ELECTRONIC ROAD CHARGING

- *Can the technology reduce congestion?*
- *How acceptable would it be?*

Charging drivers for road use could raise revenues for transport projects and reduce congestion and improve the environment in urban areas. The results of initial trials of both the technology and driver behaviour are becoming available, but many issues remain unresolved. The Transport White Paper in May 1998, will be the opportunity for Government to clarify its view on the future role seen for such technologies.

This briefing examines recent experience, current research and its implications.

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POSTnotes are intended to give Members an overview of issues arising from science and technology. Members can obtain further details from the PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (extension 2840).

BACKGROUND

Projections of future traffic consistently show substantial increases in demand (**Box 1**). Previously, such estimates were used as an input to defining the need for new roads but, following the recognition by the Department of Transport (DoT) in 1994 that new roads generate additional traffic, the previous Government accepted that the capacity necessary to meet future forecast traffic demand could never be provided. Policy thus moved from the old 'predict and provide' approach to one of demand management.

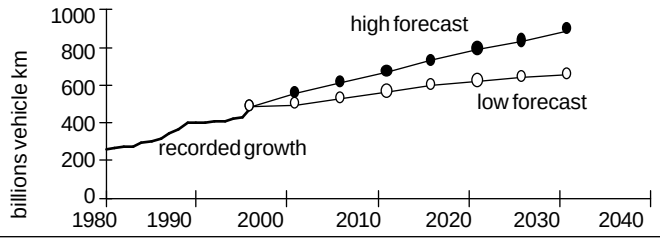
Road user charging (RUC) could have a role to play in reducing overall demand and the Royal Commission on Environmental Pollution (RCEP) concluded in 1994 (and also in 1997) that RUC could help reduce the dominance of motor traffic if local authorities were given powers to introduce RUC in their own areas. The last Government set in train technology-development and proving trials (see later), envisaging that motorway charging could make more effective use of the existing network, provide an extra source of finance for improving roads, make users more aware of the costs of road use, and help encourage private sector involvement in road provision. Legislation was introduced to allow tolling on privately financed roads (through the 1991 New Roads and Street Works Act).

At the local level, the 1997 Road Traffic Reduction Act requires local authorities to draw up plans to reduce traffic in their areas. Also, the Road Traffic Reduction (United Kingdom Targets) Bill is currently before Parliament and would give the Secretary of State powers to set national targets for reducing traffic if other mechanisms failed. **Neither however, provides the necessary legal authority for local authorities to introduce RUC schemes.** Questions on whether and how traffic growth might be restrained using pricing signals featured again in the present Government's consultation on developing an integrated transport policy, and may thus feature in the White Paper in Spring 1998.

BOX 1 ROAD TRAFFIC TRENDS

The forecasts under which the last Government's policy was debated (1989 National Road Traffic Forecasts) projected a doubling of the distance travelled by car from 1989 to 2025. These overestimated traffic growth because they assumed that road capacity would continue to expand to meet demand and thus underestimated the constraining effects of congestion. The latest (1997) projections published by DETR expect traffic in 2031 to be 36-84% higher than in 1996 (Figure). Looking at different types of roads, the forecasts suggest that traffic on motorways might double by 2031, while that on urban roads might increase by 31-70%. Journey times are also expected to increase - possibly doubling on urban motorways by 2031.

Figure TRAFFIC GROWTH AND PROJECTIONS, 1980-2031



EXPERIENCE TO DATE

Motorways/Toll Crossings

Charges for using motorways are well-established abroad but limited to tolled estuary crossings in the UK (**Table 1**). At the Dartford Crossing, ~46 million toll payments are made each year, of which 7.5M (15%) are made using the DART-TAG automatic payment system. Worldwide, there are currently ~17,000 toll-gated lanes of which 36% are equipped with automatic vehicle identification (AVI) antennas such as DART-TAG[1]. By 1997, the capital cost of these schemes had reached ~£2.7B and they generated ~£2B / yr in revenue. Maintenance costs account for about 10% of revenue.

Table 1 EXAMPLES OF ELECTRONIC MOTORWAY TOLLING PROJECTS

Country	Scheme	Commenced	Electronic transactions (million/yr)	(%)
UK	Dartford Crossing	1991	7.5	16%
	Mersey Tunnels	1993	3.8	15%
	Severn Crossing	1993	1.5	15%
Canada	Highway 407, Ontario	1997	14	50%
Australia	Melbourne	due 1999	36	100%

Source: Transport Technology Publishing

The vast majority of these schemes comprise adding the capability for electronic payment onto an existing lane at a toll plaza and thus require drivers to slow down, and perhaps change lane, to pass through. The ideal system would automatically charge drivers without their having to alter their driving behaviour. Such a full-speed free-flow tolling system could require:

- a 'dumb tag' or an on-board unit to carry a payment system with vehicle details and amounts of credits
- means of detecting the vehicle and 'talking' with the on-board unit or interrogating the tag;
- the 'back office' systems to work out charges, issue bills and enforce the tolls.

The requirements of such systems are described in more detail in **Box 2.** To date, the only operational full-speed free-flow electronic RUC system is on the 69-km Highway 407 in Canada (see Table 1) which, since October 1997, employs radio communications between overhead gantries and transponders on the windscreens of passing vehicles. Vehicles without transponders are detected and a video image of the rear number plate is taken at entry and exit points, and drivers billed later. Following an early underestimate of demand, there are now 100,000 vehicles fitted with transponders (i.e. in 50% of vehicles using the road), and in its first year, the operators expect to receive $70M (rising to $100M per year by 2000).

UK trials for electronic RUC for motorways were proposed by DoT in July 1995, and 8 industrial consortia expressed interest in participating. Six consortia planned microwave systems to communicate between road-side gantries and in-car units (the main differences related to the size of the microwave beams used, and the methods of locating, classifying and charging a vehicle). One consortium proposed infrared communications, while the final system was based on using global positioning systems - where an in-car unit would use satellites to determine the vehicle's position.

Before the trials began, however, six consortia dropped out; leaving only those led by Bosch-Telecom and GEC Marconi - both of whom were operating 5.8 GHz microwave systems. Two trial sites were established on opposite sides of a 2.2km circuit test track, with gantries and track-side facilities such as power and communications links to a central control centre. Tests covered small to large cars, multi-purpose vehicles, light and heavy goods vehicles, motorcycles, coaches and buses. Results are available for 50,000 tolling transactions for each system tested. On the basis of these, TRL concludes "*the trials have demonstrated the ability of both systems to toll vehicles at a variety of vehicle speeds, for a range of environmental conditions, and for both normal and unusual traffic manoeuvres.*" Also, both systems could capture images of violators in a wide range of traffic, speed, weather and lighting conditions.

Box 2 ELECTRONIC ROAD USER CHARGING SYSTEMS

There are two main components to ERUC systems:

'front-end' equipment which includes the systems for:

- detecting a vehicle in the road (e.g. via microwave beacons fixed to overhead or road-side gantries) in order to classify the type of vehicle and verify its payment system;
- enforcing a penalty if a vehicle does not have valid payment system by taking photographs of number plates;
- communicating with a vehicle to transact the toll charge, using either simple 'dumb' tags or sophisticated 'smart-card' systems.

'back office' systems for**:**

- handling the very large amounts of data involved in tolling potentially millions of vehicles each day;
- verifying the transactions (and communicating with the enforcement agencies in the event of a violation);
- handling payments, managing accounts and generating bills;
- integrating systems to ensure that all communicate.

In practical terms, a driver could fit an on-board unit (OBU) onto the windscreen, into which is inserted a smart-card carrying information on the registration number of the vehicle and the amount of credit remaining. As the driver passes a road-side beacon, charges would be deducted automatically, and displayed on the OBU.

Charges might be levied in a number of ways:

- where vehicles cross from one area (or 'cordon') to another;
- depending on the level of congestion on a particular road;
- depending on the levels of pollution in an area.

The driver might be able to pay the toll through:

- an 'electronic purse', where the road-side beacons deduct money from a pre-paid card (cf phonecards);
- a smart-card or tag linked directly to the driver's bank account for instantaneous payment (as with debit cards);
- a smart-card or tag linked to an account held elsewhere for later billing and payment.

Urban Areas

There are no **urban** systems in place anywhere in the world on which working models can be based[2], but some local trials are underway in the UK funded by DETR in collaboration with local authorities (**Box 3**).

These studies have led to some concerns about the prospects for developing a viable urban ERUC scheme. While the early demonstration of the basic technology in Cambridge can be viewed as a technical success, the consultant's study in London showed how difficult it would be to implement congestion charging in large cities and also the likely extent of public resistance to such schemes despite the potential benefits. This caused

1. These use read-only ('dumb') tags fitted to the offside bottom corner of the windscreen, which are interrogated by antennae mounted on poles adjacent to the lane. A signal is then sent to a central control office, where bills are generated and sent to customers.

2. Although not an electronic RUC scheme, Singapore has had a paper-based licence system to restrict entry to the city centre and found that traffic levels dropped by 20%; an electronic version is now planned. Proving trials are being completed now, and full implementation will begin in March. Also, Trondheim, Oslo and Bergen in Norway have operated a tolled ring cordon for some years.

Box 3 URBAN ROAD USER CHARGING TRIALS

Cambridge - In 1993, a demonstration trial showed that it was technically possible to install and operate a system comprising road-side beacons and on-board units. Vehicles also had displays, showing the distance travelled and the cost of the journey. Vehicles were charged according to the level of congestion, as determined from the distance travelled over certain distances, but this encouraged drivers to speed through cordons to make up for congested spots, and reduce the charge. As this raised safety concerns, such a charging scheme is no longer considered suitable.

London - In 1995, the DoT supported a mathematical modelling study of the effect of congestion pricing on traffic in London. The study looked at two illustrative charging schemes. The simplest was a single cordon for central London, defined by the inner ring road. The second, comprised the central area with two additional concentric cordons, each split into four sectors. The effects of low and high charges on traffic and journey speeds under each scheme were investigated, and the results are summarised in the **Table.**

TABLE EFFECTS OF CONGESTION CHARGING ON CENTRAL LONDON TRAFFIC

Charge	Single Cordon		Triple Cordon	
	traffic	speed	traffic	speed
low (£2)	-8%	+10%	-5%	+9%
high (£8)	-22%	+32%	-17%	+26%

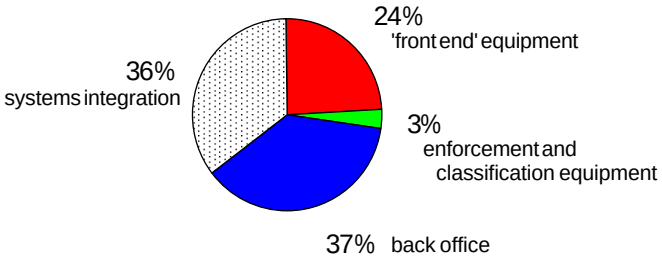
Source: MVA Consultants

Significant traffic reductions and savings in travel time resulted with an £8 charge to enter Central London, and this led also to reduced pollution levels along certain road corridors. The capital costs were estimated to be £240-340M, and the system would cost ~£150M/yr to operate. The revenues generated would be expected to be 3-5 times the operating costs (including enforcement), and the consultants estimated that over the 30 year life of the system, up to £3B would be generated, thus providing a significant revenue stream for re-investment into public transport. Nevertheless, because of the sheer size and complexity of the road network, the technology was considered not yet sufficiently advanced. Also, the level of public acceptability was not high enough to make congestion charging in London feasible for at least 10 years.

Newcastle, Bristol and Leicester - In 1997, small scale trials began to determine drivers' reactions to urban road tolls. Field trials are aimed at studying drivers' responses to a range of RUC tariff structures, to identify ways of reducing diversion from charged roads, and to improve estimates of the benefits of charging. The results of the experiments should be published by the end of 1998. Early indications are that drivers are quite resistant to switching from their vehicles; charges of £3 per day are reported as reducing commuter car usage by only 15%, and the toll needs to be set higher (perhaps £5-10) to deter many from driving at peak times. Such trials also reinforce the danger that drivers may simply divert to non-tolled roads to avoid the charge, and other difficulties of evasion.

attention to switch to smaller urban centres as possible sites of early ERUC introductions - hence the experiments currently underway in Newcastle, Bristol and Leicester. Until the full results of the trials are available, it is not possible to know urban road pricing's effects on car use, and there are also questions how far these studies will deliver definitive results because of constraints such as a small sample size. Also, for legal reasons, volunteers were not paying real tolls in the experiment, but were given smart-cards complete with money credits to a certain level, and allowed to keep the balance on the card at the end of the trial period. This motivation to reduce car use may not be the same as when drivers must make decisions with their own money.

Figure 2 COSTS OF ELECTRONIC TOLL COLLECTION



Source: Transport Technology Publishing

ISSUES

Is the Technology Ready?

Trials to date suggest that the basic technologies required for communication between beacons and vehicles, and for automated payment are capable of dealing with a range of traffic and weather conditions. However, experience of actual implementation costs and practicality are limited to small-scale motorway charging schemes operating on previously tolled roads or (in the case of Highway 407) on a new road built specifically to include ERUC. Because ERUC equipment has not yet been mass-produced, the current £2.7B implementation costs of electronic toll booths provides little guidance as to the costs of implementing free-flow tolling systems. There are other uncertainties; for example, at toll plazas, electronic payment is voluntary (i.e. cash lanes are still accepted), and it is easy to detect violators. On a free-flow system however, technologies would need to be more sophisticated, and would need to be be able to cope with large amounts of fast-moving traffic, creating huge volumes of high-speed data and placing heavy demands on 'back-end' systems for data handling and processing. On roads which had not been tolled before, enforcement might also be very demanding.

As **Figure 2** shows, under the current system of electronic toll booths, back-end systems already comprise the lion's share of costs, and so for free-flow or urban ERUCs, they may become even more dominant. In this respect, **many of the trials to date have concentrated so far on 'front end' equipment,** and not yet examined whether back-end systems would be able to function adequately. Most observers in Europe recognise that further research will be necessary to clarify this, as well as other aspects such as diversion to untolled roads etc.

In contrast to the relatively 'straightforward' application of ERUC to traffic flowing freely on a motorway, urban road networks are complex and provide many opportunities for diversion from tolled roads to side-roads and 'rat-runs', many interruptions to flow, and a greater variety of road-users and driving. **Technology which demonstrates resilience in these conditions has not been tested** or validated, and much research remains to be done on the communications technologies themselves, the in-car and payment systems they use, and the charging formula. Critical too will be the violation detection and enforcement methods, and the back-office systems and systems integration with other 'telematics' applications, such as route guidance and traffic information systems. Added to this technical uncertainty, the Bristol and Leicester trials aimed at the 'psychology' of ERUC leave much uncertainty over real effects on behaviour; here preliminary indications underline other findings that willingness to forego commuting by car is related to the quality and availability of alternatives, so that substantial investment in public transport alternatives may be needed before ERUC in urban areas is publicly acceptable.

Road Pricing in Context

With the current emphasis on developing an integrated transport policy, not all the previous Government's aims for RUC apply to the same degree. Principally, the initial prospect that revenue would be devoted to building more roads is clearly no longer valid; instead, there is a broad consensus between many environmental and transport organisations that ERUC's acceptability to the general public is linked to monies raised being recycled into providing otherwise unaffordable transport amenities (e.g. the proposed tunnel under Stonehenge) and broader public transport projects[3].

But increasingly, the emphasis is on reducing the amount of vehicle use where key factors are absolute and relative costs. At present, many of the costs of private transport, such as vehicle purchase, road tax and insurance are paid in advance of using the vehicle, and decisions whether to use the car on a specific journey seldom take this into account. Costs are more likely to be seen as the 'marginal cost' - basically the fuel, which RCEP found to be ~25% of total costs (even less if accidents, pollution and other external 'costs' are included). In contrast, the fare for each journey on public transport contributes to all costs - fuel, vehicle and infrastructure. In this context, DETR figures show that **motoring costs in 1996 were 2% lower in real terms than in 1974, while rail and bus fares have increased by 75% and 58% respectively** (while disposable income has increased by 62% over the same period). Thus, many point to there being an 'unlevel' playing field' between private and public transport modes. While ERUC remains an option for addressing the issue, other fiscal instruments could also come into play to redress such market distortions.

These issues are not unique to the UK and other countries have sought to develop a dialogue with the public and to understand what the 'informed' public might see as justified. As mentioned in POST's earlier report on sustainability in transport, the Danish Consensus Conference on the future of private transport distilled out three primary principles: -

- shift from fixed to running costs by increasing petrol price;
- vehicle taxes should reflect the environmental impact and encourage clean and energy-saving cars;
- restore the 1982 price differential between public and private transport (when public transport was relatively much cheaper).

Where the 'macro' picture still leaves local road use too high, ERUC remains an option to develop, but if ERUC is pursued, results so far underline the importance of it not just being seen as a 'technology' challenge, as many other issues would need to be addressed in parallel with further technological development. For instance, the philosophy of ERUC links to public acceptability, and thus motives need to be clear and supported by the public. Ownership may be important (whether LA, or private agencies). The more advanced systems could also allow vehicle movements to be tracked very efficiently and potentially lead to tensions with some views of privacy, making dialogue with the Data Protection Registrar and the DVLA desirable. When it comes to practicalities, there are many other questions, including where best to focus RUC, collateral effects of toll charges (e.g. on diversions to non-charged roads), possible effects on local economies, and international compatibility (both within the UK and the EU).

Given these complexities, the next major step towards more technologically advanced ERUC systems is likely to **require trials with 'real' money and real decisions in specific locations.** At present, current legislation does not permit such trials, making this a **key issue for the White Paper on integrated transport to address**. Meanwhile, while substantial uncertainties remain over technical and implementation issues, the option remains to apply simpler, non-electronic charges (e.g. a supplementary vehicle licence for those driving into a city), notwithstanding the difficulty of enforcement.

3. Whether toll revenues might be hypothecated in such ways is being looked at by the Treasury as part of a general review of motoring taxation.