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The Roadway INFOstructure
What? Why? How?

Providing for Integrated Information to Roadway System Managers and Users

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Providing for Integrated Information to Roadway System Managers and Users

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Workshop Summary

The intelligence and sophistication of the surface transportation system continue to grow in concert with the increasing sophistication and expectations of its managers and users. As intelligent transportation systems (ITS) have begun to permeate surface transportation, it has become increasingly apparent that good information is the primary key to managing the system effectively and for its customers to make full use of the system.

The National ITS Program Plan, published in January 2002 by the Intelligent Transportation Society of America (ITS America), calls for the development of an Integrated Network of Transportation Information (INTI) to help meet the information needs of all surface transportation stakeholders nationwide. This call was underscored and dramatized by the terrorist attacks of September 11, 2001, which made clear both the criticality and the vulnerability of the surface transportation system and the need for better information to plan for, prevent, protect against, respond to, and recover from major disruptions, whether due to natural causes or human-made.

At the January 2002 Annual Meeting of the Transportation Research Board (TRB), the Federal Highway Administration (FHWA) unveiled a preliminary vision for a Roadway INFOstructure that represented the road and highway component of the INTI. A wide range of public and private stakeholders took generally favorable note of this vision and expressed the desire to take part in its further shaping.

Exploring and evolving the vision was the topic of a two-day workshop, "The Roadway INFOstructure: Why? What? How?" sponsored by TRB's Committee on Intelligent Transportation Systems (A5009), ITS America, and the California Department of Transportation (Caltrans).

On August 21–23, 2002, more than 80 professionals from government, industry, and academia met at the National Academies' Beckman Center in Irvine, California, to participate in this workshop. In brief, the objective of the workshop was to develop a shared (and shareable) understanding of the purpose of the Roadway INFOstructure and to explore such critical issues as:

- How the Roadway INFOstructure should be developed and operated;
- Data ownership and privacy;
- Addressing transportation data needs through the INFOstructure;
- Addressing transportation security needs through the INFOstructure;
- Opportunities and requirements for performance and information security; and
- Technical, institutional, financial, and policy challenges

These objectives were pursued through invited presentations from industry experts and a structured series of breakout group sessions focusing respectively on

- Why: What is the purpose of a Roadway INFOstructure?
- What: What does it need to include? and
- How: Planning to realize the Roadway INFOstructure.

Breakout group discussions were shared and reviewed among all workshop participants during plenary sessions following each breakout session. A final plenary session summarized workshop discussions and outlined directions for the future.

Workshop discussions made it clear that there were many, not always compatible, visions for the Roadway INFOstructure and that a primary near-term objective is to pin down its scope and meaning. Some participants felt strongly that the entire INTI should be addressed simultaneously rather than focusing early attention only on the roadway portion of the surface transportation system. Other participants felt that the exploration and development of a specifically roadway-oriented INFOstructure was a large enough challenge to handle at one time and that, once developed, it could serve as a foundation for building the remainder of the INTI.

Workshop participants made the following observations:

- An INFOstructure can be a significant contributor to improved highway and vehicle safety by improving the level of information available to infrastructure and vehicle operators and by providing additional real-time information to traffic control systems and in-vehicle safety systems.
- An INFOstructure can be a significant contributor to the homeland security program as well as to addressing disasters of all kinds, before, during, and after such disasters. Preventing and mitigating major disruptions will require close coordination and partnership across multiple organizations.
- A better name than “Roadway INFOstructure” is needed for this system. Similarly, little enthusiasm was expressed for the current broader name: “Integrated Network of Transportation Information.”
- More and better information on the roadway system and from adjoining systems is critical for future management and use of the roadway system.
- A great deal of useful information is already being collected, but not in a form that is readily amenable to sharing, aggregation, or cross-jurisdiction analysis.
- There are significant untapped opportunities to collect additional useful information, notably from vehicle-based sensors; however, exploiting this opportunity will require building effective new relationships between the public and private sectors and improving communications between vehicles and the infrastructure. Gathering information effectively will require a whole family of technologies addressing multiple information sources.
- Requirements for information detail and speed of information delivery vary widely among applications. Real-time, high-detail information is mainly of local interest (local interest everywhere) for immediate transportation system management and trip planning. Planning at all levels and wide-area analysis are generally less demanding in terms of detail and delivery speed.
- Traditional models for ITS project leadership do not appear to be applicable to the INFOstructure, due its scope, complexity, and cost. A genuine public–private coalition is needed, possibly using the 511 coalition model as an example. An initial prerequisite for the INFOstructure to work is broad-based political support and leadership. Laying the groundwork for this support and leadership is an important near-term activity.
- For the INFOstructure to work, widespread private sector involvement is also essential, particularly to implement vehicle-infrastructure interactions.

At the end of the workshop, the following definition for the Roadway INFOstructure was presented:

> *A coordinated collection of systems on a national scale that consistently collects, integrates, and stores real-time and historical information about the structure, state, usage, and performance of the roadway system and its related facilities and that enables making this information readily available to applications that serve managers and users of the roadway system.*

Many of those in attendance agreed that the basic reasons for pursuing the INFOstructure were to advance the interests of

- Safety,
- Security,
- Mobility,
- Efficiency,
- Environment,
- Economic competitiveness, and
- Quality of life.

To do so effectively will require a coalition of public and private organizations with interests in these goals, including the automotive industry; public agencies involved in transportation, emergency response, public safety and security; all aspects of the freight industry; and driver and traveler advocates.

The What, Why, and How of INFOstructure

The field of ITS is a notable part of the overall revolution in information technologies that has been taking place over the past several years. ITS is commonly defined as the application of information technology to the problems and opportunities of surface transportation.

Although a national program for ITS has long been encouraged by Congress and pursued by the U.S. Department of Transportation (U.S. DOT), ITS—like politics—has largely been local. Indeed, despite the existence of a well-regarded National ITS Architecture, most of infrastructure-oriented ITS has grown up piecemeal, in individual deployments in a variety of localities, and largely in isolation from the private sector's development of vehicle-based ITS.

There have been some notable regional deployments, including multi-state systems to facilitate safe, well-regulated commercial vehicle traffic across state borders and through weigh stations. In addition, with encouragement from U.S. DOT, metropolitan planning organizations (MPOs) and Regional Operating Organizations (ROOs) have been developing and implementing regional architectures based on the National ITS Architecture.

In general, however, even these pioneering efforts are largely not able to communicate, share data, or operate with one another (or with vehicles, except via dynamic message signs along the road). The National ITS Program Plan observes that "[w]ith the exception of a small number of ... new public and private relationships, most ITS services and systems have been implemented within existing institutional and organizational structures."[1]

There is, however, a growing recognition of the need to be able to share information effectively and to make information consistently available for the use of the managers and the users of the transportation system.

THE INFOSTRUCTURE: WHY?

One reason for enabling information sharing is that the collection of agencies and jurisdictions that need to work together and with the private sector is becoming more fluid, varying with circumstances. One kind of circumstance, high in the consciousness of the transportation community, is major disruptive incidents, whether due to natural disasters or terrorist attacks.

One reason for making transportation system information available in a consistent form is the advent of a new generation of active in-vehicle safety products whose performance could be enhanced by real-time information about traffic and road conditions. In addition, the ability to do sensible and effective transportation planning and policy making on a national scale requires information that is consistent and comparable regardless of where it is gathered.

There are potentially many more reasons for working toward an Integrated Network of Transportation Information (INTI). With a focus on the roadway portion of the transportation system, exploring these reasons was the first important component of the Roadway INFOstructure workshop.

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[1] ITS America, *National ITS Program Plan: A Ten-Year Vision*, January 2002, p. 105.

THE INFOSTRUCTURE: WHAT?

The National ITS Program Plan characterizes the INTI as the bold new vision for the next 50 years, an undertaking of similar scope, magnitude, cost, difficulty, and value as the Interstate Highway System, but with a much more complex and less readily visible outcome. At its most basic, the Interstate Highway System can be simply characterized as a national network of limited access highways interconnecting major metropolitan areas. Similarly characterizing the Roadway INFOstructure was a second major focus of the workshop.

THE INFOSTRUCTURE: HOW?

The INTI and the Roadway INFOstructure are made even more complicated by the range of affected stakeholders, public and private, who must be engaged and whose interests must be considered and satisfied in order to successfully deploy a complex information product like the INFOstructure.

Addressing the mechanisms for realizing the Roadway INFOstructure, with a focus on stakeholder needs and policy challenges, was the third major focus of the workshop.

THE WORKSHOP

A workshop was held on August 21–23, 2002, to explore the basic issues surrounding the Roadway INFOstructure and to identify set directions for research, policy, and action. The workshop was jointly sponsored by the TRB's Committee on Intelligent Transportation Systems, ITS America, and Caltrans.

The primary objective of the workshop was to establish a foundation for a Roadway INFOstructure program; that is, to create a clear understanding of the issues and approaches in the areas of policy, research needs, and implementation.

A significant subtext of the workshop was to discuss options relevant to the reauthorization of the surface transportation bill, already under way by mid-2002. In this context, considerations included appropriate and relevant roles for the federal government (U.S. DOT in particular) in characterizing and realizing the Roadway INFOstructure.

It was recognized early that the success of the INFOstructure and the INTI depends on engaging the support and participation of many public and private stakeholders. It was also recognized that the success of an undertaking of the size, difficulty, and cost of the INFOstructure also requires a strong federal role.[2] A workshop objective was to discuss U.S. DOT's exploration of its role in making the INFOstructure a reality.

The workshop drew wide support from across the ITS industry, with more than 80 participants from the private sector, government agencies at all levels, and academia, from the United States, Mexico, and Japan, including

- Automotive manufacturers,
- Information providers,
- ITS consultants,
- National laboratories and private research establishments,
- Professional and industry societies,
- State and local departments of transportation,

[2] However, some strong voices did not see either the likelihood or the desirability of a strong federal role, preferring to see leadership and funding emerge from a public–private coalition.

- State and local planning organizations,
- Telecommunications services,
- Traffic equipment manufacturers and system integrators,
- Universities, and
- U.S. DOT and its support contractors.

Opening Plenary Session Summary

ITS Committee Chair **Richard Weiland** opened the first plenary session of the workshop. He welcomed attendees on behalf of TRB, ITS America, and the California DOT, and described the objectives and structure of the workshop.

The main business of the opening plenary was a series of four invited presentations[3] to introduce the main themes of the workshop.

- **Michael Freitas**, U.S. DOT ITS Joint Program Office, provided background for the workshop and the INFOstructure via a U.S. DOT perspective on roadway information needs, long-range vision vs. existing capabilities, and short-term issues and objectives.

Freitas discussed the new emphasis on operations in infrastructure management and that good information, critical to operations, is largely not available at present. A national investment in an INFOstructure will help improve security, address congestion, improve response to weather events, and facilitate national and regional traveler information.

- Transportation consultant **Matthew Coogan** spoke on “Models of Mobility: The Outcomes Supported by the Data We Collect,” to spearhead the discussion of breakout session #1 on the need for a Roadway INFOstructure.

Coogan’s theme surrounded the need to “track, monitor, and evaluate” information about transportation systems, with examples drawn from both public and private sector operations. Real-time information is needed for local control and information. Planning, especially on larger geographic scales, can make use of archived information.

- **Pravin Varaiya**, Department of Electrical Engineering and Computer Science, University of California, Berkeley, spoke on general functional requirements for building a road information system, to spearhead the discussion of Breakout Session #2 on “What” the Roadway INFOstructure needs to do.

Varaiya used the California Highway Performance Measurement System as an example of what is required and to illustrate what currently works and what does not. He noted in particular that much of the detection equipment installed in the infrastructure does not work and is not adequately funded for operation or maintenance.

- **Philip Tarnoff**, Director, Center of Advanced Transportation Technology, University of Maryland, spoke on “Getting to the INFOstructure,” to spearhead the discussion of breakout session #3 on the technical and policy challenges of realizing the INFOstructure.

Tarnoff reemphasized the importance of good information to manage the system and to allow travelers to make informed decisions. He distinguished local from national needs in terms of timeliness and level of detail, and identified major issues as funding, the role of the private sector, privacy considerations, liability concerns, and the need for leadership. The main challenge, he said, is organizational.

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[3] Papers and presentations are available on the web at http://gulliver.trb.org/conferences/INFOstructure/proceedings/.

FIRST BREAKOUT SESSION SUMMARY

Addressing ITS and Surface Transportation Data Needs Through the INFOstructure

Most of the information presented below as breakout session summaries comes, not surprisingly, from the reports of the respective breakout groups. However, TRB breakout groups, populated (as they invariably are) by active practitioners and thoughtful professionals, do not always stay rigidly focused on a single topic. In many cases, the report from Breakout Group X contained insights relevant to the issues of Breakout Group Y and vice versa. Sometimes a tangent produced extremely useful insights. Sometimes earlier breakout group discussions anticipated the content of later sessions. Sometimes later breakout sessions reflected back on the subjects of earlier breakout sessions. Therefore, the summaries that appear below draw some of their content from discussions outside the actual boundary of the stated breakout group, including the summary discussions at the end of the workshop.

WHO ARE THE STAKEHOLDERS AND WHAT ARE THEIR ROLES?

The breakout groups identified and discussed the following stakeholders:

- **Federal government.** Congress and executive agencies are both relevant. Congress is a primary enabler of the INFOstructure, both through its ability to define and give priority to national programs and because it is a traditional source of funds. A key to appropriate Congressional involvement is the education of House and Senate staff on the INFOstructure: What it is, what it can do, what is needed to make it happen. U.S. DOT has a clear role to play in defining and carrying out INFOstructure-related policy, catalyzing state and local activity, and encouraging private sector involvement. A particularly important role, at the national level, is to foster the appropriate level of uniformity, so that information can be exchanged, compared, aggregated, etc. While many stakeholders will have a role in this process, guidance and support at the national level would be particularly helpful.

  Nonetheless, some participants felt that relying on federal leadership and funding would not be an effective model for moving forward, preferring to seek national guidance and commitment from a consortium that included states and private entities.
- **State and local government.** Again, both legislative and executive roles were identified as important. Relevant agencies include planning agencies, state and local transportation agencies (highway, transit, rail), law enforcement, and emergency response agencies. These agencies will be important consumers of information related to the INFOstructure as well as important sources for this information. As such, they will probably play a key financial role in INFOstructure creation and operation. Legislative action would help make the development of local portions of the INFOstructure a priority.
- **Vehicle manufacturers and suppliers.** The role of vehicle manufacturers and suppliers is multifaceted. At the most basic level, these stakeholders have a potential interest in developing and selling technology that can use data from the INFOstructure to make travel safer, more productive, and more comfortable for individual motorists and for commercial fleets. It was also widely recognized that vehicles have a fundamental role in providing information about road, travel, and traffic conditions to the INFOstructure by serving as mobile data probes. A repeated observation was that road authorities have found it difficult to secure adequate funding

to operate and maintain infrastructure-based detectors (e.g., induction loops, video cameras), and except in very heavily traveled areas, their installation is difficult to cost-justify. Delegating a significant fraction of this detection activity to appropriately equipped vehicles could be an attractive alternative, provided mechanisms for capturing, analyzing, and delivering the probe data can be put in place.

- **Standards development organizations.** The INFOstructure will require a variety of information and performance standards to function consistently and effectively. An important early issue is to determine what kinds of information are purely of local interest and what kinds of information will be candidates for sharing, exchanging, consolidating, etc. In general, the more real-time the information is, the more local its sphere of interest (e.g., traffic conditions on local freeways). Most information to be shared will be more general and more historical. Some important research on traffic and driver behavior may need widely gathered, highly detailed information on the use of the roadway system, but probably not in real time. However, in emergency situations, real-time information over wider-than-usual areas may be vital. In any case, establishing standards for data collection and quality, formats for storing and exchanging data, and establishing good practices to ensure integrity and privacy will all be critical to the success of the INFOstructure.
- **ITS America.** ITS America was identified in the National ITS Program Plan and in the workshop as a primary enabler of the INFOstructure through its ability to reach out to a wide range of stakeholders, focus discussions, build consensus, and provide industry leadership.
- Other relevant stakeholders included
  - **Media,** for advocacy and information dissemination.
  - **Fleet operators,** as significant commercial consumers of and contributors to INFOstructure information.
  - Other points in the **freight supply value chain**, including shippers and the people and organizations to whom goods are delivered. The INFOstructure can help streamline the whole process, provide better information about goods in transit, enhance security, and lower the costs of moving freight.
  - **Advocacy organizations** like the American Trucking Associations and the American Automobile Association, to represent the views and interests of their constituencies—the traveling and driving public, both individuals and commercial interests—and to do outreach.
  - **Weather services,** as both sources and consumers of INFOstructure data that can help make travel safer, more accessible, and more productive during significant weather events.
  - **Homeland security, public safety, and emergency management agencies,** since the INFOstructure will be an aid for surveillance, protection, response, and recovery in cases of natural or human-caused disasters.
  - **Event planners** (sports, music, theme park operators), as both sources and consumers of INFOstructure data to streamline operations and the movement of traffic.

WHAT BENEFITS COULD THE INFOSTRUCTURE DELIVER?

The breakout groups identified a wide range of benefits that could accrue to operators and users of the roadway system through the availability of better information about its characteristics, current status, and use:

- **Improved safety for travelers** as a result of better information about congestion, road hazards, weather conditions and, in the long run, the location and trajectory of other vehicles.
- **Effective increase in roadway capacity** through better load management, fewer incidents, decreased congestion, increased ability to do more precise and directed maintenance.
- **Better roadway system operation** enabled by better, more current, more comprehensive information about the roadway system and better, more transparent communication among responsible agencies.
- **Environmental improvement** through the reduction of congestion, better environmental sensing and analysis, helping vehicles to perform more efficiently.
- **Quicker emergency response** both through faster and better informed detection and reporting of emergency situations and through an improved ability to get responders to the scene.
- **More efficient event management** through a better understanding of surrounding traffic patterns both through historical and real-time information and analysis.
- **More effective planning** by infrastructure managers and by travelers, through the broadened and improved ability to gather, aggregate, analyze, and report information related to roadway system operation and use.
- **Better observation, forecasting, and improved response to weather events** through more accurate land- and vehicle-based sensing of weather conditions, improved ability to gather, coordinate, model, and analyze weather data from multiple sources, improved decision support to anticipate and clear weather-related traffic obstructions (snow, ice on pavement), and improved ability to communicate weather-related travel information to the public.
- **Better transportation and homeland security** through improved mechanisms for surveillance (of transportation and other sensitive facilities, cargo, routes, commercial and transit drivers), improved ability to communicate and share data among relevant agencies, improved ability to identify, analyze, and fortify points of vulnerability, better tools to provide transportation alternatives in cases of disruption, and better mechanisms for communicating with the general public.
- **Economies and efficiencies through colocation and co-use.** The existence of a Roadway INFOstructure provides a potential foundation for both the logical and physical integration of operating centers, transportation management centers, information dissemination centers, and emergency response centers. Consistent, universally available information allows for flexibility and fluidity in organization, making it better able to respond to evolving demands.
- **New profit opportunities** in developing and marketing land- and vehicle-based sensors, communication systems, and applications that make use of INFOstructure information; in developing and exploiting communication networks to channel, share, and distribute INFOstructure data; in developing and integrating software for managing, aggregating, analyzing, exploiting, and accessing INFOstructure data.
- **An invigorated ITS and telematics industry.** Rapid, consistent, national deployment of the INFOstructure would provide a foundation for a host of related new businesses.

Participants particularly emphasized the potential safety benefits of the INFOstructure, noting that the United States loses more lives to traffic accidents each month than the total death toll from the terrorist attacks of September 11, 2001—more than 200,000 lives lost since the Transportation Efficiency Act for the 21st Century was enacted. The potential is enormous for the INFOstructure to improve safety by helping to improve the performance of the roadway system, vehicles, and drivers. The INFOstructure can help produce a better understanding of this performance through the gathering and analysis of relevant data, and it can proactively improve performance by providing better information to the people, organizations, and systems that manage the roadways and to the people, organizations, and systems that operate vehicles.

Many participants cautioned not to make the leap to specific technologies too quickly and emphasized the importance of expanding the view (a) to include other modes besides road travel and (b) beyond the United States to at least the North American Free Trade Alliance countries. It is nearly impossible to consistently and objectively rank priorities across the broad list of potential outcomes, and in many cases, benefits are not separable—they come in collections that affect multiple stakeholders.

It was also noted that getting too specific about quantifying benefits could be counterproductive. Good technology programs generate unanticipated benefits that are often more significant than those originally envisioned. The Interstate Highway System and the Space Program were cited as examples. Some participants complained that the transportation industry was unique in having so many assets that are so little understood and that make so little use of technology. The public does not understand how little we know or how valuable it would be to know more.

Some participants noted the importance of personalizing the benefits of the INFOstructure in order to gain public backing—how it can improve the individual's quality of life. Other participants recommended emphasizing the broad national issues, in part as a route to get Congressional backing.

WHAT INFORMATION IS NEEDED TO SUPPORT TRANSPORTATION ACTIVITIES? WHAT DATA ARE NEEDED TO PRODUCE THIS INFORMATION?

Some breakout groups dutifully provided lengthy lists of data elements relevant to various aspects of the INFOstructure, including data about the characteristics and state of the roadway, traffic, incidents, and road works; data about vehicles, routes, cargo, and drivers; and data about weather and the environment. However, many maintained that the consideration of low-level detail could be deferred until a later time. The more significant issues related to types of data, where it would come from, and how it would be handled.

Levels of Detail

The first observation was that data for immediate local use were different in important respects from data for later local use and from data for shared, archived, and historical use.

Large amounts of real-time detail were most germane to immediate local use: managing traffic, providing traveler information, responding to incidents/pavement problems/weather situations, and supporting in-vehicle driver assistance and safety. It was noted that "large amounts of detail" and "real-time need" could imply a high cost for information gathering and delivery. Very high-volume roadways (e.g., urban freeways) are likely to be well instrumented, with detectors included in fairly high-capacity communication networks. However, to provide guidance on travel alternatives to help relieve congestion and circumvent problems, real-time information is also required on adjoining arterial roads and streets.

Many participants felt that infrastructure-based detectors were not economical for arterial (and lower-level) coverage in cities and that the same economics would apply to nonurban roads and highways. In these areas, using vehicles such as traffic and road condition probes was viewed as more feasible. However, there are significant organizational and financial challenges in getting this technology developed and deployed and in making the connection among all data sources for consolidated analysis by either public or private services.

Local postanalysis and planning activities may still require large amounts of detail, but the time requirement is more relaxed. Individual facts can often be safely consolidated for this kind of analysis.

Generally, as the area for which data is being consolidated gets larger, the requirement for low-level detail and immediacy declines. Some participants suggested that the national sharing and aggregation of data might not require any additional communications infrastructure; the Internet will provide sufficient capacity to meet volume and time requirements. It was noted that potentially stringent security/privacy/integrity requirements need to be accommodated, and that coordination during emergencies may produce short-term demands for greater bandwidth, availability, security, and reliability than the Internet can readily provide.

Institutional Integration: Consistency of View

Participants observed that achieving consistency in the way data are gathered, aggregated, and distributed will be a major challenge, requiring an unprecedented level of institutional harmonization. Delivery of information to a mobile audience requires consistent mechanisms for access and delivery. Being able to make effective use of this information throughout the country requires consistency of view and meaning in the information delivered. This is true both for the real-time information delivered to travelers and the more consolidated information used for transportation analysis and planning. The need for data to be comparable and combinable, regardless of origin, was emphasized. It was noted that this is not an architectural issue as such, but it does require a national perspective, including the appropriate roles of the public and private sectors in achieving effective information gathering and delivery.

Funding: Operations and Maintenance

A recurrent concern was how the INFOstructure would be funded, and a particular recurrent concern related to its operation and maintenance. An endemic problem in ITS is securing and deploying resources to operate and maintain the ITS products and systems that have been deployed. This includes staffing and training concerns and is discussed at greater length in the Third Breakout Session Summary, page 17.

HOW CAN THE INFOSTRUCTURE HELP ADDRESS HOMELAND SECURITY?

Many participants viewed homeland security as the key application area that could justify and motivate the development of the INFOstructure, especially to stakeholders outside the immediate transportation family. Natural disasters over the past few years and the terrorist attacks of September 11, 2001, highlighted the critical nature of the transportation system in responding to and recovering from disasters as well as the potential for chaos that could result from serious disruptions of the transportation system.

Many of the approaches that are responsive to homeland security are also valuable in other contexts. Homeland security may require better integrated and more transparent information about the movement of freight, particularly hazardous materials, throughout the supply chain, including the ability to detect truck/railcar/container contents from the outside. Such advances, which are clearly part of an overall INFOstructure environment, would also be of great benefit to the economical and timely routine movement of freight, particularly across modes and across state and national borders.

Homeland security may require a higher level of communication and coordination among transportation agencies, other agencies, and private-sector organizations. Much of this coordination is data based—current situations, available resources, transportation alternatives, location of people and equipment, evacuation plans, etc.—and squarely relevant to the INFOstructure. Homeland security requirements may help to put INFOstructure data-gathering and data-moving capabilities in place more rapidly.

SECOND BREAKOUT SESSION SUMMARY

Making the INFOstructure Work

HOW SHOULD THE PERFORMANCE OF THE INFOSTRUCTURE BE DEFINED AND MEASURED? WHAT STANDARDS ARE NEEDED?

Much of the initial discussion surrounding the performance of the INFOstructure related to characterizing what the INFOstructure was (or rather, what it will be). It seemed clear that the INFOstructure implied the existence and processing of large quantities of information related to the roadway system, and that it would be a tool for a wide range of stakeholders from ordinary motorists to long-range regional planners. One group characterized the INFOstructure as a virtual information warehouse, with geographic information system–based support for decision making. The INFOstructure needs to include rules for information gathering, processing, and access.

It was noted that while one important objective for the INFOstructure was to help surface transportation work better, measuring the performance of the INFOstructure is different from measuring the performance of the transportation system. If the transportation system was performing badly and the INFOstructure reported this accurately and provided tools for addressing the problems, the INFOstructure would be performing well, even though the transportation system was not.

Measures of INFOstructure performance are needed. It was observed that data availability is more important than percentage of instrumented highways: outputs are what count, not inputs. Measures could include the following:

- Improvements in the transportation system attributable to the existence of the INFOstructure (reduced travel time and trip time variance, fewer and less severe crashes, environmental improvement, etc.) The ultimate measure is customer satisfaction. A variety of metrics is already available (e.g., federal mobility monitoring program, U.S. DOT Pavement Management System) for evaluating the performance of the roadway system. The question is the extent to which performance changes are attributable to the INFOstructure.
- Reduced operating costs for transportation agencies, streamlined operations, better emergency detection and response time.
- Improved access to data.
- Better interactions between the roadway system and other modes and domains.

The use of the INFOstructure to provide real-time information for immediate system performance monitoring and enhancement has different performance criteria than its use for postanalysis and data mining. Customer measures and system measures are both important.

Some participants suggested a process for defining and measuring INFOstructure performance:

- Identify key users, customers, and stakeholders (a start was made in the preceding breakout group session);
- Determine key needs, services, applications, etc., of the INFOstructure;
- Define desired outcomes, what to measure, and measurable objectives; and

- Look at the quality of information: ease of use, timeliness, user-friendliness, accuracy, validity, accessibility, appropriate to users' needs, etc.

Ensuring a high level of INFOstructure performance is an ongoing activity, including ongoing interaction with stakeholders, comparison of performance against objectives, and evolution of objectives and the INFOstructure. An important question is: Who should do this?

Standards are clearly crucial to making the INFOstructure nationally useful. The most important area to get agreement on is the data to be collected for various purposes: items, format, accuracy, breadth, and timeliness. A data dictionary or similar support tool to define the data to be collected, stored, and processed would be very helpful. Rules need to be defined on processing the data, so that results are nationally consistent and comparable. Rules are needed on how long data will be retained and in what form, as are privacy safeguards, intellectual property safeguards, etc.

HOW SHOULD INFORMATION FROM THE INFOSTRUCTURE BE MADE AVAILABLE? WHAT NEEDS TO BE NATIONALLY UNIFORM?

It was noted that a large amount of information is already available, although not always in readily accessible form. Besides producing large quantities of new information, the INFOstructure provide an opportunity to organize the information that already is being produced.

The local-regional vs. national distinction and the real-time versus historical distinction reappeared. Making local, real-time travel information available to roadway managers and users (and to managers and users of other modes) clearly requires different tools and processes than local medium- and long-range planning and national aggregation and analysis. While real-time (or at least fairly current) traffic information about a remote city might be of interest to someone arriving from out-of-town that day, this was not regarded as a mainstream issue, especially since better local real-time information would be available when the traveler arrived.

Local use for planning requires data aggregation and storage. While the immediate local planning application does not demand consistency with other areas, this is probably the same data that will be shared with others for national planning and analysis for which consistency is clearly crucial. In addition, a consistent approach for gathering and processing local data for analysis creates a market for consistent, nationally applicable software tools, whose quality and cost could be significantly better than a proliferation of one-off tools. An important tactical question is whether a physically aggregated database has any advantages over separate smaller databases that are developed using consistent rules.

National uses include contributing to homeland security, movement of hazardous materials, border crossing security, severe widespread weather events, and general crisis management. An analogy was drawn to the work done by the Centers for Disease Control and Prevention in recognizing patterns and in tracking and containing outbreaks of disease. An analogy was also drawn to the nationally consistent data gathering and presentation done by the National Weather Service. Lessons also can be learned from private-sector transportation organizations with national information operations, like FedEx and UPS. The suggestion was made that a program like the one that resulted in the National ITS Architecture and the more recent regional architectures could be established to create a framework for INFOstructure data collection, management, analysis, and distribution.

There was considerable discomfort in translating the need for national INFOstructure consistency into a single centralized database of INFOstructure information. Concerns included who would control it, who would pay for it, and what would happen if it failed. The preferred alternative appeared to be a national data distribution system that could make local data available to authorized/interested parties. It is not yet clear who would own or operate such a data distribution system, but potentially a public–private cooperation would be appropriate. Liability, intellectual property, and cost were among the issues. Use of the World Wide Web as a distribution medium could be explored. Some participants suggested that incentives be offered to data sources to help populate the INFOstructure. The reasoning was that many local data sources will not be the organizations interested in national perspectives or analysis, and their contribution needs to be motivated and encouraged. In addition, much information is not presently being collected because infrastructure-based surveillance technology is not good enough or inexpensive enough to justify widespread deployment.

The subject of standards reappeared, including national standards regarding what data are collected, how they are aggregated, and how they are processed. Concerns were also expressed that necessary standards not have the effect of stifling creative uses of INFOstructure data.

WHAT ARE THE INFORMATION AND DATA SECURITY CONCERNS?

A global concern is that information about the transportation system is a cornerstone of other national applications, including homeland security applications. If the INFOstructure gets hacked into, the transportation system and many other information intensive operations could be put at risk. Such hacking could include both improper use of INFOstructure data and the introduction of spurious data into the INFOstructure. The risk is probably greater as it relates to local/real-time data. Multiple "concentric rings" of security may be needed to apply appropriate safeguards to information with varying levels of security requirements. Responsibility for setting and enforcing security standards needs to be established.

Data privacy was also regarded as a major issue, especially for consumers. The public is wary of any large-scale data collection activity by the government. Privacy safeguards need to be put in place, and confidence needs to be built in their effectiveness. Legislative and technical safeguards are both needed.

THIRD BREAKOUT SESSION SUMMARY

Getting to the INFOstructure

The primary focus of the third breakout session was challenges to be addressed and obstacles to be overcome if the INFOstructure is to succeed. The first challenge is getting a handle on what the INFOstructure actually is. On the one hand, many felt that restricting consideration to road issues is too narrow and that all modes needed to be considered. On the other hand, there was concern that dealing with a very large abstract concept all at once risked getting anything done. High-quality, well-packaged, bite-sized pieces will appeal more to the customers. The INFOstructure needs to be "sold" to the public and to lawmakers, and it needs to be embraced by private industry (especially vehicle manufacturers and first-tier suppliers) and public agencies. This has not yet occurred. For it to happen, the INFOstructure must be comprehensible, and it must be appealing. Benefits must be clearly identified. A "killer app" would really help.

As with other areas of ITS, a convergence of industry and public-sector efforts is viewed as both vital and very difficult. The respective roles of the public and private sectors will undoubtedly emerge and evolve, but at present they are not well understood, which could slow forward progress. Many felt that national cooperation of interests, potentially led by ITS America and including at least vehicle manufacturers (possibly via the Alliance of Automobile Manufacturers or the Automotive Multimedia Interface–Collaboration), commercial shippers and carriers, AASHTO, AAA, U.S. DOT, transit interests, and others, is needed to create the necessary vision.

Funding is clearly a challenge, but if the INFOstructure can capture people's imagination in the way that the Space Program and even the Interstate Highway System did, funding will follow.

Some past investments in ITS and roadway information systems have not paid off well and have suffered from lack of accountability. The INFOstructure effort must not suffer from these defects. A powerful political champion would clearly provide needed leverage.

The concern was also expressed that the INFOstructure could be perceived as a potential competitive threat by traditional highway interests, notably the highway construction industry. Framing the INFOstructure so that everyone wins may be both difficult and necessary.

WHAT ARE THE PRIVACY, SECURITY, AND LIABILITY CONSIDERATIONS OF THE INFOSTRUCTURE?

Especially if private vehicles are needed to work as probes to gather data about traffic, weather, and road conditions, privacy is a critical issue. Probe data gathering needs to be anonymous in a way that does not depend on a company or agency simply choosing to ignore identifying information, since such choices can be reversed. Anonymity must be assured. Even so, the ability for drivers/vehicles to opt out from serving as probes must be available. Video surveillance presents additional privacy concerns that have to be addressed through rules on what can be captured and how it is used and saved.

Some participants stated that the private sector is perceived as a more reliable protector of data privacy than government agencies. People may be willing to give up some amount of privacy in return for clear value. The use of credit cards was cited as an example. They create an information trail of locations and purchases, but most people believe that enough value is delivered to make up for this. People who do not believe this have available alternatives (e.g., cash) that allow them to forgo using credit cards.

Information about users of the transportation system is more problematic. Providing information about a vehicle's and driver's location and speed to a central collection point is not intrinsic to driving in the same way that using a credit card is intrinsic to making a purchase. The fact that transportation data gathering is a side effect of travel raises the privacy bar. In addition, the prospect of large-scale data aggregation and analysis implies the ability to correlate formerly scattered facts about a person. Aggregations need to be made anonymous, or other protections have to be provided to prevent INFOstructure-enabled nosiness.

The ITS America Privacy Principles were cited as a good starting point and a valuable foundation for INFOstructure privacy considerations.

Security was regarded as a two-way street. On the one hand, the INFOstructure, properly used, can help ensure security for the transportation system and its users. However, improper use of the INFOstructure and its contents could be used to mount attacks on the transportation system and to use the transportation system as part of an attack. Once the INFOstructure becomes operational, a large number of stakeholders will come to depend on its availability. Steps to ensure a very high degree of availability, reliability, etc. were regarded by many as essential.

Liability was viewed by many as being more of a perceived problem than an actual one, sometimes an excuse for organizations not to do something. Nonetheless, there are a variety of steps that can reduce both the perception and reality of liability. These include standards, codes of practice, and careful decisions in advance on how data will be used. The issue was also raised of potential liability arising from *not* deploying available technology that is known to enhance safety and economy.

WHAT ARE THE IMPLICATIONS OF THE INFOSTRUCTURE REGARDING THE NATIONAL ITS ARCHITECTURE?

It was suggested that a great virtue of the National ITS Architecture is that it helps to break institutional barriers by illustrating the need for cooperation and the benefits that can result. The existence of the National ITS Architecture also provides a useful precedent for pursuing national ITS perspectives in a cooperative manner. In addition, the Architecture may help to identify and quantify the data needs of some stakeholders. At least selectively, the Architecture may also help to pinpoint the additional interface and data standards that are needed to make the INFOstructure functional and useful. The Archived Data user service may offer some helpful insights into parts of the INFOstructure.

However, it was pointed out that the INFOstructure and the Architecture are not the same kind of entity. The Architecture is a logical framework of interconnecting systems. The INFOstructure is an operational entity, a network of networks, and a platform (or foundation) on which to build information applications. The evolution of the INFOstructure may require a corresponding evolution in the National ITS Architecture to reflect new ways of gathering, processing, and disseminating data and to accommodate activities related to homeland security.

WHAT ARE THE DATA COLLECTION AND OWNERSHIP ISSUES: INFRASTRUCTURE VERSUS VEHICLE, PUBLIC VERSUS PRIVATE?

As previously observed, the respective roles of the public and private sectors are not currently well understood. Many felt that, in the United States, it is not practical or realistic to depend exclusively on infrastructure instrumentation to gather information about the state and use of the roads.[4] While infrastructure-based sensors will always be useful and often cost-effective in major central business districts and near particularly sensitive facilities, there is a clear need to look to other data gathering mechanisms as well, notably the use of vehicles as probes. This raises a large number of questions regarding the general public's willingness to participate in providing probe data and the mechanisms that would be used to collect and aggregate these data. It particularly raises the issue of the willingness of public- and private-sector interests to cooperate and collaborate in this data collection and analysis effort. Privacy, ownership, funding, and use are all concerns. However, given the opinion expressed by many that infrastructure-only approaches do not work, resolving public–private cooperation issues to include vehicle-based data gathering is a fundamental prerequisite for realizing the INFOstructure.

The National ITS Program Plan, in discussing the INTI of which the Roadway INFOstructure is a major component, observes:

> Realizing this vision depends critically on forging new forms of cooperation within and between the public sector at all levels and the private sector in its broadest sense, including manufacturers, carriers, service providers and travelers in all modes. A primary purpose of this cooperation is to share, leverage and use information to make surface transportation safer, more efficient and universally available.[5]

This cooperation remains a major challenge and a clear necessity.

If such a cooperation can be achieved, then the second-tier issues relate to: understanding data requirements, data quality standards, data auditing to assure standards are met, assigning particular responsibilities for various parts of the information value chain, developing incentives for contributing to the data collection process, etc.

WHAT POLICY CHANGES ARE NEEDED FOR THE INFOSTRUCTURE TO SUCCEED?

Many felt that a national approach was needed for developing the INFOstructure.

Some participants argued for a minimum of specific INFOstructure policy, suggesting that too much policy too soon could restrict the vision and actually inhibit the INFOstructure.

Other participants suggested the need for policy to

- Establish a national program for data collection;
- Ensure data accuracy and reliability (possibly recognizing and codifying relevant standards in federal regulations);
- Encourage or require information sharing;
- Foster cooperation among federal agencies (e.g., U.S. DOT, the Department of Homeland Security, and the Office of the Federal Coordinator for Meteorology);

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[4] This contrasts, for example, with Japan, where roadway sensors for monitoring traffic are widely deployed. National government responsibility for the roads, denser populations, and less rural highway mileage present a different scenario than in the U.S. Even in Japan, however, authorities are finding that many kinds of road-related data they are interested in (e.g., pavement conditions) are not readily collectible via the existing sensor base.

[5] ITS America, *National ITS Program Plan: A Ten-Year Vision*, January 2002, p. 39.

- Foster cooperation between the public and private sectors (e.g., with the automobile industry and the communications industry);
- Encourage international cooperation in INFOstructure, at least among NAFTA countries;
- Support private access to the right-of-way for data collection;
- Reinforce a commitment to operations as well as capital construction; and
- Help fund INFOstructure development.

WHERE WILL LEADERSHIP COME FROM? WHO WILL BE THE INFOSTRUCTURE CHAMPIONS?

Leadership needs to come from both the national and local arenas. For the INFOstructure to succeed, it needs to be grass-roots driven. At the same time, the need for national consistency requires a national perspective. As suggested in the National ITS Program Plan, a Congressional mandate may be the right initial combination of local/national direction and support. The House ITS Caucus was viewed by some as a potentially valuable base for moving the INFOstructure forward. Leadership from U.S. DOT and ITS America is crucial for maintaining focus and assembling stakeholders. AASHTO involvement and leadership are equally important. It could be valuable to find a key person of national stature (similar to Tom Ridge in Homeland Security) to serve as a rallying point.

SPECIAL PRESENTATION SUMMARY

Vehicle–Infrastructure Cooperation

The special workshop dinner on the evening of August 22, included an address by **Michael Noblett,** Program Manager, Advanced Technology at OnStar.[6] Noblett is also Chair of ITS America's Automotive, Telecommunications, and Consumer Electronics Forum. Noblett was introduced by **Neil Schuster,** President of ITS America.

Noblett's presentation centered on a vision of vehicle/infrastructure cooperation, providing information about the road network and its interaction with vehicles that could help to dramatically reduce crashes, injuries, and fatalities. Noblett identified three enabling technologies for this vision: extremely accurate digital maps of the roadway system, equally accurate vehicle positioning technology, and cheap, ubiquitous wireless communications. He advocated a two-way communication system that had some parallels to the Automated Highway System experiments of the middle 1990s.

[6] Noblett has since become affiliated with SEI Information Technology, Chicago.

CLOSING PLENARY SESSION SUMMARY

Reflections and Directions

The Closing Plenary Session, led by Committee Chair Richard Weiland, was intended as a wrap-up of the previous two days and an identification of useful next steps.

The session began with a presentation by **Gary Euler**, Director, Business Development of PB Farradyne, Inc., on "A Security-Oriented INFOstructure for Emergency Management." The presentation focused on the interdependence of traffic management and emergency management, particularly in the face of a critical incident or attack.

The discussion which followed focused on:

- What is the INFOstructure?
- Why should it be done?
- What comes first? What comes next?

WHAT IS THE INFOSTRUCTURE?

A considerable portion of the discussion surrounded developing an acceptable working definition of the INFOstructure that could be taken back to various constituencies. An unresolved issue was whether to expand the INFOstructure to encompass all of surface transportation, or to focus first on roadway issues. The following definition of the roadway version of the INFOstructure was presented:

> A coordinated collection of systems on a national scale that consistently collects, integrates, and stores real-time and historical information about the structure, state, usage, and performance of the roadway system and its related facilities and that enables making this information readily available to applications that serve managers and users of the roadway system.

The broader definition replaced both appearances of "roadway system" with "surface transportation system." There was considerable discussion about the extent to which the INFOstructure should include information delivery mechanisms. The original proposed definition had, in place of the last two lines of the definition above: "... and make this information available to operators and users of the roadway system through a variety of channels." Many felt, however, that providing access to INFOstructure data was both sufficient and more desirable, since it would encourage the development of a variety of innovative mechanisms for extracting and presenting INFOstructure data.

WHY SHOULD THE INFOSTRUCTURE BE DONE?

A great deal of discussion over the two previous days was distilled into a relatively short list of reasons for pursuing the INFOstructure:

- Safety,
- Security,
- Efficiency,
- Mobility,

- Environment,
- Economic competitiveness, and
- Quality of life.

Although not by design, these correspond very well on the whole with the goals for ITS identified in the National ITS Program Plan.

WHAT COMES FIRST? WHAT COMES NEXT?

A number of candidates for initial focus were presented:

- **Really good traffic information** has often been identified as the "killer app" for ITS, although there has been very little success in producing traffic information that is much better than morning radio reports. Traffic information provision that is both broad and deep, including the identification of alternatives to congested routes, needs to be operated locally, but in a manner that is nationally consistent. This kind of information is critical for doing good traffic management and for enabling dynamic route guidance. It requires both instrumented roadways and the collection of vehicle probe data. Consequently, it has many desirable characteristics for an initial effort. The primary downside is that it is mainly an urban application and may not capture the interest of a broad enough cross section of the population or of the politicians.
- **Surveillance** of roads and facilities for problems, of commercial vehicle operations for conformance to "flight plans" and for hazmat tracking, and of transit operations for purposes of security and route or schedule conformance was a second candidate starting point with the appeal of being commercially valuable and having homeland security characteristics.
- A specific focus on **homeland security** was also suggested as a jumping-off point. Besides the intrinsic value of improved homeland security, this area was recognized as one that has a high profile with both politicians and the general public and that therefore might receive funding more readily than other approaches.

Some participants argued against picking a focus – that the right approach was tackling the whole subject matter of the INFOstructure, although possibly in a layered manner. Layers might start with the National Highway System plus major transit facilities, or by working to integrate vehicles and the infrastructure.

A suggested alternate approach was to start from a future vision in which we know everything about the roads, and think about the implications of this knowledge for homeland security, traffic forecasting, etc. The knowledge could be transformed into a "national conditions map" with information on traffic flow, events and incidents, weather, etc. If this vision can be made sufficiently appealing, it could serve as the basis for political and popular support.

It was reiterated that making the INFOstructure happen requires marshalling a national commitment to cooperate, participate, contribute, and share in the benefits of the INFOstructure.

Many participants supported the preliminary program outlined in the National ITS Program Plan to

- Document INFOstructure scope and characteristics at a "thorough outline" level,
- Conduct a preliminary cost–benefit analysis, and
- Secure buy-in from principal stakeholders.

Many participants supported the convening of a national summit under the auspices of ITS America, similar to the summit which provided shape and support for the National ITS Program Plan. The objective would be to seek buy-in and to lay the groundwork for a Congressional mandate, or an equivalent national determination, to proceed.

Weiland expressed thanks to the workshop sponsors, the task force that organized the workshop, the workshop speakers, breakout leaders and recorders, and participants. Acknowledgments appear, with the thanks of the ITS Committee, in Appendix C.

APPENDIX A

Workshop Agenda

DAY ONE

Opening Plenary	The Roadway INFOstructure (What? How? Why?)	1:00 pm – 2:30 pm
Welcome	Richard Weiland, Weiland Consulting Co., Chair, TRB ITS Committee	
Speaker 1	Michael Freitas, U.S. DOT ITS Joint Program Office	
Speaker 2	Matthew A. Coogan, Consultant in Transportation	
Speaker 3	Pravin Varaiya, Department of Electrical Engineering and Computer Science, University of California at Berkeley	
Speaker 4	Philip J. Tarnoff, P.E., Director, Center of Advanced Transportation Technology, University of Maryland	
	Break	2:30 pm – 2:45 pm
Breakout 1	Addressing ITS Data Needs through the INFOstructure Preparation of Breakout Session Presentation Recess for the Day	2:45 pm – 5:30 pm

DAY TWO

Breakfast	Beckman Center	7:00 am – 8:00 am
Plenary	Report on Breakout 1	8:15 am – 9:00 am
	Break	9:00 am – 9:15 am
Breakout 2	Making the INFOstructure Work Preparation of Breakout Session Presentation	9:15 am – noon
Lunch	Beckman Center	noon – 1:00 pm
Plenary	Reports on Breakout 2	1:00 pm – 2:00 pm
	Break	2:00 pm – 2:15 pm
Breakout 3	Getting to the INFOstructure Preparation of Breakout Session Presentation	2:15 pm – 5:00 pm
	Recess for the Day	
Reception & Dinner Speaker	Michael Noblett, Manager Advanced Technology, OnStar, and Chair, ITS America's Automotive, Telecommunications and Consumer Electronics Forum	6:30 pm – 8:30 pm

DAY THREE

Breakfast	Beckman Center	7:00 am – 8:00 am
Closing Plenary	Report on Breakout 3	8:15 am – 9:15 am
Presentation	Gary Euler, PB Farradyne, Inc., “An AASHTO Security-Oriented INFOstructure for Emergency Management”	9:15 am – 9:45 am
	Break	9:45 am – 10:00 am
Conclusion	Reflections and Directions	10:00 am – noon
	Adjourn	

APPENDIX B

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APPENDIX C

Acknowledgments

The Committee on Intelligent Transportation Systems gratefully acknowledges the people who generously gave of their time and talents to make this workshop a success.

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