Case Study: Nottingham Express Transit[1]: The Role of Green Innovation in the Drive for Sustainable Mobility Through Improved Public Transport

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***Abstract**: Traffic congestion at peak times has long been a problem facing cities in the UK. Latterly concern about combating congestion has been hightened by concerns over carbon emissions and poor air quality. In tackling these problems green innovations incorporating new technologies appear to have much to offer, although progress in implementing these sorts of innovation appears to have been slow. This case study on the efforts of one city to tackle these problems by pioneering a number of green innovations including the introduction of a light rail system employing trams known as Nottingham Express Transit (NET) as well as electric and gas-powered buses. The nature of these innovation s is explored together with a detailed examination of how they came to be implemented and the impact they have had.*

***Keywords**: green innovation; public transport; sustainability; project management; modal shift;*

Introduction: Traffic in Towns[2]

Nottingham, with a population of 300,000 is located in a conurbation with 670,000 inhabitants within a 15km range. It is the seventh largest city in England and a member of the Core Cities group, an advocacy initiative formed in 1995 and comprising the largest regional cities in the UK. Located 180 km north of London, Nottingham is the largest city in the East Midlands region. Once very much an industrial city, its economic structure is increasingly based on

[1] This case study draws on a local economic evaluation (Rossiter et al 2016) undertaken by a team including Will Rossiter, Craig Bickerton, Rick Canavan, Chris Lawton and Peter Murphy and commissioned by Tramlink Nottingham.
[2] 'Traffic in Towns' was the title of the Buchanan Report of 1963, a highly influential report on the impact of increased car ownership on Britain's towns and cities (Buchanan, 2015).

business and financial services. Among the service organisations that are major employers in the city are Experian which provides business information, Capital One the financial services company and HM Revenue and Customs, the UK's tax authority, whose regional offices are located in Nottingham.

Like most cities Nottingham has a problem with the car. The city has long experienced peak period traffic congestion (Dale et al., 2014). Recent estimates put the cost to the local economy at as much as £160million per year (NCC, 2013). Consequently tackling traffic congestion has been an important issue for the city council for many years. This has grown in recent years as a result of increasing awareness of the problem of climate change and the recognition of health problems brought on by poor air quality caused by vehicle fumes.

Urban Motorway schemes

Back in the 1960s the city, like many large cities in England attempted to construct its way out the problem of traffic congestion by building more roads. Following the example of cities like Birmingham and Leeds that opted for major urban motorway building programmes involving the destruction of swathes of existing buildings, Nottingham looked to urban motorways to provide the capacity to cope with a rapidly increasing volume of traffic. With the construction of a section of inner ring road, known as 'Maid Marian Way', traffic was increasingly squeezed out of the city centre itself. This provided scope for the extensive pedestrianisation of narrow streets around the market place, thereby returning the central shopping and business area to people on foot.

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But Maid Marian Way was only the first small step in a much larger and much more ambitious scheme to create an urban motorway system around the city core. The key element in this scheme was a section of urban motorway called the 'Sheriff's Way' (see figure 1). The plan was that this urban motorway would go round the eastern flank of the city centre and funnel traffic from the wealthy northern suburbs into a major new shopping complex, the Victoria Centre. This

would have involved wholesale destruction of parts of the city with a flyover going through the Arboretum and the historic Lace Market district intersected by a slip road. However the 'Sheriff's Way' scheme was never built. Local elections in 1972 brought a change of political control in the city and with it new ideas about how to tackle the problem of traffic congestion (Aldous, 1974).

The Zone and Collar system

Instead of trying to accommodate the car through road building, the city council proposed a very different strategy of demand management through restraining car journeys. The chosen instrument for achieving this was a novel 'zone and collar system', designed to restrict access to the city centre by cars at peak times. Involving the designation of special bus lanes and double sets of traffic lights located as part of a collar around the city centre, the system gave buses priority while delaying cars. This concept introduced possibly the first example of route branded buses in the UK (now a feature of bus operations in Nottingham and other cities throughout the UK), with a fleet of dedicated vehicles known locally as " Lilac Leopards" due to their colour and Leyland Leopard chassis.

Introduced on an experimental basis for the peak morning period in August 1975 (Vincent and Layfield, 1977), unfortunately the results proved inconclusive with no significant reduction in traffic flows being achieved. Further analysis revealed that a factor that lay behind this was the very high proportion of drivers who had access to free parking in the city (Vincent and Layfield, 1977). However over time the zone and collar experiment led to the provision of extensive park and ride facilities in the city and the successful introduction of more bus lanes.

Nottingham Express Transit: Phase One

In the late 1980s the city council, now concerned about the health of the local economy (Richer and Hasiak, 2014) following several major factory closures (Rossiter and Smith, 2017), as well as the cost of peak hour congestion, began to explore new ideas for public transport. It reached agreement with Nottinghamshire County Council to collaborate on a feasibility study to explore the best modes of transport to address the future needs of the city (Richer and Hasiak, 2014).

One innovation considered as part of this study was the development of a light rail system[3] using trams as a way of relieving traffic congestion and at the same time stimulating urban renewal in some of the more deprived areas to the north west of the city. From an environmental point of view, modern trams had the advantage that they were powered by electricity rather than diesel and were three times more energy efficient than buses. Many European cities (and Blackpool in the UK) retained their original tram networks and modernised them rather than tearing up the tracks and replacing them with diesel buses. Trams were also perceived by many to be more acceptable form of transport than buses, especially for young professional people[4].

At this time the UK's first new light rail system had just opened in London's Docklands. While this was not a proper tram system in that the lines did not use roads, nonetheless it did employ very similar technology. Meanwhile other countries were establishing tram systems in cities in a bid to curb traffic congestion. France led the way in Europe, with new tram systems in Grenoble and Nantes (Wolmar, 2016), and trams even began to appear in the car-dominated US in cities like Portland and San Diego. Significantly these pioneering tram projects not only demonstrated that trams helped to reduce traffic congestion in cities, they also showed that large well-run tram networks for passengers contributed to economic development by attracting businesses in to the city (Forrest, 2014). Britain was slow off the mark but by the early 1990s tram schemes were being planned, with the first, Manchester's Metrolink Phase 1 trams becoming operational in 1992 (Senior, 2007). It was followed by Sheffield's Supertram in 1994 (Mulder, 2014) and Croydon's Tramlink in 2000 (Wolmar, 2016).

The Manchester Metrolink ran from Bury some miles north of Manchester to Altrincham on the south side via the city centre. The route comprised a mixture of on-street lines shared with other traffic and converted former railway lines. The scheme quickly proved successful. By 2001 the trams were carrying double the number of passengers carried by the railway lines in 1987 (Mulder, 2014). An extension to Salford was opened in 1999 and by 2006/7 the system was carrying 20 million passengers a year (Senior, 2009).

[3] The term light rail was coined by the US Urban Mass Transportation Administration in 1972 to collectively describe a wide range of new urban public transport systems operating on on-street lines and conventional railway lines utilizing trams and similar vehicles (Green, 2016)

[4] The apparent reluctance of professionals to use buses may possibly be a reflection of Margret Thatcher's reputed claim that, 'a man who beyond the age of 26, finds himself on a bus may count himself a failure.' (Economist, 2006)

Sheffield's 'Supertram' however proved rather less successful. Use of the tram built up more slowly than anticipated and the hoped for impact on the local economy in terms of regeneration, proved disappointing (Lawless and Gore, 1999). One factor undermining the Sheffield Supertram was intensive competition from de-regulated bus services which undercut the tram on price and often provided faster door to door journey times by deviating into residential areas en route to the city centre. These bus operators were not interested in providing feeder services to tram stops as their revenue share from a through ticket would have been insufficient and they only tended to operate during the daytime Monday to Saturday. Another significant factor was that Sheffield had only recently upgraded several of the main arterial roads around the city.

Whilst Manchester and Sheffield may have pioneered the introduction of modern tram systems in Britain, Nottingham was well placed to learn from these innovators. Two aspects that those devising a tram system for Nottingham paid attention to were the need to provide substantial park-and-ride parking facilities (see Table 1), to enable people to transfer from cars to trams, and the need to coordinate other forms of transport (i.e. buses) so that they could link up with the trams. Parliamentary approval for the scheme was obtained in 1994. In 1998 the Minister of Transport announced that government funding would be available to support the development of a tram system in Nottingham. The final green light for the project was given in April 2000. Construction of the 14km line with 24 stations began in the same year and the line opened as Nottingham Express Transit (NET) in March 2004 (Richer and Hasiak, 2014). NET Phase One stands out from other light rail systems in the UK in the extent of the park-and-ride facilities provided in order to encourage modal shift from cars to trams. Five large park-and-ride car parks offering a total of 3,000 parking spaces (Skelsey, 2007) are available. At the same time Nottingham City Transport (a partner in the NET consortium) and local bus operator Trent Barton introduced bus route revisions to act as feeders for tram operations (Skelsey, 2007).

The new tram system quickly exceeded expectations in terms of numbers using the tram, with 8.5 million and 9.8 million passengers carried in the first two years of operation (Potts and Ankrah, 2014). In addition the use of public transport in the urban area of Nottingham grew by 8% in the five years to 2008 with road traffic only increasing by 1% compared to 4% nationally. The success of Phase One of Nottingham's tram in large measure reflected the way in which the new system had been carefully integrated with other transport modes available in the city.

The original tram operating consortium included TransDev which had a minority shareholding in Nottingham City Transport (NCT), which was otherwise still municipally owned although operated as an arms length company under the requirements of the 1985 Transport Act. This meant that they had no desire to compete directly with the trams. Furthermore by the time that NET opened in 2004 the bus market had settled down in Nottingham with two high quality bus companies dominating the scene. For several years NCT Day and Season Tickets were also valid on the trams at no extra cost to passengers.

Following the success of Phase One of the Nottingham tram project, a second phase involving the construction of two further lines extending the system to the south of the city was planned. This time however Nottingham City Council opted for a novel way of raising a very substantial proportion of the capital required to finance the tram extension.

The Workplace Parking Levy

The city council had for some time been exploring alternative ways of funding public transport improvements in the city. One innovative scheme considered was the introduction of a form of pollution tax or congestion charge known as a 'workplace parking levy' (WPL). This comprised an annual charge (i.e. tax) on each parking place occupied by an employee, student or regular business visitor attending their place of work. This type of scheme had first been put forward in 1998 in a UK government White Paper 'New Deal for Transport: Better for Everyone', which proposed that local authorities be allowed to introduce road user charging (RUC) such as London's 'congestion charge'. As an alternative to road user charging the White Paper put forward the possibility of charges levied on workplace parking spaces. In both cases the revenue raised was specifically to be ring fenced for transport improvements (DTER, 1998) contained within a local authority's Local Transport Plan. This proposal was duly passed into law as part of the Transport Act 2000.

The purpose of a workplace parking levy was primarily as a demand management tool focusing on commuter parking and designed to encourage commuters to switch to alternative modes of transport. Similar schemes were being planned in other countries, most notably in Australia, where the State of Victoria was well advanced with plans for a workplace parking levy (WPL) to be introduced Melbourne's central business district (Hamer et al., 2009). Introduced in January

2006 a charge of $AU400 was applied to all public and private parking spaces with the specific aim of reducing traffic congestion and encouraging the use of public transport.

Following consultation with officials implementing workplace parking in Melbourne, the city council proposed introducing a similar arrangement in Nottingham. In this instance the transport improvement to be funded would be a major extension to the tram system. When, following local elections in 2009, Nottinghamshire County Council indicated that it was no longer able to support plans for further development of the tram system, it became clear that the introduction of a workplace parking levy was the only feasible means to implement a revenue raising scheme in time to fund the Phase Two tram extension (Dale et al., 2014).

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The plan was that the workplace parking levy should contribute as much as £170 million towards the cost of Phase Two of the tram system. More significant was the fact that having raised money locally the city council was then in a position to leverage significant additional funding from other sources such as the UK government (see table 2). When the idea of a WPL was first proposed there was fierce local opposition, especially from the business community (Pidd, 2010). There were claims that it would have an adverse effect on the local economy, forcing firms to leave the city because of the additional costs they would have to bear.

When the workplace parking levy came into force in 2012 firms employing more than 11 employees had to pay £334 per year for every parking space provided. Notwithstanding strong reservations voiced by local business leaders the scheme functioned remarkably smoothly. There were no legal challenges and 100% compliance. In the first five years of operation the workplace parking levy raised £44 million in revenue all of which was hypothecated for improvements in public transport. Along with Phase Two of the tram, this included a number of other improvements to public transport in the city (see table 2), including the introduction of a fleet of Link Buses serving key employment sites, hospitals and park-and-ride sites and the

refurbishment of Nottingham's train station. Far from an exit of firms from the city as some had predicted, there has been a movement of firms into the city creating nearly 2000 jobs.

It is unfortunate however that the environmental gains from these public transport improvements will to some extent be offset by the UK Government's recent decision to cancel electrification of the Midland Main Line (Topham, 2017), resulting in diesel powered trains continuing to operate from Nottingham train station for the foreseeable future. It is also notable that one of the major bus operators in Nottingham (although it operated the first small fleet of electric buses) appears wedded to the diesel engine, possibly because many of its routes are long with vehicles often clocking up in excess of 500km per day.

Nottingham Express Transit Phase Two

The NET Phase Two project extended Nottingham's existing tram network by 17.5km and 28 new tram stops, more than doubling the size of the network. The original estimate for the value of the 22.5 year Public Finance Initiative contract to design, build, operate and maintain the extended NET system was £570 million[5], making it one of the largest construction projects undertaken within Nottingham in recent years.

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Phase Two involved extending the tram system south from the train station through the construction of two new arms, one going to Toton located near to junction 25 of the M1 and another going south of the River Trent to Clifton (see figure 2). In extending the network south of the city, Phase Two connected major employment sites such as the NG2 business park, the University of Nottingham and the Queens Medical Centre to the tram.

[5] This figure was reduced by 15% by the then Coalition Government at the final approval stage.

The purpose of Phase One had been not only to reduce traffic congestion, but to stimulate regeneration in areas to the north of the city centre experiencing high unemployment and ones on the edge of the conurbation affected by pit closures. Phase Two in contrast shared the objective of reducing traffic congestion, but added more objectives relating to network integration and economic growth – factors reflected in the choice of routes.

As an engineering challenge, the two phases of tram development were quite different. Phase 1 was able to take advantage a number of current/former railway routes through the conurbation – reducing the proportion of the total route that had to be shared with other forms of road transport. In contrast, Phase Two saw a greater proportion of the route sharing tarmac with other road users. It also required the construction of five major engineering structures to effect crossings of the Midland Mainline railway, the River Trent and major road transport arteries within the City. The topography of the line coupled with the need to effect multi-modal interchange at Nottingham train station resulted in a significantly more complex engineering project.

Overall, Phase Two was more integrated with larger sections of the existing urban fabric than Phase One. This led to significantly greater impacts on local communities during construction and increased associated mitigation requirements. The need to integrate with highways and other public infrastructure (including utilities) presented particular challenges. One indicator of the greater complexity faced in terms of integrating the new lines into the existing urban landscape was that Phase Two required approximately 80 properties to be demolished and 500 plots of land to be compulsorily purchased, while no properties were demolished in order to facilitate the construction of Phase One. This was largely a function of the use that the route was able to make of existing rail corridors.

Work to pave the way for the construction of Phase Two commenced in 2000 before Phase One even opened, with the commissioning of a feasibility study into potential options for the further extension of the network. This study considered six routes in three transport corridors: Clifton, Beeston and West Bridgford. Its conclusions, published in 2002, were that additional routes to Clifton via Wilford and Chilwell via QMC and Beeston were viable in these terms, but that the West Bridgford option was not. The opening of Phase One in 2004 coincided with the start of work to prepare a Business Case for new lines for submission to Government. It is noteworthy

that by this time the national policy enthusiasm for light rail had cooled somewhat – largely in face of growing concern at the cost of such schemes. Proposed schemes in Liverpool and Leeds had failed to secure Government support on these grounds. A 2004 report by the National Audit Office (NAO)[6] responded to this concern by reviewing a number of constructed tramlines, including Phase One of the Nottingham tram, and made recommendations intended to inform the manner in which future light rail projects were brought forward.

An outline Business Case for Phase Two was developed by the then joint promoters of the scheme – Nottingham City Council and Nottinghamshire County Council. Programme Entry Approval (which was the first of three approval stages) was duly received from Government in 2006. It seems likely that the experience of delivering Phase One, which by this point had been running for two years, contributed to this successful outcome for the promoters. The NET System Order, providing statutory powers for the scheme, was made in 2009. The preferred bidder was selected in March 2011 and the contract awarded to a new consortium, Tramlink Nottingham, in December 2011 following the receipt of Full Approval from the Department of Transport.

Awarding the contract to a new consortium however presented a potential problem in terms of ticketing systems since the new consortium no longer included Nottingham City Transport (NCT) and TransDev but did include Wellglade, the parent company of Nottingham's second large bus operator TrentBarton. This could have been a portent of disintegrated ticketing and tram/bus competition but for the swift action of Nottingham City Council to convert its paper based Kangaroo multiple operator ticket into the Robin Hood Smartcard. This is effectively a Nottingham version of the London Oystercard.and it proved very successful in encouraging greater use of public transport of all forms in the city, when Phase Two of the tram system became fully operational in August 2015.

Impact of the Tram development on travel in the City

[6] National Audit Office (2004)

In more than doubling the size of the existing tram system, with Phase Two the tram took on a more network-like form (Rossiter, 2016) capable of feeding traffic from one line into other lines, very much as the opening of the Victoria underground line in the late 1960s acted as a conduit feeding traffic into other underground lines in London (Barker and Button, 1975), resulting in more passengers using the system overall.

In terms of its impact on traffic congestion in Nottingham it is as yet too early to see a clear picture emerging. However table 2 shows that in 2015-16 following the opening of Phase Two of NET, passenger journeys on the extended tram network, increased by 50 per cent while vehicle miles travelled more than doubled. In the first full year of operation (April 2016-March 2017) the enlarged tram network carried almost 16.5 million passengers (Pritchard, 2017), 4 million more than in 2015/16 (see table 2). While this is still some way behind Manchester's Metrolink which carried over 30 million passengers in 2015/16 (see table 2), the latter now has a significantly larger network that has been running for longer.

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In terms of a modal shift from private to public transport taking place as a result of the growth of passenger numbers on the tram system, more modest growth in car use is evident in Nottingham compared to other cities in England over the last ten years (see table 3). Clearly only a small amount of this can be attributed to the opening of Phase Two, which does appear to have made a modest contribution to date. Over the twenty years to 2016, traffic levels in Nottingham increased by 4.1%, compared to a 6.4% increase in the previous ten years (see table 3). The figure for 1996-2016 was a substantially lower increase than occured in other cities in the East Midlands region. In Derby and Leicester for instance traffic growth over this period was 10.4% and 11.6% respectively. Other core cities in England saw similar increases in levels of traffic, with traffic growth in Sheffield and Leeds amounting to 12.6% and 20.8% (see table 3) over this period.

In terms of car miles covered within the city, the figures were if anything even more striking. Over the 15 years from 2000, annual car miles in Nottingham fell by nearly 40 million to 440 million. In Bristol in contrast numbers rose by 27 million (Nottingham Post, 2016). At the same time public transport use in the city increased above 40 %, a very high percentage for the UK (Nottingham Post, 2016).

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The Nottingham Tram in spatial and strategic context

A consistent policy insight to emerge from research that has been undertaken on light rail concerns the importance of integrated transport and land-use planning (see for example Knowles and Ferbrache 2014). Some suggest that this can only occur when schemes are developed under the auspices of a single authority that is responsible for both transport and land-use planning (Dickens 1992).

In this context, it is striking to note that the NET Phase Two project has been developed under the auspices of a single project promoter – Nottingham City Council (since the withdrawal of Nottinghamshire County Council in the early stages of the project). This may have served to facilitate better integration of transport and land-use planning than is possible in areas where multiple authorities are involved. It is notable that in the case of Sheffield, a failure to fully integrate transport and land use planning is thought to have adversely affected the ability of this scheme to maximise economic development and regeneration benefits (Lawless and Gore, 1999; Dabinett, Gore, Haywood and Lawless 1999).

A striking characteristic of the NET is the degree to which it now integrates with other transport infrastructure. Transport integration was a key strategic objective for the extended network.

Indeed, both the Business Case documents prepared for NET Phase One and Two make this objective very explicit. Similarly, the Nottingham Local Transport Plan 2011-26 is equally explicit in positioning the NET at the heart of its vision for the creation of an integrated local transport network. While the implementation of this vision for an integrated network remains work in progress, the development of the NET evidences progress towards this goal.

The redeveloped Nottingham train station now forms the hub from which the NET lines radiate to the north, west and south. The station serves the function of a multimodal interchange facilitating integration between light and heavy rail networks. The siting of the new Clifton park and ride facility integrates well with the newly dualled A453 trunk road connecting Nottingham to the M1 motorway. The Toton Lane park and ride site fulfils a similar function for approaches to the city from the west. Alongside the pre-existing Line One facilities at Hucknall and Phoenix Park, NET Phase Two has effectively transformed the NET from a couple of lines arrowing out of the City to the north (see figure 2), into a functioning and integrated network.

Rossiter et al (2016) highlight the extent to which NET Phase Two has become more of a 'network' with the advent of the new lines to Toton Lane and Clifton. Furthermore, the first of these two lines has created the potential for an important link to the planned East Midlands hub for the high speed rail line HS2 at Toton. As such, NET Phase Two seems likely to have paved the way for future transport integration as and when the planned high speed rail network emerges. The choice of routes – serving major strategic employment sites in the City – further reinforces the impression that the NET has been integrated into local spatial planning such that it can support the development of key sites within the city.

The strategic integration theme is also evident in other spheres of local decision making.such as the location of recent major public sector capital projects implemented by the City Council itself and other local anchor institutions. The City Council's Loxley House offices are adjacent to Nottingham train station at the heart of the NET system. Similarly, three out of the four joint service centres built by the local NHS in collaboration with the City Council: Clifton Cornerstone (Clifton), Mary Potter Centre (Hyson Green) and Riverside Centre (Bulwell), are all located close to the network. Recent developments by Nottingham Trent University, both

teaching and residential, have consolidated the existing City and Clifton campuses, and a new fire station on London Road is close to both the train station and the tram/train interchange.

Conclusion: Achieving Modal Shift

Nottingham was one of the first cities in the UK to seek to bring about a modal shift from cars to public transport in an attempt to combat the problem of traffic congestion and latterly carbon emissions and poor air quality. The means to do this have over the years included a range of environmental or green innovations. These innovations have been both technological and behavioural in nature.

By far the biggest technological innovation in terms of investment has been the new tram system, which has been developed to the point where 30% of the population of Greater Nottingham now live within 800 metres of a tram stop, the only urban area in the UK where this is the case (Green, 2016). Nottingham has also pioneered alternative fuelled buses, with fleets of electric and hybrid buses (including the first Chinese built BYD electric buses in the UK) and more than fifty gas powered buses. The most significant innovation in behavioural terms has been the introduction of a novel form of congestion charge in the form of the WPL, designed to both manage the demand for road space and fund improvements in public transport.

A number of factors help to explain the success of Nottingham's pioneering green innovations. Foremost among these factors would appear to be the way in which the tram project has been developed under the auspices of a single project promoter – Nottingham City Council (latterly at least with the withdrawal of Nottinghamshire County Council from NET Phase Two). This facilitated careful preparation and management as well as providing clarity in relations with partner organisations. As a result NET became the only tram in the UK to be described as, 'an instant success' (Green, 2016: 238). Whilst other tram schemes only gradually started to carry the passenger volumes anticipated, Nottingham's tram exceeded the most optimistic predictions from the start, providing 90 million passenger journeys in its first decade of operations (Green, 2016). Although the construction of Phase Two did lead to delays it also saw the successful introduction of the WPL, a novel innovation in terms of funding transport improvements and curbing car use, that as yet no other local authority has been bold enough to adopt.

Having a single promoter was linked to another key factor in Nottingham's success, namely the integration of other public transport developments in the city into the tram system. From its inception transport integration was a key strategic objective of the tram system. The continued municipal stakeholding in Nottingham City Transport and the inclusion of the other major bus operator in the current Tram Consortium has strengthened the aims of integrated transport rather than the destructive deregulated bus competition which has plagued many other cities.

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Notable examples of transport developments that have been integrated with the tram include the provision of very extensive park-and–ride facilities along the tram routes which currently have the capacity to take in excess of 5,000 cars (see table 4), the provision of bus services that act as feeders into the tram system, the provision of effective information systems giving users accurate information about tram availability, and the development of a smartcard that provides for inter-modal and inter-operator travel on other forms of public transport (Skelsey, 2015). Similarly the redeveloped Nottingham train station now forms a hub from which the NET lines radiate to the north, west and south.

With the coming of the Leeds branch of HS2, the tram's Toton line has the potential for an important link to the planned East Midlands Hub station on the site of the former railway marshalling yard at Toton. As such, NET Phase Two has paved the way for future transport integration as and when the planned high speed rail network emerges.

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Teaching Note

1. **Case summary**

The case study provides several examples of green innovations in the form of new technologies applied to public transport. While trams are clearly the main focus of the case study these innovations extend to electric and gas-powered buses and facilities for walking and cycling. In environmental terms these green technologies not only help in tackling problems associated with traffic congestion such as carbon emissions, they also offer much scope for achieving significant improvements in air quality. Modern tram systems are quiet, highly efficient, and contribute to reducing carbon emissions. Similarly electric and gas powered buses are more environmentally friendly than their diesel powered equivalents

The case study shows that where urban transport systems are concerned there are a range of green technologies available.

The case study indicates that while there are a range of green technologies/innovations available to contribute to reducing carbon emissions, they won't necessarily fulfil their potential. Achieving the outcomes that are possible is dependent on a number of factors. These include:-

- The use of an integrated approach that links other facilities (e.g. car parks, information systems, ticketing etc) to major transport investments
- Appreciation of the potential value of road user charging (e.g. workplace parking levy) and its role in managing demand and funding the supply of appropriate investments
- The need for effective inter-agency collaboration
- Appreciation of the lengthy timescales associated with major development projects like trams

It is worth noting that while the main focus of the case study is on public transport, it also covers important issues such as the preservation of historical and cultural aspects of

cities, the economic development of cities, place leadership and economic opportunities for different social groups.

2. Case study themes and issues

The case study focuses specifically upon innovation, in particular innovations that ofer environmental benefits. A number of themes can be explored through the case study including:-

- The different drivers behind green innovations such as regulatory push v. technology push factors
- The various technologies contributing to green innovations
- The problems associated with trying to bring about a modal shift away from private cars and to public transport
- The value of transport networks
- Funding public transport improvements
- The role of transport policy

3. Discussion questions

(i.) Why was Nottingham's 'zone and collar' experiment in traffic demand management in the 1970s not successful? Despite the apparent lack of success, what useful lessons if any did it provide?

(ii.) What do you consider to be the main factors that led to a successful outcome for Nottingham's innovative tram system? Why does the Sheffield Supertram appear to have been less successful?

(iii.) Compare and contrast the relative merits of road user charging (like London's congestion charge) and workplace parking levies (such as that introduced in Nottingham) as (a.) demand management mechanisms designed to curb car use and (b.) sources of funding for public transport improvements.

(iv.) Given that Nottingham is the only city in Britain to have introduced a workplace parking levy, what do you consider were the key factors that enabled Nottingham to win public acceptance for this controversial form of congestion charge?

(v.) What part do you think Nottingham's smartcard and information systems played in the success of its tram system and why?

(vi.) When it comes to the successful adoption of green innovations – what do you consider to be the most important lessons that Nottingham's innovative tram system offers?

4. Suggested teaching approach and strategy

This case study is mainly intended for students studying innovation, but could be used for other subjects as well including public management and project management. It can be used in a variety of different ways including:

- As an introduction to 'green' aspects of innovation
- As an illustration of some of the real life issues and problems associated with trying to curb traffic congestion in cities
- As an example of the issues surrounding the practical application of green technologies
- As an illustration of some of the behavioural issues associated with achieving a modal shift from private to public transport

5. Model answers

(i.) Why do think Nottingham's 'zone and collar' experiment in the 1970s was not successful? Despite this what useful lessons if any did it provide?

Nottingham's zone and collar system was a form of demand management operating at peak commuting times. It was designed to curb commuting by car, while at the same time providing an alternative in the form of improved bus services and dedicated park and ride facilities.

At the time there was a lot of parking both on-street and off-street available within the city centre of Nottingham. Comparatively little pedestrianisation had taken place so cars had access to streets throughout the city centre. As a result there was insufficient incentive for commuters to get out of their cars and use the park and ride buses.

Despite this, the zone and collar experiment did provide some very valuable lessons. Not least it showed the potential value of dedicated bus lanes and the provision of park and ride facilities (both something of an innovation at the time). These facilities were significantly extended and expanded in the years that followed. Other cities in England soon followed Nottingham's lead. As a result the park and ride concept is now much more familiar and more widely used by commuters. This proved to be a key factor in the success of Nottingham's tram system which from the outset provided extensive park and ride facilities at key locations on the tram network.

The zone and collar experiment also highlighted the 'problem' of too much parking being available within the city. In the years that followed Nottingham's city centre was extensively pedestrianized, substantially reducing the amount of on-street parking available. It also provided a strong rationale for the introduction of the workplace parking levy (WPL) in 2012.

(ii.) *What do you consider to be the main factors that led to a successful outcome for Nottingham's innovative tram system? Why does the Sheffield Supertram appear to have been less successful?*

A number of factors resulted in a successful outcome to the innovation. These included: provision of large free park and ride car parks; bus services linked to the tram to act as feeders; a smartcard that was interchangeable with buses; and an information system showing tram availability.

Another factor was that Phase One made extensive use of existing railway track which considerably eased construction. Also the route of the tram in Phase One linked a number of disadvantaged communities on the edge of the city (e.g. Hyson Green and Bulwell), giving residents access to increased job opportunities (i.e. the tram route both improved public transport and contributed to economic development/urban regeneration).

The construction of the Sheffield Supertram in contrast coincided with several major road improvement projects in the city – this reduced the incentive for car drivers to undertake a modal shift. Also there were separate agencies responsible for the development of the Supertram system and economic development in the city resulting in a lack of coordination.

(iii.) *Compare and contrast the relative merits of road user charging (like London's congestion charge) and workplace parking levies (such as that introduced in Nottingham) as (a.) demand management mechanisms designed to curb car use and (b.) sources of funding for public transport improvements.*

Road Use Charging (RUC)

Has the advantage that a widely publicised precedent has been set in London in the form of the congestion charge. Likely to be complex to administer with a need to increase charges over time, differential rates for different users etc. Collection costs are also likely to be expensive (i.e. cameras, recording equipment etc)

Workplace Parking Levy (WPL)

A highly contentious alternative! This has been explored by other cities in England but they have all balked at implementing a WPL. Nottingham is very much the innovator. Having implemented a WPL scheme it has the following advantages: Very simple and easily understood; produces a predictable income; few avoidance/non-compliance problems; cheap to administer.

A key feature of both schemes is *hypothecation.* While both can deter car use the fact that income goes specifically to public transport improvements provides a strong rationale for the imposition of what is effectively a congestion tax.

(iv.) *Given that Nottingham is the only city in Britain to have introduced a workplace parking levy, what do you consider were the key factors that enable Nottingham to win public acceptance for this controversial form of congestion charge?*

A highly controversial scheme! There was very strong opposition from local business interests prior to its introduction. Success factors include: money raised allocated to highly visible public transport improvements i.e. tram, buses, train station etc. Hence there is clear evidence of where the money is going in terms of public transport improvements. Nottingham has one of the newest bus fleets and operates efficient and well used bus services. Residents have also benefited from the introduction of a very effective and versatile smartcard that can be used interchangeably on different forms of public transport. Nottingham has also been a leader in introducing green innovations such as its electric and gas-powered bus fleets.

Quite literally the evidence of where the money from WPL has gone is on the streets – in the form of modern and up to date forms of public transport.

(v.) What part do you think Nottingham's smartcard and information systems played in the success of its tram system and why?

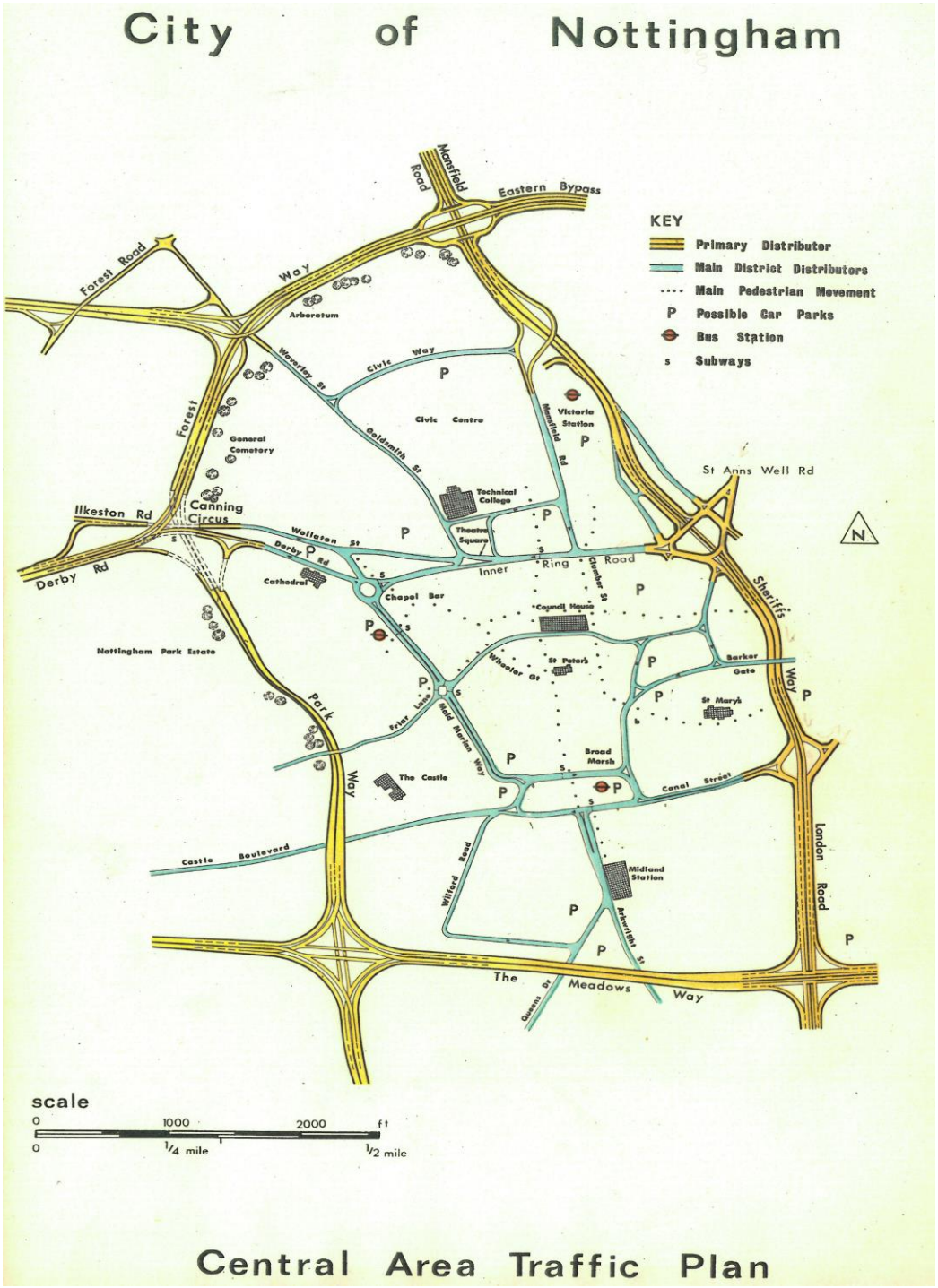
These may seem like minor features of the tram system, but they have actually been very important. Both impact directly on consumers and how they interact with and experience the tram system. From a consumers point of view they aid and assist 'usability'. Quite literally they help to make the tram system easy to use.

It is worth stressing that green innovations like the tram which are obvious symbols of technological solutions to the problems of traffic congestion/pollution, while they appear to have much to offer are *in practice* reliant on effective and easily usable ticketing and information solutions, if they are to bring about a modal shift away from cars.

(vi.) When it comes to the successful introduction of green innovations – what important lessons does Nottingham's innovative tram system offer?

A number of points emerge including: (a.) the value of having a single promoter (i.e..Nottingham City Council) who has been there throughout; (b.) careful planning and thought given to the routes – i.e. serving a number of purposes in addition to trying to reduce traffic congestion at peak times (for example - regeneration, access to the city, linking and accessing important sites/facilities in the city; (c.) planning the system as a network so that different routes feed-in passengers to the tram; (d) having access to a novel form of finance in the form of the WPL; (e) linking the development to other improvements in public transport e.g. new environmentally friendly buses.

Figure 1
Nottingham's Proposed Urban Motorway of the 1960s



Source: Little (1966)

Figure 2
Nottingham Express Transit network

Source: Nottingham City Council (2013)

Table 1

Distribution of WPL revenue

Public Transport development	**WPL contribution £m**	**External funds £m**
Tram extension (Phase 2)	199.0	371.0
Train station refurbishment	12.0	48.0
Electric buses	5.8	9.2
Bus station	1.7	1.3
Smartcard system	1.1	1.0
Information system	1.2	1.0
Total	220.8	431.5

Source: Nottingham City Council

Table 2
Light Rail/Tram statistics: England 2015/16

Tram system	**Passenger journeys (m.)**	**% change**	**Vehicle miles**	**% change**	**Passenger revenue**	**% change**
England	**252.0**	**5.8**	**21.0**	**14.2**	**336.9**	**9.3**
London systems	143.9	2.1	5.7	2.4	184.7	9.6
Docklands Light Railway	116.9	6.1	3.8	3.7	161.9	12.3
Croydon Tramlink	27.0	-12.1	2.0	0.0	22.8	-6.7
England outside London	**108.1**	**11.0**	**15.3**	**19.4**	**152.2**	**9.0**
Nottingham Express Transit	12.2	50.2	1.6	102.1	13.6	54.9
Midland Metro	4.8	10.4	1.0	6.1	8.6	11.9
Sheffield Supertram	11.6	0.6	1.4	3.0	11.4	-10.2
Tyne & Wear Metro	40.3	5.7	3.5	-0.5	50.2	4.5
Manchester Metrolink	34.3	10.1	7.2	27.1	62.4	9.7
Blackpool Tramway	4.9	20.3	0.6	10.3	6.1	8.6

Source: Department of Transport

Table 3
Changes in Traffic Levels 1996-2016

	1996-2006	1996-2016
England	+13.6%	+18.6%
Nottingham City	+6.4%	+4.1%
Nottinghamshire County	+19.9%	+27.5%
Derby	+5.1%	+10.4%
Leicester	+8.7%	+11.6%
Sheffield	+11.9%	+12.6%
Manchester	+5.9%	+5.3%
Croydon	-4.4%	-11.4%
Birmingham	+3.0%	+3.6%
Leeds	+13.0%	+20.8

Source: Nottingham City Council

Table 4
Park-and-Ride car park capacity for the Nottingham tram system

Park-and-Ride site	Capacity (parking spaces)	Tram line	Phase	Time to city centre (mins.)
Clifton	1000	Clifton	2	20
Forest	972	Hucknall	1	7
Hucknall	439	Hucknall	1	26
Moor Bridge	119	Hucknall	1	13
Phoenix Park	657	Hucknall	1	20
Toton Lane	1400	Toton	2	28
Wilkinson Street	600	Hucknall	1	13
Total	5187			

Source: Nottingham Express Transit