STRATEGIES FOR IMPLEMENTING AUTOMATIC VEHICLE IDENTIFICATION FOR CONGESTION PRICING

by

Neal A. Hudders

Professional Mentor
David Roper
Roper and Associates

CVEN 689
Transportation Information and Control Systems Design

Department of Civil Engineering
Texas A&M University
College Station, Texas

August 1992

SUMMARY

Congestion pricing has been considered by transportation economists as a viable means of controlling congestion. The basic concept of congestion pricing requires motorists to pay a fee when travelling on congested roadways. Pricing has not received serious consideration due to social and political barriers and a lack of technology. Recently, however, it has received more interest and several demonstration projects will be developed as part of the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA).

Automatic Vehicle Identification (AVI) is a process by which a vehicle can be identified while it remains in motion. To accomplish this, the vehicle is equipped with a transponder which is capable of transmitting a code to sensors in roadbed loops or mounted above the roadway. AVI systems are currently in use on some toll roads, such as the Dallas North Tollway, to automatically pay tolls, so drivers can avoid queues.

The advancements in AVI technology make a full-scale congestion pricing scheme a more feasible option because vehicles crossing checkpoints can remain in motion, reducing queues and delays at toll sites. There are, however, barriers that still exist in implementing a congestion pricing system using AVI technology.

Some of the technical barriers that need to be overcome deal with the accuracy and detection capabilities of the AVI transponder system, logistical problems dealing with the installation of the hardware, the outfitting of the vehicle fleet, geography, and the problem of uniformity of the system among multiple agencies in a region. The technical barriers may present complications in the implementation process, but overcoming the political and social barriers of gaining public acceptance is critical to implementation. The perception that pricing is an additional tax rather than an alternate tax is an important barrier, as is the fact that roads that would have a toll placed on them have already been built for public use by public funds. Other barriers include the question of invasion of privacy (as a system of this sort inherently tracks the location of vehicles), the question of equity (whether pricing would be in effect a regressive tax), and the effect of pricing on business and commercial activity in an area. All of these problems present formidable barriers to implementing an AVI based congestion pricing system.

The technical problems related to the transponders will be overcome as the technology improves, but the logistical problems may be difficult to overcome. The problems created by the installation of hardware and geography cannot be readily solved, but they can be dealt with in the planning of the project. The critical technical problem is outfitting the vehicle fleet with the proper equipment. The public must have incentives to buy into the system. Possible incentives include a rebate on other taxes (fuel, registration, income) and an appeal to the public's sense of responsibility to society and the environment.

A comprehensive and effective public education campaign is most important in overcoming the political barriers and gaining public acceptance. If the public can understand the concept early and have their primary questions answered, implementation will come much easier. To alleviate the concerns of the public several items must be

stressed in the public information campaign . First, motorists should know that the tolls they would pay are a user fee for using the road, not a congestion tax. With a toll system, revenues improve the quality of travel and reward motorists with lower rates if they drive at non-peak times. Regarding privacy, it must be stressed that this system is no different than a standard phone bill and that it will be illegal to divulge information regarding individual travel. Information will not be used for enforcement, and the operating agency is not concerned with individuals, just tags. Equity is a difficult issue to handle because any form of transportation system will be unequitable as higher-income individuals will always be able to pay more for better service. A congestion pricing system would likely not be any more equitable or unequitable than the current system, however. Very little is known about the business reaction to pricing because there has been no real example to follow. Future demonstration projects may provide more information in this area.

Congestion pricing may be a viable alternative for reducing congestion. For implementation to be effective, however, the political environment needs to be good, and the project must be presented in an effective matter. As technology improves and the results of demonstration projects can be studied, time will be an important factor in determining the future use of pricing.

TABLE OF CONTENTS

INTRODUCTION

Congestion pricing has long been considered by transportation economists as a viable means of controlling congestion. The basic concept of congestion pricing requires motorists to pay a fee when travelling on designated roadways, primarily during peak hours. The anticipated result of congestion pricing would be a shift in temporal, spatial, and modal flow patterns. Commuters would travel at different times, on different routes, or on different transport modes to avoid paying higher rates. These shifts would then reduce the demand placed on any one facility during peak periods such that congestion would be reduced and travel times would decrease for the remaining users.

Although the concept of congestion pricing has been around for many years, in the past it has not received serious consideration due to social and political barriers and a lack of technology . Recently, however, it has received more interest, as noted in *Moving America*, a statement of National Transportation Policy:

> "We also need to give greater attention to the potential for capacity-enhancing pricing techniques in transportation, such as peak-period or congestion pricing. . . . While congestion pricing is not a substitute for necessary capacity increases, it is one important way to encourage the most effective use of existing facilities, by shifting demand that would otherwise require additional capacity to other periods or modes. . . " (1)

The 1991 Intermodal Surface Transportation Efficiency Act also noted the possibilities for congestion pricing, calling for demonstration projects:

> "CONGESTION PRICING PILOT PROGRAM--The secretary shall solicit the participation of State and local governments and public authorities for one or more congestion pricing pilot projects. . . . The secretary shall monitor the effects of such projects for a period of at least 10 years, and shall report . . . every two years on the effects such programs are having on driver behavior, traffic volumes, transit ridership, air quality, and availability of funds for transportation. . . . Not to exceed $25,000,000 shall be made available each fiscal year to carry out the requirements of this subsection. . . ." (2)

This subsection shows the commitment for consideration of congestion pricing projects, and the need to look into the concept further, applying the latest technology.

Automatic Vehicle Identification (AVI) is a technology which can be used for congestion pricing that is capable of identifying a vehicle while it remains in motion, reducing delays and queues at toll sites. To accomplish this, the vehicle is equipped with a tag, or transponder, which is capable of transmitting a code to sensors located in roadbed loops or above the roadway. When a vehicle equipped with an AVI tag passes a sensor, the identification code of the vehicle is recorded by a computer, and a bill for the total amount of fees to be paid is sent to the motorist each month or a prepaid credit account is debited for each usage.

AVI systems are currently in use on some toll roads, such as the Dallas North Tollway, to automatically pay tolls, so drivers can avoid queues. (3) A congestion pricing pilot study was conducted in Hong Kong in the mid-1980s using AVI technology. While this study was technically successful, it did not develop into a working congestion pricing system due to social and political barriers discussed later in this paper. (4,5)

This paper examines the use of AVI in a congestion pricing system, the barriers to implementing such a system, and strategies for eliminating these barriers.

AUTOMATIC VEHICLE IDENTIFICATION

The use of Automatic Vehicle Identification (AVI) is expanding throughout the world, and particularly in the United States. To this time, the primary use of AVI has been for commercial vehicle operations and for electronic toll collection. (6) Its use for congestion pricing would be quite similar to its use for electronic toll collection. This section examines the available AVI technology, and its applications.

AVI for Congestion Pricing

An AVI system for congestion pricing would operate similarly to an electronic toll collection system and would normally be comprised of the following components (3,4,6):

- AVI Technology,
- Roadside equipment,
- Communications,
- Processing center, and
- Closed-circuit television system.

AVI Technology

The core of an AVI system is the AVI technology. This technology has two components: an on-vehicle tag and a device to read information from the tag. There are several different types of on-vehicle tags that can be used depending on the type of AVI technology. Each tag has an identification number that identifies that particular vehicle. This identification number can provide information on the type of vehicle, a unique code number for the vehicle, and the organization of the issuer. (6) As the vehicle crosses a checkpoint, the information on the tag is received by the reader. There are several different technologies available to read the information from the tags on passing vehicles. These include:

- Infrared (bar code)
- Optical
- Induction Loops
- Microwave/Radio Frequency

Infrared

The infrared (bar code) technology is similar to that currently used in grocery stores. A tagged vehicle has a bar code attached that is read by a laser scanner as it passes a checkpoint. The appropriate information is encoded in the tag by different line widths and spacings. This technology is not now considered as a feasible technology due to problems in reading the code at high speeds and sensitivity to extreme weather. (3)

Optical

Technology for AVI uses a video camera to read the license plate on a vehicle. The image is then digitized and processed to extract the license number. The advantage of this technology is that an additional tag for each vehicle is not needed. However, this technology is not used because of the complex processing equipment used to digitize the video image and sensitivity to extreme weather. (3)

Inductive Loop

Inductive loops embedded in the pavement were used in the Hong Kong ERP pilot study. The tag used for this technology is a sealed unit the size of a video cassette fitted underneath the vehicle. There is little difficulty fitting the tag quickly and simply, with an average fitting time of about five minutes. It contains no power source, does not need any connection to external devices, and will only operate when crossing a toll site. The toll site consists of a power loop which energizes the tag and several receiver loops to read the information from the tag. This technology had a high success rate in the Hong Kong pilot study with 99.7% of vehicle crossings accurately recorded. (4,5)

Radio Frequency

The radio frequency (RF) technology has been adopted for use in most United States AVI systems. This technology uses microwave frequencies to communicate to and from a vehicle. The tag used in RF systems is a transponder which can be either active, generating its own microwave signal, or passive, reflecting the microwave signal it receives. Active tags require power from either a battery or the vehicle, while passive tags do not. (3) Currently, most applications use passive tags. The tags used are slightly larger and thicker than a credit card, are placed on the windshield and can cost up to $30 apiece, but they will often be provided free by the operator of the system to entice the user to participate. (6) The receivers for this technology are located on a structure above the traffic stream.

The Dallas North Tollway uses this technology for toll collection to provide for more efficient toll collection and reduced traffic congestion. Over 40,000 tags have been issued as part of the system. Subscribers are required to maintain a prepaid toll balance and pay certain license fees and charges. The system is owned and operated by the vendor, Amtech, under contract to the Texas Turnpike Authority. (3)

Roadside Equipment

A roadside computer is needed to verify the identification number of each vehicle that passes the toll site. This computer also encodes the identification number with the date, time, and location before sending all information to a processing center. Other roadside equipment is needed to power and control the receivers. (4,6)

Communications

Currently, most AVI systems use leased telephone lines to handle the data transmission from the roadside computer to the processing center. An AVI system on the Hardy Toll Road in Houston is being planned and will initially use leased telephone lines for data transmission. In the future, however, the Harris County Toll Road Authority is planning on installing fiber optic cable for communications use. (6)

Processing Center

The processing center collects, checks, and stores all of the data received from the roadside equipment and controls and monitors the complete system. In a congestion pricing scheme, the validated data would be accumulated during the month, and each owner would be sent a statement at the end of the month.

In Hong Kong, the design of the processing center took advantage of local area network computer technology. This design uses inexpensive microcomputers in an efficient modular fashion that can be easily expanded with the simple addition of more computers. (4)

Closed-Circuit Television System

The final component of an AVI system is a closed-circuit television system. This system is used to provide enforcement of the overall system. A system of this type uses a TV camera to record the license plates of vehicles passing through the checkpoint with invalid tags. The picture could then be transmitted to the control center for administrative action. A high fine ($75 - $100) would be useful for effective enforcement.

Other Applications of AVI Technology

Outside of its use for Electronic Toll Collection and Congestion Pricing, AVI can have several other uses. An application that would prove very useful to the transportation departments is the use of AVI equipped vehicles as probes in the traffic stream. This would provide real-time travel time and speed information. This information would not only be useful for the transportation departments, but also for the users of the road network to help them make better decisions regarding travel route, time, or mode. Information of this type would be of great assistance in the developing Advanced Traffic Management Systems and Advanced Traveler Information Systems, which further enhance motorists' quality of travel. A further potential application of this technology is for collection of origin and destination information to provide better information for modelling and planning.

CONGESTION PRICING

Congestion pricing is a transportation systems management technique that attempts to spread peak traffic demands to less congested segments of the network and to less congested periods of the day. Although its application has been very limited in the United States, there is precedent for the general concept. The utility industries, such as telephone and electric services, bill under a congestion pricing scheme, although these industries usually refer to it as discounted rates during non-peak periods. For example, long distance phone rates are described as being reduced at night rather than increased during the day. There are several different arguments that can be presented for congestion pricing. This section will identify the different types of congestion pricing, the arguments for congestion pricing, and its anticipated effects.

Types of Congestion Pricing

There are three basic types of congestion pricing: area licensing, route control, and cordon control. (7)

Area Licensing

Area licensing is a very basic form of congestion pricing, and is being used in Singapore and several Norwegian cities. This type of control places a cordon around the central business district (CBD), and requires all vehicles to display a permit when entering the area during the morning peak period. In Singapore, this initially reduced the traffic level in the CBD by 60% during the morning peak. To some extent, congestion has increased around the perimeter of the CBD, but licensing has remained fairly effective. There are, however, limitations to this method. First, there are no restrictions to leave the CBD during the evening peak, which is often more congested. Second, to minimize the number of physical transactions on street, this type of system often allows the purchase of a permit for a set period of time (from days to one year). Once a permit is purchased, vehicle use is actually encouraged rather than discouraged. (5,8)

Because of these limitations, more comprehensive schemes will likely need to rely on some form of electronic payment for two reasons: first, because of the difficulty of collecting charges that relate closely to use and vary according to congestion levels (either directly, or using time and space zones as proxies); second, because of the problems associated with implementing a manual toll booth collection system. A manual toll booth collection system would require additional space and personnel as well as cause further congestion. (8) The electronic payment for such a system would be achieved through an AVI system. Route control and cordon control are two methods that could be utilized for congestion pricing using AVI.

Route Control

Route control can be used in an area where the congestion is concentrated on a few central routes, such as the freeways. A toll would be imposed on vehicles using a particular facility during specified hours (morning and evening peak periods). The total price of using the facility could either be based on distance traveled on the facility, or on a set price for each interim checkpoint crossed. A system of this type could be instituted on a single route or freeway that is particularly congested, or on an entire regionwide freeway network. While this method is aimed at diverting traffic from congested to uncongested routes, a potential problem with this method is heavier than expected migration of traffic to local streets that are not capable of handling that amount of traffic. This would also be disagreeable to the residents of the affected area.

Cordon Control

For areas in which congestion is evenly spread out among all facilities, cordon control may be more effective. This method places a cordon, or series of cordons, around the central area of a city. A toll would be imposed on any vehicle crossing the cordon on any facility during the specified hours. Ideally, the toll would vary by congestion level as well as time of day, but this would require a more complicated billing and pricing procedure and would likely confuse motorists. The biggest inequity with this system is for motorists who have a very short commute having to cross a cordon paying an amount equal to someone driving a much greater distance, but still only crossing that single cordon.

The Economic Argument for Congestion Pricing

Economists have argued for many years for the adoption of marginal cost pricing for congested roads. Their theoretical case for pricing derives from the rationale that automobile users should pay the full cost of the congestion their use of the road imposes on the public. (9) The private costs of travel are the costs that are considered by motorists. These costs are all the costs related to owning and operating a car (i.e., vehicle ownership, annual license, insurance, fuel, maintenance, etc.). Another private cost is the personal time that is taken to make the trip. Travel, is of course, a means to an end, and in making a trip, the individual benefits of making the trip must implicitly be weighed against the private costs. There are, however, consequential costs that are not reflected by the private cost that the individual motorist bears. Some external costs are borne indirectly by the motorists. These costs include the cost of building, maintaining, and operating, the road network.

Other social costs are not borne at all by the road users. These social costs include environmental pollution (e.g., noise, vehicle emissions). There is also a significant social cost related to the increase in travel times for other drivers as a result of traffic congestion. (10,11) If motorists actually paid the true costs (social plus private), each would face an economic decision as to whether or not to make the trip at that time. A motorist who values travelling during a peak period sufficiently would theoretically pay for these additional costs through a surcharge or a higher toll during the congested period. A motorist who did not so value his or her travel would change routes, time of travel, or mode.

Figure 1 shows the costs and benefits of road use. Line D'-D' is the travel demand during non-peak periods, and line D-D is the travel demand during peak periods. The current level of congestion is at point G, where the peak travel demand line intersects with the marginal private cost (MPC), the out-of-pocket costs with which the motorist is concerned. Economically, the intersection of the peak demand line and the marginal social cost (MSC) provides a lower congestion level (F) which balances the social cost of using the road. The additional "congestion charge" at this point would be equal to the difference between the MSC and the MPC. It is important to note that congestion is not eliminated, but simply reduced as the cost increases to account for the total cost of using the road. Congestion and delays will only be eliminated when the MSC is equal to the MPC. (10,12)

Congestion Pricing as a Means of Reducing Congestion

Reducing congestion is probably the most common reason agencies are looking at congestion pricing as a possibility. Indeed, congestion pricing is a means of reducing the number of vehicles on a facility during peak periods. Careful analysis of and repeated experience with various traffic alleviation methods demonstrate the effectiveness of auto restraint measures and the ineffectiveness of all other commonly recommended and readily available techniques. (14) The utility of congestion pricing is particularly evident when the specificity and duration of its effects are taken into account. Other auto restraint measures share a common weakness: they have only small indirect impacts when and where auto-related traffic problems are greatest.

In Hong Kong, registration and licensing fees were greatly increased in the early 1980s resulting in a limited reduction in actual automobile use, although automobile ownership was significantly reduced. This was because vehicles owned by families or corporations were used more intensively, and many of those owners who gave up use of their vehicles were owners who drove few miles. Another unfortunate result of these measures was that many low-income families in the New Territories section of Hong Kong, an area which is less dense and has less public transportation than central Hong Kong, were forced to give up their cars. The end result was that congestion in the central areas was not significantly reduced. (15) Hence, congestion pricing needs to be considered not because it is absolutely equitable and efficient, but because it, along with some other auto restraint strategies, may be the only means available to significantly reduce both long-term and short-term traffic problems. (14)

According to P. Jones and A. Hervik, a system that has a primary objective of reducing congestion in the inner city should have the following (8):

- A cordon, area license, or travel-related charge, depending on the circumstances;
- The restricted area boundary at a point where longer distance through traffic (without a trip end in the congested area) can detour to avoid payment, but one that incorporates the main congested area; and
- Charges that are normally varied by time of day to reflect congestion, being greatest at peak periods, and zero when traffic is light.

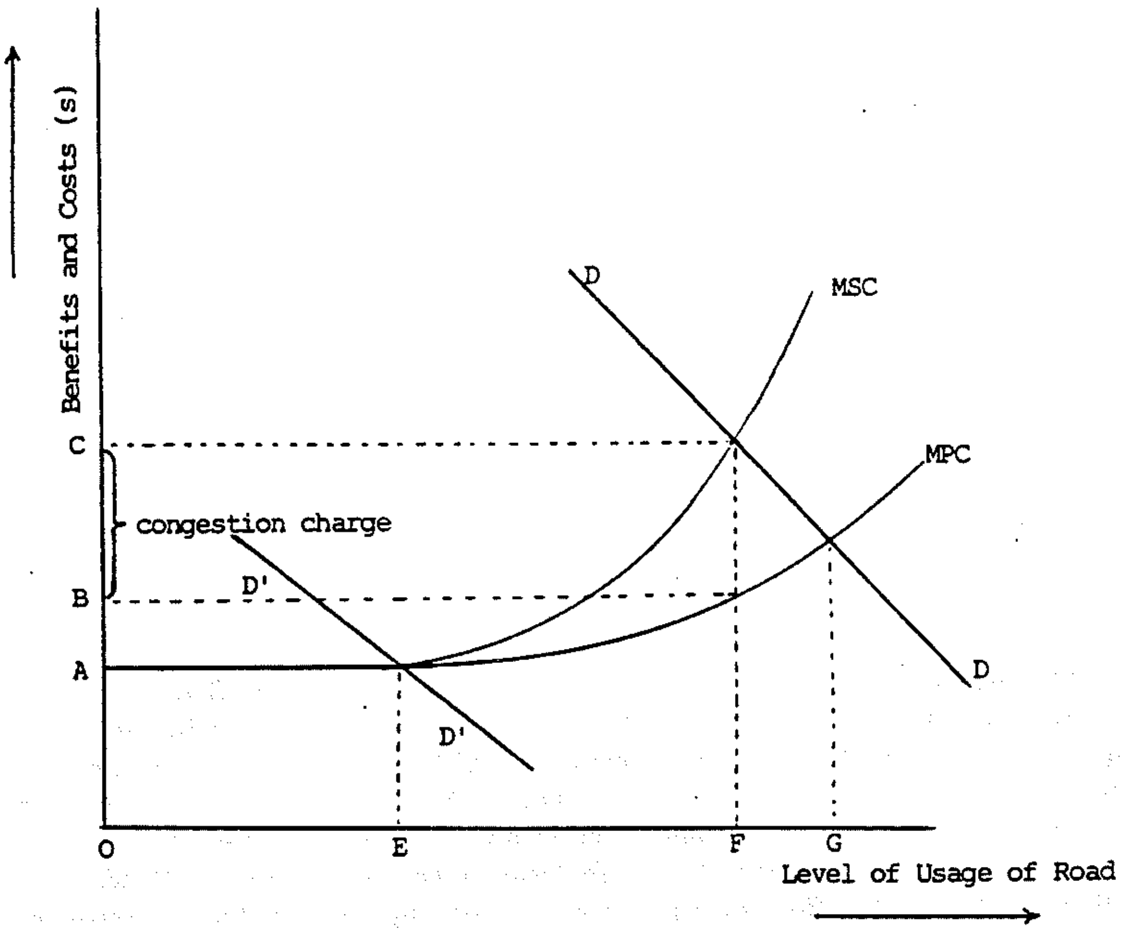

Figure 1. Costs and Benefits of Road Use (13).

These "rules" would apply for an area which has one central business district. The pattern of growth in this country, as opposed to Europe (their focus), would not allow as simple a solution. Houston, for example, has a downtown CBD, which attracts a great deal of traffic, but the West Loop is generally considered the most congested freeway. The West Loop is five miles from downtown, and adjacent to the Galleria/Post Oak area--another major generator. With several different congested areas, a system as simplistic as a single cordon around the CBD is not feasible. This shows the need for a more comprehensive system using AVI if congestion pricing were to be put in place in this country.

Motorist Options to Congestion Pricing

There are five basic ways in which motorists could avoid paying a high toll on a facility. According to a study done in the New York City area, the average motorist would react in the following order of preference to avoid paying a higher toll:

- Switch routes,
- Switch time of travel,
- Switch to transit,
- Travel less often or not at all, and
- Join a carpool.

The choices of alternative routes or time of travel vastly exceeded those choices that would take people out of their cars. More significantly, most motorists would make no change in their driving habits for toll increases of $3.00 or less. (12) Travel demand in the United States tends to be inelastic. For example, New York City doubled its bridge and tunnel tolls several years ago without a noticeable drop in cross-river traffic. The 25-30 percent increase and subsequent drop in the price of gasoline during the Persian Gulf crisis has likewise had little effect on the amount of driving. (9) In their *Assessment of the Application of Automatic Vehicle Identification Technology to Traffic Management, Appendix B*, Ferlis and Aaron reported an 18.6% reduction of trips and a 16.5% increase in speed--fairly substantial benefits of congestion pricing. They assumed, based on the success of the Singapore experience, a demand elasticity of 1.0. They also projected results using a demand elasticity of 0.1. This elasticity resulted in 3.9% reduction of trips and a 5.9% increase in speed. (7) These numbers are more consistent with the elasticities that are present in the United States. This shows that there would be an effect on the level of congestion, but it would not have the cure-all effect that many proponents believe.

Congestion Pricing as a Means of Environmental Improvement

Another reason for congestion pricing is the effect that it would have on the environment. The 1990 Clean Air Act has put pressure on major urban areas to reduce the amount of emissions. In order to achieve the goals set by the Clean Air Act, many new traffic reduction methods are being considered. One of these methods is congestion pricing. From an economic standpoint, congestion pricing pays for the cost of air pollution. This money could be used to promote more environmentally friendly modes. Also, by reducing the number of vehicles on a facility, pollution, as well as congestion, is reduced. Jones and Hervik suggest that if the primary objective of a pricing system is environmental, then (8)

- charges would be lower for "green" vehicles (fuel efficient, quiet, non/low polluting);
- an area-wide scheme (multiple cordons or an area license) would be more appropriate than a single cordon; and
- the area covered would probably be larger than for a traffic congestion objective, and the charges would probably cover a greater period of time.

These suggestions are probably more likely to be implemented in this country, due to the patterns of land use. The environmental impacts of congestion pricing, especially when looked at in the light of the 1990 Clean Air Act, are of importance, as is the goal of reducing congestion.

BARRIERS TO CONGESTION PRICING USING AVI

Although there are arguments for adopting a congestion pricing system using AVI, there are many barriers to actually implementing such a system. These barriers are not only technical, but also political. In addition, there is the question of public acceptance.

Technical Barriers

The Hong Kong pilot study proved that a congestion pricing system could be implemented on a small scale using AVI technology. The results showed that 99.7% of vehicle crossings were accurately recorded, roadside computers were working more than 99% of the time, and CCTV cameras had no difficulty identifying automobiles in testing for enforcement capability. (5) On a larger scale, however, there are technological, logistical, and uniformity problems that could hinder implementation.

AVI Technology

There are several problems surrounding the detection and enforcement of the system. A transponder could fail without the user knowing, and be considered a system violation rather than a simple equipment error. At high speeds, or in platoons, the CCTV system may not actually be capable of picking out the exact car that was in violation of the system. If a vehicle is changing lanes, it is possible that it could be recorded twice. The software needs to be capable of determining this error. (6,16) These questions need to be resolved before AVI can legitimately be considered for congestion pricing.

Logistical Problems

In order to implement a full-scale AVI congestion pricing system, several logistical problems must be addressed. The first of these problems deals with the installation of the hardware at the toll-site. For a route control system, this may not be a critical problem because the facilities concerned (freeways) are easily adaptable to the installation of the necessary hardware. Hardware installation would be a major problem in a full-scale cordon control system. With several different cordons and zones, a great number of checkpoints are needed. This could require a great deal of time and planning to install the necessary hardware at all checkpoints. Because checkpoints would be needed on all streets, structures may have to be built to accommodate the necessary hardware on local streets. This would likely be disagreeable to local residents.

Another logistical problem is outfitting the vehicle fleet with transponders. There is a problem in asking people to put something on their vehicle that will only end up costing them money. People need an incentive to entice them into buying the system. Also, while fitting a transponder to a single vehicle may not take a long time, outfitting the entire fleet in a city will be time consuming. A further problem is one of vehicles coming into a city from out of town, on business or vacation. These vehicles would not be equipped with transponders. Would they be able to use all facilities in an area, or would they be restricted from some because their vehicles are not equipped with the proper equipment? This is an important problem to consider in implementing a congestion pricing program using AVI technology.

The final logistical problem is a geographical one. The geography of a city makes a difference in the ease of adopting a program. Hong Kong is a city that is composed of an island and peninsula; it is virtually isolated from the main part of China. (15) Singapore is another city that is fairly isolated from other areas. Bergen, Norway placed a cordon around the city for an area licensing scheme. Due to the mountainous terrain of Bergen, only six toll stations were needed for access to the CBD. (17) The city of Vancouver, entirely on a peninsula, lends itself to the introduction of congestion pricing by the conversion of existing major water crossing to toll facilities. Most of the water crossings are congested bottlenecks during peak hours and can be considered the appropriate points for collecting a toll. (10) These examples show the importance of geography in implementing a system. In each of these cases, there are either a limited number of checkpoints, easing the hardware logistical problem, or there is very little travel from outside the immediate region, eliminating the problem of legitimate vehicles without transponders. In a city such as Los Angeles, which would likely benefit from a congestion pricing system, the geography would create a formidable logistical barrier.

Uniformity

Another technological question that needs to be addressed is the uniformity of the system. At the present time, there are two major vendors of AVI systems, Amtech and Vapor, whose AVI technologies are not compatible. In an area such as the New York/ New Jersey area, where there are many different transit agencies, there must be uniformity among the different agencies if an overall system is going to work. A reader needs to be developed that will be compatible with both of these systems. (18,19) Another problem is that currently no standards in the automotive application of AVI exist.

Social and Political Barriers

Although the technical issues described above present important barriers to implementation, the more critical barriers to implementing such a system are the political barriers and the generation of public acceptance.

Congestion Pricing as an Additional Tax

Many motorists view congestion pricing as an additional tax rather than as an alternative tax. It is simply perceived as another form of taxation instead of a price to use the road. Motorists already feel that they pay too much for travel. (8,20) The fact that auto travel is actually underpriced does not affect the attitude of the motorist who is more often than not concerned only with out-of-pocket costs rather than the total cost of his travel.

The other important issue to consider is that the roads which would have a toll placed on them have already been built for public use by public funds. It is very difficult to tell people that the road which they've already paid for is suddenly going to have a toll. People are wondering, instead, when the tolls are going to be removed from the toll roads that are currently in place in many cities. (21) These two examples show how accustomed the public is to the low price of travel by private vehicle, and how difficult it will be for them to accept higher costs in the future.

Privacy

The privacy issue was a critical issue in the rejection of the Hong Kong congestion pricing proposal (5,22), and has received attention when congestion pricing has been introduced as a possibility. (23) A congestion pricing system using AVI intrinsically involves two types of surveillance--the monitoring of a vehicle's movements and the photographing of license plates for enforcement. (5) The public has a natural fear of this type of "big brother" technology. They don't want their movements to be on record, and they don't want to be photographed in a place they weren't necessarily supposed to be. This rationale of fear by the public may not be completely warranted, but it is nonetheless there, and a very difficult barrier to overcome.

Equity

Equity is another barrier to implementing a congestion pricing system. Opponents of the system argue that congestion pricing is inequitable because the poorer motorists are forced off the road at the expense of the rich. (8) The impression is that such a system would be regressive because costs would fall most heavily on lower-income drivers who would be forced to change from road to public transportation. (5) While this is one of the desired effects of congestion pricing, the inequity in creating this effect is politically undesirable. Equity is not as critical an issue if there are affordable alternate modes (public transportation) readily available. Many areas are not served by affordable alternatives, however. With many jobs moving to suburban areas where there are less alternate modes, equity becomes a greater issue. (24)

Business Interests

While the three previous barriers deal with the public in general, there are also major concerns regarding commercial activity. It is very likely that businesses in the CBD would dislike a congestion pricing system. As it stands now, there is already declining interest in downtown commercial districts, with suburban megamalls becoming the standard shopping locale. The imposition of a price to travel downtown would make matters even worse for the downtown merchants. The jurisdiction itself could be placed at a disadvantage because businesses in downtown areas might leave to go to a neighboring jurisdiction that is not affected by congestion pricing. While these are not major social issues like the other major political barriers, they are important to consider in the planning process.

RECOMMENDATIONS

Strategies for Overcoming Technical Barriers

AVI Technology

The technical barriers posed by the AVI technology will largely be solved by time and more research. One way to alleviate some of those problems, however, would be to locate checkpoints at on- and off-ramps. This would reduce the problems associated with high speeds, lane changing, and, if ramps are metered, platooning. This would, however, increase the costs of implementation by increasing the necessary number of checkpoints. (25)

Logistical Problems

The logistical problems created by hardware installation and geography can not be readily solved. They must simply be identified as problems to be resolved and dealt with at the appropriate time in the developmental cycle.

The problem of outfitting the vehicle fleet is the biggest "technical" barrier to overcome. The public needs an incentive to buy into the system. For the current use of AVI on toll facilities, the primary incentive is convenience: not having to wait in queues to pay tolls. For congestion pricing, however, some form of financial incentive is probably needed. One possible financial incentive is a rebate of some kind on either the gas tax or income tax. While this may prove to be effective, there are legislative problems in approving this type of measure, especially today, when government is looking for more revenue, not for ways to lose revenue. (21,25)

Another financial incentive may be to provide a rebate on the registration tax, but this is usually not a very expensive cost for the motorist and would also require legislation. Another way to get the public to buy into a system would be to appeal to their sense of social responsibility, especially in regards to the environment. (26) The environment is an important issue, and appealing to people that this is a way of improving the environment might work better than presenting this as way of reducing congestion. In Europe, the environment has been the main impetus behind any successful introduction of any type of traffic restraint. By promoting this as a way to restrict levels of air pollution, the public seems more willing to accept it than as a response to congestion itself. (8) In Los Angeles, this incentive has not had very much success in implementing other traffic management strategies, such as HOV lanes. While it talks a good incentive, the general attitude of the motorist is to let the other people be socially responsible. (25) This incentive would likely have an effect, but only on a limited basis, and not on the regionwide level that may be necessary for implementation.

The problem of out-of-town vehicles is primarily an enforcement problem because outside vehicles would not contribute very much to the congestion problem. This could be solved by placing checkpoints around the perimeter for outside traffic and supplying them with a temporary permit or transponder, so they could travel freely throughout the system.

Precautions would need to be made so residents making daily trips would not try to bypass the system in this manner.

Uniformity

The problem of uniformity within the system would best be solved by developing standards for AVI systems that would allow a single tag to be used for travel throughout several different systems. This would entail legislative action but should not be a problem.

Strategies for Overcoming Social and Political Barriers

Many of the barriers are actually perceptions rather than realities. An extensive public education campaign is the key to overcoming the political barriers and gaining public acceptance. An effective public information campaign is important in allowing the public to gain a clear understanding of the proposed system.

The public education campaign must effectively address each of the following issues: taxation, privacy, equity, and business interests.

Congestion Pricing as an Additional Tax

In order to overcome the perception that this is an additional tax, three things must be done. First, it must be stressed that this is a user fee to support roads, instead of a tax on congestion. (23) Second, it must be stressed that revenues from the system will be linked to further expenditures on the system. The motorists will accept a system better if there is a tangible benefit for them through increased capacity, management systems, public transit, or improved traffic information. (8,27) Third, the system should describe lower rates during non-peak times as a reward for traveling during that time. The system wants to reward the motorist traveling when *you* (the operator of the system) want him to drive rather than penalize the person who travels whenever *he* wants to drive (during peak periods).(25) These three strategies should alleviate some of the concern that may be felt in this area.

Privacy

The privacy issue was one of the critical issues in the failure of the Hong Kong system. (5) Once again, the key to overcoming this barrier is public relations. There are several items that need to be stressed regarding privacy. First, under an AVI system, it can be argued that a congestion pricing payment account is no different than an itemized telephone bill, subject to similar and probably more stringent safeguards. (8) Legislation would probably be necessary to make it illegal to divulge the information. Second, it needs to be stressed that the information will not be used for any kind of enforcement. Third, regarding the closed circuit television camera usage, it needs to be stressed that pictures will only be taken of the license plates, eliminating people's fears of being photographed with someone with whom they shouldn't be seen, and it be stressed that there is no real intrusion because license plates and vehicles can already be recognized in any location that the motorist is driving, whether he wants to be seen there or not. Finally, it should be stressed that the motor vehicle department is not looking at individuals, just tags. The best situation would eliminate any information relating to a vehicle's location before attaching the identification number to a name and address.

These items can easily be stressed through an effective public relations campaign. Another method that could be used to assuage the fears of the public is to contract out the system to a private entity, as is done for the phone companies, or for credit cards. One of the conclusions of the Hong Kong study was that there would be greater public acceptance, if an independent authority operated the system. (22) There is precedence for this in the transportation industry as well, as the electronic toll facilities often contract out to the vendors, such as Amtech on the Dallas North Tollway.

Equity

The equity of congestion pricing is an issue which can be easily argued. There are solid arguments that shows that congestion pricing is regressive. Likewise, arguments can be made that it is actually progressive. In Hong Kong, for example, the argument was made that pricing was more progressive than any other form of traffic restraint. The basic issue in Hong Kong was that with a pricing system in place, the high taxes on registration and annual license would be reduced, making vehicles more affordable to the lower-income classes. (22) In the Netherlands, they have attempted to turn the equity argument on its head, saying that pricing is a tax on the rich which provides better public transportation and pedestrian facilities for the majority of people. (8) In the long run, congestion pricing is probably not any more disequitable than the system that we have currently. Any form of transportation system will be unequitable because the higher-income classes will always be able to pay more for better services. The arguments from Hong Kong and the Netherlands may provide ammunition against opponents of a system. The best way to tackle the equity issue is to tackle it straight on and show that it would not be any more equitable, or unequitable, than the present system.

Business Interests

The effects of an AVI based congestion pricing system on business and commercial activity are unknown because there has not been a successful demonstration project. The Hong Kong experiment demonstrated the technology, but no prices were actually charged. A demonstration project is needed before effective strategies can be developed for this problem.

The Importance of the Media

Finally, the importance of the media can not be underestimated. In a series of proposed demonstration projects in the U.S. (Madison, WI, Berkeley, CA, Honolulu, HI) in the late 1970s showed that agency managers and decision makers exhibited the most understanding of the system, while business and media people showed the least understanding. In a public education campaign the media must be used to gain an advantage. They must be given a clear understanding of the system early on to alleviate damage that might occur from misinformed articles or TV reports, as happened in Berkeley. Public education is the core of an effective strategy for implementation. (23)

CONCLUSIONS

Congestion pricing is an idea which has a great deal of economic merit and will likely have a positive effect on congestion if implemented. It must be stressed, however, that pricing is in no way a panacea, but is just one element in a balanced and comprehensive transportation program. Technologically, AVI provides a relatively simple and effective method of implementing congestion pricing. The larger barriers are the social and political barriers of distrust with the government and misunderstanding of the system. Sandford Borins suggested that although the political environment of Hong Kong and tactical errors in the introduction of pricing in Hong Kong were factors in the failure of congestion pricing, the major factor was that pricing is inherently unpopular and will likely not ever be adopted in any city. (5) I disagree with this assessment. The political environment and the method of introduction is critical to the success of a pricing system. Congestion pricing isn't inherently unpopular, but it will be if the government is unpopular, and if the system isn't effectively introduced to the public. Public education is the key to the concept of congestion pricing.

Time will be the most important factor in determining the future of congestion pricing. At this time, due to the political attitude of the country and the current economic problems, the adoption of a full-scale pricing system would likely be impossible. The success of the demonstration projects, the status of the environment, and the advancement of further technology will determine the fate of this idea.

ACKNOWLEDGEMENTS

This report was prepared for CVEN 689, *Transportation Information and Control Systems Design*, a graduate course in transportation engineering at Texas A&M University, under the direction of Dr. Conrad L. Dudek and Dr. Carroll J. Messer. The professional mentors for this course were Don Capelle, Randy Keir, Joe McDermott, David Roper, and Ed Rowe. The author would like to thank all the mentors for their guidance and expertise, particularly Mr. Roper and Mr. Keir. The author would also like to thank those professionals that provided further input for this report: Glen Carlson, Steve Levine, Louis Lipp, Jeff Lindley, Phil Masters, William McCasland, David Powell, and Ron Sonntag.

REFERENCES

1. U.S. Department of Transportation. *Moving America: New Directions, New Opportunities. A Statement of National Transportation Policy: Strategies for Action*, Washington, D.C., 1990.

2. *Intermodal Surface Transportation Efficiency Act of 1991*, Section 1012(b).

3. Intelligent Traffic Systems, Inc. *Automatic Vehicle Identification (AVI) Based Traffic Management System for the Interstate 90/94 (Kennedy Expressway): Phase I*, Illinois Department of Transportation, April 1992.

4. I. Catling and B.J. Harbord. "Electronic Road Pricing in Hong Kong: The technology," *Traffic Engineering and Control*, Vol. 26, No. 12, December 1985.

5. S.F. Borins. "Electronic Road Pricing: An Idea Whose Time May Never Come," *Transportation Research. Part a*, General, Vol. 22A, January 1988.

6. W. McCasland. Texas Transportation Institute, Personal interview, July 1992.

7. R.A. Ferlis and R. Aaron. *Assessment of the Application of Automatic Vehicle Identification Technology to Traffic Management. Appendix B: Evaluation of Potential Applications of Automatic Vehicle Identification to Traffic Management*, Federal Highway Administration, July 1977.

8. P. Jones and A. Hervik. "Restraining Car Traffic in European Cities: An Emerging Role for Road Pricing," *Transportation Research: Part A*, Vol. 26A:2, 1992.

9. C.K. Orski. "Congestion Pricing: Promise and Limitations," *Transportation Quarterly*, Vol. 46, No.2, Eno Transportation Foundation, April 1992.

10. P. Liivamagi. "Road Pricing: A Vancouver Case Study," *ITE 1989 Compendium of Technical Papers*.

11. M. Cameron. *Transportation Efficiency: Tackling Southern California's Air Pollution and Congestion*, Environmental Defense Fund, Regional Institute of Southern California, March 1991.

12. H.S. Levinson, E.J. Regan III, and E.J. Lessieu. "Estimating Behavioral Response to Peak-Period Pricing," *Transportation Research Record 767*, Transportation Research Board, 1980.

13. B.G. Field. "From Area Licensing to Electronic Road Pricing: A Case Study in Vehicle Restraint," *IVHS and Vehicle Communications*, Society of Automotive Engineers, Inc., August, 1991.

14. T. Higgins. *Comparing Strategies for Reducing Traffic-Related Problems: The Potential for Road Pricing*, The Urban Institute, Washington, D.C., July 1978.

15. J.A.L. Dawson, and F.N. Brown, "Electronic Road Pricing in Hong Kong: A fair way to go?," *Traffic Engineering and Control*, Vol. 26, No. 11, November, 1985.

16. J. Lindley, Federal Highway Administration, Telephone interview, July 1992.

17. O.I. Larsen, "The Toll Ring in Bergen, Norway," *Transportation Research Record 1107*, Transportation Research Board, 1987.

18. S. Levine, Texas Department of Transportation, Telephone interview, July 1992.

19. D. Powell, New York Department of Transportation, Telephone interview, July 1992.

20. I. Catling and G. Roth, "Electronic Road Pricing in Hong Kong: An Opportunity for Road Privatization?," *Transportation Research Record 1107*, Transportation Research Board, 1987.

21. J. McDermott, Illinois Department of Transportation, Telephone interview, July 1992.

22. J.A.L. Dawson,"Electronic Road Pricing in Hong Kong: Conclusion," *Traffic Engineering and Control*, Vol. 27, No. 2, February, 1986.

23. T.J. Higgins, "Road Pricing Attempts in the United States," *Transportation Research: Part A*, Vol. 20A:2, March 1986.

24. R. Sonntag, Wisconsin Department of Transportation, Telephone interview, July 1992.

25. D.H. Roper, Roper and Associates, Telephone interview, July 1992.

26. G. Carlson, Minnesota Department of Transportation, Telephone interview, June 1992.

27. P. Masters, Ontario Ministry of Transportation, Telephone interview, June 1992.

Neal A. Hudders received his B.S. in Civil Engineering from the University of Virginia in May 1991. He has been employed by the Texas Transportation Institute as a Graduate Research Assistant since August 1991. University activities involved in include: Institute of Transportation Engineers, American Society of Civil Engineers, and Chi Epsilon Civil Engineering Society. His areas of interest are transportation operation and design.