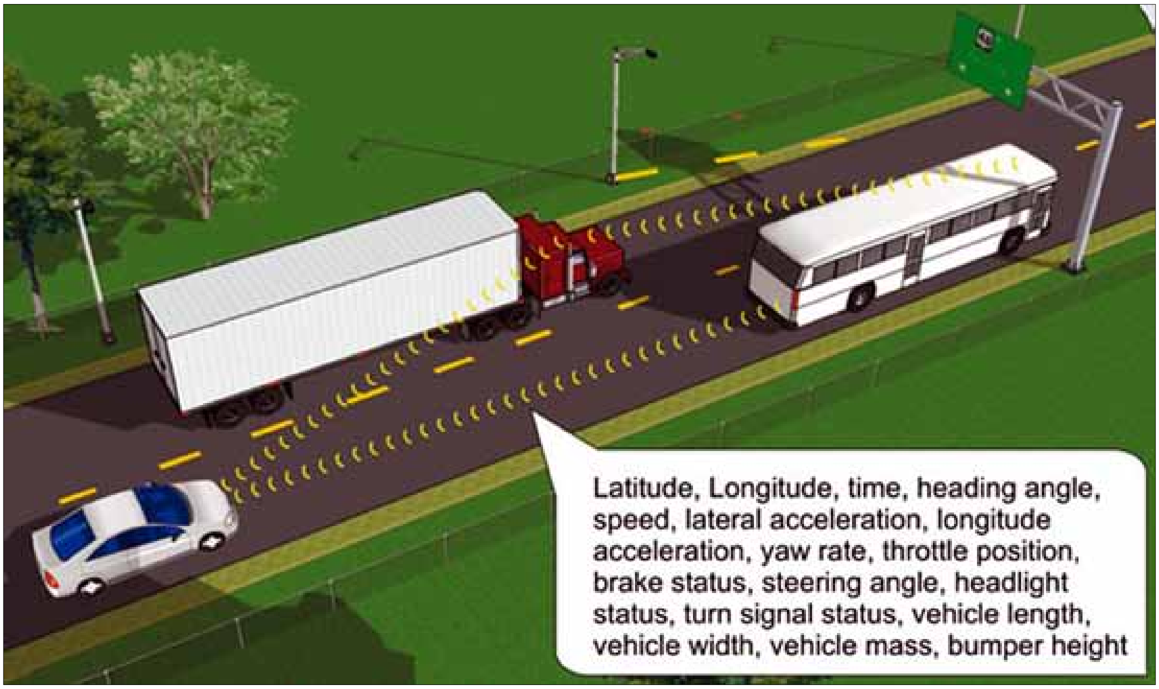
By Tom Kuennen, Contributing Editor



IntelliDrive℠ vehicle-to-vehicle and vehicle-to-infrastructure communications will provide detailed data that can help prevent collisions

Courtesy of RITA, U.S. DOT

ITS Finally Here!

It's taken nearly two decades, but intelligent transportation system technology is beginning to exert an influence

After nearly two decades of development, intelligent transportation system (ITS) technologies are finally going "mainstream."

The eyes of the ITS community – in both the public and the private sectors – remain firmly fixed on the big prize, self-controlling "autonomous" vehicles that respond to environmental and vehicle cues, and embedded signals, to avoid crashes, save lives and optimize travel. Another great goal is the ability of ITS to track vehicle movements to manage traffic volume and impose congestion pricing.

These two costly and even controversial outcomes have been long-time goals of the ITS Vehicle-Infrastructure Integration initiative, last year revised and relaunched as IntelliDrive℠, a service mark of the U.S. Department of Transportation.

But in the meantime, a host of "meat-and-potatoes," functional applications of ITS technology to vehicles and traffic already are transforming how commuters get to work and how traffic is managed throughout American road networks at all levels of government. And ongoing active research into these relatively low-cost, practical applications of ITS technology means that improvements will continue to flow, and refine how ITS will improve road system utilization.

The Promise of ITS

The promise of ITS is the high-tech transformation of automobile and truck travel, making it faster, safer and more efficient, helping optimize the traffic-carrying capacity of our congested highway infrastructure.

"Intelligent transportation systems encompass a broad range of wireless and wired communications-based technologies," says the Intelligent Transportation Society of America, better known as ITS America. "When integrated into the transportation system, and in vehicles themselves, these technologies relieve congestion, improve safety, and enhance productivity and the environment."

ITS encompasses a huge variety of applications over very wide segments of the soft-wheel transportation sector. Examples of ITS applications include vehicle collision avoidance technologies, E-Z Pass and "open road" tolling, real-time traffic and transit information, GPS-equipped navigational devices, "smart" traffic signals and parking systems, congestion pricing systems, weigh-in-motion truck inspection, electronic reservation and payment for transportation services, and advanced traffic management systems.

Applications include improvement of traffic flow, reduction of congestion and emissions, detection and response to highway emergencies, and warning of drivers of impending danger; but also improving freight security, provision of on-demand travel services, and the checking registration documents for commercial vehicles.

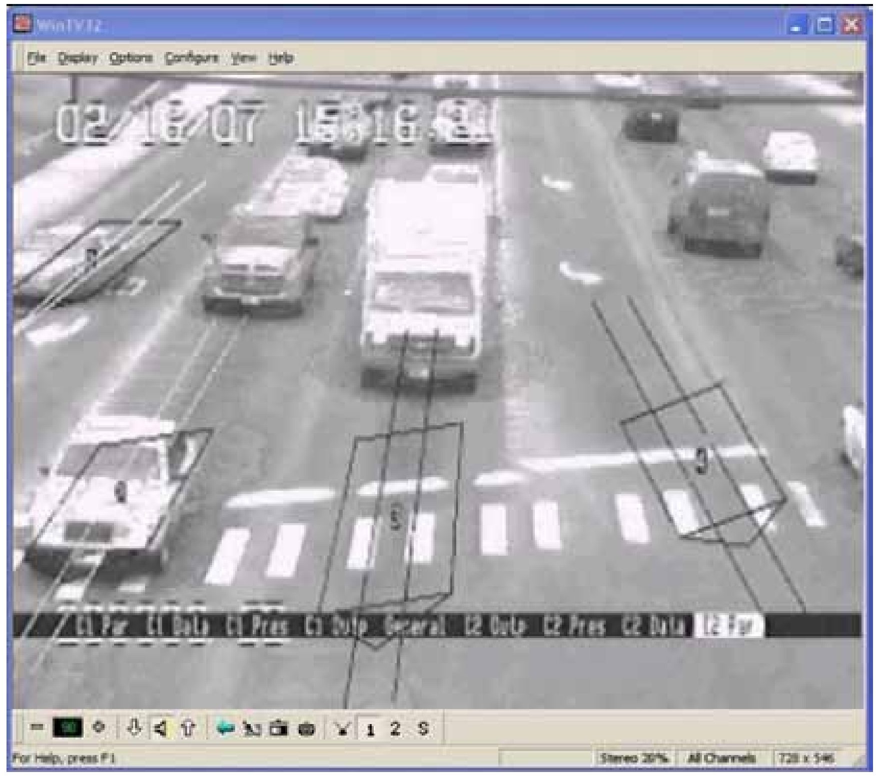
"Intelligent technologies are emerging to enable transportation networks and users to communicate with each other, improving system performance, safety and convenience, making IT just as important to 21st century transportation as airplanes, asphalt and petroleum were in the last century," said Samuel J. Palmisano, chairman and CEO of IBM Corp., at the 2010 annual meeting of the Intelligent Transportation Society of America in Houston in May.

"The idea is simple," Palmisano said. "The traveler's time, safety and experience should be the initial design point. And a system's design point matters. What you optimize it for – the way you envision its end state – will determine the value it ultimately delivers."

ITS' Slow Insinuation

Since its launch in 1991, ITS has insinuated itself almost imperceptively into road users' daily drives.

But instead of self-arresting autos, and onboard controllers that plot a trip to avoid traffic tie-ups or minimize congestion fees, today's motorists initially experience ITS via advanced traveler information systems (ATIS).



Video Image Processors (VIPs) have been increasingly deployed for intersection signal control over the past decade. A VIP can support up to 24 virtual loops, but normally less than half of the virtual loops are used. By properly configuring the spare virtual loops and analyzing the loop measurements, intersection performance can be monitored in real time.

Courtesy of Zheng, Ma, Wang, and Yi, TRB 2009

The traffic information may be provided via dashboard GPS systems which can provide real-time traffic congestion data on maps, but more commonly via overhead signage announcing travel times or delays ahead. Many urban regions also have this information displayed graphically on the Internet, providing much more detail to the road user than he or she gets from the over-the-airwaves traffic reporters (for an example, visit the Gary-Chicago-Milwaukee Corridor page, *www.gcmtravel.com*).

Such ATIS technologies are "decision support systems" that enable travelers to make their own trip routings based on current conditions, using real-time, site-specific devices like dynamic message signs, highway advisory radio, 511 telephone systems, and the Internet, all of which offer "on demand" information.

Separately, behind-the-scenes advanced traffic management systems (ATMS) "war rooms" permit toll, regional and state road agencies manage traffic flow, saving time and money for road patrons. These ATMS centers receive data and images from in-pavement sensors, motion detectors, video cams, and even automated weather stations to speed traffic flow decision making.

But two decades ago, much more was promised by ITS proponents. Via application of computers, communications and sensor technology to surface transportation, ITS was to be a pathway to entirely new ways of using, designing, and operating our road system.

ITS technologies – when fully integrated into our road system – were to form an electronic information infrastructure that would work in concert with the physical infrastructure, enhancing the efficiency and usefulness of the system. It was to be a secure system that could both detect and respond to regional crises, such as speeding hurricane evacuations.

And the future of ITS touches on science fiction. By integrating vehicle-to-vehicle and vehicle-to-infrastructure communications, ITS has the potential to independently control vehicle speeds on-the-fly, resulting in efficient more efficient traffic flow, and to make travel much safer, with far fewer and less se-

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vere crashes for all types of vehicles, and far faster response and recovery when crashes do occur.

This latter mission was dubbed VII, for Vehicle-Infrastructure Integration. But as of just last year, VII has been restyled and rebranded as IntelliDrive. The new IntelliDrive program now will drive, so to speak, the development of a wide range of vehicle control products that will reside on board vehicles, and along pavements.

New Visions for ITS

The ITS mission has changed in other ways. Under the Obama administration, which is promoting a "transformative" multi-modal and environmentally sustainable transportation policy to be codified within the stalled SAFETA-LU reauthorization, the U.S. DOT now frankly states that ITS implementation now will focus on multimodal solutions for ITS, with a "focus on moving people, not cars," and allocating transportation via price "signals," that is, congestion pricing.

This implies enhanced funding for ITS for transit and rail, perhaps at the expense of highway users. Congestion pricing always was part of the ITS architecture, which, it is thought, will manage congestion by imposing fees for the privilege of driving at peak periods, with collection enabled by ITS technology.

In June 2009, Valerie Briggs, Knowledge Transfer and Policy Team Leader, U.S. DOT ITS Joint Program Office, said the new ITS vision will result in a national, multi-modal surface transportation system that features a connected transportation environment among vehicles, the infrastructure, and portable [consumer wireless] devices, which will "serve the public good by leveraging technology to maximize safety, mobility and environmental performance."

Predictably, environmental benefits now will play a much larger role in America's ITS development than before. Among the new environmental goals of ITS research under the Obama administration, Briggs said in June 2009, are the ability to capture real-time environmental data from vehicles and all sources, create applications that use real-time data on environmental impact for use by transportation managers and for traveler information.

National Architecture Changing

In an effort to get the best use of public funds, to best leverage private sector funds, and to make sure ITS products can work from coast-to-coast, from the beginning the U.S. DOT has managed the development of a National ITS Architecture. It was given this mission in the first federal funding act of the post-Interstate era, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Subsequent federal surface transportation reauthorizations have supported the federal role.

The architecture defines the functions (e.g., gather traffic information, or request a route) that are required for ITS, the physical entities or subsystems where these functions reside (e.g., the field or the vehicle), and the information flows and data flows that connect these elements into an integrated system.

The alternative to a top-down, federally driven national architecture would have been a strictly open or market-based solution. However, this would have led to development delays as competing products went in different directions, or duplicated each other with slight variations. Instead, we now have national consistency in terms of subsystems, centers, information flows and external interfaces, so ITS in one region can be compatible with another region.

Under the direction of the U.S. DOT, major research initiatives have included:

- **Integrated Corridor Management (ICM)**, to better utilize existing corridor capacity, for which funding continues in FY 10
- **VII, now IntelliDrive**, for which funding continues in FY 10
- **Cooperative Intersection Collision Avoidance Systems (CICAS)**, for which funding continues in FY 10
- **Clarus**, a weather information network (funding set aside), and
- **Integrated Vehicle Based Safety Systems** (IVBSS, prototype vehicles designed to prevent rear-end, lane change and run-off-road crashes, funding complete).

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ITS Boosts Snow and Ice Control

In southeastern Michigan, ITS -- combined with a modern fleet management system -- is helping the three largest public road agencies in the Detroit metropolitan region to create one of the nation's most efficient and coordinated winter road maintenance systems.

The Southeastern Michigan Snow and Ice Management (SEMSIM) program is the first project of its type in the United States, in which multiple governmental agencies collectively use fleet management technologies that were originally developed by the U.S. military.

SEMSIM uses satellite-based fleet management technology to track more than 400 winter road maintenance vehicles as they cover over 5,500 miles of roads, and serve a population of more than three million.

The partner agencies include the City of Detroit, Oakland County, Wayne County, and SMART, the Suburban Mobility Authority for Regional Transportation (the area's suburban bus agency).

Following full implementation in 2006, all of the winter road maintenance vehicles of the partner agencies have been equipped with advanced fleet management and weather monitoring technologies. SMART provided a 900 MHz radio system to transmit data between the trucks and base stations and also relies on new winter road condition data transmitted from SEMSIM.

These technologies include satellite-based GPS vehicle tracking, air and pavement temperature sensors to determine if salting is required, computerized salt spreaders that regulate the amount of salt spread based on the vehicle's speed, on-vehicle sensors that collect data about vehicle activities and transmit in real time to fleet managers, the ability to remotely track fleet location and activities in real time on computerized maps, and the capability of sharing data in real time between partner agencies.

While the GPS system allows partner agencies to track vehicles in real-time so they can see exactly where they are and what they are doing, each SEMSIM truck is equipped with a number of sensors that record air and pavement temperature, and whether the front and underbelly plows are up or down. These data are fed continuously to management computers via the SMART radio system. Additionally, the computerized salt spreaders continuously tell the management computers the amount of salt being spread.

When a fleet manager looks at his computer screen, he sees a map with colored "traces" that show him where his or her trucks are and have been. The color of the trace tells him how long it has been since the truck was in that location and what the truck was doing when it was there. For example, a blue trace might indicate the truck was plowing, while a red trace might indicate the truck was salting. After 30 minutes, the trace would change to either dark red or dark blue, to indicate time passage.

The SMART bus dispatchers also receive real-time data from the trucks providing instant information about road conditions during winter storms. This allows the dispatchers to make informed route and scheduling decisions based on the most current data.

Additionally, the fleet-management software being used can automatically notify fleet managers where the nearest three support vehicles are when a truck breaks down. It also provides the ability to "play back" fleet activities to monitor and review all maintenance work.

Classic Dynamic Message Signs (DMS) *are common and provide real-time travel information.*

Photo courtesy of AAA Foundation for Traffic Safety

Adaptive Signals Move Traffic

While public and private interests both inside and outside the Beltway try to direct the development of America's ITS technologies, intelligent, practical refinements of existing traffic flow techniques – like the evolution of what used to be called "sequential traffic light timing" into "adaptive traffic signals" – offer tremendous value for both agencies and road users.

In past decades, arterial drivers were lucky if they could experience a consecutive sequence of traffic lights that would change to green as they approached. Today, sequential light timing is being fine-tuned using traffic sensors – combined with computer hardware and software – that will time lights according to traffic needs in real time.

"Classical and centralized traffic control systems are becoming obsolete and are unable to meet growing demands," says the Federal Highway Administration in its flyer, *Adaptive Control Software*. "In response, researchers at FHWA's Turner-Fairbank Highway Research Center began a 10-year research

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effort in 1992 to develop Adaptive Control Software (ACS)."

The goal of this effort was to refine traffic control systems that operate in real time, adjusting signal timing to accommodate changing traffic patterns as they unfold.

"Unlike their predecessors, these adaptive systems are not based on a fixed cycle length; they can adjust the split, offset, cycle lengths, and phase order of the control signal," FHWA says. "ACS uses sensors to interpret characteristics of traffic approaching a traffic signal, and using mathematical and predictive algorithms, adapts the signal timings accordingly, optimizing their performance."

Adaptive signal control is so appealing that on May 22, at the American Association of State Highway and Transportation Officials (AASHTO) spring meeting in Natchez, Federal Highway Administrator Victor Mendez announced that adaptive signal control technology would be one of several innovative technologies selected for accelerated deployment under his 2010 Every Day Counts initiative.

Other technologies selected were warm mix asphalt, geosynthetic reinforced soil integrated bridge systems, and prefabricated bridge elements and systems.

FHWA will host a series of strategic regional summits this fall to promote the deployment efforts, and to more broadly engage stakeholders who will be involved in mainstreaming the technologies.

New York City is developing a new integrated adaptive signal control decision support system, and is implementing it on two New York City arterials. In their 2010 Transportation Research Board paper *Integrated Adaptive Traffic Signal Control with Real-Time Decision Support*, authors Xin, Chang, Bertoli and Talas describe a new integrated adaptive signal control decision support system for use in the Big Apple.

Featuring mixed control objectives for both under- and over-saturated traffic, the system integrates a just-in-time "microscopic" traffic simulation framework, enabling the operator to supervise, review, and interact with signal operations in real-time by verifying algorithm-optimized strategies against other alternatives.

In addition to the "operator-in-the-loop" mode, the new system also supports autonomous signal optimization without operator interactions. Current implementation covers two arterials in New York City, i.e., Victory Boulevard in Staten Island with four intersections, and a section of Route 9A in Manhattan with 22 intersections.

But ACS is not limited to big governments. In November 2007, the City of Tyler, Tex., deployed the ACS-Lite technology along a 3.17-mile corridor. The deployment included $150,600 for the software module, $38,400 for traffic communication system upgrades, and $357,900 for detection devices.

Citing the results of a study of the ACS installation, the Tyler newspaper reported that on peak traffic hours on weekday mornings, motorists experienced the largest drop in drive times, with the average trip time in both directions dropping from just more than nine minutes each way to less than six minutes. On average, motorists' amount

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of stops dropped from 2.9 on the route to one stop per trip while traveling north, and from 3.1 to two per trip travelling south.

Middays, the average northbound trip time dropped from about 9.5 minutes to 8 minutes and 46 seconds, and the southbound trip was taking seven minutes, which was only nine seconds less than what it was before.

And at weekday peak evening hours, the northbound trip time was down by about 40 seconds to just less than nine minutes and the southbound trip time down by about a minute to less than eight minutes a trip.

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Improving Dynamic Message Signs

Another relatively low-cost way ITS is impacting today's drivers is via dynamic message signs (DMS), which are an important component of advanced traveler information systems. Such ATIS provide a powerful venue by which real time traffic information is accessed by motorists.

These DMS provide real-time en-route information, including roadway congestion situations, construction activities, incident events, and diversion needs. But they can be improved, according to Ricardo Jesus Aitken, Keith and Schnars, P.A., Guohui Zhang, Ph.D., Center for Transportation Research, University of Texas-Austin, Dr. C. Michael Walton, University of Texas-Austin, and Alison J. Conway, City College of New York, in their 2010 TRB paper, *Enhanced Traveler Information Dissemination Through Innovative Graphic Route Information Panels (GRIPs)*.

"Compared with traditional text-only messages, graphic-aided messages can be better recognized and understood," they authors write. "Although text-based DMS have been in operation for many years, research on graphic-based DMS is still in its early stages." The authors describe an innovative graphic-based DMS, which they call a Graphic Route Information Panel (GRIP).

The GRIP sign could provide real-time graphics of congestion, including delay times, or other messages, in a graphic way that has more impact than classic all-text DMS. "Overall, the analysis results indicate that GRIPs can provide improved traveler information dissemination to drivers when compared to traditional text-only DMS," the authors write.

ITS and Weather Reporting

Real-time weather reporting also is a feature of an integrated ITS. Unmanned state and local roadside Road Weather Information Systems (RWIS, pronounced "are-wiss") already can be accessed on the Internet on a state-by-state basis, among those states which maintain them.

But the Clarus initiative will make state RWIS data available at a single-point source, and its MDSS (Maintenance Decision Support System) program will provide road agencies at every level of government with new tools to optimize anti-icing and snow and ice control expenditures via enhanced decision making.

Modern weather information technologies promise great improvements in traffic congestion, safety, and mobility, given weather's impact on surface transportation. Because bad weather is the second largest cause of non-recurrent congestion, according to the FHWA, RWIS data helps road managers respond to future conditions in real time, effecting significant savings in material, labor costs, and congestion.

Clarus is an effort to link these systems together into an organic national whole. Clarus will provide information to all transportation managers and users nationwide that can be used to alleviate the effects of adverse weather on surface transportation.

Two components comprise Clarus: Initial development of the Clarus system, which is a network for sharing, quality checking, and exchanging surface environmental data and relevant surface transportation conditions; and development of tools (such as decision support systems) that make effective use of the Clarus system.

In the long run, RWIS will become part of the ITS architecture, via IntelliDrive. Ultimately the future smart cars and roadways of IntelliDrive will collect, transmit, and analyze real-time weather information. Even now, most cars carry onboard thermometers, and luxury models can detect airborne precipitation, which automatically triggers windshield wiper operation. In the meantime, onboard anti-skid computers analyze tire-pavement friction and automatically initiate antilock braking in skid situations. Air-density sensors that could indicate relative humidity for a network system already are used in conjunction with fuel injectors. All of these common environmental indicators could be put to use for real-time pavement conditions on a microscale.

Ultimately, information such as *Black Ice Ahead*, 100 feet will become available on the dashboard of a vehicle, as it approaches pavement that other vehicles have sensed.

The Clarus Initiative is on schedule for completion in late 2010, with transitional activities extending to 2012, according to RITA, the Research and Innovative Technology Administration of the U.S. DOT, which administers ITS development. The initiative will conduct a variety of technology transfers and ultimate transition to an operational capability of the Clarus System, including transitioning the initiative to NOAA, expansion of participation by state and local governments, continued research, integration with other systems, and promotion of wider use, RITA said.

While ITS initiatives move ahead on a regional and multi-state basis, IntelliDrive remains the "Holy Grail" of the U.S. DOT and its public and private

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sector partners.

"Imagine a world where highway crashes and their tragic consequences are significantly reduced, vehicles of all types can talk to traffic signals to eliminate unnecessary stops and help people drive in the most fuel efficient manner, travelers can get accurate travel time information about all modes and route options and the potential environmental impacts of their choices, and transportation managers have data to accurately assess multi-modal transportation system performance," suggested Peter Appel, Research and Innovative Technology administrator, in March. "This vision may be closer than you think, and is the focus of the department's next five-year *ITS Strategic Research Plan*."

The new strategic plan, released in December 2009, relies more than ever before on the potentially transformative capabilities of wireless technology to implement ITS in America.

"The core of the research plan is IntelliDrive, a multimodal initiative that aims to enable safe, interoperable wireless connectivity between vehicles (autos, buses, trucks, and other fleets), infrastructure and passengers' devices to support safety, mobility and environmental enhancements," Appel said in March.

"IntelliDrive could potentially address 82 percent of the vehicle crash scenarios involving unimpaired drivers," said Shelley Row, P.E., director of RITA's ITS Joint Program Office, in late November. "At full coverage and full effectiveness, IntelliDrive could save thousands of lives per year."

IntelliDrive proposes improved mobility, safety and environment through the adoption of smart technologies. Mobility and congestion would be improved via vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V) communications in which operations, traffic, transit, weather and even parking availability information contribute to a to a data-rich environment. IntelliDrive would use wireless communications on dedicated short range communication (DSRC) bands to provide connectivity with and between vehicles (V2V); between vehicles and roadway infrastructure; and among vehicles, infrastructure and wireless consumer devices.

It's thought that IntelliDrive can reduce congestion. By using V2I capabilities and anonymous information from passengers' wireless devices relayed through DSRC and other wireless transmission media, the program has the potential to provide transportation agencies with dramatically improved quality and quantity of real-time traffic, transit and parking data, making it easier to manage transportation systems for maximum efficiency and minimum congestion. Thus the system could also enable travelers to change their route, time and mode of travel, based on up-to-the-minute conditions, to avoid traffic jams.❖

Proposed GRIP panel *provides instant visualization of congestion ahead.*

Graphic courtesy of Aitken, Zhang, Walton, and Conway, TRB 2010

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