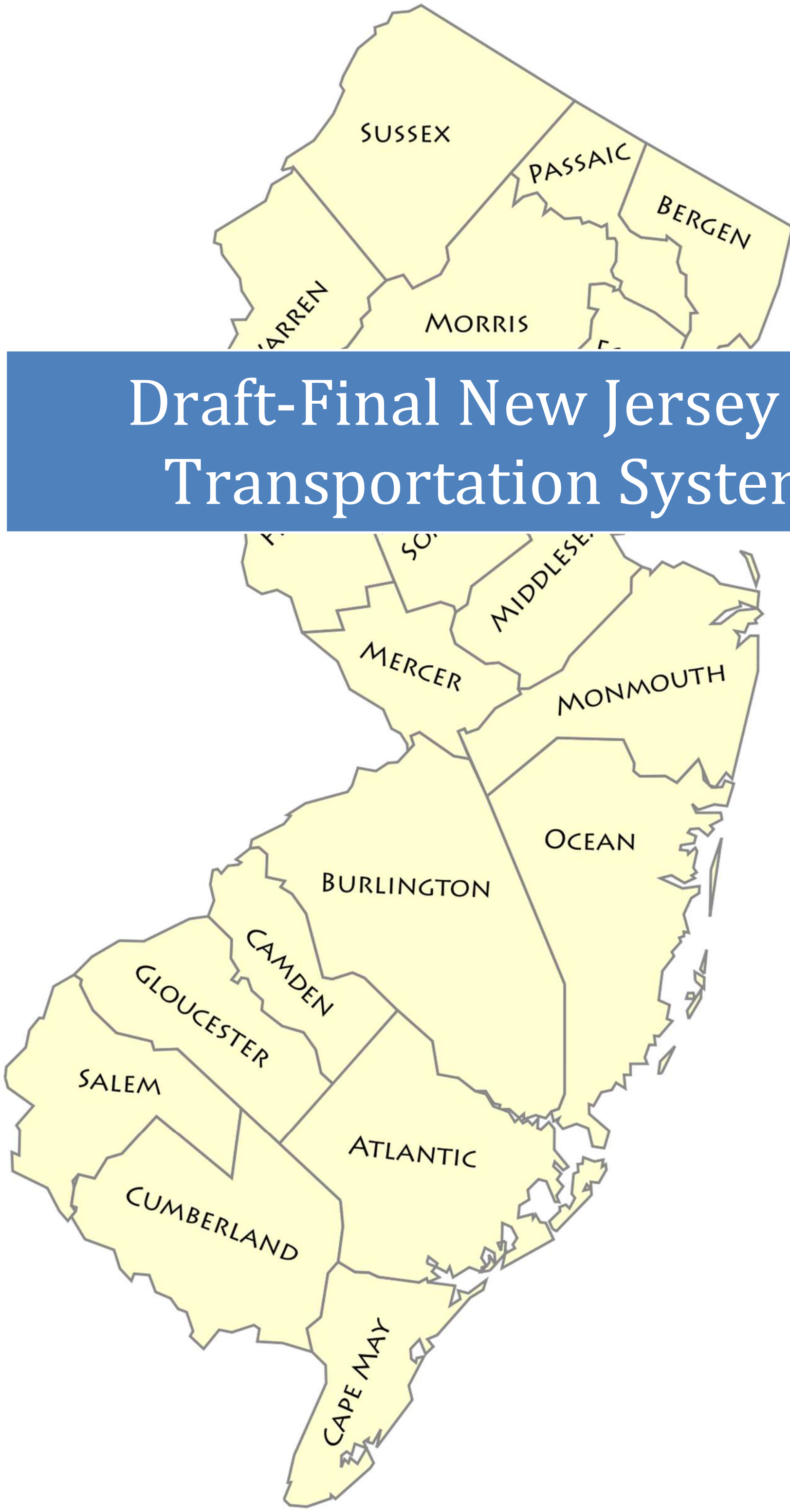
ITS Architecture Document

Draft-Final New Jersey Statewide Intelligent Transportation Systems (ITS) Architecture



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November 22, 2022

ITS Architecture Document

Revision History

Filename	Version	Date	Authors	Comment
NJ 2022 Architecture Document 2022-11-22	1.0	11/22/22	M. Insignares	Draft Revision for 2022 Maintenance Update

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1. INTRODUCTION

1.1 Background

An Intelligent Transportation System (ITS) is the application of sensing, analysis, control and communications technologies to surface transportation in order to improve safety, mobility and efficiency. ITS includes a wide range of applications that process and share information to ease congestion, improve traffic management, minimize environmental impact and increase the benefits of transportation to commercial users and the public in general. [Source: https://whatis.techtarget.com/definition/intelligent-transportation-system]

Transportation system needs and benefits supported by an ITS architecture include:

- ITS enables communication of information that plays a vital role in the coordination of response to incidents, construction, and special events. As such, transportation facility operators need to share information with neighboring and adjacent facilities and modes.
- Timely, near real-time communication of facility-specific information, gathered and aggregated into regional views, enables coordination across organizational and jurisdictional boundaries.
- Data and information about the status of the transportation system, both real-time and historical, must be managed -- a task growing in complexity and detail. Data quality, agency policies, timeliness of information, and data formats significantly impact a region's ability to share transportation information. An ITS architecture establishes a framework to enable inter-agency data sharing and interoperability.
- Stakeholders invest in ITS: that is, deploy technology projects to improve safety, mobility, and congestion on their facilities. An ITS architecture establishes a framework for data collection, real-time and historical, that enables performance-based analysis of operations and planning support.
- ITS data, collected and archived for historical reporting and analysis purposes, allows facility operators to identify and assess their short-term response to situations, long-term improvements, and historical trends. This, in turn, enables operators and planners to develop, assess, and fine-tune local and regional transportation strategies.

The purpose of an ITS architecture is to facilitate ITS project planning and development, where ITS and other technologies are used to enable improvements in regional safety, mobility, congestion management, and information sharing.

1.2 Purpose of this Document

This document, along with the project web site (http://www.consystec.com/nj2022/web/), is the main output of this New Jersey Statewide Intelligent Transportation Systems Architecture (NJITSA) 2022 update. This document does not reproduce data that is available on the web site, but rather provides a reference to web pages and PDF reports that list the information content of the NJITSA. For example, listing of stakeholders, ITS inventory, and ITS projects.

The NJITSA is a roadmap for transportation systems integration in New Jersey over the next 10 years. The architecture has been developed through a cooperative effort by the region's transportation agencies, covering all modes and all roads in the region. The architecture represents a shared vision of how agencies' ITS systems will work together in the future, sharing information and resources, to provide a safer, more efficient, and more effective transportation system for travelers in the region.

The ITS architecture is an important tool that will be used by:

- Operating Agencies to recognize and plan for transportation integration opportunities in the region;

- Planning Agencies to better reflect integration opportunities and operational needs into the transportation planning process; and
- Other organizations and individuals that use the transportation system in the region.

The architecture provides an overarching framework for deployment of ITS in the region that spans all of these organizations and individual transportation projects. Using the architecture, each transportation project can be viewed as an element of the overall transportation system, providing visibility into the relationship between individual transportation projects and ways to cost-effectively build an integrated transportation system over time. The architecture is described by this document and a hyperlinked website that can be found at http://www.consystec.com/nj2022/web/.

This architecture is not static, but will be revised and updated as plans change, ITS projects are implemented, and the ITS needs and services evolve in the region. This document, which describes the architecture, is a "living document" that will be updated each time the architecture is updated.

Within the State, the Regional ITS Architecture allows transportation agencies to comply with the FHWA Rule/FTA Policy on Architecture and Standards. The FHWA Final Rule, 23 CFR 940, (and corresponding FTA policy) to implement Section 5206(e) of the TEA-21 requires that ITS projects funded through the Highway Trust Fund conform to the United States (U.S.) National ITS Architecture (called "ARC-IT") and applicable standards. The Rule/Policy requires that the National ITS Architecture be used to develop a local implementation of the National ITS Architecture, which is referred to as a "Regional ITS Architecture." The NJITSA is consistent with the National Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) version 9.1.

The Home Page of the New Jersey Statewide ITS Architecture Web Site is shown below.

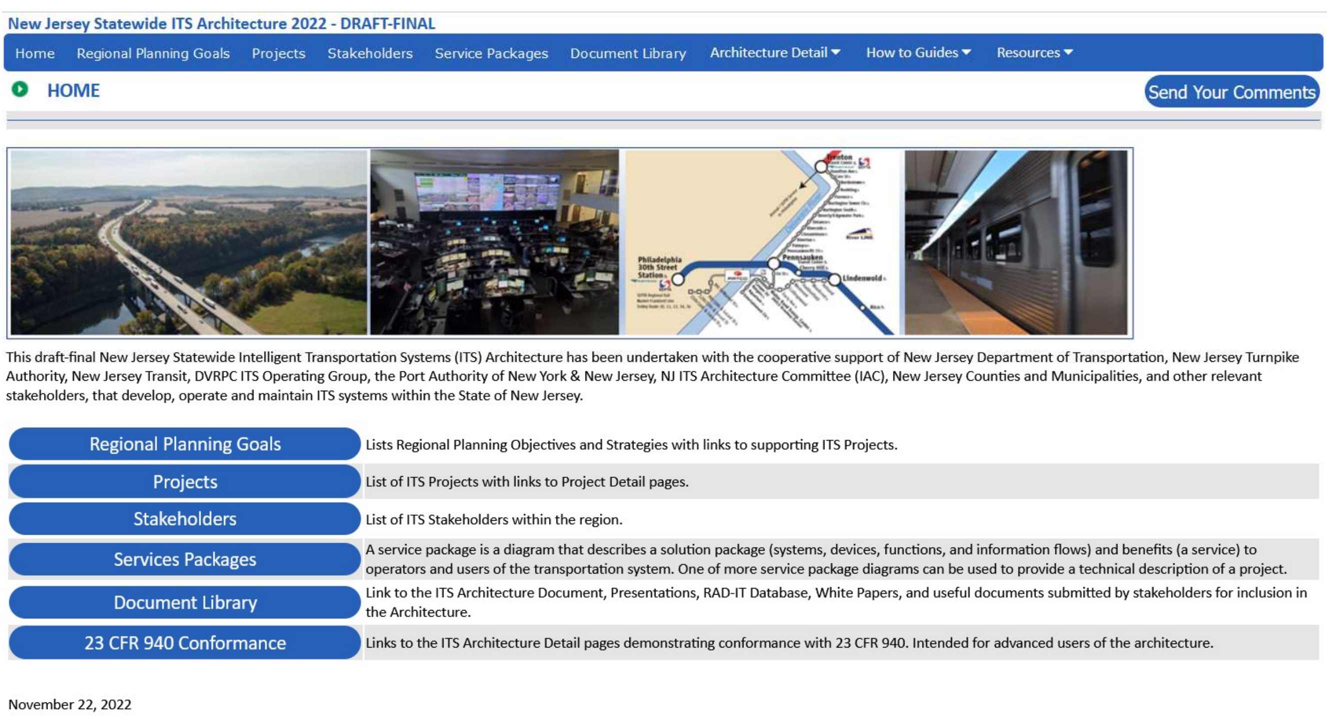


Figure 1. New Jersey Statewide ITS Architecture Web Site (Home Page)

1.3 Document Overview

This document is organized into the following sections.

- **SECTION 1: INTRODUCTION**. This section, provides introductory and background information about this document, its purpose and why a regional ITS architecture is needed.
- **SECTION 2: REGIONAL ITS ARCHITECTURE OVERVIEW.** Gives a brief introduction and overview of the National ITS Architecture, and how it relates to this Regional ITS Architecture.
- **SECTION 3: SCOPE OF THE ARCHITECTURE – GEOGRAPHIC, TEMPORAL, AND ITS SERVICES.** Provides a description of the region, future timeframe the architecture covers, and scope of ITS services covered.
- **SECTION 4: REGIONAL ITS STAKEHOLDERS.** Identifies the agencies and organizations who have an interest and participate in this regional ITS architecture, and their roles and responsibilities in providing ITS services in the region.
- **SECTION 5: STAKEHOLDER ROLES AND RESPONSIBILITIES**. Identifies the roles and responsibilities of the public agencies, private organizations or the traveling public with a vested interest, or a "stake" in one or more transportation elements within an ITS Architecture.
- **SECTION 6: ITS SYSTEMS INVENTORY**. Consists of the collection of all ITS-related elements in the ITS Architecture.
- **SECTION 7: ITS SYSTEM FUNCTIONAL REQUIREMENTS**. Details each inventory item's functionality in terms of the services it provides and role it serves within the region.
- **SECTION 8: INTERFACE REQUIREMENTS AND INFORMATION EXCHANGES.** Lists the interfaces and information exchanges that are needed to provide ITS Services in the region.
- **SECTION 9: REGIONAL ITS PROJECTS**. Presents an overview of ITS Projects being currently deployed and planned in the future.
- **SECTION 10: AGREEMENTS.** Identifies interagency agreements that may be required to support the implementation of the ITS Services in the region.
- **SECTION 11: APPLICABLE ITS STANDARDS AND TESTING PROCEDURES.** Describes the applicable ITS standards, test tools and procedures available for regional ITS deployments.
- **SECTION 12: MAINTENANCE OF THE REGIONAL ITS ARCHITECTURE.** Provides a discussion on how to maintain and update the Regional ITS Architecture.
- **APPENDIX A: ACRONYMS**. Contains a list of acronyms.
- **APPENDIX B: GLOSSARY**. Contains a glossary of terms and definitions.
- **APPENDIX C: AGREEMENTS**. Contains a list of agreements identified for the region.
- **APPENDIX D: DESCRIPTION OF APPLICABLE ITS STANDARDS**: Contains additional description of applicable ITS standards identified for the region.

Supporting Web Site Resources

- **New Jersey Statewide ITS Architecture Web Site.** http://www.consystec.com/nj2022/web/index.htm
- **How to Use the Web Site.** http://www.consystec.com/nj2022/web/howto.htm

2 REGIONAL ITS ARCHITECTURE OVERVIEW

2.1 Requirements of the Final FHWA Rule and FTA Policy on Architecture

A Federal Rule, which took effect on April 8, 2001 defines a set of 9 requirements that regional ITS architectures shall satisfy. Table 1 below shows how the requirements of the Rule are met by the outputs developed for the NJITSA.

Table 1: FHWA Final Rule Requirements

Regional ITS Architecture Requirements	Where Requirement is Documented
1. Description of region	**SECTION 3: SCOPE OF THE ARCHITECTURE – GEOGRAPHIC, TEMPORAL, AND ITS SERVICES**. Geographic definition, as well as timeframe and scope of ITS services included in the architecture.
2. Identification of participating agencies and other stakeholders	**SECTION 4: REGIONAL ITS STAKEHOLDERS**. Provides a description and definition of each ITS stakeholder.
3. An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders	**SECTION 5: STAKEHOLDER ROLES AND RESPONSIBILITIES**. Describes the operational concept, that is, roles and responsibilities, for each major regional stakeholder.
4. A list of any agreements (existing or new) required for operations	**APPENDIX C: AGREEMENTS**. Provides a discussion of existing and potential new agreements identified.
5. System functional requirements	**SECTION 6: ITS SYSTEMS INVENTORY**. Gives a description of each ITS systems and services. **SECTION 7: ITS SYSTEM FUNCTIONAL REQUIREMENTS**. Describes the process to identify functional requirements for the ITS systems and services contained in the architecture.
6. Interface requirements and information exchanges with planned and existing systems and subsystems	**SECTION 8: INTERFACE REQUIREMENTS AND INFORMATION EXCHANGES**. Provides a discussion about system interfaces and information flows contained in the architecture.
7. Identification of ITS standards supporting regional and national interoperability	**SECTION 11: APPLICABLE ITS STANDARDS AND TESTING PROCEDURES**. Provides a discussion and identifies applicable standards for ITS deployments in New Jersey. **APPENDIX D: DESCRIPTION OF APPLICABLE ITS STANDARDS.** Provides additional detailed about the applicable standards for ITS in New Jersey.
8. The sequence of projects required for implementation	**SECTION 9: REGIONAL ITS PROJECTS**. Describes regional ITS projects for New Jersey identified by stakeholders.
9. Develop and implement procedures and responsibilities for maintaining the architecture as needs evolve within the region.	**SECTION 2.3: PROCESS FOR MAINTAINING THE REGIONAL ITS ARCHITECTURE.** Describes the process and procedures for maintaining the ITS architecture. **SECTION 12: MAINTENANCE OF THE REGIONAL ITS ARCHITECTURE**. Describes the baseline content of the New Jersey ITS architecture.

2.2 Regional ITS Architecture Concepts

The NJITSA is a regional ITS architecture, which has been defined by 23 CFR 940 as a "regional framework for ensuring institutional agreement and technical integration for implementation of ITS projects". Regional ITS architectures are developed to provide a framework for the integration of intelligent transportation systems. The NJITSA is based upon the ARC-IT Version 9.1. A complete description of the National Architecture (ARC-IT) can be found at http://www.arc-it.net.

What are some of the main parts of an ITS architecture? They are made of the following:

- Stakeholder Organizations
- Systems Operated
- Information Exchanged
- Services Provided
- Functions Performed
- Regional Projects Identified

2.2.1 Stakeholder Organizations

The organizations that operate systems in the region and are covered by the architecture are referred to as stakeholders. These are public agencies, private organizations or the traveling public with a vested interest, or a "stake" in one or more transportation elements within a regional ITS architecture.

2.2.2 Systems Operated – ITS Inventory of Elements

The collection of systems operated in the region is referred to as the ITS Inventory of Elements, where each "element" represents a system (existing or future) or portion that provides ITS functionality to the transportation system. In the NJITSA, the elements represent actual and planned systems within transportation management centers, such as the New Jersey DOT Arterial Management Center. An element may also represent field devices, for example the element New Jersey DOT ITS Field Equipment. A more thorough discussion of the architecture elements is contained in **SECTION 6: ITS SYSTEMS INVENTORY**. The regional ITS architecture uses a set of common concepts drawn from ARC-IT to describe the parts of the architecture.

2.2.3 Information Exchanged

The information exchanged between elements in the regional ITS architecture, or between physical objects in the ARC-IT, is described by information flows. There are hundreds of these flows defined in ARC-IT, and it is this information that is used to create the interface definitions in the regional ITS architecture. For example, in Figure 2, the top two boxes show an interface between two physical objects, with information flows defining the exchange of information. A corresponding interface in the NJITSA is shown in the bottom two boxes.

By mapping the regional ITS architecture elements (e.g., NJDOT MOC-N [Mobility Operations Center North] and NJDOT MOC-S [South]) to ARC-IT physical objects (e.g., Traffic Management Subsystem), the interfaces defined in ARC-IT can be used as the basis for defining the interfaces in the regional ITS architecture.

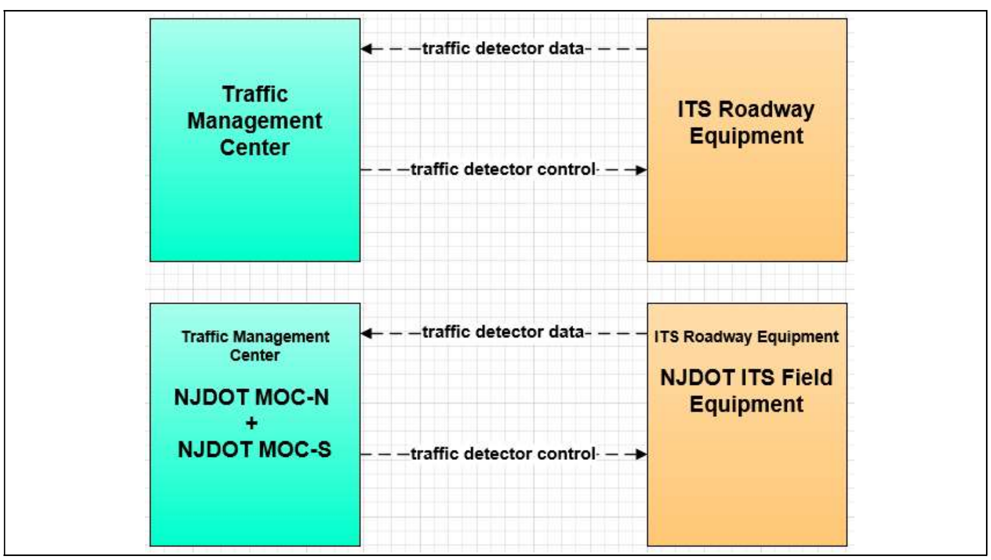


Figure 2. Information Flow

2.2.4 Services Provided - ARC-IT Service Package Diagram

The next key concept used by the architectures is that of Service Packages. These represent slices of an architecture that provide a transportation service. In ARC-IT, these Service Packages are combinations of physical objects and information flows that are used to provide the service. An example of an ARC-IT Service Package is shown in Figure 3.

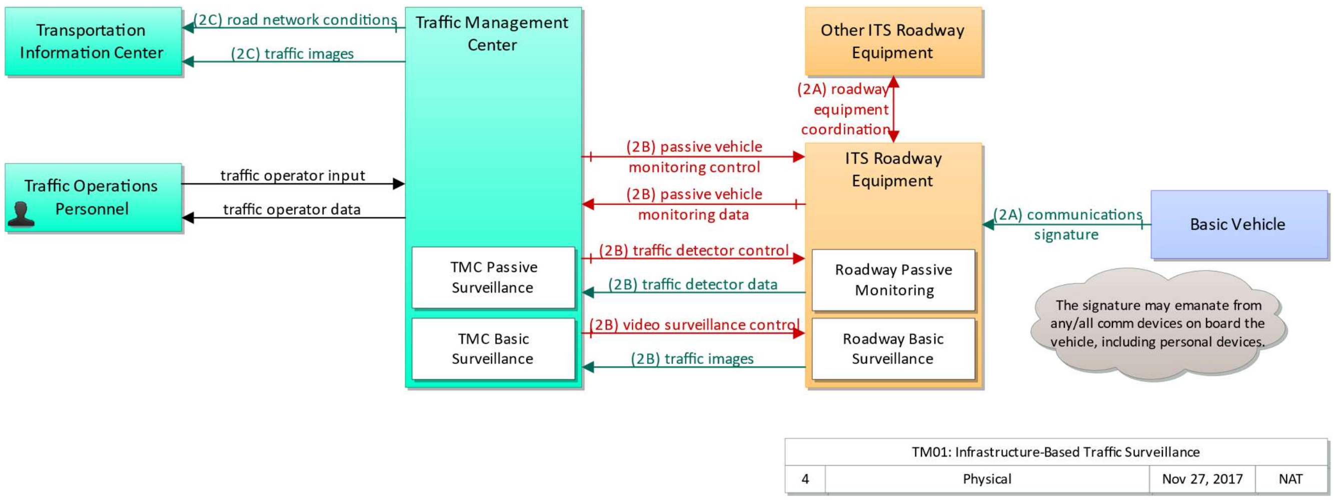


Figure 3. Example ARC-IT Service Package

Again, from the National ITS Architecture perspective, the service package diagram above shows the physical objects and information flows that perform the monitoring and control of roadway devices from a traffic management system used to monitor roadways with sensors and cameras. This diagram does not yet include any information specific for the NJITSA.

2.2.5 Regional, Customized Service Package Diagrams

In the development of regional ITS architecture, a set of customized service packages were created that define the elements and interfaces used to provide the service within the region.

Figure 4. Example Customized Service Package shows one of the customized service packages, in this case for the New Jersey Department of Transportation. This diagram shows how the New Jersey Department of Transportation might implement the TM03: Traffic Signal Control Service Package.

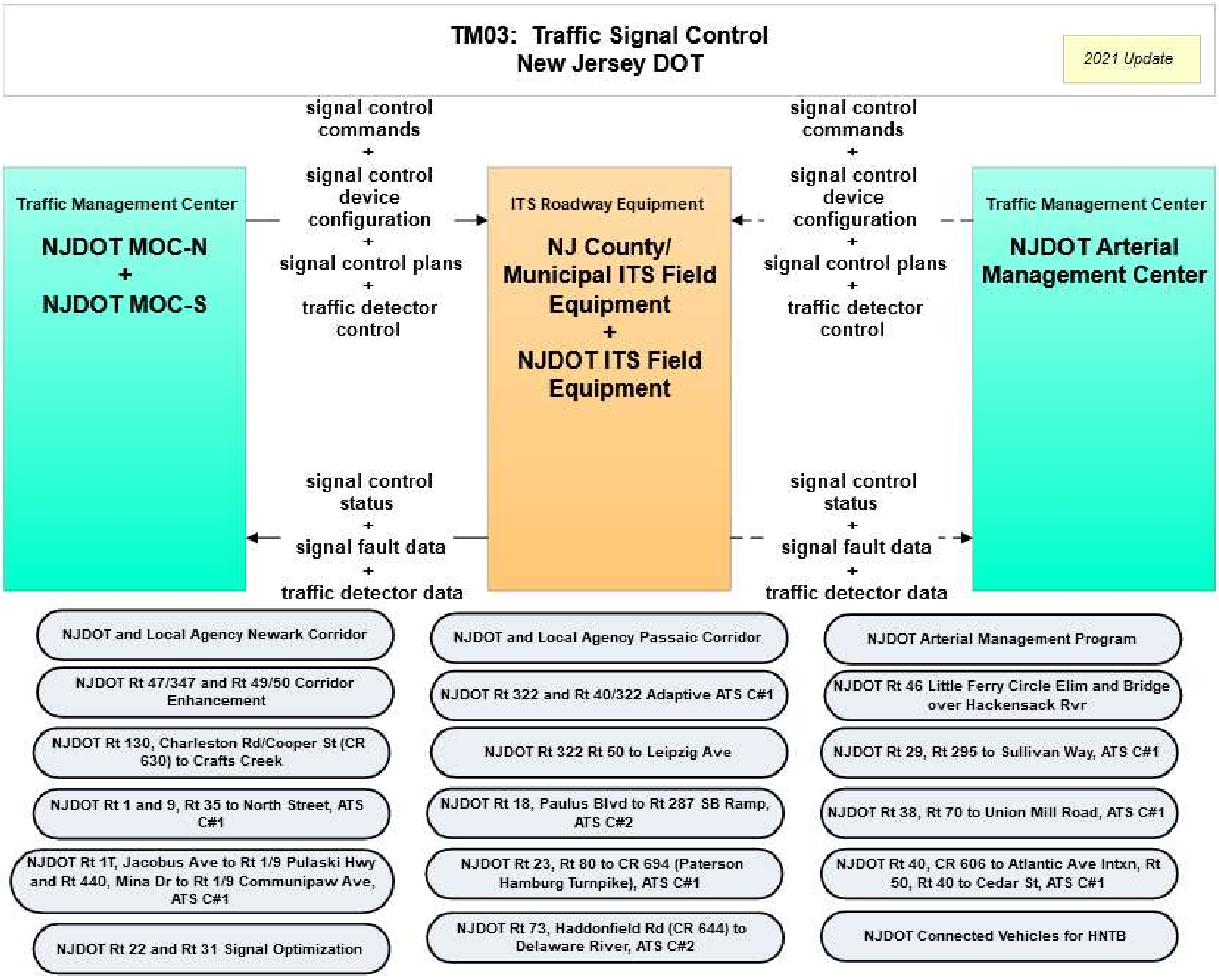


Figure 4. Example Customized Service Package

Note the following:

- ITS Projects are indicated on the Service Package as gray ovals.
- The customized service package includes only the necessary interfaces needed within a region. A region is not required to implement all the functions defined in the ARC-IT Service Package. For example, the regional customized service package diagram does not include interfaces to an Information Service Provider, personnel, or a map update provider element, as shown in ARC-IT. Conversely, the regional service package may show additional local detail not included in ARC-IT, but required within the region.
- Existing Flows are shown as solid lines, whereas Planned, or Future Flows are shown as dashed lines.

2.2.6 Functions Performed: Physical Objects, Functional Objects, and Functional Requirements

ARC-IT uses the term physical view to describe the transportation systems and the information exchanges that support ITS. The service package diagrams illustrate these high-level relationships. The Functional Objects and Functional Requirements specify the functions within a Physical Object. These are further defined in the bullets below:

As a part of developing a regional ITS architecture, each element of the region is mapped to the ARC-IT physical object that most closely defines the functions of the element. This mapping allows the regional version to use the details associated with the physical objects in ARC-IT. Figure 5 illustrates the regional ITS architecture element "Weather Service Provider Systems" mapped to the ARC-IT physical object "Weather Service".

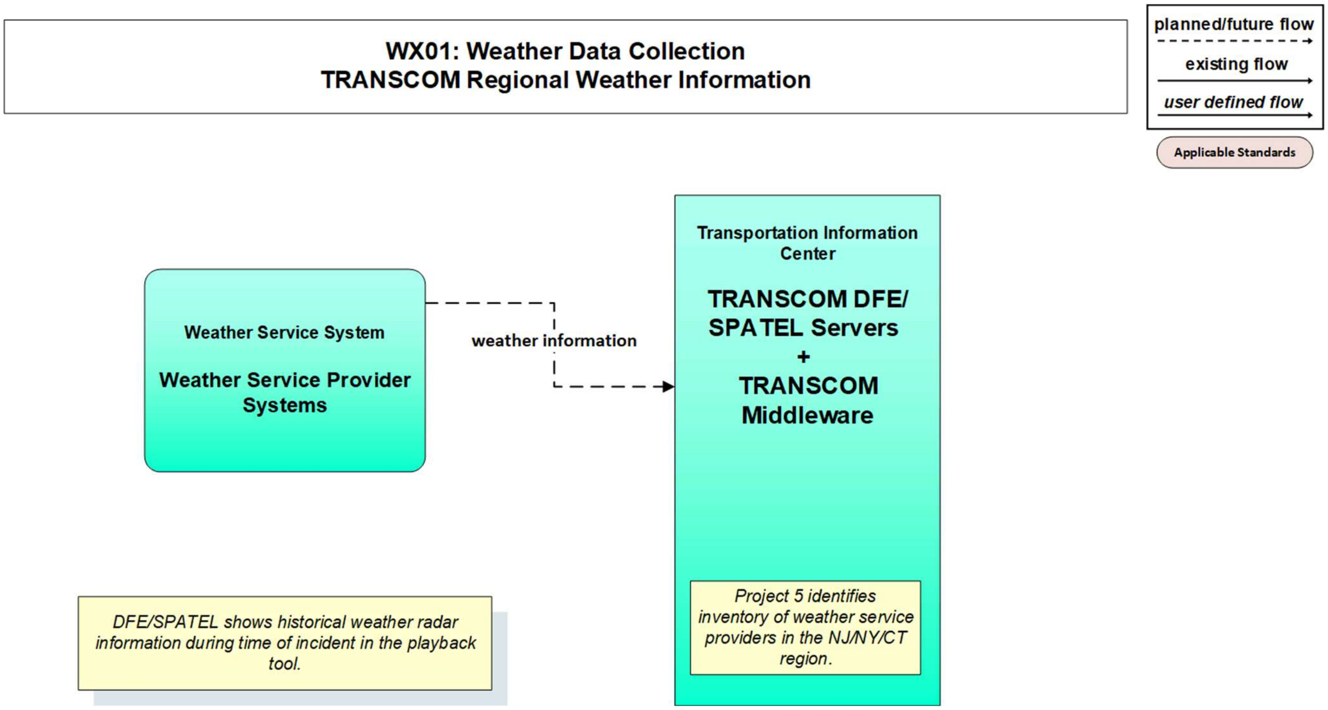


Figure 5. Mapping between Regional Architecture and ARC-IT Physical Objects

Each element contained in a square box has functional requirements identified. See **SECTION 7: ITS SYSTEM FUNCTIONAL REQUIREMENTS**. For example, the elements shown in Figure 5 would have the following functional requirement that would be mapped to the element: *The center shall be able to receive road condition information from weather service providers*.

2.2.7 Regional Projects Identified

Through stakeholder webinars, an enlarged and revised list of salient projects has been compiled during 2022. The projects in the New Jersey Statewide ITS Architecture are foundational projects that will support planning and deployment of ITS in the future. See **SECTION 9: REGIONAL ITS PROJECTS**.

2.3 Process to Maintain the Regional ITS Architecture

Maintenance of the NJITSA relied heavily on stakeholder input to ensure that it reflected current regional needs and plans. The following five-step process was used to maintain the NJITSA in 2022:

- Develop a systems engineering analysis process for the state and create a project information sheet that could be used to capture projects from a wide range of stakeholders;
- Conducted stakeholder meetings;
- Generated a complete draft ITS architecture for review;
- Gathered stakeholder review comments on the draft ITS architecture; and
- Finalized the ITS architecture based on review comments.

2.3.1 Develop an SEA process and Project Information Sheet.

A Systems Engineering Analysis Guidance white paper was developed to explain to the stakeholders what projects should be considered for inclusion in the architecture. As a part of this effort a Project Information Sheet was created to facilitate definition of projects for inclusion in the architecture.

2.3.2 Stakeholder Interviews

A series of stakeholder meetings were performed by the project team between March 2022 and October 2022. The meetings brought together key groups such as the New Jersey IAC, local transportation providers (municipalities and counties), the 3 NJ MPOs, NJDOT, NJTA, NJT, DVRPC Operating Group, and PANYNJ. The SEA process and project information sheet was explained and a series of completed project information sheets were input to the team by the stakeholders. During meetings with MPOs and Planners, connections between the ITS Architecture and Planning Objectives were reviewed.

2.3.3 Draft ITS Architecture for Review

Following the stakeholder meetings, a draft architecture update was created to include all the new project information sheets obtained from the stakeholders. Using the ARC-IT Service Packages to define ITS services, the set of customized service packages were updated to incorporate all the new projects.

2.3.4 Final ITS Architecture and Web Site Based on Stakeholder Review Comments

Stakeholders were notified by email that a review period has commenced, and feedback was solicited. Stakeholders were encouraged to review the NJITSA and were encouraged to provide feedback.

Following the comment review period, the draft ITS Architecture was revised, and the information was compiled into this final report and the final ITS Architecture web site.

Supporting Web Site Resources

- **Stakeholders.** http://www.consystec.com/nj2022/web/stakes.htm
- **Stakeholder Roles and Responsibilities.** http://www.consystec.com/nj2022/web/opsconstake.htm
- **Inventory of ITS Elements.** http://www.consystec.com/nj2022/web/inventory.htm
- **Inventory by Stakeholder.** http://www.consystec.com/nj2022/web/invstake.htm
- **ITS Services.** http://www.consystec.com/nj2022/web/services.htm
- **ITS Service by Stakeholder.** http://www.consystec.com/nj2022/web/servstake.htm
- **Information Exchange (Interfaces).** http://www.consystec.com/nj2022/web/interfaces.htm
- **ITS Projects.** http://www.consystec.com/nj2022/web/projects.htm
- **ITS Projects by Stakeholder.** http://www.consystec.com/nj2022/web/projectsstake.htm

3 SCOPE OF THE ARCHITECTURE – GEOGRAPHIC, TEMPORAL, AND ITS SERVICES

The first step of the ITS Architecture development process is to define the scope, or the boundaries, of the Architecture. The geographic scope as well as the scope of the ITS services provided were determined by the type of property operated (roadway, transit, etc.). In addition, congestion on the roadway impacts transit service, and motivates the need to share roadway status information with transit providers.

Scope covers three distinct factors:

- **Geographic Scope.** The geographic area selected should consider the institutional boundaries of ITS in the region. The geographic scope of the New Jersey Statewide ITS Architecture is the State of New Jersey, plus major crossings with other States, including: New York, Pennsylvania, and Delaware. The 2021 update of the architecture introduced the Projects Map to connect the project with area of transportation improvement. During 2022, the Project Map was enhanced to allows selection of projects by County, or by Corridor.

- **Timeframe**. The architecture is a vision for the development of ITS in the region. The timeframe for this ITS architecture is a 10-year outlook for ITS activities in the region. This means that the architecture addresses existing ITS systems as well as those planned for development over the next 10 years. It represents a snapshot of the currently anticipated ITS and other projects based on information gathered from stakeholders.
- **ITS Services Scope.** In general, the scope of ITS services is limited to whatever stakeholders do now or are planning to do in the future. The service scope of the NJITSA covers those ITS services that are regional in nature and includes: highway/tollway management, arterial management, management of bridges and crossings, transit, freight, traveler information, and connected vehicles.

Supporting Web Site Resources

- A brief discussion on scope of the architecture is available on the about page: http://www.consystec.com/nj2022/web/conformance.htm.

4 REGIONAL ITS STAKEHOLDERS

Stakeholders own, operate, maintain, and secure the transportation system. Users of the transportation system and 3rd party providers of ITS services (e.g., data, and weather) are also stakeholders.

Stakeholder coordination and involvement is one of the key elements of the development of a regional ITS architecture. Because ITS often transcends traditional transportation infrastructure, it is important to consider a range of stakeholders beyond the traditional traffic, transit, and maintenance areas. In addition, it is important to consider stakeholders at a regional level and stakeholders in adjoining regions.

The stakeholders listed represent a mix of specific agencies or organizations and generic names used to represent a variety of stakeholders.

Generic stakeholders were included to represent groups of agencies and organizations. While it may be ideal to list every stakeholder in the region, it is unrealistic - listing all potential stakeholders makes the Regional ITS Architecture unwieldy and difficult to maintain. For example, without using generic stakeholders, if a small city or town grows and begins to provide ITS services, the city or town would need to be added to the Regional ITS Architecture. However, if a generic stakeholder name was used, such as CVO Inspector, a new stakeholder would not have to be added to the Regional ITS Architecture. The definition of CVO Inspector is, “Generic commercial vehicle inspection providers.”

A representative sample of stakeholders from the NJITSA Web Site is shown below:

Table 2. Representative Example of Stakeholders

Stakeholder	Description
AMTRAK	Nationwide Passenger Rail Organization with service to entire north east corridor.
Burlington County Bridge Commission	Operates and maintains 8 bridges in Burlington County, NJ, including two toll bridges.
Cape May Seashore Lines	Provides train service between Tuckahoe and Cape May.
CVO Inspector	Generic commercial vehicle inspection providers.
DelDOT - Delaware Department of Transportation	Delaware Department of Transportation
DRBA - Delaware River and Bay Authority	Delaware River and Bay Authority (DRBA), a New Jersey-Delaware bi-state agency, operates the Delaware Memorial Twin Bridges, the Cape May-Lewes Ferry system, the Three Forts Ferry Crossing, and the New Castle, Cape May, Millville, Delaware Airpark and Dover Civil Air Terminal Airports.
DRJTBC - Delaware River Joint Toll Bridge Commission	Operates 20 river crossings over 139 miles of river within its jurisdiction, stretching from northern Burlington County, New Jersey and Bucks County, Pennsylvania northward to the New York State Line, Includes 7 toll bridges.
DRPA - Delaware River Port Authority	The Delaware River Port Authority of Pennsylvania and New Jersey (DRPA) is a regional transportation and economic development agency serving the people of Southeastern Pennsylvania and southern New Jersey. Operates 4 toll bridges in the region and the PATCO Speedline. DRPA also owns the RiverLink Ferry, the Philadelphia Cruise Terminal @ Pier 1 and the AmeriPort Intermodal Rail Center.
DRPA PATCO - Port Authority Transit Corporation	Port Authority Transit Corporation (PATCO). Operates the commuter rail (Speedline) transit between Philadelphia and New Jersey. A subsidiary of the Delaware River Port Authority.
DVRPC - Delaware Valley Regional Planning Commission	Serving the Greater Philadelphia-Camden-Trenton area for almost 40 years, DVRPC works to foster regional cooperation in a nine-county, two-state area. City, county and state representatives work together to address key issues, including transportation, land use, environmental protection, information sharing and economic development. The DVRPC is the Metropolitan Planning Organization (MPO) for the area.

Supporting Web Site Resources

- A full listing of Stakeholders is available at: http://www.consystec.com/nj2022/web/stakes.htm.
- A printable version is available at: http://www.consystec.com/nj2022/web/rptpdfs/rptStakeholders_RAD_IT.pdf

5 STAKEHOLDER ROLES AND RESPONSIBILITIES

An Operational Concept documents each stakeholder's current and future roles and responsibilities in the operation of the regional ITS systems, across a range of transportation services. The services covered include:

- **Surface Street Management.** The development of systems to monitor and operate arterials and provide coordinated intersection timing over a corridor, an area, or multiple jurisdictions.
- **Freeway Management.** The development of systems to monitor highway and tollway traffic flow and roadway conditions. Includes systems to provide information to travelers on the roadway.

- **Incident Management.** The development of systems to provide rapid and effective response to incidents. Includes systems to detect and verify incidents, along with coordinated agency response to the incidents.
- **Transit Management.** The development of systems to more efficiently manage fleets of transit vehicles or transit rail. Includes systems to provide transit traveler information both pre-trip and during the trip.
- **Traveler Information.** The development of systems to provide static and real time transportation information to travelers.
- **Emergency Management.** The development of systems to provide emergency call taking, public safety dispatch, and emergency operations center operations.
- **Maintenance Management.** The development of systems to manage the maintenance of roadways in the region, including winter snow and ice clearance. Includes the managing of construction operations.
- **Archive Data Management.** The development of systems to collect transportation data for use in non-operational purposes (e.g., planning and research).
- **Electronic Payment.** The development of electronic fare payment systems for use by transit, tollways, and other transportation-related uses (e.g., parking).
- **Vehicle Safety.** The development and defining of protocols for implementing wireless local area network communications, including Dedicated Short-Range Communications (DSRC).

A representative example of stakeholder roles and responsibilities is shown below. The example below is for the Burlington County Bridge Commission.

Table 3. Example Stakeholder Roles and Responsibilities

Functional Area	Roles and Responsibilities	Status
Data Management for New Jersey Statewide Regional ITS Architecture	Collect and archive toll information.	Existing
Electronic Toll Collection for New Jersey Statewide Regional ITS Architecture	Coordinate with the department of motor vehicles and county courts to collect tolls from violators.	Existing
	Establish relationships with financial institutions for smart card payments.	Existing
	Operate a customer service center to process toll transactions and handle violations processing.	Existing
	Operate toll collection equipment on toll roads	Existing

Supporting Web Site Resources

- Additional information on Stakeholder Roles and Responsibilities is available at: http://www.consystec.com/nj2022/web/opsconstake.htm.

6 ITS SYSTEMS INVENTORY

Each stakeholder agency, company, or group owns, operates, maintains or plans ITS systems in the region. The Regional ITS Architecture inventory is a list of "elements" that represent all existing and planned ITS systems in a region as well as non-ITS systems that provide information to or get information from the ITS systems. The focus of the inventory is on those systems that support, or may support, interfaces that cross stakeholder boundaries (e.g., inter-agency interfaces, public/private interfaces).

Most of the inventory represents ITS systems in the region, but the inventory does contain some elements that represent systems in adjoining regions. An example of an element in an adjoining region would be the PennDOT Statewide TOC, which represents the Traffic Operations Center for the state of Pennsylvania. It interfaces with other traffic management entities in New Jersey, as well as transit, traffic, maintenance, and data management entities. Figure 5 displays the interfaces between PennDOT Statewide TOC as well as other systems within the state of New Jersey as they transmit traffic situation data from their management centers to the Regional Integrated Multimodal Information Sharing Information Exchange Network (RIMIS IEN).

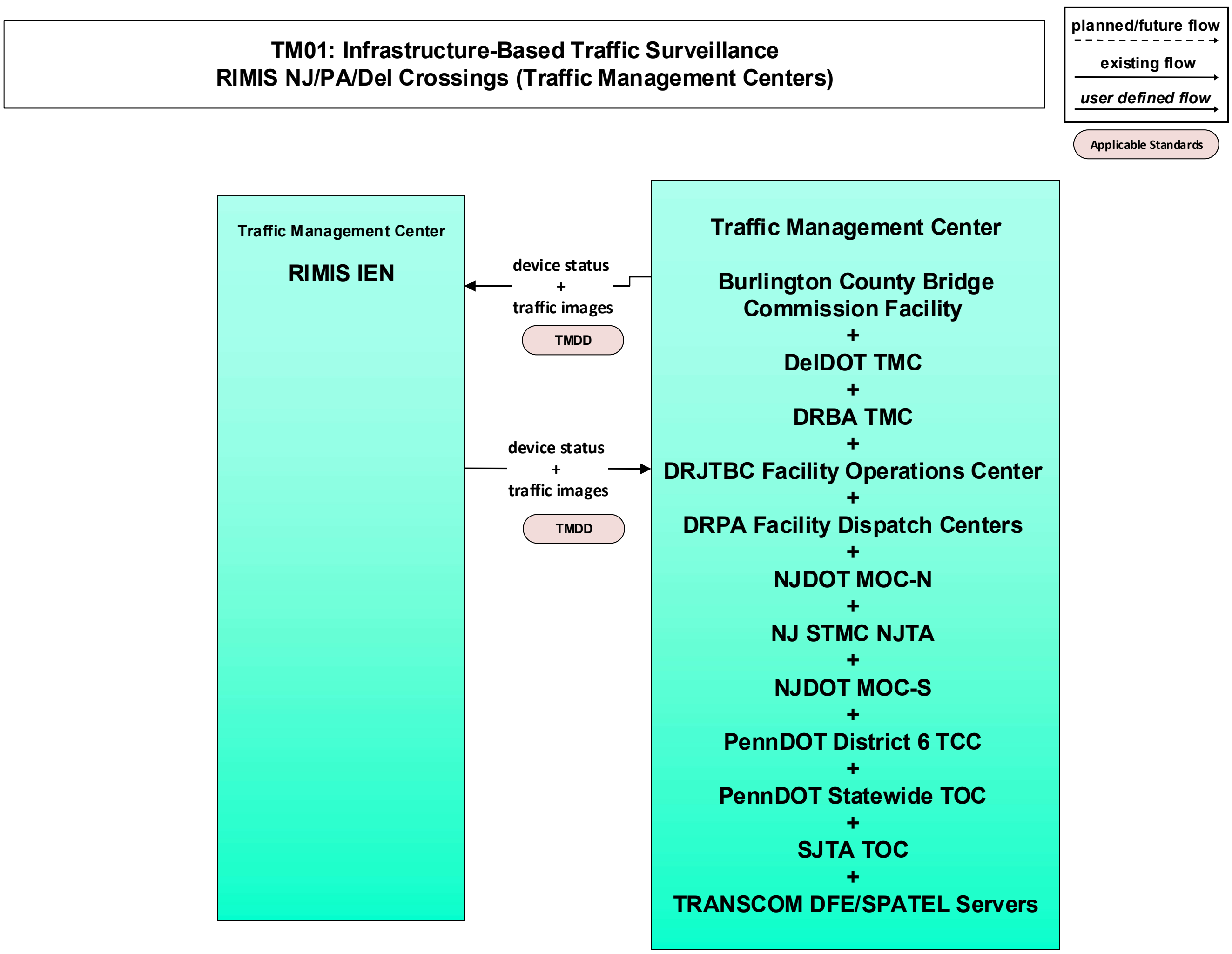


Figure 6. Information Exchange between Outside Adjoining Elements and In-State Elements

Each element in the inventory is described by a name, the associated stakeholder, a description, general status (e.g., existing or planned), and the associated subsystems or terminators from ARC-IT.

Most of elements in the inventory represent a specific existing or planned system. Some examples of specific systems are Burlington County Bridge Commission Facility and the NJ STMC NJTA.

Some of the elements represent sets of devices rather than a single specific system or device. An example of this type of element is the element NJDOT ITS Field Equipment. This element represents all the ITS field equipment, such as CCTV cameras and dynamic message signs (DMS), which are operated by NJDOT.

A third type of element in the inventory is a generic element that represents the systems of a certain type in the region. An example of this type of element Private Traveler Vehicles, which represent any road users outside of state or city transit, emergency, or management vehicles. These generic elements have been created for two primary reasons.

First, they represent elements with similar types of interfaces. From a standardization standpoint, describing how one of the major elements in the region (e.g., the NJDOT Roadside Units) interfaces with various transit management or traffic management entities would be the same. A generic element provides an implication that the interfaces between that generic element and another ITS element will be consistent and/or similar, yielding integration cost savings in the end.

Second, describing many systems with a single element helps keep the architecture from growing too large – the Regional ITS Architecture may have so many ITS elements defined that the architecture becomes unwieldy and difficult to maintain. Figure 6 depicts how a generic element (Private Travelers Vehicles) fits into the Curve Speed Warning service package.

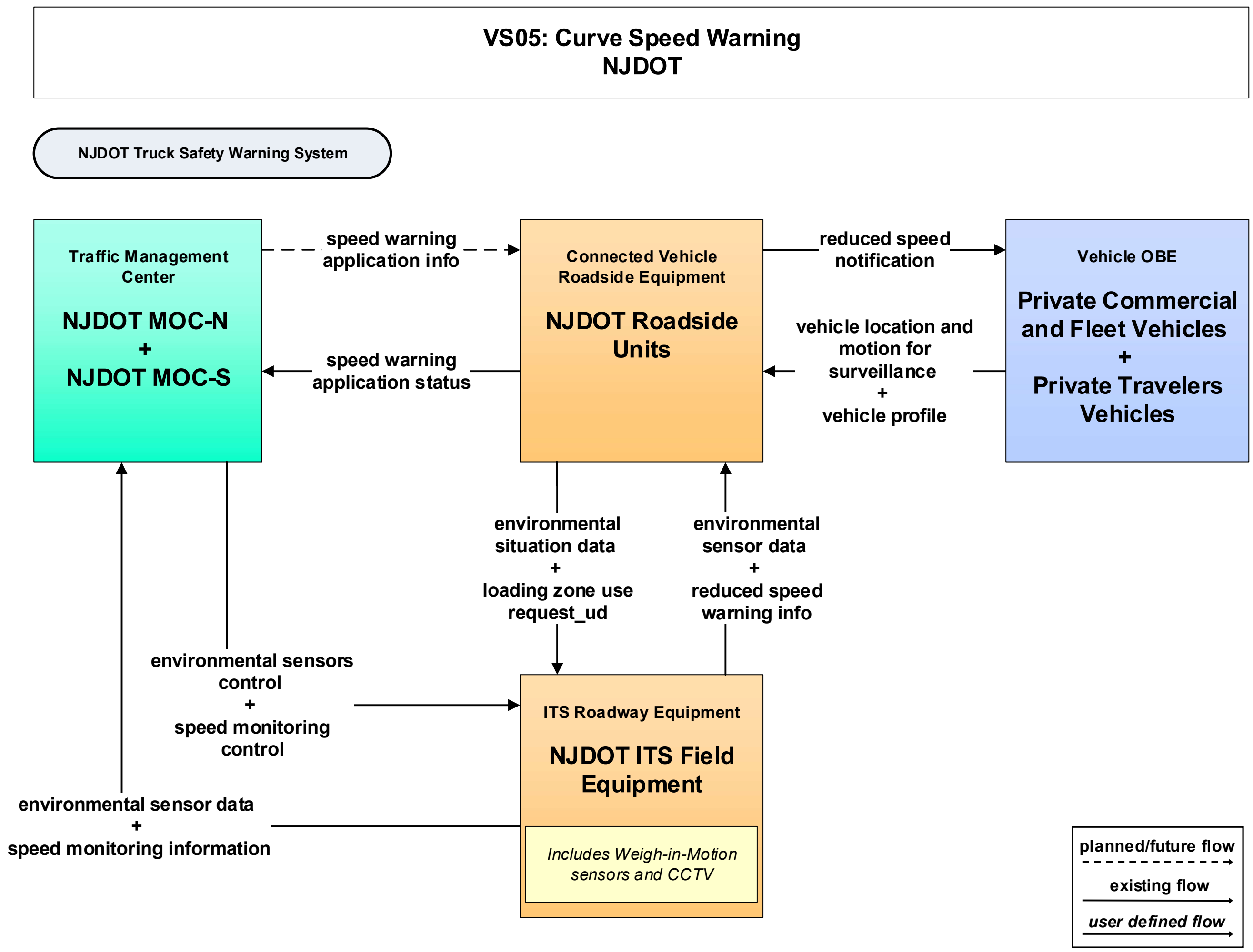


Figure 7. Information Exchange including Generic Elements (Private Commercial and Fleet Vehicles and Private Travelers Vehicles)

Supporting Web Site Resources

- The ITS inventory, an alphabetical listing of elements, is available at: http://www.consystec.com/nj2022/web/inventory.htm.
- The inventory organized by stakeholder is available at: http://www.consystec.com/nj2022/web/invstake.htm.

7 ITS SYSTEM FUNCTIONAL REQUIREMENTS

7.1 ARC-IT Perspective on Functional Requirements

ARC-IT uses the term physical view to describe the transportation systems and the information exchanges that support ITS. The service package diagrams illustrate these high-level relationships. The Functional Objects and Functional Requirements specify the functions of a Physical Object. These concepts are further defined in the bullets below:

- **Physical Objects.** These are systems or device that provide ITS functionality that comprise the physical view of the architecture. Physical objects are further subdivided to five different classes: Centers, Field Equipment, Support Systems, Personal Devices, and Vehicle-based Equipment. System architects often use the term element to refer to a physical object in a regional ITS architecture.
- **Functional Objects.** These are the building blocks of the physical objects of the physical view. Functional objects group similar processes of a particular physical object together into an "implementable" package. The grouping also considers the need to accommodate various levels of functionality. Since functional objects are both the most detailed components of the physical view and tied to specific service packages, they provide the common link between the interface-oriented architecture definition and the deployment-oriented service packages.
- **Functional Requirements.** A statement that specifies what a system must do. The statement should use formal "shall" language and specify a function in terms that the stakeholders, particularly the system implementers, will understand. In ARC-IT, functional requirements have been defined for each Functional Object that focus on the high-level requirements that support regional integration.

7.2 How to Trace to System Functional Requirements

ARC-IT provides traceability (links between) service package elements (physical objects) and functional requirements. Recalling that a grouping of requirements is referred to as a functional object, this traceability between service package elements (physical objects) and functional requirements is illustrated in the figures below.

Service Package -> Physical Objects -> Functional Objects -> Functional Requirements

Figure 8. Service Package Traceability to Functional Requirements

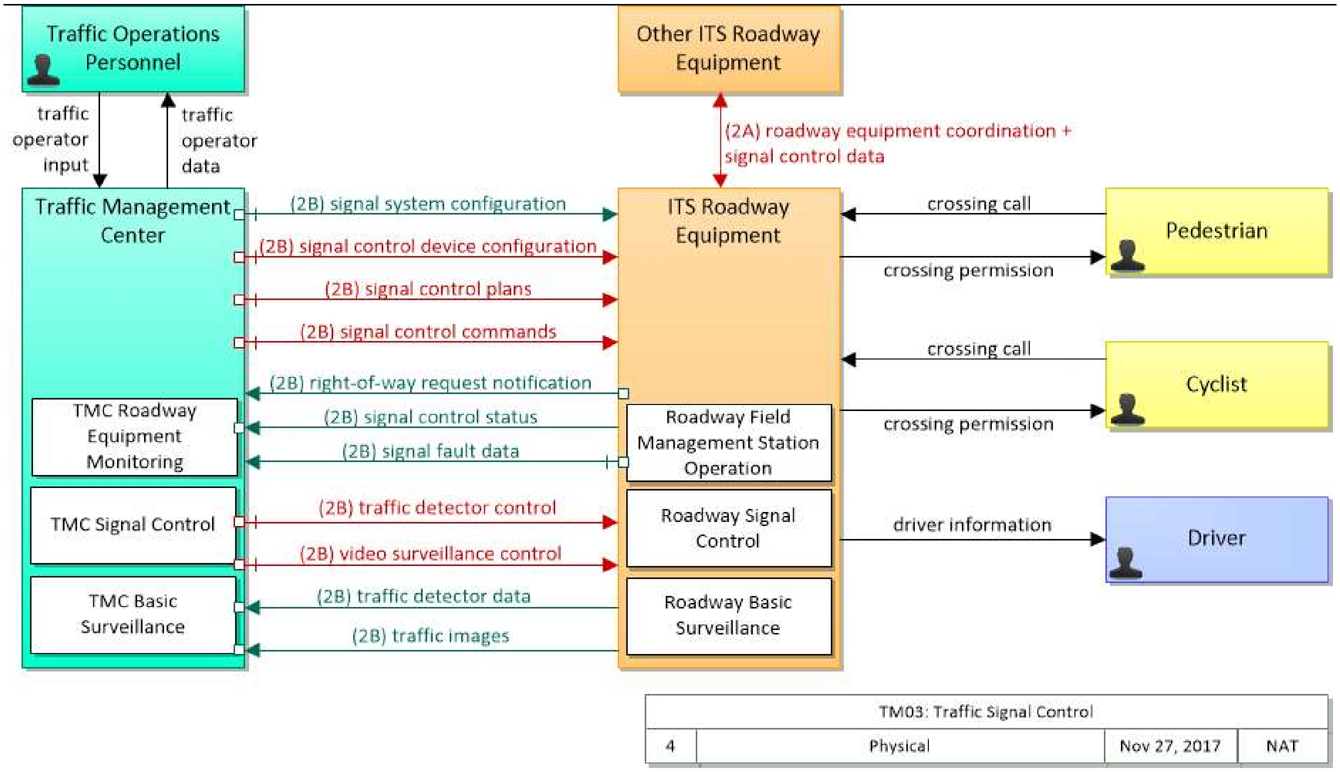
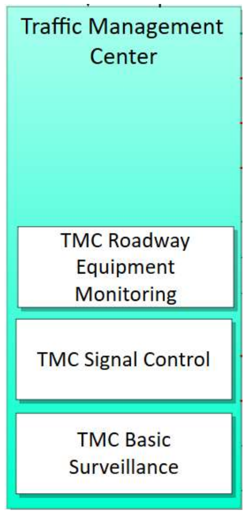


Figure 9. Example to Show Service Package Traceability to Functional Requirements (See table below)

Table 4 below parses out the necessary components from the service package to drill down to the functional requirements. In the table below, top row, Service Package TM03: Traffic Signal Control contains a Physical Object called Traffic Management Center. The Physical Object contains 3 Functional Objects: TMC Roadway Equipment Monitoring, TMC Signal Control, and TMC Basic Surveillance. Functional objects contain bundles of functional requirements.

Table 4. Service Package Traceability Chain to Functional Requirements

Service Package	Physical Objects	Functional Objects	High Level Functional Requirements
TM03: Traffic Signal Control	Traffic Management Center 	• TMC Roadway Equipment Monitoring • TMC Signal Control • TMC Basic Surveillance	See below for 'TMC Roadway Equipment Monitoring', provided as an example.
	ITS Roadway Equipment 	• Roadway Field Management Station Operation • Roadway Signal Control • Roadway Basic Surveillance	See below for 'Roadway Field Management Station Operation', provided as an example.

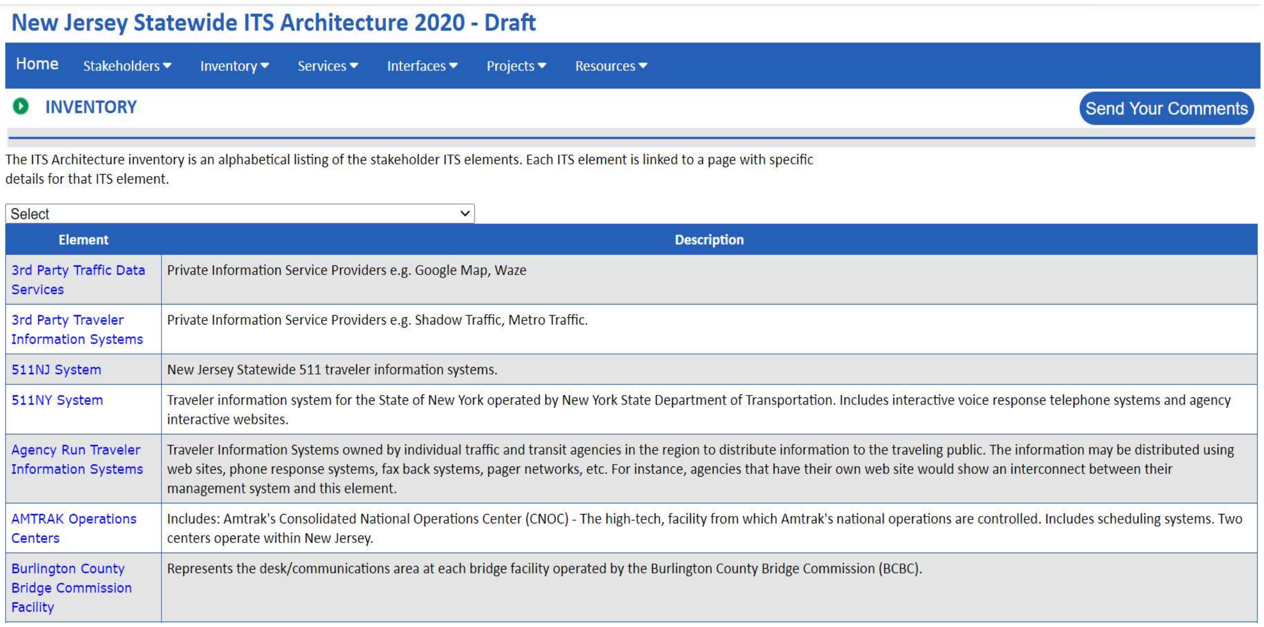
Excerpted high-level functional requirements taken directly from ARC-IT are shown below:

- **'TMC Roadway Equipment Monitoring'** has seven functional requirements with 3 shown below:
    - 01 The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) operational status.
    - 02 The center shall collect and store CCTV surveillance system (traffic, pedestrian) operational status.
    - 03 The center shall collect and store sensor (traffic, pedestrian, multimodal crossing) fault data and send to the maintenance center for repair.
- **'Roadway Field Management Station Operation'** has 2 functional requirements shown below:
    - 01 The field element shall accept configuration information from the center.
    - 02 The field element shall pass data provided by the center to local field devices and report data from the field devices back to the center.

The discussion below shows hot to access the functional requirements in the NJITSA.

7.2.1 Start from the Inventory

The web site contains an ITS Inventory. Each row in the Inventory is linked to one element, representing a system or portion of a system that provides ITS functionality. The diagram below shows a portion of the ITS Inventory.



New Jersey Statewide ITS Architecture 2020 - Draft

Home Stakeholders Inventory Services Interfaces Projects Resources

INVENTORY Send Your Comments

The ITS Architecture inventory is an alphabetical listing of the stakeholder ITS elements. Each ITS element is linked to a page with specific details for that ITS element.

Select

Element	Description
3rd Party Traffic Data Services	Private Information Service Providers e.g. Google Map, Waze
3rd Party Traveler Information Systems	Private Information Service Providers e.g. Shadow Traffic, Metro Traffic.
511NJ System	New Jersey Statewide 511 traveler information systems.
511NY System	Traveler information system for the State of New York operated by New York State Department of Transportation. Includes interactive voice response telephone systems and agency interactive websites.
Agency Run Traveler Information Systems	Traveler Information Systems owned by individual traffic and transit agencies in the region to distribute information to the traveling public. The information may be distributed using web sites, phone response systems, fax back systems, pager networks, etc. For instance, agencies that have their own web site would show an interconnect between their management system and this element.
AMTRAK Operations Centers	Includes: Amtrak's Consolidated National Operations Center (CNOC) - The high-tech, facility from which Amtrak's national operations are controlled. Includes scheduling systems. Two centers operate within New Jersey.
Burlington County Bridge Commission Facility	Represents the desk/communications area at each bridge facility operated by the Burlington County Bridge Commission (BCBC).

Figure 10. Example Portion of the NJITSA ITS Inventory

7.2.2 Navigate to the Element Detail

Selecting an element from the Inventory navigates to an Element Detail page. The example below is for the Burlington County Bridge Commission Facility.

ELEMENT DETAIL

Element Name:	Burlington County Bridge Commission Facility
Description:	Represents the desk/communications area at each bridge facility operated by the Burlington County Bridge Commission (BCBC).
Status:	Existing
Stakeholder:	Burlington County Bridge Commission
Element Interfaces: (Linked to Interface Flows)  	RIMIS Archived Data Management System RIMIS IEN
Service Packages:	DM01: ITS Data Warehouse DM01-05(RIMIS): RIMIS Regional Highway and Transit Historical Operational Data MC05: Roadway Maintenance and Construction MC05-05(RIMIS): RIMIS Regional Roadway Maintenance and Construction Status TM01: Infrastructure-Based Traffic Surveillance TM01-08(RIMIS): RIMIS NJ/PA/Del Crossings (Traffic Management Centers) TM07: Regional Traffic Management TM07-04(RIMIS): RIMIS NJ/PA/Del Crossings TM08: Traffic Incident Management System TM08-04(RIMIS): RIMIS Regional Incident Response Coordination
Element Functions: (Linked to Functional Requirements)	View All Functional Requirements TMC Basic Surveillance TMC Data Collection TMC Incident Detection TMC Incident Dispatch Coordination TMC Passive Surveillance TMC Regional Traffic Management TMC Roadway Equipment Monitoring

Figure 11. Example Burlington County Bridge Commission Facility Element Detail

7.2.3 Navigate to the Functional Requirements

Figure 11, the Element Detail figure above, contains a row of information at bottom for Element Functions. Clicking on one of the Functional Objects listed navigates to the functional requirements bundle for that functional object, as shown in the figure below.

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Home Stakeholders Inventory Services Interfaces Projects Resources

FUNCTIONAL REQUIREMENTS Send Your Comments

Functional Requirements: TMC Basic Surveillance

1. The center shall monitor, analyze, and store traffic sensor data (speed, volume, occupancy) collected from field elements under remote control of the center.
2. The center shall monitor, analyze, and distribute traffic images from CCTV systems under remote control of the center.
3. The center shall monitor, analyze, and store multimodal crossing, high occupancy vehicle (HOV) and high occupancy toll (HOT) lane sensor data under remote control of the center.
4. The center shall distribute road network conditions data (raw or processed) based on collected and analyzed traffic sensor and surveillance data to other centers.
5. The center shall respond to control data from center personnel regarding sensor and surveillance data collection, analysis, storage, and distribution.
6. The center shall maintain a database of surveillance equipment and sensors and associated data (including the roadway on which they are located, the type of data collected, and the ownership of each).
7. The center shall remotely control devices to detect traffic.

Figure 12. Example Functional Requirements: TMC Basic Surveillance

Supporting Web Site Resources

- The ITS inventory, an alphabetical listing of elements, is available at: http://www.consystec.com/nj2022/web/inventory.htm.
- The Element Detail pages. For example: http://www.consystec.com/nj2022/web/element.htm?id=438.
- The Functional Requirements pages. For example: http://www.consystec.com/nj2022/web/funreq.htm?id=14.

8 INTERFACE REQUIREMENTS AND INFORMATION EXCHANGES

The ITS Services desired for New Jersey and the ITS inventory to provide those services were identified in the previous section. This section describes how ITS inventory elements may be interconnected and what information may be shared between those ITS elements to provide one or more ITS Services.

8.1 Customized Service Packages Identify System Interfaces

A primary purpose of the architecture is to identify the services to be provided in the state and the connectivity between transportation systems in the region to provide these services. The customized Service Packages represent services that can be deployed as an integrated capability, and the customized Service Package diagrams show the information flows between the subsystems and terminators that are most important to the deployment of the Service Packages. How these systems interface with each other is an integral part of the overall architecture.

The service packages from ARC-IT were customized to reflect the unique systems and connections within the region. Each customized service package provides a graphical view that shows information flows that move between elements. These information flows between two elements are referred to as a system interface, or interface for short.

Figure 13 shows an example of an Advanced Traffic Management System service package for Traffic Signal Control that has been customized for New Jersey. This service package shows three physical objects, two Traffic Management Center and an ITS Roadway Equipment. Information flows between the physical objects indicate what information is being shared.

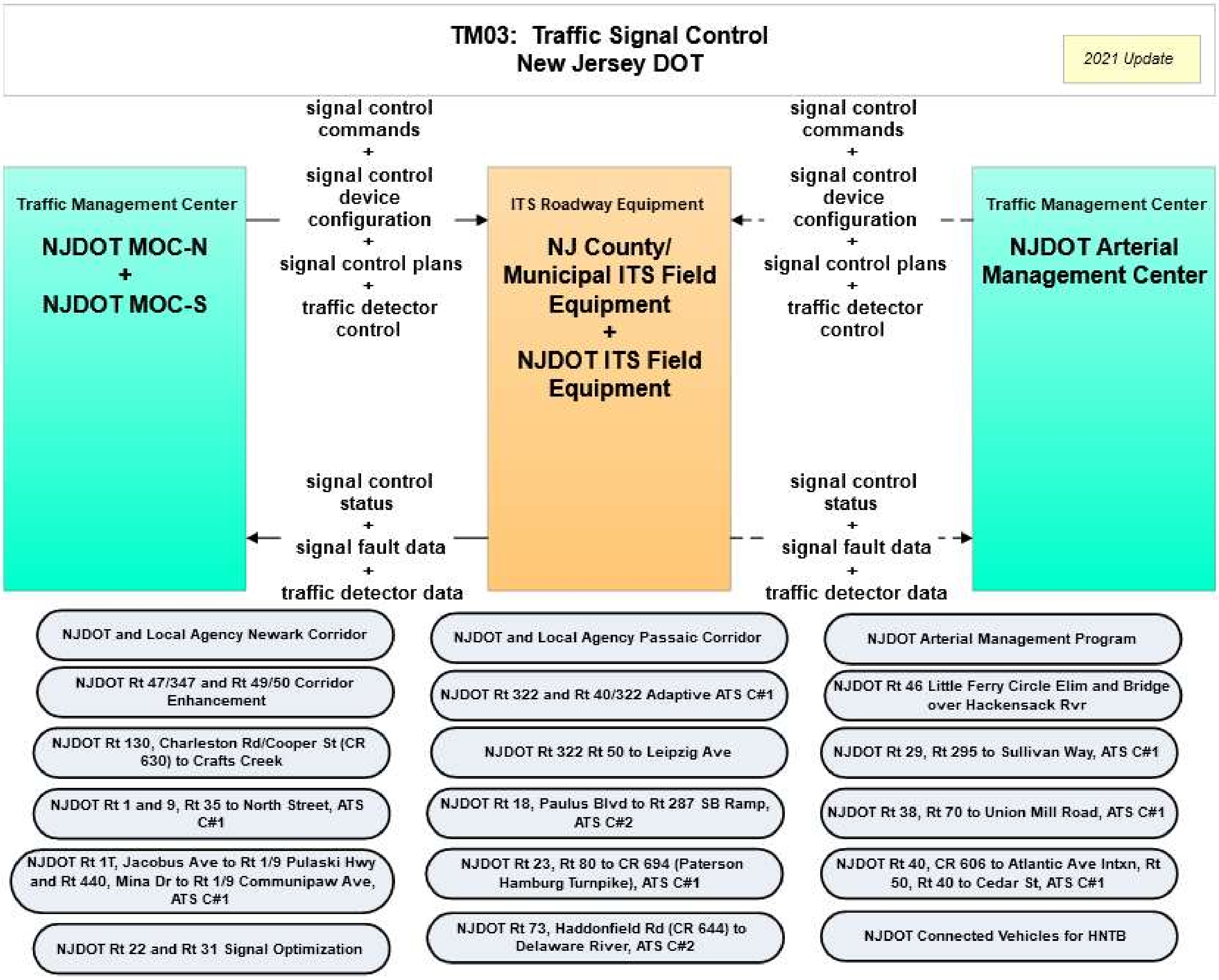


Figure 13. Example Customized Service Package – Information Flows and Interfaces

8.2 Information Flows

Information flows between the elements define specific information that is exchanged by the elements. Each flow has a direction, name and definition. Most of the flows match identical ones from ARC-IT. In some cases, user defined flows have been created for interfaces or connectivity that are not expressed in ARC-IT (Note these flows have a "_ud" at the end of the name to indicate they are user defined). These architecture flows define the interface requirements between the various elements in the regional architecture.

An example of information flows between two elements is shown in Figure 14. In this interface the flows that go between the NJ Municipal/County Local ITS Field Equipment and the NJDOT Arterial Management Center are shown. Planned flows that do not yet exist are shown with a dotted line, while existing flows that are currently implemented are shown by a solid line.

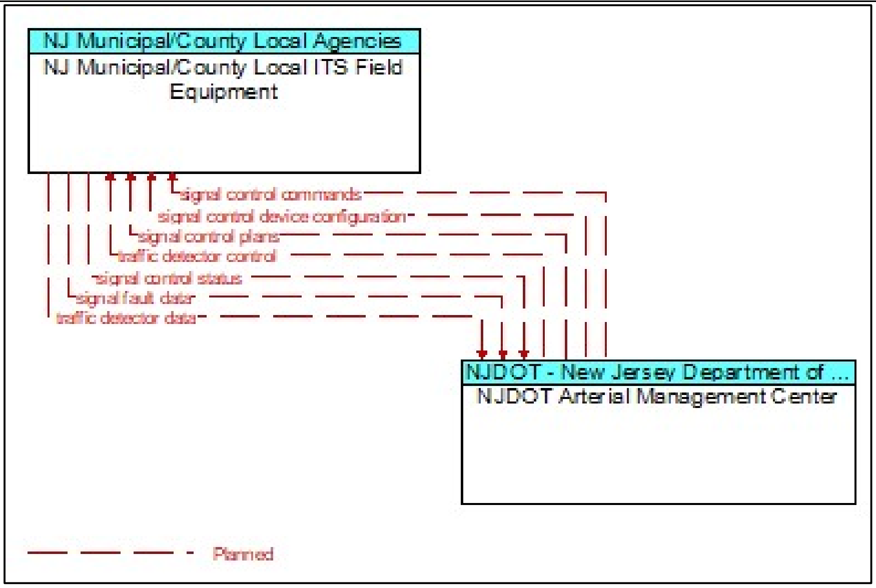


Figure 14. Example Information Flows Between ITS Inventory Elements

Supporting Web Site Resources

- **Interfaces.** http://www.consystec.com/nj2022/web/interfaces.htm
- **Flow Descriptions.** http://www.consystec.com/nj2022/web/flows.htm

9 REGIONAL ITS PROJECTS

The purpose of an ITS architecture is to facilitate ITS project planning and development, where ITS and other technologies are used to enable improvements in regional transportation safety, mobility, efficiency, congestion management, and information sharing.

9.1 ITS Projects Overview

The collection of projects identified in the NJITSA are significant projects that to a large extent address existing transportation needs and are stepping stones to addressing future needs and capabilities. As such, the projects provide foundational support for future projects. The collective set of projects are all-encompassing in terms of facility types (highway/tollway, arterials, parking, bridge/tunnel crossings), modes (transit and freight), and enabling of future ITS development in New Jersey.

Please note that some of the projects identified may not be a “specific” project, but rather may reflect a set of projects or a project that is underway that stakeholders wanted to include in the architecture. In some cases, the “project” reflects the fact that stakeholders were aware of an ITS capability, and that the project must have been created and implemented at some point, but the details were not readily available. However one looks at it, understanding what is existing and deployed – “in the ground” – is a key step to efficient planning, where targets are set against a current baseline, and from the operations perspective identify what might be expanded upon or re-used.

The bullets below provide a broad brushstroke description of the projects identified.

- **Regional Coordination**. Regional information exchange projects were identified and enable regional collaboration across agency facilities. For example, the projects of TRANSCOM, and the Delaware Valley RIMIS IEN.

- **Highway/Tollway Management**. Highway and Tollway operations projects are represented throughout the ITS architecture.
- **Arterial Management Center**. A New Jersey Statewide Arterial Management Center is planned to enable improved coordination across numerous municipal jurisdictions in the State.
- **Local Traffic Signal Control and Corridors**. Local/municipal arterial upgrade projects are identified, including those in Newark and Passaic.
- **Integrated Corridor Management**. NJ has undertaken a large integrated corridor management project that covers nearly half the State.
- **Bridge/Tunnel Crossings**. New Jersey contains numerous bridge and tunnel crossings managed by separate authorities. The projects identified enable multi-state coordination, and information sharing to address bottlenecks as traffic approaches facility entrances and exits. For example, PANYNJ, and Delaware Valley RIMIS IEN.
- **Transit Infrastructure and Security**. Rail infrastructure projects provide upgrades for improved transportation system security.
- **Transit Fare Payment**. The need to upgrade and integrate transit fare payment across transit carriers in the State continues.
- **Transit Service Information Coordination and Traveler Information**. Multi-modal roadway and transit traveler information is comprehensively deployed Statewide. New initiatives and projects reflect the need to provide improved traveler information for freight carriers.
- **Incident/Special Event Planning and Operations**. Regional information exchange projects are identified to enable regional incident management and special event management. In addition, service patrol vehicles are equipped with automated vehicle location systems and ability to report on roadway conditions and incidents from the field.
- **Construction Coordination and Work Zones**. Construction and permitting projects provide information on existing and scheduled lane closures for maintenance, construction, and work zones.
- **Freight Parking**. A Freight Parking pilot is underway.
- **Weather Information and Winter Operations**. Weather information projects provide data collection and sharing, including mobile weather stations. Winter operations information sharing is also identified.
- **Archived Data Projects**. Almost every agency interviewed has identified projects for archiving of transportation data to enable government reporting, analysis, predictive analytics, and operations support.
- **Connected Vehicle**. Future connected vehicle projects are identified include those addressing signalized intersection safety for vehicles, and pedestrian and bicycle safety.

9.1.1 ITS Project Information Sheet

As part of the NJ ITS Architecture development process, NJ transportation stakeholders are asked to fill out an ITS Project Information Sheet. Sections of the ITS Project Information Sheet (if the information is available at the time) are applicable to satisfying the requirements of a Systems Engineering Analysis. A sample ITS Project Information Sheet is included in Appendix E. The project information sheet includes the following information:

- **Agency Name:** This field may include multiple agencies. Please indicate lead agency.
- **Contact Name/E-mail:** Contact information for person providing information with whom we may follow-up.
- **ITS Project Name:** A project name. This title will be used to identify the project in the NJ ITS Architecture.
- **ITS Project Description:** Project description including location (region, section of roadway, rail line, intersection, etc.) Also, please indicate type of technology expected to be deployed.

- **Status**: Indicate whether the project is Existing or Planned.
- **Time Frame**: Indicate whether Short-term, Medium-term, Long-term, or similar in years
- **ITS Project ID**: STIP/TIP Number
- **Reference Document(s)**. If available, please provide reference materials that may have been created for the project.
- **Shared with Public (Y/N)**. Indicate whether we can include (make a copy) for the Architecture Library to be shared among NJ Stakeholders and interested parties. For example, project ConOps, System Engineering Analyses, etc.
- **Procurement Options**. Please indicate funding source. (Note: Additional discussion/guidance is included in the write-up in Section 3).
- **Procedures and Resources Necessary for Operations and Management of the System**. Please indicate staffing, hardware, software, and communications needs. (Note: Additional discussion/guidance is included in the write-up in Section 3).
- **Analysis of Alternative System Configuration and Technology Options**. If available, please provide additional reference materials or summary of alternative design considerations. (Note: Additional discussion/guidance is included in the write-up in Section 3).

9.1.2 Process to Incorporate ITS Project Information into the NJ ITS Architecture

The diagram below illustrates the process for including an ITS project in the NJ ITS Architecture, which is summarized as:

- Step #1 starts with a determination of whether a project is an "ITS project."
- This is followed with Step #2 and Step #3 to incorporate the ITS Project Information into the NJ Statewide ITS Architecture.
- Step #4 shows that the information is maintained in the NJ ITS Architecture where it can be used as a one-stop source for summary information required to complete a Systems Engineering Analysis for the ITS Project.

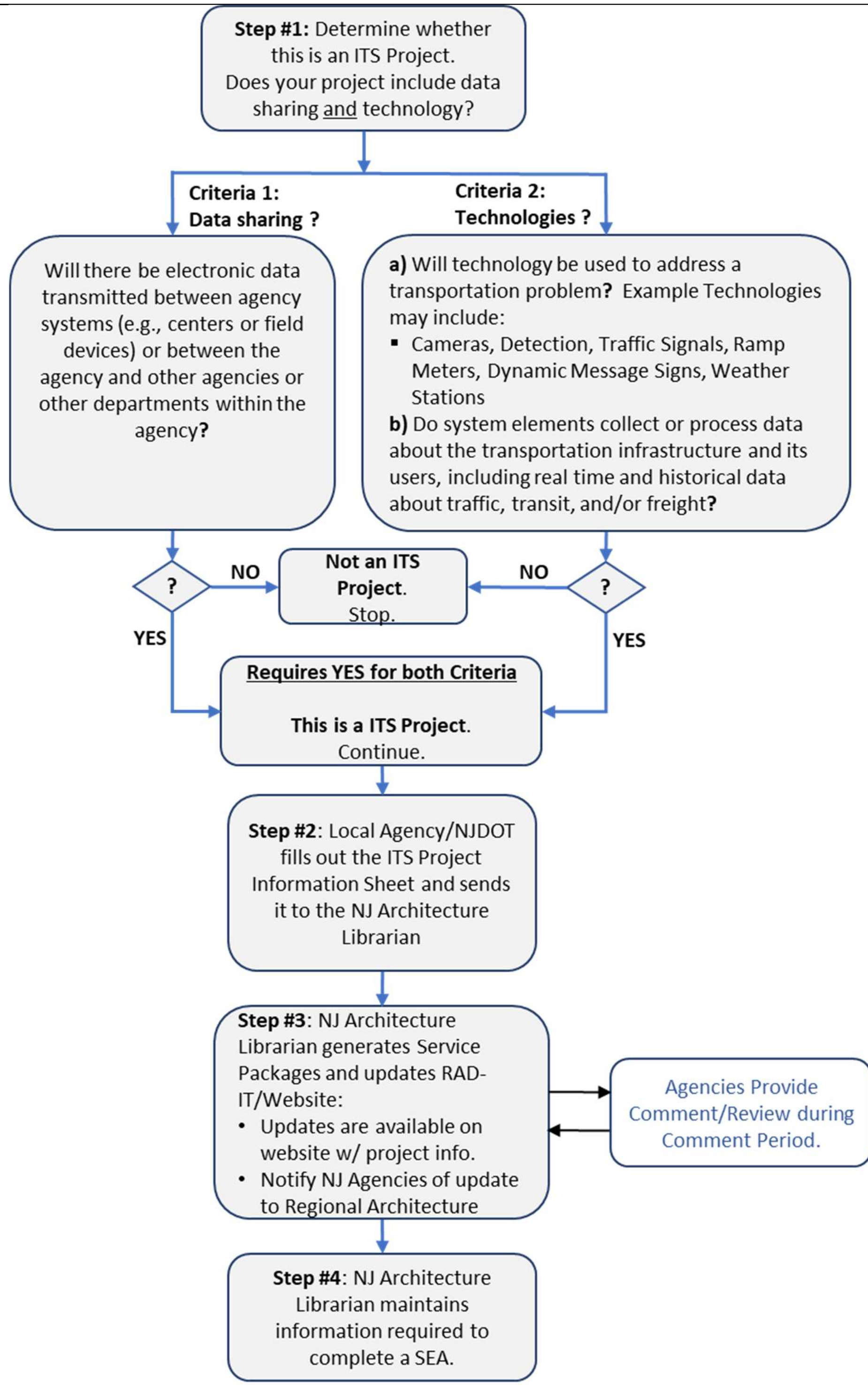


Figure 15. Process for Incorporating ITS Project Information

ITS project information is taken from the project information sheet and put into the architecture database and used to create customized service package diagrams. The information is then placed on the NJ Architecture website where it can be accessed by stakeholders.

9.2 ITS Project Information in RAD-IT

The ITS project information shown on the website is defined in the database tool used to hold the details of the architecture. This section describes the tool, RAD-IT, and how the project information is described in the tool.

According to the ARC-IT Web Site (see https://www.arc-it.net/html/resources/tools.html):

"Regional Architecture Development for Intelligent Transportation (RAD-IT) is a software application that supports development of regional and project ITS architectures using ARC-IT as a starting point."

This tool is used to organize the details of the regional ITS architecture and each project ITS architecture, which are defined as subsets of the information in the regional ITS architecture.

The ITS Project information that is contained in the RAD-IT database is used to create the information on the ITS architecture web site. The screen shot below shows the list of projects in RAD-IT. Note that the NJDOT and Local Agency Newark Corridor is selected. The tabs of the tool contain the information about

- Stakeholders
- Inventory,
- Services
- Roles and Responsibilities
- Functions
- Interfaces

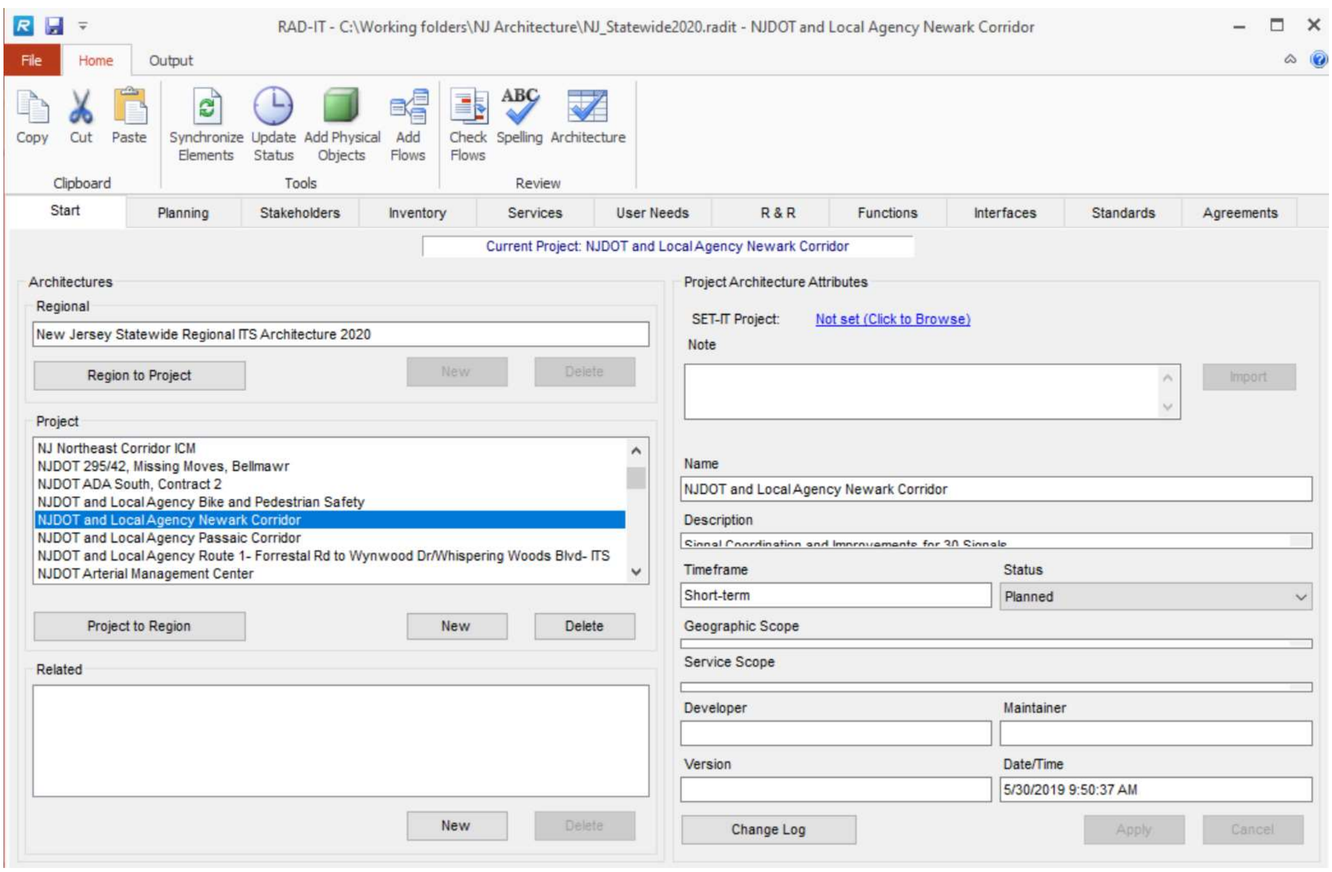


Figure 16. Example ITS Projects in RAD-IT

Clicking on the RAD-IT tabs, for example, Inventory, will show only the inventory elements for this project, as shown below.

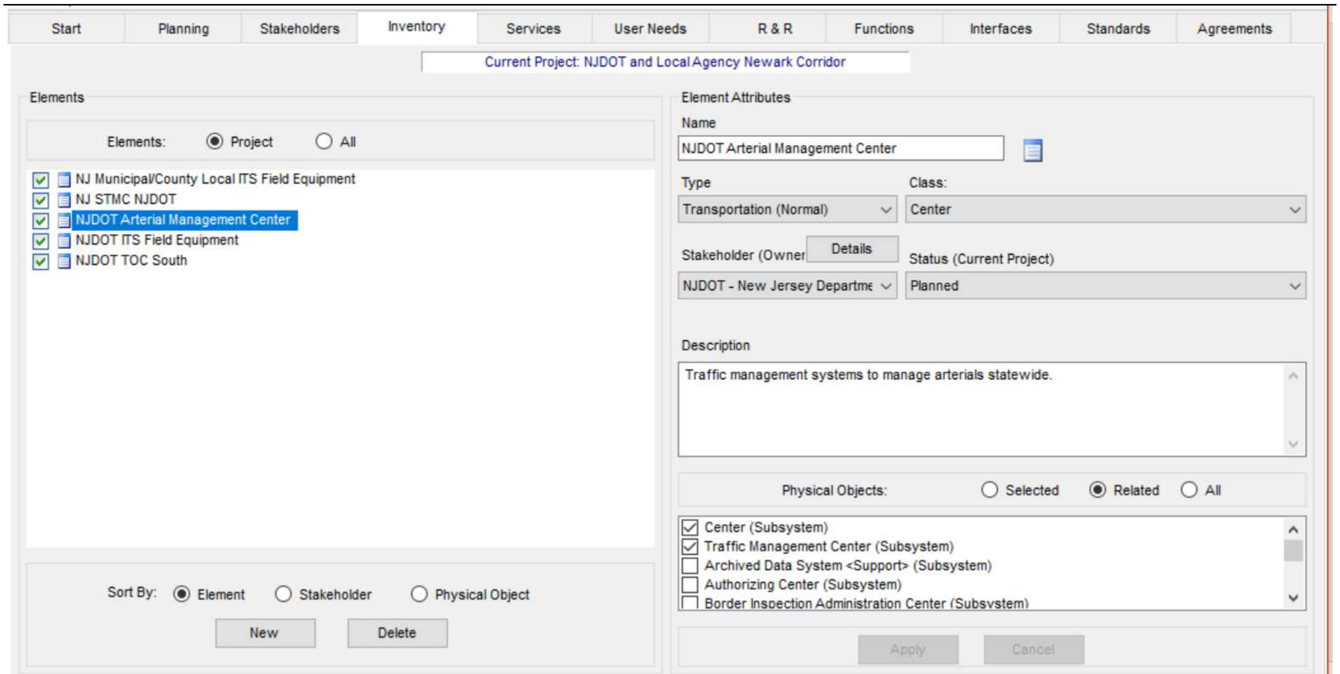
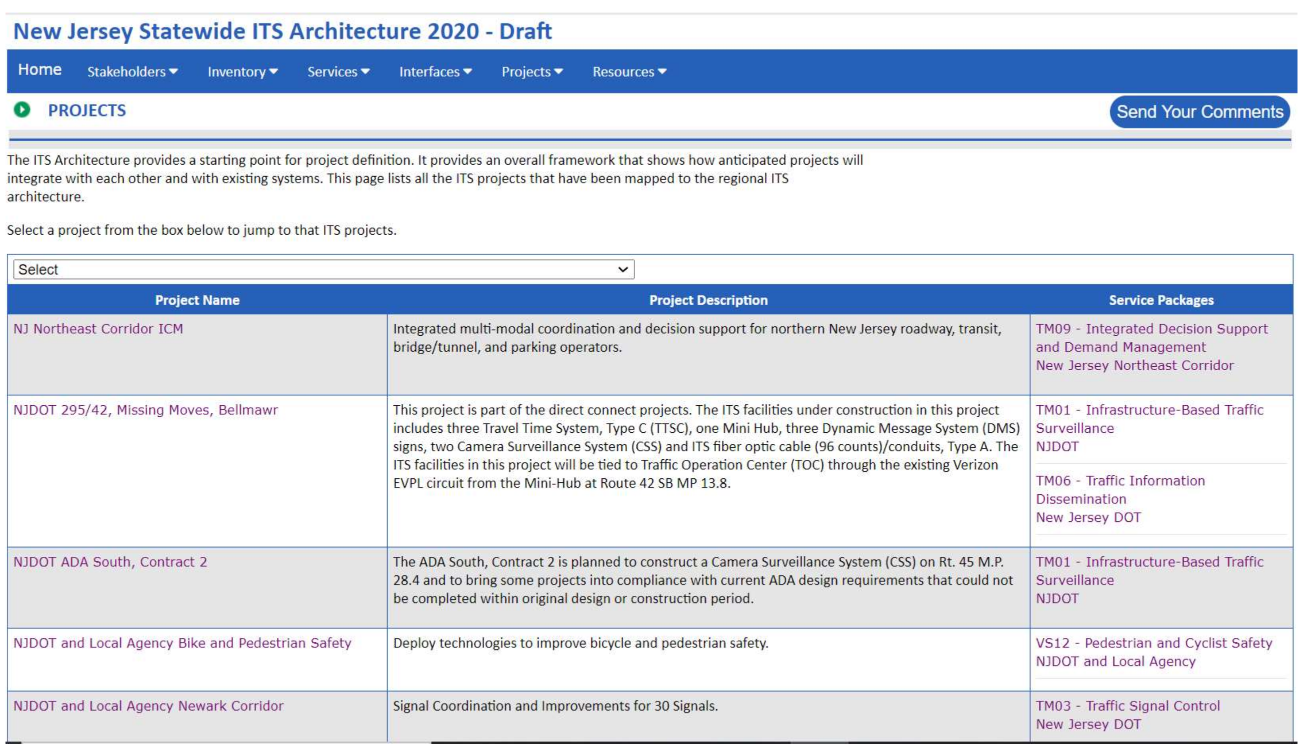


Figure 17. Example ITS Project Inventory Information Filtered in RAD-IT

9.3 Customized Service Packages Supporting ITS Projects

The New Jersey ITS Projects are also mapped in the architecture to a set of customized service packages that directly support one or more services included in the ITS project. These customized service packages are included on the web as well. This is shown in the screen shot from the ITS architecture web site below, which shows the customized service packages mapped to each project.



Project Name	Project Description	Service Packages
NJ Northeast Corridor ICM	Integrated multi-modal coordination and decision support for northern New Jersey roadway, transit, bridge/tunnel, and parking operators.	TM09 - Integrated Decision Support and Demand Management New Jersey Northeast Corridor
NJDOT 295/42, Missing Moves, Bellmawr	This project is part of the direct connect projects. The ITS facilities under construction in this project includes three Travel Time System, Type C (TTSC), one Mini Hub, three Dynamic Message System (DMS) signs, two Camera Surveillance System (CSS) and ITS fiber optic cable (96 counts)/conduits, Type A. The ITS facilities in this project will be tied to Traffic Operation Center (TOC) through the existing Verizon EVPL circuit from the Mini-Hub at Route 42 SB MP 13.8.	TM01 - Infrastructure-Based Traffic Surveillance NJDOT TM06 - Traffic Information Dissemination New Jersey DOT
NJDOT ADA South, Contract 2	The ADA South, Contract 2 is planned to construct a Camera Surveillance System (CSS) on Rt. 45 M.P. 28.4 and to bring some projects into compliance with current ADA design requirements that could not be completed within original design or construction period.	TM01 - Infrastructure-Based Traffic Surveillance NJDOT
NJDOT and Local Agency Bike and Pedestrian Safety	Deploy technologies to improve bicycle and pedestrian safety.	VS12 - Pedestrian and Cyclist Safety NJDOT and Local Agency
NJDOT and Local Agency Newark Corridor	Signal Coordination and Improvements for 30 Signals.	TM03 - Traffic Signal Control New Jersey DOT

Figure 18. Example Projects and Mapping to Service Packages

9.4 Project Systems Engineering Analysis Reports

Project information, whether from the project information sheet, web site or RAD-IT, provides information that can be used to develop a Systems Engineering Analysis. Conducting a Systems Engineering Analysis is a requirement of 23 CFR 940.11 (c) for projects using Highway Trust Fund monies.

The table below shows the requirements of a Systems Engineering Analysis and shows sources of information, and where requirements can be found in the NJ ITS Architecture (RAD-IT, and Web Site).

A more detailed description of how to find information for a Systems Engineering Analysis can be found on the web site under Project Library with a link to the following document:

- White Paper Systems Engineering Analysis Guidance: Using the NJ ITS Architecture for Project Implementation

Table 5. Sources of Information for Project Information required for Systems Engineering Analysis

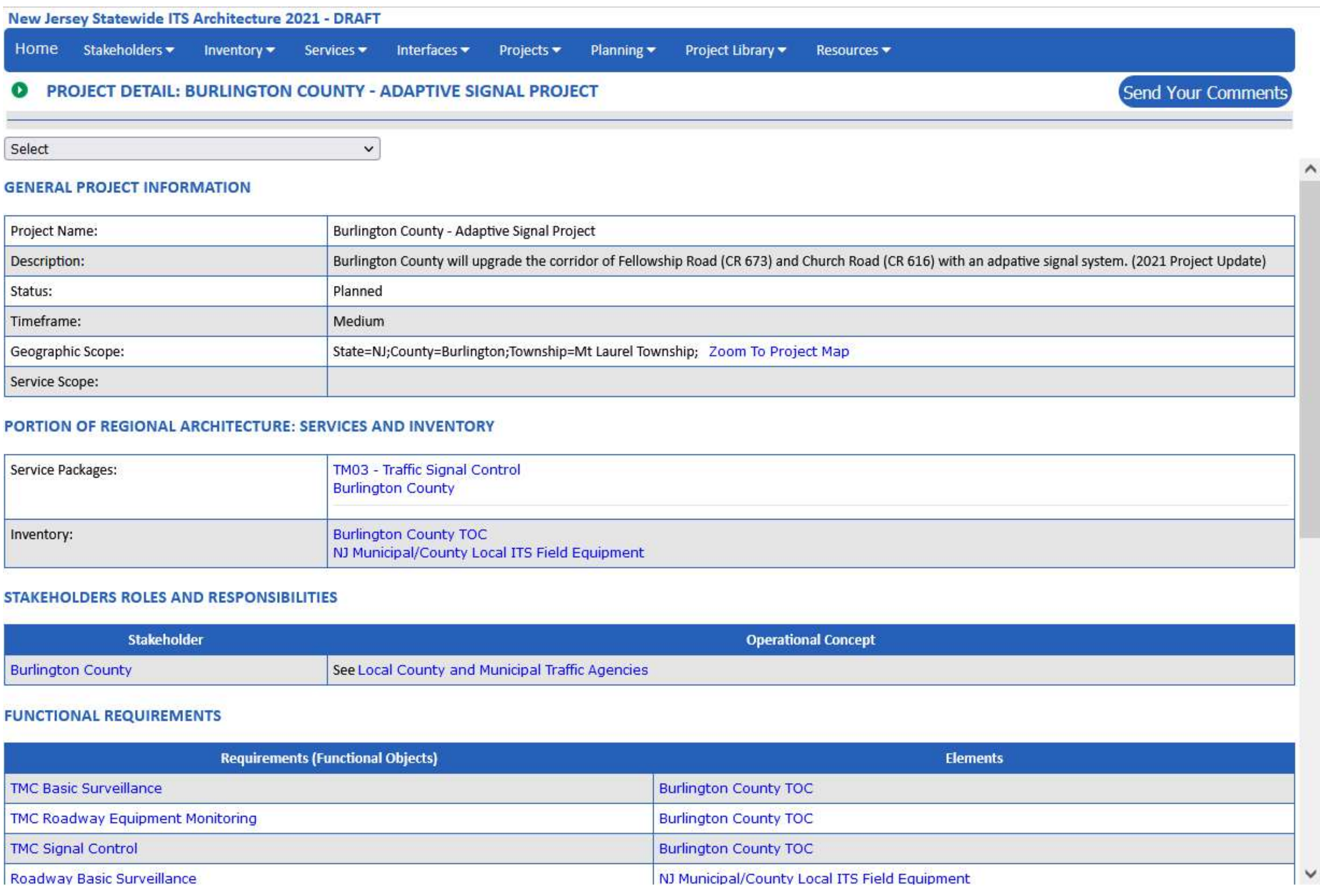
Item	Systems Engineering Analysis Requirement	ITS Project Information Sheet Information	ITS Architecture	RAD-IT Database	Architecture Web Site
Roles >>>>	FHWA Rule 940.11/FTA Policy on Project Implementation	Agency Provided	Initial Draft is Generated by the Librarian, and Reviewed/Confirmed by Agency.	Maintained by the Librarian, and directly reflects ITS Architecture.	• Generated by the Librarian. • Blends information Agencies provide in the Project Information Sheet and from the ITS Architecture. • Librarian maintains, and agencies can reference for SEA content.
1	Identification of portions of the regional ITS architecture being implemented	Not requested on Project Information Sheet.	Service Packages, ITS Elements, and Element Interfaces developed by Librarian	Stakeholders, Inventory, Services, Interfaces tabs	The Project Detail Page contains a list of corresponding Service Package Diagrams, along with the stakeholders, inventory and interfaces
2	Identification of participating agencies' roles and responsibilities	Project Information Sheet contains a field for agency name/sponsor, and project description which helps to identify ITS project elements and agency role.	Operational Concept	R&R tab	The Project Detail Page contains some high level information on roles and responsibilities. Additional information may also be found on the Operational Concepts tab under the Stakeholder pulldown.
3	Requirements Definitions	Not requested on Project Information Sheet.	Functional Requirements	Functions tab	The Project Detail Page contains a list of functional objects for the key elements, which can be selected to link to relevant high level requirements.
4	Analysis of alternative system configurations and technology options to meet requirements	Project Information Sheet will contain a field for agencies to summarize alternative options considered.	The architecture will maintain a "database" of this information as provided in the Project Information Sheet.	Not included in RAD-IT.	The Project Detail Page will in future versions contain the information from the Project Information Sheet, but does not currently have this.

Item	Systems Engineering Analysis Requirement	ITS Project Information Sheet Information	ITS Architecture	RAD-IT Database	Architecture Web Site
5	Procurement options	Project Information Sheet will contain a field for agencies to summarize procurement options considered.	The architecture will maintain a "database" of this information as provided in the Project Information Sheet.	Not included in RAD-IT	The Project Detail Page will in future versions contain the information from the Project Information Sheet, but does not currently have this.
6	Identification of applicable ITS standards and testing procedures	Not requested on Project Information Sheet.	The architecture includes identification of applicable ITS standards and content discussion on testing procedures for interfaces specified using ITS standards. Appendix D of this document contains a discussion of the standards Example ITS Standards includes: NTCIP, TMDD, SAE J2735, etc.	Standards tab	The Project Detail Page indicates relevant flows and candidate standards.
7	Procedures and resources necessary for operations and maintenance	Project Information Sheet will contain a field for agencies to described resources necessary for operations and management of the system. Project Information Sheet contains a field for TIP/STIP or other Project Identifier to correlate with planning documents or capital program.	The architecture will maintain a "database" of this information as provided in the Project Information Sheet.	Not covered in RAD-IT	The Project Detail Page will in future versions contain the information from the Project Information Sheet, but does not currently have this

In Figure 18, we showed a projects list page. The listed projects are linked to a project detail page. The project detail page contains specific information organized as follows.

- General Information
- Portion of Regional Architecture: Services and Inventory
- Roles and Responsibilities: Operational Concept
- Functional Requirements
- Interfaces and Standards

The organization of the project detail page makes it easy to find relevant information to complete a Systems Engineering Analysis report.



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PROJECT DETAIL: BURLINGTON COUNTY - ADAPTIVE SIGNAL PROJECT

Send Your Comments

Select

GENERAL PROJECT INFORMATION

Project Name:	Burlington County - Adaptive Signal Project
Description:	Burlington County will upgrade the corridor of Fellowship Road (CR 673) and Church Road (CR 616) with an adpative signal system. (2021 Project Update)
Status:	Planned
Timeframe:	Medium
Geographic Scope:	State=NJ;County=Burlington;Township=Mt Laurel Township; Zoom To Project Map
Service Scope:	

PORTION OF REGIONAL ARCHITECTURE: SERVICES AND INVENTORY

Service Packages:	TM03 - Traffic Signal Control Burlington County
Inventory:	Burlington County TOC NJ Municipal/County Local ITS Field Equipment

STAKEHOLDERS ROLES AND RESPONSIBILITIES

Stakeholder	Operational Concept
Burlington County	See Local County and Municipal Traffic Agencies

FUNCTIONAL REQUIREMENTS

Requirements (Functional Objects)	Elements
TMC Basic Surveillance	Burlington County TOC
TMC Roadway Equipment Monitoring	Burlington County TOC
TMC Signal Control	Burlington County TOC
Roadway Basic Surveillance	NJ Municipal/County Local ITS Field Equipment

Figure 19. Example Project Detail Page

Where a project description provides sufficient locational information, the project is placed on a map, as shown below. The project location helps to identify the transportation facilities that will benefit from ITS improvements.

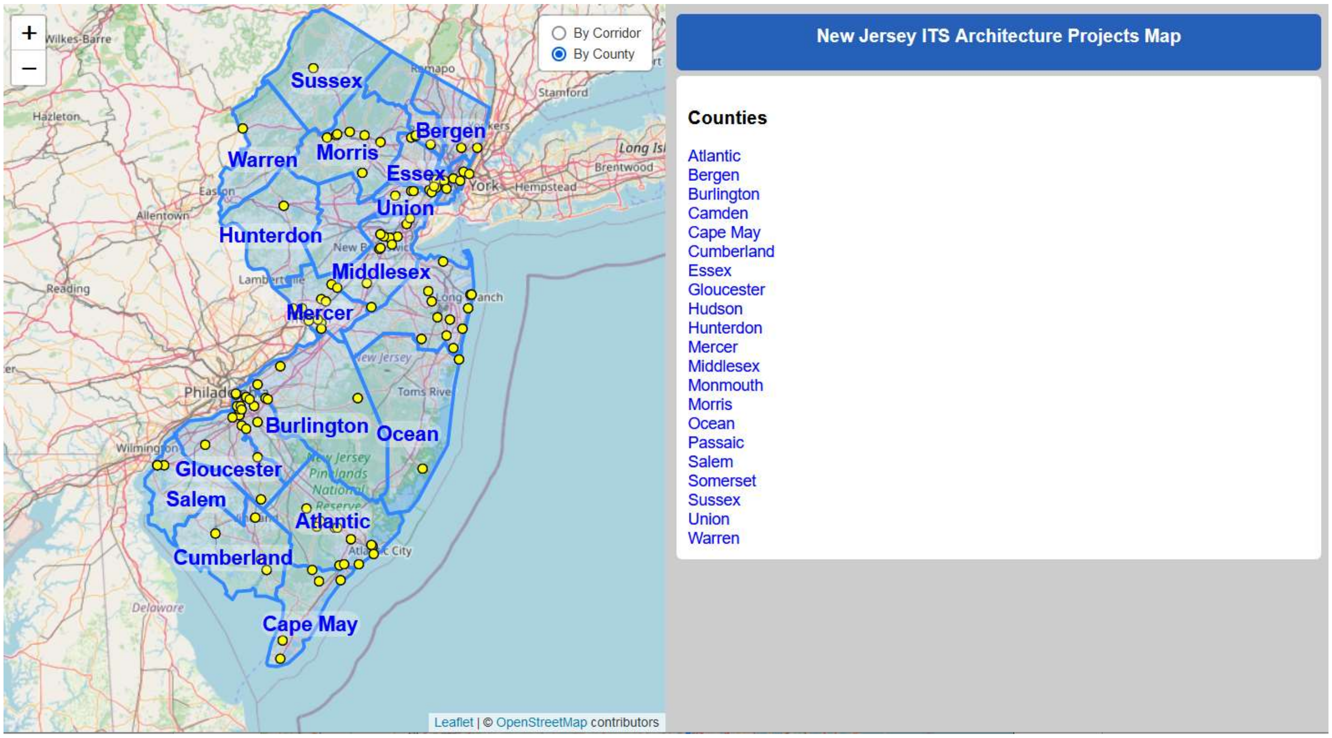


Figure 20. Example Project Location on Project Map Page

9.5 Regional ITS Architecture Connections to Planning Documents

The NJ ITS Architecture documents connections between regional transportation planning documents and relevant portions of the ITS architecture, namely ITS Projects and Service Packages. The concept behind these connections is illustrated in the figure below.

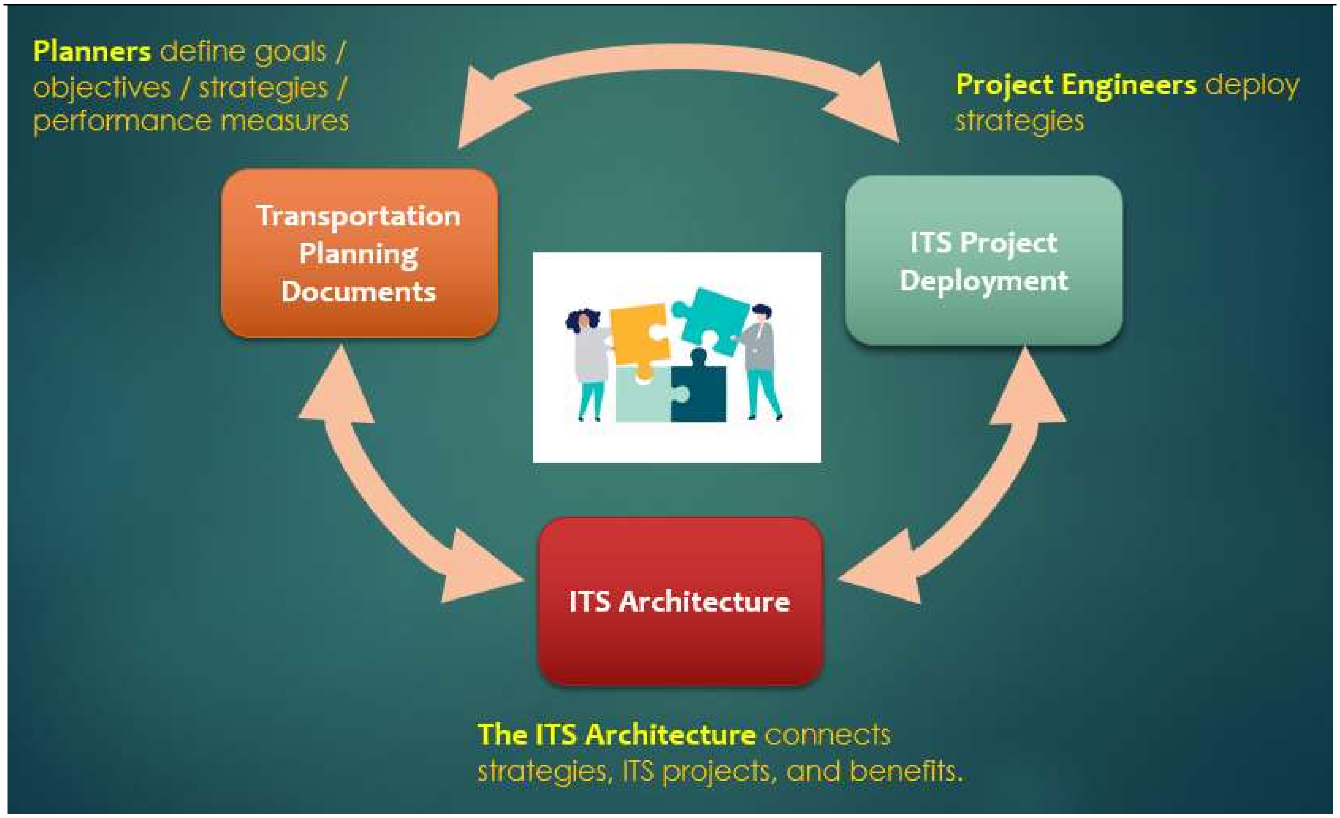
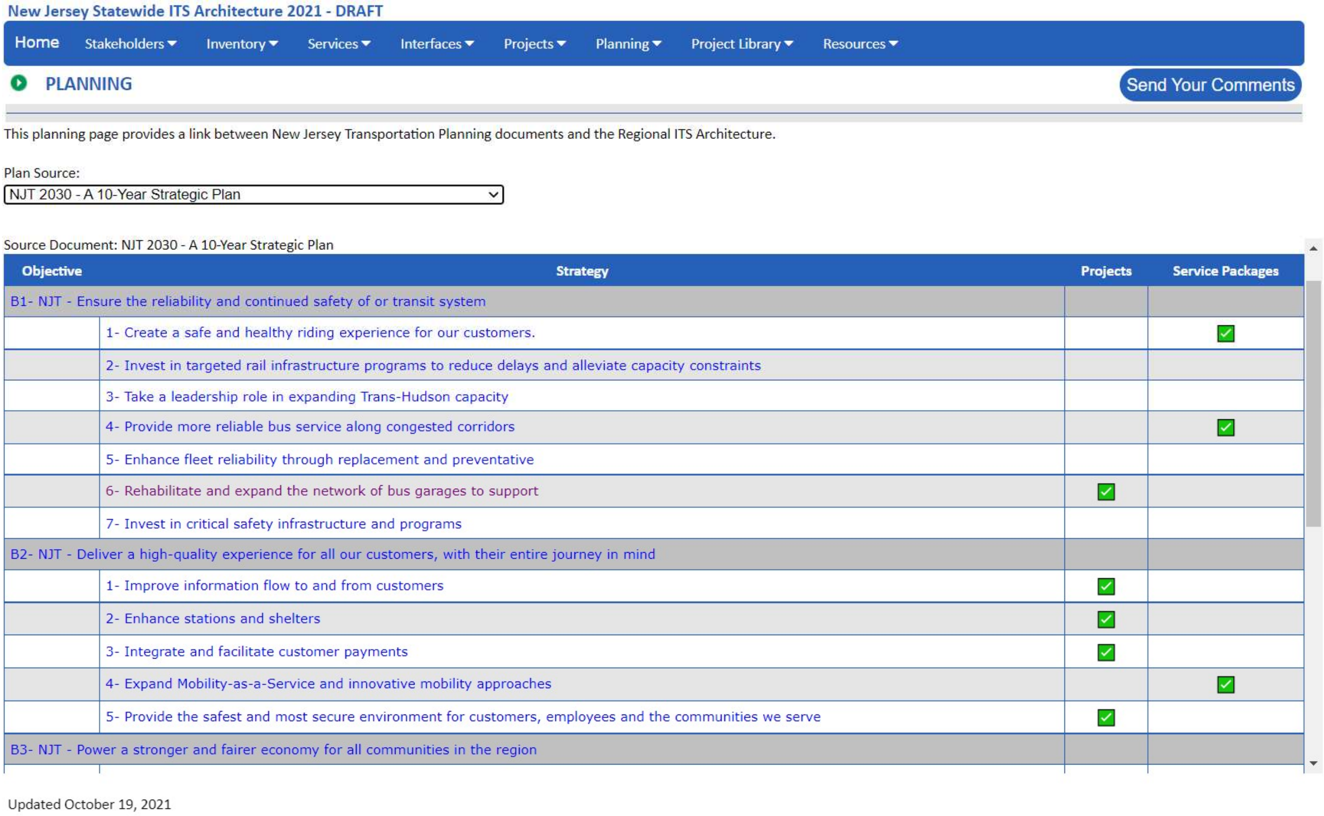


Figure 21. Connecting Planning Documents with the Regional ITS Architecture

The diagram shows the following relationships:

1. Transportation Planning documents - Define regional transportation goals/objectives. Strategies are identified to address transportation problems. The ITS Architecture documents transportation goals/objectives and strategies. Planning documents reviewed include:
   - Plan 2050 - NJTPA Regional Transportation Plan for Northern New Jersey
   - SJTPO - Regional Transportation Plan (RTP)
   - DVRPC - Connections 2050
   - NJDOT - Transportation Choices 2030
   - NJT 2030 - A 10-Year Strategic Plan
   - NJTA - Strategic Plan 2020-2029
2. ITS Projects - Implement transportation strategies. The ITS architecture documents technology projects deployed to realize transportation improvements. The NJ ITS architecture has identified approximately 150 ITS Projects.
3. The ITS Architecture – Documents connections between transportation strategies, ITS projects identified, and ITS services that are the framework of the ITS Architecture. The ITS Architecture supports the definition of ITS projects to facilitate procurement.

A fragment of the Planning Page is shown in the figure below.



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PLANNING

Send Your Comments

This planning page provides a link between New Jersey Transportation Planning documents and the Regional ITS Architecture.

Plan Source:
NJT 2030 - A 10-Year Strategic Plan

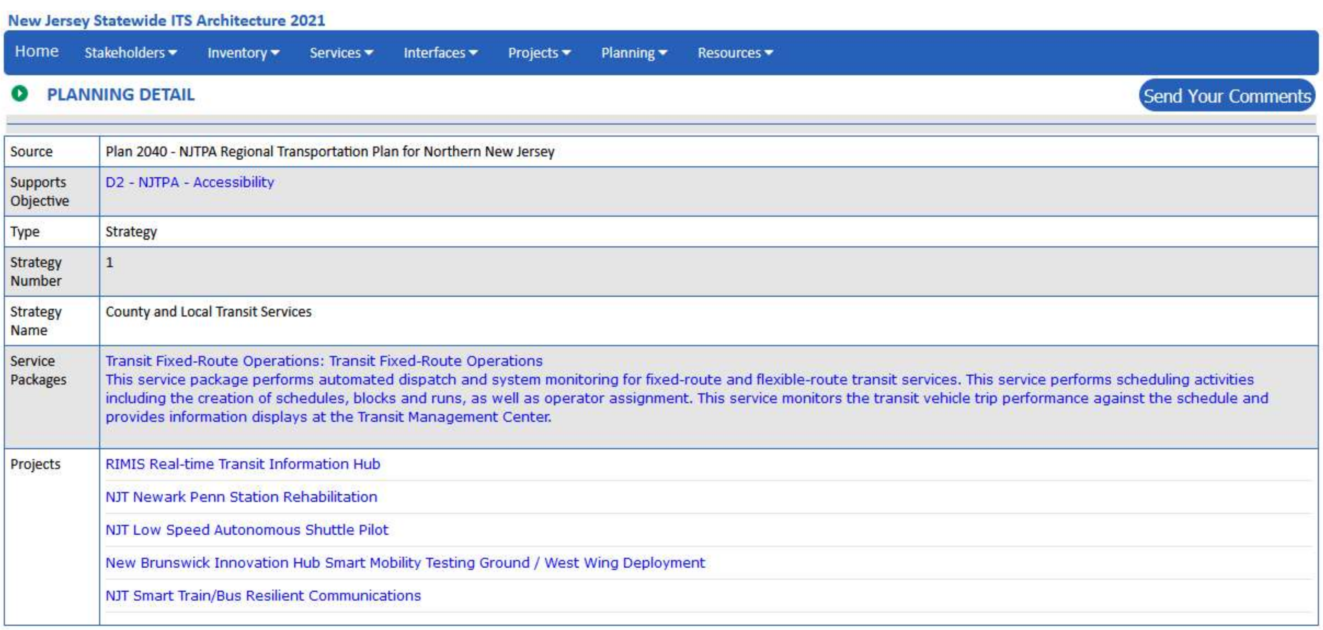
Source Document: NJT 2030 - A 10-Year Strategic Plan

Objective	Strategy	Projects	Service Packages
B1- NJT - Ensure the reliability and continued safety of or transit system			
	1- Create a safe and healthy riding experience for our customers.		✓
	2- Invest in targeted rail infrastructure programs to reduce delays and alleviate capacity constraints		
	3- Take a leadership role in expanding Trans-Hudson capacity		
	4- Provide more reliable bus service along congested corridors		✓
	5- Enhance fleet reliability through replacement and preventative		
	6- Rehabilitate and expand the network of bus garages to support	✓	
	7- Invest in critical safety infrastructure and programs		
B2- NJT - Deliver a high-quality experience for all our customers, with their entire journey in mind			
	1- Improve information flow to and from customers	✓	
	2- Enhance stations and shelters	✓	
	3- Integrate and facilitate customer payments	✓	
	4- Expand Mobility-as-a-Service and innovative mobility approaches		✓
	5- Provide the safest and most secure environment for customers, employees and the communities we serve	✓	
B3- NJT - Power a stronger and fairer economy for all communities in the region			

Updated October 19, 2021

Figure 22. Example Planning Page Showing ITS Architecture Connections – Projects and Service Packages

Clicking on a Planning Objective or Strategy provides additional detail showing specific projects and service packages, as shown below.



New Jersey Statewide ITS Architecture 2021

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PLANNING DETAIL

Send Your Comments

Source	Plan 2040 - NJTPA Regional Transportation Plan for Northern New Jersey
Supports Objective	D2 - NJTPA - Accessibility
Type	Strategy
Strategy Number	1
Strategy Name	County and Local Transit Services
Service Packages	Transit Fixed-Route Operations: Transit Fixed-Route Operations This service package performs automated dispatch and system monitoring for fixed-route and flexible-route transit services. This service performs scheduling activities including the creation of schedules, blocks and runs, as well as operator assignment. This service monitors the transit vehicle trip performance against the schedule and provides information displays at the Transit Management Center.
Projects	RIMIS Real-time Transit Information Hub NJT Newark Penn Station Rehabilitation NJT Low Speed Autonomous Shuttle Pilot New Brunswick Innovation Hub Smart Mobility Testing Ground / West Wing Deployment NJT Smart Train/Bus Resilient Communications

Figure 23. Example Planning Detail Page Showing Specific Projects and Service Packages

Supporting Web Site Resources

- Project information, including links to Service Package diagrams, for each project is available at: http://www.consystec.com/nj2022/web/projects.htm.
- Projects by Stakeholder provides a similar view with the projects sorted by lead stakeholder. http://www.consystec.com/nj2022/web/projectsstake.htm
- Projects Map. http://www.consystec.com/nj2022/web/projectsmap.htm
- Planning Page. http://www.consystec.com/nj2022/web/planobj.htm
- NJ Statewide ITS Architecture RAD-IT file. http://www.consystec.com/nj2022/web/projdocs/NJ_Statewide2022.radit.zip.zip
- Resource for developing Systems Engineering Analysis content from the NJ Statewide ITS Architecture Web Site. http://www.consystec.com/nj2022/web/projdocs/NJSEAReportGuidance.pdf
- Project Information Sheet. http://www.consystec.com/nj2022/web/projdocs/NJProjectInformationSheet.pdf

10 AGREEMENTS

The identification of institutional agreements required is crucial to the development of consensus architecture. The following pages identify the agreements associated with a Regional ITS Architecture, including existing agreements in New Jersey.

10.1 Types of Agreements

There are several types of arrangements associated with the interfaces included with the projects discussed previously. Data exchanges between systems require agreements on the transmission protocol and data formats to ensure compatibility. Coordinating field device operations owned by different agencies requires defined procedures for submitting message requests and rules governing when such requests can be honored. Such coordination can be done with informal arrangements such as a Memorandum of Understanding (MOU). Sharing control of field devices operated by different agencies involves more liability issues, which requires more formal agreements. Coordinated incident response may also require formal agreements, but also requires group training of personnel from various agencies. While all interfaces involve agreements for data compatibility, agreements for procedure and operation as well as training can also be critical elements to optimizing the benefits of the architecture.

Table 5 identifies types of potential agreements that could be used by agencies in the region.

Table 6. Types of Agreements

Type of Agreement	Description
Handshake Agreement	• Early agreement between one or more partners • Not recommended for long term operations.
Memorandum of Understanding	• Initial agreement used to provide minimal detail and usually demonstrating a general consensus. • Used to expand a more detailed agreement like an Interagency Agreement which may be broad in scope but contains all of the standard contract clauses required by a specific agency. • May serve as a means to modify a much broader Master Funding Agreement, allowing the master agreement to cover various ITS projects throughout the region and the MOUs to specify the scope and differences between the projects.

Type of Agreement	Description
Interagency Agreement	• Between public agencies (e.g., transit authorities, cities, counties, etc.) for operations, services or funding • Documents responsibility, functions and liability, at a minimum.
Intergovernmental Agreement	• Between governmental agencies (e.g., Agreements between universities and State DOT, MPOs and State DOT, etc.)
Operational Agreement	• Between any agency involved in funding, operating, maintaining or using the right-of-way of another public or private agency. • Identifies respective responsibilities for all activities associated with shared systems being operated and/or maintained.
Funding Agreement	• Documents the funding arrangements for ITS projects (and other projects) • Includes at a minimum standard funding clauses, detailed scope, services to be performed, detailed project budgets, etc.
Master Agreements	• Standard contract and/or legal verbiage for a specific agency and serving as a master agreement by which all business is done. These agreements can be found in the legal department of many public agencies. • Allows states, cities, transit agencies, and other public agencies that do business with the same agencies over and over (e.g., cities and counties) to have one Master Agreement that uses smaller agreements (e.g., MOUs, Scope-of-Work and Budget Modifications, Funding Agreements, Project Agreements, etc.) to modify or expand the boundaries of the larger agreement to include more specific language.

10.2 Existing and Planned Agreements

The identification of institutional agreements and status whether existing or needs to be formulated is a key output of a regional ITS architecture, and should be updated periodically. A listing of identified agreements is included in **APPENDIX C: AGREEMENTS**.

11 APPLICABLE ITS STANDARDS AND TESTING PROCEDURES

11.1 Overview of ITS Standards

ITS standards establish a common way in which systems, devices, and vehicles connect and communicate with one another. By specifying how systems and components interconnect, the standards promote interoperability, allowing transportation agencies to implement systems that cost-effectively exchange pertinent data and accommodate equipment replacement, system upgrades, and system expansion.

Standards benefit the traveling public by providing products that will function consistently and reliably throughout a region or state. ITS standards facilitate regional interoperability, and promote an innovative and competitive market for transportation products and services.

Establishing regional and national standards for exchanging information among ITS systems is important not only from an interoperability point of view; it also reduces risk and cost since a region can select among multiple vendors for deployment products. Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve.

The US Department of Transportation's (USDOT) ITS Joint Program Office has been funding the development of ITS standards since 1996. From its beginning, the USDOT has funded the development of the ITS standards by leveraging the existing processes within established Standards Development Organizations (SDOs). The SDOs that are involved in the development of ITS standards are:

- American Association of State Highway and Transportation Officials (AASHTO)

- American Public Transportation Association (APTA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Transportation Engineers (ITE)
- National Electrical Manufacturers Association (NEMA)
- Society of Automotive Engineers (SAE)

The overall goal of the ITS Standards Program has been to promote the widespread deployment of integrated ITS through robust, non-proprietary standards. The use of non-proprietary open standards offers transportation agencies increased flexibility and choice for operating ITS systems. Benefits of using ITS standards are described in the following subsections.

11.1.1 Provide a Choice of Vendor

There are numerous vendors of equipment, software, services, and systems within the ITS industry. Each vendor has naturally defined specific features to allow differentiation among competitors. Nonetheless, there exists core functionality that is common across multiple vendors. The ITS standards community, from the start, has engaged the public sector, equipment manufacturers, system integrators, transportation consultants, and academia to identify and standardize the communication exchanges between systems that will lead to interoperability.

The result is a basic set of functionalities described in standards, available regardless of vendor, with common programming interfaces. Today, transportation agencies, through use of standards, have an easier path to change software and equipment provided by a single vendor to an entire system supported by multiple vendors.

11.1.2 Avoid Early Obsolescence

While retrofitting legacy equipment and systems that support one or more ITS standards is not practical in most situations (due to cost), many manufacturers today offer systems that support open information and control exchange based on the ITS standards. A common industry practice is to integrate legacy equipment and systems with standards-based upgrades in a manner that ensures that an operating agency's systems and equipment remain useful and compatible long into the future. Over time legacy equipment will be replaced with standards-based solutions.

11.1.3 Phase Procurement and Deployment

Specifying ITS standards allows agencies to procure equipment and systems in phases, over several financial cycles. For example, many agencies procure a few signs one year, then a few more the next year, and so on. Sometimes devices are procured from one vendor, and sometimes from multiple vendors. Specifying ITS standards allows multiple deployment phases, over multiple years, to be integrated, with little difficulty. The initial deployment establishes an ITS communications infrastructure that can be leveraged by future deployment phases.

11.1.4 Enable Interagency Coordination

Use of ITS standards allows agencies to exchange information, and with authorization basic commands, that enable any agency to monitor transportation-related conditions from other agencies' systems. For example, agencies can implement coordinated responses to incidents and other changes in field conditions when needed. Such data exchange and coordinated response can be implemented either manually or automatically. One agency can monitor, and issue basic commands, if authorized, to field devices operated by another agency, even though those devices may be from a different vendor than those used by the monitoring agency. Potential applications of interagency coordination include:

a) Coordinating timed transfers at a shared transit center,
b) Coordinating traffic signals across jurisdictional boundaries,
c) Providing traffic signal priority for selected, e.g., behind schedule, transit vehicles,
d) Coordinating and monitoring of incident response information,

e) Providing real-time information to a shared traveler information center,
f) Monitoring traffic volumes on another agency's roadway,
g) Coordinating the operation of a freeway ramp meter with an adjacent traffic signal, or
h) Posting a warning message on another agency's dynamic message sign.

11.1.5 Use of a Common Communications Network for Multiple Purposes

The communications network is usually one of the components of a transportation management system that requires the most resource investment. ITS standards provide a way to make that resource open to multiple purposes and increased operational and potentially financial benefit.

11.2 National and Regional Applicable Standards

The initial starting point for identification of the applicable ITS standards to support regional and national interoperability was a comprehensive review of existing and planned information flows within the NJITSA. These information flows are shown in the table below.

Table 7. Applicable ITS Standards

ITS Application Area	Key ITS Standard	Information Type	Description/Purpose of Standard
Traffic Management	TMDD	Traffic Management Information: Roadway and transit Incidents, planned events, special events, roadway status, roadway weather, and device status.	The Traffic Management Data Dictionary (TMDD) provides for information and control exchanges related to roadway and traffic management operations.
	TISA TMC	Reference identifiers for roadway link data.	Traffic Message Channels
3rd Party Data Exchange	Proposed TMDD Extension	3rd Party Data Exchanges (e.g., WAZE)	The TMDD extension provides additional information to handle improved sharing of information about the roadway geometry with 3rd Parties.
Public Safety Communications	IEEE 1512	Incident information exchanged between transportation management centers and public safety.	IEEE Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers focuses on the exchange of information about traffic and public safety agency resources used during traffic incident response.
Parking Traveler Information	SAE-J2354	Parking location, lot size, hours of operation, and availability.	The Message Set for Advanced Traveler Information System (ATIS) contains sections relevant to parking management and related traveler information.
	SIRI	Real-time transit service information.	The Service Interface for Real Time Information (SIRI) is a European Union (EU) standard with numerous European deployments, and several US deployments. SIRI is implemented using a prescribed set of message request/response pairs. Messages are encoded in XML and transported using web services.

ITS Application Area	Key ITS Standard	Information Type	Description/Purpose of Standard
	GTFS	Alternative format for static transit schedule data.	The General Transit Feed Specification is a community-based standard developed outside of the USDOT Standards program. It is being widely deployed by transit agencies and is used to define transit schedule and real time transit service information. GTFS is a specification of GTFS Google Developer Community.
	GTFS-RT	Real-time transit information	The GTFS-realtime Specification is an extension to the GTFS specification developed outside of the USDOT Standards Program. It provides schedule adherence, vehicle location, and alert information. GTFS-RT is a specification of GTFS Google Developer Community.
Center-to-Center Communications	NTCIP 2306	Standard for the formatting (e.g., XML) and higher level protocols (e.g., HTTP, FTP) for center-to-center message exchange.	NTCIP 2306 defines encoding and transport of messages between transportation management centers including traffic management centers, transit management centers, and emergency management/public safety. The standard is based on the Web Services Architecture and standards of the World Wide Web Consortium.
	Protocol Buffers	Specification for the formatting and exchange of real-time information between end-points on the internet.	The Protocol Buffers specification defines encoding and transport of messages between a transit management center and provider, and transit management center and consumer of information. Protocol Buffers is a specification of Google Developer Community.
	GeoJSON	Specification for the exchange of geospatial information.	This standard supports geographic description of data not described in TMDD, which is limited to links and nodes. GeoJSON is used to describe geographic elements such as a geo-fence, or the path of a roadway in more detail than is available with links and nodes alone.
Transport / Internetworking	TCP/IP and UDP/IP	Internetworking standards	A protocol for the transmission of data across an internetwork.

A standards framework diagram showing the interrelationship of the applicable ITS standards is shown in the figure below.

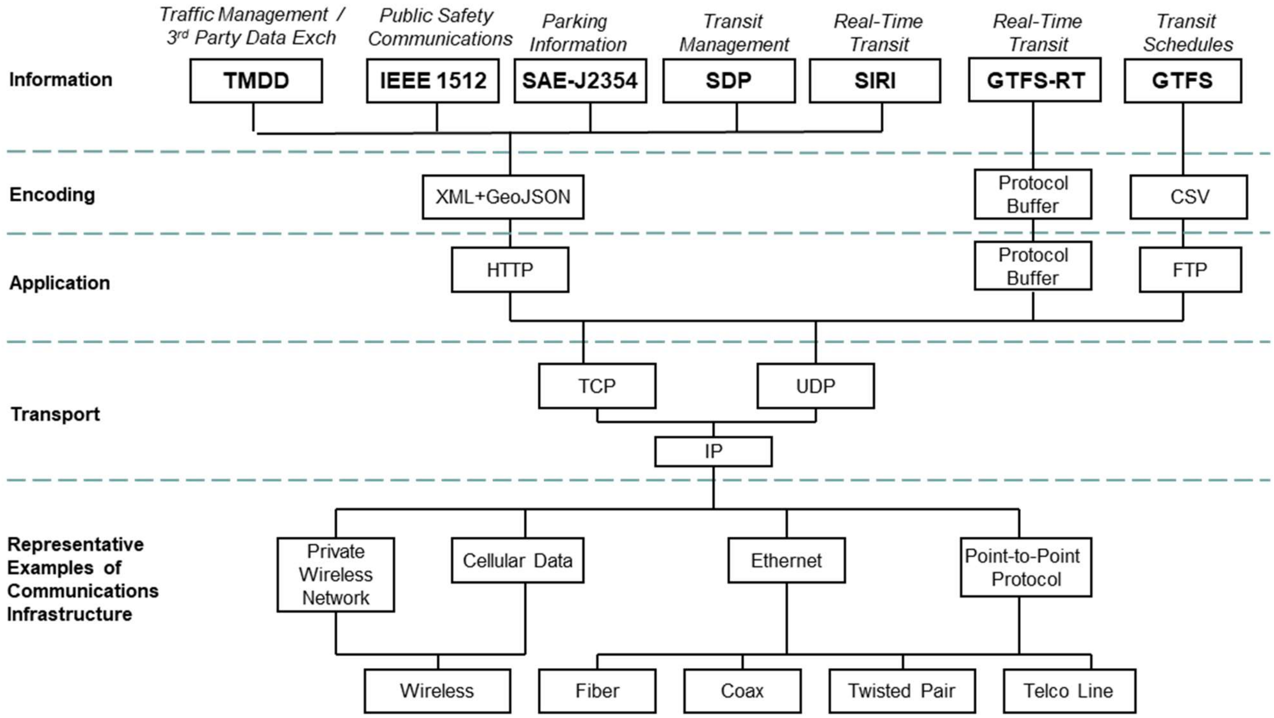

Figure 24. ITS Standards Framework

It is worth noting that the standards specified (namely TMDD and SIRI) are consistent with the Section 1201 Real-Time System Management Information Program (RTSMIP) Data Exchange Format Specification.

Also, GTFS, GTFS-RT, and Protocol Buffer (discussed below) are widely implemented specifications used in the exchange of transit static schedule and real-time service information.

11.3 Use of Non-USDOT Standards in the Region

Several standards are being used within the region that are not officially recognized standards by the USDOT. However, they are all commonly used formats, and provide a basis for system interoperability. The non-USDOT standards identified include:

- **E-ZPass InterAgency Group.** These specifications were developed by the E-ZPass InterAgency Group to support electronic payments among member agencies and travelers. Payments may be for electronic tolls, parking or other services.
- **SIRI.** This European Standard is developed by CEN for real-time transit info. It was selected because it is one of the two most common standards for real-time transit information.
- **GTFS.** This specification from Google was selected because it is the most common format for transporting static transit schedule data worldwide. The use of GTFS is necessary for interoperability of electronic transit schedule data collected and made available by regional agencies.
- **GTFS-RT.** This specification from Google was selected because it is one of the two most common formats for transporting real-time transit schedule data.
- **Protocol Buffer.** This specification from Google was selected because it is required for encoding GTFS-RT files.
- **TISA TMC.** This international specification from TISA was selected because it is currently used by TRANSCOM's legacy systems for link data.

- **GeoJSON.** A standard of the Internet Engineering Task Force (IETF), GeoJSON is a geospatial data interchange format based on JavaScript Object Notation (JSON). It defines several types of JSON objects and the manner in which they are combined to represent data about geographic features, their properties, and their spatial extents. GeoJSON uses a geographic coordinate reference system, World Geodetic System 1984, and units of decimal degrees.

A more detailed description of applicable ITS standards is included in **APPENDIX D: DESCRIPTION OF APPLICABLE ITS STANDARDS**.

11.4 Testing Procedures

The IEEE Std 829, IEEE Standard for Software and System Test Documentation provides a comprehensive overview of the processes and documentation for testing. The documents outlined in IEEE Std 829-1998 cover test planning, test specification, and test reporting.

Test documentation includes the following:

- Test Plan. Describes the scope, approach, resources, and schedule of testing activities
- Test Design. References the test cases applicable to a particular test plan associated with the test design. The test design also references the features (requirements) to be tested.
- Test Cases and Procedures. Describe the inputs, outputs, expected results, and procedures used to verify one or more requirements.
- Test Reports. Document the test plan execution.

Developing agency test documentation can take a significant amount of time and require coordination of many parties. It is recommended that test plan development begin after system interface requirements have been completed and approved. Test Design and development or Test Cases can begin after agency specification requirements have been approved and signed-off. Test Plan execution occurs throughout implementation. Test reports document test plan execution. Test documentation, as outlined, ensures that testing is thoroughly documented. In addition, test designs, test cases, and test procedures should be regularly reviewed based on past experience and results.

8.5.1 Test Tools – TMDD

The FHWA's C2C RI (Center-to-Center Reference Implementation) tool has been tested in the region. TRANSCOM completed and passed all TMDD conformance testing in August 2016. The C2C RI is a tool to aid in performing ITS Standard Conformance/Compliance testing of C2C Interfaces. It supports the use of the Systems Engineering Process, IEEE 829 Test Documentation, TMDD v3.03c dialogs and messages, and NTCIP 2306 XML encoding of messages.

8.5.2 Test Tools – SIRI, IEEE 1512, SAE-J2354, and SDP

SoapUI and XMLSpy are a set of tools that can be used together for testing conformance to ITS standards that specify XML-based interfaces. Within the region this includes: SIRI, IEEE 1512, SAE-J2354, and SDP. SoapUI is an off the shelf tool that can access any API available as either a SOAP or HTTP web service. XMLSpy is an XML editing tool that can be used to validate XML feeds against a standard schema. The tools are used in conjunction with each other. SoapUI is used to access an API and obtain a feed. Once the feed is obtained, it is validated in XMLSpy for conformance to the identified standard.

8.5.3 Test Tools – GTFS-Real Time

There are currently no off-the-shelf software products that are available to test the GTFS-RT specification, which is one of the technical specifications identified for regional real-time transit data exchange. Within the region GTFS-RT data is available for MTA (Subway, Bus, MTA Bus, LIRR, and Metro-North), and New Jersey Transit Bus and Rail. Westchester Bee-line is also developing a GTFS-RT based information. TRANSCOM has developed a suite of tool to test compliance the GTFS-RT specification.

In order to develop the GTFS-RT test software, the test cases and corresponding test procedures for the GTFS-RT feed will be written to specificity to define testing at the object level of the GTFS-RT messages. These detailed test procedures will then be converted into software algorithms and implemented as test scripts for the GTFS-RT feed. Google does provide software modules for software that uses the protocol buffer format. These modules have rudimentary functionality for validating Protocol Buffer files and will be incorporated into the custom software. In order to eliminate any concerns of bias, this software algorithms used will be fully documented, and the code developed will be published as open source software so that it can be appropriately verified by regional transit agencies and other third parties.

12 MAINTENANCE OF THE REGIONAL ITS ARCHITECTURE

Section 2.3 Process for Maintaining the Regional ITS Architecture contains a preliminary discussion on the process to maintain the regional ITS architecture.

The table below summarizes the components of the NJITSA and identifies the current version at completion and release of this document. This table should be updated any time an interim update to the architecture document is performed.

Table 8. Summary of Baseline Architecture Components

Architecture Component	Format	Version at Completion of Update
Architecture Document	Adobe PDF (.pdf)	2022
Architecture Website	Hosted Web Site	2022
Architecture Database	RAD-IT	2022

APPENDIX A. ACRONYMS

Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
AD	Archived Data
ANSI	American National Standards Institute
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
ASC	Actuated Traffic Signal Controller
ATIS	Advanced Traveler Information System
ATMS	Advanced Traffic Management System
CCTV	Closed Circuit Television
CFR	Code of Federal Regulations
CVO	Commercial Vehicle Operations
CV	Connected Vehicle
DelDOT	Delaware Department of Transportation
DMS	Dynamic Message Sign
DOT	Department of Transportation
DRBA	Delaware River Bay Authority
DRJTBC	Delaware River Joint Toll Bridge Commission
DRPA	Delaware River Port Authority
DSRC	Dedicated Short Range Communications
DVRPC	Delaware Valley Regional Planning Commission
EM	Emergency Management
ESS	Environmental Sensor Stations
GTFS	General Transit Feed Specification
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
MC	Maintenance and Construction
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
NEMA	National Equipment Manufacturers Association
NTCIP	National Transportation Communications for ITS Protocol
NJ	New Jersey
NJ STMC	New Jersey Statewide Traffic Management Center
NJDOT	New Jersey Department of Transportation
NJDOT MOC-N	NJDOT Mobility Operations Center North
NJDOT MOC-S	NJDOT Mobility Operations Center South
NJITSA	New Jersey Statewide ITS Architecture
NJTA	New Jersey Turnpike Authority
NJTPA	North Jersey Transportation Planning Authority
NJT	New Jersey Transit
PANYNJ	Port Authority of New York and New Jersey
PennDOT	Pennsylvania Department of Transportation
PT	Public Transportation
RAD-IT	Regional Architecture Development for Intelligent Transportation
RIMIS	Regional Integrated Multi-Modal Information Sharing
RIMIS IEN	RIMIS Information Exchange Network
RMC	Ramp Meter Control

Acronym	Definition
SAE	Society of American Automotive Engineers
SCP	Signal Control and Prioritization
SDO	Standards Development Organization
SEA	Systems Engineering Analysis
SET-IT	The Systems Engineering Tool for Intelligent Transportation
SIRI	Service Interface for Real Time Information
SJTA	South Jersey Transportation Authority
STIP	Statewide Transportation Improvement Program
TIP	Transportation Improvement Program
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TRANSCOM	Transportation Operations Coordinating Committee
TSS	Transportation Sensor Systems
USDOT	United States Department of Transportation
WAVE	Wireless Access in Vehicular Environments

APPENDIX B. GLOSSARY

Term	Definition
ARC-IT	The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) is the name of the U.S. National ITS Architecture. See National ITS Architecture.
Element	This is the basic building block of Regional ITS Architectures and Project ITS Architectures. It is the name used by stakeholders to describe a system or piece of a system.
Functional Object	Functional objects group similar processes of a particular physical object together into an implementable package.
Information Flow	Information that is exchanged between subsystems and terminators in the physical architecture view of the National ITS Architecture. These information flows are normally identical to the architecture flows in the National ITS Architecture.
Intelligent Transportation System	The system defined as the electronics, communications or information processing used singly or integrated to improve the efficiency or safety of surface transportation.
ITS Architecture	Defines an architecture of interrelated systems that work together to deliver transportation services. An ITS architecture defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services.
ITS Project	Any project that in whole or in part funds the acquisition of technologies or systems of technologies that provide or significantly contribute to the provision of one or more ITS user services.
National ITS Architecture	A common, established framework for developing integrated transportation systems. The National ITS Architecture is comprised of the logical architecture and the physical architecture, which satisfy a defined set of user service requirements. The National ITS Architecture is maintained by the United States Department of Transportation (USDOT).
Physical Object	These are all the elements that comprise the physical view of the architecture. Physical objects are further subdivided to show different classes: Centers, Field Equipment, Support Systems, Traveler Devices, and Vehicle-based Equipment.
Region	The geographical area that identifies the boundaries of the Regional ITS Architecture and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area.
Regional ITS Architecture	A specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them.
RAD-IT	Regional Architecture Development for Intelligent Transportation (RAD-IT) is an automated software tool used to input and manage system inventory, market packages, architecture flows and interconnects with regard to a Regional ITS Architecture and/or multiple Project ITS Architectures.
Service Package	The service packages provide an accessible, service-oriented perspective to the National ITS Architecture. They are tailored to fit, separately or in combination, real world transportation problems and needs. Service packages collect together one or more physical objects that must work together to deliver a given transportation service and the information flows that connect them and other important external systems.

Term	Definition
SET-IT	The Systems Engineering Tool for Intelligent Transportation. Picks up where RAD-IT leaves off. SET-IT is project-focused, and ideally applied to individual project deployments with scope constrained by project definitions specified in the regional architecture. SET-IT is a graphical tool, providing the user with visual feedback and tools necessary to manipulate service package physical and enterprise diagrams, develop communications stack templates, specify standards at all protocol layers, and export that information in a variety of forms and formats.
Stakeholders	A widely used term that notates a public agency, private organization or the traveling public with a vested interest, or a "stake" in one or more transportation elements within a Regional ITS Architecture.
Standards	Documented technical specifications sponsored by a Standards Development Organization (SDO) to be used consistently as rules, guidelines, or definitions of characteristics for the interchange of data. A broad array of ITS standards is currently under development that will specifically define the interfaces identified in the National ITS Architecture.
System	A collection of hardware, software, data, processes, and people that work together to achieve a common goal. Note the scope of a "system" depends on one's viewpoint. To a sign manufacturer, a dynamic message sign is a "system". To a state DOT, the same sign is only a component of a larger Freeway Management "System". In a Regional ITS Architecture, a Freeway Management System is a part of the overall surface transportation "system" for the region.
System Inventory	The collection of all ITS-related elements in a Regional ITS Architecture.
Terminator	Terminators define the boundary of an architecture. The National ITS Architecture terminators represent the people, systems, and general environment that interface to ITS, but are outside the boundary of ITS. No functional requirements are allocated to terminators.

APPENDIX C. AGREEMENTS

The following table provides a brief description of the agreements identified as part of the NJITSA development process.

Table C-1. Existing Agreements

Agreement	Executing Agency	Other Agency	Description
TRANSCOM Multi-Year Agreement	TRANSCOM	Connecticut Department of Transportation, Metropolitan Transportation Authority, Metropolitan Transportation Authority Bridges and Tunnels, Metropolitan Transportation Authority New York City Transit, New Jersey Department of Transportation, New Jersey State Police, New Jersey Transit Corporation, New Jersey Turnpike Authority, New York City Department of Transportation, New York Police Department, New York State Bridge Authority, New York State Department of Transportation (NYSDOT), New York State Police, New York State Thruway Authority, Port Authority of New York and New Jersey, Port Authority Trans Hudson Corporation	Agreement covers member agencies' share of funding for TRANSCOM's base operations which provides a cooperative approach to regional transportation management. Base operations include the sharing of traffic and transit incidents, construction activities, and special events. It also includes real-time traffic information from agencies' ITS systems, such as the TIMED system and NYSDOT's INFORM.
TIMED/OpenReach Group Regional Architecture System Agreements	TRANSCOM	Connecticut Department of Transportation, Metropolitan Transportation Authority, Metropolitan Transportation Authority Bridges and Tunnels, Metropolitan Transportation Authority New York City Transit, New Jersey Department of Transportation, New Jersey State Police, New Jersey Transit Corporation, New Jersey Turnpike Authority, New York City Department of Transportation, New York Police Department, New York State Bridge Authority, New York City Department of Transportation, New York State Police, New York State Thruway Authority, Port Authority of New York and New Jersey,, Port Authority Trans Hudson Corporation, Bergen Co. Police,	TIMED/OpenReach Group) uses vehicles equipped with the region's E-ZPass electronic toll collection tags as aggregate, anonymous traffic probes, allowing the systems to calculate link travel times and speeds and detect incidents. The TRANSCOM Regional Architecture system integrates the ITS systems of the public agencies in the NJ/NY/CT metropolitan region. The agreement allows for the electronic sharing of the transportation information, among the agencies' operations centers.

Agreement	Executing Agency	Other Agency	Description
Data Interface Agreements	TRANSCOM	Connecticut Department of Transportation (I-95 System), MTA Bridges and Tunnels (VMS/HAR System), MTA New Jersey Transit (Transit Authority System), New Jersey Department of Transportation (MAGIC System), New Jersey Turnpike Authority (Turnpike System), New Jersey Department of Transportation (CATS & MICE Systems), New York State Department of Transportation (INFORM System), New York State Thruway Authority (Thruway System), Port Authority of New York and New Jersey (GWB and LT/HT System)	The agreement allows for Data Interfaces, integrating individual agency ITS systems into the TRANSCOM Regional Architecture system, allowing for the electronic sharing of transportation information among the agencies' operations centers.

APPENDIX D. DESCRIPTION OF APPLICABLE ITS STANDARDS

D.1 ITE Traffic Management Data Dictionary (TMDD)

The latest version of the Traffic Management Data Dictionary is TMDD V3.1 (https://www.ite.org/technical-resources/standards/tmdd/3-1/).

While this version of the TMDD was intended to incorporate minor updates and corrections to the previous version of the standard, recent updates also established a single XML Schema, and a new set of rules to better promote interoperability between systems that share TMDD messages. In addition, work on a related project relevant to TMDD Testing, the Center-to-Center Reference Implementation (C2C RI), has been completed.

The Traffic Management Data Dictionary covers management center communications related to traffic management operations. It is subdivided into the following areas:

- Center Connection Management
- Center Entity Naming and Identification
- Security Data
- Manage Center Entities
- Provide Information on Organization and Contacts
- Events Information Sharing (e.g., incidents, construction, and planned events)
- Roadway Network Data (e.g., speed, volume, location, routes, stop points, device and incident location)
- Traffic Device Inventory, Status and Control
- Roadway Weather
- Archived Data

The TMDD references the SAE Location Referencing Message Specification (LRMS) to describe a link and node roadway network.

The TMDD is the basis for regional exchange of incident information within the region.

D.2 TMC- Traffic Message Channels

TMC is a specific application of FM RDS used for broadcasting real-time traffic and weather information. Data messages are received silently and decoded by a TMC-equipped navigation system, and delivered to the driver, typically by offering dynamic route guidance – alerting the driver of a problem on the planned route and calculating an alternative route to avoid the incident.[1]

In the United States of America, XM Satellite Radio and Sirius Satellite Radio provide TMC service all over the US. Navteq provides traffic data to both providers. Navteq Traffic delivers traffic information and related advertising via RDS and HD signals to navigation devices nationwide. Navteq also provided traffic data sourced from sensors, probes and other technologies in 10+ countries as of December 2009. INRIX, Inc. fuses TMC data with real-time flow information from its crowd-sourced network of floating cars and mobile devices with information from other public and private sources to deliver real-time and predictive traffic information[2].

D.3 TMDD Extension - Roadway Geometry for Event Spatial Information (Geo-linestring)

Today's expectations, and the capabilities of systems with which TRANSCOM exchanges information, require improved geographic resolution, lanes affected, and geographic extents describing the stretch (or path) of roadway along which an event is taking place. The term "geo-linestring" is used to describe a sequence of points (or a sequence of connected line segments) which describe a complete roadway section. (Moreover, as noted previously, there is a need to exchange and interpret geo-linestring information.)

[1] http://tisa.org/technologies/tmc/
[2] https://en.wikipedia.org/wiki/Traffic_message_channel

By way of example we demonstrate the importance of including new requirements to represent roadway and transit events using geo-linestrings.

- **Corridor Management**. Descriptions of corridors, roadway sections, lanes, commuter rail, and transit routes.
- **Construction Activity Conflicts**. The Construction Conflict Tool needs geographic extents and schedule information to automatically/programmatically determine construction conflicts.
- **Construction Work Zones**. Information includes: geographic extents, schedule, alternate routes, queues and tapering, and whether the construction is in effect.
- **Maintenance Activities**. Striping, grass cutting, guard rail and other repairs.
- **Transit Route and Trip Descriptions**. Trips are a sequence of stop points and time points along a geo-linestring.
- **Service Patrols Route Descriptions**.
- **Real-time Traffic Information Exchanges**. For example, WAZE data, INRIX, HERE.
- **Traffic Congestion Queues and Tapering**.
- **Freight Travel Bans**. The SPATEL DFE Roadway Ban Tool describes sections of roadway where overheight/overweight and other travel bans are in effect.
- **Performance-based Measurement**. The NPMRDS provides information correlated with roadway segments.
- **Way Points and Time Points**. Automated Vehicle Location (AVL), GPS locations, and times, for service patrols and transit.
- **Connected and Autonomous Vehicles**. Precise incident location, lanes affected, and direction of travel. A similar need exists with the location information of freeway interchanges (which ramp, overpass, lane, and direction of travel).
- **Alternate Routes**. Based on incident, construction, special event location.
- **Transit Signal Priority**. Some TSP systems describe zones (roadway sections) where TSP coordination is available.
- **Traffic Incident Management Performance Measurement** reporting needs
- **Archived Data Requests**. Corridor, and geographic zone descriptions.

D.4 IEEE 1512 Family of Standards (Emergency and Public Safety Communications)

IEEE 1512 is not a single standard, but a series of four standards. Here is an overview of each volume:

- IEEE 1512-2006, IEEE Standard for Common Incident Management Message Sets for Use by Emergency Management Centers. Foundation of the series and includes general introductory material about IEEE Std 1512 and a message set that focuses on the exchange of information about traffic incidents.
- IEEE 1512.1-2003, IEEE Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers. This volume focuses on the exchange of information about traffic and public safety agency resources used during traffic incident response.
- IEEE 1512.2-2004, Public Safety Incident Management Message Sets for Use by Emergency Management Centers. Covers the exchange of information necessary to support traffic incident response.
- IEEE 1512.3-2006, Hazardous Material (HAZMAT) Incident Management Message Sets for Use by Emergency Management Centers. Covers the exchange of information where hazardous materials have been released on or near a roadway.

IEEE 1512 contains data concepts for emergency vehicle location and trips. The IEEE 1512 references the SAE LRMS.

While the TMDD standard should be used for exchange of incident information, the IEEE standard is included due to its use as part of the Integrated Incident Management System (IIMS), and as an alternative to sharing incident information with Public Safety. Furthermore, IEEE 1512.2 has data element definitions related to casualties, injured, and care facility status not included in TMDD. Lastly, IEEE 1512.3 contains element definitions for types of HAZMAT.

D.5 NTCIP Center-to-Center Standards Group

The National Transportation Communications for ITS Protocol (NTCIP) family of standards, created jointly by AASHTO, ITE and NEMA, addresses primarily the interfaces between a transportation management center, the ITS field devices it manages, and other centers. The NTCIP Center-to-Center (NTCIP C2C) Group of Standards addresses the communications protocols between two centers (e.g. two traffic management centers exchanging information to facilitate regional coordination of traffic signals). Some of the communication protocols covered by this family are DATEX-ASN, XML, and FTP. These protocols are common across all Center-to-Center interfaces in ARC-IT.

In ARC-IT, the standards that describe the "vocabulary" (data elements and messages) are mapped to specific architecture flows rather than the entire set of NTCIP C2C interfaces. In the regional traffic coordination example above, the Traffic Management Data Dictionary and Message Set for External TMC Communications (TMDD and MS/ETMCC) standard would be mapped to the specific flows between two Traffic Management Subsystems.

To satisfy a wide spectrum of system and regional communications requirements, Center-to-Center ITS deployments should each implement the combinations of the following NTCIP C2C communications protocols that best meet their needs.

This Group includes the following Standards Activities:

- NTCIP 1102: Octet Encoding Rules (OER) Base Protocol
- NTCIP 1104: Center-to-Center Naming Convention Specification
- NTCIP 2104: Ethernet Subnetwork Profile
- NTCIP 2202: Internet (TCP/IP and UDP/IP) Transport Profile
- NTCIP 2303: File Transfer Protocol (FTP) Application Profile
- NTCIP 2304: Application Profile for DATEX-ASN (AP-DATEX)
- NTCIP 2306: Application Profile for XML Message Encoding and Transport in ITS Center-to-Center Communications (C2C XML)

D.6 NTCIP Center-to-Field Standards Group

The National Transportation Communications for ITS Protocol (NTCIP) family of standards, created jointly by AASHTO, ITE and NEMA, addresses primarily the interfaces between a transportation management center, the ITS field devices it manages, and other centers. The NTCIP Center-to-Field (NTCIP C2F) Group of Standards addresses the communications protocols between a center and the ITS field devices it manages. The family includes the communications profiles that cover the interfaces between a traffic management center and dynamic message signs, ramp meters, environmental sensors, CCTVs, and other field equipment under its control. These protocols are common across all Center-to-Field interfaces in ARC-IT.

To satisfy a wide spectrum of system and regional communications requirements, Center-to-Field ITS deployments should each implement the combinations of the following NTCIP C2F communications protocols that best meet their needs. This Group includes the following standards:

- NTCIP 1102: Octet Encoding Rules (OER) Base Protocol
- NTCIP 1103: Transportation Management Protocols (TMP)
- NTCIP 2101: Point to Multi-Point Protocol Using RS-232 Subnetwork Profile

- NTCIP 2102: Point to Multi-Point Protocol Using FSK Modem Subnetwork Profile
- NTCIP 2103: Point-to-Point Protocol Over RS-232 Subnetwork Profile
- NTCIP 2104: Ethernet Subnetwork Profile
- NTCIP 2201: Transportation Transport Profile
- NTCIP 2202: Internet (TCP/IP and UDP/IP) Transport Profile
- NTCIP 2301: Simple Transportation Management Framework (STMF) Application Profile
- NTCIP 2302: Trivial File Transfer Protocol (TFTP) Application Profile
- NTCIP 2303: File Transfer Protocol (FTP) Application Profile

The "vocabulary" (objects) is specific to the actual information flows in ARC-IT and is therefore mapped to the corresponding Data Object standard for a specific roadway field device type. For example, the information flows, "roadway dynamic signage data" and "roadway dynamic signage status" would be mapped to the "NTCIP 1203: Object Definitions for Dynamic Message Signs (DMS)" standard. Most information flows between the center to field devices are also mapped to NTCIP 1201:Global Object Definitions, which contains the vocabulary for functions that is common to most roadway field devices, such as database functions, time functions and scheduling functions.

The device standards are:

- NTCIP 1201: Global Object (GO) Definitions
- NTCIP 1202: Object Definitions for Actuated Signal Controllers (ASC) Units
- NTCIP 1203: Object Definitions for Dynamic Message Signs (DMS)
- NTCIP 1204: Environmental Sensor Station (ESS) Interface Protocol
- NTCIP 1205: Object Definitions for Closed Circuit Television (CCTV) Camera Control
- NTCIP 1206: Object Definitions for Data Collection and Monitoring (DCM) Devices
- NTCIP 1207: Object Definitions for Ramp Meter Control (RMC) Units
- NTCIP 1208: Object Definitions for Closed Circuit Television (CCTV) Switching
- NTCIP 1209: Object Definitions for Transportation Sensor Systems (TSS)
- NTCIP 1210: Field Master Stations (FMS)—Part 1: Object Definitions for Signal System Masters (SSM)
- NTCIP 1211: Object Definitions for Signal Control and Prioritization (SCP)
- NTCIP 1213: Object Definitions for Electrical and Lighting Management Systems (ELMS)

D.7 IEEE 802.11

IEEE 802.11 is a standard that defines wireless connectivity among fixed, portable and moving networking devices within a local area. An amendment (IEEE 802.11p) was added in the 2012 version that supports wireless connectivity in vehicular environments. The standard specifies channel bandwidths, operating classes, transmit power classification, transmission masks, and alternate channel requirements in the 5.9 GHz spectrum in the United States.

D.8 IEEE 1609.x Family of Standards

The IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE) defines the architecture, communications model, management structure, security mechanisms and physical access for high speed (up to 27 Mb/s) short range (up to 1000 meters) low latency wireless communications in the vehicular environment. In addition to IEEE 802.11, devices that support Dedicated Short-Range Communications (DSRC) use the IEEE 1609.x family of standards.

Collectively the IEEE 1609.x Family of Standards describes wireless data exchange, security, and service advertisement between vehicles and roadside devices, and those layers of the applicable protocols that connected vehicle applications may require access to when communicating with vehicles. They describe the physical mechanism of communication, as well as the command and management services, and provide two options (WAVE short message and IPv6) for communicating between vehicles and between vehicles and roadside devices. These standards provide the basis for the design of applications interfacing with the WAVE environment, and provide network services so that applications can be seamless without regard to specific manufacturers, including data storage access mechanisms, device management, and secure message passing.

The family consists of the following standards:

- IEEE 1609.0, Architecture (Guide). Describes the architecture and operation of a Wireless Access in Vehicular Environments (WAVE) system based on IEEE 1609 standards and IEEE Std 802.11.
- IEEE Std 1609.2, Security Services for Applications and Management Messages. Specifies security processing requirements and application message sets for secure WAVE radio system operation. Also specifies communications security for WAVE Service Advertisements and WAVE Short Messages and additional security services that may be provided to higher layers.
- IEEE Std 1609.2a, Security Services for Applications and Management Messages. Secure message formats and processing for use by Wireless Access in Vehicular Environments (WAVE) devices, including methods to secure WAVE management messages and methods to secure application messages are defined. Administrative functions necessary to support the core security functions are also described.
- IEEE Std 1609.3, Networking Services. Specifies networking services required for operation of a WAVE system that employs standard IPv6 protocol, introduces a WAVE Short Message Protocol (WSMP), and provides a collection of management functions supporting WAVE services.
- IEEE Std 1609.4, Multi-Channel Operation. Specifies extensions to IEEE Std 802.11-2012 MAC layer for multichannel operations, i.e., operating alternately on the control channel and one of several service channels.
- IEEE Std 1609.11, Over-the-air Electronic Payment Data Exchange Protocol for ITS. Application-level IEEE 1609 standard, communication technology independent, specifies a payment over-the-air protocol referencing ISO standards.
- IEEE P1609.12, WAVE - Provider Service Identifier Allocation (PSID), Specifies allocations of WAVE identifiers defined in the IEEE 1609 series of standards. Records the Provider Service Identifier (PSID) allocation decisions made by the IEEE 1609 working group, and other identifiers used by the WAVE standards.

D.9 SAE J2735

SAE J2735, Dedicated Short Range Communications (DSRC) Message Set Dictionary, specifies standard message sets, data frames and data elements for use by applications intended to utilize the 5.9 GHz DSRC for Wireless Access in Vehicular Environments (DSRC/WAVE), referenced in this document simply as "DSRC", communications systems. The scope is limited to specifying initial representative message structures and data elements and providing sufficient background information to allow readers to properly interpret the DSRC standards and message definitions from the point of view of an application developer. Although intended for DSRC communications systems, the message set dictionary can be used with other forms of wireless communications, such as 5G.

D.10 SAE J2945/x Standards

A family of standards defining the operational and performance requirements to support a set of vehicle applications. The standards currently available include:

- SAE J2945/0, Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts. Contains cross-cutting material for the J2945/x family of standards, including recommended practices for the use of systems engineering content and common requirements for DSRC.

- SAE J2945/1, On-Board System Requirements for V2V Safety Communications. Specifies the system requirements for an on-board vehicle-to-vehicle (V2V) safety communications system for light vehicles, including standards profiles, functional requirements, and performance requirements.
- SAE J2945/2, Dedicated Short Range Communications (DSRC) Performance Requirements for V2V Safety Awareness. Specifies DSRC interface requirements for V2V Safety Awareness applications, including detailed systems engineering documentation (needs and requirements mapped to appropriate message exchanges). These applications include: Emergency Vehicle Alert, Roadside Alert, and Safety Awareness Alerts for Objects and Adverse Road Conditions.
- J2945/9 – Vulnerable Road User Safety Message Minimum Performance Requirements. Provides recommendations of safety message minimum performance requirements between a Vulnerable Road User (VRU) and a vehicle. It addresses the transmission of Personal Safety Messages (PSM) from road user devices carried by pedestrians, bicycle riders and public safety personnel, to provide driver and vehicle system awareness and potentially offer safety alerts to VRUs.

D.11 IEEE 1512 Family of Standards (Emergency and Public Safety Communications)

IEEE 1512 is not a single standard, but a series of five standards. Here is an overview of each volume:

- IEEE 1512-2006, IEEE Standard for Common Incident Management Message Sets for Use by Emergency Management Centers. Foundation of the series and includes general introductory material about IEEE Std 1512 and a message set that focuses on the exchange of information about traffic incidents.
- IEEE 1512.1-2003, IEEE Standard for Traffic Incident Management Message Sets for Use by Emergency Management Centers. This volume focuses on the exchange of information about traffic and public safety agency resources used during traffic incident response.
- IEEE 1512.2-2004, Public Safety Incident Management Message Sets for Use by Emergency Management Centers. Covers the exchange of information necessary to support traffic incident response.
- IEEE 1512.3-2006, Hazardous Material (HAZMAT) Incident Management Message Sets for Use by Emergency Management Centers. Covers the exchange of information where hazardous materials have been released on or near a roadway.

IEEE 1512 contains data concepts for emergency vehicle location and trips. The IEEE 1512 references the SAE LRMS.

While the TMDD standard should be used for exchange of incident information, the IEEE standard is included due to its use as part of the Integrated Incident Management System (IIMS), and as an alternative to sharing incident information with Public Safety. Furthermore, IEEE 1512.2 has data element definitions related to casualties, injured, and care facility status not included in TMDD. Lastly, IEEE 1512.3 contains element definitions for types of HAZMAT.

D.12 GTFS – General Transit Feed Specification

The information in this section is summarized from the GTFS developer’s web site: https://developers.google.com/transit/gtfs/

The General Transit Feed Specification (GTFS) defines a common format for public transportation schedules and associated geographic information. GTFS feeds allow public transit agencies to publish their transit data and developers to write applications that consume that data in an interoperable way.

A GTFS feed is composed of a series of text files collected in a ZIP file. Each file models a particular aspect of transit information: stops, routes, trips, and other schedule data. A transit agency can produce a GTFS feed to share their public transit information with developers, who write tools that consume GTFS feeds to incorporate public transit information into their applications. GTFS can be used to power trip planners, time table publishers, and a variety of applications, too diverse to list here, that use public transit information in some way.

This GTFS defines the following files along with their associated content:

Table D-1. General Transit Feed Specification Files

Filename	Required	Defines
agency.txt	Required	One or more transit agencies that provide the data in this feed.
stops.txt	Required	Individual locations where vehicles pick up or drop off passengers.
routes.txt	Required	Transit routes. A route is a group of trips that are displayed to riders as a single service.
trips.txt	Required	Trips for each route. A trip is a sequence of two or more stops that occurs at specific time.
stop_times.txt	Required	Times that a vehicle arrives at and departs from individual stops for each trip.
calendar.txt	Required	Dates for service IDs using a weekly schedule. Specify when service starts and ends, as well as days of the week where service is available.
calendar_dates.txt	Optional	Exceptions for the service IDs defined in the calendar.txt file. If calendar_dates.txt includes ALL dates of service, this file may be specified instead of calendar.txt.
fare_attributes.txt	Optional	Fare information for a transit organization's routes.
fare_rules.txt	Optional	Rules for applying fare information for a transit organization's routes.
shapes.txt	Optional	Rules for drawing lines on a map to represent a transit organization's routes.
frequencies.txt	Optional	Headway (time between trips) for routes with variable frequency of service.
transfers.txt	Optional	Rules for making connections at transfer points between routes.
feed_info.txt	Optional	Additional information about the feed itself, including publisher, version, and expiration information.

D.13 GTFS-RT – GTFS-Realtime Specification

The real-time version of the General Transit Feed Specification is a technical specification that is developed outside of the USDOT Standards Programs which provides real-time information on transit systems. GTFS-RT messages are encoded in Google's Protocol Buffer format, and not in a common format such as XML, JSON, or CSV. The GTFS-RT specification is managed by a group of application developers, and is available at https://developers.google.com/transit/gtfs-realtime/.

The GTFS-RT specification contains three types of feeds that are contained within each message:

- Trip Updates: Provides schedule adherence information for each trip
- Vehicle Location: Provides information on the current location of transit vehicles
- Alerts: Provides information on events, incidents, delays, cancellations, and other modifications to transit service.

While the information provided by GTFS-RT is applicable to a wide variety of transit applications, it was developed with customer facing applications as the target consumer of the feed. Therefore, it does not support a request-response structure, and each GTFS-RT feed must be provided to a user as a full feed.

D.12 SIRI – Service Interface for Real Time Information

The Service Interface for Real Time Information (SIRI) is a European Union (EU) standard with numerous European deployments (particularly internal to European public transport trip planner applications), and several US deployments. SIRI is implemented using a prescribed set of message request/response pairs. Messages are encoded in XML and transported using web services. A proposal was promoted to use HTTP and REST as queries, and may help reduce the bandwidth needed by an XML web service.

SIRI is contained in 3 parts:

- Part 1: Context and framework, 2012-01
- Part 2: Communications infrastructure, 2012-01
- Part 3: Functional service interfaces, 2012-01

According to the SIRI Handbook, SIRI aims to incorporate the best of various national and proprietary standards from across Europe and deliver these as web services using a modern XML schema. The services assume a standard conceptual model for the data to be exchanged, based on the CEN Transmodal data reference model. Element names and data structures are based on this model. SIRI was developed for bus data, but can be used just as well for other modes of transport such as rail and air.

The SIRI standard is being used by MTA as part of its real-time bus arrival system MTA BusTime.

D.14 Advanced Traveler Information Systems

This standards group addresses primarily the interfaces between the Information Service Provider and travelers via the Personal Information Device (personal), Traveler Support Equipment (public), and Vehicle subsystems. Portions of this standard may also be used between the Transportation Information Centers and other ITS centers such as traffic management centers, transit management centers, etc., and is therefore mapped to the relevant architecture flows in ARC-IT. This group provides the vocabulary (called data elements and messages) necessary to exchange information between these ITS systems, and is organized into seven primary groupings shown below. A summary of the contents of each is provided before examining the traveler information group further.

- Mayday Functions. Vehicle and personal distress alerting messages
- Tight Bandwidth. Message formats for narrow bandwidth devices
- Preference Settings. User preference settings and session control messages
- Directory Services. Spatially aware yellow pages and searching messages
- Parking Data. Information about parking lots, prices, capacities, and reservations
- Trip Guidance. Multi-modal trip planning and step by step guidance services
- Traveler Information. Information about road conditions, events, weather and travel in general

The group includes the following standards:

- SAE J2266: Location Referencing Message Specification (LRMS)
- SAE J2354: Message Set for Advanced Traveler Information System (ATIS)
- SAE J2540/1: RDS (Radio Data System) Phrase Lists
- SAE J2540/2: ITIS (International Traveler Information Systems) Phrase Lists
- SAE J2540/3: National Names Phrase List
- SAE J2540: Messages for Handling Strings and Look-Up Tables in ATIS Standards

D.14 Communications Infrastructure Standards

The communications infrastructure generally refers to the physical network and devices (e.g., fiber, cables, radio modems, cell towers, routers, etc.) used in a communications network. Based on the discussion in the section above titled Internetworking Standards, the key consideration for the communications infrastructure is whether the plant level infrastructure can manage TCP/IP and UDP/IP communications.

APPENDIX E. Example New Jersey ITS Project Information Sheet

The following provides a completed example of the New Jersey ITS Project Information Sheet, for inclusion of an ITS project in the New Jersey ITS Architecture.

Agency Name: (May be multiple agencies, please indicate lead agency.)	New Jersey Department of Transportation
Contact Name/E-mail: (Person providing information we may follow-up with.)	Noel Toner/Charles Ononiwu Noel.Toner@dot.nj.gov / Charles.Ononiwu@dot.nj.gov
ITS Project Name:	Rt. 322 & Rt. 40/322 Adaptive ATS, C#1
ITS Project Description:	Installation of Adaptive Signal systems and related detection devices at 27 intersections split into two parts as following, five intersections along Route U.S. 322, and twenty-two intersections along U.S. 40/322. Also includes installation of midblock radar system detectors and a new fiber cross connect cabinet in the vicinity of the Route U.S. 40/322 and Atlantic City Express Way Fiber optic cable along the entire corridor is being installed and devices are being integrated into virtual servers.
Project Status: (Existing or Planned) • Feasibility / Concept Planning • Preliminary Design • Design • Construction/Deployment • In Operation • Removed/Cancelled	Planned
Time Frame: (Short-term, Medium-term, Long-term, or in years)	3 years
ITS Project ID: (STIP/TIP No.):	Intelligent Traffic Signal Systems UPC:153430
Reference Document(s): (if available)	1. Concept of Operations for US RT 322 and US RT 40/322 Traffic Signal System 2. Systems Engineering Review Form
Shared with Public (Y/N): Can Reference Document be	TBD
Procurement Options:	Low Bid
Procedures and Resources for Operations and Management:	No additional staff resources are required.
Alternative Design Options:	Conducted analysis across various vendor adaptive control system options available in the market. See referenced documents.