INTERNATIONAL TECHNOLOGY SCANNING PROGRAM

SAFETY APPLICATIONS OF Intelligent Transportation Systems in Europe and Japan

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16. Abstract

With nearly 43,0000 deaths a year on U.S. roads, a need exists for countermeasures to reduce the number and severity of crashes. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study of intelligent transportation systems (ITS) applications deployed in France, Germany, and Japan to mitigate traffic safety problems.

Among the safety applications of ITS technologies the scan team observed were changeable message signs to manage traffic flow, automated speed management and control efforts to reduce crashes, video incident detection and an eCall system to improve emergency personnel response times, and driver assistance initiatives such as adaptive cruise control, lane keeping, and assisted braking.

The team's recommendations for U.S. implementation include projects to increase support for and document benefits of automated enforcement systems, evaluate advanced video detection and incident analysis technology, deploy dynamic sign technologies, and conduct variable speed limit pilots. The team also recommends an initiative to encourage top-down leadership commitment to fatality reduction throughout the country.

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SAFETY APPLICATIONS OF

Intelligent Transportation Systems in Europe and Japan

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

International Technology
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The International Technology Scanning Program, sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP), accesses and evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to recreate advances already developed by other countries.

FHWA and AASHTO, with recommendations from NCHRP, jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State departments of transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use. Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, approximately 70 international scans have been organized on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology-sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvements in the Nation's transportation system.

Scan reports can be obtained through FHWA free of charge by e-mailing international@fhwa.dot.gov. Scan reports are also available electronically and can be accessed on the FHWA's Office of International Programs Web Site at *www.international.fhwa.dot.gov.* ■

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Abbreviations AND ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ADAS	Advanced driver assistance systems
ADT	Average daily traffic
ASF	Autoroutes du Sud de la France
BASt	Germany's Federal Highway Research Institute
CCTV	Closed-circuit television
DOT	Department of transportation
ERTICO	Europe's Intelligent Transport Systems and Services
EU	European Union
FHWA	Federal Highway Administration
GPS	Global Positioning System
HMI	Human-machine interface
IT	Implementation team
ITS	Intelligent transportation systems
MPO	Metropolitan planning organization
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
PSAP	Public Service Answering Point
SHRP	Strategic Highway Research Program
TMC	Traffic management center
TOC	Traffic operations center
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation
VICS	Vehicle Information and Communication System
VII	Vehicle-Infrastructure Integration
VMS	Variable message sign
VMT	Vehicle miles traveled

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Executive SUMMARY

Overview

Safety continues to be of paramount concern to transportation professionals and elected officials throughout the country. In 2004 almost 43,000 fatalities were recorded on the Nation's highways, with another 2.8 million injuries in crashes. While the fatality rate has declined slightly over the past decade, there is a clear need to reduce the high human cost of crashes logged each year.

The objective of this scanning study was to find existing intelligent transportation systems (ITS) applications deployed in other countries that could be effective in mitigating safety problems in the United States. Of particular interest to the scanning team were applications that decrease traffic crashes and their severity. Specific examples sought included collision avoidance, infrastructure-cooperative systems, automated warning and enforcement strategies, speed management, severe weather condition and hazard warning systems, and other technology deployments.

This scanning study was sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP). The scanning team visited Japan in October 2004 and Germany and France in May 2005.

In each country, the team held meetings and conducted site visits with representatives of government agencies corresponding to both the State and Federal levels in the United States, and with trade associations and private-sector organizations including vehicle manufacturers. The three countries were selected because of existing and emerging applications of ITS strategies that had resulted in measurable improvements in safety. Although the entire team visited Germany and France, only a subgroup participated in the 2004 ITS World Congress in Nagoya, Japan. While in Japan, the group also met with industry and government organizations and participated in an extensive field review of deployed ITS technologies.

The work of this scanning team focused on 11 areas where technology deployments would improve safety on the Nation's highway system:

- Automated enforcement of speed limits and traffic signals
- Infrastructure-based collision warning systems
- Vehicle-based measures for crash avoidance
- Identification and prioritization of safety problem areas
- Selection of ITS over traditional countermeasures for safety problems
- Weather mitigation systems
- Speed management and traffic calming
- Pedestrian and bicycle safety
- Navigation, traveler information, and signage issues related to safety
- Collection of safety-related data elements
- Obstacles to implementation, such as public acceptance and legal/liability issues

To help the hosting organizations focus their briefings, the scan team provided specific amplifying questions relating to each area before its visit. This report is a summary of the findings and recommendations of the team.

Sample Initiatives and Applications

The scan team was privileged to see firsthand and through host country presentations many different safety applications of ITS technologies. Some were in the research and development stage while others have seen some measure of application or deployment. The aggregate knowledge gained from this study has resulted in the findings and recommendations in this document. To indicate the genesis of these findings and recommendations, some of the observed applications and technologies are listed below:

- Overhead signs with static and changeable messages are used to manage traffic flow, reduce congestion, and communicate incidents and other information.
- Various European Union (EU) initiatives, including eSafety, INVENT, and PReVENT, represent public-private partnerships focused on specific safety applications of ITS technologies.
- The eCall system will allow for more accurate and timely response by emergency personnel to crashes and other incidents on the highways. It is projected that it will save some 2,000 lives a year once fully implemented in 2009.
- Image processing was presented in a number of formats and applications. Each application showed promise in gathering critical information for the driver, analyzing that input in an onboard processor, and then communicating it to the driver in a timely way.
- Electronic toll collection is used in France to create a more efficient travel experience on the tollways.
- Various initiatives involving digital mapping took static and dynamic information about the roadway and its geometric and

performance characteristics, as well as real-time information gathered from other sources near the vehicle, and communicated it to the driver. One of these was SafeMAP, which offers significant driver assistance by combining both digital mapping and onboard navigation features.

- Speed management and control were the focus of a number of EU efforts to reduce crashes and their consequential injuries and fatalities. These efforts ranged from informational to extensive enforcement initiatives and offered some demonstrable benefits for safety. The 85-percent reduction in crashes measured in one study of a French motorway is noteworthy and reflects the possible safety benefits of this strategy.
- Video incident detection was demonstrated to the team in a way that reflected significant potential value in improving safety. Critical to successful use of video detection are the algorithms used to discern between typical traffic flow and activity and the circumstances associated with an incident or crash.
- The European Union has established a Code of Practice to protect implementers and manufacturers from excessive liability claims associated with the deployment of ITS technologies. This code defines the standard of care that, if met, protects these providers and promotes further deployment of new systems.
- Various driver assistance initiatives were observed, including those that provide research in the area of driver behavior, human-machine interface, and anticipatory and detection systems.
- Optimizing system throughput was also viewed in Germany, where shoulder running and aggressive use of alternative routing add additional capacity to motorways.

The applications and initiatives the host countries shared confirmed the validity of their selection for this tour. They were many and varied and offered a glimpse into the possibility for improving safety on the U.S. road and highway system.

Summary of Findings and Recommendations

At the conclusion of the European visits in May 2005, the team identified a series of findings and developed recommendations. These findings and recommendations reflect specific areas where ITS technologies already underway in other countries could make a significant improvement in safety in the United States. Both the findings and recommendations are divided into four elements: the driver, the vehicle, the environment, and policy. The team believes that effectively deploying ITS applications with an eye toward these four elements will result in substantive improvements in highway safety.

Driver

Information is an important element of ITS highway safety-improvement technologies. However, not all information is essential for all drivers at the same time; rather, the right information should be given to drivers at the right time and place for them to react properly to those inputs. There is growing recognition, particularly in the manufacturing community, that the driving task is very complex; thus, one goal is to reduce the driver burden. Too much information at the wrong time is not useful, just as dated or old information is of no value in improving safety. Systems that provide information must also recognize and adjust to the diverse demographic needs of the driver population.

Another important aspect of driver safety is the balance between technology that assists the driver with inputs in the decisionmaking process and the basic responsibility that all drivers have to operate their vehicles in a proper and safe manner. Technology can assist, but it cannot replace, sound decisions. Ultimately, there is no replacement for the human mind and its ability to process complex inputs, render judgment, and take appropriate action. Technology can, however, improve the driver's ability to make good and safe decisions.

The team came away from its visits with a strong sense of the importance of the human factors element in making sure that the driver integrates well with the vehicle, environment, and policy components of ITS. Industry is concentrating on driver behavior in crash and noncrash situations to better determine the nature of this integration and to promote increased safety. European research efforts are focused on the "average driver," since this typically represents who is on the road. The average driver may be fatigued, prone to mistakes or poor judgment on speeds and distances, or distracted. Human factors research focuses on achieving safe and reliable results under these less-than-optimal conditions. Ultimately, it is imperative that the driver, vehicle, environment, and policy components work together in a harmonious way, sometimes referred to as "cooperative driving."

Finally, there appears to be no substitute for compliance with traffic laws and regulations in advancing safety. This is particularly true for speed enforcement. In Europe, the team observed measurable improvements in reducing the numbers of fatalities, crashes, and injuries as speed was regulated more carefully and enforcement activities were increased.

Two major recommendations emanate from the driver-related findings of this scan:

1. Identify stakeholders and interest groups and promote their collaborative efforts to raise the awareness of the driver's needs.
2. Advance the use of technology, driver education, insurance incentives, and other means to promote greater speed compliance and management.

Vehicle

The vehicle has been the focus of many safety improvements over the years, including seatbelts and airbags. These passive systems have netted substantial benefits to the public and have clearly resulted in reduced injuries and fatalities. The team believes that the safety benefits of these passive systems likely are nearing a maximum, and that in the future more emphasis should be placed on active systems that will further reduce the adverse effects of crashes on the Nation's highways. Active systems, such as electronic stability-control systems found on many of today's cars, should be complemented with such technologies as adaptive cruise control, assisted braking, lane keeping, and others to achieve even greater safety improvements.

Integrating the vehicle with its surrounding environment will be essential to advancing a number of the team's recommendations. While onboard navigation systems provide some operational and safety benefits, there is a need to proliferate processing devices that can send, receive, analyze, and output information in real-time fashion. Further, adding traffic-control information and warning features to the navigation system will provide drivers with critical information affecting the driving task. These systems need to be low cost to achieve the market penetration that will result in the safety improvements envisioned.

The team has two broad recommendations on the vehicle component:

3. Promote the aggressive implementation of low-cost, onboard processing devices in U.S. automobiles that will communicate with infrastructure features and receive information from other sources.
4. Promote and collaborate in the development of technology focused on driver assistance (e.g., adaptive cruise control, lane keeping, assisted braking, etc.).

Environment

The findings relating to the environment component of ITS safety systems are many and varied. They include a substantial finding that controlling speed through effective management and enforcement strategies appears to result in very real reductions in crashes, fatalities, and injuries. In fact, the team is convinced that the greatest gains in safety can be achieved by managing speed. A voluntary system resulting in no citations could achieve some level of benefit, but a more aggressive photo-enforcement process would bring substantive realization of the objectives of this scan effort.

There is a clear need to further integrate the environment and its infrastructure elements with the vehicle. An infrastructure that includes "smart" components, such as chips on signs and signals that offer two-way communication attributes (between vehicle and infrastructure), is just a part of this enhanced environment for the driver and the vehicle. Obviously, this is a long-term initiative, but one that must be advanced. Meanwhile, equipping the vehicle with the ability to recognize infrastructure features, such as traffic signals and signs, will bridge this technology gap until penetration of smart features is sufficiently thorough to result in the desired safety benefits.

Complementary to this finding is another that identifies the need to integrate, certify, and maintain detailed location codes, speed limits, and other critical information on digital maps that interact dynamically with the vehicle's onboard processor.

To achieve substantial benefits in safety improvement on the Nation's highways, the team recommends the following initiatives related to the environment component:

5. Promote additional testing and implementation of photo enforcement of speed. Implement a program of photo-speed radar with a noncitation strategy to help curb aggressive driving on roads and highways.
6. Promote the accelerated development and deployment of systems to facilitate communication between the infrastructure and the vehicle.
7. Promote the further use of changeable/dynamic graphical signs (international standards).
8. Integrate/certify/maintain detailed location codes, speed limits, and other critical infrastructure features in digital maps. Further integrate this information with onboard vehicle technology.
9. Develop and deploy technology that uses information gathered to provide real-time notice of incidents. Use data collected in traffic operations centers to react to emergencies.
10. Promote the use of operations data in planning for future improvements to the infrastructure.

Policy

While the team observed many findings related to the policy component, it has singled out two for this report. The first is the obvious relationship between political and organizational leadership and the advancement of ITS technologies that will produce substantive safety improvements. Much of what is being advanced in the countries the team studied is the result of such leadership that crosses all boundaries in the transportation industry.

Many factors contribute to safety on the Nation's highways, including governmental agencies, vehicle manufacturers, and systems developers. It is critical to find the proper balance of obligations among the car manufacturer, road authority, and systems providers on who supplies what information to the driver.

Liability is a key concern of the private sector that reduces its ability to deploy technologies proven in research studies that could be made widely available. The European community is developing a Code of Practice that will set standards of performance and a "duty of care" that it hopes will address the liability issues connected with the deployment of advanced technologies. Development of a similar U.S. code of practice would open the door to many ITS applications in use elsewhere in the world but not yet deployed in the United States.

There is a strong sense of collaboration between public agencies and private-sector organizations in the European Union. This cooperation exists in areas such as funding, research, joint public-private working groups focused on specific issues, information protocols, and others. Again, leadership is the key to advancing complex policy issues such as speed enforcement and management.

The team has two recommendations relating to policy:

11. Create a national highway safety leadership initiative focusing on safety applications of ITS technologies.
12. Create a warehouse for standardizing, gathering, managing, and analyzing before-and-after performance data relating to safety applications of ITS technologies.

Planned Implementation Actions

The implementation team (IT) is a subset of the full scanning team. It is charged with establishing the implementation strategies of this scan, disseminating key findings, and promoting the recommendations the team developed. Using these preliminary findings and recommendations, the IT is searching out opportunities to include in State projects certain safety aspects of the ITS technologies witnessed during the scanning study. As the recommendations can be generally separated into two broad categories (infrastructure-based and vehicle-based), the team will focus initially on infrastructure-based initiatives that can be readily incorporated into State projects in the preliminary or final design phases of development.

The technologies to be implemented will be oriented toward emergency transportation operations and integrated corridor management, with specific emphasis on alternate routing, alternate signal phasing, speeding warning, and variable speed limit control. In addition, technologies will be promoted that provide real-time traveler information by means of changeable message boards, 511 services, and radio or other in-vehicle methods. In the future, as advances in in-vehicle communication and video detection are made (and market penetration warrants it), the team's efforts will be expanded to include communication and integration of data between the vehicle and the infrastructure. One of the more promising technologies is video detection of incidents and emergency-response validation using image-processing algorithms within corridors. Such technologies promote both safer operation and capacity optimization through effective traffic management.

Another promising implementation topic is the development and use of in-vehicle communication with either car-to-car or car-to-infrastructure methods to promote driver safety and awareness. The scanning team is aware of the Vehicle-Infrastructure Integration (VII) initiative under development and believes its findings and recommendations will complement those efforts. It is researching the alignment of these ITS and safety elements (i.e., Global Positioning System (GPS) mapping and navigation, adaptive cruise control, lane keeping, assisted braking, etc.) to identify champions, opportunities, and roadblocks. This effort will facilitate promotion of effective standards and policies to bridge the gap between the automotive industry and government policymakers. ■

CHAPTER ONE

Introduction

Study Objective and Focus Areas

The Safety Applications of Intelligent Transportation Systems scan was jointly organized and sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP). The study began in fall 2004 and continued through summer 2005.

The objective of this study was to find existing intelligent transportation systems (ITS) applications deployed in other countries that could be effective in mitigating safety problems in the United States. Of particular interest to the scanning team were applications that decrease traffic crashes and their severity. Specific examples sought included collision avoidance (including infrastructure-cooperative systems), automated warning and enforcement, severe weather conditions warning, and automation.

The purpose of the international scan process is to build on the successes of the Strategic Highway Research Program (SHRP) Implementation Task Force in the following efforts:

- Promoting close partnerships
- Strengthening communications
- Identifying champions of technology
- Marketing technology
- Supporting implementation
- Providing a continuous assessment of outcomes

By focusing on these areas, the outcomes of this international scan will assist the U.S. Department of Transportation (USDOT), State departments of transportation (DOTs), and local transportation officials and organizations in gaining a better understanding of issues related to communications, liability, maintenance, life-cycle costs, and effectiveness of such systems, based on the experience of the countries visited. In addition, the potential exists to accelerate the application of countermeasures that can have valuable and long-lasting impact on U.S. highway safety in reducing the number and severity of crashes.

The need is clear for U.S. transportation agencies and officials to acquire information on the application of ITS technologies to enhance safety. Figure 1 reflects the trends in fatality rates in the United States from 1988 through 2004. In the most recent year on record, the total number of fatalities associated with traffic crashes on the Nation's roadways exceeded 42,800. This reflects a slight increase from 2003.

Fatality rates shown in figure 2 (see next page), indicated as deaths per 100 million vehicle miles traveled (VMT), decreased slightly to 1.46 in 2004 from 1.48 in 2003.[1] The decrease in the fatality rate, coupled with a higher number of fatalities, is the result of an increase in total VMT versus total number of fatalities. Transportation officials certainly take no comfort in this almost imperceptible decrease in the fatality rate when more than 42,000 deaths a year still occur on the Nation's highways.

The impact of these deaths is highly significant in terms of the price paid by families and friends, as well as by employers and others. The impact of injuries from a personal and medical sense is also sobering. The National Highway Traffic Safety Administration estimates that the costs associated with traffic crashes exceed $231 billion per year, which represents 2 percent of the Nation's gross domestic product.[2] In responding to this

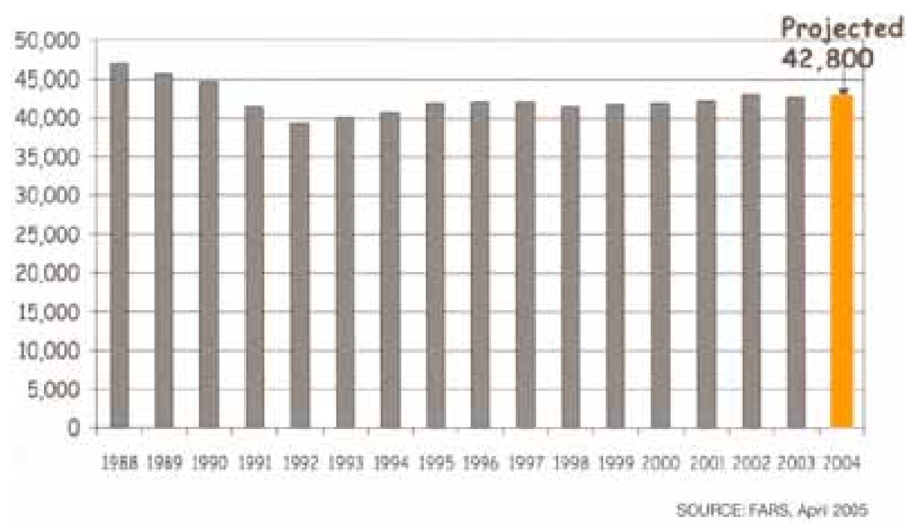

FIGURE 1. Annual number of fatalities. *(www.nhtsa.dot.gov)*

FIGURE 2. Annual fatality rate. *(www.nhtsa.dot.gov)*

WORLDWIDE ROAD TRAFFIC FATALITIES—1998

UNITS = 25,000 LIVES LOST PER SQUARE

POOR NATIONS	
Africa	170,118
Americas	125,959
China	178,894
Eastern Mediterranean	70,677
Europe	106,757
India	216,859
South-East Asia	118,608
Western Pacific	41,165
WEALTHY NATIONS	
Eastern Mediterranean	923
Europe	66,099
North America	49,304
Western Pacific	25,330
Combined Totals	1,170,694

WORLDWIDE ROAD TRAFFIC INJURIES—1998

UNITS = 750,000 INJURIES PER SQUARE

POOR NATIONS	
Africa	6,116,559
Americas	4,410,736
China	5,384,909
Eastern Mediterranean	2,533,771
Europe	3,213,104
India	7,203,864
South-East Asia	3,997,631
Western Pacific	1,432,539
WEALTHY NATIONS	
Eastern Mediterranean	
Europe	29,979
North America	2,082,321
Western Pacific	1,670,374
Combined Totals	772,838
	38,848,625

SOURCE: WORLDHEALTH ORGANIZATION

FIGURE 3. World Health Organization fatality and injury report. *(www.nhtsa.dot.gov)*

significant financial impact of crashes and their resulting fatalities, automobile insurance rates for injuries and property damage increased an average of 10 percent between 2002 and 2003 alone.[3] The timeliness of this international scan and the possibility of leveraging ITS applications already deployed in other countries to mitigate these impacts are clear.

Traffic fatalities and injuries resulting from crashes are of concern in the international arena as well. The World Health Organization considers the high death rate on roads and highways to be epidemic in proportion to the world population. Figure 3 reflects the organization's findings in the late 1990s, which caused it to be more aggressive in moving to reduce this heavy toll on societies worldwide.

To maximize the value derived from this scan, the panel divided its efforts into two phases. In phase one, a subset of the full panel participated in the ITS World Congress held in Nagoya, Japan, in October 2004. This group attended valuable sessions at the ITS World Congress and participated in a tour of innovations being advanced in Japan on safety applications of ITS technologies. A summary of the Japan phase findings is in Appendix A.

In phase two, the full scan team visited Germany and France. While much can be learned from many other countries in Europe, including England, Finland, Sweden, and Switzerland, the team's limited time required a deliberate and focused series of meetings in only two of the countries where these applications exist.

Accordingly, the panel conducted meetings in both countries with government agencies, the private sector, and members of academia. In addition, while in Japan at the ITS World Congress, panel members met with representatives from many countries not visited, with the intent of gathering further information from their experiences in this study area.

Study Organization

FHWA, AASHTO, and NCHRP sponsored the scanning study. The countries the team visited, with their respective dates, are listed in table 1, and the international contacts interviewed are in Appendix B.

The team selected France and Germany because of their significant deployment and application of ITS technologies with a focus on improving safety in their highway systems. In addition, in Germany the team was able to meet with researchers from the private sector to gain greater understanding of their efforts toward this objective. A major discriminator in making these selections was the fact that both France and Germany had actual deployment of the technologies of interest and had performance data substantiating the value of their application.

Panel Composition

Scanning team members were selected to represent a diversity of knowledge and experience so that the ITS technologies examined could be viewed in proper and valuable context for deployment in the United States. The 12-member panel represented FHWA, AASHTO, and academia. The team members have many years of experience in areas such as ITS technology deployment, organizational management, public policy issues, maintenance and operations of road and highway systems, and engineering design and construction. Team members and their organizations are listed in table 2. Contact information and biographic sketches for team members are in Appendix C.

Amplifying Questions

To focus the discussions with each of the public- and private-sector groups the scan team visited, the team developed a series of amplifying questions ahead of time. The scan's area of interest was so broad that the team thought this would assist the groups in preparing their remarks and materials for the team's visits. These amplifying questions were translated into both German and French for the meetings held in the respective countries as a courtesy to those who agreed to assist the team in its study. A list of the amplifying questions is in Appendix D.

This list of questions is significantly pared down from the comprehensive list the scan team developed at the onset of the project. The scope of ITS technology deployment and the array of safety issues of concern to the team members are very broad. However, knowing that time with the host organizations would be limited, the team developed the final set of questions to reflect a thoughtful and deliberate attempt to acquire the most critical information possible for each area of interest. In addition to specific areas of interest (including crash avoidance, pedestrian and bicycle safety, collision-warning systems, and others), each question queries the host organizations on what performance data and measures are available to assess the effectiveness of the deployed strategies. This concern for performance was a deliberate attempt by the scan team to gain insights into the effectiveness of the strategies presented.

Implementation

The key to moving the transportation industry forward in reducing fatalities, injuries, and property damage lies in finding ways to deploy promising technologies. To this end, the scan team spent considerable time evaluating the information gathered during the two phases of the scan and developed an implementation plan for use at the Federal, State, and local levels. This plan, including details of its implementation, is in Chapter 4.

Table 1. Scan itinerary.

Scan Locations	Dates Visited
Germany	May 9–11, 2005
France	May 12–13, 2005

Table 2. Team members and organizations.

JOHN R. NJORD (co-chair, Europe) *Utah Department of Transportation*	ROBERT W. BRYANT *Oregon Department of Transportation*
DR. JOSEPH I. PETERS (co-chair, Europe) *Federal Highway Administration*	ROBERT M. CALLAN *Federal Highway Administration*
MICHAEL FREITAS (co-chair, Japan) *Federal Highway Administration*	MARTIN KNOPP *Federal Highway Administration*
BRUCE WARNER (co-chair, Japan) *Oregon Department of Transportation*	LYLE KNOWLTON *New Hampshire Department of Transportation*
K. CRAIG ALLRED *Federal Highway Administration*	CARLOS A. LOPEZ *Texas Department of Transportation*
DR. ROBERT L. BERTINI *Portland State University*	TOM WARNE (report facilitator) *Tom Warne and Associates*

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1. National Highway Transportation Safety Administration *(http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/PPT/2004EARelease.pdf).*
2. Traffic Safety Facts 2001, NHTSA.
3. InsWebb Corporation, *Inswebb.com*.

CHAPTER TWO

Observed Applications and Initiatives

The scan team met with both public- and private-sector organizations in France and Germany. In every case, the host organizations were generous in sharing their latest advancements in applying ITS technologies to improve safety on their road and highway systems. This chapter provides a glimpse into the wide array of applications and initiatives the scan team observed during the course of its study in Europe.

Figure 4. International symbol.

Communicating Via Overhead Message Signs

The team observed many effective means for communicating information to the traveling public via both static and variable message signs (VMS). The Europeans rely on these signs to provide vehicle operators with up-to-date information about traffic conditions, road restrictions, and other situations affecting the safe and efficient use of the facility. In both France and Germany, the use of international symbols (figure 4) is obviously well established (as well as in other EU countries). These symbols, which transcend language barriers among countries, allow for the accurate and clear communication of information motorists need to safely use roads and highways.

This effort, focused on simplifying the communication of information, follows very closely the human-machine interface (HMI) initiatives in both countries, a deliberate effort to provide drivers with only the information that is essential at a critical time in the journey. In a transportation world where drivers are inundated with information (including that provided by typical signing, advertising, and cellular services), the opportunity to relieve the information load through use of symbols in lieu of text appears promising.

Variable or changeable message signs take many forms in the European transportation system. Some signs have standard, changeable legends that can be tailored to communicate, in textual format, key information and data, as shown in figures 5 and 6. Graphical representations of roadway networks and their level of congestion are also not uncommon in Germany, as shown in figures 7 and 8 (see next page).

Other signs included a combination of standard messaging and international symbols, providing standard inputs to the driver on road conditions, speed, or warnings.

In addition, observed signing also provided transportation system operators the ability to provide additional routing information for congestion or incident management purposes. The signs also are used to divert traffic from one route to another and often offer the driver a choice by estimating the differences in travel time for provided options.

Static signs, as shown in figure 9, are also thoughtfully designed to communicate the maximum amount of information to the vehicle operator in the clearest fashion possible. The scan team observed significantly more use of routing symbols on signs in Europe than in the United States. These symbols and graphics depict movements and give drivers a sense of how routing decisions will occur as they proceed through interchanges on the

Figure 5. Changeable message signs.

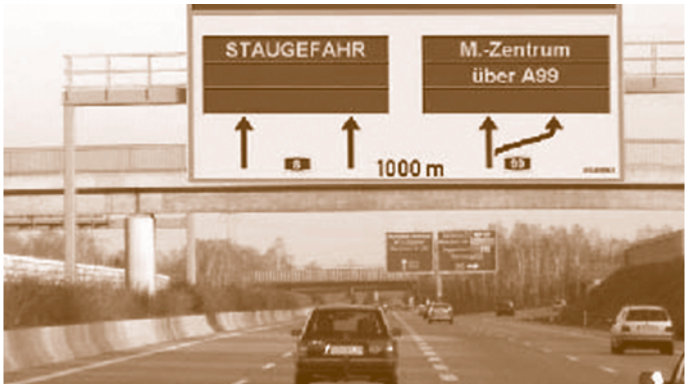

Figure 6. Variable message sign. (BMW)

Figure 7. Variable message sign with congestion indication. (BMW)

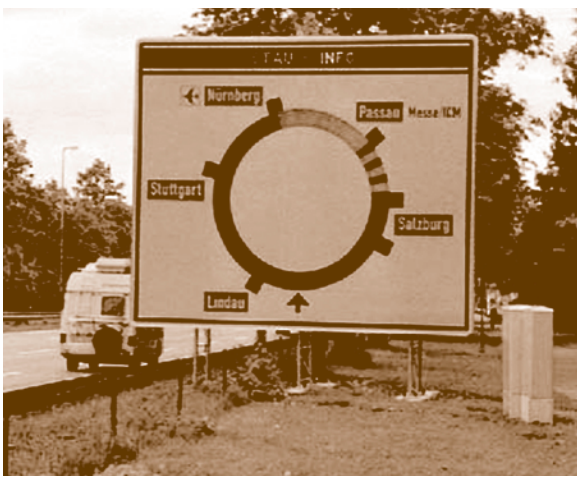

Figure 8. Variable message sign with congestion indication—ground mount. (BMW)

Figure 9. Static overhead sign.

road ahead. This combined use of symbols and text messages in a static, overhead-signing situation appears to be an effective means of communication.

eSafety Initiative

The European Commission established the eSafety effort to advance a significant number of initiatives that will result in substantial safety improvements for those who travel the roads and highways of its member countries. This eSafety Forum (figure 10) is composed of nine working groups whose projects include crash-causation analysis, human-machine interface, and others. Figure 11 shows the organization and reflects the breadth of the individual initiatives in the eSafety initiative.

The eSafety initiative has produced a collective umbrella structure for advancing the many subinitiatives that compose the overall effort. The working groups identified by each box in figure 11 are key to the success of safety, since this is where the technical research occurs and where public-private interactions result in the various products and services developed. Nevertheless, the structure is sufficiently robust at the forum level that key efforts are able to move toward implementation. The team observed that the EU members and private-sector companies who support the eSafety initiative have developed a productive and effective relationship with tangible results from their collective efforts.

The eSafety program is composed of multiple elements that will collectively contribute to the safer operation of vehicles on the roadway. To date, the European Union has committed about EUR170 million (US$212 million) to support the various programs falling within the eSafety research and deployment structure. The vision of the eSafety initiative is divided into two major categories:

- First-generation, or autonomous, systems
- Second-generation, or cooperative, systems

First-generation systems focus more on the vehicle as an isolated unit capable of gathering some external inputs but operating mostly within its own sphere of information. The following three descriptors offer insight into how this is accomplished:

- Advanced vehicle sensors and communications systems integrate with onboard navigation systems.
- Advanced GPS coordinates with digital mapping and location-based services.
- Vehicle and infrastructure information emphasizes safety and efficiency.

To move the eSafety effort forward, European Union has established what it calls second-generation initiatives, which will manage the vehicle's performance in the context of the overall system. The vehicle is no longer seen as a singular element in the roadway environment; instead, all elements (including other vehicles and the infrastructure itself) work together as a system. The two descriptors offered for this second-generation eSafety system are the following:

- Intelligent vehicles are able to link to one another and

exchange information with the roadway infrastructure with increasingly greater intelligence as more data and information are acquired.
- Sensors, system architecture, software, and positioning technologies integrate the vehicle within a global road safety system.

Many systems the scan team observed are elements of the EU eSafety initiative. PReVENT is one of these systems. With EUR55 million (US$69 million) dedicated over 4 years, the purpose of the PReVENT effort is fivefold:

- Safe speed
- Safe following
- Lateral support
- Intersections
- Vulnerable users

Each specific area constitutes a focus of intense research to provide safer operation of vehicles on EU roadways. Transportation professionals will recognize the logic behind these five areas and see why research on each would lead to safer vehicle operations.

eCall: Connecting the Driver to the Rest of the World

One challenge facing emergency response resources is timely notification. Similarly perplexing is the issue of responding with the proper personnel and resources to address a specific incident and its victims. In many cases, the individuals first on the scene were not traditional law enforcement or medical personnel, but auto club employees or others. In response to this important need, the EU eSafety initiative continues to examine many of the human-machine interface initiative's components, including notification following an incident. One such component is the eCall system in preliminary development in Europe.

Figure 10. eSafety Forum logo. (*www.escope.info*)

eCall is an initiative that will allow a motorist to either automatically or manually communicate with a Public Service Answering Point (PSAP) when an incident occurs. PSAP then notifies appropriate emergency service organizations so they can respond quickly to the situation. During this communication process, PSAP personnel will assist the reporting vehicle operator in addressing immediate needs at the scene of the incident. Simultaneous communication of critical health and safety information can be sent to the proper emergency organizations so that the response is tailored to the specific circumstances. Additionally, the GPS component of the eCall initiative will allow emergency response resources to go to the precise location of the incident without wasting precious minutes searching for the caller.

The European Commission has adopted a plan to equip all new cars in Europe with eCall as soon as 2009. eCall will join already-deployed cellular communications systems with GPS, facilitating precise location of incidents as soon as they occur. It is anticipated that 2,000 lives a year will be saved in Europe as response times are reduced by up to 50 percent in rural areas and 40 percent in urban areas.

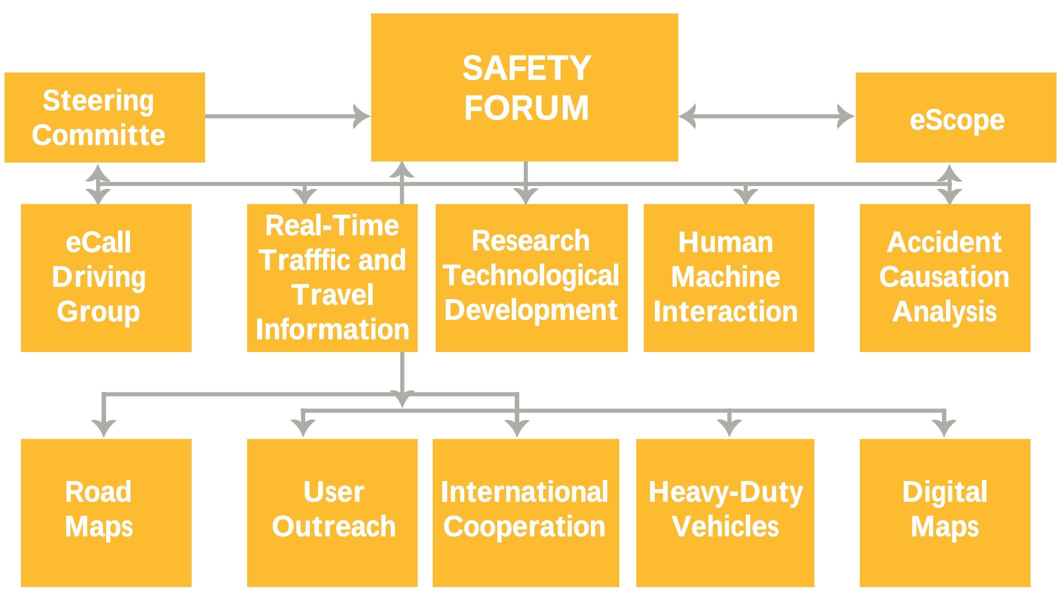

Figure 11. eSafety Forum organization chart. (BASt)

Image Processing to Assist the Driver

Creating an environment for safer vehicle operation is a major objective of a number of projects. Image processing falls under the broad umbrella of the advanced driver assistance systems (ADAS) effort, part of the eSafety initiative. Image processing centers on capturing various images, processing the information received, and communicating it to drivers to enhance their ability to safely control their vehicles.

A vehicle can gather image information from a variety of sources. These include video, laser, radar, and other inputs from the infrastructure itself. Video cameras may be located strategically around a vehicle, providing 360-degree inputs of the environment immediately next to and ahead of the vehicle. Once gathered, these video images are processed with data gathered from other sensors and intelligent outputs are then provided to the driver for use in making critical decisions.

Technology under development uses image processing to help the driver recognize infrastructure features, traffic-control devices, and other key environmental elements surrounding the vehicle. For example, a video camera could capture the image of a typical octagonal stop sign. Once that image enters the processor, it is interpreted as a traffic-control device and more particularly as a stop sign. At this point the onboard processor can communicate to the driver the proximity of a stop sign as the vehicle approaches that location. In carrying this example further, the onboard processor could sense that as the vehicle approaches the location of the stop sign it is not decelerating appropriately for the current speed and road conditions. If the vehicle were also equipped with an automated braking system, the driver would be prompted to begin braking or automatic braking could begin to avoid the car driving through the stop sign.

Other uses of image processing include detection of speed limits, traffic signals, and other traffic-control devices, as well as anomalies that may occur in front of or next to a vehicle. The images are processed based on the shape or form of the device, as well as its color, texture, and optical characteristics. The onboard processor is capable of taking the many images captured by the vehicle's sensors and sorting them so that only those that reflect specific safety needs are processed and interpreted for the driver.

One example presented to the scan team during its visit to BMW in Germany showed how images of signs are first captured by their shape and other physical characteristics. Then, as the vehicle gets closer, further details of the sign's characteristics are determined through a series of algorithms until the message is clearly known and communicated to the driver.

Examples of opportunities to use image processing for safer driving include pedestrian and hazard detection. Hazards would also include safety concerns such as disabled vehicles, construction work zones, and obstructions in the roadway.

Figure 12. Liber-t. "To receive an offer adapted to your travels, consult Liber-t's information page. Click here." (*www.autoroutes.fr*)

Electronic Toll Collection Transparency

Over the years, France has developed an extensive system of toll roads that cover much of the country and provide significant mobility to residents and visitors alike. Authorized in national legislation in 1955, tollways totaling 7,973 kilometers (km) are operated by 11 concessionaries with more than 76.3 billion km traveled each year. Total annual toll revenues across these systems have reached EUR6.1 billion. Many efforts have been undertaken to streamline the collection of these tolls. In a given year these tolls are collected by the following means:

- 36 percent by credit card
- 33 percent by Liber-t
- 31 percent by cash or check

The Liber-t system (see figure 12) was established to provide transparency among the tollways and make traveling around the country more convenient. With more than 1,156,000 subscribers, the Liber-t transponder system allows a traveler to move freely from one tollway to another knowing that tolls will be accumulated at a central processing center where one invoice will be generated, no matter where the travel occurred. Recognizing the mobility between adjacent countries and the existence of other tollways around Europe, other EU countries are moving to assure this same transparency.

Liber-t provides many incentives to its users in addition to the single-invoice feature. Discounts ranging from 10 to 20 percent are offered to frequent travelers who use the same route 10 or more times a month. If the same journey is made more than five times a month, then the sixth and tenth trips are free. Further enhancing the use of the Liber-t system is the current development and future deployment of its use in parking garages and for other motorist services. Ultimately, systems like Liber-t will make travel more efficient and provide desired transparency to users as they move from one system to another.

SafeMAP: Digital Information for Safer Driving

Two systems that have developed simultaneously in the transportation industry are digital-mapping initiatives and onboard navigation systems. In the European Union SafeMAP effort, public-sector agencies and private-sector firms work together to combine these technologies to bring a higher level of service to the driver. SafeMAP focuses on six assistance features:

- Speed limit assistance
- Curve warning
- Intersection warning
- Overtaking assistance
- Hazardous area warning
- Crash spot warning

For SafeMAP to be effective, the static and dynamic features of the roadway must be integrated into digital maps that become part of the onboard navigation system provided in the vehicle. Static information includes speed limits, roadway features, geometrics, and so forth. Dynamic information includes crash data, weather conditions, construction work zones, and other data that change with time. Combining these inputs with an onboard navigation system and its GPS capabilities provides the vehicle operator with an information-rich environment that will lead to a safer driving experience.

In some cases the data will warn drivers of a geometric feature or an area prone to icing. Perhaps the warning will alert the driver to a location with a higher-than-normal number of crashes. Other situations might include warnings that an intersection is ahead or the posted speed limit is being exceeded. While the use of a static digital map can be valuable to the vehicle operator, the combined effect of both static and dynamic information on the environment the vehicle is traveling in will be a powerful application of the ITS technologies the scan team observed. Ultimately, SafeMAP will allow the driver to focus on making key decisions with pertinent and timely information.

Speed Management and Enforcement

The scan team observed several significant speed-management and -enforcement initiatives in its review of safety applications in Europe. In particular, France is making a clear effort to address excessive speed and its contribution to crashes, with their resultant injuries and fatalities.

One system the team observed is an experimental speed-control effort on the A7 Motorway operated by Autoroutes du Sud de la France (ASF). ASF officials are concerned about increasing levels of congestion all along the A7 corridor, but especially on the section between Valence Sud and Montélimar Nord. Managing speed or, more specifically, creating an environment with more consistency in the speed level is the objective of this experiment on the A7 Motorway. Speed control is just one of the measures ASF is implementing to improve the driving experience within the system.

ASF's strategy is to provide advisory speed notices to motorists as they travel along the A7. Overhead gantries are used to both measure speed and communicate to drivers that they are exceeding the posted speed limit. Cameras take images of vehicles at two points 10 km apart. The resulting speed calculations are used to identify vehicles exceeding the posted speed limit.

Figure 13. Enforcement cameras and speed limit signage on the A7. (French Ministry of Transport)

Figure 13 shows a typical application of the cameras and variable-message sign communicating speed information. Multiple installations such as the one depicted in this figure provide ASF with sufficient information to notify motorists of their speed compliance.

Initially, the message posted on the variable-message sign was generic. In the second phase of the speed-control effort, however, researchers will assess public reaction to the posting of license plate information for more specific communication of speed violations to motorists. No citations are issued in either case. Rather, the objective is to inform and encourage speed compliance.

Preliminary results are encouraging. ASF measured a nominal 3 percent increase in capacity on the A7 where this system is in place. In addition, it found an 80 percent compliance rate in areas where the posted speed limit was 110 kilometers per hour (km/h) and a 50 percent rate where the limit was 90 km/h. This seems to indicate greater compliance at speeds where the drivers are more comfortable with the rate. Conversely, it appears that an unnatural attempt to control speed at a lower level than drivers believe is appropriate does not result in as high a compliance level. Other results include overall reductions in the maximum speeds measured. Also, ASF noted that the reaction time for motorists to voluntarily respond to a newly posted speed limit was about 5 minutes from the time the new speed limit was posted.

ASF's motto for its system, "Gain time by driving slower," appears to have merit as further efforts are made to improve the driving experience and safety aspects of the A7 Motorway.

The final and most aggressive speed-management initiative observed was implemented by the French Ministry of Transport and reflects a comprehensive approach to using enforcement to reduce crashes and their resultant injuries and fatalities. In defining its enforcement policy, the ministry adopted three objectives:

- Compliance with the law, using sanctions as education

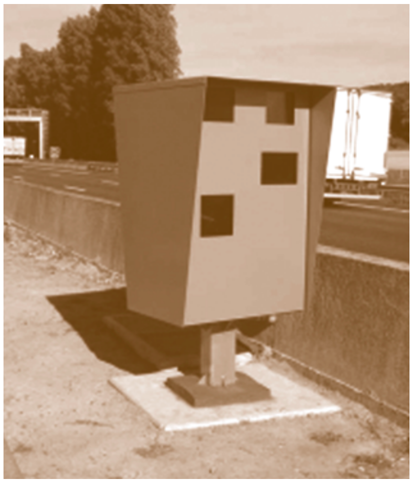

Figure 14. Fixed speed enforcement camera. (French Ministry of Transport, DSCR)

Figure 15. Speed enforcement signage. (French Ministry of Transport, DSCR)

- Improvement in enforcement efficiency
- Experimentation with legal and technological aspects

One of the first steps adopted in moving this initiative forward was to ensure that the legal framework was in place. The success of the system required non-law-enforcement personnel from a central location to have the authority to issue citations. This central location is known as the Public Prosecutor, which has the authority to remotely cite vehicles because of special validation conditions imposed on the camera system on the highway.

Once the legal framework was in place, the technological components were implemented to include fixed sites as well as mobile units. Initially, 70 fixed cameras were put in place (see figure 14), allowing for each French driver to be "enforced" twice a month. The ministry's 2005 goal was to have 1,000 fixed and mobile cameras in place. To designate areas where enforcement is occurring, special signing was installed to warn motorists of the presence of speed cameras (see figure 15). Site maps on the Web also show enforcement locations. Figure 17 depicts the overall process from violation through adjudication.

A major point the ministry made about its speed enforcement initiative is the clear and unequivocal support it has received from political leaders. The very visible endorsement of these strategies by national leaders communicates to the public the importance of taking safety seriously on the motorways.

The results of this effort by the ministry are noteworthy. Speeding violations decreased from almost 7 percent to less than 3 percent in areas where camera enforcement was in operation, as figure 16 shows.

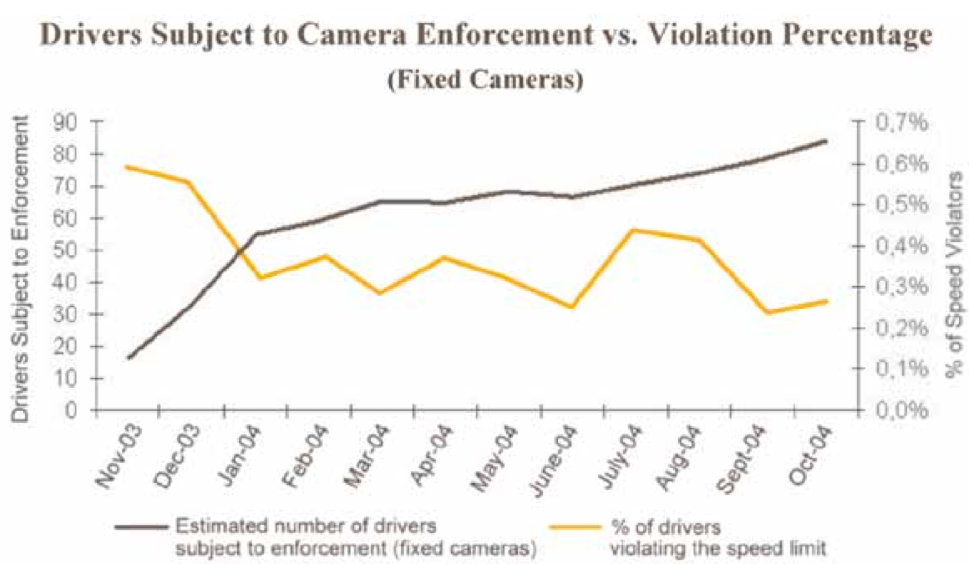

Figure 16. Measured results of automated enforcement. (French Ministry of Transport)

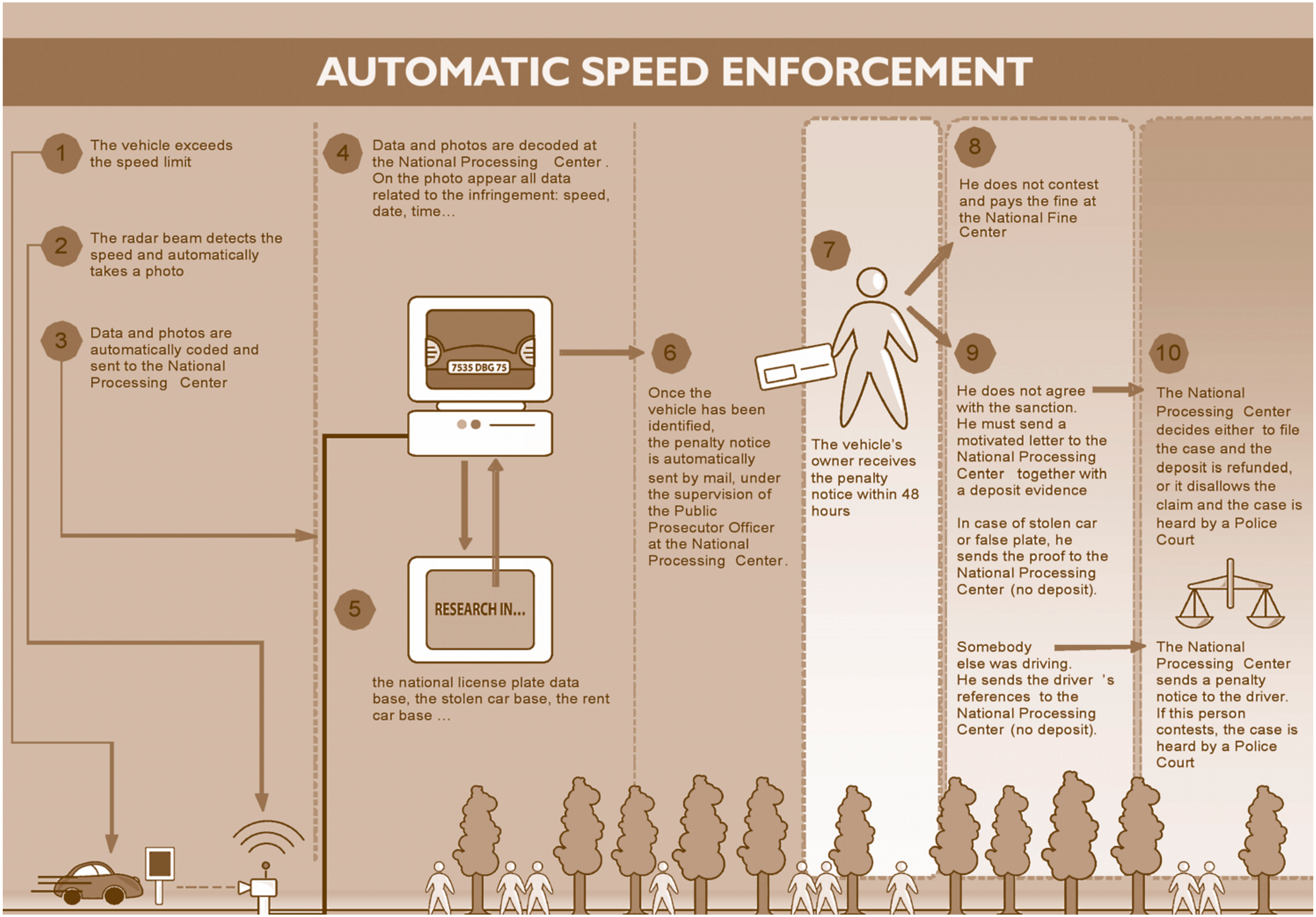

Figure 17. Automatic speed enforcement process diagram. (French Ministry of Transport, DSCR)

In addition, these sites showed a dramatic 85 percent reduction in crashes in the 10-month study period. The ministry also noted a general decrease in speeding violations elsewhere on the motorway network, even in locations with no cameras. Public reaction to the cameras includes an admission by 86 percent of drivers that their speed reduction was a consequence of the presence of the speed cameras and recognition by 77 percent that this automated speed enforcement system improved road safety.

Another effort is called LAVIA (figure 18), a French project focused on intelligent speed adaptation in which a governor system automatically limits a vehicle's speed to the locally posted limit. This governor controls the vehicle's maximum speed under three conditions described below. Under this system, the vehicle's accelerator pedal has no effect when the vehicle is traveling at the prevailing speed limit. For safety purposes, however, the system includes a feature that allows the driver to "kick down" the accelerator in an emergency to avoid a crash or hazard.

LAVIA, now in early trials, is providing valuable information to transportation researchers. In its tests, LAVIA is comparing three modes of operation:

- **Advisory Mode**—A warning is displayed on the dashboard if the speed limit is exceeded.
- **Voluntary Active Mode**—The driver can turn on the LAVIA system, allowing the vehicle's speed to be controlled per the posted speed limit.
- **Mandatory Active Mode**—The LAVIA system is always on.

For the LAVIA system to work, a sophisticated digital mapping system must be operative, making detailed speed information available for the network. In the vehicle, an onboard navigation system with GPS capabilities works in conjunction with a digital map containing speed data. The LAVIA controller merges the digital map information with both GPS data and readings from the vehicle's speedometer and reacts accordingly to control the speed of the vehicle.

Figure 18. LAVIA logo. (French Ministry of Transport)

To date, the trial size does not allow for conclusive statements on the safety aspects of the LAVIA system. However, researchers intuitively believe that controlling speed will result in safety benefits. Results indicate public acceptance of such a system at 31 percent, while 23.5 percent oppose giving up control of the speed of their vehicle. In addition, this study points to the clear need for accurate and appropriate speed limits to gain the confidence of drivers in allowing the LAVIA system to control this aspect of the vehicle's operation.

TPA Speed Horizon

Another use of sensors involves communication of speed information to vehicle operators. Speed uniformity and management are seen in the European Union as major contributors to greater highway safety. The TPA speed horizon project (figure 19) is part of the INVENT initiative. A speed horizon is a speed profile ahead of an operator's vehicle that functions by means of onboard sensors, inter-vehicle communication, and a model-based observer. It is the key for the following:

- Predictive driving
- Traffic-adaptive driving
- Damping of stop-and-go waves
- Inflow and outflow management in jams
- Rapid dissipation of jams

This process of intervehicle communication allows the onboard processor to create a vision of the operating speeds of the vehicles ahead, enabling the driver to compensate or react accordingly. The speed profile, as depicted in figure 20, provides operators with enhanced knowledge of road conditions up ahead. For example, knowing about congestion adjacent to a roadway exit 0.5 km ahead, as the right side of figure 20 shows, allows the operator to modify his speed and change lanes if necessary before that location.

Knowing other vehicles' speeds will help vehicle operators make informed and safe decisions as they move forward on the roadway. Advance notice is recognized by both the private- and public-sector organizations the scan team visited as a major safety enhancement for timely decisions by the vehicle operator.

In Germany, the federal highway agency's research arm, Bundesanstalt für Strassenwesn (BASt), has undertaken an initiative in intelligent speed management. It is coordinating this effort with the SafeMAP project discussed earlier. The safety advantages to the driver of integrating specific speed information with digital maps located in the vehicle's onboard navigation devices are clear. The challenges BASt sees cover a variety of areas, including the ability to communicate up-to-date information to the vehicle's onboard system, the accuracy of GPS and its integration with digital maps, and the collection of pertinent data and information to make the system function effectively.

Although the BASt effort is still in the early phase, researchers have arrived at a number of conclusions that will guide their efforts in moving forward:

- In-vehicle applications of legal speed limit warning, curve speed warning, and crash black spot warning will be evaluated in both Germany and France.
- Refinement is needed because assessment of benefits in Germany and France relies on several assumptions (e.g., penetration rates, acceptance rates, etc.) that need to be further analyzed.

It is clear that safety benefits will accrue from Germany's speed management research efforts as they are implemented on that nation's roadway system.

Video Detection for Traffic Management

One of the most extensive penetrations of ITS technologies around the world involves video surveillance of transportation networks. This ability to view activities and operations on bridges, in tunnels, and on highways has proved to be a valuable tool for transportation managers in maximizing the efficiency of their systems. Over the years, the challenge has been to find a means whereby numerous camera images can be processed in an automated manner that will enable system operators to respond to incidents with accuracy and in a timely manner.

A technology developed in France and observed by the scan team focuses on this ability to precisely interpret video images, discern anomalies, and alert transportation professionals to events occurring on the network. In addition, these images can be used to address emergencies in a timely manner and offer transportation agencies enhanced security inputs for critical facilities. To accomplish this complex task, specific steps are followed once the cameras are in place and operational:

- Analyze the area under observation.
- Capture the background image.
- Digitize the background image.
- Detect moving vehicles and track through “marking.”
- Perform a trajectory analysis of all “marked” vehicles.
- Measure.
- Detect incidents.

Sophisticated algorithms are used to analyze about 20 percent of the images captured by each camera every second. From these images the system is able to discern when anomalies have occurred and, when properly filtered, offer system operators timely alerts to potential problems. In addition, the analysis not only provides the most current image of the area where an incident occurred, but also images of activities that occurred just before the event. In this way, much more relevant information can be secured to enable the operator to make the correct response decision. While many attempts have been made over the years to develop an automated system for video incident detection, the technology and computational abilities of the systems were not robust enough until now to provide accurate and timely notification of incidents using the video feeds already being captured. The systems the scan team observed are a clear indication of the potential that video image processing can have on improving safety on the U.S. highway network.

WILLWARN: A PReVENT Project

The WILLWARN (Wireless Local Danger Warning) system (figure 21) is another element of the PReVENT initiative. It focuses on providing the driver with critical information on which safe driving decisions may be based. It centers on car-to-car communications in which critical information is exchanged between adjacent vehicles. As these inputs are analyzed by an onboard processor, an “electronic” horizon is created, giving the driver an enhanced view of the road ahead. Figure 22 (see next page) depicts how information from the WILLWARN system and from other components of the PReVENT project is gathered from many sources adjacent to the vehicle to create this “electronic” safety environment.

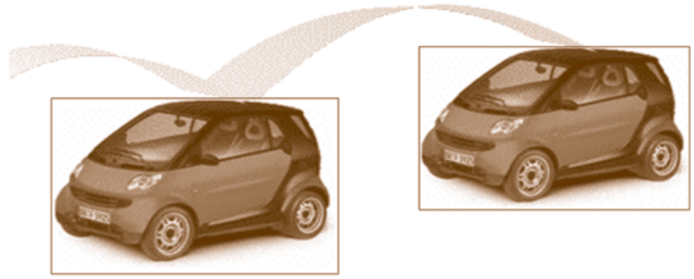

Figure 19. TPA speed horizon system. (INVENT, DaimlerChrysler)

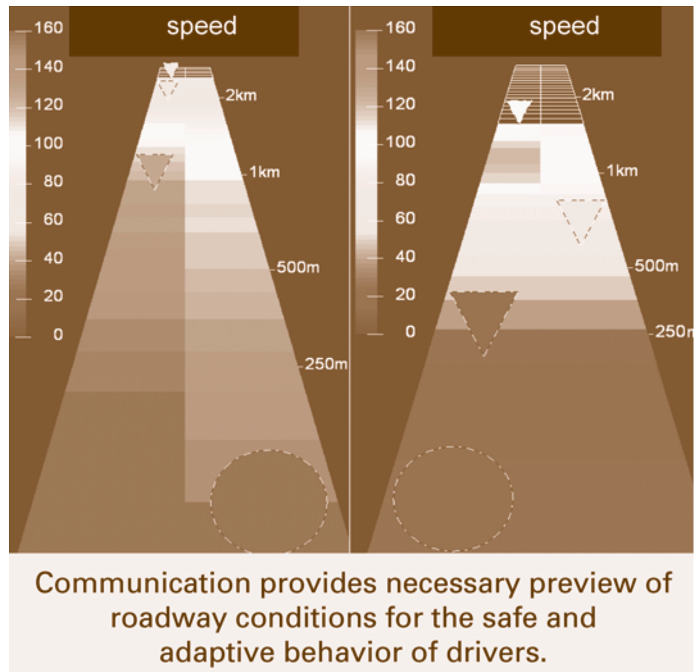

Figure 20. Speed profile diagram. (INVENT, DaimlerChrysler)

Figure 21. WILLWARN logo. (www.PReVENT-ip.org)

WILLWARN has an onboard capability that offers the following to the vehicle operator:

- Onboard hazard detection
- In-car warning management
- Decentralized warning distribution by using short-range, dedicated communications

The applications of the WILLWARN system are numerous. It will allow for safer driving conditions in rural areas or where severe weather or other difficult conditions make travel hazardous. Potential obstacles or hazards in both urban and rural areas will be highlighted to the driver through WILLWARN, offering opportunity for evasive action. In areas of low visibility, the inputs provided by this system will give drivers key information about road situations ahead that will allow them to travel safely.

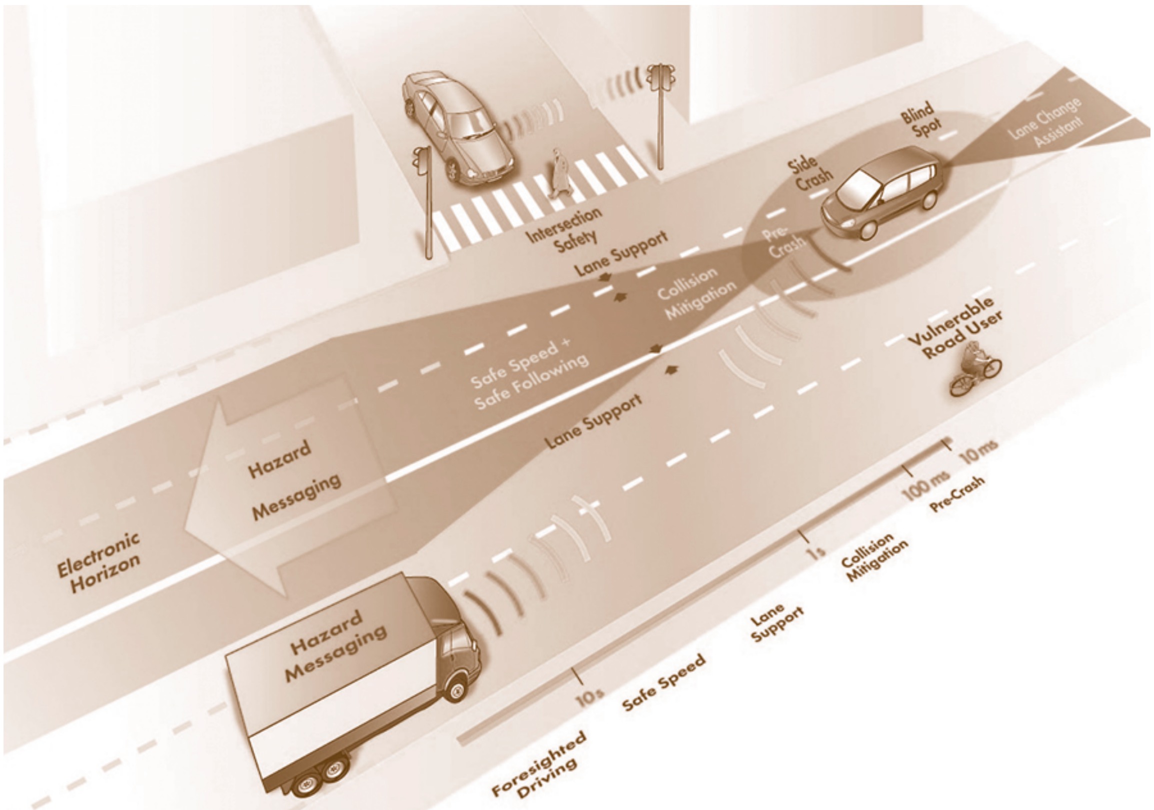

Figure 22. PReVENT project approach. (*www.prevent-ip.org*)

Finally, inputs on construction work zones will promote safety for both drivers and workers in the construction area.

WILLWARN is yet another means for gathering information from a variety of sources, processing that information, and presenting it to the driver in a format that is not distracting to the safe operation of the vehicle.

Code of Practice

Tort liability is one of the major challenges facing the European Union. It is a worldwide issue, with every country and technology implementer concerned about how crashes or other incidents might turn into major legal issues. To deal with this problem, the European Union has established a Code of Practice that defines roles, responsibilities, and "duty of care" that providers and operators have in deploying ITS safety systems.

The Code of Practice is not a new concept. Other industries, such as aircraft manufacturers and the pharmaceutical industry, have adopted such a document to stem, to whatever possible degree, the tide of litigation that may result from product failure. In many respects, highway industry standards such as the FHWA *Manual on Uniform Traffic Control Devices* (MUTCD) and others are examples of codes that organizations can follow and rely on. In Japan, officials have adopted the Japanese Industrial Standards (JIS) as their equivalent code.

The EU Code of Practice offers a risk assessment that translates product development and deployment into "reasonable safety" performance standards. By following these guidelines, product developers or system operators can be reasonably sure that their activities meet accepted expectations for safety and utility. One important aspect of the Code of Practice is that it provides the definition of "safe" for entities involved in developing the elements of the advanced driver assistance systems (ADAS) discussed elsewhere in this report.

As products or systems are developed in the European Union, they go through a series of queries that assist the developer in determining whether the concept will meet the Code of Practice in a real-world application. Typical questions that must be answered include the following:

- Is it possible that the driver may fail to perceive a system message?
- Is it necessary to support system feedback using additional information channels (e.g., acoustic in addition to optical display)?
- Does the system provide timely feedback about system reaction in a given traffic situation (e.g., take over request from adaptive cruise control)?
- Can system output and information be perceived by the driver quickly enough to facilitate appropriate reaction (e.g., take over request from adaptive cruise control)?

By answering these and other questions, product developers can determine if they have met their “duty of care” for a given product and complied with the Code of Practice, thereby qualifying to benefit from its protections.

To date, the ITS community and its related contributors have not developed a U.S. version of a code of practice. Those who hosted the scan team in Europe clearly stated that the deployment of some of the most impressive and valuable technologies could not occur until such a code is in place.

SARI: Predicting Roadway Characteristics

The French Ministry of Transportation has embarked on a research effort called SARI as part of its PREDIT program. SARI has its impetus in the notion that roadway safety can be improved if drivers are provided appropriate information to avoid surprises in their decisionmaking processes. The objectives of the SARI research effort are as follows:

- Select road conditions that affect driver behavior.
- Identify road conditions that are problematic and identify the causes.
- Develop prototype information systems to evaluate the effectiveness of the SARI system.

French transportation professionals believe that warning drivers of road conditions as they approach specific locations will improve their ability to operate vehicles in a safe and prudent way. This creation of a safer driving environment depends on providing accurate and timely information to drivers. Conditions that may be communicated include challenging geometry, high-crash locations, weather or visibility conditions, and other pertinent inputs that would impact vehicle operation.

Research will be conducted in five principal areas:

- Physical road characteristics that cause critical acceleration or deceleration and stresses
- Discontinuities in roadway visibility or legibility that could lead to inappropriate trajectories
- Road deterioration
- Presence of other vehicles when the weather is poor
- Knowledge about incidents involving other vehicles that are related to the road condition

The results of this research will be valuable as transportation professionals strive to more accurately determine how best to communicate information to drivers to improve their performance on the roadway.

Driver Assistance

The scan team observed a number of other initiatives presented by the public and private sectors in the European Union that focused on helping the driver with various tasks and operations. A joint public-private effort that concentrates on these systems functions under an umbrella called INVENT, a collection of projects that focus on driver assistance and active safety.

The individual projects in INVENT are divided into five categories:

- Driver behavior and human-machine interface
- Detection and interpretation of the driving environment
- Anticipatory active safety
- Congestion assistant
- Traffic impact, legal issues, and acceptance

Within the detection and interpretation of the driving environment are efforts to enhance information collection through individual types of sensors (e.g., cameras, laser, etc.). What is perhaps more significant is that the efforts also incorporate the concept of sensor fusion, meaning data is gathered by more than one method or collection device and combined. This combination of inputs develops synergy, and the ultimate effect of this fusion concept is a richer information environment for the driver. One goal of creating this environment is to offer early detection of moving objects, allowing a vehicle operator more time to make critical operational decisions.

In the anticipatory active safety category, efforts are divided among a variety of research projects that promise many safety benefits. Included are systems that focus on crash prevention and the reduction of their severity as well as protection of all participants in the traffic flow, including vehicle operators, passengers, pedestrians, and cyclists. Under development are technologies to help drivers make safer lane changes and maintain their lane position, as well as proximity sensors that communicate relative position of the vehicle and other roadway features and occupants. Key to this category is the word “anticipatory,” since the technologies being assessed and deployed offer an “intelligent” look at the current and possible future conditions surrounding a vehicle on the highway.

Congestion assistant systems are designed to help a driver with tasks that can cause fatigue during periods of high congestion on the highway. System benefits include the following:

- Maintaining a fixed distance from a leading vehicle
- Maintaining the vehicle in a lane
- Automatic braking, including to a fully stopped condition
- Automatic driver-confirmed acceleration from a stopped condition

Ultimately, use of these systems will greatly reduce many repetitive driving tasks and allow the driver to focus attention on more critical driving decisions.

Driver assistance can be provided in many forms. In some cases, the driver is fully aware of the systems and interacts with information received from a variety of inputs as described above. In other cases, this assistance is provided in the background and the driver often is unaware of the help provided. An example is the electronic stabilization control (ESC) systems being installed on many late-model vehicles in Europe and the United States. These ESC systems assist the driver when certain performance circumstances present themselves on the roadway. When operational, an ESC system will assist a driver in steering and movement maneuvers that will help him keep the vehicle safely on the roadway and avoid over turning or some other outcome. The significant benefits of ESC systems are shown in figure 23 (see next page).

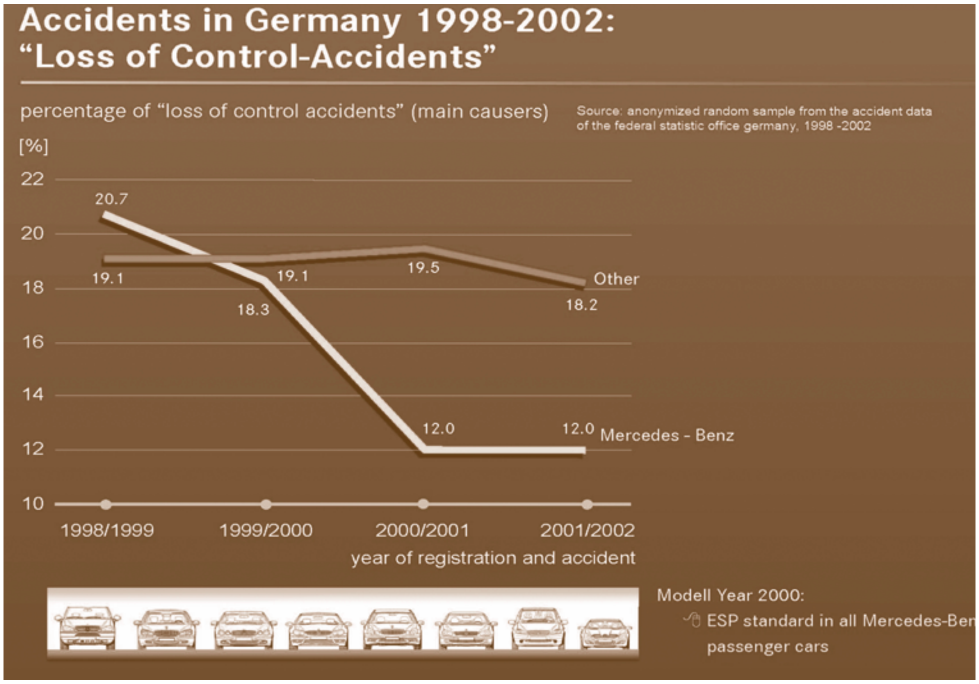

Figure 23. Crashes in Germany 1998-2002: loss-of-control crashes. (DaimlerChrysler)

In this case, the data is solely for one manufacturer's vehicles, but the point is clear that benefits are substantial for all vehicles equipped with an ESC system.

Optimizing Facility Throughput

In the Munich area the scan team visited the Traffic Operations Center (TOC) of the Autobahndirektion Sudbayern, the regional transportation agency. The team noted many interesting features of this facility and its contribution to traffic management in the area. One in particular the team found valuable was a deliberate effort to maximize the throughput on the highway network by using two strategies: active routing and shoulder running.

Active routing of traffic flow was accomplished with an aggressive use of changeable message signs that allowed TOC to offer alternative routing information to motorists to reduce the congestion on specific routes. Changeable message signs would communicate this information in the form of routing options, distance, and time consequences. Drivers could then make informed decisions on how they would traverse a certain route based on enhanced information provided by TOC.

In addition, TOC thoughtfully used shoulder running during periods of peak congestion to maximize the use of available pavement surface to carry traffic on the system. Several measures were implemented to ensure the safety of those using shoulders. For example, before opening a lane to traffic, TOC surveyed the complete length through video cameras to ensure no disabled vehicles on the shoulder would create a hazard. In addition, signing, striping, and other traffic-control devices were modified to accommodate the temporary use of shoulders for traffic flow. Ultimately, shoulder running has proven very successful for the Autobahndirektion Sudbayern. While shoulder running per se is not an ITS technology, it is a concept whose safety and effectiveness depend on appropriate use of these technologies.

One characteristic of the approach taken in Europe to transportation safety is the holistic view the European Union has of the process. The European Union looks at the driver, environment, infrastructure, and related policy issues and attempts to synchronize all of these into an approach that makes significant improvements in safety performance. It recognizes that achievements in only one of these four areas will fall short of the overall goal of reducing traffic fatalities and injuries by half in the next decade.

The scan team found the visits to Germany and France valuable in achieving the objectives of the scan tour. The technologies observed offer clear promise for improving safety on U.S. roads and highways.

CHAPTER THREE

Findings and Recommendations

This report offers a glimpse into the various ITS technologies either available or in the development stage that have the potential to improve safety on the Nation's roads and highways. Consequent to the observations offered in Chapter 2, the scan team believes some significant findings define the state of ITS deployment and its potential contribution to safety in the European Union. In addition, the team has developed 12 recommendations it believes will advance U.S. efforts to achieve greater safety, indicated by fewer crashes and reduced fatalities and injuries. The findings are presented first, followed by the recommendations.

Findings

Many findings emerged from the scan team's review of the observed technologies during its visits to France, Germany, and Japan. A few of the most salient are presented here. To organize the findings into a logical presentation, the team has divided them into the four standard components of the highway system:

- Driver
- Vehicle
- Environment
- Policy

Each of the findings and recommendations is divided into one of these four components, reflecting its role in the overall safety of the highway system.

Driver

The driver is a major focus of the safety initiatives in the European Union. Officials recognize that many crashes are caused by driver error, inattention, or poor judgment and believe that significant opportunity exists to better equip drivers with tools and information that will help them operate their vehicles more effectively. EU efforts focus on several areas relating to the driver, including driver assistance and the human-machine interface.

One important element of driver assistance is information. Transportation professionals in the European Union believe that drivers' ability to comprehend complex informational elements in a short time period and render sound decisions is without equal in the technology world. However, they believe a strong need exists to provide more useful information to drivers so they can make these decisions with the best understanding possible. Getting them the right information at the right time is key to the success of the informational element of the EU driver assistance effort.

Not all information is essential to the driver. Some may be used only by an onboard processor as background information contributing to the relevance of more important information. Transportation professionals are developing a growing appreciation that the driving task is very complex; thus, a goal of some research is to reduce "driver burden." Driver burden is a condition that describes the point at which information starts to distract from the driver's task. Too much information at the wrong time isn't useful—just as dated or old information is of no value in improving safety. Proximity is also an issue. Once the vehicle is past a certain location, information about that location may become irrelevant to the operator. In the European Union, creating information systems that recognize both timing and accuracy is the objective of public and private sectors alike.

Another significant variable in creating the driver assistance environment is the diversity of age and ability of the population of vehicle operators. Information systems and data processors must recognize these demographic differences and adjust accordingly, even if a different driver gets behind the wheel of a vehicle just operated by another driver. In the end, human factors initiatives go beyond developing systems designed for the "ideal driver." The research the team observed focused on the "average driver," who may be distracted, fatigued, prone to mistakes, or unable to evaluate speed and distance inputs properly.

Another important aspect of driver safety concerns the balance between technology that assists the driver with inputs in the decisionmaking process and the basic responsibility all drivers have to operate their vehicles properly and safely. Ultimately, there is no technological replacement for the human mind and its ability to process complex inputs, render judgment, and take appropriate action. Technology can, however, improve the driver's ability to make good and safe decisions.

The team came away from its visit with a strong sense of the importance of the human factors element in ensuring that the driver integrates well with the other three elements of the highway system highlighted in this chapter. Industry is spending considerable time trying to understand driver behavior in crash and noncrash situations to better determine the nature of this integration and improve on it to promote safety. Ultimately, it is imperative that the driver, vehicle, environment, and policy elements work in a harmonious way. This is sometimes referred to as "cooperative driving."

Finally, there appears to be no substitute for compliance with traffic laws and regulations in advancing safety. This is particularly true for speed enforcement. Measurable safety improvements are clear when speed is managed and/or regulated in a proactive manner. The efforts in Germany and France will reduce the numbers of fatalities, crashes, and injuries as speed is regulated more carefully and enforcement activities are increased.

Vehicle

The vehicle has been the focus of many safety improvements over the years, including seatbelts and airbags. These passive systems have netted substantial benefits to the public and have clearly resulted in reduced injuries and fatalities. The scan team believes that the safety benefits of these passive systems likely are nearing a maximum, and that in the future more emphasis should be placed on active systems that will further reduce the adverse effects of crashes on the Nation's highways. One noteworthy active system is electronic stability control. The evidence is clear that the presence and functionality of such systems reduces crashes, injuries, and fatalities. Other active systems, such as adaptive cruise control, assisted braking, and lane keeping, will also help achieve the desired safety improvements envisioned by this scan effort.

Integrating the vehicle with its surrounding environment will be essential to advancing a number of the team's recommendations. Onboard navigation systems can provide some safety benefit, especially when integrated with digital mapping and other features. However, the current processing ability of these onboard navigation devices is not adequate to handle the significant processing duties envisioned when analyzing video images and other very taxing tasks must be accomplished. Thus, a different type of device will have to find substantial penetration in the market to achieve the results envisioned with some of the systems the team observed. There is a need to proliferate processing devices that can send, receive, analyze, and output information in real-time fashion. Further, adding traffic control information and warning features to this system will provide drivers with critical information affecting the driving task. These systems need to be low cost to achieve the market penetration that will result in the safety improvements envisioned.

Environment

The findings relating to the environment component of ITS safety systems are many and varied. They include a substantial finding that controlling speed through effective management and enforcement strategies appears to result in very real reductions in crashes, fatalities, and injuries. Operating facilities with more uniform speed patterns and slightly reduced speeds are obviously assisting France in its quest for safer highways. While the team members understood the importance of speed management before the scanning study, they are now even more convinced that some of the greatest safety gains can be achieved by managing this critical safety variable. A voluntary system resulting in no citations could achieve some level of benefit, but a more aggressive photo-enforcement process would bring substantive realization of the objectives of this scan.

The need to further integrate the environment and its infrastructure elements with the vehicle is obvious. An infrastructure that includes "smart" components, such as chips on signs and signals that offer two-way communication capabilities (between vehicle and infrastructure), is just part of this enhanced environment for the driver and the vehicle. Many safety benefits will accrue with vehicle-to-environment communications in place that enhance the driver's ability to anticipate road geometrics and react to traffic control situations, and otherwise improve the atmosphere in which the driver makes key decisions.

This integration is obviously a long-term initiative, but one that must be advanced. In fact, realization of this goal is many years away. However, an intermediate step would be to equip the vehicle with the ability to recognize infrastructure features such as traffic signals and signs. This step will bridge this technology gap until penetration of smart features is sufficiently thorough to result in the desired safety benefits. Developing standards that many manufacturers can follow and that drivers can become accustomed to will go a long way toward improving the penetration of technologies in the transportation market.

Complementary to this finding is another that sees the need to integrate, certify, and maintain detailed location codes, speed limits, and other critical information on digital maps that interact dynamically with the vehicle's onboard processor. This ability to gather information from the environment and incorporate it with other information relating to crash history, weather conditions, and other factors will further enhance drivers' abilities to safely operate their vehicles.

Policy

While many findings can be articulated within the policy component, the team has singled out several for this report. The first is the obvious relationship between political and organizational leadership and the advancement of ITS technologies that will produce substantive safety improvements. Much of what is being advanced in the countries visited is the result of such leadership that crosses all boundaries in the transportation industry. The results of France's automated speed enforcement program are clear: reduced crashes and resultant fatalities and injuries. This came about only when national and local leaders made safety a major initiative of their political leadership and held governmental agencies accountable for achieving the stated safety objectives.

Public agencies and private-sector organizations in the European Union have a strong sense of collaboration. This cooperation exists in areas such as funding, research, joint public-private working groups focused on specific issues, information protocols, and others. A compelling case can be made that leadership is the key to advancing complex policy issues such as speed enforcement and management.

Many factors contribute to safety on U.S. highways. They include governmental agencies, vehicle manufacturers, systems developers, and others. It is critical to find the proper balance of obligations among the car manufacturer, road authority, and systems providers of technology on who supplies what information to the driver and in what format. Much needs to be organized and structured so that ITS technologies can be deployed in the most efficient manner possible.

Liability is a key concern of the private sector that reduces its ability to deploy technologies proven in research studies that could be made widely available. The European community is developing a Code of Practice to set standards of performance and a "duty of care" that it hopes will address the liability issues faced with the deployment of these advanced technologies. Development of a similar U.S. code of practice would open the door to many ITS applications in use elsewhere in the world but not yet deployed in the United States.

Recommendations

The scan team developed 12 recommendations to achieve the objectives of this scanning study. Like the findings, they are divided into four elements—driver, vehicle, environment, and policy. The implementation plan in Chapter 4 addresses how the team will advance these recommendations.

Driver

The two recommendations for the driver element are as follows:

1. **Identify stakeholders and interest groups and advance their collaborative efforts to raise awareness of the driver's needs.** This recommendation will help public and private organizations identify key driver inputs, establish human-machine interface communication protocols, and promote an optimal decisionmaking environment for safe vehicle operation.
2. **Advance the use of technology, driver education, insurance incentives, and other means to promote greater speed compliance and management.** The scan team believes a concerted effort that covers all members of the transportation community focused on speed management and enforcement will bring landmark benefits to system users in the form of reduced crashes and their collateral effects.

Vehicle

The team's two recommendations on the vehicle element are as follows:

3. **Promote the aggressive implementation of low-cost, onboard processing devices in U.S. automobiles that will communicate with infrastructure features and receive information from other sources.** The future use of onboard processing devices appears to be central to deploying many of the ITS technologies observed during the scanning study. The ability to achieve significant penetration will be governed by the strength of the partnership achieved between the private sector and public agencies that provide transportation services.
4. **Promote and collaborate on the development of technology focused on driver assistance (e.g., adaptive cruise control, lane keeping, assisted braking, etc.).** Active systems that provide assistance to the driver must be incorporated into new vehicles as rapidly as the technologies will permit. This pace may be determined by how quickly Recommendations 3 and 4 are completed. The same benefits now offered by electronic stabilization systems will begin to accrue from these other technologies as fast as they can be deployed.

Environment

To achieve substantial benefits in safety improvement on the Nation's highways, the team recommends the following in the environment element:

5. **Promote additional testing and implementation of photo enforcement of speed. Implement a program of photo speed radar with a noncitation strategy to help curb aggressive driving and address speed variability on the Nation's roadways.** In conjunction with Recommendation 2, the team further recommends a strategy that focuses on voluntary efforts to curb excess speed as an intermediate measure leading to full enforcement of speed on U.S. highways. This would not replace a more aggressive effort to manage and enforce speed limits.
6. **Promote the accelerated development and deployment of systems that facilitate communication between the infrastructure and the vehicle.** The public and private sectors must unite to establish architecture, communication protocols, and other standards to facilitate this communication. Included must be the deployment of chips and other technology devices on infrastructure features and the development of onboard systems to process these inputs.
7. **Promote the further use of changeable/dynamic graphical signs (international standards).** The need to communicate information to drivers through static and changeable message signs continues to grow. Text messages are limited in their ability to communicate pertinent information in any volume, given the travel speed of most vehicles. The increased use of graphical signs using international standards will achieve a higher and more effective level of communication.
8. **Integrate/certify/maintain detailed location codes, speed limits, and other critical infrastructure features on digital maps. Further integrate this information with onboard vehicle technology.** The scan team recognizes the importance of bringing information from many sources to the onboard processor. Much of this information is static and, once digitized, can easily be input to multiple devices and platforms.
9. **Develop and deploy technology that uses existing information gathered to provide real-time notice of incidents.**

Process data collected in traffic operations centers to react to emergencies. A large volume of information is available to transportation agencies and operating systems that relate to the driver, vehicle, and environment. The ability to synthesize this information, manage its use, and communicate it to emergency responders is critical to the safe operation of roads and highways.

10. **Promote the use of operations data in planning future improvements to the infrastructure.** In conjunction with the information gathered and processed in executing Recommendation 9, there is a need to take this robust data set and create an environment of enhanced asset management that will benefit both the public and private sectors.

Policy

The scan team made two recommendations relating to policy:

11. **Create a national highway safety program leadership initiative focusing on safety applications of ITS technologies. Leadership is an essential component of observed advances in the deployment of ITS technologies.** The scan team recommends that key individual and organizational leaders be identified, and that an era of new and stronger leadership emerge to launch these ITS initiatives for greater highway safety.
12. **Create a warehouse for standardizing, gathering, managing, and analyzing before-and-after performance data relating to safety applications of ITS technologies.** More information is gathered today than is being used productively by public and private entities. Even more will be collected when new technologies are deployed. A significant need exists to create the systems and structures necessary to effectively manage the volumes of data and information that will be characteristic of these ITS initiatives and address the inherent legal issues that will emerge from this effort.

There is no question that these recommendations are ambitious. The scan team believes that their fulfillment will be essential to achieving the paramount objective of this scan and that of all transportation professionals: improve the safety of the Nation's transportation system.

An implementation team (IT) was established from among the members of the scan team. This subgroup was charged with developing strategies to achieve the recommendations contained in this chapter. These strategies are in Chapter 4.

CHAPTER FOUR
Implementation

The recommendations in Chapter 3 encompass a broad array of initiatives that will individually and collectively have a profound impact on safety in the United States. Some are long term or strategic in their objectives and others are more tactical. As part of its responsibility, the scan team formed a subgroup called the Implementation Team and charged it with establishing an implementation plan for the recommendations in this report. This chapter contains the initial elements of the plan that will advance some of the team's recommendations. Others will follow as these initiatives mature in the future.

A. Automated Enforcement Systems

Background

There is sufficient evidence to show that speed is a major factor contributing to major-injury and fatality crashes. Driving in excess of the posted speed or regulatory speed limit is an ever-increasing problem in both rural and urban environments. Closely related to speed is the increasing occurrence of red-light running. Both problem areas significantly affect a jurisdiction's ability to achieve its goal of improving motor vehicle safety. Other modes in the transportation corridor, such as bicycling and walking, are similarly impacted.

Most U.S. roads and streets are not designed to be self-explaining in providing guidance or regulatory information to the driver. Everything from lane markings to guide and regulatory signs to traffic-control devices is provided to help drivers safely navigate streets and highways. While certain traffic control devices are "regulatory," they can be considered "advisory" when drivers choose to disregard them. When these devices are disregarded, the potential for serious crash events—many involving innocent second parties—rises significantly.

The human factor is the major consideration when evaluating these speed-related problems. A number of subconscious factors may contribute to speeding. For example, it is known that the power, suspension, and luxury ride of today's vehicles make it easy to drive at speeds in excess of those posted. The smooth ride, when combined with the safer roadway geometry and cross-section provided by today's modern highways, contributes to a comfort factor for driving faster than the targeted safe speed.

Another factor that contributes to both speed and red-light running is a changing U.S. culture in which many individuals are in a hurry to get from one point to another. Coupled with this trend are greater demands on the law enforcement community to address drug, crime, and homeland security issues within budget limits. With this reduced enforcement presence on roadways, the perceived risk of consequence to drivers who decide to exceed the speed limit is also reduced.

The scan team noted a high priority for speed management in Germany and France, evidenced by the support from top elected officials and decisionmakers as well as the number of routine deployments. While the degree of political and social acceptance affects the deployment level and schedule, the technology appears mature to help U.S. jurisdictions confront the problems and tragedies associated with vehicles driving over the speed limit.

Proposal

Many examples of ITS technology have proven beneficial in reducing congestion and improving safety for the traveling public. One technology deployed throughout Europe to proactively manage speeding and red-light running is automated enforcement systems using photo detection and photo-radar. This will include data on both enforcement and red-light running.

Objectives

1. Expand on efforts underway in the United States to educate and inform both the public and political bodies about the severity of these problems. Emphasize the tools available to help jurisdictions and State and local agencies improve safety and reduce major crashes and accompanying fatalities.
2. Explore the level of public and political support for developing and deploying these technologies as a tool for managing speeding and red-light running across a full range of options from awareness to issuing citations for violations.
3. Develop standards and guidance documents for jurisdictions on the use of these technologies.

Tasks

1. Gather case studies of locations where these two technologies have been deployed in the United States.
2. Research and survey States and major metropolitan planning organizations across the country to create a database of legal and regulatory requirements and limitations on the use of these technologies.
3. Develop a survey tool that agencies and jurisdictions can use to

measure the public's awareness of the problem and the level of acceptance for using these technologies.
4. Produce a deployment document that includes information on available devices, cost data, pertinent standards, and best practices for deploying the technologies. Include methods to overcome resistance and guidance on developing and administering the next generation of automated-enforcement programs.
5. Develop an educational campaign strategy that can be used to alert the public and elected officials to the significance and consequences of the problems of excessive speed and red-light running. Emphasize the benefits that could be realized by deploying this type of technology as documented by a recent FHWA Turner-Fairbank Highway Research Center report on red-light running and other studies.
6. Explore the possibility of establishing a demonstration site in a high-problem area that could be used both to measure the effectiveness of tools developed and to document the safety benefits realized. After seeing a scan team presentation, the Oregon Department of Transportation showed interest in piloting an automated speed notification system similar to the system used in France. The Terwilliger Curves on I-5 in Portland present a recurring safety condition where an automated system for posting vehicle license plates of speeding vehicles approaching the curves could help reduce overall speeds and crashes.

Scan Team Lead

Robert Bryant, Craig Allred, Robert Bertini, and Martin Knopp

Deliverables

1. A documented research, adoption, and deployment inventory of where the two technologies have been deployed in the United States
2. A documented education and campaign strategy describing products and tools that need to be developed
3. An instrument that can be used to survey and assess the level of public acceptance of such policies and efforts
4. A documented inventory of State laws and local regulations pertaining to this technology
5. A Web site that serves as a clearinghouse for U.S. case studies and information on pertinent technology
6. A manual (or the framework for a manual) that could be made available for use by States or local jurisdictions interested in pursuing automated enforcement
7. A demonstration project for automated license plate messaging on signs for speeding vehicles. Based on the interest of the Oregon Department of Transportation, work initially with that agency.

B. Evaluating Advanced Video Detection and Incident Analysis Technology

Background

ITS technologies often have evolved and been implemented with the major emphasis on traffic flow (i.e., mobility). Safety may be mentioned as a side benefit, but may not be quantified or emphasized. An example of such a service application is the use of data from inductance loop detectors for automated incident detection. These are used to alert operators in traffic management and operations centers (TMC/TOC) that existing conditions appear to match those typically associated with an incident.

In the United States, these applications have largely been discontinued because of both the high error and false-call rates from the loop data and the increasing use of cellular phone technologies by the general population. Operators simply were distracted (and frustrated) by the false alarms, and benefits of such a system were never realized or appreciated by transportation decision-makers. Most TMCs/TOCs moved to more reliable technologies and real-time information via closed-circuit television (CCTV) and cell phone calls from travelers or dispatchers about roadway incidents.

Today's systems are less robust for prioritizing the information an operator needs to deploy response teams or advise motorists via dynamic message signs or other means. The challenge remains to manage the effective flow of incident data generated by traffic and the information that public safety operators need during the early minutes of the response where dispatch decisions on people and equipment are critical. Furthermore, for the most part, the causes and effects of such incidents are not shared with State DOT safety engineers who assess highway safety and design mitigation treatments.

The scan team was briefed on and observed a demonstration of an emerging technology developed in France to improve the integration of CCTV networks and operators for both automated incident detection and enhanced video access leading to the occurrence of the incident. Computer systems analyze video images to isolate a potential incident from a number of scenarios. Information from numerous cameras is analyzed and the operator then receives visual indicators that a particular video may include an active incident. The operator can select the video and replay the last few minutes leading up to the incident, then transport the video sequences to other dispatch operators or offline analysts. The system appears to overcome the user-interface limitations of the early systems used in the United States and appears easily configurable by the user. This technology has the potential to link to existing CCTV networks and enhance incident response and post-incident safety assessments.

Objectives

1. Evaluate the potential benefit of a system in the United States to accurately detect incidents through existing CCTV networks.
2. Evaluate the user interface for ability to overcome human-factors issues and gain a general level of acceptance by operators and dispatchers.
3. Provide incident response personnel with improved tools for response decisions.

4. Provide safety engineers with effective access to incident videos that can improve their assessment of factors contributing to a crash.

Tasks

1. Develop briefing materials on the system to promote initial, basic communication of this technology among the extended team.
2. Contact locations in the United States that have shown an interest in this system and ascertain their goals, users, and planned evaluations of the system. Issue requests for information from potential providers to ascertain the availability and capability of functionally equivalent systems and providers. Synthesize this initial information.
3. Contingent on Task 2, fund a deployment of this system in an existing TMC/TOC to evaluate accuracy rates, determine benefits for responders, identify human-factors issues, and assess benefits relating to the post-crash review processes. Potential test candidates include Atlanta, Denver, Kansas City, Maryland's Montgomery County, New Hampshire, Portland, and Salt Lake City.
4. Develop a focused technology transfer document that describes the technology, its effectiveness and availability, and the downstream policy and legal issues of applying it.
5. Conduct an NCHRP synthesis of current uses of video for transportation and archiving practices and issues.

Scan Team Lead

Lyle Knowlton, Robert Callan, and Martin Knopp

Deliverables

1. Briefing materials
2. A list of groups contacted for briefings and a briefing schedule
3. Project deployment and evaluation
4. Deployment document
5. Video use and archiving synthesis

C. Advanced ITS Signing for Safety and Mobility

Background

The use of signs to inform motorists of traffic conditions have been deployed around the United States for many years. The typical application is a multiline text sign to advise travelers of an incident or conditions downstream from the sign. The signs also are used to inform motorists of public safety issues and, more recently, child abduction notifications known as AMBER Alerts. Some smaller signs are used at limited locations for lane-control indications that more graphically alert the driver to potential lane changes downstream. U.S. practitioners are making efforts to use these text-based signs more effectively by striving to remediate limitations of sign technology to convey meaningful and relevant information.

The scan team observed technologies in France, Germany, and Japan that appeared to increase the receptiveness of congestion messages in a more effective manner. In some locations, signs were observed that displayed dynamic congestion maps similar to those used on Web sites in the United States. In addition, dynamic signs were used proactively to route travelers to destinations or provide lane assignments, in contrast to the United States where signs typically display the message "USE ALTERNATE ROUTES." The team noted the use of symbols and common formatting of speeds and destinations, and believes that this practice provides a more effective transfer of messages to travelers. Further, some countries have developed protocols for displaying static and dynamic information on overhead signs.

Objectives

1. Increase awareness and adoption of the use of symbols for traffic management by U.S. transportation agencies and the MUTCD standards body.
2. Deploy sign technologies that display congestion, travel time, and incident information via dynamic maps and symbols. Develop appropriate protocols and standards for sign layout. Evaluate user acceptance, message comprehension, and potential increases in erratic maneuvers by motorists reading the signs.
3. Deploy sign technologies that dynamically change route directions based on traffic conditions. Evaluate deployed technologies for user acceptance and impacts on congestion.
4. Deploy sign technologies that dynamically assign lanes based on traffic conditions, events, and destinations to better segregate traffic involved in commuting trips, special events, long-haul transport, etc.

Tasks

1. Develop briefing materials on the system for information sharing during the early phases of expanding the team.
2. Consult with MUTCD officials on the status and potential benefit of adopting uniform symbols for congestion and safety messaging. Discuss development of protocols to guide comprehensive standardization of the static and dynamic signing along road segments. This will promote more unified expectations of travelers around the country and facilitate more complex messaging as users more easily direct their attention to common interfaces. Develop a cooperative action plan.
3. Meet with the human factors specialists at FHWA's Turner-Fairbank Highway Research Center to assess past experience with the driving simulator used to test graphic map displays for motorists. Develop a cooperative action plan.
4. Contingent on Task 3, deploy and evaluate dynamic congestion map signs at a test location as a pilot deployment.
5. Deploy and evaluate dynamic parking signs in test locations.
6. Deploy dynamic lane assignment and evaluate the complexity and achievable benefits.

Scan Team Lead

Martin Knopp

Deliverables

1. Briefing materials
2. MUTCD action plan for mobility symbols and static/dynamic signing protocols
3. A list of groups contacted and a schedule for briefings
4. Project deployment and evaluation

D. Safety Benefits of Vehicle-Infrastructure Integration Systems

Background

Significant advances have been made in the development of onboard navigational systems technology to provide real-time information to the driver for making operational decisions. Much of the focus by automakers in Europe (as well as in the United States) is on developing onboard video-detection and radar-detection devices. These devices detect objects such as hazards, pedestrians, or other vehicles within a prescribed range, process and interpret the nature and proximity of the object, and provide information to the driver. This information is advisory and intended to help the driver make critical decisions.

In Japan, the scan team observed presentations on efforts to link the infrastructure and vehicle. Examples include pedestrian motion detectors at crosswalks that trigger attention-getting messages to vehicles from roadside signs and work zone proximity warnings that notify drivers of changing or migrating hazard locations during the life of a project.

While video- and radar-detection systems are complex and expensive, this approach to capturing data requires less reliance on the infrastructure component for transmitting roadside information to the vehicle. The auto industry assumes that it cannot rely on public agencies to provide this critical component. While this approach could work, it shifts the responsibility to the automobile manufacturers, who depend on public acceptance and market penetration.

Proposal

Collaborate and partner with the Vehicle-Infrastructure Integration (VII) Steering Committee and U.S. auto industry in designing and implementing a VII project to develop the technology for roadside features. Included would be regulatory signs, advisory signs, and traffic-control devices that could communicate information to a vehicle's onboard device. Enhanced safety for all motorists would be the primary goal.

Objectives

1. Expand on the efforts in the United States to advance technology focusing specifically on research and development of the roadside-device component of VII.
2. Advocate for the design of a prototype project that can be used to evaluate the technology of roadside infrastructure, and provide an assessment of the expected benefits for improving safety.
3. Use the prototype project to evaluate the human-factors component, including driver reaction, utility of information provided, and driver acceptance.

Tasks

1. Review existing VII use cases and assess the level of consideration for safety applications. Prepare a matrix comparing and contrasting the use cases with the applications observed on the scan.
2. Meet with VII Steering Committee representatives to assess both the progress of VII and the level of interest in pursuing prototype projects that focus specifically on safety enhancement.
3. Review the prioritization of existing USDOT Intelligent Transportation Systems Joint Program Office (ITS JPO) research initiatives related to VII and synthesize the identified issues, priorities, and schedules for safety-related applications. Communicate findings and recommendations to ITS JPO.

Scan Team Lead

Robert Bryant and Martin Knopp

Deliverables

1. Matrix of use cases related to safety
2. Feasibility report resulting from meeting with VII Steering Committee representatives and auto manufacturers
3. Memorandum to ITS JPO on VII research on safety

E. Dynamic Speed Limits: Improving Safety And Mobility

Background

ITS technologies increasingly have been deployed to assist in traffic operations and control. Enhanced mobility and safety have been joint products of these advances in ITS. An ever-increasing awareness in the transportation community supports the idea that mobility suffers without an emphasis on safety, resulting in both a costly breakdown of the transportation system and a negative environmental impact.

Incidents and congestion may result in secondary crashes, many of which are more serious than the original incident. Fixed or static speed limits in use since the early deployment of traffic control devices are often disregarded. Drivers traveling over the speed limit usually assume a 5- to 10-mile-per-hour (mi/h) tolerance before a law enforcement official pulls over a driver. Many courts have adopted or accepted these tolerances. The resulting speed differential between vehicles can easily reach 50 mi/h before enforcement on a roadway with a 75-mi/h speed limit unless there is active management. Drivers attempting to push the upper limits often drive aggressively to maintain their speed.

The scan team participated in a Paris, France, briefing by Paul Maarek on the A-7 Motorway variable speed control experiment. This private corporate project developed and funded by the concessionaire ASFA has listed as its dual goal the reduction of congestion and the improvement of service.

Traffic on route A-7 has been increasing by 3 percent each year. This important tollway constitutes the major route to Spain and the Riviera. Rural sections of A-7 routinely carry 75,000 average daily traffic (ADT), peaking to 117,000 ADT during the summer holiday months, making it even more difficult for ASFA to safely manage traffic.

ASFA developed algorithms that anticipate traffic conditions 30 to 45 minutes into the future. The algorithms were used to conduct an evaluation of speed on a 19-km section (one direction) of A-7 from July 31 to September 15, 2004. Using the traffic data for time of day and season, optimal speeds were determined and posted on mainline signs and at tollway entrances. Drivers not following these speed recommendations, while not officially cited, found their license tag numbers displayed on variable message signs. This pilot study is still experimental to evaluate the effectiveness of variable speed enforcement and the public's reaction.

Overhead signs and bridges have license-tag readers in place over each lane. Recommended speeds of 110 km/h had a compliance rate of 80 percent, while recommended speeds of 90 km/h had a compliance rate of 50 percent. The optimal speed was determined to be between 90 and 105 km/h. The results of this pilot are very promising, both in terms of reducing congestion but more importantly in a dynamic increase in safety. The pilot study found that congestion was reduced by 16 percent, and delay from congestion was reduced by 2 hours. The study projected an annual savings of 30,000 hours and US$1.8 million from reduced congestion, and a 48 percent reduction in crashes on the tollway. Public awareness of the speed-control messages was 87 percent, and 98 percent of drivers remember seeing at least five variable message signs. Sixty-one percent of surveyed drivers approved of the project.

Objectives

1. Evaluate the potential benefit of a similar pilot in the United States to jointly increase safety and improve mobility.
2. Evaluate the acceptance level of a similar project in the United States.

Tasks

1. Develop briefing materials on the variable speed limit (VSL) system.
2. Develop methodology and algorithms to determine optimum speeds based on differing traffic conditions.
3. Conduct an evaluation of recommended speeds using modeling software.
4. Test and evaluate VSL and its impact on safety on a congested highway segment.

Scan Team Lead

Robert Bertini and Craig Allred

Deliverables

1. Briefing materials
2. Selected algorithms
3. Analysis report
4. Project deployment and evaluation

F. Top-Down Safety Leadership Commitment: Making It Personal

Background

Safety was observed to be a core value in the daily life of citizens of the countries the scan team visited. Leaders at the highest levels of government have made a strong commitment to improving road safety and have established national goals for fatality reduction. In France, road safety was a campaign issue in past national elections. In fact, the current president has established roadway safety as a national priority. ITS has played an important role in working toward realization of the goal of improving roadway safety.

Through a top-down leadership commitment, the leaders and governments of these nations followed through with strong, automated enforcement programs showing very positive results. Both the high priority placed on road safety and the belief in safety as a core value of society were clearly evident from the behavior demonstrated by the people the scan team met. Traffic safety laws are very stringent in France, Germany, and Japan. As a result, fatality rates are lower in these countries than in the United States. This personal commitment to safety has had a dramatic impact on the design and operation of transportation facilities as well as on speed enforcement programs.

Objectives

1. Share the models of top-down leadership commitment ("make it personal") in fatality reduction and improved roadway safety with key governmental leaders at both the Federal and State levels in the United Sates.
2. Provide key governmental leaders at both the Federal and State levels in the United States with critical facts and information that will motivate a similar personal leadership commitment throughout the Nation.

Tasks

1. Develop briefing materials describing the concept of top-down leadership commitment and its role in fatality reduction and improved roadway safety, using France, Germany, and Japan as examples.
2. Convene a meeting of co-chairs from previous international

scans involving safety on developing stronger safety leadership in the United States. Develop an action plan.
3. Contact key groups to request time on their national meeting agendas for briefings on the state of road safety in the United States and the benefits that can be achieved through top-level, committed personal leadership. Groups will include the Governors Highway Safety Association, the National Governors Association, the National Conference of State Legislatures, and key members of the U.S. Congress and Administration.
4. Procure the services of a marketing/public outreach firm to craft a safety message that can be easily understood by legislators, executives, and the public at large and that emphasizes the importance of taking action now rather than later.

Scan Team Lead

Carlos Lopez, Robert Callan, Joseph Peters, and John Njord

Deliverables

1. Briefing materials
2. Action plan of integrated scans on safety related to leadership
3. A list of groups contacted and the schedule for these briefings
4. Printed materials, brochures, and a video news release-type presentation on the use of ITS to enhance safety

G. Enhanced Roadway Features Database

Background

This scan uncovered many current and proposed applications of ITS technologies aimed at improving safety that rely on an enhanced map database resident in either the vehicle, at some centralized location, or both. In many cases these map databases would be designed to "learn" from data reported by vehicles and to provide information to other vehicles, emergency responders, incident management systems, or transportation authorities. With current navigation systems that contain static maps, the scan revealed a need to develop means of updating map data in real time, perhaps depending on the vehicle's position in real time.

The scan team also observed that some ITS safety applications require detailed speed limit boundaries. The delivery of this information sounds simple initially, but experience in both Germany and France has proven that this is quite difficult from an inventory and location basis for even a small study area. It is possible that systems could be developed using image processing to automatically update and improve speed limit boundary databases in the future, or future speed limit signs could be installed with small chips capable of communicating their location and status to a central system.

In the United States there have been, and continue to be, efforts to include map databases and to make the providers' systems interoperable in terms of location codes, accuracy, etc. All of these examples of future ITS safety applications have highlighted the importance of assessing both the level of need and the feasibility of enhancing electronic map databases used in navigation systems. A first step in this evolution would be to capture and display accurate speed limit information on the various roadway segments. This is anticipated to include acquiring the perspectives of current map data providers, as well as road-mapping specialists involved with the GIS-T software program.

Objectives

1. Improve the accuracy and completeness of data of the roadside inventory relevant to enabling more advanced ITS applications and interactions between vehicle and roadside, and vehicle and driver. Initially, data are anticipated to include speed limits, types of crossing points (pedestrians, midblock crossings, schools), and types of control.
2. Increase public and private partnerships mutually benefiting from increased data quality.

Tasks

1. In the future, systems will be needed to integrate, certify, and maintain detailed location codes, speed limits, and other critical infrastructure features within digital maps. Further integration of this information with onboard vehicle technology will also be required.
2. Prepare a synthesis and documentation of current activities in the United States related to mapping and feature integration, plus a literature review to gather recent and relevant research in this area, including consideration of future NCHRP problem statements in this area.
3. Conduct discussions with the National Science Foundation and the GIS-T community to assess research needs and opportunities.
4. Conduct discussions with commercial map data service providers to understand their perspectives on needs, benefits, and opportunities.
5. Conduct a case study or field trial in conjunction with ongoing VII and other field implementations.

Scan Team Lead

Robert Bertini and Lyle Knowlton

Deliverables

1. A PowerPoint® presentation and briefing book
2. A list of groups contacted and a schedule for briefings
3. Printed materials, brochures, and a video news release-type presentation on the use of ITS to enhance safety
4. Based on decisions and resources discovered above, a plan for a potential pilot study or test project to assess benefits, with cost and schedule estimates

APPENDIX A

Scan Subteam Report ITS World Congress—Nagoya, Japan

The ITS World Congress is an international gathering of professionals and vendors with the common objective of advancing intelligent transportation systems throughout the world. The following is the general makeup of those attending the conference:

1. Government officials
2. Members of academia
3. Private-sector firms offering ITS-related services
4. Suppliers of ITS-related products and services
5. Law enforcement personnel and organizations
5. Other emergency services providers

The timing of the 11th World Congress on ITS in Nagoya, Japan, and the launching of this safety-related technology scan provided a unique opportunity for panel members to take advantage of the year's most comprehensive showcase of technology-related products and services available in the ITS environment. Seven members of the panel were able to attend the congress from October 18 to 22, 2004:

- Michael Freitas, co-chair, FHWA
- Bruce Warner, co-chair, Oregon DOT
- Dr. Robert L. Bertini, Portland State University
- Carlos Lopez, Texas DOT
- John R. Njord, Utah DOT
- Lyle Knowlton, New Hampshire DOT
- Thomas R. Warne, report facilitator, Tom Warne and Associates

While at the ITS World Congress, scan team members attended technical sessions, delivered presentations, moderated technical sessions, reviewed the myriad of trade fair exhibits, and participated in an ITS safety technical tour. Panel members also met several times to discuss their findings, observations, and other pertinent information that could become a part of the final report for this scan.

In addition, on Monday, October 18, 2004, the panel met with representatives of FHWA, AASHTO, the U.S. private sector, ERTICO, and European countries that are well advanced in their implementation of ITS practices. ERTICO is a not-for-profit, public-private partnership established in 1991 to advance intelligent transportation systems in the European Union. It was envisioned that this meeting would establish a clear understanding of the opportunities to be explored by the scan team during the second phase of this scan.

The meeting with the European officials included discussion of a variety of ITS applications in various EU countries. Among the topics discussed were the following:

1. Officials described the general purpose of ERTICO and how the European Union is advancing ITS technologies to improve safety performance on roads and highways. EU has set a goal of reducing fatalities by 50 percent by 2010 and eliminating fatalities altogether by 2020. Also, its eSafety program focuses on deployment of new technologies.
2. It was reported that Sweden is operating a system in which the vehicle and the roadway infrastructure communicate and function collaboratively. In addition, Sweden has speed control technology in place as a safety measure. It is attempting to prevent crashes, protect occupants in crashes, and implement faster systems for getting aid to crash victims.
3. France has achieved a 21-percent reduction in fatalities with the speed-management strategies it is using. A strong commitment to road safety comes from the highest levels of government. While skeptical at first, the French public now accepts speed-management strategies as a necessary and life-saving addition to the highway system.
4. ADAC, Germany's equivalent of the U.S. American Automobile Association (AAA), reported on its efforts to improve driver education.
5. The Netherlands has implemented automatic enforcement strategies to improve speed management.
6. There is concern in the European Union that all improvements are focused on the vehicle and roadway infrastructure, while more than 90 percent of crashes are caused by driver error.
7. Renault is one equipment manufacturer that has made speed limiters available on its trucks as original installed equipment.

Figure 24. Driving support system—poor visibility. (Ministry of Land, Infrastructure, and Transport, Japan)

Figure 25. P-MAC warning system—work zone. (Ministry of Land, Infrastructure, and Transport, Japan)

8. Efforts in the United Kingdom have focused both on crash causation and on reduction of the impact of crashes that do occur.

The meeting was valuable for the panel as a precursor to making decisions on which European countries to visit during the 2005 study.

TT-3, ITS Safety Frontline Tour

The "TT-3, ITS Safety Frontline Tour" offered scan team members the opportunity to see how both public and private entities in Japan have combined efforts to offer a wide array of ITS-related safety improvements to the transportation system. This daylong technical tour included a wide variety of technologies with direct application to U.S. systems. The technologies showcased during the tour included the following systems.

Driving Support System

Using the differential GPS onboard navigation system, the driving support system (DSS) offers drivers of snowplows and law-enforcement vehicles enhanced views of obscured objects in front of the vehicle, thereby facilitating safer operation on the highway. This system translates detected obstacles into visual images depicting dangerous conditions ahead, as noted in figure 24.

P-MAC

P-MAC (figure 25) is a system intended to increase worker safety. In this case, a variable-message sign is combined with radar detection of approaching vehicles, offering a real-time messaging system that warns oncoming traffic of activity in a work zone. Message content changes if the vehicle approaching the work zone fails to take apparent evasive action.

Mobile Radio LAN System

The Japan Highway Public Corporation has installed a high-speed network for mobile objects aimed at communicating real-time information to vehicles and their occupants. It allows continuous communication of vital safety information using a radio local area network (LAN) in the 2.4 GHz bandwidth. The system is capable of communicating a wide variety of information, including data and images, to the vehicle systems.

Advanced Cruise-Assisted Highway Systems

Advanced cruise-assisted highway systems (AHS) provide information on highway features (curve data or other roadway information) as well as warnings of obstacles that may be ahead on the roadway but not yet visible. Advanced warning and information enables the driver to respond safely even under adverse driving conditions.

Vehicle Information and Communication System

The Vehicle Information and Communication System

(VICS) is a real-time system that provides information to the onboard navigation system in vehicles. Information includes such elements as weather, road conditions, navigation assistance, traffic conditions, and virtually any other data that might help drivers operate their vehicles in a safe manner. The system had 9.2 million subscribers by March 2004. Users pay a one-time setup fee, in addition to purchasing the onboard navigation system, and then receive the VICS service free. See figure 26.

Radar Cruise Control (with Low-Speed Following Mode)

The radar cruise control (with low-speed following mode) system was demonstrated by Toyota, Nissan, and Mitsubishi at a test site. When activated, this system enables drivers to adjust headway between their vehicles and the one immediately ahead, thereby providing for a uniform flow of traffic and automatic adjustment of speed based on the actions of the leading vehicle.

Vision-Assist Technology

Vision-assist technology allows vehicle operators to "see" objects and roadway features that otherwise would be invisible because of blind spots or obscured-vision conditions. Cameras mounted on the vehicle at strategic locations can provide the vehicle operator with direct video images or enhanced visual renderings of conditions and obstacles.

Adaptive Cruise Control

Adaptive cruise control differs from radar cruise control in that it provides the added benefit of mild to increasingly intense braking if the driver of a vehicle does not respond safely to a slowing or stopping vehicle ahead. Designed to reduce or eliminate rear-end collisions, this system increases the safety of vehicles and their occupants through automated braking actions.

Japan Road Traffic Information Center

The Japan Road Traffic Information Center is operated by the Japanese Ministry of Land, Infrastructure, and Transport and offers motorists a wide variety of services, including weather conditions, road conditions, congestion conditions, and construction restrictions. Operated in conjunction with many of the other systems featured during this tour, the center is a significant modern component of the ministry's ITS initiative.

Road Construction Management System

The Road Construction Management System involves more than 1,500 taxi probes that travel extensively throughout the Nagoya region and provide a wealth of information for use by the Japan Road Traffic Information Center in managing the transportation system. GPS technology is combined with data on traveling speed and wiper operation to give a more complete picture of the operation of the system elements and any weather-related concerns to be communicated to other motorists.

Figure 26. VICS.
(Ministry of Land, Infrastructure, and Transport, Japan)

Driving Safety Support Systems

The driving safety support systems operation consists of a collection of field tests focused on offering motorists additional information to improve their safety and that of vehicles and pedestrians around them. It includes the frequent communication of location-specific crash information to encourage drivers to be more cautious as they approach certain locations. It also communicates real-time information on congestion and the presence of pedestrians in crosswalks.

In addition to the above-described technologies, the panel observed many other safety-related technologies and strategies at the ITS World Congress that may have application in improving the safety of the Nation's transportation system. The themes the team observed are summarized below:

1. Japan has a vast number of vendors of ITS-related products and services, making the country a competitive environment for procurement, deployment, and operation of ITS.
2. Interoperability is advanced because of the maturation of system integration.
3. The onboard navigation system serves as the catalyst for ITS deployment in motor vehicles, with other technologies emanating from that point.
4. The Japanese use cameras, vehicle-performance information, sensors, infrastructure inputs, and other information in com-

bination to achieve safety-related improvements in their transportation system.

5. VICS technology has substantial penetration in Japan.
6. The Japanese put a strong emphasis on how the use of ITS will improve both safety and the environment.
7. Strong national leadership on safety exists in both Japan (by the national government) and Europe (by the European Union).
8. The goals and objectives of the Europeans and Japanese to reduce crashes and fatalities are not constrained by current knowledge, practices, or technology. These goals are seen to be sufficiently important to drive researchers toward eventual encompassing solutions.

Overall, the experience in Japan at the ITS World Congress complemented the onsite visits to Germany and France and confirmed many of the findings and recommendations contained in this report.

APPENDIX B

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BIOGRAPHIC SKETCHES

John R. Njord *(AASHTO co-chair, Europe)*, executive director of the Utah Department of Transportation since June 2001, leads a team responsible for the planning, design, construction, and maintenance of Utah's transportation system. Njord joined the department in 1988 and has served in various engineering capacities, including deputy director. He also served on the Salt Lake Organizing Committee as director of transportation planning for the 2002 Olympic Winter Games. In 2002, he was named Utah Communicator of the Year by the Public Relations Society of America. He was president of AASHTO in 2004, and is now chair of the Transportation Research Board Executive Committee. He also chairs the 511 Travel Information Deployment Coalition and the Vehicle-Infrastructure Integration (VII) Executive Leadership Team. Njord is a graduate of the University of Utah and a registered professional engineer.

Dr. Joseph I. Peters *(FHWA co-chair, Europe)* is manager of ITS program assessment for USDOT's Intelligent Transportation Systems Joint Program Office (ITS JPO). He has 33 years of experience in research, development, testing, and evaluation. His career started in 1972 with university grant research in support of FHWA and the U.S. Navy. He joined FHWA in 1975, followed by positions managing U.S. Army and U.S. Air Force research programs. Beginning in 1984, he spent 11 years in the private sector and became an assistant vice president with Science Applications International Corporation (SAIC). He returned to Federal service in September 1995 with ITS JPO, where he develops and manages its evaluation program. Major activities under his supervision include the evaluation of ITS field operational tests, model deployments, and select local deployments of ITS. He leads the development of Web-based decisionmakers' resources, including the ITS Technology Overview, which integrates ITS benefits, costs, deployment statistics, and lessons-learned information according to ITS technology application areas. He received his Ph.D. in applied-experimental psychology from the Catholic University of America in 1977.

Michael Freitas *(FHWA co-chair, Japan)* is a civil engineer with 35 years' experience with FHWA. For much of his career, Freitas was involved in safety research, including crash analysis, roadside safety, and large truck safety. He has been involved in the ITS program since its inception and is now the travel management coordinator in the USDOT ITS Joint Program Office. As such, he has budget and general program overview responsibilities over those portions of the ITS JPO program dealing with advanced traffic management, traveler information, and rural ITS programs. He also serves as the day-to-day manager of ITS JPO in support of the acting director.

Bruce Warner *(AASHTO co-chair, Japan)* is director of the Oregon Department of Transportation (ODOT), which manages or regulates highways, rail, public transit, motor carrier, and driver and motor vehicle services. Warner's department has about 4,800 employees and a biennial budget of $1.7 billion. Before assuming his present position, Warner was chief operating officer of Metro, the regional government of the Portland, OR, metropolitan area, which administers Oregon's unique land use and transportation planning laws. Warner also worked as ODOT's regional manager for the Portland area, where he championed deployment of ITS technology. Warner has been involved in transportation issues for more than 25 years. He is chair of AASHTO's National Standing Committee on Highway Traffic Safety, which is developing strategies to reduce the number of motorists, pedestrians, and bicyclists killed on U.S. roadways. Warner has a bachelor's degree in civil engineering form the University of Washington in Seattle and is a registered professional civil engineer.

Kenneth Craig Allred is a transportation specialist on the Safety and Design Team at the FHWA Resource Center. He is part of a national team of specialists who deliver state-of-the-art training, provide technical assistance, promote market-ready technologies, and support technology deployment in the areas of road safety and geometric design. The team works closely with the FHWA Divisions to assist State departments of transportation, local road safety officials, and others in advancing practices related to intersection safety, roadside design, pedestrian safety, and context-sensitive solutions. Previously, Allred was the public safety coordinator for the USDOT ITS Joint Program Office, working with law enforcement, fire, emergency medical services, and engineering staffs. He was the USDOT lead for two major initiatives, Wireless E911 and the AMBER Alert program for missing children. Allred retired from the Utah Department of Public Safety after 25 years, starting as a trooper and leaving as a department director. Director of the Utah Highway Safety Office for 8 years, he worked to enhance highway safety and led efforts to increase safety belt use in the State from 43 to 82 percent. Allred is a past chair and vice chair of the National Governors Highway Safety Association. He has presented and instructed at the national, State, and local levels in 42 States and U.S. territories. Allred has been an active member of the International Association of Chiefs of Police Highway Safety Committee since 1990. He has a bachelor's degree in psychology and criminal justice from Weber State University.

Dr. Robert L. Bertini is associate professor of civil and environmental engineering and urban studies and planning and director of the Center for Transportation Studies at Portland State University. Building on a career that includes planning, designing, and constructing highway, rail, and airport facilities, Bertini has developed a research program, laboratory, and graduate curriculum in intelligent transportation systems (ITS). As director of the university's Center for Transportation Studies, he focuses his research on the integration of new technologies and collaborates with other disciplines such as urban planning, electrical engineering, and computer science. Bertini received the prestigious National Science Foundation CAREER Award, and as part of that grant is developing a regional ITS data archive program in the Portland metropolitan region. Before his academic appointment, Bertini was a senior research scientist with DaimlerChrysler Research, and worked as a transportation engineer with Parsons Brinckerhoff Quade and Douglas, Parsons Transportation, and the San Mateo County Department of Public Works. Bertini has a bachelor's degree in civil engineering from California Polytechnic State University, a master's degree in civil engineering from San Jose State University, and a Ph.D. in civil engineering from the University of California at Berkeley, where he was an Eisenhower Transportation Fellow and a University of California Transportation Center Fellow. Bertini is a registered professional engineer in California and Oregon, and serves on committees of the Transportation Research Board, Institute of Electrical and Electronics Engineers, and Institute of Transportation Engineers.

Robert W. Bryant has served as manager of Region 4 for the Oregon Department of Transportation (ODOT) since December 1998. ODOT is responsible for planning, design, construction, maintenance, and operation of the State highway system, and for providing State citizens with a safe and efficient highway system. Region 4 makes up the central one-third of the geographic area of Oregon and contains 3,701 kilometers (2,300 miles) of State highways. Bryant joined ODOT in February 1984 in the Region 2 Location office as a highway engineer, and transferred to Region 4 in 1987 as a consultant contract liaison. Throughout his ODOT career, he has held various positions in engineering, project development, and highway construction. He entered into management as the Region 4 project development engineer, and held positions as construction project manager and region technical services manager before becoming region manager.

Robert M. Callan is the division administrator for the FHWA Georgia Division in Atlanta, GA. Callan leads a multidisciplinary staff responsible for administering the Federal-Aid Highway Program in Georgia. He provides leadership and guidance to State and local officials in identifying surface transportation needs and related priorities in carrying out national transportation program goals. Callan's emphasis is directed at reducing fatalities and injuries on Georgia's highways, as well as leading efforts aimed at improving mobility and reducing congestion in the State. Callan has a bachelor's degree in civil engineering from the University of Massachusetts Dartmouth and has completed graduate work in public administration at Virginia Polytechnic Institute and State University and the University of Southern California. He is a licensed professional engineer in North Carolina and serves on the board of ITS Georgia. He is a member of the Division Administrator Safety Advisory Council, which advises FHWA's Office of Safety on policy and program issues dealing with FHWA's overall approach to safety.

Martin Knopp is a supervisory highway engineer at the FHWA Resource Center in Olympia Fields, IL. The Resource Center provides technical assistance, promotes market-ready technologies, and offers training to FHWA divisions, State departments of transportation, metropolitan planning organizations, and other transportation partners. Knopp is the team leader for the Operations Technical Service Team, which focuses on traffic operations, traffic engineering, ITS, emergency transportation operations, and freight operations. In the past, Knopp served as director of ITS for the Utah Department of Transportation and in FHWA assignments in Colorado, Florida, Georgia, Kentucky, Seattle, and Utah. Knopp has extensive experience with ITS deployment, traffic management, and special events. He is an associate member of the Institute of Transportation Engineers and participates on the steering committee of ITS America's Transportation Systems, Operations, and Planning Forum. Knopp is a registered professional engineer in Utah and received a bachelor's degree in civil engineering from Pennsylvania State University.

Lyle "Butch" Knowlton is director of operations for the New Hampshire Department of Transportation (NHDOT). Knowlton is responsible for the operations and maintenance activities of the Bureaus of Highway Maintenance, Bridge Maintenance, Traffic Operations, Turnpikes, and Fleet Services. He is leading NHDOT's first efforts to implement several ITS initiatives, including incident management (511) in the I-95, I-93, and the Central Turnpike corridors. He has also been instrumental in planning a new Transportation Management Center, which will be occupied jointly by the State Police, 911, NHDOT, and Emergency Management Services. Knowlton is a graduate of Clarkson College of Technology with a degree in civil and environmental engineering and has a master's degree in business administration from Plymouth State University. He is a licensed professional engineer in New Hampshire, serves on the AASHTO Subcommittee on Systems Operation and Management, and chairs the Interstate Bridge Authority.

Carlos A. Lopez is director of the Traffic Operations Division of the Texas Department of Transportation. The division is responsible for statewide traffic operations, including all ITS programs. Selected as special project engineer in 1988, Lopez was responsible for traffic light synchronization and traffic management. Lopez became the division's Traffic Engineering Section director in 1993 and was appointed division director for Traffic Operations in 1999. Lopez earned his bachelor's degree in civil engineering in 1982 and his master's degree in 1989, both from the University of Texas at Austin. He became a licensed professional engineer in 1987. Lopez is a member of the Texas Section of the Institute of Transportation Engineers and serves on Transportation Research Board and AASHTO committees that deal with traffic operations.

Thomas R. Warne *(report facilitator)* is the president and founder of Tom Warne and Associates, LLC, a management and marketing consulting firm serving the transportation industry. His clients include engineering companies, contractors, and Federal and State agencies, as well as a variety of private-sector clients. Major projects include engagements on the Woodrow Wilson Bridge, San Francisco Oakland Bay Bridge, Trans-Texas Corridor, Tri-Rail Double Track project in Florida, and Hudson Institute's 2010 and Beyond Project. Warne is the former executive director of the Utah Department of Transportation (UDOT), where he was responsible for the $1.59 billion reconstruction of I-15 through Salt Lake City as well as leading UDOT through its preparations for the 2002 Winter Olympic Games. Before his work in Utah, Warne spent 12 years at the Arizona Department of Transportation, where he served as that agency's chief operating officer for the last 3 years of his tenure. He is a past president of AASHTO, a former member and vice chairman of the Transportation Research Board's Executive Committee, and a former member of the Eno Transportation Foundation's Board of Advisors. Warne has a bachelor's degree in civil engineering from Brigham Young University and a master's degree in civil engineering from Arizona State University. He is a registered professional engineer.

APPENDIX D

Amplifying Questions

The scan team developed the following amplifying questions to assist the hosting organizations in focusing their presentations on specific areas of interest within the main topic of this international scan. The questions represent the most essential elements or issues within the topic of safety applications of ITS technologies and should not be considered all inclusive. Simply stated, they were drafted both to provide an outline of the scan team's major areas of interest and an opening point in the discussion on this very important and multidimensional subject.

1. Automated enforcement of speed limits and traffic signals

a. What technologies are deployed in vehicles and/or the infrastructure to achieve automated enforcement?
b. What institutional barriers existed prior to deployment and how were they addressed?
c. What was the role of the private sector in implementing automated enforcement of speed limits and traffic signals?
d. How have performance measures been used to determine the effectiveness of automated enforcement?
e. Given the historical experience of your agency/organization with automated enforcement, how will this technology and practice change in the future?

2. Intersection-collision avoidance systems

a. What kinds of ITS-related systems have been deployed in your country?
b. What is the role of the public and private sectors in developing an effective intersection-collision avoidance system?
c. What sociopolitical barriers existed prior to deployment and how were they addressed?
d. How have performance measures been used to determine the effectiveness of the deployed intersection-collision avoidance systems?

3. Vehicle-based measures for crash avoidance

a. What vehicle-based measures for crash avoidance have been deployed in your country?
b. What is the role of the public and private sectors in developing effective vehicle-based measures for crash avoidance?
c. What sociopolitical barriers existed prior to deployment and how were they addressed?
d. How have performance measures been used to determine the effectiveness of vehicle-based measures for crash avoidance?

4. Identification and prioritization of safety problem areas

a. What ITS technologies are used to assist public agencies in identifying safety problem areas, and how are they utilized to establish priorities for improvements?
b. How has the use of ITS technologies assisted your agency in more effectively addressing safety-related problems in your transportation system?
c. What public involvement processes are in place to allow public input into establishing priorities?
d. How have you measured your success in this process?

5. Selection of ITS over traditional countermeasures for safety problems

a. How are safety countermeasures chosen in your agency/country?
b. How have performance measures been used to determine the effectiveness of the chosen countermeasures?
c. How are ITS countermeasures integrated into the transportation system?

6. Weather-mitigation systems

a. What technologies have been deployed to improve the safety of the transportation system?
b. How have performance measures been used to determine the success of the weather-mitigation systems that have been deployed?
c. How is the information derived from the weather-mitigation systems used by different agencies and levels of government?

7. Speed management and traffic calming

a. What ITS technologies are used for speed management and traffic calming?
b. What has been the public involvement process for identifying locations and technologies to deploy?
c. How have performance measures been used to determine

the success of speed-management and traffic-calming deployments?

8. Pedestrian and bicycle safety

a. What unique and successful ITS technologies have been deployed to improve pedestrian and bicycle safety in your country?

b. What other agencies are involved in advancing successful pedestrian and bicycle safety programs (e.g., schools, law enforcement, insurance companies, etc.)?

c. How have performance measures been used to determine the success of the pedestrian and bicycle safety measures that have been deployed?

9. Navigation, traveler information, and signage issues related to safety

a. What ITS technologies are being utilized to improve the navigation, traveler information, and signage components of your transportation system?

b. How are these technologies identified, prioritized, and deployed?

c. How have performance measures been used to determine the success of the navigation, traveler information, and signage elements?

10. Collection of safety-related data elements

a. What safety-related data elements are deemed critical to the decisionmaking process when it comes to deploying ITS technologies to enhance safety on your transportation system?

b. What privacy issues have resulted from efforts to collect safety-related data and how have they been addressed?

c. What jurisdictional issues have had to be addressed in deploying collection systems for safety-related data elements?

d. What measures are in place to ensure the quality of the data collected?

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