The Acceptability of Road Pricing

John Walker
May 2011

RAC Foundation

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RAC Foundation
89–91 Pall Mall
London
SW1Y 5HS

Tel no: 020 7747 3445
www.racfoundation.org

Registered Charity No. 1002705

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About the Author

Dr John Walker MA (Oxon), MSc, PhD, CPhys, FIET

Following a first degree in Physics at Oxford University, an MSc in Applied Solid State Physics at Brighton University, a PhD in the physics of diamonds at Reading University and diamond research at the University of Paris VII John joined Racal (now Thales) as Technical Manager in 1980. He managed collaborative projects in Artificial Intelligence, Software Engineering, Intelligent Transport Systems, Traffic Information Broadcasting, and road pricing, funded by the UK Department of Trade & Industry, the Technology Strategy Board, the UK Department for Transport and the European Commission. He led the security work-package of the DfT-funded DIRECTS Road Pricing demonstration project. His role as Chief Technical Consultant before he retired from Thales in February 2010 included business development and project management in road pricing and ITS. John was an Expert Advisor to Transport for London in their Congestion Charging technology trials. He is a member of the Executive Team of the Institution of Engineering and Technology's Automotive and Road Transport Technical and Professional Network, and of its Berkshire Network; he has organised and chaired five international seminars on Road Pricing and two on Managed Motorways for the IET. He is the editor of two books: “Mobile Information Systems” (1990) and “Advances in Mobile Information Systems” (1998), and of two Artech House book Series, “ITS” and “Mobile Communications”. John is currently an independent consultant working part-time for Thales and other clients. He is also a Visiting Senior Research Fellow in the Transportation Research Group at Southampton University, and Honorary Secretary of the Road User Charging Interest Group of ITS(UK). His professional interests have included solid state physics, software engineering, artificial intelligence, and mobile communications, but are now centred on Intelligent Transport Systems, especially road pricing (including technology, deployment, and public acceptability).

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Any errors or omissions are of course my own responsibility.

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Foreword

This paper reviews global experience of paying for roads as you use them and reports that it is commonplace across much of the developed world. It is technically successful; meets objectives ranging from managing congestion to raising revenue to fund road improvement; need not be prohibitively costly; and once in place, tends to gain public acceptance.

The present UK government seems unwilling to consider new ways of charging for the use of our roads. But it is generally accepted that a different approach will be needed in the future, not only because of the potential to manage worsening road congestion but also because of a fall in fuel duty revenue from greener vehicles that use less petrol and diesel fuel or, in the longer term, electricity alone which does not attract duty.

Further, whilst the government wishes to encourage economic recovery and industrial growth, it is manifestly unwilling to use money raised by the existing charging mechanisms to pay for the necessary enhancement and management of our roads. The paper demonstrates how things are different in other countries.

Of course there are lessons to be learned from the experience of others. It is important that the objectives of any scheme are clear from the outset and that any charging scheme is placed in the context of an overall transport policy. In particular, the public must have an understanding of whether a scheme is to be revenue-neutral; and if not, how the revenues are going to be used; and what improvements to the levels of service on the network they can reasonably expect as a result of the scheme.

Charging systems must be technically robust and accurate but experience elsewhere suggests they need not be excessively complex and hence expensive. Put simply, the theoretical needs to move at the same pace as the practical, while recognising circumstances change and systems will evolve.

Motorists in France, Italy, Spain, Portugal, Stockholm, Norway, Singapore, Australia, and North America are familiar with the idea that they pay as they use certain roads and this report shows how they receive better service in return.

We should be willing to embrace the messages of this report and recognise the benefits that new charging systems for roads have delivered in London and in many countries overseas. Far from being a vote-loser, the evidence is that if it is introduced in the right way road pricing can be perfectly acceptable to the majority of the population.

S. Glaister.

Professor Stephen Glaister,
Director RAC Foundation.

Executive Summary

It is generally accepted amongst transport professionals that, as Eddington put it, 'the potential for benefits from a well-designed, large-scale road pricing scheme is unrivalled by any other intervention' (Eddington, 2006). That view was endorsed by the UK Department for Transport in 'Towards a Sustainable Transport System' (DfT, 2007a), where it states: 'The Government accepts the Eddington analysis regarding the exceptional case for exploring the potential of road pricing'.

Road pricing contributes positively to the environment as well as reducing road traffic congestion, thereby benefiting the economy. However, governments worldwide have been slow to implement it on a large scale, mainly through fears that it is not acceptable to the electorate.

This paper demonstrates that, despite the negative referenda in Edinburgh and Manchester, road pricing seems to be acceptable to public opinion, provided that certain conditions are met:

- that it is equitable – which in general it is, at least compared to alternatives. Schweitzer and Taylor (2010) demonstrated that it is less regressive than other taxation. As they put it 'We should not subsidise all drivers (and charge all consumers) to help the small number of poor travelers who use congested freeways in the peak hours and peak directions. Rather we should help those who are less fortunate, and see to it that the rest of us pay our own way on the roads';
- that it is revenue-neutral, or that revenues are reinvested in transport;
- that it does not have a high cost overhead – which it need not; a 5% overhead would seem to be achievable. This is much higher than the cost of collecting fuel duty, which is estimated at 0.2% of the total revenue; but fuel duty does not have traffic management and congestion reduction effects;
- that people who are likely to be affected have experience that road pricing works. Public education and, above all, public demonstration are necessary.

A number of aspects of road pricing are surprising or counter-intuitive, or at least not in accord with popular belief:

- People voted for the introduction of road pricing in Stockholm. Despite the initial opposition of 62% of the population, following a temporary road pricing scheme which demonstrated the benefits, a majority of the local residents voted to make the scheme permanent. It is currently supported by 74% of the population, and is no longer a political issue (Borjesson et al., 2010).
- Ken Livingstone was elected as Mayor of London on a manifesto which included the introduction of congestion charging.

- The referenda in Edinburgh and Manchester would seem to provide counter-examples, but studies indicate that Edinburgh voters did not understand what was being proposed, and anecdotal evidence suggests the same in Manchester.
- Significant traffic reductions can be achieved with minimal charges. In Stockholm, SEK 10, 15 or 20 (between 87p and £1.74), depending on the time of day, produced traffic reductions of more than 20%.
- It does not seem to result in traffic diversion onto other routes, at least not in the urban environment. Minimal diversion was seen in Stockholm and in London, for example. But the German lorry-charging scheme was extended to major trunk roads in the Hamburg area and near the French border to prevent what was seen as toll avoidance by some lorry drivers. So there may be a difference depending on the type of vehicle and driver, and/or in urban as opposed to inter-urban areas.
- Provision of improved public transport will not of itself get most people out of their cars. In Stockholm, extra buses were introduced in August 2005, but there was no effect on road traffic until January 2006 when the Congestion Tax came into operation. The Transek (2006) study suggests that the expansion of bus services accounted for only 0.1% of the reduction in vehicle passages during the trial.

Public opinion:

- prefers Automatic Number Plate Recognition (ANPR) to tag-and-beacon technology for electronic road pricing; and
- does not like higher charges at busy periods.

This paper estimates the setup and running costs for a UK road pricing scheme based on various sources, and suggests they would now be much less than in previous government estimates, due to falling technology costs, and to GPS-based navigation and fleet management equipment already in vehicles which might be suitable for generating charge data. This suggests that a closer look at costs, preferably combined with a pilot scheme to confirm cost figures, would be a good idea.

Given the above, it is recommended that the Government should:

- publish the results of their Road Pricing Demonstrator studies;
- look again at road pricing, rather than ruling it out as a 'war against the motorist';
- in collaboration with a local authority, implement a temporary urban congestion charging scheme in a UK town or city, to demonstrate the benefits and give people experience of road pricing;
  - preferably with rebates of fuel duty; and
  - using ANPR technology in the first instance;
- implement lorry road user charging, again using ANPR technology in the first instance if it is viable;

- disseminate information about the benefits of road pricing, conduct an educational campaign and proactively stimulate a genuine public debate; and
- commission further research on some of the issues identified in this paper, including:
  - scheme technology and costs;
  - how best to achieve phased implementation;
  - whether a voluntary opt-in phase would be possible;
  - the effect of lorry road user charging on the cost of goods and services;
  - whether a modal shift will occur without road pricing;
  - how best to implement an educational programme; and
  - revenue-neutrality.

In summary, road pricing can influence demand, can match an individual's road use and environmental pollution with the payments made, and can raise revenue. So it has long been recognised as potentially a good policy, but the problem has been crossing the threshold from theory to reality. The 'proof of acceptability' has been outlined above and is demonstrated in detail in the main paper. Attitudes seem to be changing, technology has changed radically in scope and price, and the time seems to be ripe for a serious and practical Stockholm-style trial which would enable Government to get real-world answers to very important questions on road pricing.

The best way to take forward some of these suggestions would be to instigate a 'Road Charging Options for England' study, along the lines of the Road *Charging Options for London* study (ROCOL, 1999).

1. Introduction

1.1 Context

Road pricing has fascinated transport economists since the 1920s (Pigou, 1920) and was first advocated in the UK 47 years ago (Smeed, 1964).

However, it *appears to be* unacceptable to the public, having *apparently* been resisted in many countries, by drivers in particular, who: regard it as an extra tax; object to paying again for something they think they have already paid for; and sense that the benefits may not always be returned to them, but rather to other travellers such as public transport users (Pickford & Blythe, 2006). There is also the (mistaken) belief that road pricing schemes necessarily have a high cost overhead. New toll roads, such as the M6 toll, do not suffer from negative public opinion in the same way, because it is perceived that the payment is for the extra new capacity – which is local, visible and direct – and because there is still the choice of using the un-tolled road.

Also, and again contrary to popular belief, the objective of road pricing is *not* to drive people off the roads, but to encourage them to consider driving – at least some of the time – at a different time of day, or on different routes, or using different modes of transport, or not driving at all on some occasions.

There are also misapprehensions and misunderstandings amongst politicians and activists about the extent to which road traffic congestion and pollution problems can be solved by transfer of travellers and freight to other modes. Studies have shown that only a small proportion of freight traffic can sensibly transfer from road to rail. Eiband (2009), for example, showed that in Germany no more than 10% of freight could make that shift. This is just as well, because a larger proportion would completely swamp the already overloaded rail network, since roads carry 85–90% of both passenger and freight traffic. A shift of 5% of traffic from road would mean a 30% increase in traffic on the rail network. As Gerondeau (1997) says, ‘Only the road can relieve the road’. A notable example of this is the reduction in pollution from vehicle emissions over the last 20 years, achieved not by ‘modal shift’ (for example by a transfer from road to rail), but by an improvement in engine efficiency and a reduction in harmful emissions from road vehicles.

There is also plenty of evidence that people are reluctant to get out of their cars, usually for very good reason. Apart from the convenience, driving is usually much quicker than travelling by public transport, especially if modal or other interchange is necessary. People put a significant value on their time.

Furthermore, one of the disadvantages of conventional public transport is that it is inherently ‘hub and spoke’ in operation, so does not allow the direct journey that private road transport does, nor ‘trip chaining’ (combining trips, such as dropping off children at school on the way to work or to the shops).

Consequently we should use tools such as road pricing to manage demand for road transport – a tool that is already common in rail and other transport modes (train fares are more expensive in the ‘rush hour’, air fares are higher during school holidays).

1.2 Road pricing is not new

Road pricing has a very long history. As Munroe et al. (2006) indicate, toll roads were used in India in the 4th century BC, in Europe in the Holy Roman Empire in the 14th and 15th centuries, and in the USA in the 18th and 19th centuries.

In England, turnpike roads were created under Acts of Parliament during the 18th and early 19th century (Figure 1). Trustees were appointed to administer a length of highway and were empowered to raise tolls from road users. Tariffs, based on the type of traffic current in those days, could be quite complex and included environmental and road damage considerations such as levying a higher charge on vehicles with narrower wheels (or ‘fellies’, as the rims were called) at any given weight, which did more damage to the road – see Figure 2. Most turnpike trusts were wound up in the 1870s when their powers were transferred to local Highways Boards (later taken into the new County Councils) which financed road maintenance from rates (Rosevear, 2010). So in implementing road pricing in the UK we would simply be returning to the ‘status quo ante’.

Figure 1: Part of Castle Street from the turnpike, Reading

Source: Courtesy of Alan Rosevear and the Milestone Society

Figure 2: Pangbourne toll charges 1871

PANGBORNE LANE GATE

Tolls to be taken at this Gate

For every horse or other beast drawing any coach, stage coach, van, caravan, sociable, berlin, landau, chariot, barouche, phaeton, chaise marine, chaise calash, car, curricle, chair, gig, hearse, litter or other such like carriage	*Three Pence*
For every horse or other beast drawing any waggon, wain, cart or other such like carriage (except a taxed cart or any cart drawn by one horse or beast only) the several sums herein after mentioned according to the breadth of the wheels, viz.	
If having the fellies of the wheels of less breadth than four inches and a half at the bottom of soles thereof	*Three Pence*
If of the breadth of four inches and a half and less than six inches	Two pence half penny
If of the breadth of six inches or upwards	*Two pence*
For every horse or other beast drawing any taxed cart, and for the horse or beast drawing any cart drawn by one horse or beast only	*Three Pence*
For every horse or mule laden or unladen but not drawing	*One penny half penny*
For every score of oxen, cows or neat cattle And so in proportion for any greater or less number	*Six Pence*
For every score of calves, sheep, lambs or swine And so in proportion for any greater or less number	*Three Pence*
For every vehicle moved or propelled by steam or machinery or by any other power than animal power	*Two shillings & Six Pence*
For every dog or goat drawing any cart, carriage or other vehicle	One penny

The Toll for any ass shall in every case be less than by one penny than the toll for a horse. Two oxen or neat cattle drawing any carriage shall be considered as one horse. A Ticket denoting payment of Toll at this gate will clear this Gate and Pangborne Gate. At every time of passing on the same day, except in respect of dogs and goats which are liable to Toll at every time of passing and in respect of horses &c drawing post-chaises. Or other carriages travelling for hire, which are liable on every new hiring and in re-spect of horses &c drawing any stage coach, waggon or other stage carriage and also carriages propelled by other than animal power, which such Ticket shall free once only the same day through Pangborne Gate.

By Order of the Trustees

Wallingford

January 1871 CHAS. HEDGES. *their Clerk*

Source: Courtesy of Alan Rosevear and the Milestone Society

1.3 The objectives of this paper

It is generally accepted amongst transport professionals that 'the potential for benefits from a well-designed, large scale road pricing scheme is unrivalled by any other intervention' (Eddington, 2006).

Eddington's view is endorsed by the DfT in *Towards a Sustainable Transport System* (TaSTS) (DfT, 2007a), where it states: 'The Government accepts the Eddington analysis regarding the exceptional case for exploring the potential of road pricing'.

The TaSTS goals are:

1. to support national economic competitiveness and growth, by delivering reliable and efficient transport networks;
2. to reduce transport emissions;
3. to contribute to better safety, security and health;
4. to promote greater equality of opportunity for all citizens; and
5. to improve quality of life, and to promote a healthy natural environment.
6. Road pricing would directly address TaSTS goals 1, 2 and 5, and could contribute to goals 3 and 4 – in the latter case by funding improved public transport.

Despite these advantages, governments in the UK and elsewhere have been reluctant to endorse or introduce road pricing, mainly because of its perceived unacceptability to the voting public.

There are also obvious technical and financial challenges facing any government committed to implementing road pricing schemes, but this paper is concerned primarily with addressing the particular challenge of understanding – and improving – the public acceptability of such schemes.

It seeks, in particular, to demonstrate that road pricing:

- may not be as unacceptable as is popularly thought;
- has lower cost overheads than is generally believed; and
- can, if handled well, probably be introduced with a minimum of adverse public reaction.

2. Transport and the Economy

2.1 The importance of the road network to the economy

It is often not realised how important the road network is to transport and the economy. Table 1 shows UK passenger travel by mode in 2007; travel by road comprised 92% of passenger-km (including buses). Public transport (buses and trains) carried 13%, and private transport 87%.

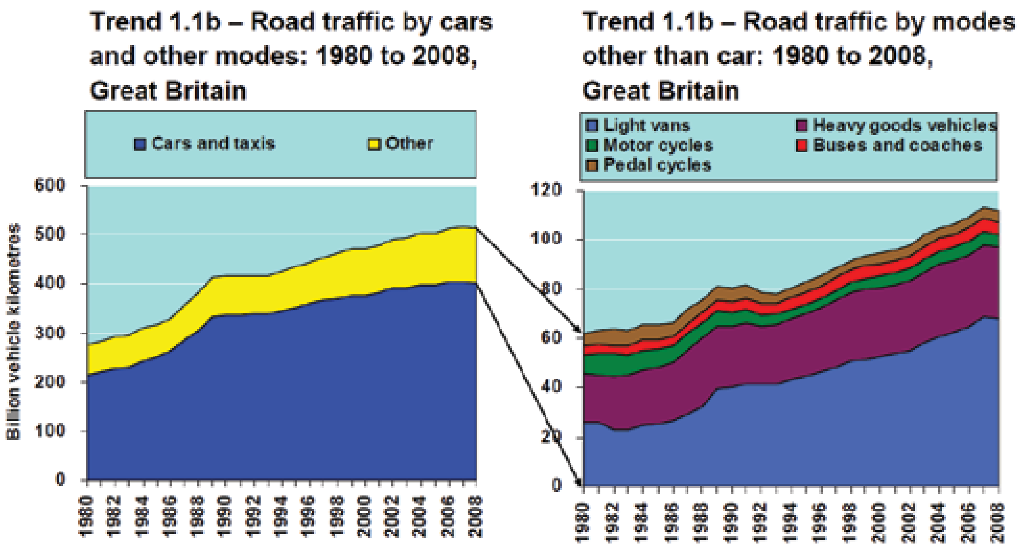
Table 1: UK passenger travel by mode 2007

Mode	Car, van, taxi	Motor-cycle	Pedal-cycle	Bus	Rail	Air
Passenger-km (%)	84%	1%	1%	6%	7%	1%

Source: DfT (2009a)

This is illustrated in Figure 3, which also shows how the figures have varied since 1980 – the amount of UK passenger travel carried by road has increased, whereas other modes have stayed almost constant.

Figure 3: Passenger travel by mode, 1980–2007



Source: DfT (2009b)

For freight, the proportions appear to be similar, with 67% of freight transported by road in 2008, compared to 9% by rail, 20% by water and 10% by pipeline – though Table 2 shows how the percentage conveyed by road has increased significantly since1953, with a corresponding fall in rail freight.

Table 2: Freight transport by mode 1953–2008 in tonne-km

Year	Road	Rail	Water	Pipeline	All modes
1953	32 (36%)	37 (42%)	20 (22%)	-	89 (100%)
1980	93 (53%)	18 (10%)	54 (31%)	10 (6%)	175 (100%)
2008	163 (67%)	21 (9%)	50 (20%)	10 (4%)	244 (100%)

Source: DfT (2009a, Table 4.1)

But as Gerondeau (1997) points out, freight transport is often quoted in meaningless units – namely tonne-km, as above. If we are concerned with effects on the economy, we should use economic (i.e. monetary) units instead. In tonne-km, railways represented 18% of European freight transport in the mid-1990s; but the economic share, in terms of financial turnover, was 2–3%, and the physical share, in terms of distance, was less than 1%. In other words, much of the rail and water-borne freight is bulk cargo of low economic value, whereas a truckload of pharmaceuticals could be worth £500,000.

The figures show not only the preponderance of road transport for both passenger and freight traffic, but also the futility of attempting to relieve road traffic congestion by getting people to travel by train – a shift of 10% from road would need more than double the current (and already overloaded) UK rail capacity.[1] This does ***not*** mean that there should not be investment in rail transport – but it must be recognised that it cannot by itself solve the road traffic congestion problem.

2.2 Congestion

The US National Surface Transportation Infrastructure Financing Commission report (NSTIFC, 2009) states, using figures from the Texas Transportation Institute (TTI) 2007 *Urban Mobility Report*, that 'Traffic congestion in many of the nation's metropolitan areas is endemic, with the cost of congestion – including lost time, wasted fuel, and vehicle wear and tear – topping $78 billion per year for the nation's 437 urban areas'. The 2009 TTI report (Schrank & Lomax, 2009) puts the US urban congestion cost at $87.2 billion, with extra travel time of 4.2 billion hours and extra fuel of 2.8 billion gallons. Figures of £10–20 billion have been estimated for the cost of congestion in the UK (e.g. Eddington, 2006), and €120 billion (US$168.7 billion) per year in the EU (or 1% of EU GDP).

A key point in tackling congestion is that it is non-linear – a small reduction in the number of vehicles on the road will produce a large reduction in congestion – as happens for example during school holidays. This paper will also present evidence (e.g. from Stockholm – section 5.5) that the problem of road traffic congestion cannot be cured by improved public transport alone, but that a package of measures is needed.

1 Whilst the US and UK situations are different, a US comparison is instructive: 'With railroads reaching only one-fifth of U.S. communities, it's a gross misconception that the ability exists to significantly ease congestion by shifting freight from the roads to the rails. Even if intermodal tonnage doubled by 2020, intermodal rail would account for just 1.8 percent of freight movement, compared with the 1.5 percent that is currently projected for 2020. By comparison, trucks will move 71 percent in the same time frame.' Bill Graves, President and CEO, American Trucking Associations, from a letter to US Secretary of Transportation Ray LaHood, April 30, 2010. Quoted By Robert W. Poole, Jr, in Surface Transportation Innovations newsletter, Reason Foundation, Issue No. 83, September 2010.

2.3 Motoring taxation

As the Commission for Integrated Transport (CfIT) (2002) has pointed out:

> 'There is a wide range of views on the cost of motoring, some saying we pay too much, others that we pay too little. This study shows that, whatever the level of motoring taxation, there is a strong case for reviewing the way we pay for road use, with more focus on payments which reflect the impact road use has on congestion and on the environment… the preferred choice for travel for most journeys will remain the car. Current motoring taxation is a very blunt, non-use-related instrument which often penalises those who can least afford it and those who have to rely on a car because of poor or non-existent public transport alternatives'.

A congestion charge raising £5.7 billion p.a. could be used to reduce fuel duty by 12p per litre, or to abolish vehicle excise duty (VED) altogether and reduce fuel tax by 2p per litre as well. As a result, 'Road users in aggregate would be financially no worse off as a result of the transfer, but would be better off overall because of the benefits of less traffic congestion'.

What the CfIT report did not take into account was that with improved fuel economy (e.g. average fuel economy for cars in the USA in 2010 was 25.5 miles per gallon, compared to 13.5 mpg in 1975; USEPA, 2010, Figure 1), and with the trend to alternative-fuel vehicles, fuel duty is bringing in less and less tax revenue anyway, and an alternative or supplement will be needed in the near future.

There are similar concerns in the USA, where NSTIFC has stated that 'The current federal surface transportation funding structure that relies primarily on taxes imposed on petroleum-derived vehicle fuels is not sustainable in the long term and is likely to erode more quickly than previously thought. This is due in large measure to heightened concerns regarding global climate change and dependence on foreign energy sources, which are creating a drive for greater fuel efficiency, alternative fuels, and new vehicle technology' (NSTIFC, 2009).

The NSTIFC went on to say that:

> 'A federal funding system based on more direct forms of "user pay" charges, in the form of a charge for each mile driven (commonly referred to as a vehicle miles traveled or VMT fee system), has emerged as the consensus choice for the future. The Commission cast a wide net, reviewed many funding alternatives, and concluded that indeed the most viable approach to efficiently fund federal investment in surface transportation in the medium to long run will be a user charge system based more directly on miles driven (and potentially on factors such as time of day, type of road, and vehicle weight and fuel economy) rather than indirectly on fuel consumed… The Commission believes that such a system can and should be designed in ways that protect users' privacy and civil liberties, that incorporate any necessary cross-subsidies (for instance, to benefit the national network or to meet social equity objectives), that do not interfere with interstate commerce, and that support goals for carbon reduction. Moreover, greater use of pricing mechanisms, including both targeted tolling and broadbased VMT pricing systems, may spur more efficient use of our highway network and, by shifting demand to less congested periods of the day or to other modes, may in turn enable more efficient investment, thus reducing the additional capacity that needs to be built' (NSTIFC, 2009).

3. What is Road Pricing?

3.1 Terminology

Terminology in this field is not well-defined, and to some extent terms are used interchangeably, depending on who or where you are, rather than any objective distinction:

- road tolling (usually used for bridges, tunnels, and charges on motorways);
- road pricing (used by transport economists);
- road user charging (used in UK and elsewhere);
- congestion charging (used in London and increasingly elsewhere);
- value pricing (USA – especially for HOT lanes – see below);
- congestion pricing (USA – especially for HOT lanes – see below);
- open road tolling (ORT – USA);
- road use charging (USA, European Commission);
- electronic fee collection (European Commission);
- automatic debiting systems (European Commission); and
- electronic road pricing (ERP – Singapore).

But, in general, 'tolling' refers to charges on new roads as a financing mechanism, whereas 'road pricing' tends to imply traffic management on existing roads.

Additional relevant terminology is:

- High-Occupancy Vehicle (HOV) lanes – which can be used only by vehicles with at least one (or, in some cases, two) passengers in addition to the driver – the objective being to reduce the number of cars on the road by encouraging car sharing.
- High Occupancy Toll (HOT) lanes – which can be used either by HOVs free of charge, or by Single-Occupancy Vehicles (SOV) on payment of a toll. (But many HOV lanes in the USA are being converted to HOT lanes, because they tend to be underutilised and because many vehicles using them would have had several occupants anyway e.g. families going on holiday.)

3.2 Principles of road pricing

The objective of road pricing, from the transport economist's perspective, is to charge drivers for the costs they impose on other road users (and indeed on non-road users through the generation of greenhouse gases, pollution and noise), in order to optimise the use of (scarce) road space. As already stated, the objective is NOT to price people off the roads. Nor is it necessarily to get people to switch from cars to public transport – which is only one of the options (see Table 32). From the transport planner's perspective, it is a tool to encourage people not to use certain roads at certain times of day.

It can also generate revenue, though it may not do so since that may not be an objective of a particular road pricing scheme. See for example sections 5.4 (Singapore) and 5.5 (Sweden).

As can be seen from the body of evidence gathered in this paper, there needs to be clarity about the objective(s), so that informed choices may be made in the implementation.

3.2.1 Congestion reduction and traffic smoothing

Barth and Boriboonsomsin (2009)[2] have plotted CO_2 vehicle emissions versus speed. They find that below 25 mph, emissions range from 400 to 1,000 g/mile; from 30 mph to 55 mph, emissions are around 350 g/mile. Above 70 mph, emissions rise more rapidly, but even at 80 mph emissions are only 400 g/mile – significantly less than low speed stop-go driving.

These authors propose various techniques for reducing CO_2 emissions:

- at lower speeds: congestion mitigation using congestion pricing, ramp metering, and incident management;
- at mid-range speeds: traffic smoothing using congestion pricing and variable speed limits; and
- at higher speeds: better enforcement of speed limits and Intelligent Speed Adaptation.

Each of these strategies alone is estimated to reduce CO_2 emissions by 7–12%; all three combined could reduce them by about 30%.

3.2.2 Low Emission Zones

There are environmental as well as social and time-saving benefits from the use of road pricing. Firstly, charges can be related to vehicle emissions class – as they are for example in the German lorry tolling scheme, which has seen a dramatic increase in the proportion of modern low-emission HGVs since it was introduced (section 5.2) – as well as to road class and time of day. Secondly, by congestion reduction and hence minimisation of stationary traffic and stop-go driving, road pricing can be used to reduce emissions from vehicles as they are driven, since engines are more polluting and less fuel-efficient at low speeds.[3] Similarly, by congestion pricing, traffic speeds can be kept uniform ('traffic smoothing'), again contributing to fuel efficiency. Thirdly, Low Emission Zones (LEZ) – pricing by pollution rather than congestion – can be established using the same technology as conventional road pricing, and may be a useful stepping stone to it.

The Greater London LEZ was established on 4 February 2008 to combat the serious air pollution due to particulate matter (PM_{10}) caused by diesel-engined road traffic. It was estimated that there are 1,000 deaths and 1,000 hospitalisations per year due to this pollution. The charge of £200 per day applied initially to lorries over 12 tonnes not meeting the Euro III standard for particulate matter. On 7 July 2008 it was extended to lorries between 3.5 and 12 tonnes, and to buses and coaches with more than eight passenger seats over 5 tonnes. From 3 January 2012 it will be extended to larger vans and minibuses not meeting the Euro III standard (£100 charge), and to the Euro IV standard for lorries over 3.5 tonnes and buses and coaches over 5 tonnes (TfL, 2008b; 2010).

2 See also Figure 2.4 of Banks, Bayliss and Glaister (2007a).
3 See Appendix C and Figure 2.4 of Banks, Bayliss and Glaister (2007a).

Unlike congestion charging, the LEZ charges apply 24/7/365, and include all of Greater London, including parts of the M1, M4, and the Heathrow Spur. Vehicles built since 2001 are likely to be compliant. The penalty for unregistered vehicles is £1,000/day. The London scheme is policed by cameras and ANPR (Figure 4), exactly like the Western Extension to the Congestion Charging Zone.

Figure 4: London Low Emission Zone – enforcement site

Source: Photo courtesy of Trevor Ellis Consulting Ltd

The costs of setting up and running the London low emission zone were outlined by AEA Technology Environment (2003). According to their report, a manually enforced scheme was estimated to have the lowest costs (£2.8 million to set up, running costs £4 million p.a.). The cost of setting up a dedicated network of fixed cameras was thought to be prohibitively high, so the report recommended using the existing Central London Congestion Charging Scheme infrastructure, plus mobile ANPR cameras, with a few additional fixed cameras outside the central area. This was estimated to cost £6–10 million to set up, with annual running costs of £5–7 million, and potential annual revenues of £1–4 million. It was stressed that the LEZ scheme would not be self-financing – though of course its objective was not to raise money but to enforce compliance with prescribed emission categories.

3.2.3 Demand management

There are many techniques to address road traffic congestion in addition to road pricing; they are generically referred to as 'demand management' (ITS(UK), 2007). They include traffic control, travel information, parking charges and controls, park-and-ride schemes, route guidance, green transport plans, car sharing, teleworking, improved public transport, cycle, bus and HOV lanes, pedestrianisation, workplace parking charges, and access controls (restrictions on access to defined areas, by vehicle types or time of day).

Although all of these are valuable, this paper concentrates on road pricing, since it is generally regarded by transport professionals as the most effective approach.

3.3 Issues

3.3.1 Misunderstood facts

Eliasson (2010), who was responsible for the design of the Stockholm congestion charging scheme (section 5.5.1) and chaired its evaluation panel, points out that the following are commonly misunderstood:

- Investments in roads and public transport on their own will not eliminate road congestion for a number of reasons, including scarcity of land and insufficiency of available funding.
- Congestion charging will reduce, but not eliminate, the need for other transport investments.
- Congestion charges should be introduced only when there is a congestion problem. Other purposes may be to raise revenues, or to reduce traffic emissions, such as in the London Low Emission Zone (see section 3.2.2).
- Some drivers are sensitive to costs. Increasing the cost of driving a vehicle at certain times and places will decrease the number of drivers choosing to drive at those times and places. (Hence Time-Distance-Place-based charging – section 11.4.)
- There are many ways for drivers to adapt to a congestion charge, including change of mode, route, destination and time of travel discretionary trips (e.g. shopping or leisure) may not be made.
- Commuter trips are only a part of car traffic (maybe 40%), the remainder being 'professional' traffic (typically 15%) and discretionary trips. The latter have more ways to adapt. Some professional trips are difficult to change, some are not; but values of time are high, contributing significantly to scheme benefit.
- Travel patterns are not stable, especially for occasional drivers. Moreover, there are longer-term processes, such as change of job or residence, which affect these travel patterns.
- Effects on retail business are generally small, contrary to what such businesses fear (as also indicated in section 3.4).

3.3.2 Costs

Another ostensible reason for the unacceptability of road pricing is the belief that schemes are expensive to implement and run, especially compared to conventional taxation – Barton (2008) quotes fuel tax collection costs in the UK as 0.2% of the generated revenue. However, the problem with fuel tax is that it does not discriminate by time or place – which are key characteristics of congestion. It also does not apply to the increasing number of alternative-fuel vehicles.

As Amdal et al. (2007) state:

> 'Controversial issues such as congestion charging rely heavily on public acceptance. This is demanding but, in our opinion, any road user charging scheme should at least pass a social cost–benefit analysis, generate substantial net revenues and be acceptable to a major proportion of the public. Minimising the operating costs is critical for meeting all these three basic criteria'.

The objective of this section is to indicate that high overhead figures are not inevitable and that current schemes are cheaper to run than earlier schemes, with lower costs projected for the future.[4] Where possible, system costs are indicated in their original currency, to avoid distortions due to exchange rate changes; current exchange rates are indicated in Table 15 and Table 33 for information, but may not be the ones prevailing at the time a system was purchased.

Cost comparisons: the dangers

As Pickford (2007) states:

> 'There are frequent examples of schemes being compared by their relative operating cost… this is fraught with difficulty, prone to large errors, can lead to unfair comparisons and in the worst case could lead to the wrong charging policy being chosen. The usual comparison is the ratio (operating costs / revenues)'.

He lists the following:

(a) Operating cost drivers:

- volume (economies of scale and scope; diversity of payment channel options);
- the proportion of services provided internally;
- measures (such as education and publicity) to achieve higher levels of compliance;

4 A useful overview of some of the schemes described can be found in AASHTO (2010).

- accounting treatment (amortisation) of scheme implementation costs; and
- cost of enforcement (related to choice of civil or criminal regime).

(b) Revenue drivers:

- charging policy (high charges versus low charges);
- to collect tolls to pay for infrastructure build/operations or to elicit change in road user behaviour;
- demand and willingness to pay charges for services received (elasticity of demand); and
- whether or not enforcement revenues are included (accounting policy).

And what is published on costs is often fragmented and incomplete. Nonetheless, it seems to be the case that more recent road pricing schemes have much lower overheads than the London scheme – because of the type of technology and level of automation used.

Efficient procurement and technology leads to low costs

As Eliasson (2010) points out, low costs can be achieved by efficient procurement and choice of the right technology. In Stockholm the ‘uptime’ of the system was required to exceed 99.9%. To meet this, the system design duplicated almost every component, large quantities of spare parts were obtained, staff had to be available at short notice, and technical IT support was initially on standby 24/7. All of this increased the investment and operating costs. But a lower uptime requirement of say, 95%, would still motivate drivers to change their behaviour. So capital and operating costs could have been reduced significantly, without losing the benefits.

Contrary to prevailing orthodoxy, Eliasson also suggests that it may be cheaper NOT to use microwave tags and transponders. Though they are more efficient in identifying a vehicle passage (close to 100%, rather than the high nineties percentage now typical of ANPR operating in good conditions and, perhaps more realistically, the low nineties for ANPR dealing with bad weather or dirty and damaged plates which even humans find difficult to read), a frequently unrecognised cost is the support to road users: the administration of tags, as tags are lost, stolen, or broken, and vehicles change owners – although of course the back office has to be notified when the vehicle ownership changes, whatever the technology used in the scheme.

Another issue for Eliasson is that risks and their related costs should be borne by the same party. Unusually, this was not the case for the call centre in Stockholm, the staff for which was provided by the authorities rather than the contractor, and was initially much larger than necessary. One could, though, argue that the cost of additional start-up capacity is lower than the reputation loss to a scheme operator if capacity is inadequate.

Hamilton (2010) covers similar ground and identifies a number of significant cost drivers in the Stockholm scheme, most of which could in principle be avoided in future procurements. They included items such as initially oversized call centres, use of microwave tags rather than ANPR, excessive transaction costs due to over-stringent payment times for vehicle owners, time delays due to legal challenges (though these can benefit the contractor), excessive service level requirements, and changes in scope.

The Department for Transport Feasibility Study

The DfT published its Feasibility study of road pricing in the UK in July 2004 (DfT, 2004). It estimated the set-up costs of a national road pricing scheme as being in the range £3.5–4.3 billion, with annual running costs of £3.1–7.3 billion. A breakdown is given in Table 3. The expected annual revenue was £12 billion, giving a cost/revenue ratio of 25–64%.

Table 3: Set-up and running costs for national road pricing

Set-up costs	
£3bn	30m vehicles, £100 per OBU
£20–60m	Roadside cameras
£0.5–£1.3bn	Back office, billing etc
Running costs/year	
£2–5bn	Telecomms costs
£273–530m	Roadside cameras
£0.845–1.8bn	Back office, billing etc

Source: DfT (2004)

Banks et al. (2007a; 2007b) updated the DfT figures. They estimated that the cost of setting up and operating a UK national road pricing scheme would be £4.5 billion a year (which includes capital costs). It would generate an income of £25–30 billion a year, of which they recommend that £4.5 billion a year should be spent on road building and widening (600 lane-km/year), with the remaining £15–20 billion a year to be used primarily to reduce the existing taxes on road users. A breakdown of the costs for 2010 traffic levels and 2005/06 prices excluding optimism bias is shown in Table 4.

Table 4: Banks et al.'s estimate of national charging system costs

	Set-up Costs	Average Annual Running Costs
Low	£10.7bn	£2.1–2.8bn
Medium	£16.9bn	
High	£28.1bn	

Source: Banks et al. (2007b, Table 4.25)

Commission for Integrated Transport estimates

CfIT (2010) has estimated set-up costs of a UK national scheme to be about £3 billion, with annual operating costs of £3–5 billion a year. Revenue would depend on tariffs but could be £5–7 billion gross annually if the scheme is not revenue-neutral; net revenues could be £6 billion per year.

CfIT's assumption is that the introduction of a national charging scheme would be a major undertaking; assuming a 2010 start, it would not be operational until 2016 at the earliest. Introduction could be phased to help with acceptability and to learn from experience, starting with the main areas of congestion as illustrated by Eddington (2006), such as within the M25, and taking account of potential diversion onto uncharged roads. Also the tariffs could be phased in gradually.

CfIT also makes the point that the introduction of road user charging removes the need for some of the proposed expenditure on increasing road capacity. It also expresses an interest in exploring McKinnon's (2006) proposal for a simple distance charge based on lorry tachometer readings (see section 6.2.1) since it could be implemented quickly and make an early contribution to the public finances.

Finally, CfIT points out that 'The option of introducing a time-based vignette was rejected several years ago'. See also section 12.1.

3.3.3 Equity

It is important to address concerns about equity; one argument against road pricing is that less-well-off motorists may be priced off the roads, or at least financially disadvantaged.

In this context it is important to realise just how much car ownership has grown in the last 60 years, as Bayliss (2009) has pointed out. Between 1950 and 1966 the number of cars increased fivefold and the proportion of families with cars more than trebled. Motoring became more affordable and within reach of poorer families. In the mid -1960s one in ten low-income households (the two lowest quintiles) had a car; this has grown to more than half, and a quarter of them have more than one car. Almost two-thirds of people in the two lowest income quintiles have access to a car. Over 70% of adults can drive, compared with 15% in 1950; 63% of women and over 50% of the over-seventies now have driving licences. In low-income car-owning households, cars provide 83% of their travel compared with only 32% in car-less households (Bayliss, 2009).

So cars are important to low-income as well as higher-income households. But will these low-income car-owning households be disproportionately affected by road pricing?

First, if measures are revenue-neutral – perhaps a greater challenge in the UK than in the Netherlands (section 5.7), where motor taxes are quite high – there will on balance be no financial inequity. There may, however, be individual winners and losers. Cain and Jones (2008), in a study connected with the proposed Edinburgh congestion charge, found that although only a quarter of households in the lowest income quintile possessed a car, up to 10% of this quintile could potentially suffer some hardship – although, as Borjesson et al. (2010) and others point out, in the long term it is difficult to identify who are winners and losers anyway, as people change jobs or move house. Conversely, in a study in the State of Oregon in the USA, Zhang et al. (2009) found that the distributional effects of a $0.12 per mile flat vehicle mileage tax fee (as an alternative to the 'gas tax') were not significant in either the short term or long term, i.e. they did not place a significantly greater burden on either lower-income or rural populations.

Second, a lot depends on how the revenue is spent, especially if some of it is hypothecated (that is, 'ring-fenced' for a particular type of expenditure; e.g. US 'gas tax' revenues can only be spent on transport infrastructure) into transport improvements, especially public transport. As Patricia Hewitt, a former British government minister, pointed out (Hewitt, 1989), quoting a study for the London Planning Advisory Committee (LPAC, a statutory body established after the abolition of the Greater London Council):

> 'It is clear that less affluent car users are more likely (as with parking controls) to respond to increased charges. Against this, bus users, who are more likely to include members of lower-income groups, will benefit. Past studies suggest that lower-income bus users in central London outnumber lower-income car users by a factor of perhaps four to one. Most commentators have concluded that *"road pricing would be regressive for car users, but indeterminate, or progressive, for travellers as a whole"*.'(MVA & Buchanan, 1989 – emphasis added by Hewitt).

Third, as Schweitzer and Taylor (2010) point out, road pricing may be regressive, since lower income groups tend to pay a larger share of their income on transport than do the wealthy; but this is not automatically unfair, and the choice is often between regressive alternatives, not between a regressive and a progressive choice. The question should be: ‘Are congestion tolls fairer than other means of transportation finance?’. The authors studied whether the State Route SR91 Express Lanes (HOT lanes) in Orange County, California, should be funded by sales taxes (an increasingly popular taxation mechanism in the USA) or by tolls, and found that transportation sales taxes were doubly unfair; ‘They disproportionately burden the poor and those who drive little or not at all’. Conversely, the heaviest users of the 91 Express Lanes — and the largest beneficiaries — are higher-income households. Their conclusion is that ‘funding freeway capacity with sales taxes is a pro-auto/pro-driving policy that taxes all residents, rich and poor alike, to provide benefits to a much smaller group of drivers and their passengers’.

They also point out that transportation systems have both costs and benefits. So whilst being regressive, road pricing has benefits that other transportation finance mechanisms do not, such as paying for road building, reducing traffic delays, fuel consumption and vehicle emissions. Sales tax finance does none of these things (unless of course it is hypothecated to transport).

Furthermore, a transparent payment mechanism is a good payment mechanism. People who use scarce public resources, including road space, should pay for what they use, and should know why. ‘Knowing that resources have a cost is essential to using those resources judiciously, and our road network will function better when drivers pay the costs of their travel’ (Schweitzer & Taylor 2010). We can still be concerned about the burden tolls place on the poor, but ‘We should not subsidise all drivers (and charge all consumers) to help the small number of poor travelers who use congested freeways in the peak hours and peak directions. Rather we should help those who are less fortunate, and see to it that the rest of us pay our own way on the roads’ (Schweitzer & Taylor, 2010). Consistent with this philosophy, New York City’s cordon pricing proposal (section 5.8.1) included tax rebates for low-income individuals for any charges greater than the public transport fare (FHWA, 2009b).

Fourth, studies of HOT lanes, as reported in Gilroy and Pelletier (2007), show that there is in fact a fairly even social mix, and that most drivers use the HOT lanes only occasionally. In the State Route 91 Express Lanes in Orange County, California, whilst usage increases slightly with income group, 19% of drivers have an annual household income of less than $40,000, and another 23% have between $40,000 and $60,000. In a telephone survey of San Diego I15 Express Lane users, 80% of the lowest-income motorists (less than $40,000 annual household income) agreed that ‘People who drive alone should be able to use the I15 Express Lanes for a fee.’ In fact, they were more likely to agree with that statement than the highest-income users. These figures gainsay the view that these HOT lanes – sometimes dubbed ‘Lexus lanes’ – are used only by wealthy drivers. Furthermore, 66% of non-users supported the HOT lanes, and 89% of customers would like them to be extended.

So road pricing in reality would appear to be less unfair than is generally assumed, and should not be opposed on grounds of equity. And in one sense we would all be winners because congestion and pollution would be reduced.

3.3.4 Privacy

Privacy would seem to be an issue in principle, since the location of a vehicle can be identified through charging schemes, and movement profiles could be built up, especially if satellite-based technology is used (section 12.4) – though there is evidence from existing toll schemes such as the Melbourne CityLink and Highway 407 in Toronto that very few people take up the anonymity option offered. And Table 11 suggests that – even though tracking was referred to in the Downing Street Petition (see section 4.1) – privacy is not a major public concern in the UK (RAC Foundation, 2010b), though it did seem to be one in the Netherlands (Ellis, 2010a), even though privacy would have been assured by technical means (see also section 12.)

However, as Oerhy (2010) indicates, these technical means may result in extra costs and it may better to address privacy through institutional arrangements, allowing drivers to pay their road user charge '…to somebody unsuspicious, such as my automobile club, the supermarket, or my mobile phone company.' This is consistent with the sort of value-added services suggested by MRC McLean Hazel (2010).

3.4 Summary

We have seen in this section that there needs to be clarity of purpose when planning a road pricing scheme; principally clarity about traffic management and revenue objectives. Traffic management objectives may employ a range of demand management techniques other than road pricing, and can of course include environmental objectives.

There is a considerable challenge to be met in correcting widespread public misunderstandings about the objectives and effects of charging schemes.

Cost considerations should include a social cost–benefit analysis, within which the issues of equity and privacy must be considered.

With economies of scale, efficient procurement and falling technology costs, the overall financial costs are becoming more manageable. Care needs to be taken, however, with cost comparisons, as can be seen from Table 5, which shows an order-of-magnitude variation in running costs as a percentage of revenues. It is not strictly speaking comparing like with like, since different technologies and widely varying policy objectives underpin the schemes. Furthermore, schemes such as London, Stockholm and Singapore were designed for traffic management rather than revenue-raising. But nonetheless the table indicates that relatively low overheads are achievable (see sections 6.2.1and 6.4 for some estimated UK figures.)

Table 5: Comparative scheme running costs

Scheme	Running costs/ revenues	Technology	Comment
London	42%	Camera + ANPR	Operational scheme
Stockholm	21%	Camera + ANPR	Operational scheme
Germany	12%–>25%	GPS & manual declaration	Operational scheme
Austria	11%	DSRC	Operational scheme
Switzerland	6%	Tachograph & GPS & DSRC	Operational scheme
Norway	8–14%	DSRC	Operational scheme
Singapore	20–30%	DSRC	Operational scheme
Netherlands	3–5%	GPS	Vodafone estimates
US modelling	8–16%	DSRC	Spreadsheet modelling
San Francisco	20–30%	DSRC ('Fastrak')	Proposed scheme

Source: Author

Overall, the strengths of road pricing are that it:

- targets congestion well (depending on the tariff structure adopted);
- is flexible and adaptable; and
- complements other demand management strategies such as access controls or parking restraint).

Its weaknesses are its:

- perceived lack of political and/or public acceptance;
- potential visual impact on the streetscape (though this can be mitigated – compare Figure 6 or Figure 7 with Figure 11 or Figure 14);
- potential economic impacts, such as fears that it may discourage retail trade[5]; and
- perceived lack of equity.

5 The evidence is that it does not – see Bent and Singa, (2009), who studied San Francisco, and TfL (2004c) who studied London – though it is fair to say that contrary claims have been made for London.

4. Acceptability of Road Pricing in the UK

4.1 Introduction

Justified or not, there is a great deal of sensitivity on the part of the British Government about committing to real road pricing (as opposed to trials and demonstrations) – based apparently on the belief that it would not be acceptable to motorists in particular. There is certainly some evidence for this apparent unacceptability – for example:

- the 1.8 million-signature petition against road pricing on the UK Prime Minister's website. The original petition said: 'The idea of tracking every vehicle at all times is sinister and wrong. Road pricing is already here with the high level of taxation on fuel. The more you travel – the more tax you pay. It will be an unfair tax on those who live apart from families, and poorer people who will not be able to afford the high monthly costs. Please Mr Blair – forget about road pricing and concentrate on improving our roads to reduce congestion' (PM Petition, 2007);
- the opposition of small but vocal bodies such as the Drivers' Alliance (founded by Peter Roberts, who initiated the petition above) and the Association of British Drivers; and
- the recent 'No' votes in referenda on road pricing in Edinburgh in 2005 and in Manchester in 2008, by margins of 3:1 and 4:1 respectively.[6]

6 The wording for the Manchester ballot actually was: 'Do you agree with the Transport Innovation Fund proposals?'. The congestion charge comprised only about 10% of the overall funding bid – £318 million out of a total bid of £3 billion. But the 'anti' campaigns focused on this aspect rather than on the remaining £2.7 billion of transport infrastructure investment.

However, as has been pointed out by Goodwin and Lyons (2009), there are dangers in over-generalising about public opinion. Responses to surveys depend on the precise questions asked and the people who respond to them. It is also clear that there is much ignorance and misunderstanding amongst opinion-survey and referenda respondents where road pricing is concerned, and some of this is addressed here. Furthermore, if there is to be any improvement in roads and in driving conditions, it is likely that it will only come about through the introduction of road pricing, especially in these economically straitened times.

4.2 Theory

4.2.1 Department for Transport studies

The Department for Transport has been studying the public acceptability of road pricing for many years. The most recently published studies (DfT, 2007b; 2010) indicate that whilst a majority thinks that ‘pay per use’ is a good idea, charges should not be higher on busy roads or at busy times (Table 6). Similar results were found by Owen et al. (2008), as reported below.

Table 6: Attitudes towards changing the method of charging for road use

Question	Strongly agree/ Tend to agree (%)		Tend to disagree/ Strongly disagree (%)	
	2007	2010	2007	2010
The current system of paying for road use should be changed so that the amount people pay relates more closely to how often, when and where they use the roads.	53	52	31	31
People who drive on busy roads should pay more to use the roads than people who drive on quiet roads.	25	22	58	55
People who drive at the busiest times should pay more to use the roads than people who drive at quiet times.	23	21	60	61

Source: DfT (2010b)

In answer to the question ‘Do you think a new charging scheme to use roads will reduce congestion?’, 29% said ‘Yes’; 52% said ‘No’. When the latter were asked why, they gave the reasons shown in Table 7, (although, as we see in section 5.5.1, these reasons did not apply in Stockholm).[7]

Table 7: Survey respondents’ reasons why a new charging scheme will not reduce congestion

	% response
People will not be able to change behaviour	58
People do not want to change behaviour	33
Alternatives are inadequate / unsatisfactory	19
People will use other non-charged routes, causing congestion on those instead	19
The system would be ‘unenforceable’	16
People will be unable to pay	16
People will refuse to pay	12
Congestion is not a problem	0

Source: DfT (2010b)

When asked ‘Do you think a new charging scheme is fair?’, 26% said ‘Yes’, 55% said ‘No’; the responses in the 2007 survey were 29% and 52%

7 See for comparison, in Table 11, the answers to a related but rather different question in the RAC Foundation study.

respectively. As reported in the 2007 study, drivers were far more likely to consider it unfair (58%) than non-drivers (39%). Also 39% of adults agreed that an itemised bill would reassure them of the accuracy of a road pricing system, whilst 37% disagreed (DfT, 2007b).

According to respondents, 'Reasons why a new charging scheme would not be fair' are shown in Table 8 (see also the RAC Foundation study – Table 11).

Table 8: Reasons why a new charging scheme would not be fair

	% of respondents
People will not be able to change travel behaviour	59
The cost would be too much	37
Poor people would be affected worse than rich people	31
There are no adequate alternatives to the car	23
People will not want to change	16

Source: DfT (2010b)

In response to the statement that 'I would be prepared to accept road pricing as long as there was no overall increase in the amount of taxation paid by motorists as a group, even if this meant some people paying more than they do at present', 38% agreed, 34% disagreed, 6% needed more information, and 6% did not know. In comparison, in 2007 the figures were 41%, 35%, 5% and 6% respectively. To the question 'How should the revenue from such a scheme be spent?', 47% thought it should be spent only on roads and transport, 20% that it should be spent on a range of public services, and 20% would need to know more before they could say; 12% did not agree with road pricing under any circumstance.

In summary, there seems to be an acceptance of the principle of road pricing by the majority, though not to charging more at busy times or on busy roads, combined with (unjustified) scepticism as to whether it would work and whether it is fair.

The BMRB UWE study

A particularly interesting and extensive study was carried out by Owen et al. (2008)[8] for the DfT, and is partly the basis for some of the proposals in this paper. It used an innovative methodology involving a large number of participants reconvening several times over the project in small deliberative

8 Rachael Owen, Anna Sweeting and Sue Clegg are with BMRB Social Research, and Charles Musselwhite and Glenn Lyons are with The Centre for Transport & Society, University of the West of England.

focus groups. A stakeholder workshop of policy experts identified key areas to be studied. Groups of participants were selected from eight UK local authority areas considering introducing road pricing, reflecting a range of urban and rural locations (see section 6.2.2). A total of 446 participants took part in the first wave of the study, with numbers gradually reducing in later waves. Because of the significance of this study, it will be covered in some depth.

The objective of the study was to:

- address the current state of public opinion on road pricing and to understand the factors that influence it;
- go beyond results of opinion polls and surveys to address the underlying motivations and attitudes; and
- explore how and why public acceptability changes, particularly in relation to information and greater exposure to the issues.

The authors point out that public acceptability for road pricing is not stable and can change over time. Indeed, during the initial phases, participants did not want road pricing to be introduced. However, as more specific information on road pricing was introduced and people understood the proposed scheme, the attitudes of some of them, particularly females, became more positive. They understood that 'something had to be done' about the problem of congestion and that road pricing would be the most effective way of addressing it.

Previous research had suggested ten key areas that were important to public acceptability of road pricing – see Table 9.

Table 9: Ten factors for the acceptability of road pricing

A recognition that there is a (transport) problem (such as congestion) that requires a solution like road pricing and that road pricing is seen to work to reduce the problem.
It needs to be part of an overall traffic management plan within a consistent transport strategy, Including public transport improvements, green travel plans, park-and-ride schemes and car park levies.
Travel alternatives need to be available to facilitate choice, including free alternative routes and good public transport.
Revenue should be identified and used appropriately; support is increased when revenue benefits the motorist (i.e. reduction in road tax and fuel duty), or the local transport network (especially public transport), or is used on expanded road capacity and maintenance.
The scheme must be simple (see also section 4.3.2).
The scheme must be fair; it must take account of vehicle size, people's income, health and disability needs and proximity of residence or business to the charging zone.
Information on the scheme, and on the success of road pricing elsewhere, must be disseminated via education, publicity and marketing; lack of knowledge leads to lower acceptance (see also section 4.3.2), but increasing knowledge can also increase negative attitudes (see Figure 9); a leader/champion is also important.

The local authority or agency must be trusted to deliver, manage and run the scheme.
The technology used must be reliable and easy to understand; it should minimise evasion; and the implementation cost should not be borne 'up front' by the motorist.
Concerns over privacy and data protection must be addressed.

Source: Owen et al. (2008)

Public acceptability of the need for demand management

Although the term 'demand management' was not used in the BMRB UWE study, the topic was addressed in discussions. Participants felt that such measures would restrict choice, though support was found as options were discussed in depth. Participants preferred 'carrots', especially better public transport, flexible working and car sharing. 'Sticks', such as increased fuel tax, access restrictions and road pricing were regarded negatively. Participants generally felt their car use was necessary, for various reasons[9] including:

- no suitable public transport alternative;
- need to transport large items or children, and/or for long journeys;
- enables a combination of journeys, therefore saving time; and
- important at particular times of the year and day.

The freedom to drive when, where and how often they like was reported as extremely important by the participants. It was linked to independence, particularly amongst the oldest (65+) and youngest (18–24) age groups. Across all groups, the importance of driving was linked to civil liberties and in some cases basic human rights.

Public acceptability of the principle of road pricing

Initially, road pricing was viewed as an extra cost without clear benefits, and with revenue generation as the objective. Also, participants questioned its efficacy – people drive because they have to, and would find alternative routes, so congestion would simply be displaced elsewhere; road pricing would only be acceptable if it really did reduce congestion. Other concerns included a lack of trust in the responsible authorities, how the revenue would be spent, whether it was fair, and the impact on businesses.

However, as more specific information on road pricing was introduced and people understood the scheme, some attitudes, especially amongst female participants, became more favourable – congestion had to be tackled and road pricing would be the most effective way to do this. But in general the negative feelings were sustained and in some cases became more entrenched, especially with younger males and those from C2/D/E backgrounds (the lowest three socio-economic groups); people felt that they had paid a lot of money for

9 For a more detailed treatment of the importance of the car in British society see Lucas and Jones (2009).

their car and wanted to 'get their money's worth', though there was a general feeling – at least at the time the study was carried out – that the introduction of road pricing was inevitable, as evinced in the RAC Foundation (2010b) study, in which 34% of people agreed with the statement 'It is inevitable that charging car and van drivers through a pay-as-you-go system will be introduced on Britain's roads in the future', with 45% disagreeing.

Factors influencing acceptability included:

- whether it really did reduce congestion;
- cost – participants did not want to pay more for using a vehicle; a key theme was to reduce or eliminate road and fuel tax, otherwise they were 'paying twice', though there was uncertainty about whether the government would allow any such trade-off to happen;
- whether it is part of an overall traffic plan with alternative modes and routes;
- improvements in public transport (reduction in fares, increased reliability, new routes, shorter journey times, cleanliness, staff attitude and personal safety) – all funded by the road pricing revenue;
- equity and fairness for all road users; people were clear they wanted this, though it was accepted that it would be difficult or impossible to achieve;
- evidence of improvements to congestion, public transport and road networks;
- access to (educational) information, preferably from an independent body, with open communication and transparency about costs and projected income; success of other schemes should be made explicit; and
- a trial prior to implementation, although there was scepticism, and distrust of local and national government. Some participants would consider opting in to a road pricing scheme if they benefited from other concessions such as a reduction in fuel tax or vehicle excise duty.

Other factors affecting acceptability included: the need to minimise evasion of payment, combined with an easy-to-understand scheme; transparency in scheme management to facilitate trust, perhaps with an executive board involving local residents and businesses; and concern about their information being sold on to private companies.

Public acceptability of a specific road pricing scheme

To explore people's attitudes in more depth, and in response to the need for more information, two types of road pricing scheme were described during the next phase of the research, a cordon charge and a distance charge.

The cordon charge model was generally considered more familiar and easier to understand. But there were fears that charging zone boundaries might be unclear, that places such as such as hospitals, railway stations and park-and-ride schemes would be located inside the charging zone and hence not free to access, and that charging zones would not cover areas of highest congestion levels. There were also concerns, especially with the distance-based model, about implementation and administration costs, and lack of visibility of charges incurred in real time. On the positive side, it was assumed that people would be more likely to use public transport or car share, which would reduce congestion, and people could avoid paying by driving outside the charging periods. But there was still scepticism about the efficacy of charging in reducing congestion, and whether it would simply displace it to other locations and times. On this latter point, the evidence from Stockholm (section 5.5.1) and from the London Congestion Charging Scheme (section 4.3.1) is that it does not. And, on the general efficacy point, congestion is non-linear – so a small reduction in traffic will produce a large reduction in congestion – as happens for example during school holidays.

Cost was a key consideration, both of personal travel and of goods and services as businesses passed on higher transport costs, and also the 'hidden costs' of running the schemes.

Equity was also an issue. Workers and parents of school children were perceived to have little choice but to drive during charging times. Local businesses and low-income earners would also suffer. More positively, distance-based charging was regarded as fair, though urban residents felt that it would be unfair to them as compared to rural residents; they felt they would pay a relatively high proportion of the cost and would be paying more for something everyone would benefit from. But privacy was a concern; it was assumed that drivers would need to install a tracking device in their car.

Acceptability was increased if new roads would be built, if there were improvements to roads and public transport, if charges applied only in peak times, and if there were exemptions for certain groups.

Public acceptability of the detail and design of a road pricing scheme

In the next phase, more detailed issues including billing, fines, privacy, and technology (Automatic Number Plate Recognition and microwave tag-and-beacon) were discussed.

ANPR technology, as used in the London Congestion Charging Scheme, was found to be easier to understand than microwave tag technology, due to its familiarity and its similarity to speed cameras. Participants had more confidence that the technology would work; microwave tags were perceived to be more complex and less likely to function successfully. ANPR was also considered to be cheaper to install and administer (every car has a number-plate, but is not currently fitted with a microwave tag). ANPR was also considered to be less intrusive than a tag, since there is no equipment needed inside the car, and there were detection points only where cameras were located.

However concerns regarding ANPR were also raised. The technology was considered to be susceptible to fraud, and it was argued that number plates could be cloned or stolen, allowing a criminal to incur charges at another driver's expense.

Concerns about microwave tag technology included:

- enforcement: how to ensure that every car has a tag;
- privacy: tags were thought to enable cars to be tracked, whereas in reality the tag can only be detected when the vehicle passes an equipped gantry; people also thought that road pricing technology simply added to the trackability they already experienced through mobile phones, credit cards etc – all of which bring benefits and are freely chosen by consumers;
- cost: the technology was perceived to be more expensive than ANPR because it was more complex, roadside cameras would still be needed, and the installation of a tag into every car would be expensive, which would reduce the revenue available to be invested in transport. Also there was the cost of the tag to the car owner – especially for families owning more than one car;
- evasion – including by foreign drivers and motorbike riders – and fraud, though there was a view that the technology was more sophisticated and therefore more difficult to use fraudulently than ANPR;
- health risks from the microwaves;
- a loss of freedom, if vehicles could be located by the technology;
- visual impact of the masts and gantries used for microwave tag technology, especially in historic towns;
- inconvenience of installing the tag – which might mean taking the car to a garage; and
- security: thieves might break into cars to steal the tags.

Payment methods were easy to understand as they were similar to mobile phones, and it was generally felt that drivers would want to see the charges incurred in real time on the onboard tag. Detailed billing was preferred, to allow drivers to check and challenge bills, preferably with a wide range of payment options. There was also a lack of trust in the billing technology; ANPR technology was favoured over microwave tags as the photographic evidence that the technology provided was perceived to be incontrovertible.

Fines should not be too high; the purpose of road pricing is to encourage some road users to change their driving habits, rather than to penalise them or use the scheme to raise revenue, and to signal the cost of driving within a congested area, which has been addressed in Singapore – see section 5.4. Also, fines could be incurred unintentionally, if a tag broke.

It was generally thought that the government rather than drivers should pay for the technology, though it was recognised that this meant ultimately the taxpayer.

This was felt to be fairer since everyone, not just drivers, would benefit from reduced congestion.

Appropriate organisations to collect road pricing information

Various organisations were suggested as suitable for dealing with road pricing information, including:

- local government – it was considered more likely that revenue would be invested in the local transport system. A local authority was also considered more accessible and more accountable. Participants wanted to be able to speak to somebody based locally to discuss a query or grievance;
- a private company – thought to be more competent and efficient than a local authority. Data would also be more secure with a private company since it would be subject to regulations and restrictions, as opposed to a 'Big Brother' state. On the other hand, a private, profit-making company would seek to increase its profits; and
- an independent, not-for-profit organisation – which was thought more likely to be transparent about how the revenue was spent. The DVLA (Driver and Vehicle Licensing Agency) was suggested as one possibility, since it is well-respected and authoritative.

Impact of the media, family, friends and the research

Awareness of road pricing and congestion in the media increased during the study, partly due to the Eddington (2006) Report, and to the petition on the Prime Minister's website (PM Petition, 2007), though some respondents felt that the latter overstated issues on privacy and overhyped the costs.

Participants felt they knew more about road pricing as a result of participating in the study and were more likely to influence friends and family than the other way around, as well as being sceptical about some newspaper reporting. However, they still wanted more information on road pricing, particularly government-directed publications, to counteract the negative stories in the press and to back up the more positive views, especially:

- examples of other road pricing schemes working;
- a positive steer from the government. Although ministers had spoken positively about road pricing, there was not a consistent message, raising fears that there was a hidden agenda and it was more about revenue-raising than solving congestion; and
- education on the theory and principles of road pricing.

Conclusions

People struggle to understand what road pricing would mean for their daily lives and travel needs, which inhibits acceptance. Similarly, information on hypothetical road pricing schemes is hard to grasp – *'real' examples with evidence of impact are desirable*.

Privacy is not an initial concern to many people, but can become so as they learn more.

A targeted approach is desirable, since different groups of individuals view road pricing in different ways. In particular, female participants tended to become more open to road pricing while younger males and those from C2/D/E socio-economic backgrounds remained or became more negative.

The study arrived at two key questions which will govern the acceptability of road pricing:

- Will it effectively tackle congestion?
- Will it make life better for me, i.e. would it be a price worth paying?

4.2.2 RAC Foundation studies

The RAC Foundation, a charity which explores the economic, mobility, safety and environmental issues relating to roads and responsible road users, has produced a number of reports that bear on the subject of the public acceptability of road pricing.

Motoring Towards 2050

Motoring Towards 2050 (RAC Foundation, 2002) reported that only 43% of drivers would be willing to pay tolls to drive on motorways or in city centres, and only 16% were willing to pay tolls to drive on all roads; but this figure went up to as much as 76% under certain conditions – see Table 10.

Table 10: Driver willingness to pay road tolls

	%
If equivalent reductions in fuel duty	76
If equivalent reductions in tax disc fees	73
As part of a package of better roads, public transport and traffic management	71
If roads were improved to guarantee better journey times	71
If there were equivalent reductions in public transport fares	65
If the level of tolls were set in accordance with level of congestion	54

Source: RAC Foundation (2002)

And although around 40% claimed that 'I would use my car less if public transport were better', the (admittedly limited) evidence from Stockholm (section 5.5.1) is that this is not the case in practice. Even in the RAC Foundation survey, although motorists realised that congestion is a problem, only one in five felt that they could use a bus or a train more.

Governing and Paying for England's Roads: the Ipsos MORI survey

According to a more recent Report from the RAC Foundation (Glaister, 2010), it is essential to change the way England's roads are managed and paid for if the country is to avoid traffic gridlock in the coming decades, including some form of pay-as-you-go scheme. The report is discussed in more detail in section 6.1, and a summary of it will be found in RAC Foundation (2010a).

Of more immediate relevance to the acceptability of pay-as-you-go road pricing is the associated survey (Ipsos MORI, 2010) conducted on behalf of the RAC Foundation (RAC Foundation, 2010b), which found that 65% of British adults oppose, in principle, the introduction of a pay-as-you-go system on motorways and major roads, and only 18% support it. However, if it also included the abolition of vehicle excise duty and a cut in fuel duty, then 46% would support it, and only 34% would oppose it; if it were run by 'a regulated private sector company' then support would increase to 58%, with only 19% opposing; and *if it covered all roads then support would increase to 70%, and opposition would fall slightly to 18%*.

When people were asked 'Why do you say that you would oppose, or neither support nor oppose, such a pay-as-you-go proposal the answers were as shown in (Table 11).

Table 11: Response to question 'Why do you say that you would oppose, or neither support nor oppose, such a pay-as-you-go proposal'.

	%
It would cost more	17
Don't know enough about the system to support it/need more detail	13
We pay too much tax already	12
The system is fine as it is/I'm happy with how we pay for our roads now	11
This doesn't sound fair/poor people would be affected worse than rich people	9
We pay enough already to use the roads/drive	9
It would be inconvenient	8
Don't think it would work/ this wouldn't work in Britain	8

It would reduce people's right to movement/right to travel	6
Don't trust government to spend the money raised on the roads/transport	4
The government cannot be trusted to deliver a workable system	4
The system might not be accurate	3
This is just a way for the government to raise more money	3
People will use other non-charged routes causing congestion on those instead	2
It wouldn't deliver what is expected	2
The new system should be extended to include lorry drivers and motorbikes	2
Fuel duty should be abolished, not just reduced	2
There are no adequate alternatives for people to use instead of the car/ we do not have good enough public transport to support this system	1
It would be difficult to enforce	1
Other	17
It would invade the privacy of the motorist	<0.5
A private body cannot be trusted to deliver such a system	<0.5
Don't know	8

Source: RAC Foundation (2010b)

Thus if people were given more information, and could be convinced that a system would work and would not be expensive to run, many of these objections would disappear – *supporting the thesis that education, and experience of a real working and inexpensive system, is what is needed for acceptability*. System costs are addressed in section 3.3.2 and throughout section 5, and indicate that it may be less than people think.

Note also that less than 0.5% answered that 'It would invade the privacy of the motorist' – whereas most pundits maintain that privacy is a big issue. Also many people would trust a private body to deliver such a system.

4.3 Practice

4.3.1 London

London Congestion Charge

A central London congestion charge was part of the manifesto of London Mayoral candidate Ken Livingstone, based on the *Road Charging Options for London* report (ROCOL, 1999), and following his election in 2000 it was implemented. The scheme went live on 17 February 2003.[10] The charge was originally £5, but was raised to £8 in July 2005. The charge zone covered 22 square kilometres in central London (see Figure 5), and charges applied between 7 a.m. and 6.30 p.m. on weekdays (now 7 a.m. to 6 p.m.). Some vehicles are exempt or get a discount, including buses, taxis and those used by emergency services, disabled people and residents, and alternative fuel vehicles (formerly via the Alternative Fuel Discount, but from January 2011 via the Greener Vehicle Discount, which gives a 100% discount to cars that emit 100 gCO_2/km and that meet the Euro 5 standard for air quality; Evans & Firth, 2006a; Dix, 2007). A detailed account of the background to the scheme and its early days will be found in Richards (2006).

Figure 5: The Central London Congestion Charging Zone

Source: Courtesy of Transport for London

The scheme depends on self-declaration – users declare their intention to drive into the zone either in advance or before midnight on the day they travel (or, since mid-2006, before midnight the following day), and pay by various mechanisms. In 2006 there were typically 106,000 payments per day. Vehicles are not fitted with an On-Board Unit (OBU); the system is enforced by fixed cameras located at the boundary of the charging zone, supplemented by 'screen-lines' of cameras inside the zone (Figure 6) which record the vehicle registration mark (VRM) using ANPR, and compare it to the declarations in the payment database. Users who do not pay are subject to a penalty charge (originally £100, now £120).

10 See http://www.tfl.gov.uk/roadusers/congestioncharging.

The daily charge increased from £8 to £10 on 4 January 2011, but a 'payment in arrears' scheme called Auto Pay was introduced at the same time; TfL automatically records the number of charging days a vehicle travels within the charging zone each month and bills a debit or credit card with a daily charge of £9. Auto Pay also removes the possibility of receiving a Penalty Charge Notice. The approach in London up to now has been payment in advance, which makes the task of ANPR easier, since so you do not need to identify people who have paid. If 70% pay, and 30% do not, and there is a 95%-efficient ANPR system in place, it only misses 5% of 30%, i.e. 1.5% of the total. It will be interesting to see what effect Auto Pay will have.

Figure 6: Central London Congestion Charging Scheme – enforcement site

Source: Courtesy of Trevor Ellis Consulting Ltd

It is important to note that the charge applies to vehicles circulating within the zone, whether or not they cross the boundary – in other words it is an area scheme, not a cordon scheme, despite the cameras at the boundary.

When the scheme was introduced, congestion in the charging zone fell by 26%. Traffic entering the charging zone was 17% down, with chargeable vehicles down 31%. Bus patronage increased, and journey time (and its reliability) improved. There was minimal change in the number of trips to the central area; 50–60% of travellers switched to public transport, 20–30% diverted around the zone, the remainder made other adaptations. Net revenues in 2005/06 were £122 million (Dix, 2007).

However, there was minimal extra traffic on the road bounding the charging zone. According to TfL (2004a), 'Total vehicle kilometres on the Inner Ring Road are estimated to have increased by 4% overall. For vehicles with four or more wheels, the equivalent figure is 1%, a change that is not statistically significant'.

When the Western Extension was implemented, traffic on its boundary route increased by 4%; on the 'free passage route' between the original Central Zone and the new Western Extension there was no change (TfL, 2007).

According to TfL, the benefits of the scheme, paid for by the revenue, included:

- less congestion;
- more people using public transport (350 more buses were provided);
- reduced road traffic emissions;
- 72 km of new cycle routes; and
- improved road safety.

As regards acceptability, public opinion was equivocal prior to the introduction of the central London scheme, but after it was introduced, opinion shifted in favour, with opposition levels falling. Subsequently, the proposal for an extension (see below) produced a drop in support, but it increased following a campaign promoting the benefits. This is summarised in Table 12.

Table 12: Support for London Congestion Charge 2002–2006

%	2002	Pre-congestion-charge		2003 post-congestion-charge				2005	2006
Support	40	38	39	57	50	59	48	40	59
Neither	19	16	18	16	18	15	21	24	12
Oppose	40	43	41	27	31	24	28	35	26

Source: Dix (2007)

Scrappage of Western Extension

In 2007 the scheme was extended westwards, approximately doubling the area charged (Figure 7 & Figure 8). The objective was to extend the benefits of the central zone to other parts of London, and the western area was chosen because of its traffic congestion, good public transport alternatives and a suitable diversionary route to form a charging boundary and aid traffic management. It operated in the same way as the central scheme, but some of the enforcement technology was upgraded, including the use of digital cameras (Figure 7), the processing of number-plate images at the roadside, and ADSL data links (Evans & Firth, 2006a; TfL, 2007 & 2008a).

Figure 7: London Congestion Charging Scheme – Western Extension enforcement site

Source: Courtesy of Trevor Ellis Consulting Ltd

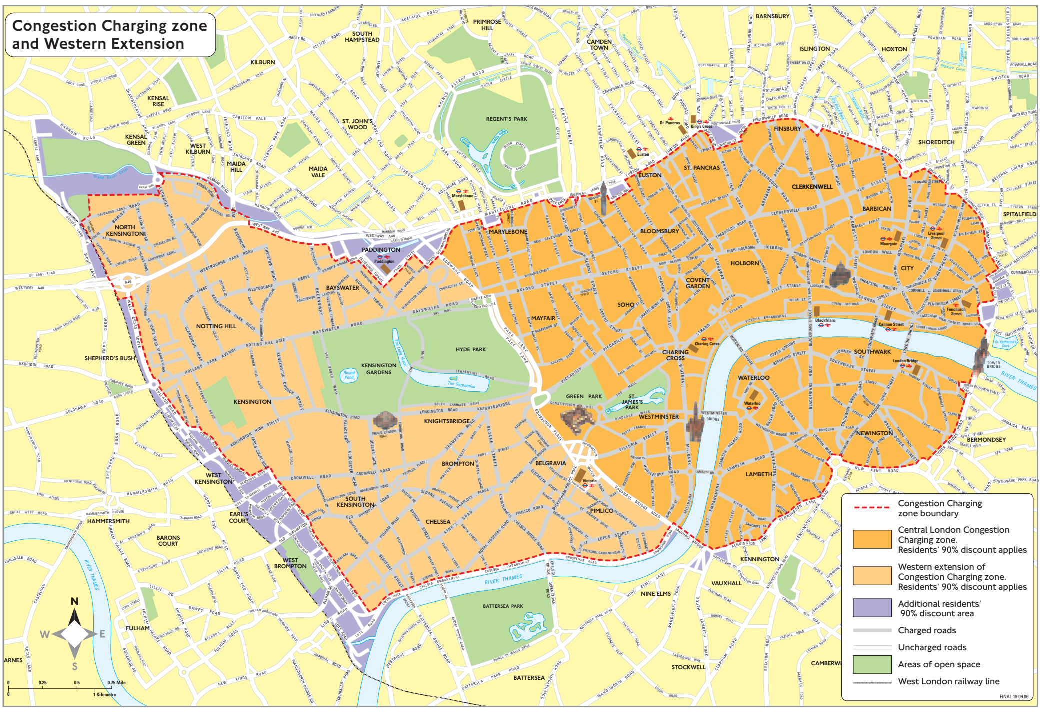
The impacts of the Western Extension were broadly in line with expectations:

- Traffic entering the area was down by 13%, but increased by only 4% on the boundary route; on the free passage route between the original Central Zone and the new Western Extension there was no effective change.
- Traffic in the original zone increased slightly, but there were no adverse traffic impacts beyond the zones.
- The extra bus services coped well with increased passengers.
- Total number of charges paid per day, and the Penalty Charge Notices, both increased by 50%.

However, the Western Extension seemed to be more controversial than the original scheme, and the new Mayor, Boris Johnson, was elected in May 2008 with a manifesto commitment to consult on whether to keep the Western Extension or abolish it. In an initial consultation by TfL, 67% of the public and 88% of businesses voted to abolish it (Dix, 2009) – a rather surprising result given the support shown in Table 12. A more formal, statutory consultation process then took place, as a result of which the Western Extension was removed after 24 December 2010. This result contradicts the thesis that familiarity breeds acceptance. The original scheme was associated with the Labour politician Ken Livingstone, and the residents of Kensington are predominantly not Labour, so it may have been a political vote. Residents benefited from the reduced traffic, paid only 10% of the standard charge, and did not have to pay extra to drive into the central zone, so it would seem to have been in their interests to keep the scheme.[11]

11 Private communication with Trevor Ellis (see also http://www.tfl.gov.uk/roadusers/congestioncharging/17094.aspx#removal).

Figure 8: London Central Charging Zone plus Western Extension



Source: Courtesy Transport for London

Costs

Critics often cite the running costs of the London congestion charging scheme, which were 42% of the revenue (see Table 13). The figures in this table are based on Transport for London's *Congestion Charging Impacts Monitoring Fifth Annual Report* 2007 (TfL, 2007).

Table 13: London Congestion Charging Scheme: original revenues and running costs

Revenues	(£m provisional)
Standard daily vehicle charges (£8)	125
Fleet vehicle daily charges (£7)	27
Resident vehicles (£4 per week)	6
Enforcement income	55
Total revenues	213
Total operation and administration cost	-90
Net revenues	123

Source: TfL (2007)

The London scheme was totally new, and there was little comparable experience in the UK, or indeed anywhere else in the world. Apart from the political imperative to implement an operational scheme within a single mayoral term of office (4 years), it had to be designed to be proof against legal challenge, which meant using technology similar to that used for red-light running, speeding and bus lane infringement – which come under criminal law and hence require a higher standard of proof than civil law enforcement schemes. Such technology (e.g. fibre-optic links to cameras, and central processing of camera images and ANPR) is relatively expensive. The later Western Extension adopted less expensive technology (local processing of number plates at the roadside, image transmission to the back office only when necessary, ADSL data links) to reduce running costs, though no figures of the resulting overhead rate have been broken out. As TfL (2008a) points out, the original Central London Zone (CZ) and the Western Extension Zone (WEZ) were operated as a single scheme. The figures shown in Table 14 are taken from Table 10.2 of TfL (2008a).

Table 14: Scheme revenues and costs, Central Zone and Western Extension, Fiscal Year 2007/08 (provisional)

Costs	**£m**
Scheme operational, publicity and enforcement costs	91
Other costs: TfL staff; traffic management; TfL central costs	40
Total costs	131
Revenues	**£m**
Standard daily vehicle charges (£8)	146
Fleet vehicle daily charges (£7)	37
Resident vehicles (£4 per week)	12
Enforcement income received	73
Total revenues	268
NET REVENUES	137

Source: TfL (2008a, Table 10.2)

The running costs appear to have gone up from 42% to 51% of revenues, though it is difficult to disaggregate and compare pre-WEZ and post-WEZ situations, for a number of reasons, including:

- more resident and disabled concessionary applications to process;
- decreased revenue from residents in the WEZ travelling into the CZ;
- increased number of boundary enforcement sites; and
- overlap of installation and maintenance contracts for CZ and WEZ cameras.

4.3.2 Edinburgh and Manchester

There is evidence that people do not understand what is being proposed or why, and vote against a proposed road pricing scheme even though they would benefit from it.

In Edinburgh the public voted against the proposed scheme by a ratio of 3:1 so the scheme was abandoned. Gaunt, Rye and Allen (2007) did a 'post-mortem' study which showed that car use was the principal determinant of voting behaviour: car owners strongly opposed the scheme; non-car owners (i.e. public transport users, who would have benefited from the scheme) only weakly supported it. The limited understanding of the scheme increased the opposing vote:

- The maximum charge was £2 but 38% of respondents thought it could be higher;
- 20% of respondents' journeys would not have been charged but respondents thought they would be; and
- 37% incorrectly thought that outbound traffic was charged.

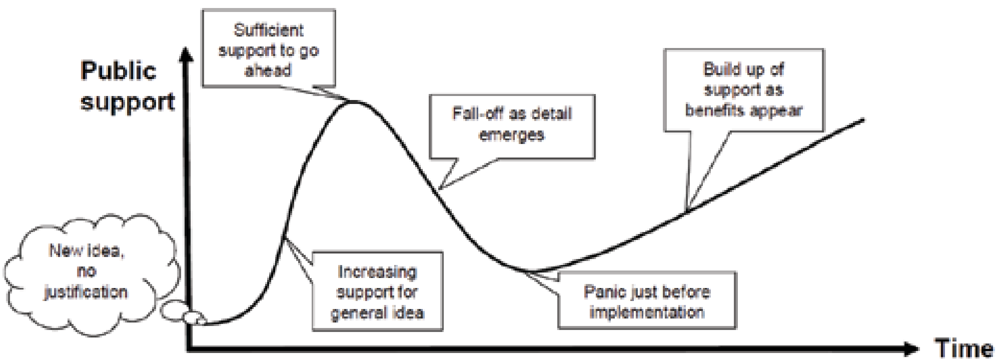
Furthermore, people were not convinced that the scheme would achieve its objectives of reduced congestion and improved public transport, though 75% thought that congestion was a problem. The conclusion of Gaunt et al. (2007) was that a simpler, more easily communicated scheme was needed to convince residents, particularly public transport users, of the benefits.[12]

The situation was almost certainly much the same in Manchester in 2008, where the vote was 4:1 against the proposed road pricing scheme in all ten Boroughs of Greater Manchester – despite the fact that this meant turning down £1.5 billion of transport infrastructure investment, the equivalent of 50 years' government funding through 'normal' mechanisms such as the Regional Funding Allocation for transport.

An interesting sidelight has been cast by Marsden (2009), as reported in Bonsall and Young (2010). The congestion charging plans in Edinburgh and Manchester might have been more popular if they had included a reduction in parking charges. We return to this in section 6.3.2.

There is also evidence that the worst possible time to hold a referendum is immediately before the scheme is due to be introduced, which is when public opinion is at its most negative; 'After initial support acceptability decreases the closer and more specific the proposal gets' (Goodwin, 2006; Owen et al., 2008; CURACAO, 2008).[13]

Figure 9: Road pricing acceptability may vary with time



Source: Goodwin (2006) and Owen et al. (2008)

12 In some respects this result was surprising. According to Cain and Jones (2003), a lot of effort was put into a public information and consultation campaign, and surveys showed that there was significant support for a congestion charging scheme, especially amongst the residents of the City of Edinburgh.
13 See Figure 9, which is an illustration, based upon insights from road pricing schemes that have been pursued/implemented, of how public acceptability of the road pricing scheme may change over time along a trajectory towards (and beyond) implementation.

5. Evidence from Abroad

There is a great deal of evidence, going back 20 years, that motorists *are* prepared to accept road pricing, at least under certain circumstances, including studies in the UK by Jones (1991; 1995), Transport for London (TfL, 2004b), the Department for Transport (DfT, 2007b), the RAC Foundation (2002), and from abroad by Arseneau (2009), studies in San Francisco (Fairbank et al., 2008), and most notably the Stockholm trial and the Dutch National Road Pricing scheme. Schemes are especially acceptable if:

- voters have experience and understanding of the benefits of road pricing;
- Cost overheads of schemes are low
- any revenue is ring-fenced for transport projects; and
- there are reductions in other motoring taxes, as was proposed in the Netherlands.

The evidence from experience in several countries is set out below. A useful overview of some of the schemes described will be found in AASHTO (2010).

Note that financial data is given in the original currency, to avoid the distorting effects of fluctuating exchange rates; but for clarity the relevant exchange rates are given in Table 15.

Table 15: Currency exchange rates (August 2010)

CHF	1.00 Swiss franc = 0.66 GBP
EUR	1.00 EUR = 1.29 USD= 0.82 GBP
GBP	Pound Sterling (Great Britain) 1.00 GBP = 1.21 EUR = 1.57 USD
NOK	Norwegian Kroner 10 NOK = £1.04 = 1.25€ = 1.64 USD
SEK	Swedish Kronor 10 SEK = £0.87= 1.05€ = 1.36 USD
SGD	Singapore Dollar 1.00 SGD = 0.47GBP = 0.57 EUR = 0.73USD
USD	US Dollar 1.00 USD = 0.64 GBP = 0.78 EUR

5.1 Austria

The Austrian scheme applies only to trucks, and covers mainly motorways.

Costs

The Austrian lorry tolling scheme was reported on by Kollenhofer (2008) of Asfinag, the Austrian state-owned highway operator. In 2006 the ratio of running costs to revenues was 11% (Table 16).

Table 16: The Austrian lorry tolling scheme: key figures

Annual number of toll transactions (2007)	658m
Toll gantries (2006)	450
Total proceeds (2006)	€825m
Costs / proceeds (2006)	11 %
Kilometres charged (2007)	3.26bn
OBUs (active contracts) (end-2007)	841,600
OBUs actually used	533,400 (63 %)
Capture quota (2006)	99.7 %
Toll evasion rate (2006):	less than 1 %

Source: Kollenhoffer (2008)

5.2 Germany

Like the Austrian scheme, the German scheme applies only to trucks, and again covers mainly motorways.

Costs

For the 2007/08 fiscal year, the system operator, Toll Collect, billed the Federal Government €598 million for services including operating costs and all expenses related to toll collection via satellite, terminals and the Internet, fees paid to payment service providers, the cost of operating local and decentralised systems including mobile radio, enforcement gantries and computer centre. Added to this are the costs of system depreciation and the net income before taxes and interest. The company has reduced its operating costs, which are expected to be 11–12% of toll income in 2009.

There were also significant environmental benefits. By the end of 2009 the proportion of modern low-emission HGVs had increased dramatically. Vehicles in the low emission categories S5 and EEV[14] accounted for less than one per cent of the toll mileage recorded in 2005, but 55% by the fourth quarter of 2009. Over the same period, the mileage driven by lorries in the higher emission categories S0, S1 and S2 dropped from 36.5% to 3.7% (Toll Collect, 2009).

The scheme is reportedly being expanded to cover four-lane federal roads as well as autobahns from 2011 (ITS International, 2010). The Ministry of Transport is currently examining the judicial and technical aspects of the plan. In 2009, revenues from the scheme amounted to more than €4.4 billion.

14 All these emission categories are explained in BfG (2010).

Walker, Pickford and Blythe (2008) have compared the costs of implementing various existing HGV charging schemes, including the Austrian, German and Swiss schemes. But the treatment in Table 17 is based on Felix (2008).

Table 17: Comparison of the Swiss, Austrian, German and Slovakian lorry charging schemes

	Austria	Germany	Switzerland	Slovakia
Start date	1 January 2004	1 January 2005	1 January 2001	1 January 2010
Objectives	Finance extension & operation of motorway network	Finance extension & operation of motorway network Charge the real costs; the ‘user pays’ principle Promote efficient use of HGVs	Charge the real costs; internalisation of external costs Finance new railway infrastructure Limit HGV traffic growth	- Finance the operation of the motorway network. - Charge ‘through- traffic’
Charged network	Motorways & some expressways	Motorways plus some ordinary roads	All roads	2400 km of roads and highways
Liable vehicles	HGV>3.5 tonnes	HGV>12 tonnes	HGV >3.5 tonnes	HGV>3.5 tonnes
Charge parameters	distance axles (emission class)	distance axles emission class	all distance weight emission class	
Legal nature	Fee subject to VAT	Tax, no VAT	Tax, no VAT	
Technology	DSRC (mandatory OBU)	GPS/GSM or journey booking	Tachograph/GPS/DSRC or manual	
Typical charge	13.5 eurocents/km	24 eurocents/km	108 eurocents/km	
Investment costs	€370m (commissioning the scheme)	Estimated €1500m	€200m plus €30m for 2nd generation OBU	€860m (13-year concession)
Personnel	ASFINAG 120 operators, 120 enforcement staff	750 operators 650 enforcement staff	120 customs staff	
Annual Revenue (2007)	€984m	€3.4bn	€835m	$35m in first quarter
Running costs (2007)	€100m	€770m (excludes enforcement)	€58m	
Running costs as % of revenue	10%	>25% (excludes enforcement)	7%	

Source: After Felix (2008)

Although they do not compare revenues with running costs, Springer and Estiot (2008) indicate how the costs of such schemes would decrease in the future. They point out that the cost of the (GPS-based) on-board unit is following the classical pattern of economies of scale (Table 18), and that therefore 'Within less than 10 years investment costs can be divided by five'. Given that OBU costs may be as much as 85% of scheme costs (see the proposed Dutch scheme – section 5.7), this is very significant.

Table 18: German toll scheme: expected decline in OBU costs

Item	Cost in Year		
	2003	2006	2010 (est.)
OBU	> 500€	250€	< 100€
Communications costs/OBU/month	> 5€	< 3.5€	< 1€

Source: Springer and Estiot (2008)

5.3 Norway

In Norway, tolling has been used to part-finance new roads since 1934, and now represents 35% of the annual road building budget. In 2007 there were 44 toll projects, the majority being fjord crossings through tunnels and bridges. But 7 were toll cordons around cities, and they account for most of the annual revenues. Norwegian motorists spend 1400 NOK per year on tolls per vehicle (Amdal et al., 2007).

In places (especially the toll rings) where road pricing has been introduced, support is initially low but gradually increases (Tretvik, 2002):

- In Oslo, 70% of respondents were opposed prior to the implementation of road pricing in 1990. Immediately after the charges were introduced, opposition dropped to 64%. In 2009 the figure was 54% negative and 43% positive; but when respondents were presented with projects financed by toll road funds, 74% were positive and only 24% were negative. Three-quarters of them were willing to accept further toll collection, provided that the money was spent on road building, public transport and environmental improvements (Fjellinjen, 2009; see also Figure 10).
- In Bergen, two-thirds of the citizens were against a toll ring prior to its introduction, but a majority supported it sometime after the implementation.
- In Trondheim, 72% were negative prior to the implementation but only 35% were negative two years later.

Figure 10: Acceptability of Norwegian toll rings

Extract from Fjellinjen (2008) Annual Report

(Fjellinjen AS is the largest toll road company in Norway; it was established on 13 February 1986)

With a total population of 4.9 million and an area of 324,000 square kilometres in extension, Norway has Europe's second lowest population density. Vast stretches of the Norwegian landscape are predominated by deep fjords, high mountains and long valleys. The Norwegian government has a target to create an infrastructure which paves the way for a sustainable way of life in every part of this long and narrow nation. Building and maintaining a network of roads in Norway is an expensive business.

The very first project to be financed by toll road funds was a bridge outside of Tønsberg in 1934. National road legislation requires municipal councils and county councils to apply for financing from toll road funds. Since then, innumerable tunnels, roads and bridges have been wholly or partly financed by toll road funds.

The mid 1980s saw the introduction of the toll road rings in Norway's two largest cities, first in Bergen then in Oslo. Revenues from these toll rings are allocated towards the realisation of a portfolio of projects including new roads and the development of the public transport infrastructure.

Over NOK 5 billion is collected in toll road funds in Norway (2009), while total allocations to national roads from the fiscal budget are in the region of NOK 17 billion. The Norwegian government has budgeted for revenues from toll road funds to remain at this level in the years to come.

Fjellinjen AS is the largest toll road company in Norway, responsible for the collection of 40% of nationwide toll road funds. Fjellinjen AS is responsible for the operation of the toll rings in Oslo and on the border between Bærum and Oslo.

Oslo and Akershus together have 1.1 million inhabitants and are areas of significant growth. Every day, around 260,000 vehicles pass the toll booths managed by Fjellinjen AS. The projected growth in population for the next twenty years is 30%.

The collection of toll road funds in Oslo dates back to 1990. The initial collection period established has been extended twice since then. The current collection period is now valid until 2027. The initiative to collect toll road funds is made by locally-elected politicians. However, each resolution regarding collection must be passed by the Norwegian parliament.

Every year, a survey is carried out of attitudes towards toll collection, road standards and the public transport service. The 2008 survey included a question about people's attitudes towards automation of toll collection. The interviews were held in November, when Fjellinjen was still experiencing start-up problems with the transition to the automatic toll ring. A clear majority of 57% were satisfied with the new automatic system. 30% had no opinion on the matter. The remaining 13% were negative to the development. Negative comments were related to the number of invoices sent out, the increase in price and the removal of punch cards and monthly cards.

Support for the toll rings as a positive measure has fluctuated between 30% and 51% since 1990. Between 49% and 70% are negative to toll rings.

Opposition peaked at the very start. However, the 'positive' ratio has grown over the years, although with a few drops in support: The price increases in 2001 and 2008 most probably had a role to play in the marked decline in support registered for these years.

When information is provided that the funds are spent on building roads and investing in improvements to public transport, the majority tend towards a positive attitude. During the 2008 survey, 51% of those interviewed could report a positive attitude once they had learned of how the funds are spent.

Three persons out of four state that they are willing to accept further collection if the way the money is spent meets their expectations for a satisfactory development of transport. This support is based on requirements that the funds are spent on e.g. building roads, improvements to public transport and projects which help reduce environmental impact.

23% are negative to further toll collections, irrespective of conditions. There has been a gradual decrease in the number of bombastic opponents in recent years, and the current number is at an all time low. The proportion of support for toll collection is practically identical for all regions. Road tolls are a necessary evil if we want to have better roads and public transport.

Source: Fjellinjen 2008 Annual Report

Costs

Norway has been funding road building through tolls since 1934, with over 100 successful projects to date. The operating-cost-to-revenue ratio varies, in some projects being only 5–10% whilst in others it can be up to 35–40%. The average for all Norwegian toll projects over the period 1995 to 2005 varied from just under 8% in 1995, rising to 12.5% in 2002, and falling to 10% in 2005. In general the toll rings are the most efficient, probably because of economies of scale and use of the latest technology; their operating cost per paying vehicle is NOK 1.3, as opposed to NOK 8.2 for the others (Amdal et al., 2007). Ieromonacho et al. (2006) estimate the capital and annual running costs of the

Oslo toll ring to be NOK 169 million and NOK 120 million respectively.

Fjellinjen is the largest toll road company in Norway, with 20 years of experience with toll road projects. It has 600,000 customers and registers 89 million toll booth passages per year. The company's primary objective is to channel its revenues into the development of the major road network. It has operating revenues of NOK 1.3 billion. Operating costs in the period 2001–2009 varied between 9.6% and 13.6% of operating revenues (Fjellinjen, 2009; see also Figure 10, Table 19 and Table 20).

Table 19: Operating revenues and costs of the Oslo toll ring

Amounts in NOK millions	2009	2008	2007
Operating revenues	2144	1641	1285
Operating costs	292	199	149
Result before financial items	1852	1441	411
Financial items	–2	6	4
Contributions to road projects	1 850	1 447	415
Costs/revenues	0.136	0.121	0.116

Source: Fjellinjen (2009)

Table 20: Fjellinjen allocations to road projects and public transport in 2009

Oslo	NOK 892 million
Akershus	NOK 529 million
Public Transport	NOK 540 million

Source: Fjellinjen (2009)

5.4 Singapore

This section is based on Gopinath Menon (2000), Gopinath Menon and Chin (2004), and Chin (2010).

Singapore operated a manual road pricing scheme called the Area Licensing Scheme (ALS) from June 1975. A motorist had to purchase and display a paper licence to enter a restricted zone (RZ) in the city during weekdays and part of Saturday. The cost was higher in the morning and evening rush hours, and also depended on the type of vehicle. The licences were different shapes for different vehicles and were colour coded for different months, facilitating enforcement by policemen stationed at entry points. Offending vehicles were not stopped but would subsequently be fined. There was no policing within the RZ. The ALS was a very useful traffic management measure, but was cumbersome, labour-intensive and inflexible, and was replaced by an automatic Dedicated Short Range Communication (DSRC) system called the Electronic Road Pricing (ERP) scheme in 1995.

Figure 11: A Singapore ERP gantry at Victoria Street

Source: Courtesy of Singapore Land Transport Authority

An ERP controlled point uses two overhead gantries 15 metres apart and 6 metres above road level (Figure 11). Each gantry has two microwave beacons per lane. Optical sensors on the second gantry detect the passage of vehicles. Two cameras cover each lane on the first gantry and photograph the rear licence plates of unequipped vehicles.

Because the scheme was for traffic management rather than revenue-raising, and to make it more palatable to motorists, annual road tax was reduced and there was a one-off rebate for each vehicle owner, so that overall the ERP was revenue-neutral. Although the revenue was not hypothecated for transport, it was stressed that the scheme was a traffic management tool and was not for revenue collection. And in fact, the ERP scheme revenue initially was 30% lower than with the ALS – though the number of gantries has increased, and so has revenue, which is now marginally more than under the ALS.

There were no explicit cost–benefit assessments, although much effort was put into minimising the implementation and operational costs, and into allaying motorists' fears. Being an 'active' system, with charges deducted from a smart card in the In-vehicle Unit (IU), the central computer system does not need to keep track of vehicle movements. Records of all transactions are stored on the driver's smart card. The authorities also assure the public that all transaction records required to secure payments from the banks are erased – typically within 24 hours.

Figure 12: Singapore's new dual-mode in-vehicle unit with a CashCard

Source: Courtesy of Singapore Land Transport Authority

One major lesson from Singapore's experience is the importance of being flexible and adaptive, and ready to change the scheme to target specific groups contributing to traffic congestion, for example the Orchard Cordon, to deal with shopping traffic and the New Pricing Line that passes through the city to manage intra-city traffic.

The rationale for congestion pricing should be robust and supported by the real-life experiences of motorists. Speeds on road sections are monitored and the charges adjusted up to six times per year (i.e. charges are increased if there is congestion and lower speeds, or reduced to encourage traffic if speeds are high). This makes it clear that the scheme is for traffic management and not for revenue generation, though this is continually stressed anyway. There are always viable alternative routes or times of travel for drivers who do not wish to pay. There are also good public transport alternatives.

In the 2008 revisions to the ERP pricing strategies, public transport capacity was increased, with premier buses (private buses offering seated bus services almost door-to-door during peak periods), reduced headways on public buses and underground trains and expanded bus lanes and bus priority schemes. And to reinforce the message about traffic management rather than raising revenue, in 2008 vehicle taxes were reduced by SGD 110 million per year, which was much higher than the expected SGD 70 million increase in ERP revenue.

There seem to have been minimal issues with public acceptability of the ERP scheme. Initially motorists had concerns about the equipment working at speed, and would slow down as they approached the gantries, but this is no longer the case. There were also complaints from motorists trying to plan their trips to coincide with cheaper charging periods. Gantries have now been fitted with a clock display so there is no problem about discrepancies with people's own watches. Also motorists would wait (illegally) on hard shoulders until the cheaper period commenced; this has been addressed by graduating the charges. For example, if the charge is due to increase from S$1 to S$2, for the first five minutes the increased charge is held at S$1.50. Another complaint was from motorists who had forgotten to take their smart card with them, or to insert it in the IU, thereby incurring a S$70 fine; they now simply incur an administrative charge of S$10 in addition to the ERP charge (Gopinath Menon, 2000; Gopinath et al., 2004).

The Singapore authorities stress that congestion charging is not the only solution to urban traffic congestion. Travel demand has to be managed through proper land use planning, the right policies on decentralisation, parking, car ownership (the Vehicle Quota Scheme) and effective public transport, as well as selective increases in road network capacity, optimisation of the available capacity through technology, and by rapidly clearing obstructions caused by traffic accidents. And notably the Land Transport Authority (the scheme owner and operator) is now seeking to trial distance-based charging solutions as part of the evolution of the ERP scheme.

Costs

This section is based on Chin (2010) and Gopinath, Menon and Chin (2004).

The Singapore ERP scheme went live in 1995, using 2.45 GHz DSRC technology and camera-based enforcement. The contract was worth SGD 196 million, of which half was for equipment for up to 60 overhead gantries, the other half for 1 million IUs (see Figure 12) for the existing and projected vehicle populations. There were originally 33 gantries set up, but this has since increased to 66. The cost of the IU including installation was SGD 150, which was borne by the government for the 680,000 initial vehicle owners. In 2004 the annual revenue was SGD 80 million, with running costs of SGD 16 million.

The cost of each ERP gantry has increased and is now 50% more than in 1998. The IU cost has also increased, but the installation costs have fallen as installers gain experience and reduce their overheads, so the IU installation cost remains SGD 150. The cost of managing and maintaining the ERP system has increased over the years, consistent with the increase in the number of gantries and IU numbers, but remains at 20–30% of total revenue collected – though as indicated earlier, the objective is traffic management, not revenue generation.

5.5 Sweden

The major Swedish experience is in Stockholm, where a permanent scheme was introduced in August 2007, following a successful trial between January and July 2006. Public acceptability rose throughout the trial period and up to the subsequent (positive) referendum. It then fell back prior to the start of the permanent scheme, but has continued to rise since, reaching 74% in 2010. A detailed examination of the scheme is given below. In the description of the impending Gothenburg scheme (2013 launch), it is clear that public acceptability is low (20%), but that political consensus is secured because of the positive implications the scheme has for national government funding in the city.

5.5.1 Stockholm

The political situation leading up to the trial and subsequent implementation of the Congestion Tax in Stockholm is touched on by Hamilton (2010) and Borjesson et al. (2010), and covered in more detail in Gullberg and Isaksson (2009).

The scheme is cordon-based (Figure 13), with cameras on gantries at all entry and exit points (Figure 14).[15]

The tax, which is regulated by the Congestion Tax Act (2004: 629), is charged for Swedish-registered vehicles entering or leaving Stockholm on weekdays between 6 a.m. and 6.29 p.m. There is no charge at weekends, public holidays, the day preceding a public holiday or during July. Some vehicles are exempt.[16] Each inbound or outbound trip to/from the city centre costs a relatively small amount; SEK 10, 15 or 20, depending on the time of day, capped at SEK 60 per day per vehicle.

The effects on vehicle traffic were remarkable, and surprised even the transport planners, who had expected a relatively small effect. In January 2006 traffic dropped 28% (Borjesson et al., 2010; Hook, 2009; Söderholm, 2009), from 450,000 vehicle passages per day to just over 300,000. And though it slowly increased to 390,000 in June 2006, it is clear that this was a seasonal effect – traffic always increases in spring and summer – rather than a falling-off in effectiveness of the congestion tax; traffic was still down by 21% in June 2006. The trial was terminated at the end of July 2006 but surprisingly, though traffic increased, it remained 5–10% below 2005 values even though there was no congestion tax!

15 Microwave transponders were used in the trial but are not used in the current operational system. See http://www.transportstyrelsen.se/en/road/Congestion-tax/Congestion-tax-in-stockholm/How-do-control-points-work.

16 Initially, alternative-fuel vehicles were exempt, but the numbers grew significantly following the introduction of the scheme, and since they contributed to congestion if not to pollution, the exemption was removed for vehicles registered in 2010 and subsequently. The exemption for vehicles registered earlier will be removed from 1 August 2012.

There was also no significant diversion onto other routes. On the Essingeleden and Södralänken bypasses, average daily traffic volumes increased by a few percent, mainly outside the rush hours (Eliasson, 2009b). Of commuter trips crossing the cordon, 24% ‘disappeared’, but only 1% switched route to avoid the cordon; of the discretionary car trips, 22% disappeared, mainly by changing destinations and decreasing trip frequencies (Borjesson et al., 2010).

After a ‘Yes’ vote in the subsequent referendum, charges were reintroduced in August 2007, causing traffic levels to drop 21%, much the same result as in the trial period. Furthermore, the effect of charges has increased over time; traffic is estimated to be 24% less in 2009 than it would have been without the congestion tax (Borjesson et al., 2010).

The public acceptability figures from Stockholm changed significantly before, during and after the trial. Surveys in spring 2004 and 2005 showed 40% support for a congestion charging scheme. Immediately before the trial began this fell to 36%, with 62% against it. However, public opinion then shifted dramatically. Support rose to 52% during the trial, and in a referendum after the trial 53% of Stockholm citizens voted to reinstate the charging scheme and bring back the tax. It was reintroduced permanently in August 2007 and in December 2007 support for the scheme stood at 66%. Currently, in 2010, it stands at 74% (Borjesson et al., 2010; Hook, 2009; Soderholm, 2009; Fairbank et al., 2008).

Eliasson (2010) and Borjesson et al. (2010), consistent with figure 10, comment that support for congestion charging often follows a typical pattern of initial

support when a scheme is proposed, followed by decreasing support as details of the scheme emerge; but when the scheme is in place, support generally increases ('familiarity breeds acceptability') – especially as in Stockholm the positive effects on congestion and pollution were much larger than anticipated. Also people often find that the charges do not affect them as much as they had expected. As Eliasson points out, this has implications for the political process. Elections or referenda should not be held when support for the charging scheme is lowest. In London, the mayoral election was held before the scheme details were worked out, although the winning candidate's manifesto included a reference to congestion charging; in Stockholm, the charges had been in place for seven months; in both cases the electoral result was favourable. In contrast, in Edinburgh and Manchester (section 4.3.2.) the scheme details had been published but neither scheme had been implemented, and both schemes were rejected in local referenda.

These authors also point out that the system must deliver benefits – this was the most important factor in Stockholm, especially the reduced congestion. People who perceive positive effects are likely to support them – particularly if the positive effects are measured and published. This is enhanced by appropriate branding – people are more supportive of environmental benefits, which are a concomitant of congestion charging. They also value fairness – though this can mean different things; there may be initially a concern for the economically disadvantaged, but this can switch to 'polluters and those causing congestion should pay' when a scheme is established.

Also, as Eliasson (2010) points out, in the longer term people change jobs and move homes, and the congestion charge will be one factor they take into account, so identifying winners and losers will become increasingly meaningless.

Furthermore, according to Transek (2006), the winners are determined by how the revenues are used. In general, the travel time savings do not compensate for the increased travel costs. It is only when the income is used to benefit residents or road users, for example through investments in traffic infrastructure, that any net socio-economic benefit is created. So how the income is used is very important in deciding who are winners or losers.

One important point from the Stockholm trial is that extra buses were introduced in August 2005, but there was no effect on road traffic until January 2006 when the Congestion Tax came into operation. Surveys found very few former car drivers on the new buses. Of the vehicle traffic reduction of 22% over the charge cordon, at most 0.1% can be ascribed to the extended bus services (Transek, 2006; Eliasson, 2008). This shows that provision of alternative travel modes such as improved public transport will not by itself get people out of their cars. This is consistent with the results found in the Owen et al. (2008) study (section 4.2.1).

Another important observation is that car drivers apparently changed behaviour without realising. When they were asked if the congestion charging had made them change their travelling habits, there were not enough answering 'Yes' to correspond with the actual reduction in measured traffic volumes (Eliasson, 2008).

Thus Stockholm demonstrates convincingly that:

- congestion charging works: congestion is dramatically reduced;
- traffic is *not* diverted onto other routes: drivers have alternatives other than diversion; and
- an initially sceptical public accepts (and votes for) congestion charging once it has experienced its effects; congestion charging is now a non-issue in Stockholm – even amongst politicians.

Costs

The treatment of the Stockholm charging system in this section is based largely on Transek (2006), Eliasson (2009a; 2010) and Hamilton (2010). Eliasson designed the charging system, forecasted its effects, and chaired the subsequent evaluation panel. Hamilton at the time worked for the prime contractor (IBM) and was involved in the system design; his account also draws on archive material from the Swedish National Road Administration (Vägverket) and the Swedish Transport Agency (Transportstyrelsen) which partially succeeded it, as well as on interviews with key stakeholders.

The political situation leading up to the trial and subsequent implementation is touched on by Hamilton (2010), and covered in more detail in Gullberg and Isaksson (2009). The public acceptability aspects have been covered above. As indicated there, the scheme was introduced as a trial between January and July 2006. After a subsequent (positive) referendum, the system was reintroduced permanently in August 2007. It is cordon-based (Figure 13), with cameras[17] on gantries at all entry and exit points (Figure 14). The charge varies between SEK 10 and 20 (87p–£1.74) during weekdays, depending on the time of day. Evenings and weekends are free of charge.

17 As indicated above, microwave transponders were used in the trial but are not used in the current operational system (see Swedish Transport Agency, 2010).

Figure 13: The Stockholm congestion charging scheme boundary

Source: Swedish Transport Agency (2010b)

Figure 14: The Stockholm congestion charging scheme – gantries

Source: Swedish Transport Agency (2010a); Photographer: Mikael Ullén

Hamilton (2010) then goes into system costs. He comments that there were many media stories claiming that the system was very expensive to run (e.g. 50% of the revenue spent on collection of the congestion tax), especially when compared to Norwegian toll rings, which typically have 9–10% overhead, according to Amdal et al. (2007) (see section 5.3.). However, as he points out, the Norwegian toll rings are primarily revenue-generating schemes, for which a reasonable measure of efficiency is the revenue generated compared to system costs. But the objective of the Stockholm system was not primarily to collect money, but to improve the traffic situation, as it is also in Singapore (section 5.4) so the relevant ratio is the social benefits of congestion reduction in relation to the costs.

According to Transek (2006) the revenues on an annualised basis were SEK 763 million during the trial; the estimated annual running costs were SEK 220 million. The start-up cost, including capital cost and operating cost for the first year, was estimated to be about SEK 2 billion (SEK 1.1 billion prior to the start of the system and SEK 0.9 billion for 2006). Thus in financial terms it would take 3.5 years for net income to cover the investment cost, or 4 years in socio-economic cost–benefit terms, both of which are very short repayment periods compared to investments in road infrastructure or public transport, which have a repayment time of 15–25 years at best. After that, net income is estimated to be SEK 540 million p.a. (not taking into account any growth in traffic). So net income for 10 years' operation would be SEK 3.5 billion, or close to SEK 9 billion over 20 years.

The costs were artificially high because it was a trial, and for other reasons such as provision of increased public transport and new park-and-ride facilities, though it could be argued that some of these are necessary complementary measures and should be included as part of the costs. The running costs fell to SEK 200 million in 2009, and are likely to be SEK 180 million in 2010, reducing the societal cost–benefit ratio to 27% and the financial cost rate to 21%. So a comparable scheme could now be implemented at a much lower cost (Hamilton, 2010).

The transition from use of OBUs and transponders in the trial, with cameras and ANPR as backup enforcement schemes, to just cameras and ANPR in the subsequent scheme, is particularly interesting from a number of perspectives, including cost. Although microwave transponder technology was not specified explicitly in the invitation to tender for the trial, it was assumed by all concerned that this technology would be used, and in all probability any bid not using transponders would not have been successful (Hamilton, 2010). However, the Government concluded that under Swedish law, transponder information was not a valid basis for a tax charge; an image of the licence plate was required. Transponders were initially used in the trial scheme, since the ANPR was initially only 60–70% accurate, whereas transponders have close to 100% accuracy. However, an intensive development effort by the contractor, and adding cameras at every charging point to capture both front and rear number plates, improved the ANPR accuracy to well above 90% in time for the system go-live in January 2006. Subsequently it was improved still further so that with some manual support the accuracy was consistently 95–99%, and this was deemed to be adequate for the system relaunch in August 2007. Consequently transponders are not now used (Hamilton, 2010; Eliasson, 2010; Swedish Transport Agency, 2010a).

As indicated above, the use of microwave technology incurs costs – the gantries or poles have to be equipped with transceivers, vehicle OBUs have to be issued, paid for, installed [18], and replaced if they fail or are stolen or if the vehicle changes hands. Consequently it is a moot point as to whether the benefits outweigh the costs (Hamilton, 2010; Eliasson, 2010); a subject for further study – see section 8.1.2.

5.5.2 Gothenburg

The success of the Stockholm scheme has encouraged the setting up of a congestion tax scheme in Gothenburg (Swedish Transport Agency, 2009); it is planned to start in January 2013. As in Stockholm, the tax, which is regulated by the Congestion Tax Act (2004: 629), will be charged for Swedish-registered vehicles on weekdays between 6 a.m. and 6.29 p.m. There will be no charge at weekends, public holidays, the day preceding a public holiday or during July. Some vehicles will be exempt. Each inbound or outbound trip from the city centre will cost SEK 8, 13 or 18, depending on the time of day, capped at SEK 60 per day per vehicle.

Although one of the motivations in Gothenburg is to relieve congestion, another is to secure transport investment funding from the government – schemes which also have local funding get priority. Thus Gothenburg is particularly interesting in that the plans have *political* consensus and acceptability, though public acceptability is currently only around 20%.

5.6 Switzerland

The Swiss Heavy Vehicle distance-based charging system (LSVA) began operation on 1 January 2001. Hofstetter (2003) published the following data (Table 21).

Table 21: Swiss heavy vehicle scheme: installation and maintenance costs

On-Board Unit	**€**
Procurement cost (OBU issued at no cost to HGV owners)	800
Installation (approx).	200
Investments of Swiss Government	
Road side equipment and background system	100m

18 Though in some cases, such as microwave tags, installation is simple and can be performed by the owner rather than by a third party.

Cost of OBUs	60m
Operational costs (yearly)	16m
Personnel requirements	120 staff
Total collection costs	4–6 % of revenue

Source: Hofstetter (2003)

More recently (Rapp, 2008), the annual gross revenue from the Swiss LSVA scheme was predicted to be 1.5 billion Swiss francs in 2008. The running costs are shown below (Table 22).

Table 22: Swiss heavy vehicle scheme: costs and revenues, 2008

	Million Swiss Francs
Gross revenue 2008 (estimated)	1500
Investment costs:	
Roadside equipment	150
Enforcement systems	50
OBUs	90
Total	290
Annual operating costs (including enforcement & equipment amortization)	90

Source: Rapp (2008)

Thus, although there are some discrepancies between the two sources, they agree on running costs being about 6% of revenues.

5.7 The Netherlands

In late 2007, the then Government of the Netherlands proposed to introduce a national road pricing scheme to improve accessibility and the quality of the living environment (ABvM – Anders Betalen voor Mobiliteit – Different Payment for Mobility). The principle was that payment should be made for using rather than owning a car. Motorists would be expected to pay per kilometre driven on a road, instead of paying through the motor vehicle tax (Motorrijtuigenbelasting – MRB) and purchase tax (Belasting van personenauto's en motorrijwielen – BPM). The price would depend on the time and place of driving and the environmental characteristics of the vehicle. But fuel duty was not to be changed.

A good review of the Dutch proposals and their current status is given by Ellis (2010a).

However, at the time of writing this scheme is 'on hold' due to a change of government. Nonetheless, there are some pointers to public acceptability. The biggest Dutch motoring organisation, ANWB (Royal Dutch Touring Club), representing four million drivers, conducted a survey amongst its members (ANWB, 2010) on the principle of paying according to use, and a large majority found it acceptable. The principle that someone who drives a lot pays more than someone who seldom drives was regarded as fair; more so than the current Dutch system in which, due to the high tax on car ownership, those who seldom drive subsidise those who drive a lot.

The member survey, which was conducted by independent companies, consisted of an online questionnaire and online discussions. Over 400,000 respondents took part in the questionnaire, 350,000 of whom were ANWB members, and 7,000 members participated in online discussions. The key outcomes were:

1. Paying for use was assessed positively and is regarded as a fair way to calculate costs. It was noted that this would lead to higher costs for those who drive a lot, and that such drivers were less enthusiastic.
2. Members do not want to pay more overall in road charges and taxes. There should not be an increased burden on motorists as a whole.
3. The road pricing revenues should be invested in roads or other solutions for improving traffic flow, or in improving public transport. It should not be a matter of 'milking the motorist'.
4. Cleaner cars should pay less than polluting ones. But if this means that the costs for existing cars rise, imposition of charges should be gradual because people may not be able to purchase a cleaner or more economical car immediately.
5. A higher peak-hour charge was emphatically rejected, and regarded as punitive, especially as public transport is often not an alternative because it is unavailable or has limited capacity. It was not regarded as a way of distributing costs more fairly or as a reward for those who avoid travelling in peak hours.
6. There was significant opposition to location-dependent charging units (e.g. in-vehicle GPS receivers). Respondents regarded this as complex, expensive, fraud-prone and a violation of privacy. Members did not trust the security of the data, and did not want their movements tracked.
7. There were concerns about having to pay more in the transition phase. It should be fair to road users and not, as was perceived to be the case, aiming to minimise government shortfalls during the transition.
8. There should be no, or as few as possible, exceptions, which were regarded as potentially unfair. Only vehicles for the disabled should be entirely or partially exempt. Any other exceptions should be examined very critically.
9. Lack of clarity leads to opposition. If details are not known, the conse-

quences are unclear, and this leads to uncertainty and opposition. Where large, complex system changes are concerned, those who will be involved must be included in the change process.

10. Government plans are viewed with distrust, partly because of previous experience with other large-scale projects such as the Ovchipkaart (similar to the Oyster card system used on public transport in London). The fact that plans are constantly changed and then not completed reinforces this distrust. Communication that only begins once the policy has been approved comes too late and adds to the distrust.

Although the ABVM project is currently on hold, the ANWB did express a number of opinions and comments:

- some members preferred an increase in excise taxes on fuel. But ANWB comments that they probably did not realise that this would result in a price rise of one euro per litre, plus ‘fuel tourism’, where many Dutch residents would refuel in neighbouring countries, allowing them to avoid such taxes.
- As was found in the study by Owen et al. (2008), most members do not believe that the problem of road congestion would be solved by road pricing. But conversely the Government emphasises precisely this benefit as the most important reason for introducing road pricing. Furthermore, most people regard congestion as a social problem that affects them very little, so they do not feel involved and are not prepared to pay towards resolving the problem. Though Owen et al. found that as people were given more information, they became more concerned.

Finally the ANWB recommends that the new government should not present new plans but should move further in the direction taken by the Different Payment for Mobility platform – though it now seems unlikely that the new Dutch coalition will take it forward, except possibly for lorries.

Costs

The treatment in this section is based on Walker, Pickford and Blythe (2008).

The Netherlands has a long history of interest in road pricing. It recently specified what it required for a national distance-based road pricing scheme (Netherlands). Although, as indicated above, this scheme is on hold due to a change of government and seems unlikely to go ahead, it is very instructive as a case study. A number of system suppliers were asked to estimate implementation and running costs of a national scheme covering the whole of the Netherlands and all Dutch vehicles. Three significant requirements of the scheme were:

- Requirement 17, that ‘The costs for development and initial implementation of the road pricing system shall not exceed €2.2 billion’;

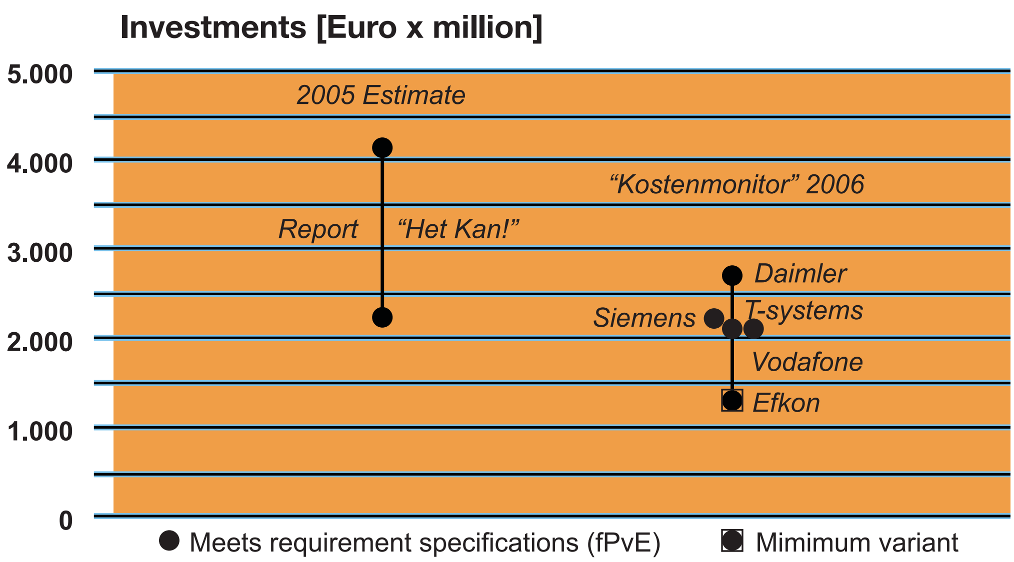
- Requirement 18, that 'The annual costs for operation and enforcement of the road pricing system shall not exceed 5% of the system revenue'; and
- Requirement 22, that 'The road pricing system shall have adequate capacity to charge the road use of 8,159,000 vehicles'.

The scheme was intended to be revenue-neutral overall. The total revenue was to be limited to the total sum of fixed taxes for vehicles, including purchase tax (BPM) and motor vehicle tax (MRB). This total annual revenue would have ranged from €3 billion to €7 billion, depending on the amount of reduction of fixed taxes.

In 2005 the implementation costs were estimated to be around €3 billion – see the figures below. However, more recent estimates (Dutch Ministry of Transport, 2006b) for the Dutch government from various private sector organisations, suggest that the cost goal indicated in Requirement 17 is within reach, as shown below (although, as the report states, these estimates contain uncertainties and assumptions).

Figure 15 and Figure 16 show investment and operating costs estimated by Daimler, Siemens, T-Systems and Efkon in 2006, compared to the 2005 estimate. All the proposed schemes were GPS-based, though this was not mandated by the Dutch Government.[19] The amounts include VAT and a 15% surcharge for uncertainty. The cheapest variant is shown. The minimum variant (Efkon) does not meet all requirements.

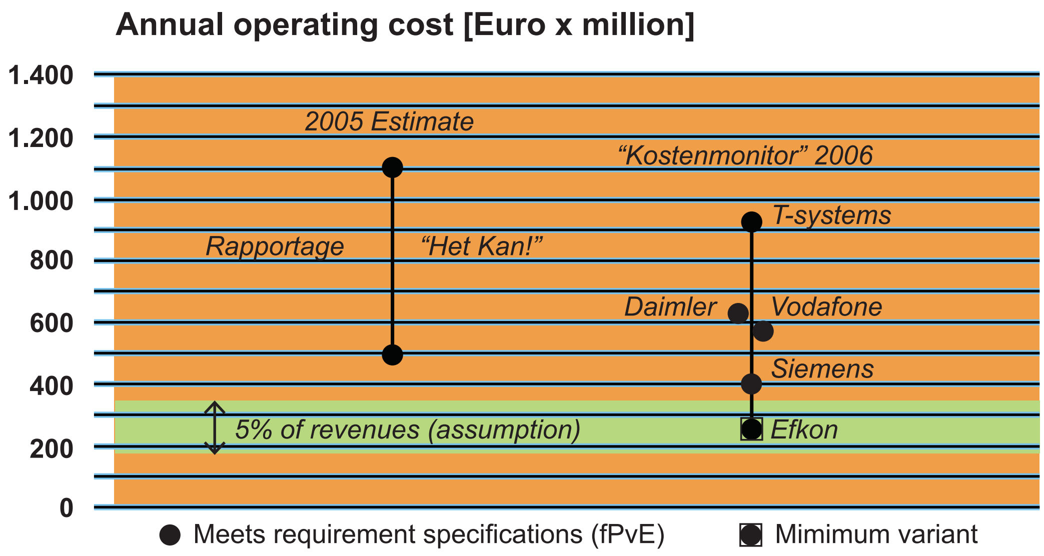
Figure 15: Dutch kilometre-pricing scheme: capital costs



Source: Netherlands (2006b)

19 The only technology stipulation was Requirement 11: the road pricing system shall comply with the European directive on the interoperability of electronic road toll systems (EU Directive 2004/52/EC), which mandates the use of one or more of satellite positioning, mobile communications using the GSM/GPRS standard, and 5.8 GHz microwave technology.

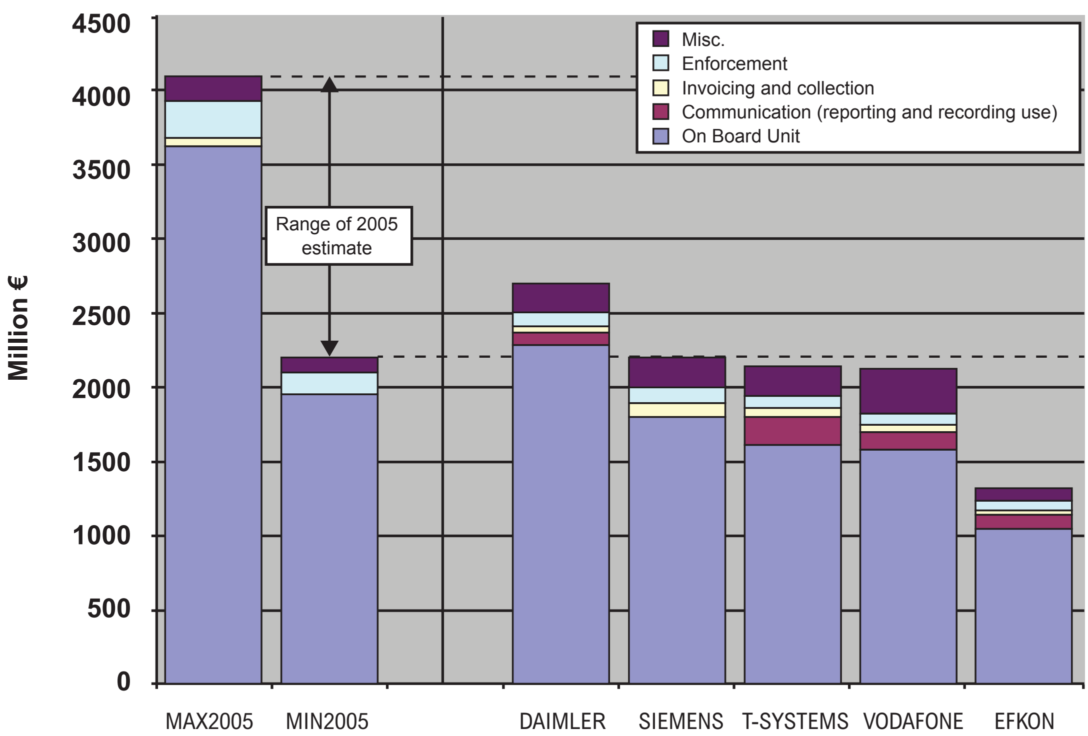
Figure 16: Dutch kilometre-pricing scheme: annual operating costs



Source: Netherlands (2006b)

Figure 17 breaks down the capital costs; note that 70–85% of the costs are due to the OBU, which is relatively complex and hence costly in a GPS-based scheme.

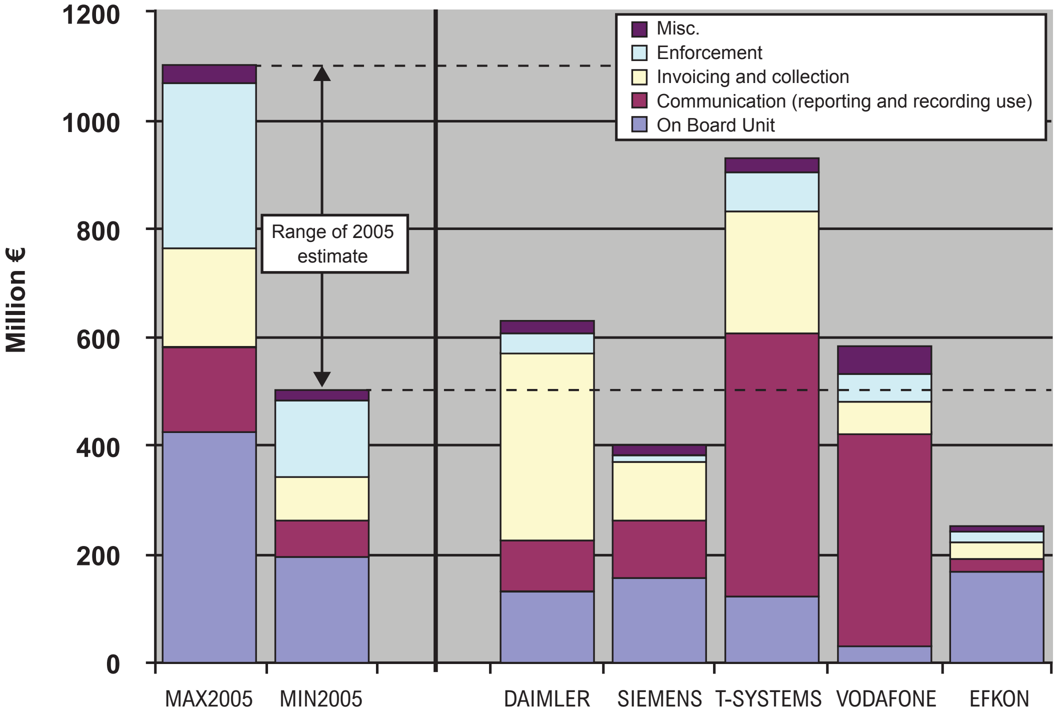
Figure 17: Dutch kilometre-pricing scheme: capital cost breakdown



Source: Netherlands (2006b)

Figure 18 breaks down the operating cost, which includes 19% VAT plus a 15% uncertainty surcharge. Again the minimum variant (Efkon) does not meet all requirements.

Figure 18: Dutch kilometre-pricing scheme: operating cost breakdown



Source: Netherlands (2006b)

It is worth examining some of these costs. The Vodafone submission (Vodafone, 2006) indicates that running costs could be as low as 3%. The 'base case' (Table 23) is HGVs in Year 1, vans in Year 2, cars and motorcycles in Years 3–5, and all vehicles from Year 5 onwards. Other scenarios, such as 'no foreign users' and 'no EETS provider' gave similar results to the base case. The 'HGVs and vans only' case gives the best ratios because they account for disproportionately more travel on charged roads and they pay higher tolls per km because of their environmental impacts (wear and tear on roads, noise, pollution).

Table 23: Vodafone cost estimates to the Dutch Government

	Base case	HGVs & Vans only
Sum of investment years 0–5	€1546m	€362m
Sum of Operations & Mobile Enforcement in year 5	€426m	€141m
Ratio of Investment/Revenue in years 0–5	6.1%	1.9%
Ratio of Operations & Mobile Enforcement/Revenue in year 5	5.2%	3.2%

Source: Vodafone (2006)

5.8 USA

The USA offers an interesting, and very diverse, set of cases. Road tolling is widespread, and much of it has been or is being converted to electronic form (Open Road Tolling – ORT). HOV lanes are relatively common, and many of them are being converted to HOT operation. Trials of distance-based charging have been carried out in a number of places, most notably Oregon (Whitty, 2007), aimed primarily at a vehicle mileage fee as a replacement for the 'gas tax'. But so far there is no case of a US city adopting congestion charging, though New York came very close in 2008 and San Francisco has studied it at length, and recently published congestion pricing proposals (Toll Roads News, 2010).

5.8.1 New York

The New York case study is particularly instructive, as described in Schaller (2010).

A congestion pricing proposal was introduced in April 2007 by New York City (NYC) Mayor Michael Bloomberg as part of a wider sustainability plan. NYC residents supported the proposals by 67% to 27%, provided the revenue was used to expand public transport, though there was some scepticism as to whether it would be used in this way, in which case support dropped to 40%. As Schaller (2006) reports, earlier polls found New Yorkers divided on congestion pricing in the Manhattan Central Business District, with one survey showing 44% in favour and 45% against, and another showing a 2:1 majority against. The Bloomberg proposal also had the support of the NY City Council and the NY State Senate, though crucially not of the NY State Assembly.

A number of transportation-oriented planning and advocacy groups, business and environmental groups, university-based research centres and some elected officials became key proponents of congestion pricing, as part of a larger sustainability plan (PlaNYC) to create a 'greener, greater New York'. They estimated the regional cost of congestion to be $13 billion. Rather as the ROCOL report (ROCOL, 1999) did for London and Mayor Livingstone, these groups laid the foundation for the NY Mayor's congestion pricing proposals.

As in Manchester, most attention was focused on the congestion charging proposals, which were: $8 on weekdays from 6 a.m. to 6 p.m. for cars travelling in Manhattan south of 86th Street. Payment could be made via the well-established E-ZPass electronic freeway tolling system, or through various other payment channels. Bridge and tunnel tolls would offset the congestion charge so that no driver would pay more than $8 per day. The revenues would be devoted to transportation improvements.

While congestion pricing generated strong feelings, overall press and public reaction was surprisingly positive, probably because it was part of the wider sustainability plan. A Traffic Congestion Mitigation Commission was set up to evaluate different approaches to congestion in central Manhattan, including both pricing and non-pricing approaches, and recommended a simplified and cheaper version of the original proposals, covering the somewhat smaller area south of 60th Street. The plan was estimated to reduce vehicle miles travelled (VMT) in the charging area by 6.8%, with over 30% reduction in congestion in the zone and over 20% in adjacent areas. Projected net revenues of $491 million annually were to be devoted to public transport improvements. In addition the city and the Metropolitan Transport Authority, which runs its public transport, applied for, and was allocated, $354 million from the Federal Department of Transportation for implementation of the congestion pricing scheme and the complementary transport improvements.

The plan was supported by the Mayor, the State Governor, a coalition of 135 civic, business, labour, environmental and advocacy groups, and the editorial boards of all four major newspapers, as well as by several suburban elected officials. There seemed to be very little opposition; what there was came from the four NYC boroughs outside Manhattan, especially Queens and Brooklyn, which tend to be more car-dependent than other neighbourhoods, and have less good public transport.

The NYC council voted 30 to 20 to adopt the Commission plan; but congestion pricing needed authorisation under state law; this was blocked (without a vote being conducted) by Democrats, who had control of the State Assembly, so the plan failed to meet the Federal funding deadline, and was abandoned. Schaller (2010) poses the question of why the broad support for sustainable transport and congestion pricing failed to translate into approval of the proposal: 'The short answer is that a relatively small group of auto users believed that congestion pricing was against their best interests… The intensive interests of one group were thus able to overcome widespread public support'. He then goes on to examine people's views in more detail.

Firstly, congestion pricing is supported only if it makes sense on both societal and individual levels – sometimes leading to surprising results such as public transport users opposing if they think it is unfair to drivers (Schaller, 2006).

Secondly, opposition is motivated primarily by individual-level impacts on drivers, who thought that public transport could not be a viable alternative to driving, that the travel time savings were questionable and not worth the $8 charge, and that the societal benefits would not in fact materialise. Many opponents also had little experience of public transport, and what experience they had was often negative. Furthermore, only 5% of workers in eastern Queens and southern Brooklyn commute by car into Manhattan and would have had to pay the charge; many more commute by public transport.

Schaller draws the following lessons for acceptance and adoption of road pricing:

- Build support for the proposals by:
  - an extensive public outreach and education campaign;
  - involving the public in the plan;
  - having strong leadership from the Local Authority, preferably with a high-profile project champion (in this case Mayor Bloomberg);
  - having a 'package' approach (as advocated by Jones, 1991), covering public transport and land use; in New York the congestion charging proposal was part of a wider sustainability plan; and
  - availability of external funding. The potential $354 million Federal grant built further support and the timescales it imposed accelerated the planning process.
- In designing pricing proposals:
  - do not underestimate the disproportionate power of small groups of vocal opponents;
  - offer a non-priced roadway alternative. For example, both HOT lanes and new toll roads provide 'free' – not really free of course; they are paid for by other means and/or other people – alternatives, so motorists have little reason to oppose them (though see 5.8.2 below); and
  - schemes that require all drivers to pay will need to convince drivers that they personally will benefit from the scheme, whatever the overall societal benefits. Even if revenues are devoted to road improvements, it is still necessary to demonstrate why some drivers should pay while others do not. The Dutch scheme (section 5.7) would have met this criterion had it gone ahead.

5.8.2 Minnesota

The introduction of HOT (High Occupancy Toll) lanes on I-394 in 2005 as part of Minnesota Department of Transportation's Congestion Pricing Program was preceded by much local opposition and controversy. However, drivers liked the end-result (95% satisfaction with all-electronic tolling; 85% satisfaction with traffic speed in lane; and 76% satisfaction with dynamic pricing, where the charge is higher at busy times) and the proposed new HOT lane I-35W in 2009/2010 has had no opposition at all (Arseneau, 2009).

5.8.3 San Francisco

Studies in San Francisco (Fairbank et al., 2008) found that Bay Area residents were largely unfamiliar with the concept of congestion pricing and that this lack of familiarity caused them to be initially split on the idea of implementing congestion pricing in San Francisco (45% pro, 44% anti). However, as they learned more about the policy their support increased significantly (53% pro, 38% anti) – consistent with the findings of Owen et al. (2008) in the UK.

As reported in Toll Roads News (2010), a proposed congestion pricing proposal by the San Francisco County Transportation Authority (SFCTA) would charge $3 for travel through a cordon in the north-east of the city from 6 a.m. to 9 a.m. and 3 p.m. to 7 p.m. on weekdays, capped at $6/day. Rebates of 50% would be given to residents, low-income people and disabled drivers; taxis, public transport and emergency services would be exempt. A second proposal is a toll cordon at the southern border of San Francisco County, either as a stand-alone toll, or as a supplement to the northeast cordon. In addition, parking spaces will be priced dynamically to maintain availability of parking spaces at all times. Extra public transport and other infrastructure is planned for to cope with the expected modal shift. Opinion polls show 71% support (14% want a permanent system, 46% prefer a pilot and 11% would like a modified scheme), with 16% opposed and 17% not sure.

The scheme would start with a pilot, allowing a response to public feedback, a demonstration of proof of concept, and scheme evaluation. Potential pilots include:

- the north-east cordon, evenings outbound;
- a hybrid scheme: the southern gateway with parking pricing.

The scheme would probably use tag-and-beacon ('Fastrak') technology. Expected costs and revenues are shown in Table 24.

Table 24: Expected costs and revenues of proposed San Francisco congestion pricing scheme

	NE Cordon (AM/PM)	NE Cordon (PM Outbound)	Southern Gateway (AM/PM)
Net operating revenue	$80m	$70m	$60m
Operating ratio (expenditure/ gross revenue after discount)	30–35%	20–25%	25–30%

Source: Toll Roads News (2010)

The scheme would generate $185 million a year in revenue before discounts, $145 million after discounts. Operations costs would be $45 million and capital amortisation $20 million a year based on upfront revenue of $80 million. Travel time savings are estimated at $370 million a year, with vehicle operating savings of $30 million, compared to $145 million in congestion tolls.

Congestion currently costs San Francisco $2 billion a year. The toll scheme would result in 12% fewer car trips during the tolled periods, 5% fewer vehicle-miles travelled, a 20% improvement in street speeds and a 21% reduction in vehicle-hours delay.

The potential timeline is:

- 2010–11: implement and evaluate parking projects and study congestion reduction;
- 2011–13: environmental analysis, system design, legislation;
- 2013: implementation decision;
- 2013–14: final design and procurement; and
- 2014–15: construction of system and capital improvements, additional public transport.

5.8.4 Americans prefer tolls over taxes

According to the August 2010 issue of *Surface Transportation Innovations* (STI, 2010a), quoting a nationwide survey commissioned by HNTB Corporation, conducted in June 2010 by Kelton Research, 'Americans prefer tolls over taxes'. According to the survey, when given a list of funding options, tolls ranked highest (39%), compared to increased public transportation taxes (29%), vehicle registration fees (23%), sales taxes (20%), gas taxes (18%), income taxes (11%), or property taxes (9%).

As reported in the previous issue of *Surface Transport Innovations* (STI, 2010b), similar sentiments were expressed by mid-west residents in relation to proposals for 'managed lanes' in Illinois.[20] A survey by Wilbur Smith Associates found that 85% of respondents would pay a premium toll if it gave them congestion relief and 82% supported the idea of using tolling to pay for highway improvements that relieve congestion.

On a wider scale, the National Cooperative Highway Research Program report *Compilation of Public Opinion Data on Tolls and Road Pricing* (NCHRP, 2008) summarised 110 surveys of public opinion, mainly in the US since 2000, of which 56% indicated support for tolling/road pricing, 31% opposition, with no majority either way in 13% of cases. In contrast, only 27% supported tax-related initiatives, with 60% opposed. Table 25 shows how the support varied by type of charging scheme.

20 Managed Lanes: a term used in the USA to refer to HOV and HOT lanes. See FHWA (2007) for advice on conversion of HOV to HOT lanes, FHWA (2009a) for a survey of congestion pricing and managed lanes, and FHWA (2008) and (2009b) for a description of the US Value Pricing Program. The latter paper also covers similar ground to the present paper.

Table 25: Public opinion based on type of pricing

	Cordon Tolling	Public–Private Partnership	Express Toll Lanes	Traditional Toll Road	HOT Lanes
Majority Support	32%	0%	62%	71%	73%
Majority Opposition	53%	60%	23%	26%	15%
Neither Majority	16%	40%	15%	3%	12%
Total Percent	100%	100%	100%	100%	100%
Total Cases	19	10	13	35	26

Source: NCHRP (2008, Table 2)

The NCHRP report identified eight broad themes in public opinion results, which were independent of who was polled, where they lived, or the type of road pricing project. They are:

1. The public is interested in value. When a benefit is identified (e.g. reduction in congestion on a particular road) and communicated, public support is higher. Benefits should be identified for individuals, for communities, and/or for society as a whole.
2. Support is higher for specific projects as opposed to general principles. Road pricing is perceived as 'choice' rather than punishment. This is assumed to be why low-income individuals generally support tolling and road pricing.
3. Use of tolling revenues is a key factor in acceptability. Support is higher when revenues are used for highway infrastructure, public transport improvements, or speeding up construction.
4. Support increases with knowledge, and is higher when a toll road exists than when it is a future possibility. Building support is a long-term process that should continue after implementation.
5. Support is higher when there is educated opinion on how tolling works and its pros and cons. This may explain why people oppose road pricing but will use a tolled road when it opens.
6. People want equity and fairness. Opposition is higher where there is perceived unfairness. This is why an alternative toll-free route is important, and why support is generally higher for tolling new roads than for charging on existing roads. Everyone benefits from having a choice.
7. People want simplicity. Opposition increases as proposals become more complex.
8. People prefer tolls and charges to taxes. Only users pay.

There is much commonality in these eight themes with the 'Ten factors for the acceptability of road pricing' listed in Table 9.

5.8.5 US congestion pricing modelling

The US Department for Transportation has produced a spreadsheet-based modelling tool to estimate the costs of implementing a congestion pricing scheme in a typical US State (DeCorla-Souza & Luskin, 2009). Depending on whether the congestion pricing was 'aggressive' (25 cents/mile) or 'moderate' (13 cents/mile), the toll collection costs as a percentage of revenue would be 8% in the former and 16% in the latter, according to the model, based on tag-and-beacon technology.

5.9 Summary

All of the above case studies show that, contrary to popular belief, road pricing *is* acceptable to the public provided that:

- they are sufficiently informed;
- they have experience of charging schemes so they know exactly what the costs and benefits are;
- they know that the revenues will be spent on transport; and, perhaps,
- they perceive it as inevitable.

By way of a coda to this, an intriguing shift of perspective is provided by Schade and Baum (2007), who studied the psychological theories of 'reactance' and 'dissonance' in the context of road pricing acceptability. They conclude that the latter applies. In other words, people who think that the introduction of road pricing is inevitable develop more positive attitudes towards it.

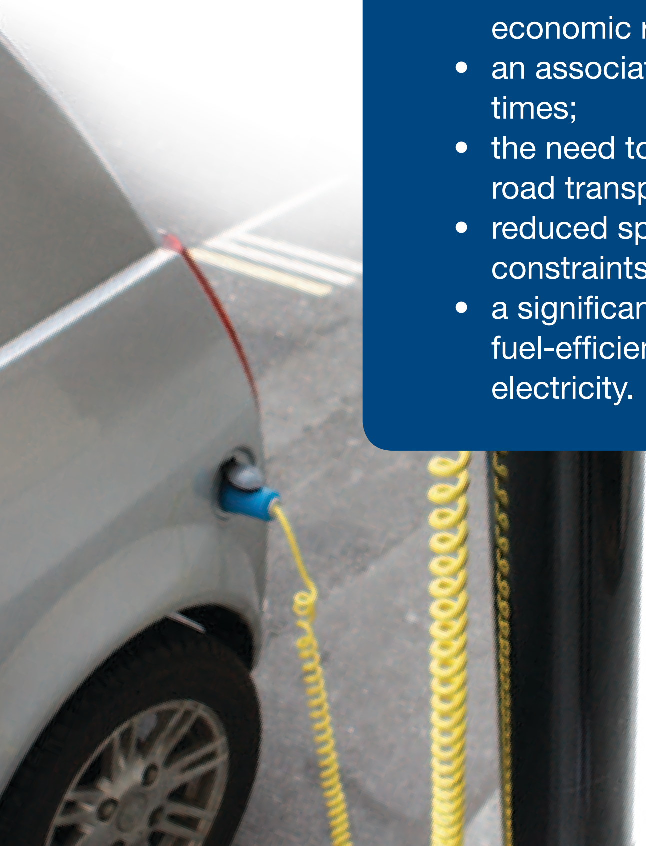
In general, the shifts in opinion described earlier in this section have been ascribed to the benefits experienced after road pricing has been introduced, or to the fact that 'familiarity breeds acceptability'. However, Schade and Baum's results suggest that these shifts might be partially explained by 'cognitive dissonance reductions'.

6. The Future of Road Pricing in the UK

6.1 Introduction

According to the RAC Foundation's report *Governing and Paying for England's Roads* (Glaister, 2010), a fundamental shift in the way England's roads are managed and paid for is essential if the country is to avoid traffic gridlock in the coming decades, including a pay-as-you-go scheme. Glaister identifies several major problems facing road users and the government:

- a lack of vision for the road network;
- a 33% traffic increase by 2025 due to population growth and economic recovery;
- an associated increase in congestion and unreliable journey times;
- the need to meet targets for cutting carbon emissions from road transport;
- reduced spending on roads because of financial and political constraints; and
- a significant fall in fuel duty revenue as cars become more fuel-efficient and increasingly use alternative fuels such as electricity.



Glaister goes on to assert that the lack of a long-term strategy and funding cannot be adequately addressed within the present road network management arrangements, and that it must be placed at arm's length from government, to remove roads policy from the political arena and to restore public trust in road taxation and spending. Ways forward include creating one or other of:

1. an enhanced Highways Agency with full maintenance and capital investment responsibility for its entire network (motorways, trunk roads and other major roads);
2. a public corporation or trust with shadow tolls – similar to (1) but with legal independence from government, with a duty to promote a long-term strategy. This could be a preliminary step towards direct road user charging;
3. a public corporation or trust with direct charges, with a concomitant reduction in motoring taxation;
4. a regulated private utility with shadow tolls, extending the current Private Finance Initiative road schemes to the whole network, with assets sold to the private sector; and
5. a regulated private utility with direct road user charges – similar to (3) but with a substantial capital sale value.

Glaister's preference is either a public corporation/trust, or a privatised utility. Both would require a measure of independent, public interest regulation. The former avoids the controversy of 'privatising a national asset'. But from the viewpoint of a cash-starved government a major attraction of the latter is that it could raise new capital from the sale. Either way, the new body must implement road user charging and the revenues must be sufficient for it to fund its own activities and make a contribution to the Treasury. And to make the scheme acceptable there must be a reduction in fuel duty and vehicle excise duty, and a requirement to improve the road network.

In the rest of this section, we set out a trajectory of some of the significant thinking about road pricing in the UK, by: discussing the previous government's plans for lorry road user charging and its *Feasibility study of road pricing in the UK;* looking at potential costs of a UK lorry road user charging scheme by extrapolating from schemes in other European countries; and suggesting some possible ways ahead for local and national road pricing as well as lorry road user charging.

6.2 Recent history of road pricing initiatives in the UK

6.2.1 Lorry Road User Charging Mk 1

This section outlines the British Government's original (2002) plans to introduce lorry road user charging (LRUC) in the UK. It is based on McKinnon (2006), who was a critic of the plans.

The UK Treasury (Ministry of Finance) wanted to tax foreign-registered lorries (see Table 35) for their use of UK roads on a comparable basis to UK-registered vehicles, including implementing a level playing field to correct the anomaly that foreign lorries were buying diesel outside the UK at lower duty rates and competing with British lorries buying more expensive fuel in the UK. The vast majority of the respondents to its initial consultation supported distance-based taxation rather than time-based paper vignettes. Following further consultation, it was proposed to reimburse UK-registered operators for the additional road charges by rebating fuel duty.[21]

There would therefore have been three components in the scheme:

1. Main scheme: would have applied to almost all UK-registered vehicles, plus foreign-registered lorries frequently visiting the UK, and would probably have been GPS, cellular network and digital-map based.
2. Occasional user scheme: would have applied mainly to foreign-registered lorries visiting the UK infrequently – which was not defined but would probably have been ones covering less than 12,000 km p.a., which is in fact the majority of foreign lorries. Such vehicles would need a 'low-use-OBU', perhaps DSRC-based. Thus, as McKinnon points out, the main LRUC scheme would not have applied to most foreign vehicles.
3. Fuel duty repayment scheme: to rebate fuel duty to UK operators and to foreign hauliers buying UK fuel.

It would also have been necessary to create registers of vehicles covered by the main and low-use schemes, operators and companies qualified to install and, where necessary, service OBUs, and companies eligible for the fuel duty rebate, as well as procedures for enforcement, quality assurance and debt management.

21 Though it is not clear to what extent this is permissible under EU rules.

The 'first generation' scheme would have charged different rates on motorways as opposed to other roads. The 'second generation' scheme, if implemented, would have had four different rates; for motorways, trunk roads, A-roads and other roads. In both cases there would have been two different tariffs depending on time of day.[22]

The estimated cost of setting up and running LRUC for 10 years would have been £4 billion, based on the costs of the German lorry tolling scheme; but since that applies only to autobahns and to 12-tonne vehicles, as compared to the UK scheme which would have covered the whole road network and all vehicles above 3.5 tonnes, with the fuel duty rebate as well, the annual cost could have been significantly over £400 million.

The scheme would have started in 2008, but would not have been extended to other vehicles before 2015, and perhaps not until 2020 or later. It was also not clear whether it would be used as a traffic management tool as opposed to simply raising revenue. McKinnon estimated that the scheme would raise £140–190 million a year from foreign lorries, considerably less than the annual operating costs. Also road tolling technology would continue to improve, so in his opinion it would have been a mistake to introduce a scheme ten years before it would be applied to other vehicles. Also, delaying LRUC until road pricing would be applied to all vehicles would have advantages including a more equitable and efficient means of allocating road space between vehicles, and a powerful traffic management capability.

McKinnon identified five objectives of LRUC, of which he thought only the first three should be addressed in the short term:

- Tax foreign operators the same as British hauliers for using the UK road network.
- Decouple the taxation of lorries from that of cars.
- Tax lorries in relation to distance travelled, weight, and emission class.
- Vary taxes in relation to geographical differences in environmental impact and track costs.
- Vary taxes by time of day, road type and geographical area based on level of congestion.

As regards the fifth objective, it is worth noting that lorry traffic represents only 6% of road traffic in the UK (or 14% if it is rated as the equivalent of 2.5 passenger-car units); furthermore, freight's share of total traffic is lower during peak periods.

McKinnon concluded that the case for LRUC, at least as proposed, was very weak, and he suggested an alternative method of charging based on the tachograph, as an interim lower-cost measure until road user charging could

22 All in all, a rather complex set-up.

be applied to all vehicles. He did not provide costs for his proposals, but stated that 'The incremental cost of the alternative scheme is likely to be much less than the extra revenue raised from foreign hauliers, making it self-financing'.

The House of Commons Transport Committee made a number of comments on, and expressed concerns about, the plans for LRUC (HCTC, 2005), presumably based partially on McKinnon's criticisms. The Government responded as follows (HMG, 2005):

> 'The Secretary of State for Transport announced in a Statement to the House of Commons on 5 July that distance-based charging of lorries will be taken forward as part of the wider work on national road pricing, to work towards a single, cost-effective and comprehensive system. The procurement for Lorry Road user Charging (LRUC) will therefore not now be taken forward. The work undertaken to develop LRUC has however confirmed that national distance-based charging has the potential to offer a workable and practical way forward. The Government will continue to work with the road haulage industry and ensure that we carry the full experience gained from the project into the wider work to develop a national road pricing system for cars and lorries, reflecting the concerns of road haulage operators'.

6.2.2 The Transport Innovation Fund and the Road Pricing Demonstrators

In 2005 the then Labour Government established the Transport Innovation Fund (TIF) (DfT, 2005; 2006). Its objectives were to support:

- innovative local transport schemes that combined demand management measures such as road pricing with modal shift and better bus services;
- innovative mechanisms which raised new funds; and
- the funding of regional, inter-regional and local schemes that would be beneficial to national productivity.

The Fund was forecast to grow from £290 million in 2008/09 to over £2 billion by 2014/15. In early 2007, ten English local authorities were given 'pump-priming' funds to begin studies of traffic schemes which incorporated road pricing. However, after initial investigations a number of them pulled out of the process, and by early 2010 when the programme was scrapped by the Labour Government, only two local authorities, Reading and Cambridgeshire, were still actively pursuing their schemes. In fact, the demise of TIF had been widely expected ever since the Greater Manchester electorate rejected the proposals for congestion charging and public transport investment in the December 2008 referendum (see section 4.3.2).

In parallel with TIF, the Department for Transport (DfT) commissioned a number of R&D-based 'road pricing demonstrators', whose objective was to test the feasibility of TDP (Time, Distance, Place) charging in a hypothetical future when there might be several road pricing schemes operating across the country (local, regional and on specific roads). They were intended to explore how a TDP scheme could safeguard privacy whilst operating reliably, accurately and cost-effectively. They were also intended to inform the development of local TIF schemes, the timescales for the practical implementation of real TDP schemes, and the feasibility of developing a common approach to compliance/ enforcement. The initial budget was £10 million. Four projects were funded to develop and operate Global Navigation Satellite System-based (GNSS) charging schemes, and three to develop compliance methods to ensure that all the (hypothetical) charges were correctly and fairly calculated (HoC, 2008; DfT 2007d). However, nothing has been published about their progress to date, though all 7 projects are thought to have completed.

Prior to the 2010 election campaign the then Secretary of State for Transport announced that road pricing would not be part of the Labour party manifesto and would not be implemented during the next parliament if they were re-elected (Adonis, 2009).

6.2.3 Lorry Road User Charging Mk 2

The Liberal Democrats were in favour of national road pricing before the 2010 General Election, though expecting that it could not be introduced in a single parliament. The Coalition Government has repudiated this, but has announced that lorry road user charging will be introduced. ('We will work towards the introduction of a new system of HGV road user charging to ensure a fairer arrangement for UK hauliers'; HMG, 2010.) The timetable was announced in early November 2010 by the DfT in its 'Business Plan 2011–2015' (HMG (2010), but there are no details of the proposed technology or implementation plans.

Table 26: UK Government timetable for lorry road user charging

	Start	End
i. Agree scope and goals of a road user charging scheme	Started	June 2011
ii. Consult and communicate with road users on the introduction of the scheme	January 2011	December 2013
Iii/ Seek to introduce legislation in Parliament to bring HGV road user charging into effect	May 2012	May 2013
iv. Undertake formal procurement for scheme elements and commence operation	March 2011	April 2014

Source: DfT (2010a)

6.3 How national road pricing could be implemented

6.3.1 Phased implementation

Dix (2007) outlined a process in which TfL could successively upgrade the London Congestion Charging scheme. Although any plans for such upgrades seem to have been shelved, the process, which might also be applied to a UK scheme, is as follows:

- STEP – 1 is a simple area-based charge using ANPR technology, as implemented in London. It has the following advantages:
  - no OBUs are required;
  - the scheme allows for visitors, and for anonymity; and
  - area charges could cover congested town centres or specific routes.

- STEP – 2 would use tag-and-beacon, with the following advantages:[23]
  - it would be optional – users could opt to stick with the ANPR option, and the area charge could still be paid anonymously;
  - variable time of day charging is possible;
  - tag take-up could be incentivised by offering more flexible/cheaper charging; and
  - more convenient for users especially those who might also use schemes in other areas (i.e. it would provide for interoperability).

- STEP 3 – provide ‘distance-based charging’ with GPS OBUs as yet another method of payment. Advantages would include:
  - users may already have OBUs with which distance-based charges could be determined; and
  - take-up would again be incentivised by even more flexible charges more closely related to distance travelled.

- STEP 4 – with voluntary take-up of distance-based charging, in time it may be possible to move to wholesale use across the country

Note that an ANPR-based lorry road user charge, or even an electronic vignette (see section 12.1) could be a pilot of STEP 1, before extending it to all vehicles. Also, Dix suggested that STEP 4 could probably not be implemented within five years (i.e. within the duration of a UK Parliament). However, with improved technology and with existing GPS-based equipment already in many vehicles, a shorter timescale might be realistic.

23 Both Toronto (http://www.407etr.com) and Melbourne (http://www.citylink.com.au) have operational schemes which have been running since 1997 and 1999 respectively, using both tags and ANPR.

6.3.2 Outline of possible scheme

Rationale

Gathering the themes we have addressed so far, road pricing:

- is a sensible way ahead for UK transport policy. It has advantages for government, business and commerce, and for travellers, both public transport users and motorists alike;
- is acceptable to the electorate, contrary to popular belief – especially if they have experience of it – and to the haulage industry, provided certain conditions are met;
- may not be as costly as previous studies have suggested;
- is a powerful traffic management tool, and will also generate a wealth of real-time traffic data for other traffic management and intelligent transport systems; and
- uses technology that is available and can be introduced in a phased way.

How to proceed

The strong message from Owen et al. (2008) is that people are more accepting of camera and ANPR-based charging, because of their familiarity with CCTV and so forth. Furthermore, Stockholm has shown that a real urban road pricing scheme based solely on cameras and ANPR is perfectly practical, and has cost and other benefits over OBU-based schemes. Conversely, ANPR has the additional operations costs of image processing and communications. The break-even point to introduce DSRC is said to be 35% tag take-up.

Therefore a UK national road pricing scheme should:

- adopt a revenue-neutral approach, at least in the first instance;
- begin implementation using camera and ANPR technology (Figure 19), which may be cheaper to implement than tag-and-beacon, and may need less roadside infrastructure, minimising both cost and visual intrusion (roadside poles can often be used to mount the ANPR equipment, rather than overhead gantries or cantilevers);
- subsequently, as outlined by Dix (2007) (see 6.3.1) introduce tag-and-beacon, with incentives (e.g. lower charges) for drivers to adopt the technology voluntarily, followed at a later stage by true Time-Distance-Place (TDP) charging, using satellite-based technology for selected (or all) roads – again with further financial incentives for adoption by drivers.

Figure 19: ANPR cameras on the A14

Source: Courtesy of Vysionics Intelligent Traffic Solutions

Implement an initial pilot programme

As a starting point, the UK should repeat the Stockholm trial in a UK city or cities – preferably selected from the former Transport Innovation Fund bidders (see section 6.2.2) since they are likely to be best prepared. And if a referendum is necessary, it should be held *after* the scheme has been trialled and demonstrated, so that people are voting on the basis of real knowledge and experience. Such a trial and subsequent vote would meet the requirement of the former Secretary of State for Transport, Lord Adonis, for a democratic mandate for the introduction of road pricing (Adonis, 2009). If the referendum resulted in a 'No' vote, the investment in the trial would not be wasted because the camera infrastructure could still be used for traffic management.

The trial also needs to be full-scale, as in Stockholm – not just a single road or a few hundred cars. As Stockholm found, only a full-scale system with real charges would be able to demonstrate clearly the advantages of congestion charging, as well as the visibility of the effects of the charge (Eliasson, 2009b).

Assuming a positive result in a subsequent referendum, it may be possible to introduce it in a phased way in other cities, gradually spreading to all cities (NSTIFC, 2009), and ultimately to all the roads that need to be charged – many rural B-roads will probably never be charged.

An alternative (or additional complementary) strategy would be to introduce it nationally just for lorries initially, again using cameras and ANPR (or a electronic vignette scheme see section 12.1); including foreign lorries would need the database being compiled under the recommendations of the Freight Data Feasibility Study described in section 12.1.1 and the registration of foreign vehicles with the scheme. Benefits would include levelling the playing field between those who pay and those who currently do not (NSTIFC, 2009). However, as discussed below, using just ANPR for a national scheme would be more problematic than using it for an urban scheme.

Another (and again complementary) option is to introduce charging for motorways, though that might create diversion away from them, which would be a bad idea since they are very safe roads.[24] The advantage of starting with towns and cities is that it is a relatively bounded problem.

But, either way, the topic of how best to introduce road pricing in a phased way needs further study.

Implement a public information and participation campaign

As Schaller (2006) and Owen et al. (2008) have pointed out, the process followed in developing a road pricing programme is just as important as the programme itself in gaining public support. Three key elements should be included in this process:

1. Start a public dialogue about transportation problems and the importance of doing something about them.
2. Engage the public in a discussion of a range of possible solutions.
3. Take steps showing that things are moving in the right direction.

As NSTIFC (2009) has suggested, eventual implementation of full mileage-based pricing could perhaps start with a voluntary opt-in phase. This could demonstrate the system's fairness and benefits to drivers – as well as addressing privacy, reliability and cost issues – before any motorist is compelled to pay a mileage-based charge. Eventually a congestion pricing overlay could be introduced, covering the places and times of greatest congestion – though we know from Owen et al. (2008) and other studies (see section 4.2.1) that the public is currently more resistant to this. Because the charge can be specific to individual road segments, mileage-based pricing can directly link motorists' payments to improvements to roads and public transport services, which can be critical in building public support; this may be its most significant long-term contribution to the transportation system (NSTIFC, 2009).

24 A time-based vignette scheme, as described in section 12.1, does not suffer from this disadvantage.

As an incentive, Marsden (2009) and Bonsall and Young (2010) have proposed a scheme where the introduction of road user charging is accompanied by abolition of parking charges. The latter find that, in some circumstances, peak period congestion could be reduced while preserving and even enhancing the city centre as a retail location, and at the same time increasing equity. Such a scheme could produce more winners than losers and could be more politically and publicly acceptable than road charging on its own, though with a dilution of the demand management effect of road pricing and a reduction in revenues. This approach should be included in the further studies.

6.3.3 Deployment of the ANPR technology

I am grateful to Geoff Collins, Trevor Ellis and Brian Smith on whose inputs much of this section is based.

The figures given here are meant to be outline and broad-brush only, as a starting point for more detailed study. Refinements to the charging regime (time of day, vehicle weight and emission class) could be added later as an upgrade, if appropriate.

Performance and cost of the ANPR technology

It is generally accepted in the industry that the ANPR percentage read rate is in the high 90s – the very high 90s if the number plates are clean and maintained correctly. The figure of 95–99% was achieved in Stockholm (section 5.5) using both front and rear cameras, and in Norway[25], but it should be borne in mind that Scandinavian plates are relatively easy to read; they have a small number of contexts/syntax, and large letters and numbers. The price of ANPR systems has dropped considerably over the last 20 years, as is typical with any technology that sees wider use. There has also been a general movement from cameras connected to a controller to integrated units complete with illumination, processing and communications. Such systems currently cost between £2,500 and £6,000 per camera module, to monitor one or two lanes. For a high-volume application, and allowing for further technology improvements, prices could drop to £1,000 per camera module. Installation cost, including the pole on which the camera module is mounted, would depend on the location; installation on a soft roadside verge in a rural location would be significantly cheaper than in London where it is necessary to avoid underground/buried services. Cameras can also be mounted on existing infrastructure (Figure 20).

25 'Since November, the number of unread plates has been reduced to 3%' (Fjellinjen, 2008).

Figure 20: A traffic-signal-mounted ANPR camera

Source: Courtesy of Trevor Ellis Consulting Ltd

There is also the cost of communications. Images would be stored locally for a certain period of time, and only ANPR data sent to the back office in the first instance. Many locations would already have a hardwired landline communications connection, so the communications costs would be negligible. Where there is no existing landline communication, a mobile communication (3G) contract would typically be £30 per month, or £360 per year.

As a ‘reality check’, the cost of the camera and ANPR systems for the Western Extension to the London Congestion Charging Scheme involved the installation of 686 camera and ANPR systems at 137 locations, for a contract value of £66 million, of which £6 million was for the communication system, £20 million was capital expenditure and £40 million was for operating and maintaining the system over 10 years. The scope of the contracts included on-street civil engineering, camera and ANPR technology, DSL communications, and a complex in-station systems integration to the existing back office payment and PCN processing system (Ellis, 2010b). Thus the average capital cost per site was £146,000. Using more recent cost estimates, as shown in Table 27, and assuming two installations at each site (i.e. one on each side of the road), the capital expenditure could conceivably be reduced by a factor of three, from £20 million to just under £8 million.

Table 27: Estimated current costs of ANPR installation in London

	£ total
137 out-station locations, each including:	
6 × cameras at £6,000 each	36,000
2 × mounting columns at £2,000 each	4,000
2 × civils works at £2,000 each	4,000
2 × communications installation at £500	1,000
2 × power connections at £500	1,000
2 × commissioning and testing at £2,000	4,000
Total per location	50,000
Cost of 137 sites	6,850,000
Complex in-station & systems integration	1,000,000
Total in-station/out-station cost for 137 sites	7,850,000

Source: Industry estimates

Practical considerations for an ANPR-based scheme

Firstly, in any tolling or road pricing system, a false positive charge (i.e. an erroneous charge where no charge is in fact due) is unacceptable. The converse, a false negative (i.e. where a charge is due but the system does not detect the vehicle) is more acceptable, although this represents lost revenue and is also perceived as unfair.

With a microwave DSRC system, the accuracy is around 99.9%, and it will almost never give a false positive charge. Any system failure can be detected by comparing the DSRC data to other vehicle detection systems such as ANPR. Such discrepancies can be checked by manual examination, which would be on only a small number of reads, and will usually occur where there is a genuine problem, such as a swapped or failed OBU.

For ANPR-only charging, the situation is different. If there is a 95% ANPR read accuracy, for two million reads a day[26] there would be 100,000 misreads. Clever filters can reduce this figure, though with the loss of some valid charges, but a significant proportion of vehicles would be falsely charged through a

26 Average daily traffic flows on UK roads in 2009 were 76500, 10900, 19800, 900, 2300 vehicles per day on motorways, rural and urban A-roads, and rural and urban minor roads respectively (see Table 34).

misread being a different but valid account holder – where letter B is misread as number 8, or letter D as number zero for example. This would not be acceptable.

With a pre-payment system, as in London, the majority pay in advance, so it is less of a problem if vehicles are not detected. If 30% do not pay in advance, and 95% of them are correctly identified, only 1.5% are missed (i.e. 5% of the 30%), which is more acceptable. Also, since there are cameras inside the zone as well as at the boundary, most vehicles are seen several times, giving more opportunity to identify them correctly.

In Stockholm both front and rear plates are read, which not only gives a better chance of a correct read, but also a way of detecting misreads when they occur. It is unlikely that front and rear plates will be misread in exactly the same way. And if they are, it is very unlikely to be a valid alternative plate. A further check is to use vehicle classification equipment, allowing cross reference of the ANPR read with the expected class of the vehicle. All of this can bring the false positive level down to an acceptable (almost zero) level, as well as significantly reducing false negatives. The downside is that three gantries are needed at every detection point, making it much more expensive, and giving a much greater streetscape impact.

Foreign vehicles are a further complication. Usually the ANPR equipment is optimised for UK plates, and the more nationalities that it needs to cover, the lower the overall read accuracy. This is because the ANPR equipment post-processes the data based on the syntax of UK plates, in which there are only certain permissible combinations of letters and numbers, such as AB12CDE or ABC123. This helps it to distinguish between number 8 and letter B, or letter S and number 5. So the accuracy might be much lower for foreign lorries, exacerbated by some of them having several plates on their trailers.

Cost for an urban scheme

The costs obviously depend on the particular town or city involved. But Cambridge is a useful guide as a medium-sized city. In its bid for Transport Innovation Funding from the DfT (Section 6.2.2), Cambridgeshire County Council published figures of the expected costs and revenues of an area-based charging scheme in the city of Cambridge (Cambridgeshire, 2007) – though since the demise of the Transport Innovation Fund the scheme is presumably ‘on hold’ if not abandoned.

The charges would have been around £4 per user per day during the week-day morning peak period, irrespective of the number of trips or distance travelled. There would have been 15 exit and entry points, plus 22 internal charge points, plus 5 mobile enforcement units. The proposed technology was tag-and-beacon, enforced by cameras and ANPR at all sites.

The congestion charging scheme would have been preceded by £500 million of transport investments including dedicated car lanes and express bus routes to and from park-and-ride sites, subsidised bus fares, bus priority and bus lanes, extra trains, a new rail station and a network of cycle paths. Road traffic was expected to be reduced by 27% as a result.

Table 28, based on Tables 0.7 and 0.8 of Cambridgeshire (2007) shows the expected congestion charging scheme costs and revenues in £ million. The capital investment costs are in 2007 prices. The operating costs and revenues are in current year pricing. The opening year was assumed to be 2011.

Table 28: Cambridge congestion charging scheme costs and revenues in £m

Year	-3	-2	-1	Opening Year	+1	+2	+3	+4	+5
Capital investment	2.3	8.6	7.5	0					
Revenues	0	0	0	40.18	40.93	41.700	42.47	43.26	44.06
Operating Costs	0	0	0	10.90	6.43	6.59	6.76	6.92	7.10
Operating Surplus	0	0	0	29.28	34.50	35.10	35.72	36.33	36.96
Costs/ Revenue	-	-	-	27%	16%	16%	16%	16%	16%

Source: Cambridgeshire (2007)

The capital investment costs of £18.4 million would be reduced significantly if only ANPR were used. Based on the figures in Table 27, for 37 fixed charge point sites, and assuming 2-lane 2-way roads with capture of both front and rear plates, each charge point would need four poles and eight cameras. So the cost per charge site would be £76,000, making a total of £2.8 million for the total out-station cost. Of course these figures do not include communications or back office costs, which are unfortunately not broken out in the Cambridge published figures; but it is clear that the cost could be lower than £18 million if DSRC is not used.

Furthermore there is no doubt that the ANPR technology would work successfully in a UK city; as we have seen, it already does in Stockholm, where drivers pay monthly in arrears – an approach adopted by TfL from 4 January 2011 – see section 4.3.1.

Cost for a national scheme covering the Strategic Road Network

There are about 2,500 junction-to-junction links on the UK Strategic Road Network of motorways and trunk A-roads (DfT, 2008a), each of which would need at least one camera and ANPR installation – mounted more or less mid-way along each link on roadside poles or on existing infrastructure (gantries or bridges). They are relatively reliable, so require little maintenance, but should be sited for ease of access once they are operational.

Assuming 3-lane roads, and based on the figures in Table 27 of £50,000 per site, the total out-station cost would be £125 million*, or £50 million if front and rear plates are read. The actual figure could be lower than this, since installation costs would be lower than in London, and lower again if prices do indeed drop to £1,000 per camera module.[27] Conversely, the cost would be increased if vehicle classification equipment were also deemed necessary at each site.

Based on the London WEZ figures of £40 million to operate and maintain the system over 10 years, the *annual* cost of maintaining 2500 sites would be:

£40 million x 2500/(10 x 137) = £73 million

For a lorry road user charging scheme, it is important that foreign plates can be read by the ANPR, and as we have outlined above, they are more of a problem, though probably manageable provided they are reasonably clean and in the correct format (although Belgian plates with red letters can be a little problematic). A scheme would ideally include monitoring stations to make sure that plates are present, correct, legible and being read correctly – rather like a weigh-station.

The charge per link would depend on the length of the link, since we are aiming for a distance-based charge; so drivers cannot pay in advance, unlike the fixed-charge area or cordon schemes. Therefore, 97% accuracy of ANPR would not be good enough, which is why we suggest using both front and rear plates. *So an ANPR-based scheme of this nature needs further study*.

There has not been time or scope within this paper to investigate back office costs, so the approach taken in the last column of Table 30 is simply to average the other supplier costs. Also, the figures in Table 31 show significant variation between the estimates made in this section and those based on scaling of the Swiss and Dutch schemes. *More detailed studies are needed. It would also be helpful if the results of the Road Pricing Demonstrator projects (see section 6.2.2) were published, since they addressed this topic.*

27 There are 18,000 links in the major road network (DfT, 2007c), so to instrument them all at the lower cost figure would be feasible. For a very large network, further integration and cost savings would be possible. For example, many smartphones now have a high resolution video camera, OCR/ANPR capability, GPS and 3G communications, for £200.

* Figure corrected, June 2011, from £25 million to £125 million.

Utilisation of existing infrastructure

There is already considerable camera infrastructure on UK roads, both for security and for traffic management applications. For example, the National Traffic Control Centre (NTCC) Journey Time system uses ANPR monitoring of over 1,000 lanes at 480 sites in England; Trafficmaster has ANPR cameras for congestion at over 2,500 sites in England (Figure 21). All UK ports have ANPR traffic monitoring, which would be particularly useful for identifying when and where foreign lorries enter and leave the UK. Much of this infrastructure might be available and useful for piloting and implementing LRUC in the UK, thus defraying the costs.

Figure 21: Existing camera and ANPR infrastructure (NTCC and Trafficmaster)

Source: Courtesy of Trevor Ellis Consulting Ltd

6.4 Costs

6.4.1 Potential costs of a UK LRUC scheme

As stated earlier in this report, the acceptability of a UK road pricing scheme depends amongst other things on its cost, especially as a proportion of the revenue generated (assuming of course that it is treated as a revenue-raising scheme – if it is conceived as a traffic management scheme then the criteria are different). A number of cost estimates have been published, and they are listed below along with some more recent figures, as well as estimates based on scaling from other real or proposed schemes.[28]

28 Some of these estimates are simplistic. The objective is not to come up with a definitive figure, but to indicate that earlier estimates may have been on the high side, and that further and more detailed investigation would be a good idea. Note also that some of the estimates are for a national scheme covering all vehicles; others are just for HGV schemes. Also different schemes may use different technologies, which might affect the scaling factor. For example, scaling by the ratio of the number of vehicles involved is probably more appropriate for GNSS-based schemes, whereas for DSRC the scaling factor should be based on the respective road network lengths and/or number of links.

Costs based on the DfT Feasibility Study

Section 3.3.2 outlined the DfT (2004) estimates of the costs of a national road pricing scheme covering all vehicles. Of course, the figures for charging just lorries, of which there are currently 415,000 (DfT, 2009c), would be significantly less; the total OBU cost at £100 per unit would be £42 million[29], and assuming £40 million for cameras plus £900 million for a back office, would give a total set-up cost of around £1 billion. Running costs would be one to two orders of magnitude lower than for all road vehicles – say £100 million for telecoms, £500 million for the cameras and £800 million for the back office, giving a total of perhaps £1.4 billion p.a.

Costs based on the Swiss HGV scheme

According to the EU Road Federation (ERF, 2010), the UK road network is six times the size of the Swiss road network, so assuming 100 Swiss Francs equals £66, and multiplying the Swiss figures in Table 22 by six, we get an estimated cost as shown in Table 29.[30]

Table 29: UK HGV scheme cost estimates based on the Swiss scheme

	£m
Gross revenue	6,000
Investment costs:	
Roadside equipment	600
Enforcement systems	200
OBUs	400
Total	1,200
Annual operating costs (including enforcement and equipment amortisation)	400

Cost based on the Netherlands proposed scheme

As indicated in section 5.7, implementation costs of the proposed Netherlands national scheme were estimated by various suppliers to be around €2.2 billion

29 The OBU used in the German scheme cost €400 originally, and is now down to €200; given larger scale production, a cost of £100 should be achievable.

30 Alternatively, the scaling for OBUs could be based on the number of trucks. According to the Swiss Federal Statistical Office (SFSO, 2010a), in the category of Goods Vehicles in Switzerland in 2009 there are 40,811 goods trucks (lorries), 12 light articulated vehicles, 92 heavy articulated vehicles, and 10,657 articulated trucks (lorries), making a total of 51,572 vehicles that would presumably be due to pay the LSVA charge. According to Table 4.1 of DfT (2009c), the equivalent UK figure is 415,300 goods vehicles over 3.5 tonnes licensed in 2009 – a factor of eight more. So the factor used should perhaps be eight rather than six. Conversely the Swiss figures would be increased by around 20% if we added in the transit traffic (SFSO, 2010b: 16). But the intention is simply to get a broad-brush figure.

(£2 billion), for the eight million vehicles, but could be as low as €362 million (£330 million) for just HGVs and vans. Since the UK has around 33 million vehicles, this suggests set-up costs of four times the Dutch scheme, namely £8 billion for a national scheme for all vehicles, or as low as £1.3 billion for just HGVs and vans.

Estimated annual running costs for the Dutch national scheme were in the range €250–900 million, or possibly as low as €141 million for lorries only. Scaling to the UK as above would give £820 million to £3 billion, or £462 million for lorries only.

Costs based on supplier estimates

The Swiss and Dutch schemes were conceived and designed using bespoke technology. In the intervening time, supplier experience has improved, which should result in better and lower-priced schemes currently. Table 30 indicates estimates from various suppliers of the cost of implementing a UK LRUC scheme. For an explanation of the right-hand column, see section 6.3.

Table 30: Supplier-estimated costs of a UK LRUC scheme

£ millions	Supplier 1	Supplier 2	Supplier 3	This paper
Technology	Microwave tags	GPS/GSM	GPS/GSM	ANPR
Weight limit for charging	3.5 tonnes	N/a	12 tonnes	3.5 tonnes
Coverage	Motorway and trunk road network	All roads for charging, but enforcement only on major routes		UK Strategic Road Network
Charging stations	221	200 (for 350–500 units)	-	25–50
Enforcement stations	75		-	
Mobile & portable enforcement	11	50	-	31
Central system	2	100	-	74
WAN	45		-	
OBUs	9	200	-	-
Other (project management, integration, testing, commissioning)	3	150	-	77
Initial upfront CAPEX	367	700	200–300	207–232
Operations costs per year	57	-	100–150	73
Revenue per year[31]	2150	-		
Costs/revenues	3%		< 10%	

Source: Private communications

According to one supplier, a lorry road user charging scheme for all vehicles over 3.5 tonnes on the motorway and trunk road network would take 24–30 months to implement and would break even within its first six months of operation. Over the ten-year lifetime of the scheme, it would cost £1 billion to implement and operate and would generate additional contribution to the Treasury in the region of £20 billion. The scheme proposed is highly flexible so that the same infrastructure could be used in future if it was deemed appropriate to extend the charge to other vehicles (which would also result in a lower cost per vehicle, reflecting the sharing of fixed costs and economies of scale).

31 An average tariff of £0.19 per km has been used, based on tariffs used elsewhere in Europe – though the charge rate would be determined by the scheme operator, not the equipment supplier. Also, if charge rates double then the cost/revenue ratio halves.

Some countries such as the Czech Republic started their scheme with a 12-tonnes limit and then reduced this to 3.5 tonnes after a period of operation. This approach requires virtually the same level of capital expenditure as a scheme for 3.5 tonnes, but produces lower revenues because fewer vehicles are in the scheme.[32] Setting a higher weight limit may also be counter-productive if hauliers choose to operate two small vehicles rather than one large one to avoid paying the charge – though that would reduce road damage since it is proportional to the fourth power of the weight i.e. one 12-tonne lorry will do eight times as much damage as two 6-tonne lorries.

Cost reduction trends

Costs are reducing, due to improved technology and wider deployment – by a factor of five for DSRC roadside technology according to one estimate (Kawakami & Uozumi, 2004), and by similar amounts for GNSS (Springer & Estiot, 2008 – see Table 18). Such technology-driven factors were not taken into account in most previous cost studies. As electronic road pricing becomes more mainstream as a demand management and revenue-raising tool and there are successful examples of implementation, the technologies will reduce in cost.

6.4.2 Summary of costs for a UK LRUC scheme

Table 31: Summary of estimated costs for a UK LRUC scheme

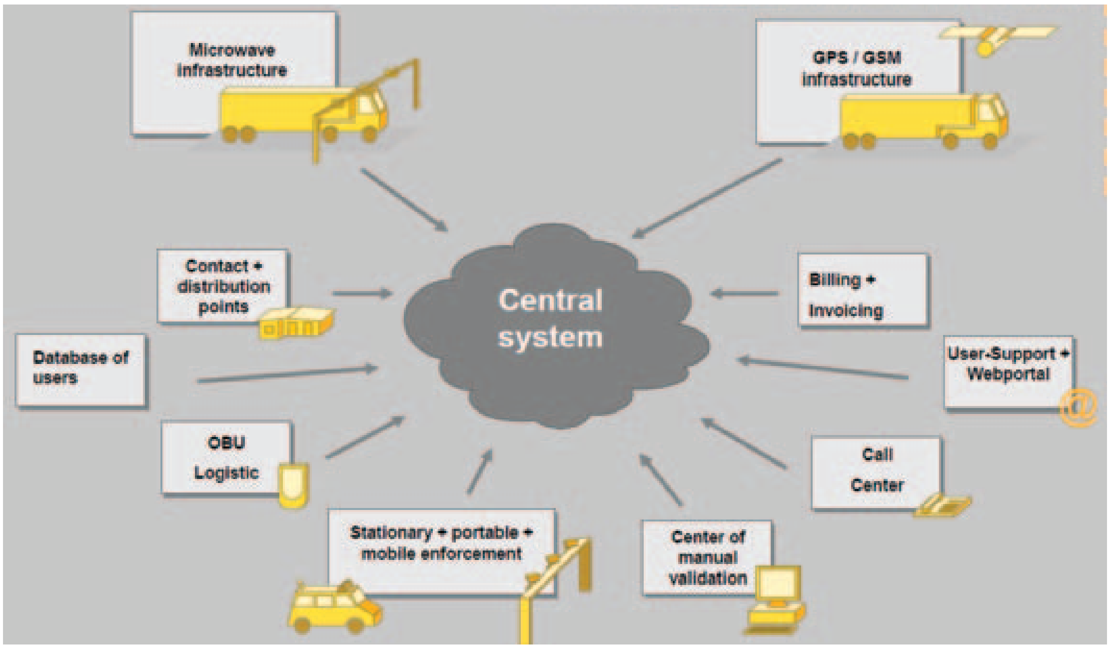
Set-up costs	Annual Running Costs	Comments
£1bn	£1.4bn	Estimate[33] based on DfT (2004); Banks et al., (2007); CfIT, (2010)
£1.2bn	£400m	Based on Swiss scheme
£1.3bn	£462m	Based on Dutch proposals for lorries only
£367m	£57m	Supplier 1
£700m	–	Supplier 2
£200–300m	£100–150m	Supplier 3
£207–232m	£73m	This paper – estimated (section 6.3.3)

32 At the end of 2009 there were 415,000 goods vehicles over 3.5 tonnes registered in Great Britain, of which 23,500 were over 15 tonnes; 303,000 were rigid and 112,000 were articulated, and there were 95,000 operators. The average fleet size is therefore 4 vehicles, though 800 operators have more than 50 vehicles (DfT, 2009c).

33 These organisations' estimates were for a scheme covering all vehicles.

Table 31 summarises the set-up and running costs for a UK LRUC scheme based on the sources and estimates above. It shows a variation in set-up cost estimates of an order of magnitude, but the supplier estimates indicate relatively low figures. This is partly due to falling technology costs, which are now much less than in previous government estimates (though there may also be an element of 'optimism bias'). In addition, existing GPS-based navigation and fleet management equipment already in vehicles might be suitable for generating charge data, thus reducing capital costs even further. Combined with the cost reduction trends illustrated above, this suggests that a closer look at costs, preferably combined with a pilot scheme to confirm cost figures, would be a good idea, perhaps based on the architecture shown in Figure 22, although admittedly this is a DSRC/ANPR architecture, applying to motorways, trunk roads and urban areas, but probably not to the complete road network, so vehicles could potentially divert to avoid charges, which would be undesirable environmentally.

Figure 22: Possible system architecture for a UK lorry road user charging scheme



Source: Courtesy of Kapsch TrafficCom Ltd

6.5 Summary

This section has given some reasons why we need to change the way England's roads are managed and paid for, outlined some previous government approaches to road pricing of various kinds, and suggested how national road pricing might be implemented – though we stress that considerable further work is needed to confirm our tentative figures.

7. Conclusions

This paper has shown that national road pricing can be publicly acceptable, and may well cost significantly less to implement than previous estimates have suggested; but there is considerable ignorance and misunderstanding about it.

In section 4.2.2 we presented the results of an Ipsos MORI (2010) survey which found that 65% of British adults opposed, in principle, the introduction of a pay-as-you-go system on motorways and major roads, though this could decrease to 18% under certain circumstances. We reproduce here, as Table 32, part of Table 11, which tabulated the public's reasons for opposing pay as you go, but with the addition of responses to their answers. Similarly, in section 4.2.1 we described a UK DfT (2010b) survey, with people giving reasons why they think that a charging scheme will not reduce congestion. We include here the data from Table 7, but augment it with the evidence presented in this paper, which shows that people's opinions are incorrect.

Table 32: Pay as you go – myth and reality

Public's opinion	The reality
People won't be able to change behaviour.	Over 21% of drivers did in Stockholm, and 17% in London.
People don't want to change behaviour.	In practice they did in London and Stockholm. In Stockholm some people seemed to have changed their behaviour without realising.
Alternatives are inadequate/ unsatisfactory.	Whilst it is the case that nothing can replace the flexibility and convenience of the car, in reality some drivers have a range of alternatives some of the time, such as driving at a different time or on a different road, combining trips, taking public transport, not travelling at all, and/or telecommuting. And since congestion is non-linear, a small drop in traffic produces a large drop in congestion. Also, as indicated in section 5.5.1 (Eliasson, 2010), there is also the longer-term effect of influencing people's home and work locations.
It would cost more/too much.	Depends on what this response means. If it means the system's overhead cost, then sections 4 and 5 indicate that it could be less than 10%, not counting the benefits of reduced congestion and pollution. If it refers to people paying more taxes and charges then the answer is that a system could be made revenue-neutral overall – though of course from an individual perspective some would pay more, others less.[34]
Don't know enough about the system to support it/need more detail.	For urban road pricing a public demonstration is needed, as in Stockholm, supported by a public information campaign. A lorry road user charging scheme might serve a similar purpose, and would also be appropriate as the first phase of a national road pricing scheme.

34 Of course, if road pricing is revenue-neutral then there is no extra money to spend on improving the road network. Banks, Bayliss and Glaister (2007a) suggested that a compromise might be to make it not revenue-neutral, but to use the excess revenue to build an extra 600 road-lane-miles p.a.

We pay too much tax already.	A scheme could be revenue-neutral. That is, existing charges such as fuel duty and vehicle excise duty could be reduced to compensate.
The system is fine as it is. I'm happy with how we pay for our roads now.	But congestion is a problem now, and will get worse in the future. And as alternative-fuel vehicles proliferate, government revenues from fuel duty will fall, so an alternative system is needed.
This doesn't sound fair. Poor people will be affected worse than rich people. People will be unable to pay.	In general, this is not supported by the facts – see section 3.3.3. And as Schweitzer and Taylor (2010) say: 'We should not subsidise all drivers (and charge all consumers) to help the small number of poor travellers who use congested freeways in the peak hours and peak directions. Rather we should help those who are less fortunate, and see to it that the rest of us pay our own way on the roads.'
We pay enough already to use the roads/ drive.	A scheme could be revenue-neutral.
It would be inconvenient.	Not if it's electronic/automatic, as it is in Stockholm – and will be in London when Auto Pay comes into operation.
Don't think it would work/this wouldn't work in Britain.	It has worked everywhere it has been tried so far. And the residents of Stockholm were initially just as sceptical as the British. There is no reason to think our behaviour and attitudes are significantly different from anywhere else.
It would reduce people's right to movement/right to travel.	But only at certain times, for the most part. And of course congestion also hinders people's right or ability to travel.
Don't trust government to spend the money raised on the roads/transport.	The revenue can be hypothecated, and/or the scheme could be run by a public corporation or trust, or by a privatised utility, as indicated in section 6.1. But setting up the right governance and regulation parameters is important.
The government cannot be trusted to deliver a workable system.	Workable systems have been delivered elsewhere. The scheme could be implemented and run by a public corporation or trust, or by a privatised utility, as indicated in section 6.1.
The system might not be accurate.	As indicated in section 12.2 and elsewhere, accuracies of around 100% are attainable by tag-and-beacon schemes, and the high 90%s for ANPR-based schemes.
This is just a way for the government to raise more money.	This is a political decision. As argued in Banks, Bayliss and Glaister (2007), a scheme could be revenue-neutral, or it could have the extra revenue hypothecated to transport schemes including road building and widening.
People will use other non-charged routes causing congestion on those instead.	This didn't happen to any significant extent in London or Stockholm (sections 4.3.1 and 5.5.1) – though it might for a lorry-charging scheme on motorways and trunk roads.

It wouldn't deliver what is expected.	The experience in London and Stockholm (sections 4.3.1 and 5.5.1) demonstrates otherwise. In fact congestion was reduced much more than expected.
The new system should be extended to include lorry drivers and motorbikes.	There are numerous lorry road user charging schemes already, including Switzerland, Germany, Austria, the Czech Republic and Slovakia, with schemes planned in Poland, France, Sweden and even the UK. The Singapore scheme covers motorbikes, so they could also be charged if it were deemed appropriate.
I think fuel duty should be abolished, not just reduced.	Roads, and transport generally, have to be paid for one way or another. The issue is not whether we pay, but how we pay.
There are no adequate alternatives for people to use instead of the car. We do not have good enough public transport to support this system.	The evidence, especially from Stockholm (section 5.5.1), is that the provision of public transport makes very little difference to whether people stop using their cars. But other alternatives are: to travel at a different time; to take a different route; to combine trips ('trip-chaining'); to telecommute; and/or not to travel. And in the long term, as people move house and/or change their place of work, winners and losers are hard to identify anyway (Eliasson 2010).
It would be difficult to enforce. The system would be unenforceable.	The experience from dozens of schemes, whether city congestion charges or toll roads, is that enforcement is very successful. And it need not cost too much to administer, as sections 4 and 5 indicate.

Recommendations

For urban congestion charging and national road pricing for all vehicles in the UK, we recommend repeating the Stockholm trial in a UK city – perhaps one of the former Transport Innovation Fund bidders since they are likely to be best prepared – using ANPR technology. A referendum, if one is deemed to be necessary, should be held *after* the scheme has been demonstrated, so that people are voting on the basis of real knowledge and experience.

Subsequently, road pricing could be introduced throughout the country in a phased way – starting with those towns and cities which choose to adopt it – with some incentives for drivers, such as reduction in other motoring taxes.

Similarly we should implement a lorry road user charging scheme in the UK at the earliest opportunity; the benefits are clear, the microwave and GNSS technologies are proven and ANPR may be able to do the same job at lower cost. There would be significant economic and environmental benefits for the UK.

8. Recommendations for Further Research

8.1 Areas for investigation

This report was not intended to come up with definitive solutions, but to bring evidence to the debate (some of it new, some of it not new but apparently not well-known) and to suggest a re-examination of previous conclusions. Inevitably this has exposed new issues which need further study. Here are some of them.

8.1.1 Choice of type of trial

The issue is whether to start with an urban trial/demonstration (which would apply to all vehicle types in that urban area) or with lorries and with an identifiable set of roads such as the motorways or the strategic road network – or whether to do both in parallel.

It would be very helpful in furthering this study if the DfT were to publish the outputs of the Road Pricing Demonstrators, which apparently have trialled road pricing on a relatively large scale and in realistic environments – though not with real money.

8.1.2 Scheme technology and costs

Another issue is which technology to use, and how much it would really cost. An extrapolation to national scheme costs would be made much easier by the implementation of local schemes first, and/or of schemes restricted to certain vehicles such as lorries. Further investigation and modelling is needed, especially of electronic vignette versus ANPR/video tolling versus hybrid ANPR and tag-and-beacon, in both cost and efficiency terms.

In particular there are a number of techniques that ought to be trialled that could make video tolling (i.e. cameras plus ANPR) more accurate (Ellis, 2010b), including:

- reading of both front and rear plates, perhaps coupled with a separate vehicle detector to ensure that the reads are from the same vehicle;
- passing the ANPR camera images through a second, and even a third ANPR system, where the three systems use different principles for character recognition (e.g. template matching, or neural networks, or edge analysis respectively); and
- vehicle classification or vehicle model identification to cross-check the vehicle type that is expected from the ANPR read.

It might be the case that ANPR is adequate for the urban situation, but that tag-and-beacon or GNSS technology is needed for charging on a national scale, whether for lorries or for all vehicles. Again, publication of the outputs of the Road Pricing Demonstrators (section 6.2.2), which used GPS technology, would be helpful.

8.1.3 How best to achieve phased implementation?

It would be best to introduce road pricing in a phased way, avoiding a ‘big bang’. How best to do this – by the evolution of local schemes or by using LRUC as a precursor to a national scheme for all vehicles – needs further study.

8.1.4 Would a voluntary opt-in phase be possible?

This question is related to the previous one. If it were feasible, it would need incentives, especially for the early volunteers.

8.1.5 Knock-on effect of LRUC on the cost of goods and services

As Eddington (2006) has pointed out, an efficient transport system benefits the economy. But another issue is what effect an LRUC would have on the cost of goods and services to the public. It depends on various things, including whether other taxes are reduced, and the efficiencies brought about by reduced congestion. This is again a topic for further study.[35]

8.1.6 Will modal shift occur without road pricing?

It has been suggested in this report and elsewhere (see section 5.5) that other measures to combat road traffic congestion (for example by improving public transport) do not work on their own.

Banks, Bayliss and Glaister (2007a) considered the contribution that improving public transport could make to relieving congestion; they concluded that it would have a relatively small effect in reducing the expected growth in road traffic, especially for the main inter-urban routes with which they were principally concerned.

Ellis (2010a) points out that the Netherlands has more road space per vehicle than the UK. Their trains and trams have more extensive networks, and are more frequent, less crowded and cheaper than in the UK. The Dutch also use bicycles a great deal. But they still have significant congestion. His conclusion is that 'these alternatives alone are not enough to significantly reduce congestion, and reduce our addiction to car journeys'.

On the other hand Goodwin (2010) disagrees that without road pricing modal shift is unachievable. In the case of public transport improvements, typically between a quarter and a half of the extra demand is from former car users; but in the absence of anything else, this successful modal shift is offset by increased car use by other people. Also there are many cases where city centre pedestrianisation has been accompanied by public transport improvements, resulting in substantial mode shift with little or no use of price levers. The Smarter Choices stream of work, including Sustainable Travel Towns, achieved car use reductions of 5–10%, and could achieve more. But none of this challenges the positive assessment of road pricing made in this paper.

Further study is needed in this area, in both urban and inter-urban situations – or possibly just the wider dissemination of existing knowledge. It might also

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35 Though a European Commission study suggests that the maximum impact on product prices of the Eurovignette would be 0.34%, and considerably less on some goods (Mayet, 2011).

address what value people put on their time, and why they accept congestion every day when there may be alternatives.

8.1.7 How best to implement an educational programme

As we have seen, one of the problems in public acceptability of road pricing is the lack of knowledge in many quarters of what it can do and why it is needed. Owen et al. (2008), Schaller (2006; 2010), Dix (2007) and NCHRP (2008) give some pointers. But again further work is needed to devise a programme of education.

This should perhaps be coupled with further studies of public acceptability, including issues such as:

- Is public opinion different for city-centre-based charging as opposed to major roads charging?
- Would the successful implementation of LRUC make national road pricing for all vehicles more acceptable?

8.1.8 Revenue-neutrality

Close consideration also needs to be given to:

- how feasible this is;
- how best to ensure it initially;
- whether there should ever be a shift to a revenue-positive position; and, if so,
- how the revenue should be spent.

8.2 Road Charging for England?

The best way to take forward some of these suggestions would seem to be to instigate a ‘Road Charging Options for England’ study, along the lines of the *Road Charging Options for London* study (ROCOL, 1999).

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10 Appendix A: Glossary

Table 33: Glossary of acronyms, abbreviations and exchange rates

Abbreviation	Description
5.8 GHz	The internationally standard 5.8 GigaHerz Dedicated Short Range Communication link used for microwave tag-and-beacon tolling technology
ABvM	Anders Betalen voor Mobiliteit – Different Payment for Mobility – the proposed Dutch national road pricing scheme
ALS	Area Licensing Scheme – the paper-based road pricing scheme used in Singapore between 1975 and 1995
ANPR	Automatic Number Plate Recognition
ANWB	Royal Dutch Touring Club
ASECAP	Association Européenne des Concessionaires d'Autoroutes et d'Ouvrages à Péage - the European Association of tolled road infrastructure operators. http://www.asecap.com/
BMRB	British Market Research Board
bn	billion (10^9)
BPM	Belasting van personenauto's en motorrijwielen – Dutch purchase tax
CAPEX	Capital Expenditure
CBD	Central Business District
CO2	Carbon dioxide
CRM	Customer Relationship Management
CZ	Central Zone of the London Congestion Charge Scheme
DfT	UK Department for Transport
DSRC	Dedicated Short Range Communication
ECTRI	European Conference of Transport Research Institutes
EETS	European Electronic Tolling System
EFC	Electronic Fee Collection
ERP	Electronic Road Pricing – the term used particularly in Singapore
EUR	Euro (European Community) 1.00 EUR = 1.29 USD = 0.82 GBP
GBP	Pounds Sterling (Great Britain). 1.00 GBP = 1.21 EUR = 1.57USD
GHz	GigaHerz – a frequency of 1 billion cycles per second

GNSS	Global Navigation Satellite System (e.g. the American GPS, the Russian Glonass, the European Galileo and the Chinese Beidou)
GPS	Global Positioning System
HGV	Heavy Goods Vehicle
HOT lanes	High-Occupancy Toll lanes – lanes on a roadway which can be used only by High-Occupancy Vehicles (HOV), or on payment of a toll
HOV lanes	High-Occupancy Vehicle lanes – lanes on a roadway which can be used only by High-Occupancy Vehicles – i.e. vehicles with at least one (or in some cases two) passengers in addition to the driver – the objective being to encourage car-pooling.
IU	In-vehicle Unit (in the Singapore ERP scheme)
LEZ	Low Emission Zone
LPAC	London Planning Advisory Committee (a statutory body established after the abolition of the Greater London Council)
LRUC	Lorry road user charging
LSVA	Leistungsabhängige SchwerVerkehrsAbgabe – the Swiss Heavy Vehicle charging scheme
m	million (10^6)
MLFF	Multi-Lane Free Flow road charging (European terminology, equivalent to the ORT acronym used in the USA, and implying all-electronic tolling with no toll barriers)
MPV	Multi-Purpose Vehicle
MRB	Motorrijtuigenbelasting – Dutch motor vehicle tax
NOK	Norwegian Kroner. 10 NOK = £1.04 = 1.25€ = $1.64 (11 August 2010)
NSTIFC	The US National Surface Transportation Infrastructure Financing Commission
OBU	On-Board Unit
OECD	Organisation for Economic Co-operation and Development
OPEX	Operational Expenditure
ORT	Open Road Tolling (US terminology, equivalent to the MLFF acronym used in Europe, and implying all-electronic tolling with no toll barriers)
PCN	Penalty Charge Notice
PM10	Particulate Matter of size ≤10 microns
ROCOL	Road Charging Options for London
RZ	Restricted Zone - the charged area within the Singapore Area Licensing Scheme (ALS)

SEK	Swedish Kronor 10 SEK = £0.87= 1.05€ = $1.36
SGD	Singapore Dollar 1 SGD = 0.47GBP = 0.57EUR = 0.73USD
SOV	Single Occupancy Vehicle
SRN	The UK Strategic Road Network: The inter-urban road network including all motorways and trunk ‘A’ roads managed by the Highways Agency, plus the M6 Toll
TASTS	Towards a Sustainable Transport System. See DfT (2007a)
TDP	(charging by) Time, Distance, and Place (i.e. charging by the actual distance travelled, by time of day, and by location (e.g. whether it is an urban or rural area, or by class of road.)
TfL	Transport for London
TRX	DSRC Transceiver
TTI	Texas Transportation Institute
USD	US Dollar 1.00 USD = 0.64 GBP = 0.78 EUR
UWE	University of the West of England
VED	Vehicle Excise Duty
VMT	Vehicle Miles Travelled
VOSA	UK Vehicle and Operator Services Agency
VRM	Vehicle Registration Mark (number-plate or licence plate)
WAN	Wide Area Network
WEZ	Western Extension Zone of the London Congestion Charge Scheme

11 Appendix B: Types of Road Pricing

Although it probably does not affect public acceptability significantly, note that we are particularly concerned here with electronic charging and tolling – vignettes and other paper-based or cash-based schemes (section 12.1) are obsolescent, and in general are being phased out. For example, in the USA many toll plazas are being converted from barriers with cash payment to all-electronic operation – Open Road Tolling (ORT) – known in Europe as Multi-Lane Free Flow (MLFF).

The charging scheme classification outlined below is based on the ITS(UK) White Paper (ITS(UK), 2007). Note that in all cases charges may be also be based on vehicle type or emission class.

11.1 Point-based charging: tolling

This is charging at a single point such as bridges and tunnels, for example the Dartford Crossing and the Tamar Bridge in the UK.

11.2 Area licensing and entry permit schemes

Road users who wish to use their vehicles within a defined area during a defined time period purchase an area licence, which may be a paper licence displayed in the vehicle, or the number plate (also known as the licence plate or Vehicle Registration Mark/VRM) entered into a computer database. The London Congestion Charging Scheme is an area licensing scheme based on declaration of the vehicle's VRM. Cambridge in the UK was also considering an area-based scheme (Cambridgeshire, 2007).

In entry permit schemes, vehicles need a licence to enter a defined area, i.e. this applies to moving vehicles passing through entry points on a defined boundary. The paper-based Singapore *Area Licensing Scheme* that operated from 1975 until 1998 was actually an entry permit scheme.

These schemes are simple to understand and straightforward to implement. But they are a blunt instrument for influencing travel demand, because charges are typically levied on a time period (e.g. a day), rather than a 'per trip' basis, so there is no incentive to restrict the number of trips or the distance travelled. There are also practical limits on the number of licence variants (e.g. charging zones, time periods, vehicle types) within a scheme.

11.3 Cordon charging schemes

These are the most commonly proposed form of electronic road pricing, and have been implemented in Bergen and Oslo in Norway, Stockholm in Sweden and in Singapore. They involve setting up a cordon of charging points around a defined area of a town. Road users are charged each time they cross the cordon. Cordon charging has the significant advantage that each trip made into the area is charged, which can therefore influence the number of trips. Charges can also be varied by time of day and vehicle type. On the downside they have 'boundary effects', which may lead to increased parking just outside the boundary. Also residents just inside or outside the cordon may feel disadvantaged, and redistribution of traffic onto roads outside the cordon may occur (though the evidence in general is that it does not – see sections 5.5.1 and 4.3.1).

Multi-cordon (two or more concentric cordons – as proposed for Edinburgh and Manchester in the UK) and zone-based charging schemes are more complex variations on the theme. They can more closely reflect problem traffic movements, and boundary problems can be reduced, but they may be more expensive to implement and more difficult to understand. There is some evidence that this was a factor in the public's rejection of the Edinburgh scheme, and suggests that for public acceptability it is better to implement a simple scheme initially, even if it is sub-optimal (Gaunt et al., 2007).

11.4 Time- and distance-based charging schemes

Distance-based charging schemes charge by distance travelled, for example on toll roads, where distance between toll plazas is known. They reflect a usage-based approach more accurately than other schemes. Charges may also vary to some extent by time of day and/or day of the week.

Time-based charging schemes charge by time spent in a defined area, which does not directly relate either to distance travelled (and hence to wear and tear on roads), or to congestion – a vehicle may be parked off-road. This may be why there are no schemes of this type currently in operation. Also research has suggested that they would induce drivers to drive less safely (May et al., 1998) and may not be acceptable because of the unpredictability of charges in advance.

The most recent and most sophisticated variant is 'Time-Distance-Place' (TDP) based charging, where charges are related to distance travelled, to time of day and to location, so that charges are higher at certain times of day (e.g. rush hours) and in certain places (e.g. town centres).

11.5 Closed tolling

The most common form of interurban highway tolling is closed tolling, where the toll is related to the distance travelled between entry and exit points on the toll road. The charge is measured by registering when and where the vehicle enters and leaves the toll road network; thus there is a need for a series of entry and exit points. See for example the French motorway network, the M6 Toll in the UK, Highway 407 in Toronto, and the Melbourne City Link.

12 Appendix C: Charging Technologies

It is sometimes stated that the technology for UK national road pricing is not available or is not proven. The examples given in earlier sections of this paper should demonstrate that it is available, and is in widespread and successful use world-wide. The three electronic technologies used are described below. Note, however, that they are not necessarily competitors, but rather are complementary, and indeed all three are used to some extent in existing schemes such as the German and Swiss lorry-tolling schemes.

However, we will start with an obsolescent technology – the vignette.

12.1 The vignette

Paper vignettes – coloured paper stickers rather like the UK road tax disc, attached to windscreens – have been used to implement road pricing of one form or another for many years. They are relatively cheap to implement, but manually intensive to enforce, and inflexible in use.

The Eurovignette (EU, 2006; 2010) is a road user charge. Heavy goods vehicles with a gross vehicle weight of 12 tonnes must buy it to use motorways and toll highways in any of the Eurovignette countries (Belgium, Denmark, Luxemburg, the Netherlands and Sweden). The annual charge is €1,329 to €2,233, depending on the emission category, or €11 per day.

Vignettes for lorries have been used in other European countries in the past but have been largely abandoned or are being phased out in Austria, Bulgaria, Czech Republic, France, Germany, Hungary, Poland, Romania, Slovakia and Switzerland in favour of electronic road pricing. As indicated in section 5.4, vignettes were abandoned in Singapore in 1995. And during previous LRUC consultations in the UK, respondents supported distance-based taxation rather than time-based paper vignettes (section 6.2.1).

However, as Linnemann (2011) has pointed out, no European country has gone direct to a kilometre-based road charging scheme; all have gone via a vignette scheme, which lasted from 7 years in the case of Austria to 16 in Switzerland, and even longer in the case of the proposed road pricing schemes in Denmark and Belgium. Furthermore, as of October 2008 an electronic version of the vignette has been available, in which the vehicle number-plate is used as a link to a database entry, replacing the paper sticker (see also below). And an advantage of a vignette scheme, as a stepping stone to distance-based road pricing, is that people become accustomed to paying for their road use.

12.1.1 The Freight Data Feasibility Study

In December 2005, the UK Government set up a Haulage Industry Task Group to study fuel prices, freight taxes and foreign competition. In April 2007 the DfT awarded a contract to carry out a *Freight Data Feasibility Study*, to identify options (including a HGV vignette scheme) to compile a database linking non-UK vehicles to their operators, including associated costs, benefits and risks. Part One of the study identified 11 options for compiling this database, including vignettes and road pricing; it reduced this to a shortlist of four options, including vignettes but not road pricing.

A vignette scheme has the following advantages. It:

- achieves a high percentage of registrations in a short space of time;
- allows a charge, so bringing in revenue to pay for the scheme;
- requires self-registration and thus makes individual operators take responsibility for registering;
- allows relevant information to be captured from the HGV operator, thereby improving data quality; and
- has fewer strategic legal concerns (e.g. compliance with European law) than some of the other options.

The disadvantages are that a vignette:

- would require significant investment in technology to process registrations and payment;
- would offer comparatively slow realisation of benefits if the database were compiled only from journey registrations;
- would require a significant marketing campaign to make operators and drivers aware of the need to purchase a vignette;
- would require detailed legal risks related to the Eurovignette Directive (such as whether cash payment kiosks are required across the country, and relating to the precise coverage of roads included in the scheme) to be addressed;
- could take up to three years to implement from a decision to progress the scheme (assuming relevant legislative provisions could be included in a Finance Bill);
- would have a business case that was highly dependent on difficult-to-predict revenue estimates; and
- would limit financial revenue received by government, due to the restrictions imposed by the Eurovignette Directive.

The final report (DfT, 2008b) outlined a scheme in which UK hauliers would purchase a vignette at the same time as payment of VED. Foreign hauliers would register with the scheme authority via the Internet or telephone, and would be assigned a unique ID. They would then purchase a vignette to cover each journey to the UK made by a vehicle in their fleet, using the internet, phone, or cash at ferry agents or train operators. The purchase record would identify the operator, the vehicle and the validity dates for the vignette. The unique identifier of a vehicle would be its VRM and country of registration.

Vehicles that did not have a valid vignette when they arrived in UK could be identified during checks at ports and motorway service areas by VOSA (the UK Vehicle and Operator Services Agency). Unregistered vehicles would pay a penalty.

The study considered the use of ANPR for more widespread enforcement, but concluded that it would be costly and of limited value.

Scheme costs were estimated as £194 million over 10 years, or £104 million over 5 years (these durations being chosen because the scheme would be superseded by alternative EU legislation by 2015, and because full UK-wide road pricing was expected to be introduced within 10 years). But the benefit–cost ratios were only in the range 1.06 to 1.2 when 'optimism bias' was applied. So the 2008 Budget announced that the vignette scheme should not be progressed; other options were likely to offer better value for money and less risk (DfT, 2008b).

12.1.2 Vignette conclusions

The above study was carried out under the previous UK government. The position of the current Coalition Government is unclear. Rickett (2010) states that:

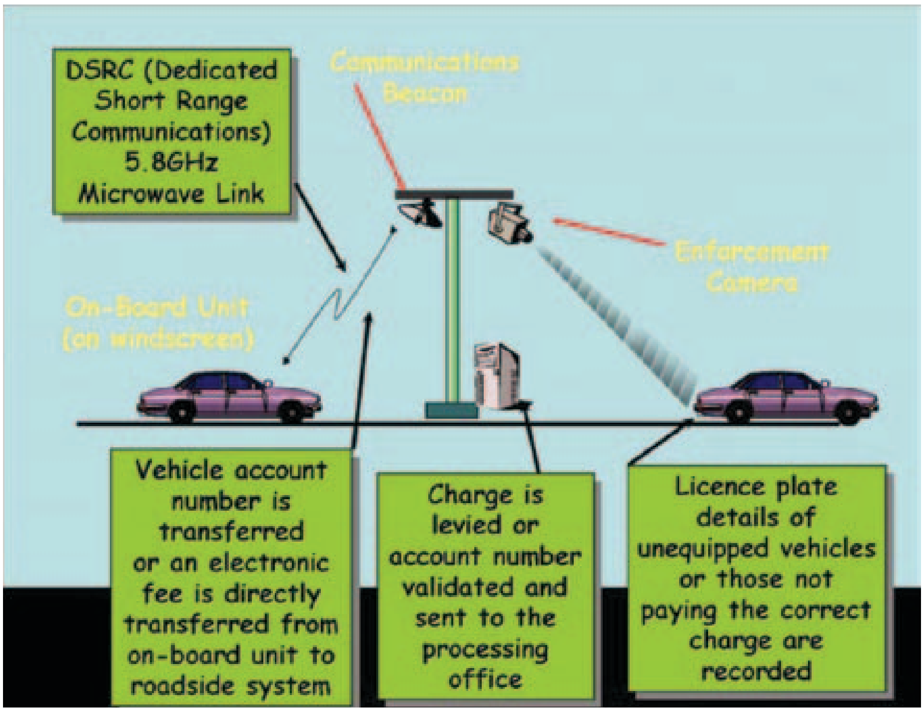
> 'There is a commitment to introduce lorry road user charging in the Coalition Agreement. Provided this is a commitment to charge lorries by time, place and distance, as in Germany, then it may be an encouraging first step in a new direction. If it is just a scheme to introduce paper permits, or 'vignettes' for lorries, as in other parts of Europe, then it is a lost opportunity'.

We agree with this, with the caveat that an electronic vignette could be a useful starting point or interim measure.

12.2 Microwave tag-and-beacon

Contrary to what some people have argued, the microwave electronic technology for road pricing is not only effective and available commercially, but has been in use in many places world-wide for over twenty years: the world's first commercial electronic toll scheme at Ålesund in Norway, commenced operations in October 1987; the Oslo toll ring began operation in 1990; the Singapore ERP scheme in 1995; Highway 407, the world's first all-electronic highway, in Toronto in 1999 (Pickford & Blythe, 2006; ITS(UK), 2007). It operates as illustrated in Figure 23, where a vehicle equipped with a battery-powered OBU (Figure 24) communicates with a transponder on an overhead or roadside gantry to register its passage through the charge point. Unequipped users would have their number plate recorded by a camera and identified via ANPR either at the roadside or at a remote back office. The microwave technology is virtually 100% efficient in detecting equipped vehicles.

Figure 23: Microwave tag-and-beacon charging technology with camera enforcement



Source: Courtesy of the Transport Operations Research Group, University of Newcastle

Figure 24: A microwave tag as used in the Austrian lorry tolling scheme

Source: Courtesy of Kapsch TrafficCom Ltd

Figure 25: A charging point in the Austrian lorry charging scheme

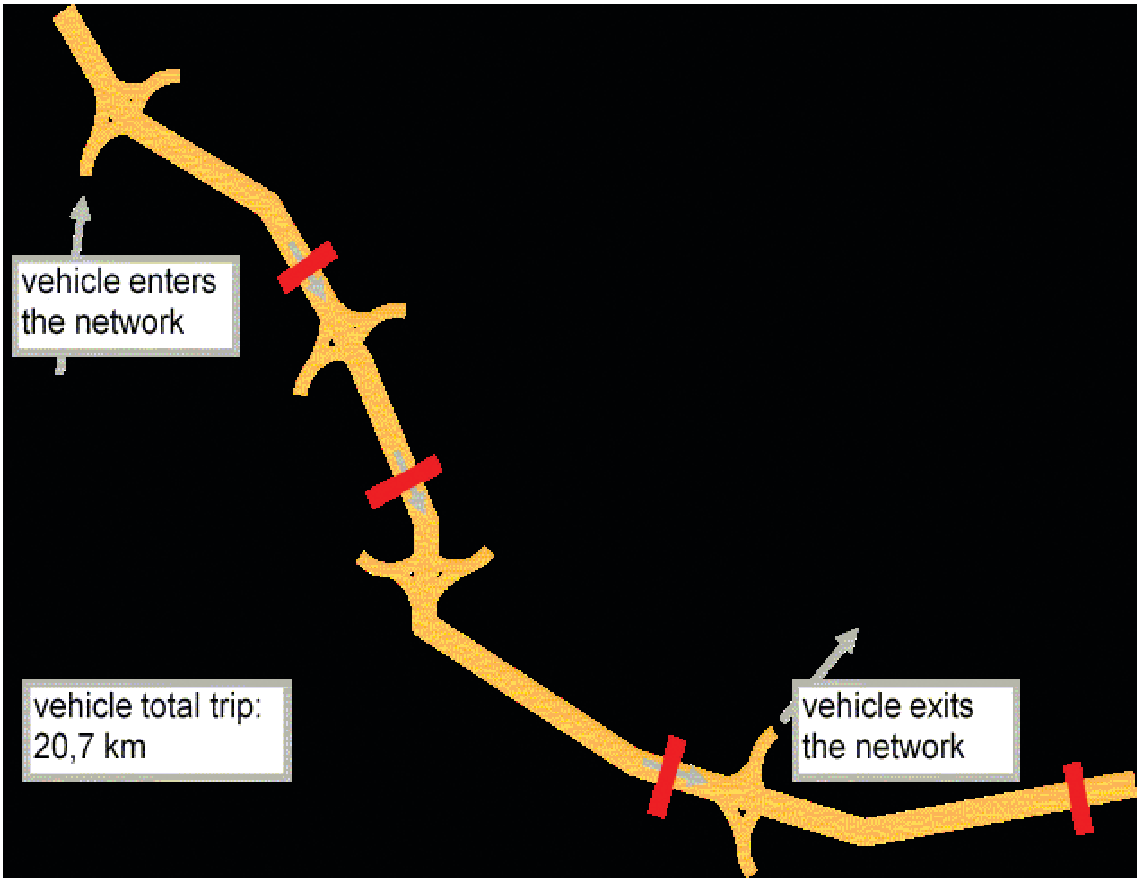
Source: Courtesy of Kapsch TrafficCom Ltd

Tag-and-beacon based charging can charge by time and place but not by actual distance travelled, except on a very coarse scale, because it only detects vehicles as they pass beacons on gantries or roadside poles (Figure 25 and Figure 26).

12.3 Automatic Number Plate Recognition (ANPR)

ANPR used to be regarded as only 80–90% accurate. However, the experience in London (section 4.3.1) and more recently in Stockholm (Eliasson, 2010; Hamilton, 2010) suggests that cameras plus ANPR can have a detection ratio of 95–99% with a small amount of manual support (i.e. with human beings checking the number plates that the ANPR cannot resolve), so that the DSRC tags and beacons can be dispensed with. The Stockholm story is particularly interesting – section 5.5.

Figure 26: Charging points are located between junctions.

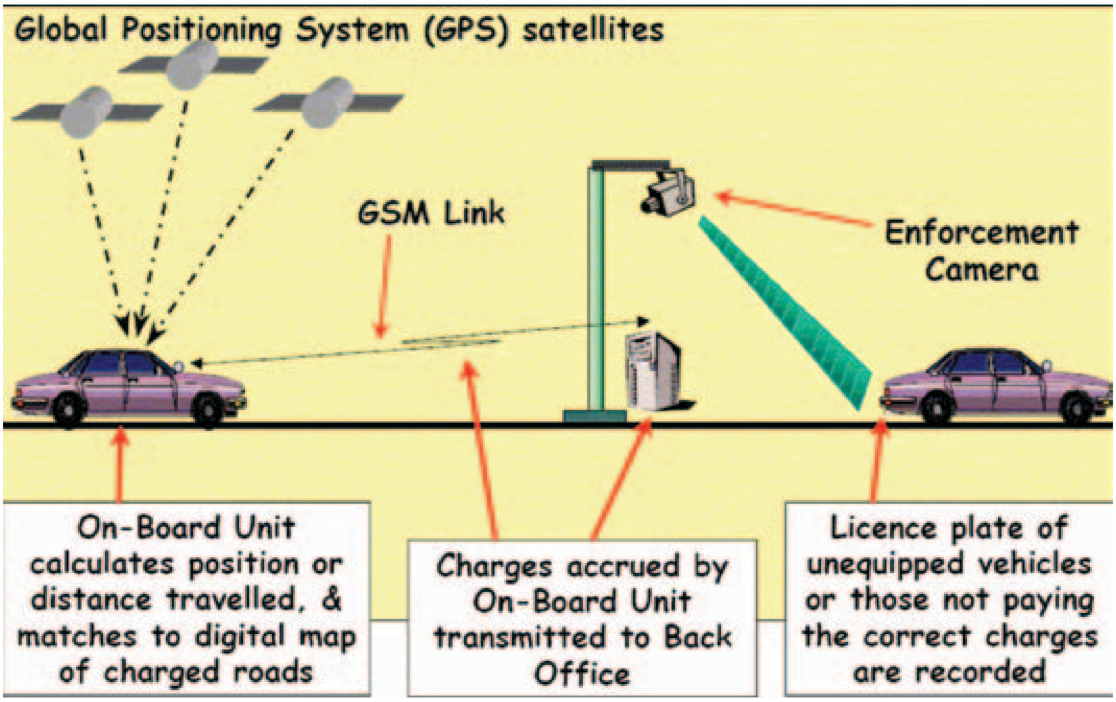


Source: Courtesy of Kapsch TrafficCom Ltd

12.4 Satellite-based charging

An alternative scheme which dispenses with DRSC beacons is shown in Figure 27. A GPS receiver in the vehicle, combined with a digital map of the road network, enables the vehicle to calculate which road it is on – exactly like a satnav. If a charge apples to that road at that time of day, it can be calculated either in the vehicle or sent via a mobile radio link to the back office, which calculates the charge – the so-called 'Thick Client' (also known as 'Intelligent Client') or 'Thin Client' approaches respectively. There are pros and cons to each approach. The Thick Client needs a more powerful OBU containing a digital map, which needs to be kept up to date, as does the road tariff data; but privacy of the vehicle's location is easier to maintain. The Thin Client is a much simpler, cheaper unit, and only the digital road map and tariff data in the back office need to be updated; but maintaining privacy is a bit more complicated – though, as the Trusted Driver project demonstrates, it can be done (http://trusteddriver.com/#Top).

Figure 27: Satellite-based charging technology



Source: Courtesy of the Transport Operations Research Group, University of Newcastle

Although GPS technology on its own may not be able to accurately identify which of two adjacent roads a vehicle is on at any one instant, the use of 'map-matching' (i.e. comparing a series of locations with the digital map) significantly improves the accuracy. The availability of other GNSS such as the Russian Glonass, the European Galileo and the Chinese Beidou, as well as upgrades to GPS, will further increase the reliability and accuracy of this charging technology. Augmentation technologies such as heading sensors can also improve positioning accuracy, although they may increase the complexity and cost of the OBU.

Satellite-based technology is currently the only realistic way to achieve true Time-Distance-Place (TDP) charging (section 11.4).

Satellite-based charging has been used in the German motorway tolling scheme since 2005 (Kirchmann, 2008; Estiot, 2008), covering 12,500 km of motorways, with over 650,000 lorries equipped as of mid-2008, and generating €3.4 billion in revenues in 2007. The charging is based on motorway segment lengths, so it is not true TDP charging. It has also been used in Slovakia since January 2010, for lorries of over 3.5 tonnes on 2,000 kilometres of highways and parallel first class roads. Again, it is not true TDP charging; it uses zones, though this makes it simpler to implement.

13 Appendix D: UK Road and Traffic Statistics

13.1 Road Statistics 2009: traffic, speeds and congestion

Table 34: GB Road Traffic Statistics 2009

Motor vehicle flow by road class, Great Britain: 1993 to 2009[1,2]

Thousand vehicles/day	Major roads					Minor roads			
		A-roads							
	Motorway[3]	Rural	Urban	All A-roads	All major	Rural	Urban	All minor	All roads
1993	58.2	8.9	19.2	11.3	14.4	0.7	2.1	1.3	2.9
2000	69.6	10.0	20.1	12.4	16.4	0.8	2.2	1.3	3.3
2001	71.6	10.3	20.1	12.6	16.7	0.8	2.2	1.4	3.3
2002	73.0	10.5	20.2	12.8	17.0	0.8	2.3	1.4	3.4
2003	73.3	10.7	20.1	13.0	17.2	0.8	2.3	1.4	3.4
2004	74.9	10.9	20.3	13.1	17.5	0.9	2.4	1.4	3.5
2005	75.5	10.9	20.1	13.1	17.5	0.9	2.4	1.5	3.5
2006	76.6	11.0	20.3	13.2	17.7	0.9	2.2	1.4	3.5
2007	77.4	11.0	20.0	13.2	17.7	0.9	2.4	1.5	3.6
2008	76.9	11.0	19.7	13.0	17.6	0.9	2.4	1.5	3.5
2009	76.5	10.9	19.8	13.0	17.5	0.9	2.3	1.5	3.5

1. Average daily flow is estimated by dividing the annual traffic estimate by road length and number of days in the year

2. Urban roads: Major and minor roads within an urban area with a population of 10,000 or more.

3. Includes trunk motorways and principal motorways.

Source: DfT (2009d, Table 2.4; last updated June 2010)

13.2 Proportion of foreign registered vehicles in GB traffic

Table 35: Foreign registered vehicles in GB traffic

Proportion of foreign registered vehicles in GB traffic, by country, region and body type: 2009

Region	Percent			
	Cars	Light vans[1]	HGVs	Buses & coaches[1]
North East	0.1	..	2.2	..
North West	0.2	..	2.9	..
Yorkshire and the Humber	0.2	..	4.0	..
East Midlands	0.1	..	3.0	..
West Midlands	0.2	..	3.4	..
East of England	0.3	..	5.3	..
London	0.4	..	2.0	..
South East	0.3	..	7.6	..
South West	0.3	..	3.2	..
England	0.2	..	4.2	..
Wales	0.3	..	3.5	..
Scotland	0.3	..	1.7	..
Great Britain	0.2	0.2	3.9	1.0

[1] Sample sizes for Light vans and Buses & Coaches too small to produce robust estimates at local authority level

Source: DfT (2009d, Table 2.10; VED Evasion Survey, last updated June 2010)

The Royal Automobile Club Foundation for Motoring Limited is a charity which explores the economic, mobility, safety and environmental issues relating to roads and responsible road users. Independent and authoritative research, carried out for the public benefit, is central to the Foundation's activities.

RAC Foundation
89–91 Pall Mall
London
SW1Y 5HS

Tel no: 020 7747 3445
www.racfoundation.org

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