MOBILITYPLAN 2050

Appendix E

ITS-System Architecture

Contents

Knoxville Regional Transportation Planning Organization – KRTPO
ITS Technical Memo – Knoxville, TN Regional ITS Architecture
Draft July 2024

PURPOSE

This report describes the role of current Intelligent Transportation Systems (ITS) operations in the Knoxville, TN region and their impact on the 2050 Knoxville-Lakeway Metropolitan Transportation Plan (MTP). It outlines the purpose and value of ITS, describes the current status of ITS deployments through Tennessee Department of Transportation (TDOT) ***SmartWays program***, and offers observations for future considerations by the Metropolitan Planning Organization (MPO). Also, this document highlights the potential of ITS to improve safety, mobility, and efficiency and suggests strategies for its effective integration into the long-term transportation plan.

What is ITS?

ITS encompasses a broad range of technologies that integrate information and communication with transportation infrastructure and vehicles. It can be applied to roads, vehicles, and travelers within transportation systems. Examples in Figure 1 include vehicle detection sensors (VDS), closed-circuit television (CCTV) cameras, dynamic message signs (DMS), and road weather information system (RWIS).

Figure 1. Examples of ITS technology

Also, ITS is the backbone of Traffic Management Centers (TMCs) as shown in Figure 2. TMCs rely on ITS data and technology to monitor traffic flow, identify incidents, and implement strategies to improve overall traffic management. ITS is applied in TMCs through the following:

- **Data Collection**: CCTV cameras, VDS, and weather stations gather real-time information on traffic conditions, weather, and road infrastructure. This data is fed into the TMC for analysis.
- **Traffic Monitoring**: TMC operators use the ITS data to monitor traffic flow, identify congestion points, and detect incidents like accidents or disabled vehicles.
- **Incident Response**: With real-time information on incidents, TMC operators can dispatch emergency services, activate variable speed limit signs, and update dynamic message signs to warn drivers about delays and suggest alternate routes.
- **Traveler Information**: TMCs can use ITS data to provide travelers with up-to-date information on road closures, accidents, and travel times through radio broadcasts, websites, and mobile apps.

From deployments of ITS technology, the TMC is provided with the critical data needed to proactively manage traffic flow, improve safety, and minimize congestion.

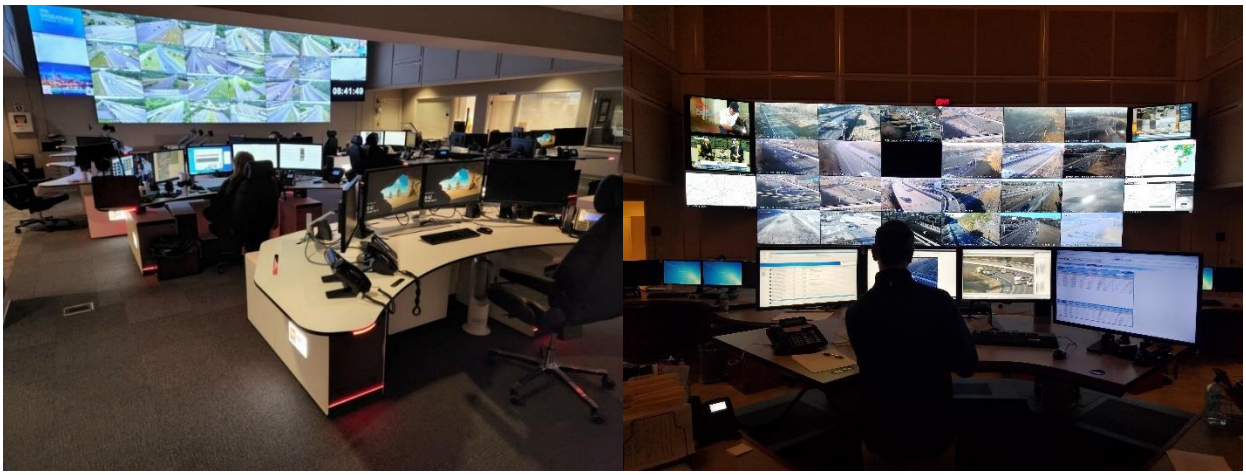

Figure 2. TMC Operations

Value of ITS for Residents

Effective ITS implementation can offer significant benefits for residents, including the following:

- **Improved Safety**: Reduced traffic congestion and accidents by providing drivers with real-time information about road conditions, hazards, incident response or other dangers.
- **Enhanced Mobility**: Smoother commutes and more reliable travel times through real-time traffic data from sensors and cameras and optimized signal control.
- **Reduced Environmental Impact**: Less emissions and fuel consumption from congestion mitigation and optimized traffic flow minimizes.

- **Increased Productivity**: More reliable travel times and efficient travel experience by providing travelers with information about the best route options, real-time arrival times for public transportation, and other services.

CURRENT STATUS

TDOT ITS Program

The Tennessee Department of Transportation (TDOT) maintains an ITS program known as TDOT ***SmartWay*** to focus on improving the efficiency and safety of the state's transportation network. TDOT SmartWay consists of live video cameras to monitor highways from TMCs across the state, sensors to detect and measure traffic flow, and electronic message boards to provide urgent traffic notices and safety messages to drivers on the highway. Currently, the cities of Memphis, Nashville, Chattanooga, and Knoxville have fully integrated TDOT SmartWay systems in the state. Their ITS devices can be viewed on the TDOT 511/SmartWay Map: https://smartway.tn.gov/traffic?features=cameras,incident,messageSign,traffic.

TDOT has also been deploying SmartWay ITS expansion design projects across the state. They include new CCTV cameras, radar detection systems (RDS), DMS, RWIS, travel time message signs (TTMS), fog warning beacons, and fiber optic communications. TDOT has been working closely with local TMC staff to ensure that the deployed projects meet the needs of the TMCs and provide value to the traveling public. In addition to the TDOT 511/SmartWay Map, TDOT uses a separate GIS database of ITS devices and communications including its fiber network along the interstate highways.

In recent years, TDOT has been focusing on the following areas to improve its traffic and ITS operations throughout the state:

- **Integrated Corridor Management (ICM)**: Leverage available capacity across all modes of travel to move people and goods along a corridor through real-time information, predictive tools for anticipating traffic conditions, and decision support systems to balance travel demand across various transportation assets
    - **AI-Based Decision Support System (AI-DSS)**: Develop a system based on artificial intelligence (AI) for improving incident response and traffic management along major corridors such as I-24 and I-40.
    - **Data-Driven Decision Making**: Utilize AI and data from a variety of sources to make more informed decisions about traffic flow, congestion, and safety in developing traffic management strategies.
- **Advanced Traffic Management System (ATMS)**: Deploy additional ITS communications and devices to expand the ATMS systems for improving traffic management and operations.
- **Infrastructure Improvement**: Upgrade the traffic signal controller equipment and system to address safety concerns and improve mobility due to increase in traffic.

ITS Administration, Evaluation, and Deployment

In collaboration with the Knoxville Regional Transportation Planning Organization (KRTPO), TDOT oversees the administration, evaluation, and deployment of ITS in the Knoxville region. To achieve these functions, the Knoxville Regional ITS Architecture document was first developed in 2000. Since then, it has been updated in 2003, 2012, and 2021.

The Regional ITS Architecture document defines how different transportation systems and technologies will work together in a specific region (https://www.tn.gov/tdot/traffic-design/intelligent-transportation-systems/regional-architecture/knoxville.html). This resource serves as a roadmap that ensures all the ITS components including ITS devices communication networks are compatible and can be integrated within the region. Also, it allows stakeholders to plan for what they want their system to achieve and compartmentalize it into different components that can be deployed based on available funding. Developing a regional ITS architecture encourages interoperability and resource sharing among agencies and allows for cohesive long-range planning among regional stakeholders. Furthermore, the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA) require completion and continual updates of the Regional ITS Architecture document before the region can use federal grant funding for ITS projects.

To recap, the Regional ITS Architecture document contains the following key components:

- **Function**: It ensures institutional agreement between local governments and provides technical integration for implementing ITS projects within a region.
- **Benefits**: It improves communication and collaboration among different transportation agencies, leading to a more efficient and safer transportation system.
- **Components**: It outlines existing and planned transportation systems, how they connect, and the data they exchange.
- **Development**: A regional-scale investment like this is typically created by state Departments of Transportation (TDOT) and supported by MPOs (KRTPO) that are similarly based on a national framework and customized for the specific needs of a region.

TDOT and KRTPO collaborated on the update to the Knoxville Regional ITS Architecture in conjunction with the Mobility Plan 2045 effort. After this latest update in 2021, several ITS projects including Traffic Operations Centers (TOC), Advanced Traffic Management Systems (ATMS) for central management of traffic signals, and fiber network expansion have been ongoing throughout Knoxville region. Considering these changes in the ITS infrastructure, a scheduled maintenance and update to the regional ITS architecture is critical for reflecting the current conditions accurately and recording the changes in the region's needs and vision for ITS.

In the Knoxville region, the existing ITS infrastructure comprises wireless VDS, CCTV cameras, DMS, highway advisory radio (HAR) signs, and over-height vehicle detectors (OVD) along the interstate highways. As the Knoxville region continues to grow in population, more focus on urban and suburban ITS strategies will be recommended in coordination with the City of Knoxville, other municipalities, and other stakeholders. This may include, but is not limited to, the following:

- **ATMS Software**: Monitor and manage signals along local and arterial routes from the TOC/TMC.

    - **Adaptive Signal Control**: Configure the signal control algorithm to adjust the signal timing and improving traffic flow real-time to avoid unnecessary delay.
    - **Traffic Signal Coordination**: Optimize signal timing along major roadways to decrease the number of stops and improve traffic flow.
    - **Performance Measurement**: Implement performance metrics to assess the effectiveness of signal timing and make data-driven changes through methods such as Automated Traffic Signal Performance Measures (ATSPM).
- **Transit**
    - **System Information Dissemination**: Alert passengers about bus locations and traffic conditions for more streamlined trip planning during scheduled maintenance or unforeseen delays.
    - **Transit Signal Priority (TSP)**: Adjust the signal timing by either extending the green time for buses on main street or truncating the red time for cross street, which reduces bus wait time at intersections and enhances schedule adherence and/or travel time
    - **Queue Jump**: Install a separate bus signal to allow the bus on a dedicated bus queue jump lane to receive early green time and bypass other vehicles waiting in the queue at the intersection
- **Freeway and Arterial Management**
    - **Ramp Metering**: Control the vehicular flow entering the freeway on the entrance ramp through detectors and traffic signals that are adjusted based on real-time traffic congestion levels on the freeway and on the entrance ramp
    - **Reversible Lane**: Change the travel direction of one or more lanes dynamically through signals as well as signing and marking based on vehicular flow to address heavier traffic volume in one direction

Furthermore, KRTPO intends to leverage ITS projects in the near-term to address travel time reliability as part of its Performance Measure (PM) 3 – System Performance and Freight Reliability and Air Quality along its most significant corridors. Deploying ITS technologies can lead to improving the travel times and achieving more consistent travel times. Based on the importance of PM 3, KRTPO may consider ATMS as well as freeway and arterial management strategies to improve traffic flow by identifying problem areas for congestion, enhancing incident detection, and optimizing signal timing. While connected and autonomous vehicles (CAV) can also accomplish these initiatives, deploying vehicle-to-everything (V2X) communication may be considered in the distant future due to ongoing research and longer timeline for development.

OBSERVATIONS

Considerations for the TPO

As the 2050 Knoxville-Lakeway MTP is developed, several key considerations for KRTPO should be addressed regarding ITS:

- **Prioritization**: Identify critical transportation challenges that ITS deployments can effectively address such as congestion "hot spots" or areas of recurring safety concerns.
- **Funding Strategies**: Explore various funding mechanisms for ITS projects, including public-private partnerships (P3), federal grants, and innovative user-based fees such as intelligent toll systems and congestion pricing.
- **Data Sharing and Integration**: Develop secure and efficient data-sharing protocols to allow for seamless integration between various ITS components and external data sources.
- **Coordination with Local Jurisdictions**: This is a primary function of the TPO, and to this end the needs of ITS can be daunting for smaller communities with more limited staffing resources. The TPO can continue to serve as a conduit for information on best practices, new technology capabilities, and industry trends so that its member jurisdictions are informed to make regional decisions that benefit more than their community.
- **Public Transportation Optimization**: Collaborate with transit agencies to optimize schedules and routes and improve traffic flow across entire corridors.

Improving ITS in the Future

Looking ahead to the next 10 – 25 years, KRTPO should consider strategies for the following:

- **Emerging Technologies**: Advancements in connected and autonomous vehicles (CAV), artificial intelligence (AI), and big data analytics to enhance ITS capabilities and interoperability with other traffic systems or technologies.
- **Security**: Robust physical security and cybersecurity measures to protect ITS infrastructure from attacks that could disrupt critical operations in the transportation network.
- **Accessibility**: Ensure that ITS deployment benefits all residents, including those who may not have access to smartphones or other devices for communication.
- **Data Analytics**: Use data to identify trends in traffic flow and congestion for making informed decisions in prioritizing ITS projects.

ITS is a rapidly evolving field, and new technologies continue to be developed. As ITS continues to advance, it has the potential to make transportation safer, more efficient, and more environmentally friendly.

TPO Coordination Efforts

To prepare for the future, the KRTPO can begin laying the groundwork through the following coordination efforts:

- **Public Outreach**: Educate the public about the values of ITS technology and the benefits of optimizing signal timing and implementing traffic management strategies.

- **Survey and Feedback**: Gather input from the public on their needs and concerns early.
- **Industry Collaboration**: Engage with technology companies, transportation service providers, and research institutions to collaborate and explore innovative ITS solutions that meets all stakeholders' needs and concerns.
- **Training and Development**: Invest in programs that train and equip the workforce with skills necessary to operate and maintain advanced ITS equipment and systems.
- **Public-Private Partnerships**: Collaborate with private-sector partners to streamline the expansion and deployment of ITS solutions.