FREQUENCY IS FREEDOM, BUT IS ON-DEMAND BETTER?

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Context

We know, for public transport users, that 'frequency is freedom'. But how does it apply outside urban cores?

Where populations are sparse and travel patterns variable, a 'critical mass' of people using specific routes is unlikely, undermining the traditional bus business model of full peak time buses cross-subsidising off-peak services. Indeed, experience suggests that rural routes have been cut, and rural areas experience transport desertification for this precise reason.

This paper looks at designing transport in a sparsely populated area in Hertfordshire consisting of scattered villages, the distribution of which creates travel needs between multiple origins and destinations. Those bus services that exist do not cover the whole area and have infrequent service patterns.

The DRT (Demand Responsive Transport) service was created to trial additional solutions to enable people to travel, funded by the Rural Development Fund.

This paper looks at the use patterns (by origin destination pairs) of the DRT services. It considers the routes and frequency of fixed line buses which would be needed to meet the use patterns and provide the same level of service as the DRT.

These findings have implications for decarbonisation policy, levelling up, bus strategy and the best use of funding. Car dependency is a major factor contributing to the higher carbon footprint of people in rural areas. Rural deprivation creates a downward spiral of missed opportunity, lack of access to work and further deprivation. Improving bus services are key to reversing these trends. We ask how to do this - frequency may be freedom, but -measured by a variety of metrics - is DRT better?

Summary

'Frequency is freedom' has become transport planning catchphrase, popularised by Jarrett Walker in his 2012 book ' Human Transit: How clearer thinking about public transit can enrich our communities and our lives'.

« *To be useful, transit must exist in both space and time. It must run not just where we need it but also when we need it. Unless it does both, it doesn't exist for us at all.* »

Outside the urban core, particularly in rural areas, one could be excused for thinking that public transport does not exist at all on this measure.

Examining the North East Hertfordshire area, we look at the population distribution, the underlying fixed line transport network (bus and rail) and the addition of DDRT to this mix.

For each system we look at:

- Numbers of people served by the network (absolute and by at least hourly services)
- Frequency of services
- Service span
- Speed of service

We find that DRT services serve a much higher proportion of the population in the area, they are faster and also create an experience similar to introducing a more frequent service without requiring as many vehicles or service hours.

However, we also find that there are some gaps in provision and that no matter how smart DRT is, without more vehicles there is likely to still be unmet demand.

Methodology

- For the numbers of people served by the network we use a mapping tool with isochrones and population estimates.
- For frequency and span we evaluate the utility of fixed services by analysing both advertised service times and a sample of potential journeys to give absolute journey times (from origin public transport node – bus or rail – to the destination node). This gives an indication of real world experience of public transport, not just the absolute speed advised by journey planner travel times. We compare both against private car travel.
- For speed and frequency of service it is hard to compare time tabled services with DRT services, however we suggest a metric based on a combination of the DRT theoretical journey time and how far ahead this would need to be booked to achieve it. To compare this with fixed route travel we take three journeys with a constraint (depart by or arrive by) and measure the absolute time required to make this journey under those constraints. We use this measure to compare the utility of fixed and DRT services.
- Where one service provides a more useful service we look at what would need to happen to make them equivalent and the relative cost of this. Relative cost estimates are based only multipliers of the existing service (eg double frequency implies double cost, increase span of a 10 hour service to 12 hours implies an increased cost of 20%). With these relative service levels and relative costs calculated, we can provide outline conclusions on the relative costs of providing services to similar numbers of people, with similar degrees of utility (frequency, span and speed).

Area background

Population

East Hertfordshire is an area with a relatively low population density, with 316 persons per square kilometre. It's the 17th least densely populated of the East of England's 45 local authority areas. The neighbouring authority, North Hertfordshire is a little denser, with 355 persons per square kilometre[1].

However neither authority has many large centres of population, and in North Hertfordshire around 40% of the population lives outside the three towns, whilst in East Hertfordshire around 57% are outside the two towns. There are particular areas where this pattern is exaggerated. The zone bounded by Royston in the north, Stevenage in the west and Bishop's Stortford in the east is home to around 50,000 people. with people distributed across the area in isolated dwellings, small hamlets and villages with only one small market town, Buntingford (population 6,844).

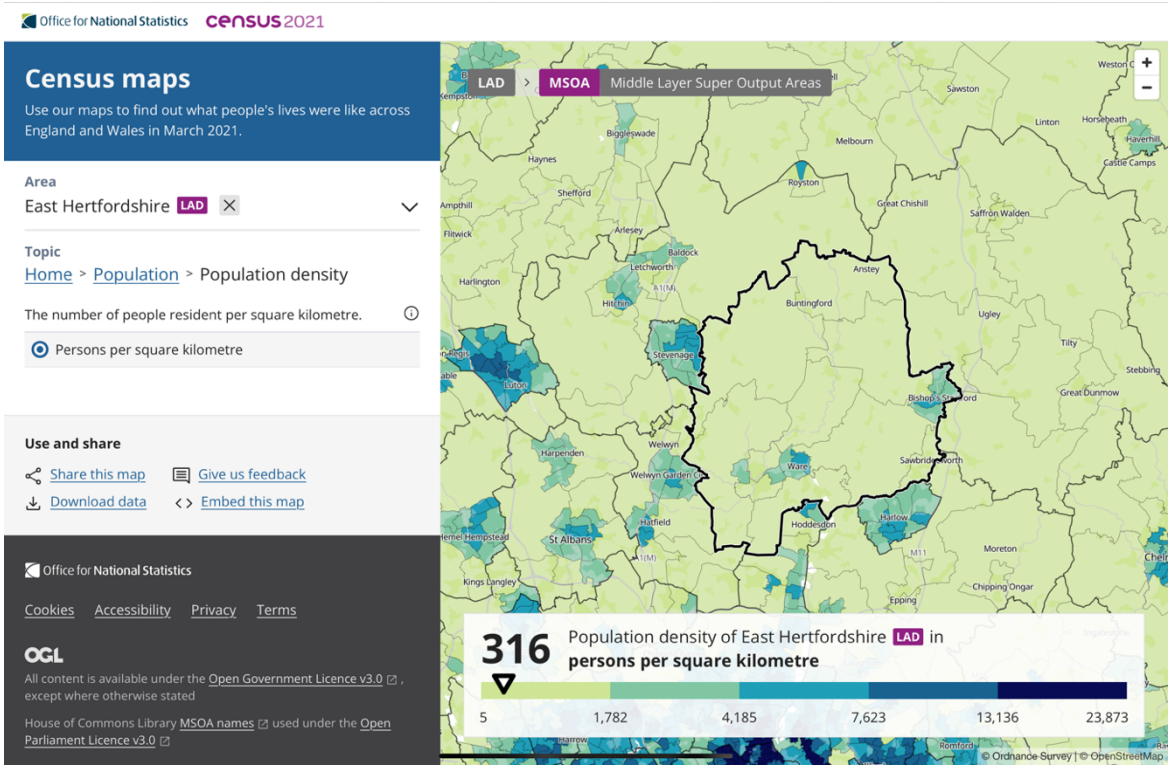


Figure 1: Population density for East Hertfordshire (Office for National Statistics Census 2021)

Travel

Many people travel within the area (to and around Buntingford) or to jobs, services and rail links located in surrounding towns: Stevenage, Letchworth, Hitchin, Baldock, Royston and Bishop's Stortford.

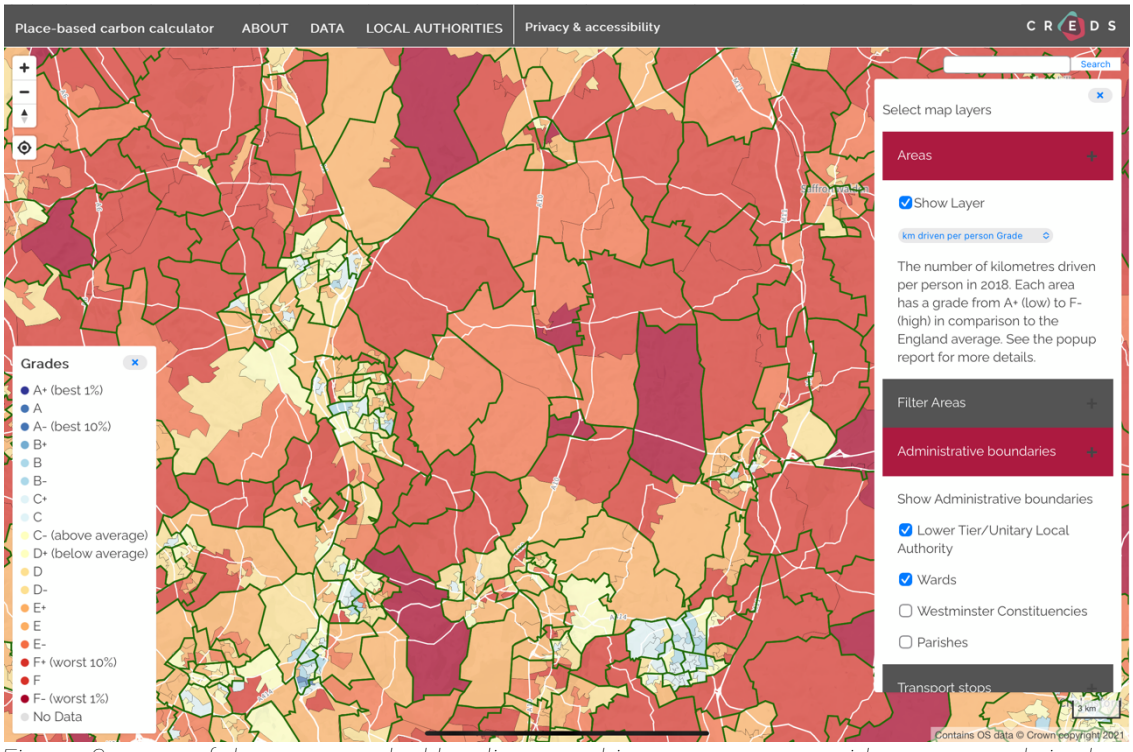


Figure 2: map of the area graded by distance driven per person, with some wards in the zone among the highest 1% of distance driven per person in England. [2]

The area is heavily car dependent. Although it is served by some bus routes, the services are often infrequent. Figure 2 indicates the degree of car dependency by mapping distance driven.

Transport stops are sparsely spread across the area.

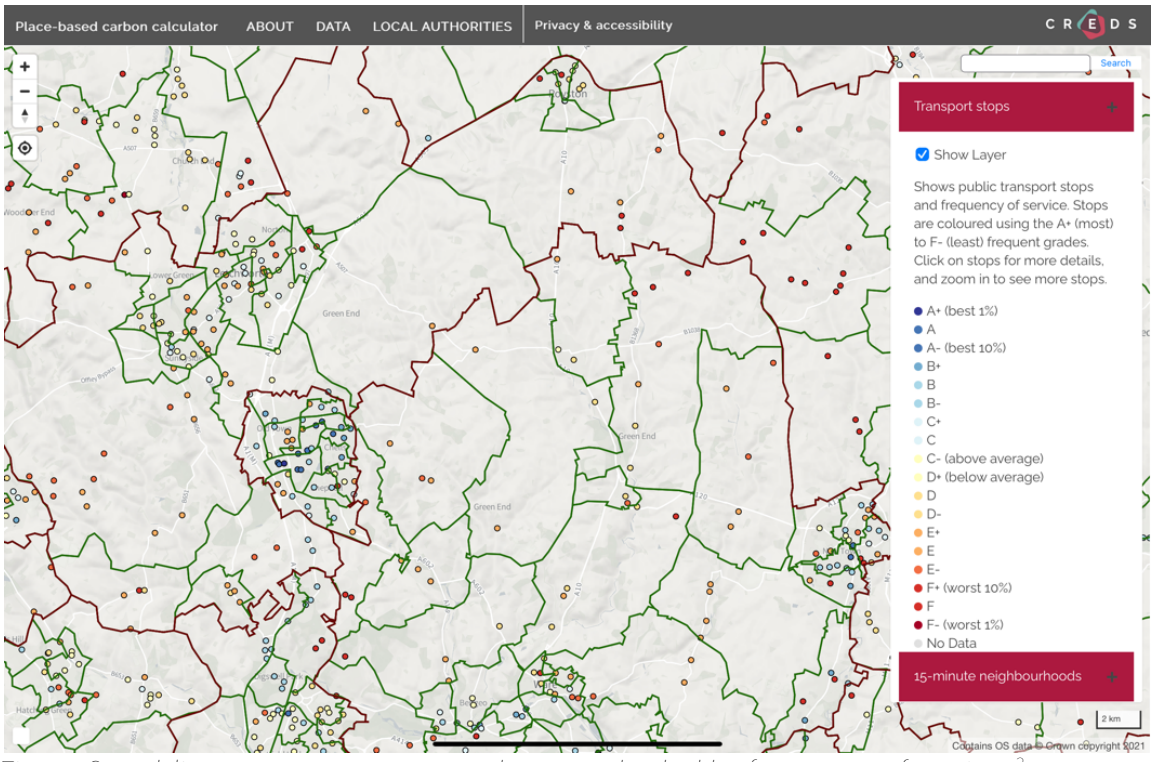


Figure 3: public transport stops across the area, shaded by frequency of service. [3]

The least frequent services coincide with the areas where people drive more (see figure 3)

Hertfordshire County Council identified this area as including 4,000 people who had no access to bus on any metric prior to 2021.

In addition, mapping isochrones around fixed bus stops with an hourly frequency or better (figure 5) shows huge areas without access to service meeting even a minimal a definition of useful public transport (hourly services).

The net consequence is that it is impractical for the vast majority of the rural population of the area to walk to these bus stops as most people live beyond a 15 minute walk. This is an estimated 40,000 of the 50,000 people in the area.

The introduction of the HertsLynx DRT scheme

HertsLynx is designed to serve residents in the designated operating zone covering villages in North and East Herts, as well as providing transport links to fixed destinations in Key Hub Towns: Stevenage, Letchworth, Hitchin, Baldock, Royston and Bishop's Stortford.

It covers an area between 7 and 9 miles in each direction from Buntingford, serving a total area of around 150 miles^2 / 400km^2.

HertsLynx launched with three 16 seater minibuses each with one space for a wheelchair user and increased to 4 vehicles in 2022..

The service operates 0700 – 1900 Mondays to Saturdays and 1000 – 1600 on Sundays and Public Holidays.

Journeys can be booked in real-time or in advance.

Fares are based on distance travelled, starting at £2 (upto 2 miles) to £5 for over 10 miles at launch. They increased by £1 per category in 2023. Concessionary pass holders travel for free, SaverCard holders and children under 10 travel for half fare. HertsLynx runs as a cashless service.

Passengers can use HertsLynx for travel anywhere in the Free-Floating Operator Zone. There are no fixed routes on this service, instead passengers can be picked up and dropped off at a vast number of stops within the zone. They are also able to travel from the Free-Floating Operator Zone to designated locations in the Key Hub Towns. Travel is permitted between Key Hub Towns but is not available for journeys between points within one Key Hub Town.

Figure 4: HertsLynx operating zone

Although it is possible to limit bookings if a trip could be made by fixed route bus (within certain constraints), this has not been implemented. It may be implemented in future service developments.

The service was commissioned by Hertfordshire County Council, funded by the Rural Mobility Fund of the Department for Transport. The service is operated by Uno Bus, which runs fixed route buses across Hertfordshire. It is the first DRT service Uno Bus has run. HertsLynx is managed using the Padam Mobility DRT platform

Fixed line and DRT service comparison

In this section we look at the data for DRT and fixed line transport services detailing:

- Population served
- Speed
- Frequency
- Service span.

Population: who is served and how?

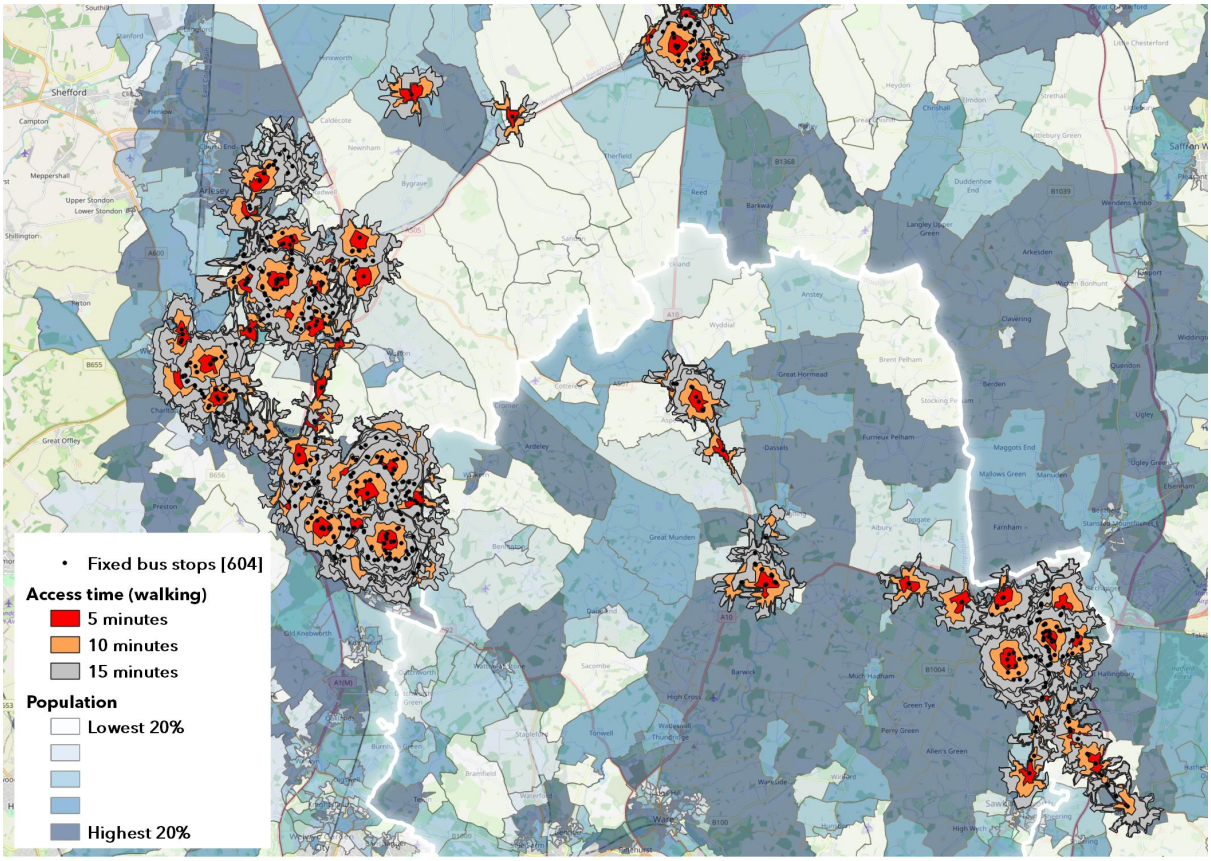


Figure 5: isochrones for fixed bus stops with hourly or better service in the HertsLynx area

The addition of the HertsLynx virtual bus stops increases the proportion of the population covered as shown below. These stops are served by 4 buses (2023). It would be virtually impossible to plot any kind of sensible linear service to cover all these stops with just 4 vehicles.

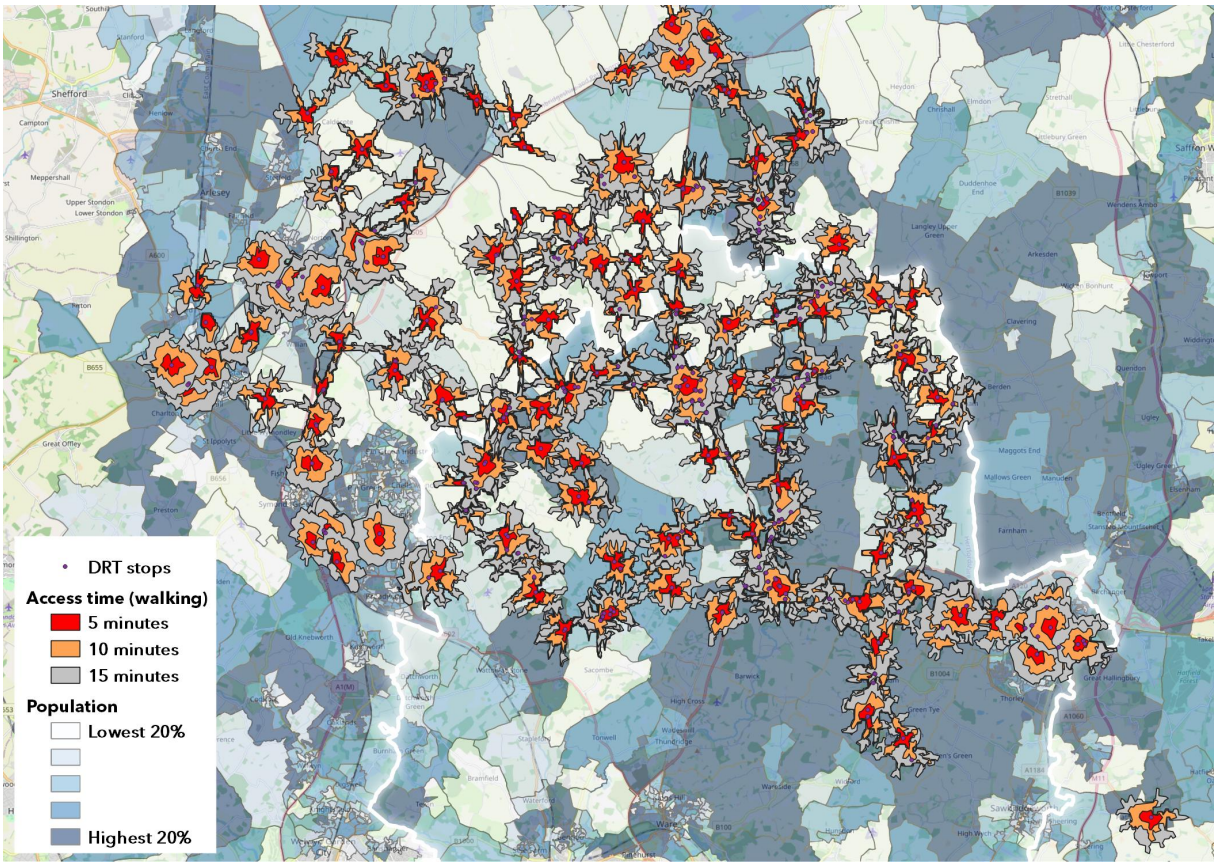


Figure 6: isochrones for the HertsLynx virtual stops

Frequency, speed and span

Since the launch of the HertsLynx service, it has become possible to derive a set of 'transport desire lines' from the journeys people have requested. These have the advantage that they reflect the trips people want to make rather than those they are forced to make by the available fixed routes. These desire lines are the basis for our analysis.

The top three origins are:

- Royston rail station
- Stevenage bus station
- The Crown, Buntingford (at the centre of the town)

In the following section we use one of the most popular origin destination pairs to analyse travel speed, frequency and span of transport options for people wanting to travel between these points. The journeys we analysed are:

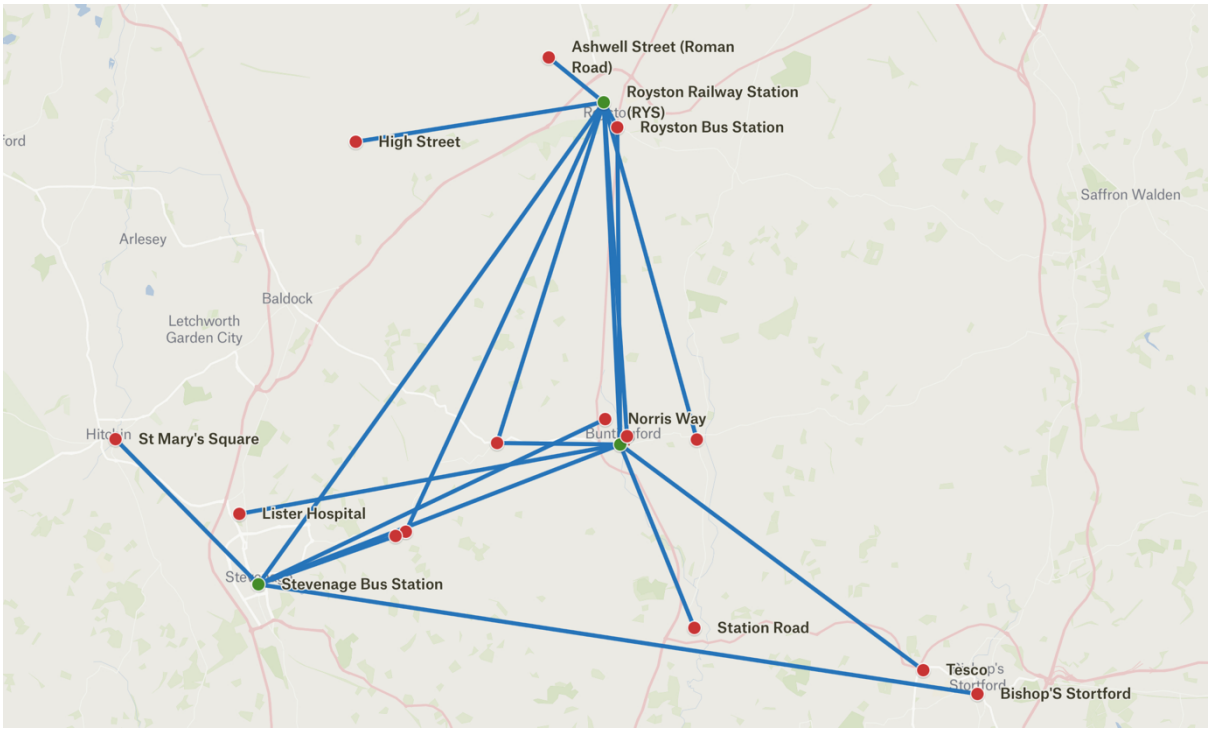
Royston station to:

- Paddock Road Buntingford
- Hare Street Buntingford
- High Street Ashwell
- Hight Street Walkern

Figure 7: top DRT three origins (in green) mapped against their top ten destinations (red).

We compare advised journey times for car travel, fixed route lines and DRT for each origin and set of destinations. These are the times suggested by route planners and are very much the 'best case scenarios' for trips where the traveller can choose when to leave and when they arrive by. For our study we used Google Maps for car and fixed line transport, and the HertsLynx app for DRT. For frequency of fixed line routes we used timetables (as published to Google Maps).

As neither advised travel times for fixed line nor DRT reflect real world experience, and DRT does not operate to a timetable and therefore frequency cannot be compared, it was



necessary to create a different metric for the utility of the services. To do this we compared the utility of the fixed line transport with utility of DRT to create a 'journey time penalty score' for each mode.

The journey time penalty score was created using the following methodology.

For each set of trips we set a constraint – a fixed start or end point. This type of constraint is typical of journeys that people have to make, for instance to be on time for an appointment, college or work or because they finish activities at a certain time that they don't have control over. We look at a set of three standard trips, each with a single constraint, spread across the course of the day. For each we produced a total journey time for the trip to meet the constraint. We then calculated the difference between that and the journey by car. This calculation gave us a journey time penalty for the mode.

Utility of DRT

The utility of DRT looks at the actual trip offered (to meet the constraint) and also combines this with its bookability. Because the DRT service can be booked up to 4 weeks in advance, we have scored it for three booking intervals:

- a day in advance
- a week an advance
- two weeks in advance

We look at each possible OD pair for each of our constrained journeys and look at what real DRT trips are available for each at these booking intervals. This gives us a journey time penalty for the mode.

Whilst this is very much an indicative score, it provides a basis for comparison as it is elevated by low frequency fixed services or by lack of available DRT services. This is a basis for a reasonable comparison that will also have resonance with real world experiences.

Data

Speed / journey time

The following table shows the journey times for a direct trip by car compared to the fixed line bus or rail journey times as calculated by Google Maps.

	Car journey time (mins)	Fixed line bus journey time	Fixed line bus time penalty
Paddock Road Buntingford	17	43-53	26 – 36 mins
Hare Street Buntingford	20	84 - 704	1hr 4 mins to overnight
High Street Ashwell	14	27 - 55	13 to 41 minutes
High Street Walkern	24	79	55 minutes

The time penalties for using the bus are already quite extreme, at least double the journey time by car and in some cases four to five times it (even excluding the overnight trip required to get from Royston to Ashwell) – especially considering that they will include people arriving by rail so making onward journeys.

Some trips are only possible by combining with rail, which adds cost (particularly for concessionary pass holders) and complexity. Cost has not been specifically factored into this study, however two fares are greater than one.

Frequency

Fixed bus frequency (weekdays):

Royston station to Paddock Road Buntingford

Bus service 18 every 2 – 3 hours from 0749 to 1708 (5 times per day)

Royston station to Hare Street Buntingford

Bus service 18 every 2 – 3 hours from 0749 to 1708 (5 times per day)

Change onto

Bus service 331 every 1 – 3 hours from 0632 to 1757 (8 times per day)

Royston station to High Street Ashwell

Bus service 90

0927 (one per day)

Or

Bus service 91 0730 or 1222 (2 times per day)

Effective service 3 times between 0730 and 1222

If the train (Royston to Ashwell Station) is combined with bus, this increases to 4 times per day (although cost is likely to be a factor in whether people will choose this).

Royston station High Street Walkern

The only public transport options between Royston station to High Street Walkern go via rail to Stevenage station and then require a bus (the 384 service) which runs 6 times per day.

Span

The maximum service span across these destinations is 0632 to1757 (11 hours 25 minutes) however Royston station to High Street Ashwell is only served between 0730 and 1222 (4 hours 52 minutes).

The maximum service span across these destinations for DRT is 0700 to 1900 (12 hours) in 2023.

Utility

To gauge utility we allocate a journey time penalty score which is calculated using a constraint – in this case the arrival times of trains at Royston station. These trains were chosen to be one in the morning peak, one off peak and one later in the day.

Fixed line utility

If a constraint is included, the fixed line public transport times become even more exaggerated. In the following table we see total journey times for a set of potential journeys, morning, off peak and evening, connecting with train arrival times at Royston Station.

	Train arrival	Earliest possible arrival at destination by fixed PT	Total journey time from arrival at Royston station (mins)	Journey time penalty score
Paddock Road Buntingford	0846	0957	71	55 minutes

	1018	1248	150	2 hours 13 minutes
	1838	1940	62	45 minutes
Hare Street Buntingford	0846	1038	112	1 hour 32 minutes
	1018	1301	163	2 hours 23 minutes
	1838	0746 (next day)	788	Next day
High Street Ashwell	0844	0945	61	47 minutes
	1601	1804	123	1 hour 49 minutes
	1838	0754 (next day)	794	Next day
High Street Walkern	0846	1301	255	3 hours 51 minutes
	1535	1759	144	2 hours
	1838	0759 (next day)	807	Next day

It can clearly be seen that the frequency of services means that the 'journey time' served by travel planners is optimistic in the extreme. If you're lucky enough to arrive at Royston station at 1838 and be travelling to central Buntingford your journey will be just 9 minutes more than the advised journey time of 53 minutes – but at 62 minutes it is still over 3.5 times the 17 minutes this trip takes by car. A total journey time penalty of 45 minutes for taking public transport. The additional time is partially due to the diverted route – to cover more people the bus deviates from the most direct route to call at stops in Barkway.

Whilst Paddock Road is close to the centre of Buntingford and its main axis, the travel times are even less appealing for people travelling from points off that corridor. Trips from Royston Station to Hare Street Buntingford (8.6 miles / 20 minutes in a car) vary from 1 hr 52 minutes) to 2 hours 43 minutes pointing to journey time penalties of over two hours. This journey requires a connection taking over 40 minutes.

The small villages of Ashwell and Walkern have infrequent services which can make trip times inordinately long.

Finally, it's not possible to get to three of the four destinations on the same day if you happen to arrive at Royston station after 1800.

DRT utility

DRT times are advertised as much shorter than fixed line services. However, those times are only possible if a vehicle is available. DRT service users tend to book as soon as they know they are going to travel and can book up to 4 weeks in advance. For this reason we sampled three different booking patterns.

Royston station to Paddock Road Buntingford

The advertised DRT journey time is 30 minutes (13 minutes longer than a car journey).

For the three sample times the morning time proves the hardest to book with the longest delays. We sampled booking with one day, one week and two weeks notice.

Depart from constraint	1 day notice	one week notice	2 weeks notice
0846	d 1030 a 1100	d 0928 a 0958	D 0935 a 1005
1018	d 1030 a 1100	d 1018 a 1048	d 1018 a 1048
1838	d 1930 a 2001	d 1900 arr 1930	d 1838 a 18.53

Using these times, we can calculate a time penalty for using DRT over driving :

0846: 117 / 55 / 62 minutes

1018: 29 / 13 / 13 minutes

1838: 70 / 39 / 13 minutes

The morning peak service is difficult to book, presumably because there is high demand. Booking in advance reduces the journey time penalty for all services, and the off peak and evening service attract lower time penalties.

Royston station to Hare Street Buntingford

The advertised DRT journey time is 32 minutes (12 minutes longer than a car journey)

Our booking attempts at one day, one and two weeks notice yielded trips as follows:

Depart from constraint	1 day notice	one week notice	2 weeks notice
0846	d 1030 a 1103	d 0929 a 1016	d 0935 a 1007
1018	d 1030 a 1103	d 1018 a 1050	d 1018 a 1050
1838	d 1930 a 2003	d 1903 a 1950	d 1838 a 1910

The comparable time penalty for using DRT is:

0846: 117 / 78 / 61 minutes

1018: 25 / 12 / 12 minutes

1838: 65 / 52 / 12 minutes

Royston station to High Street Ashwell

The advertised DRT journey time is 27 minutes (13 minutes longer than a car journey).

Our booking attempts at one day, one and two weeks notice yielded trips as follows:

Depart from constraint	1 day notice	one week notice	2 weeks notice
0846	d 1053 a 1120	d 1004 a 1032	d 0935 a 1002
1601	all vehicles booked	d 1657 a 1725	d 1736 arr 1803
1838	all vehicles booked	d 1911 a 1938	d 1838 a 1905

The comparable time penalty for using DRT is:

0846: 150 / 92 / 62 minutes

1601: * / 74 / 108 minutes

1838: * / 46 / 13 minutes

The later service when no fixed line service is available in the afternoon is the most difficult to book. A large amount of pre-booking is observed in the service, reducing options for late-notice bookings (trips were available with more notice). This is particularly the case as many trips are to or from transport hubs.

Royston station to High Street Walkern

The advertised DRT journey time is 40 – 51 minutes (16 to 37 minutes longer than the same journey by car).

Our booking attempts at one day, one and two weeks notice yielded trips as follows:

Depart from constraint	1 day notice	one week notice	2 weeks notice
0846	d 1053 a 1133	d 1005 a 1045	d 0935 a 1015
1535	all vehicles booked	d 1657 a 1738	d 1715 a 1804
1832	d 1842 a 1936	d 1900 a 1947	d 1832 a 1912

The comparable time penalty for using DRT is:

0846: 140 / 95 / 65 minutes

1535: * / 99 / 125 minutes

1832: 40 / 51 / 16 minutes

Emerging themes

Although these metrics are indicative, it is possible to see themes emerging.

1. Booking DRT services in advance reduces the time penalties considerably.
2. Certain times of day are congested and it is hard to book sufficiently in advance to benefit from the reduced journey time penalties DRT can offer.
3. The lack of available vehicles for short notice bookings will hamper take up and reduce options.
4. Despite this, the table below shows that the time penalties for DRT even in the worst case scenarios are almost universally lower than those for fixed services. An indicative aggregate score is calculated for each trip group.
5. DRT provides a particular improvement in for those wishing to make off peak services or travel later in the day.
6. DRT significantly improves journey time where it is replacing a journey that can only be made with a connection.

OD pair	Time	Fixed penalty	DRT penalty
Royston Station Paddock Lane Buntingford	0846	56	117 / 55 / 62
Royston Station Paddock Lane Buntingford	1018	133	29 / 13 / 13
Royston Station Paddock Lane Buntingford	1838	45	70 / 39 / 13
Aggregate total journey penalty		78	45.6
Royston Station Hare Street Buntingford	0846	112	117 / 78 / 61
Royston Station Hare Street Buntingford	1018	163	25 / 12 / 12
Royston Station Hare Street Buntingford	1838	*	65 / 52 / 12
Aggregate total journey penalty		137.5 *	48.2
Royston Station High Street Ashwell	0846	59	150 / 92 / 62
Royston Station High Street Ashwell	1601	123	* / 74 / 108
Royston Station High Street Ashwell	1838	*	* / 46 / 13
Aggregate total journey penalty		91*	77.9*
Royston Station High Street Walkern	0846	163	140 / 95 / 65
Royston Station High Street Walkern	1535	50	* / 99 / 125
Royston Station High Street Walkern	1832	79	40 / 51 / 16
Aggregate total journey penalty		97.3	78.9

* where a trip is not offered it is not included in average total penalty time

Relative costs

To provide fixed line services with similar journey time penalties to DRT, additional buses would be needed to improve frequency. This is particularly true in the off peak and later in the day, as fixed line services are most frequent in the morning peak. Whilst this is likely to reflect outbound demand being concentrated into a small window, it also begs the question of how people are expected to make the return leg of their trips. Whilst passenger numbers are usually lower outside the morning peak, the availability of buses throughout the day affects whether people are able to use the bus in both directions.

Royston station to Paddock Road Buntingford

To reduce the advised journey time the route of the number 18 bus could be made more direct (not diverting from the A10 to call at Barkway). In addition, to reduce the total journey time penalties, the frequency would need to increase to an hourly service across an additional 2 hours of day.

Costs would also be increased by needing an additional service serving Barkway.

This would also imply a second vehicle as analysis suggests that the current service is a single vehicle at maximum capacity. A third vehicle may be required to serve Barkway.

Estimate additional requirements, 2-3 additional vehicles and drivers operating 2-3 x service hours.

Royston station to Hare Street Buntingford

To reduce both advised and total journey time would require the increased frequency of the number 18 bus as above and in addition, raising the frequency of the 331 from 1-3 hourly to hourly and increasing the span by 2 hours.

This improvement depends on the additional services above, plus further service hours would be required to increase the frequency of the 331 sufficiently to reduce the total journey time penalty.

Royston station to High Street Ashwell

This service is only available 4 times per day, so frequency and span uplift would be required.

To increase this service to 8 times per day the service hours and cost would be doubled.

Royston station to High Street Walkern

A direct bus service would have to be introduced to reduce the time penalty. This would imply an additional vehicle and full day timetable.

In total, for this small section of the north east Hertfordshire area, we estimate that 3-4 additional vehicles would be required, and at least 3 times the service hours with the driver and fuel costs this implies to improve the total journey penalties. In reality the numbers of passengers are likely to be low, particularly at first.

It should be noted that the DRT service in 2023 is being run with 4 vehicles across the entire north east Hertfordshire service area covering multiple origin destination pairs besides those analysed above. These vehicles complete a variety of different trips across the zone in addition to the ones analysed.

Whilst demand is high, making trips booked at short notice longer, this could be improved by growing the fleet. As for fixed lines, more buses are associated with higher service levels, but also attract proportionate costs.

Conclusion

Across our four metrics we see that:

- There is a large increase in the population served by adding DRT;
- The span of the service is increased for some trips and is similar for others;
- Absolute speed is increased as journeys are more direct and do not require connections;
- The benefit of more frequent service, as calculated by our 'journey time penalty' is replicated by DRT, sometimes by a small amount and sometimes by a large amount (depending on the number of days booked in advance);
- In addition, the resource comparison indicates that DRT services have reduced journey time penalties and increased service span at the cost of adding 4 vehicles to the public transport fleet. If the authority had chosen to improve services by

augmenting the network with additional fixed services, we are confident that it would require additional routes and a much larger uplift in the number of buses running on routes to achieve similar results. In addition, we cannot see how the total population now served could be achieved without the introduction of DRT.

It is important to reflect that, despite the benefits of the new DRT service, the overall picture of services still reflects a large journey time penalty for users of public transport, particularly at busier times of day.

To give this some context, the average UK commute is 27 minutes (2021)[1].

The trip patterns that emerge when a DRT service is implemented reveal that there is demand beyond the transport corridors and across the day. People using buses should be served by high standard services and not expected to pay excessive journey time penalties for their choice or lack of other options.

It should be remembered that transport is not the end goal. The benefits of better transport lie in greater social and economic goals - reducing isolation and increasing opportunity. Reducing car travel will also reduce carbon emissions as well as congestion and land use issues. Improving buses should be a priority.

Our analysis of DRT in Hertfordshire indicates that DRT has made a good start improving transport options, reducing the journey time penalties and connecting a much higher number of people to the transport network, it is cost effective in comparison with fixed routes, but there is more work to do.

1

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