A TRANSPORT SYSTEM WHOSE TIME HAS COME?

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Introduction

It took a long time and the personal commitment of a president of the United States for the concept of travel to the moon to be made a reality and there were many who doubted it would ever happen. Personal Rapid Transit (PRT) has had a similarly long gestation and the concept was perhaps oversold in the 1960's when, in the UK, drawings were published of clumsy elevated structures cutting through central London and looking almost as intrusive as the 6 lane expressways to which they were claimed to be an alternative. The promises made about PRT in those early days still blight it today and there are many transport planners who will give a wry smile when told that the first PRT system will come into service next year at London's Heathrow Airport.

Heathrow Terminal 5 PRT system (Courtesy of Arup)

Whereas PRT was formerly something that would be nice to have, if it could be made to work and demonstrated to be acceptable in city centres; today it is fast becoming essential and we now need a latter day John F Kennedy to challenge the public transport industries to deliver PRT systems in the variety of shapes and with the range of performance characteristics that will be needed.

Why a new and better form of public transport is needed

Competing with the car in the urban/suburban travel markets

The requirement for PRT systems arises for three main reasons. The first is that the car, since its invention about 120 years ago, has now had such a massive influence on our lifestyles and on the shapes and densities of our urbanised areas, that it has made most of the latter extremely difficult to serve efficiently with conventional public transport. The consequence of this has been a runaway success for the car, more suburban and semi-rural development, increasing and more widespread traffic congestion and struggling bus and rail services, many of which require substantial subsidies from the public purse to deliver services, which are used mainly by those without cars.

Luton and Dunstable provide a good example of what has happened all over the country. In 1920 they were two separate towns, but both then experienced extraordinary growth. In 1931 Luton had a population of around 140,000, which grew to 208,500 in 1951, and reached 326,000 in 1971. By 2000 the two towns had grown into a single formless, urban area, bisected by the M1 and with the railway line which had once connected them closed for want of passengers.

1920

1946

1963

1994

Public transport, of course, still dominates in the travel markets which it can serve effectively. For travel to the major urban centres, such as central London or Manhattan, rail is overwhelmingly the dominant mode and neither cars nor PRT nor even buses could possibly deliver the numbers of commuters to work in these major centres of wealth creation within the narrow time windows and across the long distances required. Despite planners' attempts to encourage development at higher densities and to guide it into corridors which can be conveniently served by conventional public transport, the economics of development and the availability of the car mean that most UK towns have continued to expand by adding housing developments, business parks and educational establishments around their fringes and by additionally relocating major developments such as hospitals from cramped sites in city centres to the same fringes of the urbanised areas. The result has invariably been a major increase in car use and the creation of travel markets where distances are too long for many to walk or cycle and where public transport is a very poor alternative to the car.

The traffic congestion arising from this process has provided one of the few brakes on it and has in some towns led to policies aimed at regrouping employment into and around town centres where it has some chance of being served by conventional public transport. Some towns have even taken the step of banning or severely restricting the use of the car to access such centres and thus creating a stronger public transport market. But if major employers or retailers demand locations which are accessible by car, there are few authorities in the UK unprepared to compromise. The resulting traffic congestion and the lack of a realistic alternative to the car has created an urgent need for a public transport system able to compete with the car and this is not too formidable a challenge since the car itself is not a particularly fast form of transport, particularly when it is obliged to use congested urban streets.

Climate change

The second significant driver of the need for PRT is climate change. The 2001 "Shanghai Memorandum", issued by working group 1 of the Inter-governmental Panel on Climate Change (IPCC) made the seriousness of the situation abundantly clear. The paper showed beyond any reasonable doubt and in plain, unemotional language that climate change was definitely happening and that it was undoubtedly man made. It explained that the process was accelerating and that there was little prospect of reversing, stopping or slowing it. All that appeared feasible was to cut the rate of acceleration. This dire warning was accompanied by an explanation of the consequences of melting the ice caps and glaciers. It caused some activity in Kyoto but was otherwise largely unnoticed and in cases even actively denied by those who should have known better. The even sterner warnings from the IPCC in 2007 seem at last to have alerted most political leaders to the situation. But politicians have very short timescales compared to climate change and are still cheerfully promising that they can and will "tackle it", though none stop to explain exactly what they mean by this offer.

Transport currently accounts for nearly 30% of greenhouse gases and is therefore a major contributor to the acceleration of climate change. Curbing transport emissions is possible by reducing/controlling the demand for travel, by cleaning up existing forms of transport and by switching to forms of public transport that are cleaner. Encouraging people to switch to public transport is relatively easy in two of the main travel markets: travel to and between city centres. In many of these markets in

Europe public transport is already overwhelmingly the preferred mode and most people and businesses rely on it and accept restrictions on car use which help to keep public transport competitive. In Central London, for example, it has proved politically uncontroversial to charge car drivers a penal £8 per day in order to encourage them to switch to the excellent public transport system. And within the City of London developers are advised to plan for only 5% of the workforce in new buildings commuting by car. Rail and air are similarly dominant in the European inter city travel markets, particularly those over 300km.

The requirement for improved public transport therefore lies mainly in the other "dispersed" travel markets in the suburbs, around the fringes of the great cities and beyond in the semi-rural areas. It is in these areas that the car is dominant and that a large part of transport emissions are produced. It is therefore in these areas that the new form of public transport needs to be found and made to succeed.

The second industrial revolution.

The third reason why we should now be expecting far better and fully automated public transport, capable of out-performing the private car is that we live at the height of the second industrial revolution. This revolution of communications, automation and control systems, has already wrought huge changes in the ways we live, work and use our leisure. Yet a bus is still a bus and a train is still a train. And both need to change substantially if they are to compete with the car in the new travel markets which the car has created.

Characteristics of the emerging PRT technologies.

The main features of the emerging PRT technologies include:

- Small lightweight vehicles typically carrying 2-20 people
- Driverless operation on segregated tracks which may be elevated, surface or sub-surface
- Stops or stations located off the running tracks and possibly within buildings
- Very short waiting times with vehicles waiting for passengers at stops rather like taxis at taxi ranks
- Operation on one-way networks rather than on conventional parallel tracks in order to give a greater coverage of suburban areas per kilometre of track
- A great variety of wheel/track types ranging from rubber tyres on concrete through conventional steel wheel on steel rail to magnetic levitation and even evacuated tube technology
- A similar variety in the forms of power supply and traction, ranging from battery to linear induction motor
- Operation at close headways (typically 2 seconds) in order to achieve the required capacities and (sometimes) to reduce air resistance
- Merge/diverge junctions
- Occasionally, the ability for vehicles to leave the tracks and proceed at slow speeds through pedestrian areas
- A wide range of track operating speeds from 30kph to 200kph and even more imaginative targets

If such technologies can be delivered, the reasons they are likely to be attractive to passengers, capable of easily out performing conventional bus systems, and thus a genuine alternative to the private car are:

- The ability of the networks to serve "dispersed" demand or "many to many" origins/destinations
- The very short waiting times
- Non stop travel between boarding and alighting stations
- Resulting relatively fast journey speeds even when vehicle speeds are not particularly fast
- Simplicity for users so that they can make full use of the network without needing to understand its structure of routes/services/fares

The provision of non-stop travel is of particular importance since time spent at intermediate stops is a major cause of delay on bus and rail systems (often accounting for 30% of the ride time), with buses also being delayed by traffic signals and congestion. If long waits and intermediate stops/delays can be avoided then public transport vehicles do not need to travel particularly fast in order to out-perform conventional bus and rail systems and to compete with the car.

Two emerging European PRT systems illustrate the range and diversity of the PRT products that may eventually enter public service. The ULTra system, developed by Professor Martin Lawson and with an operational test track in Cardiff uses light, 4 seat vehicles of elegant design which are battery powered and rubber tyred. They are planned to operate at a constant speed of 40kph, the low speed meaning that tracks can be accommodated on or beside existing urban roads, and the light vehicle offering the potential for stations to be located within buildings. An early application of ULTra is to be as a link between the terminals and the parking areas at London's Heathrow Airport. ULTra will also clearly have urban applications and one of these, Daventry, is described later in this paper.

At the opposite end of the scale to ULTra is the Neue Bahntechnik Paderborn (NBP). This aims to provide non-stop, station to station journey speeds of 160kph on existing, adapted, poorly used rail tracks. The vehicles are intended to have capacities of up to 15 passengers and are far lighter than conventional rail vehicles since they are powered by linear induction motors. The vehicles steer themselves through points which are fixed. The NBP system is currently running on a test track at a scale of 1:2.5. The vehicle incorporates tilting technology to enable the constant speeds to be achieved and the inventors' own description, "you will not know that you are moving" provides an interesting measure of the quality at which they are aiming.

The likely impact of urban PRT systems on car use and transport emissions.

While the early applications of PRT systems are likely to be relatively simple, like that now under construction at Heathrow, studies have already been made of their potential impact on car use in urban and suburban areas. A systematically modelled Swedish study of a PRT network in Gothenburg suggested it would halve car use in this significant, dense and historic town. A more recent study of the very different, smaller and much more car-oriented town, Daventry, adds to the evidence that PRT will be capable of competing with the car, out performing the bus and enabling towns to be expanded in a sustainable way.

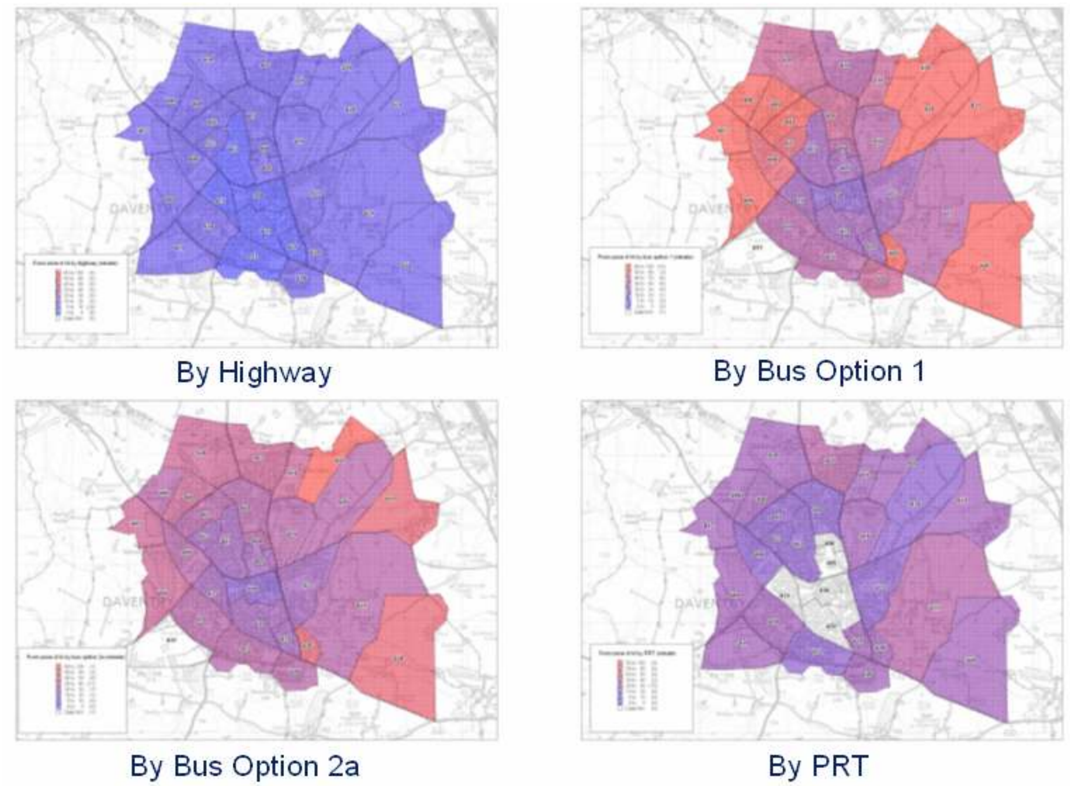
Daventry has a population of 23,000, which is due to rise to 40,000 under the UK Government's Sustainable Communities Plan. In the UK's first comprehensive study of the possible role of an urban PRT network, Colin Buchanan defined the town's transport problems as:

- An under-used and expensive bus network
- A massive planned expansion of the town
- A need to accommodate the growth
- …and the resulting traffic and parking
- …while supporting the town centre plan
- A need to attract jobs of the right type
- … and hence to put Daventry on the "map"
- A need for a good public transport system, capable of providing a genuine alternative to the car

The proposed network and market share

A PRT network comprising 50km of one way track and with 50 stations was designed and compared with two alternative upgrades of the existing bus services, supported by bus priority measures. These alternative networks were then tested using the County Council's multi-modal model to estimate mode switching between car, bus and PRT. This showed that, depending on the fares charged and the modal penalties assumed for PRT, the latter would reduce internal car trips by between 22% and 33%,

whereas even the best bus network would increase its share of the mechanised trip market from the current 4% to only 10%.
A second, simulation model (PRTSim) was then used to check that the PRT network would not overload and to estimate the number of driverless cabs that would be required to carry the passengers with minimal waiting times averaging less than one minute. This was found to depend on the fare.



Daventry: Travel time by different modes from central zone (blue:less than 10 minutes, red more than 40 minutes)

Financial and cost/benefit performance

Capital and operating costs were then estimated, taking advice on PRT costs from Arup, who are currently designing the Heathrow PRT system. The complete PRT network, including depot, track, safety fencing and 300-500 cabs was estimated to have a capital cost of £80-85m, the difference being related to the number of cabs required and hence the fare. Annual operating costs ranged for the same reasons from £4m to £6m at 2006 prices. Summed and discounted over the government's required timescale of 60 years, the PRT network was capable of earning substantial operating profits provided its fares were raised well above the current average bus fare of 80p. With a fare of £1.60 the demand was still substantial and the operating surpluses were estimated to be almost sufficient to fund the full capital costs, a remarkable prediction when compared with the finances of trams and guided buses. It was judged that with such a network the town bus services would be withdrawn.
The reasons for the apparent financial success of the PRT network when compared with even the best bus alternative relate to its much greater competitiveness with the car. Daventry is a town largely laid out for the car and with many housing estates designed to semi-Radburn principles. There is little congestion and it is possible to get almost anywhere in the town by car in a drive of 10 minutes or less. The bus is

very much slower with services and connections that mean some journeys can take over an hour. PRT is not as fast as a car but it is very much quicker and more convenient than a bus. This bodes well for the success of PRT when introduced in more conventional towns where traffic congestion is far more widespread and severe. In such situations it is easy to see that the Swedish prediction (for Gothenburg) that PRT could cut car use by 50% may prove realistic. Even without such speculation it is clear that PRT is likely to achieve greater reductions in urban traffic than any policy alternatives yet tried. This potential was reflected in a healthy benefit/cost ratio of 5.3-7.6 (depending on the fare level).

The pilot network

Daventry is now set to move swiftly on with the procurement of the first part of its PRT network as a pilot for the exploration of issues such as the suitability of the system for the journey to school, the likelihood of cab sharing, the modal penalty, the control system, the actual costs and construction problems and the dangers of vandalism. On the assumption that these problems prove not to be insuperable, PRT will then be confirmed as a form of urban public transport capable of providing a genuine and commercial alternative to the car in areas largely laid out for the car, and thus able to deliver on a commercial basis substantial reductions in carbon emissions.

Conclusion

Advances in control technology and the intelligent assembly of the various components mean that the long cherished dream of PRT networks in urban and suburban areas is now close to becoming a reality. The result is likely to be a range of PRT systems, capable of serving a variety of different travel markets from the “one to many” problem of the air terminal-car park bus to the “many to many” travel markets in the suburbs and around the fringes of urban areas.

It is no accident that the world’s first operational PRT system is being introduced in a major airport – London Heathrow, by one of the world’s leading airport operators, BAA. Airports have to handle intense traffic and parking demands and have long been major innovators in providing public transport alternatives to the car and controlling its use, whilst at the same time maximising the revenues from parking. BAA has ambitious plans to extend its PRT system into a network covering the whole airport and its immediate hinterland. This example is bound to be followed at other airports in the UK and worldwide. And what happens at airports today usually begins to happen tomorrow in urban areas.

The provision of PRT systems is initially likely to become a planning requirement for many new housing developments and town expansions, where they will both reduce the additional traffic generated by the development and cut that already circulating within the towns. In small towns PRT is likely to replace many existing bus services and to greatly reduce the market for conventional taxis. In larger existing urban areas PRT will replace many conventional suburban bus services. It will also be used greatly to enlarge the catchment areas of metro and rail stations, thus fostering the use of existing urban rail networks.

PRT networks are also likely to become a feature of town centres, where they will cut the need for parking, enable less convenient and cheaper parking sites to be used and thus release land for more intensive retail and office development. They will also provide a cheaper alternative to city centre taxis, which are often a significant part of the congestion problem. By permitting remote parking, PRT systems will also enable superstores to locate in city and suburban centres, by linking them to remote car parks, in the same way that BAA is already linking T5 at Heathrow to a short term car park.

PRT systems will also replace the single bus route from many existing park and ride sites to city centres. Instead they will offer a much better service to a far greater range of destinations and from more and smaller P&R sites. And at suburban retail parks small PRT networks are likely to be used to enable customers to visit several different stores without moving the car.

PRT control technology may even be able to deliver new, more frequent, faster and more convenient services on the inherited networks of poorly used rail tracks which might enable them to return to profitability and better to support the mainline rail services. If it can deliver the vision of the German team at Paderborn, PRT technology could eventually greatly improve all journey speeds on the rail network, thus potentially eroding the case for new high speed rail lines by delivering far better and faster services on the existing network.

These developments come at a time of unprecedented need for innovation when the car has created travel markets which only it can serve and when the resulting traffic congestion, car dependency and emissions are major causes of the uncontrolled and accelerating process of climate change. PRT technology offers the opportunity to reduce traffic congestion and emissions by cutting car use through the provision of a better alternative. Unlike many public transport initiatives, PRT will not depend for its success on the introduction of road pricing or punitive parking regimes. Its journey speed and convenience, together with the fact that it does not have to be parked, will make it competitive with the car.

The new technology will be applicable not only in the advanced western economies: it will also be capable of providing cheap, on demand, shared taxi services in developing countries, such as China, where it could thus deliver many of the benefits of the car without the cost and environmental damage of providing the roadspace and parking for it.

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