Implementation of Electronic Toll Collection and Traffic Management Systems in New England

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The successful efforts that have been achieved to date for the first phase of an operational testing program being developed in New England to investigate and implement electronic toll collection and traffic management (ETTM) Systems are discussed. The New England ETTM Group was formed in 1990 to establish a cooperative effort that will provide a systematic and scientific method for testing and evaluating currently available technologies to determine which one(s) are most effective in New England. Accordingly, uniform standards and specifications are being developed, such as having a set of minimum common data in the tag to capture all the advantages and benefits for both the user and agency in a multiagency situation. The New England ETTM Group includes all the toll collection facilities in the region, the Massachusetts Bay Transit Authority in Boston and Logan International Airport in Boston. The application of a process that might be useful to practitioners seeking to implement ETTM systems is discussed. Future work will document the analytical procedures currently being developed. Many institutional and technical concerns must be addressed before the implementation of ETTM can be successfully achieved. An essential ingredient for successful implementation of such a program in areas such as New England that include many separate, independent agencies is the need to establish a coordinated effort among the agencies in the same region. Significant success has been achieved so far in doing so.

This paper describes the successful efforts that have been achieved to date in developing an operational testing program in New England to investigate the capabilities of automatic vehicle identification (AVI) and electronic toll collection and traffic management (ETTM) technologies for toll collection, for bus operations in Boston, and for the regulation of taxis, limos, common carriers, trucks, and other commercial vehicles at Logan International Airport in Boston. A detailed cost-benefit analysis by the same authors using some facilities in New England as a case study is now under way. That work is expected to provide a more analytical follow-up to this paper at a later time.

The rapid development of AVI and ETTM systems (in this paper referred to as ETTM only) in a number of locations in the United States and elsewhere has helped to illustrate the benefits of using this technology. However, there are still a number of questions to be answered and issues to be resolved before toll agencies and airport and transit managers will be ready to fully implement them. One way of addressing those questions is through carefully designed and monitored operational testing programs.

The use of ETTM technologies represents only one, but an important, element of the programs in the United States, now commonly referred to as intelligent vehicle-highway systems (IVHS). The potential applications of IVHS, however, to address problems of congestion, safety, air pollution, and energy consumption are often misunderstood as being far in the future. The term IVHS is sometimes incorrectly interpreted as being primarily the development of advanced vehicle control systems (AVCS) only. Even AVCS may sometimes be inaccurately viewed as "Buck Rogers," far-out space-age technology, when some near-term advances appear to be feasible. In fact, although it is an important element within the overall framework of IVHS, ETTM deals with available and operational technologies. Automatic toll collection systems are fully operational in the United States in Texas, Oklahoma, Louisiana, Colorado, Florida, and Michigan; and systems are being planned for near-term implementation in the New York City Metropolitan area, elsewhere in New York state, and in other states such as New Jersey and Pennsylvania. Furthermore, ETTM is being used for the regulation of commercial and common carrier vehicles at airports in Los Angeles, San Francisco, and New York, and their application is being planned for use in Boston and other cities. Advanced toll collection systems are also being planned in California, Virginia, Illinois, Georgia, and Florida. There are numerous examples of successful implementation of ETTM in Europe and elsewhere.

The six states comprising New England are relatively small geographically, but they generate substantial congestion and travel needs in urban and rural areas. Because of the high density and compact nature of the region, the six states are somewhat dependent on one another as an integrated economic development region. To a large extent, the quality of New England's transportation system plays a major role in maintaining its economic vitality, both regionally and nationally. Consequently, the states recognize the importance of establishing cooperative efforts as one way to maintain their economic vitality. One example of this recognition was the formation of the New England Transportation Infrastructure Consortium in 1985, which has focused on transportation infrastructure research and development. Massachusetts Institute of Technology (MIT) took the lead in establishing a

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consortium composed of state DOTs, the state universities and MIT's Center for Transportation Studies, together with FHWA and AASHTO. The success of that consortium provided the motivation for establishing the NE ETTM Group.

Given this background, the toll and airport agencies of New England have joined together to establish an interagency agreement for the purpose of jointly evaluating the potential application of ETTM as a region. The NE ETTM Group includes the Massachusetts Executive Office of Transportation and Construction; the Massachusetts Turnpike Authority; the Massport Authority (which includes the Tobin Memorial Bridge and Logan International Airport); the Maine Turnpike Authority; the New Hampshire Turnpike Authority; the Rhode Island Bridge and Turnpike Authority; the Massachusetts Bay Transit Authority (MBTA); The Massachusetts Department of Public Works; and MIT—Region One University Transportation Center. MIT has facilitated its formation and provides technical assistance to the group. MIT has also undertaken extensive research concerning the application of ETTM technologies.

OBJECTIVES AND GOALS

This section describes the three major objectives of the New England program: (a) the objectives of an ETTM research and operational testing program (*1*); (b) the objectives in forming The New England ETTM Group; and (c) the system goals to be achieved as identified by this group.

Objectives of ETTM Research and Operational Testing Program

The motivation for developing and implementing innovative advanced transportation system technologies is based on several important needs to

- Help relieve urban congestion,
- Provide safer vehicle travel,
- Reduce air pollution and other adverse environmental impacts,
- Reduce energy consumption, and
- Provide for more cost-effective urban mobility.

Basic and applied research activities have been under way to develop and apply technologies to meet those objectives for two or more decades. Although there are renewed efforts in the United States and throughout the world to seriously evaluate and implement some of the technologies, there are still many unanswered policy and technical questions to carefully consider and resolve before public and private policy makers can commit the substantial funds required to apply ETTM to deal with the issues summarized above.

Several advanced research activities are under way in the United States designed to test and implement some of the technologies being considered. California, Massachusetts, Minnesota, Michigan, Florida, New York, and Texas are in the forefront of those efforts, in cooperation with the FHWA, FTA (formerly the Urban Mass Transportation Administration), and NHTSA. However, the costs of implementing various innovative technologies are still uncertain because many of those technologies are still evolving and being tested. The benefits to be derived from such technologies are also uncertain. An initial research project sponsored by FHWA undertaken at MIT took the first step toward better describing and analyzing the tangible and intangible benefits to be derived from new highway technologies on a national scale. The purpose of that project as to assess the benefits associated with the development and implementation of new highway technology. An analysis framework that described those costs and benefits in broad qualitative terms was developed. It provided a basis for a more comprehensive and systematic analysis of those benefits, which was undertaken by Mobility 2000 (*2*).

A number of research efforts completed over the past several years have concluded that an essential element in promoting the advancement of new vehicle and highway technologies is to design and implement operational testing programs. Such programs will not only provide the incentives for operational agencies to become actively involved in the development of IVHS, but they will also allow researchers to test the reliability, costs, and benefits of various innovative projects and programs.

A research project undertaken at MIT to develop such operational testing programs was designed as a three-phased program. The objectives for phase one (completed) are the following:

1. Using the research under way or recently completed as a springboard, identify possible technological innovations that are potentially available to make a major breakthrough in developing cost-effective solutions to transportation congestion in New England.
2. Select potential candidate technologies to deal with the most critical transportation problem(s) in New England—such as toll collection and traffic management—using New England as a case study.
3. Develop a planning report with the details required to design a demonstration program to be implemented in New England, but also having broader regional and national implications.

Phase one was funded by a grant under the Region One University Transportation Center program with matching funds from the Massachusetts Turnpike Authority and the Massachusetts Port Authority. It was completed satisfactorily, resulting in the continuation of the project into phases two and three (*1*).

The objectives for phase two (under way during preparation of this paper) are

1. Develop the details of a demonstration program designed to implement at least one cost-effective innovative technological improvement to deal with current transportation issues in New England (as a case study). The selected technologies would have a high probability for successful implementation.
2. Develop the funding package and commitments required to implement this demonstration, which would include state, federal, and private sector funds, and their involvement in this demonstration.

3. Establish a specific schedule for implementing the demonstration program.

The objectives for phase three are

1. To work with the public agencies to implement the demonstration program and evaluate its results.

Objectives In Forming The New England ETTM Group

In carrying out Phase One of this project, the issues related to toll collection and traffic management were identified as being critical in New England. In June 1990, the first informal meeting of officials from the New England Toll Agencies and Logan International Airport was held in Portsmouth, New Hampshire. The purpose of the meeting was to provide an opportunity for the agencies to discuss the plans they were considering for the possible use of ETTM within their agencies.

The New England ETTM Group began as an informal, ad hoc committee that met periodically beginning in June 1990. The central purpose of this group was to establish a cooperative effort that would provide a systematic, scientific method for testing and evaluating currently available technologies to determine which one(s) would be most effective in New England. The members of the group agreed that it is essential to develop compatible systems to provide

- Customer convenience for automobiles, trucks, buses, and other commercial vehicles.
- Congestion relief during peak hours, with the possibility of facilitating mobility improvement measures, such as high-occupancy vehicle lanes.
- Cost reductions and more efficient handling of revenues.
- Enhanced traffic management opportunities.

System Goals To Be Achieved As Identified By The New England ETTM Group

As part of the research project undertaken by MIT concerning ETTM application to New England and with the coordination of the New York, New Jersey, Pennsylvania Interagency AVI/ETTM Technical Committee, the following goals were identified and proposed to the New England Group by the research team (*3*). These goals constitute the minimum achievement to ensure a successful operating system for any group working to implement ETTM. They focus on the need for

1. Single-tag/multiple-agency system;
2. Compatibility of equipment during all phases of any system implementation;
3. Safety and feasibility;
4. Uniform/standard/consistent policies and procedures to minimize customer confusion and safety concerns while maximizing customer acceptance and user friendliness; and
5. Provision of program results to other areas of the country.

All agreed that the only way to achieve the above goals would be through full coordination among the concerned authorities in the same region.

Research and testing conducted in this regard, particularly that of the New York, New Jersey, Pennsylvania Interagency AVI/ETTM Technical Committee has shown the following (*3*):

1. Multiple identification devices or tags on one vehicle would result in a negative public reaction. People would not be encouraged to use ETTM if they knew it might involve placing more than one tag on their vehicle to take advantage of ETTM at toll plazas of various agencies. The need for multiple transponders would also create conflicts regarding suitable mounting locations on vehicles, since it is likely that the identification devices will be required to be physically separated from one another to avoid interference and guarantee operation.
2. Operating different systems in the same region would require unnecessary additional equipment, installation, and maintenance costs, especially if the systems are not compatible, and would lead to non-uniformity of system upgrading and difficulty in coordinating a traffic management system. Any agency operating an ETTM system for toll collection only, and not using it for traffic management would be neglecting important benefits that the system offers. To take advantage of these benefits, the system should be integrated with the region's other transportation systems.
3. Interference caused by multiple tags on a vehicle could result in one or more of the following situations:

- All tags being unreadable.
- Only the strongest or nearest tag being read.
- Incorrect identifications being made.
- Incorrect writes being made in a read/write system.

These situations are possible but not necessary in the case of multiple tags mounted on a vehicle. The technology differs between manufacturers and consequently the degree of "smartness" of readers and tags differ.

4. Non-uniformity of system operational requirements and standards may lead to safety problems and customer nonacceptance. Confusion among users concerning standards and procedures, such as the approach speed to a toll station, or whether it is a stop or non-stop station, could cause accidents and further nonacceptance of the system.

ADVANTAGES OF AN ETTM SYSTEM

Numerous advantages and benefits of ETTM were identified by manufacturers, potential users, and researchers in this field (*4*). The primary benefits are summarized below. (A detailed cost/benefit analysis of implementing ETTM is under way at MIT and is expected to be published soon.)

1. Customer convenience: by reducing travel time for the users and giving them alternatives for paying the tolls that do not involve cash/coins or ticket handling.
2. Additional payment alternative: for users who would find the alternative more convenient.

3. Congestion relief: implementing ETTM decreases the time required to process ETTM-equipped vehicles at toll plazas and thereby increases the throughput efficiency and toll lane capacity. The queuing times at toll plazas are thereby reduced. Thus, total travel time on the highway would decrease for both ETTM users and non-ETTM users. Table 1 shows sample average capacities estimated for several lane types: staffed, automatic coin machines, mixed lanes that would accommodate ETTM and non-ETTM users, ETTM lanes within a conventional toll plaza configuration, and express ETTM lanes allowing vehicles to pass through at highway speeds.

4. Environmental impact: as vehicles stop at toll stations to pay their tolls, excess emissions occur at toll plazas as a result of idling, acceleration, and deceleration (U.S. Environmental Protection Agency, 1978). At a toll station, these emissions are a function of the capacity and productivity of each toll booth. As ETTM improves toll plaza productivity by increasing vehicle throughput, these emissions are reduced (5).

5. Traffic management: the implementation of a comprehensive electronic traffic management could be made possible once the basic hardware for a system is installed. All that is required are strategically placed additional reading locations and a supplementary computer system software package to calculate travel times for vehicles traveling between reading stations on the basis of these probe travel times. Consequently, traffic can be directed and diverted according to congestion levels.

6. Improved security: ETTM systems allow transactions to be made without any physical handling of funds in the toll lane, thereby elminating cash handling, fraud, and error, and improving accountability and security.

7. Cost reductions: operating and maintenance costs, land acquisition and construction costs, and user fuel costs are reduced as a result of implementing ETTM. Operating and maintaining toll stations are expected to be less expensive once ETTM is installed. Furthermore, as the implementation of these systems increases the throughput of each lane, fewer lanes and booths need to be built. Eventually all that may be necessary is a bridge above the highway on which to install the reader. Some systems will even allow for the use of reading equipment embedded in the roadway's pavement, thereby eliminating even the need for an overhead mounting structure. Finally, as ETTM can reduce congestion and increase throughput and vehicle speed, fuel savings are expected.

8. Potential for increased public acceptance of toll roads: the use of ETTM will make the use of toll roads (and/or the tolling of new roads and bridges, etc.) more acceptable to the public and increase the acceptability of tolls as a means of funding the construction, operation, and maintenance of new roads, bridges, and tunnels.

TABLE 1 Comparison of Five Sample Toll Station Types

Lane Type	Vehicles/Hour
Staffed (with change making transactions, receipt issuing, etc.)	350
Staffed (only distributing commuter tickets and such)	500
Automatic Coin Machine (only coins--no tokens)	500
Automatic Coin Machine (receiving primarily tokens--few coins)	650
Mixed AVI (includes any of types 1-4 as well as AVI in the same lane)	700
AVI (dedicated AVI lanes in a conventional plaza with barriers)	1200
Express AVI (dedicated AVI lanes in a highway speed pass-through)	1800

Sources: Center for Urban Transportation Research, University of South Florida, Tampa & Ronald Cunningham, Port Authority of New York and New Jersey.

ORGANIZATIONAL REQUIREMENTS AND PROCEDURE FOR IMPLEMENTATION

One of the most challenging aspects of developing an operational testing program for any IVHS related activity will be the organization of the several public agencies that ultimately will be responsible for the design, implementation, and continuing operation of a program such as the one described in this paper.

The experience of the New York, New Jersey, Pennsylvania Interagency AVI/ETTM Committee provides an example that has been beneficial to the New England Group. After several informal meetings, the New England ETTM Group developed and signed an inter-agency agreement that described the potential uses of ETTM technology, the potential benefits to be realized and the importance of considering regional perspectives. The agreement lays out actions to be taken by the group, the role of MIT, and the structure of the regional effort. The agreement formalizes the role of the group and states that meetings will be held as needed, and that decisions will be reached by a consensus of the representatives of each organization. It also identifies the need for regional agreements on a wide variety of necessary subjects such as

- Compatibility questions involving the use of various technologies;
- Standards for noninterfering systems;
- Demonstration and standards for existing testing efforts;
- Performance specifications for ETTM systems;
- Legal issues that may arise;
- Market research possibilities; and
- Operational coordination (tag distribution, account management, etc.)

The process used in developing this agreement included the formation of policy and technical committees. The policy committee consists of the directors of the agencies, as policy representatives from each agency authorized to make decisions, set goals, and monitor the ongoing work in the project. The meetings of this committee are on an as-needed, rather than a regular, basis and usually before and after any designated task for the technical committees. Meetings have occurred about every 6 to 8 weeks. The technical committee could branch into several committees, each dealing with a specific task. At present, one technical committee consists of technical

people from each agency, researchers from the Center for Transportation Studies at MIT and engineers from MIT's Lincoln Laboratory, working on the research, design, testing, implementation, and promotion of the project. The first task for this committee is the setting of requirements/standards for ETTM systems to be implemented and tested in the specific sites in New England. Reports including analysis and recommendations prepared by the technical committee are then presented to the policy committee for final decisions.

TECHNICAL AND LEGAL ISSUES FACING IMPLEMENTATION OF ETTM IN NEW ENGLAND

A number of technical and legal issues must be addressed in developing and implementing ETTM in New England. These technical and legal issues are common among most of the authorities in the group.

Technical Issues

Starting with the technical concerns that have been raised, the most sensitive one if the need for the capability of the system to work under the various climatic conditions that are witnessed in New England. In addition to the effect of snow, rain, wind, and humidity, temperatures vary between less than 0°F in the winter to above 100°F in the summer. Previous experiments have shown that the capabilities of some video enforcement systems are limited in the winter. In addition, automatic vehicle classification systems using vertical soundwaves might get distorted as a result of strong wind.

A second concern is the accuracy of the available systems. One must distinguish between the level of accuracy achieved and the level that could be measured. To test for a level of accuracy of 99.95 percent, which is still low at peak periods, one would need to run 40,000 to 50,000 samples. In addition to that, very little performance testing of the various ETTM technologies in various weather conditions has been formally documented. The authorities argue that security and loss of revenue concerns must not be compromised.

A third category of concern involves payment systems. Questions related to payment systems include the existing variation among the agencies in toll structures, prepayment versus postpayment policies, and methods of payment (*4*). Since most of the authorities cannot extend credit to customers, prepayment system methods are most likely to be required. These would include cash, check, use of the credit card to buy future trip entitlement, and electronic funds transfer (EFT). The credit card system or EFT would be ideal since it allows automatic replenishment of a prepaid toll entitlement account. One problem that has not yet been addressed as part of this effort is the issue of creating a system that could act as a clearing house between the various authorities so that toll-paying customers would have to maintain only one account that would be used for tolls from all participating agencies.

A fourth concern is the operation at individual toll stations. These operations will change significantly after implementing ETTM systems. Customer understanding of the system and safety to both the public and the remaining toll collection staff are the main issues. This stresses the importance of a coordinated system for the whole region since having non-uniform standards and operational requirements could have implications on safety and customer acceptance of the system. Pavement markings, adequate signing, channelization, speed limits, and passing areas must be examined to safely and efficiently accommodate ETTM usage (*4*).

Some authorities raised issues that dealt with traffic operation after tolls are paid at stations where a bottleneck situation emerges; in such cases the maximum benefit of throughput increase after installing ETTM might not be captured. This would occur in two situations: the first would be when there are more lanes before the toll station than after it and the toll station assists in merging traffic (see Figure 1a); and the other is when the authority prefers to keep the existing toll station with more lanes at the plaza than before and after (Figure 1b), rather than implement high-speed express ETTM systems (Figure 1c).

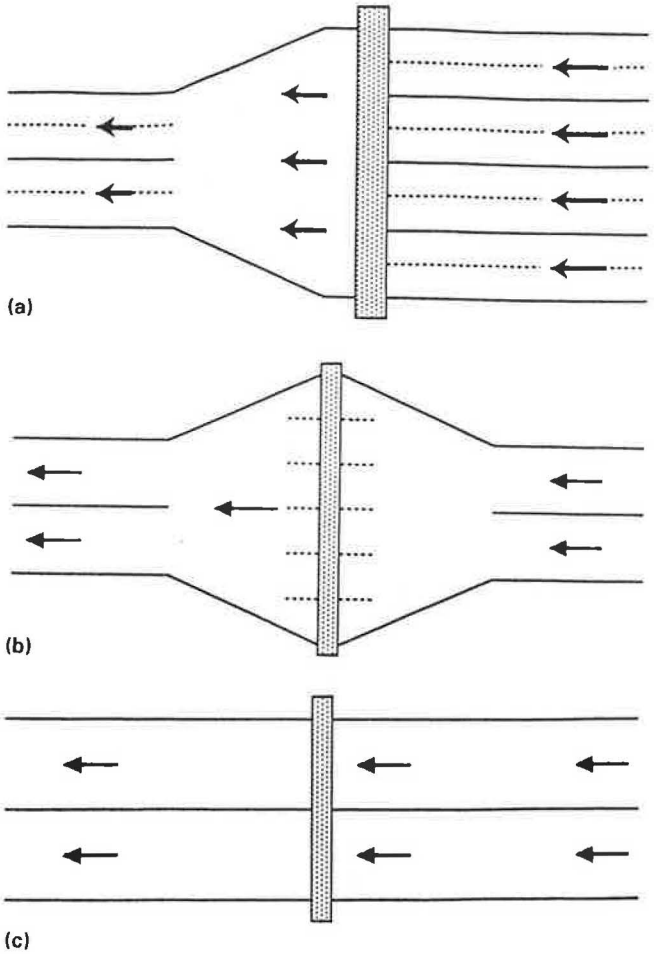

FIGURE 1 Idealized plan of toll station having *a*, more lanes before station than after; *b*, same number of lanes before and after station, with more lanes at station; and *c*, same number of lanes before and after station, with same number of lanes at station.

Legal Issues

Probably the most important issue to address is the one related to privacy. Authorities are concerned that potential customers will not accept it if the system can track people as they move from one place to another. This issue has been addressed in other parts of the country in different ways, such as creating an anonymous user account without requiring the user to give a name. This possibility is still being examined.

A second concern of the authorities is the legal issue involved in issuing violation tickets to drivers of moving vehicles who abuse the ETTM system. A video enforcement system might not be allowed to capture the picture of the offending driver, leaving the vehicle owner as identified by the license plate as the only option. Unfortunately, in some states, such tickets cannot be issued to the owner—only to the driver. Thus, enforcement capability is still unclear.

A third concern about possible customer nonacceptance of the system involves the issue of traffic management and its potential capability of enforcing speed limits in a strict manner. Few people would be encouraged to participate in a program that would put them at high risk of being identified when breaking the speed limit.

The issue of dedicating lanes for ETTM users raises another question. On one hand, some would argue that they cannot justify dedicating one lane for ETTM users unless the proportion of those users would match the proportion of lanes dedicated to them. That is, if 25 percent of the customers are ETTM users and the road in question is a four-lane highway, then it would be justified to dedicate one lane for ETTM users. On the other hand, others argue that if lanes are not initially dedicated to ETTM users, the users would not enjoy the most important benefit from ETTM, which is the savings in time; thus, potential users would be discouraged from using ETTM. Consequently the possibility exists for never getting the desired proportion to dedicate a separate lane.

Finally, officials were concerned about the reaction of toll collector unions toward ETTM. Although toll collectors could be assured of assignment to other jobs dealing with operating and maintaining the system, some collectors are understandably concerned about their long-run future.

SETTING REQUIREMENTS AND TESTING PROCEDURES

One way to resolve the technical issues concerning implementing ETTM systems is through setting requirements/standards and testing systems to determine if they meet those requirements/standards. Some questions that might be answered in a testing program would be

1. Is ETTM appropriate for use in New England?
2. What are the appropriate hardware and software requirements for such use?
3. What system or technology will best serve New England needs?
4. What are the advantages and disadvantages of the options?
5. How will the system operate?
6. What is the reliability of the system?

Furthermore, the answer to "Why have a New England testing and evaluation program?" should be addressed. Five issues (AVI Testing Options, C. Much, T. Hotz, and A. Kanaan, unpublished data) to be further explored include

1. Most operational systems in the U.S. commenced with a testing program. Most of them encountered unexpected problems and recommended a testing phase before implementation.
2. The consequences of a faulty system are severe. They might lead to lost revenue, increased congestion, and public dissatisfaction and distrust in technical solutions for traffic management.
3. Testing would provide opportunities to measure benefits before full-scale operation.
4. Testing will allow for a start-up period to choose the applicable technology, validate the system's reliability, determine the maintenance requirements, monitor the sensitivity to climate, measure background RF environment, and verify that the system can meet all the fundamental operating requirements or standards that are set.
5. Testing would allow for a lead time that is required to demonstrate the benefits to the public, create a sufficiently large user group, and create an infrastructure for tag distribution, data base management, and system failure contingencies.

Accordingly, the most appropriate procedure for a testing and evaluation program would be to design a comprehensive test for the system's operation (AVI Testing Options, C. Much, T. Hotz, and A. Kanaan, unpublished data), use existing or controlled toll stations, use cooperative test vehicles, perform a 9- to 12-month test under a variety of weather conditions, and, if test results meet the requirements/standards, recommend a system to the policy committee for follow-on operational implementation.

So far, the standards that systems have had to meet are not uniform or formal within the United States or anywhere else. Many standards have been developed by various groups and organizations. The New York, New Jersey, Pennsylvania AVI/ETTM Interagency Group has developed a specification for equipment that will eventually lead to a standard. The Heavy Vehicle Electronic License Plate (HELP) program, American Trucking Association, and others have developed or are in the process of developing standards. The problem in creating the standards is that each organization has a different set of requirements from a system. Some organizations need it for toll collection purposes only; some need it for toll collection and weigh-in-motion; others need it for traffic management; and so on. It is possible, though, to set basic requirements or specifications for electronic toll collection and basic traffic management only. If weigh-in-motion, for example, is needed in addition to ETTM, then other requirements could be added to the list.

A set of basic operational requirements is being developed now based on the review of relevant literature and research and analysis of the systems. Many of these are adopted from requirements set by the HELP program, The New York, New Jersey, Pennsylvania ETTM Group, and others (*3,6,7*).

FUTURE NE ETTM GROUP ACTIVITIES

The New Hampshire Turnpike Authority has started an individual testing program that is likely to lead to implementation of an ETTM system by late 1992. The Authority was to test several technologies and examine operational systems between spring 1991 and spring 1992. By that time, it will have decided on the best system for New Hampshire and will begin implementation by the end of 1992.

The MBTA (Boston's transit agency) is currently testing the use of AVI to monitor fuel use for its bus fleet. Tobin Bridge, directed by the Massport Authority, had plans to test various technologies by the spring of 1992. The agencies are formulating plans for possible ETTM applications. MIT will continue working on this research project under sponsorship from the Region One University Transportation Center and will continue to work with the agencies to enhance the design of a testing procedure suggested earlier (AVI/ETTM Testing Methodology, A. Y. Kanaan and T. F. Humphrey, unpublished data). At the same time, MIT will use real data from the various New England agencies and from the authorities operating ETTM systems in the United States to undertake a cost-benefit analysis for ETTM systems. Currently, information about users' reaction to ETTM is being collected by means of a telephone survey. This carefully designed statistical survey will be used to collect data to determine whether implementation of the system is feasible.

The New England ETTM Group's technical committee is currently working on the technical requirements for a system to be considered by each agency. The requirements to be determined by the technical committee will state the minimum operational needs of each agency first; then the general requirements will be developed into detailed specifications.

The technical committee will also review the latest version of the New York, New Jersey, and Pennsylvania Group's specifications. If found appropriate for application in New England, one of the options considered would be to adopt these specifications with necessary modification. This option would be more efficient for the two regions, but especially for New England. The resources that would have to be allocated for testing and setting requirements could be used in other complementary work such as traffic management.

CONCLUSION

The first year of this project has been extremely successful. For the first time, we have been able to generate great interest in New England concerning the possible coordinated application of new technologies to deal with transportation congestion. We have expanded the regional scope of this project to include not only the Massachusetts Turnpike Authority (which was our original intent) but all the transportation agencies in Massachusetts and toll agencies in New England. As we pursue this program, we also plan to undertake an economic analysis of the application of ETTM.

In conclusion, the benefits of ETTM systems for the agency and the user have been documented in various operational systems within the United States and around the world; however, many authorities still have questions and concerns to be answered and resolved. Some concerns can be resolved by proper coordination and agreements between agencies. One way to deal with various constraints is by setting requirements and testing various systems to determine which one best meets those requirements. By doing so, authorities will not compromise security and loss of revenue.

The challenge to be met, however, is the need to develop the appropriate institutional arrangements required to establish compatible systems. It appears we are well on our way in this regard.

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