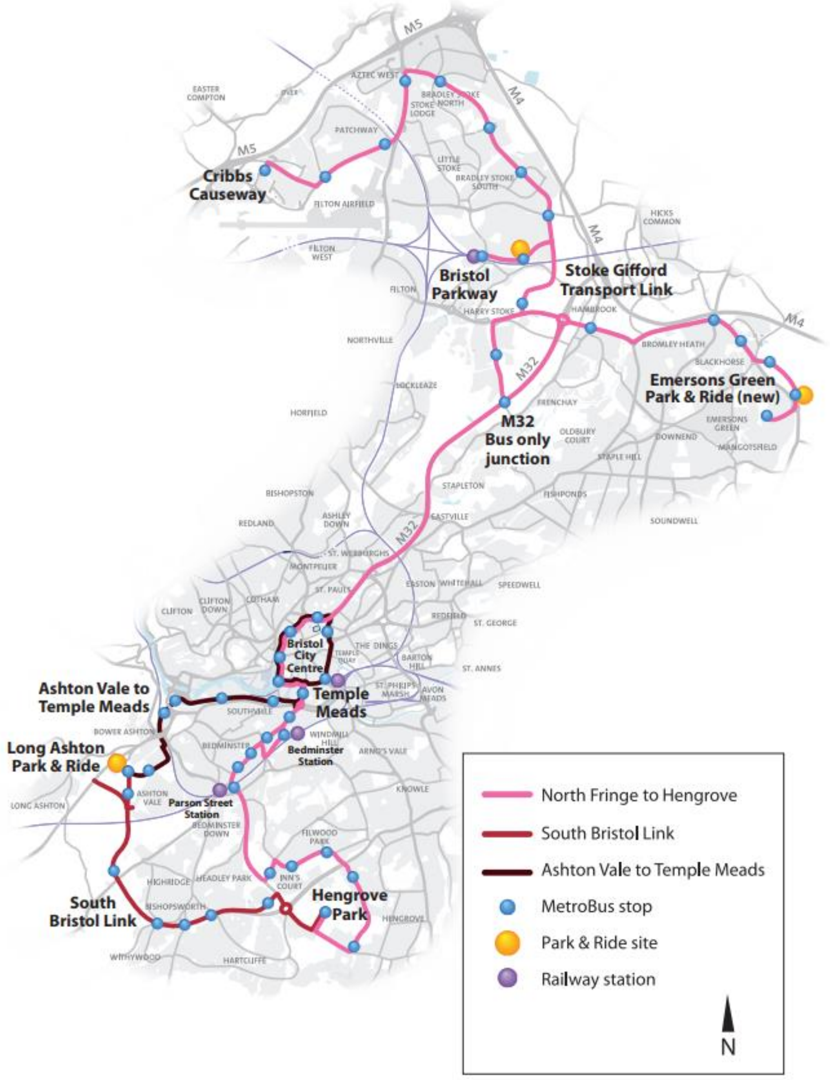
Bristol MetroBus system is planned to offer a smarter way of travelling that will speed up journey times, relieve congestion and reduce levels of congestion. The MetroBus has been promoted as offering a new express bus service along the 50km network[8], and is therefore likely to provide single stop services in the city centre, with express links in between.

<table>
<tr><th>Service Type</th><th colspan="3">Local</th><th colspan="3">Urban mass transit</th><th colspan="3">Semi-Express</th></tr>
<tr><th>Infrastructure Type</th><td colspan="3">Shared</td><td colspan="3">Reserved</td><td colspan="3">Dedicated</td></tr>
<tr><th>Guidance</th><td colspan="4">Unguided</td><td colspan="5">Guided</td></tr>
</table>

[8] https://travelwest.info/metrobus

Part of the scheme will run on a disused railway line, making use of segregated busways (dedicated) and bus lanes (reserved). The guided sections of the route will again offer the benefits discussed in Table 4-5.

Figure 4-11: Proposed MetroBus route[9]



:he world to be built outside a major city by a partnership of local authorities and private companies with automatic vehicle location, pre-trip and in-trip passenger information and automatic traffic signal priority from the start.

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[9] https://s3-eu-west-1.amazonaws.com/travelwest/wp-content/uploads/2013/08/metrobus_leaflet-map-June2016.pdf

<table>
<tr><th>Service Type</th><th colspan="2">Local</th><th colspan="2">Urban mass transit</th><th colspan="2">Semi-Express</th></tr>
<tr><th>Infrastructure Type</th><td colspan="2">Shared</td><td colspan="2">Reserved</td><td colspan="2">Dedicated</td></tr>
<tr><th>Guidance</th><td colspan="3">Unguided</td><td colspan="3">Guided</td></tr>
</table>

The Fastway system provides a local transit service serving the Crawley, Gatwick Airport and Horley area. Fastway operates along sections of dedicated guided busway and reserved bus lanes and has been specially designed to speed past congestion hotspots and offers a comfortable, reliable and efficient alternative to travel by car.[10]

A total of 1.5km of the route runs on guideway, offering some of the key benefits highlighted in Table 4-5. Sections of guideway have been used to prevent the use of certain road links between neighbourhoods by general traffic. However, longer sections of guideways tend to work better than multiple short sections of guideways with regards to achieving reliable journey times and faster services.

The routes run close to stations at Crawley, Three Bridges, Gatwick Airport and Horley, but interchange is of low quality. When introduced, services through Gatwick Airport were able to run on non-public roads within the airport perimeter, however security restrictions now mean that routes must stop at laybys on the main A23.

[10] http://www.fastway.info/about-fastway/

Figure 4-12: Image of Crawley Fastway system[11]

4.5 Light rail transit (LRT or tram)

Although trams can present reputable levels of modal shift, such systems also incur high capital costs (costing more than most bus-based systems) associated with transporting passengers to their ultimate destination, since trams are limited in terms of their flexibility and therefore typically run on simple routes with few branch lines. Costs can be categorised into construction, infrastructure, operations and maintenance. Tram and light rail services are typically urban mass transit. Longer routes can offer semi-express services – for example between suburbs and urban centres

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11 https://www.google.co.uk/search?q=crawley+fastway&rlz=1C1GGRV_enGB774GB774&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiL-qPQsoTYAhVjKsAKHfiIAbAQ_AUIDCgD&biw=1680&bih=919#imgrc=71DPkLlss4MrLM:

Example 1 – Freiburg

Line extensions and development around the tramlines has resulted in approximately 80% of Freiburg's population living within 800m of a tram stop offering a local transit type of service. The type of infrastructure in Freiburg varies between shared and dedicated, since all vehicles, cyclists and pedestrians can cross the tram lines, yet the trams themselves run on specific routes with the guided rail system embedded into the ground.

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

Figure 4-13: Freiburg's LRT system[12]

[12] http://www.lightrailnow.org/images02/fbg-lrt-stc-Hornusstrasse-grassy-pvtrow-btw-Stuhlingerbrucke-n-Fehrenbachallee-20040423_Michael-Taylor.jpg

Example 2 – Manchester Metrolink

The Manchester Metrolink was originally designed to take over two rail lines which required extensive modernisation, and to provide a more affordable cross-city link than the proposed heavy rail line. It has subsequently been expanded on new alignments to serve regeneration areas of the city and provide local links to the airport.

Service Type	**Local**	**Urban mass transit**	**Semi-Express**
Infrastructure Type	**Shared**	**Reserved**	**Dedicated**
Guidance	**Unguided**		**Guided**

Thus in comparison to the Freiburg scheme, the Metrolink provides longer distance services over a wider area. However, more people are using buses than the Metrolink since the bus network is more extensive with a larger proportion of residents living within walking distance from bus stops.

The Manchester Metrolink offers a frequent semi-express service, running on shared, on-street and dedicated infrastructure using a guided system. However, because the original parts of the system serve repurposed rail stations, the trams have high floors to align with standard height rail platforms. This means that stops at on-street sections are much more intrusive than those for low-floor trams, and cannot be shared with other modes.

Figure 4-14: Image of Manchester Metrolink[13]

Example 3 – Edinburgh Tram (GBRT to LRT)

The Edinburgh Tram has been chosen as a key example due to the fact that part of the route originally operated as a busway known as the 'West Edinburgh Guided Busway' or 'Edinburgh Fastway'. The 1.5km guided busway was built with a future tram network in mind. This flexibility and adaptability is one of the key advantages associated with bus rapid transit based systems. Essentially a 'pre-tram' system can test whether a tram system would fit the forecasted demand. In time, the bus based system can attract and increase passenger numbers, and once a desired level of patronage is reached, it could be upgraded to a LRT system.

The Edinburgh Tram connects to multiple transport interchanges, including Edinburgh Airport, a park and ride site at Ingliston, and connects with bus and rail services.

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[13] http://www.railtechnologymagazine.com/Rail-News/work-begins-to-transform-crumpsall-metrolink-stop-ahead-of-350m-expansion

Service Type	**Local**	Urban mass transit	**Semi-Express**
Infrastructure Type	**Shared**	**Reserved**	**Dedicated**
Guidance	Unguided	**Guided**	

The Edinburgh tram route covers 14km from York Place in the city centre to Edinburgh Airport. With 16 stops, the system offers an urban mass transit system with stops approximately 1km apart. The trams run on guided dedicated infrastructure, which is also shared with other road users at junctions in order to enable all traffic to turn.

Figure 4-15: Edinburgh tram

4.6 Very light rail

Conventional tram and light rail schemes are considered relatively expensive to implement because:

- Construction of the running lines and the associated foundations generally requires diversion of underground utilities, which is particularly expensive and disruptive in urban centres;
- Vehicles are of relatively heavy construction to ensure compliance with requirements for crashworthiness; and
- The vehicles are generally powered from overhead electric cables.

This means that trams are more difficult to justify for smaller scale schemes. Consideration is therefore being given to possible solutions including:

- Less disruptive forms of track construction to enable easier and lower-cost installation;
- Smaller, lighter weight vehicles, which can operate on lighter weight track; and
- Self-powered electric vehicles using new developments in battery and charging technology.

Example – Coventry Very Light Rail[14]

A new system known as 'Very Light Rail' (VLR) is currently being developed as part of a research project by the University of Warwick. The system will use a state-of-the-art rail system which is claimed to be cheaper, quieter and more environmentally friendly than anything currently available.

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[14] https://warwick.ac.uk/fac/sci/wmg/research/hvmcatapult/research/rail/vlr/

Figure 4-16: Coventry VLR system

The project is funded by the Government’s Local Growth Fund through the Coventry and Warwickshire Local Enterprise Partnership and West Midlands Combined Authority Devolution Deal (which is subject to approval of the business case). It is claimed that this will use a state-of-the-art rail system which will be cheaper, quieter and more environmentally friendly than anything currently available. Vehicles would be self-propelled using battery technology only, removing the need for overhead line equipment. It is anticipated that VLR could come into operation by 2025.

4.7 Tram-train

A tram-train system offers a vehicle and service type that can operate in the street as a tram, but can also operate on standard railway lines. Tram-trains often share lines with intercity passenger rail and freight, to go longer distances into the surrounding suburbs. One of the key issues with tram-trains is that they become less effective for longer journeys since trams typically operate at slower maximum speeds than trains on shared sections of track.

Tram-trains can offer semi-express services with the advantage of better penetration of urban centres than heavy rail. Note, however, that the more common way of achieving this in the UK is for sections of heavy rail to be disconnected from the main network and modified for tram operation, as in

Manchester, Birmingham and Croydon. This avoids issues of interoperability, electrification systems, and crashworthinesss.

The potential of tram-train services and operation in North Essex was established as limited due to the current frequency of trains on the mainline leaving limited room for joint running with tram-trains (Jacobs, 2017). In addition, as shown in Chapter 2, the existing train lines do not follow most of the key corridors under consideration for a rapid transit system.

Example 1 – Karlsruhe Stadtbahn, Germany (Tram-Train)

Service Type	Local	Urban mass transit	**Semi-Express**
Infrastructure Type	**Shared**	**Reserved**	**Dedicated**
Guidance	Unguided		**Guided**

In 1992, tram train operations between Karlsruhe and Bretten-Gölshausen started on the Kraichgau Railway (then line B, now S4). The tram and rail networks were linked by building a connecting line between Durlacher Allee and Grötzingen Station.This connecting line also contains the equipment that controls the change between the two electrification systems. The scheme offers a semi-express service on dedicated guided tram/rail lines. On some sections of the system, other vehicles are able to cross the tramlines or run alongside trams. Where the Karlsruhe system meets the rail network, the tram trains share the dedicated infrastructure with conventional trains.

Figure 4-17: Image of Karlsruche Stadtbahn system[15]

Example 2 – Sheffield – Rotherham (Tram Train)

The Sheffield – Rotherham system is a two-year pilot scheme funded by the Department for Transport with the objective of allowing passengers to make a single journey between tram stops and conventional rail stations. The system will run on dedicated guided tracks which, similar to the Karlsruhe system, share the rail sections with conventional trains.

Once open for operation, this scheme will offer three tram-train services an hour, running on the national rail network from Rotherham Parkgate Retail Park via Rotherham Central Station. They will join the existing Stagecoach Supertram network at Meadowhall South and continue to Sheffield City Centre. Express services are likely to run from Rotherham, becoming more of a semi-

[15] http://www.cmbln.de/Bahn/rheinneckar/rn-88.JPG

express service as the route approaches Sheffield and connects with the existing Supertram route.

Service Type	Local	Urban mass transit	Semi-Express
Infrastructure Type	Shared	Reserved	Dedicated
Guidance	Unguided		Guided

Figure 4-18: Tram-train vehicle in Sheffield[16]

4.8 Rail

Heavy rail is another mode to be considered in terms offering a capacity that supports travel demand in a certain area. Rail often covers larger geographical

[16] https://www.railengineer.uk/wp-content/uploads/DSC_5454-online-1440x961.jpg

areas. This mode can offer local stopping services as well as express services dependent on the type of infrastructure in place. All trains operate on dedicated, guided railway lines that are only shared in the case of the tram-train examples previously discussed. As there is not spare rail capacity which coincides with the key corridors, this report does not give rail examples.

4.9 Key Drivers

Of relevance to planning a rapid transit system in North Essex, are the reasons for the transport authorities in the examples choosing the systems they did. Accordingly, an analysis has been carried out to identify some of the key drivers leading to technology systems chosen for each scheme as shown in Table 4-6. On purpose the very light rail example has been omitted as it is an experimental scheme.

A tram system was chosen over other transport modes in Edinburgh because of its powerful symbol. The business case[17] noted that trams would help reinforce the city’s international image as a business location. This links back to the earlier discussion (Section 4.1) around the permanence and dedicated infrastructure of different transport modes.

On the other hand, in Coventry the traditional tram solutions were deemed to be very costly (around £3 million for each tram). One of the key drivers for choosing a VLR system is cost, in this case small rail vehicles will have the capability to operate autonomously without a driver, which will reduce the operational costs and enable more frequent services for passengers. The vehicles will be battery operated using rapid charging solutions and therefore will not require overhead cables. However, it should be noted that this is not a tried and tested solution so, in many respects, cannot be a considered as a solution for North Essex.

Similarly, cost is also a key driver the Manchester Metrolink, Cambridgeshire Guided Busway, Bristol MetroBus, Crawley Fastway and Runcorn schemes.

Flexibility was considered one of the key drivers for the Kent Thameside Fastrack scheme. A BRT system was chosen due to the large levels of growth forecasted across a relatively large area and long period, demanding a transport system that can grow with time. As a bus-based system Fastrack has that flexibility built in, yet at the same time offers the reliability and

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[17]www.edinburgh.gov.uk/download/meetings/id/4562/edinburgh_tram_draft_final_business_case_part_1 edinburgh tram business case

attractiveness of a modern tram. This BRT scheme is designed to serve new developments.

The Zuidtangent scheme also considered the flexibility of bus based systems as an important driver, since the system can adapt to space constraints in the historic centre of Harleem. In addition to this, it was considered that the estimated demand was too low for Light Rail, however the BRT system is considered as a pre-tram stage, where a transition from BRT to LRT will be made when the target for demand is hit.

Table 4-6: Drivers for examples

Mode	Scheme	Main driver
Bus	Reading	Existing bus network
	Oxford	Historical City Centre
BRT	Runcorn	Unguided Busway Cost
	Zuidtangent, Amsterdam	Demand Flexibility Historical City Centre
	Kent Thameside Fastrack	Flexibility
	East London Transit	Existing bus networks
GBRT	Cambridgeshire Guided Busway	Disused railway line Less land uptake Cost Historical City Centre
	Bristol MetroBus	Implementation/construction times Flexibility Value for money (cost)
	Crawley Fastway	Cost
LRT	Freiburg	Existing tram network
	Manchester Metrolink	Cost Use existing railway lines
	Edinburgh Tram	Existing busway Symbol of tram Steeper gradients than rail
Tram-train	Karlsruhe Stadtbahn	Rapid acceleration/deceleration Seamless transfer between rail networks
	Sheffield - Rotherham	Pilot scheme to assess technical issues Integration of light and heavy rail infrastructure

GBRT was chosen for the Crawley Fastway in order to minimise start-up costs, and remove the need for public consultation exercises. Further to this GBRT systems can access residential areas, is not constrained by a costly fixed infrastructure and power supplies, minimises land use without cluttering the street scene and is a flexible option, which can be expanded and adapted to meet local changes and demands.

The Bristol MetroBus also opted for a GBRT system since a tram based system did not meet the value for money requirements set by the Department for Transport[18]. Yet, in Manchester light rail emerged in the early 1980s as a cost-effective option that could make use of existing railway lines and run through the city centre at street level, eliminating the need for costly tunnelling works.

Tram trains were implemented in Karlsruhe because of the convenience of transferring between rail networks, and tram-trains can also accelerate, decelerate more rapidly.

The examples identified here demonstrate both similarities and differences when considering some of the key drivers for technology choices. It is clear that each location should be treated differently as each place varies in density, population and built environment, and each mode is best suited to a certain type of place.

4.10 Combining rapid transit choices with corridor options

The applicability of the different rapid transit options to the key corridors which have been identified previously is based on consideration of how have been used and their characteristics.

Four options are considered unsuitable (Table 4-7).

Table 4-7: Rapid transit options that are considered unsuitable

Option	Reasons why considered unsuitable
Bus	Unlikely to match local vision for quality and presence
Very Light Rail	Unproven technology, relatively small vehicles
Tram train	Rail network constraints
Rail	Rail network constraints

[18] https://travelwest.info/metrobus/all-you-need-to-know

BRT, guided BRT and tram options are therefore identified as the most versatile options for potentially meeting the demand on the corridors. Hence these become the core options which are investigated further.

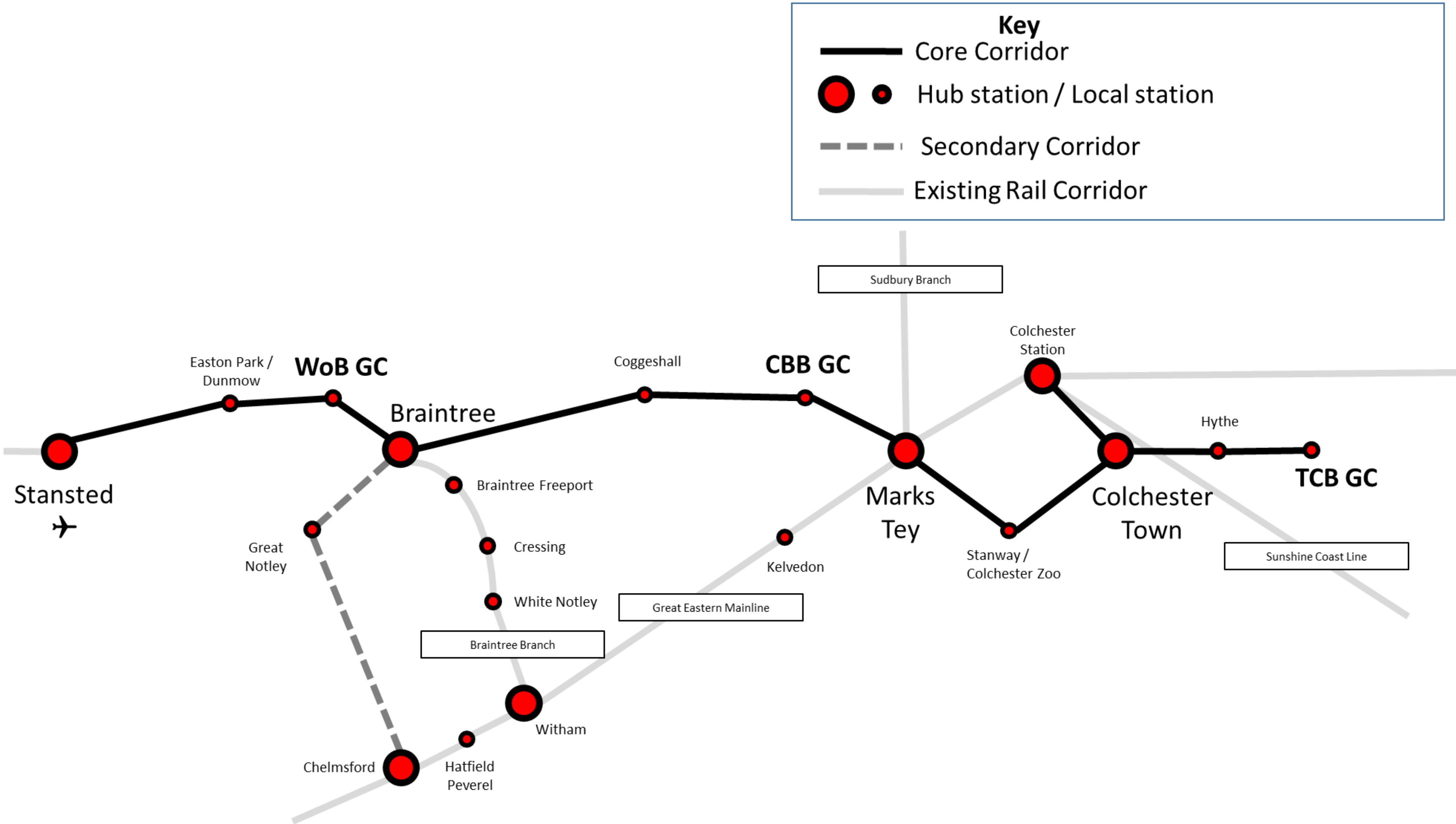
In addition, consideration was given to an ideal network configuration reflecting that there are different ways in which centres can be connected along these corridors. For example, just the main town centres could be connected and onward services be used to travel on to destinations such as garden communities.

In discussion with the NEGC transport working group the network configuration which was preferred was to connect all the key destinations as shown in Figure 4-19. In subsequent design phases it might be appropriate to optimise the network configuration to suit the growth in the area. For example, this could include adding in other stops with sufficient demand or removing stops until demand grows to a sufficient from developments.

It should be noted that in the transport model an additional stop has been incorporated for the university by Hythe. Also in the model the link between Colchester town and Colchester station has been extended north to the hospital. In any next stage consideration could also be given to extending this branch further north to the park and ride site for Colchester.

Chapter 7 proceeds to test combinations of the rapid transit options on different sections in order to identify workable options. But first Chapter 5 describes practical matters and challenges for design which need to be considered in the appraisal. Meanwhile Chapter 6 summarises how the transport model was developed.

Figure 4-19: North Essex rapid transit outline network configuration



5 Route choices and future proofing

5.1 Background

Based on the shortlist of scenarios this section will describe a practical outline for the routes and how the rapid transit lines, stops and interchanges will interact with existing infrastructure.

This section will highlight the design issues that:

- Inform transport modelling of rapid transit scenarios
- Inform cost implications of the different scenarios
- Should be considered in the next phases of work (in which concept designs can be prepared and more detailed business cases prepared)

Since each scenario might take similar routes and use similar locations, the chapter will be arranged by route section. Within each section the difference between the scenarios will be described.

It is important to realise that this section is not designing the route. But it will provide useful information to set up a brief for the design stages.

5.2 Route choices

5.2.1 Tendring Colchester Borders garden community

The 2016 East Colchester report identified possible routing options to connect the garden community with the city centre and rail stations, using a dedicated route through the new garden community and dedicated or shared onward routes to provide a good alternative to travel by car. These included a branch to serve the Knowledge Gateway and University, and also served a proposed Park and Ride site on the A133.

There are relatively few options which can be considered which are relevant for rapid transit services between the garden community and the city centre. It is assumed that the rapid transit route will leave the garden community by heading towards Hythe. This is the preferred route from east Colchester as it also gives the opportunity to access the university and the knowledge gateway. The proposed route continues to Hythe, via a new crossing of the A133 and then making use of existing bus only and restricted access roads to the rail station at Hythe. From Hythe, the route either connects to the local rail line into Colchester Town or takes a route on existing road with segregation and priority measures. The options depend on the choice of mode. Hythe would act as the major transit hub and would connect to various modes/routes to Colchester.

5.2.2 Colchester subsystem

Within Colchester, the key transport modes are as follows

- Colchester station
- Colchester town station
- Colchester bus station
- Hythe station (to the east)
- Colchester park and ride (to the north of Colchester on the A12)

Key issues to be addressed are:

- How to make efficient connections between the key nodes and the demand generators
- Limited scope within Colchester for new segregation on existing roads
- Congestion in network/roads inside the city

The primary issue is to identify the rapid transit interchange in the city centre The route through the city centre will depend on choice of route to and from Hythe. The decision in likely to depend on whether the rapid transit route from Hythe enters via the existing rail corridor or the road network.

A branch of the rapid transit system could run to the north between Colchester city centre and the Colchester park and ride site via Colchester station and the hospital, in this way capturing extra demand. The design would have to consider whether it is feasible to allow existing buses and the rapid transit system to share the same space. Moreover, consideration needs to be given to a stop by the hospital. The northern section (nearest to the park and ride) of this corridor is less congested than the southern portion and has the possibility of segregation of the rapid transit from the other traffic. However, there is currently no bus priority through the North Station roundabouts, or along the A134 under the rail overbridge linking these to the Essex Hall roundabout.

Continuation of the rapid transit corridor from the Colchester rapid transit hub to the west is also constrained.

Possible routes include

- Lexden Road, and the A133 London Road to Stanway
- The A133 Cymbeline Way and the A12
- The B1022 Stanway Road

Consideration needs to be given to the implications on existing traffic for whichever route is chosen.

It may be difficult to provide appropriate segregation and/or priority for rapid transit on the options using the A133 and/or A12, and a route via the B1022 may offer an alternative with greater potential for reassignment of road space.

Overall, creating a segregated route for rapid transit through Colchester will present challenges of road space reallocation by reducing the space available for cars. In addition, there will be challenges at junctions where the rapid transit routes cross trafficked roads.

5.2.3 Colchester to Marks Tey

A route via the B1022 would require new alignment to sweep round from Stanway Green into the Colchester Braintree Borders garden community and access Marks Tey from the south.

Should a more direct route between Colchester and Marks Tey be favoured there are may be greater challenges in identifying a rapid transit corridor which provides the required segregation from existing traffic.

5.2.4 Colchester Braintree Borders garden community

Within the Colchester Braintree Borders garden community, key points for consideration include:

- Current severance caused by A12 and railway line
- Options for upgrading the A12, including possible realignment of the section between Kelvedon and Marks Tey.
- Options for realignment of the A120, including a new junction on the A12.
- Connection to Marks Tey station towards the east
- Potential challenge in terms of improving journey time and reliability

When Colchester Braintree Borders garden community is being laid out a decision needs to be made where the focus of the garden community is to be. This could be at Marks Tey station or at another location in the site. The rapid transit service needs to be routed to the centre of the community and, if not at Marks Tey station, also stop at this station. This decision is also dependent on the choices made for the A12 and A120 schemes and will need to take into account the possibility that the station at Marks Tey might be moved.

5.2.5 Marks Tey to Braintree

The design stages need to consider the best route option. There are two main options, both of which depend on opportunities which could be created by the A12 and A120 schemes. They are based on:

- Use of the existing A12 corridor and new construction parallel with the proposed realignment of the A120; or
- Use of the existing A120 corridor, taking advantage of reduction in traffic levels and scope for reassignment of capacity through A120 upgrading and realignment.

If the A12 is realigned between Kelvedon and Marks Tey, part of the old alignment could potentially be used for rapid transit. Construction of a rapid transit corridor parallel with the realigned A120 (or passive provision during construction for later fit out) could then extend the route to Braintree. This would be particularly attractive if the central corridor route of the new A120 is the favoured option.

An alternative would be reuse of the A120 corridor between Marks Tey and Braintree. This would have the advantage of serving Coggeshall. Even if the A12-A120 option is preferred for rapid transit, the reduction of traffic on the old A120 alignment offers the opportunity for improvement of local bus services which could complement the rapid transit network.

Whichever option is chosen, further detailed design consideration is required for the location where the rapid transit network crosses the A12, especially if this is in the vicinity of Marks Tey station.

5.2.6 Braintree

Access to Braintree will depend on the choices made in the previous subsection.

A connection adjacent to the realigned A120 would provide access to Braintree Freeport in addition to a stop in the town centre. The town centre interchange could be adjacent to the station or bus station.

5.2.7 Braintree to West of Braintree garden community

The key challenge is to identify the rapid transit hub inside the garden community and the connectivity to Braintree, as this will determine the routing of the rapid transit corridor. It is assumed that that the link will mainly follow a new alignment.

5.2.8 West of Braintree to Stansted Airport

The route choice on this section will be determined by which new developments are to be served, and whether the route serves the existing centre of Great Dunmow. Most of this development is to the north of the A120, and it is therefore unlikely that the rapid transit corridor would follow the A120.

This study has not explored the options for access to Stansted Airport, or the additional interchange facilities which may be required.

5.2.9 Braintree to Chelmsford

There is an existing rail corridor between Braintree to Chelmsford via Witham. Scope for the improvement of the rail service on this branch line to Witham is limited which may restrict the opportunity to develop this as a major rapid transit corridor.

The existing road connection between Braintree and Chelmsford is via A131/ Beaulieu Park/A130. This points to the need to identify a rapid transit corridor parallel to the A131/A130 which could possibly also serve a new station at Beaulieu Park if developed.

5.2.10 Marks Tey to Chelmsford

The A12 improvement options between Chelmsford and the A120 are being developed which comprise widening and possible realignment of sections of the A12. This offers the possibility to improve local public transport in this corridor, especially if using sections of the old A12 replaced by new alignments.

However, there is already an existing rail service on the Great Eastern Mainline) between Marks Tey and Chelmsford, and, notwithstanding capacity issues discussed in Chapter 2, it is envisaged that rail will continue to provide the main rapid transit service on this corridor and through to Colchester station.

5.3 Anticipating technology changes and smart travel

5.3.1 The transport revolution

Even if traditional transport technology (e.g. rail or tram based transport scheme) is chosen to be applied in the proposed corridors, the wider technological landscape will still have an impact, for example by seamlessly feeding passengers to public transport nodes, better passenger information and more informed planning decisions enabled by big data.

Transport is undergoing a quiet revolution with major developments in vehicle technology, big data, mobile ticketing and commercial models. The digitisation of transport and the introduction of 'mobility as a service' (MaaS) as well as the deployment of 'connected and autonomous vehicles' (CAVs) are leading contributory factors to this revolution**.** It is recognised that this wider technoloigcal landscape should to be taken into account when planning new rapid transit corridors in order to maximise benefits and support the emerging Local Plans.

Health concerns, particularly related to particulates in diesel engine emissions, and legislation across the globe are forcing transport operators and vehicle manufacturers to reduce fossil fuel emissions. In response, the market has seen steps towards the electrification of railways and road vehicles whilst various countries are in the process of banning or limiting diesel engined vehicles. Electric or hybrid private vehicles are becoming widely accepted by commercial and personal users, supported by an ever-expanding charging infrastructure network and encouraged by increases in range through recent developments in battery technologies.

5.3.2 Changing patterns of car ownership and use

Technology, innovation (e.g. mobile phone apps) and the sharing economy in particular, are leading to changes to traditional notions of 'owning a car'. Increased urbanisation and a generation which relies more on the sharing economy have also seen an increase in the number of people who do not own a vehicle, but instead rely on forms of public and commercial mechanisms such as car clubs and on-demand transport services (e.g. Uber, Lyft, Gett). However, despite the potential to reduce car ownership, the rapid expansion of tech-driven private transport services has sparked concerns all over the world, with regards to regulation, privacy, affordability, abstraction from public transport and increased congestion.

CAVs are already being used to deliver passenger services – the personal rapid transport system at Heathrow Airport is one such example. CAVs in operation today do so mostly at slow speeds and in segregated environments. Vehicles which are able to negotiate more complex environments are expected to be providing commercial services by the end of 2020 or even earlier. Ford is targeting 2021 to deliver high-volume fully autonomous vehicles with other major manufacturers anticipating similar timescales. The introduction of highly automated vehicles will probably coincide with the launch of large-scale vehicle sharing schemes, some of which will be operated by, or in close conjunction with, the vehicle manufacturers of on-demand transport providers such as Uber.

The wide scale adoption of vehicles as part of a sharing economy is an inevitable consequence of the move to the higher levels of vehicle automation. Given that currently a car is parked for around 90% of the time, there will be limited utility in owning a vehicle privately. CAVs will provide the final element of a mobility ecosystem which has become known as mobility as a service (MaaS). Operators and/or local authorities are planning or have launched MaaS services, such as MaaS Global which already provides services in Helsinki (Finland) and in the West Midlands (UK) under the Whim brand. MaaS seeks to emulate the mobile phone monthly payment model by bundling various transport options and modes under one booking/ticketing platform for a single monthly fee. Many local authorities are developing strategies which incorporate MaaS services as an integral mechanism to enable people and freight to move around their cities and to deliver better services for residents.

5.3.3 Planning for emerging corridors

With regards to planning for a transit corridor, autonomous vehicle innovation is one of the most relevant technologies to take into account. CAVs can potentially provide new solutions by adding mode options along the corridor, including for example the possibility to replace low-demand scheduled services with on-demand driverless transport and feed passengers to rapid transit and other public transport nodes**.** Considering that the development of a rapid transit corridor has a long time horizon, it is important to take into account these wider technological trends when developing a corridor solution and for future operations.

In addition to CAV technology, there are also other strands of technology to consider when designing a rapid transit corridor. There are many potential synergies, and yet unimagined solutions to come from these technologies. For example, machine learning can be applied to traffic modelling for the corridor; combine machine Learning with Internet of Things (e.g. sensors) and smart asset management principles and you get real time and predictive traffic management, leading to improved resilience. Another example, is that by combining blockchain and CAVs, new possibilities are opened up for road pricing, cybersecurity and enhanced user privacy by providing the ‘right to be forgotten’ (e.g. by keeping journey history private).

5.3.4 Smart initiatives

A key element of many smart initiatives around the world is the provision of a digital infrastructure and the use of advanced digital and telecommunication solutions to increase overall efficiency, improve service delivery, asset management and eventually make a place more attractive for residents and businesses. A more liveable and better connected place, together with more efficient governance and service provision, is also a more competitive place which will more easily attract jobs and investment. Hence a smart strategy and developed solutions should be tailored to respond to the existing local needs and challenges.

However, 'smart' extends far beyond the technological aspect of infrastructure and more cost-effective and efficient public service delivery. A smart city is also a city that empowers citizens to actively engage with public authorities and other residents. By making existing networks and capital smarter, this allows for better two-way communication between residents, businesses and service providers.

The notion of 'smart' also includes an element of reactiveness to new challenges, such as via citizen feedback, real-time sensing and constant asset monitoring which allows decision-makers and residents to better adapt to new situations and address and resolve emerging issues faster, eventually optimising existing systems and networks to everyone's needs, which also contributes to more resilient places.

Better access to information enables better management. Therefore, 'smart' solutions are strongly data-driven, as they require the production of real-time and accurate information but also tools to mine and harness existing flows of information and turn them into useable knowledge and insights. The data gathered can also help to inform (planning) decisions but also to 'nudge' people towards behavioural change.

5.3.5 Delivering a personalised transport experience

Smart initiatives can complement a modern transit corridor by personalising the experience of travelling on a (public) rapid transit corridor, thus enhancing attractiveness of public transport and meet passenger expectations. Hence, in the context of a North Essex rapid transit scheme we are looking to use smart initiatives to deliver a personalised service through enabling:

- Easier access to and from rapid transit hubs (e.g. undertake the first and last mile of a trip in an on-demand automated vehicle or cycle);
- Secure, easy to understand and transparent ticket booking and payment systems – this is critical to the widespread adoption of MaaS;
- More efficient and resilient operations; and
- Flow of data from transport operators to passengers (and vice versa).

- Examples of technologies or smart initiatives that can potentially influence the development principles of a rapid transit system:
- New propulsion technologies (bus, rail, car, shared cars) with impact on congestion, emissions, network capacity, etc;
- Vehicle autonomy (partially or completely driverless);
- Car and e-bike charging infrastucture;
- Big data (complex data sets that exceed standard processing abilities) and data management can help with managing the corridor;
- Predictive analytics (data mining, machine learning, predictive modelling) and user behaviour analytics, can help to improve network resilience and management of the corridor, for example with regards to congestion;
- Internet of things (interconnected devices that are able to connect and exchange data, e.g. for air quality monitoring) could enable more efficient asset management along the corridor by installing sensors to gather data. This data can be used to monitor assets in real time, scheduling maintenance and predict failures;
- New business models in car sharing and MaaS in general, impacting on how people travel;
- Mobile phone apps or contactless smart cards (using NFC on phones or RFID technology such as Oyster cards and contactless payment cards) can provide an integrated, smart ticketing platform which should be able to accommodate bookings and payment/fare collection for MaaS initiatives;
- Smart grids and community power generation (using demand and supply monitoring and management tools such as smart energy meters) – the electricity to power the transit corridor can be potentially generated locally; and
- Wireless, 5G or dark fibre networks to connect sensors and infrastructure.

5.3.6 Alignment with ECC strategy

Should the rapid transit system be taken forward it is recommended the scheme is closely aligned with ECC's emerging strategy for digital technologies. Specifically the next stage should look to:

- Investigate in more detail how CAVs will influence the potential transit corridors and in particular technology requirements (e.g. navigation system requirements) and how it will impact on future demand and design of corridor;
- Explore the different business models that MaaS offers and prepare a shortlsit of the most appropriate for the needs of ECC;

- Design and build flexibly, with adaptation to future technolgy in mind. For example, sections of a bus transit corridor might be initially designed with a driver on board, but as technology improves, the scheme should be able to accommodate improvements in autonomy leadng to a driverless operation (with a passenger attendant on-board). Similarly, when designing for car parking provision at stations, it should be noted that the parking demand at stations is likely to change in the future, as some passengers will be dropped-off/picked-up by automated vehicles and thus not require parking;
- Model the energy requirements and emissions of each potential mode (car, minibus, bus, rail, CAV);
- Devise a communications plan during the design phase, e.g. 5G networks and Wifi along the corridor. Telecommunications provision should not be an afterthought, as it vital for guiding automated vehicles and sharing data;
- Engage early with potential transport operators (MaaS, rail, bus, on-demand taxi services) to validate the technology options proposed for the corridor, especially on telecommunications, ticketing and energy requirements;
- Carry out a benchmarking exercise to establish what passengers want to see at stations (e.g. mobile phone charging points, cycle storage or hiring scheme, etc) with the results fed into the station design typology or development principles.

It should though be stressed that technological advances and the growth in on-demand transport services do not replace the need for rapid transit or public transport in general. Rather technological advances are the opportunity to create a higher quality personalised experience on public transport.

6 Modelling and forecasting

6.1 Overview and purpose

In Chapter 4 a longlist of rapid transit options was developed based around a service configuration reflecting future demand and requirements in North Essex. The service configuration proposed frequent rapid transit services with an attractive generalised cost (a measure of journey and cost) compared to private car travel.

A transport model has been developed in order to identify which combinations of rapid transit options could practicably meet the service criteria; and then provide the output required to carry out an economic appraisal to compare these options. These findings are presented in Chapter 7, which also includes qualitative appraisal and consideration of non-economics factors.

However, before presenting these findings and recommendations for rapid transit in North Essex, this chapter describes the transport model and the assumptions used. In broad terms the development of a transport model involves creating a base model, which is then calibrated and validated to ensure it reflects reality. The base model is then altered to reflect future scenarios, such as growth in trips from new developments and new transport infrastructure such as the rapid transit system.

The transport model used is an Emme-based public transport assignment model. In essence the inputs are a matrix showing the number of public transport trips between the zones in a model; and a depiction of the public transport networks, which are bus and train services. The model then assigns the trips shown in the matrix to public transport services. The outputs are information on journey time and numbers of passengers per service, which is used in the assessment and appraisal.

The base model year is 2014. It should be noted that that the base model that has been developed has not been fully validated as it does not meet WebTAG guidelines for accuracy and rail passenger data was unable to be obtained in time. However, the model predicts bus passenger levels well on busier bus routes, in accordance with WebTAG accuracy, and overall bus and train passenger flows have been sense-checked. Therefore, the base model is considered fit for purpose to identify and help decide between rapid transit options. In the next phases of work the model would be able to be incrementally improved to ensure a WebTAG validated model is able to be used for a full business case.

To use the model for the future scenarios, new inputs are produced for the forecast trips and the changed public transport network, which includes a do-minimum case and a rapid transit network. The future years, which are to be modelled are 2033 and 2051. The forecast year 2033 was chosen in order to coincide with the end of the Local Plan period; and 2051 was chosen as the garden communities are nearing full growth after this time.

In forecasting trips for the future network, an additional modelling step is used to estimate the proportion of trips that will use public transport. This mode choice mode allows for the fact that since rapid transit will be more attractive than current bus-based public transport option, some trips undertaken by private car could be attracted to public transport.

In accordance with the above description, this chapter is organised around:

- Development of the 2014 public transport assignment base year model
- Development of the 2033 and 2051 forecast total trip matrices
- Development mode choice model used to produce the 2033 and 2051 forecast public transport trip matrices
- Coding of the rapid transit network for the 2033 and 2051 scenarios.

6.2 Assignment base model

6.2.1 Background

As introduced in Section 6.1, the development of the 2014 base public transport assignment model involves:

- Defining an input public transport trip matrix (showing trips between zones)
- Coding the existing public transport network
- Calibrating and validating the assignment of trip to the network against observed data

6.2.2 Public transport base trip matrix

The starting point for building the base trip matrix was the following data sources:

- NTEM data from 2014 (which is extracting using TEMPro 7.2)
- Census 2011 journey to work data
- Saturn highway base matrix 2007, which is a validated highway assignment model developed for Colchester local plan traffic modelling (Jacobs, 2017)

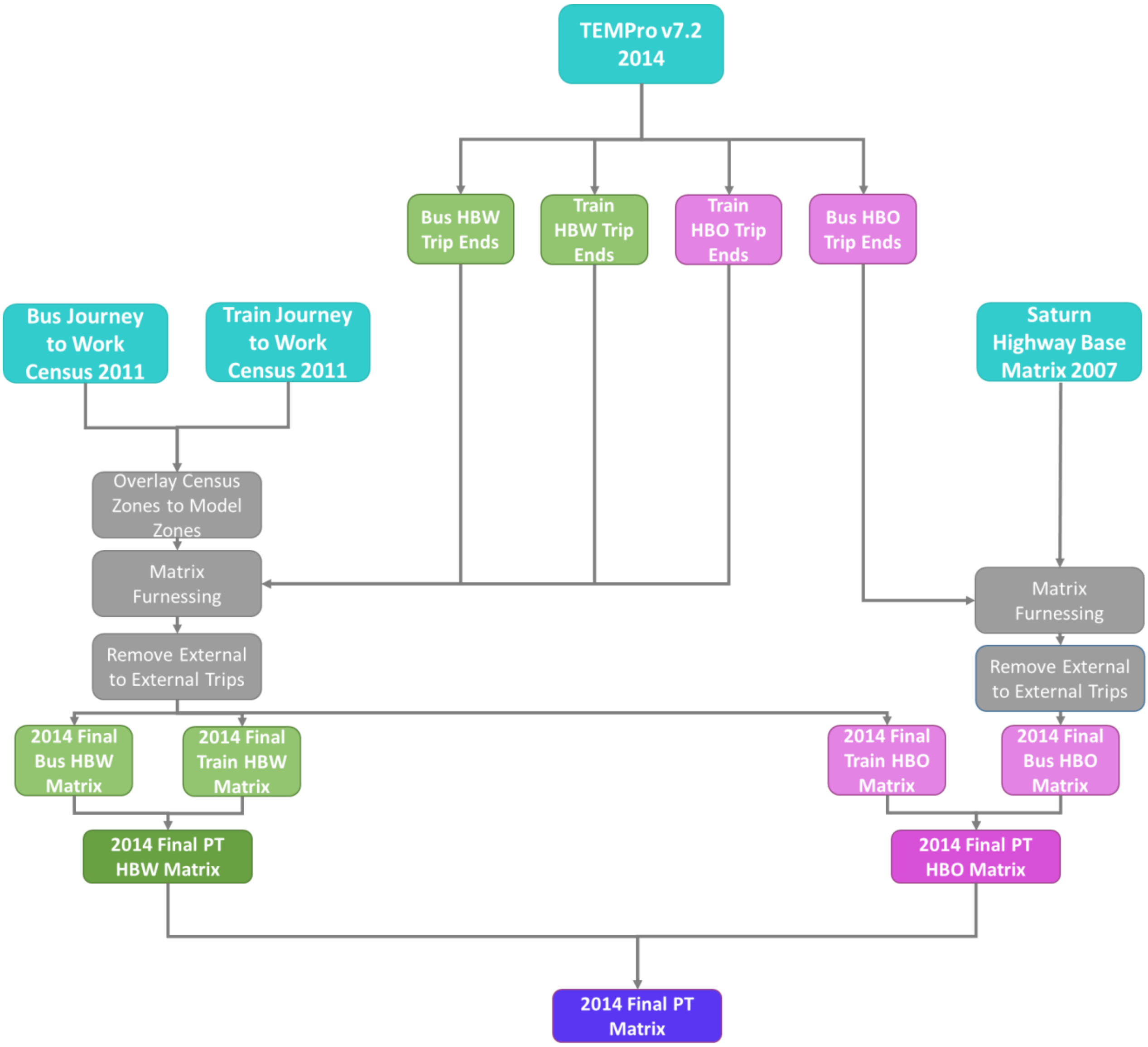
Trip ends by mode and by purpose have been extracted from NTEM data using TEMPro. Both bus and train modes have been taken into account, while two different purposes, home based work (HBW) which reflects commuting trips and home based other (HBO), have been considered. The 2014 was chosen to reflect the time for which observations on bus patronage was available, used to validate the model.

Census (2011) journey to work data and the SATURN highway base matrix (2007) have then been used to inform the distributions of these trips to and from zones used in the model. Since the Census and SATURN data is only used to inform distribution it is considered acceptable that the years differ from 2014, used to extract trip ends from NTEM.

- Census journey to work data has been used for distributing all HBW trips and those HBO trips on train; meanwhile
- The SATURN highway base matrix has been used for distributing the trips for bus HBO.

Based on the above HBW and HBO public transport matrices are created. These are then combined in order to produce a single public transport base trip matrix. Figure 6-1 shows the methodology for building the public transport base trip matrix.

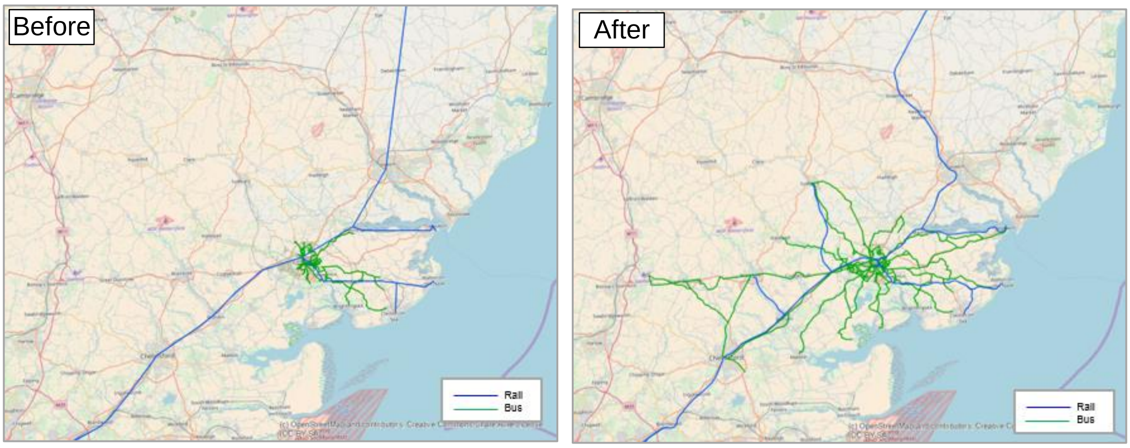
Figure 6-1: Methodology for building the base trip matrix



6.2.3 Public transport base network

The network structure from the Emme public transport assignment model has been developed by extending the network in the Emme model created from the previous Colchester rapid transit study (Jacobs, 2016). This network was based on the network in the SATURN highway model onto which bus and rail services of relevance to East Colchester had been coded. The coding involves specifying the headway (time between services which gives the service frequency) and speed for each service. A significant extension to the network coverage was undertaken, which involved coding all bus and rail services in Colchester, Braintree and Tendring with links to key adjacent destinations in Chelmsford and Uttlesford (namely Stansted).

Figure 6-2: Bus and rail network coded into the base model



6.2.4 Calibration and validation

In order calibrate and validate the model bus flow information was compared with the model outputs. This information was provided from counts of passengers at bus stops and annually aggregated numbers of passengers on bus routes for 2013/14. While there is a reasonable match on routes with high passenger numbers it should be noted that the model does not meet the WebTAG criteria for accuracy. In addition, no data was able to be obtained on rail passengers. Hence rail flows were sense-checked as being reasonable, which was the same approach taken in the previous Colchester rapid transit study.

It is expected if rapid transit planning progresses to the next stage that data would be obtained in order to properly validate the model and improvements made.

6.3 2033 forecasts for total trips

6.3.1 Background

In order to use the transport model to assess rapid transit, the forecast matrices for 2033 and 2051 are required. These combine general background growth and details of specific developments. It should be noted that while in Section 6.2 a matrix of public transport trips was produced the forecasts described in this section are for total trips. A mode choice model, described in Section 6.4, is then applied which estimate the number of public transport trips.

6.3.2 2033 total trip forecast

The forecast for the total number of trips in 2033 combines:

- Forecasts at Local Plan developments in Colchester, Braintree and Tendring derived from TRICS data; and
- Background growth taken from NTEM

The study has combined the preferred options for developments found in the draft Local Plans for Colchester, Braintree and Tendring districts into a single uncertainty log of developments. The log provides information on development growth expected across the three districts mentioned, as well as the North Essex garden communities (NEGC). The assumptions made are consistent with the Local Plan traffic modelling studies for Braintree, Colchester and Tendring (Jacobs, 2017) and further information can be found in these studies. Forecasts contain trips from both residential and employment developments.

In most cases, the distribution of trips to and from a development is based on the model zone in which it is located taken from the base model. Exceptions are where a development occurs at a greenfield site where the base distribution is not similar. This occurs at the garden community developments, where the distribution of trips is based on nearby zones, in either Braintree or Colchester.

In the Local Plan period the number of forecast dwellings are shown in Table 6-2, which shows that garden community developments are part of far wider growth. Employment developments are not summarised in the table but, as a rule of thumb, for each dwelling one job could be created. The geographical spread of these developments can be seen in Figure 2-2, including key developments in adjacent districts in Chelmsford and Uttlesford.

Table 6-1: Summary of Local Plan residential developments in North Essex (2033)

Developments	Number of dwellings (rounded to nearest 100) – exc. GCs	Garden Community	Number of dwellings (rounded to nearest 100)
Braintree District	9,000	West of Braintree	2,500
Colchester Borough	11,000	Colchester Braintree Borders	2,500
Tendring District	3,300	Tendring Colchester Borders	2,500
Total	23,300		7,500
Grand Total	**30,800**		

The NTEM data for background growth between 2014 and 2033 is used to increase the number of trips in the base matrix of total trips (produced in similar way to the public transport trip matrix described in Section 6.2). However, to avoid double counting background growth is reduced to account for the Local Plan developments. It should also be noted that growth is constrained to NTEM, so we cannot exceed NTEM predictions, which is standard practice.

Hence, at the end of this process, matrices showing the total number and distribution of all trips for 2033 have been produced.

6.3.3 2051 total trip forecast

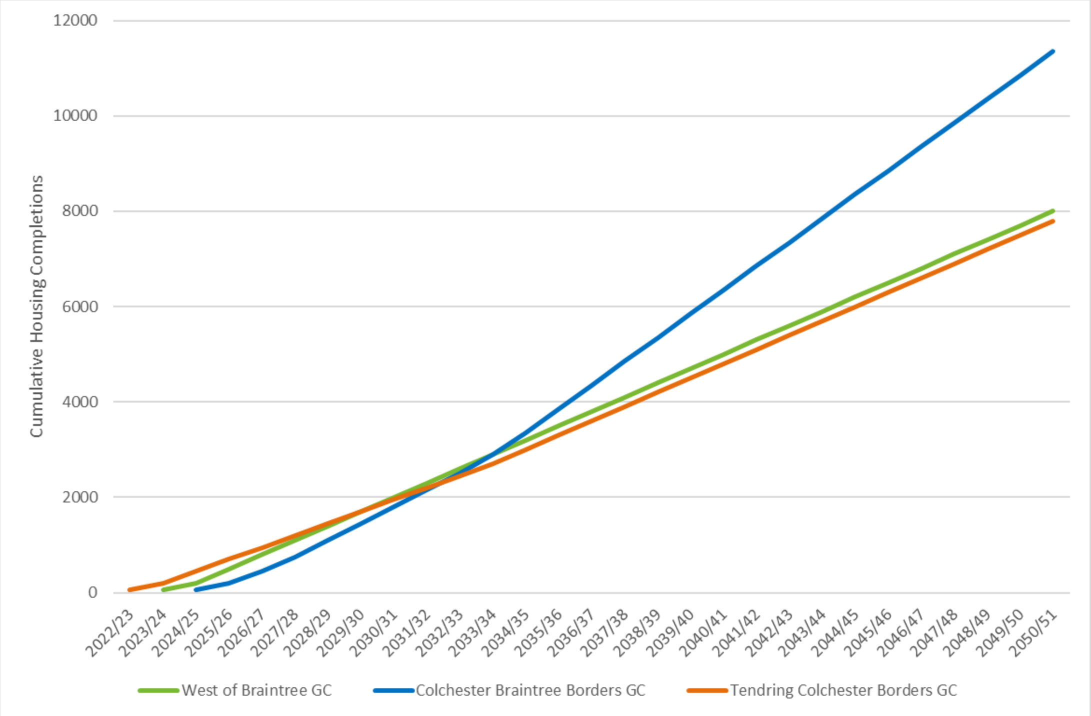
Residential growth

The Local Plan polices (SP7) indicate residential growth at each of the garden communities:

- West of Braintree Borders Garden Community will deliver a total of between 7,000-10,000 homes;
- Colchester/Braintree Borders Garden Community will deliver a total of between 15,000-24,000 homes; and
- Tendring/Colchester Borders Garden Community will deliver a total of between 7,000-9,000 homes.

Figure 6-3 presents housing growth assumptions up to 2051 for each garden community that are used in the transport model.

Figure 6-3: Transport model assumptions for housing growth at NEGC sites



Based on the above housing trajectories the total dwellings forecast for 2050/51 at the NEGC sites is shown in Table 6-2.

Table 6-2: Housing growth for each GC for 2050/51

Garden Community	Homes in 2050/51
West of Braintree	8,000
Colchester/Braintree Borders	11,350
Tendring/Colchester Borders	7,800

Based on the number of dwellings, the number of additional trips in 2050/51 was calculated using trip rates from TRICS. These additional trips were added to the trip matrix for 2033. The NTEM data for background growth between 2014 and 2051 is used to increase the number of trips in the base matrix of total trips (produced in similar way to the 2033 trip matrix described in Section 6.3.2). As it has been mentioned in Section 6.3.2, growth is constrained to NTEM, so we cannot exceed NTEM predictions, which is standard practice.

<u>Employment growth</u>
Cambridge Econometrics and SQW (2017) has determined the likely demographic profile of each Garden Community to inform future service provision planning, and to develop quantified scenarios for future employment growth, to inform job creation targets.

The study considers three broad employment scenarios. The scenarios have been quantified to 2050 using Cambridge Econometrics' Local Economy Forecasting Model, which analyses employment growth through 45 economic sectors, taking into account demographic change and historic trends. In summary they are:

- Scenario 1: "Business as Usual" (the baseline trend-based forecast)
- Scenario 2: "Business as Usual + A120 improvements" (a scenario taking into account the additional employment that may be generated as a result of the dualling of the A120 between Braintree and Colchester)
- Scenarios 3a and 3b: "Potential Unlocked" (an aspirational scenario taking into account the potential for further, higher value employment growth)

Table 6-3 shows the growth assumptions for employment for each scenario that have been derived from this study.

Table 6-3: Growth assumptions for employment - North Essex Garden Communities Employment & Demographic Studies

Growth assumptions for employment (FTE)		2033	2050
Scenario 1 (Business as Usual)	West of Braintree	1,697	5,976
	Colchester/Braintree Borders	1,617	5,662
	Tendring/Colchester Borders	1,512	4,303
Scenario 2 (Business as Usual + A120 improvements)	West of Braintree	2,024	6,297
	Colchester/Braintree Borders	1,755	5,808
	Tendring/Colchester Borders	1,582	4,377
Scenarios 3a and 3b (Potential Unlocked)	West of Braintree	2,913	7,752
	Colchester/Braintree Borders	2,914	8,799
	Tendring/Colchester Borders	3,880	9,747

Only Scenario 1 – "Business as Usual", which assumes that economic growth continues to follow current trends, within the context of a growing (and ageing) population, has been used to inform forecast trip matrices.

Based on the amount of full time equivalent (FTE) jobs created assumptions were made on the amount of trips generated. These were then added and distributed across the garden community sites, thus increasing trips to and from garden communities to reflect employment in the 2050/51 trip matrix. In addition, a similar adjustment has been made in the 2033 total trip matrix.

Hence, at the end of this process, matrices showing the total number and distribution of all trips for 2050/51 have been produced.

6.4 Mode choice base model

The mode choice model is a probability model which estimates the proportion of total trips which will travel by public transport. It is based on generalised journey times between car and public transport and the modal split of traffic taken from the 2014 base matrices.

The Emme base model is used to produce the time for public transport journeys between all origins and destinations in the model, which includes adjustment for average time to get to stops and wait for services – which is why is it referred to as a generalised journey time. Meanwhile the SATURN highway model was used to provide journey times for travel by car between the same origins and destinations. Since the Emme model imported the network from SATURN there was consistency in zones.

The probability model was then calibrated using the base matrices for the number of public transport trips and number of total trips. This process involves adjusting the parameters in the probability model to provide a best fit. In such a simple probability model there is error compared to the actual base data. Hence, the mode choice model is applied incrementally to reduce the error.

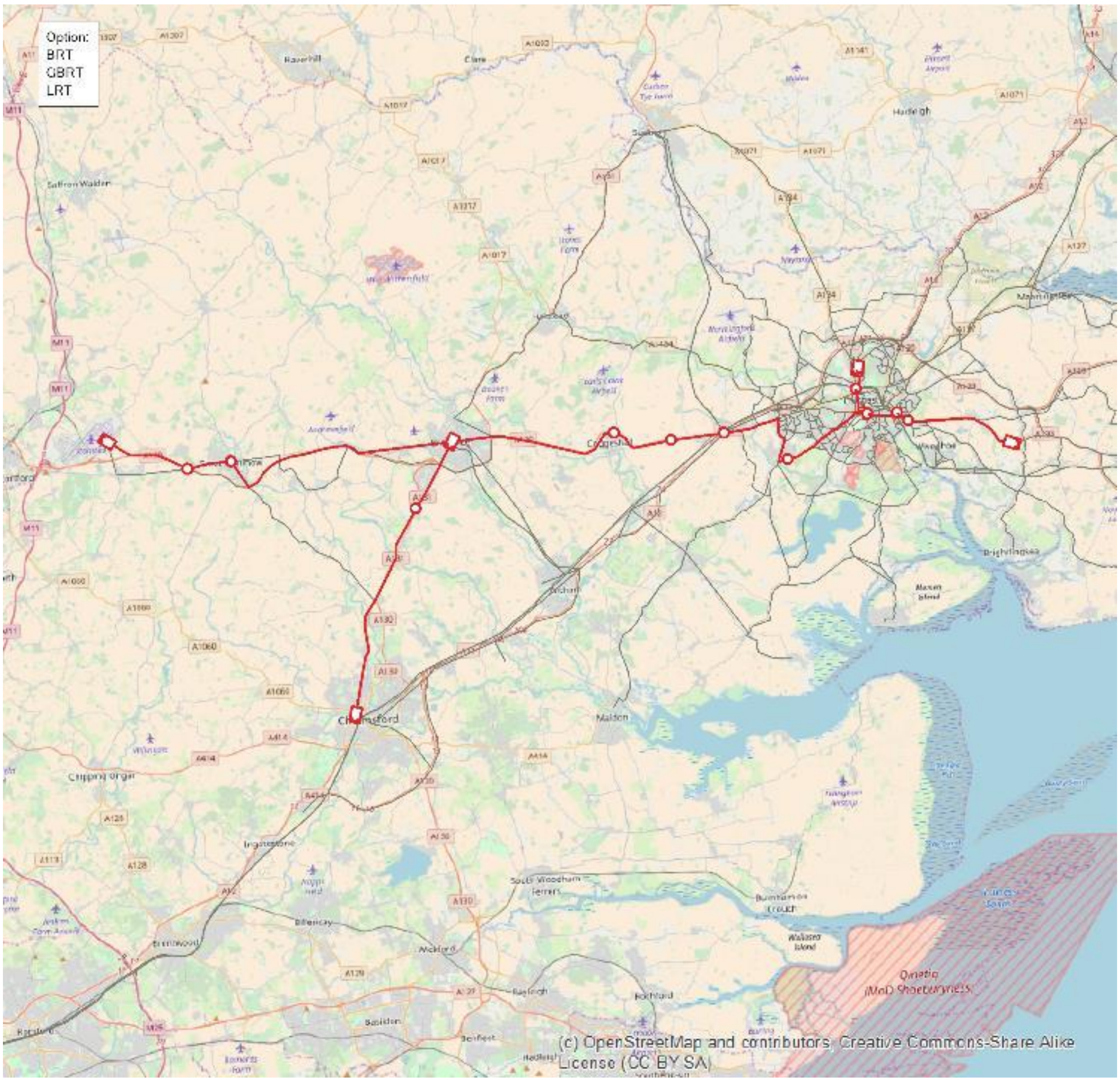
Once the rapid transit network is coded into Emme revised journey times can be extracted. These journey times can be used in the mode choice mode to predict as new proportion of public transport trips.

6.5 Coding rapid transit options and a do-minimum

In order to assess rapid transit a reference case network was coded into the Emme transport model. This reference case is based on a do minimum situation of linking the new garden communities by bus to the nearest centres. The bus frequency chosen was two services per hour.

Next a rapid transit network was coded which, within the structure of the model, represents the network depicted in Figure 4-19 at the end of Chapter 4. The outline of this network is shown below.

Figure 6-4: Rapid transit network



Since the rapid transit modes to be tested included BRT, guided BRT and LRT an assumption was then made on how the services would be coded. It was decided that the boarding penalty – which is a time penalty added to a public transport journeys – would be altered to reflect the comparative attractiveness between each of the modes. Specifically:

- BRT has a boarding penalty of three minutes;
- GBRT has a boarding penalty of two minutes; and
- LRT has a boarding penalty of one minute

For reference the boarding penalty of taking a local bus in the model is five minutes. In the previous east Colchester rapid transit study the boarding penalty for LRT was actually set to zero.

Since all the modes under consideration would be either entirely segregated or partially segregated (for sections where there is congestion), the same speed and service frequency was used for each of the modes. The speed was set at 30 kmph in built-up areas and 50kmph for interurban greenfield stretches. Local buses in the model travel at 20 kmph, for comparison. Meanwhile the frequency was set at four services per hour. Hence the modelled rapid transit service is, as far as possible, consistent with the vision set out in Chapter 3.

A number of scenarios were then set up in the model, which could be tested and inform choices for taking rapid transit forward. This involved testing the entire network operating using a single mode (BRT, GBRT or LRT); and then testing combinations of these modes on different sections of the route.

Six scenarios are reported on as shown in the table below. While it is possible to test more combinations using the model this set was considered sufficient to provide finding to guide decisions on whether or not rapid transit would be an appropriate transport intervention to pursue further.

Table 6-4: Key scenarios tested

Key links	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	*All BRT*	*All GBRT*	*All LRT*	*BRT with Col LRT*	*Braintree and Col GBRT*	*GBRT with Col LRT*
TB GC to Hythe	BRT	GBRT	LRT	LRT	GBRT	LRT
Hythe to Colchester centre	BRT	GBRT	LRT	LRT	GBRT	LRT
Colchester centre to Hospital	BRT	GBRT	LRT	LRT	GBRT	LRT
Colchester centre to Marks Tey	BRT	GBRT	LRT	LRT	GBRT	LRT
Marks Tey to CBB GC	BRT	GBRT	LRT	BRT	BRT	GBRT
CBB GC to Braintree centre	BRT	GBRT	LRT	BRT	BRT	GBRT
Braintree centre to WoB GC	BRT	GBRT	LRT	BRT	GBRT	GBRT
WoB GC to Great Dunmow	BRT	GBRT	LRT	BRT	GBRT	GBRT
Great Dunmow to Stansted	BRT	GBRT	LRT	BRT	BRT	GBRT
Braintree centre to Chelmsford	BRT	GBRT	LRT	BRT	BRT	GBRT

6.6 Limitations of the transport model and further improvements

It should be recognised that the transport model that has been developed gives approximate results which are appropriate to guide the early stage of option generation. If rapid transit design proceeds a more accurate WebTAG compliant model will be required. This can be developed by improving the current model and making use of the current SATURN highway model for Colchester in order to assess the effects on the highway network. In particular, any next stage should look to:

- Improve the mode choice model by incorporating more variables than journey time; and
- Recalibrate and validate the Emme assignment model against fresh survey data.

7 Appraisal

7.1 Demand and level of service

As described in Section 6.5 the outputs from six scenarios are appraised. Figures showing the forecast demand in 2051 for the three core options are shown below. These are:

1. Bus rapid transit (BRT) throughout the network
2. Guided BRT(GBRT) throughout the network
3. Light rail transit (LRT) throughout the network

Figure 7-1: BRT volume plot for 2051

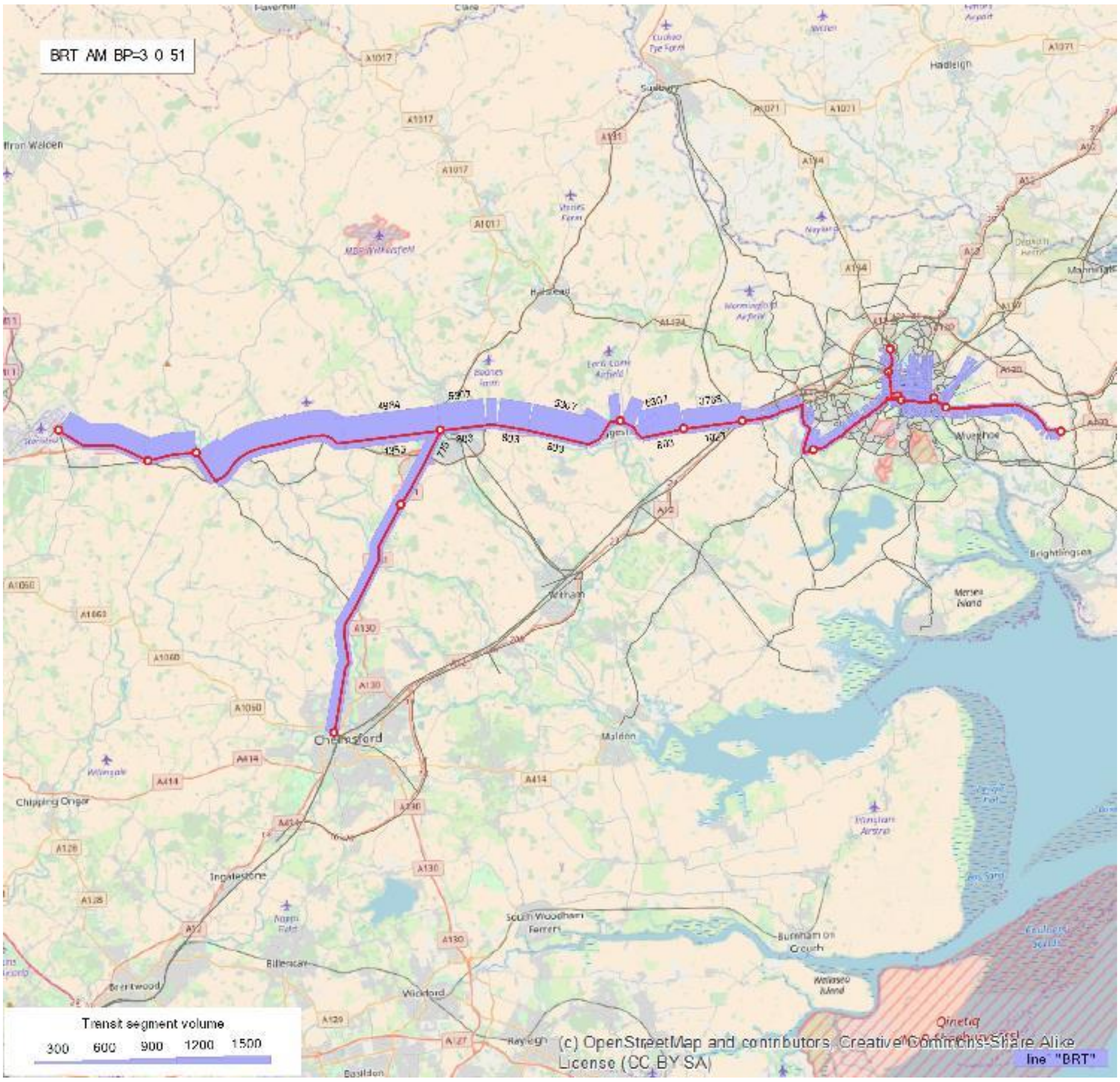


Figure 7-2: Guided BRT volume plot for 2051

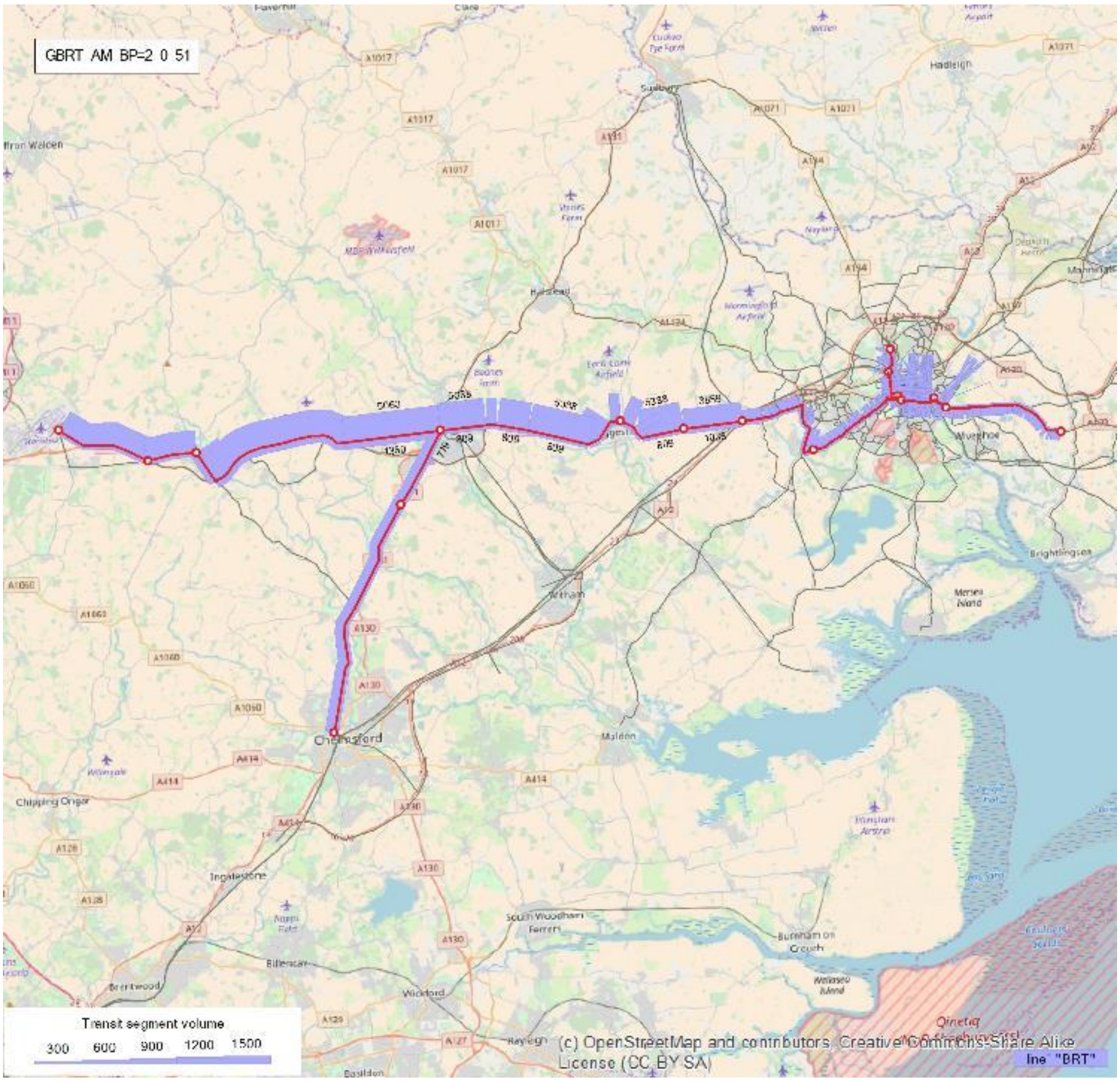
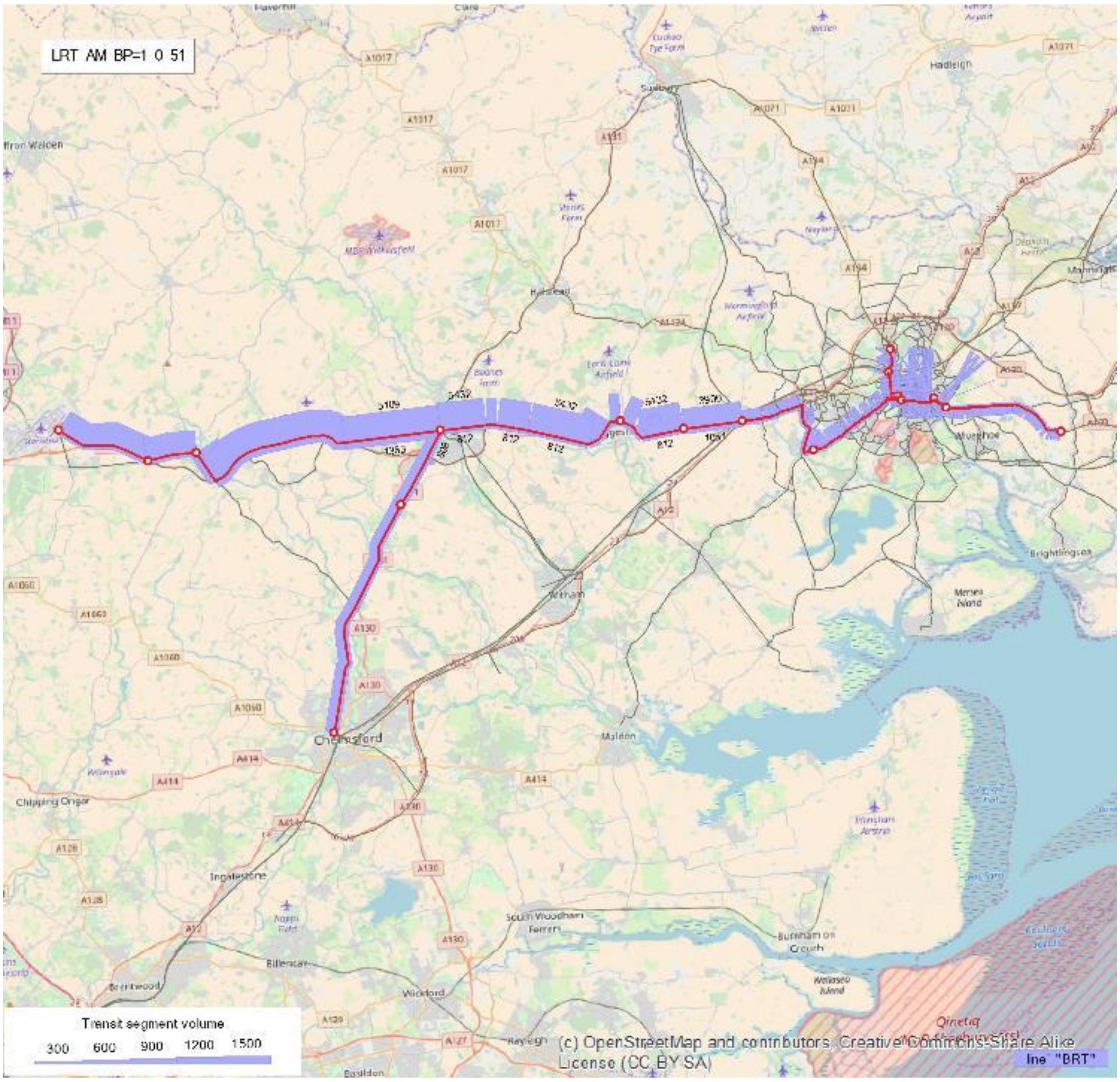


Figure 7-3: LRT volume plot for 2051



Meanwhile a summary of the forecast demand for all six of the scenarios in 2033 and 2051 are shown in Table 7-1 and Table 7-2. As can be seen all combinations attract a significant number of journeys.

Table 7-1: Demand Forecast Summary: 2033

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	BRT	GBRT	LRT	BRT with Col LRT	BRT with Col GBRT/Br GBRT	GBRT with Col LRT
AM 3-hour peak h Rapid Transit trips	25,669	26,723	28,439	29,159	30,708	29,256
AM 3-hour peak h Rapid Transit Pax kms	339,039	344,907	357,390	325,658	242,022	329,181
Annual Rapid Transit trips (m)	30.80	32.07	34.13	34.99	36.85	35.11
Average trip length (kms)	13.2	12.9	12.6	11.2	7.9	11.3

Table 7-2: Demand Forecast Summary: 2051

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	BRT	GBRT	LRT	BRT with Col LRT	BRT with Col GBRT/Br GBRT	GBRT with Col LRT
AM 3-hour peak h Rapid Transit trips	28,569	29,641	31,319	32,002	33,805	32,102
AM 3-hour peak h Rapid Transit Pax kms	376,473	382,806	395,215	359,512	272,803	363,049
Annual Rapid Transit trips (m)	34.28	35.57	37.58	38.40	40.57	38.52
Average trip length (kms)	13.2	12.9	12.6	11.2	8.1	11.3

7.2 Cost assumptions

In order to carry out an appraisal information on costs are required, which are split between capital costs and operating and maintenance costs.

In order to derive capital costs, the costs from previous schemes were considered in 2010 prices, since the appraisal used prices from this year. Also considered was cost difference between interurban greenfield sites and built-up urban areas. From this information a unit cost was derived per kilometre of line. This is shown in the table below.

Table 7-3: Capital cost assumptions

Mode	Urban cost (£m / km)	Interurban (£m /km)
BRT	2	1.3
GBRT	7.5	6
LRT	15	7.5

In addition, a fixed cost of £7m has been added to the cost of LRT when used at Hythe to reflect the estimated cost of a turnback to allow the LRT to use the rail corridor from Hythe to Colchester town which is described in the previous east Colchester study (Jacobs, 2017).

It should also be noted that BRT is significantly less that GBRT based on the understanding that BRT would not operate on a fully segregated route.

On other capital costs the LRT has included a cost assumption of £1.5m per tram. Meanwhile the cost BRT and GBRT vehicles is incorporated under the operating costs. Operating and maintenance assumptions are set out in the table below.

Table 7-4: Operating cost assumptions

	Unit cost	Source
LRT combined operating and maintenance cost per route km	£7.5	Consultant's analysis of previous schemes
GBRT and BRT operating costs per vehicle km	£2.18	Consultant's analysis of UK bus industry
GBRT and BRT maintenance costs per route km pa	£60,000	Consultant's analysis of previous schemes

The total capital and operating costs for each of the scenarios tested can be seen in the following subsection.

7.3 Economic and financial appraisal

The economic appraisal assumes an opening year of 2025 and is appraised over a 60-year period up to 2085. In order to inform the appraisal, information from the 2033 model run has been extrapolated back to 2025 using linear growth assumptions reflecting growth in the garden communities up to 2033. Then a linear growth is applied up to the second modelled year of 2051. From 2051 no further growth assumptions are applied up to 2085.

The appraisal has been carried out using a standard appraisal spreadsheet in which the latest WebTAG parameters have been applied. These parameters are detailed in Appendix A.

The following tables summarise the results. The full set of WebTAG appraisal tables are not provided in this report but are held in the project folders. These include tables for:

- Transport economic efficiency
- Public accounts
- Analysis of monetised costs

Table 7-5: Appraisal Summary: 2033 Costs and Revenues (PV, 2010 prices)

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	BRT	GBRT	LRT	BRT with Col LRT	BRT with Col GBRT/Br GBRT	GBRT with Col LRT
Capital costs	-£249m	-£1,034m	-£1,672m	-£733m	-£771m	-£1,313m
Operating costs	- £284m	- £284m	- £949m	- £443m	- £284m	- £443m
Total costs	**-£533m**	**-£1,318m**	**-£2,620m**	**-£1,175 m**	**-£1,055 m**	**-£1,755m**
Net revenue from increased demand	**-£16m**	**£16m**	**£24m**	**£74m**	**£199m**	**£75m**
Total Financial Effect	**-£549m**	**-£1,301m**	**-£2,596m**	**-£1,102m**	**-£857m**	**-£1,681m**

Table 7-6: Appraisal Summary: 2033 Social Benefits (PV, 2010 prices)

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	BRT	GBRT	LRT	BRT with Col LRT	BRT with Col GBRT/Br GBRT	GBRT with Col LRT
Time savings, business users	**£137m**	**£144m**	**£152m**	**£141m**	**£101m**	**£143m**
Time savings, commuting	**£1,097m**	**£1,154m**	**£1,215m**	**£1,131m**	**£810m**	**£1,147m**
Time savings, other users	**£891m**	**£938m**	**£987m**	**£919m**	**£658m**	**£931m**
Road operating cost savings	**£17m**	**£19m**	**£20m**	**£17m**	**£11m**	**£17m**
Road decongestion	**£8m**	**£10m**	**£11m**	**£9m**	**£5m**	**£9m**
Accidents	**£48m**	**£54m**	**£59m**	**£49m**	**£31m**	**£50m**
Noise, air quality and greenhouse gas	**£3m**	**£3m**	**£3m**	**£3m**	**£2m**	**£3m**
Total Social Benefits	**£2,201m**	**£2,321m**	**£2,446m**	**£2,268m**	**£1,617m**	**£2,300m**

Table 7-7: Appraisal Summary: NPV and Benefit/Cost Ratio

	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Description	BRT	GBRT	LRT	BRT with Col LRT	BRT with Col GBRT/Br GBRT	GBRT with Col LRT
PV of project costs	£533m	£1,317m	£2,620m	£1,176m	£1,055m	£1,755m
PV of net revenue	-£16m	£16m	£24m	£74m	£199m	£75m
Present Value of Costs (PVC)	**£549m**	**£1,301m**	**£2,596m**	**£1,102m**	**£857m**	**£1,681m**
PV of social benefits	£2,201m	£2,321m	£2,446m	£2,268m	£1,617m	£2,300m
PV of indirect taxation impact	£6m	£7m	£8m	£6m	£4m	£6m
Present Value of Benefits (PVB)	**£2,195m**	**£2,314m**	**£2,439m**	**£2,262m**	**£1,613m**	**£2,294m**
Net Present Value (NPV=PVB-PVC)	**£1,646m**	**£1,013m**	**-£157m**	**£1,160m**	**£756m**	**£613m**
Benefit/Cost Ratio (BCR=PVB/PVC)	**4.00**	**1.78**	**0.94**	**2.05**	**1.88**	**1.36**

Based on a value for money assessment[19] the provision of a BRT has the best benefit to cost ratio. However, this should be interpreted in the context of the assumptions made in the study. The service level is comparable to the other options – hence it is attracting a similar volume of passengers – yet the cost is

[19] Value for Money Assessment: Advice Note for Local Transport Decision Makers, DfT, December 2013:
- Poor VfM if BCR is below 1.0
- Low VfM if the BCR is between 1.0 and 1.5
- Medium VfM if the BCR is between 1.5 and 2.0
- High VfM if the BCR is between 2.0 and 4.0
- Very High VfM if the BCR is greater than 4.0

significantly less. Should either or both of these assumptions be wrong the ratio will reduce.

It is nevertheless notable that the benefit to cost ratio for GBRT offers medium value for money. This indicates that even if the BRT assumptions are incorrect a business case could be justified.

Although LRT just falls in the range of poor value for money, it should be noted that other benefits of this scheme could be considered. For example, LRT might be more successful at attracting a modal shift away from private car travel; it might contribute more than the other modes to economic growth; and it might increase land values more than other modes which can be used to, in part, finance the capital cost.

It should be noted that the economic appraisal looks at the incremental change in revenue. This does not take into account developer contributions nor ticket revenue.

7.4 Sustainability and added value

In deciding between the options other factors should be considered related to the vision set out the in the Local Plans for North Essex Authorities and the draft Development Planning Documents for the garden communities.

The ability of the options to drive modal shift could be important alongside the contribution to environmental improvement. These could be related to impacts on severance and townscape or to measurable impacts on air quality.

If a rapid transit policy is taken forward it is recommended that multi-criteria analysis accompanies the choice between options. These are likely to vary by mode and by route.

7.5 Deliverability

Delivery should consider financing, operating model and implementation of the system. If a system were to be opened by 2025, say, to coincide with the growth of the garden communities, it is recommended that the county council commence option refinement and refinement of business cases as soon as possible. The table below shows an indicative timeline based on a 2025 opening.

Table 7-8: Delivery stages

Stage	Date
Confirmation of preferred option	2018
Refinement of business case	2018
Public consultation	2018
Outline funding agreements	2018
Development of full business case	2019
Outline design	2019
Further public and stakeholder consultation	2019
ECC decision to proceed with the project	2019
Start of Consents process (including TWAO if required)	2020
Consent obtained	2021
Design and Construct tender process	2021
Detailed design	2021/22
Construction phase	2022-2024
Testing and Commissioning	2024
Scheme Opening	2025

One of the key decisions that will need to be made is whether upfront investment is to be made in order to create the entire system earlier on in the Local Plan period. Arguments in favour would be to capture existing demand, demonstrating intent to alter travel behaviour, economies of scale if built with the A12 and A120 schemes, and creating an uplift in land value. However, cons would be the cost of financing such a system or obtaining external funding for it.

As an alternative, an incremental approach could be taken where those parts of the system where demand is highest are implemented first around Colchester and Braintree. The longer interurban connections would then be created at a later date. The advantage of this is that it is potentially easier to finance the scheme. However, the downsides are that it would be competing with local bus services and not meeting inter-urban demand.

An alternative incremental approach, as followed in Edinburgh, would be to create a segregated route along which BRT or GBRT services could run. Then, in time, as external funding and developer contributions become available and there is certainty over the level of growth, sections are upgraded to LRT and service levels enhanced.

8 Conclusion

This study has explored the case for creating a rapid transit network over North Essex in order to facilitate growth and contribute to local congestion, environment and quality of life improvements.

It has been argued that rapid transit is a keystone in public transport provision for North Essex filling a gap between local bus services and longer distance train services. Furthermore, a rapid transit system is compatible with design principles for garden communities, which will encourage a modal shift away from private car travel and contribute to the design of high-quality living places. A rapid transit system also fits well with major roads projects in the area on the A12 and A120. In fact, sections could be built together creating economies of scale and a genuinely integrated transport system.

It has also been shown that an economic case could be formed to take forward the implementation of a rapid transit system. A bus rapid transit (BRT) and guided BRT have high and medium benefit to cost ratios, respectively. And while a system based entirely on light rail transit (LRT) has a lower benefit to cost ratio, a case for considering LRT on busier sections such as in Colchester could be justified from the perspective of an economic appraisal. It is noted that any decision on which mode of rapid transit to use should be influenced by other factors such as contribution to the regional economy and sustainability.

Consequently, the report concludes that there is sufficient reason to believe that creating a rapid transit system in North Essex which also connects adjoining destinations in Chelmsford and Uttlesford would be a measure worth pursuing as part of an integrated transport and planning strategy. In the next stages there are still issues to address including route and technology options; impact on the highway network; financing and operating models; and implementation plan.

It is feasible that a system could be constructed in one go in order to promote the area and drive modal shift. However, a more incremental approach might be favoured. This could involve securing the space for a segregated system early on but only implementing in stages to match growth in demand from developments. Alternatively, a system whereby a largely segregated BRT or GBRT system is introduced early on and then sections are upgraded to LRT once demand is sufficient and sufficient funding contributions have been secured.

The sections of this report provide the foundations from which it is hoped that the pros and cons of a rapid transit system in North Essex can be explored further. This includes a review of technology options; a look ahead to technology changes; a transport model which can be developed further to test options; and an economic appraisal to refine further.

Essex Highways

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Glossary and abbreviations

Term	Abbreviation (if used)	Definition or explanation
Bus rapid transit	BRT	A bus-based public transport system designed to improve capacity and reliability relative to a conventional bus system.
Big data		Big data is used to refer to techniques to store, present, analyse and utilise the contents of extremely large data sets which are now routinely collected due to the ubiquity of digital technologies and devices.
Connected and Autonomous Vehicles	CAV	There are different levels of automated vehicles. Currently tests of CAV required driver monitoring. In the highest level of CAV, the car would be completely diiverless.
Development planning document	DPD	A document which sets out the spatial planning policies for a strategically significant development within a local authority area.
Full time equivalent	FTE	A unit that indicates the workload of an employed person equal to the hours worked by one employee on a full-time basis.
Furnessing	-	Furnessing is a technique to generate future year trip matrices using a distribution in a base year trip matrix.
Generalised cost	GC	The sum of the monetary (fare, fuel, toll etc.) and non-monetary (journey time, crowding) costs of a journey.
Generalised journey time	GJT	A composite term for public transport journey time including travel time, headway and interchange.

Guided bus rapid transit	GBRT	A bus system using a segregated track. It is considered an intermediary between the conventional bus and tram systems in terms of achieving a similar speed, capacity and design.
Home based other trips	HBO	Home based other trips are: • trips between an individual's home and other places apart from the place of employment (e.g. leisure and education) • business trips
Home based work trips	HBW	Home based trips are trips between an individual's home and place of employment for the purpose of working. i.e. commuting trips.
Light rail transit	LRT	Urban public transport using rolling stock similar to a tram, but offering a higher capacity and often on an exclusive right-of-way.
Mobility as a Service	MaaS	Mobility as a service covers many recent development in transport often based around digital information and payment systems and a growth of on-demand transport services.
National Trip End Model	NTEM	Provides a set of predictions of growth in car ownership and car traffic, with associated planning data projections, at any geographical level down to local authority districts.
Near Field Communications	NFC	A set of standards for portable devices. It allows the devices to establish peer-to-peer radio communications, passing data from one device to another by touching them or putting them close together.
North Essex garden communities	NEGC	A company set up in 2017 to take forward proposals for three new garden communities across North Essex.

Oyster		Oyster is a smartcard which can hold pay as you go credit, Travelcard and Bus & Tram Pass season tickets. It can be used for transport services in and around London.
PlusBus tickets		The PlusBus tickets price includes unlimited local bus and tram travel around the whole urban area and is purchased alongside a rail ticket.
Radio-frequency identification	RFID	RFID- a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal or person.
Simulation and Assignment of Traffic to Urban Road Network	SATURN	A computer program that calculates transport assignment on road networks. It was developed by the University of Leeds and Atkins.
Train per hour	tph	A an abbreviation used to indicate train service/schedules for a particular railway station.
Trip End Model Presentation Program	TEMPro	A modelling tool designed to allow users to look at the growth in trip ends from NTEM. The version used is TEMPro v7.2.
Trip Rate Information Computer System	TRICS	A database of trip rates for developments used in the UK for transport planning purposes, specifically to quantify the trip generation of new developments.

Appendix A: Appraisal assumptions

Parameter	Assumption	Source
Appraisal Base Year for costs and discounting	2010	WebTAG
Appraisal Period	From 2010 to 60 years after scheme opening	WebTAG
Opening Year	2025	Scheme Assumption
Discount factor	3.5% until year 30 3.0% from year 31	WebTAG
Optimism Bias Uplift, Capital Costs	64%	WebTAG
Optimism Bias Uplift, Maintenance Costs	64%	WebTAG
Optimism Bias Uplift, Operating Costs	41%	WebTAG
Capital Cost Phasing	2021 10% 2022 30% 2023 30% 2024 30%	Consultant's estimate
Market Price Uplift	1.19	WebTAG
Annualisation Factors **- Demand and revenue** **- Operating costs** **- Road decongestion benefits**	 1,200 6,552 600	 Consultant's estimate[20] Consultant's estimate[21] Consultant's estimate[22]
Average Revenue per trip in 2010	£0.82	DfT bus statistics[23]
Real Growth in Fares	0.7% pa	Based on DfT bus statistics, Table BUS0402a, extrapolated after 2016
Value of time and VoT Growth	As per databook	WebTAG table A1.3.2 (PSV)[24]
Trip Purpose Split	As per databook	WebTAG table A1.3.4 (Light Rail)[25]

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[20] Two peak periods a day, daily demand is twice the peak period demand, a weekend is equivalent to one-week day (2x2x300)

[21] 18 hours a day for 364 days a year (18*364)

[22] Two peak periods a day, a weekend is equivalent to one week day (2x300)

[23] Table BUS0402a, for English non-metropolitan areas. Values factored using data from Table BUS0501a to allow for passenger fare receipt as proportion of total operating revenue

[24] WebTAG provides values of time for PSV (Bus) passengers, Rail and Underground but not light rail. PSV was thought to be the most appropriate value.

[25] In contrast to values of time, WebTAG provides a separate set of purpose splits for light rail, with higher proportions of Business and Commuting trip purposes compared with bus. Given the expected profile of new residents in the Garden Settlement, we felt it was appropriate to use these.

Benefits and Revenue build-up	35% in year 1 70% in year 2 90% in year 3 100% in year 4	Consultant's estimate
Demand growth prior to first modelling year (2033)	3% pa	Consultant's estimate
Demand growth after first modelling year (2033) and prior to second modelling year (2051)	5.5% pa	100/18
Demand growth after final modelling year	0% pa	Consultant's estimate
Marginal External Costs included	Infrastructure cost saving Accident Local air quality Noise Greenhouse gases Indirect taxation	Calculated using WebTAG MECC methodology