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TEXAS TRANSPORTATION INSTITUTE • THE TEXAS A&M UNIVERSITY SYSTEM



PB99-128613

# **Development of an Intelligent Transportation Systems Education Module for Undergraduates**

TTI/ITS RCE-98/02

Texas Transportation Institute • The Texas A&M University System • College Station, Texas



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16. Abstract Professional capacity building (PCB) throughout the transportation profession is critical to the success of ITS nationwide. The purpose of this study was to develop an ITS educational module that could easily fit within any existing transportation undergraduate course or appropriate technical courses in other engineering and non-engineering disciplines. A case study analysis of specific job roles and tasks of staff from the various agencies that work at Houston Transtar revealed that individuals hired have a variety of skill levels expected by these agencies and the tasks that these staff perform can be enhanced by ITS knowledge. The desirability of these skills indicates that the transportation professional of today and the future needs a variety of skills that are not generally obtained in the traditional transportation engineering curriculum. The objectives of this educational module are to provide a definition of ITS; discuss the importance of ITS with respect to the future of transportation; discuss how ITS affects the user; outline the major areas of ITS in which transportation professionals work; describe how others around the country are using ITS technologies to operate their transportation systems more safely and efficiently; and outline potential career paths in ITS and transportation. The visual aids, lecture notes, and module exercises developed for this module were created from a variety of sources, including the FHWA ITS Awareness Seminar, reports, projects, workshops, transportation course materials, Internet sites, and other sources containing ITS-related information that was pertinent to the objectives of the module. They were designed to target an undergraduate engineering audience and were compiled on Microsoft® PowerPoint® for easy dissemination.  To obtain an electronic copy of the education module, please contact the author.			
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# **DEVELOPMENT OF AN INTELLIGENT TRANSPORTATION SYSTEMS EDUCATION MODULE FOR UNDERGRADUATES**

by

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**Research Report 98/02**  
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## SUMMARY

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While Intelligent Transportation Systems (ITS) deployment has been widespread throughout the United States since the passing of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, its current and future success depends on developing a larger cadre of transportation professionals capable of designing, planning, managing, operating, and maintaining the ITS program. Furthermore, overall awareness of ITS by the general public is necessary to ensure political, community, and financial support of future ITS efforts. This movement to educate and prepare existing and future transportation professionals and the general public with respect to ITS has been labeled professional capacity building (PCB). It is the goal of this movement to ensure that the next generation of transportation professionals emerging from undergraduate and graduate programs in our universities have the tools they need to work with the transportation infrastructure of the 21<sup>st</sup> century.

The purpose of this study was to develop an ITS educational module that could easily fit within any existing transportation undergraduate course or appropriate technical courses in other engineering disciplines. The study was conducted by the Center for Professional Capacity Building, Texas Transportation Institute staff and involved the following major tasks: a case study analysis of specific job roles and tasks of staff from the various agencies that work at Houston Transtar; the development of draft education materials (visual aids, lecture notes, exercises) as appropriate to address educational needs related to these roles; a presentation of the draft module to the agencies for review and comment; and the development of a final module for distribution.

The case study analysis of specific job roles and tasks of staff from the various agencies that work at Houston Transtar revealed some hiring preferences and knowledge requirements regarding staff that work at Transtar. In short, all of the agencies that operate within Transtar hire either individuals with (1) an undergraduate degree in engineering with an emphasis in transportation, (2) an undergraduate degree in engineering with no knowledge of transportation, or (3) a non-engineering undergraduate degree. With respect to skill levels expected by these agencies and the tasks that these staff perform that are enhanced by ITS knowledge, expectations varied but most

expected or desired basic traffic engineering knowledge and brief background knowledge of ITS for all positions. Other skills noted as desirable in staff include verbal communication, interagency cooperation, communication technology (fiber, etc.), Internet site development and design, contracting and procurement, time management, and general computer skills. The desirability of these skills indicates that the transportation professional of today and the future needs a variety of skills that are not generally obtained in the traditional transportation engineering curriculum. Thus, these findings support the development of the ITS Education Module and provide argument for the development of future modules aimed at enhancing the knowledge, skills, and abilities (KSAs) in these areas. Similar knowledge and hiring preferences reported by traffic management center (TMC) staff from Arizona and Georgia confirm the general assumption that most TMCs have similar needs with respect to staff roles and KSAs.

The project team determined that the educational module would have six objectives. These objectives are to:

- (1) provide a definition of ITS;
- (2) discuss the importance of ITS with respect to the future of transportation;
- (3) discuss how ITS affects the user;
- (4) outline the major areas of ITS in which transportation professionals work;
- (5) describe how others around the country are using ITS technologies to operate their transportation systems more safely and efficiently; and
- (6) outline potential career paths in ITS and transportation.

The success of incorporating new educational materials into a course relies heavily on the functionality and appropriateness of the material itself. Faculty must be willing to use the material. In a recent survey of faculty at universities in Arkansas, Louisiana, New Mexico, Oklahoma, and Texas, respondents identified the three most preferred material formats: presentation slides, lecture notes, and video clips. Since many videos already exist on ITS and since their production cost is considerably high, the project team determined that a video was out of the scope of this project. Thus, they selected visual aids and lecture notes as primary delivery mechanisms to be supplemented with exercises for students.

Presentation slides are an easy way to deliver a significant quantity of information in a visually attractive and comprehensive manner. Based on the widespread use of the presentation software, Microsoft® PowerPoint®, the project team determined that this software would be the platform for the visual aid development. The visual aids developed for this module were created from a variety of sources. Initially, the project team began with the ITS Awareness Seminar prepared by the Federal Highway Administration (FHWA) Office of Traffic Management and ITS Applications and the Federal Transit Administration (FTA) Office of Mobility Innovation. This seminar was produced as part of the ITS Professional Capacity Building Program of the U.S. Department of Transportation. The team began with this seminar as it was available on CD-ROM in PowerPoint® and provided an excellent overview of ITS from which the module could be developed. Visual aids were developed, modified, and updated to target an undergraduate engineering audience. Additional material for the visual aids was compiled from reports, projects, workshops, transportation course materials, Internet sites, and other sources containing ITS-related information that was pertinent to the objectives of the module.

Lecture notes are a natural complement to presentation slides when developing an educational module. Faculty members can refer to the notes when presenting the material, and they provide more detailed information than feasible to present on a slide. The lecture notes for the module were developed from the same sources noted previously, designed to target an undergraduate engineering audience, and compiled directly on the PowerPoint® notes pages.

ITS is an information and technology based arena of the transportation profession. In fact, the utilization of technology to address future problems is the cornerstone of ITS. Thus, the study team decided that module exercises designed to expose students to ITS and its technologies would support the objectives of the module. The exercises developed capitalize on the accessibility of the Internet to students and the host of ITS-related resources located there. The exercises provide students with the opportunity to learn more about the various technologies in use in cities across the country, their purpose and the information they provide to transportation professionals, and the user-oriented services provided by TMCs to enhance mobility. If, for some reason, a student does not have access to the Internet, the exercise can still be completed as most of the information required for completion is also available in traditional dissemination media.

The results presented in this report address an educational need of the transportation profession. While the focus was on the staff needs within Houston Transtar, the ITS-related objectives the module addresses are needed across the country. The educational module can easily be incorporated into any undergraduate engineering program, transportation or otherwise, to increase ITS awareness and to encourage students to pursue transportation and ITS as a career. Furthermore, the material can be used in non-engineering arenas to increase awareness of transportation as a viable career choice for the wide variety of individuals with technical backgrounds necessary to operate and maintain the complex technologies being used in our cities to make transportation more safe and efficient. Thus, this module works to meet the goals and objectives of the national PCB program, especially as it relates to educating the future professionals that will design, build, operate, manage, and maintain the transportation

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# 1. INTRODUCTION

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While Intelligent Transportation Systems (ITS) deployment has been widespread throughout the United States since the passing of the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, its current and future success depends on developing a larger cadre of transportation professionals capable of designing, planning, managing, operating, and maintaining the ITS program. Furthermore, overall awareness of ITS by the general public is necessary to ensure political, community, and financial support of future ITS efforts. This movement to educate and prepare existing and future transportation professionals and the general public with respect to ITS has been labeled professional capacity building (PCB). It is the goal of this movement to ensure that the next generation of transportation professionals emerging from undergraduate and graduate programs in our universities have the tools they need to work with the transportation infrastructure of the 21<sup>st</sup> century.

## 1.1 BACKGROUND

Currently, many university programs across the country have minimal expertise in transportation and ITS-related topics. In these programs, course material is often limited or non-existent. Furthermore, faculty members who are already overburdened do not have the time to develop additional materials for use in their classes. Thus, an opportunity exists to take advantage of expertise available at some universities for the benefit of the entire transportation education program as it pertains to ITS.

As stated above, PCB throughout the transportation profession is critical to the success of ITS nationwide. The three ITS Research Centers of Excellence (RCE) and the ITS Institute at the University of Minnesota committed a portion of their FY 98 financial resources to support ITS PCB activities. This study was sponsored by the Texas A&M ITS RCE, and its objective was to develop an ITS education module to address an ITS education need for one or more of the RCE local sponsoring agencies. While the immediate focus was regional, the resulting module can be

incorporated into virtually any undergraduate engineering program, transportation or otherwise, to increase ITS awareness and to encourage students to pursue transportation and ITS as a career.

## **1.2 PURPOSE**

The purpose of this study was to develop an ITS educational module that could easily fit within any existing transportation undergraduate course or appropriate technical courses in other engineering disciplines. The study was conducted by the Center for Professional Capacity Building, Texas Transportation Institute staff and involved the following major tasks: a case study analysis of specific job roles and tasks of staff from the various agencies that work at Houston Transtar; the development of draft education materials (visual aids, lecture notes, exercises) as appropriate to address education needs related to these roles; a presentation of the draft module to the agencies for review and comment; and the development of a final module for distribution.

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## 2. CASE STUDY ANALYSIS

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Each state in the United States has a transportation infrastructure that is constantly expanding and improving to meet the needs of the motoring public. Thus, future transportation professionals must have the knowledge, skills, and abilities to perform their role in maintaining that infrastructure in the 21<sup>st</sup> century. The paradigm shift occurring within the profession is moving its emphasis from construction to operations. In response to this shift, state and local agencies in over 50 cities across the nation are building and operating transportation management centers (TMCs). The purpose of these centers is to coordinate the use of advanced technologies to work to maximize the efficiency of the existing roadway and provide the best level of service possible to the transportation system user while improving safety.

Houston Transtar is the transportation management center in Houston, Texas. Four agencies - Texas Department of Transportation (TxDOT), the Metropolitan Transit Authority of Harris County (METRO), the city of Houston, and Harris County - work in tandem under one management structure to operate a variety of traffic-related management programs to assist the motoring public. These agencies share the expense and responsibility of operating Transtar while other agencies in the region assist in operations to ensure interagency coordination and to minimize administrative boundaries. The various ITS-related transportation management programs coordinated from Transtar include the following:

- traffic signalization systems;
- freeway management systems;
- transit management systems;
- incident management systems;
- electronic toll collection systems;
- electronic transit fare payment systems;
- smart railroad grade crossing systems;
- coordinated emergency and disaster services; and
- real-time traveler information systems.

As with similar TMCs across the country, Transtar hires numerous individuals that perform the roles necessary to maintain the variety of operations within Transtar. However, these individuals may or may not have a background in transportation or ITS upon hiring. While some may not necessarily need that information to perform their job, they could definitely benefit from such background knowledge. Therefore, the first task in developing the ITS education module was to determine specific knowledge requirements with respect to ITS. This task was accomplished through a case study analysis.

## **2.1 CASE STUDY METHODOLOGY**

The case study analysis consisted of conducting personal interviews of select individuals within Transtar who are responsible for hiring and managing personnel in the various agencies. Since each agency has specific roles and responsibilities under the Transtar management structure and as identified by its overall mission, an individual from each sponsor agency was interviewed. Additional surveys of staff from two other TMCs in other states were conducted to determine if the needs within Transtar are similar to those in other regions of the country. A copy of the basic questionnaire used during the interviews is included in Appendix A. It is important to note that this questionnaire was used as a starting point to probe for information; discussion frequently diverted from the original questions as the interview progressed.

## **2.2 TOPICS INVESTIGATED**

The information sought from the questionnaire included whether the sponsor agency hires graduates into entry-level positions in which little or no work experience is required. These new hires were categorized as: (1) individuals with an undergraduate degree in engineering with an emphasis in or knowledge of transportation; (2) individuals with an undergraduate degree in engineering with NO knowledge of transportation; or (3) individuals with a NON-engineering undergraduate degree. These distinctions were made since many TMCs hire individuals with varying levels of transportation knowledge depending on the position in question. For example, it is not

unusual for such centers to hire such non-transportation staff as electrical engineers, software programmers, and communications specialists.

Once the agency identified the classification of individuals it employs within Transtar, the questionnaire asked for the specific entry-level positions filled with those individuals, the levels of knowledge regarding transportation and ITS that is required or desired of them, and the specific tasks these individuals perform that might require or be enhanced by ITS knowledge.

## **2.3 STUDY RESULTS**

All of the agencies that operate within Transtar hire individuals with either an undergraduate degree in engineering with an emphasis in transportation and individuals with a non-engineering undergraduate degree. The city of Houston also hires individuals with an undergraduate degree in engineering with no knowledge of transportation. The following sections outline the skill levels expected by these agencies and the tasks that these staff perform that are enhanced by ITS knowledge.

### **2.3.1 Engineering Degree with Transportation Knowledge**

Graduates with engineering degrees and some knowledge of transportation are hired into various entry-level positions within each agency. These positions range from operators, engineering assistants, and signal engineers to project managers and supervisors of control room operations. All of these positions require brief background knowledge of ITS. Specific required knowledge includes, but is not limited to, signal operations and timing, signal systems, system engineering, system integration, electronics in ITS, and general traffic engineering concepts. Note that many of these topics overlap with traditional transportation-related knowledge. Within their roles, these individuals perform various tasks that require this ITS and transportation-related knowledge. These tasks include signal investigations and troubleshooting, monitoring of existing systems, operations and maintenance of the Automatic Vehicle Identification (AVI) system, evaluation and monitoring

of project progress, and project management. Depending on the depth of their transportation background, these individuals might be a potential audience for the ITS Education Module.

### **2.3.2 Engineering Degree with No Transportation Knowledge**

Graduates with engineering degrees and no knowledge of transportation are hired primarily within Transtar by the city of Houston. As with individuals with a transportation background, these individuals, who might have a civil, mechanical, or electrical engineering degree, are hired as signal engineers. It is desired that they have a brief background knowledge regarding transportation and ITS, but such knowledge is not required for employment. Tasks these individuals might perform that would be enhanced by ITS knowledge include signal investigations and signal problem troubleshooting, which includes operational issues, re-phasing, sequencing, and signal timing. Thus, these individuals are a potential audience for the ITS Education Module as they generally have little to no transportation background.

### **2.3.3 Non-Engineering Degree**

Graduates with non-engineering degrees and no transportation background are hired into various entry-level positions within each agency. The entry-level positions they fill range from police officers, electrical estimators, and ITS operators to engineering technicians and maintenance and inspection technicians. Most, but not all, of the agencies desire a brief background knowledge of transportation for individuals in these positions. Those tasks these individuals perform within their jobs that would be enhanced by ITS knowledge include, but are not limited to, system engineering, dispatch and emergency radio operations, data analysis and reduction, high-occupancy vehicle (HOV) operations, lane control signal operations, dynamic message sign (DMS) operations, signal maintenance, and traffic signal design. As with the previous staff categories, these individuals are a target audience for the ITS Education Module.

### 2.3.4 Other Findings

During discussion with agency staff representatives, other KSAs were revealed as desirable in entry-level hires. These skills include, but are not limited to, the following:

- interpersonal and verbal communication;
- interagency cooperation;
- communication technology (fiber, etc.);
- Internet site development and design;
- contracting and procurement;
- time management; and
- general computer skills.

This list combined with the other general skills outlined in the previous sections indicates that the transportation professional of today and the future needs a variety of skills that are not generally obtained in the traditional transportation engineering curriculum. Thus, these findings support the development of the ITS Education Module and provide argument for the development of future modules aimed at enhancing the KSAs in these areas. Furthermore, similar knowledge and hiring preferences were reported by TMC staff from Arizona and Georgia, confirming the general assumption that most TMCs have similar needs with respect to staff roles and KSAs.



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### **3. MODULE DEVELOPMENT**

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A key to developing educational materials for widespread dissemination is to provide relevant and useful information in a medium that is easy to use and pervasive throughout the profession. The intent is for faculty to incorporate new material into existing course outlines with a minimum of effort on the part of the instructor. Thus, the second task in developing an educational module for ITS was to create a draft module, including all its components, for review and revision by professionals who hire individuals that can benefit from the included knowledge.

The project team determined that the educational module would have six objectives. These objectives are to:

- (1) provide a definition of ITS;
- (2) discuss the importance of ITS with respect to the future of transportation;
- (3) discuss how ITS affects the user;
- (4) outline the major areas of ITS in which transportation professionals work;
- (5) describe how others around the country are using ITS technologies to operate their transportation systems more safely and efficiently; and
- (6) outline potential career paths in ITS and transportation.

The following sections outline the process undertaken to accomplish the task of developing this module.

#### **3.1 DRAFT MODULE DEVELOPMENT**

The success of incorporating new educational materials into a course relies heavily on the functionality and appropriateness of the material itself. Faculty must be willing to use the material. In a recent survey of faculty at universities in Arkansas, Louisiana, New Mexico, Oklahoma, and Texas, respondents identified their preferences in resource material for use in the classroom. The three most preferred material formats, in order of preference, were presentation slides, lecture notes, and video clips (1). Since many videos already exist on ITS and since their production cost is

considerably high, the project team determined that a video was out of the scope of this project. Thus, they selected visual aids and lecture notes as primary delivery mechanisms to be supplemented with exercises for students. The following sections provide a description of the material developed for each component of the module.

### **3.1.1 Visual Aids**

Presentation slides are an easy way to deliver a significant quantity of information in a visually attractive and comprehensive manner. Based on the widespread use of the presentation software, Microsoft® PowerPoint®, the project team determined that this software would be the platform for the visual aid development. Once developed, the slides can be provided to faculty in electronic or hard-copy format and can be printed or used in various formats for presentation (i.e., electronic, slide, or transparency). Furthermore, lecture notes can be included in the slide files to minimize the number of files that must be used. Moreover, PowerPoint® files can be converted to HTML files for use on the Internet, increasing the flexibility of the module in its use and application.

The visual aids developed for this module were created from a variety of sources. Initially, the project team began with the ITS Awareness Seminar prepared by the Federal Highway Administration (FHWA) Office of Traffic Management and ITS Applications and the Federal Transit Administration (FTA) Office of Mobility Innovation (2). This seminar was produced as part of the ITS Professional Capacity Building Program of the U.S. Department of Transportation. The team began with this seminar as it was available on CD-ROM in PowerPoint® and provided an excellent overview of ITS from which the module could be developed. Visual aids were developed, modified, and updated to target an undergraduate engineering audience. Additional material for the visual aids was compiled from reports, projects, workshops, transportation course materials, Internet sites, and other sources containing ITS-related information that was pertinent to the objectives of the module. The result was 56 PowerPoint® slides which address the objectives of the module as an overview.

### **3.1.2 Lecture Notes**

Lecture notes are a natural complement to presentation slides when developing an educational module. Faculty members can refer to the notes when presenting the material, and they provide more detailed information than feasible to present on a slide. Furthermore, faculty can make additions and changes to the notes as needed. As with presentation slides, the target team determined that Microsoft® PowerPoint® was an appropriate software for lecture note development, since notes can be easily included in slide files and printed for faculty use. Once developed, the notes can be provided in electronic format for HTML conversion or in hard-copy format for direct distribution to students. The lecture notes for the module were developed from the same sources noted previously as those used in development for the presentation slides. The notes were designed to target an undergraduate engineering audience and were compiled directly on the PowerPoint® notes pages, resulting in lecture notes for the 56 presentation slides.

### **3.1.3 Module Exercises**

As discussed in this report and numerous others, ITS is an information and technology based arena of the transportation profession. In fact, the utilization of technology to address future problems is the cornerstone of ITS. Thus, the study team decided that module exercises designed to expose students to ITS and its technologies would support the objectives of the module. The exercises developed capitalize on the accessibility of the Internet to students and the host of ITS-related resources located there. Using the Internet, students are asked to identify and research five different transportation management centers that have a presence on the Internet and discuss a variety of issues associated with them. The exercises provide students with the opportunity to learn more about the various technologies in use in cities across the country, their purpose and the information they provide to transportation professionals, and the user-oriented services provided by TMCs to enhance mobility. If, for some reason, a student does not have access to the Internet, the exercise can still be completed as most of the information required for completion is also available in traditional dissemination media.

### **3.2 DRAFT MODULE REVIEW**

Task three of this project was to present the draft education module to staff at Transtar to provide the opportunity for them to review and critique the module, identifying areas of improvement as appropriate. The presentation slides and lecture notes were printed in the PowerPoint® notes format and sent to the key staff in each organization at Transtar that participated in the case study analysis. They were asked to review the material and provide a critique of it, identifying any areas needing improvement based on the educational objectives of the module. Reviewers were given three weeks in which to look at the material, and comments were welcome in all formats: e-mail, fax, surface mail, or telephone. No comments were received from the reviewers, which led the project team to assume that they desired no changes in the either presentation slides or lecture notes.

### **3.3 FINAL MODULE DEVELOPMENT**

Since no comments were received from the module reviewers, no major alterations to the educational module were necessary. Minor changes to format of the presentation slides and lecture notes were made to streamline the module, and copies of the presentation slides, lecture notes, and module exercises are located in Appendices B and C, respectively.

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## 4. FINDINGS AND RECOMMENDATIONS

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The purpose of this study was to develop an ITS educational module that could easily fit within any existing transportation undergraduate course or appropriate technical courses in other engineering disciplines. A case study analysis of specific job roles and tasks of staff from the various agencies that work at Houston Transtar revealed some hiring preferences and knowledge requirements regarding staff that work at Transtar. In short, all of the agencies that operate within Transtar hire either individuals with (1) an undergraduate degree in engineering with an emphasis in transportation, (2) an undergraduate degree in engineering with no knowledge of transportation, or (3) a non-engineering undergraduate degree.

With respect to skill levels expected by these agencies and the tasks that these staff perform that are enhanced by ITS knowledge, expectations varied but most expected or desired basic traffic engineering knowledge and brief background knowledge of ITS for all positions. Other skills noted as desirable in staff include verbal communication, interagency cooperation, communication technology (fiber, etc.), Internet site development and design, contracting and procurement, time management, and general computer skills. The desirability of these skills indicates that the transportation professional of today and the future needs a variety of skills that are not generally obtained in the traditional transportation engineering curriculum. Thus, these findings support the development of the ITS Education Module and provide argument for the development of future modules aimed at enhancing the KSAs in these areas. Similar knowledge and hiring preferences reported by TMC staff from Arizona and Georgia confirm the general assumption that most TMCs have similar needs with respect to staff roles and KSAs.

The results presented in this report address an educational need of the transportation profession. While the focus was on the staff needs within Houston Transtar, the ITS-related objectives the module addresses are needed across the country. The educational module can easily be incorporated into any undergraduate engineering program, transportation or otherwise, to increase ITS awareness and to encourage students to pursue transportation and ITS as a career. Furthermore, the material can be used in non-engineering arenas to increase awareness of transportation as a viable

career choice for the wide variety of individuals with technical backgrounds necessary to operate and maintain the complex technologies being used in our cities to make transportation more safe and efficient. Thus, this module works to meet the goals and objectives of the national PCB program, especially as it relates to educating the future professionals that will design, build, operate, manage, and maintain the transportation infrastructure.

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## APPENDIX A: CASE STUDY QUESTIONNAIRE

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*Action Item 1. Case Study Analysis*

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**Organization**

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**Representative**

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**Title**

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**Address**

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**City**

**State**

**Zip**

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**Phone**

**Fax**

**E-Mail**

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3. Do you hire any of the three following types of graduates into entry-level positions in which little or no work experience is required?

- Individuals with an undergraduate degree in engineering with an emphasis in or knowledge of transportation (*go to Question 2*).
- Individuals with an undergraduate degree in engineering with NO knowledge of transportation (*go to Question 6*).
- Individuals with a NON-engineering undergraduate degree (*go to Question 9*).

4. What entry-level positions do you fill with individuals with an undergraduate degree in engineering with an emphasis in or knowledge of transportation?

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5. What level of knowledge regarding Intelligent Transportation Systems is REQUIRED of these entry-level staff?

- Thorough       Brief Background       None

6. What specific ITS knowledge is REQUIRED of these entry-level staff?

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7. What tasks performed by these entry-level staff REQUIRE this ITS knowledge?

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*Action Item 1. Case Study Analysis*

8. What entry-level positions do you fill with individuals with an undergraduate degree with NO knowledge of transportation?

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9. What level of knowledge regarding Intelligent Transportation Systems is DESIRED of these entry-level staff?

- Thorough       Brief Background       None

10. What tasks performed by these entry-level staff would be enhanced by ITS knowledge?

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11. What entry-level positions do you fill with individuals with a NON-engineering undergraduate degree?

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12. What level of knowledge regarding Intelligent Transportation Systems is DESIRED of these entry-level staff?

- Thorough       Brief Background       None

13. What tasks performed by these entry-level staff would be enhanced by ITS knowledge?

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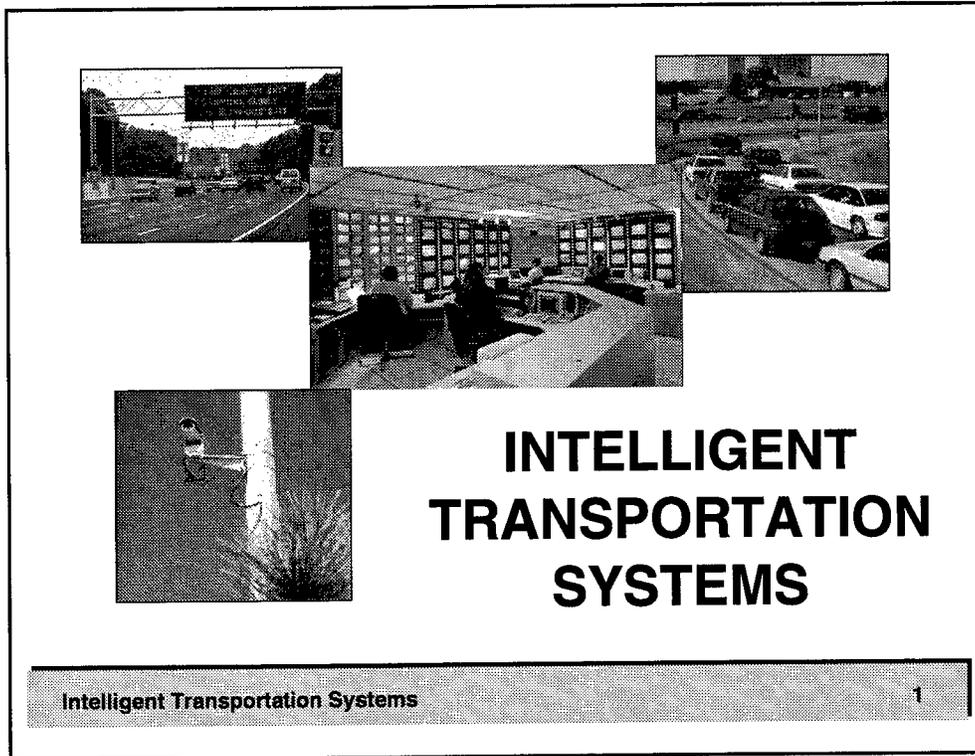
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**APPENDIX B: MODULE PRESENTATION SLIDES / LECTURE NOTES**

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## **INSTRUCTOR**

*Pose these questions:                    Have you ever heard of ITS?  
   As a traveler, do you think you have encountered ITS?*

*Before showing the slides, have the class break into small groups and ask them to write down answers to this question:*

*1) Define what you think ITS might be (in words or drawings).*

### **Slide 1 - Intelligent Transportation Systems**

*Use this as a background slide for the group participation.*

- This will provide awareness of ITS.
- You will not be ITS experts.
- You will obtain a better understanding of the U.S. Department of Transportation's mission of "operations and management" of the existing and future transportation systems.
- ITS is a part of the changing world of new technology - the world of transportation in the "Information Age," an age of which we are all a part.
- ITS program is a joint highway, public transportation, and safety ITS program.
- You will learn about potential career paths in ITS.

# Learning Objectives

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- **Definition of ITS**
- **Importance with respect to the future of transportation**
- **How ITS touches YOU!**
- **Major ITS areas**
- **ITS successes**
- **Potential careers in ITS**

## Slide 2 - Learning Objectives

*During this segment, you will learn the following:*

- Increased awareness of ITS. What is it? What technologies are involved? What makes it “intelligent”?
- How ITS fits into the overall framework of transportation and how it impacts the future of transportation.
- How ITS affects the user.
- The major areas of ITS in which transportation professionals work.
- How others around the country are using ITS technologies to operate their transportation systems more safely and efficiently.
- Potential career paths in ITS and transportation.

## Transportation Facts

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- If all Americans who take transit to work drove instead, their cars would circle the earth in a line of traffic 23,000 miles long.
- There are more than 160,000 traffic signals in the U.S.
- The cost of sitting in traffic congestion costs travelers and businesses \$40 billion each year.

### Slide 3 - Transportation Facts

*Here are some interesting facts about transportation and our society.*

- If all Americans who take transit to work drove instead, their cars would circle the earth in a line of traffic 23,000 miles long.
  - 10 million Americans use public transit every working day.
- There are more than 160,000 traffic signals in the U.S.
- The cost of sitting in traffic congestion costs travelers and businesses \$40 billion each year.
  - Americans lose more than 1.6 million hours a day stuck in traffic.
  - The average American driver spends about one hour in a car each day, including weekends.

*Ask the class what the various modes are: air, rail, highways, water, and pipeline (intermodal transportation).*

## What are Intelligent Transportation Systems (ITS) ?

- The application of high *technology* and *computer power* to current freeway, traffic, and transit systems to increase the safety and efficiency of the surface transportation system.
- Have the potential to solve future problems.

Intelligent Transportation Systems

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### Slide 4 - What are Intelligent Transportation Systems (ITS)?

- The application of high **technology** and **computer power** to current freeway, traffic, and transit systems to increase the safety and efficiency of the surface transportation system.
- Have the potential to solve future problems.

*Various components and products in use in everyday life can be applied to the transportation arena (bring some of these "toys" if you have them).*

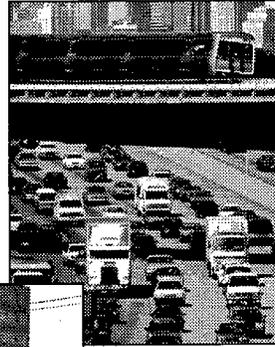
- |                  |                       |
|------------------|-----------------------|
| -computers       | -CCTV                 |
| -cellular phones | -loop detectors       |
| -modems          | -GPS bus antenna      |
| -E-mail          | -RWIS                 |
| -World Wide Web  | -electronic fare card |
| -pagers          |                       |

*With ITS, as with other areas of life, lots of information is exchanged, communicated, and managed. The private sector (rail, trucking, air, water) are well ahead in these applications.*

- Traveler information services
- Ford and GM Mayday systems

*How does technology affect your life daily? Aside from transportation.*

**ITS is...**



**...Traffic and Transit Management**

Intelligent Transportation Systems

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**Slide 5 - ITS is ...**

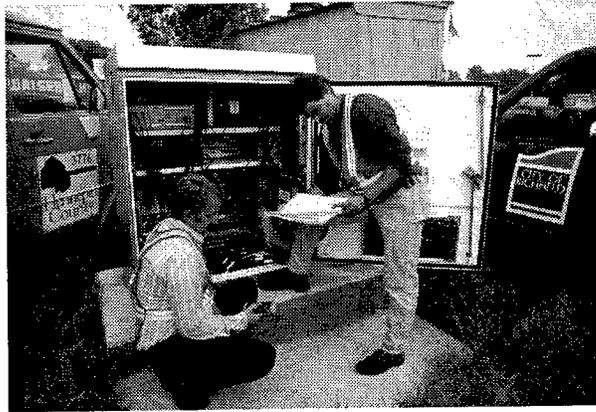
Traffic and Transit Management

*ITS can assist us in operating our facilities as safely and efficiently as possible, especially as new construction becomes more scarce.*

Picture

*Management/Operations Center*

**ITS is...**



**...Traffic Signal  
Systems**

Intelligent Transportation Systems

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**Slide 6 - ITS is . . .**

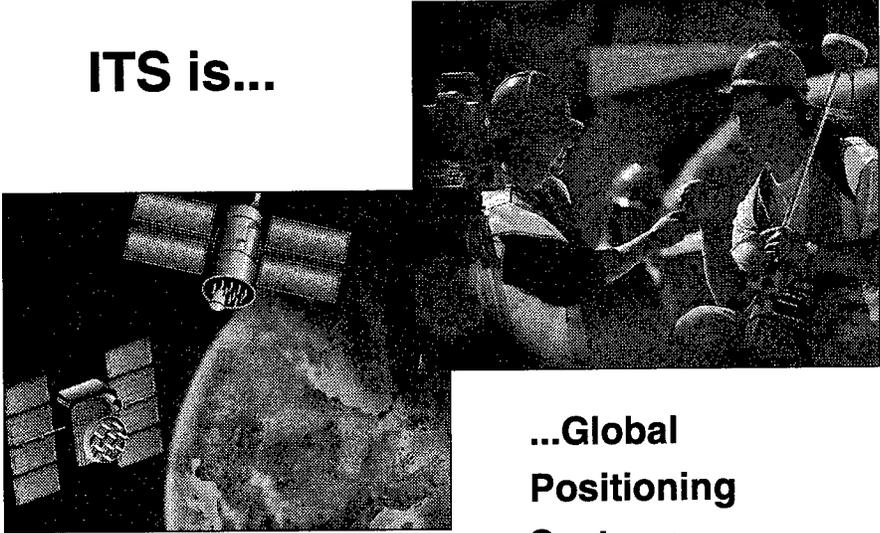
**Traffic Signal Systems**

*Advanced traffic signal systems can minimize the stop and go traffic flow. They are especially helpful during incident management or during special events.*

**Picture**

*Traffic signal control cabinet. Can change signal timing here. With computerized signal system and a link to your office and/or home, you can change it from those locations, too.*

**ITS is...**



**...Global  
Positioning  
Systems**

Intelligent Transportation Systems 7

**Slide 7 - ITS is . . .**

Global Positioning Systems

*Useful for tracking car, bus, truck, train, and ferry location.*

**Pictures (left to right)**

- 1) *Satellites used for determining positions of objects (a good example is transit operators locating their buses).*
- 2) *Using global positioning systems for surveying instead of traditional equipment-more accurate and precise.*

## ITS is...



- **Weather Information Systems**
- **Commercial Vehicle Electronic Clearance**

Intelligent Transportation Systems

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### Slide 8 - ITS is . . .

#### Weather Information Systems

*ITS can provide information such as:*

- *Are the roads flooded?*
- *Are the roads covered with snow?*
- *Is visibility reduced because of heavy fog?*

#### Commercial Vehicle Electronic Clearance

- *With this system, trucks don't have to stop numerous times on a single trip to be checked.*

**ITS is...**

**...Real-Time  
Traveler Information**

Intelligent Transportation Systems 9

**Slide 9 - ITS is . . .**

Real-Time Traveler Information:

*ITS lets travelers, businesses, and commercial carriers know what to expect so that the trip time can be precisely predicted.*

Pictures (left to right)

- 1) *Real-time display of bus information at a bus stop (Atlanta)*
- 2) *Dynamic Message Sign (message reads: COURTLAND ST EXIT MOVING SLOWLY USE ALTERNATE EXIT)*
- 3) *Traveler information on the Internet*

## Why is ITS Important?

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- Offers the next major leap forward in improving safety, convenience, and productivity of our personal and commercial travel.
- Critical as population and congestion increase, and land and funding for new roads decrease.

### Slide 10 - Why is ITS Important?

- Offers the next major leap forward in improving safety, convenience, and productivity of our personal and commercial travel.
- Critical as population and congestion increase, and land and funding for new roads decrease.

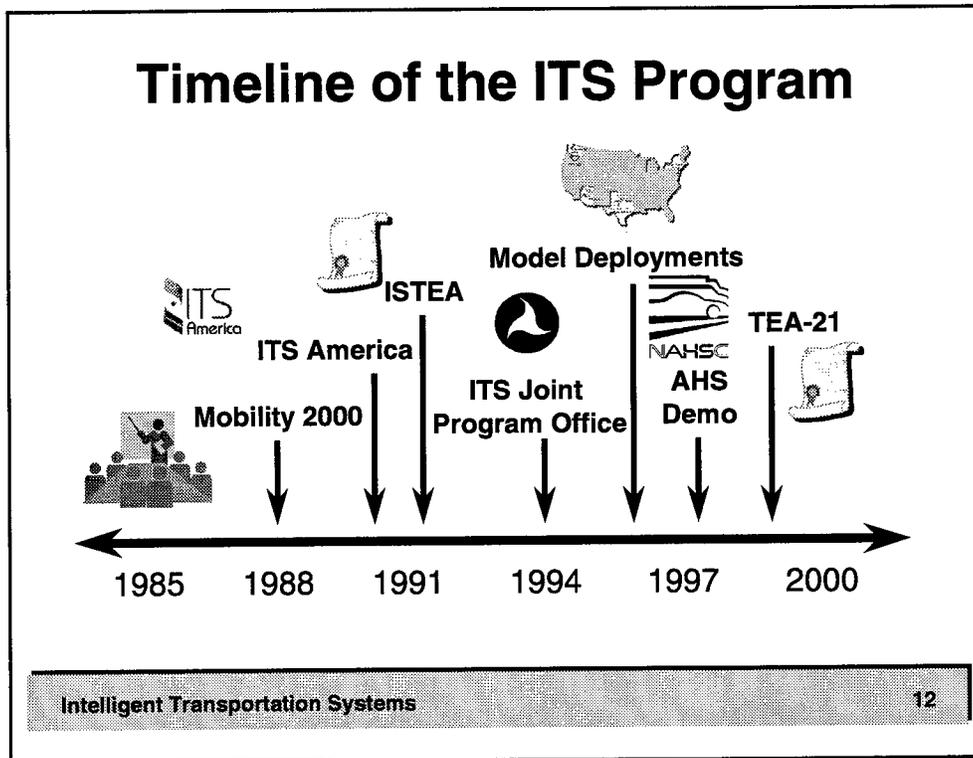
*It is time for a paradigm shift. We have to think in terms of operating what we already have more efficiently rather than building our way out of congestion.*

## What are We Doing Differently?

- Improving productivity through advanced technology and management techniques
- Operating existing programs more efficiently
- Integrating systems
- Providing travel information

### Slide 11 - What Are We Doing Differently?

- Improving productivity through advanced technology and management techniques.
- Operating existing programs more efficiently.
  - *In urban areas, no more room to build highways*
  - *Greater attention to efficient operation and management of systems*
  - *With advances in communications and computing, it has become easier to do more with greater information, and exchange and access information easier than ever before*
  - *Miniaturization of electronic components (Seiko watch), affordability, software capabilities (graphics, data processing)*
  - *Computer and communications infrastructure*
  - *Greater emphasis and need for electronics, telecommunications, and software skills in the workforce*
  - *Need for continuous technology training of the current workforce to keep them up to date in the world of rapidly changing technology*
- Integrating systems (making older systems “talk” to each other)
- Providing travel information (travelers, business, commercial carriers)
  - *Give examples (ETTM, ATIS, etc.)*



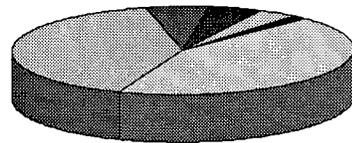
**Slide 12 - Timeline of the ITS Program**

- Much of what is now the ITS Program took root in the mid-80s with the group known as Mobility 2000.
- The underlying concepts are not new-FHWA and FTA researchers started the effort for the whole world in the '60s, but the ITS program is relatively new.
- ISTEA signaled the end of the Interstate construction era and the beginning of the operations management era-be as safe and as efficient as possible.
- Passage of ISTEA (1991) provided the legislative buy-in and funding to “kick-start” a program of research and operational testing.
- TEA-21 (1998) moves ITS more into implementation.

*In preparation for next slide, ask your audience:*

- “Do you have any examples of how technology (“information age”) has benefitted you or has been implemented in your area?”
- Financial databases (ATM machines)?
- Electronic surveying?
- Internet for receiving information?
- Bridge and pavement sensors?
- Total stations accident investigation?

## Projected ITS Infrastructure Benefits (1996-2015)



■ Accident Cost Savings (44%)
■ Time Savings (41%)
■ Emissions/Fuel (6%)
■ Operating Cost Savings (5%)
■ Agency Cost Savings (4%)
■ Other (< 1%)

Source : Apogee Report on Global ITS Benefits

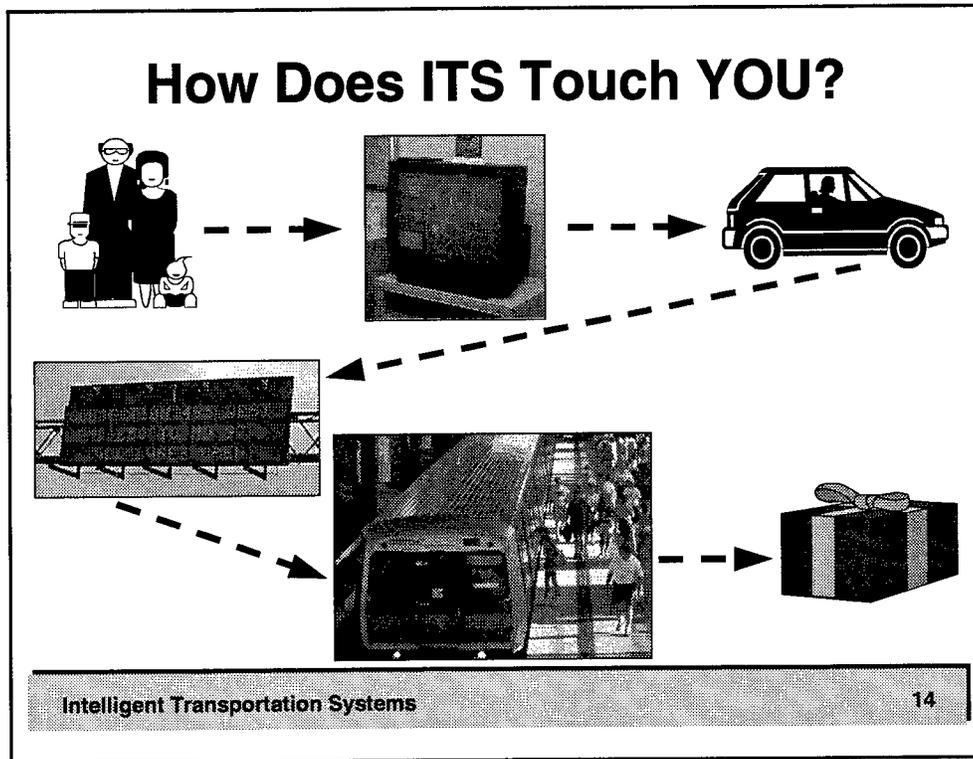
Intelligent Transportation Systems

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### Slide 13 - Projected ITS Infrastructure Benefits

- This figure depicts the estimated benefits of deploying ITS.
- It should be noted that almost half of the benefits are safety related.
- Other benefits (time savings/operating cost savings) directly benefit the consumer.
- Reduced impact on the environment (emissions/fuel).
- Agency costs should not be overlooked in these times of downsizing.

This information is from the **Apogee Report on Global ITS Benefits**.



### Slide 14 - How Does ITS Touch YOU?

It is Sunday and you are going on a family outing to your grandmother's house in the next county. Mom and Dad ask you to help plan the trip. Your task is to keep the family on schedule, and help the family to arrive safely and on time. "How's the traffic?" Dad asks. You go to the television and check the local cable traffic station. You report, "Dad the traffic flow is normal now, but the weather station is calling for drizzle. We should leave soon." First you must travel the highway to the transit station, then the family will take the commuter rail, about a 45-minute ride, to your grandmother's house. You are running just a little late. You push the family along, ushering your brother and sister to the car. Remember your task is to keep the family on schedule. Your family is on the way. As the car turns onto the highway the rain is beginning to fall and you hear a siren. A police car whizzes by, followed by a tow truck. Two miles ahead of you, a car has a flat tire. Traffic is stopped. In class you learned that traffic centers monitor freeways and major roads, using video systems. You ask your Mom to turn on the radio, and say, "Dad, listen for the traffic report, and I will watch for the typed message on the overhead highway sign." As you speak, a specialist monitoring the freeway from a traffic center notifies the police, a tow truck driver, and a traffic reporter. The police call for an ambulance in case of an emergency. The electronic highway messaging sign flashes. You say, "Look Dad, the sign advises taking another route." He takes the advice and arrives at the transit station right at boarding time. You run to the travel kiosk in the lobby to check the arrival time, and shout to your family, "We have one minute to make the train, or we can wait for one hour." You make a mad dash -- WHAT ABOUT YOUR TICKETS? No need to stop to buy tickets, you all have electronic fare cards. Do you make it? Yes, safely and in time for your grandmother's surprise birthday party. And, as a bonus, when your mother decides the family will stay the weekend, what is your task? You borrow your Uncle's laptop computer and surf the Internet for hotels, historical sites, festivals, theme parks, a rental car-and travel schedules back home on Monday. Now you understand how ITS technology works for you today.

This is a real life example of how Intelligent Transportation Systems benefits us all. Transportation professionals are developing systems to make all transportation safer and more efficient. Research, tests, and technology are contributing to better transportation for all Americans.

## What's it Worth? Identified Benefits

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- Time Savings
- Improved Throughput
- Reduced Crashes and Fatalities
- Cost Avoidance
- Increased Customer Satisfaction
- Energy and Environmental Benefits

Intelligent Transportation Systems

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### Slide 15 - What's it Worth? Identified Benefits

These are 6 good measures for the Federal Government Performance Results Act:

- Time Savings
  - Faster to respond to incidents from CCTV; Select fastest mode from advanced traveler information
  - Electronic toll facilities reduce stopping delays; Electronic clearance for CVO
  - Inform (Long Island): estimates of savings as high as 1900 vehicle-hours for peak period incident
- Improved Throughput
  - Seattle freeway management: traffic up 10% to 100% along I-5
  - Doing what we can to keep traffic off of residential streets; Improve transit vehicle on-time performance
  - Helping highway throughput due to advanced traveler info decision.
- Reduced Crashes and Fatalities
  - Minneapolis: 27% reduction in annual accident rates on I-35W
  - Faster incident notification time means a reduction in fatalities
  - With Mayday systems in rural areas; with cellular phones, urban areas
  - Blind spot detection sensors - on school buses
- Cost Avoidance
  - NJ Transit: annual reduction of \$2.7 m in cash handling with electronic fare
  - Trucking deliveries up 10-20% with computer-assisted dispatching
  - Trucking also saves money by saving time thru electronic clearance
- Increased Customer Satisfaction
  - Improve on-time performance for transit vehicles/customers
  - Smart Card - interoperability; can use one card for many systems
  - Express bus routes (Phoenix, AZ) report 90% of fares paid by bus pass cards
- Energy and Environmental Benefits
  - Improved efficiency results in reduced emissions and fuel savings

## Major ITS Areas

- **Multimodal Travel Management and Traveler Information**
  - *Advanced Traffic Management Systems*
  - *Advanced Traveler Information Systems*
  - *Advanced Public Transportation Systems*
  - *Advanced Rural Transportation Systems*
- **Commercial Vehicle Operations**
- **Advanced Vehicle Control and Safety Systems**

### Slide 16 - Major ITS Areas

(Highlighted - Multimodal Travel Management and Traveler Information)

- Advanced Traffic Management Systems (ATMS)
- Advanced Traveler Information Systems (ATIS)
- Advanced Public Transportation Systems (APTS)
- Advanced Rural Transportation Systems (ARTS)

*Now that we've given you a snapshot of the benefits of ITS, we want to key in on 3 major areas and begin to show you how everything fits together.*

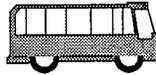
*This sets the stage for the discussion to occur from now on.*

*These three topics set the context for "what is ITS" - 3 major areas for ITS implementation.*

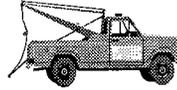
# Multimodal Travel Management and Traveler Information



Multimodal  
Regional  
Traveler  
Information



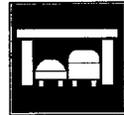
Transit  
Management



Incident  
Management



Freeway  
Management



Electronic  
Toll  
Collection



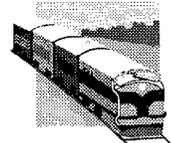
Emergency  
Management



Traffic Signal  
Control



Electronic  
Fare  
Payment



Highway Rail  
Intersection  
Safety

Intelligent Transportation Systems

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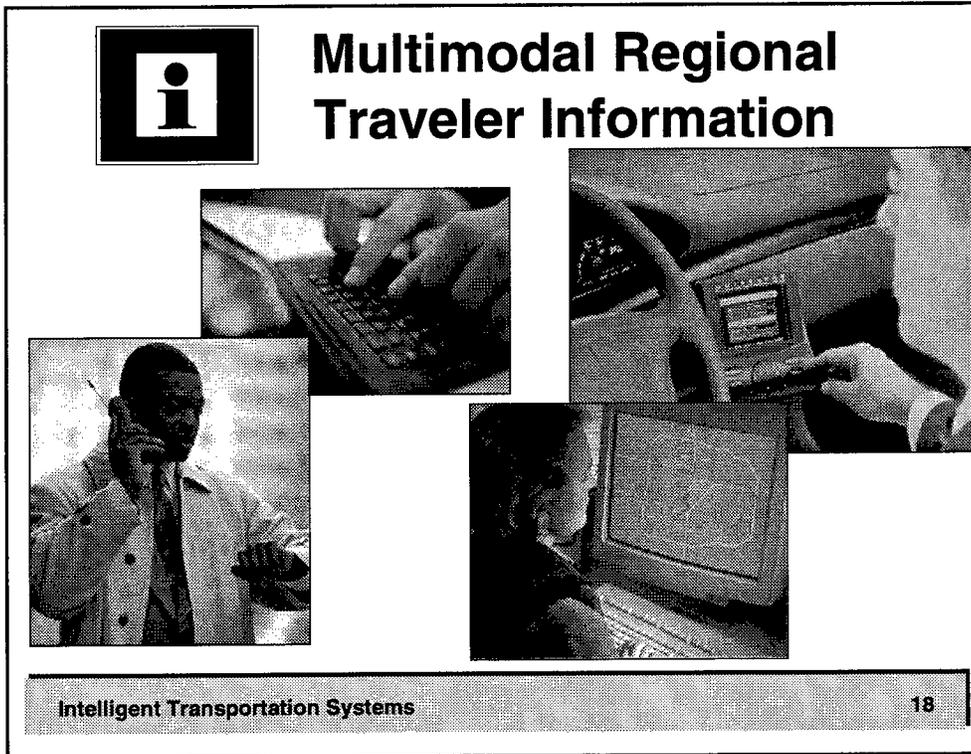
## Slide 17 - Multimodal Travel Management and Traveler Information

*This is the first of the three ITS areas.*

*These are the various components of Multimodal ITS (individual slides and subsequent discussion will follow).*

*Applicable in both urban and rural areas.*

*Emphasize that they are interrelated - they can all work together to make a better system.*



**Slide 18 - Multimodal Regional Traveler Information**

*Traveler Information can let people know what's ahead so they can accurately predict their trip time. It can especially be important for just-in-time deliveries.*

**En-route Traveler Information**

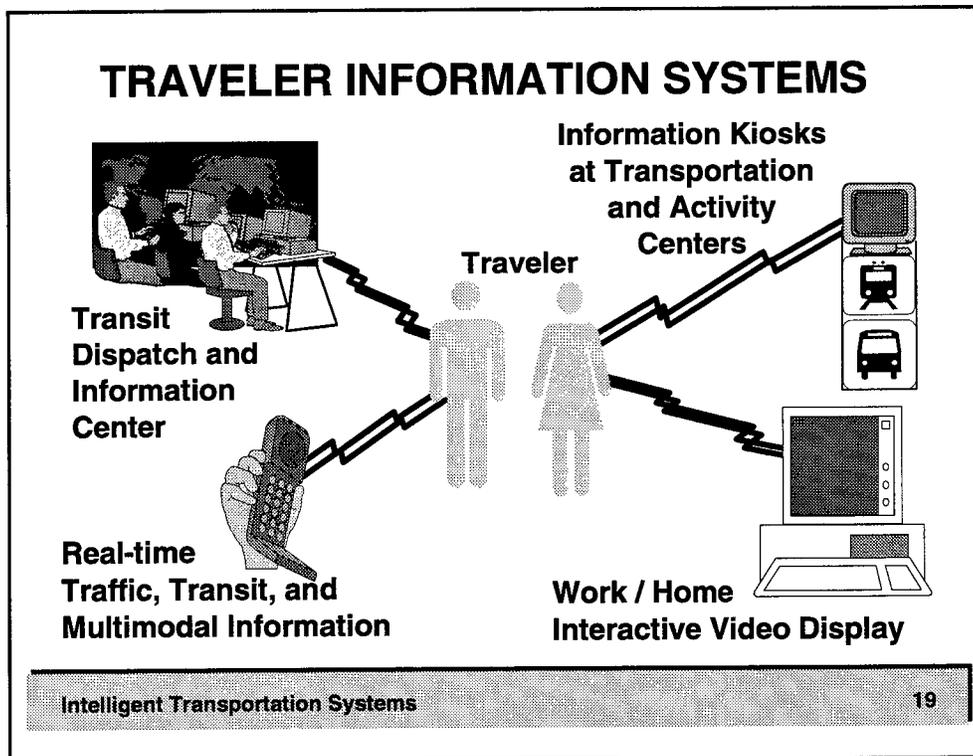
- In-vehicle units and AM/FM radio (traffic reports); Highway Advisory Radio (HAR)
- Kiosks at rest areas
- Watches and/or pagers that receive information and display it on the device
- Telephone

**Pre-Trip Traveler Information**

- Cable TV
- Interactive TV
- Internet
- Telephone / Fax

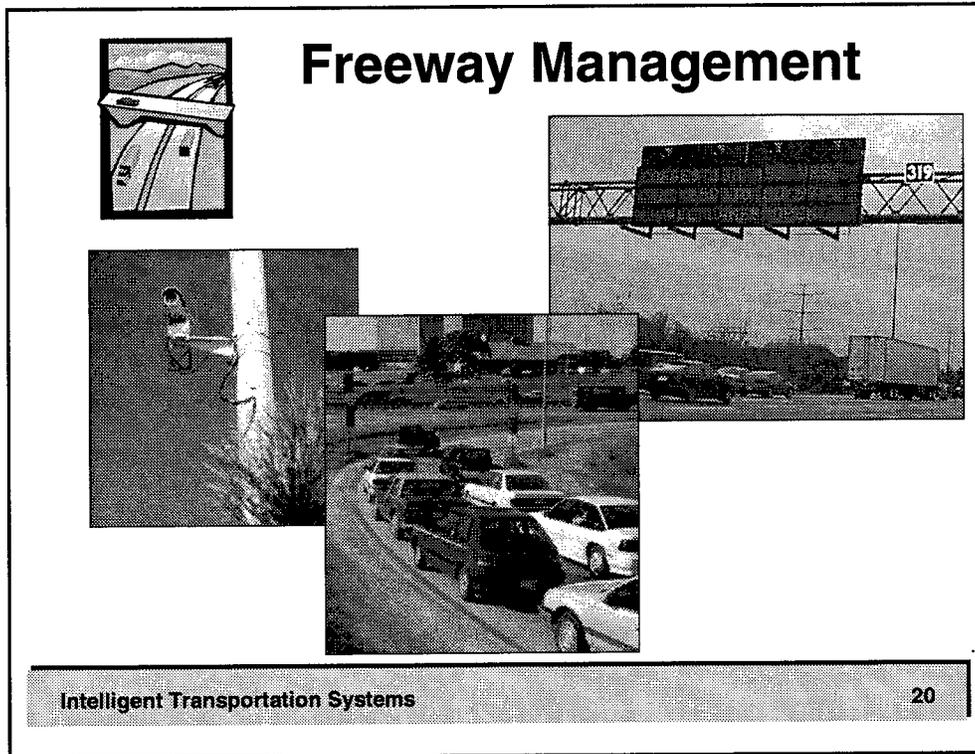
**Pictures (left to right)**

- Receiving information by
- 1) Cellular phone and watch
  - 2) Handheld personal device
  - 3) Internet
  - 4) In-vehicle device



### Slide 19 - Traveler Information Systems

- Advanced Traveler Information Systems (ATIS) includes a broad range of advanced computer and communication technologies designed to provide transit riders real-time information to make better informed decisions regarding their mode of travel, planned routes, and travel times. ATIS include in-vehicle annunciators/displays, terminal or wayside based information centers, kiosks, telephone information systems, cable and interactive TV, and the Internet.
- ATIS also can include Transportation Demand Management (TDM) strategies utilizing technologies to promote the use of existing transportation infrastructure to serve the increased demand for transit. These applications include strategies to promote ridesharing and coordinated transportation services among transit and non-transit providers.



**Slide 20 - Freeway Management**

*Know what is happening to maximize safe flow.*

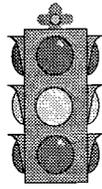
*Advanced Traffic Management Systems (ATMS)*

*Meter ramp traffic (as shown in left-most slide) can achieve smoother traffic flow on freeways by not allowing traffic to enter all at one time; stagger their entrance onto the freeway every couple of seconds.*

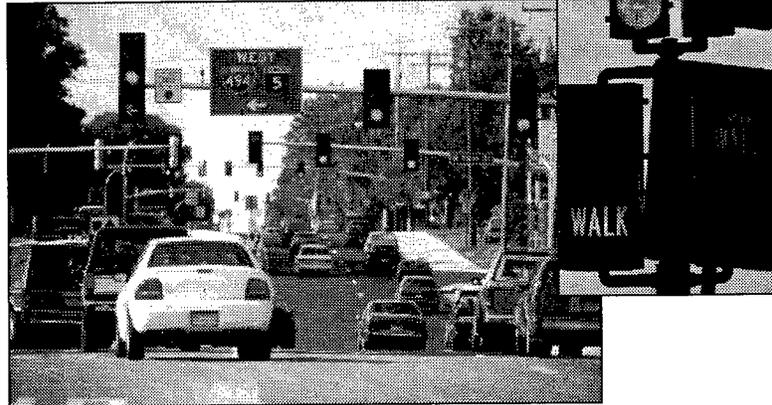
*Freeway Management goes hand-in-hand with incident management and emergency services component .*

*Pictures (left to right)*

- 1) Receiving roadway information by Closed Circuit Television*
- 2) Ramp metering/Flow signals*
- 3) Providing information to motorists by Dynamic Message Signs*



## Traffic Signal Control



Intelligent Transportation Systems

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### Slide 21 - Traffic Signal Control

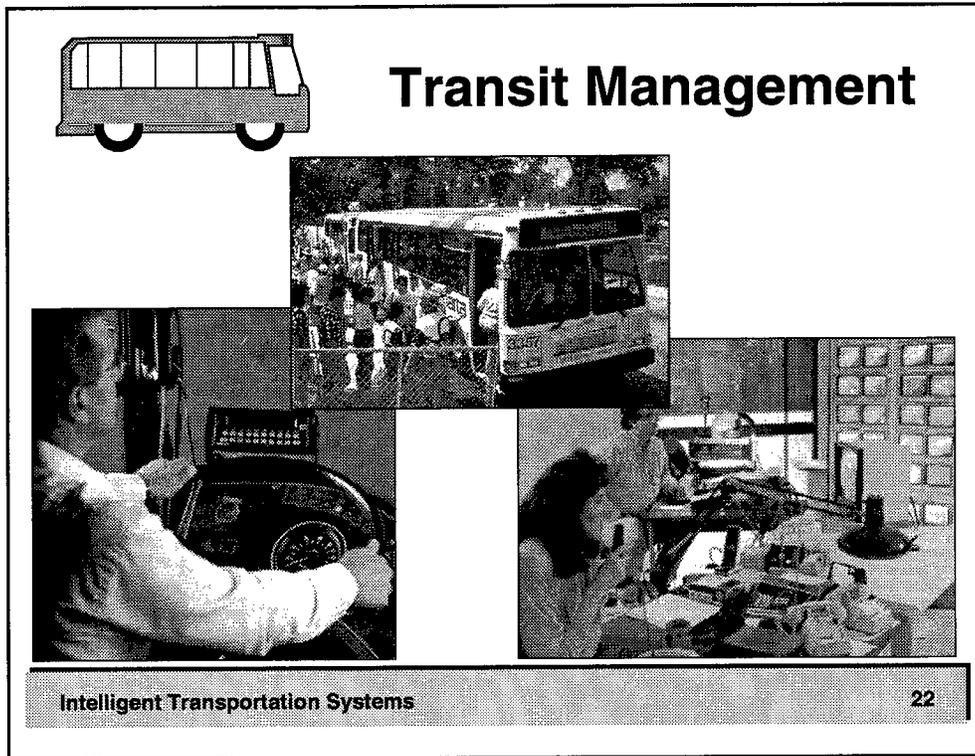
*Think of the last time the signals along your way home were goofed up and you suffered delays.*

*Signals should be retimed every 2 years to reflect current traffic flows.*

*Every signal within 0.4 to 0.8 kilometer (1/4 to 1/2 mile) of another should be interconnected (coordinated) and hopefully to a central computer system. If these things occur, you will not experience as much delay.*

*Coordination with freeway system (frontage roads and surface streets) can assist when handling an incident on the freeway and traffic diversion is necessary.*

*Are especially helpful to aid police and fire vehicles respond to an emergency.*



**Slide 22 - Transit Management**

*Operate our bus and rail systems as efficiently as possible.*

- *know where buses are at all times for security and schedule adherence AND to facilitate paratransit services.*
- *possibly include bus fleet systems*

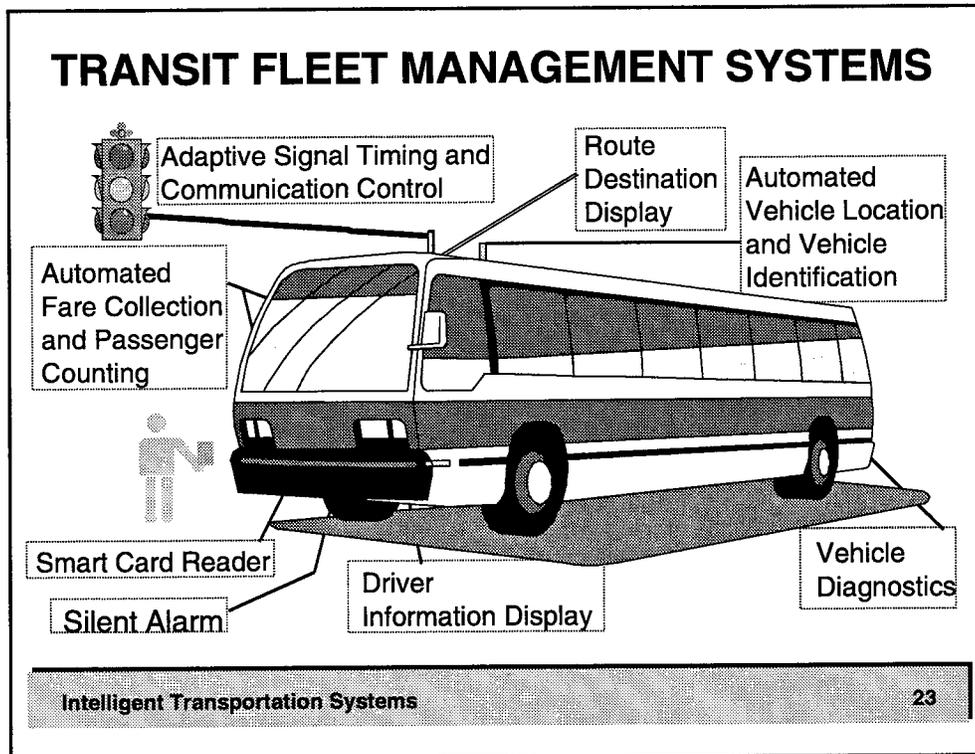
*Advanced Public Transportation Systems (APTS)*

*Components of system*

- *computer-aided dispatching*
- *automatic passenger counting*
- *automatic vehicle location*
- *advanced voice and data communication*
- *electronic payment*

*Picture on Right:*

*Transit Managers/Dispatchers*



**Slide 23 - Transit Fleet Management Systems**

Transit Management Systems focus directly on vehicles and operations, improving the efficiency and effectiveness of the services provided, and passenger safety.

Advanced technologies for fleet communication, vehicle positioning, automatic passenger counting, vehicle diagnostics, computerized demand responsive and fixed route transit reservation and dispatching, and transportation infrastructure control are applied by transit systems to improve the overall planning, scheduling, and operations of transit systems.

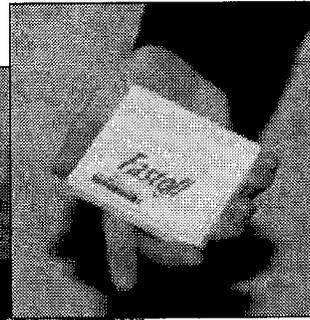
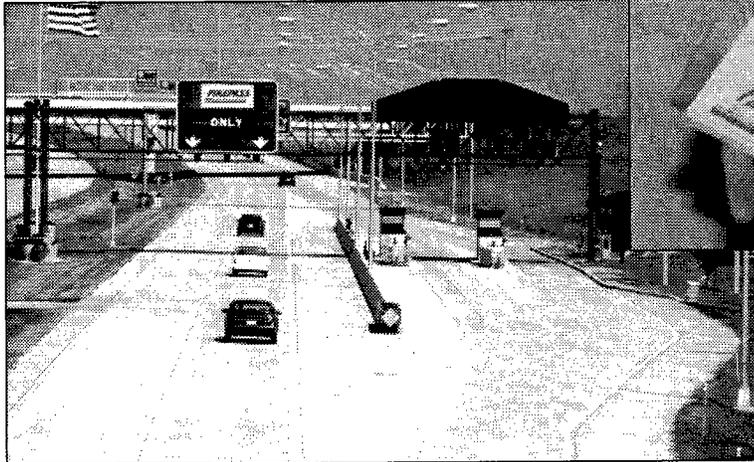
By making transit more efficient and reliable, it should be more attractive to prospective riders, transit operators, and the municipalities they serve.

Transit Management Systems encompass technologies that are used from the time the vehicle is pulled out for service in the morning to when the passenger enters the vehicle, all day when the vehicle is in operation, to when the vehicle is pulled into the service bays at night.

Whereas the fare payments and transit information technologies benefit the customer, the primary focus of transit management systems is on vehicle controls and monitoring, directly benefitting the transportation service provider, with indirect benefits to the traveler.



## Electronic Toll Collection



Intelligent Transportation Systems

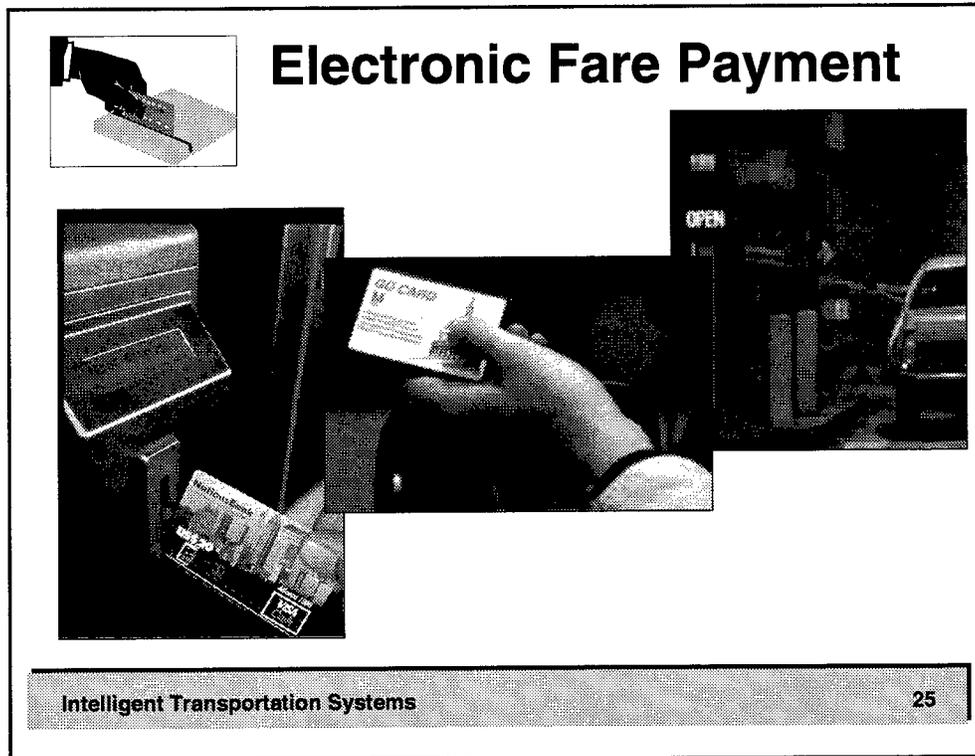
24

### Slide 24 - Electronic Toll Collection

*Where areas have toll facilities, electronic toll collection not only reduces delays to travelers, but also reduces the costs and security of counting coins.*

#### Pictures (left to right)

- 1) *PikePass system - Oklahoma (statewide)*
  - *two left lanes are for PikePass users - drive right by the toll booths - also have manual toll booths in the two right lanes*
- 2) *Transponder that is put on windshield - the system reads this card when the vehicle drives by. The computer chip stores account information. When you drive by the toll booth, it will tell you with a sign whether your account is low (less than \$10) (This is a "Fastoll" transponder from Northern Virginia's Dulles Toll Road system)*



### **Slide 25 - Electronic Fare Payment**

*In many situations, travelers have to pay as they use the system - at times they need to have exact change.*

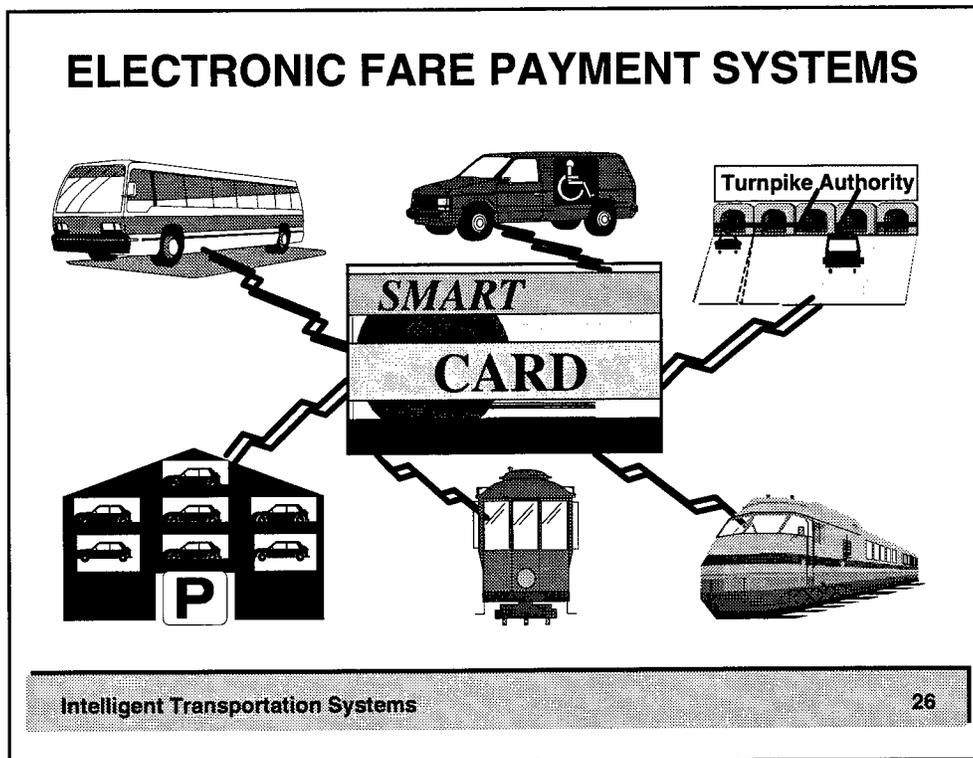
*Wouldn't it be nice to use your charge/banking card or some other electronic card?*

*The idea is to use a single card to pay bus, rail, parking, and even toll fares; works as a debit card.*

*Expedites transactions; eliminates need for cash.*

#### **Pictures (left to right)**

- 1) *Paying with a charge card to ride a bus in Atlanta*
- 2) *Electronic payment system for Washington, D.C.'s Metro train.*
- 3) *Electronic payment card for Washington, D.C.'s Metro system - use the "Go Card" to pay to ride the train, ride the bus, or pay for parking in park-and-ride lots.*
- 4) *Using an electronic card to pay at a toll booth*



**Slide 26 - Electronic Fare Payment Systems**

*Electronic Fare Collection Systems are advanced fare collection, format, and issuing technologies, designed to make fare payment more convenient for transit users and to simplify fare collection methods and processes. It eases cost and security to system operators by not having to collect and count cash.*

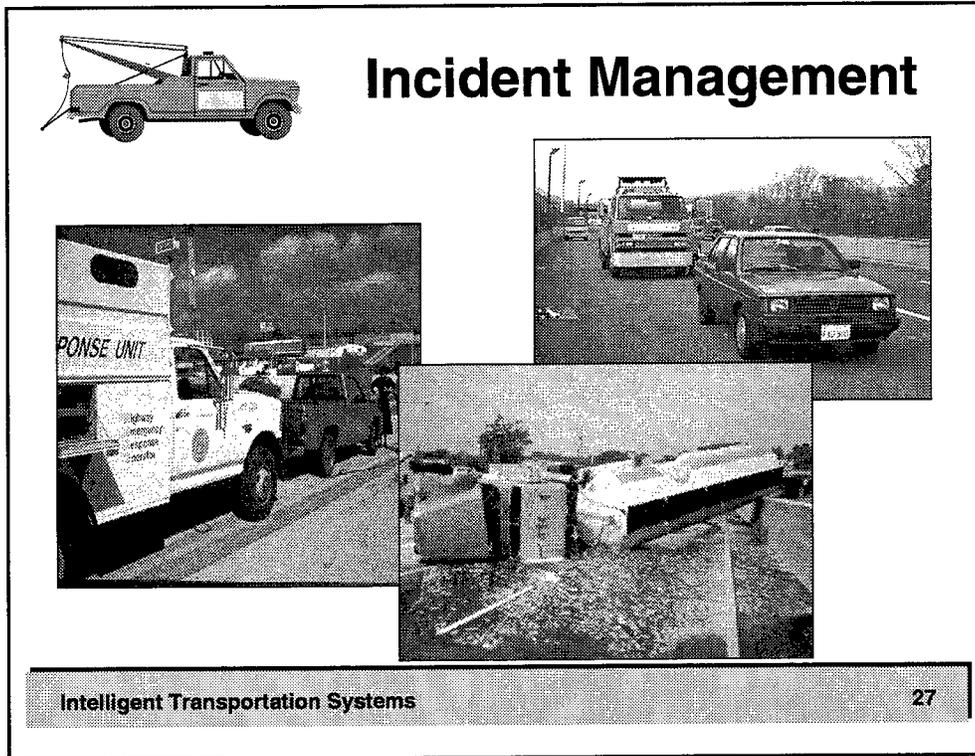
*These systems include fare media, ranging from magnetic strip cards to smart cards, their associated fare purchase, collection, and processing systems and equipment.*

*This illustrates the EFP/Smart Card applications:*

- Transit (bus, light rail, heavy rail, commuter rail)
- Paratransit (many times has a collection system different from fixed-route services)
- Taxis
- Parking (initially at transportation centers, park-and-rides)
- Highway Tolls

*While these applications are all transportation oriented, future uses of the "Smart Card" could be for shopping, no different than the credit card you and I are now carrying.*

*A number of credit card companies are examining the expansion of their card services to include fare/toll capabilities.*



**Slide 27 - Incident Management**

*Every minute an incident remains on the roadway causes an additional 5 minutes of delay after the incident is cleared.*

*Through an incident management system:*

- Detect the incidents (crashes, disabled vehicles, spilled debris, etc.)
- Determine the nature of the incident
- Notify the proper authorities
- Manage the scene safely
- Remove the vehicles as quickly as possible
- Reduce delay and possible secondary incidents.

*Think of what agencies might need to be involved in the management of an incident:*

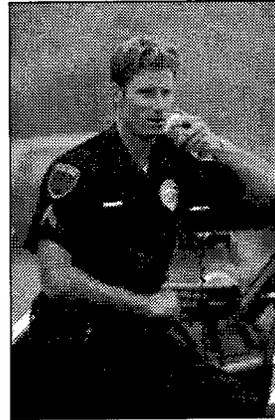
- police, fire, EMS, hazardous material team, state DOT, city transportation department, emergency management agency, medical examiner, traveler information agencies, etc.

Pictures (left to right)

- 1) *Emergency response unit - Atlanta*
- 2) *(bottom picture) Closing roadway during a major incident, re-routing traffic, clearing incident as quickly as possible*
- 3) *Virginia DOT's Highway Patrol - Northern Virginia (near DC)*



## Emergency Management



Intelligent Transportation Systems

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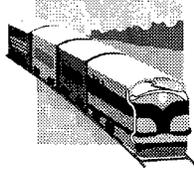
### Slide 28 - Emergency Management

*Getting the proper resources to the scene as quickly as possible.*

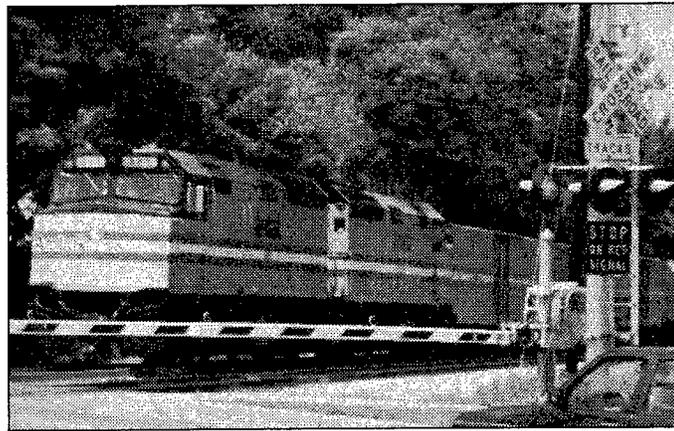
- Use vehicle location technologies to know where vehicles are
- Signal pre-emption to clear the way for emergency vehicle
- Geographical Information Systems to tell response teams where to go

*Works as part of an incident management strategy.*

*Critical to periodically assemble key personnel from various agencies to map out strategies, discuss roles and responsibilities, and find ways to enhance the process to improve efficiency and safety.*



## Highway Rail Intersection Safety



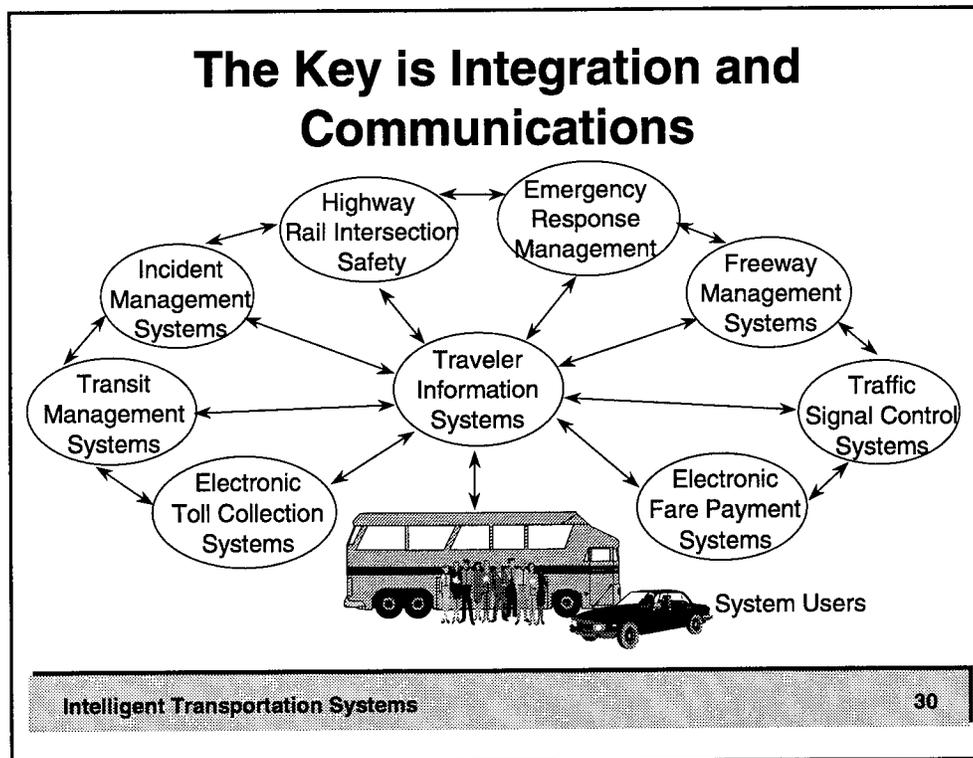
Intelligent Transportation Systems

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### Slide 29 - Highway Rail Intersection Safety

*We must make our highway/intersections as safe as possible.*

- In the future, ITS may warn drivers through an in-vehicle device on an on-coming train - can avoid fatal collisions and reduce delay.
- ITS can also warn train operators of automobiles or any objects obstructing their path. It is important that they receive such information quickly since it takes a heavy train a few miles until it can stop.



### Slide 30 - The Key is Integration and Communications

*Each successful alone, together a powerful system.*

*Example: Hurricanes, floods, snow, fires, earthquakes and other emergencies/disasters tend to uncover gaps in communication among emergency response agencies.*

#### 3 levels of integration:

- *Share information*
- *Provide travel info. to public, business, and commercial carriers*
- *Share control-part-time, weekend or evening, or full-time*

#### Example of integration vs. non-integration

- *Non-integration: stand-alone signal system*
- *Integration: pull example from case study*

*Discuss the importance of an ITS infrastructure to achieve this integration.*

*Mustard example- you wouldn't eat mustard by itself. You have to have the other "components" with it (bread, lunchmeat, etc.) for it to "work."*

- Do you see any common threads in the 9 components - information - need to share it!!
- What you've heard so far basically applies to urban areas. These solutions address our urban issues of congestion, delay, throughput, and transit.

## **Rural Issues**

### **Safety, Mobility, Transit**

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#### **ITS Enhancements:**

- **Incident management/Mayday system**
- **Transportation management in congested areas:**
  - *Tourist sites*
  - *Seasonal harvesting areas*
  - *Construction zones, etc.*
- **Integrated traveler information: tourist/road/weather/traffic conditions**

#### **Slide 31 - Rural Issues**

##### *Advanced Rural Transportation Systems (ARTS)*

- Need to clearly describe how ITS will enhance these areas
- Define “Mayday” system -GPS device to determine where that vehicle is, coupled with a system to call emergency services to find and aid you
- Paratransit - demand responsive transit - transit will provide rides to people who call and collect them (especially today for the elderly and handicapped)
  - With moving map technologies, it is easier for drivers to find their homes
- Seasonal harvesting - dramatic increase in “hauling” traffic causes spot congestion

## Major ITS Areas

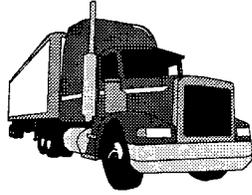
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- **Multimodal Travel Management and Traveler Information**
- **Commercial Vehicle Operations**
- **Advanced Vehicle Control and Safety Systems**

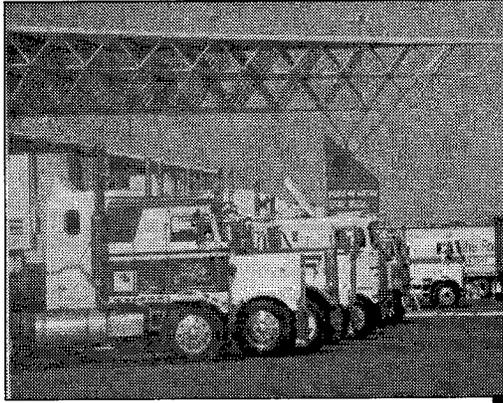
### Slide 32 - Major ITS Areas

(Highlighted - Commercial Vehicle Operations)

- *Describe CVO briefly and why it is important*
- *Private sector is already well ahead of public sector for CVO*
- *Importance of CVO operation for the economy*



## Commercial Vehicle Operations



Intelligent Transportation Systems

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### Slide 33 - Commercial Vehicle Operations

*Why make trucks stop every so often, especially when most are safe and legal?*

*Let's do our credential checking and weighing electronically at highway speeds.*

#### Pictures

*These are pictures of trucks waiting to cross an international border.*

*They even have a designated place for queuing as a holding area because the process is so slow!*

*(Picture on right - Inspection station at top left of the picture)*

## Commercial Vehicle Operations

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- **Achieve safe, simple, and cost-effective commercial vehicle operation through cooperation and advanced technologies**
- **Meet demands by:**
  - *Automating operations and technologies*
  - *Networking systems and information sources*
  - *Changing traditional public/private sector processes, roles and relationships*

### Slide 34 - Commercial Vehicle Operations

- Cooperation is needed within states, as well as between states and across international borders.
- Today, all commercial vehicles must stop at every weigh and inspection station, regardless of time of previous weight or inspection (intra-state trucks may stop at the same station 6 or 8 times per day).
- Safe and compliant commercial vehicles should be able to pass weigh and inspection stations and cross borders as easily as automobiles.
- Working together and using advanced technology, regulatory agencies and the motor carrier industry can achieve safe, simple, and cost-effective operations.
- The idea is to have a seamless system.

*Why do all of this? For at least some part of the delivery from factory to consumer, commercial trucking carries every product we use! We need to increase safety & efficiency for carriers in order to reduce commercial carrier costs. This keeps the cost of our potato chips (etc.) down and keeps American products globally competitive.*

*“If you’ve got it, a truck brought it.”*

# Commercial Vehicle Operations

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## ITS Enhancements:

- Commercial vehicle electronic clearance
- Automated roadside safety inspection
- On-board safety monitoring
- Commercial vehicle administrative processes
- Hazardous materials incident response
- Freight management
- International border crossing applications

### Slide 35 - Commercial Vehicle Operations

- Commercial vehicle electronic clearance can be achieved through the use of on-board transponders and electronic license plate readers. Once identified, safe and legal commercial vehicles may be electronically cleared to bypass weigh and inspection stations. Safety inspectors may signal any vehicle to be inspected.
- Portable computers are replacing pencil and clipboard for recording inspection information. This provides a reduction in inspection time and an electronic record that is sent to a database. Any other inspector may call up this record by entering the motor carrier DOT number. This type of electronic record provides the basis for improving safety and efficiency regarding administrative response.

# Commercial Vehicle Operations Benefits



- **Electronic Data Interchange (EDI):**

- *Improved safety monitoring*
- *Paperwork reduction*
- *Revenue collection improvement*



- **Electronic Screening/Weigh-In-Motion**

- *Stop only high-risk drivers/carriers/vehicles*
- *Simplify/speed up/reduce roadside inspections*

- **Electronic one-stop shopping**

- *Tax payments, licenses, and permits*

## Slide 36 - Commercial Vehicle Operations Benefits

- Commercial vehicles require license, fuel tax, insurance, and in some cases oversize/overweight permits. EDI allows information to be entered once and shared throughout regulatory agencies and the motor carrier. These records can also be checked by electronic screening devices, allowing safe and legal commercial vehicles to electronically clear weight and inspection sites. The ability to obtain licenses, permits, and pay taxes electronically is called one-stop shopping. It sure beats driving to three or four locations to obtain the same.
- The bottom line . . . Saves time and money!

## Commercial Vehicle Operations Benefits

- **Rover Vans**

- Perform safety inspections anywhere
- Portable computers simplify inspections



- **In-vehicle systems:**

- Equipment malfunction warning systems



- **Other:**

- Electronic toll collection keeps vehicles moving
- Cost-effectiveness



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### Slide 37 - Commercial Vehicle Operations Benefits

Rover vans are similar in concept to a police car with a radar unit to check “out of compliance” speeding motorists.

These electronically equipped vans can randomly pull commercial vehicles over at random sites to check the vehicle’s and driver’s conformance. This helps to increase safety through the ability to check commercial vehicles which may be using routes to avoid weigh station checks.

This electronically advanced van containing portable weigh-in-motion (WIM) equipment, a license plate reader, and reader for transponders. This equipment is portable and allows an enforcement officer to set up a weigh and inspection site in a location that does not have a permanent site. It can be set up in minutes and later relocated to another site as needed.

In-vehicle warning systems are designed to alert a driver of malfunctions (i.e., brakes overheating, air leaks, broken suspension, lights out, etc).

Electronic toll collection allows commercial vehicles to maintain speed, reducing brake wear, air pollution, drive train strain, and driver fatigue.

# Commercial Vehicle Information Systems and Networks (CVISN)



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## Slide 38 Commercial Vehicle Information Systems and Networks (CVISN)

\*\*\*CVISN brochure

*Commercial Vehicle Information Systems and Networks (CVISN) automate labor/time-intensive administrative tasks by integrating existing individual computer information systems owned/operated by motor carriers, industries, state governments, and the federal government.*

### Pilot States Selected:

*Washington/Oregon*

*California*

*Colorado*

*Minnesota*

*Michigan*

*Kentucky*

*Connecticut*

### CVISN Prototype States

*Maryland and Virginia*

## Major ITS Areas

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- **Multimodal Travel Management and Traveler Information**
- **Commercial Vehicle Operations**
- **Advanced Vehicle Control and Safety Systems**

### Slide 39 - Major ITS Areas

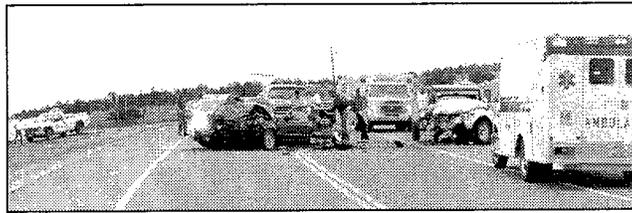
(Highlighted - AVCSS)

*Advanced Vehicle Control and Safety Systems are especially important from safety aspects:*

*Major segments of this part of the program*

- *Short-term solutions to safety problems in the collision avoidance program led by NHTSA*
- *Longer term solutions to congestion and safety in the Automated Highway System program led by FHWA*
- *Intelligent Vehicle Initiative*

# Collision Avoidance Program



- **Rear-End Collision Avoidance System**
- **Intelligent Cruise Control**
- **Road Departure Collision Avoidance System**
- **Lane Change/Merge Collision Avoidance System**

## Slide 40 - Collision Avoidance Program

### Rear-End Collision Avoidance System

*Alerts driver when a rear-end collision is imminent. This can occur because the vehicle ahead stops suddenly, or because the driver doesn't recognize that a vehicle ahead is stopped, such as occurs when approaching a queue formed by congestion. These systems will consist of a sensor (such as a radar) that senses the distance and relative speed to vehicles ahead, a computer to process the sensor data and make decisions about the need for a warning to the driver, and a driver interface to present the warning to the driver. The driver interface might include a head-up display and/or an audible message such as a distinct tone or a spoken message.*

### Intelligent Cruise Control

*Cruise control exists today, but you have to hit the brakes if you get too close to the vehicle in front of you. A precursor to rear-end collision avoidance systems will be an intelligent, or adaptive, cruise control system. This advanced system automatically adjusts vehicle speed when the vehicle ahead slows down or speeds up. The system also will reset to the original set speed when the path is clear. These systems will probably begin to be available to the buying public in the next 1 or 2 years.*

### Road Departure Collision Avoidance System

*Alerts driver when the vehicle is about to run off the roadway. The system will include the same three elements (sensors, processor, and driver interface) that were described for the rear-end collision avoidance system and will perform in a similar fashion. One mode of operation might be to mimic the sensation that drivers have today when they unintentionally drive onto the rumble strips that are being installed on the shoulders of many sections of interstate highways. These systems promise to be especially helpful for rural areas.*

### Lane Change/Merge Collision Avoidance System

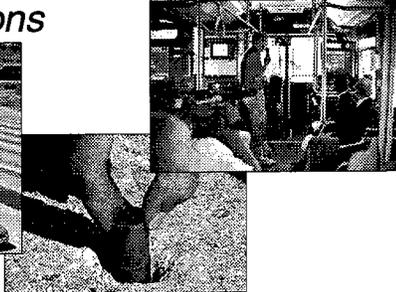
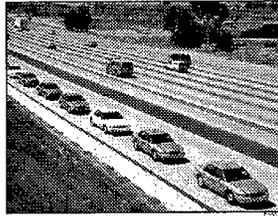
*This system alerts the driver if it is not safe to change lanes because there is another vehicle in the adjacent lane. It will perform in the same manner as the other collision avoidance systems.*

**Benefits** *A preliminary study of benefits estimates that if all vehicles on the road were equipped with these three collision avoidance systems, about 1.1 million collisions per year would be eliminated.*

# Automated Highway System

- **Demonstration - August 1997**

- San Deigo, CA
- Proof of Concept, Required by ISTEA
- Included a variety of technology demonstrations



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## Slide 41 - Automated Highway System

### *Demo used reversible lanes of I-15 in San Diego*

- A broad range of transportation decision makers and their ITS staffs, including States, localities, and MPOs were invited. There were opportunities to take rides in the demo vehicles, as well as an extensive accompanying exposition which told the story in terms of benefits, deployment paths, early spinoff applications, and related new products on the market.
- National Automated Highway System Consortium - a consortium of 100+ participants
- Attended by over 3,500 people from across the profession, worldwide
- Addressing safety, congestion, and the environment.
- Vehicle platooning, automatic steering, adaptive speed/cruise control, safety features, etc.

### Picture

- *In the platoon scenario, eight cars in a tight formation - 6.5 meters apart - at nearly 105 km/h traveled the demo course as coordinated unit with the vehicles "communicating" with each other 50 times per second.*
- *Sensor in the roadway*
- *Bus installed with equipment*

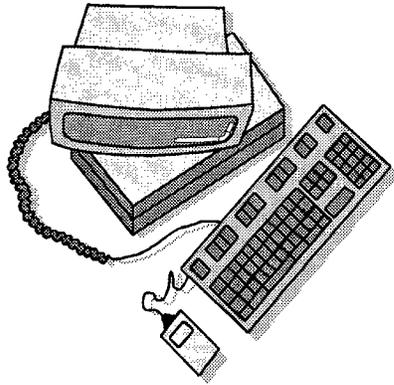
## Intelligent Vehicle Initiative

- **Merging of all vehicle-focused ITS activities**
- **Emphasizes the significant role of the driver in highway safety**
- **Develop and made available driving assistance and control intervention systems**
- **Applications for all types of vehicles on all types of highways**

### Slide 42 - Intelligent Vehicle Initiative

- Merging of all vehicle-focused ITS activities
  - *multi-agency research and development program*
- Emphasizes the significant role of the driver in highway safety
- Develop and made available driving assistance and control intervention systems
  - *objectives: to reduce motor vehicle crashes and increase traffic efficiency*
  - *integrate driving assistance and motorist information systems*
- Applications for all types of vehicles on all types of highways
  - *provisions: warning drivers, recommending control actions, intervening with driver control, introducing temporary or partial automated control in hazardous situations*
  - *sensors, processors, actuators, control systems, driver displays, information systems all integrated into the vehicle*

# Systems Architecture



- What is a “System”?
- What is an “Architecture”?
- What is a “Standard”?

Intelligent Transportation Systems

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## Slide 43 - Systems Architecture

Use analogy of computer throughout this slide

### **What is a system?**

Integrated collection of interrelated components that yields a product greater than the sum of the parts  
For example: a computer system. The computer will not give you any useful information unless you have a cpu, monitor, keyboard, disks (hard or floppy), software, and the wires to connect them.  
Can now link other things into this system - printer, scanner, LAN, modem, etc.

### **What is an architecture?**

Architecture definition - framework for describing information flows and physical arrangement - describes how the pieces fit together

What is the computer’s architecture?

Can have a “distributed” system or a “centralized” system

- Distributed system has many separate parts (separate components) and the centralized system (laptop) has the whole thing within one piece, but the information flows are the same (a “box” has it all in one)

### **What is a standard?**

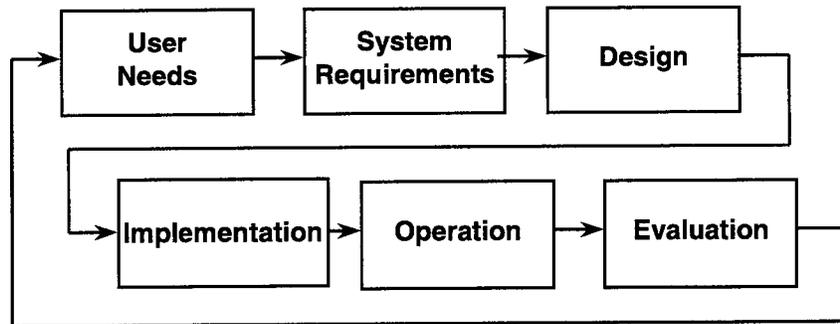
Standards definition - it ensures that pieces are interchangeable and interoperable - the information flowing through must be the same format for it to work

What are some standards on a computer?

For example, you don’t have to throw away your computer to get a new monitor (plugs are the same)

- You can use components from many vendors - (i.e., the Samsung monitor is compatible with the Compaq computer)

# Systems Engineering for ITS Deployment



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## Slide 44 - System Engineering for ITS Deployment

### *Transportation (Transit) example:*

Systems engineering is more critical in ITS than in other projects - especially involve users during development

- User needs
- |             |  |                                  |
|-------------|--|----------------------------------|
| Transit     | - Improve on-time reliability of buses           | - Prevent "bunching"             |
|             | - Provide quick response to emergencies          | - Coordinate passenger transfers |
| Paratransit | - Help drivers find customer pick-up points      |                                  |
|             | - Dispatch closest vehicle for on-demand transit |                                  |

Requirements - Know where your buses/paratransit vehicles are

Design - What technologies are required? A possible trade-off between requirements and costs

Differential GPS will provide location of buses, but signal may be blocked by tall buildings

Could use sign posts to supplement GPS in areas where the GPS signal is blocked

Is the added expense necessary, or is it OK if you "lose" a bus for a block or two? Will that still meet the basic requirement?

- Implementation
- Install the equipment on the buses
  - Install and test the software
  - Integration testing of the software and hardware

Operation - Need to consider training of personnel; warranty and maintenance issues

Evaluation - Determining whether the system adequately addresses the user needs

- What enhancements/expansions would be desirable?

### **ITERATIVE PROCESS**

- User needs evolve and are better understood through increasingly detailed levels of analysis
- Many activities are performed in parallel
- Iterative process continues throughout life cycle (system concepts, design reviews, modifications, users feedback)
- Most iterations SHOULD take place in the initial phases (planning and design)
- Consider all elements required to satisfy the user services and needs in an integrated manner
  - Human; Hardware; Data/information; Software; Institutional

## The National ITS Architecture

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- National interoperability
- Promotes use of off-the-shelf equipment
- A lot of this work is done for you

**<http://www.its.dot.gov>**

(see architecture link)

### Slide 45 - The National ITS Architecture

*The National ITS Architecture provides framework/Big Picture; provides guidance on how jurisdictions can think regionally while implementing locally:*

- Identifies interfaces
- Is implemented through the development of standards to allow interoperability
- Strongly linked to the issue of integration
- Framework for describing information flows and physical arrangement - describes how the pieces fit together

*Result: is open-ended framework; identifies where standards are needed; promotes use of modular, off-the-shelf products; builds on existing transportation and communications infrastructure; for more info: [www.rockwell.com/itsarch](http://www.rockwell.com/itsarch)?*

#### Architecture development:

*Minimize risks*

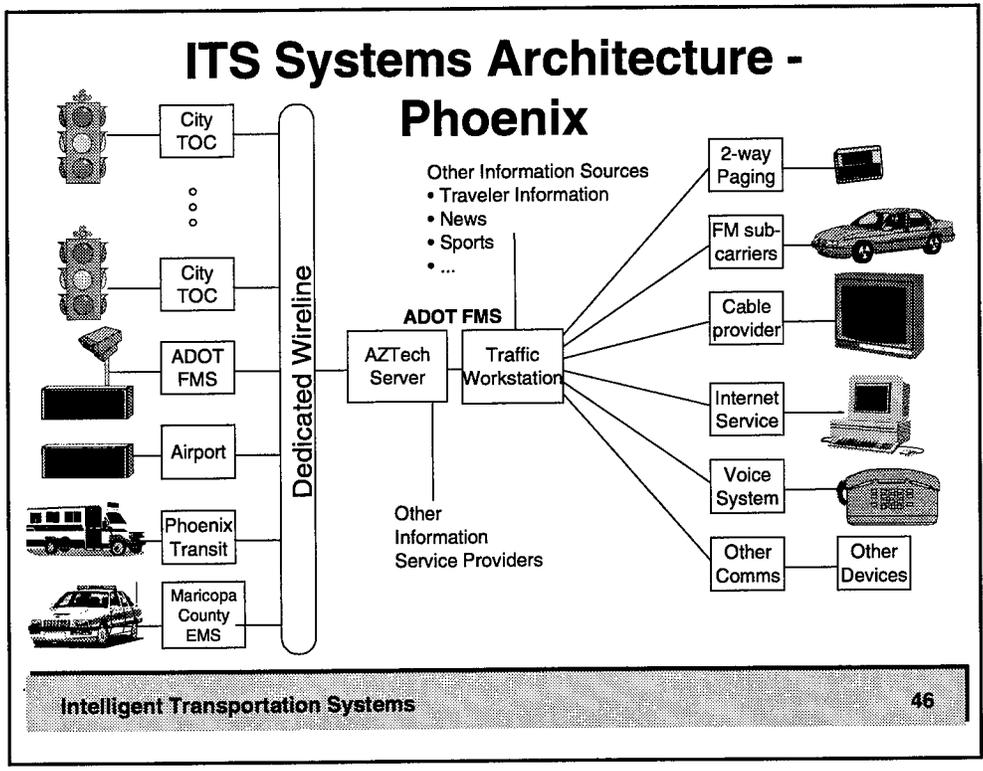
*Fully engage all major stakeholders*

*Eliminate duplication*

*Systems integration*

*Standards*

*Promotes use of modular, off-the-shelf hardware and software so that it doesn't have to be built or developed for each system*



**Slide 46 - ITS Systems Architecture - Phoenix**

The City Traffic Operations Center, Arizona DOT, Airport, etc. are all connected by dedicated wireline. Information from these systems is received by the ADOT Freeway Management System, where they process the data and distribute the information to traveler via paging, FM subcarriers, cable tv, etc.

**NTCIP National Transportation Communications  
for ITS Protocol**

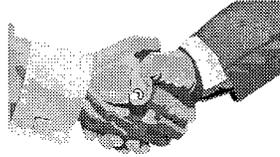
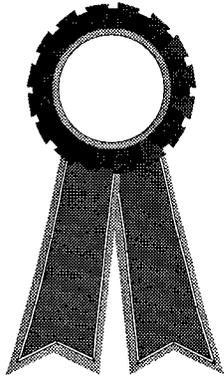
- **Objective: to provide a communications standard that ensure the interoperability and interchangeability of traffic control and ITS devices**

**Slide 47 - NTCIP**

Objective: to provide a communications standard that ensures the interoperability and interchangeability of traffic control and ITS devices.

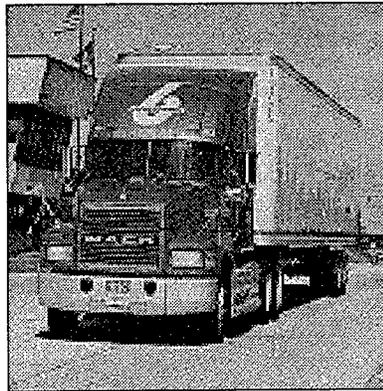
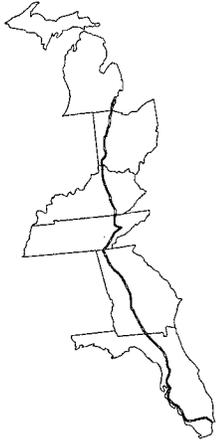
*The first protocol for the transportation industry that provides an interface between disparate hardware and software products.*

*This effort not only maximizes the existing infrastructure, but it also allows for flexible expansion in the future, without reliance on specific equipment vendors or customized software.*



## **SUCCESS STORIES**

## ADVANTAGE I-75



- 29 weigh station sites
- Over 90 carriers, more than 4,000 trucks

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### Slide 49 - Advantage 75

#### *Project Description:*

*Long lines of trucks waiting to be processed at state weigh stations may soon be a thing of the past. Advantage I-75 is testing a mainline automated clearance system (MACS), to process trucks electronically, thus eliminating the need to stop at multiple weigh stations during a trip in this corridor. With MACS, participating trucks can have their weight and credentials checked at highway speeds without exiting the mainline. Trucking participants are volunteers, selected from a list of applicants based on their safety records and vehicle inspection programs.*

*Minimizes stopping for safe and compliant vehicles*

*Compliance - properly licensed driver, properly registered vehicle, fuel tax paid, insurance requirement met*

*Safe - the vehicle is safe to operate*

#### Pictures

*Commercial vehicle passing a weigh and inspection station*

# Montgomery County, MD ATMS



- **Transit Management System co-located with Traffic Signal Control System**
- **Traveler Information Services:**
  - Changeable Message Signs
  - Cable TV
  - Highway Advisory Radio

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## Slide 50 - Montgomery County, MD ATMS

- They are particularly unique in that their Transit Management System is in the same room as their Traffic Management Center. Their staffs note that they receive some of their greatest benefits with the arrangement of their transit and traffic managers being able to interact on a daily basis. It helps both systems to run more smoothly when they can easily exchange information.
- They are a major “player” in the new Regionwide Metropolitan Washington Traveler Information Services Project (under development) - numerous partners in this project.

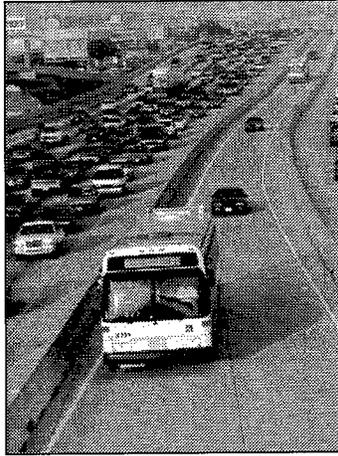
### Pictures

*(Top) - Traffic and Transit Management Center*

*(Bottom Left) - This is a picture from Montgomery County's cable channel. It continuously shows video of various roads and intersections within the county. It also displays major incident information on the screen (as shown on this picture)*

*(Bottom Right) - Automated sign control - this picture, for example, shows the left lane is left-turn only and the middle lane is thru only. At other times of the day, this may change to left turn and through for the middle lane to accommodate higher left-turn volumes.*

# Houston TranStar



- Pooled resources
- Regional Emergency Management Center
- Use toll tags for surveillance

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## Slide 51 - Houston TranStar

### Pooled resources:

*Consortium of 4 agencies (TxDOT, METRO, Harris County, city of Houston). The center is operated by an executive director and staff hired by the four agencies and answers to an executive committee composed of CEOs of the four agencies.*

*Administered on a daily basis by an executive director and 4 full-time TranStar employees.*

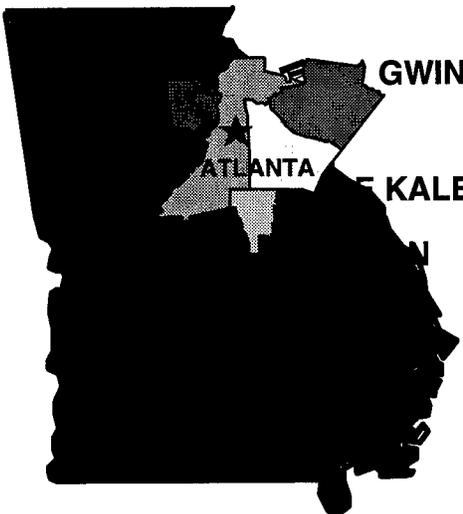
### Regional emergency center:

*One part of the center serves as an emergency management facility - Set up as a stand alone disaster center (their own water supply, electrical generator, kitchens, etc.) for every agency that participates in natural disasters (i.e., hurricanes) - the command post.*

### Toll tags:

*They have installed additional toll tag readers on various non-toll highways around the metropolitan area. Many vehicles in Houston are equipped for electronic toll collection with transponders. By using these vehicles as probes, they can determine average roadway speeds regionwide. This speed information is provided to the public on a web site.*

# Atlanta



- **Distributed System**
- **Functionally Identical**
- **Multimodal Traveler Information**
- **Showcase Devices**

**Intelligent Transportation Systems** 52

## Slide 52 - Atlanta

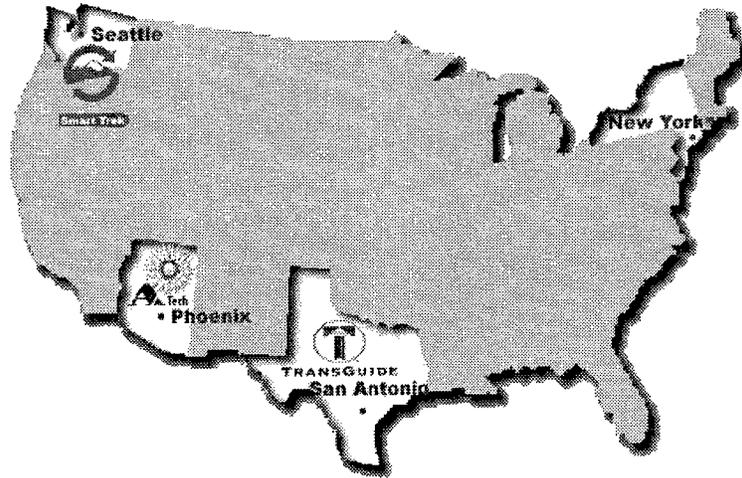
- Technology allows distributed network and distributed operation - provides improved reliability (protection from catastrophic failure). On a daily basis, each control center controls their own components/area (each star); however, when one control center is not staffed, any of the other control centers can, by agreement, assume control. Any of the centers can view and control each other's cameras. This has been very successful.
- All centers have a common functionality and use identical digital maps and databases, which facilitate providing information to the public. The projects were designed to work together as a single system.
- Required only one software development effort - instead of different software for each control center.
- Some of this traffic and transit information was provided to travelers through an extensive traveler information distribution system.

### Background Information

#### Current Participating Agencies:

- Georgia DOT: Statewide Management Center  
Highway Emergency Response Operators (HEROs)  
High-Occupancy Vehicle lanes
- Metropolitan Atlanta Regional Transportation Authority (MARTA)
- City of Atlanta: Traffic Engineering  
Atlanta Police Department
- Gwinnett, Clayton, Fulton, DeKalb, and Cobb Counties
- Georgia Emergency Management Authority
- Georgia Net: Statewide information network; kiosks

## Metropolitan Model Deployment Initiative



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### Slide 53 - Metropolitan Model Deployment Initiative

Purpose: Compare the MDI to model homes

Like a model home in a new subdivision, the metropolitan area model deployments will be showcased where the traveling public and local officials can see and experience the benefits of a fully deployed intelligent transportation infrastructure. All the capabilities of a regional, multimodal transportation management and traveler information system will be featured at these model deployment sites.

**Phoenix, AZ (Aztech):** Integrated transportation management system that coordinates freeway and traffic signal systems across jurisdictional boundaries

- Private-sector partners to manage traveler information component

**San Antonio, TX (TransGuide):** Co-location of TxDOT, city traffic operations, transit dispatch services, police, traffic and police and fire emergencies

- Intelligent Vehicle Registration Tags as traffic probes

**Seattle, WA (TimeSaver):** Intermodal transportation management. Integrated, real-time highway and transit information services through private sector partners. North Seattle Advanced Traffic

- Management System links traffic signal systems of 15 jurisdictions

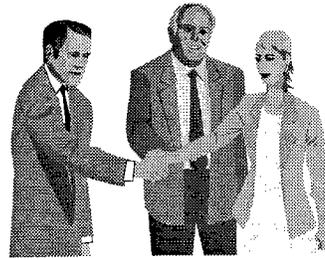
**New York City, NY/NJ/CT (TRANSCOM):** Current information on traffic conditions. Regional, multi-agency transportation management system connected to “virtual” transportation management center

- Personalized information available to public for a fee through private-sector partner

## ITS Career Opportunities

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- **ITS = High-Tech Jobs**
- **Career Goal: Improve the safety and responsiveness of the nation's transportation system**
- **Not limited to civil engineering**



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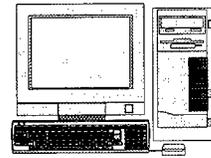
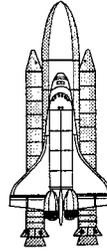
### Slide 54 - ITS Career Opportunities

- ITS = High-Tech Jobs
- Career Goal: Improve the safety and responsiveness of the nation's transportation system
- Not limited to civil engineering

*The landscape of transportation is changing. No longer are only civil engineers with transportation backgrounds suited for careers in the industry. With the emergence and application of technology to the infrastructure, individuals with new and diverse knowledge, skills, and abilities (KSAs) are needed to plan, design, build, operate, and maintain the complex infrastructure of the 21st century.*

## ITS Opportunities: Specialists

- Aerospace Engineers
- Environmentalists
- Systems Engineers
- Computer Scientists
- Communications Engineers



Intelligent Transportation Systems

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### Slide 55 - ITS Opportunities: Specialists

- Aerospace Engineers
- Environmentalists
- Systems Engineers
- Computer Scientists
- Communications Engineers

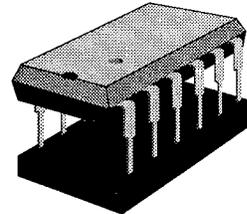
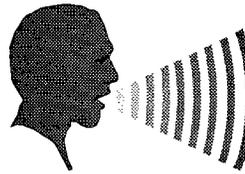
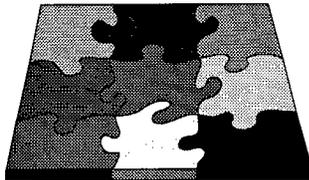
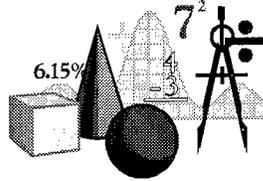
*Each of these specialists have a role to play in ITS, as evident by the information and technologies discussed in this session.*

*Other fields of study for careers in ITS are:*

- Economics
- Political Science
- Modeling/Simulation
- Logistics
- Statistics
- Anthropomorphics
- Cognition
- Marketing

## ITS Opportunities: Required Skills

- Engineering
- Electronics
- Communications
- Systems Integration



Intelligent Transportation Systems

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### Slide 56 - ITS Opportunities: Required Skills

- Engineering
- Electronics
- Communications
- Systems Integration

*Together, working as a team, individuals with these skills are necessary to plan, design, build, operate, and maintain the infrastructure being put in place today. These skills are critical to ensuring mobility in the next century.*

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## APPENDIX C: MODULE EXERCISES

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## **ITS MODULE EXERCISES**

- (1)** Conduct research (e.g., visit Internet site, read articles and reports, etc.) on five different transportation management centers that provide real-time traffic information to users. Use the attached list of Internet sites as a starting point.
  
- (2)** For each of the five TMCs you select, provide the following:
  - the name of the city and/or region served by the TMC;
  - a list of the different types of technologies (including an estimate of the number of each) used to obtain real-time traffic information;
  - a list of the types of real-time traffic information that are provided to users of the system served by the TMC;
  - a list and description of any additional information provided to users other than real-time traffic conditions; and
  - a list of the different entities (e.g., public agencies, private companies, etc.) that are involved in or part of the TMC cooperative effort.
  
- (3)** Provide a brief discussion comparing and contrasting the five centers you chose. This discussion should include your opinions on the quality of the information provided by the TMC and suggestions for improvement. Rank the five centers you researched in order of overall quality and justify your ranking.

## ITS MODULE EXERCISES

### Transportation Management Center and Real-Time Traffic Internet Sites

Accuttraffic	<a href="http://www.accuttraffic.com">www.accuttraffic.com</a>
Atlanta	<a href="http://www.atlanta-traveler.com/traffic">www.atlanta-traveler.com/traffic</a>
Boston	<a href="http://www.smartraveler.com">www.smartraveler.com</a>
British Columbia	<a href="http://www.th.gov.bc.ca/bchighways/jump3.htm">www.th.gov.bc.ca/bchighways/jump3.htm</a>
Cape Cod	<a href="http://www.capecodusa.com/cams.asp">www.capecodusa.com/cams.asp</a>
Chicago	<a href="http://www.ai.eecs.uic.edu/GCM/CongestionMap.html">www.ai.eecs.uic.edu/GCM/CongestionMap.html</a>
Cincinnati	<a href="http://www.smartraveler.com">www.smartraveler.com</a>
Detroit	<a href="http://www.campus.merit.net/mdot">www.campus.merit.net/mdot</a>
Georgia	<a href="http://www.georgia-traveler.com">www.georgia-traveler.com</a>
Honolulu	<a href="http://www.eng.hawaii.edu/~csp/Trafficam">www.eng.hawaii.edu/~csp/Trafficam</a>
Houston	<a href="http://traffic.tamu.edu">traffic.tamu.edu</a>
Kansas City	<a href="http://www.kctv5.com/weather/citycam.htm">www.kctv5.com/weather/citycam.htm</a>
Lexington, KY	<a href="http://www.lfucg.com/trafficw/trafinfo.htm">www.lfucg.com/trafficw/trafinfo.htm</a>
Long Island	<a href="http://www.trafficam.com">www.trafficam.com</a>
Los Angeles	<a href="http://www.maxwell.com/caltrans/la">www.maxwell.com/caltrans/la</a>
Manitoba	<a href="http://www.umtig.mgmt.umanitoba.ca">www.umtig.mgmt.umanitoba.ca</a>
Maryland	<a href="http://www.chart.state.md.us">www.chart.state.md.us</a>
Milwaukee	<a href="http://www.jsonline.com/traffic">www.jsonline.com/traffic</a>
Minneapolis	<a href="http://www.trafficview.twincities.sidewalk3.com">www.trafficview.twincities.sidewalk3.com</a>
Montgomery County	<a href="http://www.dpwt.com/TraffPkgDiv/index.html">www.dpwt.com/TraffPkgDiv/index.html</a>
New York City	<a href="http://www.metrocommute.com">www.metrocommute.com</a>
Ontario	<a href="http://www.mto.gov.on.ca/english/traveller/compass">www.mto.gov.on.ca/english/traveller/compass</a>
Philadelphia	<a href="http://www.smartraveler.com">www.smartraveler.com</a>
Philadelphia	<a href="http://www.trafficam.com">www.trafficam.com</a>
Orange County, CA	<a href="http://www.maxwell.com/caltrans/oc">www.maxwell.com/caltrans/oc</a>
Phoenix	<a href="http://www.azfms.com">www.azfms.com</a>
Pittsburgh	<a href="http://www.ontv.com/parkway">www.ontv.com/parkway</a>
San Antonio	<a href="http://www.transguide.dot.state.tx.us/map">www.transguide.dot.state.tx.us/map</a>
San Diego	<a href="http://www.maxwell.com/caltrans/sd">www.maxwell.com/caltrans/sd</a>
San Francisco	<a href="http://www.etaktraffic.com">www.etaktraffic.com</a>
San Francisco	<a href="http://www.web2.kpix.com/traffic">www.web2.kpix.com/traffic</a>
San Jose	<a href="http://www.ci.san-jose.ca.us/traffic">www.ci.san-jose.ca.us/traffic</a>
Seattle	<a href="http://www.trafficview.seattle.sidewalk1.com">www.trafficview.seattle.sidewalk1.com</a>
Seattle	<a href="http://www.ivhs.washington.edu/trafnet">www.ivhs.washington.edu/trafnet</a>
Toronto	<a href="http://www.skywords.com/realtime.html">www.skywords.com/realtime.html</a>
Washington, DC	<a href="http://www.smartraveler.com">www.smartraveler.com</a>
Wilmington, DE	<a href="http://www.trafficam.com">www.trafficam.com</a>

### Other Internet Sites of Interest

U.S. Department of Transportation	<a href="http://www.dot.gov">www.dot.gov</a>
Federal Highway Administration	<a href="http://www.fhwa.dot.gov">www.fhwa.dot.gov</a>
Federal Transit Administration	<a href="http://www.fta.dot.gov">www.fta.dot.gov</a>
Bureau of Transportation Statistics	<a href="http://www.bts.gov">www.bts.gov</a>
ITS America	<a href="http://www.itsa.org">www.itsa.org</a>
Institute of Transportation Engineers	<a href="http://www.ite.org">www.ite.org</a>
Transportation Research Board	<a href="http://www.nas.edu/trb/index.html">www.nas.edu/trb/index.html</a>