Executive Summary: Intelligent Transportation Systems

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Information technology (IT) has transformed many industries, from education to health care to government, and is now in the early stages of transforming transportation systems. While many think improving a country's transportation system solely means building new roads or repairing aging infrastructures, the future of transportation lies not only in concrete and steel, but also increasingly in using IT. IT enables elements within the transportation system—vehicles, roads, traffic lights, message signs, etc.—to become intelligent by embedding them with microchips and sensors and empowering them to communicate with each other through wireless technologies. In the leading nations in the world, ITS bring significant improvement in transportation system performance, including reduced congestion and increased safety and traveler convenience. Unfortunately, the United States lags the global leaders, particularly Japan, Singapore, and South Korea in ITS deployment. For the most part, this has been the result of two key factors: a continued lack of adequate funding for ITS and the lack of the right organizational system to drive ITS in the United States, particularly the lack of a federally led approach, as opposed to the "every state on its own approach" that has prevailed to date.

This report examines the promise of ITS, identifies the global leaders in ITS and why they are leaders, discusses the reasons for the U.S. failure to lead, and proposes a number of recommendations for how Congress and the Administration can spur robust ITS deployment. If the United States is to achieve even a minimal ITS system, the federal government will need to assume a far greater leadership role in not just ITS R&D, but also ITS deployment. In short, it is time for the U.S. Department of Transportation to view ITS as the 21st century, digital equivalent of the Interstate highway system, where, like then, the federal government took the lead in setting a vision, developing standards, laying out

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routes, and funding its construction. Just as building the Interstate Highway System did not mean an abandonment of the role of states, neither does this new role; but just as building the Interstate required strong and sustained federal leadership, so too does transforming our nation's surface transportation through ITS. Accordingly, this report recommends that in the reauthorization of the surface transportation act, Congress should:

- **Significantly increase funding for ITS at the federal level, by $2.5 to $3 billion annually, including funding for large-scale demonstration projects, deployment, and the ongoing operations and maintenance of already-deployed ITS. Specifically, the next surface transportation authorization bill should include $1.5 to $2 billion annually in funding for the deployment of large-scale ITS demonstration projects and should also provide dedicated, performance-based funding of $1 billion for states to implement existing ITS and to provide for ongoing operations, maintenance, and training for already deployed ITS at the state and regional levels.**

- **Expand the remit of the ITS Joint Program Office to move beyond R&D to include deployment.**

- **Tie federal surface transportation funding to states' actual improvements in transportation system performance.**

- **Charge DOT with developing, by 2014, a national real-time traffic information system, particularly in the top 100 metropolitan areas, with this vision including the significant use of probe vehicles.**

- **Authorize a comprehensive R&D agenda that includes investments in basic research, technology development, and pilot programs to begin moving to a mileage-based user fee system by 2020.**

Transportation systems are networks, and much of the value of a network is contained in its information: For example, whether a traffic signal "knows" there is traffic waiting to pass through an intersection; whether a vehicle is drifting out of its lane; whether two vehicles are likely to collide at an intersection; whether a roadway is congested with traffic; what the true cost of operating a roadway is; etc. Intelligent transportation systems empower actors in the transportation system—from commuters, to highway and transit network operators, to the actual devices, such as traffic lights, themselves—with actionable information (that is, intelligence) to make better-informed decisions, whether it's choosing which route to take; when to travel; whether to mode-shift (take mass transit instead of driving); how to optimize traffic signals; where to build new roadways; or how to hold providers of transportation services accountable for results. This information can be used both to maximize the operational performance of the transportation network and to move towards performance based funding for transportation systems. ITS also represent an emerging new infrastructure platform, from which a whole host of new products and services are likely to emerge, many which can barely be imagined today.

Intelligent transportation systems include a wide and growing suite of technologies and applications. ITS applications can be grouped within five summary categories: 1) Advanced Traveler Information Systems provide drivers with real-time information, such as transit routes and schedules; navigation directions; and information about delays due to congestion, accidents, weather conditions, or road repair work. 2) Advanced Transportation Management Systems include traffic control devices, such as traffic signals, ramp meters, variable message signs, and traffic operations centers. 3) ITS-Enabled Transportation Pricing Systems include systems such as electronic toll collection (ETC), congestion pricing, fee-based express (HOT) lanes, and vehicle miles traveled (VMT) usage-based fee systems. 4) Advanced Public Transportation Systems, for example, allow trains and buses to report their position so passengers can be informed of their real-time status (arrival and departure information). 5) Fully integrated intelligent transportation systems, such as vehicle-to-infrastructure (VII) and vehicle-to-vehicle (V2V) integration, enable communication among assets in the transportation system, for example, from vehicles to roadside sensors, traffic lights, and other vehicles.

ITS deliver five key classes of benefits by: 1) increasing safety, 2) improving operational performance, particularly by reducing congestion, 3) enhancing mobility and convenience, 4) delivering environmental benefits, and 5) boosting productivity and expanding economic and employment growth.

ITS are contributing to a fundamental reassessment of vehicle safety. Whereas most developments in transportation safety over the past 50 years were designed to protect passengers in the event of a crash, VII and V2V systems such as Japan's Smartway or the United States' IntelliDrive are being designed to help motorists avoid the accident altogether. For example, the U.S. IntelliDrive system could potentially address 82 percent of vehicle crash scenarios involving unimpaired drivers.

ITS maximize the capacity of infrastructure, reducing the need to build additional highway capacity. For example, applying real-time traffic data to U.S. traffic signal lights can improve traffic flow significantly, reducing stops by as much as 40 percent, reducing travel time by 25 percent, cutting gas consumption by 10 percent (1.1 million gallons of gas annually), and cutting emissions by 22 percent (cutting daily carbon dioxide emissions by 9, 600 tons). ITS can contribute significantly to reducing congestion, which costs U.S. commuters 4.2 billion hours and 2.8 billion gallons of fuel each year, costing the U.S. economy up to $200 billion per year. Overall, ITS can reduce congestion by as much as 20 percent or more. ITS also enable transportation agencies to collect the real-time data needed to measure and improve the performance of the transportation system, making ITS the centerpiece of efforts to reform surface transportation systems and hold providers accountable for results.

By improving the operational performance of the transportation network, ITS enhance driver mobility and convenience, deliver environmental benefits, and even boost productivity and economic growth. For Japan, ITS have been crucial as the country strives to meet its goal to reduce, by 2010, CO_2 emissions by 31 million tons below 2001 levels, with 11 million tons of savings come from improved traffic flow and another 11 million tons of savings from more effective use of vehicles. For many countries, ITS represents a rapidly expanding, export-led growth sector which contributes directly to national economic competitiveness and employment growth. For example, the U.S. Department of Transportation has estimated that the field of ITS could create almost 600,000 new jobs over the next 20 years, and a study of ITS in the United Kingdom found that a £5 billion investment in ITS would create or retain 188,500 jobs for one year.

Intelligent transportation systems deliver superior benefit-cost returns when compared to traditional investments in highway capacity. Overall, the benefit-cost ratio of systems-operations measures (enabled by intelligent transportation systems) has been estimated at about 9 to 1, far above the addition of conventional highway capacity, which has a benefit-cost ratio of 2.7 to 1. A 2005 study of a model ITS deployment in Tucson, Arizona, consisting of 35 technologies that would cost $72 million to implement, estimated that the average annual benefits to mobility, the environment, safety, and other areas would total $455 million annually, a 6.3 to 1 benefit-cost ratio. If the United States were to implement a national real-time traffic information program, the GAO estimates the present value cost of establishing and operating the program would be $1.2 billion, but would deliver present value benefits of $30.2 billion, a 25 to 1 benefit-cost ratio.

Despite their technical feasibility and significant benefit-cost ratios, many nations under-invest in ITS, partly because there are a significant number of challenges involved in developing and deploying ITS. While some ITS, such as ramp meters or adaptive traffic signals, can be deployed locally and prove effective, the vast majority of ITS applications—and certainly the ones positioned to deliver the most extensive benefits to the transportation network—must operate at scale, often at a national level, and must involve adoption by the overall system and by individual users at the same time to be effective, raising a unique set of system interdependency, network effect, and system coordination challenges. For example, VII systems like IntelliDrive must work on a national basis to be truly effective: it does a driver little good to purchase an IntelliDrive equipped vehicle in one state if it doesn't work in other states the driver frequents. Likewise, drivers are not likely to demand on-board units capable of displaying real-time traffic information if that information is unavailable. Many ITS systems work optimally at scale: For example, it makes little sense for states to independently develop a vehicle miles traveled usage-fee system because, in addition to requiring an on-board device in vehicles (ideally as part of the original factory-installed equipment), VMT requires a satellite system and a back-end payment system, and it makes little sense for states to independently replicate these infrastructure investments. Moreover, auto manufacturers would not want to have to make or install up to 50 different on-board devices to accommodate states' potentially differing implementations of a VMT system.

But whether it's with regard to ITS systems that face systemic barriers or those that can be deployed locally, many regions, states, and countries underinvest in ITS. This happens, in part, because transportation funding is often allocated without consideration of performance, giving transportation planners little incentive to preference investments that can have a maximum impact on optimizing system performance. Part of the problem is that state and local transportation agencies were created to build and maintain infrastructure, not to manage transportation networks, and thus see themselves as "builders of pieces" and not "managers of a system" and therefore place more emphasis on building new roads than ensuring the system functions optimally. For companies developing new ITS products and services, the effort entails much higher risk than does development of many other products and services, in part because governments are key buyers, and in some countries, such as the United States, they have demonstrated at best mixed signals as reliable purchasers. Apart from being generally underfunded, another challenge for ITS projects is that they often have to compete for funding with conventional transportation projects—fixing potholes, repairing roads, building new ones, etc.—that may be more immediately pressing but don't deliver as great long-term returns. Finally, ITS face a range of institutional and organizational barriers, including limited understanding of the technology and jurisdictional challenges, such as which level of government—federal, state, county, city, public authority, or interstate compact—has responsibility for or jurisdiction over ITS deployments.

But while intelligent transportation systems face a number of challenges, none of them are insurmountable, and many nations have overcome them. Japan, South Korea, and Singapore appear to have done so the best. Japan leads the world in ITS based on the number of citizens benefitting from an impressive array of operationally deployed intelligent transportation systems. Japan's VICS, Vehicle Information and Communication Systems, provides an up-to-the minute, in-vehicle digital data communication system providing traffic information to drivers through an on-board telematics unit. VICS, which makes extensive use of probe data to generate real-time traffic information, launched in 1996 and has been available nationwide since 2003. Following upon VICS, Japan is now launching Smartway as "Version 2.0" of the country's state-of-the art ITS service. The system will be able to marry knowledge of the vehicle's location on the roadway with context-specific traffic flow information, enabling it, for example, to warn the driver, via voice instruction, "You are coming up to a curve with congestion backed up behind it, slow down immediately." Impressively, Smartway evolved from concept development in 2004, to limited deployment in 2007, to initial national deployment in 2010, an extremely fast development timeline. At least 34 million vehicles have access to real-time, in-vehicle traffic information in Japan, and citizens can view maps with real-time traffic information for most roads in Japan over the Internet. Lastly, Japan operates a single national standard for electronic tolling, with 68 percent of vehicles using ETC. The country invests just under $700 million a year in ITS.

South Korea will invest $3.2 billion in ITS deployment from 2008 to 2020, about $230 million annually, as part of the country's ITS Master Plan. South Korea built its ITS infrastructure on a city-by-city basis, establishing four initial "ITS Model Cities" that implemented: 1) adaptive traffic signal control, 2) real-time traffic information, 3) public transportation management, and 4) speed violation enforcement in these model cities. 29 South Koreans have now deployed similar ITS implementations. 9,300 buses and 300 bus stops have deployed real-time bus location and status notification systems. South Koreans use T-money, an electronic money smart card (or mobile phone application) to make 30 million contactless transactions per day on public transit. The country's Hi-Pass ETC system covers 50 percent of highway roads (expanding to 70 percent coverage by 2013) and is used by 31 percent of vehicles.

Singapore was the first country in the world to introduce an electronic congestion pricing system in 1998 (and has actually had some form of congestion charging in place in its city center since 1975). The country generates and disseminates real-time traffic information through a fleet of 5,000 probe vehicles. Singapore has deployed adaptive computerized traffic signals nationwide, installed real-time bus status screens at most bus stops, and launched a national parking guidance system in April 2008. Singapore's i-Transport system is at the cutting edge of predictive traffic flow modeling based on the use of historic and real-time traffic data.

In contrast to the leaders, the United States lags in ITS deployment, particularly with regard to provision of real-time traffic information, progress to date on vehicle-to-infrastructure and vehicle-to-vehicle integration, adoption of computerized traffic signals, and maximizing the effectiveness of its already fielded ITS systems. While the United States certainly has pockets of strengths with regard to ITS in particular regions and applications—including use of variable rate highway tolling, electronic toll collection, certain advanced traffic management systems such as ramp metering, and an active private sector market in telematics and travel information provision—overall the implementation of ITS varies significantly by state and region, thus tending to be sporadic and isolated and not connected into a nationally integrated "intelligent transportation system." As one illustration of U.S. challenges in ITS, the percentage of U.S. metropolitan areas delivering real-time highway travel time and highway travel speed information to the public in 2007 was, respectively, 36 percent and 32 percent, while for arterial roadways, only 16 percent of U.S. metropolitan areas disseminate real-time travel speed information and only 19 percent distribute real-time travel time data.

For the most part, U.S. challenges in ITS have been the result of two key factors: a continued lack of adequate funding for ITS; and the lack of a federally led approach, as opposed to the "every state on its own approach" that has prevailed to date. At the federal level, the U.S. ITS effort focuses on research, is funded at $110 million annually, and operates out of the U.S. Department of Transportation's Research and Innovative Technology Administration's (RITA) ITS Joint Program Office (JPO). To reorganize and reanimate the U.S. ITS effort, on January 8, 2010, RITA unveiled a new, five-year "ITS Strategic Research Plan, 2010-2014." While the Strategic Plan represents an important step forward, the United States needs to make a fundamental transition from a focus mostly oriented around research to include a much greater focus on deployment and endeavor to accelerate the speed at which ITS technologies reach the traveling public.

In explaining international leadership in intelligent transportation systems, policy factors appear to be much more important than non-transportation policy factors. Overall, countries leading the world in ITS deployment: 1) demonstrate national level commitment and vision, 2) make substantial investments in ITS deployment, and 3) feature strong government leadership in crafting a clearly articulated ITS vision, setting a national agenda, convening relevant stakeholders, and spearheading implementation. Many of these countries enjoy a high degree of centralization in ITS decision making and deployment, and in some cases federal governments (as in Japan) have direct control over roadways. But these countries also invest in ITS. For example, South Korea and Japan each invest more than twice as much in intelligent transportation systems as a share of GDP than the United States. Further, these countries recognize ITS as a "force-multiplier" for their transportation networks that will enable a shift to a performance-based transportation funding system, have built their ITS infrastructure through public-private partnerships, and view their ITS investments as a platform that will lead to the creation of new value-added products and services, many of which can scarcely be foreseen today.

Over the next five years, the United States is poised to invest more than $500 billion on the nation's surface transportation infrastructure. Intelligent transportation systems must be a critical component of these investments in order to maximize the operational performance of the transportation system and attain the significant benefits enumerated in this report. If the United States does not take advantage of the current opportunity to significantly fund ITS as part of the next surface transportation authorization, it risks not only falling further behind world leaders and other developed economies in ITS, but also losing ground to rising countries such as China and India, which are beginning to make substantial investments in ITS development and deployment.