

# 12. Transportation



As anyone who has driven a late-model automobile knows, information technology (IT) has made major inroads into the personal vehicle. Most late-model cars have at least an auxiliary input to the sound system for iPods and other music players, and some offer full integration of portable media players to allow selection of music by title, artists, genre, or other criteria. They have antilock braking systems that electronically monitor the speed of the wheels and regulate the hydraulic pressure to improve stopping power and control on dry, wet and icy pavements. And cars increasingly have navigational systems that rely on satellite technology to help drivers find where they want to go.

These changes in personal vehicles began to appear in the latter part of the 20th century following improvements in sensor, computational, and communication technologies. Previously, interactions between automotive vehicles, occupants, and their environments consisted of a few simple elements. A vehicle's tires interacted physically with the roadway; and systems in the vehicle such as power braking, power steering, and cruise control assisted the driver in operating the vehicle safely and comfortably. The driver (and passengers) generally sensed the environment by relying on visual observation (through the windshield, side windows, and rear view mirrors); tactile sensation (the feel of the steering wheel, pedals, and other control devices, and the movement of the vehicle itself). Most vehicles were equipped with a one-way radio (AM or FM), and some had two-way mobile communication devices (e.g., CB radio, police radio). The driver paid attention to pavement markings, traffic signals, signs, and billboards. For people outside the vehicle, information about a vehicle and its occupants came primarily from observing such things as driving speed or patterns, the vehicle's license number, inspection certificates, etc.

Following improvements in sensor, computational, and communication technologies in the latter part of the 20th century, in-vehicle systems such as antilock braking systems and adaptive cruise control began to proliferate and improve. In addition, in-car concierge systems like General Motors' OnStar that rely on cellular networks and in-car navigational devices that rely on satellite systems began to appear. Personal vehicle owners are not the only ones in the transportation sector who have benefited from improvements in sensor, computational, and communication technologies. Highway owners are using automatic, electronic toll collection systems such as

IT into their control systems and using it to provide better information to transit patrons. And on the horizon are "intelligent transportation systems" with ubiquitous connectivity that can provide real-time warning and safety information to vehicles on the road to prevent fatalities and injuries, improve public transit, reduce traffic congestion, improve the allocation of resources to the transportation infrastructure, and mitigate transportation's negative impacts on the environment.<sup>1</sup>

As described below, the combination of sensor, computational, and communication technologies—or telematics—in the transportation sector has opened up a whole range of new possibilities for improving access to transportation-related information; enhancing the safety of transportation; and improving transportation system monitoring and management.

### Improving Access to Transportation-Related Information

One of the big benefits of IT is improving access to transportation-related information. As discussed below, applications of telematics collectively promise to make our transportation systems come alive with information.

#### *Directions for Getting Places*

Thanks to the Internet, a vast amount of information is available to anyone contemplating a trip of any length from a walk to the corner store (is it open at this hour?), to a drive or bus trip across town (how is the traffic?) or across the country (how far is it and what is the shortest, or most scenic, or least congested route?). Online booking of travel for air, train, or

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E-ZPass in the eastern United States and FasTrak in California to improve the efficiency of toll collection, reduce fuel emissions, and help manage congestion. Public transit providers are incorporating

rental car is now par for the course. Checking the status of a flight to see if it is on time or has been canceled is easily accomplished by mobile phone or Web browser.

Both Google and Microsoft now have systems announced or already available that will provide traffic information in real time. Google Maps provides a “traffic” button on its maps in metropolitan areas that shows red-yellow-green indicators for traffic speeds. And Google recently introduced a feature that reports “normal” traffic levels by the time of day and day of the week. Microsoft has announced a new software feature called Clearflow that uses artificial intelligence to provide navigation advice that takes into account expected traffic conditions on a roadway-by-roadway basis.<sup>2</sup>

Finally, cars in the United States increasingly have global positioning system (GPS) navigational devices—either a factory installed GPS device, a GPS device installed after the vehicle’s purchase, or a mobile GPS device such as those available from Garmin or on mobile phones. Factory-installed GPS devices are currently available on 69 percent of all vehicle models sold in the United States. In 2007, 1.8 million navigation systems were sold, bringing the total to 7 million units with GPS-based navigation on the road.<sup>3</sup>

### *Information About Ridesharing, Public Transportation, and Car Sharing*

IT is making it easier for drivers to connect with potential passengers traveling between the same origins and destinations, improving public transportation, and making it possible for car sharing companies to give urban dwellers access to a car at a moment’s notice without actually owning one.

Casual carpooling systems are already in place in a few cities around the United States. Passengers stand in shopping center parking lots near high-occupancy vehicle (HOV) entrances, and drivers cruise by to find a passenger going to approximately the same destination. In the evening, the reverse process occurs. Picking up an extra passenger provides drivers with access to an HOV lane or someone to share the cost of a toll. A more technologically advanced system to facilitate “on the fly” ridesharing, could provide added safety and efficiency, and increase market share.

On the public transit front, a major barrier to more widespread adoption of public transportation is that commuters—especially in America’s sprawling suburbs—personally find public transit to be

less efficient than driving a car. Personalized public transportation is designed to directly address these problems by tying together several modes of public transportation through IT, minimizing wait times in the process. A personalized public transportation system can deploy circulating on-call minibuses, for example, to pick up individual passengers and bring them to a waiting train or bus that might travel between suburbs or into a central city. A Finnish software company called MobiSoft has developed software for this sort of personalized public transportation network that works over existing mobile phone networks.<sup>4</sup>

A number of public transportation systems are also using telematics to improve existing services. One of the leaders is Paris. Bus stops in Paris have a digital display that shows when the next bus is expected to arrive for each line serving the stop. During the city’s transit strike in fall of 2007, the signs were updated to announce the lack of service. The subway system in Washington, D.C., has a similar system that shows estimated train arrival times for every station in the system. The bus system in Washington has also experimented with a “Next Bus” system that shows information about arrival times for buses based on real-time tracking of bus locations available via Web-enabled mobile devices.<sup>5</sup>

Giving urban dwellers cheap access to cars makes people more likely to give up owning a car that they seldom use, resulting in fewer cars, more efficient utilization of resources, and lower carbon emissions. Car-sharing companies like Zipcar allow consumers to use the Internet to easily rent locally located cars at a moment’s notice. Car sharing would be impossible without the Internet to locate and coordinate the substitutes for personally owned cars and without IT-enabled car locks that let only the user drive the car.

Finally, some companies are relying on IT to transform their employees’ commutes to and from work. Microsoft, for example, now offers employees at its headquarters in Redmond, Washington, the opportunity to travel to work aboard one of its new fleet of Wi-Fi-enabled buses. Not only are the buses a more environmentally friendly means of transportation, but their computer jacks and Wi-Fi access also allow Microsoft’s employees to become more productive by working during their commute.<sup>6</sup>

### *Parking Information*

For people who have arrived at their destinations, telematics is increasingly helping with information about parking. Parking is one of the more complicated phenomena in the transportation sector, giving rise to questions such as how much parking to provide, how to price it, how to enforce it, where to locate it, and how to design it so it is visually attractive.

Telematics has the potential to make parking a little easier to manage both from a user and a provider standpoint. At Baltimore Washington International Airport, for example, the recently opened parking deck has a system that shows how many spaces are available on each parking level. When drivers reach a particular parking level, red and green lights above each space that are visible from the end of the aisle allow them to quickly determine whether an aisle has any vacant spaces.

Finding a parking space on the street may also get easier with telematics. Systems are being deployed that would indicate to drivers where vacant spaces are located and would even allow drivers to reserve spaces in advance. San Francisco, where in 2007 a teenager was stabbed over a parking spot argument, is installing wireless sensors in 6,000 parking spots. Drivers will automatically be able to know where an empty spot is by either downloading the information onto a cell phone or GPS device or looking at street signs that are hooked up to the system.<sup>7</sup> Pooled parking markets have also been proposed. Parking space owners, including homeowners or retail stores, could register their parking places in an auction or reservation system, thereby allowing enrolled users to bid for or reserve a space, which could be charged to a linked credit card.

Given that 30 percent of urban traffic in some cities consists of drivers cruising for curbside parking, smart parking systems made possible by telematics have the potential to provide benefits not only in terms of reducing frustration but also of reducing congestion, reducing fuel consumption, and improving air quality. One survey found 45 percent of the cars driving in Park Slope in Brooklyn, New York, were searching for a parking spot on the street.<sup>8</sup> Another survey found that in one small Los Angeles business district, drivers looking for parking spots drove the equivalent of 38 trips around the world throughout

the course of a year.<sup>9</sup>

Telematics is even helping with the pesky problem of parallel parking the car in the city. On its LS model, Lexus is currently offering an advanced parking guidance system that parallel parks the car automatically. The driver positions the vehicle slightly forward of the open space, and the vehicle does the rest (the driver controls the speed using the brake pedal, but the system handles the steering). (It is not clear whether this system will be allowed for use during driving tests at the local department of motor vehicles.)

Another area where telematics is coming into play is parking enforcement. The District of Columbia and other jurisdictions are on the verge of deploying high-tech parking enforcement systems that automatically read license plates and vehicle locations while the parking enforcement vehicle moves along the street. On the next pass of the parking enforcement vehicle, the high-tech system quickly identifies vehicles that have overstayed a space that allows parking for only a limited time, such as one or two hours—even if the vehicles' owners have fed the meter. Such enforcement would free up curbside spaces, potentially reducing the amount of time others cars spend cruising around looking for a parking space. (It might also just put another car back on the street cruising for an open space on the next block.)

### *Information Tailored to an Individual's Location*

Telematics makes possible applications that sift and present information based on an individual's location—sometimes called location-based services. On the Internet, for example, individuals can go to Google Maps, MapQuest, or other online mapping systems and type in a specific location; the mapping application will then find and identify services (e.g., gas stations, restaurants, hotels) nearby. Thus, such mapping systems can even direct individuals to the nearby station with the cheapest gas or a station that sells diesel fuel.

In addition, concierge services available by subscription through General Motors' OnStar, Mercedes' TeleAid, and similar services have used a vehicle's location read from the vehicle's onboard GPS transponder, in combination with databases used by a concierge, to find restaurants, hotels, Wal-

Marts, and other establishments near the vehicle, as well as to help with traffic navigation. Such systems, which have been available for a decade or more, are increasingly fully automated. Possible extensions of such systems may give retailers opportunities to offer promotions (e.g., coupons, discounts, or other incentives) to vehicle occupants that are based on the vehicle's location in real time.

## Improving Transportation Safety

One of the biggest potential benefits of telematics is significantly improving transportation safety. In 2006, almost 43,000 people in the United States died in vehicle crashes. Telematics has the potential

to reduce that number by providing a rich stream of information to and from automotive vehicles and even preventing accidents through collision warning and avoidance systems, speed advisories, and even speed control systems.

With dedicated short-range communication (DSRC) tags that offer the potential of a single-sensor in-vehicle safety device, the price barriers may come down. Thus, it may be possible to offer much more advanced safety features on a broader price range of vehicles, or even to make them standard equipment on all vehicles. If automakers installed DSRC tags on all vehicles, a world of opportunities opens up, building on a virtuous cycle of a broadening installed base of DSRC-equipped vehicles and a broadening range of services and applications that could be provided economically.

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### *In-Vehicle Safety Systems*

A host of in-vehicle safety systems enabled by telematics are already available. Adaptive cruise control, which maintains a minimum distance between a vehicle ahead, reduces the risk of rear-end accidents. Side-looking and rear-looking sensors warn drivers of objects behind them when backing up or in adjacent lanes if the driver begins to change lanes and risks a collision. Sensors can warn drivers when tire pressures are below specification, or even when tires are wearing out.

One challenge is making in-vehicle safety systems affordable. At General Motors, current onboard safety systems use up to eight separate sensors (cameras and radars) to provide 360-degree visibility around the vehicle. The cost of these systems is on the order of thousands of dollars per vehicle because of the expense of the sensors themselves, their integration with other onboard systems, and servicing their war-

ranties. The high cost limits the use of such security systems to luxury or premium vehicles. With dedicated short-range communication (DSRC) tags that offer the potential of a single-sensor in-vehicle safety device, the price barriers may come down. Thus, it may be possible to offer much more advanced safety features on a broader price range of vehicles, or even to make them standard equipment on all vehicles. If automakers installed DSRC tags on all vehicles, a world of opportunities opens up, building on a virtuous cycle of a broadening installed base of DSRC-equipped vehicles and a broadening range of services and applications that could be provided economically.

On the transportation safety front, the Holy Grail is collision avoidance via what are known in the trade as “cooperative intersection collision avoidance systems” (CICAS). For CICAS to work, most or all vehicles on the road would have to be equipped with DSRC tags, and the necessary roadside equipment would have to be widely deployed. In that case, two DSRC-equipped vehicles approaching an intersection would be in continuous communication with roadside devices that would recognize when a collision was imminent and warn the drivers of an impending collision or communicate with the vehicles to brake or take appropriate evasive action.

Telematics has the potential to make possible a rich stream of information to and from automotive vehicles and prevent accidents via collision warning and avoidance systems, speed advisories, or even speed control systems. But the vehicle fleet takes more than a decade to turn over, and installing and maintaining hundreds of thousands of roadside devices poses challenges for state departments of transportation that are strapped for funds. For that reason, the goal of the Vehicle Infrastructure Integration initiative that has been undertaken by the Research and Innovation Technology Administration at the U.S. Department of Transportation is to

work toward deployment of the advanced vehicle-vehicle and vehicle-infrastructure communications that are necessary to avoid collisions.<sup>10</sup>

### *Better Traveler Information and In-Vehicle Signage*

A number of applications for DSRC would be available on the first day factory-installed DSRC-equipped automotive vehicles hit the street. Several of these Day 1 applications are intriguing. One would be improved traveler information. Drivers could receive information about estimated travel times, like the currently available navigation systems, as well as alerts about construction, road closures, detours or traffic incidents on the route ahead. Another Day 1 application would be in-vehicle signage that would alert the vehicle's driver to speed limits, school zones, stop signs, etc., as the trip progressed. Ideally, traffic control zones that changed by time-of-day and day-of-week would be announced only when active.

ing with a lightly used cross street, most of the green time should be allocated to the thoroughfare. If there are two thoroughfares with roughly equal traffic, the green time should be more evenly divided. More complicated intersections with dedicated left turn lanes or multiple streets intersecting require more elaborate signaling plans. Traffic flows can also be considerably improved if adjacent intersections along a thoroughfare or even across a whole network are coordinated. And of course, traffic patterns vary by time-of-day, day-of-week and around holidays, as well as with the share of automobiles, buses and trucks that make up the traffic stream. Signal timing plans should reflect all of these factors.

Therein lies the challenge: collecting all the data needed to inform signal timing plans is time-consuming and extremely expensive. The old fashioned pneumatic tube counter, which lies across a traffic lane, has been supplemented by more advanced sensors that automatically count and classify the types

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In-vehicle signage could also provide information about roadside services at highway exits, replacing or supplementing the familiar “gas-food-lodging” signs currently in use.

### *Improved Traffic Signal Timing*

Another goal of the transportation world that DSRC would help with is improving the timing of traffic signal timing. How many times have you waited seemingly forever at a red light while no cross traffic went through the intersection? Shouldn't the system “know” there was nobody using the intersection?

Better timing of traffic signals would allow the owners and operators of highways to improve traffic flow and reduce congestion. The problem today is that most of the signal timing in the United States is based on seriously outdated traffic information. Developing a traffic signal timing plans requires lots of data. The optimal signal timing plan depends on the relative volume of traffic going through the intersection. If there is a heavy thoroughfare intersect-

of vehicles using a lane. But even so, the Achilles heel of traffic engineers for decades has been bad data. The vast majority of the 272,000 signalized intersections in the United States use outdated timing plans based on data that was collected years or decades ago, or perhaps just based on typical plans looked up in a handbook. The signals at one key intersection in Washington, D.C., still allocate green time for traffic on a road that has been closed since September 11, 2001. An estimated 5 percent to 10 percent of the congestion on major roadways in America today—amounting to 295 million vehicle hours—is due to bad signal timing.<sup>11</sup>

Telematics has the potential to make data collection much easier. DSRC-equipped vehicles could provide traffic engineers with an affordable and continuous data source for updating and maintaining signal timing plans. That way, traffic signals would become “intelligent.” And having intelligent traffic signals would offer several benefits, not only reduced delays for people on the road but also reduced fuel

consumption and tailpipe emissions.

### *Roadway Weather Information*

Telematics has the potential to provide greatly improved information about roadway weather, such as road surface temperatures and visibility. With an “intelligent transportation system,” vehicles operating on a roadway could act as weather “probes” sending information to a control center, which could then compile the data to provide much greater detail about real-time conditions. Such information could be provided to individual motorists, along with information about whether a particular road had been treated, and how recently—e.g., the system could warn a driver of icy road surfaces ahead, using a visual and/or an audio alert. Such information could also be used to deploy snow and ice treatment operations more efficiently and effectively.

Europeans are experimenting with a system called “intelligent speed adaptation,” which allows a system external to a vehicle to provide a warning when the vehicle exceeded recommended speeds or actually limit the vehicle’s speed. The limitations on vehicles’ speeds imposed by the system could be based on real-time weather or road conditions, or simply on the posted speed limit for a roadway.

## **Improving Transportation System Monitoring and Management**

Currently, most roads in the United States are not managed in any active way; they are just built and then many seem to be forgotten about. But IT is beginning to change that by bringing intelligence about the transportation infrastructure to transportation system managers. IT also has the potential to improve the allocation of resources to the transportation infrastructure.

### *Monitoring Transportation Infrastructure*

The catastrophic collapse in Minnesota of the eight-lane Interstate 35W bridge across the Mississippi River in 2007 clearly illustrates transportation managers’ need for real-time information on the state of bridges, highways, and other transportation infrastructure. That incident led Lee and Sternberg to propose the deployment by the United States

of a national bridge monitoring and reporting system that would use electronic sensors embedded in bridges to monitor and report on their structures. Electronic systems are more accurate than manual testing and would alert bridge owners in the event of extreme events, such as excessive loads or structural failures.<sup>12</sup>

Transportation departments in more than 20 states already deploy wireless sensors on bridges that can detect cracks and stresses. These sensors monitor vibration, temperature, and corrosion, as well as sounds such as creaks and popping cables that reveal structural problems before they can cause a catastrophe.<sup>13</sup>

A country at the forefront of remote bridge monitoring is South Korea. The Korean Bridge Management System is a network of wireless sensors that connect to a centralized database that analyzes and stores 230 variables per bridge including carry capacity and environmental variables such as vibrations, temperature, and humidity to help ensure the safety of these structures.<sup>14</sup>

IT-enabled systems for monitoring pavements have been proposed as a method for improving road safety. Sensors embedded in the pavement can provide real-time, continuous data on the condition of pavement surfaces, such as temperature or presence of ice. Electrical power and water distribution companies have long used computer-monitored “supervisory control and data acquisition” (SCADA) systems to acquire data on the system status and to control devices on the system from a control center. The deployment of similar SCADA systems to monitor and manage highways and transit systems could lead to significant improvements in efficiency and effective control.

### *Improving the Allocation of Transportation Resources*

IT boosts allocative efficiency—the production of the right goods for the right people at the right price—by enabling the creation of markets and market signals in areas where market signals have not generally existed. In the transportation sector, for example, IT enables roadway space to be allocated on the basis of demand and price. Economists have long recognized that road pricing (charging by distance traveled, place traveled and/or time of day),

is the most efficient way to allocate scarce transportation resources. But until recently, it was too expensive and cumbersome to institute road-pricing schemes. Now the emergence of inexpensive vehicle transponders and other technologies is allowing regions to institute road pricing. An electronic road pricing program in Singapore, for example, reduced morning traffic volume by 45 percent as many travelers opted to carpool, take transit or telecommute; and the program almost doubled average speeds in the restricted area surrounding the central business district.<sup>15</sup>

In the United States, IT is allowing regions to make more efficient use of the more than 1,600 miles of HOV lanes operating in 31 metropolitan areas. Most of the time, HOV lanes are underutilized. IT-based transponders allow regions to let cars willing to pay a toll use these lanes, with the result that throughput on the roads goes up and additional investments in new, expensive roads are not immediately required.<sup>16</sup> Electronic toll payment is already available with the current generation of electronic tags like E-ZPass and FasTrak. Airports in New York are even allowing payment for parking with E-ZPass. By allowing vehicles to pass through toll plazas more quickly, these systems cut pollution and fuel consumption. Similarly, new technology can weigh trucks on the fly, making the stopping and idling that used to accompany truck weigh stations no longer necessary. The fuel and emissions savings from reduced congestion can be enormous, especially if traffic congestion increases fuel consumption by 80 percent, as has been estimated.<sup>17</sup>

Stockholm's automatic tolling system is a pioneering example of how IT can help to alleviate congestion and reduce pollution by discouraging automom-

obile travel at peak travel times. Under the system, tolls for the roads vary depending on the time of day, type of car (hybrids pay less), and route traveled, with the highest fees applied during peak rush hour when pollution is worst to encourage commuters to seek out alternative transportation. Underpinning the system is an IBM network that includes access points that correspond with smart tags in vehicles to deduct tolls automatically from drivers' accounts. Drivers without smart tags can pay tolls over the Internet, and their usage of the roads is tracked by a camera system that captures and identifies license plate numbers.<sup>18</sup> Such sophisticated tolling—both tailored and “on the fly” to avoid impeding traffic flow—would not be possible without smart systems that rely on information technology.

Stockholm's congestion pricing scheme has yielded immediate results, reducing traffic by 25 percent in the first month of implementation as legions of commuters opted for public transportation.<sup>19</sup> After a seven-month trial period, the system was so popular that voters approved its permanent implementation. And Stockholm is not the only city experimenting with IT-based traffic management. London has successfully implemented a similar system, and plans to extend its variable pricing to reflect the carbon emissions of particular vehicles, charging higher fees to less fuel-efficient cars.<sup>20</sup> Meanwhile, Singapore is taking the idea even further, working to develop a system that predicts traffic flow based on a network of sensors and cameras—including sensors in taxi cabs to monitor traffic flow in real time—in order to improve traffic management.<sup>21</sup>

Through telematics, big benefits for consumers and for transportation system operators seem to be within reach.

## Endnotes

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ITIF is a non-profit, non-partisan public policy think tank committed to articulating and advancing a pro-productivity, pro-innovation and pro-technology public policy agenda internationally, in Washington DC and in the states. Recognizing the vital role of technology in ensuring American prosperity, ITIF focuses on innovation, productivity, and digital economy issues.

Technological innovation, particularly in information technology, is at the heart of America's growing economic prosperity. Crafting effective policies that boost innovation and encourage the widespread "digitization" of the economy is critical to ensuring robust economic growth and a higher standard of living. However, as in any new and changing situation, policymakers have varied awareness of what is needed and what will work. In some cases legislators have responded to new and complex technology policy issues with solutions more suited for the old economy. And as the innovation economy has become increasingly important, opposition to it from special interests has grown. Finally, the excitement that the press, pundits and decision makers showed toward the information technology (IT) revolution in the 1990s has all too often been replaced with an attitude of "IT doesn't matter." It is time to set the record straight—IT is still the key driver of productivity and innovation.

As a result, the mission of the Information Technology and Innovation Foundation is to help policymakers at the federal and state levels to better understand the nature of the new innovation economy and the types of public policies needed to drive innovation, productivity and broad-based prosperity for all Americans.

ITIF publishes policy reports, holds forums and policy debates, advises elected officials and their staff, and is an active resource for the media. It develops new and creative policy proposals to advance innovation, analyzes existing policy issues through the lens of advancing innovation and productivity, and opposes policies that hinder digital transformation and innovation.

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