ITS Vision Statement

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Intelligent Transportation Systems. ITS. A dream in 1992, initiated by a small piece of a far-reaching transportation bill a year earlier. Thirty years later, in 2022, this seed has been nurtured through the enthusiasm of the public and through a partnership of public and private investments into the base for a 21st century marvel: the nationwide Intelligent Transportation System.

Let us look at the state-of-the-practice in 2022, to see just how far we've come from the travel conditions of the early 1990s. Then let us take a few steps back, and review some of the fitful but steady progress that has led to today's great gains.

2022: Thirty Years of Progress in Intelligent Transportation Systems

We are now well into the 21st Century. The year is 2022. It is the 30th anniversary of the launching of the national ITS effort provided by the Intermodal Surface Transportation Efficiency Act (*ISTEA*) and its successors. Historians have tagged these acts as the bipartisan legislation that spawned a successful frontal attack on traffic congestion problems. In transportation, as in other walks of life, there are some defining moments that drastically and positively impact the quality of life. After these defining moments pass, people wonder how they ever managed to get by before. Such has been the case with ITS. Those who remember the debates of the early 1990s muse at the fact that these were debates about things that we now take for granted, like traveling with knowledge rather than ignorance of what is happening around us.

A small part of the early ISTEA funding was spent on developing a National ITS Architecture. It was hoped that this architecture would provide guidance on how to deploy and integrate interoperable systems that would move roadway transportation into the 21st century. The result has been the proliferation of improved traffic management techniques, public transportation improvements, advanced information technologies, driver aids, and vehicle safety enhancements.

To receive the new information, over half of the vehicles on the road today have at least basic on-board ITS instrumentation that provides good linkage with the infrastructure information sources. The availability of information, though, is only one piece of the bigger picture. Drivers also benefit from collision warning, intelligent cruise control, lane keeping, and other on-board safety and convenience enhancements. The overall ITS deployment has nearly reached the full implementation envisioned in the National ITS Architecture. The Architecture has provided a roadmap that time, technological progress, and hard work have followed to make the current reality possible.

Building upon the framework provided by the National ITS Architecture, standards, communications, and data format commonality have been defined and maintained throughout the phased deployments. The original plan for a distributed surface transportation information model is now a reality. This has permitted coordination and planning across geographic and jurisdictional regions using distributed data. In turn, this has allowed the development of new effective strategies to tackle traffic congestion, roadway maintenance, transportation security, vehicle routing, regional pollution, and a host of other issues. Travelers have reaped the benefits of these solutions as they utilize the seamless travel services provided across the nation. The National ITS Architecture showed what needed to be done and the implementors have made it happen.

The National ITS Architecture clearly spelled out the pivotal importance of communications to 21st century transportation. No technology has taken a greater role in defining the transportation systems of 2022 than the revolution in data communications. Just as the nature of day-to-day life has been affected at home and at business by ubiquitous and inexpensive data communications, so also has the experience of travel, from the response to emergencies to restaurant reservations. People no longer arrive at traffic jams unaware of the current conditions. They now have the information that may lead them to use transit or seek alternate routes to avoid congestion. And the use of multiple transit modes for a trip is no longer an inconvenient or confusing option. The summary of all this? Reduced uncertainty has made travel more pleasant for all.

How has this occurred? Through a combination of infrastructure and services, provided by both the public and private sectors. The infrastructure is used primarily to support the communication of real-time data. This has, in turn, enabled services that provide useful information to travelers to help them make intelligent travel decisions.

The traveler now receives a level of transportation service only dimly imagined 30 years earlier. Commercial entities, in the form of "Information Service Providers", or *ISPs*, have been built upon the early public sector foundations of ITS. These ISPs provide value-added services, by collecting data from various sources and creating valuable information products and services that consumers now see as just as necessary as their TV, computer, and telephone services. ISPs have arisen in many markets: some run the general communications infrastructure, some serve the personal needs of the traveling public, and some serve special markets like the freight operators.

The reality of the national ITS effort is that there is now nearly total coverage of urban and inter-urban areas by Transportation Management Centers (*TMCs*), and sensor, vehicle probe, and appropriate TMC coverage for rural regions. Working cooperatively with the TMCs is a constellation of public and private ISPs who offer urban, inter-urban, and rural travelers the full range of transportation information services. In many areas TMCs also cooperate seamlessly with other management centers that provide specialized functions such as transit, maintenance and construction, emissions or travel conditions monitoring.

For personal travel, each ISP travel customer has a *User Profile* that comprises characteristics of both the user and the vehicles they operate. The following shows an example of such a profile for a private vehicle traveler:

- On board instrumentation
  - On-board computing
  - On-board databases (e.g. digitized maps)
  - Communication capability
  - User interfaces, (e.g. voice, display)
  - Driver-aid equipment available on-board (e.g. adaptive cruise control)
- Personal characteristics
  - Regular travel destinations
  - Route type preference (highway versus side streets)
  - Preferred user interfaces
  - Information needs
  - Pay-for-service subscriptions

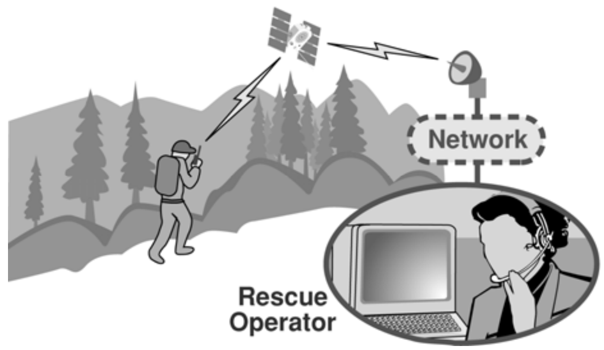
Before setting out on a trip, users may enter modifiers to their profile, then plan the trip aided by recommendations from the ISP. This information is available at home, at the office, at public kiosks, while enroute using smart phone capabilities that have proliferated in the past 15 years, or on-board the vehicle. Where desired, ISPs coordinate multiple customers to create ride-sharing opportunities when needed.

The National ITS Architecture laid out the plans and requirements for the long-term deployment of a coordinated roadway transportation system. Planners and deployers have followed this guidance, producing the great gains enjoyed today in 2022. Let us now focus on a few specific areas to see the reality that has resulted from the Architecture guidance.

Communications

The developments in portable wireless devices and data communications have been, in many ways, the key enabling technology in ITS for the traveling public. Many of the ITS gains, though significant, were incremental in nature and not obvious to the average consumer. However, the availability of personal wireless data services has been a true revolution. For the individual traveler, hand-held and in-vehicle devices now support myriad traveler information services throughout the *entire* continental US. The vast majority of the populace has access to these services using equipment that works with either the pervasive cellular networks or Low-Earth Orbit (*LEO*) satellite systems to ensure that traveler services are available everywhere at all times.

Though the traveler mass market has embraced the cellular data standards, other markets exist in specialized standards that are particularly appropriate to certain situations. Short range wireless communications, typically using Gigahertz frequency radio transmissions, are in widespread use for dedicated short-range communications needs. These systems support electronic toll collection, commercial vehicle clearance, and parking payment. The short range wireless communications are also being used to support a variety of connected vehicle applications including crash prevention, advisory messages, in-vehicle signing, and probe information collection. In rural areas the short range wireless systems now supplement visual hazard warning signs, providing the warning information directly to the driver’s information system.



Other types of communications are widely used by vehicle fleets. These include the use of private radio networks by paratransit, bus, and emergency vehicles fleets for communications with the dispatching and management centers. Regional freight operators also use ESMR; in particular, large fleets find that the customized services continue to be cost-effective for them. In all cases, network connections provide communication interfaces to the larger transportation information infrastructure to keep private radio network users integrated with the rest of ITS.

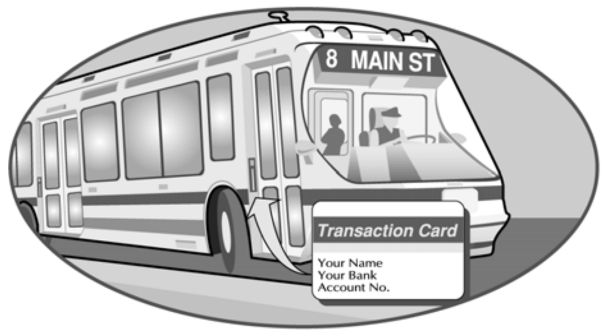
Besides the historical use of private radio networks, freight and public transit operators share other characteristics. Both have traditionally been leaders in putting technology into vehicles. Both have increasingly emphasized the movement of freight and people between transportation modes to most efficiently and quickly provide their services. Both operate in regulatory environments with a strong emphasis on safety. ITS has been a catalyst for progress in all these areas.

Public Transit

Public transit has benefited greatly from the modernization impetus of ITS. The new generation of buses that support standardized data interfaces and safety enhancements is now widely deployed on urban streets. Besides the many enhancements in information services required by the Americans with Disabilities Act (*ADA*), these new vehicles support information kiosk and communications systems to help travelers make the most effective use of their ride time. Transit management centers also support kiosks at remote locations that provide up-to-the-minute transit information to travelers.

The general trend has been towards integration and flexibility. Paratransit, ride sharing, parataxi, and other flexible route options all have bus and train schedule and parking data readily available to them either directly from transit agencies, or via ISPs and general media dissemination. The buses and passenger rail services are fully coordinated with each other, and all systems use a common fare media. A passenger can pay for an entire trip and use a single proximity sensed fare card for all modes. Besides the convenience, the selection of the entire multimodal trip allows continuous adjustments to be performed by the agencies to ensure successful connections for the traveler.

Measures have been taken in most urban areas to make bus travel a desirable commuter option. Transit agencies recognize that riders want buses that provide fast, convenient, safe, and flexible service. Dedicated bus guideways have been installed in many cities to provide bus rapid transit services. Special bus lanes on urban roadways are still in use, but they have been supplemented by sophisticated signal adjustment and priority schemes. Based on a bus's performance relative to schedule and the vehicle's planned route, plus the destinations and connection requirements of the passengers, traffic signal timing can accommodate the schedule needs. This can be as simple as extending a traffic signal's green time to allow a bus to pass through the intersection without having to stop, or as complex as a special green wave to get the bus back on schedule or to make a critical connection.

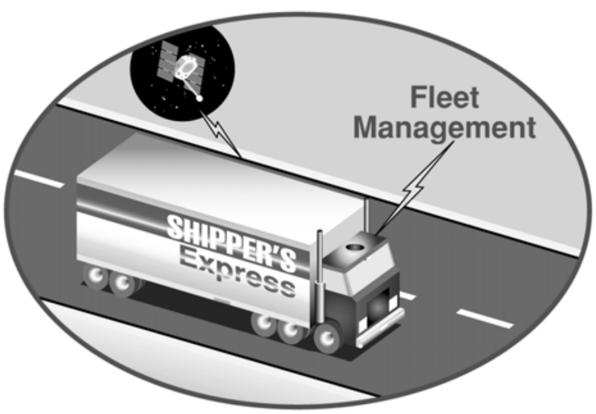


The capability to accurately track buses and to plan routes to accommodate passenger needs has changed the nature of bus scheduling. Real time bus locations can be used to provide next bus arrival information at stops and via smart phone applications, which allows travelers to know precisely when their buses will arrive. In addition, transit buses that once ran on inflexible fixed routes now vary their schedules and routing to directly satisfy individual customer needs. This is made possible through the use of "bus hubs" that allow passengers to be gathered to and dispersed from mainline express buses, operating in tight synchronization with flexible local buses. Besides serving as bus transfer points, the bus hubs also support quick connection to other transportation modes and to useful services for commuters like dry cleaning and food shopping. It is both the technical foundation the National ITS Architecture provided for integration and the spirit of cooperation that ITS has fostered that has made this level of transit service possible.

The nature of public transit has become more complex as a blend of public and private suppliers has evolved. Paratransit requirements and intra-suburban commuting have created many niche opportunities for private enterprise. ISPs now provide many trip planning and coordination services. These ISP functions have made the public transportation experience simpler, more available, and more convenient for the consumer.

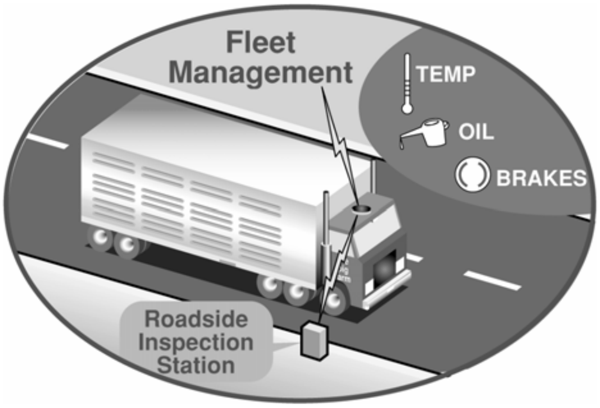
Commercial Vehicles

Commercial vehicle operators are now closely linked with water, air, and rail freight transportation modes. Using many ITS technologies, tight interaction has evolved for intermodal freight. The ITS infrastructure has provided enablers for much of the roadway portion. The overall result has been a steady progression of increasing efficiency in freight operations.



The freight handling industry serves many critical needs. Included are the needs of the US Department of Defense (*DOD*), where efforts to trim costs and increase efficiency have led to significant dependence on commercial shipping to meet both military peace time and war time needs. Early DOD initiatives to support logistics and asset visibility during shipping have now blended with the commercial ITS initiatives, providing an overall boost to this backbone of American productivity.

Commercial roadway vehicles have become technologically more sophisticated. Safety innovations developed for passenger cars have been adapted and evolved for use in trucks. Antilock brake systems (*ABS*) are now universal on tractors and trailers. On-board monitoring of brake conditions is now possible, along with other critical safety measurements such as cargo position. Some technology innovations have been added to improve the security of commercial vehicles and their cargo. Commercial shipments are not only tracked by the fleet manager, but their locations are constantly compared to planned routes so that any significantly off-route vehicles can be identified by the fleet manager and the appropriate public safety agencies notified. Similarly, drivers may need to identify themselves to equipment in the vehicle with some combination of ID cards, Personal Identification Numbers (PIN codes) or even in some cases biometrics. If an unknown driver tries to operate the vehicle, then the fleet manager can notify the appropriate public safety agency and/or the vehicle may not start. This is particularly important for the shipment of security sensitive hazardous materials (HAZMAT) that might be targeted for hijacking. Security features within the freight containers and the commercial vehicles themselves allow the identification of tampering or a breach of the cargo. Through sophisticated communications both the drivers and the fleet operations centers can monitor these systems. The roadside regulatory and safety enforcement infrastructure for trucking has also changed. Truck weight can be measured at mainline speeds by both roadside checking stations and properly equipped mobile inspectors. Dynamometer technology allows quick brake performance assessments. Electronic logs have allowed no-stop safety enforcement evaluations for participating carriers that have appropriately equipped their vehicles.



The biggest roadside change is not even visible to the eye...it is the adoption of uniform Electronic Data Interchange (EDI). The earlier EDI protocols (based on ANSI X12 and EDIFACT standards) have been supplanted by eXtensible Markup Language (XML) based protocols to provide all aspects of commercial and regulatory data and monetary transactions. The roots of this capability are more than twenty-five years old; public and private efforts have jointly yielded the current paperless system. One catalyst for this effort was the Commercial Vehicle Information Systems and Networks program (*CVISN*), a US Department of Transportation sponsored project now in its twentieth year of deployed operation. This program, along with International Border Clearance programs, has helped to create a seamless commercial vehicle network that extends from Mexico to Canada.

Route plans, required regulatory clearances, fuel and registration fee payments, and all other record keeping and financial transactions are now provided electronically from fleet management centers, or contracted ISPs, to the appropriate roadside stations and to government agencies, as needed. Carriers choose to participate because it makes business sense for them, producing many dollars of savings for each dollar of investment.

As both the national, state and local governments and industry have embraced these standards, it has become possible to have “one-stop” credential shopping on a national scale. A nationwide network of administrative systems supports the necessary electronic data gathering and exchange. This has created a great increase in the efficiency of commercial vehicle regulation, as essentially seamless commercial vehicle travel from Mexico, throughout the US, and into Canada has become commonplace. The carriers and regulators alike have applauded

Wayne, like most other Maximum Trucklines Inc. owner-operators, uses the company authorized on-board computer, Global Positioning System receiver, and communications system. Maximum Trucklines recommends this equipment for drivers who haul the company's premium business (including highly hazardous materials). Wayne has the latest on board equipment, which provides forward collision warning and other vehicle to vehicle safety applications. He also has a lane tracking device which alerts him when his truck starts to move out of its lane or off the road, as well as forward and rear collision avoidance systems.

In addition to helping Wayne better maintain and operate his truck, his computer/communications system performs automated state mileage accumulation and apportionment for automated electronic submission of quarterly International Fuel Tax Agreement reports and annual reporting of International Registration Plan apportionments. Wayne's communications system also has several safety and security features including mayday messaging to the local or state police, truck or cargo security alarms, driver authentication, and automatic service paging for requesting vehicle repair services. Maximum Trucklines has found the pay back on these equipment investments to be very quick; dropping costs and improved security coupled with insurance savings and streamlined operations, have made the technology attractive.

Before starting each trip, Wayne swipes his ID card and enters his secret PIN, then enters his destination and scheduled arrival time allowing the on-board computer to assist him in planning the route. The on-board system locks the ignition until Wayne passes the ID and alertness tests and then updates the electronic logbook. It also includes a black box device that compares steering wheel corrections with past movements, brake applications, and other diagnostics sensors. This data is valuable for both driver alertness monitoring and vehicle maintenance planning. The improvements in the infrastructure, in technology, and in security/safety have benefited everyone.

the results: lower costs for both enforcement and compliance, as well as fairer, more uniform, and more effective regulation and enforcement. The biggest winners, however, are the freight customers. Their cargo now travels with fewer stops and delays, arriving sooner and with certainty.

Cooperation Between Systems

The technology that has enabled electronic forms handling in freight operations has also revolutionized all other aspects of ITS. Accompanying the wireless communications technology deployments is an equally profound increase in wide area network (*WAN*) infrastructure. High-speed broadband services have been deployed connecting all urban and inter-urban areas. This has yielded enormous benefits to ITS.

An important communications ramification has been in the realization of true real-time data exchange between ITS systems, such as TMCs, Maintenance Operation Centers, Public Transit Centers, and ISPs. Real-time information sharing also extends beyond ITS to railroads, airports, and other entities involved in the many facets of transportation. Even travelers and home computer users now enjoy broadband services through cable TV-based and digital subscriber loop (DSL) right to their machines. This has led to more sophisticated services, better coordination of routing and signals, and dramatically improved system reliability.

A pleasant synthesized voice momentarily diverts Dan's attention from the Transportation Management Center console. As Dan looks up, the problem intersection is highlighted on the area map presented on the main wall display. Hitting a single response key, Dan's local display presents the information the TMC computer system has collected on the potential incident. One display window shows a closed-circuit television (CCTV) camera image, the camera already trained on the suspected incident location by the computer control system. A second window provides an incident log indicating pertinent information received from other TMCs or an Emergency Management Center (police or fire station) close to the incident. The third window displays any actions that are recommended by the computer control system.

Without requiring any attention from Dan, the TMC automatically shares information with the maintenance center responsible for the interaction, the regional TMC that controls freeway traffic, and other local TMCs that handle the adjacent arterials. Additionally, the TMC enables the Emergency Management Center to monitor the situation by providing a live video feed via a fiber optic interface.

But the communications revolution is not only driving real-time services. The tremendous integration brought about by ITS has created an enormous distributed data resource. Many regions through either publicly owned or privately contracted facilities now summarize and archive huge amounts of data from every corner of their transportation networks. Sophisticated data analyses are run against this data, producing planning models and annual reports with unprecedented accuracy and efficiency. Many locations now have well over a decade of archived data to draw on; the initial investment to create these extensive repositories has been repaid many times over.

The significant percentage of vehicles that now provide probe data has created a wealth of traffic surveillance information for real-time traffic management. Transit and emergency centers also provide probe data from their fleet Automatic Vehicle Location (AVL) systems. Probe data is also received through connected vehicle instrumented intersections. ISPs now provide full enroute guidance services to subscribing travelers. The probe data that the ISPs receive from their subscribers is summarized and sent to the TMCs, which keep track of the travel times on all the links in their transportation network. This information is used to optimize the scheduling of the traffic controls. The ISPs benefit, in return, by receiving the TMC traffic and network status information. This tight coordination is made possible by affordable high-speed data communications.

The array of available data has also triggered significant automation of TMC systems. Data fusion, expert systems, model-based reasoning, and a host of other technologies are employed. The goal has been to reduce operator workload while substantially improving the accuracy of dynamic traffic information. At the same time, improved fault detection has reduced the operations and maintenance costs of these complex systems.

In addition to traffic management, the maintenance of existing infrastructure (both ITS and non ITS) has benefited immensely from both ITS technologies and the ability to share data between centers. Maintenance fleets are tracked, their conditions monitored, and their operations for both winter and non-winter activities are coordinated to provide efficient roadway management. Maintenance organizations have been monitoring weather and road conditions for over 20 years, but advances in technology and data collection now allow development of weather and road condition models for individual road network links. Using this information and advanced decision support tools, the maintenance organization can provide the right treatment in the shortest time to each road segment. This has resulted in both safer roads and fewer road closures. Weather and road condition information is widely distributed to ISPs, TMCs, Transit and Emergency Centers providing real time conditions to travelers and operations centers. Work zone operations are coordinated beforehand with affected centers (e.g. TMCs and Transit Centers), information about work zone operations and road closures are shared with all key transportation centers. In addition, sensing and alerting technologies, such as vehicle intrusion warning devices, are now commonplace in work zone or construction areas, significantly reducing the risk to maintenance crews working near traffic flow.

Information Service Providers

The early recognition of the key role of public and private Information Service Providers in making the ITS dream a reality has borne real fruit in 2022. Much of the required infrastructure development has been financed by private for-profit and not-for-profit ventures. Besides creating an array of value-added services that make transportation better, the ISPs also have proven to be the critical link necessary to realize many services.

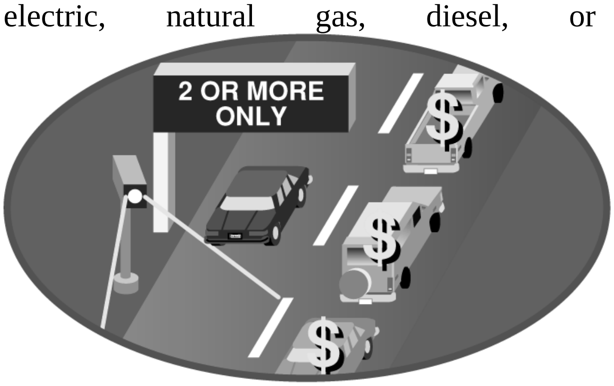
Publicly run ISPs ensured that all regions maintain basic levels of self-funding information services. This includes the voice based 511 systems that have been in place in almost every state for many years. Private enterprises have proven nimble enough to turn niche opportunities into viable commercial enterprises and, in some cases, even nationwide systems. Most importantly, these private sector ISPs have been able to effectively deal with the institutional implications of ITS technology. Their status as private entities allows them to assure clients of confidentiality. The private sector ISPs can also manage their legal liability to ensure the protection of consumers while at the same time limiting their own susceptibility to litigation and damaging judgments. This mix of public and private efforts has led to the rapid expansion of new services, while at the same time ensuring that everyone has access to basic transportation information.

The true equity of ITS becomes apparent in the partnership between the public ITS infrastructure providers and the private sector ISPs. We see the public agencies funding the critical innovations and deployments that will benefit all. We see the ISPs creating services that cater to the needs of specific groups of users. And together we see a public-private partnership based on the exchange of information that enhances the success of both the public agencies and the private ISPs.

The wide acceptance of ITS technologies and the proliferation of ISP-based services have seen some ITS technologies merge with other broader markets. Tag devices that 20 years ago commonly held cash balances only usable for tolls, and that needed to be replenished or replaced when exhausted, have given way to universal payment media that have many uses beyond ITS. Functioning like credit or debit cards, these payment devices have also enabled ISPs that once provided only ITS-based route planning to now provide many new services, from take-out food ordering to dry cleaning pickup. In addition, the almost universal use of GPS enabled smart phones has allowed transportation related services to merge seamlessly with the broader communications market.

Demand Management

Over the decades, consumer choice, environmental concerns, and technological innovations have impacted the very nature of transportation. Personal vehicles may now be electric, natural gas, diesel, or



gasoline/alcohol fueled. Hybrid vehicles are widely in use. This fact, coupled with the contention for roadway space between personal, commercial, public, and paratransit vehicles, has led to fundamental re-evaluations of how road infrastructures should be financed. The result is that some regions have decided to try completely new transportation pricing strategies. The underlying assumption is that all transportation, from roadway use to air travel, represent services with costs. These costs should be paid fairly and directly by the beneficiaries of these services.

These are *demand management* strategies, which are being employed by local departments of transportation to help meet roadway capacity and emissions goals. The National ITS Architecture provided an early identification of the systems and technologies that would be needed to address ever-expanding transportation network demands. Demand management technology is a cornerstone of this critical tool set.

ITS has been an enabler for the new transportation pricing strategies providing the technological infrastructure to support fee-for-service. The consumers have found this evolution acceptable; they have been provided one new or enhanced service after another, with each carrying a reasonable fee. Much like the evolution from broadcast to cable television, users not only prefer the new services, but also are grateful for the choice.

The routing information provided to the TMCs by the ISPs has also allowed some jurisdictions to implement sophisticated demand management policies. The TMCs can use historical, projected, and measured data to make pricing decisions for system usage. Travelers can have the ISPs use pricing as a factor in trip planning, routing, and even in arranging ride matching. By adjusting pricing, and using the ISP dissemination mechanism, public agencies can actually achieve the system-wide capacity and service level goals they have set, while still giving individual travelers complete freedom of choice for selecting their routes and travel times. The coupling of route guidance, signal controls, and demand management allow agencies to more actively manage the traffic in their networks.

While demand management strategies are most visible in their impact on the daily driver, broader activities are also occurring. The revolution in data gathering and dissemination has allowed long term planning to dovetail effectively with day-to-day operations. Diverse goals such as emissions reductions, minimized community impacts, business revitalization, and others can be factored into the modern demand management planning process.

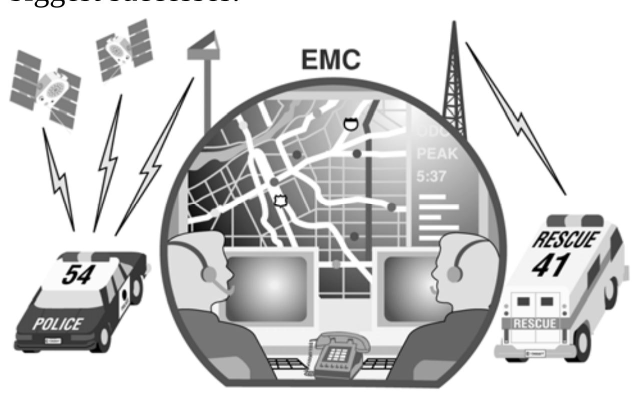
Incident and Emergency Management

Incident management and emergency services are related areas that have benefited greatly by advances in technology and in the deployment of infrastructure, particularly for communications. Many people who would have died subsequent to accidents 30 years ago are now saved. In rural areas response times have been cut in half or better, resulting in an over 30% reduction in fatalities. Just as important as responding to accidents is their prevention: public exposure to high-risk traffic situations has been reduced through effective traffic management and remedial action as well as the introduction of vehicle based crash prevention systems.

Incident management has seen tremendous gains from improvements in coordination and automation. Where 10 years ago the private caller on a cellular phone was the most effective detection mechanism, now automated systems can detect and verify incidents using probe data much more rapidly and at lower public sector cost than with loops or *CCTV* alone. In the critical high usage corridors the detection portion of the detect-and-verify process takes only a few seconds using probe data. Additionally, many vehicles are now equipped with emergency notification, or “mayday”, systems that automatically transmit identity and location when a serious collision occurs or a “panic button” is pressed, providing direct incident detection by the involved vehicles.

Emergency management services have seen the early experiments in signal preemption long since grow to maturity. Now, instead of locally signaling an intersection from the vehicle, the entire route is planned and coordinated. And these routes consider the real-time railway operations data, to avoid any unnecessary delays at highway-rail intersections. An emergency vehicle receives priority routing and signal scheduling to ensure both the fastest route to the scene of the emergency and the minimum danger to the public.

Emergency management dispatchers are advised of accident situations by the automated mayday signaling and by incident management systems. Automated HAZMAT response recommendations are created for all commercial vehicle HAZMAT carrier routes when fleet managers select and file them with affected jurisdictions. Should a problem arise, this guidance is immediately available to dispatchers and drivers. The improvements in the detection of emergencies and the response have saved many lives, yielding one of ITS’s biggest successes.



While ITS has had a significant impact on the daily management of traffic incidents and other emergencies, it also now plays a major role in supporting response to disasters and in supporting evacuations of areas that are or might be affected by disasters. ITS systems provide enhanced access to the scene for response personnel and resources, provide better information about the transportation system in the vicinity of the disaster, and provide more efficient, safer evacuation for the general public if needed.

The surveillance systems installed to monitor the transportation infrastructure also serve to provide early identification of the scope and extent of a disaster. In addition the integration of transportation centers allows the status of the infrastructure to be quickly shared among all relevant agencies, thus assisting in the initial response to a disaster. Responding agencies can identify what resources to send immediately, and can seek regionwide assistance as needed. Maintenance organizations can obtain up to the minute status of the transportation system, allowing them to prioritize emergency repairs needed to get the transportation system moving again after the disaster. And the traveler information systems that are a part of ITS mean that travelers can be informed of which roads are open and which transit routes are operating.

Evacuation of areas due to natural events (such as hurricanes) or man-made disasters (such as a HAZMAT accident) has been greatly improved through the use of ITS systems. The miles of bumper-to-bumper traffic along evacuation routes are a thing of the past. With improved planning and traffic management transportation agencies are able to move more people more quickly out of the affected area. Traveler information, from both public and private sources, informs residents of the appropriate evacuation routes, and gives them real time information on the status of the routes. Evacuation is managed in shifts where circumstances allow to spread demand and make the evacuation as quick, safe, and efficient as possible. Transit vehicles can be brought into service more quickly to evacuate those with limited mobility. And agencies of all types can better coordinate their activities.

Transportation Infrastructure Security

While one of the original goals of ITS was to improve the safety of the nation’s transportation system, this was expanded in the early years of this century to include improving the *security* of the transportation system. ITS has been able to play a major role in protecting our transportation infrastructure and the people and vehicles that move on it.

A variety of sensors are used to detect threats to the transportation infrastructure. These range from CCTV cameras with image recognition software, to explosives, chemical, biological, and radiological sensors that are placed at key locations such as bridges, tunnels, and interchanges. Similar sensors are now widely used on-board transit vehicles, as well as at transit stations to provide security for the transit users. Because of the integration of systems, threat information can be quickly shared with all involved agencies.

ITS systems not only detect threats to the infrastructure, but are also used to prevent damage to infrastructure or to mitigate the impact of damage. For example, bridge approaches are equipped with automatically activated barrier systems that can close a bridge to traffic if an incident occurs. Tunnels have automatically activated exhaust systems that can remove dangerous fumes.

Connected Vehicles

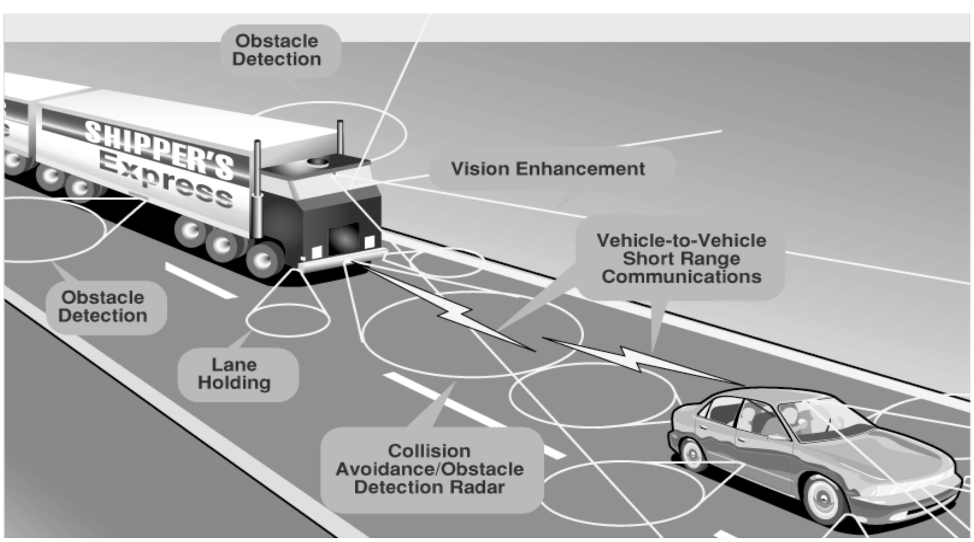
Even as the congratulations flow in on the 30th anniversary of ITS, the dawn of the next great transportation era has begun. Since being mandated for new vehicles a few years ago, Vehicles are equipped with Dedicated Short Range Communications (DSRC) that exchange information with other vehicles as well as the infrastructure. These vehicles have available a wide range of vehicle to vehicle safety applications, including crash prevention and lane change warning. A growing number of intersections are also instrumented to provide signal phase and timing information to vehicles approaching the intersection, reducing the likelihood of vehicles running a red light and also allowing vehicles to optimize their fuel efficiency performance.

Summary

All these services are available to the users who need them. The advanced traffic management and traveler services, public transportation and commercial vehicle operations, and all the other services, provide real value to rural, inter-urban, and urban users. A trip interaction involving mode and route recommendation requests and the receipt of enroute guidance and updates is not an intimidating experience for a traveler; it is now as natural and necessary as phone and mail service. The gains promised by ITS are starting to be broadly realized by many different stakeholders. It is the surge in private sector investment that has started to drive the progress of ITS, leveraging the early public sector investment very effectively.

Thirty years of effort have yielded substantial dividends. We have seen improvements in safety, transport capacity, security, emissions, consumption of resources, productivity, and personal mobility. These gains have benefited the nation and enhanced the quality of life.

The progress in 2022 is substantial. Let’s go back and review the early work that led us to this point.



2012: ITS Current Status

Here in 2012, the first three congressionally mandated ITS programs have been completed. The US DOT has just concluded its seventh official release of the National ITS Architecture as a blue print for standardization and deployment. Many new technologies have been subjected to operational tests to gauge their usefulness and readiness for wide-scale deployment.

Under the auspices of an effort initiated and coordinated by US DOT, professional standards development organizations (*SDO*) have defined numerous interoperability standards for key ITS system interfaces, based on the guidance of the National ITS Architecture program. Using the Architecture documents, the SDOs have filled in the details to create the critical standards needed to move ITS forward. The National ITS Architecture has provided the starting point for defining national interoperability. All parties involved have seen these standards and their testing as critical to the long term success of ITS.

Most regions of the country have developed their own architectures to ensure that the separately conceived elements of the ITS roll-out will all fit together and provide the benefits of integration. Development of these regional ITS architectures have been encouraged by the US DOT through a policy on conformance to the National ITS Architecture and emerging ITS standards. To support these regional ITS Architecture developments the USDOT has released *Turbo Architecture*, an interactive software tool for the creation of regional and project ITS architectures.

Deployers have already been working with both released standards and the National ITS Architecture tools (including *Turbo Architecture*). By supporting the standardization process, and recognizing the areas of least certainty, those who have been the leaders in the deployment of ITS can protect their investments through good design practices and through active standards participation. Most have found that the National ITS Architecture allows much flexibility in selecting the specifics of their deployments. As long as they support the core functionality and data interfaces described in the Architecture guidance, these deployments should not need more than interface upgrades to maintain future compatibility. The Architecture itself has been under maintenance for almost sixteen years, receiving the revisions needed for new ideas and capabilities.

The introduction of ITS traffic management and traveler advisory features, including current travel times, in most metropolitan areas has captured the imagination of the American driving public and made driving a less uncertain endeavor.

Increasingly effective outreach activities have been carried out. ITS America has been the leader, spreading the word through forums and through the print, radio, and TV media. Formerly reticent or suspicious institutions are now constructively engaged in defining ITS, and all stakeholders have a clearer idea of how ITS will affect them. Even the general public is now showing genuine interest as the popular media has started to publicize how technology is transforming transportation.

The communications technology needed to realize the long-term National ITS Architecture goals is now widely available. Wireless communications is widely available with the number of active units equaling the US population. This has provided the base for an affordable wireless data communications capability. Mobile workers have been the first to use this technology, but ITS applications are not far behind. Smart phones providing data access are now used by 50% of the population. Widespread use in automotive entertainment systems is on the near horizon.

Public Transit

A number of developments have contributed to an increase in public interest and use of public transit. First, the availability of information about public transportation options (from kiosks, for example), has made it easier for users to choose the public transportation option when it makes sense. In some areas, flexible public transportation schedules, in response to service requests, are also now possible through the combination of AVL, communications, and adaptive scheduling provided by ITS.

Early successes abound in transit. New York City Transit has begun to coordinate bus stop departures with subway arrivals. This allows passengers to make more efficient multimodal trips and increases their safety. Minnesota has placed real-time transit information in the public domain, available by phone, kiosk, or Internet. Real time bus arrival signs have been introduced in a number of transit markets. The availability of real time bus location data streams from transit agencies has led to a wide array of applications providing real time bus arrival information.

In response to the ADA mandates and community needs, "Personalized Public Transportation" (paratransit) services, such as vanpool and mini-bus services, are increasingly available. Though more expensive than traditional fixed route public transportation, these modes offer a service with many of the benefits of a personal vehicle. The inducement offered by the designation of High Occupancy Vehicle (*HOV*) and High Occupancy Toll (HOT) lanes and the financial incentives to municipalities, imposed by energy and clean air legislation, are driving the efforts to make available information services that match riders and drivers with each other and also with available transportation services. The goal is to make alternatives to single occupancy vehicle travel easy and more appealing.

The most forward-thinking transportation agencies have begun to plan how to coordinate public transit, ride sharing, parking availability, and paratransit. Using the communications infrastructure accessible through their nascent ITS deployments, it is becoming possible to begin coordinating formerly independent entities. When deployed, these integrated services will yield an attractive time savings over single occupancy vehicle travel on congested rush hour roads.

Route Guidance and Digital Maps

Autonomous navigation systems for vehicles are becoming quite common. Many car models can be purchased with original equipment manufacturer (*OEM*) units, and there are multiple after-market providers of these systems. Unfortunately, most of these autonomous guidance systems can only guess at probable travel times, based on free flow speeds, but this has begun to change as product manufacturers have begun to provide ways to provide real time updates to the units.

Despite the limitations of early systems, route guidance is something that consumers want, as part of a suite of in-vehicle services. Government and industry have recognized that there will be increasingly common need for digital navigation maps for both public and private uses -- to support trip planning and navigation, to support signal controls, to perform planning studies -- and on and on. Rather than leave the evolution of these maps completely to market forces, a more proactive solution has been adopted.

The set of minimum standards for the exchange of digital map data and attributes has been adopted. Digital map vendors have flexibility in how they encode links, while map users can buy digital maps for their products and systems confident that they will not be locked into a single provider or be unable to send or receive map data when needed.

Local agencies and service providers will maintain the link attributes, such as free flow speed, current travel time, historical travel times, adjacent points of interest, signage locations, and other regionally appropriate information. It is anticipated that some TMCs will use this data for their own operations, while covering a portion of their costs by selling this data to ISPs. In the future, as more and more jurisdictions acquire map databases and start to record real-time traffic data, it may become possible to access current information about any roadway in the United States.

Infrastructure

Although the infrastructure upgrades to support ITS traffic management have only occurred in the vicinities of major urban areas, a substantial portion of the US population now travels in these covered areas. Where these new TMCs occur in adjacent jurisdictions they now exchange data with each other on an as needed basis. An array of wide area networking options have provided the ability to support a much higher degree of interaction.

Where appropriate, different types of transportation management operations are choosing to use shared facilities. Public transit, maintenance operations, and emergency management, as examples, are realizing the benefits of tighter integration with TMC operations. The burgeoning capability for data exchange, coupled with improvements in traffic sensors and the computer processing of data, have led to increased accuracy and confidence in real-time data. In many jurisdictions this information is furnished automatically to dynamic message signs (DMS) and highway advisory radio (HAR) during normal operation. Rail crossing signals are being linked with adjacent traffic controls in many locations.

Considerable infrastructure has also been deployed in rural areas. Sensing of weather and road conditions has become widespread in many states. A joint USDOT/ National Weather Service effort called Clarus has been successful in collecting road weather information from various sources, quality checking the sensor inputs and providing the data to a wide array of agencies. Maintenance organizations use the information to decide when and how to treat the roads and are already beginning to share the information directly with travelers via DMS and with other centers that use the information in managing their operations. Specialized weather service providers have sprung up to provide transportation specific weather forecasts to maintenance and other transportation organizations.

Not all of the infrastructure deployed in the past fifteen years is “fixed”. Portable dynamic message signs are widely used by maintenance and construction operations to provide traveler information around work zones, and also by traffic management operations to provide traveler information at special events.

Industry, recognizing the consumer market for travel services, has formed the first commercial ISPs to provide ITS-defined services. In particular, a few ISPs already exist that provide enroute guidance to travelers, using Internet technologies. These ISPs gather data from their own systems and from traffic management sources, using the fused information to update travel time estimates. Early arrangements to share this information back to TMCs, as a supplement to their own sensors, are also appearing. The more progressive TMCs continue to provide ISP services themselves, via on-line access to real-time travel data gathered and processed at the centers.

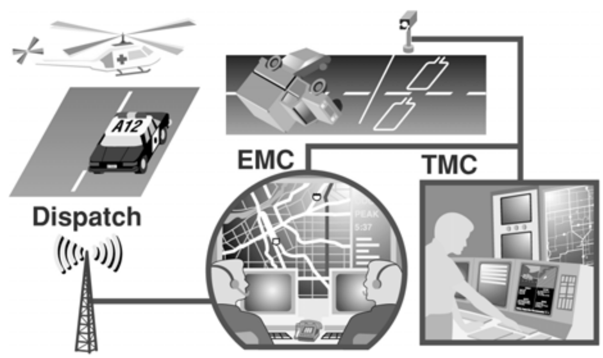
Here in 2012 there have already been substantial improvements in traffic control technology. A number of the large metropolitan areas have begun to implement sophisticated adaptive traffic control systems, backed by extensive sensor deployments. Many locales even coordinate with other modes, like drawbridges and highway-rail intersections. Major metropolitan areas have regional incident management programs, with plans for full instrumentation of area highways for automated incident detection and management. The most advanced regions have begun to integrate arterial and freeway incident management, and almost all regional authorities have put plans in place to support direct dissemination of information to police, fire, emergency medical, and other agencies. Such improvements in traffic control and incident management have achieved an estimated reduction of delays due to congestion and incidents by 10%-20%.

Many TMCs now use the common surveillance technologies, like CCTV cameras and video detection systems. DMS, HAR, and the TV and radio media reach the majority of vehicles and ensure that everyone receives some improvement in real-time services. This is the beginning; we are realizing the major goal of ensuring that everyone receives benefits from ITS.

One of the refined capabilities emerging in traffic control research is the TMC-coordinated “individual green wave”. Centrally coordinated or supervised signaling systems are being widely deployed that give preferential signal treatment to certain classes of vehicles. Emergency vehicle signal preemption as well as signal priority for public transit buses are seeing widespread deployment.

Incident and Emergency Management

Incident management is evolving rapidly in the aftermath of the 9/11 terrorist attacks. Improved communications, better inter-agency coordination, and clear plans for dealing with different types of incidents have all helped. The cellular phone calls of nearby travelers to 9-1-1 have proven the fastest detection mode by far, exceeding the performance of infrastructure-based incident detection in most cases. Telematics services like OnStar™ is an increasingly popular option in new vehicles, enabling vehicles and drivers to immediately report their own incidents. Additional detection methods are anticipated in the near future. Information from ISPs, in the form of vehicle probe data, is an example of a promising data source for incident detection.



Emergency management services are becoming more effective and integrated. Emergency Management Centers (*EMCs*) are appearing with increasingly sophisticated abilities to dispatch, track, and monitor responses. These public safety dispatch centers are tied directly to 9-1-1 services and to TMCs, to allow coordination with these other agencies. Some centers support data communications to their vehicles and AVL position tracking. Others are now capable of accepting electronic notification of

HAZMAT transport through their jurisdictions.

Public safety dispatch centers are beginning to move beyond voice communications to data communications with peer agencies, and are using this capability not only for day-to-day incident response, but also for response to area-wide disasters, or to support evacuations. They are also connecting to TMC's to obtain realtime video images that allow them to assess the status of the transportation network and factor this into their response activities.

Vehicle Transponder Tags

Nearly all toll authorities are using toll-tag technology to ease congestion at toll plazas. Allowing commuters and commercial users to pay tolls while in motion has enormous appeal to agencies and customers alike.

Early efforts to expedite commercial vehicle processing also use the toll-tag technology. In this case the primary purpose is to identify vehicles for tracking through weigh-in-motion and automated electronic clearance systems. This technology has been applied to key commercial vehicle corridors throughout the country. Large commercial vehicle operators are starting to supply electronic documentation and payments to regulatory and enforcement agencies from their fleet management centers, to support their trucks while enroute. These operators see the competitive advantage in keeping their trucks moving.

In general, the early efforts to speed vehicles past tollbooths and weigh stations have been applauded by drivers. In a few special locations long standing congestion problems have even been solved with the relatively straightforward transponder tag technology. The use of tags for automated vehicle identification (*AVI*) is clearly on track to support many future ITS services, like parking payment and even in-vehicle signage.

Promising technologies have been identified, and the standards and systems are under development. While the road ahead is not completely clear, we know we are on our way.

As Fran passed through the toll plaza, a green light signaled a successful electronic reading of her EZ-Pass toll-tag. She immediately accelerated from 20 back to 55 MPH and merged into the stream of freeway traffic. Having used the tag technology for three years, Fran didn't even think of the old congestion problems; she was late to pick up her son from day care and felt annoyed that she even needed to slow for the tolling system. She glanced up at the variable message sign: "Travel time to First Ave- 15 minutes". Well, good she thought. At least I probably won't get the "last parent" fine.

Back at the freeway TMC, the time at which Fran's car passed the plaza was correlated with other tag read events from the toll plaza and from strategically placed tag readers along the roadside. This data is used to calculate highly accurate traffic flow information. The message sign Fran saw was updated automatically from this information. Any flow irregularities would trigger an alarm for the TMC operators to investigate. The highway patrol also had a dispatching office with real-time access to the TMC status map. If the TMC operators didn't assign a status to a potential incident alert promptly, the dispatcher would call up to the control room to see what was happening...

As Tony pulled his rig into the automatic read lane, he felt real relief. After the long drive in from Kentucky, he would have to stop soon, and he was very happy not to be in the 10-minute line for the coin toll lanes. He had made excellent time; all the weight and credential checks had been done while he was on the mainline and he hadn't hit any serious congestion. Thank goodness they upgraded the tag readers, he thought as the EZ-PASS system read his ADVANTAGE I-75 tag. The lane light and his in-cab indicator light both flashed green almost simultaneously as he rolled the big International on through the plaza.

Let's jump just a few years ahead from the present and see what progress has occurred in the drive for advancing transportation systems through the use of communications and technology.

2017: Private Industry takes the Driver's Seat

It is now over twenty years since the National ITS Architecture was released. The information from this program has driven deployments and standardization efforts. It has also driven regional ITS architectures by the hundreds throughout the nation. The Architecture continues to be updated and used as a reference framework for the ongoing efforts to deploy a nation-wide ITS intelligent transportation infrastructure. Standards have been developed and tested to support the core interfaces; committees have melded the National ITS Architecture information with information from early deployers and other stakeholders to create these critical consensus standards.

There are many indicators of the expansion of ITS deployment since the celebration of the new millennium. ITS equipment is starting to appear in consumer vehicles. With more ITS-equipped vehicles on the road, the operators of driver information and advisory services have been able to collect enough useful information about traffic conditions from their customers' vehicles, acting as probes, to be able to provide timely and accurate dynamic guidance.

Standards and Deployment

The establishment of ITS national standards has started to trigger the expansion of a robust, thriving US ITS industry. Much as earlier standardization and competition have driven the development of immense industries in telecommunications and computers, the US DOT-sponsored efforts in ITS have created the start of a commercial revolution in transportation. Manufacturers of traffic sensors and traffic control equipment are confidently investing R&D resources to bring existing products into conformance with ITS standards, and to develop innovative new products for the rapidly emerging ITS market. Entrepreneurial and creative companies are beginning to create new ISPs that provide exciting traveler service capabilities that supplement the publicly owned portions of the ITS system.

The US DOT emphasis on ITS infrastructure and the deft application of federal funding has served as the stimulus for this nationwide roll out of infrastructure. The National ITS Architecture, and the appropriate ITS interoperability standards, serve as requirements for all TMC and roadway system procurements, and the ITS Standards Testing documents provide the basis for acceptance testing of the installed systems.

The openness of the specifications and standards has allowed considerable latitude in the selection of the computer, networking, communications, and roadway equipment. This has provided a very cost-competitive environment and has encouraged rather than restricted the timely introduction of cost-effective advanced technology products into ITS usage.

At the same time as new systems are being deployed, existing systems are also being brought into the nationwide ITS infrastructure. By creating ITS-compliant interfaces to existing systems, one-of-a-kind solutions can still access and benefit from the new technologies. In particular, the regional bodies that drove the earliest pre-standard ITS efforts and those groups who feel that their existing traffic controls infrastructure is adequate for their needs are not left out of the process. They are preserving their investments, as the modular and extendible nature of the National ITS Architecture allows them to selectively grow their capabilities.

Developing Fee-for-Service

Even at this stage in the commercialization of ITS technologies, multiple flavors of ISPs have already emerged. The ISPs, some publicly run and some private, are typically physically located wherever is most cost effective. Some provide their services from remote locations, while others are located right at the roadside. Typically, the remotely located ISPs provide trip planning, traveler information, electronic yellow pages, and other functions. The ISPs that are physically located near the roadside, right at the place where their services are accessed, transact vehicle or traveler electronic payments; manage modern parking facilities with reservation capabilities, and other similar functions.

The use of DSRC based toll-tags for automated toll collection has become widespread on tollways. In some cases, such as bridges in crowded urban areas, this technology has been a huge success. Point congestion problems associated with tolling, once viewed as intractable, have been significantly improved in a very cost effective manner. In some areas travel demand management for critical roadways is being effectively accomplished through the combined use of automated toll collection and HOV/HOT restrictions. In these situations, road usage fees are biased to discourage single occupancy vehicles (*SOV*); this, coupled with dedicated lanes, has provided a strong incentive to increase vehicle occupancy.

There is a strong movement to try to merge toll-tag technology with other payment media, to allow broader use in purchases with a universal smart cards that could be used nationwide for many applications beyond simple toll payments. Such universal payment instruments are already in use in some large regional markets.

In-Vehicle Systems

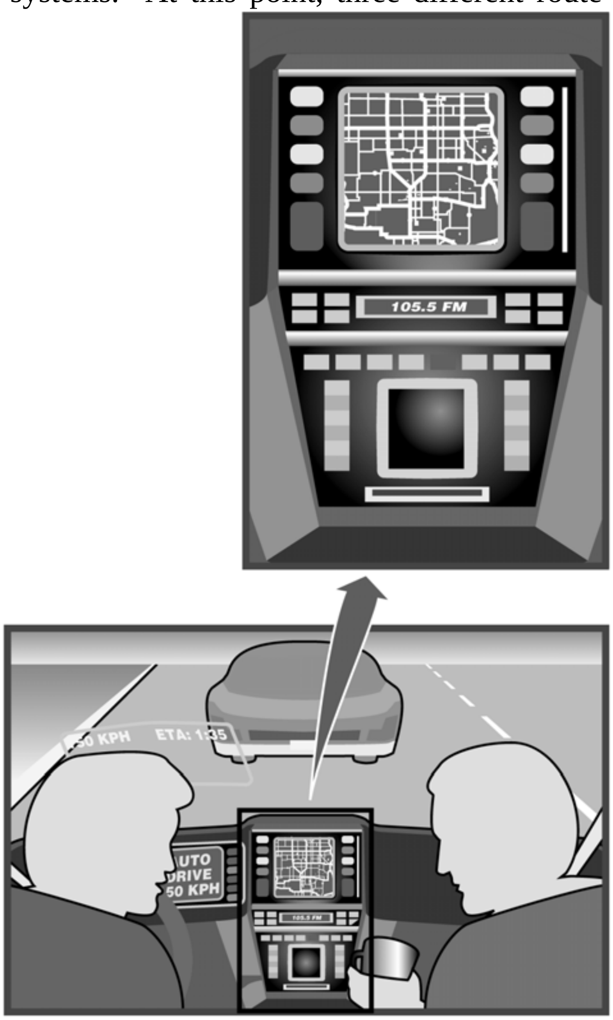
Trucking and other commercial fleets have led the way in deploying advanced in-vehicle systems. Based on business needs, they have been installing hardware in vehicles in order to allow drivers to accurately determine their locations, and to select the best way to their destinations. Some commercial vehicles use stand-alone instrumentation, while others are aided through communication with ISPs. Some 60% of the non-fixed route commercial vehicles, (“truckload” trucks, rental cars, etc.), now have some type of navigational or route guidance instrumentation, as does about 30% of the general driving public. All vehicles are becoming more sophisticated, with new electronics and safety systems. Recently mandated DSRC equipment has begun to allow vehicle to vehicle and vehicle to infrastructure communications creating the “connected vehicle”.

There has also been broad deployment of advanced adaptive traffic control in most urban and inter-urban areas, including full monitoring and control coverage of freeways. Automatic incident detection and management is commonplace in major metropolitan areas, as is AVL and the use of traveler information systems in public transit. In addition, some metropolitan areas are creating a network of TMCs, equipped with communications capabilities and software to support integrated operations, cooperative data collection, data fusion, data archiving, and the supply of this information to other agencies and travelers.

This information is disseminated in real-time via the media, via kiosks, smart phone applications and by HAR and DMS systems. It also goes to the ISPs that supply navigation and advisory information to travelers. The consumers of travel information have free access to basic ITS data and can buy services from ISPs that cater to their specific needs.

The driver support systems in typical private vehicles have become increasingly sophisticated in the last few years. Cars right off the showroom floor now sport wireless digital communications and centralized driver information systems. Though the vehicles have become more complex, using them has become easier thanks to careful human factors engineering, including head-up displays and audio for eyes-on-road presentation of information. Gone are the days of the mystifying “idiot lights”.

In-vehicle travel guidance systems have now been commercially available in the US for over 20 years. Though many of the mobile vehicle/traveler navigation units are still autonomous, consumers are increasingly able to obtain real time updates to their guidance systems. At this point, three different route guidance technologies exist. The first to appear were the fully autonomous units that required no communications. These units perform all their route computations locally using static navigation data. The local databases have evolved in sophistication to contain information about historical congestion patterns, and can use the day and time of travel to improve their routing plans.



The second type of route guidance technology adds limited communications capability to the fully autonomous units. Using broadcast or point-to-point communications technology, significant exceptions to the expected traffic conditions are communicated by ISPs to the in-vehicle systems. These local systems then determine their routes autonomously, as before, but with better data.

The third type of route guidance technology moves the navigable route database and the route planning process out of the vehicle and into the infrastructure. The in-vehicle part of the system handles reporting vehicle motion or “probe” data, communications, and the interface to the driver. The subscribers to these services gladly provide the probe data; in exchange they receive personalized real-time guidance and travel mode options while enroute, and personal security as a benefit of disclosing their location. Routing plans are provided by ISPs, who pool vehicle probe data, TMC information, and all other available inputs to provide real-time optimal routing. In all cases, encryption protects the privacy and security of the communications between the ISP and the traveler.

These latter two types of dynamic route guidance are of interest to commuters and local residents, as well as to visitors. Convenient real-time information about commonly traveled routes helps drivers make better pre-trip decisions, picking the appropriate time to leave for work or shopping, and the best route for the trip.

All three-route guidance technologies are currently available, and consumers can select whichever they prefer. All offer improvements over naive guidance without even historical data. The first two types of units' autonomous nature, though, makes coordinated routing difficult. As long as the market penetration of the autonomous units remains below 10%, their impact on traffic patterns for uncoordinated decision-making is tolerable. But this is still well short of accurate real-time and predictive modeling. Access to these real-time services, plus the lower in-vehicle cost of the units that receive routes from the infrastructure, has made these route guidance systems increasingly popular.

Cooperation between Systems

The connectivity of TMCs with other TMCs with maintenance operations and with ISPs is much improved. The increased scale of deployment has created substantial contiguous areas under multi-jurisdictional control. What were "islands of ITS" five years ago are often now networked and cooperating. ISPs convey information to all affected TMCs, and complex activities like traffic signal prioritization can be handed off transparently from TMC to TMC in some areas. This has also enabled other services, like dynamic ride share matching, to be much more practical as jurisdictional boundaries blur for information access.

Traffic management and road maintenance management are also developing increasing levels of cooperation. From the coordination of maintenance or construction work plans to the sharing of the ever expanding array of

Ken commutes to his downtown office on a daily basis. Glancing out his office window one rainy afternoon, he is concerned about how the weather will affect his commute home. Ken accesses the Internet on his office computer and logs into his account with his traveler information service. Based on his ID, the computer provides Ken tailored information based on his previously supplied travel routes and preferences. Ken consistently uses the service only to determine the quickest route between office and home; although a wide range of other options are available. Ken is pleasantly surprised that all is clear and his expected travel time along his route will be within 2-3 minutes of normal. Since he pays an extra fee for real-time congestion information and transit route planning, Ken is able to log a request for automatic notification if traffic conditions should change for the worse. In response, the information service will automatically post a message to Ken's computer if his expected travel time deviates by more than five minutes. Ken returns to his work reassured that any changes will be noted on his computer in near real-time...

Judy arrives at the Metropolitan Airport for the first time and merges into the rushing crowd heading towards the multimodal transfer facility. Carried along with the crowd, she easily locates a row of traveler information kiosks and stops to orient herself. She places her smart card near the contactless card reader and queries the kiosk regarding the optimum route from the airport to her hotel. She selects the shuttle as the best option. On the other side of town, the driver of an electric shuttle van notices that a new rider request has been added to his list of required pick-ups. The shuttle's integrated route guidance system factors Judy's destination into its near term schedule plans and prompts the driver to turn left at the next major street. The shuttle arrives at the bus stop within one minute after Judy arrives at the passenger waiting area. As Judy steps into the shuttle, the driver confirms her intended destination and pulls away from the curb as soon as she is safely aboard...

Standing by the bus stop outside the mall, Barbara reaches into her pocket and pulls out her smart phone. Barbara starts an application providing current bus schedule information. The unit uses its integrated position location facility and geographic information system to determine Barbara's bus stop and transmits a query using its wireless communications service. Behind the scenes, the query is transmitted on the wireless communications network and forwarded to the local traveler information service over a series of wireline networks. Within seconds, real-time schedule information is returned indicating that the next bus to Barbara's destination, which is running about two minutes late, will arrive in just five minutes...

weather and road condition information, to the sharing of roadway maintenance needs and activities, these two types of centers are finding many opportunities for data sharing to mutually improve their operations.

ISPs, TMCs, Emergency Management Centers and many other facilities are also recognizing the tremendous long-term value of the data they collect. Individually and collectively across regions, groups of transportation data gatherers and users have created data archives. Standards for accessing the data have been developed and a future vision is forming of improved planning and simplified reporting using the data products generated from these archives.

Integrating the Modes

Transportation planning has always been far more than just "roads". The revolution in ITS technologies has made this abundantly clear; the significant improvement of any single element will not yield full benefit unless all the adjoining elements can keep pace.

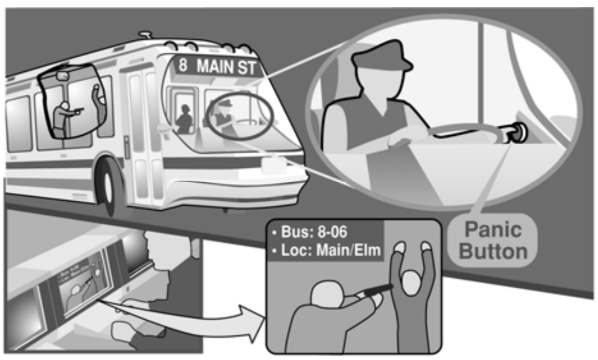
As airports have expanded to meet travel demands, they have been linked to transit systems, to support the ever-growing flow of passengers. Many airport-specific traffic and parking management systems have been created that tie into the overall integrated transportation information system. Freight shippers have pushed for the coordination and seamless transfer of cargo information between ships, trucks, rail and air freight carriers. The result has been the ascendance of the intermodal shipping industry as an enormous international success story.

Providers of transit services are dramatically improving the linkages between their different modes. Bus and train schedules are being cooperatively planned and this schedule information, along with parking availability information, will soon be easily obtained by the consumer as needed. There have also been regional resurgences of interest in passenger rail: the carefully planned deployment of light rail services promises to once again make trains an attractive choice for regional travel.

One critical link in the deployment of light rail has been the increase in the safety of highway-rail intersections (HRI). Traffic management centers can now obtain real-time operational data directly from HRIs and rail operations centers. This information is used to better control the vehicle traffic at rail crossings and to help public safety and emergency vehicles avoid unnecessary delays. In the future, many ITS safety innovations, like in-vehicle signage, will be drawn upon to support the continued modernization of HRIs. The increase in HRI safety has allowed for more cost effective upgrades of key intercity rail corridors, as they move incrementally towards high-speed service. In rural areas ITS-based low cost HRI technology has allowed a substantial increase in the percentage of crossings protected by active warning devices.

A trip today can be planned better, and conducted with greater safety and ease, than was possible five short years ago. Before a trip, a traveler can consult an ISP service to decide on the best mode of transportation for current conditions. It may be that it does not make sense to drive a personal car at all, but rather to depend on public transportation, to share a ride in an HOV, or to defer the trip for a while. Whatever the decision, the travel experience is becoming more and more predictable and efficient.

Public transit management has seen a surge in the availability of advanced scheduling tools, supporting everything from paratransit operations to vehicle (and its operator) selection and vehicle maintenance. Long used by large organizations, this technology has contributed to the overall reliability and efficiency of transit operations. In general, fixed route services have much better on-time performance, through schedule adherence and recovery algorithms, and through coordination with ISP and TMC operations. The coordination of multmodal connections and flexibly routed transit, along with the widespread availability of real time bus information have made public transit a much more convenient option. Surveillance systems have also been widely deployed, to track queues at transit stops and vehicle occupancy to ensure appropriate levels of service. These systems also contribute to enhanced personal security of transit riders. This security aspect has expanded to include not just transit stops, but also other traveler areas such as transit stations, transfer points, or rest stops.

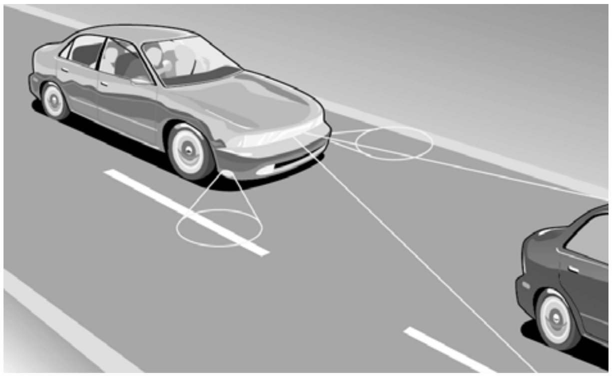


Commercial vehicles are benefiting not only from improved traffic management, but also from a host of other innovations. Weigh-in-motion systems are now being extensively deployed, as are services that start to automate administration. Congestion or delays at state checkpoints and international border crossings are beginning to fade from memory, as public agencies have recognized the value of the ITS initiatives. More progressive agencies have hooked into the communications infrastructure to support paperless administration through the standardized ITS interfaces. Most commercial vehicle safety inspectors have wireless touch screen "pads" that let them efficiently observe and record safety inspection results, uploading and downloading nationally coordinated carrier safety records as they proceed with inspections.

The traditional difficulty of finding urban parking for shopping, transit, and other needs is also being addressed through technology and cooperation. Modern parking management systems now electronically furnish rates, capacities, and availabilities to ISPs, TMCs, and through dynamic message signs directly to drivers. Some systems even allow reservations. Drivers, arriving at these facilities, are recognized by their toll tags and guided to their reserved spots. Their parking charges are applied automatically to the same account that supports their toll tag.

Vehicle Safety Systems

There has been yet another significant improvement in road transportation in the last few years. Sophisticated driver-aids, such as radar with "head-up" presentations of warnings, which were introduced several years ago, are now more widely available, helping drivers avoid collisions and other accidents. Intelligent cruise control, following its debut a decade ago, has become another widely deployed vehicle option. This feature adds headway detection to traditional cruise control, such that the system automatically tries to maintain safe stopping distances. These technologies are expected to significantly reduce accidents, particularly rear-end collisions in poor visibility conditions. Automated lane-keeping technology is available for specialized vehicles such as snowplows and is nearing deployment readiness in the research and development labs for the general vehicle population. Insurance companies are now offering reduced insurance rates to owners of vehicles with this equipment, much as they once did for the now mandated air bags and antilock brakes. Connected vehicle technology is just entering the marketplace, with the promise of providing crash prevention and other safety benefits.



Commercial vehicles have seen even more innovations that reflect their special needs. Continual monitoring of on-board systems and loads is now possible through sensors. The results are displayed using intelligent interfaces that reduce driver distractions. In some cases, this information is even made available via wireless communications to the fleet management center. In addition, on-board electronic logs for both trucks and trailers help the drivers and fleet managers track proper procedures and preventive maintenance requirements.

With the key standards in place, and many of the public infrastructure upgrades done, the long predicted private market is emerging with force. The future gains in transportation efficiency and safety can only increase, as more and more options open to transportation providers and consumers.

When Jim woke up in the medevac helicopter, he initially had no idea where he was or what had happened. The paramedic told him he had been in a bad accident and they were taking him to the hospital in Gillette. As Jim's disorientation cleared, he started to recall earlier events.

Jim had left his home in the rural area around Gillette, Wyoming several hours earlier, heading west into the Big Horn Mountains. He was to join up with some high school friends for a few days of camping and revelry. However, enroute he had unexpectedly come upon icy road conditions and could vaguely recall losing control of his 4x4.

The paramedic told him he was lucky; Jim's truck's traction control had kept him from going off the road at the most dangerous part of the turn. He had been smart enough to fit his truck with an updated mayday system, which includes data from vehicle sensors as a part of the automated mayday message. The paramedic said the helicopter had been in the air headed for Jim one minute after his air bag had deployed, automatically sending the mayday message and location data. Jim wouldn't even have been knocked unconscious if he had properly stowed his tackle box, the paramedic said: it had flown off the passenger seat when Jim's truck slid into the ditch, striking him square in the side of the head.

Jim realized he was lucky, but he cursed his timing. He had planned on installing an updated driver display right after the camping trip. It would have provided him with warnings that the road surface had dropped below freezing. Then maybe he wouldn't have been going quite so fast.

After 30 years of achievements, many of the original ITS goals have been realized and are embodied in this national system. We have made much progress, creating a whole new industry along the way. Let's take a step back, bask in our progress and extend our vision another 20 years into the future.

Epilogue: What Road from Here?

Transportation. Via air, water, rail, or roadway, it is an intrinsic part of the American culture. Transportation has defined the commercial and personal experiences of Americans, for good and for bad, since the earliest settlers emigrated to this continent. Key transportation events stand like mile markers in our nation's history: the Transcontinental Railway, the Panama Canal, the automobile, commercial air travel, the Interstate Highway System ... the list goes on.

ITS has continued this heritage of transportation pioneering. ITS has set goals that are fundamental and have been shared, explicitly or implicitly, by the transportation revolutions that have preceded it: improved safety, increased efficiency, reduced energy and environmental impact, enhanced productivity, and enhanced mobility. These are the drivers for industrial productivity and competitiveness, and for personal quality of life in America.

While pre-ITS transportation advances have often come from a single decisive stroke of technology, ITS has been different. The cumulative changes in transportation and communications technology have made the world a smaller place. The new revolution is in continuously tuning the system to most efficiently meet changing needs.

The National ITS Architecture has well served the needs of this revolution. Once a showpiece effort, the Architecture now lives on in the standards, the regional ITS architectures that are maintained in all regions of the country, and the integration that we take for granted in the Intelligent Transportation System.

ITS in the 30 years to 2022 has addressed the fundamental goals in both the public and private sectors. What has become clear is that the prosperity of the nation requires an efficient transportation system across all modes. And all modes must work together. The first thirty years has created the technology and the infrastructure to make roadway transportation better with respect to all the goals. And to improve the coordination of roadway transportation with the other modalities.

The first 30 years have also fundamentally changed the nature of how great projects are accomplished. The desire to leverage the efficiencies of the free market, while still providing for the common good, has entrenched the Public-Private partnership model. Where possible, projects are structured so that the costs and benefits are distributed equitably between the public and private sectors.

The next 20 years promise many things. The roadway transportation improvements will march onward. Vehicle safety technology will continue its advances. Ways will be found to preserve and even increase personal mobility, in the face of increased population and the scarcity of resources. Coordination between vehicles, routes, and signals will become feasible at finer and finer levels. Most importantly, the vision of the national Intelligent Transportation System will continue to evolve, enhancing intermodalism and creating new more efficient options to define commercial and leisure travel. The fundamental nature of progress is change; the view back from 2042 will likely be nothing short of spectacular.