Module 1: Introduction to ITS

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Introduction

Imagine a world where transportation systems provide real-time information for every available mode of travel, allowing commuters to make informed decisions about their next trip to minimize time and cost; where technology monitors the flow of vehicles, people, and goods to maximize efficient movement and minimize fuel consumption and vehicle emissions; or where, in the face of an impending hurricane, transportation operations are changed to accommodate mass evacuations between States through electronic monitoring, transit, and traffic control. Even more exciting is a world where vehicles monitor the conditions and traffic around them to warn drivers of weather changes, traffic congestion, and potential hazards or a world where vehicles drive themselves, eliminating crashes and maximizing system capacity. The technology to deliver that world exists today in the field of intelligent transportation systems (ITS), which brings diverse disciplines together to deliver safe, efficient, and sustainable transportation.

ITS technology enhances investments in transportation infrastructure and supports the management and operation of a system that is essential to the economy and social fabric of our nation. Transportation agencies, private sector technology developers and vendors, and professionals from a wide array of disciplines come together through ITS to enhance local, regional, and multimodal transportation systems. For example, active traffic management (ATM) provides advance notice of traffic conditions to motorists using variable speed limit signs, lane management signs, and overhead message signs that warn drivers of congestion or collisions. As a result, the I-5 corridor in Seattle, WA, and other regions adopting this strategy have experienced reductions in collisions, reduced congestion, and enhanced emergency response and emergency management. On the eastern seaboard of the United States, the I-95 Corridor Coalition provides comprehensive and continuous travel time information on freeways and arterials using probe technology that runs from New Jersey through Florida. To facilitate safe and efficient evacuations, transportation engineers in metropolitan areas such as Washington, DC, are devising methods to allow transit vehicles priority access at traffic-controlled intersections during evacuations in which no police assistance is available. With the advent of connected vehicle technology, researchers, automobile manufacturers, communication providers, and State and local agencies are coming together to build a technological platform that will enable a connected, data-rich travel environment that will reduce crashes, decrease congestion, and facilitate environmentally friendly travel choices.

Adaptive Signal Control Technology: An ITS Success Story

(Extended Text Description: This image uses time-lapse photography to demonstrate adaptive signal control technology. The image shows a busy intersection, with each roadway featuring multiple lanes of traffic. Three directions of traffic are stopped at the intersection, and one direction is shown as streaks of yellow light, with some streaks continuing straight through the intersection and some turning to the right at the intersection.)


Adaptive signal control technology (ASCT) uses real-time traffic information to cut costs and reduce congestion, improve traffic flow, and reduce vehicle emissions. ASCT collects and evaluates traffic data and uses the data to develop and implement signal timing to improve traffic flow. By continually collecting information and updating signal timing to reflect current traffic conditions, ASCT can respond to traffic incidents, special events, recurring traffic congestion, and construction impacts to reduce delays and improve system efficiency. According to the Texas
Transportation Institute, traffic congestion costs $87.2 billion in wasted fuel and lost productivity, or $75 per traveler. On average, ASCT improves travel time by more than 10 percent, reducing delays, fuel consumption, and labor costs.

Other ASCT resources are available at the following sites:

- Adaptive Traffic Control in Los Angeles Video
- ASCT Case Studies
- Training

The coming of age of ITS in the 21st century provides unprecedented opportunities to monitor, evaluate, and manage multimodal transportation systems to sustainably maximize safety, efficiency, and user convenience in a complex environment. Modern transportation systems support national, regional, and local economies, providing access to employment, goods, and services. The ability to manage and operate these complex systems efficiently and effectively to meet economic, social, and mobility needs depends on strategic ITS technology applications. ITS has evolved over several decades—from early initiatives in traffic operations and intelligent vehicle highway systems to current practices in systems management and operations to emerging applications such as connected vehicle technologies and active traffic and demand management (ATDM). ITS applies a variety of technologies to monitor, evaluate, operate, and manage transportation systems to enhance efficiency, reliability, and safety.

ITS is redefining how transportation agencies and managers think about system investment and operation. It changes the role of agencies and expands the opportunity to coordinate and collaborate across systems, disciplines, and industries. ITS applies technologies developed by industry, university, government, and military researchers and inventors to maximize transportation system safety and efficiency.

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**ITS Overview**

ITS applies information, technology, and systems engineering principles to the management and operations of surface transportation facilities and systems, including freeways, arterials, and transit. It provides numerous benefits to transportation systems management and operations. ITS is an engineering discipline that encompasses the research, planning, design, integration, and deployment of systems and applications to manage traffic and transit, improve safety, provide environmental benefits, and maximize the efficiency of surface transportation systems. This field includes strategic planning; systems architecture; multimodal and multijurisdictional integration of technology, data, and communications interoperability; real-time data monitoring; and timely and accurate user information.

ITS stakeholders are multidisciplinary, representing a broad spectrum of user types and technical experts who, together, develop and constitute the ITS discipline. Each stakeholder brings perspective and knowledge to the profession, and this diversity is necessary to plan, develop, implement, manage, and maintain multimodal ITS. Civil, electrical, computer, and systems engineers; roadway and transit planners; logistics, policy, finance, and management experts; multimodal users; maintenance and operations professionals; public safety and emergency responders; and members of other disciplines that use and support transportation facilities and systems are all integral to the ITS discipline. Each stakeholder is part of a complex and collaborative team that envisions, deploys, and manages ITS.

Transportation systems include multiple modes (such as automobiles, transit, freight, bikes, and pedestrians) and facility types (such as highways, arterials, fixed guideways, dedicated bikeways, sidewalks, and multimodal facilities). ITS has evolved to encompass programs, applications, and coordination across modes and facility types, thereby increasing the system's complexity and providing an opportunity to apply systems engineering to support multimodal ITS.

Integrated corridor management (ICM) is an example of a systems approach to transportation management that integrates freeways, parallel arterials, high-occupancy facilities, and transit services to optimize a network of facilities and services. This shift from individual facilities to networks and systems can be seen in Dallas, TX, where ICM strategies in the Route 75 corridor, including combined route and mode diversion strategies for incidents, high-occupancy vehicle/high-occupancy toll strategies, smart parking systems for light rail transit, and advanced traveler information systems have been implemented. Oakland, CA, is coordinating operations of existing I-880, arterials, rails, and bus transit networks through an integrated transportation system that balances real-time demand and supply. These ICM systems increase system capacity, reliability, and safety, while reducing congestion, fuel consumption, and vehicle emissions.

Systems engineering provides a framework for the development and application of successful ITS systems. By focusing ITS on customer needs and required functionality, systems engineering integrates multiple disciplines in a
structured development process that considers business and technical needs. Systems engineering has provided a foundation for ITS development, leading to the National ITS Architecture that guides ITS from a concept of operations to application deployment.

Transportation Challenges

Over the past 30 years, the demand for the use of public roads has increased approximately 95 percent, as measured in vehicle miles traveled (VMT). Over this same time the number of lane miles on public roads has increased less than 9 percent. These statistics indicate a sharp rise in demand while capacity, in terms of the number of lane miles, has stayed relatively constant. Although economics, changes in commuting patterns through flextime and telecommuting, and increasing availability of transit options have slowed the growth in VMT, vehicle miles traveled continue to grow. The graph below shows the percentage of increase in VMT over a 30-year period and the corresponding increase in capacity. To meet the increasing demand, transportation agencies must manage existing lane miles to maximize safety and efficiency. ITS offers a wide variety of management and operation tools to address increasing demand while enhancing safety and using technology to maximize facility throughput.

Figure 1. Trends in Capacity and Demand

![Percent Change 1980-2010](image)


Although funding for highways and public transportation almost doubled every 10 years from 1980 to 2000, limited funding and increasing pressure to do more with less at the beginning of the 21st century have significantly reduced the funding available for highways and public transportation through the U.S. Highway Trust Fund. This reduced growth in funding, seen in the graph below, also increases the need to improve the efficient operation of limited infrastructure and to find new and innovative ways to safely manage the existing transportation system. ITS technologies support operational strategies such as ATM and ICM to address congestion and system reliability.

Figure 2. Highway Trust Fund Expenditures (in billions)
Public transportation ridership increased in the first decade of the 21st century, providing opportunities to move more people within current and expanded infrastructure. According to the American Public Transit Association (APTA), nearly 60 percent of public transportation trips are commuter trips, and as employment increases, so too does the number of transit trips. Approximately 900 million trips were taken on public transportation per month in the United States in 2012. This number includes riders of heavy rail, light rail, and buses. ITS addresses this transportation challenge by managing transit systems and roadways to enhance transit mobility and integrate public transportation and highway facilities. In the past two decades, traveler information, transit prioritization, electronic fare collection, shared data, and integrated operations support increased ridership, system safety, and efficiency.

Benefits of ITS

ITS applications that improve safety, mobility, and the environment, combined with traveler information and system demand management, enhance travel options and livability while minimizing costs to system owners, operators, and users. ITS technologies offer a wide variety of benefits for personal and public transportation, such as making trip scheduling and mode selection easier, and provide public safety improvements by managing transportation systems during incidents, emergencies, and natural disasters.

ITS provides the technologies, tools, and applications to improve the capacity, reliability, and safety of surface transportation systems. The main purpose of ITS is to enhance system efficiency and safety. System efficiency supports the larger economy and environment while minimizing costs to system owners, managers, and users. ITS benefits transportation system users by reducing travel time and cost, simplifying toll and fare collection, and enhancing safety. Commercial carriers save time and money with electronic screening and timely route information.

Safety is a significant goal of transportation policy served by ITS programs and applications. ITS technology directly addresses safety through current and emerging programs such as ATDM, traffic incident management, emergency traffic operations, and emerging connected vehicle applications. ITS also provides increasing capabilities to monitor conditions and develop data-driven programs to enhance safety. Many of these applications have been implemented and have evolved since the emergence of ITS in transportation operations. These applications, along with other safety initiatives such as enhanced vehicle and roadway design, seat belt usage, and drunk driving public education campaigns, have contributed to the reduction of roadway fatalities in the United States. In 2010, fatal crashes on highways were down more than 35 percent from 1980, despite significant increases in the number of vehicle miles traveled.

ITS applications also benefit the transportation system by addressing specific challenges in system management and operations. For example, road weather management addresses challenges associated with adverse weather conditions through the use of advisory, control, and treatment strategies. These applications monitor and inform motorists of adverse conditions, regulate motorist behavior to improve safety, and actively maintain roads to minimize
weather effects. The United States Department of Transportation (USDOT) developed a library of best practices for road weather management, available at [www.ops.fhwa.dot.gov/weather/mitigating_impacts/best_practices.htm](http://www.ops.fhwa.dot.gov/weather/mitigating_impacts/best_practices.htm), which presents State and local practices and case studies from around the country. The benefits of road weather management include better traveler information, more effective use of agency staff and resources, reduced incident response time, and improved planning for traffic management and weather events.

ITS enhances safety, improves mobility, and protects the environment through applications such as electronic toll collection. Applying ITS to high-occupancy toll (HOT) lanes allows for the deployment of variable pricing programs to manage congested freeway corridors. The technology that automates tolled express lanes can separate express traffic from general-purpose lanes and maintain free-flow conditions. The system has been found to increase the value of express lanes by more than 50 percent compared to carpool lanes, largely by saving significant travel time. For example, the ITS Joint Program Office (ITS JPO) of USDOT estimates that electronic tolling provides over $1 billion per year in savings. Additional information is available on the USDOT Office of the Assistant Secretary for Research and Technology (OST-R) site (available at [www.itsknowledgeresources.its.dot.gov/ITS/benecost.nsf/ID/0095631D5E70108A852576CE004C795A?OpenDocument&Query=Home](http://www.itsknowledgeresources.its.dot.gov/ITS/benecost.nsf/ID/0095631D5E70108A852576CE004C795A?OpenDocument&Query=Home)).

Another benefit comes from red light cameras, which detect red light violations at signalized intersections. By generating citations for vehicle violations, the technology is estimated to provide $1 billion in safety-related benefits by reducing injuries and fatalities as well as damage to property. ITS applications that improve vehicle operations and reduce congestion have positive implications for fuel consumption and vehicle emissions, minimizing environmental impacts from transportation sources.1

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### History of ITS

Management and operation of surface transportation systems that focus on safety and efficiency can be traced back to the mid-20th century, when roadway planners began to address increasing commuter travel and system congestion. During the 1980s and early 1990s, many of the technological advances in computing and communications enabled the development of applications that spawned modern ITS programs. In 1988, the USDOT Federal Highway Administration (FHWA) convened Mobility 2000, a working group focused on developing a national program of automated technology. The group brought together public, private, and academic representatives to explore and promote the application of advanced technologies on highways to improve safety and efficiency.

The 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) and subsequent reauthorization encouraged new technologies to improve safety, information exchange, system capacity, and travel times. These initiatives spawned the development of ITS and technology applications that form the foundation of the modern ITS program in the United States. ISTEA also required the development of standards and protocols to promote compatibility among the technologies that were being deployed by State and local agencies. The initial development of the National ITS Architecture began in the mid-1990s, with the involvement of multidisciplinary public, private, and academic teams, which provided the foundation for current ITS national and regional architectures.

The term *intelligent transportation systems* emerged in the late 1990s to include a more multimodal focus. The USDOT’s ITS program is structured to meet a wide variety of user needs through ITS strategies and technologies. Advances in ITS development include expanded multimodal applications such as transit operations, intermodal and commercial vehicle operations, and integrated traveler information. These applications support a systems approach to surface transportation that allows the sharing of information and ITS infrastructure across multiple modes of transportation.

Increased focus on intelligent vehicles has evolved over the past decade to enhance safety, operations, and the environment through vehicle-based applications and technologies, including collision avoidance, driver assistance, and collision notification. These applications, developed in partnership with vehicle manufacturers, offer opportunities to expand ITS capabilities with minimal infrastructure costs. This evolution to a system of connected vehicles will reduce the need to invest in large, centralized infrastructure-based systems while supporting and expanding system capabilities.

Recent enhancements in technology and infrastructure include public-private partnerships between USDOT and auto manufacturers to test connected vehicle applications and private sector products and services such as smartphone applications that provide real-time information on route options and selection, ridesharing, parking, and transit times. ITS continues to evolve and to expand the application of systems engineering and technology to the transportation system. The National ITS Architecture provides support and guidance for ITS expansion continue to address new developments in technology.

The 2012 surface transportation funding legislation, Moving Ahead for Progress in the 21st Century (MAP-21), transformed the policy and programmatic framework for investments in transportation; created a streamlined and
performance-based surface transportation program; and built on many of the highway, transit, bike, and pedestrian programs and policies established in 1991 with the passage of ISTEA.

An increased focus on performance measures and system management changed the role of ITS in two fundamental ways. First, ITS offers greater system efficiencies with potentially smaller investment than capacity-expanding infrastructure programs; therefore, a performance-based system may favor increased investments in the operational and safety capabilities offered through ITS. Second, ITS is built on the collection, exchange, and evaluation of management and operations data. This data will be critical to any performance-based system. ITS infrastructure and personnel are uniquely positioned to support data-driven, performance-based policies and processes.

MAP-21 required States and metropolitan planning organizations to set performance targets and report annually on their progress. The integration of management and operations into regional and statewide planning requires coordination with regional ITS architecture and collaboration with multiple jurisdictions and multimodal providers. Regional ITS architectures, which are modeled on the National ITS Architecture, provide a foundation for linking planning and operations and support the delivery of regional planning objectives for operations. Integrated regional planning, performance measures, and ITS architecture promote efficiency, safety, and reliability of transportation systems while leveraging limited resources to meet shared goals and objectives.

The Fixing America's Surface Transportation (FAST) Act, signed into law on December 4, 2015, largely maintains the previous program structures and funding shares, increasing funding by 11 percent over five years. FHWA has provided information on a FAST Act website, available at https://www.fhwa.dot.gov/fastact/index.cfm. ITS presents broad opportunities and benefits to support national goals called for in legislation. It brings together programs, professionals, technologies, and information to enhance safety, reliability, efficiency, environmental sustainability, and economic vitality in the U.S. transportation system.

**National and Regional ITS Architectures**

In the 1990s, as applications and deployment of intelligent vehicle highway system became more extensive and complex, there was a need for a shared architecture to provide a framework for systems planning and operation that addressed compatibility, functionality, integration, and interoperability. Architecture development was initiated in 1994 and continues to evolve to meet current needs of ITS. The National ITS Architecture and Standards Program is part of USDOT’s Office of the Assistant Secretary for Research and I Technology (OST-R).

The National ITS Architecture provides a framework for the following:

- The functions that are required for ITS
- The physical subsystems where these functions reside
- The information exchanges that connect these functions and physical subsystems into an integrated system

The National ITS Architecture is maintained and updated by USDOT in collaboration with ITS stakeholders. Version 7.0 was released by USDOT in January 2012. It includes expanded guidance on integration with transportation planning and project development, active traffic management, connected vehicles, commercial vehicle operations, road user pricing, and coordination with the Canadian ITS Architecture.

**Architectural Layers**

The National ITS Architecture includes three architectural layers: institutional, transportation, and communications. The institutional layer is built to address transportation system user needs and to support ITS planning and project development. Currently 33 user services are identified and grouped into eight user service bundles: travel and traffic management, public transportation management, electronic payment, commercial vehicle operations, emergency management, advanced vehicle safety systems, information management, and maintenance and construction operations. The institutional layer also establishes the program objectives and requirements and addresses institutional policies, processes, and funding mechanisms that support the ITS program.

**Figure 3. The Architectural View**
Regional Architecture

Whereas the National ITS Architecture guides ITS programs at the national level and addresses all subsystems, technologies, and standards, regional ITS architectures define the plans, programs, goals, and objectives for implementation on a more localized basis. A regional ITS architecture is developed for regional implementation areas through the participation of regional stakeholders, including highway and transit agencies, public safety agencies, motor carrier organizations, and other public transportation facility owners and managers.

Any region that implements an ITS program is required to develop a regional ITS architecture if it is using Federal funds. Although a regional architecture will not include all subsystems or services within the National ITS Architecture, it must use the National ITS Architecture as a template for those programs and services it does include.

A regional ITS architecture is developed to meet the specific needs of a region, define program goals, identify a concept of operation, develop institutional agreements, and focus on technical integration of ITS systems within the region. Crafting a regional ITS architecture builds a shared vision for ITS implementation and advances regional transportation improvement programs and long-range transportation plans by defining goals and planning operations for regional ITS programs.

National ITS Standards

The ITS Standards Program focuses on interfaces and information exchanges identified in the National ITS Architecture to ensure that development and implementation of the system and system components by Federal, State, and local agencies, as well as private sector developers and vendors, maintain technological compatibility and functional communications. Standards development is supported by the ITS Standards Program of USDOT's ITS
JPO and provides a collaborative process to define and update standards for use by all public and private entities involved in the development of ITS applications and technology. The ITS Standards Program works with standards development organizations, such as the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), the American Public Transportation Association (APTA), and the Institute of Electrical and Electronics Engineers (IEEE), to address interface requirements between different ITS applications.

ITS standards provide the technical guidance and requirements for each component of an ITS system. They guide every aspect of technical applications and system communications, and compliance is required for all applications. The collaboration between a broad range of stakeholders to develop the ITS standards continues through standards management and professional capacity building. As part of its Standards Implementation Assistance program, the ITS JPO offers technical assistance, guidance, and training. Recent initiatives include a Web-based, modular ITS Standards training series, available at www.pcb.its.dot.gov/standards_training.aspx, as part of a larger ITS Professional Capacity Building Program.

**Growth of ITS Deployment**

The nation's public sector investment in ITS nearly tripled in 15 years, from approximately $6.5 billion in 1997 to $18.5 billion in 2010. Technologies such as electronic toll collection systems have achieved near universal deployment, while other applications, such as arterial surveillance and freeway communications, have seen some of the greatest growth in deployment. Regional planning policies and ITS architectures have stimulated deployment through increased funding and prioritization. In 2000, two-thirds of freeway operations agencies were using closed-circuit television cameras for surveillance and dynamic message signs for traveler information; by 2010 this had grown to about 85 percent of these agencies. The use of electronic fare payments on fixed-route buses increased from 30 percent in 1997 to 80 percent in 2010. In major urban areas, 50 percent of signalized arterial intersections are now covered by electronic surveillance cameras and 17 percent of arterial miles are covered by service patrols. Private sector investments in ITS deployment can be seen in commercial vehicle management and fleet vehicle tracking, and in public-private initiatives in tolling and connected vehicle applications. The demand for increased deployment by system users continues to grow as travel reliability and safety are improved. Technology advances that make deployment more efficient and more cost-effective, combined with expanded opportunities with emerging technologies, continue to fuel the deployment of ITS applications across the country. A study conducted by the Intelligent Transportation Society of America (ITS America) predicts continued expansion of the ITS industry, with expected industry revenues to climb over 40 percent from 2009 through 2015. The study determined that the economic impact of the ITS industry is significant, with an estimated end-use ITS market of $48 billion. It concluded that the "U.S. ITS market revenues exceed those for electronic computers, motion picture and video products, direct mail advertising, or internet advertising... and anticipates continuing expansion and a projected CY 2015 total U.S. private sector ITS market of $67 billion." Private sector investments in ITS deployment can be seen in commercial vehicle management and fleet vehicle tracking, and in public-private initiatives in tolling and connected vehicle applications. The demand for increased deployment by system users continues to grow as travel reliability and safety are improved. Technology advances that make deployment more efficient and more cost-effective, combined with expanded opportunities with emerging technologies, continue to fuel the deployment of ITS applications across the country. A study conducted by the Intelligent Transportation Society of America (ITS America) predicts continued expansion of the ITS industry, with expected industry revenues to climb over 40 percent from 2009 through 2015. The study determined that the economic impact of the ITS industry is significant, with an estimated end-use ITS market of $48 billion. It concluded that the "U.S. ITS market revenues exceed those for electronic computers, motion picture and video products, direct mail advertising, or internet advertising... and anticipates continuing expansion and a projected CY 2015 total U.S. private sector ITS market of $67 billion."

**Future Vision for ITS**

In May 2014, the USDOT's ITS Joint Program Office released a five-year ITS Strategic Plan 2015-2019 focused on transforming the way society moves.

The ITS Strategic Plan builds on prior and current research and focuses on realizing connected vehicle (CV) implementation, advancing automation, and shaping the ITS Program around research, development and adoption of emerging automation-related technologies. The strategic themes of the plan align with USDOT strategic priorities: enable safer vehicles and roadways, enhance mobility, limit environmental impacts, promote innovation, and support transportation system information sharing.

The Connected Vehicle Program offers a fundamental shift in the vision for ITS programs and applications. By focusing on information collected by and distributed between vehicles, the program presents opportunities for real-time information sharing, and it expands vehicle operations tremendously with minimal improvements needed for field and center subsystems. Connected vehicle development and deployment require a robust technological platform that integrates research in systems engineering, human factors, international standards and architecture, and connected vehicle applications. The connected vehicle environment of the future will require vehicle-to-vehicle and vehicle-to-infrastructure communications. It also will require research and analysis of the policy and institutional issues associated with connected vehicles. The work being done on connected vehicles is multimodal and multinational, and it involves public and private sector investment and initiatives.

In August 2012, USDOT launched a year-long pilot study of nearly 3,000 connected vehicles, including cars, trucks, and buses, to test the ability of Wi-Fi technology to improve traffic flow and avoid crashes through enhanced driver awareness. Data from this study will help define how vehicle-to-vehicle communications will shape the future of ITS.
In September 2015, USDOT selected three connected vehicle deployment sites to look at the use of connected vehicle technology to improve safety, enhance efficient truck movement, exploit vehicle-to-vehicle and intersection communications to improve vehicle flow and pedestrian safety, and improve safety and mobility on facilities employing reversible lanes. These initial pilot deployments will occur in three phases and are designed to facilitate rapid and robust connected vehicle application deployment.

The future vision of ITS is far reaching. Current ITS architecture and deployment provide a strong foundation for transportation system management and operations. Future opportunities provided through connected vehicles, performance-based Federal funding, and linkages with regional planning and other policy initiatives offer a rich environment for ITS research and applications. The technology-based nature of ITS makes it a dynamic field with limitless potential, both in terms of leading and supporting innovative applications in the public and private sectors.

ePrimer Overview
The ITS industry is an expanding market for information, engineering, and technology professionals. A study by ITS America found that ITS jobs pay well above the national average and that the ITS value chain will contribute 500,000 private sector jobs in the United States by 2015. This ITS ePrimer introduces the expanding field of ITS to students and professionals and addresses ways to integrate it with the practical applications of transportation engineering in the field of surface transportation management and operations. To support changing transportation and environmental needs and system challenges, the ePrimer updates information presented in the Intelligent Transportation Primer, published in 2000, and considers systems engineering, multimodal applications, institutional and policy issues, and new and emerging technologies. ITS provides an array of technical and systems management applications to maximize system management and operations.

The structure of the ePrimer was developed to provide an introductory overview of a wide range of multimodal ITS topics. A project management team composed of the USDOT's ITS JPO, the FHWA Office of Operations, the Federal Transit Administration, the Institute of Transportation Engineers, and ITS America led the development of the primer and the selection of module authors.

The ePrimer is organized in a series of modules that address key ITS concepts and applications. The modules were written by a team of ITS practitioners, and each focuses on a specific aspect of ITS. The individual authors were selected as subject matter experts, and each brings his or her experience, perspective, and approach to the module topics. For that reason, the modules vary somewhat in level of detail, depth of discussion, and writing style. It is hoped that these differences enhance the overall product and reflect the authors' experience.

Each module provides specific learning objectives, an introduction to the module topic, and topical discussions developed to introduce ITS to university students and transportation professionals. The modules incorporate multimedia resources that provide topic-related examples, training materials, case studies, or other linked media. This current module provides an introduction to ITS and an overview of the ePrimer. Subsequent modules of the ePrimer present various aspects and applications of ITS in managing surface transportation systems. The following is a brief description of the modules:

Module 2. Systems Engineering
Systems engineering is used to develop ITS projects in an interdisciplinary, structured process that meets the needs of the users, providers, and other stakeholders while it maintains the schedule and budget. This module provides an overview of systems engineering and its application to ITS architecture, planning, and deployment.

Module 3. Application of ITS to Transportation Management Systems
Transportation management systems provide the tools and framework for managing roadway systems. This module addresses the ITS available for roadway management. It focuses on the application of ITS technology to transportation supply, recurring transportation demand, and congestion.

Module 4. Traffic Operations
Roadway applications of ITS have roots in highway safety and efficiency initiatives dating back 50 years. Today's traffic operations are generally focused on transportation management centers (TMCs) that integrate ITS applications on highways and major arterials. This module examines how TMCs incorporate, integrate, and manage an array of ITS applications to address traffic safety and reliability focused on nonrecurring and human factor operations.

Module 5. Personal Transportation
ITS technologies offer an array of applications and enhancements for personal transportation, from real-time information to safety applications and driver conveniences. This module explores current and emerging applications that enhance driver experience and safety.
Module 6. Freight, Intermodal, and Commercial Vehicle Operations
ITS applications in commercial fleets and intermodal and freight movement address safety, security, efficiency, and driver services. This module highlights various ITS applications used in commercial vehicles and freight management.

Module 7. Public Transportation
ITS offers a broad range of applications to enhance efficiency, convenience, safety, and security in public transportation and transit systems management. This module discusses system and fleet management, advanced traveler information, and safety and security applications in transit and public transportation. It identifies ways in which ITS can be integral to achieving multimodalism, facilitating round trips from origin to destination, and trip linking.

Module 8. Electronic Tolling and Pricing
ITS technologies play a significant role in facility pricing and collection applications, including multimodal, highway, and transit applications. Pricing and collection systems provide the technological foundation for user fees and managed facilities. This module considers both the application and integration challenges and technologies available.

Module 9. Supporting ITS Technologies
Data collection, weather and traffic monitoring, communication, and in-vehicle systems are all essential supporting technologies for effective ITS. Advances in technology and integration provide opportunities for system enhancement. This module provides an overview of various support technologies and considers opportunities for deployment and integration.

Module 10. Rural and Regional ITS Applications
The application of ITS in different geographic, jurisdictional, and land use contexts presents unique challenges and opportunities to ITS professionals. This module considers varying contexts, from rural applications to large, multistate, multimodal programs.

Module 11. Sustainable Transportation
ITS technologies can support a number of sustainable transportation initiatives, including monitoring, evaluating, and enhancing system efficiency and sustainable transportation programs. This module explores opportunities to integrate ITS technologies in support of sustainable transportation.

Module 12. Institutional Issues
ITS institutional issues are as complex and challenging as technological issues. Public concerns with personal privacy and political and organizational challenges with funding, system ownership, and legal requirements need to be addressed effectively to deploy ITS on a consistent and systematic basis. This module looks at several of these issues and provides guidance on addressing institutional concerns and opportunities.

Module 13. Connected Vehicles
Connected vehicles offer a fundamental change in systems management and ITS infrastructure by focusing on vehicle-to-vehicle and vehicle-to-roadway communication. This module looks at the current and emerging technology and the institutional, policy, legal, and funding challenges of connected vehicle applications.

Module 14. ITS Emerging Opportunities and Challenges
ITS, like other technology fields, is changing and evolving at an unprecedented pace, opening new fields and applications in transportation systems management. This module explores some of the emerging applications, information management, and technologies as well as anticipated changes to current practices and infrastructure requirements.

Although the 13 modules are structured around specific topic areas, some applications, technologies, and other considerations cut across two or more topics. Each module is designed to stand on its own, so some information may be discussed in more than one module, with an orientation or focus on the module topic. To receive maximum benefit from each module, the reader should click on the links provided to take advantage of the interactive nature of this ePrimer.

References


APTA Statistical Reports, [www.apta.com/resources/statistics/Pages/OtherAPTAStatistics.aspx](www.apta.com/resources/statistics/Pages/OtherAPTAStatistics.aspx)


