THE EVOLUTION OF ITS IN TRANSPORTATION ASSET MANAGEMENT

FINAL REPORT

May 6, 2020

ENTERPRISE TRANSPORTATION POOLED FUND STUDY TPF-5(359)

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16. Abstract Intelligent Transportation Systems (ITS) provide cost-effective solutions for agencies to achieve their mobility objectives. Both agencies and travelers are dependent upon the availability and reliability of advanced technologies. As a result, the use of technology is increasing and agencies' investments in ITS assets are increasing along with the effort required to plan, procure, manage, and operate them. The purpose of this report is to summarize the current state of ITS asset management, both in the ENTERPRISE member agencies and across North America, and to describe the attributes and criteria being used to effectively support ITS asset management.			
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Project Champion

Kevin Price, Illinois Department of Transportation (IDOT) and Barbara Russell, Texas Department of Transportation (TxDOT), served as the ENTERPRISE Project Champions for this effort. The Project Champions served as the overall lead for the project.

ENTERPRISE Members

The ENTERPRISE Board consists of a representative from each of the following member entities of the program:

- Illinois Department of Transportation
- Iowa Department of Transportation
- Kansas Department of Transportation
- Michigan Department of Transportation
- Minnesota Department of Transportation
- Ontario Ministry of Transportation
- Pennsylvania Department of Transportation
- Texas Department of Transportation
- Wisconsin Department of Transportation

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Contents

1.0 Report Overview

1.1 Purpose

Intelligent Transportation Systems (ITS) provide cost-effective solutions for agencies to achieve their mobility objectives. Both agencies and travelers are dependent upon the availability and reliability of advanced technologies. As a result, the use of technology is increasing and agencies' investments in ITS assets are increasing along with the effort required to plan, procure, manage, and operate them.

The purpose of this report is to summarize the current state of ITS asset management, both in the ENTERPRISE member agencies and across North America, and to describe the attributes and criteria that can be used to effectively support ITS asset management.

1.2 Report Summary

This report is comprised of the following sections:

1. **Report Overview**, describing the purpose of this project and the content of this report.
2. **Background** information on existing ITS asset management activities and research.
3. **ITS Assets** providing a summary of the types of devices, systems, and infrastructure that can be considered ITS assets.
4. **ITS Asset Attributes** describes typical characteristics of ITS devices and systems that may be useful to document for the purpose of managing and investing in them.
5. **ITS Asset Management Criteria** discusses the unique characteristics of ITS and the criteria that may be used to assess its performance, health, lifecycle, and value.
6. **Current ITS Asset Management Practices in ENTERPRISE Member Agencies**, summarizing the current state of ITS asset management in the member agencies, including their common challenges and best practices.

2.0 Background

Interest in ITS asset management has grown in recent years because of the increasing investment DOTs are making in technology and the reliance upon it. While there is a lack of guidance and consistency in ITS asset management and reporting, there have been efforts made to document and manage ITS assets. This section discusses recent and current ITS asset management activities.

2.1 Federal Efforts

There are numerous actions that have been taken or are underway at the federal level. The following is a brief summary of those efforts that have been identified.

- **Transportation Asset Management Plans**
  The Moving Ahead for Progress in the 21st Century (MAP-21) Act was passed in 2012. The Act established a performance-based highway program with the goal of "improving how Federal transportation funds are allocated."[1] State departments of transportation are required to submit an annual Transportation Asset Management Plan (TAMP) to the Federal Highway Administration (FHWA) that is intended to serve as a "strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle."[2] A TAMP provides a framework for resource allocation and utilization to optimize transportation investment decision making using quality data and consistent analysis. FHWA requirements for the TAMP are for reporting and analysis on, at a minimum, bridges and pavement. The FHWA provides guidance to states on the content and analysis of assets in TAMPs to ensure consistent reporting.

  MAP-21 requires each state to develop a risk-based TAMP that must contain:
  - **A summary of bridge and pavement assets on the National Highway System within the state**, such as quantities of bridges or miles of pavement
  - **A condition report for bridges and pavement**, often in terms such as "Good," "Fair," and "Poor" condition
  - **A performance gap identification**, which describes the gap between the existing and predicted performance level for each asset type and the level required based on current and future factors, such as traffic demand growth
  - **Lifecycle costs**, defining capital and maintenance and operation costs for assets and the methodology for determining the costs
  - **Risk management analysis**, analyzing the programmatic and system risks associated with the assets
  - **A financial plan** that summarizes the funding outlook for managing the assets in the short and long terms
  - **Investment strategies** that describe key work strategies that have been derived from the asset management process

[1] Generic Work Plan for Developing a TAMP (FHWA, 2013)
[2] TRB Report 632 (National Cooperative Highway Research Program, 2009)

Although optional, states may include assets beyond bridges and pavement in their TAMPs, and many do. Some include other infrastructure such as culverts and guardrails. Others include technologies, including ITS. Examples of ITS in FHWA-submitted TAMPs are summarized in this report. Because reporting ITS is not required in federal TAMPS, there is no consensus on what ITS assets are or how to manage them. There is currently a lack of guidance for consistent data collection and analysis that is needed to consistently report ITS asset condition, performance, lifecycles, and potential risks. Similarly, the lack of guidance limits the number of standard tools and resources available to agencies seeking to manage ITS assets.

- **ITS Asset Viewer**

  The ITS Joint Program Office (JPO) launched the ITS Asset Viewer web site[3] developed by Oak Ridge National Laboratory in 2013. Using a survey of states and municipalities, the JPO developed a website that provides a map-based view of ITS asset inventory across the United States. The site focuses primarily on ITS field devices and classifies them in groups such as message signs, cameras, and traffic control. The inventor is dependent upon states' survey responses, and the site includes some device attributes, such as its manufacturer and type, when states provided them. Unfortunately, the ITS Asset Viewer has received few updates since its launch, and the data does not accurately represent the current inventory of many states.

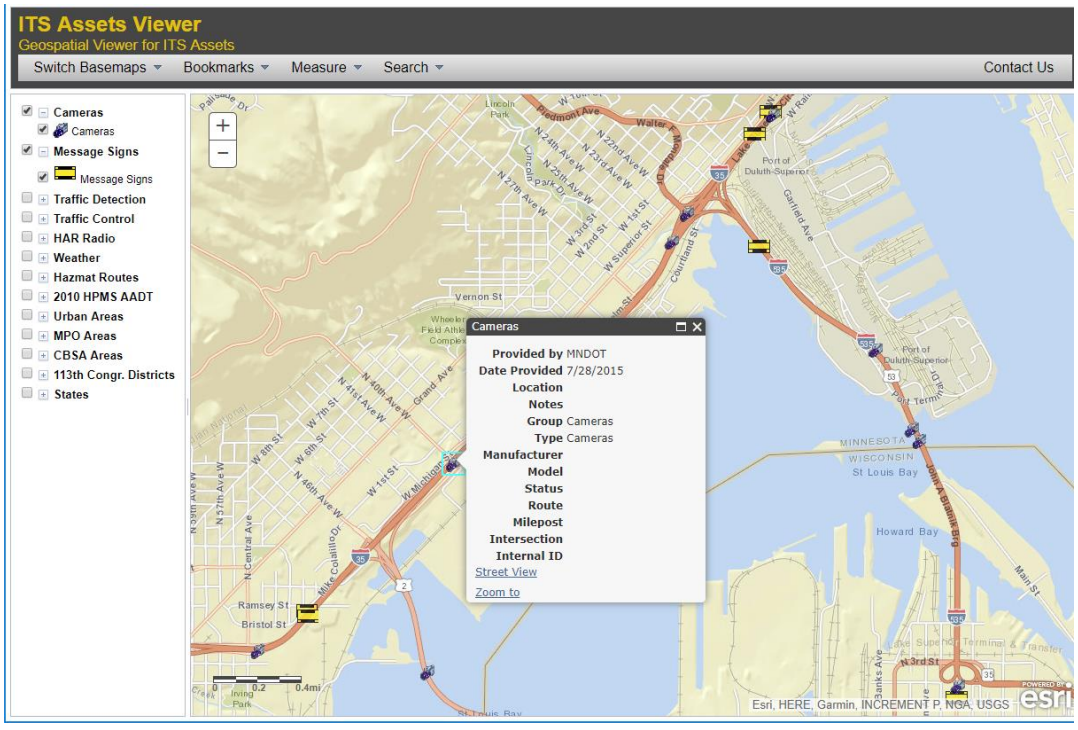

Figure 1: Screen Capture of FHWA ITS Asset Viewer

[3] ITS Asset Viewer, https://www.itsassets.its.dot.gov/

- **FHWA ITS Asset Management Studies**
  The FHWA is currently undertaking studies that will provide guidance on how to incorporate ITS asset reporting as part of a state's federally required TAMP. An additional federal study is documenting the role of ITS asset management in Transportation Systems Management and Operations (TSMO). These efforts are forthcoming but reflect an increased interest in supporting ITS asset management at the federal level. Although there is no official date for the release of the studies, they are expected to be made public in 2020.

2.2 Reporting of ITS in TAMPs

In addition to pavement and bridges, some states report on ITS in their TAMP to document their state's inventory, value, and condition. The NWP ITS Asset Management study reviewed several TAMPS that included assets that are considered ITS. The TAMPs reviewed are summarized in **Table 1**.

The table lists for each TAMP:

- Agency that developed the plan
- Whether the plan was submitted to the FHWA
- ITS asset classes included in the plan
- The extent to which ITS assets were reported, including condition, asset value, risk analysis, and funding considerations

Table 1: ITS Assets in TAMPs

State – Plan (Year)	FHWA Submittal	ITS Asset Classes Included	Condition	Performance Targets	Lifecycle Costs	Risk Analysis	Funding
Alaska – Asset Management Synthesis for the Parks Highway Corridor (2012)	N	• Field Devices	Y	N	N	N	N
California TAMP (2017)	Y	• Field Devices	Y	N	N	N	N
Colorado Risk Based Asset Management Plan (2013)	N	• Field Devices • Communications	Y	Y	Y	Y	Y
Connecticut TAMP (2018)	Y	• Field Devices	Y	Y	N	N	N
Georgia TAMP (2014)	Y	• Field Devices • Communications and Networking • Hardware	N	N	N	N	N

State – Plan (Year)	FHWA Submittal	ITS Asset Classes Included	Condition	Performance Targets	Lifecycle Costs	Risk Analysis	Funding
Minnesota TAMP (2018)	Y	• Field Devices • Communications • Hardware and Software	Y	Y	Y	Y	Y
New Jersey TAMP (2014)	Y	• Field Devices • Software	Y – for signals	Y – for signals	N	N	Y
Pennsylvania TAMP (2014)	Y	• Field Devices	N	N	N	N	N
Rhode Island TAMP (2018)	Y	• Field Devices • Communications and Networking • Hardware and Software	Y	Y	Y	Y	Y
Utah TAMP (2018)	Y	• Field Devices • Communications	Y – reports whether or not devices are opera-tional	Y	Y	Y	Y

The review of existing TAMPs with ITS assets illustrated that, at least in part due to lack of guidance, there is little consistency in what or how states assess and report ITS. In addition, the criteria used to assess bridge and pavement conditions indicating poor, fair, and good may not be appropriate for ITS. In fact, states varied in how they determined the condition of their ITS. Some determined condition based solely on age, such as that all traffic signals over 25 years old are in "poor" condition, while all signals newer than ten years are "good." Others used operational status to indicate condition; devices are either "operational" or "non-operational."

As is discussed in this document, ITS has unique attributes and requires its own criteria to determine the current and future value of assets.

3.0 ITS Assets

Table 2 provides a list of ITS assets that has been developed through interviews with ENTERPRISE members and NWP states, the device inventory in the FHWA ITS Asset Viewer, and through literature review. The table lists the asset class, provides asset types that further distinguish the assets by function, and presents examples of assets that may fall within each type. The examples are not exhaustive because states may have unique assets, and not all agencies consider all example assets to be ITS. For example, some states do not classify hardware and software as ITS because it is owned and maintained by their information technology groups.

Table 2: ITS Asset Classes

Asset Class	Asset Types	Asset Examples
Field Devices	Cameras	• Traffic • Video detection • License plate reader
	Connected and Automated Vehicle	• Roadside Units (RSUs) • Antennas
	Emergency Call Boxes	• Call Boxes
	Electronic Clearance	• Toll plazas • Commercial vehicle ports
	Highway Advisory Radio (HAR)	• Broadcast units
	Message Signs	• Dynamic Message Signs (DMS) • Blank out
	Sensors	• Traffic detectors • Commercial vehicle dimension • Weigh in Motion (WIM) • Roadway intersection conflict warning systems
	Road Weather Information Systems (RWIS)	• Stations
	Traffic Control	• Controllers • Gates • Lane control • Pre-emption signals • Ramp meters • Reversible lane sign • Signals • Variable Speed Limit • Warning flashers
	Traffic Detection	• Detectors
	Weigh in Motion	• Fixed • Portable
Communications and Networking	Communications	• Fiber • Copper • Wireless
	Networking	• Networking hardware • Video equipment

Asset Class	Asset Types	Asset Examples
Hardware/ Software	Servers	• On-site server facilities • On-site servers • Workstations
	State-owned, licensed, cloud-based software	• Asset management • Connected vehicle • Geographic Information Systems (GIS) / Linear Referencing Systems (LRS) • Maintenance Decision Support Systems (MDSS) • Traffic management • Traveler information • Video management
Portable	Mobile	• Probes (e.g. snowplows), courtesy vehicles
	Portable	• Smart work zone • Arrow boards • Portable DMS, cameras, etc.

4.0 ITS Asset Attributes

Attributes describe the characteristics of ITS devices and systems. Attribute data can be used to track the ITS assets owned and/or operated by an agency, and as input into the process of determining the performance and effectiveness of ITS assets in achieving agency objectives. Attribute data that an agency collects can be categorized in the following areas:

- **Inventory** quantifies the ITS assets and their associated elements.
- **Location** identifies where devices and systems are located.
- **History** tracks the age of assets and their maintenance and other notable events and activities that may impact them.
- **System environment** describes the electronic platforms upon which ITS assets operate.
- **Infrastructure** describes elements that are not specifically part of ITS assets but are required for their operations.

This section provides more detail on the attributes in each of the attribute areas. Not all attributes described are applicable for every ITS asset, and **Table 3** is a matrix that follows the descriptions and maps the most appropriate attributes to ITS asset classes from Table 2.

4.1 Inventory

Inventory provides an agency with a basic count and understanding of the ITS assets it owns. The inventory can include a record of individual devices and of multiples of similar or identical devices. Within ENTERPRISE, the agencies track inventory through a range of tools that include customized databases, spreadsheets and within other systems, such an ATMS or ATIS. However, some agencies use different tools for different assets. Agencies may also not centralize their inventories and have that information tracked separately in different regions.

Attributes that can be associated with inventory are:

- **Functional description** – A description of the device, such as camera, sign or detector, that allow it to be grouped with assets with similar functionality.
- **Make and model** – The manufacturer and specific model for each ITS asset an agency owns.
- **Serial number** – This distinguishes the assets within assets of the same make and model and allows for documenting attributes separately for each asset.
- **Specifications** – Specifications define the expected functionality and performance of an asset. For example, camera assets may be fixed or pan/tilt/zoom.
- **Quantity** – The number of assets to allow for grouping by type, functional description, make and model or other attributes.
- **Components** – For assets with swappable components, such as a DMS with a logic or control board or modem, it may be valuable to track those components. This information is valuable in understanding the need for and availability of spares and to more accurately identify strengths and weaknesses of specific assets.
- **Capital costs** – Capital costs represent those costs associated with the initial procurement and deployment of ITS assets. The capital costs for similar assets may be different for several reasons

including environment, deployment timing, fluctuating purchase prices, and the level of infrastructure required for the asset's deployment.

- **Contract and warranty** – For each asset, procurement contract information allows for referring to information such as terms and conditions and the start and end dates of warranty periods.
- **Status** – This may describe the current status for each asset, such as whether it is operational, non-operational, retired, or stored as a spare.

4.2 Location

The location of an ITS asset provides information that may be useful in understanding its relationship with other devices and systems, and other agency activities, such as construction projects. Location also enables an agency to view assets geospatially and to perform geospatial analysis, such as the impact of a DMS on detours at interchanges. Within the ENTERPRISE member agencies, location data is collected for field devices. However, how it is documented varies. In some cases, the location data is stored in a GIS database, or the inventory is related to a GIS. In other agencies, the latitude, longitude and other information, such as roadway and reference marker, are stored in a spreadsheet along with inventory.

Attributes that can be associated with location are:

- **Physical location** – The current location of an ITS asset. This may be in the field for a device, or at a facility for a server. In addition, some assets that are not currently deployed may be noted as being in storage or retired.
- **Physical environment** – Environmental factors such as elevation, temperature range, precipitation, and wind may inform requirements for a deployment, the asset's performance, and lifecycle.
- **Vehicle information** – For mobile and portable equipment, vehicle information may include type of vehicle, vehicle identification, power capabilities, and the home yard location for the vehicle.

4.3 History

ITS asset history describes what has happened to an asset, including the construction, maintenance, and costs of a device and can provide a timeline of when all activities occurred. History includes the timing and actions of all preventative maintenance and maintenance requests, the costs associated with labor and replacement parts, and whether the device or its components are deactivated or installed in a different location. ITS asset types may include very different types of details for history. For example, a central software system history would be expected to be documented very differently from a device installed in the field.

Attributes that can be associated with history are:

- **Procurement date** – This is the date an asset was procured and put into inventory by an agency.
- **Deployment date** – This date is when an asset is actually deployed and operational. This will likely be after procurement because of such factors as testing, or a device being placed at the roadside during a construction project but not operational until the project is complete. Depending on the contract, a warranty can start at procurement, deployment, or another agreed upon date.
- **Performance history** – The level of functionality provided by an ITS asset as measured periodically. Performance history may be documented as the ability of a system to achieve its

performance specifications. Performance history is particularly valuable for ITS assets and components that are expected to degrade over time, such as solar panels, batteries, or devices that experience wear and tear.

- **Maintenance history** – The maintenance activities performed on an asset, both scheduled and unscheduled. For ITS assets, maintenance may also include multiple locations if an asset has been moved and the replacement of components.
- **Maintenance and operations costs** – This represents the costs of operating and maintaining ITS assets, to the extent that those costs can be assigned specifically to assets. These costs are historical and may vary from year to year depending on the needs of an asset and how it is operated.
- **Condition** – Condition may be assessed from visual inspection and testing as part of maintenance activities. Recording the condition of assets over time allows for identifying trends in performance and reliability, and the impact of maintenance activities.

4.4 System Environment

The system environment is different than the physical environment and describes the technology platform required for an ITS asset to perform its functions. These attributes are relevant to those that have processing capabilities and require underlying subsystems, such as operating systems and databases in order to function. In the ENTERPRISE member agencies, the system environment can be important because agencies seek to deploy systems that are consistent with their experience and abilities to administer and operate systems.

Attributes that can be associated with system environment are:

- **Software and firmware** – Software and firmware represent the version of any system code and any operating system a system requires. This information is useful in understanding if the asset is up to date with the most recent desired versions or may have security vulnerabilities.
- **Hardware** – Some ITS assets are a combination of software and hardware and they may rely on specific hardware, such as servers with a minimum resident memory, processing speeds, physical data storage, and rack space.
- **Licenses** – Agencies may not own some software assets and instead license them. The licenses may require renewal. Also, some assets, such as HAR and RSUs for connected vehicle communications, may require licensing by the FCC that the agency will maintain and renew.

4.5 Infrastructure

ITS Assets frequently rely on infrastructure for placement, protection from the environment and the utilities necessary to operate. Awareness of the infrastructure attributes may be valuable in understanding the full extent of maintenance and costs for an asset. In the ENTERPRISE member agencies, data is collected and considered part of ITS assets that includes infrastructure such as poles, concrete mounts, as well as the providers of utilities and the capacities of the utilities at field sites.

Attributes that can be associated with infrastructure are:

- **Infrastructure** – Some assets require physical infrastructure such as poles, concrete bases, and guardrails that require maintenance and replacement, or may be used for multiple ITS assets.
- **Utilities** – Field assets may rely on utilities such as power and communications that are provided by third parties. The providers of the utilities and their contact information may be valuable when troubleshooting assets that are not functioning.
- **Enclosures** – Enclosures, such as cabinets, may house field ITS devices or their components. The size, available space and capacity of the enclosures may be valuable information in determining upgrades or the addition of other ITS assets at a location.

4.6 Relevant Attributes by Asset Class

Table 3 maps the attributes to the classes of ITS assets from Table 2. For each class, a **Y** means that the corresponding attribute may be valuable for ITS asset management. An **N** means the corresponding attribute may not be relevant for that ITS class. Because of the diversity of ITS devices and systems, the table is guidance for an agency in identifying the appropriate attributes and is not definitive.

Table 3: Attributes by Asset Type

Attribute		Asset Classes			
Area	**Attribute**	**Field Devices**	**Comm. and Networking**	**Hardware/ Software**	**Portable**
Inventory	Functional description	**Y**	**Y**	**Y**	**Y**
	Make and model	**Y**	**Y**	**Y**	**Y**
	Serial number	**Y**	**Y**	**Y**	**Y**
	Specifications	**Y**	**Y**	**Y**	**Y**
	Quantity	**Y**	**Y**	**N**	**Y**
	Components	**Y**	**Y**	**N**	**Y**
	Capital costs	**Y**	**Y**	**Y**	**Y**
	Contract and warranty	**Y**	**Y**	**Y**	**Y**
	Status	**Y**	**Y**	**Y**	**Y**
Location	Physical location	**Y**	**Y**	**Y**	**N**
	Physical environment	**Y**	**Y**	**N**	**N**
	Vehicle information	**N**	**N**	**N**	**Y**
History	Procurement date	**Y**	**Y**	**Y**	**Y**
	Deployment date	**Y**	**Y**	**Y**	**Y**
	Performance history	**Y**	**Y**	**Y**	**Y**
	Maintenance history	**Y**	**Y**	**Y**	**Y**
	Maintenance and operations costs	**Y**	**Y**	**Y**	**Y**
	Condition	**Y**	**Y**	**Y**	**Y**
System Environment	Software and firmware	**Y**	**N**	**Y**	**Y**
	Hardware	**Y**	**N**	**Y**	**Y**
	Licenses	**Y**	**Y**	**Y**	**Y**
Infrastructure	Infrastructure	**Y**	**Y**	**N**	**N**
	Utilities	**Y**	**Y**	**N**	**N**
	Enclosures	**Y**	**Y**	**N**	**N**

5.0 ITS Asset Management Criteria

The goal of ITS asset management is to optimize an agency's ITS investment. Optimization requires an agency to make decisions regarding whether and when to maintain, upgrade, replace, or discontinue investing in assets. Criteria are mechanisms agencies use to make objective judgments about their ITS assets. Each agency's determination is unique and based on its own set of criteria to understand the following about its ITS assets:

- **Performance prediction** – The anticipated future performance of existing and potential ITS assets and their alignment with agency needs.
- **Cost prediction** – The predicted costs to procure, deploy, operate, and maintain ITS assets, including money that has already been spent.
- **Other Considerations** – Other considerations are criteria that agencies may include in their determination of ITS asset management but are typically beyond the control and evaluation of the specific ITS assets. They include factors such as agency mission and the impact of other projects on ITS assets.

This section describes criteria used by the ENTERPRISE member agencies and other states to make ITS asset investment decisions. For each criterion, the attribute data that may be useful in analysis is listed.

5.1 Performance Prediction

Performance prediction criteria reflect the anticipated ability of existing and potential ITS assets to provide the functionality expected and needed by an agency. These criteria build on attributes to estimate maintenance needs and costs, as well as considerations regarding replacement of the asset. ENTERPRISE member agencies have generally indicated difficulty in predicting performance. However, some states, including Wisconsin and Pennsylvania have developed systems with capabilities to support this function in the future.

The criteria that may be used to evaluate the performance of ITS assets are described in **Table 4**. For each criterion, the attributes that may be valuable in performing analysis of the criterion are listed.

Table 4: Performance Prediction for ITS Assets

Criteria	Description	Associated Attributes
Performance Trend	This criteria measures change in performance of an ITS asset over time. For example, as a weigh-in-motion sensor in the roadway ages, it may become less accurate and, therefore, provide less valuable data. Or, a camera may experience deterioration of the lens or fogging of a plastic housing that results in lower-quality pictures.	**Inventory** • Make and model • Serial number • Specifications • Quantity • Components • Contract and warranty • Status **Location** • Physical environment **History** • Procurement date • Deployment date • Performance history • Condition **System Environment** • Software and firmware • Hardware
Reliability Trend	As some ITS assets age, they may become less reliable. Reliability trends can be exhibited as requiring more maintenance, replacement of components, an asset experiencing more downtime or providing less useful data. In addition, an asset may be expected to be more or less reliable based on the environment it is placed in.	**Inventory** • Make and model • Serial number • Specifications • Quantity • Components • Contract and warranty • Status • Software and firmware • Hardware **Location** • Physical environment **History** • Procurement date • Deployment date • Maintenance history • Condition

Criteria	Description	Associated Attributes
Predicted Lifespan	The predicted lifespan of an ITS asset is the length of time it can be expected to perform to the level required by the agency. Agencies often forecast lifespans based on their experience with similar assets. When adequate data is unavailable, agencies often use the warranty period to estimate lifespan.	**Inventory** • Functional description • Make and model • Specifications • Components • Contract and warranty **Location** • Physical environment **History** • Procurement date • Deployment date • Maintenance • Condition **System** • Software and firmware • Hardware • Licenses
Needs Assessment	An agency's needs constantly change and existing ITS assets may be evaluated to determine whether they adequately meet current and future needs. This criterion helps in determining whether newer or different technologies should be considered. Another consideration for needs is whether an agency uses a system adequately, or whether it is paying for and maintaining more capability than needed.	**Inventory** • Functional description • Specifications • Quantity **History** • Performance history • Condition
Technology Support	Technology evolves. This can result in shifts in ITS to take advantage of technological advancements. As a result, existing systems may become obsolete, no longer cost effective, or built upon components and standards that are not or may no longer be supported. For example, components for cameras that perform as expected may no longer be available because cheaper and better cameras have become available.	**Inventory** • Functional description • Make and model • Serial number • Specifications • Components • Contract and warranty **System Environment** • Software and firmware • Hardware • Licenses
Infrastructure Impacts	Existing and planned infrastructure may impact the future performance of ITS assets. This can include the placement of existing infrastructure, such as that resulting from realigning or widening a road, and changes in utilities, such as the extension of fiber optic to a location or changes in cellular coverage and technologies.	**Location** • Physical location • Physical environment **Infrastructure** • Infrastructure • Utilities • Enclosures

5.2 Cost Prediction

Life cycle costs (LCC) refer to all costs associated with the acquisition and ownership of a product or system over its full life. Those costs may be for existing and potential ITS assets and include costs and expenses related to procurement, deployment, maintenance, and operations. Reliable lifecycle costs support accurately determining the most effective use of ITS assets, planning, budgeting and requesting funding. The criteria that may be used to evaluate ITS asset costs are described in **Table 5**.

Table 5: Cost Prediction for ITS Assets

Criteria	Description	Associated Attributes
Deployment Costs	Deployment costs are those associated with the procurement and implementation of ITS assets. It may include costs that can be associated from planning through the start of the asset's operations. This value may be useful to determine the quantities and timing of new ITS assets in budgeting. Deployment costs for new assets can be estimated based on information from vendors and the experience of other states.	**Inventory** • Make and model • Quantity • Capital costs **Location** • Physical location • Physical environment • Vehicle information **Infrastructure** • Infrastructure • Utilities • Enclosures
Ongoing Costs	Based on an asset's history, costs, performance, and reliability predictions, an agency can calculate previous ongoing costs and predict future ongoing costs. This value may be useful to determine the ongoing operations and maintenance costs for budgeting. Ongoing costs of new assets can be estimated based on information from vendors and the experience of other states.	**Inventory** • Make and model • Quantity • Components • Contract and warranty • Status **Location** • Physical location • Physical environment • Vehicle information **History** • Performance history • Maintenance and operations costs • Condition

Criteria	Description	Associated Attributes
Net Present Value	Net present value represents what an asset is worth at the present time. It is not based on the money that has been invested in an asset, but rather in the value the asset provides and the predicted remaining lifespan for the asset. Net Present Value allows for a value comparison of existing assets with potential alternatives.	**Inventory** • Make and model • Quantity • Specifications • Components • Capital costs • Contract and warranty • Status **History** • Performance history • Maintenance and operations costs • Condition
Lifecycle Costs	Lifecycle costs represent the costs of a system over its entire lifespan. It factors the deployment and ongoing costs over the predicted lifespan and considers factors such as the potential for increased costs for maintenance as an asset ages. Lifecycle cost provides a mechanism for an agency to compare the total cost of different alternatives.	**Inventory** • Make and model • Quantity • Specifications • Components • Capital costs • Contract and warranty • Status **History** • Performance history • Maintenance and operations costs • Condition

5.3 Other Considerations

While performance and cost prediction criteria provide quantifiable data to support ITS asset management decisions, agencies identified other considerations that may impact the further investment in existing assets or the procurement of new assets. This section provides a brief discussion of the considerations identified by the ENTERPRISE member agencies.

5.3.1 Agency Goals and Objectives

Agency goals and objectives change due to a variety of factors that are beyond the control of the staff performing ITS planning and asset management. The factors can include changes in the administration and their vision of technology use, financial impacts such as reductions or increases in the state budget, or reallocation of funds.

5.3.2 Functional Obsolescence

Many ITS technologies continue to rapidly evolve and that creates the risk of ITS assets becoming functionally obsolete before the end of their predicted lifespan. Functional obsolescence can be the result of a variety of factors:

- **Assets are no longer supported** – Some technologies lose technical support because vendors go out of business or adopt more advanced or improved devices or systems that can provide the same or more functionality. As states transition to the newer technology, there is little incentive for vendors to continue to support a small number of older deployments and, therefore, spare parts or technical support may not be provided.
- **Firmware and software obsolescence** – ITS assets may be built using code or software platforms that become obsolete before the systems would otherwise stop functioning. Firmware and software can become obsolete if significant and unrepairable security vulnerabilities are discovered, if it is built upon code that cannot be updated, or if it does not work with newer systems. An example is an ITS asset built upon the Windows 7 operating system, which is no longer supported by its developer Microsoft. If the asset cannot be migrated to a newer operating system, an agency would be forced to choose to either disable a system or continue operating it with no technical support and no remedies if it becomes unstable or a security risk.
- **"Sunsetting" standards** – As with technology, the standards for communications among ITS can evolve, and the previous standards defined for ITS to communicate data can be "sunsetted." Existing systems may perform as expected but are unable to communicate effectively because the defined standards have changed and not all systems are able to use the most recent versions.

Additional information on obsolescence can be found in the ENTERPRISE report "Evolving and Phasing Out Legacy ITS Devices and Systems.[4]"

5.3.3 Alignment with Other Activities

Other activities in an agency may represent barriers or opportunities for ITS asset investment. By coordinating early in the planning process, ITS asset managers can identify when construction or other projects may impact the operations or performance of existing ITS or be an opportunity to cost-effectively deploy new assets. For example, an agency seeking to deploy a weigh-in-motion sensor may work with a

[4] Evolving and Phasing Out Legacy ITS Devices and Systems, http://enterprise.prog.org/Projects/2019/evolving-and-phasing-out-legacy-ITS-devices-and-systems.html (ENTERPRISE Program, 2019)

district to coordinate resurfacing the road to meet the specifications required by the sensor. Such coordination may require the schedule of either the resurfacing or sensor installation to be accelerated or delayed and ultimately result in lower costs and a more effective deployment.

6.0 Current ITS Asset Management Practices in ENTERPRISE Member Agencies

This section provides a brief summary of the current practices in the ENTERPRISE member agencies. It is followed by a more detailed discussion of the activities related to ITS Asset Management, including the challenges encountered and best practices employed by the member agencies.

6.1 Summary of Agency Practices

Table 6 provides a high-level summary of the current status of ITS asset management in the ENTERPRISE member agencies. The information has been collected through interviews and the review of documentation. The summary briefly lists:

- Each state/province participating in an interview
- If there is a formal plan for managing ITS assets and what that plan is called
- The classes of ITS that the agency considers part of its ITS assets
- Any tools, such as software, used by the agency to document and manage ITS assets
- Information that clarifies each agency's status or activities.

Table 6: Current ITS Asset Management by Agency

State/ Province	ITS Asset Management Plan	ITS Asset Classes Managed	Asset Management Tools Used	State Notes
Illinois	ITS is referenced in long-term plan.	• Field Devices • Communications and Network • Portable devices (maintained and tracked at the district level)	The Traveler Information System is repository for some device information.	• Most ITS asset management is done at the district level, where they are maintained, with no specific tool or centralized system. • The Chicago district is most advanced and does have a system for managing ITS in the district. Their system may be upgraded and may also become used statewide. • State is currently working on a fiber management strategy.
Iowa	No formal ITS management plans.	• Field Devices • Communications and Network	The Advanced Traffic Management System (ATMS) contains location and inventory of	• Net Designer[5] software is used to track fiber communication network. • OnRamp by Oracle[6] is used by maintenance contractor to track inventory and maintenance records including device age.

[5] Net Designer Software, https://www.enghousenetworks.com/net-designer/
[6] OnRamp Application, https://docs.oracle.com/en/cloud/saas/data-cloud/data-cloud-help-center/Platform/ManagingTaxonomy/onramp.html

State/ Province	ITS Asset Management Plan	ITS Asset Classes Managed	Asset Management Tools Used	State Notes
			devices, but limited detail.	• State has hired a consultant to study its ITS asset management needs.
Kansas	Two Long-range ITS Asset Management Plans for the Kansas City area and for Statewide and Wichita.	• Field Devices	Field devices are inventories and tracked in Excel spreadsheets.	• The Statewide asset management plan describes Wichita separately because of the quantity of devices in the area. • Maintenance is part of annual ITS budget.
Michigan	No formal ITS management plans.	• Field Devices • Communications and Networking • Central Systems	A custom database developed by a consultant contains a centralized inventory.	• Various ITS assets are managed by different groups and each group documents and manages them separately. • ITS budget also includes infrastructure for ITS, such as air conditioning and tower poles. • The centralized database has reporting capabilities for maintenance, condition reporting and cost management.
Ontario	ITS documented in a provincial ITS Investment Plan.	• Field Devices • Communications and Network • Hardware and Software • Mobile and Portable	Excel worksheets (1 for field devices, 1 for central systems) track ITS field inventory and characteristics.	• The Excel worksheets are very detailed and contain significant information on each device. • Communication field switches and hardware related to ITS devices are tracked by fiber network and are not part of ITS. • Ontario also considers purchased data, such as bluetooth traffic data, as an asset, but it is not currently tracked. • Are seeking to consolidate data in Excel into a single centralized location.
Pennsylvania	ITS is included in federally-submitted TAMP. ITS is also included in regional	• Field Devices • Mobile and Portable	The custom Traffic Signal Asset Management System (TSAMS) includes inventory,	• TSAMS[7] is a custom-built database for PennDOT and has been enhanced over time to include ITS. • TSAMS tracks ITS assets and includes mapping but does not

[7] TSAMS Landing Page, https://www.tsams.penndot.gov/tsams/login.do

State/ Province	ITS Asset Management Plan	ITS Asset Classes Managed	Asset Management Tools Used	State Notes
	operations plans.		condition, and reporting tools.	do some analysis, such as performance prediction. • PennDOT would like to see ITS systems (e.g. ATMS) added to TSAMS.
Wisconsin	ITS Strategic Plan is used to plan investment for next three years.	• Field Devices • Communications and Networking (limited)	Vueworks[8] commercial traffic operations asset management software is used.	• There is a statewide ITS maintenance contract that covers maintenance of ITS field devices. • Still in the process of populating the Vueworks databases.

6.2 ITS Asset Management Challenges

In interviews, the ENTERPRISE member agencies expressed their challenges in performing successful ITS asset management. Many of the challenges were echoed by multiple agencies and a set of common challenges were identified. This section describes those challenges as they relate to attributes and criteria.

6.2.1 ITS Asset Attribute Challenges

As previously discussed, attribute data provides the foundation for making informed decisions on ITS asset investment. The following are the challenges the ENTERPRISE member agencies identified.

Within ENTERPRISE, the agencies track inventory through a range of tools that include customized databases, spreadsheets, and within other systems, such an ATMS or ATIS. However, some agencies use different tools for different assets. Agencies may also not centralize their inventories and have that information tracked separately in different regions.

- **Management of ITS asset management data**

  ITS asset data collection and management requires coordination among multiple stakeholders. The first challenge is to have a tool or process for collecting and storing the data. There are many commercial tools that support traditional transportation asset management including software that integrates and interfaces with other state systems such as GIS or Linear Referencing Systems and maintenance tracking systems. The availability of similar tools for ITS is limited. As reported in Table 6, some agencies have developed custom tools, while others have procured highly customized commercial products. Both approaches require tools with significant flexibility in order to capture all of the ITS asset types and attributes.

  Management of ITS asset management data also requires staff coordination. Some agencies indicated that ITS is currently stored in different locations and different systems, such as at the regional level or in different repositories for different ITS asset types. For example, data regarding traffic management field devices may be stored in a traffic management system, while RWIS is stored in a maintenance support system. In some cases, different attributes are stored in different

[8] Vueworks Home Page: https://www.vueworks.com/

systems for a single asset, such as condition and maintenance history in a maintenance management system, while location and make and model were stored in GIS.

- **Consistent definitions of ITS assets and attributes**

  Agencies indicated a significant challenge in asset management is having access to reliable data on ITS asset attributes. The federal definition of ITS is "electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system[9]." This definition is intentionally broad, and agencies typically define their ITS assets more narrowly. However, when agencies develop their own definitions, it potentially limits the value of that data to their own uses because it is more difficult to combine or compare with the data collected by other agencies.

  Clear national guidance on the assets and attributes that are valuable to collect could provide agencies with a framework and the knowledge that other agencies are collecting the same data. This will be valuable in predicting the performance and costs of ITS assets and potential alternatives. In addition, clear definition of ITS assets and attributes may encourage software developers to build ITS asset management tools by reducing the amount of customization and cost required for each deployment.

- **Documentation of ITS asset management practices**

  Closely related to the lack of consistent definition is that there are few resources available to agencies to guide ITS asset management. The result is as indicated in Tables 2 and 6 where each state develops their own definitions of assets, criteria, and documentation of ITS assets. Traditional transportation asset management has many available information resources, and the FHWA provides guidance through an asset management subsection of its web site.[10] However, to date there is little documentation to support ITS.

  Agencies stated they would like documentation based on broad surveys of agencies to help them understand expected lifecycles of assets, likely trouble issues for specific devices, and sample maintenance documents that can be used to estimate ongoing costs and to include in third-party maintenance contracts.

- **Guidance on maintenance and inspection**

  A common theme among ENTERPRISE member agencies was a need to better understand how to maintain and evaluate the health of their ITS assets. Agencies indicated a desire to have guidance on what and how to inspect for their ITS assets. Such standardization is difficult because of the wide range of asset types, including variation within specific types, such as in dynamic message signs which can be of different size, resolution, color, and function. However, guidance will support agencies in understanding the maintenance requirements for different types of ITS, and to better estimate costs, condition, and lifespans for devices.

[9] Intelligent Transportation Systems Architecture and Standards, Definitions, https://ops.fhwa.dot.gov/its_arch_imp/policy_1.htm#940_3, FHWA, 2001

[10] FHWA Asset Management Home Page - https://www.fhwa.dot.gov/asset/

6.2.2 ITS Asset Criteria Challenges

The ENTERPRISE agencies reported challenges with determining the performance, lifespan, and costs associated with performing ITS asset management. A common theme among members was related to the attribute challenges regarding a lack of national information and guidance. Similarly, states have developed their own criteria based on their own experiences. Lacking experience with a specific asset, agencies often rely on data such as warranty period to estimate lifespan, and long-term support contracts to estimate ongoing costs.

- **Catastrophic Failures**
  While agencies can predict some performance issues based on attributes such as age or through visual inspection, the failure of ITS assets can often be instant and catastrophic. A camera may function as expected one moment and then fail entirely and unpredictably. The failure may be because of the failure of a component or an external attribute such as power or communications. Agencies are not able to predict these failures but must be prepared for them by maintaining inventories of spares and having staff available to respond to unexpected failures.

- **Differing lifespan estimates for similar assets**
  The ENTERPRISE member agencies indicated that there are limited information resources beyond those they develop on their own. These in-house resources typically rely on past experiences and available warranty information. However, warranty time periods are sometimes confusing given uncertainty of when the warranty period starts, i.e. when the device was manufactured or installed in the field, which may occur months or possibly years later. Additional challenges can arise when attempting to link these component warranties with integrator contract durations.

  As previously discussed, many ITS assets are made of multiple components. For example, a traveler information system may have servers, communications, and various software components for web pages, 511 phone service, and mobile applications. All may have different functional lifespans determined not only by the function they provide, but also by the support of the component vendors and the needs of the public. In instances where an asset has many replaceable components, agencies are challenged to track and determine lifespans and plan for the replacement of systems in whole and in part.

- **Cost prediction models**
  ENTERPRISE member agencies indicated that they lack guidance in modeling cost predictions. The agencies stated they would like models they can use directly or review and modify for their purpose. Access to models that have proven useful would provide some information on the data needed, and on the results and accuracy experienced by other agencies.

6.3 ITS Asset Management Best Practices

This section identifies best practices from the ENTERPRISE member agencies and from interviews and documentation from other states and studies. A single practice can often address many challenges across the different asset management activities. For that reason, the best practices are summarized in the next subsection.

Manage ITS Assets Differently From Other Transportation Assets

The review of state TAMPs showed a tendency for agencies to treat ITS assets as they treat pavement and bridges, including assessing their condition and value based on age. This approach potentially limits properly using data that is unique to ITS assets.

An alternate approach is to manage ITS assets like Information Technology (IT) assets in their characteristics such as:

- Software / firmware updates
- Component-swappable
- Dependence on communications and power for operation
- Obsolescence from technological advance or lack of technical support
- Security concerns

IT assets are considered to "rapidly depreciate and require constant update and replacement."[11] They require an asset management strategy that covers their entire lifecycle, including not only replacement but upgrades, continual improvement and awareness of the impact of moving the assets or changing the external resources upon which their operations rely, such as networks and data sources. IT assets also benefit from "well-defined processes that ensure efficient, consistent and accurate execution of IT asset management tasks and activities."[12]

Centralize ITS Asset Information

As previously discussed, some states store ITS asset information across multiple repositories. This can result in difficulty in aggregating data for analysis. Many of the ENTERPRISE member agencies, such as Wisconsin and Iowa, are working toward strategies and tools for centralizing ITS asset data. They include custom configuration of a commercial asset management software in Wisconsin and Pennsylvania's custom-built database and interface.

In some agencies, staff has access to asset data at the office and in the field. Staff performing maintenance and inspections on specific assets can directly update information regarding condition and history. Field staff can also access to information such as maintenance history or the histories of similar devices to better understand potential problem areas.

A consideration for centralizing ITS asset information is developing interfaces to other systems that contain and use ITS asset information to ensure that all systems are using the same information. Interfaces may also enable staff to access and enter data and provide robust reporting tools and a platform that allows for different levels of access for different types of users. For example, field staff may use tablets that allow for capturing images and location data.

Flexible Data Tools

ITS assets are so varied and evolve so quickly that it is necessary to use a data collection tool that is flexible and allows for adding both new data types for existing assets and entirely new assets. States should look

[11] ITS Asset Management: It's All About Process, https://www.gartner.com/imagesrv/media-products/pdf/provance/provance_issue1.pdf, July, 2011
[12] ibid

to procure tools that allow for configuration by the state. This allows the tools to be flexible and quickly updated without reliance on a third party such as a software vendor.

The tools developed by Michigan and Pennsylvania are custom databases with interfaces that allow for customizing specifically for the states. Spreadsheets also can lend themselves to being managed and updated in-house, as used by Ontario and Kansas.

Beyond the ENTERPRISE members, South Dakota's new ITS asset management system can store attachments and photos of the assets. This allows the agency to capture photographic evidence of the condition of the asset as well as any structures and housing associated with the asset. For example, photos can show the condition of mast arms or housings or can demonstrate the wiring of a device to field staff. Attachments can include maintenance documentation, troubleshooting guides, as-built diagrams, or warranty information useful to office and field staff.

Lifespan and Cost Estimation

- As a result of limited guidance, the ENTERPRISE member agencies have developed their own strategies for estimating lifespans. Lifecycle estimates are based on staff experience, information and support from consultants and vendors. Agency practices include Michigan DOT is developing an ITS device replacement plan based on an industry scan that includes industry recommendations, as well as best practices from other agencies to generate lifecycle estimates.
- Pennsylvania DOT has used their TSAMS to track lifecycle information for their ITS devices since 2018. Because this practice is still relatively new, limited lifecycle information is currently available. However, over time TSAMS will have increasingly sufficient data to generate valuable lifecycle information.
- Ontario MTO retains manufacturer information on device lifespans in cost sheets and historical maintenance data to predict how long ITS assets will last. The latest value bid price for each ITS device is also tracked. Lifecycle estimates are largely based on staff expertise and experience.
- Wisconsin DOT uses work orders and a field tracking device mechanism to track each device type. This management database tracks maintenance costs, and a separate system tracks utility costs, which are the main operations cost except for solar devices. A thorough check was conducted to estimate lifecycle costs in 2009, and new collected data is being used to validate those numbers; however, these are not used in practice given reliance on engineering judgement.
- Wisconsin DOT has also leveraged some FHWA sources as a starting point about the overall cost of ownership for ITS that staff update annually. Additionally, Wisconsin DOT has engaged with other practitioners at conferences and information exchanges, such as the Upper Midwest Conference held every 18 months to understand the ITS asset management practices, issues, challenges, and solutions used in other states.

Use Staff Knowledge to Identify Issues

Agencies rely on their own staff experience to assessing the health of their ITS assets. Some agencies have had success involving field staff in identifying health issues, such as the performance of specific devices or components. For example, the field staff may be the first to identify that a particular type of battery performs poorly under certain environmental conditions, or that a wireless communications medium does not meet the requirements in a certain area due to poor coverage.

Agencies benefit from formalizing the process of gathering the knowledge and experience of staff, even allowing for field staff notes within a centralized data management tool. Other successful processes included holding regularly scheduled meetings to discuss ITS asset health and conditions. Staff members can compare notes and share ideas to help identify common issues, to share successful maintenance strategies, and to determine cost-effective approaches to keeping ITS operational.