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Report to Congressional Committees

September 2005

HIGHWAY CONGESTION

Intelligent Transportation Systems' Promise for Managing Congestion Falls Short, and DOT Could Better Facilitate Their Strategic Use

GAO-05-943

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Highlights

Highlights of GAO-05-943, a report to congressional committees

September 2005

HIGHWAY CONGESTION

Intelligent Transportation Systems' Promise for Managing Congestion Falls Short, and DOT Could Better Facilitate Their Strategic Use

Why GAO Did This Study

Congestion is a serious and growing transportation problem for the nation. Many strategies—like adding new lanes—have the potential to alleviate congestion but can be costly and have limited application. Another strategy is the use of communications, electronics, and computer technologies—intelligent transportation systems (ITS)—to more effectively utilize existing transportation infrastructure by improving traffic flow. Congress established an ITS program in 1991, and the Department of Transportation (DOT) subsequently set an ITS deployment goal.

In this report GAO (1) describes the federal role in deployment; (2) assesses DOT's ITS goal and measurement efforts; (3) identifies what ITS studies have found regarding the impacts of ITS deployment; and (4) identifies the barriers to ITS deployment and use.

What GAO Recommends

GAO recommends that the Secretary of Transportation improve the measurement of ITS deployment and address some barriers to ITS deployment to help state and local governments select projects that cost effectively meet transportation goals. GAO provided a draft of this report to the Department of Transportation for its review and comment. The department generally agreed with the information in the report and agreed to consider the recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-05-943.

To view the full product, including the scope and methodology, click on the link above. For more information, contact JayEtta Z. Hecker at (202) 512-2834 or heckerj@gao.gov.

What GAO Found

The federal role in ITS deployment includes goal setting, funding, and facilitating states' investment in ITS. In 1991, Congress set broad goals and established funding for ITS, and in 1998, Congress established a program to support ITS deployment. In a 1996 speech, the Secretary of Transportation established a vision for ITS deployment to save time and lives and improve quality of life. As part of this vision, the Secretary also established a goal that the 75 largest metropolitan areas deploy a complete ITS infrastructure by 2005 and measures to track progress toward this goal. DOT has taken several actions to support this goal, though it does not plan to update it.

Progress has been made toward achieving DOT's deployment goal, but DOT's goal and measures have limitations and fall short of capturing ITS's impact on congestion. Among other things, the measures do not capture the extent to which deployed ITS technologies are effectively operated, and we found that some metropolitan areas' operations of ITS technologies are limited. For example, Chicago developed 10 traffic management centers to monitor and respond to traffic congestion by notifying emergency responders of traffic accidents, among other things; however, 6 centers do not have full-time operators, which is likely to limit their impact on congestion mitigation.

Many of the ITS studies we reviewed suggest that ITS deployment can have benefits such as relieving congestion, traffic throughput, safety, and air quality. Results from some studies suggest that ITS benefits depend on effectively operating ITS technologies to meet local conditions. However, few studies provided information about cost effectiveness of the ITS deployments, which is essential for maximizing public investments.

According to transportation officials GAO spoke with, barriers to ITS deployment and use include the limited public awareness of the impact of ITS, difficulty of funding ITS operations, limited technical expertise, and lack of technical standards. DOT actions have had limited success in overcoming these barriers.

A Chicago Metropolitan Area's Traffic Management Center That Lacks Staff Dedicated throughout the Day

Source: GAO.

Contents

Abbreviations

CMAQ	Congestion Mitigation and Air Quality Improvement program
DOT	Department of Transportation
FHWA	Federal Highway Administration
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	intelligent transportation systems
JPO	Joint Program Office
NHS	National Highway System program
NTOC	National Transportation Operations Coalition
SAFETEA-LU	Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users
SDO	standards development organization
STP	Surface Transportation Program
TEA-21	Transportation Equity Act for the 21st Century

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, D.C. 20548

September 14, 2005

The Honorable James M. Inhofe
Chairman
Committee on Environment and Public Works
United States Senate

The Honorable Christopher S. "Kit" Bond
Chairman
Subcommittee on Transportation and Infrastructure
Committee on Environment and Public Works
United States Senate

The Honorable Sherwood L. Boehlert
Chairman
The Honorable Bart Gordon
Ranking Minority Member
Committee on Science
House of Representatives

Increasing passenger and freight travel has led to growing congestion in the nation's transportation system, which has posed a burden on the nation's quality of life through wasted energy, time, and money; increased pollution; and threats to safety. According to transportation researchers, even with slow growth in jobs and travel in 2003, the cost of congestion to the nation's economy in terms of extra fuel used and time spent in congestion was $63 billion.[1] Moreover, passenger and freight traffic are expected to grow substantially in the future, increasing the challenge of preventing congestion from overwhelming the transportation system. For example, by 2010, the Department of Transportation (DOT) forecasts that travel on roads will have increased by about 25 percent from 2000, while freight traffic will have increased by 43 percent from 1998. One tool available to help reduce congestion is the use of intelligent transportation systems (ITS), such as electronic technologies designed to monitor or control traffic flow, in order to improve transportation system operations, management, and performance.[2]

[1]David Schrank and Tim Loma, Texas Transportation Institute, *2005 Urban Mobility Report* (College Station Texas, 2005).

[2]ITS technologies are also used for a number of other purposes, including improving safety. However, safety impacts are not in the scope of this review.

We have previously reported that there are a range of strategies to mitigate the effect of increasing congestion, including building capacity through construction, corrective and preventative maintenance, rehabilitation, managing system use through pricing or other techniques, and operations and system management, including the use of ITS.[3] We have also reported that using the full range of these strategies offers the promise of being more effective than placing emphasis on any one technique. For example, building new infrastructure can ease congestion, but it is not always a viable solution due to constraints such as the cost of construction or limited availability of land. Moreover, improving system operations, management, and performance through the strategic use of ITS technologies has the potential to reduce congestion without major capital investments. ITS technologies range in complexity from ramp meters, which are small traffic light-like devices that control the traffic flow on ramps leading to freeways or tollways, to fully integrated systems in which several technologies work together to process information and respond to traffic conditions. For example, a traffic-sensing device could collect data on traffic flow by monitoring traffic volume and speed, which could be used to alter the timing of freeway ramp meters and arterial road traffic signals to improve traffic flow as well as to alert travelers to specific traffic conditions using variable message boards or other devices.

Over the past 14 years, the federal government has provided billions of dollars for investment in surface transportation projects through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and its successors, the Transportation Equity Act for the 21st Century (TEA-21) and the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU).[4] Recognizing the potential of ITS as a tool to improve mobility, among other benefits, Congress established a federal ITS research program and some dedicated ITS funding in ISTEA and continued this program and funding in TEA-21 and SAFETEA-LU. Dedicated funding for integrating ITS deployments from TEA-21 has

[3]GAO, *Surface and Maritime Transportation: Developing Strategies for Enhancing Mobility: A National Challenge*, GAO-02-775 (Washington, D.C.: Aug. 30, 2002).

[4]State and local governments provide an even greater share of the funding for surface transportation investments than the federal government. For example, in fiscal year 1999, state and local governments contributed 61 percent of the total public sector spending for public roads.

averaged about $113 million a year.[5] Although it continued to fund the ITS research program, SAFETEA-LU did not directly reauthorize the ITS integration deployment program. It did create a new program, known as the intelligent transportation infrastructure program, that will help states monitor real time traffic and travel conditions on major U.S. highways. In addition to dedicated ITS funding, state and local governments may choose to spend some of the billions of dollars of federal funds provided through other surface transportation programs on ITS technologies. Among many activities DOT has undertaken in support of the ITS program, in 1996, it established a goal that 75 of the nation's largest metropolitan areas would have a complete intelligent transportation infrastructure by 2005.

SAFETEA-LU authorized billions of dollars more in federal funding for surface transportation projects through fiscal year 2009. As we have reported, for these funds to have the greatest effect on the congestion of the existing transportation system, transportation planners and decision makers need to select the appropriate mix of tools and resulting projects to efficiently use available funds. Making appropriate and cost-effective investment choices will become even more critical if, as we and other analysts have been reporting, the nation faces a sustained period of deficits and fiscal imbalance, resulting from the growing mandatory commitments for programs including Social Security and Medicare as well as a large investment in homeland security. Given these fiscal challenges, careful decisions will need to be made to ensure that transportation investments maximize the benefits of federal highway funds and achieve projected performance outcomes. However, as we have noted previously, there are currently no mechanisms in the federal-aid highway program that link federal funding to project performance.[6]

In order to assess the extent to which ITS is being effectively used as a tool to reduce congestion, this report has the following objectives:[7] (1) describe the federal role in ITS deployment; (2) assess progress toward DOT's ITS deployment goal and DOT's measures for assessing the status of ITS; (3)

[5]SAFETEA-LU authorized funding for the 2005 ITS integration deployment program.

[6]GAO, *Federal-Aid Highways: Trends, Effect on State Spending, and Options for Future Program Design*, GAO-04-802 (Washington, D.C.: Aug. 31, 2004).

[7]Although the federal ITS program has also included a research component and ITS technologies are used for a number of purposes, in this report we are focusing on the federal role in the deployment and use of ITS technologies to mitigate congestion rather than on the research and development of such technologies.

identify what ITS studies have found regarding the impacts of ITS deployment; and (4) identify barriers to ITS deployment and use.

To describe the federal role in ITS deployment for mitigating congestion, we reviewed legislation, the Secretary of Transportation's 1996 speech for the Transportation Research Board's annual conference, as well as documents from DOT, including performance plans and other relevant materials. To assess progress toward DOT's ITS deployment goal and DOT's measures, we reviewed DOT's status reports on ITS deployment and interviewed DOT ITS officials who track deployment of ITS technologies in over 75 metropolitan areas. We also selected four congested areas to study in depth by sorting the 75 largest U.S. metropolitan areas according to both congestion level and DOT's integrated deployment rating and selecting two areas that DOT has determined have deployed ITS to a great extent and two areas that DOT has determined have deployed ITS to a lesser extent. During our visits to these four areas—Chicago, San Francisco, Indianapolis, and Las Vegas—we interviewed federal, state, and local transportation officials about their experiences with ITS and the ITS technologies deployed in each area. To identify the impacts of ITS deployment on congestion, we reviewed 38 studies issued since 2000 that we obtained from our site visits and DOT's ITS benefits database, a repository of academic and government papers evaluating the deployment of ITS technologies in U.S. and international locations, including any cost-effectiveness information encompassed in the studies. A DOT contractor reviewed the studies for methodological soundness before including them in DOT's benefits database. We also reviewed the DOT benefit database studies we selected to ensure these studies were based on sound methodologies and determined these studies were sufficiently reliable for describing actual and potential impacts of ITS technologies. We selected only studies on U.S. deployments, since our review is focused on ITS deployment in the United States and the federal ITS program. In addition, we did not assess the potential benefits of any one technology, such as open road electronic tolling, on the nation's transportation system. To determine barriers to ITS deployment in congested metropolitan areas, we discussed barriers to deploying and maintaining ITS technologies with the federal, state, and local transportation officials we visited at our four case study locations. Although ITS technologies can be used for many purposes, including improving highway safety, we focused this analysis on the role of ITS for mitigating congestion. We conducted our work from October 2004 through August 2005 in accordance with generally accepted government auditing standards. (See app. 1 for more information about our scope and methodology.)

Results in Brief

The federal role in ITS deployment includes setting goals, providing funding, and performing other activities to facilitate states' and localities' investment in ITS. Congress set broad goals and established funding for ITS through ISTEA in 1991. In 1998, TEA-21 established the ITS integration program with the goal of improving ITS deployment through supporting the integration of ITS systems across and within metropolitan and rural areas. TEA-21 authorized about $113 million annually for the integration program since 1998, and each year since, Congress has designated these funds to specific states or projects. In addition, other federal-aid highway funds are available for states to use for ITS technologies. In a 1996 speech, the Secretary of Transportation, Federico Peña, DOT established a vision for ITS deployment to create an intelligent transportation infrastructure across the United States that would save time and lives and improve the quality of life for Americans. In this speech, Secretary Peña articulated an ITS deployment goal—to achieve a complete ITS infrastructure in the country's 75 largest metropolitan areas within 10 years—by the end of fiscal year 2005 according to DOT officials. The Secretary also emphasized the importance of strategic investment in ITS technologies; projected impacts of increasing infrastructure capacity and reducing Americans' travel time by at least 15 percent; and emphasized the cost effectiveness of ITS. The Secretary's goal was incorporated into subsequent DOT performance plans with interim measures under its mobility and economic growth goal. DOT does not plan to update the deployment goal once it expires at the end of 2005. DOT has undertaken several roles to facilitate states' ITS deployment, such as showcasing ITS benefits through a benefits database available on its Web site. DOT also developed measures to track progress toward the ITS deployment goal. DOT biennially surveys the 75 metropolitan areas' transportation-related agencies and rates the areas' deployment levels according to its measures.

Progress has been made toward achieving DOT's deployment goal, but DOT's goal and measures have limitations and fall short of capturing ITS's impact on congestion. According to DOT, 62 of the 75 metropolitan areas had met its goal of deploying integrated ITS infrastructure in 2004. DOT defined the Secretary's goal of complete intelligent transportation infrastructure to include two elements—deployment, meaning the extent that certain technologies are installed over certain areas such as freeways, and integration, meaning the extent of coordination between different agencies that deploy ITS technologies. However, although the Secretary's goal calls for a "complete" ITS infrastructure, according to DOT's criteria, metropolitan areas with relatively low thresholds of ITS infrastructure—

such as 20 percent of freeway miles and 33 percent of signalized intersections covered by certain ITS technologies—may meet the goal. DOT officials stated they established these relatively low thresholds because they did not have a way to determine the extent to which ITS should be deployed in each metropolitan area, and they also stated that complete deployment is a very long-term goal that perhaps will never be reached. In addition, although DOT's goal and measures give a sense of progress of ITS deployment, they fail to capture a number of important dimensions of evaluating the status of ITS that the Secretary alluded to in his 1996 speech: they do not take into account the level of ITS needed to accomplish local goals and priorities; they do not capture the extent to which deployed ITS technologies are being effectively operated; and they do not evaluate the impact or cost-effectiveness of ITS. The lack of evaluation of outcomes, including impact or cost effectiveness, also has been identified as a limitation of other highway programs. The status of ITS in the four metropolitan areas we visited illustrate the shortfalls of DOT's ITS deployment goal and measures. Although San Francisco and Chicago, both of which DOT counted toward meeting the deployment goal, have made considerable strides in implementing ITS, they face limitations related to operating their ITS technologies. For example, Chicago developed 10 traffic management centers, which monitor traffic conditions and can respond to traffic incidents by dispatching emergency vehicles to quickly clear highway accidents, thus reducing traffic delays. However 7 of the 10 centers do not have full-time operators, which limits the centers' potential congestion mitigation benefits. Similarly, although neither Indianapolis nor Las Vegas were rated by DOT as contributing toward meeting the deployment goal, transportation officials in these metropolitan areas stated they had deployed the amount of ITS needed to meet their local needs. For example, Las Vegas was rated as not meeting the goal because the area had not yet deployed ITS technologies on freeways—a key measure in DOT's rating of ITS deployment. However, Las Vegas officials said they had focused on deploying ITS on arterial roadways because they experienced more congestion on the arterials than on the freeways.

While studies show that ITS technologies can provide benefits including reducing congestion and increasing safety, the studies also indicate that the existence and level of most benefits depends on the extent to which ITS technologies are effectively operated to coordinate with local traffic conditions. In addition, most studies do not include an analysis of cost effectiveness. Although congestion is a serious problem, ITS is one tool that has the potential to reduce the delay due to congestion. The Texas

Transportation Institute, a leading transportation research institution, estimated that in 2003, congestion caused 3.7 billion hours of travel delay, while operations improvements, including ITS, reduced the hours of delay by 336 million hours in 85 urban areas. In addition to congestion benefits, ITS deployment can improve traffic throughput (number of vehicles accommodated on highways), safety, air quality, and traveler behavior. However, studies also suggest that the effectiveness of ITS technologies depends on local conditions and how state and local agencies implement and operate the ITS technology. For example, one study suggested that ramp metering in Detroit would be most effective during major events or traffic incidents when freeway congestion was higher, because during average conditions, the improvement of traffic flow on the freeway due to ramp metering did not outweigh the delays on entrance ramps and arterials leading to the freeway. In addition, 33 of the 38 studies we reviewed did not include a review of cost effectiveness. Cost information in relation to benefits is necessary to help states and localities choose the best tool for addressing their congestion problem while maximizing the return on their transportation investments. This is especially important because ITS applications may have different cost structures and life cycles as compared to other types of highway investments—for example, relatively low initial deployment costs but ongoing operational costs—that need to be understood in order to strategically evaluate ITS as a tool.

State and local agencies responsible for deploying ITS technologies have faced several barriers to deploying ITS. One barrier to deployment is that state and local transportation officials often view other transportation investment options, such as adding a new lane to a highway, more favorably than ITS when deciding how to spend their limited transportation funds. DOT has worked to make ITS projects a more appealing option by emphasizing the benefits of ITS technologies through its benefits database on its Web site and field office support to local transportation officials. However, in prior work, we found that information on benefits does not have a decisive impact on the final investment choices made by state and local officials.[8] Another barrier to ITS deployment cited by state and local transportation officials is a lack of funding for ITS installations and operations. We also found that officials in four areas we visited were not aware that federal funds could be used for operational costs. DOT officials said they have attempted to inform state transportation agencies that

[8]GAO, *Surface Transportation: Many Factors Affect Investment Decisions*, GAO-04-744 (Washington, D.C.: June 30, 2004).

operational costs are eligible for federal assistance, but confusion on this issue remains. State transportation officials also told us that a lack of technical expertise has hindered ITS deployment. Finally, state transportation officials said that a lack of technical standards for ITS technologies makes it difficult to ensure that systems purchased by different localities can be integrated. DOT has taken steps to support the issuance of technical standards by standards organizations, but they have had difficulty keeping up with the pace of technological advances. According to transportation officials we spoke with, these barriers have reduced the amount of ITS deployed, and therefore have likely limited the impact of ITS on mitigating congestion on our nation's roads.

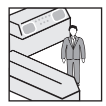
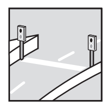
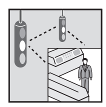
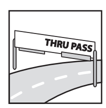
Generally, the promise of ITS as an integrated tool for managing congestion has not yet been met. Although we recognize that DOT can not always influence ITS investments, limitations of DOT's efforts in goal setting, measuring, and other activities such as evaluating outcomes have reduced DOT's ability to facilitate state and local governments' strategic investment in ITS. We are making a recommendation to improve DOT's ITS deployment measures. We also are making recommendations to improve DOT's efforts to address some barriers to ITS deployment to help state and local governments invest strategically in ITS. We provided a draft of this report to the Department of Transportation for its review and comment. DOT officials generally concurred with the report and agreed to consider the recommendations.

Background

ITS technologies use communications, electronics, sensors, and computer hardware and software to improve the performance or safety of freeway and transit systems that are designed to improve traffic flow. Traffic congestion results from many sources such as recurring high levels of daily traffic as well as nonrecurring events such as traffic incidents, special events and bad weather that can limit the usable physical capacity of existing roadways. Therefore strategies, such as ITS, that are designed to improve the operations or efficiency of existing roadways may improve traffic flow and reduce congestion.

The ITS technologies that local transportation agencies deploy to manage traffic in congested areas typically are ones that have gone through research and development and are readily available. Some technologies, like pavement loop detectors (devices that indicate the presence or passage of vehicles), have been around for at least 40 years, while others, like adaptive traffic control systems (traffic light systems that are timed according to current traffic conditions) are just beginning to be deployed. Figure 1 depicts some examples of ITS technologies that are used to address congestion.

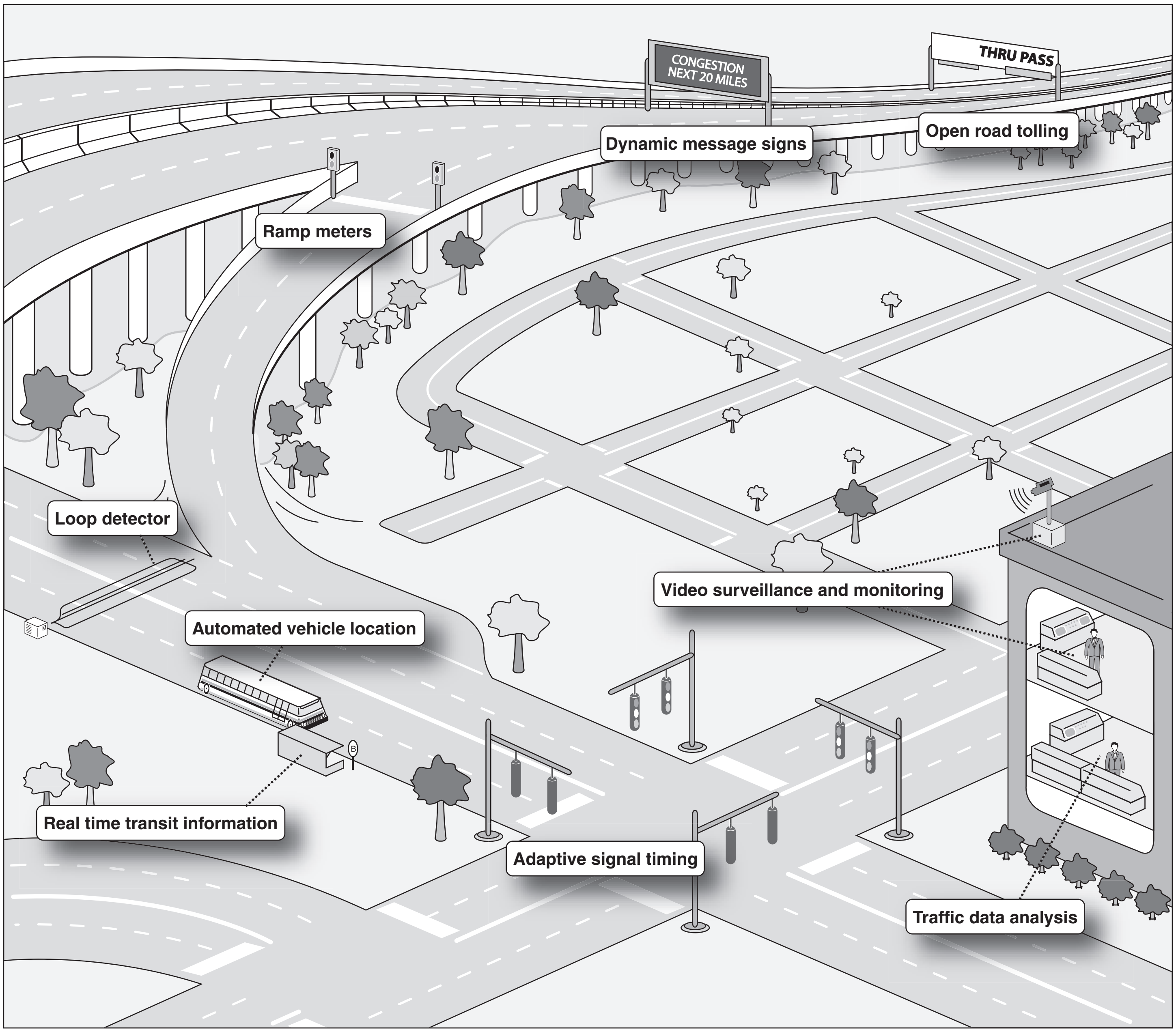
Figure 1: Select ITS Technologies Used to Manage Congestion

Key ITS applications to address congestion		ITS technologies
Monitoring traffic conditions		Closed-circuit television (CCTV) Sensors such as loop detectors Automatic vehicle identification Video image processing
Metering traffic onto freeways		Ramp meters
Optimizing the timing of traffic signals		Signalized intersections under computerized control Adaptive traffic signal systems that adjust timing to respond to real-time traffic conditions
Implementing electronic money transactions on toll roads		Hardware or software that can communicate with in-vehicle "tags" to process transactions
Faster and anticipatory responses to traffic incidents		Automatic incident detection (AID) Automatic crash notification from vehicle On-call publicly sponsored service patrols or towing services
Providing travelers with information on travel conditions as well as alternative routes and modes		Dynamic message signs (DMS) Highway advisory radio (HAR) 511 Traveler information phone number Kiosks Web-based Internet sites Pagers

Source: GAO analysis of FHWA information.

In highly congested metropolitan areas, ITS infrastructure tends to be more complex because it typically consists of a set of systems deployed by multiple agencies. For example, the state transportation department, city traffic department, transit agency, and toll authority may each deploy different ITS technologies that address their transportation needs. Transportation agencies may integrate their ITS technologies by coordinating ITS information sharing and other operations. For example, a city transportation department that deploys loop detectors designed to measure the number and speed of vehicles passing through an intersection may use technology to provide the traffic volume data collected by the loop detector to the state highway agency, in order that a different ITS technology can create travel time reports for variable message signs. Integration like this can facilitate the flow of information between a number of technologies and involved institutions and improve the overall traffic flow throughout a system. ITS can be further refined—and made more “intelligent”—by the deployment of technologies that adjust automatically to current traffic conditions, such as adaptive traffic control systems. Figure 2 illustrates some of the ITS technologies that can be deployed and integrated to improve transportation system management.

Figure 2: Examples of ITS Technologies That Can Be Deployed and Integrated in Metropolitan Areas



Source: GAO.

Funding for transportation projects, including ITS, comes from a variety of sources, including federal, state, and local governments; special taxing authorities and assessment districts; and user fees and tolls. Federal transportation funds primarily come from the federal Highway Trust Fund—the mechanism to account for federal highway user tax receipts. These funds are distributed to states through formulas that determine the amount of money given to each state.

As we reported earlier, although DOT has established goals and performance measures for the federal-aid highway program to enhance mobility and economic growth, the program's current structure does not link funding with performance or the accomplishment of these goals.[9] In addition, because the federal-aid highway program is primarily funded under a formula program, projects are not subject to an evaluation process at the federal level, and there are no federal requirements for performance evaluation of highway investments—although the Federal Highway Administration (FHWA) does ensure that federal highway funding is being spent on an eligible roadway for eligible purposes. State and local transportation officials have the flexibility to select projects on the basis of their communities' priorities and needs.[10] ITS technologies, which can be developed as projects in their own right or as one component of a larger project (for example, a project to replace the surface of a roadway could include the installation of loop detectors), are among the many types of projects transportation officials may consider during the project selection process.

The Federal Role in ITS Deployment Includes Goal Setting, Funding, and Activities to Support States' Deployment of ITS

Congress set broad goals for ITS through ISTEA and TEA-21 and established funding for ITS deployment in TEA-21. In 1996, DOT established a goal for ITS deployment that was incorporated into DOT's performance plans. DOT also has taken on several roles and activities related to facilitating ITS deployment.

[9] GAO-04-802.

[10] GAO, *Highway and Transit Investments: Options for Improving Information on Projects' Benefits and Costs and Increasing Accountability for Results*, GAO-05-172 (Washington, D.C.: Jan. 24, 2005).

Congress Set Broad Goals and Established Funding for ITS Deployment through Recent Legislation

The federal ITS program was established by ISTEA, when Congress authorized the program to support the development and field testing of ITS systems. During ISTEA, Congress provided the ITS program with about $1.3 billion for research and testing of ITS technologies such as adaptive traffic signal control and advanced vehicle control systems. This funding included $645 million for ITS under ISTEA and $624 million provided through the appropriations process. While ISTEA did not establish a deployment program per se, the field test program consisted of testing and evaluating the application of ITS technologies in real world conditions.

In 1998, TEA-21 authorized a total of about $1.3 billion for ITS. It provided about $679 million—an average of about $113 million annually—for a newly established ITS integration program with the broad goal of improving ITS deployment through supporting and accelerating the integration of ITS systems across and within metropolitan and rural areas, and about $603 million primarily for ITS research.[11] TEA-21 also directed DOT to fund projects that demonstrated or considered a number of elements, including cooperation among agencies and ensuring long-term operations and maintenance, among other things. In practice, however, the appropriations and authorizing committees together have fully designated the amount of funding for the ITS integration program through legislative earmarks. For example, in fiscal year 2001, Congress designated about $128 million to 92 projects in 41 states and the District of Columbia. DOT reviews the projects to ensure that the projects being funded meet guidelines DOT established based on legislative direction, but has not had a role in directing the funding to specific projects.[12]

In addition to the congressionally designated funds, Congress has made federal funding available to state and local governments for ITS technologies through other federal transportation programs within the federal-aid highway program. For example, ITS projects are funded through the Congestion Mitigation and Air Quality Improvement program (CMAQ), which provides funding for projects that contribute to air quality improvements and congestion mitigation in areas with poor air quality; the

[11]These projects, like most federal-aid highway projects, would require some matching of federal funds. The federal share of the cost of a project from integration program funds cannot exceed 50 percent, with the total federal share from all sources of funding not to exceed 80 percent.

[12]GAO-04-744.

National Highway System program (NHS), which provides funding for improvements to rural and urban roads that are part of the NHS, including the Interstate System; and the Surface Transportation Program (STP), which provides funding for projects on any federal-aid highway. In general, FHWA distributes highway program funds to state transportation departments through formulas; and the states, in turn, allocate the funds to urban and rural areas primarily on the basis of local priorities and needs. Consistent with requirements protecting state and local agencies' ability to select projects, the federal government does not control the allocation of these formula funds to projects. To determine which projects they will fund, state and local governments go through a planning process that involves the participation of many stakeholders and entails evaluating goals, finances, and other factors. DOT estimates that states and localities annually invest between $500 million to $1 billion in ITS projects, but DOT does not track the actual amounts invested in ITS. According to DOT and local transportation officials, tracking would be difficult because often ITS is funded as one element of a larger project, such as building a road, and the funds that go toward the ITS application are not separated from the funds for the overall project.

DOT Established a Goal for ITS Deployment in 1996 and Incorporated It into DOT's Performance Plans

In a 1996 speech, 2 years before TEA-21 established the ITS integration program, the Secretary of Transportation, Federico Peña, established a broad vision for ITS deployment to create an intelligent transportation infrastructure across the United States that would save time and lives and improve the quality of life for Americans. In articulating this vision, Secretary Peña compared the potential for ITS to past accomplishments including building the interstate system and landing a man on the moon. He also compared it to the development of the Internet, saying that the next frontier for surface transportation would be in the information age, and that if Americans could surf on the information superhighways, they should be able to drive on high-tech highways. As part of this speech, the Secretary articulated an ITS deployment goal—to achieve a complete ITS infrastructure in the country's 75 largest metropolitan areas within 10 years—by the end of fiscal year 2005 according to DOT officials.[13] The

[13]The Secretary of Transportation also included a commitment to upgrading technologies in 450 other communities and on rural roads and interstates. We did not focus on this area of the goal as DOT included the goal for the 75 metropolitan areas in its performance plan and has put greater effort into tracking and reporting progress toward this goal and because ITS for rural areas are less likely to be focused on congestion mitigation.

Secretary emphasized that achieving this goal would require partnerships between federal, state, and local officials and the private sector.

The Secretary also projected several results or impacts of this goal: reduced congestion-related costs and commuting times and increased safety through reduced response time for emergency vehicles responding to traffic accidents, and he declared that DOT would measure progress toward this goal and report on it annually. He also included an outcome-oriented measure for the goal, declaring that the initiative would reduce the travel time of Americans by at least 15 percent, whether they traveled by car, bus, train, or subway—an amount that he declared was the equivalent to an extra week of vacation every year for Americans who commute one hour a day.

In addition, the Secretary emphasized the importance of integration so that the different technologies could be used together. He described nine components that should make up ITS in the 75 metropolitan areas, including such systems as traffic control systems and freeway management systems.[14] He stated that the federal role in making this goal a reality included developing a national architecture and standards for ITS technologies to ensure that local ITS investments would be interoperable, investing in model deployment sites to serve as examples for the rest of the country, and investing in training to expand technical expertise for deploying ITS technologies. He emphasized strategic investment to pay for this infrastructure, alluded to the fact that federal-aid funds could be used to fund it, and emphasized the cost effectiveness of ITS, saying that building the needed highway capacity for 50 cities in the next 10 years would cost $150 billion, while implementing an intelligent transportation infrastructure for these 50 cities would cost $10 billion and gain two-thirds of the capacity needed.

The metropolitan deployment goal established by the Secretary in this speech was incorporated into subsequent DOT performance plans as a measure under the broader goal of mobility. In addition, in DOT's 2004 *Performance Plan*, ITS was included as a strategy to achieve another performance measure under the goal of mobility—to limit annual growth of

[14]The other seven mentioned in the speech were transit management systems; incident management programs; electronic toll collection for roads and bridges; electronic fare payment systems for such things as the bus, train, and toll lanes; railroad-grade crossings; emergency response providers; and traveler information systems.

urban area travel time under congested conditions to 0.2 percent below the otherwise expected increases in congestion.

DOT officials indicated that they do not plan on updating the ITS deployment goal once it expires at the end of 2005. They noted that SAFETEA-LU provides for or implies several other challenging goals for the ITS program, such as reducing metropolitan congestion by not less than 5 percent by 2010. DOT officials are reviewing the statute and considering how to implement these new provisions.

DOT Has Established Several Roles to Facilitate ITS Deployment

DOT has established several roles to facilitate ITS deployment in line with the federal roles laid out in the Secretary's 1996 speech. Although DOT originally included creating funding incentives for ITS as one of its roles, it has since dropped that role because Congress, through the authorization and appropriations process, has fully designated the locations and amounts of funding from the ITS integration program during TEA-21. Other roles DOT has maintained include demonstrating ITS deployment, showcasing deployment benefits, facilitating the development of technical standards, and building technical expertise.[15]

To demonstrate deployment, DOT established model deployment sites to provide real-world examples of ITS technology's potential application to other metropolitan areas across the country. In 1996, DOT chose the Phoenix, San Antonio, Seattle, and New York/New Jersey/Connecticut areas to lead a new program to demonstrate the value of ITS technology in improving transportation. This program called for public and private sector partners to develop and integrate ITS technology to reduce travel times, improve safety, and provide enhanced travel information to the public. To ensure that lessons from these sites were documented and available to be shared, DOT conducted and documented a comprehensive ITS evaluation for the Seattle, San Antonio, and Phoenix sites. In addition, a national evaluation was performed with a focus on synthesizing findings across the entire program. These evaluations are available in DOT's benefits database.

DOT established this benefits database in 1998 to showcase and expand the understanding of ITS benefits and transmit existing knowledge of ITS benefits to transportation professionals. The database is accessible on

[15]DOT also continues to play a role in ITS research, which we did not examine in this study.

DOT's Web site and contains about 230 summaries of academic, government, and other studies of ITS deployments in the United States and internationally. The summaries in the database generally include information such as the type of ITS deployment, the location of the ITS deployment, and the results of the deployment. DOT also maintains a database on ITS costs. The purpose of this cost database, which contains a range of costs for various ITS technologies as reported from completed projects and from the initial phases of ITS projects, is to provide cost data to state and local transportation officials in the planning and initial cost estimation phases of ITS projects. While benefits and cost information are not directly linked, the two databases do use the same classification scheme for categorizing different ITS, and by browsing the various categories, users could obtain benefits and costs information for similar systems.

DOT is also facilitating the development of technical standards. These technical standards specify, in detail, how technological components will communicate with one another. By specifying how systems and components interconnect, the standards promote interoperability—the ability of systems to provide services and to accept services from other systems so that different ITS technologies can be integrated and operated together. DOT, through cooperative agreements with six standards development organizations (SDOs) such as the Institute of Transportation Engineers, develops nonproprietary, industry-based, consensus ITS standards. To date, SDOs have published 75 ITS standards, approved another 9, and have begun processing another 6. The SDOs are developing 21 other standards and DOT officials expect that many will be completed by the end of 2005. In addition, to implement a requirement in TEA-21 that ITS projects conform to national architecture and standards, DOT finalized a rule in 2001 requiring ITS projects using federal funds be part of a regional architecture plan that establishes a process to ensure that ITS projects conform to national standards in order that they can be integrated with other areas. Regions and states then had until April 2005 to complete their regional ITS architectures.

Further, to build technical expertise on ITS technologies, DOT has provided education, training, and technical assistance for ITS technologies through FHWA resource centers, divisions, and guides and pamphlets. DOT also has a professional capacity building program that is designed to provide state and local transportation officials the curriculum needed to install ITS applications. In addition, DOT headquarters office offers additional resources including a Peer-to-Peer program designed to link technical experts from one local area to an agency in a different geographic location.

DOT also used the nine components established in the Secretary's speech to develop criteria to track progress toward the goal of having 75 of the largest metropolitan areas outfitted with a complete intelligent transportation infrastructure by 2005. DOT biennially surveys the areas' transportation-related agencies and rates the areas' deployment levels according to its criteria.[16]

Although Progress Has Occurred, DOT's ITS Goal and Measures Have Limitations and Fall Short of Capturing Impact on Congestion

Although progress has been made toward DOT's ITS deployment goal, DOT's goal and measures provide a misleading picture of the status of ITS, are not designed around local priorities, do not assess the level of operations of deployed ITS, and do not capture information on ITS impacts or cost effectiveness. In past work, we have found that analyses of impacts and cost effectiveness are absent from other federal-aid highway programs as well, in part due to the structure of the federal-aid highway program. The four metropolitan areas we visited illustrate limitations of DOT's goal and measures.

Some Progress Has Been Made Toward Achieving DOT's Deployment Goal, but DOT's Measures and Rating System Overstate the Status of ITS Deployment

DOT's reporting on progress toward its deployment goal shows that many of the 75 metropolitan areas targeted in the goal have increased their level of ITS deployment since 1997, when DOT began tracking this progress, but DOT's ratings overstate the actual status of ITS in these metropolitan areas. According to DOT, 62 of the 75 metropolitan areas had met DOT's goal of deploying integrated ITS infrastructure in 2004, up from 36 metropolitan areas meeting the goal in 1997. While 13 of the 75 metropolitan areas still were rated as falling short of the goal in 2004, the increase in the number of metropolitan areas counted toward meeting the goal since 1997 suggests that a significant increase in the level of ITS has occurred in many of the 75 metropolitan areas.

Although many metropolitan areas have made progress in deploying ITS, the measures and rating system that DOT uses to report progress toward

[16]In 1994, DOT established the ITS Joint Program Office (JPO) to coordinate the ITS program among the modal administrations. The JPO staff perform many of the tasks mentioned here, such as tracking ITS deployment.

the ITS deployment goal, particularly when compared to the language of the Secretary's goal—for a "complete" intelligent transportation infrastructure—provides an overstated sense of success regarding the actual status of ITS in these metropolitan areas. Specifically, DOT defined the Secretary's goal of complete intelligent infrastructure to include two measurable elements—deployment, meaning the extent that certain technologies have been installed over certain areas, such as freeways; and integration, meaning the extent of coordination between different agencies that deploy ITS technologies. DOT used the 9 components established in the Secretary's speech to develop criteria to measure ITS deployment,[17] and also developed criteria to measure integration between three entities in each metropolitan area—state governments, local governments, and public transit authorities. (For more information on DOT's rating system, see app. 2.) DOT also developed criteria to combine metropolitan areas' measures for deployment and integration to come up with an overall rating of high, medium, or low.

DOT considers its goal met when all 75 metropolitan areas are rated high or medium. However, it established fairly low thresholds for rating an area as high or medium because it did not have a way to determine the extent of ITS that should be deployed in each area based, for example, on local traffic conditions or priorities. For example, an area can be rated medium—and thus meet the goal—if its level of deployment includes 20 percent of its freeway miles under electronic surveillance and 33 percent of its signalized intersections under computerized control—even if it has no ITS applications related to transit management, traveler information, or emergency management services.[18] In addition, the area rated as medium would have to demonstrate its level of integration by including some coordination between state government, local government, and the transit authority. According to DOT, it set these thresholds at relatively low levels because few metropolitan areas have local ITS goals establishing the level of ITS deployment they deem appropriate. Without such local goals, DOT

[17]DOT closely followed the nine components established by the Secretary in developing its criteria, but grouped them into five areas, including freeway management/incident management; transit management/electronic fare payment; arterial management; regional multimodal traveler information; and emergency management services. According to DOT officials, DOT did not consider tollway miles in its assessment, since tollway miles are such a small part of the expressway network.

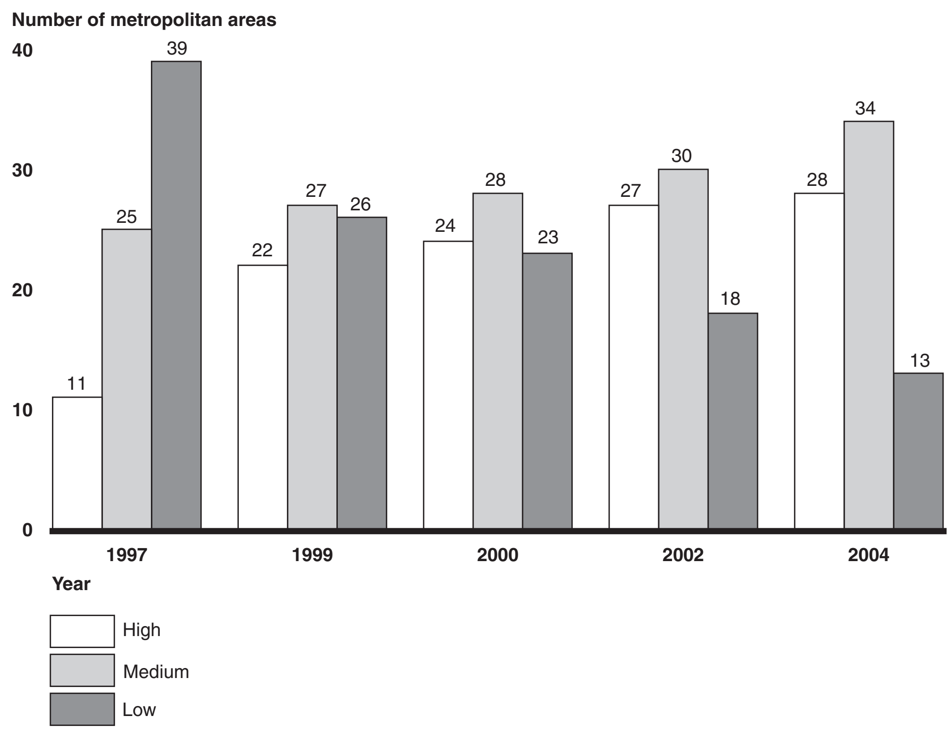
[18]An area is rated medium if it exceeds the threshold value for freeway management/incident management or transit management/electronic fare payment and at least one other component.

decided to measure (1) the extent of ITS deployment in locations where ITS could be deployed and (2) current integration compared to extensive integration between three government entities—but to use low thresholds for considering a metropolitan area to have met the goal.

DOT itself states that the metropolitan areas it rates as meeting the goal do not have a complete ITS infrastructure. For example, in its 2004 report on progress toward the goal, DOT states that even metropolitan areas that are deployment leaders may still have "miles to go" before deploying a complete ITS infrastructure—a level of deployment beyond DOT's rating of high deployment, which DOT does not define. DOT officials told us that complete deployment is a very long-term endeavor that may never be reached and that it was important to get the "seeds" of deployment planted. DOT officials stated that according to its criteria, metropolitan areas that received high ratings had officials who demonstrated an understanding of ITS and were making improvements in deployment and integration to an already existing ITS infrastructure. However, those metropolitan areas may not have deployed or integrated ITS technologies to their fullest potential and may be experiencing significant challenges to more fully deploying and integrating these technologies.

In spite of these issues, DOT's criteria and the deployment information it collects have been useful in measuring the 75 metropolitan areas' progress in increasing deployment and integration since 1996 and DOT intends to continue to track deployment even though it does not plan to update the deployment goal once it expires at the end of 2005. For example, the Tucson metropolitan area was rated low in 1997 but was rated as high in 2004, suggesting that it has made substantial progress in deploying and integrating ITS. Similarly, DOT officials said their tracking methods provide a basic means of comparing the extent of ITS in one metropolitan area versus another. For example, in Chicago, which is rated high, 55 percent of the area's freeway miles are covered by electronic surveillance, and several ITS deployments controlled by the state are linked to deployments controlled by local transportation or law enforcement agencies. On the other hand, in Las Vegas, which is rated low, none of the area's freeway miles are covered by electronic surveillance, and the state DOT is just beginning to link its deployments with those of the local transportation and law enforcement agencies. DOT officials indicated that they intend to continue to track deployment after the 2005 deadline expires. Figure 3 shows the number of the 75 metropolitan areas ranked high, medium, and low from 1997 to 2004.

Figure 3: ITS Deployment Ratings for 75 Metropolitan Areas, 1997 to 2004



Source: GAO analysis of DOT deployment data.

DOT's ITS Goal and Measures Fail to Capture Important Dimensions of Evaluating ITS Status, Including, Similar to Other Highway Programs, Evaluating Outcomes

DOT's ITS goal and measures fail to capture a number of important dimensions of evaluating ITS status that were alluded to in the Secretary's 1996 vision for ITS: they do not take into account the level of ITS needed to accomplish local goals and priorities; they do not capture the extent to which deployed ITS technologies are being effectively operated; and they do not evaluate the impact or cost-effectiveness of ITS. The lack of evaluation of outcomes such as impact or cost effectiveness has also been identified as a limitation in other highway programs and is partly due to the structure of the federal-aid highway program.

DOT's ITS Goal and Measures Do Not Take into Account the Level of ITS Needed to Accomplish Local Goals

In establishing DOT's vision for ITS deployment, the Secretary emphasized the need for strategic investment; however, DOT's ITS goal and measures do not incorporate any evaluations of local ITS needs that could help ensure that ITS was used as a component of a balanced strategy to address local transportation conditions. Without an idea of what a metropolitan area's integrated transportation system, including ITS, should consist of, it is difficult to determine what the right percentage of deployment of different technologies would be. In the absence of such information, DOT created a goal and thresholds for the measures that assumed that all 75 metropolitan areas should exceed specified levels of ITS rather than reflecting local priorities established through local ITS strategies and goal setting.

DOT officials acknowledge that the goal focuses on measuring what a metropolitan area could deploy rather than what a metropolitan area should deploy and that deployment goals should be specific to a metropolitan area and its specific transportation needs. According to a DOT official, a goal focused on what metropolitan areas should deploy would be ideal but would be difficult to establish because it would require establishing the transportation needs of each metropolitan area. According to a 2003 DOT ITS deployment report, this could be done, for example, through locally defined deployment goals that could then provide the basis for establishing a national goal. According to DOT, while this approach would be more meaningful, few metropolitan areas have completed ITS needs assessments or set deployment goals.

DOT's ITS Goal and Measures Do Not Capture the Extent of ITS Operations

Another dimension of evaluating ITS status not captured in DOT's goal and measures is the extent to which deployed ITS technologies are operated and maintained effectively. Among other things, the 1996 DOT Secretary's speech envisioned that ITS would increase the capacity of existing infrastructure, an outcome likely to depend on ITS technologies being operated effectively as well as deployed and integrated. However, although DOT tracks progress toward the goal by measuring deployment and integration, it does not track the operational level of ITS technologies in the 75 metropolitan areas.[19] This is a concern since there are indications that some metropolitan areas have not been fully operating systems that are deployed and integrated. For example, the National Transportation Operations Coalition recently gave a collective grade of D minus for the operations of about 83,000 of the 260,000 traffic signals across the U.S.[20]

[19]Although DOT does obtain some information on the operations of transportation management centers, it is not used to measure progress toward the deployment goal.

[20]The National Transportation Operations Coalition (NTOC) is an alliance of national associations, practitioners and private sector groups to represent the collective interests of stakeholders at state, local and regional levels, who have a wide range of experience in operations, planning and public safety.

According to the study, a contributing factor to this low grade was that officials operating traffic signals are updating the signal timing plans so infrequently that they are not responding to current traffic conditions.

DOT's ITS Goal and Measures Do Not Capture Evaluation of Outcomes, Similar to Other Highway Programs

Another limitation of DOT's goal and measures in evaluating the status of ITS is that they do not include outcome-oriented measures such as the impact or cost-effectiveness of ITS. Although the Secretary's 1996 speech envisioned that ITS would lead to positive impacts on congestion and even included an outcome measure of reducing travel time of Americans by at least 15 percent, DOT's goal and measures focus on outputs such as a metropolitan area's deployment of certain types of ITS on certain types of roads. However, DOT's rating system does not consider the impact of such deployment on outcomes such as travel time or road capacity.

In its 2004 *Performance Plan*, DOT identified ITS deployment as a strategy to help it meet the outcome-oriented goal of limiting annual growth of urban area travel time under congested conditions to 0.2 percent below the otherwise expected increases in congestion. However, it did not establish a method to measure whether ITS deployment was helping to meet this outcome. DOT's 2004 *Performance Plan* also incorporates its ITS deployment goal as a performance measure for the strategic goal of mobility. However, the strategies and initiatives for achieving this performance measure also emphasize deployment and integration rather than impact. For example, DOT's strategies include continued deployment of ITS applications, systems operations and training, and ITS standards setting.

Moreover, in his 1996 speech, the Secretary emphasized the cost effectiveness of ITS investments in comparison to investments in increasing highway capacity through construction. However, no element of the cost-effectiveness of deployed ITS technologies is included in DOT's measures. In addition, while DOT collects and summarizes benefits established by ITS studies in its ITS benefits database, and summarizes cost estimates in its cost database, it has not highlighted benefit-cost information on ITS technologies and has not incorporated such information into its goal or measures. Furthermore, although DOT's cost database may help state and local transportation officials budget for ITS technologies they wish to deploy, such cost information is not directly linked to benefit information. Without this linkage, the cost information is of limited use in helping state and local transportation officials evaluate the value of ITS investments as a tool to reduce congestion in comparison to other alternatives.

DOT's lack of measures for the impact or cost-effectiveness of ITS deployment makes it difficult to evaluate the overall effectiveness of ITS and the federal investment in ITS as a strategy to reduce congestion. However, this lack of evaluation also exists for many other federal-aid highway programs. According to a DOT official, it is critical to compare the benefits of ITS with the costs of implementation, and the ITS program should allocate resources to improving benefit-cost analyses. However, it would be difficult for DOT to obtain the information needed to evaluate the cost effectiveness of ITS deployment, as in many cases this information is not collected.

As we have previously reported, in general there is no requirement for state and local governments to set goals for highway projects, nor to use specific analytical methods such as benefit-cost analysis to choose projects. Moreover, the federal-aid highway program does not have the mechanisms to link funding levels with the accomplishment of specific performance-related goals and outcomes.[21] In addition, we have found in previous work that such requirements would require legislative change because the federal agencies cannot require benefit-cost analysis as a condition of receiving highway funds.[22]

In addition, while TEA-21 requires recipients of congressionally designated ITS integration funds to report cost data annually and complete self-evaluations, it does not require formal benefit-cost analyses.[23] In general, we found that evaluations of outcomes of completed highway projects are typically not conducted and, as a result, officials only have limited or anecdotal evidence of whether projects produced the intended results. Thus, transportation agencies miss opportunities to learn from successes and shortcomings of past projects or to evaluate how well investment strategies are meeting goals or priorities.[24]

[21]GAO-04-802.

[22]GAO-05-172.

[23]DOT has made available a software program known as the ITS Deployment Analysis System (IDAS) for state and local planners to estimate the benefits and costs of ITS investments.

[24]GAO-05-172.

Four Case Studies Illustrate Limitations of DOT's Goal and Measures

The status of ITS in the four metropolitan areas we visited—two that were rated high by DOT and were therefore counted toward meeting the ITS deployment goal and two that were rated low by DOT and therefore were not counted toward meeting the goal—illustrate the shortfalls of DOT's ITS deployment goal and measures. While the two metropolitan areas we visited that were counted toward meeting the goal have both made considerable investments in ITS technologies, both have limitations in terms of the level of operations of deployed ITS technologies, which may reduce their potential impact on congestion. Officials from the two metropolitan areas we visited that were considered not to have met the goal indicated that they had appropriate levels of ITS given their local conditions and needs. (See app. 3 for additional information on activities each metropolitan area has taken to support ITS deployment.) Specifically, we found:

- The San Francisco Bay Area, which was ranked by the Texas Transportation Institute as the fifth most congested area in 2003,[25] was rated high by DOT in part because of its level of ITS deployment—4,700 traffic sensing detectors on its over 2,800 freeway miles. As a result, 29 percent of the freeways featured sensing devices spaced every 1 mile or less, and 40 percent of the freeways featured sensing devices spaced every 2 miles or less in order to provide local transportation agencies information on traffic data such as speed and volume. However, about 45 percent of these devices are out of service, reducing the ability of staff to collect traffic data.[26] According to DOT Resource Center's Operations Technical Service Leader, while having about half of the traffic detectors out of service happens in other areas, it is not typical.

- Chicago, which the Texas Transportation Institute ranked as the fourth most congested area in 2003, was also rated high by DOT, partly because area transportation agencies have the potential to monitor 55 percent of the area's freeway miles. A combination of traffic sensors and management centers provide the area the ability to quickly spot traffic problems and take appropriate action such as providing the traveling

[25]The ranking is based on the congestion measure—percent of daily travel under congested conditions.

[26]According to transportation officials we met with, if an agency has a working detection of traffic sensing within a mile, then it can develop a good estimation of travel time and congestion.

public information on traffic conditions, alternative transportation routes or options during special events affecting traffic to avoid traffic delays, and dispatching appropriate officials to clear incidents quickly to decrease delays. We found, however, that six of the ten traffic management centers do not have any staff dedicated to monitoring traffic conditions and that an additional center has only one part-time staffer. Periodically, staff will go to the centers to change message signs to alert travelers to likely congestion due to a planned event such as a construction project or sports game. However, without staff dedicated to monitoring traffic conditions on a regular basis, the centers can not be used to respond to unplanned or non-recurring incidents such as traffic accidents, which limit congestion mitigation benefits.

- Indianapolis, which the Texas Transportation Institute ranked as the 25th most congested city in the nation in 2003, was rated low by DOT because of a lack of investment in ITS technologies, and therefore was not counted toward meeting the goal. However, Indianapolis officials stated that the current level of ITS deployment and integration meets the area's needs, as they do not consider the area very congested, and they do not see the need for many ITS technologies.

- Las Vegas, which the Texas Transportation Institute ranked as the ninth most congested city in the nation in 2003, was also rated low by DOT, partly because in order for a metropolitan area to be rated medium, it must meet the threshold of having either at least 20 percent of its freeways covered by ITS technologies or at least 33 percent of its transit covered by ITS technologies (to be rated high it would have to meet these thresholds plus additional thresholds). However, Las Vegas transportation officials told us that the metropolitan area has experienced high levels of congestion on the arterial roadways and relatively low levels of congestion on freeways. Therefore, rather than focusing on freeways or transit, transportation agencies in the Las Vegas metropolitan area have made considerable investments in deploying and integrating ITS technologies on their arterial roadways and only recently have begun investing in ITS technologies for freeways. Las Vegas transportation officials said that this strategy made the most sense for their specific local conditions.

Studies Have Found Positive Impacts of ITS Deployment Depend on Effective Operations, but Few Have Included Cost-Effectiveness Analyses

Studies evaluating ITS deployment have found improvements in congestion, throughput of traffic (number of vehicles accommodated on highways), safety, environmental quality, and traveler behavior.[27] Studies also have found that the existence and level of most benefits depends on operating the ITS technology effectively given local conditions. Few of the studies analyzed the benefits of ITS investments in terms of the costs, information that could help state and local governments make sound investment decisions.

Studies Indicate ITS Deployment Can Provide Benefits

A number of studies show that ITS applications have provided some benefits either nationally or locally, including improvements in congestion, throughput of traffic, safety, environmental quality, or traveler behavior. Although congestion levels are high, ITS technologies are estimated to limit the increase in congestion. For example, the Texas Transportation Institute, a leading transportation research institution, estimated that in 2003, congestion caused 3.7 billion hours of travel delay in 85 urban areas.[28] However, the study also estimated that ramp metering, incident management, traffic signal coordination, and arterial access management combined reduced delay in 2003 in the same urban areas by 9 percent—336 million hours, leading to a $5.6 billion reduction in annual costs due to reduced fuel consumption and hours of delay. The study also estimates that if ITS or similar operational treatments were deployed on all major freeways and streets in the 85 urban areas, it would reduce the delay by 15 percent. Thus, although delay due to congestion is increasing, this increase is limited by ITS deployment.

Many of the studies in DOT's database focus on examining the impacts of particular ITS technologies deployed in particular locations. For example, one study measured the impacts of a regional system in the Cincinnati-Northern Kentucky metropolitan areas that uses traffic monitoring

[27]Although DOT identified ITS deployment as a strategy to achieve the 2004 target to limit annual growth of urban area travel time under congested conditions to 0.2 percent, the ITS benefits database does not provide information relating to progress toward this goal. Rather, the information in the database focuses on individual ITS deployments and local improvements.

[28]Schrank and Lomax.

technologies to detect incidents and provide traveler information. The study, which measured the impacts of the system on several factors such as traveler behavior, safety, and environmental quality, found that of 375 survey respondents in the area, 56 percent changed their morning routes based upon the availability of traffic information provided by the system. In addition, modeling efforts estimated that the system had contributed to a 3.2 percent reduction in fatalities by responding to incidents earlier, and a 3.6 to 4.7 percent reduction in vehicle emissions. Table 1 provides examples of study findings related to several commonly studied impacts of ITS deployment.

Table 1: Examples of Deployment Impacts from Our Review of ITS Studies

Impacts	Examples
Congestion	• Deployment of E-Z Pass, an electronic tolling system, on the New Jersey Turnpike reduced delay for all vehicles at toll plazas by 85 percent. • Adaptive traffic signal control reduced travel times at several intersections in Tucson, Ariz. by 7.9 percent and delay by 17.9 percent.[a]
Throughput	• A study in Minneapolis-St. Paul found that during peak traffic conditions, freeway throughput decreased by an average of 14 percent during the period that they turned off the ramp meters.
Safety	• Evaluations of the Maryland based freeway and incident management program, known as CHART, showed a potential reduction in secondary incidents by 1,267 based on reported incidents. • An integrated freeway and incident management system in San Antonio reduced the average annual secondary crash risk for all travelers by 2.8 percent.[a]
Environmental quality	• Computerized operations of 40 traffic signals in the Tysons Corner area of Virginia decreased the total annual emissions for carbon monoxide, nitrogen oxides, and volatile oxygen compounds by 134,611 kilograms. In addition, annual fuel consumption improved by 9 percent, thus an estimated savings of about $1.48 million. • Traffic signal coordination among two jurisdictions in Phoenix, Ariz. indicated benefits of a 1.6 percent reduction in fuel consumption.
Traveler behavior	• Over 600 users in the Seattle area ranked the state-sponsored traveler information Web site as their most useful source of traffic information. In addition, most of the respondents (88 to 94.8 percent) reported they used the Web site to decide among alternative routes, when to start a trip, and had reliable indications of how long a trip would take. • In the DC metro area, a simulation model estimated that commuters who used traveler information arrive on time and within 15 minutes of the target arrival time 79 percent of the time. Those not using the traveler information arrive on time and within 15 minutes of the target 42 percent of the time.[a]

Source: GAO analysis of studies gathered by DOT.

Notes: Examples in this table are not necessarily representative of what would happen with a similar deployment in another location.

[a]These examples report on potential improvements using estimated data, rather than actual improvements using empirical data.

Anecdotally, several state and local officials we spoke with agreed that ITS applications have improved congestion in their areas. For example, Las Vegas officials stated the FAST program, an integrated traffic management system that adapts traffic signal plans to real-time conditions, had definitely improved traffic congestion on the Las Vegas arterials. One official stated that without the FAST system, the city of Las Vegas would be "shut down," especially during events such as New Year's Eve, NASCAR weekends, and major boxing events.

Studies Suggest That ITS Benefits Depend on Effectively Operating ITS Technologies to Meet Local Conditions

The studies in DOT's benefits database also suggest that the existence and level of benefits from ITS deployment depend on adapting the deployment to local conditions and monitoring the effect in order to make operating adjustments. For example, as discussed earlier, the National Transportation Operations Coalition recently found that across the country traffic signals are not operating as efficiently as they could be, resulting in unnecessary delay to travelers. A benefit database study of traffic signal timing in North Seattle found that a single signal-timing plan could not satisfy all traffic conditions. The study suggested that more benefits could be expected if signal systems were implemented so that they would respond to traffic levels based on demand and weather conditions. For example, agencies could develop longer timing plans when demand is heavy and shorter cycle lengths for light demand conditions. One researcher we talked to also emphasized that to effectively deploy traffic signal control systems, signal timing plans should be regularly adjusted to respond to changes in traffic patterns surrounding the intersection.[29]

Similarly, a study on deploying ramp meters on Detroit area freeways found that effectively operating the meters to maximize benefits meant using the meters only during specific traffic conditions. The study concluded that using ramp meters helped reduce congestion during major events or traffic incidents when traffic demand or congestion was high. During average conditions, however, the study found that the benefits of ramp metering in terms of moderating the flow of traffic on the freeway would not outweigh

[29]In 1994, we reported that the potential benefits of properly designed, operated and maintained traffic control signal systems were not being realized. GAO, *Transportation Infrastructure: Benefits of Traffic Control Signal Systems Are Not Being Fully Realized*, GAO/RCED-94-105 (Washington, D.C.: Mar. 30, 1994).

the delays on the entrance ramps and arterials leading to the freeway. The study found that by turning off metered ramps in the absence of major events or incidents, corridorwide delay would improve.

Few ITS Studies Include Analysis of ITS Projects' Cost Effectiveness

Most of the ITS studies we reviewed did not include information on the cost effectiveness of ITS deployment, such as benefit-cost analyses. Analysis of benefits in relation to costs is essential to helping local decision makers determine whether and when ITS is a good investment. As we have shown in previous work, careful decisions need to be made to ensure that transportation investments maximize the benefits of each public dollar invested. Moreover, according to a recent study, compared to other highway projects, such as highway construction projects, many ITS applications have distinct cost structures and life cycles—for example, relatively low initial deployment costs but ongoing operational costs that do not apply to many construction projects—that need to be explicitly described and evaluated in order to determine the benefits and costs of ITS technologies compared to other alternatives.[30]

Thirty-three of the 38 studies we reviewed (87 percent) did not measure benefits in relation to total dollars invested. The five studies that did include an evaluation of benefits reported that the benefits of the ITS deployment examined were greater than the costs.

Several Barriers Limit the Widespread Deployment of ITS

Transportation officials in the four metropolitan areas we visited identified four barriers that our previous work and DOT officials acknowledge limit the deployment and integration of ITS in metropolitan areas. These barriers include the limited appeal of ITS as an option for congestion mitigation, the difficulty of obtaining funding for implementing and operating ITS technologies along with confusion about the fact that ITS operational costs are eligible for federal funding, a lack of technical training in deploying and operating ITS technologies, and a lack of technical standards to help ensure that ITS technologies will be able to be integrated with other ITS systems within and across metropolitan and rural areas. These barriers have limited the amount of ITS deployed and therefore have likely limited the impact of ITS on mitigating congestion on our nation's roads.

[30]E. Bekiaris and Y J Nakanishi, *Economic Impacts of Intelligent Transportation Systems, 8* (Elsevier, 2004).

ITS Projects Are Sometimes Seen as a Less Appealing Investment Option for Mitigating Congestion

According to transportation officials we spoke with, one barrier to ITS deployment is that in light of a high number of potential projects competing for limited transportation funds, system enhancements such as ITS are sometimes less appealing than transportation investment options that improve the physical condition of the roads.[31] Demand for transportation funding usually exceeds the supply of these funds. For example, in the San Francisco Bay area, the MPO estimates that it needs an additional $419 million above its available funding to fully deploy the area's regional operations programs—including ITS applications. Furthermore, state and local governments face difficult decisions regarding the allocation of their highway and transit funds, especially when federal and state budget deficits exist. Within these funding constraints, transportation officials must prioritize and make trade-offs between projects that add new or preserve infrastructure and those that enhance the existing infrastructure, such as ITS. Thus, ITS must compete with other highway investments that add new infrastructure or preserve existing roads.[32] In previous work, we found that state and regional transportation decision makers are increasingly giving priority to highway investments that preserve the existing infrastructure.[33]

In addition, ITS applications sometimes have limited public and political appeal. We have reported in prior work that public input and political considerations shape transportation investment decisions. However, unlike capital improvements that build or expand new roads and those that preserve existing roads, the benefits of traffic operations improvements such as ITS are not always visible to the public. According to DOT officials, deteriorating roadways, like those with potholes and other physical problems, affect the public's ability to drive on the road. Conversely, many ITS applications that are not operating well or need maintenance, like nonworking message signs or delayed traffic signals, do not necessarily affect the public's ability to drive on the road in an obvious way. As a result, drivers may not realize that a failing ITS application could be contributing to congestion. One state responded to this public perception issue by

[31]System enhancements consist of traffic operations improvements and environmental enhancements.

[32]System preservation projects would include capital improvements on existing roads and bridges intended to sustain the existing infrastructure, but not include routine maintenance activities.

[33]GAO-04-744.

ordering a shut down study so that levels of congestion with and without ITS could be compared. In 2000, the Minnesota legislature passed a bill to study the effectiveness of ramp meters due to public questioning of the effectiveness of ramp meters on freeways. The state undertook a study that demonstrated the effectiveness of the ramp meters and increased public support for the ramp meters.[34] The state DOT conducted two, 5-week studies—one with the ramp meters in operation, the other without—and estimated that ramp meters annually saved 25,121 hours in travel time, 2,583,620 hours of unexpected delay, and 5.5 million gallons of fuel. Consequently, commuter support for ramp meters significantly increased.[35] However, in the absence of such studies, the public may not realize the potential benefits of ITS deployment and therefore may not support them as much as the more visually obvious benefits of such things as improved road surface conditions.

Moreover, several officials in the metropolitan areas we visited agreed that investments in system "enhancements," such as ITS, are not as politically appealing as expanding roadways. Specifically, Chicago and San Francisco transportation officials stated that since ITS applications do not usually offer groundbreaking ceremonies, which offer positive media attention, politicians are generally not motivated to support ITS projects.

In its role of encouraging interest in ITS, DOT has taken steps to counter this lack of appeal for ITS technologies, such as establishing the benefits database we previously described. In addition, according to DOT officials, DOT division staff advertise the benefits of ITS or suggest it as a way to mitigate congestion to state and local transportation officials. Furthermore, DOT officials are planning to develop lessons learned information from studies of ITS technologies to share with states and localities on how to implement effective ITS applications. This is important information to begin disseminating as we found that DOT's benefits database did not consistently provide information on lessons learned for maximizing the benefits of ITS, even when that information was included as part of a study

[34]Cambridge Systematics, Inc., "Twin Cities Ramp Meter Evaluation" (prepared for Minnesota Department of Transportation pursuant to laws 2000, ch. 479, HF2891, Feb. 1, 2001).

[35]Over 250 respondents rated ramp meters on a scale from zero to 10, with a rating of 1 meaning that respondents strongly disagreed with a statement and a rating of 10 suggesting that they strongly agreed. The respondents rated their overall satisfaction with ramp meters at 4.99, on average, in 2000. After the shutdown study was completed, the average rating increased to 6.13 in 2001.

summarized in the database. For example, a study of the impacts of call boxes in Georgia provided lessons-learned information on reducing maintenance costs to improve the cost-effectiveness of the deployment, but the summary in the ITS benefit database did not include this information. DOT officials acknowledge that lessons learned information is needed to provide practitioners with helpful advice on how to cost effectively deploy ITS. Consequently, DOT plans to unveil a new database in September 2005 that will provide lessons learned information from the ITS studies and other sources.

Although DOT has undertaken these efforts to make ITS more appealing, DOT's ability to affect state and local decisions to deploy ITS has been limited by its inability to use funding incentives to encourage ITS. As we previously noted, although TEA-21's ITS integration program included funding to help state and local governments integrate ITS technologies, Congress has fully designated this funding. Moreover, the extent to which DOT's benefits database is helping to counter the limited public appeal of ITS deployment is unclear. In 2004, we found that although useful, impact analysis such as benefit-cost information does not play a decisive role in many investment decisions.[36]

Lack of Operational Funding and Misunderstanding of Federal Funding Policy Are Barriers to Deployment

Another barrier to deploying and operating ITS technologies, according to metropolitan transportation officials, is that once an ITS application has been deployed, state and local transportation agencies do not always fund operations on an ongoing basis, in light of other priorities for transportation investments. As previously mentioned, state and local governments face difficult decisions regarding the allocation of their highway and transit funds, especially when state and local governments face budget deficits. At times, funding for ongoing operations is not fully available. In the San Francisco Bay area, for example, the MPO estimates that it needs an additional $419 million above its available funding to fully deploy the area's regional operations programs--including ITS applications. Similarly, although the Chicago area funded the establishment of 10 transportation management centers, they have operators in 3 of the centers and a part-time operator in a fourth center due to a lack of operational funding. Finally, Indianapolis transportation officials said that operations were one of the first areas cut during budget crunches.

[36] GAO-04-744.

In addition to limited funds in state and local operation budgets, several state and local officials were not aware that they could use federal transportation funds, such as Surface Transportation Program funds, to operate and maintain ITS technologies. Operating costs for traffic monitoring, management, and control systems such as integrated traffic control systems, incident management programs, and traffic control centers are eligible for federal reimbursement from National Highway System and Surface Transportation Program funding.[37] In addition, for projects located in air quality nonattainment and maintenance areas, Congestion Mitigation and Air Quality Improvement Program funds may be used for operating costs for a 3-year period—as long as the funded systems measurably demonstrate reductions in traffic delays. The lack of understanding about the availability of federal funding for operations has at times led to poor financial decision making. In San Francisco, for example, FHWA officials told us that the state and local officials' lack of knowledge that federal funds could be used to operate and manage ITS technologies had led some agencies to use federal funds to replace their technology systems at much higher costs than would be needed to operate and maintain their existing technologies.

DOT officials are aware of this lack of understanding and have taken steps to inform state transportation agencies about the eligibility of ITS operational expenses for federal funding. DOT provides guidance on its Web site indicating that federal-aid policies allow federal assistance to be used for virtually any operational costs. DOT has issued policy manuals to its division offices to pass along to state officials that explain federal funds can be used for operational expenses. However, the misconception that federal funds can be used only for ITS capital expenses still exists in some locations. DOT officials believe they are making progress in educating transportation officials about funding for operating costs and believe that understanding will grow as transportation departments place more emphasis on operating roadways.

[37] Operating costs include labor costs, administrative costs, costs of utilities and rent, and other costs including system maintenance costs, associated with the continuous operation of the system. Routine maintenance items that are not critical to the successful operation of the system, such as the painting of traffic signal controller cabinets, would normally fall outside of eligible operating costs.

ITS Deployment Is Hampered by a Lack of Technical Expertise

According to metropolitan transportation officials and as we previously reported in a 1997 report, another barrier state and local transportation agencies face when selecting and implementing ITS is a lack of appropriate skills and knowledge needed for selecting and operating ITS technologies.[38] This lack of skills exists both in transportation agencies and, according to transportation officials in one metropolitan area, in consultants that agencies hired to help them purchase and deploy ITS technologies. According to DOT officials, it is often hard to find people who are knowledgeable in both of two fields that are important for fully understanding ITS applications—traffic systems and electrical engineering. Consequently, some transportation agencies hire contractors to perform some of the technology functions associated with ITS. In Las Vegas, however, transportation officials told us that consultants lacked needed skills as well. As a result, localities may face difficulties selecting and procuring appropriate systems for their areas. For example, according to an FHWA official, a lack of business knowledge led a San Francisco Bay Area agency to lease rather than purchase telecommunications lines needed for transmitting data from roadway sensors—a decision that ended up costing the agency money in the long run.

According to DOT officials, DOT has taken numerous actions to address the lack of technical expertise; however, external factors have limited DOT's ability to resolve this issue. DOT provides technical assistance through FHWA. FHWA divisions in each state work with state and local transportation agencies to provide needed technical assistance. FHWA's resource center offices are staffed with technical experts in various fields including operations and ITS and thus provide state and local officials across the country with more specific technical expertise and support when needed.[39] In addition, FHWA headquarters office offers a number of additional resources such as training programs, guidance documents, technical assistance, and a Peer-to-Peer program that facilitate the exchange of technical expertise across different locations. Finally, DOT also has a professional capacity-building program that is designed to help state and local transportation officials gain the expertise necessary to install ITS applications. In addition to DOT training, several universities

[38]GAO, *Urban Transportation: Challenges to Widespread Deployment of Intelligent Transportation Systems*, GAO/RCED-97-74 (Washington, D.C.: Feb. 27, 1997).

[39]FHWA Resource Center offices are located in Baltimore, Chicago (Olympia Fields), Atlanta, and San Francisco.

have developed programs to provide intelligent transportation education to develop the skills needed in the ITS industry. Both the University of Michigan and the Virginia Polytechnic Institute and State University have developed programs, as has the Consortium for Intelligent Transportation Education housed at the University of Maryland. DOT officials believe, however, that the lack of technical expertise will remain until an institutional change in transportation agencies occurs--a change that increases emphasis on operations.

ITS System Integration Is Limited by Delayed Technical Standards

Another barrier that has limited the deployment and integration of ITS is that state and local decision makers do not have enough of the technical standards needed to select ITS equipment that can integrate with other systems.[40] Having technical standards is important because purchasers who adhere to the standards can avoid being locked into proprietary systems that cannot integrate with those of other manufacturers and for which replacement equipment or service may not be available if the vendor goes out of business. According to transportation officials we spoke with, in some cases, the lack of standards may have discouraged state and local decision makers to invest in ITS technologies; in other cases, the lack of ITS standards may have led to the deployment of ITS technologies that could not easily be integrated with other technologies within or across metropolitan or rural areas.

In each of the metropolitan areas we visited, state and local transportation officials stated that DOT has facilitated the issuance of standards slowly and that this has limited the confidence officials have in the technology they select. For example, an official in Chicago told us that the lack of standards has resulted in the agency not knowing if it is purchasing quality ITS applications. In another example, a San Francisco official stated that the slow completion of the standards development process at the national level caused transportation officials to pick a standard in the draft stage that they hope will have the ability to connect with future ITS deployment in the area.

According to DOT, although it has worked to facilitate the issuance of technical standards, technology has been developing faster than the SDOs

[40]Standards promote interoperability—the ability of systems to provide services and to accept services from other systems and to use the services so exchanged to enable them to be operated effectively together.

that DOT works with can handle. Furthermore, the issuance of standards by SDOs is done voluntarily, and there is no private-sector market influencing speedy issuance—the SDOs do not have a profit incentive in issuing standards. DOT has accelerated development of over 100 standards and identified 17 standards critical to ensure ITS operability across the country. However, according to DOT officials, standard setting is a difficult, consensus driven, and time-consuming process.

Conclusions

Generally, the promise of ITS for managing congestion has fallen short. Although DOT established a vision to build an intelligent transportation infrastructure across the United States to save time and lives and improve the quality of life for Americans, DOT's deployment goal ends in 2005. Studies show that when implemented properly, ITS technologies can reduce congestion, as well as lead to other benefits such as improved safety and reduced emissions harmful to the environment. However, transportation agencies have been slow to adopt and deploy ITS technologies, facing many barriers along the way. Funding for ITS deployments, particularly for ongoing operations and maintenance costs, is critical to ensuring that ITS deployments are used effectively. However, such funding continues to be a problem for state and local governments. In addition, state and local transportation agencies do not always consider ITS when developing their transportation plans. Moreover, DOT does not have clear information on the extent to which areas have deployed ITS to meet their particular needs, nor does it have clear information on the operating status of ITS where it has been deployed. Limitations of DOT's efforts in measuring the deployment of ITS technologies, among other things, have reduced its ability to help state and local governments invest strategically in ITS.

Successful ITS deployment depends on selecting the appropriate level and types of ITS for the area, effectively integrating these technologies, and committing the necessary resources to operate and maintain them. We recognize that DOT has not been able to influence deployment through funding, and state and local governments are free to choose the extent to which they direct other federal highway funds to ITS. However, DOT has opportunities to assist metropolitan areas in developing appropriate, efficient, and cost effective transportation systems which include ITS. Although analyses of a project's cost effectiveness often do not drive transportation investment decisions—many factors, political as well as other, influence project selections—such analyses should be part of the decision making process. And impact analysis for all highway projects, including ITS projects, would help decision makers view all tools together and make well-reasoned decisions about investment of their limited funds to develop the best possible transportation system. In addition, as the Secretary of Transportation indicated in 1996, providing national guidance is important to ensure ITS deployment. Nationally tracking measures for ITS deployment and operations would continue to support awareness of progress toward improved mobility and help states and local areas considering ITS determine how they could deploy and operate ITS technologies to help mitigate congestion and realize other benefits.

Recommendations for Executive Action

We recommend that the Secretary of Transportation take the following three actions:

- revise measures for ITS deployment to incorporate local needs and operational status for deployed ITS technologies;
- develop new strategies to better advertise the availability of federal funds for operating ITS technologies; and
- encourage cost-effectiveness analyses and their use in transportation planning and decision making.

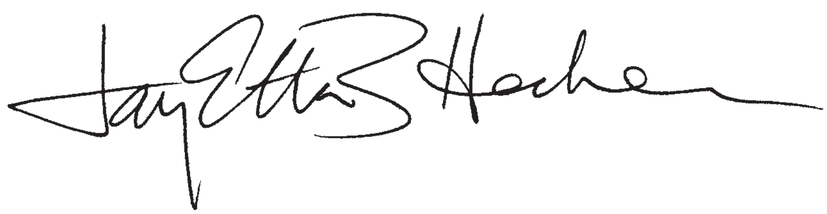
Agency Comments

In commenting on a draft of this report, officials from DOT's ITS Joint Program Office and the Office of the Assistant Secretary for Transportation Policy provided comments through the Office of the Secretary's audit liaison generally concurring with the report and agreeing to consider the recommendations. DOT officials provided technical clarifications and information, which we incorporated in the report, as appropriate. The officials also provided general comments about the ITS deployment goal.

Although DOT officials did not comment on the recommendation to revise and update the goal and measures for ITS deployment, the officials said that they do not plan on updating the ITS deployment goal after it expires in 2005. In addition, officials noted that SAFETEA-LU repealed the ITS integration deployment program. However, ITS Joint Program Office officials have indicated that they intend to continue to track ITS deployment. In the absence of an ITS integration deployment program, we revised our recommendation so that it no longer calls for revising and updating the goal for ITS deployment. However, we continue to recommend that DOT improve its ITS deployment measures to obtain clear and accurate information on ITS deployment that will support DOT's efforts to help states and local areas select, implement, operate, and maintain ITS technologies to address increasing congestion and other transportation needs in their areas.

We are sending copies of this report to interested congressional committees and to the Secretary of Transportation. We will also make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or heckerj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix IV.



JayEtta Z. Hecker
Director, Physical Infrastructure Issues

Scope and Methodology

To address our first objective—to describe the federal role in ITS deployment and the goals and measures for the federal ITS program—we reviewed transportation legislation, DOT performance plans, and other documents related to ITS and the federal role. We reviewed TEA-21 goals for the ITS deployment incentives program. We also reviewed the Secretary of Transportation's 1996 speech describing his vision for ITS deployment and met with DOT and FHWA officials to clarify the federal role in deploying ITS. Although ITS technologies can be used for many purposes, including highway safety, we focused this analysis on the role of ITS for mitigating congestion.

To address our second objective—to develop information about the progress of ITS deployment toward DOT's deployment goal and DOT's measures—we reviewed reports that describe DOT's deployment program and its methodology for rating metropolitan areas. We interviewed ITS officials who track deployment of ITS technologies in over 75 metropolitan areas. To determine progress toward the 2005 goal, we summarized ratings from DOT's deployment reports and deployment and integration tracking database—which identify the number of metropolitan areas with high, medium, and low ratings—and obtained rating information for the period of 1997 to 2004.[1]

To assess the reliability of the deployment and integration tracking database, we interviewed officials from DOT's Joint Program Office who are knowledgeable about how data are collected, analyzed, and reported, and we collected deployment data from the state and local transportation agencies that we visited to compare it with the data used in the database and DOT deployment reports. In addition, in 2000, the Bureau of Transportation Statistics (BTS) reviewed and reported on the data quality of the ITS deployment and integration tracking database. BTS noted that the database frequently had been monitored and improved upon. The report found some reporting errors and made recommendations for additional improvements. DOT implemented some of the recommendations. DOT has not conducted any subsequent quality reviews. Based on interviews with DOT officials and analysis of the data, we determined that the data were sufficiently reliable for our purposes.

[1]In 1996, Secretary Peña established the goal that 75 of the largest metropolitan areas would be outfitted with a complete intelligent infrastructure by 2005. Since 1996, DOT has increased the number of metropolitan areas for which it tracks deployment from 75 to 78. However, to maintain reporting consistency across the 10-year goal, DOT only reports on the original 75 metropolitan areas.

To discuss DOT's measures for assessing the status of ITS deployment in metropolitan areas, we interviewed DOT officials and reviewed reports that explain the methodology DOT uses to rate the metropolitan areas (high, medium, and low) in terms of deployment and integration of ITS technologies. (See app. 2.) We reviewed the Secretary's 1996 speech, recent DOT performance plans, and GAO reports that relate to impact analysis. We also interviewed federal, state, and local transportation officials from our four case study locations about their experiences with ITS and the ITS technologies deployed in each area. (For more information about site selection and agencies we contacted, see discussion later in this section.) We did not review the appropriateness of the rating that DOT had assigned to the 75 metropolitan areas. However, we did compare the overall rating that DOT assigned to the four metropolitan areas we studied in depth with the information we gathered from our interviews with transportation and planning officials in those areas.

To address our third objective—to identify the impacts of ITS deployment—we reviewed 38 studies issued since 2000 from our site visits and DOT's ITS benefits database, a repository of academic and government papers evaluating the deployment of ITS technologies in U.S. and international locations, including any cost effectiveness analysis included in the studies. We asked officials at each of the four locations if they documented the results of their ITS deployments. Las Vegas and San Francisco had conducted evaluations of their ITS deployments while Chicago and Indianapolis had not. Las Vegas conducted two evaluations for a traffic-signal-timing system on two major arterial roads. San Francisco conducted three evaluations for ramp meters deployed on two freeways in the metropolitan area. Therefore, we collected five studies from our site visits. We also reviewed 33 recent evaluations from the ITS benefits database.

In order to summarize the benefits of ITS deployment on congestion, we reviewed those studies that relate to mobility and capacity/throughput. DOT used our criteria to develop a list of 76 studies. We further refined our review to studies published after 2000 that involved deployments in the U.S., ending up with 33 evaluations in total. DOT provided us with copies of the evaluations. We did not assess the potential benefits of any one technology, such as open road electronic tolling, on the nation's transportation system.

In order to assess the reliability of the benefits database, we interviewed the DOT manager responsible for the database about data sources, data entry, and quality control procedures. We assessed the database summaries by comparing them with the complete evaluations. We found that they generally contained accurate information regarding the location of the deployment, the type of ITS technology, and the impacts of the ITS deployment. We determined that the benefits database was sufficiently reliable for our purpose of identifying evaluation reports.

We also reviewed the 38 evaluations to ensure that findings from the studies were based on sound methodologies. A DOT contractor reviewed the studies for methodological soundness before including them in DOT's benefits database. We also reviewed the studies we selected from the DOT benefit database to ensure that these studies were based on sound methodologies and determined these studies were sufficiently reliable for describing actual and potential impacts of ITS technologies. We created a data collection instrument to systematically collect information from each evaluation we selected, including information about the evaluation design, expected and documented benefits, and inclusion of cost information. We then compiled and analyzed the information from the data collection instruments. We determined that the results contained in the studies were sufficiently reliable for our purpose of describing what is known about the impacts of ITS deployment.

To address our final objective—to identify factors that limit deployment and use of ITS—we used a case study approach and interviewed federal, state, and local transportation officials about barriers to deploying and maintaining ITS technologies. We also used case study information to illustrate limitations of DOT's deployment integration rating measurement approach. We used level of congestion and DOT's integrated deployment rating to select four congested metropolitan areas—two areas that DOT has determined have deployed ITS to a great extent and two areas that DOT has determined have deployed ITS to a lesser extent—to study in depth.[2] We selected areas with either high or low levels of integrated deployment in order to try to capture information that could explain the different levels of deployment in those locations. For example, we were interested in finding out whether such areas encounter similar or different barriers to deployment.

[2]There are many ways to measure the level of congestion. In this report, we used DOT's measure of congestion—the percent of travel under congested conditions--to identify congested metropolitan areas.

To identify congested metropolitan areas, we applied DOT's integrated-deployment congestion rating to the largest 75 metropolitan areas and sorted them according to congestion level. DOT measures congestion as the percent of travel under congested conditions. We used the Texas Transportation Institute 2004 Urban Mobility Report—which ranked congestion under DOT's definition during our selection process—to identify congested metropolitan areas. The 2004 Urban Mobility Report used 2002 travel data to rank congestion levels. We then identified a list of congested metropolitan areas with varying levels of deployment. In our deliberations about which high deployment area to visit, we took into account practical considerations such as proximity of metropolitan area to the state capital. We selected Chicago and San Francisco, which were ranked fourth and fifth respectively in terms of congestion and which DOT rated as high in integrated deployment and Las Vegas and Indianapolis, which were ranked 15th and 26th respectively in terms of congestion and rated by DOT as low in integrated deployment. We determined that Las Vegas is the most congested location that DOT rated low, and Indianapolis is the second most congested location rated low. After we visited these locations, the Texas Transportation Institute issued its 2005 Urban Mobility Report using 2003 travel data to rank congestion levels. In that report, Chicago and San Francisco were ranked fourth and fifth respectively in terms of congestion, and Las Vegas and Indianapolis were ranked ninth and 25th respectively.

We developed a semistructured data collection instrument to use during interviews with transportation and planning officials in the metropolitan areas. The data collection instrument included questions about local transportation challenges, ITS decision-makers, ITS deployments, barriers and facilitators to deploying ITS, and future deployment. We obtained a list of contacts from the FHWA division offices and identified a group of state and local officials involved in ITS deployment in the metropolitan area. In each metropolitan area, we interviewed officials from the FHWA division office, the state department of transportation ITS office, state department of transportation district engineer, metropolitan planning organization, city department of transportation, and transit authority. (A complete list of agencies we contacted is included at the end of this section.) We conducted our site visits between November 2004 and March 2005. We conducted our work from October 2004 through August 2005 in accordance with generally accepted government auditing standards.

Organizations Contacted

Department of Transportation

Federal Highway Administration Operations Office
ITS Joint Program Office

Chicago Metropolitan Area

FHWA National Resource Center (Olympia Fields, Illinois)
FHWA Illinois Division
Illinois Department of Transportation, ITS program office
Illinois Department of Transportation, District 1
Chicago Area Metropolitan Planning Organization/Chicago Area Transportation Study (CATS)
City of Chicago
Illinois State Toll Highway Authority
Regional Transportation Authority

Indianapolis Metropolitan Area

FHWA Indiana Division
Indiana Department of Transportation, ITS program office
Indiana Department of Transportation, Greenfield District
Indianapolis Metropolitan Planning Organization
Indianapolis Department of Public Works
Indianapolis Public Transportation Corporation (IndyGo)

Las Vegas Metropolitan Area

FHWA Nevada Division
Nevada Department of Transportation, Operations
Nevada Department of Transportation, District 1
Regional Transportation Commission/Freeway and Arterial System of Transportation Organization (FAST)
Regional Transportation Commission of Southern Nevada

San Francisco Metropolitan Area

FHWA National Resource Center
FHWA California Division
California Department of Transportation (CALTRANS), ITS program office
CALTRANS, District 4

San Francisco Department of Traffic
San Francisco Municipal Railway (MUNI)
Metropolitan Transportation Commission
Bay Area Rapid Transit (BART)
Santa Clara Valley Transportation Authority
Alameda County Congestion Management Agency

Highway Associations

American Association of State Highway and Transportation Officials
American Highway Users Alliance
International Bridge, Tunnel and Turnpike Association
Intelligent Transportation Society of America

Other

Northwestern University, Evanston, Illinois
University of Illinois, Chicago, Illinois
University of California, Berkeley, California

Summary of DOT's Deployment Tracking Methodology

In 1996, Secretary Peña established the goal that 75 of the largest metropolitan areas would be outfitted with a complete intelligent transportation infrastructure by 2005.[1] DOT tracks the level of deployment and integration and reports on the progress toward this goal periodically in its deployment progress report. Metropolitan areas are rated as high, medium, or low in terms of deployment and integration of ITS technology. DOT considers any metropolitan area having a high or medium rating as contributing to fulfilling the goal. At the end of 2004, DOT rated 28 areas high, 34 medium, and 13 low.

In order to track progress toward this goal, DOT set up the metropolitan ITS deployment tracking methodology. The tracking system includes data about nine specific ITS components, including freeway management, incident management, arterial management, emergency management, transit management, electronic toll collection, transit electronic fare payment, highway-rail intersections, and regional multimodal traveler information. DOT created a set of measurable indicators of progress toward the overall goal and created nine data collection instruments (surveys) that correspond to the ITS systems. DOT contracted with Oak Ridge National Laboratory (ORNL) to collect the data from the entities in the 75 metropolitan areas associated with ITS deployment. These entities included transit agencies, toll authorities, municipal governments, and state transportation departments, among others. ORNL sent out the first deployment and integration surveys in 1997, which represented the baseline as of the end of fiscal year 1997. The data were initially collected by a fax/mail survey, which later became a Web-based survey. After 2000, ORNL surveyed all metropolitan areas on a biennial basis and completed a telephone interview with the metropolitan areas with a low rating in the interim years to determine whether their rating should be increased. It completed the 2004 survey in September 2004 and published the results in July 2005. According to DOT officials, the 2005 survey was released in July 2005, and was a Web-based rather than telephone survey. The 2005 data will be available in 2006.

From the survey questions, DOT compiles data about the level of deployment of ITS systems and the level of integration. To measure ITS deployment, DOT created five ITS component categories (collapsing the

[1]Since 1996, DOT has increased the number of metropolitan areas on which it tracks deployment from 75 to 78. However, to maintain reporting consistency across the 10-year goal, DOT only reports on the original 75 metropolitan areas.

nine components mentioned above into five categories) and nine component indicators. For example, an indicator of the arterial management component is the percent of signalized intersections under computerized control. In order to assign a rating for deployment, DOT created threshold values for the ITS component indicators. (See table 2.) For example, the threshold value for the percent computerized signalized intersections is 33 percent. DOT then assigns a rating of high, medium, and low for deployment depending on how many thresholds the metropolitan area exceeded. An area is rated high in component deployment if it exceeds the threshold value for at least one of the indicators in each of the five components. An area is rated medium if it exceeds the threshold value for freeway management/incident management or transit management/electronic fare payment and at least one other component. An area is rated low in component deployment if it exceeds the threshold value for one or fewer components.

Table 2: DOT's Deployment Component Indicators and Threshold Values

ITS components	Component indicators	Threshold values
Freeway management/incident management	• Percent freeway miles under electronic surveillance • Percent freeway miles with freeway service patrols • Percent freeway miles with closed circuit TV (CCTV)	Greater than or equal to 20 percent
Transit management/electronic fare payment	• Percent buses equipped with automated vehicle location • Percent buses equipped with electronic fare payment	Greater than or equal to 33 percent
Arterial management	• Percent signalized intersections under computerized control	Greater than or equal to 33 percent
Regional multimodal traveler information	• Percent geographic coverage of traveler information from freeway electronic surveillance and freeway CCTV cameras	Greater than or equal to 10 percent
Emergency management services	• Percent emergency vehicles operating under computer-aided-dispatch (CAD)	Greater than or equal to 33 percent

Source: DOT.

To measure the level of integration, DOT defined a set of links involving three major organizations that operate the infrastructure—state governments that manage freeway management and incident management components; local governments that manage most arterial management components; and public transit authorities that manage the transit management component. DOT created integration indicators about how agencies connect, like sharing traffic condition information with other agencies, and assigns a value greater than zero for any integration indicator when a link is present. DOT then rates the metropolitan area according to how many links are present. An area is rated high if all three links are present; medium if any two out of three links are present; and low if one or fewer links are present.

To measure the level of integrated deployment, DOT combines the component classification and the integration classification into a single classification. For example, a metropolitan area which DOT rated as high in ITS components and high in integration, will be rated as high overall. (See table 3.)

Table 3: DOT's Integrated Deployment Classification Scheme

Component classification	Integration classification	Combined classification
High	High	High
High	Medium	Medium
High	Low	Medium
Medium	High	High
Medium	Medium	Medium
Medium	Low	Low
Low	High	Medium
Low	Medium	Medium
Low	Low	Low

Source: DOT.

Metropolitan Area Case Studies

We studied four metropolitan areas that were among the 75 metropolitan areas included in DOT's deployment database to help identify barriers to deployment and use of ITS technologies that address congestion and help assess DOT's deployment measures.[1] We visited two metropolitan areas (Chicago, Illinois, and San Francisco, California) that DOT rated as having a high level of integrated deployment and two areas (Las Vegas, Nevada, and Indianapolis, Indiana) that DOT rated as having a low level of ITS integrated deployment. The officials we interviewed and documents we received provided detailed information on each area's transportation challenges, the extent to which the areas were using and planned to deploy different types of ITS technologies, and the factors that influenced ITS deployment and use in their areas. We were also able to observe the extent to which the two areas with more ITS deployed were operating their existing systems. In Las Vegas and Indianapolis, however, we did not observe much in terms of operations, likely because of the limited deployment in those areas. (See app. 1 for details on our scope and methodology for our case study selections.)

Chicago, Illinois

Level of Congestion

In 2003, Chicago was the fourth most congested area in the nation; commuters spent 42 percent of their travel time in congested conditions. Chicago travelers that year on average spent 58 hours delayed in traffic costing the area over $4.2 billion in lost wages and wasted fuel—about 150 million gallons.

Transportation System

The Chicago metropolitan planning area consists of seven counties encompassing a population of about 8.1 million in 2000. The population is expected to reach 9.8 million by 2030. Seven interstates enter the Chicago region. In 2002, 20.5 million vehicle trips were made daily on the area's 24,092 miles of interstates, freeways, and principal and minor arterial roads, and an additional 1.5 million daily trips were made on transit

[1] We defined congestion as the percent of travel that is under congested conditions—DOT's measure of congestion.

systems—Chicago has both rail and bus service. In 2003, over 165.7 million vehicle miles were traveled on area roadways daily.

Transportation Challenges

Highway congestion is a major transportation challenge for the Chicago area. The roadway system has not grown fast enough to keep pace with the increase in roadway demand, especially with commercial truck driving. Currently, trucks comprise up to 40 percent of daily traffic on three of the area's most congested freeways. Furthermore, by 2030 the number of trucks on Chicago area highways is expected to increase by 80 percent. Trucks use twice the average road space used by cars and will account for more than half of the additional vehicles and two thirds of the effective increase in traffic on the region's roads.

ITS Applications

Chicago uses many ITS technologies. The Illinois Department of Transportation (IDOT) operates 22 changeable message signs that display real-time traffic information on Chicago's freeways. IDOT utilizes over 2,400 loop detectors to collect such information. IDOT also utilizes 113 ramp meters, closed circuit television cameras, and video surveillance cameras. Drivers with cellular telephones can also call *999 to notify IDOT of incidents on arterials and freeways. IDOT also operates three traffic management centers including the Gateway Traveler Information System which serves as the multimodal traveler information hub for the three-state Gary-Chicago-Milwaukee Corridor Coalition. Gateway collects, processes, validates, fuses, and distributes real-time traffic, travel-time, congestion, construction, incident, special event, and transit information from and to over a dozen operating agencies in the corridor to support more effective management and operation of the transportation system. In addition, IDOT operates an Emergency Traffic patrol providing over 100,000 expressway motorists with incident assistance annually. Finally, multiple agencies have the capability to monitor area traffic from 10 traffic management centers.

On its arterial roadways, the Chicago DOT has designed six "smart corridors" connected by fiber optic signals. In those corridors, cameras and remote devices are used to improve efficiency through traffic signal preemptions or fast incident management. Some corridors, such as Lake Shore Drive, use dynamic message signs. The Chicago DOT also has a traffic management center with the capability of monitoring its roadways.

In addition, transit agencies such as the Chicago Transit Authority have many ITS components on their trains and buses such as Automatic Vehicle

Location, computer-aided dispatch and control, and real-time passenger information signs.

The Illinois State Toll Highway Authority has also deployed ITS applications along its 150 miles of highways in the Chicago area. Specifically, the agency has an electronic toll collection system, a traffic incident management system to manage operations and incidents that is integrated with the Illinois State Police computer-aided dispatch, about 400 closed-circuit televisions, and over 100 detectors that use speed measurements to provide travel time estimates.

Factors Impacting ITS Deployment

Chicago has a high level of ITS deployment due to significant federal funding, congested conditions, and ITS advocates. Since 1991, Chicago has received over $43 million in federal funding for deployment of ITS applications. The Gary-Chicago-Milwaukee area was one of four locations the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 funded as part of the ITS priority corridor program. ISTEA authorized the Gary-Chicago-Milwaukee area with over $18 million for ITS applications. Being a part of the ISTEA program also helped to create the coalitions between transportation agencies that were needed for further advancement of ITS after the program ended. In addition, transportation officials in Chicago stated that the level of congestion on Chicago's roadways combined with limited ability to build additional roadways compelled them to look into operational improvements such as ITS technologies. Finally, Chicago's high deployment level is also the result of its having ITS advocates at the state and local levels. IDOT has an ITS office that seeks opportunities to deploy ITS applications and secure the necessary funding for such applications.

While Chicago transportation agencies have achieved a high level of ITS deployment, they have faced challenges in operating their ITS technologies. Transportation officials stated that their agencies lack funding for operations and were not aware that federal funds could be used for operations. Consequently, 6 of the 10 transportation management centers do not have operators monitoring traffic, updating message signs, and notifying incident management officials when necessary. (See fig. 4.)

Future ITS Initiatives

Chicago transportation agencies are proposing 85 ITS projects—ranging in size from small, low cost actions to multimillion-dollar efforts—at a total cost of over $304 million. These efforts include the following:

- IDOT proposes to develop a statewide 511 information program, install an additional 350 cameras for closed circuit television at 1-mile intervals or less, and install additional dynamic message signs on its roadways.

- The Chicago DOT proposes to design and implement a city traffic management center and hub with interfaces to the city's 911 center and IDOT Gateway Center to cover traffic management, traveler information, and incident management.

- The Regional Transportation Authority is proposing to install transit signal prioritization, large message displays of train schedules at five locations, and regional traveler information kiosks in six locations.

- The Illinois State Toll Highway Authority has begun a 10-year renovation to transfer its tollways into an "open road" system. The open road concept calls for cash-paying customers (those not using the electronic toll collection passes) to exit the mainline to pay tolls at new express plazas located at the sides of the roadway. Those using electronic passes will be able to experience end-to-end, unimpeded travel over the entire 274-mile toll system.

Figure 4: A Chicago Metropolitan Area's Traffic Management Center That Lacks Staff Dedicated to Monitoring Traffic throughout the Day

Source: GAO.

San Francisco, California

Level of Congestion

In 2003, the San Francisco Bay Area was ranked the fifth most congested area in the nation; commuters spent 41 percent of their travel time in congested conditions. Bay Area travelers that year on average spent 72 hours delayed in traffic, costing the area over $2.6 billion in lost wages and wasted fuel—an excess of 96 million gallons.

Transportation System

The San Francisco Bay Area consists of nine counties encompassing a population of about 7 million in 2004. The population is expected to reach 8.8 million by 2030. In 2000, about 17 million trips were made daily on the area's 21,218 miles of interstates, freeways, and principal and minor arterial roads. An additional 1.4 million daily trips were made on transit systems; San Francisco has ferry, rail, and bus service. In 2003, over 91.5 million vehicle miles were traveled on area roadways daily.

Transportation Challenges

Changes in the Bay Area's demographics will have significant transportation implications in the future. The percentage of residents age 65 or older is expected to increase from 10 percent currently to 25 percent in 2030. Meeting the mobility needs of the aging population will require changes in a number of areas, from the design of cars to increases in paratransit systems. In addition, average household incomes in the Bay Area are expected to rise in real terms from $92,000 in 2000 to $118,000 in 2030. The level of auto ownership is likely to rise with this income increase, as more families will be able to purchase additional vehicles.

The Bay Area also has a political culture that has significantly impacted transportation mobility. In the late 1950s, the city of San Francisco passed legislation opposing new freeway construction in the city limits. Almost all roads in the city are arterials. In addition, the Bay Area is expected to spend less on new freeway projects than any other large urban area in the country.

The geography of San Francisco is a challenge for transportation solutions. The eight toll bridges in particular are consistently crowded since they are the main entrance and exits into the metropolitan area. San Francisco's peninsula geography makes entrance and exit via a vehicle very challenging. Unless a commuter is driving from the north, drivers must take a bridge to enter San Francisco.

California has also significantly decentralized transportation decision making. In 1997, the state passed legislation allocating 75 percent of the state's transportation funds (including federal transportation funds) to local entities for regional improvement projects. The remaining 25 percent is for state administered interregional improvement programs.

ITS Applications

Transportation agencies in San Francisco have deployed a wide variety of ITS technologies. The Bay Area is the largest metropolitan area in the country to activate a 511 service. The 511 service provides Bay Area callers and those who visit the 511 Web site with real-time traffic information about conditions and incidents including point-to-point driving times on routes throughout the area. The service also includes fare, schedule and trip planning information on the area's public transit systems; online ride-matching for ride-sharing, bicycle route information; and updates on construction projects and special events affecting traffic. The Metropolitan Transportation Commission (the area's MPO) partnered with the CALTRANS (the state DOT) and other transit agencies to launch the service in 2002. Since its inception, the 511 system has received praise from the Intelligent Transportation Society of America and the American Public Transportation Association.

Transportation agencies in the Bay Area also control freeway movement through communication and roadside equipment that supports ramp control, lane controls, and interchange controls. Agencies operating freeways, such as CALTRANS, also have traffic management centers that monitor freeways to report on traffic information and detect incidents. Area transportation agencies feature 4,700 traffic sensing detectors on its 2,800 freeway miles. As a result, 29 percent of the freeways have a sensing device within 1 mile or less, and 40 percent of the freeways have a sensing device within 2 miles or less. About 45 percent of these devices, however, are out of service reducing the ability of staff to collect traffic data such as speed and volume.[2] According to a DOT official, having 45 percent of traffic detectors out of service is on the low-end nationally and is not typical. In addition, San Francisco area drivers can also utilize a highway-advisory radio station that provides traffic information to highway travelers.

The San Francisco Department of Parking and Traffic (DPT) is leading an integrated transportation management system effort to utilize ITS technologies to make traffic flow on arterial streets. DPT has begun an integrated transportation management system program for eight city areas. DPT officials stated that they have completed the initial phase of the effort and have installed electric traffic controls and loop detectors at 35 intersections and have 15 cameras, 5 video surveillance monitors, 4 fixed

[2]According to transportation officials we met with, if an agency has a working traffic sensing detector within a mile, then it can develop a good estimation of travel time and congestion.

variable message signs, and a traffic management center that provides the ability to monitor traffic.

The Bay Area Toll Authority has an electronic toll collection program for bridge toll users. The system has three components: a transponder, which is placed inside the vehicle; an overhead antenna, which reads the transponder and collects the toll; and video cameras to identify toll evaders. The Toll Authority has added at least one electronic toll collection lane to each of the eight area bridges.

The Metropolitan Transportation Commission (MTC) and six San Francisco Bay Area transit agencies have developed a regional fare payment system. The system enables customers to use a single card to ride Bay Area buses, trains, light rail lines, and ferries. The nine-county Bay Area will be the first region in the U.S. to have a single card that can be used on all forms of public transit. In addition, the Bay Area Rapid Transit agency has installed real-time information, such as expected arrival time of next transit vehicle, at every rail station platform.

Factors Impacting ITS Deployment

The San Francisco Bay Area's level of ITS deployment is high due to active advocates, federal resources, and a cultural climate that favors managing over expanding the roadway system. The MTC has taken a strong role in advocating and moving ITS deployment forward. In addition, federal funding helped in deploying ITS applications. For example, an ITS earmark helped launch the agency's ITS initiatives. Between 2004 and 2005, Congress earmarked over $3.7 million for ITS applications in the Bay Area. The Bay Area also has several cultural factors that have helped to facilitate ITS deployment. The transportation planners have maintained a decades-long commitment to preserving and managing the roadway system over expansion. In addition, according to MTC officials, the Bay Area has a sense of pride toward developing technology systems since the nation's technology hub, Silicon Valley, is in the region.

While San Francisco transportation agencies have achieved a high level of ITS deployment, they have also faced challenges in operating their ITS technologies. Transportation officials stated that their agencies lack funding for operations, awareness that federal funds could be used for operations, and technical standards. In the San Francisco Bay Area, for example, the MTC estimates that it needs an additional $419 million above its available funding to fully deploy the area's regional operations programs—including ITS applications. In addition, some local officials were not aware that federal funds can be used to operate and manage ITS technologies, leading some agencies to use their federal funding to replace their technology systems at much higher costs than would be needed to operate and maintain their existing technologies. A lack of business knowledge also led an agency to lease rather than purchase telecommunication lines needed for transmitting data from roadway sensors—this decision ended up costing the agency money in the long run. In addition, a San Francisco official stated that the slow completion of the standards development process at the national level caused them to pick a standard in the draft stage, hoping the technology they chose would be able to connect with future ITS deployment in the area.

Future ITS Initiatives

The MTC has taken the lead on future ITS initiatives and plans to collaborate with local agencies to further the deployment of the following applications:

- On the freeways, MTC is planning to improve the traffic operations system and enhance its transportation management center, freeway service patrol, incident management, technical assistance, and real time travel information. (See fig. 5 for planned use of traveler information.)
- On arterial roads, MTC, in cooperation with the San Francisco Department of Parking and Traffic, plans to implement smart parking. Smart parking would provide drivers with real-time information on available parking spots at city garages. This information may improve efficiency from drivers searching for available parking or double parking.
- On all roadways, MTC plans to increase coverage of the 511 traveler information system.
- On transit, MTC is partnering with other transit agencies to further the deployment of the smart card system and make it available to more commuters.

Figure 5: Artist's Depiction of Real-Time Travel Information in San Francisco

Source: California Center for Innovative Transportation.

Las Vegas, Nevada

Level of Congestion

In 2003, Las Vegas was the ninth most congested area in the nation; commuters spent 39 percent of their travel time in congested conditions. Las Vegas drivers that year on average spent 30 hours delayed in traffic costing the area about $380 million in lost wages and wasted fuel—about 14 million gallons.

Transportation System

The Las Vegas metropolitan planning area is a collection of five incorporated cities and unincorporated rural and urban areas, all located in Clark County and encompassing a population of about 1.6 million in 2003. The population is expected to reach almost 2.4 million by 2025. In 2003, over 3.6 million trips were made daily on the area's 6,569 miles of roadways. An additional approximately 124,000 daily trips were made on transit systems. In 2003, over 27.4 million vehicle miles were traveled on area roadways daily.

Las Vegas is one of the fastest growing urban areas in the nation. Gaming, proximity to natural scenic attractions, a favorable climate, and direct access by air and ground resulted in a population boom between 1990 and 2000. During that time, the population rose from 741,000 to about 1.38 million—an increase of 86 percent. Phoenix, by comparison, which during the same time period was the second fastest growing area had a population increase of 45 percent.

Transportation Challenges

The Las Vegas population growth has outpaced transportation infrastructure development. The increase in population has placed an increased demand for transit and roadway services. Las Vegas, however, has only two major freeways, the U.S. 95 and the I-15. Although Clark County Public Works is planning on building a Beltway, motorists rely primarily on arterials for mobility.

ITS Applications

Las Vegas transportation agencies have coordinated efforts to establish an ITS system on the arterial roadways in the metropolitan area. The Las Vegas MPO manages the Freeway and Arterial System of Transportation organization (FAST)—an integrated freeway and arterial management system designed to reduce congestion, and improve incident response time and management. FAST is designed to both monitor and control traffic. To monitor traffic, FAST plans to move into a new traffic management center in the summer of 2005 to monitor all roadways. However, none of the area's freeway miles currently are covered by electronic surveillance, and the state DOT is just beginning to link its ITS sensory technologies with those deployed by the local transportation and law enforcement agencies.

Factors Impacting ITS Deployment

Some of the barriers that have impacted ITS deployment in Las Vegas include funding inflexibilities, staffing limitations, and technological barriers. A few transportation officials stated the federal integration deployment program funds are specifically designated for integration and not strictly for deployment. This requirement made it difficult for Las Vegas to use a congressional earmark since it has already highly integrated its limited ITS deployment. In addition, transportation officials stated that most agencies do not have enough staff to keep up with developing technologies. Finally, needed equipment is not always readily available. Transportation officials stated that the ITS market is small, making it difficult to find equipment that meets standards and is not expensive.

Future ITS Initiatives

The FAST organization plans to deploy ramp meters, dynamic message signs, and a 511 statewide traveler information system for area roadways. In addition, the Las Vegas area plans to provide real-time information on one of the two area freeways and at transit area kiosks.

Indianapolis, Indiana

Level of Congestion

In 2003, Indianapolis was the twenty-fifth most congested area in the nation; commuters spent 34 percent of their travel time in congested conditions. Indianapolis drivers that year on average spent 38 hours delayed in traffic costing the area about $362 million in lost wages and wasted fuel—about 14 million gallons.

Transportation System

The Indianapolis metropolitan area includes Marion County and portions of Hamilton, Boone, Hendricks, Johnson, and Morgan counties encompassing a population of about 1.4 million in 2000. The population is expected to reach about 1.7 million by 2030. The city and county are a unified, consolidated government entity. In 2002, over 5.5 million vehicles traveled daily on the area's 5,644 lane miles of roadway. An additional 28,000 trips were made on the transit systems. In 2003, over 30.6 million vehicle miles were traveled on area roadways daily. The area has five major Interstates.

Transportation Challenges

Indianapolis has an entrenched car culture. Drivers use the Interstates for local trips and generally do not use public transit. Between 2002 and 2030, the Indianapolis MPO forecasts that daily vehicle trips will increase from 5.5 million to over 6 million trips. Transportation officials stated that the area has no natural barriers to limit sprawl. In addition, the transit system has been underutilized because of the continuing challenges with the number of routes, convenience, and a culture that does not support public transit.

Indianapolis has isolated instances of congestion. Many large special events attracting tourists, such as the Indianapolis 500, NASCAR, and NCAA tournaments create heavy episodic congestion. Although the entire metropolitan area is not considered very congested, certain locations in the metropolitan area experience heavier congestion than others.

ITS Applications

Indianapolis features few ITS applications. In 2004, the Indiana DOT opened a traffic management center. The traffic management center has incorporated cameras, sensors, and other technologies on about 25 percent of the Interstates and is charged with posting traffic information via changeable message signs, highway advisory radio, pagers, and real-time on the Web to inform drivers. The state DOT also runs the Hoosier Helper program—an emergency roadside assistance program that assists stranded motorists, removes debris from roadways, and sends for help in emergency situations. (See fig. 6.) On arterial roads, the Indianapolis Department of Public Works also has a traffic control center where the agency can control and coordinate signals and view intersections.

Factors Impacting ITS Deployment

Some of the barriers that have impacted ITS deployment in Indianapolis include a lack of congestion, agency coordination, ITS staff and technical expertise. The public does not perceive congestion levels to be significant. The public is not knowledgeable or interested in ITS technologies and may object to ITS deployment. According to a transportation official, the Indianapolis community may not welcome the deployment of ITS technologies such as ramp metering, causing local agencies to avoid implementing or upgrading ITS applications. Furthermore, some local agencies are not willing to commit to ITS, fearing it will take away funds from other programs. ITS deployment is not part of the locally established planning process and, therefore, planners do not consider it in their roadway building alternatives. In addition, transportation agencies in Indianapolis generally do not coordinate their ITS efforts. The state DOT traffic management system, for example, does not have a link to the city's traffic management center operated by the Department of Public Works; the agencies are operating independently. ITS staff is limited and lacks technical expertise. The ITS staff located at some agencies have increasing workload constraints that hinder the deployment of ITS. This ITS staff also lack technical expertise—there are few engineers that can provide the skills and knowledge needed to deploy ITS systems.

Future ITS Initiatives

The state DOT is advancing its traffic management system, while the Indianapolis Department of Public Works is determining the ITS needs for arterial roadways. The state DOT is moving into advanced phases of its advanced traffic management system and plans to install a total of 125 cameras spaced approximately every mile and a system of vehicle detection underneath the pavement placed every half mile on high-volume roads and one-mile on lower volume roads to measure the overall traffic flow. The agency plans full implementation of the system by 2008. The Indianapolis Department of Public Works is in the process of examining its ITS goals and the potential of ITS technologies such as a traffic management center with real time traffic information. The Department of Public Works also plans to centralize traffic control with the capabilities to respond to incidents, weather, and events over the next 5 to 10 years.

In addition, an DOT official stated that technical expertise in ITS is growing. The state DOT is expanding its ITS and traffic management staff. FHWA is offering additional training to the MPO staff as well.

Figure 6: Indiana Hoosier Helper Van

Source: GAO.

GAO Contact and Staff Acknowledgments

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