Technology and the Heavy-Vehicle Electronic License Plate Program: Potential Uses for Government and Industry

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Automatic vehicle identification (AVI) developments in Oregon and the heavy-vehicle electronic license plate project are discussed. An overview is given of some worldwide developments. Potential applications of AVI technology and its use in conjunction with other state-of-the-art techniques for vehicle weighing and classification are examined. Potential advantages associated with the implementation of large-scale AVI systems for the monitoring of vehicles are discussed. Some of the technological options for AVI are reviewed, and the major highway-based applications of AVI technology are examined.

Current methods of collecting extensive data on the nation's highway system are costly to both government and industry. Many of these data collection activities entail substantial efforts, yet the data produced over the years have such inconsistencies among states and among sources, or have such important elements missing, that much of the data are not directly useful. A solution to many of these problems may be found in new electronic technology.

Developments in data transmission, processing, and communications have increased the viability and reliability of automatic vehicle identification (AVI) equipment, and parallel developments have occurred in weigh-in-motion (WIM) and automatic vehicle classification (AVC) technology. Thus techniques for the collection of data on traffic volumes, speeds, and vehicle weights and types have now become a practical proposition as has the reliable transfer of data from remote sites. The combination of these technologies could improve the potential of AVI in a number of applications.

A total traffic-monitoring system would include components that automatically weigh, classify, measure speed, and specifically identify individual vehicles. This state-of-the-art technology provides an extraordinary opportunity to bring about a quantum jump in multiuse data collection of heavy-vehicle characteristics.

OREGON DEMONSTRATION PROJECT

Since 1983 Oregon has been involved in an individual effort to investigate how identifying and weighing vehicles in motion could be used to the advantage of both the government and the trucking industry. It was hoped that integration of AVI and WIM technology could help not only with planning and design information but also in size, weight, and speed enforcement. The Oregon Department of Transportation (ODOT) also believes that the Oregon system, when fully implemented, has the potential to improve the tracking of hazardous materials, help fleet managers monitor movement of their vehicles, and promote a reduction of thefts of vehicles equipped with AVI devices *(1)*. To reach its full potential, it is recognized that many more sites in addition to every port of entry (POE) and most weigh stations need to be equipped with AVI and WIM technology. These additional sites would provide more information to trucking firms for fleet management as well as monitor bypass routes *(2)*.

The Oregon Automatic Vehicle Identification/Weigh-in-Motion demonstration project began in February 1984 with the installation of high-speed weigh-in-motion scales in both northbound lanes of Interstate 5 near the Jefferson exit. This system is used primarily for the collection of planning data. The scales register vehicle weight, length, axle spacing, 18-kip equivalent single axle loads, speed, and time. Since these scales were installed, more than 15 million vehicles have been weighed and classified. About 20 percent of these vehicles are trucks *(3)*.

Also in February 1984, about 28 mi further north at Woodburn, a moderate-speed WIM and overheight sorting system was installed at a northbound weigh station. This WIM equipment is used to screen trucks as part of Oregon's ongoing truck weight enforcement program. Legally loaded vehicles that enter the weigh station and cross over the weigh pads at from 25 to 35 mph are automatically given a green light to return to the freeway. Approximately 90 percent of the vehicles are passed through the station with the green light. Trucks with overheight, overweight, or axle weight distribution problems are directed to the static scale. This sorting system has allowed the Weighmaster Unit to operate the station with one person rather than the three previously needed.

Although data from these two sites are still being analyzed, it is noteworthy that the high-speed Jefferson WIM scales record from 50 to 100 percent more overloads than the Woodburn sorter scale. This would appear to indicate a substantial scale bypass problem at the Woodburn weigh station.

In the spring and summer of 1984, General Railway Signal Automatic Vehicle Identification reader-activators were installed at these two sites and at the Ashland POE and the Ridgefield, Washington, POE on I-5. These reader-activators read data from precoded passive transponders, mounted on trucks. Twenty-one trucking firms are enthusiastically participating in the Oregon project and have installed 200 transponders on their vehicles. These trucks are automatically tracked as they travel I-5 from the California-Oregon border north to the Oregon-Washington border, a distance of 310 mi *(4)*.

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The information received at these five locations has been tied together with a data base management system, creating a unified, accessible AVI/WIM data base.

Another element of the Oregon project is a portable bridge weighing system (BWS) that employs strain gauges to convert a bridge into a scale, weighing trucks as they pass over it. The strain gauge data are converted to vehicle weight information by a computer housed in a van. This system is used primarily on rural highways and is useful in determining which roads are used as bypass routes by overloaded trucks. Through a federal grant to the ODOT in June 1983, Science Applications International Corporation, in cooperation with ODOT, successfully interfaced and tested, in a rural location, the portable BWS and a portable AVI system *(4–6)*.

Trucking firms participating in Oregon's demonstration project see two of the biggest advantages coming from this system as the time they save at weigh stations and the possibility of the system promoting fairer competition. There appears to be an increasing number of violators attempting to gain a competitive edge by either running trucks overloaded or evading taxes. Because of these violators, the industry as a whole suffers because the legal operators are at a competitive disadvantage and because the negative image of the violators reflects on all operators *(7)*.

Oregon is currently working on plans for automating ports of entry. The prototype will be the newest Oregon POE at Woodburn, southbound on I-5. This port is open 24 hr a day, with as many as 200 trucks per hour at peak times. AVI, WIM, and AVC will be combined with a supervisory computer and various software and hardware packages to link the technologies. In addition to the usual weighing functions, personnel at POE also fulfill regulatory and tax-collecting functions. It is estimated that 9 of the 13 manual tasks currently required of a weighmaster per truck can be eliminated. With this technology, 85 percent of the vehicles going through the POE can be automatically processed, saving time for both government and industry *(4)*.

The benefits to be derived from a system of this type are potentially immense. Oregon is planning for further expansion of its automated vehicle-monitoring program. Preliminary plans suggest the possibility of instrumenting 100 bridges for the portable BWS as well as other low-cost weigh-in-motion systems. Many of these installations will be interfaced with AVI. With the information derived from such a system, highway planning and designing would be greatly improved. The proper placement of these installations should also go a long way toward eliminating the scale bypass problem and, therefore, the vehicle overload problem *(4)*.

HEAVY-VEHICLE ELECTRONIC LICENSE PLATE PROGRAM—A MULTISTATE PROJECT

About the same time the Oregon Heavy-Vehicle Monitoring Project got under way, the Arizona Department of Transportation received a grant from the FHWA to study the feasibility of a WIM/AVI demonstration in a multistate environment. This study was completed by Castle Rock Consultants in December 1984. The report was encouraging about the technical feasibility as well as the potential benefits to both government and the private sector. This preliminary study indicated that such as program, fully implemented, could soon pay for itself *(8)*. Another, more thorough, study is to be conducted under the Heavy-Vehicle Electronic License Plate (HELP) program to either confirm or disclaim the optimism of the Castle Rock report.

Results of the Arizona feasibility study and the positive feedback from the Oregon concept demonstration project generated interest, especially in Western states, in developing a multistate program. In February 1985, a kick-off informational meeting of government officials and trucking representatives was held in Portland, Oregon, to determine the possibility of a multistate demonstration project. The meeting marked the beginning of the HELP project and resulted in the formation of a multistate organization. A decision was made that the best management approach was to have both government and trucking industry representatives work together to oversee the project.

The project was originally dubbed the Crescent Study because the states that showed the strongest initial interest formed a crescent shape from the Canadian-Washington border, through the Pacific Coast states, across to Texas. The study now includes Alaska, Arizona, California, Idaho, Iowa, Minnesota, Nevada, New Mexico, Oregon, Pennsylvania, Texas, Washington, and most recently Virginia. The participation of states outside the crescent has made it necessary to change the name of the overall study to HELP *(9)*.

The multistate HELP System Development Program is essentially a cooperative research and demonstration project to investigate the new technological tools available for gathering pertinent heavy-vehicle data. The purpose of research such as this is not to reach conclusions but to discover things that are presently unknown. What the participants hope to learn from the testing of the HELP system is what functional and practical applications there are for automated systems on the nation's highways. From the study, transportation professionals should gain insight into whether or not it is cost-effective to develop and implement a national vehicle-monitoring system that may benefit both government and industry. The multistate program has now reached the stage where a number of developmental and testing phases, which will continue for the next 2 years, are beginning *(8)*. Within this framework, the following program elements can be identified:

1. An AVI testing project has just been begun at Ford Motor Company's Yucca, Arizona, Motor Vehicle Test Track Laboratory, and field tests are soon to follow. The results of these tests will be used to develop a generic AVI system specification. The specified system will then be put through a similar testing program and any necessary fine-tuning will be carried out.
2. The WIM/AVC performance specification elements are similar efforts to address the weigh-in-motion and automatic vehicle classification components of the HELP system. A contract was just awarded to Texas Transportation Institute to conduct this study.
3. The Systems Design Study, awarded to Cimarron Software of Texas, is now under way and will define the communications and processing requirements for public- and private-sector applications. The main tasks involve communication

systems design and computer systems analyses for data processing and utilization.

4. The Motor Carrier Services Plan Study, soon to be awarded, will involve an examination, in greater detail, of how the HELP system may benefit the motor carrier industry.

5. The Satellite Reference Design System Study, soon to be awarded, will investigate the economic and technical feasibility of a satellite-based traffic-monitoring system. This will include definition of the system, costs and benefits to both government and industry, and comparison with alternative gound-based data collection systems. Ways in which satellites could be integrated with a ground-based HELP system will also be covered.

6. A Site Selection Study will involve the development of guidelines that will enable states to locate HELP stations along the planned demonstration routes. This study will determine the optimal number and location of HELP sites to meet the aims and requirements of the program. Sites will be selected so that they can also be readily incorporated into a national system if the demonstration should prove worthwhile.

7. The final phase of the HELP program is the actual deployment of a heavy-vehicle monitoring system in the Crescent states. The states of Texas, New Mexico, Arizona, California, Oregon, and Washington (and perhaps the province of British Columbia) are now planning installations of WIM and AVI stations along two major Interstate highways, I-5 and I-10. After installation, an evaluation study is scheduled to assess the practicality and usefulness of this type of technological integration. Unfortunately, a complete measure of the possible benefits to be derived from a fully developed HELP system is not possible without a more saturated implementation of sites than is provided for in this research.

8. Two closely related projects, which are being undertaken during the same time frame as HELP, are a study on the potential for a Low-Cost Automatic Weight and Classification System and the National Cooperative Highway Research Program's (NCHRP's) study of the Feasibility of a National Heavy-Vehicle Monitoring System.

Iowa, Minnesota, Washington, and Oregon are involved with research on the durability and accuracy of piezo-electric sensors for weighing trucks in motion. The output from these low-cost sensors and loops will be analyzed using microprocessor technology. The system will include off-scale detection, tire width measurement, vehicle speed, classification by axle spacing, axle and gross weights, and equivalent single axle loading calculations. In addition, NCHRP is about to award a contract for development of a low-cost bridge weigh-in-motion scale. Both of these low-cost weighing concepts are aimed at producing installed sensors for under $10,000—a price at which automation of virtually all weighing activities becomes quite attractive *(8)*.

The objective of the NCHRP research, which is being conducted by Arthur D. Little, Inc., and SYDEC, is to identify and evaluate the needs, issues, requirements, and feasibility of using AVI on a national level. This study will serve as a guidepost to national decision makers. Can it be a cost-effective, statistically sound replacement or supplement to existing heavy-vehicle data collection systems? The NCHRP study will build on the knowledge gained from the HELP program and any other related studies.

The HELP System Development Program is both ambitious and complex. The program, since October 1985, has employed a management consultant whose chief task is to manage and coordinate the technical aspects of the program. A policy consultant has just been hired to address policy issues that emerge during the course of the program and handle public relations, educational, and promotional activities. The policy and management consultant services are a direct response to the complexity of the program.

Selection of a generic AVI system under the HELP program is currently scheduled to be completed in 1988. Within a few months after this selection, the states along the crescent path are expected to have 10,000 test vehicles from about 200 trucking companies equipped with transponders. The demonstration continues through 1989. The final evaluation of the project and the report should be finished by March 1990.

To summarize, the overall aim of the HELP System Development Program is to investigate the potential benefits and costs of automatic traffic-monitoring systems to both states and the trucking industry.

OVERVIEW OF POTENTIAL APPLICATIONS OF AVI

Automatic vehicle identification systems could have applications throughout the field of highway transportation. Specific applications will be found in such areas as planning, design and operation of highway weight enforcement systems, surveillance, communications, and control. These include

- Heavy-vehicle monitoring,
- Revenue collection and road pricing,
- Traffic operations and urban transport planning, and
- Law enforcement.

Heavy-Vehicle Monitoring

AVI, coupled with state-of-the-art techniques for weighing vehicles in motion, provides a method by which truck data collection efforts may be simplified and coordinated. The technique improves productivity while reducing long-term data collection costs. In addition, AVI/WIM systems offer advantages to the operators of commercial vehicle fleets by providing a means by which fleet managers can monitor the location of vehicles and, therefore, utilize the resources at their disposal more efficiently.

Finally, AVI/WIM technology can be used in the enforcement of size and weight limits. Using a combination of automatic identification, weigh-in-motion, and vehicle classification, enforcement agencies could identify a truck and determine its size and weight and whether it is covered by a special permit exemption.

Before completion of two important studies, NCHRP's study on the Feasibility of a National Heavy-Vehicle Monitoring System and the HELP System Demonstration Project, it is impossible to be conclusive about the net benefits of heavy-vehicle monitoring systems. There may be a threshold level of deployment necessary before net benefits are achieved.

However, at this time AVI/WIM appears to offer substantial benefits in the monitoring, control, and operation of the heavy-vehicle population. To be sure, in recent years there has been tremendous growth in the use of heavier commercial vehicles, which has resulted in an accelerated deterioration of the nation's major highway systems. Many states have attempted to limit the use of heavy vehicles to certain routes as well as conduct vigorous weight enforcement programs, but these are difficult and costly to administer.

Concern about the effectiveness of current taxation structures in ensuring that commercial vehicles contribute a proportionate payment for road costs is also of concern to many states. The influx of larger and heavier vehicles has reinforced the need for increased vehicle-weighing and vehicle-monitoring activities. Both federal and state governments have shown concern for the problem and have begun to investigate scenarios for automatically monitoring truck size and weights including the use of AVI techniques. The multistate HELP System Demonstration Project is most notable among these efforts. Oregon's own project has already demonstrated that AVI interfaced with weigh-in-motion systems has a reasonable, if not promising, chance for widespread adoption.

Revenue Collection and Road Pricing

AVI used in revenue collection applications can greatly speed operations at toll booths, car park entrances, truck ports of entry, and other facilities where a vehicle has to come to a stop to either present payment or evidence of legal weight and proper papers. The system can be operated in either a prepaid or a credit mode. In either case, the patron would receive periodic statements of usage and account records. Such a system would offer the patron convenience of payment, nonstop passage through the facility, and printed records of usage. An AVI-based revenue collection system could offer the operator significant labor savings and better information on vehicular movements through the facility *(8)*.

In revenue collection systems, where the operation is hindered by lack of capacity at the collection point, the faster passage afforded by an AVI system can substantially improve operations. A further extension of this concept is the introduction of toll charges on congested facilities using AVI for electronic road pricing. The concept of road pricing, whereby users of congested highways would pay for the use of the road on a differential basis, has been widely examined and is currently being studied in Hong Kong. All preliminary technical work has been accomplished, but actual implementation will depend largely on the attitude of the Republic of China. The study indicated that an AVI road-pricing system could be made flexible by charging differential prices by type of vehicle, occupancy rate, time of day, and traffic density of the corridor during peak hours. The conclusion was that the system was cost-effective and easily justifiable on the basis of the benefits resulting from reduced congestion and pollution.

Another form of revenue collection to which AVI may make a contribution is weight-distance taxation. A few states implement this form of heavy-vehicle taxation whereby a particular vehicle is charged on the basis of the distance traveled and registered load. An AVI system for the administration of weight-distance taxes would have several advantages over the present tax collection process. States that have weight-distance taxes could use a common data base for standardized truck taxation, which would make it possible to achieve a uniform and continuous tax program. The use of AVI technology could lead to considerable reductions in the cost of operating the revenue collection process and, in addition, lead to equally significant reductions in evasion *(1)*.

Moreover, states that have this form of taxation could make further improvements in the overall equity of their tax structures by basing the tax rate on a combination of vehicle parameters such as gross weight, axle weights, vehicle configuration, location, time, functional class of highway, and the like so as to reflect the broader impacts of transportation users on the community as a whole. It is important to keep in mind that most states do not have weight-distance taxes; fuel taxes and registration fees are preferred as the primary source of tax payment from heavy vehicles. Here too, AVI systems can offer state officials information necessary to adequately assess trucking firms' reports of fuel used within the state and the accuracy of the report of registration fees the firm has prorated among the various states in which it operates.

Traffic Operations and Urban Transport Planning

AVI offers potential for improved traffic operations, particularly where priority access systems are planned or utilized. The ability to uniquely and accurately identify vehicles by type could greatly increase the effectiveness of priority access systems. Surveillance and control systems could also benefit because AVI information, coupled with data on vehicle speeds, lengths, and types, would permit more precise definition of traffic composition and flows.

The prediction of the number of interzonal trips and their distribution by time of day, route, and mode is inherent in the transportation planning process. These predictions are based on large quantities of origin-destination data, the collection of which is expensive and time consuming. It is unlikely that an AVI system would be installed specifically to benefit the transportation planning process, but if the installation of AVI systems for other applications became a reality AVI readers at specific locations could produce automatic and accurate origin-destination data in a form that could be used efficiently by transportation planners *(8)*.

Law Enforcement

Motor vehicles are used directly or indirectly in a wide variety of criminal activities. These range from the theft of private automobiles and the hijacking of trucks to use in perpetrating a crime or fleeing from the scene of a crime. The present methods of locating these vehicles are, in large part, cumbersome and ineffective, although recent developments in automatic video scanning of conventional license plates have shown promising results.

In one application an electronic video scanning system was located at a toll plaza to the Dartford Tunnel, near London, England. As a vehicle stopped to pay the toll, its number was electronically read and compared with an on-line data base of license plate numbers of wanted vehicles. Detection of a wanted vehicle resulted in a message being relayed to a local police control center. The development of this equipment is continuing with the adaptation of the system to read the license plates of vehicles as they move at highway speeds.

AVI, coupled with speed-monitoring techniques, has obvious applications in speed limit enforcement activities. Systems that automatically photograph a speeding vehicle's license plate are already commercially available. An AVI-based speed trap could operate unmanned to automatically record and store the identity of violators who could subsequently be warned or prosecuted.

Another law enforcement application is in the trucking industry where hijacking of vehicles is a serious problem. The location of trucks equipped with AVI transponders would be determined automatically as they moved along known routes. Knowledge that the truck had not reached a specific point within a predetermined time interval could indicate a potential problem.

A recent marketing distribution plan developed for the Lo-Jack Corporation of Boston, Massachusetts, by Touche Ross & Company assessed the potential market for the company, which has developed and patented a vehicle theft detection system based on state-of-the-art technology. In defining the nature of the motor vehicle theft problem, the report uses as evidence costs borne by society and the trucking industry. It was estimated that annual losses through theft to the trucking industry amount to approximately $7 billion. The number of automobiles stolen each year in the United States was put at more than 1 million, at an estimated cost to society of $2.9 billion and with automobile insurance losses due to theft approximately $3 billion annually. It was also noted that drivers of stolen cars and trucks are responsible for causing more than 5,000 disabling injuries and fatalities annually. If increased deterrence through use of a traffic-monitoring system could lead to even a small reduction in these figures, the benefits to society would be substantial.

CONCLUSIONS

To reiterate, the goal of the Oregon and multistate HELP AVI projects is to investigate the potential use of AVI and WIM technology to serve both government and industry in monitoring heavy vehicles. The potential for benefits from AVI looks promising for both sectors.

Government needs a way to improve its truck safety, weight, and enforcement programs. Current methods are largely ineffective and costly. State DOTs are in desperate need of obtaining better, more reliable, and less expensive data for the planning and design of highways. Also, it should not be forgotten that government is responsible for ensuring the collection of taxes that truckers pay. AVI offers a promising alternative to the current labor-intensive tax-auditing methods.

Stopping at weigh stations and ports of entry takes away valuable trucking time, and time is money. Monitoring truck movements at critical checkpoints could induce more truckers to pay their "fair share" of road user taxes, and honest truckers would definitely benefit. The HELP program is also studying the potential of AVI to assist truckers in fleet management control and to reduce the expense and effort involved with the filing of numerous reports through automating the entire process.

Other developments that involve AVI are taking place around the world. Hong Kong is experimenting with AVI as a potential road-pricing tool to control congestion. London is investigating use of AVI for apprehending toll violators, and Boston is interested in AVI for tracking vehicle thefts. The Port of New York and New Jersey is interested in AVI for monitoring buses as are other cities around the United States.

The technology described in this paper should be just as useful in the Far East and in Europe as it is in North America. All of the AVI applications discussed are viable. The people involved in the HELP project are anxious to find out just how viable some of them are.

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