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THE DEPLOYMENT EFFORTS FOR INTELLIGENT INFRASTRUCTURE AND IMPLICATIONS AND OBSTACLES

: Focusing on Metropolitan Intelligent Transportation Systems Infrastructure

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Introduction and Background

Emerging new information and transportation technologies in data processing, communications, and vehicle control and navigation are often expected to become a promising underpinning in tackling the chronic transportation problems. Yet, at least so far, intelligent infrastructure and vehicle technologies have not been able to fully satisfy the nation's mounting transportation needs for congestion and safety. It is in part due to ineffective integration of intelligent transportation technologies in the metropolitan and rural areas. Such difficulties range from the issues of technical capability and system design to a variety of social and institutional challenges. However, if the technologies are successfully deployed to address the existing challenges, it may well be possible for intelligent transportation systems (ITS) to provide substantial improvements in people's safety, mobility, and accessibility.

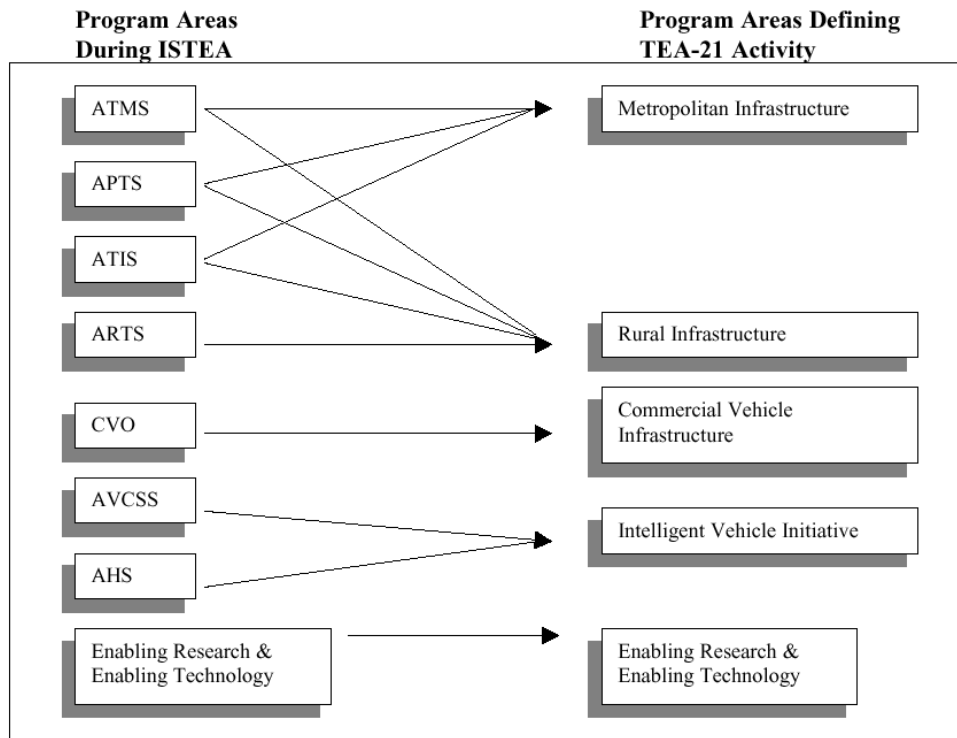
During the period of the Intermodal Surface Transportation Efficiency Act (ISTEA), the Congress provided the intelligent transportation systems (ITS) program with \$1.3 billion for research and development (R&D), operational tests of the technologies, and various activities for deployment.¹ New technologies and applications were explored by the research and development efforts, and operational tests were carried out to link these efforts to deployment. In addition, the federal and the state agencies endeavored to develop an ITS architecture and a series of early deployment plans to build an integrated ITS environment.

Since the Transportation Equity Act for the 21st Century (TEA-21) of 1998, the U.S. Department of Transportation realigned the national ITS program to actively encourage national deployment and integration of ITS technologies. The program has been

¹ *A Report to Congressional Committees: Challenges to Widespread Deployment of Intelligent Transportation Systems*. Report No. GAO/RCED-97-74. U.S. GAO. February 1997. pg.3.

reoriented from eight technical areas during the ISTEA period to three newly integrated areas: metropolitan, rural, and commercial vehicle (Figure 1). This restructuring is driven by U.S. DOT's ambitious hope for fostering both deployment of intelligent infrastructure and evaluation of intelligent vehicle technology.

(Figure 1) ITS Program Reorientation



(Source: *Intelligent Transportation Systems Projects Book*. U.S. Department of Transportation, Intelligent Transportation System Joint Program Office. 1999. pg.3.)

ATMS: Advanced Traffic Management Systems, APTS: Advanced Public Transportation Systems, ATIS: Advanced Traveler Information Systems, ARTS: Advanced Rural Transportation Systems, CVO: Commercial Vehicle Operations, AVCSS: Advanced Vehicle Control and Safety Systems, AHS: Automated Highway Systems

Metropolitan Infrastructure integrates various components of Advanced Traffic Management Systems (ATMS), Advanced Public Transportation Systems (APTS) and Advanced Traveler Information Systems (ATIS) in order to achieve improved efficiency and safety and to provide enhanced information and travel options for the public. Rural Infrastructure accommodates the previous endeavors of Advanced Rural Transportation System (ARTS), which use technologies under Metropolitan and Commercial Vehicle Infrastructure to satisfy rural community needs. The Commercial Vehicle ITS infrastructure continues to use the research of the Commercial Vehicle Operations (CVO) Program as its foundation, and aims to integrate technology applications in improving commercial vehicle safety, enhancing efficiency, and facilitating regulatory process for the trucking industry and government agencies. The national ITS program will focus on facilitating integrated deployment of ITS components of the above-mentioned three categories in near term horizon. Intelligent Vehicle Initiative (IVI) consolidates the in-

vehicle components focusing on applying driver assistance and vehicle control systems to reduce vehicle crashes in the long-term scope. Much effort is made in merging effective vehicle operation and information processing.

This paper discusses the current status of the national intelligent infrastructure deployment, with a particular focus on the efforts in the metropolitan areas. The reorientation of the federal ITS program requires public agencies have a different role and work style in managing the integrated infrastructure system, whereas in the past they merely dealt with isolated ITS user services. This request is primarily caused because public authorities should work on the sharing of resources, the sharing of information, and the coordination with other jurisdictional areas. This is closely related to the current obstacles facing successful deployment and integration of metropolitan ITS infrastructure that will be discussed later in the paper.

Metropolitan Intelligent Transportation Infrastructure

Metropolitan ITS infrastructure is the combination of various components of advanced traffic management, public transportation, and traveler information systems. The infrastructure is anticipated to allow a metropolitan area's multimodal transportation systems to operate in a coordinated manner, providing travelers with timely and reliable information on trip and en-route alternatives. It can also facilitate information access across agency and organizational lines. Therefore, in principle, this integration of technologies can considerably improve individual functions and generate a set of public and private services that can build a basis for the evolution of the long-term goal of ITS.²

Metropolitan infrastructure consists of nine major components³ are described briefly in the following, although the specific technical features are not fully discussed in this paper.

Traffic Signal Control provides coordinated traffic signal control to optimize traffic flow across the metropolitan area. Traffic information is shared as necessary between jurisdictional systems to support the extended coordination area. Variation in control sophistication range from automated generation of timing plans to adaptive traffic signal control.

Freeway management monitors traffic conditions and traffic flow hindrances, employs appropriate traffic control and management approaches such as ramp metering and lane control, and presents information to travelers using dissemination methods such as Variable Message Signs (VMS) and Highway Advisory Radios (HAR).

² *Intelligent Transportation Systems Projects Book*. U.S. DOT, Intelligent Transportation Systems Joint Program Office. pg.9~14.

³ *Tracking the Deployment of the Integrated Metropolitan Intelligent Transportation Systems Infrastructure in the USA*. U.S. DOT, Prepared for ITS Joint Program Office and Federal Highway Administration. Washington, DC. September 1998. pg.1-2~1-3.

Transit Management monitors and maintains transit fleets and provides reliable and timely information to increase the operational efficiencies through advanced vehicle locating devices, equipment monitoring system, and fleet management systems. In addition, on-board sensors automatically monitors other relevant data such as passenger loading, fare collection, drive-line operating condition, etc., providing real-time management response.

Incident Management is an organized system that enables authorities to identify and respond to incidents or vehicle breakdowns with the most appropriate and timely emergency services. By aiding accident victims promptly and facilitating rapid clearance of the accident from the roadway, it minimizes recovery times and also probable damages. It is thus crucial to have real-time input from the freeway and arterial surveillance systems and agencies responsible for managing them.

Emergency Response supports coordination of emergency services across jurisdictional boundaries and makes emergency fleet management more efficient through application of Automatic Vehicle Location (AVL) and dispatch-support system.

Electronic Toll Collection provides motorists and transportation agencies with convenient automated transactions so that the operation of toll collection can be more efficient, thereby improving traffic flow at toll plazas. A series of road-side and in-vehicle hardware and software perform automated vehicle identification, determination of tolls for differing classes of vehicles, enforcement of violations, and flexibility in financial arrangement.

Electronic Fare Payment enables drivers to pay for transit fares, parking fees as well as tolls, by using a single smart card. Technologies for roadside, in-vehicle, and in-station electronic payment eliminate the need for travelers to have exact fare amounts.

Advanced Rail-Highway Intersections coordinate traffic signal operations and train movements, and inform drivers of approaching trains through in-vehicle warning systems.

Regional Multimodal Traveler Information works as a repository for current, comprehensive roadway and transit performance data. It receives and combines data from a variety of public or private sources, and provides road and transit information to travelers, businesses, and truckers to enhance the effectiveness of trip planning and en-route alternatives.

The technologies utilized for metropolitan infrastructure progressed substantially during the ISTEA period with the purpose of addressing the transportation problems of metropolitan areas: safety, congestion, and mobility. U.S. DOT's report⁴ on deployment tracking shows that many places throughout the U.S. have deployed at least more than one components of metropolitan infrastructure. Many state and local agencies made an effort to expand their capability of traffic management by developing fully integrated,

⁴ *ibid.*

dynamically adaptive, and regionally-covered traffic control systems and strategies. They eventually seek to achieve real-time control capabilities which are adaptive to traffic movement for more efficient and reliable service.

Predicated on the legacy of ISTEA, the future metropolitan ITS infrastructure is directed toward integrating this traffic management systems with advanced traveler information systems and public transportation systems. The traveler information systems enable individual and public agency to make informed choices, by expanding up-to-date information for both "pre-trip" and "en-route" travelers. Therefore, the metropolitan infrastructure potentially increases vehicle occupancy, and reduces traffic demand. The advanced public transportation system applications have been also developed to support three components of the metropolitan infrastructure: Transit Management, Electronic Payment and Regional Multimodal Traveler Information. They will improve the operations and productivity of transit agencies and the safety and convenience of their passengers, further encouraging the use of public transportation.

The Past and Current Deployment Efforts

Metropolitan model deployment initiative

The metropolitan Model Deployment Initiative Program is a current project that supports metropolitan area deployment goals. In order to become deployment showcases of fully integrated metropolitan intelligent infrastructure, four site have been selected: (1) New York-New Jersey-Connecticut (Transcom) ITS infrastructure Deployment (2) Phoenix, Arizona Aztech Deployment (3) San Antonio, Texas Tranguide Metropolitan Deployment (4) Seattle, Washington Smart Trek Deployment. These projects are intended to demonstrate the benefits of integrated transportation management systems featuring effective, regional, multimodal traveler information services. The sites are anticipated to provide improved transportation management and high quality services to the public, business, and commercial carriers by integrating the conventional traffic signal control components; transit, freeway, and incident management; emergency services management; regional, multimodal traveler information services; and electronic toll and fare payment. The projects also will conduct scrupulous evaluations of the benefits that integrated metropolitan infrastructure systems can provide.⁵

Houston, Texas: TranStar

Due to extensively scattered employment, shopping, and housing, Houston is vastly dependent on its freeway networks for their people's travel and traffic jams are not unusual conditions in Huston. Houston suffers from an average of 200 major and 4,000

⁵ *Intelligent Transportation Systems Projects Book*. U.S. DOT, Intelligent Transportation Systems Joint Program Office. pg.13.

minor road blockage a year. And, because of the stop-and-start traffic and the idling of engines, the region also has serious air pollution problem.⁶

Funded partly by Congestion Mitigation and Air Quality Improvement (CMAQ) Program, under ISTEA, Houston launched \$11.4 million TranStar project, which is responsible for the planning, operation, and maintenance of transportation operations and emergency management operations in the area. It integrated a freeway management system, incident and emergency management program, and a traffic signal control system. The system monitors traffic conditions on a real-time basis, decreasing the time between the occurrence of incidents and their detection and clearance.

The project reduced the average time responding to accidents by approximately 5 minutes, from 15 to 10 minutes.⁷ Total annual delay saving is estimated about \$ 8.4 million a year. Integrating high-occupancy-vehicle (HOV) lanes with other Intelligent Transportation Systems has been evaluated to help reduce congestion, especially during incident conditions. Ramp metering were estimated travel time savings of 2,875 vehicle-hours per day, or \$37,030 a day.⁸ Recently, the new Web Site is integrated into the regional ITS, compiling data on road projects from various public sources. It will allow commuters to check their routes in advance and support construction crews to coordinate their projects.⁹

Houston TranStar is a partnership between the city of Houston, Harris County, the Metropolitan Transit Authority, and the Texas Department of Transportation. A study evaluates that Houston TranStar is a leading example of the regional coordination and partnerships that should be promoted.¹⁰ The stakeholders have combined the resources and expertise of each agency, to share a common vision in accomplishing the successful integration of ITS infrastructure. The benefits of TranStar have come mainly from the partnership's performance that can overcome institutional barriers and work together to mobilize technology as a partial solution of regional transportation problem.¹¹

Implications and Obstacles

Implications of Deployment

The previous discussion reflects the fact that the success of metropolitan infrastructure system cannot be completely achieved by implementing only a single component of ITS.

⁶ Hoffman, Cheryl, Lawrence Paulson. "Keep the Good Times Rolling: ISTEA Success Stories" *Public Roads On-Line*. Winter 1997. <http://www.tfsrc.gov/pubrds/winter97/p97wi17.htm>

⁷ *ibid.*

⁸ Proper Allen. *T. Intelligent Transportation Systems Benefits: 1999 Update*. Report No. FHWA-OP-99-012. Prepared by Mitretek Systems Inc. May 1999. pg.49.

⁹ Colley, Jenna. "Trouble With Traffic". *Houston Business Journal*. February, 26, 2001. <http://houston.bcentral.com/houston/stories/2001/02/26/story2.html>

¹⁰ Hoffman, Cheryl, Lawrence Paulson. "Keep the Good Times Rolling: ISTEA Success Stories" *Public Roads On-Line*. Winter 1997. <http://www.tfsrc.gov/pubrds/winter97/p97wi17.htm>

¹¹ *ibid.*

Rather, it depends strongly on the degree of integration of traffic management systems, advanced transportation systems and traveler information systems. It is so because the ITS deployment in urban areas is an collective program consisting of a variety of complementary projects such as traffic control, freeway management, incident management, transit management and traveler information. It also combines different kinds of analysis, control and communication technologies. In many cases, the intelligent infrastructure deployment projects cut across more than one technology components in order to maximize its benefits while minimizing costs. In addition, these metropolitan systems are by and large designed for multiple mode including both roadway and transit system. For example, traffic signal control system in a certain area will also have linkages to transit fleet management in term of sharing information and resources.

Consequently, the metropolitan infrastructure systems will need multiple jurisdictions to manage their system in a more coordinated way and to work closely together for implementing various management actions more effectively. In other words, the potential for maximizing benefits of intermodal management and delivery of ITS services lies not just in successful technical integration but also in inter-jurisdictional incorporation of these elements.¹²

These integrations are accomplished by creating diverse links between ITS program areas and services, and public and private agencies working on the infrastructure deployment. These links can allow more efficient sharing of infrastructure between ITS services. In this kind of integrated environment, traffic information will be shared among jurisdictions as well as with transit agencies, travelers, business, and commercial carriers. Eventually, the integrated metropolitan ITS infrastructure systems can be deployed in stages that tie together isolated services, and therefore, they not only share resources and information but also coordinate control between different ITS user services throughout different geographic and political boundaries.

Obstacles

Achieving this vision will require successful resolution of several other key institutional problems, however.

It has been indicated that ITS deployment has not previously occurred in an integrated manner. A study shows that, despite the previous deployment efforts, urban areas have not integrated the individual ITS components and there are only few examples of a fully integrated ITS.¹³ More seriously, the efforts for inter-governmental cooperation are too feeble to work on deployment among different jurisdictions and departments. Another study illustrates that transportation agencies were implementing ITS to improve the

¹² *Intelligent Transportation Systems Projects Book*. U.S. DOT, Intelligent Transportation Systems Joint Program Office. pg.9.

¹³ *The National Intelligent Transportation Program (draft)*. U.S. DOT, Intelligent Transportation Systems Joint Program Office. A Report to Congress. January 1997.

efficiency of their agencies but were not integrating these technologies with other transportation agencies.¹⁴

Since individual users and private manufacturers can also pay for a substantial portion of the ITS deployment cost and contribute to success of deployment, the creation of viable public-private partnership in ITS deployment is obviously highly valuable. For example, a key feature of many regional travel information projects is the enthusiastic participation of private sector companies interested in marketing traveler information.¹⁵ (U.S. DOT. ITS Joint Program Office. 2000. *Intelligent Transportation Systems Projects Book*). However, as shown in the case of National Automated Highway Systems Research Consortium, partnerships can sometimes be ineffective, inflexible and vulnerable to pursuing stakeholders' own interests.¹⁶ Acceptance by consumers in the market is crucial in the fate of ITS user services. Yet, efforts have not been sufficiently made to evaluate the user acceptance of the technologies. It is partially due to the fact that most suppliers of these technologies are public officials who tend to have less understanding on the market mechanism and knowledge on marketing issues; consequently, many of them have been unaware of this issue until recently.¹⁷

Yet another concern about the lack of knowledge and awareness on ITS has arisen in the state and local level.¹⁸ Most public officials being in charge of transportation do not have technical knowledge and skills required for operating and maintaining the information and computing technologies. Perhaps it is thus not surprising that they do not currently have clear understanding of what ITS deployment is, how it works and what the benefits are. A U.S. DOT's report¹⁹ addresses the staffing and educational needs of transportation agencies as one of the most urgent and critical problems facing the ITS Program. Furthermore, a lack of awareness about ITS among politicians and agency managers is identified as barriers to successful intelligent infrastructure deployment at the local level. In many cases, elected officials do not consider ITS deployment as an absolute priority, and few of them foresee any potential benefits of devoting more time and capital on ITS.²⁰

Little concern has been raised on the lack of analysis to measure the cost and benefits of

¹⁴ *Intelligent Transportation Systems: Assessment of ITS Deployment*. U.S. DOT. Research and Special Programs Administration-Volpe National Transportation Center. July 1996.

¹⁵ *Intelligent Transportation Systems Projects Book*. U.S. DOT, Intelligent Transportation Systems Joint Program Office. pg.11.

¹⁶ Transportation Research Board National Research Council. *National Automated Highway Systems Research Program, A Review*, TRB Special Report 253. National Academy Press, Washington, DC. 1998.

¹⁷ *Commercializing Infrastructure Technologies: A Handbook for Innovators*. Civil Engineering Research Foundation. 1997. www.iti.northwestern.edu/clear/infr/cerf2

¹⁸ *A Report to Congressional Committees: Challenges to Widespread Deployment of Intelligent Transportation Systems*. U.S. General Accounting Office. Report No. GAO/RCED-97-74. February 1997. pg.8~9.

¹⁹ *Nontechnical Constraints and Barriers to the Implementation of Intelligent Transportation Systems*. U.S. DOT. Joint Program Office for Intelligent Transportation Systems. A Report to Congress. January 1997

²⁰ *A Report to Congressional Committees: Challenges to Widespread Deployment of Intelligent Transportation Systems*. U.S. General Accounting Office. Report No. GAO/RCED-97-74. February 1997. pg.9.

deploying metropolitan ITS infrastructure.²¹ In addition, there has been little effort to address the socioeconomic and environmental consequences of deployment. Most of intelligent infrastructure evaluation projects have been predicated on micro-level transportation network simulations which are sometimes unreliable, when varied socio-environmental settings impact more significantly on transportation performance of a certain area. If there are no adequate and clear explanation on economic, social and environmental benefits, it is impossible for transportation planners to justify expenditures on ITS deployments.

One of the most pressing problems are caused by the lack of funding for ITS at the state and local level.²² It is interconnected with other obstacles and so is particularly important, as adequate amount of funding is essential in order to provide technical trainings for their officials, to conduct studies about the ITS impacts on local areas, and to disseminate information for service users. Many local officials also concern that the competition for limited financial resources between ITS and traditional transportation projects will limit the deployment of intelligent infrastructure. In many urban areas, due to the need to maintain the deteriorating roads and bridges, local governments are left with little funding to actually implement ITS infrastructure projects. In addition, local transportation planners would not want to make large capital investment in deploying ITS infrastructure, since they might struggle with the lack of fund available for the maintenance of ITS.

Although the majority of local jurisdictions want to increase the funding levels for ITS in order to actively deploy ITS infrastructure, mixed views have existed as to the appropriate federal actions for funding the systems' deployment. Some argue that a large-scale federal deployment program would be necessary to achieve widespread deployment. On the other hand, others oppose such a large-scale program, since it would restrict local flexibility and they insist that a smaller-scale federal seed program could be more cost effective in facilitating deployment.²³

As discussed thus far, due to a range of nontechnical problems, the deployment of integrated infrastructure systems can be much more difficult than single ITS user service.

Conclusions

Since the Transportation Equity Act for the 21st Century (TEA-21) of 1998, the U.S. Department of Transportation has redirected the national ITS program to actively foster deployment and integration of ITS, particularly in large urban areas. Focusing on deploying metropolitan infrastructure system entails that there will be more requests for multi-jurisdictional incorporation and intergovernmental cooperation in order to

²¹ *ibid.* pg.9~10.

²² *ibid.*

²³ *Surface Transportation: Prospects for Innovation Through Research, Intelligent Transportation Systems, State Infrastructure Banks, and Design-Build Contracting.* U.S. General Accounting Office. Report No. GAO/T-RCED-97-83. March 1997. pg.5.

materialize its benefits, as the metropolitan infrastructure both intersect multiple technology components. The success of deployment relies not only on integration of technical features of ITS, but perhaps more strongly on institutional relationships that can shape the strengths and limitations of public agencies' performance for progressive problem solving.²⁴

Furthermore, the obstacles mentioned in this paper should be overcome in order for the federal, state, and local agencies to effectively pursue the goal of widespread deployment of integrated metropolitan infrastructure. They are the following:

- (1) Public-private partnerships are often ineffective, inflexible and vulnerable to pursuing stakeholders' own interests.
- (2) Little effort has been made to evaluate the user acceptance of ITS, because suppliers lack knowledge and understanding on the marketing of the technologies.
- (3) State and local politicians are often unaware of the importance of ITS and transportation planners have limited knowledge and skills to manage the deployment of ITS.
- (4) Analyses are not yet sufficient as to the cost and benefits of deployment and what the socioeconomic and environmental consequences will be.
- (5) Many states are struggling with the lack of funding for ITS, but conflicting perspectives exist as to the appropriate federal roles

Widespread integrated deployment of metropolitan ITS infrastructure cannot easily happen without addressing these non-technical obstacles. Transportation planners at the federal, state, and local level must understand that focusing on integration and deployment is not just a matter of technology, but it requires institutional innovation which in some sense is more difficult.

²⁴ Todd Goldman and Elizabeth Deakin. "Regionalism Through Partnership? Metropolitan Planning Since ISTEA". *Berkeley Planning Journal*. Vol. 14. 2000. pg.46-75.

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