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**National Vision for the  
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# National Vision for the Surface Transportation System

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## Executive Summary

This white paper forecasts the long-term impact of technology on the nation's highway transportation system. The forecast is based on a vision, which anticipates that *within the next 30 years, the transportation system will be characterized by the ubiquitous application of technology to ensure that the system operates at the highest possible levels of efficiency, reliability, safety, security, and ride quality.* The 30-year vision anticipates the application of technology to infrastructure and vehicles in a manner that ensures safe, comfortable, and reliable travel. Many of the technical capabilities required to achieve this vision already exist, or are in their final stages of research and development. Taken together, these capabilities offer the potential for significant reductions in crashes, improvements in both recurring and non-recurring congestion, improved pavement condition, and more reliable and comfortable vehicles. The challenge is to ensure that appropriate research, implementation processes and policies are in place to ensure that these capabilities are used proactively to achieve the vision.

One obstacle is the significant amount of time required for a new technology to find its way into common practice within the public sector. It is not uncommon for the public sector to wait for 20 to 30 years before accepting new technology. On the other hand, the private sector, including the automobile industry, typically adopts new technologies within less than three years.

## Recommendations

While the recommendations of this white paper cover areas in which additional research is required, their emphasis is on actions that must be taken to improve the rate at which new technology is accepted for the management and operation of the nation's transportation system. If these actions are not taken, the technology that represents the state-of-the-art in 2007, will just be finding its way into common use at the end of the 30-year time frame represented by this paper. The following recommendations are based on the discussion presented in the white paper.

- Support research to continue to advance the state-of-the-art in transportation service provision, safety, mobility, construction, maintenance, and environmental preservation. Increase investment in research to take advantage of advances in technology in the materials and electronics industries, make use of the data available from the VII system, and address the requirements of the transportation community.



- Aggressively fund and continue collaborative research and development with the private sector related to advanced safety applications. As part of this process, identify need for those safety applications in which government regulation is required to ensure their implementation.
- Implement a national system that supports vehicle-to-vehicle and vehicle-to-roadside communications (known as the Vehicle Infrastructure Integration (VII) system), to ensure the availability of ubiquitous information needed to support the management, operation, and maintenance of the transportation system. The success of this implementation depends on a near-term decision to either continue the current cooperative development of the system (involving the Federal government and the automobile industry) or to pursue a laissez-faire approach in which the automobile manufacturers act independently. Continuing with the current cooperative development requires assurance of Federal funding support. If this is not received, the laissez-faire approach will emerge by default. If the laissez-faire approach emerges, it is essential that the Federal government proactively obtain the industry’s agreement regarding the use of open standards and sharing of data for public applications.
- Invest in research, development, demonstration, and implementation support for applications that will make effective use of the data produced by the VII system including adaptive controls, automated updates for time-of-day systems, demand management programs, and pavement condition monitoring systems.
- Support life cycle costing of transportation assets and contracting procedures that favor life cycle costing.
- Enable flexibility for states to use performance-based and innovative contracting.
- Further re-orient public sector contracting procedures to encourage innovation through the use of simplified procedures for sole source acquisitions of proprietary products and processes, and the use of processes such as the Invitation to Negotiate (ITN) utilized by the State of Florida (see text).

## Introduction

This paper has been prepared by the American Association of State Highway and Transportation Officials (AASHTO) to provide a thoughtful analysis of the impact of technology on the future of the nation’s transportation system. Technology is a cross-cutting area that affects all aspects of the transportation system and many different industries (information technology, devices, materials, structures, and construction). In recognition of the breadth of the subject matter, a panel of experts was assembled including representatives from the highway transportation, operations, transit, materials, automobile, and IT industries. The panel developed a high-level vision, and provided information regarding the current state of transportation technology. The information provided by the panel was used as a starting point for this paper.

## The Vision

The following vision is used as the basis for defining technology's contribution to the future management and operation of the nation's transportation system.

*Within the next 30 years, the transportation system will be characterized by the ubiquitous application of technology to ensure that the system operates at the highest possible levels of efficiency, reliability, safety, security, and ride quality. The technology will be implemented and integrated nationally to facilitate its use by travelers on all roadways, and for all vehicle types. This will be accomplished through the creation of an institutional environment that emphasizes the use of technology to advance the creation of a responsive highway system.*

This vision recognizes the relationship between technology and the mobility and safety of the transportation system and implicitly recognizes the importance of policy to its effective application. Also implied by this vision is the integration of vehicle and highway systems, in a manner that makes use of the latest technology, aggressively applied by the public and private sectors. The vision recognizes the importance of the ubiquitous monitoring of the roadway and traffic conditions, and emphasizes the application of the latest in crash prevention technology, the aggressive use of traffic control and monitoring applications, and the use of modern materials and processes for construction, management, and operation of the system.

### Safety in 30 Years

Imagine a highway system without crashes, except for those unavoidable situations involving unanticipated obstacles or mechanical failures. The transportation system of 2037 will approach this goal through the use of vehicles with on-board intelligence and communications to prevent collisions with other vehicles and roadside obstacles. Vehicles will be equipped with automatic speed control and braking that override the actions of the driver if safe speeds are being exceeded or there are obstacles ahead or on either side. They will also alert drivers departing from their intended lane in an unsafe manner. The vehicle of 2037 will also assess the driver's capabilities to operate a motor vehicle by sensing blood-alcohol levels and identifying inattentive drivers who may be sleepy or ill. If driver impairment thresholds are exceeded, the vehicle will take appropriate corrective action. The operation of these features and the vehicle itself will be continuously monitored by its manufacturer using automatic status reporting capabilities integrated into the vehicle's electronics and communications system. Drivers will be alerted that service is needed if malfunctions are identified or upgrades required. Software upgrades will be automatically downloaded to the vehicles.

Many of these capabilities already exist. Those that do not, are in the final stages of research. The combined impact of these capabilities will be the reduction or elimination of crashes due to speed, drunk driving, inattention, unsafe operation, or unsafe external conditions. When combined, these features offer the ability to reduce or eliminate the majority of crashes along with the resulting pain, suffering, and financial losses incurred. Another benefit will be significant improvement in travel time reliability due to reduction or elimination of these unanticipated (no-notice) incidents.

Technology will be the key to achieving these capabilities. Some of these capabilities will be provided by more advanced autonomous systems in the vehicle, however significant advancements are expected to occur with the national deployment of vehicle-to-vehicle and vehicle-to-roadside communications. These communications capabilities are being developed both by the individual vehicle manufacturers (original equipment manufacturers—OEMs), and in cooperation with the U.S. Department of Transportation within a program known as Vehicle Infrastructure Integration (VII).

### Mobility in 30 Years

Imagine a highway system with reliable and predictable travel times, where increases in congestion are significantly reduced. Reliability and predictability will be achieved through major reductions in crashes with the result that most non-recurring congestion will be caused by “advanced notice” incidents such as planned events (construction, sporting events, etc.) and weather. Recurring congestion and advanced notice events will be managed through an effective combination of measures that address both supply (improved management and operation of existing roadway and transit infrastructure) and demand (reductions in the number of vehicle miles of travel). Construction processes will be implemented to minimize impacts, ensure long life and maximize service, thus further enhancing mobility.

Effective management and operation of transportation infrastructure requires comprehensive real-time status information for all roadway facilities and all transportation modes. In 30 years, most information provided by traditional traffic sensor-based systems will have been replaced with a rich flow of information generated from vehicles communicating their location, speed, roadway condition, and environmental information directly to roadside receivers. Transportation supply is effectively managed using the information flow generated by on-board vehicle sensors and transmitted to the roadside. This information will permit the economical implementation of adaptive strategies for traffic signal control and ramp metering; technologies that will automatically adjust to traffic conditions ensuring the most effective use of available roadway capacity. By the year 2037, such information will be used to support additional enhancements such as variable speed control for individual lanes implemented to minimize speed variability and to gradually slow the traffic stream in advance of bottlenecks. Other enhancements will permit managers to continuously monitor flow on parallel routes, diverting traffic to roadways with underutilized capacity to ensure the most efficient possible operation of roadway corridors during both incident and non-incident conditions. Enhanced traffic monitoring information will be used on less congested facilities to provide automatic updates of time-of-day traffic signal timing and ramp metering systems, ensuring that these less sophisticated systems are operating at their peak efficiency. Adaptive strategies and load balancing have been shown to reduce travel times by 20 percent to 50 percent depending on roadway and traffic conditions. Signal timing updates have been demonstrated to reduce travel times by as much as 15 percent.

The year 2037 will see increased use of demand management strategies to influence travel patterns for reduced peak period congestion and slower overall growth in vehicle

miles of travel (VMT). Representative strategies include congestion pricing (variable tolling, parking fees, and variable automobile insurance fees). These pricing strategies shift highway industry financing closer to those of other transportation modes and utilities in which utilization peaks are managed through demand-based fees for service. In 2037, pricing strategies will be used both for long distance and local travel. However, pricing is not the only demand management technique to be used within the next 30 years. Telecommuting, which is already increasing rapidly, will become an increasing factor in the reduction of transportation demand. Technology will play a key roll in this increase as broadband internet service becomes pervasive, and new technologies are introduced that permit telecommuters to “see” each other, using either video or sophisticated animations that permit on-line interaction nearly equivalent to that of personal contact. The Bureau of Transportation Statistics estimated that in 2002, the saving of vehicle miles traveled (VMT) during peak periods grew from 2.0 percent in 1997 to 4.5 percent in 2002 a factor of two increase, within five years.<sup>1</sup> This trend suggests that by the year 2037, the impacts of telecommuting could lead to significant peak period reductions in VMT exceeding 30 percent. While, this improvement may be offset by other changes in travel behavior as well as limitations on the number of individuals for whom telecommuting is practical, there is little doubt that telecommuting will become a significant component of the demand management equation. In 30 years, telecommuting will be recognized by public agencies as a critical transportation management strategy.

When taken together, the combination of supply and demand management will improve facility operations and reduce growth in VMT to provide reliable, predictable service.

### Traveler Information in 30 Years

Imagine the availability of traveler information for end-to-end pre-trip planning and en-route updates that provides reliable real-time estimates of travel times and costs, including parking availability and transfer times for all transportation modes using both push and pull technology. This capability will be attained well before the 30-year time-frame of this paper. With the availability of improved information regarding the status of the transportation system the success of these services is assured. Traveler information will become a commodity, available on a subscription basis. Sophistication of traveler information systems will continue to evolve as improved travel time forecasting methodologies are developed. The structure of the traveler information industry of 2037 will be characterized by the consolidation of today’s startup companies into two or three large national firms competing to gather and sell information to shippers, travelers, and public agencies

### The Vehicle in 30 Years

Imagine the vehicle of the future, as a safe comfortable conveyance offering a mix of driver assists, safety monitors, comfort, business, and entertainment features. In response to the increasing percent of time that the public spends in their automobiles, OEMs are incorporating increasingly sophisticated features to ensure that travel is spent in a safe, comfortable, and productive environment. The increasingly sophisticated

and lower cost equipment produced by the electronics industry has enabled the OEMs to introduce devices that enhance safety through the use of automatic braking systems, adaptive cruise control, traction control, suspension control, rollover control, lane departure warnings, backup warnings, and many others. These safety features will continue to proliferate. Vehicle-to-roadside communication will permit vehicle occupants to conduct businesses and access entertainment while en-route. Motorists will be able to download movies, access banking services, and place carry-out food orders from their vehicles. In-vehicle information services will be greatly enhanced through the integration of advanced mapping features that will locate all roadway features (e.g., speed humps), provide in-vehicle displays of sign messages, support headlight direction control that follows the road alignment, etc.

The vehicle of the future will use technology to reduce driver distraction through increased use of voice recognition, heads-up displays, and interlocks that prevent the use of certain features while the vehicle is in motion. The vehicle of the future will incorporate adaptive antenna and software defined radio technologies that will permit reception of information and entertainment from a variety of sources using any frequency band, modulation technique and communications protocol, to permit unconstrained two-way communication with an unlimited number of voice, data, entertainment, and other communications providers.

### Materials Technology in 30 Years

Imagine a roadway and bridge infrastructure created using long-lasting, durable, high performance materials that provide a smooth, safe, comfortable ride for travelers. Imagine a system in which pavement failures and potholes are immediately identified and repaired, before they can become hazardous and expensive to fix. One approach to providing these capabilities is the use of innovative materials such as fiber-reinforced polymers (FRPs). FRP composites are comprised of a polymer matrix (resin system) reinforced with fibers (such as glass, carbon, and aramid), much like steel reinforces concrete but on a molecular scale. The combination of resin and fibers creates a material with attributes superior to either component alone. FRP composites are lightweight, high-strength, corrosion resistant, large parts can be constructed (limitation to current construction materials), and the engineering properties can be tailored to the application giving engineers a unique and special design alternative. These unique benefits of composites result in modular construction that speeds installation, large parts and factory made parts reduce field construction time, thereby minimizing traffic impacts, and the inherent properties make composites a more durable and lower maintenance alternative to standard construction materials. By 2037, composite technology will have expanded to include nanocomposites. This is an extremely fast growing area of materials development in which composites are created using original (parent) materials that are extremely fine grained (typically less than 100 nanometer) and in which the properties of the resulting material depend on both the properties of the parent materials, as well as their interactions. Nanomaterials are already in limited use by vehicle manufacturers. By 2037, many new materials with novel and beneficial properties will have become available for use throughout the transportation industry.

Advances in materials technology by the year 2037 will not be limited to increased use of composites. Other technologies currently under evaluation such as crump rubber chip seals in which scrap (crump) rubber is added to conventional asphalt for resurfacing applications, will be in common use. Other techniques for improved pavement sealing, bonding, and reinforcement will also have moved from their current demonstration status to routine use with the objective of increasing pavement life, reducing construction time, and improving safety.

The year 2037 will have seen a migration from traditional low-bid contractor selection to one that considers total life-cycle cost and performance during the procurement process, a change that will favor the increased use of innovative materials and techniques. The year 2037 will also see the automatic, early identification of locations for which pavement and other infrastructure failures lead to the deterioration of ride quality. This will be accomplished through monitoring of ride quality measured by vehicles using information such as the vertical acceleration of the vehicle's wheels and communicating the information to the roadside. Using ride quality information, agencies responsible for roadway maintenance will be quickly alerted, and maintenance crews dispatched to correct pavement quality problems before major repairs are required.

### Construction Technology in 30 Years

Imagine the highway system of 2037 in which highway construction and maintenance meets the goal of minimizing interruptions to the transportation system, rapid implementation, and long life. In other words, “get-in, get-out, and stay-out.” Continuing advances in highway construction equipment, such as increased use of robotics, high-performance materials, increased use of precast and prefabricated elements, and improved procedures including new scheduling and traffic management techniques, will permit agencies to attain these goals. One example would be the use of self-propelled modulated trailers to precast bridges off-site and move them into place when completed, a process that will reduce impacts on the traveling public. An example of improved equipment and procedures is demonstrated by the “rollable road system,” built for the Dutch Ministry of Transport. This system includes the use of a prefabricated asphalt pavement (one lane wide) that is transported on a specially designed truck, from which it is unrolled on the roadway surface like a carpet, and then bonded to the existing road surface. This technique offers the potential for significantly reduced construction time, winter application, and use by traffic immediately after its application.

Mobility and safety in work zones will have improved in 2037 as a result of improved merge control techniques such as the routine use of variable length no passing zones and zipper lanes in which merging in advance of the work zone is managed to avoid lane drop conflicts. Additional safety improvements will occur as a result of more extensive speed enforcement, and sophisticated dynamic signing. Mobility in the vicinity of workzones will be improved through the use of analytical tools and simulation to optimize workzone layout and scheduling to minimize impacts on traffic flow.

## Premium Transportation Services in 30 Years

Imagine the highway system of 2037 which includes premium service to motorists and freight carriers willing to pay in congested areas. Far from “Lexus lanes” available only to the rich, these facilities will be used by travelers from across social and economic classes who have a need to reach their destination within a reliable time frame, making the fee worth it to them. Usage statistics from existing premium service facilities in California and Minnesota support this projection. Premium service will be provided through applications of technology that will offer travelers the assurance of minimum travel times with the highest possible safety and ride quality. This will be accomplished through continuous video roadway surveillance so that service interruptions can be rapidly addressed. Technology will also be used for automated congestion pricing, sophisticated displays of travel conditions, and extensive use of variable speed limits. Premium service facilities will be constructed using the latest in long-wearing smooth riding pavement technologies to provide their customers with the highest possible quality of service. Construction impacts will be minimized by scheduling these activities for periods of light traffic conditions.

## The State-of-the-Art and the State-of-the-Practice

The path to achieving the vision of 2037 begins with its starting point in the year 2007. Current technology is best described in terms of the current state-of-the-art (SOA) and the current state-of-the-practice (SOP). Where differences exist, they represent the lag in the adoption of technology by the transportation community.

### Safety Technology

Safety technology can be divided into categories of in-vehicle, infrastructure, and enforcement technologies. The consistent and intensive application of these technologies can potentially have a significant impact on crashes due to speed, drunk driving, driver inattention, and the presence of unexpected hazards. Implementation of proven technologies varies depending on the automobile manufacturer and agencies responsible for their implementation. Recently, automobile manufacturers have accelerated their implementation of safety technologies, such that they become available to consumers soon after they have been field proven. However, it is possible that manufacturers will be reluctant to implement some technologies either due to a perceived lack of customer demand, or their potential implementation liabilities and costs. One example might be the use of sensors that disable a vehicle if driver impairment is detected. In these cases, it will become the public sector’s responsibility to require their installation either through legislation or regulation. These options are continuously examined by the OEMs and the Federal Government and must be addressed on a case-by-case basis. While the impairment sensors are autonomous to the vehicle, the majority of new safety technology requires the development of a capability for vehicle-to-vehicle and vehicle-to-roadside communications.

The public sector tends to be more cautious in its application of infrastructure related safety technology, with implementations frequently requiring years, if not

decades. Regulatory processes, competing public interest groups, funding constraints, a risk-averse culture often slow the pace of technology adoption in the public sector. A representative example of implementation time-frames can be found in the installation of shoulder rumble strips (SRSs). SRS technology has been in existence since 1987. In 1994, the Pennsylvania Turnpike Commission and others have demonstrated the ability of SRSs to reduce drift-off-road incidents by as much as 70 percent.<sup>2</sup> Yet, in spite of these proven benefits, the use of SRSs technology has lagged by as much as 20 years. Some of the delays are the result of both funding and operational concerns including objections of bicyclists to their implementation. Another example of delays associated with the implementation of safety-related technology can be found in the use of photo enforcement, where public concerns about privacy and its use as a form of revenue enhancement has delayed its implementation in spite of its demonstrated ability to reduce speed-related and red light running collisions.

### Infrastructure-Based Mobility and Traveler Information Technology

Many mobility-related advances in the state of the art have occurred during the past 20 years as technologies such as adaptive traffic signal control and traffic responsive ramp metering have been developed and field proven. Yet because of their higher costs, they are rarely used in the United States. The majority of public agencies continue to use traffic signal control technologies in existence during the 1970s rather than taking advantage of the more effective (and more expensive) adaptive strategies. Other mobility-related capabilities such as variable speed control, and parking information systems, are in common use in Europe and Asia, but are not used in the United States.

Dissemination of traveler information through the use of websites, variable message signs, highway advisory radio, and most recently 511, has gradually increased. However, the reliability of this information is still relatively low due to the absence of high quality, real-time traffic flow information. Technology for collection of traffic flow (vehicle detectors) has been available for more than 30 years. Yet, its use is still lagging due to the high capital and maintenance cost of this equipment. Currently, real-time traffic data is collected on fewer than 40 percent of urban miles of interstate and six percent of urban arterials.

Electronic payment systems are an exception to the slow pace of technology adoption. These systems have been implemented by the majority of toll agencies. Interoperability among electronic payment systems is also high and rapidly improving. Public sector and traveler satisfaction with these systems is very high.

### Vehicle Technology

Vehicle technology includes the electronic systems (telematics), propulsion, and materials technologies used in the modern motor vehicle. Telematics includes vehicle manufacturer-centered services (data on vehicle usage and customer relationships), vehicle-centered services (automatic crash notification, remote door unlock, etc.) and user-centered service (navigation and entertainment systems).<sup>3</sup> Telematics is a rapidly expanding field that takes advantage of accelerating pace of development in the electronics and communications industries. Other vehicle technologies such as

improved engines that use hybrid or alternative fuels and lighter stronger materials, are finding increasing acceptance by the OEMs. The competitive nature of the industry combined with increasing oil prices provides the incentive to use the latest technologies in their products.

### Materials Technology

In bridges, FRP composites have been used as a lightweight deck alternative in moveable and lift bridges. Composites have also been used as reinforcement in concrete decks, parapets, sidewalks, and guardrails; dowel bars in concrete pavements; they have also been used to restore strength, stiffness, and seismic protection to slabs, beams, columns, and piers. In marine environments, composites are being used to protect bridge piers and well as restore capacity to marine piles. Despite their lower life-cycle costs and demonstrated structural benefits, the acquisition cost of FRP materials is still an obstacle to its common use in bridge projects. As of 1998, of the half million bridges in the United States, there were 31 FRP bridge projects, 27 of which were built within the past four years. In spite of the fact that the life-cycle cost of this material is significantly less than that of these competing materials, it is difficult, if not impossible for contractors to propose their use in a procurement that favors more traditional materials.

The use of advanced materials is progressing slowly in other areas as well. For example, many state DOTs have only recently initiated demonstration projects to evaluate the effectiveness of the use of crump rubber chip seals, although this material has been in common use worldwide since the 1970s.

### Construction Technology

Construction technology includes the use of more rapid and sustainable techniques as well as improved methodologies for traffic management in construction zones. New construction technology is adopted by contractors, only when it offers them with an advantage in the competitive low-bid selection process. However, state and local agencies have been slow to adopt new traffic management and enforcement techniques including improved forms of merge control, and more sophisticated approaches to scheduling lane closures.

### Vehicle Infrastructure Integration (VII)

Vehicle Infrastructure Integration is the term used to generally describe ongoing national efforts to deploy the vehicle-to-vehicle and vehicle-to-roadside communication capabilities needed to support the 30-year vision. Many feel that the VII system with its significant traffic management, traveler information, safety, and pavement management potential, could revolutionize the quality of service provided by the nation's surface transportation system. The capabilities generally ascribed to VII are crucial to achieving the transportation vision for the future.

As described in the 30-year vision, the VII system offers the potential for significant reductions in crashes, as well as greatly enhanced traffic management. The former is accomplished by taking advantage of vehicle-to-vehicle communications in order to avoid collisions, receive early warning of hazards and to ensure more accurate



lane keeping by drivers. Mobility is enhanced through the transmission of traffic, roadway, and environmental conditions measured by the on-board vehicle sensors, and accumulated at traffic management centers, with the intent of using this data for sophisticated traffic management.

From the public sector's perspective, the success of VII as currently conceived depends on three considerations: availability of funding, development of reliable and effective safety applications, and public-sector implementation of advanced traffic management applications. While research related to safety applications is progressing, issues associated with long-term funding to support its implementation and initiation of applications research, remain unresolved.

## Achieving the Vision

If technology is to play a meaningful role in addressing the mobility, safety, and ride quality issues of the future, it will be necessary to change existing practices as necessary to accelerate adoption of state-of-the-art technologies. Travelers and shippers should not have to wait 10 to 20 years for the highway industry to take advantage of new, potentially beneficial technologies. Constraints on the public sector's ability to adopt new technologies are significant and include requirements to adhere to the low-bid procurement process, obstacles to collaborative development of new technologies, limitations on hiring needed staff, and performance measures that focus on expenditures rather than cost savings and efficiencies. It will be necessary to correct these structural problems before the public sector can easily adopt new technology to improve the quality and efficiency of its service delivery. Changes will be required to reduce the gap between the state-of-the-art and the state-of-the-practice and attain the 30-year vision. The following discussion provides additional background for the recommendations presented earlier.

### Expanded Research Program

Many areas of research must be aggressively expanded if the transportation community is to take advantage of advances in the fields of information technology, materials, robotics, and the emergency of probe-based traffic monitoring and communications technology that will be the result of VII and other programs. Expenditures for highway research and technology are inadequate. The highway industry spends on the order of 0.3 percent of total highway expenditures on research and technology.<sup>4</sup> This level of research investment compares unfavorably with expenditures of other industries which are typically more than five times this amount. It is clear that overall United States research expenditures must increase, to ensure industrial competitiveness in both overseas and domestic markets, and to ensure continuing improvements in the efficiency with which the nation's transportation infrastructure is constructed, maintained, and operated.

The list of research needs is long and well-documented. Representative areas of research with the potential for high payoff include:

- Improved operations technologies such as predictive tools for anticipating changes in travel time due to non-recurring congestion, and techniques for using the vehicle probe data produced by systems such as VII for applications such as adaptive signal control, adaptive ramp metering, and congestion management.
- Improved materials technologies for both structures and pavements that can be used to reduce the time required for highway resurfacing and restoration, and extend the life of these improvements. For example, the support of nanomaterials technology research to expand the potentially beneficial materials that might be used for these applications
- Research into the use of vehicle probe data for rapid identification of situations in which pavement deterioration has occurred, and techniques for rapid response and repair of these conditions.
- Research into the use of vehicle probe data for geographic information systems (GIS) applications and support of car following/lane keeping activities.
- Research into the use of vehicle probe data for managing traffic during major incidents and major evacuations. This would include the development of more effective decision support tools and displays of traffic conditions (including 3-D displays) to provide emergency managers with effective information related to changing traffic conditions.
- Development of more effective planning tools including simulation and analysis that will permit metropolitan planning organizations and state planning departments to evaluate the impacts of system management applications on system operations.

These are just a small sample of research possibilities that should be considered for application of the technologies of the future. It is essential that these activities be funded for near-term initiation, if these technologies are to be available and in use by the year 2037.

### Revisions to the Procurement Process

Modifications to the public-sector procurement process are needed to achieve the flexibility required for the adoption of new technology. Modifications should permit agencies to engage in collaborative processes leading to adoption of new technologies through consideration of life-cycle costs as an integral element of the contractor selection process, and to permit more flexible negotiations during the procurement process. One successful example of such a concept is the state of Florida's Invitation to Negotiate (ITN) which provides the ability for the state and the contractor to develop an agreement based on their common interests as part of the selection and award process.<sup>5</sup>



## Increased Emphasis on the VII Program

The VII program, and the development of appropriate transportation applications that make use of its data, are essential ingredients for achieving the 30-year vision. The chances of VII success within the current public-sector institutional framework as a bottoms-up project struggling for recognition, funding, and consensus, are currently in question. VII will only succeed as a unified system, if strong Federal support and leadership emerges. Attaining this support will require the coordinated support of the OEMs and associations, such as AASHTO in cooperation with the U.S. Department of Transportation. Without high level support, VII is likely to evolve as an uncoordinated activity pursued independently by the individual OEMs, each of which will introduce systems with VII-like capabilities for use with their own product lines.

In the event that independent developments occur, emphasis must be placed on the reorientation of the Federal program to one that guarantees the public sector's ability to acquire and fuse (combine) the data produced by the individual manufacturers into a single, high quality data stream. This can only be accomplished through consensus on data exchange formats and assurance of access to non-proprietary OEM data. In either case, additional focus is required on the applications that use the VII data, including the research, development, and financial support of their implementation.

## Potential Impacts of Privatization and Outsourcing

Although the terms privatization and outsourcing may be used interchangeably, for the purpose of the following discussion, privatization is defined as granting the rights for construction, maintenance, and operation of a roadway facility to a private-sector organization with the intent of establishing a “for profit” operation. This may include either the sale of existing roadways or rights for construction of new roadways or other facilities. Privatization of transportation facilities is not new. It is rapidly gaining momentum as roadways in Alabama, Alaska, Illinois, Indiana, New Jersey, New York, Ohio, Pennsylvania, Texas, and Virginia have been either privatized or are being considered for privatization.<sup>6</sup>

The advantage of privatization is that the private sector has the flexibility of acquiring and using the mix of technologies that will optimize their management and operation of the outsourced facilities without concern for the constraints of categorical funding, contracting and personnel restrictions typically imposed on the public sector. For this reason, the private sector can often make use of the latest technologies, in a more effective manner than the public sector. But privatization is not without its problems, foremost of which are the public's objections to the sale of valuable infrastructure to the private sector. There are also issues of equity related to the ability of lower income travelers to make use of transportation facilities that might be priced beyond their financial means. Privatizing facilities does not inherently lead to superior quality or technology adoption. Public-private partnerships and the contracts that create them must be structured to support the often lengthy time frames needed to reap the benefits of life-cycle costing and must contain performance-based incentives.

In this discussion outsourcing (as opposed to privatization) includes contracting with a private-sector firm for performance of agency functions such as planning, design, operations, and maintenance. It might also be expanded to include outsourcing of entire functions such as traffic monitoring and traffic signal control. If given adequate flexibility, the contractor has the ability to utilize technology in a manner that optimizes personnel efficiency without concern for artificial constraints of categorical funding. Outsourcing the acquisition of traffic data collection to firms that specialize in traffic monitoring using either video surveillance, conventional traffic detectors or probe technology is becoming increasingly popular because of the private-sector's ability to offset its investment in these systems from a number of revenue sources including the public sector. When traffic signal systems are outsourced, the private-sector firm can replace outdated equipment with new equipment and more modern forms of control at appropriate times in the system's life cycle. Replacement is possible without the need to negotiate a lengthy budget process that delays equipment replacement causing unnecessary maintenance cost to support a failing system that has outlived its useful life. But there are also problems with outsourcing of agency functions that include lack of direct control over private-sector staffing and training, and in some cases, the requirement for periodic re-competition of outsourced functions. Public-sector agencies engaging in outsourcing also experience difficulties maintaining trained and experienced public-sector staff required to manage the outsourced activities.

Again, well structured contracting is critical to achieving desired results. Transportation agencies could benefit from additional case study analysis and peer exchange to better understand the true impacts of privatizing facilities and outsourcing traditional in-house functions, and how to create contracting mechanisms that support their aims.

## Concluding Thoughts

The recommendations presented within the Executive Summary of this white paper have been derived from the vision and the review of the current state of the practice. It is essential that these recommendations be addressed in order for the transportation community to take advantage of the significant potential offered by new technology. An aggressive proactive approach to the adoption of new technology including institutional change and public education is required to continue to support rapid economic growth and meet social demands over the next 30 years. However, there is little doubt that with the appropriate use of technology, most of which exists today, the U.S. transportation system can rise to these challenges.

## Endnotes

1. “Transportation Implications of Telecommuting,” *Bureau of Transportation Statistics*, U.S. DOT Transportation Library, <http://ntl.bts.gov/DOCS/telecommute.html>.
2. Wood, N. (1994). *Shoulder Rumble Strips: A Method to Alert Drifting Drivers*, Pennsylvania Turnpike Commission, January 1994, [http://safety.fhwa.dot.gov/roadway\\_dept/docs/shoulderdrift.pdf](http://safety.fhwa.dot.gov/roadway_dept/docs/shoulderdrift.pdf).
3. Yuka, G., et al. (2006). “Personal Services,” *Thinking Highways*, Nov–Dec 2006.
4. *Highway Research and Innovation: Role of the Public Sector*, TRB Accession Number: 00728417, <http://pubsindex.trb.org/document/view/default.asp?lbid=468000>.
5. A brief definition of the term “Invitation to Negotiate” can be found at the Florida Senate’s 2006 Statutes website: [http://www.flsenate.gov/Statutes/index.cfm?App\\_mode=Display\\_Statute&Search\\_String=&URL=Ch0287/Sec012.HTM](http://www.flsenate.gov/Statutes/index.cfm?App_mode=Display_Statute&Search_String=&URL=Ch0287/Sec012.HTM).
6. Schulman, D. and J. Ridgeway, “The Highwaymen,” *MotherJones.com*, January/February 2007, <http://www.motherjones.com/news/feature/2007/01/highwaymen-3.html>.