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June 2016

INTELLIGENT TRANSPORTATION SYSTEMS

Urban and Rural Transit Providers Reported Benefits but Face Deployment Challenges

Accessible Version

GAO-16-638

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GAO Highlights

Highlights of GAO-16-638, a report to the Committee on Transportation and Infrastructure, House of Representatives

Why GAO Did This Study

Public transit providers are adopting electronics and information-processing applications called ITS to help improve operations and service. ITS technologies can play an important role in facilitating multimodal choices in a rapidly changing transportation environment. This report describes: (1) the extent to which selected transit providers in large urbanized areas are using ITS, (2) the extent to which transit providers in small urban and rural areas are using ITS, (3) the benefits and challenges these transit providers experience in deploying ITS, and (4) the extent to which transit providers have utilized DOT resources to promote and support ITS.

GAO reviewed DOT's ITS deployment data and ITS studies; interviewed DOT officials and public transit stakeholders; conducted three site visits, selected based on geographic dispersion and DOT recommendations; interviewed 31 transit providers serving large urbanized areas selected for geographic dispersion and use of multiple transit modes; and conducted a national survey of small urban and rural transit providers to obtain information on ITS technologies used.

What GAO Recommends

GAO recommends that the Secretary of Transportation develop a strategy to raise awareness of federal resources for ITS deployment in the transit community and include ITS adoption by small urban and rural transit providers in ITS-monitoring efforts. DOT agreed with the recommendations and provided technical comments, which GAO incorporated.

View GAO-16-638. For more information, contact Mark Goldstein at (202) 512-2834 or goldsteinm@gao.gov.

What GAO Found

Selected large and medium urban transit providers have deployed most Intelligent Transportation Systems (ITS) technologies, such as automatic vehicle location (AVL) and electronic fare payment. Most of these providers reported sharing data collected from ITS with the public or regional transportation providers to enable technology innovations and improve regional planning. Large and medium urban transit providers have also deployed advanced types of ITS technologies, such as smart phone applications to provide passengers with travel information and mobile ticketing. GAO estimates that small urban and rural transit providers are using security systems, computer-aided dispatch, AVL, and geographic information systems to, among other things, monitor safety and security and improve record-keeping and billing capabilities. However, most small urban and rural transit providers are not using other ITS technologies—such as automatic passenger counters or electronic fare payment—due to the cost of the technologies or because there is no perceived need.

Transit providers GAO surveyed and interviewed reported various benefits from ITS including improved scheduling and routing, on-time performance and schedule adherence, and customer satisfaction. In addition, many large and medium urban transit providers reported that using combinations of technologies can increase benefits. By using technologies such as AVL and electronic fare payment together, for example, transit providers can obtain more precise ridership information, which can further improve their planning. However, transit providers GAO interviewed and surveyed noted that it can be difficult to quantify the benefits of using ITS technologies because, as reported by large and medium urban providers, it may be difficult to identify a unit of measurement, such as for greater staff efficiency, or attribute benefits to either ITS deployment or a specific technology. Transit providers also face an assortment of deployment challenges, including competing for funding internally with state-of-good-repair needs, reluctance from the transit workforce and leadership to embrace ITS technologies, coordinating deployment across regional agencies, and integrating technologies purchased from different vendors.

The Department of Transportation (DOT) offers a variety of information resources to support ITS deployment, but few of the transit providers interviewed or surveyed reported using these resources. DOT officials, selected large and medium transit providers, and other public transit stakeholders told GAO that the transit community may not be using these resources because transit providers lack sufficient staff and the information provided may not reflect the transit community's needs. Additionally, DOT does not include small urban and rural transit providers in its ITS deployment survey, a tool officials said is used in designing information resources. DOT could improve the awareness and applicability of ITS resources by developing a strategy to raise awareness of DOT's resources available to the transit community and monitoring the adoption of ITS by transit providers in small urban and rural areas. Without greater efforts from DOT to make the transit community more aware of federal ITS resources and to tailor these resources to the needs of smaller providers, transit providers may be missing information that could help them make the most informed ITS deployment decisions.

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Abbreviations

APC	automatic passenger counters
APTA	American Public Transportation Association
AVL	automatic vehicle location
CAD	computer-aided dispatch
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CTAA	Community Transportation Association of America
DOT	Department of Transportation
EFP	electronic fare payment
FAST Act	Fixing America's Surface Transportation Act
FTA	Federal Transit Administration
GIS	geographic information systems
GPS	Global Positioning System
GTFS	General Transit Feed Specification
ICM	Integrated Corridor Management
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation Systems
ITS America	Intelligent Transportation Society of America
JPO	Joint Program Office
MAP-21	Moving Ahead for Progress in the 21st Century Act
MSAA	Mobility Services for All Americans
NTD	National Transit Database
NTI	National Transit Institute
PCB Program	Professional Capacity Building Program
RTAP	Rural Transit Assistance Program
SIRI	Service Interface for Real Time Information
TCIP	Transit Communications Interface Profiles
TCRP	Transit Cooperative Research Program
TIS	traveler information systems
TRB	Transportation Research Board

TSP	transit signal priority
UZA	urbanized area
VTCLI	Veterans Transportation and Community Living Initiative

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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June 21, 2016

The Honorable Bill Shuster
Chairman
The Honorable Peter A. DeFazio
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

Ridership on public transit has grown 60 percent since 1973, and in 2014, Americans took 10.8 billion trips on public transportation systems, the highest annual public ridership in 58 years.[1] To help improve the operations of transit vehicles and services, U.S. transit providers are adopting a variety of wireless and wire line communications-based information and electronic technologies—collectively called Intelligent Transportation Systems (ITS). ITS encompasses a broad range of technologies, from security cameras to scheduling software, to improve the operations and efficiency of public transportation. ITS technologies can play an important role in improving transit operations in urban and rural areas and facilitating multimodal choices in a rapidly changing transportation environment. For example, software applications on mobile devices can help urban transit riders optimize their travel by showing arrival information for transit vehicles in real time. Transit providers in major metropolitan areas have used ITS technologies for years, but less is known about the extent of ITS use among transit providers in smaller towns and rural areas.

In this context, you asked us to review the use of ITS by transit providers in the U.S. We addressed the following questions:

1. To what extent are selected transit providers in large urban areas using ITS?
2. To what extent are transit providers in small urban and rural areas using ITS?

[1]American Public Transportation Association, *Public Transportation Ridership Report: Fourth Quarter & End-of-Year 2014* (March 2015).

3. What benefits and challenges are transit providers in large urban, small urban, and rural areas experiencing in deploying ITS?
4. How does DOT promote and support the use of ITS technologies, and to what extent do transit providers utilize these resources?

To determine the extent of ITS use among transit providers in large urban areas, we reviewed 2013 data on national ITS deployment from the Department of Transportation (DOT). On the basis of interviews with DOT officials and analysis of the 2013 ITS deployment data, we determined that the data were sufficiently reliable for our purposes. We conducted site visits to Pittsburgh, Pennsylvania; Portland and Eugene, Oregon; and Tampa and Orlando, Florida to observe transit ITS deployments. We selected these site visits based on criteria including geographic dispersion and recommendations by the ITS Joint Program Office (JPO) and Federal Transit Administration (FTA) officials and industry stakeholders. During these site visits, we obtained documentation and interviewed officials from public transit stakeholders including municipalities, academic researchers, state departments of transportation, and metropolitan planning organizations. We also conducted semi-structured interviews on the use of ITS with a judgmental sample of 31 transit providers serving large urban areas. We selected transit providers that were geographically dispersed across the country and represented the variety of transit modes offered in these areas. We cannot use the information obtained from these interviews to generalize to a broader population of transit providers. We separated the transit providers into two categories:

- medium urban: 13 providers serving urbanized areas with populations of 200,000–1 million, and
- large urban: 18 providers serving urbanized areas with populations of more than 1 million.

We also interviewed officials from related industry associations such as the American Public Transportation Association (APTA), Community Transportation Association of America (CTAA), and Intelligent Transportation Society of America (ITS America), and representatives from two ITS vendors and four independent ITS consultants. We selected the ITS vendors based on interviews with several transit providers in large urban areas who utilized their products, and the consultants based on a review of published transit ITS reports.

To determine the extent of ITS use among transit providers in small urban and rural areas, we conducted a generalizable, web-based survey of

transit providers serving small urban and rural areas from November to December 2015. We define small urban transit providers as organizations that provide public transit service primarily to urbanized areas of 50,000–199,999 people, and rural transit providers as organizations that primarily serve rural areas (i.e., non-urbanized areas with fewer than 50,000 people). Based on discussions with several industry associations and after conducting initial survey pretests with several transit providers, we limited our scope to the providers for which the topic of ITS use was likely most relevant. We therefore excluded rural providers that reported fleets of 10 or fewer vehicles to the FTA's National Transit Database (NTD) in reporting year 2013 from our sample frame.[2] We identified a sample frame of 896 small urban and rural transit providers using reporting year 2013 data from the NTD, and selected a stratified random sample of 312 of these providers for participation in the survey.[3] The sample is comprised of 146 recipients of Section 5307 FTA urbanized area formula grants and 166 sub-recipients of Section 5311 FTA non-urbanized area formula grants.[4] Approximately 75 percent of our sample—or 233 respondents— completed the survey. All estimates from the sample in this report have a margin of error, at the 95 percent confidence level, of plus or minus 10 percentage points or fewer, unless otherwise noted. The

[2]We also excluded Section 5311 FTA non-urbanized area formula grant sub-recipients that reported to the NTD as (1) urban recipients, because they are not strictly rural transit providers; (2) rural recipients reporting separately, to avoid double-counting providers; and (3) intercity bus providers, because intercity bus service is excluded from the definition of public transportation for purposes of the chapter in title 49 of the U.S. Code which pertains to public transportation. *See* 49 U.S.C. § 5302 (14).

[3]Congress established the National Transit Database (NTD) Program as a means to collect information and statistics on transit agencies in the United States. Under 49 U.S.C. § 5335, DOT is required to maintain the NTD and may award formula grants under section 5307 or 5311 of title 49 only if the applicant, and any person who will receive benefits from the grant, is subject to the reporting requirements. The 2013 NTD was the most current information available at the time we developed our survey.

[4]49 U.S.C. § 5307 and 49 U.S.C § 5311(a)(1) and (2). Sub-recipients of the Section 5311 formula grant program include state or local governmental authorities, nonprofit organizations, or operators of public transportation or intercity bus service that receive federal transit program grant funds indirectly through a recipient such as a state or Indian tribe that receives a federal transit program grant directly from the federal government.

survey questionnaire and a more comprehensive tabulation of the results can be viewed at GAO-16-639SP.[5]

To identify the benefits and challenges that transit providers in large urban, small urban, and rural areas are experiencing from deploying ITS, we interviewed JPO and FTA officials, industry associations, officials from public transit stakeholders in our site visits, and 31 transit providers in large urban areas; surveyed transit providers in small urban and rural areas; and reviewed published research on ITS. We analyzed the interviews, survey results, and published research to identify commonly cited benefits and challenges. To determine how DOT promotes and supports the use of ITS technologies, we interviewed officials from the JPO and FTA about the federal resources and assistance available to support deployment and how transit providers use these resources. We reviewed the JPO's program and strategic planning documents, including documents related to the ITS Professional Capacity Building Program. In addition, we reviewed the JPO's efforts to promote and support ITS technologies, including various studies, guidance, websites, and the JPO's ITS databases. We determined the extent to which transit providers are utilizing DOT's ITS resources by asking transit provider officials about their awareness and use of the training, technical assistance, or knowledge resources programs offered by the JPO, whether they had used these programs, and how helpful they had found them to be, in interviews and through the survey. In prior work, we and the National Academies' Transportation Research Board identified leading practices for successfully encouraging the adoption of new technologies.

We conducted this performance audit from March 2015 to June 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. Additional information about our scope and methodology is provided in appendix I.

[5]GAO, *Intelligent Transportation Systems: Survey of Small Urban and Rural Transit Providers, an E-supplement to* GAO-16-638, GAO-16-639SP (Washington, D.C.: June 21, 2016).

Background

Urban and Rural Transit

According to APTA, 6,800 organizations— ranging from large multi-modal systems in major metropolitan areas to single-vehicle special demand-response service providers that transport senior citizens and the disabled—provided public transportation in 2013.[6] While it is difficult to establish the exact dimensions of urban and rural transit service because transit providers headquartered in urban areas may also serve rural areas, urban transit providers primarily serve areas with populations of 50,000 or more.[7] Within this category, small urbanized areas are those with populations under 200,000, and include small cities, college towns, and vacation or resort areas, while large urbanized areas are those with 200,000 or more people, including the country's major metropolitan areas. The 834 agencies that serve urban areas accounted for more than 98 percent of all transit passenger trips in 2013, according to APTA.

Non-urbanized, or rural, areas have populations of fewer than 50,000 people.[8] In 2013, approximately 1,400 public transit agencies operated in rural areas, accounting for 1.5 percent of all passenger trips, according to APTA. Transit providers in rural areas operate in a variety of environments, serving areas that may span thousands of square miles in remote areas—meaning that trips may be long with only a few riders at any given time—or be located in more developed rural areas surrounding major cities. Compared to large urban systems, rural transit providers generally have low budgets, few employees, and small vehicle fleets. However, these transit systems provide vital mobility and connections to

[6]According to APTA, the majority of transit providers (4,583) providers are non-profit organizations that exclusively operate demand-response service, primarily for senior citizens and persons with disabilities. These providers carried less than half of 1 percent of all passenger trips in 2013.

[7]FTA bases urbanized area (UZA) designations on the most current Census. FTA Office of Budget and Policy, *NTD Policy Manual—2015 Report Year*. (Washington, D.C.: October 2015).

[8]The U.S. Census Bureau considers a densely populated area of 50,000 or more to be a UZA. The NTD refers to non-urbanized areas as rural areas or non-UZAs.

essential services for the approximately 75 million people who live in rural America.[9]

Transit providers serve the public through a variety of transportation modes.[10] In this report, we use the following descriptions of transportation modes:

- **Fixed-route bus service**: rubber-tired passenger vehicles that operate on fixed routes and schedules over roadways. Diesel, gasoline, battery, or alternative fuel engines power these vehicles. This category includes bus rapid transit, commuter bus, and trolley bus.
- **Paratransit**: accessible, origin-to-destination transportation service that operates in response to calls or requests from riders. It is an alternative to fixed-route transit service, which operates according to regular schedules along prescribed routes with designated stops.[11]
- **Demand-response (also referred to as dial-a-ride)**: vehicles that operate in response to calls or requests from passengers. Small buses, vans, or taxis to provide transportation service that is not on a fixed route or schedule. For example, transportation may be provided for individuals whose access may be limited or whose health condition prevents them from using the regular fixed-route bus service.
- **Commuter rail**: vehicles that operate along electric or diesel-propelled railways and provide train service for local, short distance trips between a central city and adjacent suburbs.
- **Heavy rail**: vehicles that operate on electric railways with high-volume traffic capacity. This mode has separated rights-of-way, sophisticated

[9]For more information on rural transit, see GAO, *Public Transportation: Federal Role Key to Rural and Tribal Transit*, GAO-14-589 (Washington, D.C.: June 24, 2014).

[10]Other less common transit modes include aerial tramway, automated guideway transit, cable car, commuter bus, ferryboat, hybrid rail, inclined plane, monorail, streetcar, transit vanpool, and trolleybus.

[11]Paratransit service is defined in Department of Transportation regulations as "comparable transportation service required by the Americans with Disabilities Act of 1990 for individuals with disabilities who are unable to use fixed route transportation systems." 49 C.F.R. § 37.3.

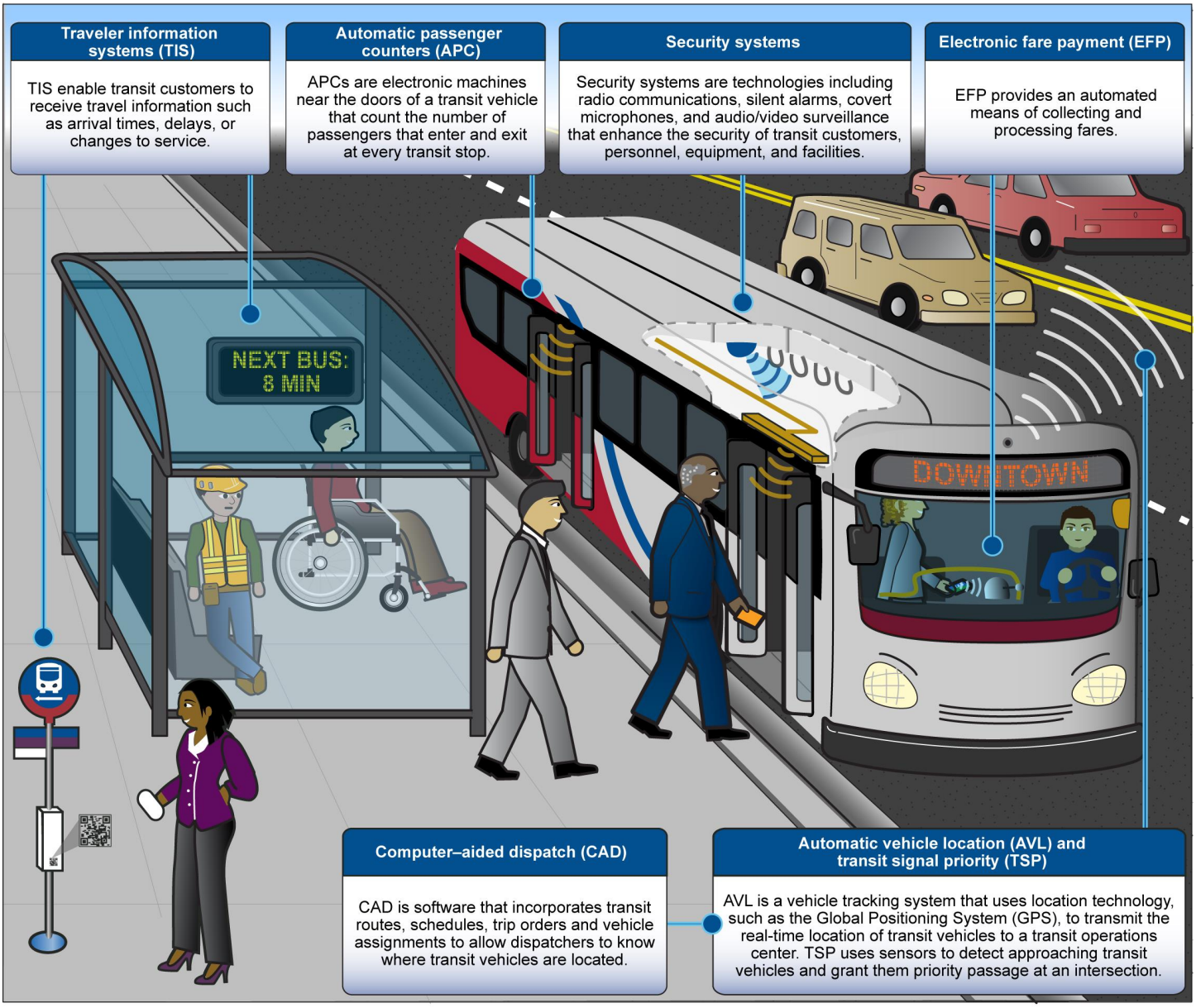
signaling, high platform loading and high-speed rapid-acceleration rail cars operating singly or in multi-car trains on fixed rails.

- **Light rail**: vehicles that operate on electric railways with light-volume traffic capacity. The mode may have either shared or exclusive rights-of-way, low or high platform loading, or single or double car trains.

Transit ITS

ITS encompasses a broad range of wireless and wire line communications-based information and electronic technologies, including technologies for collecting, processing, disseminating, or acting on information in real time to improve the operation and safety of the transportation system. DOT identifies 11 core technologies that are useful for public transit providers to deploy. Figure 1 illustrates how seven ITS technologies are used on a transit bus and how the public may interact with them when utilizing fixed-route bus service.

Figure 1: Use of Selected Transit ITS Technologies



Source: GAO analysis of Department of Transportation documents. | GAO-16-638

Other ITS technologies not depicted in figure 1 include:

- **Communication technologies**: technologies that pass information from one user to another in a useable form via wire, wireless, radio, the Internet, or other links to facilitate interaction among drivers, dispatchers, emergency responders, and other personnel.
- **Geographic information systems (GIS) & data management**: systems that manage and create spatial data such as location of bus stops, routes, transit facilities and the regional street network. The management, analysis, communication, and display of this information supports automatic vehicle location, automatic passenger counters, computer aided dispatch, and other technologies.
- **Maintenance management systems**: technologies that monitor everything from fuel and other fluid levels to engine temperature.
- **Weather information systems**: the hardware, software, and communications interfaces necessary to provide real-time information on weather conditions to transportation agencies and their customers.

Deployment of transit ITS may involve a variety of transportation stakeholders in the public and private sectors. Transit ITS technologies may be proprietary systems sold by technology firms in the private sector. Transit providers may also hire consulting firms to assist them in the ITS procurement and deployment process, including developing system requirements and the request for proposals from vendors. Further, the operation of certain ITS, such as a transit signal priority system, involves not only the transit provider but the municipality that owns and operates the traffic signal equipment. Smaller neighboring transit providers may also participate in an ITS deployment, such as a regional electronic fare collection system, spearheaded by a larger transit provider. Metropolitan planning organizations may serve a key role in planning ITS deployment, as they have responsibility for the regional transportation processes in urbanized areas.

Transit Funding for ITS

Transit providers may use FTA formula and discretionary grants, among other sources, for projects that include ITS deployments. They may also acquire ITS components such as security systems through funding provided by the Department of Homeland Security. Additionally, state and local governments may use their own funds to finance ITS projects. The primary formula grant programs that transit providers could use to fund ITS are (1) urbanized area grants, which provide funds to urban areas for capital projects, such as purchasing buses, planning, job access and

reverse commute projects, and operating and other expenses, and (2) rural area grants, which provide funds to states and tribal areas to be used for capital, operating, and other expenses to support public transportation in rural areas.[12]

The Fixing America's Surface Transportation (FAST) Act authorizes several competitive grant programs that recipients could use to fund transit ITS projects, including (1) the Advanced Transportation and Congestion Technologies Deployment Initiative, which provides grant funding for recipients to deploy a range of technologies, including transit ITS such as advanced traveler information systems and electronic pricing and payment systems,[13] and (2) the Pilot Program for Innovative Coordinated Access and Mobility, which funds innovative projects that improve the coordination of transportation services with non-emergency medical transportation services, and could include ITS projects.[14] Other FTA competitive funding programs that have been used, at least in part, for transit ITS include:

- *Veterans Transportation and Community Living Initiative (VTCLI)*: VTCLI has funded projects in urban, suburban, and rural communities to strengthen and promote "one-call" information centers and other tools that enable veterans, active service members, military families, and others to learn about and arrange for locally available transportation services that connect them with work, education, health care, and other vital services in their communities.[15]

[12]49 U.S.C. §§ 5307 and 5311.

[13]23 U.S.C. § 503(c).

[14]Pub. L. No. 114-94 (2015). For purposes of this report, we are referring to provisions in the Public Transportation Act of 2015, which was enacted as title III of the FAST Act, and the Transportation for Tomorrow Act of 2015, which was enacted as title VII of the FAST Act, as the FAST Act.

[15]49 U.S.C. § 5312. For example, the Jacksonville Transportation Authority received $50,000 in fiscal year 2012 to develop the Northeast Florida One-Call/One-Click Transportation Resource Center, which aimed to enable veterans to obtain immediate information to connect to transit services through a single call or visit to a web page. For additional discussion of VTCLI, see GAO, *Transportation Disadvantaged Populations: Nonemergency Medical Transportation Not Well Coordinated, and Additional Federal Leadership Needed*, GAO-15-110 (Washington, D.C.: December 10, 2014).

- *Mobility Services for All Americans (MSAA) Deployment Planning Projects*: DOT's MSAA initiative aims to improve transportation services and access to employment, healthcare, education, and other community activities through a coordinated effort enabled by various ITS technologies and applications.[16] MSAA funds are awarded to selected local and regional organizations to plan coordinated mobility services. Funded projects use ITS to coordinate deployment of on-demand public transportation systems, such as paratransit, for people with mobility issues. The grants help provide vital services for veterans, seniors, people with disabilities, and others who rely on community transportation providers to access everyday needs such as employment, medical care, and groceries.[17]

Transit providers often integrate ITS technologies into other capital purchases, like new buses; therefore, it is difficult to determine the total amount of FTA funds transit providers use solely for ITS. Although this does not represent total ITS spending, FTA officials estimated that the federal funds awarded for engineering, acquiring, constructing, rehabilitating/renovating, and/or leasing signal and communication equipment, surveillance/security systems, route signing, mobile fare collection equipment, vehicle locator systems, and signage (all of which, according to officials, would be considered ITS) totaled nearly $527 million in fiscal years 2012 through 2014.

Federal ITS Program

Congress established the federal ITS program in the Intelligent Vehicle-Highway Systems Act of 1991, which was enacted as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) to research, develop, and operationally test ITS technologies and promote their implementation.[18] More recently, the FAST Act authorized $100 million annually for the federal ITS program for fiscal years 2016 through

[16]According to DOT, the MSAA ITS initiative is related to the United We Ride national campaign that implements the Executive Order on Human Service Transportation Coordination issued by President Bush in February 2004. Exec. Order No. 13330, Human Service Transportation Coordination, 69 Fed. Reg. 9185 (Feb. 26, 2004).

[17]For example, Ride-On Transportation of San Luis Obispo, CA, received $141,725 towards the San Luis Obispo County Travel Management Coordination Center, which plans to use innovative technologies to link databases and services in real time, enabling customers to enjoy more integrated service from the county's transportation providers.

[18]Pub. L. No. 102-240 title VI, part B, § 6051, 105 Stat. 1914, 2189 (1991).

2020, the same levels the previous surface transportation authorization—Moving Ahead for Progress in the 21st Century (MAP-21)—authorized for fiscal years 2013 and 2014.[19] Within the Office of the Assistant Secretary for Research and Technology, the JPO coordinates the federal ITS program and initiatives in consultation with other surface transportation modal administrations across DOT, including the Federal Highway Administration, Federal Motor Carrier Safety Administration, Federal Railroad Administration, FTA, Maritime Administration, and the National Highway Traffic Safety Administration. The JPO supports the overall advancement of ITS through investments in major research initiatives, such as research on advanced connected vehicle and automation technologies, exploratory studies, and a deployment support program that includes technology transfer and training.[20]

Selected Urban Transit Providers Reported Using Most Types of ITS, and Some Reported Using More Advanced Technologies

DOT's 2013 Survey Found Broad Deployment of ITS in Major Metropolitan Areas

DOT has reported that transit providers located in major U.S. cities have deployed a majority of the core transit ITS technologies described above. To determine the extent to which ITS technologies have been deployed, DOT conducts a survey on a regular basis that measures ITS deployment by state and local transportation agencies—including transit providers.[21]

[19]Pub. L. No. 112-141 § 51001, 126 Stat. 405, 864 (2012).

[20]For a discussion of connected vehicle technologies, see GAO, *Intelligent Transportation Systems: Vehicle-to-Vehicle Technologies Expected to Offer Safety Benefits, but a Variety of Deployment Challenges Exist*, GAO-14-13 (Washington, D.C.: November 1, 2013). See also GAO, *Intelligent Transportation Systems: Vehicle-to-Infrastructure Technologies Expected to Offer Benefits, but Deployment Challenges Exist*, GAO-15-775 (Washington, D.C.: September 15, 2015).

[21]DOT has conducted this survey since 1997.

The results of DOT's most recent survey from 2013 indicated that 142 transit providers had deployed many of the core transit ITS technologies across several types of transit vehicles, including buses (see table 1).[22] The survey also showed that these transit providers had deployed traveler information systems—using technologies such as websites, mobile applications, and electronic message signs at transit stops and stations—to provide customers with information on routes, schedules, fares, and real-time information on vehicle arrival and departure times.[23] Transit providers also reported on planned ITS deployment between 2013 and 2016, and the survey found that future deployment focused on computer-aided dispatch, automatic vehicle location, traveler information systems to provide transit information in real time, and improvements to electronic fare payment systems.

[22]In 2013, nearly 2,100 surveys were distributed to state and local transportation agencies in the country's largest cities. Agencies included were involved in freeway management, arterial management, transit management, transportation management centers, electronic toll collection, and public safety. The DOT sent the deployment survey to 221 transit service providers and received responses from 142, achieving a response rate of 64 percent. The survey provides information on the extent of deployment by these providers across the following types of transit vehicles: bus, rail, paratransit, demand-response, and ferry boat. In this report, we include results on the extent to which transit providers have deployed ITS on their bus service because this is the most prevalent mode reported by survey respondents (87 percent). The survey did not provide deployment information on two ITS technologies included in our review—GIS and weather information systems. For the complete 2013 survey results, see http://www.itsdeployment.its.dot.gov/.

[23]The 2013 ITS deployment survey did not provide information on the extent of deployment of traveler information technologies by mode of service.

Table 1: 2013 Results of DOT's ITS Deployment Survey for Bus Transit Providers

ITS technology	Percentage of bus providers deploying technology
Safety and security systems (audio or video surveillance)	80
Automatic vehicle location	73
Automatic passenger counters	54
Electronic fare payment methods:	
• Magnetic stripe cards	54
• Smart cards	34
Computer-aided dispatch	40
Maintenance management systems	40
Transit signal priority	30

Source: DOT. | GAO-16-638

Note: DOT collected deployment surveys from 124 transit providers that responded that they operated bus vehicles.

Selected Urban Transit Providers Reported Deploying the Majority of ITS Technologies, Mainly on Bus Services

Similar to the JPO's 2013 survey results, the 31 large and medium urban transit providers we interviewed told us they had deployed most of the ITS technologies in our review. As shown in table 2, officials from the large and medium urban transit providers we interviewed reported deploying 9 of the 11 ITS technologies in our review, but medium urban transit providers reported deploying some of these to a slightly lesser extent.[24] Only three of the selected large and medium urban transit providers had deployed a weather information system, which as described above, consists of equipment such as pavement and water-level sensors to monitor weather conditions.[25] The large and medium urban transit providers we interviewed generally told us that they had deployed most of the technologies across several modes of service to some extent, but primarily on their bus services. Exceptions were traveler information systems, which the majority reported using across all modes of services, and GIS, which they used in concert with their computer-

[24]We did not ask large and medium urban transit providers about communication technologies because these technologies are commonplace in large urbanized areas.

[25]We did not receive information on weather information systems from 6 of the 31 large and medium urban transit providers in our review.

aided dispatch and automatic vehicle location systems and for transit planning, and which can be applied across all modes of service.[26]

While officials across the selected transit providers reported deploying these technologies, we found there was variation by provider in the specific features and types of technologies deployed. Specifically, there was variation among providers in both the type of traveler information—such as real-time information on vehicles' schedule adherence versus static information on routes, schedules, and fares—and the ways in which the information was provided, such as through websites, text messages, and electronic message signs at transit stops. We found another example in security systems, where, depending on the provider, different components were deployed, such as on-vehicle cameras, audio surveillance, and silent alarms. There were also differences in the length of time the large and medium urban transit providers had deployed certain ITS technologies. For example, officials from 13 of the 18 large urban transit providers told us that they had deployed automatic vehicle location and computer-aided dispatch technologies prior to 2010, and 6 transit providers said that they are currently updating or have updated these technologies at least once since then. Officials from 7 of the 13 medium urban transit providers said they were in the process of deploying or had deployed these technologies in or after 2010.[27]

Table 2: ITS Deployment by Selected Large and Medium Urban Transit Providers

ITS technology	Total number of large/medium urban providers equipped (of 31)[a]	Number of large urban providers equipped (of 18)	Number of medium urban providers equipped (of 13)
Automatic passenger counters	25	18	7
Automatic vehicle location	31	18	13
Computer-aided dispatch	31	18	13
Electronic fare payment[b]	27	17	10

[26]The number and kinds of modes of services offered by the transit providers in our review varied.

[27]We did not obtain information from six transit providers on when they acquired automatic vehicle location and computer-aided dispatch technologies.

ITS technology	Total number of large/medium urban providers equipped (of 31)[a]	Number of large urban providers equipped (of 18)	Number of medium urban providers equipped (of 13)
Geographic information systems	27	17	10[c]
Maintenance management systems	23	15	8[d]
Security systems	31	18	13
Transit signal priority	18	14	4[e]
Traveler information systems	31	18	13

Source: GAO. | GAO-16-638

[a]We included transit providers that told us they had deployed or were currently deploying a technology.

[b]For this report, we considered electronic fare payment deployment to include magnetic stripe cards, smart cards, or mobile fare payment.

[c]We did not obtain information from two transit providers about whether they had deployed geographic information systems.

[d]We did not obtain information from one transit provider about whether it had deployed a maintenance management system.

[e]We included only 12 medium urban transit providers in our review of transit signal priority because of the transit providers we selected and interviewed only one operated ferries and transit signal priority is not used by ferry operators.

Although a majority of the large and medium urban transit providers reported that they had deployed transit signal priority, the extent to which they used this technology varied by provider. For example, most of the transit providers that reported using transit signal priority told us they did so in a limited manner, such as along one or two major corridors in their transit system, or on their bus rapid transit service.[28] We previously found that transit signal priority is the most common ITS technology included in bus rapid transit projects.[29] While 18 large and medium urban transit providers reported using transit signal priority, if only to a limited extent, officials from six of these transit providers told us they had plans to expand or would like to expand its use. Officials from three of the medium urban transit providers who were not using transit signal priority told us

[28]Bus rapid transit service is a type of bus service in which transit providers have added enhancements, such as building dedicated bus lanes and enabling pre-paid off-board fares, to replicate features found in rail transit, which may help reduce bus travel times.

[29]GAO, *Bus Rapid Transit: Projects Improve Transit Service and Can Contribute to Economic Development*, GAO-12-811 (Washington, D.C.: July 25, 2012).

that the technology was being considered in their plans for proposed bus rapid transit projects.

Large and Medium Urban Transit Providers Are Sharing ITS Data

Transit providers are now making some of the data collected from their ITS technologies, such as GIS, computer-aided dispatch, automatic vehicle location, and automatic passenger counters, available to the public, a concept which is known as “open data.” A 2015 Transit Cooperative Research Program (TCRP) study on open data found an increasing number of transit providers have begun making their schedule and real-time operational data available to the public since 2010. Open data has resulted in numerous benefits and innovations that could not have been accomplished solely by transit staff, such as the proliferation of mobile phone applications developed by outside entities that provide passengers with access to transit information.[30] Officials from 22 of the 31 large and medium urban transit providers we interviewed told us that they had made data from their ITS technologies open to the public, and officials from the majority of these providers said that outside software developers had used or hoped to use this data to create mobile applications for their passengers. Officials from three of the large and medium urban transit providers reported that having external entities develop mobile applications reduced costs and saved staff time.

To make ITS data available to the public or other users, transit providers must use a data standard that allows users to open and read the information contained. According to the literature, General Transit Feed Specification (GTFS) is the standard adopted by most transit providers

[30]Transit Cooperative Research Program, *Open Data: Challenges and Opportunities for Transit Agencies, A Synthesis of Transit Practice*, TCRP Synthesis 115 (Washington, D.C.: 2015). The study reported that open data benefits transit providers in additional ways, such as improved perception, visibility, and customer satisfaction. The TCRP study surveyed 67 transit providers about their open data practices and found that almost 83 percent of those providers had made their data open and about half began using open data in the 2010–2012 timeframe. The survey was sent to 67 agencies, including 3 Canadian and 14 European transit providers, and had a 100 percent response rate.

and enables them to share static schedule information.[31] Officials from 28 of the 31 large and medium urban transit providers reported using GTFS, while 12 of the 31 large and medium urban transit providers reporting using GTFS-realtime, which allows transit providers to format real-time vehicle information and service alterations. Several of the large and medium urban transit providers told us they use GTFS because it allows them to publish their data into Google transit maps. Two of the transit providers we interviewed told us that while they have not made their data open to the public, they have formatted their data into GTFS to allow it to be used for Google transit maps.

In addition to sharing data with the public, the large and medium urban transit providers in our review reported that they share data with regional transportation stakeholders to support multimodal planning and management. For example, officials from one of the large urban transit providers we interviewed told us they shared their data with local university researchers who received funding through the local metropolitan planning organization to archive regional transportation data, including transit and highway performance data. According to these officials, these data have been used for research and regional transportation planning. According to DOT, an Integrated Corridor Management (ICM) approach, where transportation agencies operate transportation corridors in a coordinated and integrated manner, can include providing multimodal traveler information en-route in addition to pre-trip information as travel conditions change. Officials from a large urban transit provider that is using ICM along a major road corridor told us that having integrated data on real-time traffic conditions, transit, and parking availability has enabled travelers to make better travel decisions and reduces congestion on roadways.

[31]GTFS is one of the more commonly used formats because of its relative ease of use by transit providers. Other examples include the Service Interface for Real Time Information (SIRI), which includes a component for schedule data, but is designed for real-time information; the Transit Communications Interface Profiles (TCIP), which is an APTA standard that includes components for passenger information and scheduling and other business divisions in transit; and NextBus, which delivers real-time arrival information.

Large and Medium Urban Transit Providers Reported Using Advanced Technologies

As we have described above, the large and medium urban transit providers are deploying the majority of the core transit ITS technologies in our review; however, some of the transit providers described using more innovative types or features of these technologies. Many of the ITS technologies in our review represent a range of systems or components from which a transit provider can select different options, depending on needs and desired uses, and some of these options are more sophisticated than others. For example, there are various types of electronic fare payment systems available to transit providers. Some types, such as mobile phone payment applications, are considered more advanced than others, including magnetic stripe cards. Transit providers may also select different fare systems, including closed systems, which use smart cards that store cash value and can only be used within that transit system or on other transit systems that accept that smart card, or a more advanced open system, which accepts numerous payment types, such as credit or debit cards, issued by other organizations. For technologies such as computer-aided dispatch, maintenance management systems, and security systems, transit providers can choose from a variety of offered features, some of which may be considered more advanced than others. In addition, according to DOT, the proliferation of mobile devices and real-time information has led to a shift over the past several years in the way transit providers can disseminate traveler information to their existing and potential passengers.[32] For example, new opportunities have emerged for transit providers to offer mobile ticketing and mobile applications for passengers to retrieve real-time transit information, conduct trip planning, and make transit reservations (see fig. 2). Below are examples of some of the more advanced types and features of ITS technologies.

- *Smart card electronic fare payment*: Officials from 15 of the 18 large urban transit providers and 4 of the 13 medium urban transit providers we interviewed told us that they have deployed a smart card electronic fare payment system. Four large urban transit providers have deployed an open payment system.

[32]DOT, ITS Joint Program Office, *Intelligent Transportation Systems Benefits, Costs, and Lessons Learned: 2014 Update Report*, FHWA-JPO-14-159 (Washington, D.C.: June 2014).

- *Predictive and real-time maintenance management systems*: Officials from six large urban transit providers and one medium urban transit provider told us they have deployed maintenance management systems that can transmit maintenance information to the provider in real time or make predictions when vehicle parts may fail.
- *Traveler information and mobile fare payment smartphone applications*: Many of the large and medium urban transit providers we interviewed have made smartphone applications available to their passengers. These applications can provide traveler information or the ability to pay fares electronically. Specifically, 15 of the 18 large urban transit providers and 4 of the 13 medium urban transit providers we interviewed said they have deployed smartphone applications that provide passengers real-time transit information. Officials from one of the large urban transit providers told us that they were about to deploy a smartphone application that allows passengers to make ride requests, instead of calling a dispatcher, on their demand-response service that connects residents living in less-populated areas to transit. Additionally, officials from five large urban transit providers and two medium urban transit providers told us they have deployed mobile ticketing, and two of these providers told us they were using or were developing a smartphone application that used mobile ticketing in creative ways. These capabilities included providing passengers with the ability to purchase mobile tickets for transit and special events, such as tickets to the state fair or local zoo, and linking mobile ticketing to private ride-hailing companies to help passengers reach destinations that are outside the transit service area.

Figure 2: Different Uses of Smartphone Applications

Source: GAO analysis of interviews with transit providers regarding smart phone applications. | GAO-16-638

There are several factors beyond the size of the transit provider and population served that may contribute to a transit provider's decision to adopt more advanced technologies. We found several examples from literature and our interviews of transit providers located in smaller areas deploying advanced ITS technologies. The JPO has reported that there are a number of factors that influence ITS adoption across transportation agencies, including:

- agency characteristics, such as their risk tolerance, level of knowledge and expertise, and adoption rate of peer agencies;
- external environmental characteristics, such as agency budgets, funding opportunities, agency priorities, and presence of a technology champion; and

- the characteristics of the transportation user, such as public acceptance and attitudes toward proposed technologies.[33]

We found examples of advanced ITS adoption among small urban and rural transit providers in some of the studies that we reviewed and from stakeholder interviews. For example, a 2015 Transit Cooperative Research Program report on next generation electronic fare payment systems highlighted the experiences of one small urban transit provider's upgrade to smart card-enabled electronic fare payment.[34] Officials from one of the industry associations we interviewed told us that smaller transit providers may receive and use grants to invest in more innovative technologies. For example, FTA officials provided us with examples of how transit providers are using MSAA and VTCLI grants to deploy ITS technologies in innovative ways to help improve human service transportation in rural areas. An official from another industry association told us that smaller transit providers located in niche communities, such as cities where universities or vacation destinations are located and communities that border metropolitan cities, are using more innovative ITS technologies. These communities have riders that have certain expectations of and are more reliant on transit and these factors drive providers to adopt advanced technologies.

[33]DOT, ITS Joint Program Office, *Review of Existing Literature and Deployment Tracking Surveys: Decision Factors Influencing ITS Adoption*, FHWA-JPO-12-043 (Washington, D.C.: April 2012). The JPO reported that the characteristics of the technology may also influence ITS technology adoption, including price of technology, technology readiness, demonstrable benefits, and compatibility. Many of these factors are discussed later in this review as challenges to ITS deployment.

[34]Transit Cooperative Research Program, *Preliminary Strategic Analysis of Next Generation Fare Payment Systems for Public Transportation*, TCRP Report 177 (Washington, D.C.: 2015).

Small Urban and Rural Providers Are Primarily Using Four ITS Technologies, and Use of Other ITS Is Limited

We surveyed a stratified random sample of 312 small urban and rural transit providers to learn about the extent of their use of ITS technologies.[35] This sample is generalizable to a target population of 314 Section 5307 recipients serving small urbanized areas and 582 Section 5311 sub-recipients serving non-urbanized (rural) areas that reported to the FTA's National Transit Database in reporting year 2013.[36] We refer to this target population as "small urban and rural transit providers."

Roughly Three-Quarters of Small Urban and Rural Transit Providers Are Using Security Systems

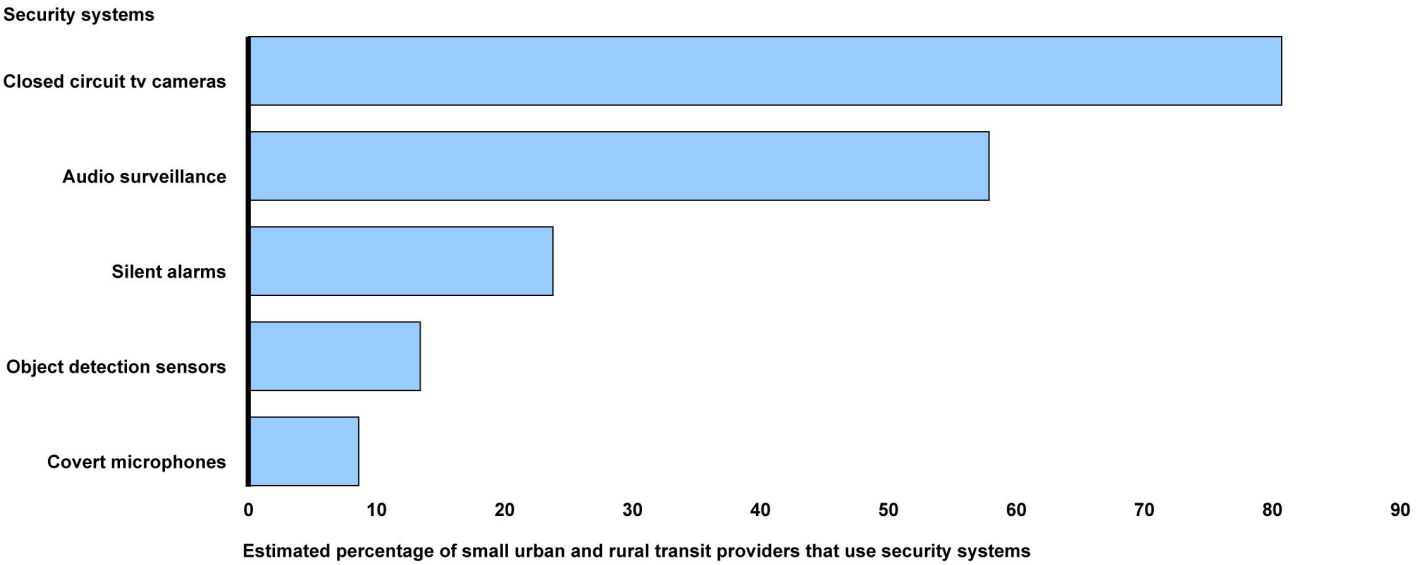
We estimate that nearly 75 percent of small urban and rural transit providers use ITS through the deployment of security systems. Of those providers, approximately 81 percent are using closed circuit TV cameras and 58 percent are using audio surveillance; other less-common systems include silent alarms, object detection sensors, and covert microphones (see fig. 3).[37] Further, we estimate that of those transit providers that are using this technology, about 69 percent of small urban and rural providers use security systems on their bus fleet, and approximately 72 percent use this technology on demand-response vehicles. According to the JPO, urban and rural public transportation systems can benefit from the implementation of security systems because they can be used to monitor the safety and security of passengers, employees, equipment, and materials.

[35]The survey questionnaire specifies transit provider "use" of ITS rather than "deployment" because pretests indicated that small urban and rural transit providers may be using ITS technologies that were actually deployed regionally by a larger entity.

[36]The sample frame for our survey excludes 728 Section 5311 sub-recipients who reported 10 or fewer vehicles in their fleet to the National Transit Database in reporting year 2013.

[37]Covert microphones operate as one-way communications in order not to alert a person responsible for an incident that the dispatch and/or police are listening in.

Figure 3: Types of Security Systems Used by Small Urban and Rural Transit Providers



Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level.

About Half of Small Urban and Rural Providers Are Using Computer-Aided Dispatch, Automatic Vehicle Location, and GIS

Small urban and rural transit providers are also using other ITS technologies. Based on the survey results, we estimate that about half of small urban and rural providers are using computer-aided dispatch, automatic vehicle location, and GIS. Approximately 55 percent of small urban and rural providers are using computer-aided dispatch software. According to a 2010 North Dakota State University study on technology adoption by small urban and rural transit providers, computer-aided dispatch packages are a core component of rural transit technology systems, and may provide record-keeping and billing capabilities, improve the accuracy of reservations, and give transit providers the ability to provide real-time customer information.[38]

[38]North Dakota State University, Upper Great Plains Transportation Institute, Small Urban & Rural Transit Center, *Technology Adoption by Small Urban and Rural Transit Agencies*, (Fargo, North Dakota: June 2010).

Further, we estimate that approximately 51 percent of the target population is using automatic vehicle location technology. By providing the real-time position of transit vehicles to a central location, this technology can enable transit dispatchers to increase the average number of rider pick-ups per hour.[39] Additionally, approximately 47 percent of small urban and rural providers reported using a GIS system. According to a DOT report on rural ITS, although GIS is assumed to be a component in urban ITS deployment, it can be a significant stand-alone technology for rural transit agencies.[40] The report states that GIS applications have given smaller operators new tools for improving service planning and operations and may provide the basis for additional deployment, such as automatic vehicle location and computer-aided dispatch.

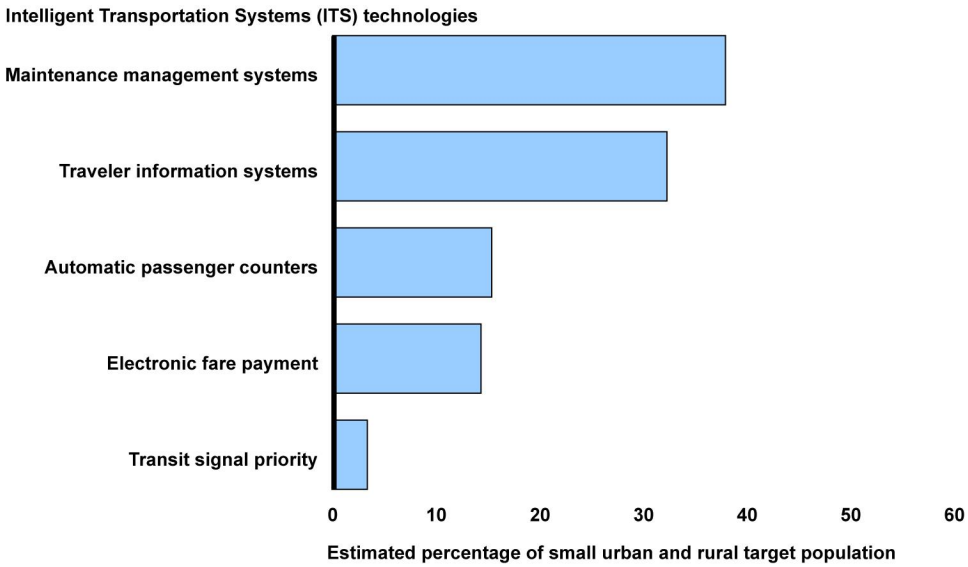
Most Small Urban and Rural Transit Providers Are Not Using Other ITS Technologies, Primarily because of Technology Costs or Perceived Lack of Need

Although about half of small urban and rural transit providers reported using the three aforementioned technologies, based on our survey results, we estimate that most small urban and rural transit providers are not using each of five other technologies in our review: maintenance management systems, traveler information systems, automatic passenger counters, electronic fare payment, and transit signal priority. Estimated use of these five technologies is illustrated in figure 4.

[39]Federal Transit Administration, *Technology in Rural Transit: Linking People with Their Community*, FTA-MA-99-0356-01-1 (Washington, D.C.: January 2002).

[40]DOT, ITS Joint Program Office, *Rural Transit ITS Best Practices*, FHWA-OP-03-77 (Washington, D.C.: March 2003).

Figure 4: Small Urban and Rural Transit Provider Use of Five ITS Technologies



Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level.

In some cases, small urban providers are using technologies that we did not find widely deployed by rural providers. For example, according to our survey, approximately 50 percent of small urban providers are using a variety of means to provide traveler information (see table 3).

Table 3: Top Five Types of Traveler Information Used by Small Urban Transit Providers

Types of Traveler Information	Description	Estimated percentage using each type of traveler information
Static service information	Non-dynamic information on transit routes, schedules, and fares.	82
Real-time transit vehicle location and/or arrival time	Information on transit vehicle location, such as when the next vehicles will arrive at a stop or station.	60
Trip planners	Trip planners use vehicle location systems (e.g., AVL-GPS), GIS, and scheduling software accessible via an agency's website to provide interactive maps, routes, and other trip-planning tools.	58
Text messaging/e-mail	Use of text messages or email by transit providers to communicate static or dynamic information.	56
Audible annunciators	Digitally-recorded audio announcements to onboard riders and those waiting to board a fixed-route vehicle.	49

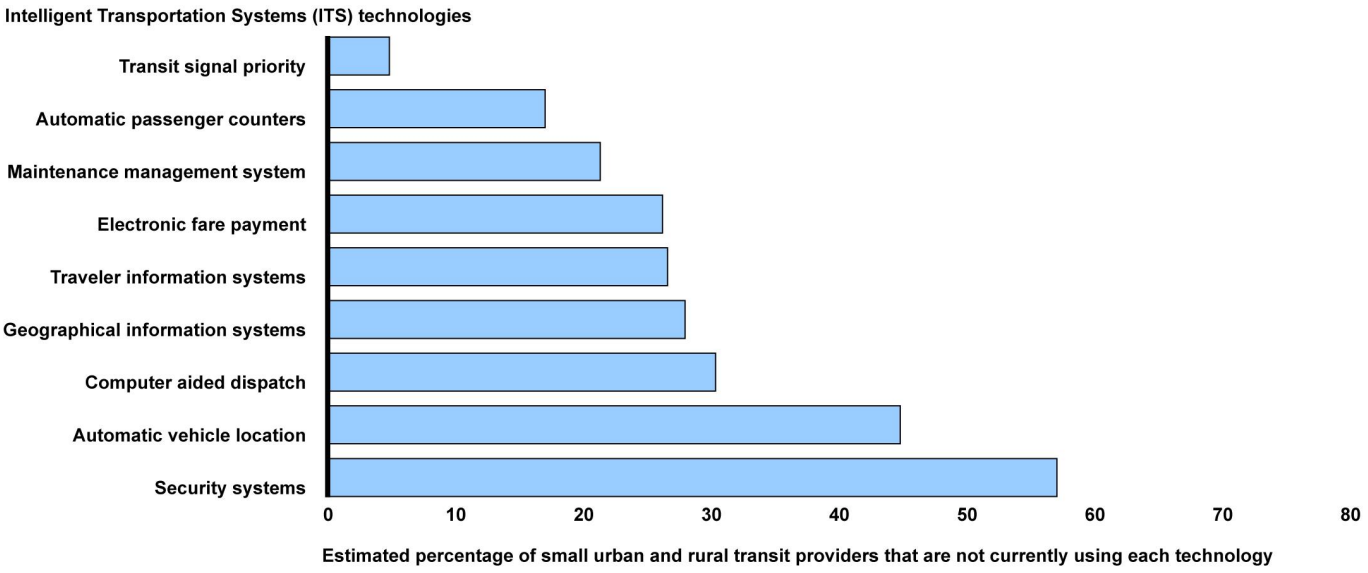
Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Percentages listed are of the 57 small urban providers that reported using any traveler information systems.

We estimate that about half or more of small urban and rural providers that are not using traveler information systems, automatic passenger counters, electronic fare payment, and maintenance management systems reported the cost of the technology as the reason they are not using that technology. Additionally, most of the small urban and rural transit providers that are not using transit signal priority indicated that they do not perceive a need for this technology in their operations. In open-ended responses to the survey, some small urban and rural transit providers offered other reasons they were not currently using ITS. For example, five providers reported they are not using a maintenance management system because they contract out their maintenance services; four providers said that they do not use automatic passenger counters because they either provide only demand-response service, or they manually count passengers; and finally, four providers reported that they do not use electronic fare payment because they do not charge a fare for their transportation services.

Small urban and rural providers reported that their plans to deploy ITS in the future focus on security systems and automatic vehicle location. For each of the nine technologies, our survey asked transit providers that indicated they were not using the technology if they had plans to deploy it in the next five years (see fig. 5).

Figure 5: ITS Technologies That Small Urban and Rural Transit Providers Plan to Deploy within 5 Years



Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level, with the exception of estimates for security systems, which have a margin of error of plus or minus 11.85 percentage points.

Transit Providers Reported Five Key Benefits from ITS, but Benefits Are Difficult to Measure and Deployment Challenges Exist

Transit Providers Reported Five Primary Benefits from ITS Deployment

Each ITS technology a transit provider deploys may provide a unique set of benefits, and DOT has reported on some of these benefits based on the results of its regular ITS deployment survey and in evaluations of ITS benefit studies from the JPO's Knowledge Resources Databases. For

example, DOT's 2013 ITS deployment survey showed that transit providers rated communication technologies, automatic vehicle location, and security cameras as having provided them with the highest benefits.[41] Also, in DOT's 2014 updated report on information on the benefits, costs, and lessons learned regarding ITS deployment studies, the agency reported findings that transit providers experienced improvements in operations and fleet management, such as achieving improved service reliability through computer-aided dispatch, decreased transit travel times through the use of transit signal priority, and increased ridership from using traveler information systems.[42] We asked the large and medium urban transit providers in our review to describe the types of benefits their ITS has collectively generated.[43] Transit providers we interviewed identified benefits from ITS broadly related to improvements in administration, operations, and customer satisfaction. Below are descriptions and examples of the five main types of benefits reported by the majority of the large and medium urban transit providers we interviewed.

Improvements in on-time performance and schedule adherence: Officials from 25 of the 31 large and medium urban transit providers said that data from their ITS technologies—such as automatic passenger counters, automatic vehicle location, and computer-aided dispatch—have improved or were expected to improve the extent to which service remains on schedule, which has improved their on-time performance. For example, officials from 7 of these providers told us computer-aided dispatch and automatic vehicle location enable them to monitor service in real time and

[41]DOT, ITS Joint Program Office, *Deployment of Intelligent Transportation Systems: A Summary of the 2013 National Survey Results*, FHWA-JPO-14-146 (Washington, D.C.: August 2014).

[42]DOT, ITS Joint Program Office, *Intelligent Transportation Systems Benefits, Costs, and Lessons Learned: 2014 Update Report*, FHWA-JPO-14-159 (Washington, D.C.: June 2014).

[43]We asked the 31 large and medium urban transit providers we interviewed about specific types of ITS benefits, including cost savings, greater staffing efficiencies, improvements in record-keeping and/or reporting, increased customer satisfaction, increased operator satisfaction, increased ridership, increased safety, reduced travel times, and reduced wait times. We also asked them to provide any other types of benefits that they had experienced and we analyzed their responses. We aggregated the total number of large and medium urban transit providers that told us they experienced these and other benefits reported during interviews.

react to situations that might create service delays—such as traffic, accidents, or vehicle breakdowns—by holding buses or creating route detours. Further, officials from 4 of the large and medium urban transit providers said they have used information from these technologies to change schedules to better reflect actual arrival and departure times, which has improved their on-time performance.

Enhanced safety: Officials from 24 of the 31 large and medium urban transit providers we interviewed told us that ITS technologies—such as automatic vehicle location, computer-aided dispatch, and various elements of their security systems—have improved the safety of their passengers and operators by helping them prevent, manage, and review incidents, such as criminal behavior and accidents. For example, officials from 3 of these transit providers told us that automatic vehicle location and computer-aided dispatch have reduced the number of accidents by automating some of the driver's tasks, including providing drivers with turn-by-turn directions and automating bus stop announcements, and eliminating some of their distractions. Also, officials from 7 of the large and medium urban transit providers told us that audio and video surveillance technologies have enabled their organizations and emergency responders to monitor and better respond to incidents.

More efficient scheduling and routing: Officials from 24 of the 31 large and medium urban transit providers told us that data from their ITS technologies—such as automatic passenger counters, automatic vehicle location, computer-aided dispatch, and electronic fare payment systems—have enabled them to make improvements to their transit service. For example, officials from 16 of the transit providers experiencing this benefit told us these technologies provide them with more precise information, such as passenger travel behavior and traffic congestion. This information enables them to make data-driven decisions about service—such as routes, schedules, and bus stop locations—that make travel more efficient. Some of these officials told us that prior to these systems, agencies made service changes based on customer complaints and on-site observations, which was less efficient, required more resources, and was less accurate.

Improvements in reporting and record-keeping: Officials from 21 of the 31 urban transit providers told us that ITS technologies including automatic passenger counters, automatic vehicle location, computer-aided dispatch, and maintenance management systems have improved their ability to document and report new or more accurate data. For example, officials from 11 of these providers said that they are now able to collect additional

and more accurate statistics, such as on their on-time performance, number of bus passengers by stop, and vehicle health and parts inventory. In addition, officials from 7 of the large and medium urban transit providers we interviewed told us that these technologies have made it easier to collect and report data on transit service to their governing boards and to meet federal reporting requirements. For example, 3 of the large and medium urban transit providers told us that they are able to use ITS technologies to automatically collect information such as number of passengers rather than sending staff out to collect this information.

Increased customer satisfaction: Officials from 17 of the 31 large and medium urban transit providers told us that ITS technologies, especially traveler information systems, have improved customer satisfaction. For example, officials from 10 of these transit providers attributed this increase in customer satisfaction to their expanded use of traveler information systems, which have enabled them to provide their customers with improved ability to access travel information, through such venues as websites, mobile phone applications, and electronic signs at transit stops. Additionally, 3 of the large and medium urban transit providers told us that customer satisfaction has improved with the deployment of electronic fare payment options. For example, officials from 1 provider told us that they believe that some of their customers want to be able to make all of their transactions using smartphones.

According to our survey results, small urban and rural transit providers rated the same top five benefits from using ITS as the 31 large and medium urban transit providers we interviewed (see table 4). In order to reduce the respondent burden and due to potential difficulties isolating the impacts of individual ITS technologies, our survey asked small urban and rural transit providers to report on the great or slight benefits of their collective ITS technologies. We are therefore unable to attribute the benefits they reported to individual technologies.

Table 4: Top Five ITS Benefits Reported by Small Urban and Rural Transit Providers

ITS Benefit[a]	Estimated percentage of small urban and rural transit providers that identified a great or slight benefit[b]
Improvements in record-keeping, reporting, and data analysis	70
Enhanced safety	66
More efficient scheduling and routing	66
Improvements in on-time performance and schedule adherence	59
Increased customer satisfaction	58

Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level.

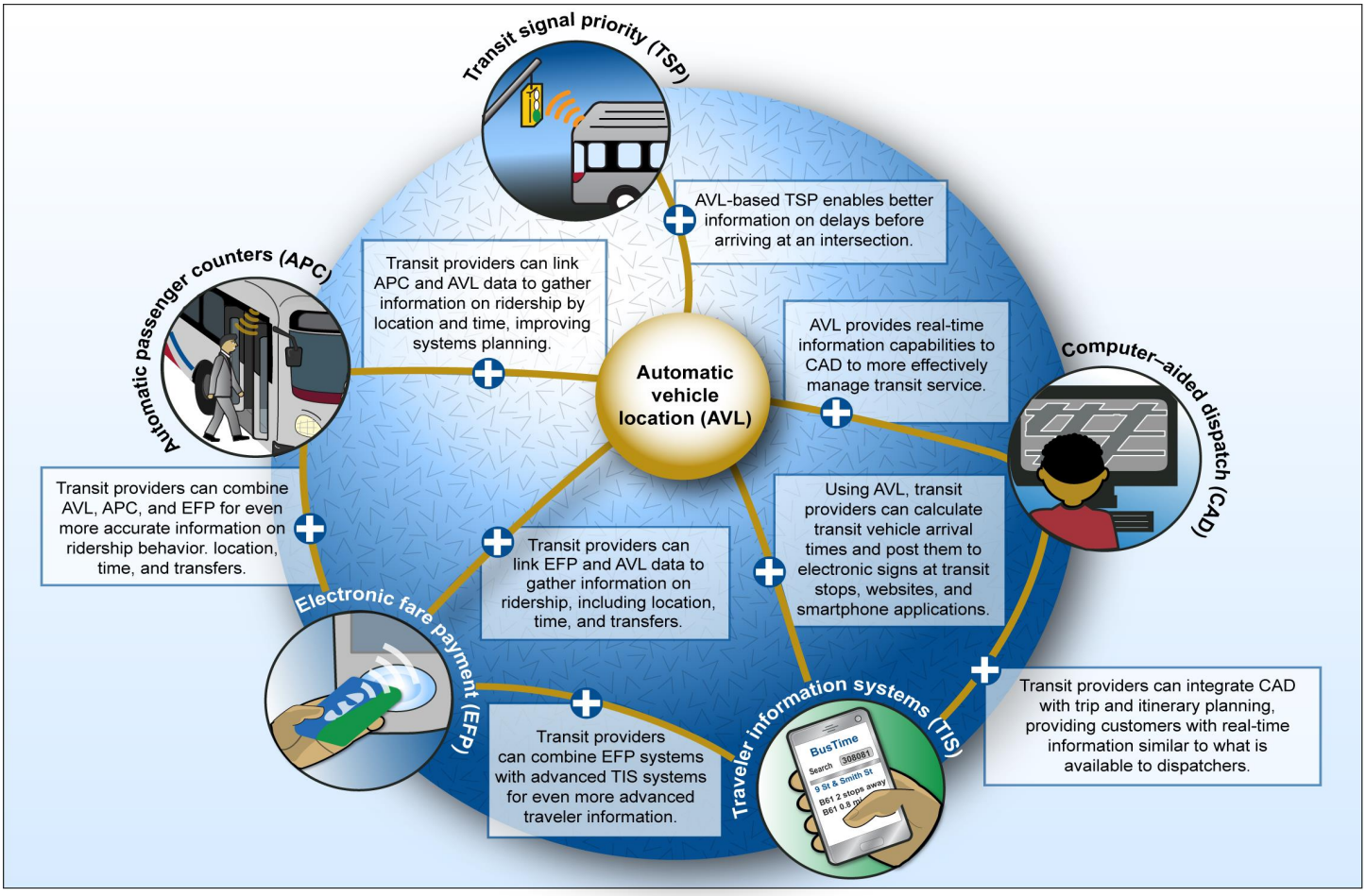
[a]Other benefits reported by small urban and rural transit providers include increased operator satisfaction, reduced wait times, cost savings, increased ridership, more efficient staffing, and reduced travel times.

[b]Survey respondents also had the opportunity to select 'No benefit,' 'Too soon to tell,' or 'Not applicable.'

We also found from our interviews that the 31 large and medium urban transit providers achieved other types of benefits to a lesser extent, such as cost savings, increased operator satisfaction, increased ridership, greater staffing efficiencies, and reduced travel and wait times. Officials from the selected large and medium urban transit providers also described other types of benefits they have experienced from ITS technologies, such as enhanced communication capabilities between dispatchers and drivers, improved marketing, and the ability to keep drivers more accountable. For example, officials from one large urban transit provider told us they were able to use data from their electronic fare payment system to measure the impact that a recent marketing promotion had on ridership, and officials from another large urban transit provider told us they have used their adoption of some ITS technologies in their marketing campaigns to improve their image and attract new customers. In addition, transit providers can use their technologies together, and officials said this combined use can increase the magnitude of the benefit they experience. For example, three of the large urban transit providers told us they use data from automatic passenger counters, which indicate many passengers get on and off at particular transit stops, in tandem with electronic fare payment data, which can provide the exact travel patterns of passengers because it can track the locations passengers get on and off vehicles and show how riders are transferring between service modes. Such combinations of technologies

can lead to precise information on ridership behavior that can contribute to benefits such as more efficient routing and scheduling. See figure 6 for an illustration of how other benefits may be derived from combinations of ITS technologies.

Figure 6: Combinations of ITS Technologies and Their Potential Benefits



Source: GAO analysis of Department of Transportation documents. | GAO-16-638

Certain Benefits of Transit ITS Are Difficult to Quantify

About half of the transit providers we interviewed and most small urban and rural transit providers surveyed found it difficult to measure or have not measured the benefits they experienced from ITS deployment. Officials from 11 of the large and medium urban transit providers we interviewed told us that it can be difficult to quantify the benefits of using ITS technologies for a number of reasons, such as that it may be difficult

to identify a unit of measurement for enhanced safety or greater staff efficiency, for example. Several of these officials also told us that it was difficult for them to attribute benefits exclusively to ITS deployment or identify the specific ITS technology that created the benefit. For example, officials from three of the large and medium urban transit providers told us that ITS technologies are integrated—often installed at the same time—and may result in similar benefits, making it challenging for them to specify which ITS technology made the positive impact. In addition, factors other than ITS deployment may contribute to an observed benefit. For example, officials from two large urban transit providers told us they have experienced reduced travel times, but it would be difficult to determine whether this was caused by using transit signal priority due to factors such as the ability of passengers to pay for their fares prior to entering the vehicle, city traffic, and the number of boarding passengers. Also, officials from four of the large and medium urban transit providers we interviewed told us that their ridership levels have increased, but this could be a result of different ITS technologies, such as traveler information systems or electronic fare payment, or other factors, such as improved service. Furthermore, we estimate that approximately 71 percent of the small urban and rural transit providers were not able to quantitatively measure any benefits received from ITS. Officials from five large and medium urban transit providers told us that they had not measured benefits from ITS deployment for a variety of reasons, such as the deployment had occurred too recently to be able to measure any benefits.

Despite these challenges, we found several examples in our interviews, survey, and review of recently published ITS studies where transit providers and researchers quantified some of the benefits of ITS deployment. Officials from several of the large and medium urban transit providers that we interviewed reported that they had quantified several benefits using a variety of methods, such as:

- Increased customer satisfaction, through passenger surveys and reviews of customer service call rates;
- Improvements in on-time performance and schedule adherence, through reviewing performance data; and
- Cost savings, by estimating the value of conducting preventative maintenance or reduction of staff that was a result of deployed ITS technologies.

Officials from two of the large urban transit providers told us that they collaborated with university researchers to measure the benefits obtained from specific ITS deployments and found that traveler information systems had a positive impact on customer satisfaction and transit signal priority resulted in reduced travel times. According to officials from these providers, the university researchers were able to isolate these technologies from some of the factors mentioned above that may also influence the experienced benefit. Among the small urban and rural transit providers that reported taking steps to measure ITS benefits, 15 providers told us they analyzed either ridership or on-time performance data to document the impact of ITS deployment. We also found recent ITS studies that measured the benefits experienced by transit providers that had deployed ITS technologies such as traveler information systems and transit signal priority. For example, a 2011 study that analyzed the impact of implementing transit signal priority on 27 intersections along a corridor in Minneapolis found that transit signal priority reduced bus travel times by 3 to 6 percent.[44]

Transit Providers Face an Assortment of Challenges in Deploying and Using ITS

Funding Challenges

Transit providers face a variety of challenges in securing funding for an ITS deployment. For example, officials from 12 of the 31 large and medium urban transit providers we interviewed told us that ITS projects may compete for funding with an agency's state-of-good-repair needs.[45] In 2013, FTA estimated that more than 40 percent of buses and 25 percent of rail transit assets were in marginal or poor condition. We have previously reported that transportation officials must identify priorities and

[44]University of Minnesota Department of Civil Engineering, *Field Testing and Evaluation of a Wireless-Based Transit Signal Priority System* (October 2011).

[45]"State of good repair" generally refers to the point at which all of a transit agency's assets are in good condition. We reported on transit agencies' asset management approaches in 2013, see GAO, *Transit Asset Management: Additional Research on Capital Investment Effects Could Help Transit Agencies Optimize Funding,* GAO-13-517 (Washington, D.C.: July 11, 2013).

make tradeoffs between funding projects that preserve or add new infrastructure and those that improve operations, like ITS.[46] Officials from one large urban provider told us that technology has historically been a second-tier funding project next to capital funds for bridges, stations, and upkeep of infrastructure, and a medium urban provider stated that because transit providers have so many needs, it can be difficult to say that acquiring new technology is a bigger need than new buses, for example. Another large urban provider told us that every project within an agency has to obtain funds based on its merits, and while providing real-time information at every transit center in a city may be useful, for example, this project may rank lower among the agency's priorities. A 2014 JPO report identified securing funding as a challenge when ITS is competing for attention with "ribbon-cutting" projects that have higher visibility.[47] According to officials from one large urban provider, it can be difficult for ITS to compete with other projects internally, in part because it can be hard to measure the return on investment from ITS. Officials from another large urban provider told us they have seen an increase in competition for funding between bus and rail needs, due to rail maintenance and costs associated with positive train control requirements.[48] Officials from seven large and medium urban transit providers told us that competition for external funding with other transportation agencies can also be a challenge. For example, officials from a large urban provider told us that highway projects tend to receive

[46]GAO-12-308.

[47]DOT, ITS Joint Program Office, *Use of Incentives to Encourage ITS Deployment*, FHWA-JPO-14-149 (Washington, D.C.: August 2014).

[48]Positive train control is a communications-based system designed to prevent certain types of rail accidents caused by human factors. The Rail Safety Improvement Act of 2008, Pub. L. No. 110-432, div. A, title I, § 104, 122 Stat. 4848, 4857 (2008) as amended by the Positive Train Control and Enforcement Act of 2015, Pub. L. No. 114-73 title I, subtitle D, § 1302, 129 Stat. 568, 576 (2015), codified at 49 U.S.C. § 20157, mandated the implementation of positive train control systems by December 31, 2018. See GAO, *Positive Train Control: Additional Authorities Could Benefit Implementation*, GAO-13-720 (Washington, D.C.: August 16, 2013).

more funding than public transit from federal programs such as the Congestion Mitigation and Air Quality Improvement Program (CMAQ).[49]

Transit providers may also face obstacles in funding the operations and maintenance costs associated with ITS systems, as we reported in 2012.[50] Officials from 16 large and medium urban providers we interviewed indicated that preparing for the future operations and maintenance costs related to ITS deployment is a key challenge. For example, officials from one large urban transit provider said that the maintenance and support contracts for ITS technologies are expensive, and that those expenses are more difficult to predict than the capital costs associated with implementing ITS. The officials said they also anticipate higher operational costs in the future based on the need for unlimited cellular data plans to collect real-time data from their vehicles.

Finally, limited opportunities to fund ITS are a challenge, according to officials from 20 of the 31 medium and large urban transit providers we interviewed. As we reported in 2012, funding is an ongoing challenge in the transit community, as transportation agencies face difficult decisions regarding the allocation of their transportation funding. Many have faced severe revenue declines in recent years, restricting the availability of funds for transportation improvements. For example, officials from one medium urban provider said that the economic recession resulted in fewer local funds available for transit. Officials from a large urban provider told us that transit providers must plan and execute new software deployments effectively because there may not be funding available to correct a mistake for 5 to 10 years if the agency makes a poor decision in selecting a vendor or the software selected does not meet a business need.

[49]CMAQ provides funding to nonattainment or maintenance areas for ozone, carbon monoxide, and/or particulate matter as defined in 42 U.S.C. § 7407(d). States that have no nonattainment or maintenance areas still receive a minimum apportionment of CMAQ funding for either air quality projects or other elements of flexible funding , which is funding not tied to a single mode of transportation. Funds may be used for any transit capital expenditures otherwise eligible for FTA funding as long as they have an air quality benefit. 23 U.S.C. § 149.

[50]GAO-12-308.

In our survey of small urban and rural transit providers, we asked respondents to rate their experiences with a number of different challenges, including several similar funding-related challenges they have encountered with ITS (see table 5).

Table 5: Funding Challenges for Small Urban and Rural Transit Providers

Challenges related to funding	Very great or great challenge	Moderate challenge	Somewhat/Little or no challenge
Limited funding opportunities to pay for ITS deployment	59%	14%	16%
Operational costs	55%	17%	19%
Maintenance costs	47%	22%	21%
Competition for funding with other transportation projects outside your organization	38%	14%	30%

Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level. Estimated percentages in table do not total 100 percent because survey respondents also had the opportunity to select 'Not applicable' for each stated challenge in the survey.

Additionally, we estimate that 22 percent of small urban and rural providers experienced unexpected costs in deploying, operating, or maintaining ITS technology. Costs cited include increases in annual licensing and maintenance fees, the need for additional internet speed and storage, software upgrades, cellular service, and training costs.

Leadership and Workforce Challenges

The familiarity and comfort of a transit provider's leadership and workforce with ITS technologies and their benefits—from a board of directors to bus operators—may have a significant impact on its ability to successfully deploy these technologies. According to a 2015 ITS America report on ITS deployment challenges, a transit provider's board of directors may not be familiar with ITS technologies and the potential benefits they bring to operations and ridership.[51] Similarly, we reported in 2012 that leaders do not always place a priority on ITS, especially in the context of limited funding, and other infrastructure projects can take

[51]Intelligent Transportation Society of America, *Challenges in Deploying and Achieving the Full Potential of Transit ITS; a Discussion Paper*, Public Transportation ITS Discussion Paper #15-1 (Washington, D.C.: July 28, 2015).

precedence. Officials from nine of the large and medium urban transit providers we interviewed reported that obtaining support for deploying technologies from leadership and decision-makers in the organization can be a challenge. Officials from a large urban provider, for example, told us that because ITS projects may not be as exciting as projects such as implementing a new rail line or replacing rail cars, staff may have to spend time explaining the value of an ITS project to board members. Officials from another urban provider told us that their general manager has been able to gain the support of their board members by taking them to ITS conferences so they can see firsthand what other transit providers are doing.

The introduction of transit ITS also has the potential to significantly alter the work and responsibilities of a transit provider's workforce, including dispatchers and operators. Officials from 21 of the 31 large and medium urban transit providers indicated that the workforce may be reluctant to embrace new technology that changes their job responsibilities. For example, officials from a medium urban provider explained that bus operators were initially resistant to the installation of surveillance systems, but their apprehension subsided after they learned that the video footage could prove that they were not at fault for particular incidents that occurred on the bus. Officials from a large urban provider also told us that transit staff tends to include "lifers" who were hired with one expertise and it can be difficult to train them to work with new technology, or the funding for that training may not be available.

ITS is a rapidly developing field that requires a specialized workforce familiar with emerging technologies.[52] Officials from 14 of the 31 providers we interviewed said that a lack of technical expertise in the workforce is a deployment challenge. For example, officials from one large urban provider said that it can be difficult to find applicants who have worked with certain proprietary ITS products, and as a result, they train new staff in-house with vendor support. The agency risks losing its investment if staff leave the organization or department. Additionally, officials from one medium urban provider told us that it can be difficult to attract and maintain staff with technical expertise because their union rules are more

[52]GAO-12-308.

protective of senior staff, and it is largely younger, more recent hires who can adapt to new technologies.

In our survey, we asked small urban and rural transit providers about the extent to which they encountered similar leadership and workforce challenges with ITS (see table 6).

Table 6: Leadership and Workforce Challenges for Small Urban and Rural Providers

Challenges related to leadership and workforce	Very great or great challenge	Moderate challenge	Somewhat/Little or no challenge
Lack of technical expertise in workforce	23%	22%	40%
Workforce apprehension to introduction of technology	19%	30%	38%
Obtaining support for technologies from leadership and decision makers	16%	17%	54%

Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level. Estimated percentages in table do not total 100 percent because survey respondents also had the opportunity to select 'Not applicable' for each stated challenge in the survey.

Coordination Challenges

The success of an ITS deployment may depend on effective coordination between several transportation stakeholders in a region, and we have previously found that ITS coordination across agencies is a challenge.[53] Complex systems such as electronic fare payment and transit signal priority may involve multiple entities, including neighboring transit providers and cities, among others. Officials from seven large and medium urban transit providers considered coordinating ITS deployment across agencies to be a challenge. Officials from two large urban providers told us that obtaining buy-in from regional partners on their respective regional fare collection systems was difficult because of resource limitations and apprehension from smaller regional providers about a larger agency moving forward with decisions about the system without their input. Officials from a large and medium provider told us they have had difficulty implementing transit signal priority in their cities because state or local transportation authorities have opposed the system

[53]GAO-12-308.

or have not upgraded the fiber optic network so that traffic signals are connected.

Technology Procurement and Vendor Challenges

Transit providers using federal funds typically purchase ITS technologies from technology vendors through the federal procurement process.[54] However, officials at three large and medium providers said that it may take months to years to procure technology from the request for proposal to actual deployment, a point at which the deployed technology is already old and could be replaced or upgraded. Officials from two large urban transit providers told us that FTA's "Buy America" requirements—which require manufactured products used in a project receiving FTA funds to be produced in the U.S.—are also a factor in prolonging the procurement process, as agencies may have difficulty meeting the requirements.[55]

Officials from 16 of the 31 large and medium urban providers told us they have experienced challenges in working with ITS vendors. Issues cited by providers we spoke with include (1) difficulty changing vendors after ITS has been deployed, (2) turnover among vendor staff during ITS projects, and (3) difficulty getting vendors to work with one another to integrate ITS amid concerns about making changes to proprietary systems. Officials from a large urban provider told us that even though contracts may make the vendors responsible for integrating ITS technologies, the costs are passed on to the transit provider. According to DOT, including ITS standards such as Transit Communications Interface Profiles (TCIP) in procurements can help to integrate different technologies by establishing a common framework for the exchange of information between systems, and allows the transit provider to go beyond a single vendor when considering an upgrade or adding to an existing system. However, an ITS consultant we spoke with said that developing standards to enable different vendors' products to work together is one of the biggest

[54]FTA Circular 4220.1F provides contracting guidance for recipients of federal assistance awarded by the FTA when using that assistance to finance procurements. See Federal Transit Administration, *Third Party Contracting Guidance*, FTA Circular 4220.1F, Rev. 4 (Mar. 18, 2013).

[55]49 U.S.C. § 5323(j); see also FTA Buy America regulations at 49 C.F.R. Part 661. In general, under these Buy America requirements, all iron, steel, and manufactured products used in FTA-funded projects must be produced in the U.S. Section 5323 also includes a phased increase in domestic content requirements for rolling stock from the current requirement of more than 60 percent domestic content to more than 70 percent domestic.

challenges in the industry as it requires vendors to share information, and implementing the interfaces between technologies may add to the cost of a project.

Our survey asked small urban and rural transit providers about the challenges they encountered related to working with ITS vendors. Although most small urban and rural providers did not rate limited vendor support as a particular challenge, 33 percent indicated that vendors offer ITS technology solutions that are not designed for the smaller scale of small urban and rural transit systems. (See table 7.)

Table 7: Vendor Challenges for Small Urban and Rural Providers

Vendor challenges	Very great or great challenge	Moderate challenge	Somewhat/little or no challenge
Vendor technology solutions designed for larger-scale transit operations	33%	19%	28%
Integrating new technologies with current systems	24%	17%	42%
Limited vendor support	14%	17%	52%

Source: GAO analysis of transit provider survey data. | GAO-16-638

Note: Estimates in this figure have a margin of error of plus or minus 10 percentage points or fewer at the 95 percent confidence level. Percentages in table do not total 100 percent because survey respondents also had the opportunity to select 'Not applicable' for each stated challenge in the survey.

Connectivity Challenges in Rural Areas

Successful ITS deployment requires the capacity to reliably transmit data, such as vehicle location, between systems. We have previously reported that rural areas can have conditions that increase the cost of deploying broadband Internet infrastructure and services, such as remote areas with challenging terrain like mountains, which increase construction costs, or conditions that make it difficult to recoup deployment costs, such as relatively low population densities and incomes.[56] Similarly, in their comments on our survey, three rural transit providers reported that geographic conditions in rural areas, such as mountains and large service areas, can limit connectivity. For example, one rural provider reported that "mapping technology" (e.g., GIS) may not recognize all of the rural roads

[56]GAO, *Telecommunications: USDA Should Evaluate the Performance of the Rural Broadband Loan Program,* GAO-14-471 (Washington, D.C.: May 22, 2014).

in an area, which limits its usefulness for a demand-response service. Finally, an official from the National Rural Transit Assistance Program (RTAP) told us that infrastructure and access to data are inadequate in rural areas, and the lack of investment in making communications more reliable to reduce cell phone dead zones and connect drivers to dispatchers is making rural communities structurally isolated.

DOT Supports ITS Deployment Through a Variety of Training and Technical Assistance Resources, but Providers' Use of These Resources Is Limited

DOT Offers a Number of Resources to Promote and Support ITS Technologies

The JPO and FTA provide a variety of information resources related to transit ITS deployment. In addition to their responsibility for conducting ITS research, development, and testing, the JPO runs programs to support transportation providers in the deployment of ITS technologies. According to JPO officials, they design their programs to be applicable to any transportation mode, including highways, railroads, and transit, but they also develop resources that are transit-specific. To help inform them of the transit community's resource needs, JPO officials told us that they coordinate with officials from FTA and transit industry groups, such as APTA and CTAA, and consider other information, such as relevant research and ITS deployment information from DOT's ITS deployment survey of state and local transportation agencies. The following are some of the ITS information resources that are made available to the transportation community, including some that are more targeted to transit providers:

JPO Technical Assistance Programs: The JPO offers a number of technical assistance programs covering various ITS topics, including ITS standards implementation, systems engineering, and ITS architecture

implementation, which JPO officials told us include the interests of the transit community.[57]

ITS Professional Capacity Building Program (PCB Program): The JPO offers different ITS learning opportunities for transportation agencies, including transit providers, to ensure the effective implementation and operation of ITS.[58] These opportunities include web-based and classroom training, webinars, on-line resources, peer-to-peer assistance, and their Knowledge Resources Databases, which include past studies of ITS benefits, costs, and lessons learned, and some of these are more focused on transit. For example, the JPO provides online training modules on ITS transit standards, ITS transit fact sheets that describe transit-specific ITS technologies, transit-targeted webinars, and has identified transit ITS research in its Knowledge Resources Databases. Additionally, according to JPO officials, it coordinates jointly with FTA and APTA on an annual ITS Best Practices Workshop for transit providers and with APTA and ITS America on the Passenger Transportation Systems and Services Committee of the Transportation Management Forum, which is an industry forum that focuses on transit ITS issues.

In addition to the ITS resources the JPO provides, FTA—and within FTA, RTAP, which promotes the delivery of transportation services in rural areas—also provides support to transit providers in their ITS deployment through research, testing, evaluation, training, and outreach. For example, the National Transit Institute (NTI), which provides training and educational programs for the transit industry and is funded by an FTA grant, offers transit ITS courses, such as an introductory workshop on ITS data management, training on using ITS standards when purchasing ITS technologies, and a course on rural technology adoption, which FTA officials told us includes ITS technologies.[59] FTA officials also told us that

[57]Pursuant to 23 C.F.R. § 940.11, all ITS projects funded with highway trust funds must include a systems engineering analysis, which should include, among other requirements, identification of portions of the regional or national ITS architectures, analysis of alternative system configurations and technology options, and procedures and resources necessary for operations and management of the system.

[58]The PCB Program was launched in 1996 to help create a workforce with the competencies required to transform the transportation infrastructure through ITS.

[59]NTI courses are also listed as part of the JPO PCB Program. DOT officials told us NTI also offers courses on systems engineering and using regional ITS architectures.

FTA headquarters staff provide guidance to transit providers that contact them with questions about ITS deployment and have quarterly calls with their 10 regional offices to discuss ITS development in their regions. Some of RTAP's activities include providing technical assistance and training materials to rural transit providers, surveying state RTAP managers, and participating in conferences and webinars, which an RTAP official told us include information on ITS deployment. For example, RTAP developed technical guidance for moving data into the GTFS format to enable transit providers to adopt website trip planning, and on-line training that introduces ITS technologies for scheduling and dispatching to rural transit systems.

Transit Providers Are Generally Relying on Non-Federal Resources to Inform Their ITS Deployment

Few of the transit providers we interviewed and surveyed reported using DOT resources, particularly JPO resources. For example, officials from 10 of the 31 large and medium urban transit providers we interviewed told us they had used JPO resources. Additionally, based on our survey results, we estimate that about two percent of small urban and rural transit providers received some form of technical assistance from the JPO, such as for the planning, deployment, operation, or maintenance of ITS technologies. In addition to asking these providers questions about receiving JPO's general technical assistance, we also asked them about resources received through the JPO's PCB Program. And, of the 233 small urban and rural transit providers who responded to our survey, 43 indicated they were aware of the training, technical assistance, and knowledge resources programs provided by the JPO PCB Program and 24 reported using any of these resources. Consistent with this information, JPO officials told us the data they collect on use of PCB Program resources showed low participation rates by transit providers and estimated that, based on historical participation, transit providers comprise 3 to 5 percent of the program's users, or about 1,100 to 1,800 transit providers in fiscal year 2015.[60] JPO officials told us that transit providers participate in certain PCB Program offerings more than others.

[60]JPO officials did not provide us with information on the number of transit providers that use their technical assistance programs or if they collect this data. They also told us that the data they collect on PCB Program users may undercount the number of transit stakeholders using these resources because they are based on self-identification and users may associate themselves under one classification, but still be involved with the transit community. Additionally, they said that the number of transit providers using Consortium for ITS Training and Education training courses is not tracked.

For example, they said that approximately 6 to 10 percent of the webinar attendees and archives users represent transit providers and these figures may be higher depending on the topic of the webinar.

More transit providers in our review reported using FTA resources for ITS deployment than JPO resources. For example, officials from 14 of the 31 large and medium urban transit providers told us that they had received FTA assistance. Most of these transit providers reported that FTA assistance was related to the administration of grants rather than technical deployment, or that they received assistance through NTI courses that officials from four providers said were focused on technology in general and may not have included information on ITS. Likewise, our survey found that small urban and rural transit providers had also used FTA resources more than JPO resources. For example, based on our survey results, we estimate that about 33 percent and 17 percent of small urban and rural transit providers had received some form of technical assistance from FTA and RTAP, respectively, such as in the planning, deployment, operation, or maintenance of ITS technologies.

The transit providers in our review reported relying mostly on non-federal resources for assistance with ITS deployment. For example, 22 of the 31 large and medium urban transit providers that we interviewed told us that they rely on peer or regional transit providers and officials from 7 of these transit providers told us that other transit providers are their main source of ITS information. Officials from several of these transit providers told us they are part of peer networking groups where information about ITS is shared, such as a consortium of transit chief information officers and an organization of bus transit providers that compare performance and identify best practices. The large and medium urban transit providers also reported relying on industry groups and vendors for ITS information. For example, officials from 18 of the 31 selected large and medium transit providers said they rely on groups such as APTA, and officials from 7 of the 31 large and medium urban transit providers said that they rely on vendors and attending annual vendor user conferences. Based on our survey results, we estimate that small urban and rural transit providers receive technical assistance—such as in the planning, deployment, operation, and maintenance of ITS technologies—from state DOTs (52 percent) and ITS vendors (48 percent) more frequently than from FTA (33 percent).

JPO and FTA officials told us that transit providers may not be using federal ITS resources because these providers may not have the ability to send staff to training opportunities and the topics may not be of interest to

them. For example, FTA officials told us they have not received a lot of demand for NTI courses to include ITS-focused training because transit providers have high turnover of staff and staff may not have ITS expertise. Although JPO officials told us they coordinate with various stakeholders to ensure their resources are responsive to transit community needs, officials from JPO, FTA, and RTAP told us that transit providers may not be using JPO resources because these resources are more focused on urban areas and highway transportation, including advanced connected vehicle technologies, which are not of current interest to the transit community.[61] Officials from five of the large and medium urban transit providers and four public transit stakeholders we interviewed, including officials from two industry associations and one ITS consultant, told us that the information provided was either outdated, focused on highways rather than public transit, or otherwise did not match their needs. JPO officials told us that they expect participation rates to increase among the transportation community with their publication of new ITS Standards Training Modules in late 2015, which they say are applicable to transit. JPO officials also told us that they solicit and review feedback on their PCB Program offerings. For example, officials said they obtain feedback from users of their Knowledge Resources Databases through an online feedback link and formally twice a year through a webinar. They said that the transit providers that have provided feedback have reported that the information on lessons learned is valuable, but would like more reports on costs of technologies. These officials said that overall, given the complexity and number of different types of users of the databases, it is very difficult to meet everyone's needs. Officials noted that they also collect live participation and on-demand use numbers of the PCB Program, but only began collecting more detailed user data for these programs in 2014. With more detailed data on each PCB Program offering, they said they hope to focus more on the types of transportation stakeholders using their resources in 2016 to help them better understand the reach and effectiveness to various stakeholders, and incorporate this information into the PCB Program's strategic plan and assign PCB Program resources as needed.

[61]The PCB Program's 2010-2014 strategic plan states that the program is refocusing its agenda and is shifting from training in existing technology to accelerating the adoption of emerging technology, such as connected vehicles, which is part of a broader plan to support the JPO's ITS Strategic Research vision.

Better Outreach and Information Collection Could Improve DOT's Promotion of ITS

Although DOT, through JPO and FTA, offers a variety of different ITS resources, as discussed above, most of the transit providers in our review were unaware of the resources offered through the JPO and reported relying largely on resources other than those offered through DOT. In addition, officials from DOT and industry groups, as well as an ITS consultant and several transit agencies, generally said DOT's ITS support programs and research may not reflect the needs of the transit community, particularly in rural areas, because, for example, these programs focus on urban areas, highway ITS, and connected vehicle technologies. We and the National Academies' Transportation Research Board (TRB) have previously identified a number of leading practices for successfully encouraging the adoption of new technologies that may improve the extent to which transit providers use DOT resources.[62] These leading practices include (1) choosing appropriate methods to promote the use of technology by the target audience and (2) monitoring technology adoption. Improving the availability and awareness of DOT resources is a key component to promoting the use of technology by the target audience and can enhance efforts to assist others in making decisions regarding the use of technologies.[63] Also, monitoring technology adoption can provide lessons about efforts to encourage technology implementation. For example, according to a TRB report on promoting technology use, such monitoring of information is needed for

[62]See GAO-12-308. See also Transportation Research Board, *Transportation Technology Transfer: Successes, Challenges, and Needs: A Synthesis of Highway Practice,* National Cooperative Highway Research Program Synthesis 355 (Washington, D.C.: 2005); Transportation Research Board, *Managing Technology Transfer: A Strategy for the Federal Highway Administration,* Special Report 256 (Washington, D.C.: 1999); GAO, *Technology Transfer: Clearer Priorities and Greater Use of Innovative Approaches Could Increase the Effectiveness of Technology Transfer at Department of Energy Laboratories,* GAO-09-548 (Washington, D.C.: June 16, 2009); *Rail Safety: Federal Railroad Administration Should Report on Risks to the Successful Implementation of Mandated Safety Technology,* GAO-11-133 (Washington, D.C.: Dec. 15, 2010); *NextGen Air Transportation System: Mechanisms for Collaboration and Technology Transfer Could Be Enhanced to More Fully Leverage Partner Agency and Industry Resources,* GAO-11-604 (Washington, D.C.: June 30, 2011); and *Best Practices: Stronger Practices Needed to Improve DOD Technology Transition Processes,* GAO-06-883 (Washington, D.C.: Sept. 14, 2006).

[63]See GAO, *Intermodal Transportation: DOT Could Take Further Actions to Address Intermodal Barriers*, GAO-07-718 (Washington, D.C.: June 20, 2007).

managing technology promotion activities and for successfully assessing progress toward the goals of those activities.[64]

Making users aware of ITS resources

JPO officials told us that they advertise PCB Program offerings through e-mail lists that include the major transit industry associations and FTA staff, who they say consistently share news and information with transit, state, regional, and local stakeholders, and the private sector. They also told us that many individual transit providers subscribe to their e-mails. There are other ways that transit providers hear about their offerings, according to JPO officials, including advertisements through ITS America-sponsored webinars and newsletters. When there are products for a specific audience, such as transit-specific offerings, JPO officials said they will make additional efforts to inform that audience of the products' availability. DOT officials also told us that FTA publishes information on PCB Program opportunities and JPO has a dedicated multimodal knowledge and technology task that includes outreach and marketing. Despite these efforts, officials from RTAP, two ITS consultants, and officials from 12 of the 31 large and medium urban transit providers we interviewed told us they were unaware of the resources offered through the JPO. We estimate that the majority of small urban and rural transit providers are also unaware of JPO's PCB Program offerings. Specifically, based on our survey, we estimate that about 75 percent of small urban and rural transit providers are unaware of JPO's PCB Program training, 85 percent are unaware of PCB Program technical assistance, and 85 percent are unaware of PCB Program knowledge resources information.[65] The ITS consultants we spoke with told us that outside of federal resources the level of support transit providers may receive for ITS deployment varies and transit providers generally rely on vendors for technical support. Improving the availability and awareness of DOT resources could help transit providers take advantage of these resources.

[64]TRB, Special Report 256.

[65]We define JPO training as including ITS training offered through PCB Program partners, such as the Consortium for ITS Training and Education; NTI; Institute of Transportation Engineers; and FHWA. We define JPO technical assistance as including its ITS Peer-to-Peer program and ITS webinars. We define JPO knowledge resources as databases that offer resources for ITS deployment that focus on ITS costs, benefits, lessons learned, and deployment statistics.

Without greater efforts from DOT to make the transit community more aware of federal resources, transit providers may be missing information that could help them make the most informed ITS deployment decisions.

Monitoring of technology adoption

As described earlier, the JPO monitors the adoption of ITS technologies through the ITS deployment survey and uses this information, according to JPO officials, to understand the level of deployment and to help them make decisions on how to encourage the future deployment of ITS technologies through its information resources. However, the deployment survey has focused on technology adoption by transportation providers, including but not limited to transit, that are located in major metropolitan areas and does not collect deployment data from transit providers that primarily serve small urban and rural areas. JPO officials told us they have no plans to survey rural transit providers because these providers are generally very small and serve specialized functions often associated with federal programs, such as the transportation of elderly to medical appointments, which would have required them to contact each provider individually to get information and that this was outside of the project's scope. Additionally, officials told us the purpose of the survey is to document trends and to understand how ITS deployment, which generally occurs in larger cities, has progressed, although some of the information JPO collects may include deployment in small cities because providers in larger cities may also provide service in those areas.[66] However, we estimate from our survey results that a majority of small urban and rural transit providers are using several ITS technologies— such as security systems, computer-aided dispatch, and automatic vehicle location—but have experienced challenges in using funding opportunities for ITS as well as the operational costs associated with these technologies. Additionally, we estimate from our survey that small urban and rural providers have plans to continue deploying ITS in the next 5 years. While there may be some difficulties in including small urban and rural transit providers in DOT's deployment survey, there may be other ways to

[66]While JPO had plans previously to survey ITS deployment among transportation agencies in these areas, JPO officials told us that the survey would not have included transit and was abandoned because of the success of another initiative that provided location data for ITS assets from each state, but which also does not include information from transit providers.

monitor their ITS deployment, including engaging with state DOTs to collect information on rural transit ITS. FTA considers state DOTs a useful resource in understanding rural transit issues as they distribute section 5311 rural grant funding to the state's subrecipient rural transit providers. Including the deployment of ITS by small urban and rural transit providers in its ITS monitoring efforts may provide the JPO with information to customize ITS resources to address the challenges faced by this transit community. Without greater efforts from DOT to tailor its resources to include the needs of small urban and rural transit, these transit providers may be missing information that could inform their ITS deployment decisions.

Conclusions

As public transit ridership grows, ITS technologies provide opportunities for transit providers to improve planning, increase the efficiency of their operations, and make their services more attractive to riders. In the nation's major metropolitan areas, transit providers are using ITS in new and innovative ways to improve fare collection and keep the public informed about the status of transit services, even in real time through smartphone applications. Although less prevalent, ITS technologies are helping transit providers in small communities and rural areas increase their scheduling capabilities, enhance the safety of their services, and improve their reporting and billing processes. However, in deploying ITS, the transit community faces challenges related to identifying ITS funding opportunities, paying for the operations and maintenance costs of technology, integrating systems, and managing the disruption that the introduction of new technologies can bring to the transit workforce.

Although DOT provides a variety of information resources to promote and support the use of transit ITS technology including technical assistance and classroom and online training, few of the transit providers in our review were aware or making use of these resources, relying instead on information and support from peer transit providers, industry groups, ITS vendors, and state DOTs. DOT could improve the awareness and applicability of these resources through greater use of leading practices for successfully encouraging the adoption of new technologies. Specifically, DOT could better ensure that federal ITS resources reach their intended audience and help make informed ITS deployment decisions by developing a strategy to increase the transit community's awareness of these resources. Additionally, including the deployment of ITS by small urban and rural transit providers in ITS monitoring efforts could help DOT customize ITS resources to address the challenges these providers face. Without greater efforts from DOT to make the transit

community more aware of federal ITS resources and tailor these resources to the needs of smaller providers, transit providers may be missing information that could help them make the most informed ITS deployment decisions.

Recommendations for Executive Action

To improve access to and awareness and applicability of ITS resources for ITS deployment, we recommend that the Secretary of Transportation direct the ITS JPO, in coordination with FTA, to take the following two actions:

- develop a strategy to raise awareness of JPO's training, technical assistance, and knowledge resources for transit ITS deployment in the transit community, and
- include ITS adoption by small urban and rural transit providers in ITS monitoring efforts.

Agency Comments

We provided a draft of this report to DOT for review and comment. DOT concurred with both of our recommendations. In its comments, which we have reproduced in appendix II, DOT noted that it is leveraging its FAST Act authorities to further evaluate and validate its efforts to advance urban and rural ITS; for example, the JPO is developing a course catalog to describe its knowledge resource offerings and is considering developing a small urban and rural ITS transit survey as part of the 2019 ITS Deployment Survey. DOT also provided technical comments on the draft, which we incorporated as appropriate.

We are sending copies of this report to the Secretary of Transportation and the appropriate congressional committee. In addition, the report will be available at no charge on GAO's website at http://www.gao.gov.

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

Mark Goldstein
Director, Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

This report addresses: (1) the extent to which selected transit providers in large urban areas use Intelligent Transportation Systems (ITS); (2) the extent to which transit providers in small urban and rural areas use ITS; (3) the benefits and challenges transit providers experience in deploying ITS; and (4) the extent to which transit providers have utilized the Department of Transportation's (DOT) resources to promote and support ITS.

To determine the extent of ITS use among transit providers in large urban areas, we reviewed 2013 data on national ITS deployment from DOT. On the basis of interviews with DOT officials and analysis of the 2013 ITS deployment data, we determined that the data were sufficiently reliable for our purposes. We conducted site visits to Pittsburgh, Pennsylvania; Portland and Eugene, Oregon; and Tampa and Orlando, Florida, to observe transit ITS deployments. We selected these site visits based on criteria including geographic dispersion and recommendations by JPO and FTA officials and industry stakeholders. During these site visits, we obtained documentation and interviewed officials from stakeholders in public transit decision-making including municipalities, academic researchers, state departments of transportation, and metropolitan planning organizations. We are not able to generalize our findings in these site visits to the whole country but used the other sources mentioned above to gain a more general perspective.

We also conducted semi-structured interviews on the use of ITS with a judgmental sample of 31 transit providers serving large urban areas.[1] We selected transit providers that were geographically dispersed across the country and represented the variety of transit modes offered in these areas. We separated the transit providers into two categories:

- medium urban: 13 providers serving urbanized areas with populations of 200,000–1 million, and
- large urban: 18 providers serving urbanized areas with populations of more than 1 million.

Because we used a judgmental sample of transit providers, findings from these interviews cannot be generalized to a broader population. However,

[1]Large urbanized areas are areas with populations of 200,000 or more, according to the National Transit Database (NTD).

we determined that the selection of these transit providers was appropriate for our design and objectives and that these interviews would generate valid and reliable evidence to support our work.

We also interviewed officials from related industry associations such as the American Public Transportation Association (APTA), Community Transportation Association of America (CTAA), and Intelligent Transportation Society of America (ITS America), and representatives from two ITS vendors and four independent ITS consultants. We selected the ITS vendors based on interviews with several transit providers in large urban areas that utilized their products, and the consultants based on a review of published transit ITS reports.

Small Urban and Rural Transit ITS Survey

To determine the extent of ITS use among transit providers in small urban and rural areas, we conducted a web-based survey of transit providers from November through December 2015. Results of this survey and the survey instrument have been published in GAO-16-639SP, an E-supplement to GAO-16-638 and can be found at the GAO website.

Survey Population and Sample Design

We constructed the population of transit providers for our survey sample using reporting year 2013 data for recipients of Section 5307 FTA urbanized area formula grants and sub-recipients of Section 5311 FTA non-urbanized area formula grants in FTA's National Transit Database (NTD).[2] Using data from the NTD's urban module, we determined that there were 314 providers that primarily served small urban areas. Using the NTD's rural module, we identified 1310 providers that primarily serve rural areas. We excluded from this population transit providers that reported as urban recipients, rural recipients reporting separately, intercity bus providers, and 7 agencies that were also included in the urban module. To target the population of rural providers to those that are most likely using ITS, we also excluded transit providers with fleets of 10 or fewer vehicles. The outcome was a survey sample frame of 314 small

[2]We assessed NTD data on the small urban and rural transit providers that reported in 2013 by reviewing documentation about the dataset, taking steps to check completeness of the data, and when discrepancies occurred, resolving issues by contacting FTA officials. We determined that the NTD data were sufficiently reliable for the purpose of constructing our sample.

urban providers and 582 rural providers. We selected a stratified random sample of 312 transit providers: 146 small urban providers and 166 rural providers. We obtained contact information for the rural transit providers from CTAA. During our data collection, we identified two organizations that were not currently providing transit service and removed them from our sample as out of scope. We obtained completed questionnaires from 233 respondents, or about a 75 percent response rate. The survey results can be generalized to the target population of 314 transit providers that serve small urban areas and 582 transit providers with more than 10 vehicles that serve rural areas. And, as noted above, we are issuing an electronic supplement to this report that shows a more complete tabulation of our survey results.

Administration of Survey and Quality Assurance

We developed a questionnaire to obtain information about transit providers' use of ITS technologies. On November 23, 2015, we sent an initial e-mail alerting agency contacts to the upcoming web-based survey, and a week later, the web-based survey was also delivered to recipients via e-mail message. Our e-mail message described the purpose and topic of the survey, and encouraged the respondent to consult with other individuals in the provider's organization if that would increase the accuracy of their responses. The web-based survey requested information on types of ITS technologies deployed and any reasons for not deploying a technology; costs, benefits, and challenges associated with ITS; sources of funding and technical support; and federal resources used. To help increase our response rate, we sent a reminder e-mail on December 14 and called agency officials. The survey was available to respondents from November 30 through December 18, 2015.

To pretest the questionnaire, we conducted cognitive interviews with officials from 7 transit providers with knowledge about their organization's use of ITS. Each pretest was conducted on the phone. We selected pretest respondents to represent small urban and rural areas in different parts of the country. We conducted these pretests to determine if the questions were burdensome, understandable, and measured what we intended, and to ensure we could identify an appropriate individual who was knowledgeable about ITS use to respond to the survey. On the basis of feedback from the pretests and expert review we modified the questions as appropriate.

Sampling Error and Estimation

To produce the estimates from this survey, answers from each responding case were weighted in the analysis to account statistically for all the members of the population, including those who were not selected or did not respond to the survey. Estimates produced from this sample are generalizable to the population of transit providers that served small urban areas and transit providers with more than 10 vehicles that served rural areas as reported to the FTA's National Transit Database in reporting year 2013.

Because our results are based on a sample and different samples could provide different estimates, we express our confidence in the precision of our particular sample's results as a 95 percent confidence interval (for example, plus or minus 10 percentage points). We are 95 percent confident that each of the confidence intervals in this report include the true values in the study population. Unless we note otherwise, percentage estimates based on all transit agencies have 95 percent confidence intervals of within plus or minus 10 percentage points. Confidence intervals for survey estimates are presented in our supplemental survey product (GAO-16-639SP).

Non-Sampling Error

In addition to the reported sampling errors, the practical difficulties of conducting any survey may introduce other types of errors, commonly referred to as non-sampling errors. For example, differences in how a particular question is interpreted, the sources of information available to respondents, or the types of people who do not respond can introduce unwanted variability into the survey results. We included steps in both the data collection and data analysis stages for the purpose of minimizing such non-sampling errors.

We took the following steps to increase the response rate: developing the questionnaire, pre-testing the questionnaires with small urban and rural transit providers, conducting multiple follow-ups to identify the appropriate contact at some organizations and to encourage responses to the survey, and contacting respondents to clarify unclear responses.

To identify the benefits and challenges that transit providers in large urban, small urban, and rural areas are experiencing from deploying ITS, we interviewed JPO and FTA officials, industry associations, officials from public transit stakeholders in our site visits, and 31 transit providers in large urban areas, surveyed transit providers in small urban and rural areas, and reviewed published research on ITS. We analyzed the interviews, survey results, and published research to identify commonly

cited benefits and challenges. To determine how DOT promotes and supports the use of ITS technologies, we interviewed officials from the JPO and FTA about the federal resources and assistance available to support deployment and how transit providers use these resources. We reviewed the JPO's program and strategic planning documents, including documents related to the Professional Capacity Building Program. In addition, we reviewed the JPO's efforts to promote and support ITS technologies, including various studies, guidance, websites, and the JPO's ITS databases. We determined the extent to which transit providers are utilizing DOT's ITS resources by asking transit provider officials about their awareness and use of the training, technical assistance, or knowledge resources programs offered by the JPO, whether they had used these programs, and how helpful they had found them to be, in interviews and through the survey. In prior work, we and the National Academies' Transportation Research Board identified leading practices for successfully encouraging the adoption of new technologies.

We conducted this performance audit from March 2015 through June 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Transportation

U.S. Department of Transportation

Office of the Secretary of Transportation

Assistant Secretary for Administration

1200 New Jersey Ave., SE
Washington, DC 20590

JUN 8 2016

Mark Goldstein
Director, Physical Infrastructure Issues
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Mr. Goldstein:

The Department of Transportation (DOT) is leveraging its Fixing America's Surface Transportation Act (FAST Act) authorities to further evaluate and validate its efforts to advance urban and rural ITS. For example, the ITS Joint Program Office (JPO) Professional Capacity Building Program has a number of initiatives under development that will raise the awareness and increase the usability of all the ITS knowledge resources, including the transit-specific resources. One of these initiatives includes the development of an overall Course Catalog that clearly describes all available knowledge resource offerings. Further, JPO is considering the development of a small urban and rural ITS transit survey component as part of the 2019 ITS Deployment Survey.

Upon review of the draft report, we concur with GAO's recommendations for JPO, in close collaboration with the Federal Transit Administration (FTA), to develop strategies to raise awareness of JPO resources for ITS deployment in the transit community and to expand ITS monitoring efforts to include ITS adoption by small urban and rural transit providers. The Department will provide a detailed response to each recommendation within 60 days of the final report's issuance.

We appreciate the opportunity to respond to the GAO draft report. Please contact Madeline M. Chulumovich, Director, Audit Relations and Program Improvement, at (202) 366-6512 with any questions or if you would like to obtain additional details.

Sincerely,

Jeff Marootian
Assistant Secretary for Administration

Appendix III: Public Transit Stakeholders GAO Interviewed

Federal agencies	Federal Transit Administration
	U.S. Department of Transportation, Office of the Assistant Secretary for Research and Technology, Intelligent Transportation Systems Joint Program Office
Academic institutions	Carnegie Mellon University
	North Dakota State University, Upper Great Plains Transportation Institute, Small Urban and Rural Transit Center
	Portland State University
	University of South Florida, Center for Urban Transportation Research
Industry associations	American Public Transportation Association
	Community Transportation Association of America
	Intelligent Transportation Society of America
ITS consultants	Brendon Hemily
	Carol Schweiger
	C.R. Peterson Consulting, LLC
	Trillium Solutions
ITS vendors	Clever Devices
	RouteMatch Software
Metropolitan planning organizations	Lane Council of Governments
	MetroPlan Orlando
	Southwestern Pennsylvania Commission
Municipalities	City of Orlando
	City of Portland
Public transit providers	Antelope Valley Transit Authority
	Bi-State Development Agency (Metro Transit—St. Louis)
	Capital Metropolitan Transportation Authority
	Casco Bay Island Transit District
	Central Florida Regional Transportation Authority (LYNX)
	Charleston Area Regional Transportation Authority
	Dallas Area Rapid Transit
	Des Moines Area Regional Transit
	Greater Cleveland Regional Transit Authority
	Greater Dayton Regional Transit Authority
	Hillsborough Area Regional Transit Authority
	King County Department of Transportation Metro Transit Division

	Lane Transit District
	Los Angeles County Metropolitan Transportation Authority
	Manatee County Area Transit
	Massachusetts Bay Transportation Authority
	Memphis Area Transit Authority
	Metropolitan Atlanta Rapid Transit Authority
	Metropolitan Transportation Authority—New York City Transit
	Nashville Metropolitan Transit Authority
	Pinellas Suncoast Transit Authority
	Port Authority of Allegheny County
	Regional Transit District—Denver
	Rio Metro Regional Transit District
	Rock Region Metropolitan Transit Authority
	Southeastern Pennsylvania Transit Authority
	South Metro Area Regional Transit
	Tri-County Metropolitan Transportation District of Oregon
	Utah Transit Authority
	Valley Regional Transit
	York Adams Transportation Authority
State departments of transportation	Florida Department of Transportation
	Oregon Department of Transportation

Source: GAO. | GAO-16-638

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Mark Goldstein, (202) 512-2834 or goldsteinm@gao.gov

Staff Acknowledgments

In addition to the contact named above, the following individuals made important contributions to this report: Susan Zimmerman (Assistant Director), James Ashley, Namita Bhatia-Sabharwal, Anne Doré, Heather MacLeod, Cheryl Peterson, Justin Reed, Malika Rice, Michelle Weathers, and Elizabeth Wood.

Appendix V: Accessible Data

Agency Comment Letter

Text of Appendix II: Comments from the Department of Transportation

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U.S. Department of Transportation

Assistant Secretary for Administration

1200 New Jersey Ave., SE

Washington, DC 20590

Office of the Secretary of Transportation

Mark Goldstein

Director, Physical Infrastructure Issues

U.S. Government Accountability Office

441 G Street NW

Washington, DC 20548

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Sincerely,

Jeff Marootian

Assistant Secretary for Administration

Data Tables/Accessible Text

Accessible Text for Figure 1: Use of Selected Transit ITS Technologies

Traveler information systems (TIS):
TIS enable transit customers to receive travel information such as arrival times, delays, or changes to service.

Automatic passenger counters (APC):
APCs are electronic machines near the doors of a transit vehicle that count the number of passengers that enter and exit at every transit stop.

Security systems:
Security systems are technologies including radio communications, silent alarms, covert microphones, and audio/video surveillance that enhance the security of transit customers, personnel, equipment, and facilities.

Electronic fare payment (EFP):
EFP provides an automated means of collecting and processing fares.

Computer–aided dispatch (CAD):

CAD is software that incorporates transit routes, schedules, trip orders and vehicle assignments to allow dispatchers to know where transit vehicles are located.

Automatic vehicle location (AVL) and transit signal priority (TSP): AVL is a vehicle tracking system that uses location technology, such as the Global Positioning System (GPS), to transmit the real-time location of transit vehicles to a transit operations center. TSP uses sensors to detect approaching transit vehicles and grant them priority passage at an intersection.

Accessible Text for Figure 2: Different Uses of Smartphone Applications

- Mobile ticketing
- Vehicle tracking
- Trip planning
- Transit on-demand

Data Table for Figure 3: Types of Security Systems Used by Small Urban and Rural Transit Providers

Security Systems	Estimated percentage of small urban and rural transit providers that use security systems
Closed circuit tv cameras	80.72
Audio surveillance	57.86
Silent alarms	23.78
Object detection sensors	13.42
Covert microphones	8.61

Data Table for Figure 4: Small Urban and Rural Transit Provider Use of Five ITS Technologies

Intelligent Transportation Systems (ITS) technologies	Estimated percentage of small urban and rural target population
Maintenance management systems	37.91
Traveler information systems	32.26
Automatic passenger counters	15.34
Electronic fare payment	14.31

Intelligent Transportation Systems (ITS) technologies	Estimated percentage of small urban and rural target population
Transit signal priority	3.35

Data Table for Figure 5: ITS Technologies That Small Urban and Rural Transit Providers Plan to Deploy within 5 Years

Intelligent Transportation Systems (ITS) technologies	Estimated percentage of small urban and rural transit providers that are not currently using each technology
Transit signal priority	4.8
Automatic passenger counters	16.98
Maintenance management system	21.29
Electronic fare payment	26.16
Traveler information systems	26.56
Geographical information systems	27.93
Computer aided dispatch	30.32
Automatic vehicle location	44.76
Security systems	57.03