Electronic Road Pricing in Hong Kong: An Opportunity for Road Privatization?

IAN CATLING AND GABRIEL ROTH

The Hong Kong Government investigated the feasibility of introducing electronic road pricing (ERP) to the territory as a means of controlling congestion. By selectively charging road users at busy times and places, road pricing offers a method of restraining the usage of vehicles on the road network and is potentially more equitable and more efficient than the main alternative policy option, restraint of car ownership. To assess all aspects of the feasibility of ERP, the government engaged Transpotech to carry out a 2-year pilot project. A full subset of the road system engineering components of a road-pricing system ran successfully for more than 6 months in the central area of Hong Kong. Evaluation of the system has shown that there are no technological barriers to the introduction of ERP in Hong Kong. A major transportation study was conducted to assess the effects of road pricing in Hong Kong. The results showed that full system would be extremely efficient and cost-effective, and a number of viable schemes were presented. The accounting, administrative, and legislative aspects of ERP were fully investigated and reported on by Transpotech. These aspects present no problems. ERP was presented as a method of restraining traffic and not as a way of financing roads. Privatization issues were not explored in the studies, nor in subsequent discussions. ERP was not well received by local people and the government of Hong Kong is not proceeding with the implementation of a full ERP system.

In 1985 Transpotech completed a 2-year contract with the Hong Kong Government to demonstrate the viability of electronic road pricing (ERP) in the territory. The work was described in detail elsewhere *(1–4)*.

The contract was *(a)* for the supply of the pilot stage of a potential full system, involving a complete subset of such a system, installed and working in central Hong Kong and *(b)* for transport studies to assess the effectiveness of road pricing as a new and efficient tool for the control of traffic congestion.

Transpotech was supported by a number of subcontractors and suppliers. Plessey Controls Ltd., supplied all of the road system engineering equipment, which was developed from the company's experience with traffic control systems and automatic vehicle identification systems. The MVA Consultancy completed a major study of Hong Kong's traffic conditions up to 1991 and the effects that alternative implementations of a full road-pricing system would have. Other suppliers included GEC Avionics; Logica, who helped to provide a demonstration accounting system for the pilot stage; Logica's sister company in Hong Kong, Jardine Logica Systems; and a number of other Hong Kong–based firms.

The project progressed extremely well: all of the equipment was installed on or ahead of schedule and worked well above its performance specifications; the accounting and administration of a full system were thoroughly investigated; a detailed final system outline design was proposed; and transport studies showed that ERP offers a highly efficient and equitable method of dealing with Hong Kong's intense traffic problems.

I. Catling, Ian Catling Consultancy, 19 Marchmont Road, Wallington, Surrey SM6 6NT, England. G. Roth, The Services Group, 1815 North Lynn Street, Suite 200, Arlington, Va. 22209.

WHAT IS ERP?

ERP is a system for automatically assessing vehicles for road-use charges at specific locations and time periods. Unlike conventional tolls, it does not require vehicles to stop, or payments to be made, when the charges are incurred.

Figure 1 shows how the ERP system works. A small, inexpensive and extremely tough solid-state device called an electronic number plate (ENP) is attached in minutes to the underside of each vehicle. The ENP is a passive unit that contains custom-built integrated circuits and will transmit a unique identification code.

A series of charge zones, which in the Hong Kong urban area would include as many as 200 sites, is defined, and motorists are charged for each zone boundary crossed during busy times. At each site an array of loops is buried in the road surface. As a

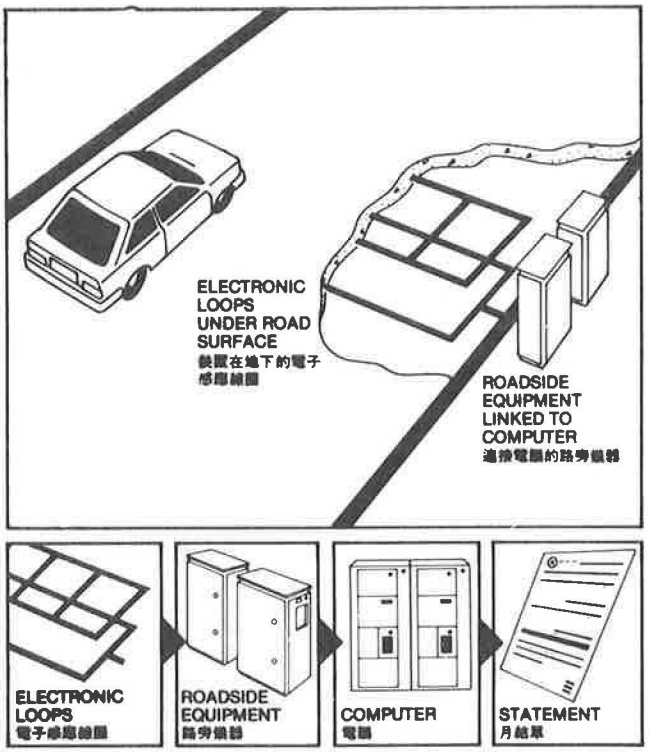


FIGURE 1 ERP system.

vehicle passes over the array, a power loop energizes its ENP, and one of a series of inductive receiver loops picks up the vehicle's transmitted coded identity.

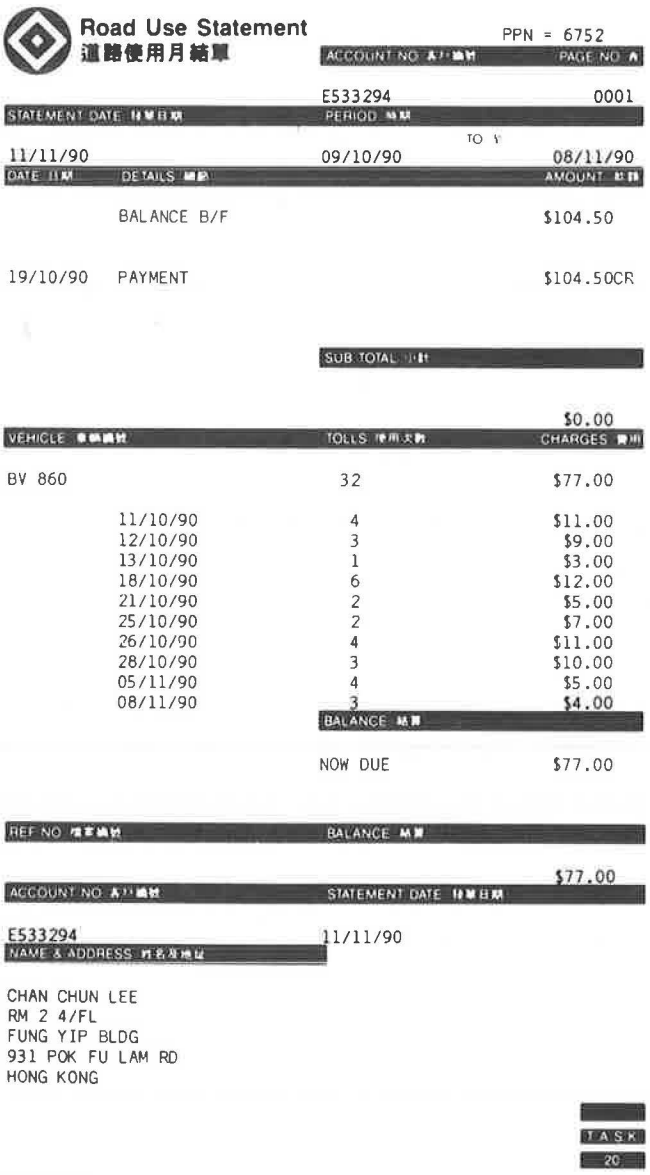
Roadside cabinets similar to those used for traffic signal control contain a number of microcomputers that handle data from the receiver loops. These contain vehicle detection logic, interrogators to decode the ENP signals, and modems for transmission of data to the control center.

At the control center vehicle data are rigorously checked and validated before being passed to the accounting system that generates regular bills for vehicle owners. The design of the control center computers makes innovative use of local area network computer technology, which means that the system can be designed in an extremely efficient modular fashion using inexpensive microcomputers and that the pilot scheme is a true subset of a full system, which does not require the use of large mainframe computers.

Validated data are accumulated during the month, and each owner is sent a statement of road-use charges at the end of the period. The bill is similar to a credit card statement, and in Hong Kong would be payable by a number of methods familiar to vehicle owners. A typical statement is shown in Figure 2.

A closed-circuit television (CCTV) system, supplied in the pilot scheme by GEC Avionics, with cameras installed at selected sites, ensures that any vehicle without an ENP—or one the owner of which is trying to cheat the system—is photographed. The pictures are transmitted to the control center where appropriate enforcement action is automatically initiated.

The system incorporates strict controls on access to the vehicle data collected and ensures that no permanent record of a vehicle's movements is kept. Although records of individual transactions are kept until after the appropriate charges are paid, there is no record of individual trip patterns or of who was driving a vehicle—the CCTV photographs are specifically designed for number plate recognition and do not include the driver of a vehicle.


Road Use Statement
道路使用月結單

PPN = 6752

ACCOUNT NO. PAGE NO.

E533294 0001

STATEMENT DATE PERIOD

TO

11/11/90 09/10/90 08/11/90

DATE	DETAILS	AMOUNT
	BALANCE B/F	$104.50
19/10/90	PAYMENT	$104.50CR
	SUB TOTAL	$0.00

VEHICLE	TOLLS	CHARGES
BV 860	32	$77.00
11/10/90	4	$11.00
12/10/90	3	$9.00
13/10/90	1	$3.00
18/10/90	6	$12.00
21/10/90	2	$5.00
25/10/90	2	$7.00
26/10/90	4	$11.00
28/10/90	3	$10.00
05/11/90	4	$5.00
08/11/90	3	$4.00
	BALANCE	
	NOW DUE	$77.00

REF NO. BALANCE

$77.00

ACCOUNT NO. STATEMENT DATE

E533294 11/11/90

NAME & ADDRESS

CHAN CHUN LEE
RM 2 4/FL
FUNG YIP BLDG
931 POK FU LAM RD
HONG KONG

TASK
20

FIGURE 2 Typical statement.

POLICY BACKGROUND OF ROAD PRICING IN HONG KONG

By 1982 Hong Kong's increasing prosperity had led to such pressure on the roads from a rapidly increasing vehicle fleet that, despite a massive road-building program, traffic problems were reaching intolerable levels in the urban areas during workdays. At that time private cars accounted for two-thirds of the total vehicle fleet and their numbers were increasing by more than 10 percent per year. The government sought to check the spread of congestion by taxes on car ownership. The actions taken to increase the cost of motoring included, for example, a trebling of the annual license fee and a doubling of the first registration tax on new vehicles entering the territory.

Car ownership actually dropped and the fiscal measures were certainly effective in taking cars off the road at congested times and places, but these fiscal measures also removed cars from uncongested roads and denied many people the choice of whether to use their cars on uncongested roads. The government recognized that ERP would be more efficient and fairer than ownership restraint.

Figure 3 shows that more than 40,000 cars have been given up since 1982 and that pressure from the fast-growing economy is expected to bring about an increase in the number of cars. Without more restraint of some form, by 1991 there will again be too much traffic competing for the heavily congested road network. If the restraint were to take the form of continued increases in car ownership taxation, annual license fees equivalent to U.S. $2,500 could be the order of the day.

PILOT-STAGE TECHNOLOGY

Introduction

In the Central district of Hong Kong Island, 18 on-street sites were successfully installed for the pilot stage (two off-street sites were used for commissioning and testing). The sites defined a "watertight" zone through which any vehicle entering Central had to pass, and the test sites within the zone

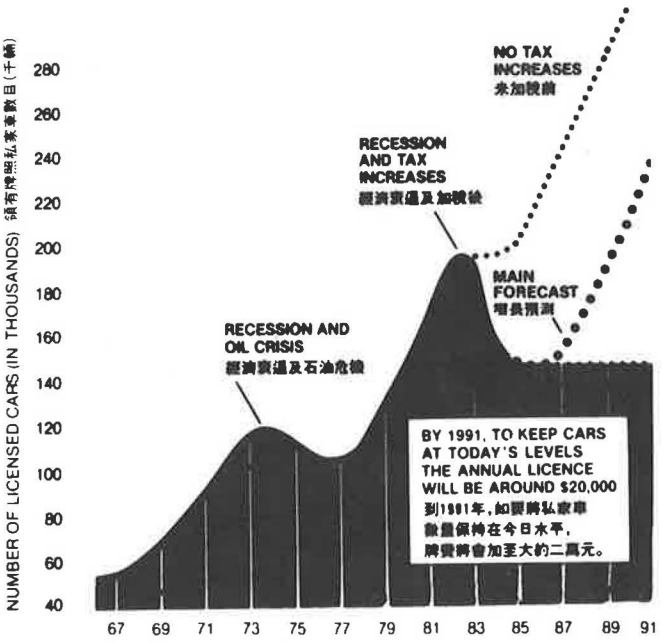


FIGURE 3 Car ownership.

ensured that most movements through the system generated three or more transactions.

More than 2,500 vehicles were fitted with ENOs for the pilot stage. About 1,200 of these were government vehicles, 700 or so were buses, and the remainder belonged to volunteers—companies and individuals—who regularly used the area. A wide range of vehicle types was included, and there were no difficulties in fitting the ENP quickly and simply (average fitting time was around 5 min).

All of the control center computers were installed on or ahead of schedule and successfully handled the large amount of data (about 30,000 transactions per day) generated by the vehicle fleet as it crossed the Central sites.

The pilot-stage data-capture equipment was a complete subset of a potential full system. Because of the modular nature of the control center computers, the design and implementation of each part of the pilot-stage system were also appropriate to a full system.

Electronic Number Plate

Each vehicle was fitted with an electronic number plate, which transmits a string of data on a phase-modulated signal to a roadside interrogator at each outstation. The data included a securely coded serial number that uniquely identified the vehicle. The standard ENP requires no electrical connection and, once fitted, requires no manual intervention and is maintenance free.

Outstation

The roadside outstation is housed in a cabinet identical to those used for traffic signal controllers. It is made up of an interrogator connected to a number of loops of cable buried in the road, a processor, a transmission unit, and a number of interfaces to local equipment. The interrogator demodulates the signals from each road loop and passes the identity data to the processor, which implements message assembly and transmission to the central office.

The outstation has a number of interfaces with external equipment:

- Closed-circuit television interface. Some outstations are fitted with camera equipment to capture photographs of vehicles that have not been satisfactorily identified and transmit these photographs to the central office. The outstation computer passes information (such as registration mark) to the camera equipment for automatic imprinting on photographs and controls requests for the transmission of photographs.
- Police terminal. A portable terminal or handset may be plugged into any outstation to provide information for purposes of police enforcement. The display can indicate the status of each vehicle and show whether its ENP identity has been received by the outstation or whether it appears to be an "unfitted" vehicle.
- Maintenance handset. A maintenance handset may be plugged into any outstation to enable the operation of the outstation to be checked and to obtain a readout of the fault log.
- Toll display unit. Each outstation is designed to drive a toll display unit. The display would show the toll rates as specified by the operating authority. The toll display unit would be controlled by its own microprocessor so that rates displayed could be confirmed, operational faults reported, and default to a null or zero charge display enforced.

Control Center

Vehicle identity data are transmitted from the outstations to a control center via telephone lines. Processing within the control center is distributed among

- A set of communication controllers to handle communications with a fixed set of outstations;
- A set of data validators, each responsible for a subset of all available ENPs; and
- The supervisory processor that supervises the system as a whole and performs "anomaly" processing.

All processors are interconnected via the Ethernet Local Area Network (LAN) because each one may need to communicate with any other and the system must be capable of handling a large amount of data in real time.

ACCOUNTING AND ADMINISTRATION

The pilot scheme included a demonstration accounting system that provided most of the functions of a full system, including the production of simulated statements similar to those that would be sent to vehicle owners (Figure 2). Interfacing with the Hong Kong computerized vehicle-licensing system was most encouraging and Transpotech successfully integrated the accounting system into the control center.

Part of Transpotech's project brief was to report on all aspects of implementing and running a full ERP system, and the legislative and administrative requirements were fully investigated. The lessons drawn from the development of the demonstration accounting system, together with the definition of a full system's administrative requirements, led to the outline specification of a joint accounting and administrative system. Some of the more detailed work was undertaken by the Hong Kong–based systems house, Jardine Logica Systems.

The specification of the administrative requirements included a thorough assessment of debt collection procedures. Similarly, the use of automatic enforcement procedures was fully specified. These procedures were based on the CCTV system, a small team of enforcement officers, and a system of vehicle "call-in" notices that would operate if there was the suspicion of a faulty ENP.

OTHER POTENTIAL USES OF THE SYSTEM AND THE TECHNOLOGY

Automatic vehicle identification (AVI) offers a large number of exciting possibilities beyond the direct application to road pricing. Some of these have been investigated in the course of the Hong Kong pilot-stage project, others are still ideas.

One of the major side benefits of an ERP scheme would be its potential for automatic traffic data collection. For various purposes, data are needed by traffic authorities on traffic counts, trip matrices, journey items, routes, and axle counts. An ERP system could fulfill all of these requirements, automatically and at a fraction of the cost of the extensive special surveys that are currently conducted.

The benefits of real-time traffic information from an ERP system would be substantial. The police, motoring organizations, and local radio stations all need up-to-the-minute information about traffic conditions and incidents.

One of the major potential applications of AVI technology is in automatic toll collection. The costs of running a conventional toll collection facility are substantial, and a number of toll authorities around the world have been investigating the potential of AVI for some years. The technological advances made by Plessey in recent years, in particular in the Hong Kong project, have made the practical widespread automation of tolls a realistic possibility.

The system could also easily be applied for billing buyers of fuel; a simple loop at the entrance to a service station would be easy to install and could offer enormous administrative savings.

With well-defined and closely controlled access to the system, the system offers potential for tracing stolen vehicles. Because the system is quite securely designed, the movements of a stolen vehicle could be tracked between zones.

In the longer term, perhaps the most exciting use of the technology might be in systems that rely on two-way communication between on-board vehicle computers and roadside equipment. Automatic route guidance—based on genuine real-time traffic conditions—is indeed a practical possibility, as is a comprehensive in-vehicle driver information service.

POLITICAL RESULTS

After the technology was shown to be effective and reliable, local authorities in Hong Kong were invited to comment on the advisability of introducing it as a method of restraining the use of congested roads. The system was explained in a brightly colored booklet entitled *A Fair Way to Go (5)*, and the government undertook to reduce annual license fees if ERP were introduced, so that the cost of using vehicles on uncongested roads would fall substantially. But the local authorities did not support ERP, and the government has decided not to introduce it, except possibly as an optional method of paying tolls at the entrances to the Cross Harbour Tunnels. Observers believe that the opposition to ERP is due to vehicle owners objecting to paying more taxes and having their journeys monitored.

The second objection might have been met by giving motorists the option of paying a (large) fixed fee. The first is more difficult because the fiscal system of Hong Kong (like that of the United Kingdom) recognizes no formal connection between the amounts paid in road-user taxes and expenditures on roads. Although the Hong Kong Government proposed a reduction in vehicle licensing fees in its proposal for ERP, it did not satisfy the objectors, who feared that the fees could easily be raised subsequently.

A SELF-FINANCING ROAD AUTHORITY?

Might the Hong Kong authorities have been more successful if they had proposed to treat the financing of roads like that of other scarce resources such as, say, electricity or telephone *(6)*? A financially independent Hong Kong Road Authority could, for example, be established to act like a private concern by charging market-clearing prices, paying all its costs (including rent of land, payable to the city), and expanding the road network as far as was financially viable. Furthermore, the ERP technology developed in Hong Kong could allow private suppliers, independent of government, to add road links (such as the Cross Harbour Tunnel), install their own pricing loops, and collect payment by means of monthly bills, as do the private long-distance telephone companies in the United States. The Hong Kong ERP proposals, proven to be technically workable, can be used not only to restrain traffic but also to privatize road space. ERP offers the possibility of the private sector providing not only vehicles but also roads on which to run them. This possibility, if allowed, would give road users the strongest defense against the authorities' collecting excessive revenues from a road network restricted in size: the power of the private sector to provide, at a profit, alternative road links would limit the power of the government to extract monopoly profits from its own network.

CONCLUSIONS

The pilot scheme of the Hong Kong ERP system successfully met its objectives. The technology for a full ERP system has been demonstrated by the pilot scheme. Exhaustive tests of the system confirmed that the Hong Kong pilot system was accu-

rate, reliable, and robust enough to be extended to a full system.

The transport studies indicated that ERP is the fairest and most efficient restraint policy option open to the Hong Kong Government for dealing with the continued problems of traffic congestion that are expected to be associated with continued economic growth.

The Hong Kong project brought together a number of significant technological advances and combined these with established theory to demonstrate the practicality of road pricing as an important method of dealing with traffic problems.

Public reaction to the scheme has been mixed. ERP was often perceived as an additional, rather than an alternative, tax on the motorist. It was certainly not regarded as a price for using roads. Its reception by the public, and particularly by motorists, might have been more favorable if it had been designed not only to restrain traffic but also as a method of enabling road users to pay for maintaining and strengthening their road network.

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Impact of Toll Policy in the United Kingdom

KENNETH J. BUTTON

Historically tolls played a significant role in financing the development of roads in the United Kingdom, but, with the exception of a limited number of estuarial crossings, they have now fallen into disuse. This paper is concerned with two issues. First, the role that tolls played in the early growth of the road system is discussed and lessons that may be learned from this are considered. Second, current official policy with respect to existing tolled facilities is examined. Attention is particularly focused on the financial problems that have arisen because of the presently favored "accountancy" approach to tolling and cost recovery. Some evidence is also offered that there are effects on industrial location and traffic patterns when only specific links in the road network are subjected to tolls. The main conclusion of this work, which itself stems from a much larger study of the tolling of estuarial crossings in the United Kingdom, is that there are serious problems in initiating ill-thought-out toll policies. Although on first-best economic principles there is a logical case for charging the road user the relevant costs of the infrastructure provided, and doing it in such a way that the user is fully cognizant of the resource costs involved in each journey, in a world where annual taxation and other less direct means of road user charges abound it is difficult to devise the appropriate second-best pricing rules on which tolls should be based. Simply "tacking" tolled facilities on to an existing road network is seen to be potentially distortive.

Applied Micro-Economic Research Group, Department of Economics, Loughborough University, Loughborough, LE11 3TU, England.

The road system in the United Kingdom is funded almost exclusively from central government taxation revenue and monies generated by local authority rates (i.e., property taxation). The designated trunk road network (including motorways) is the direct responsibility of central government, and the secondary and local road network comes under the local authorities (although there are substantial transfer payments from central government to supplement local rates in the financing of the system). Road users are not directly charged for using the vast majority of the road network and, indeed, although there have been attempts at assessing the relationship between the aggregate level of user charges (e.g., fuel taxes,