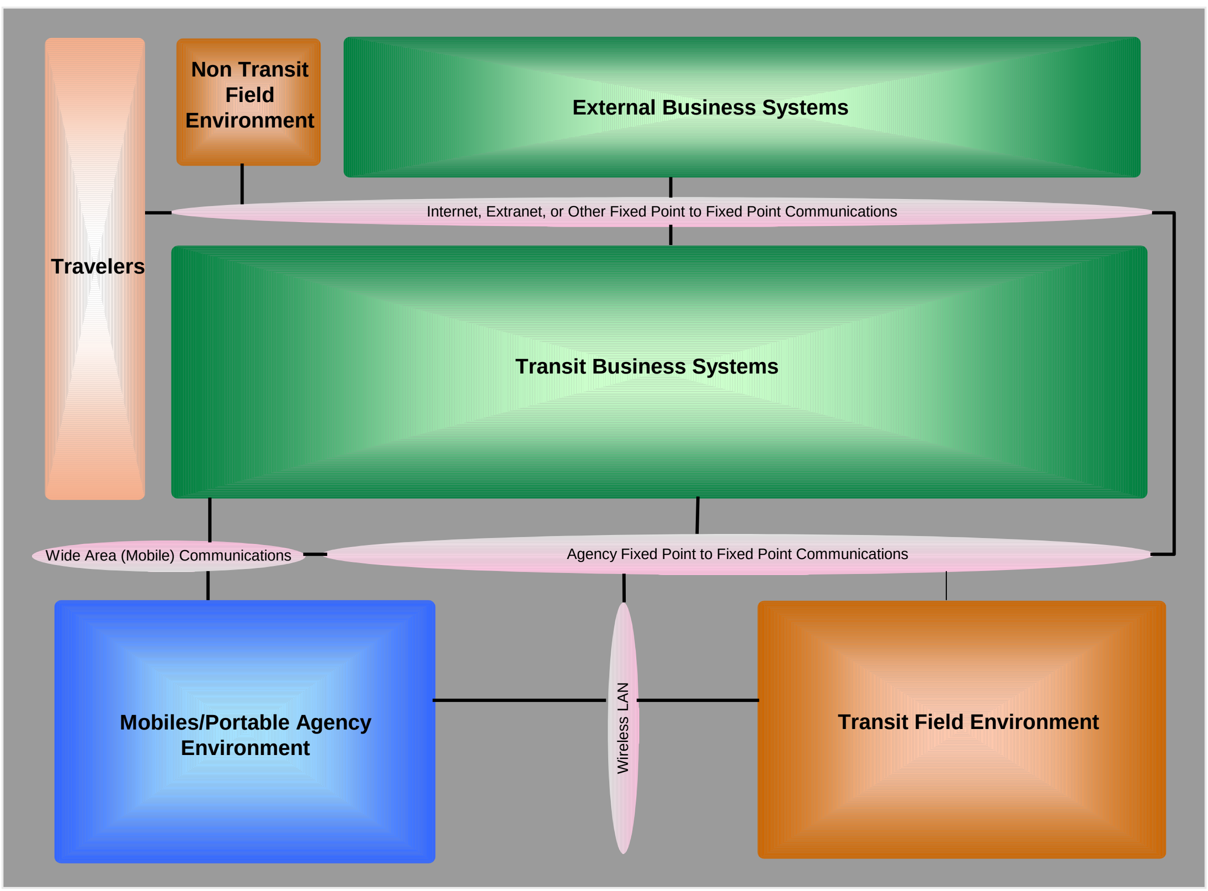
APTA TCIP-S-001 4.1.1, APTA Standard for Transit Communications Interface Profiles

Version 4.1.1

Volume I
Narrative



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This document was developed by APTA under cooperative agreement to the Federal Transit Administration and with funding from the United States Department of Transportation, Intelligent Transportation Systems Joint Program Office. Support was provided by two principal subcontractors to APTA: ARINC Inc. and Critical Link LLC, in cooperation with the APTA TCIP Technical Working Groups. The APTA TCIP Technical Working Groups and industry review efforts are overseen by the APTA TCIP Task Force, co-chaired by Isaac Takyi and Jerome Lutin.

The APTA TCIP Executive Review Committee is chaired by John Bartosiewicz, Executive Vice President/COO of McDonald Transit Associates, Inc., formerly the General Manager of Fort Worth Transit.

This document contains material originally published in the NTCIP 1400 series standards, some of which has been modified or adapted for TCIP Version 3.0.0. TCIP Version 2.8.1(Ballot Version) contained substantial changes from earlier versions, many of which are the result of comments received from the public, TCIP Technical Working Groups, and other members of the transit industry. Version 3.0.0 contains minimal changes from Version 2.8.1 to resolve comments received in the balloting process and to reflect the documents status as a balloted standard. Version 3.0.1 was a schema-only release to correct errors in the version 3.0.0 TCIP XML Schema. Version 3.0.2 contains minor changes (primarily corrections) to Version 3.0.0. Similarly Version 3.0.3 contains minor revisions to version 3.0.2 resulting from comments from early adopters and pilot implementations. Version 3.0.4 addresses additional comments from early pilots, and adds support for multiple languages to much of the text-based content. Version 3.0.5.1 deals with bug fixes found in TCIP Version 3.0.4 and additional minor additions of optional fields to support the needs of pilot projects and RFPs currently underway throughout the industry. Additional fields were added to increase the flexibility of stop announcements, the ability to include route identifier in AVL location messages was added, optional agency designators were added to TCIP identifiers, and existing designator maximum lengths were increased from 8 to 255 characters. An error in the schema for data element CPT-DateTime was corrected. References to CcStopAndDestInfo message (which was renamed to CcAnnouncementInfo several versions ago) were corrected. Errors in the definition of data elements used for providing onboard parameter information to central were corrected. Version 3.0.5.2 adds a new highly configurable, lightweight AVL dialog "Publish Short Location". If also adds a dialog "Load GTFS Timetable Data" to carry General Transit Feed (GTF) within TCIP. It adds support for Schedule Calendar Exceptions. Finally, Version 3.0.5.2 extends the scope of SAE-J1939 support by adding a dialog to transfer J1939 fault code information ("Publish J1939 Fault Codes"). Version 3.0.6 deals with bugs and errors found in the interim working Version 3.0.5.2. This version also added new frames, enumerated types, and dealt with the need to make some fields optional to handle projects that are currently underway. Version 4.0 adds the capabilities to support transit light rail operations. Version 4.0 allows the agency-unique portions of the identifiers to be alphanumeric and standardizes the naming of fields within TCIP Iden frames. This version also deals with minor bug fixes and updates the figures in Volume I. Version 4.1.1 deals with the broken links in Volume 2 for dialogs. 4.1.1 also removes orphan frames that are no longer used and corrects some errors to frames that are missing fields.

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Contents

1. Overview

1.1 Purpose of the TCIP Standard

The Transit Communications Interface Profiles (TCIP) Standard constitutes the transit industry standards component of the US Intelligent Transportation Systems (ITS) program. The ITS Program is a multiyear, multimodal initiative aimed at introducing advanced technologies into transportation systems to improve the safety, security, and efficiency of those systems.

TCIP is an interface standard. Its primary purpose is to define standardized mechanisms for the exchange of information in the form of data among transit business systems, subsystems, components and devices. The standardization of these interfaces is intended to reduce the cost of future procurements of transit computer based systems, and to facilitate a greater degree of automation and integration of those systems.

TCIP recognizes that transit agencies operate differently, and have different internal architectures for their business systems, vehicles, and field systems. As a result TCIP does not mandate a single agency operating paradigm or any agency ITS architecture. Instead TCIP provides a rich vocabulary of possible information exchanges that agencies can use on an a-la-carte basis according to their specific business needs.

TCIP is not intended to be adopted by an agency all at once. Agencies purchase business systems, vehicles, devices and equipment intending to use them for a period of years. These systems are not replaced all at once, but rather gradually over time.

TCIP is designed to minimize the impact on transit agency operating paradigms, and on existing products and systems. TCIP allows a transit agency to implement TCIP on an incremental, modular basis by implementing only the dialogs and/or file transfers required to meet business requirements at any point in time rather than requiring wholesale conversion of all business systems to TCIP. Thus agencies can maintain legacy non-TCIP systems and interfaces in place alongside TCIP systems and interfaces, while achieving compliance with TCIP and the National ITS Architecture.

TCIP is designed to minimize the impact on developer systems and products as well. TCIP does not specify interactions within the components produced by developers, or between computer applications and users. For example, if a user requests a trip itinerary from a traveler information system, TCIP does not specify the screens, user interactions, etc. TCIP does provide the dialogs or file transfers to facilitate the traveler information system obtaining schedule information from the scheduling system. TCIP also provides dialogs to allow one traveler information system to provide itinerary information to another (e.g., to another agency). TCIP uses extensible markup language (XML) to provide a widely-known and supportable data exchange format between business systems, but allows for other transfer syntaxes to be used.

In practice TCIP provides the tools for a transit agency to select the standard information flows required to meet its business needs, and to implement those flows cost efficiently. Information flows are standardized by defining the message formats for the exchange, as well as the dialogs that define how sequences of messages are used to implement an information flow. Some information flows can be implemented using message file transfers –TCIP messages transferred in a file.

The procuring transit agency, after selecting the appropriate information flows for its needs, specifies what new and existing systems are to play what roles in what dialogs and/or file transfers. For example a traveler information system may be designated a subscriber, and a schedule repository a publisher for an information flow to convey availability of scheduled service. The procuring agency also determines what systems are authorized to access what information, and specifies what systems are responsible for controlling access. TCIP does not specify the agency-specific security procedures used to validate an information request, but does provide error messages to allow an unauthorized request to be rejected.

A transit agency ITS architecture defines the systems and interfaces within a transit agency as well as the interfaces between the agency and other agencies and/or private entities. The agency ITS architecture is the repository for capturing and documenting the agency's legacy and planned business systems, legacy interfaces, as well as the TCIP interfaces. The agency ITS architecture may specify a series of development phases. Each phase would represent upgrades or replacements of existing systems and interfaces, or new systems and interfaces being added. In each phase the specification of the interfaces would call out the TCIP dialogs required to be implemented by that interface and/or the legacy data flows to be at the interface.

TCIP contains a model architecture for transit as well as a transit Concept of Operations. These are <u>not</u> intended to be binding on any agency. Instead these sections are intended to <u>illustrate</u> the types of systems being interfaced with TCIP, and how those interfaces can be useful in a transit operation. Each agency that uses TCIP will find some parts of the standard which are not needed by that agency. TCIP's a-la-carte approach allows each agency to adopt only those parts of TCIP that meet their needs.

TCIP provides a-la-carte flexibility at multiple levels:

- Each dialog (automated information exchange) and file transfer defined by TCIP is <u>individually selectable</u> by an agency for inclusion or exclusion in the agency ITS architecture. Some dialogs and file transfers may be inappropriate for adoption initially, and adopted later as various business systems or components are replaced.

- Dialogs and file transfers are defined in terms of TCIP messages. These messages may contain <u>optional data</u> which can be used by an individual agency, or not, based on agency policies, operating paradigms and technical requirements. TCIP messages (and their contents) include a variety of opportunities for local extensions. Local extensions allow standard messages to be used and simultaneously tailored to meet agency needs.

- Each dialog or file transfer can be <u>redirected</u> by an agency. The TCIP Concept of Operations illustrates how dialogs and message transfers may be used to communicate among the physical and logical elements defined in the TCIP Model Architecture, however each agency is free to use these same dialogs and file transfers to convey information between any physical and logical elements in the agency or regional ITS architecture.

- TCIP defines data and messages to be exchanged in the ASN.1 data description language. TCIP provides an XML Schema that defines the data in a readily exchanged well-understood format. TCIP also recognizes that XML transfers are not a universal solution to transit data transmission requirements. Consequently TCIP allows for <u>alternative transmission syntaxes</u> to be specified by a transit agency. Alternative syntaxes include, but are not limited to, zipped XML documents, ASN.1 Packed Encoding Rules, and the example TCIP Narrowband Encoding.

- TCIP messages are able to be exchanged over a variety of communications networks and physical media, TCIP does not limit an agency's communications architecture.

- TCIP provides an extremely flexible, broad-based set of data exchange capabilities. These facilities are modular allowing agencies to select only those items required to meet their needs. Most agencies will not use all TCIP elements, but will begin adopting TCIP in phases consistent with the agency's overall long-term systems upgrade program.

1.2 Major Features of TCIP

File transfers allow standardized information to be transferred from one business system to another with or without network connection. File transfers involve having one business system write a message file containing a TCIP message. The file is then moved to another system to be read.

Automated information transfers are defined by dialogs. Dialogs define a sequence of TCIP messages that allow TCIP enabled systems, components and devices to interact automatically based on timers, manually generated events, and automatically detected events. Implementations that begin using TCIP for file transfers may consider migrating to automated dialog based transfers as part of their planning process. Automated information transfers occur over network connections, and may occur within very short time spans following an event that causes the information transfer (real-time). In other cases, automated transfers may be deferred for operational reasons. For example, although a schedule for Tuesday of next week becomes available on Sunday, the CAD/AVL system may defer loading the schedule until Monday night.

TCIP provides an example narrowband polling protocol which may be employed on agency-owned narrowband private radio links to communicate with transit vehicles. This protocol provides the first open systems interface available to transit for this purpose. Agencies are not obligated to adopt this protocol.

1.3 TCIP Background and History

The Transit Communications Interface Profile (TCIP) development effort began under the auspices of the Institute of Transportation Engineers (ITE) in cooperation with the U.S. Federal Transit Administration (FTA), the U.S. Federal Highway Administration (FHWA), and the ITS Joint Program Office. This development was performed in the context of the national Intelligent Transportation System (ITS) standards development effort and the National Transportation for ITS Protocols (NTCIP) effort of the American Association of State and Highway Transportation Officials (AASHTO), National Equipment and Manufacturing Association (NEMA), and ITE. The purpose of this effort was to provide the transit standards to support the transit segment of the ITS National Architecture. This effort produced message formats and defined data elements for the exchange of information among transit computer systems in several TCIP business areas. These standards were published by AASHTO, NEMA, and the ITE as: NTCIP 1400-1408. These standards have since been rescinded.

The definition of TCIP “dialogs” which define the rules for sending and receiving these messages was not completed as a part of this initial effort. The dialogs are a key element in developing useful standard interfaces between transit business systems. These rules create relationships between messages and systems which are essential to successful real-time interfaces. For example, the rules in the dialogs specify how a server must respond to a request for information (such as a schedule), by returning a specified information message, or a specified error message to the requester.

After completion of the initial TCIP data element and message standards, APTA was invited by the FTA to take a more prominent role in TCIP development. This resulted in the development of this document, as well as a variety of tools to support TCIP implementers. These tools are available free of charge on the Internet http://aptatcip.com/.

This document subsumes the work done to date in creating the 9 NTCIP Standards, and extends this work by adding additional data elements, data frames, messages and dialogs. This document also redefines conformance to allow for limited implementations scaled to agency and project needs, and to incorporate the use of file-based transfers of transit information using TCIP messages in situations where agencies do not want or need the automated information transfers specified in the dialogs. Finally this document provides a model transit ITS architecture and Concept of Operations which are non-normative, and intended to introduce the reader to possible uses of TCIP dialogs and file transfers in a typical transit agency.

1.4 Document Overview

The TCIP Standard is organized into 4 volumes. This section describes the contents of each volume.

Volume I of the TCIP Standard contains the Narrative. The narrative is divided into 10 sections as shown below:

- Section 1 – Overview – General Description and background of TCIP
- Section 2 – References and Definitions – Ties TCIP to other standards and defines terms and acronyms used in the standard.
- Section 3 – TCIP Data –Describes how TCIP defines data in ASN.1 and XML.
- Section 4 – Understanding TCIP – Provides background information and defines the Model Architecture.
- Section 5 – Concept of Operations – Provides a high-level discussion of transit agency operations, and business processes. This section ties these operations and processes to the TCIP dialogs and file transfers that support them.
- Section 6 – TCIP Message Encoding – Defines TCIP supported encoding of data for transmission.
- Section 7 – Dialog Patterns – This section defines the dialog patterns that are used to specify TCIP Dialogs. Dialog Patterns specify the rules for exchanging messages, message definitions define the content of messages, and dialog definitions specify a set of messages to be used according to the rules in the dialog pattern to accomplish a data transfer.
- Section 8 – Conformance – Defines Conformance requirements for TCIP conformant implementations.
- Section 9 – TCIP Procurements – Describes how an agency can go about procuring TCIP conformant systems. This section is informative and does not levy conformance requirements.
- Section 10 – TCIP Communications – Discusses communications networks used by TCIP Implementations. This section is informative and does not levy conformance requirements.

Volume II of the TCIP Standard contains the data and dialog definitions for TCIP. This volume is organized into four annexes as shown below:

- Annex A – Data Element Definitions in ASN.1
- Annex B – Data Frame Definitions in ASN.1
- Annex C – TCIP Message Definitions in ASN.1
- Annex D – TCIP Dialog Definitions

Volume III of the TCIP Standard contains the TCIP XML Schema, which is defined to be Annex E.

Volume IV of the TCIP Standard contains additional annexes as listed below:

- Annex F – This material intentionally deleted
- Annex G – National ITS Architecture Traceability Mapping
- Annex H – Base Type Definitions
- Annex I – TCIP Narrow Band Encoding. This annex defines an example mechanism for encoding information for transfer across limited capacity communications links.
- Annex J – TCIP Polling Protocol. This annex defines an example polling protocol for use over private narrowband radio systems.
- Annex K – Sample PRL and PICS.

1.5 Normative Portions of the Standard

The TCIP Standard contains both normative and non-normative material. Non-normative material is included to explain:

- How TCIP may be used by transit agencies and product developers,
- To provide context for the normative portions of the standard, and/or

- To contain technical material that has been developed, but is not yet deemed mature enough for balloting and implementation. Specifically, the TCIP Task Force, responsible for TCIP developments, has determined that the Fare Collection business area is not yet mature enough for balloting and/or implementation.

The normative portions of the standard are:

Section 2.1.1 Normative References – This section provides references to other standards that must be followed, where applicable in a TCIP-conformant interface.

Section 2.2 Definitions - This section defines terms that are in turn used to define concepts necessary to TCIP implementation.

Section 3 TCIP Data – This section defines how TCIP conformant data structures are specified and used.

Section 4.3 Data Configuration Management – This section defines how data is managed in TCIP conformant interfaces.

Section 4.6 Schema Files – This section defines how TCIP and related XML schema files are uniquely identified.

Section 6 TCIP Message Encoding – This section defines how TCIP data is encoded into messages that can be exchanged using a TCIP conformant interface.

Section 7 Dialog Patterns – This section defines the patterns that in turn define the semantics of TCIP message exchanges in dialogs.

Section 8 Conformance - This section defines the criteria that must be met for an interface to be TCIP-conformant.

Annexes A-B – These annexes define the data elements and data frames that are used to convey TCIP data.

Annex C (Excluding FC Messages) – This annex defines the messages used to convey TCIP information across a TCIP conformant interface, using dialog(s) or file transfers. *Messages defined in the Fare Collection business area are not balloted, are not normative and are not considered mature enough for implantation as of the publication date of this TCIP version.*

Annex D (Excluding FC Dialogs) – This annex defines the dialogs used to convey TCIP information. *Dialogs defined in the Fare Collection business area are not balloted, are not normative and are not considered mature enough for implementation as of the publication date of this TCIP version.*

Annex E (Excluding FC Messages) – This annex provides the Extensible Markup Language Schema for all TCIP data. *Fare Collection messages are not considered a normative part of the schema.*

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2.2 Definitions

Table 2.2 provides definitions for terms used in this standard.

Table 2.2 Definitions

Term	Definition
511 System	A telephone-based system that allows travelers to obtain travel information by dialing ‘511’.
AASHTO	American Association of State Highway & Transportation Officials. AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia, and Puerto Rico. It represents all five transportation modes: air, highways, public transportation, rail, and water. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system.
ABS	See Authorized Business System
Action List	A list of issued cards that are to have some action performed on them if presented to any applicable CID in the system. The action list is distributed to the necessary CIDs.
ADA Accessible	Americans with Disabilities Act accessible. The Americans with Disabilities Act requires public facilities in general, and transit facilities and services in particular, to be made accessible to persons with disabilities. The definition of an accessible facility is an evolving one, as interpretations of the act change over time and from locality to locality.
ADD	The act of adding cars to a train’s consist
ADUS	Archived Data User Service. A user service within the National ITS Architecture. ADUS requires ITS-related systems to have the capability to receive, collect, and archive ITS-generated operational data for historical, secondary, and nonreal-time uses.
AFC	Automatic Fare Collection. A fare collection system that provides a method of processing electronic fare media through computational devices to account for a ride or access onto a public transportation system. Each AFC transaction is processed in the order of acceptance or rejection followed by information local storage, remote or permanent storage, accounting/settlement and reports generation. AFC systems are intended to require little or no operator interaction. Also can accept fare in coins, tokens, or tickets.

Term	Definition
Agency ITS Architecture	The repository for capturing and documenting the agency's legacy and planned business systems, legacy interfaces, as well as the TCIP interfaces. The agency ITS architecture may specify a series of development phases for the agency's ITS systems.
Allocation Update	A data structure sent across the radio channel from the polling controller to the PTV announcing recent allocations and deallocations.
ANSI	American National Standards Institute. A private, non-profit organization (501(c)3) that administers and coordinates the U.S. voluntary standardization and conformity assessment system. The Institute's mission is to enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.
APC	See Automated Passenger Counter
Application	Sometimes known as a client or an "app," this is a self-contained program that performs a well-defined set of tasks. The application can reside on a smart card, PC, browser, etc.
APTA	American Public Transportation Association. Serves and leads its diverse membership through advocacy, innovation, and information sharing to strengthen and expand public transportation.
APTS	Advanced Public Transportation System
Artifact	Any message or file provided as an output of a business system. Schedule artifacts include definitions of patterns, time points, route schedules, vehicle assignments, operator assignments, etc.
ASCII	American Standard Code for Information Interchange. This 7-bit character code is capable of representing 128 characters, some of which are special control characters used in communications control and are not printable.
ASN.1	Abstract Syntax Notation Revision One. A standard promulgated by the International Telecommunications Union as ITU-T X6.80 for "…defining the syntax of information data." It defines a number of simple data types, and specifies a notation for referencing those types, and for specifying values of those types. TCIP allows 2 formats for the date and time fields.
ASN.1 Type	A data type defined by ASN.1 and used as a base type for defining TCIP data elements.
Asset Management (AM)	A transit business system responsible for managing a variety of operational assets and activities including assigning PTV's to planned work (blocks), maintenance planning and tracking, spare parts , work orders etc.

Term	Definition
Asset Management Process	A transit business process associated with managing and maintaining capital assets, primarily PTVs, required for transit operations. Section 5.7 describes this business process.
ATIS	1. Advanced Traveler Information System. A system for collecting and disseminating information to travelers, usually on a multimodal basis. Typical information provided includes transit, traffic, tourism, and weather. 2. A message set for ATIS promulgated as SAE J2354.
ATM	Asynchronous Transfer Mode. A dedicated-connection switching technology that organizes digital data into 53-byte cell units and transmits them over a physical medium using digital signal technology. Individually, a cell is processed asynchronously relative to other related cells and is queued before being multiplexed over the transmission path. units and transmits them over a physical medium using digital signal technology.
Attribute	A quality or characteristic inherent in, or ascribed to, someone or something.
Authorized Business System	A generic business system used to represent agency designated entities which may participate in a dialog. Examples include bus stop management systems, complaint management systems, and various agency-specific back office reporting systems.
Automated Passenger Counter	An onboard function that counts passenger boardings and/or alightings. This may refer to a subsystem, component, or a logical entity within an onboard component. The corresponding logical entity is PTV-PAS.
Automatic Fare Collection (AFC) or Automatic Fare Collection System	A fare collection system that provides a method of processing electronic fare media through computational devices to account for a ride or access onto a public transportation system. Each AFC transaction is processed in the order of acceptance or rejection followed by information local storage, remote or permanent storage, accounting/settlement and finally reports generation. AFC systems were intended to require little or no operator interaction. Also can accept fare in coins, tokens, or tickets.
AVL	Automatic Vehicle Location. A means for determining the location of a vehicle and transmitting this information to a point where it can be used.
Bandwidth	The range of frequencies that can be used for transmitting information on a channel, equal to the difference in Hertz (Hz) between the highest and lowest frequencies available on that channel. Channels with limited (narrow) bandwidth generally have very limited information transfer capacity.
Banks	Established financial institutions. These institutions interact with transit agencies with currency transfers, smart card transactions, credit card transactions, etc.

Term	Definition
Base Fare	The price charged to one adult for one transit ride; excludes transfer charges, zone charges, express service charges, peak period surcharges, and reduced fares
Base Map	1. A map depicting background reference information such as landforms, roads, landmarks, and political boundaries, onto which other, thematic information is placed. A base map is used for locational reference and often includes a geodetic control network as part of its structure. 2. A map to which GIS data layers are registered and re-scaled.
Basic Encoding Rules (BER)	A transfer syntax associated with ASN.1 and defined by ISO/IEC 8825-1.
BER	1. Basic Encoding Rules. A transfer syntax associated with ASN.1 and defined by ISO/IEC 8825-1. 2. Bit Error Rate- the ratio of erroneous bits to correct bits transferred across a communications channel in an interval of time.
Bit	Binary digit, a single basic computer signal consisting of a value of 0 or 1, off or on.
Bit Error Rate (BER)	The number of bits transmitted incorrectly. In digital applications, it is the ratio of bits received in error to bits sent.
Block	A vehicle work assignment.
Blocking	The process or organizing scheduled PTV trips into vehicle work assignments.
BOOLEAN	A variable whose values are limited to True and False.
Bound	A state of a vehicle or operator work assignment in which the work defined by the assignment has been associated with the specific vehicle or operator expected to perform the assignment.
BPS	Bits Per Second. A unit of measure of the tansmission rate (speed) of data.
Business Area	See TCIP Business Area.
Business Process	See TCIP Business Process.
Business System	A fixed computer application within the Model Architecture that performs a particular business function or group of related functions.
Byte	A group of bits acted upon as a group, which may have a readable ASCII value as a letter, or number, or some other coded meaning to the computer. It is commonly used to refer to eight-bit groups.

Term	Definition
CAD	Computer Aided Dispatching. A method of dispatching transit vehicles, couriers, field service technicians, emergency services or other mobile assets by computer. It can either be used to send messages to the dispatchee via a mobile data terminal (also called an MDT) and/or used to store and retrieve data (e.g.,, Radio Logs, Field Interviews, Client Information, Schedules)
CAD/AVL System	Computer Aided Dispatching/Automatic Vehicle Location System. A business system that dispatches, and monitors the activities of PTVs, and may provide emergency/incident management capabilities. Some agencies develop and/or purchase CAD and AVL separately; however, TCIP does not define interfaces between CAD and AVL.
Canned Message	A text message which has been predefined, and stored in at least 2 locations, allowing the message to be specified for display to a human by transmitting its identifying number rather than by transmitting the entire message text. Some canned messages contain designated locations where canned text ("takes") can be inserted from a list (e.g., a bus stop name), into the message.
Car	See rail car.
CC	Control Center. A TCIP business area. See Control Center.
CCTV	Closed-Circuit Television. The use of television cameras for surveillance. It differs from broadcast television in that all components are directly linked via cables or other direct means.
Centroid	1. The geometric center of an area. 2. In Geographical Information Systems (GIS) terminology, the centroid is the point in a polygon linking information to that specific area.
Checksum	An arithmetic sum used to verify data integrity.
CID	Card Interface Device. Provides application services and communications to interface a farecard to backend systems.
Codec	Coder/Decoder. An entity that translates between two different message encoding formats (e.g., TCIP XML Encoded messages and TCIP Narrowband Encoded messages).
Command List	A list of actions to be performed by a device.
Common Public Transportation	A TCIP business area. This TCIP business area involves the definition and distribution of information which is needed by several other TCIP business areas. Examples are transit facilities information, stop point lists, etc.

Term	Definition
Component	1. A physical element of a system or subsystem that may contain one or more logical entities. 2. A constituent element of an organization or system.
Conformance	The fulfillment of all applicable criteria and requirements specified in TCIP Section 8. Conformance in TCIP is applicable to the TCIP PICS produced by a developer and to the TCIP implemented interface provided by a developer.
Consist	The sequence of rail cars comprising a train
Control Center (CC)	A TCIP business area. Control Center activities include dispatching, monitoring, controlling, and managing transit operations in real-time. Most TCIP CC activities involve interactions between the CAD/AVL and other fixed business systems and transit vehicles.
Controlled Device	In the control dialog pattern there is a device that executes commands and a device which issues commands to be executed. The controlled device is the command-executor in those dialogs.
Controller	In the control dialog pattern, there is a device that executes commands, and a device which issues commands to be executed. The controller is the command-issuer in those dialogs.
CPT	Common Public Transportation. A TCIP business area. See Common Public Transportation.
CSS	See Customer Service System
Cut	The act of removing cars from a train's consist
Customer Service System (CSS)	A business system used to support a transit agency's customer service department, including managing mailings, supporting the call center, etc.
Data Element	An atomic piece of information related to a person, place, thing, or concept. For example, CPT-PersonFirstName and CPT-Footnote are data elements.

Term	Definition
Data Frame	A grouping of data elements primarily for the purpose of referring to a group with a single name, and thereby efficiently reusing groups of data elements that commonly appear together (as an ASN.1 SEQUENCE, SEQUENCE OF , or CHOICE) in a TCIP message. This data concept type may also be used to specify groups of data elements for other purposes as well. A data frame may contain other data frames as well as data elements.
Data Repository	1. A business system in a transportation organization, whose primary function is to accept and store agency data, which may include the output of other business systems, and to make the data available to authorized business systems on demand. Some repositories may combine data from different business systems and provide the results on request, or may process the data and provide the processed result to authorized business systems. Data repositories may serve as the primary location where some data is stored and maintained for use by authorized business systems (e.g., bus stop inventory). 2. In the IT Community, a logical partitioning of data where multiple databases that apply to specific applications or sets of applications reside. For example, several databases that support financial applications could reside in a single financial data repository.
Data Repository Operations Process	A transit business process associated with developing, operating, and maintaining a transit Data Repository. Section 5.9 describes this business process.
Device	See Controlled Device
Dialog	An ordered sequence of message exchanges between two or more entities. The rules of the exchange are defined by a dialog pattern. Messages specific to the type of exchange are specified by the dialog.
Dialog Pattern	A description of a message exchange between two or more entities, including the rules associated with the exchange. Generally, the same pattern can be used to convey more than one type of information. For example, a Publication could convey schedules or alarm information.
Dispatcher	The person responsible for sending out transit vehicles to operate according to schedule. Depending upon the transit agency this term may refer instead, or in addition, to the person who deals with exception conditions and incidents occurring during daily operations.
DR	See Data Repository
DSRC	Dedicated Short-Range Communications. A short to medium range wireless protocol specifically designed for automotive use. It offers communication between the vehicle and roadsite equipment. This technology for ITS applications is working in the 5.9GHz band.

Term	Definition
EIA	Electronics Industry Alliance. A trade organization for electronics manufacturers in the United States. EIA is accredited by ANSI to help develop standards on electronic components, consumer electronics, electronic information, telecommunications, and Internet security.
Emergency Management	A business system, external to the transit agency which performs emergency management related functions for another (transit or non transit) agency.
Engine Control Unit	A component on a public transit vehicle responsible for monitoring and reporting drive train and other core vehicle information on the VAN.
Entity	An instance of a software process.
ENUMERATED	A variable whose value is restricted to a specified list of values. These values can be, but are not required to be numeric. In TCIP, enumerated types are typically assigned both token values (e.g.,, red, white, and black) and corresponding numeric equivalents (1, 2, and 3).
Event	A term covering any of three kinds of events: transportation-related incidents, planned roadway closures, and special events. The term covers any event of the three, including information about which is received by an incident management system, whether or not the event actually affects traffic flow or whether or not it requires a response.
Event-Driven	A transaction or response in a transit business system or component that is based on the occurrence of an event. Events in this context include human actions, vehicle movements, monitored parameter changes, received, messages etc. The Publication dialog pattern provides for a subscription wherein updates to the subscriber are event-driven – meaning that updates are sent to the subscriber based on the occurrence of events.
External ATIS	An Advanced Traveler Information System (ATIS) provided by an organization other than the transit agency.
Fare (Distance-Based)	A Distance-Based Fare is a product that charges on the basis of distance traveled. This may be related to mileage, specific locations (stops or stations), or fare zones (covering zone checks). A record shall be made that allows a distance-based fare to be calculated. The entry record shall contain the location of origin and other information required by business rules.
Fare Category	The grouping of passengers by how much they are supposed to pay.
Fare Collection	A TCIP business area. This TCIP business area involves the collection and processing of revenue from customers including the exchange of fare information.
Fare System (FS)	A business system that manages the fare and revenue collection functions.

Term	Definition
Fare Tables	The basic set of fare prices that comprise an authorities' fare structure. All of this data is complied into a set of "fare tables" that are used by the AFC equipment to sell and collect media (and or fares). Fare information that is transferred to each device for determining fares to be paid by patrons.
Farebox	An electro-mechanical device normally installed unto a public transportation vehicle (normally a bus), for the purpose of vaulting fare media or currency to gain riding privileges. The Farebox often contains a mechanism to receive currency and fare media with and without operator intervention. The Farebox with the interaction of the user and operator can also dispense fare media. The latest generation of Fareboxes often include modules that accept and process electronic fare media as well as offer methods to communicate off the vehicle for real-time information and data reporting. These types of Farebox's are also becoming known as Mobile Vendors
FC	Fare Collection. A TCIP business area. See Fare Collection.
FCC	Federal Communications Commission. An independent United States government agency directly responsible to Congress. The FCC was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite, and cable. The FCC's jurisdiction covers the 50 states, the District of Columbia, and U.S. possessions.
Feature	1. A representation of a real-world object on a map. Features can be represented in a GIS as vector data (points, lines, or polygons) or as cells in a raster data format. To be displayed in a GIS, features must have geometry and locational information. 2. A grouping of spatial and/or nonspatial data that together represent a real-world entity. A complex feature is made up of more than one spatial element. For example, a set of line elements with the common theme of roads representing a road network.
Feature Class	A collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can stand alone as a feature set or be contained within other feature sets. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes. For example, highways, primary roads, and secondary roads can be grouped into a line feature class named "roads."
Feature Set	A collection of feature classes stored together that share the same spatial reference system that is, they have the same coordinate system, and their features fall within a common geographic area. Feature classes with different geometry types (e.g.,, line, polygon) may be stored in a feature dataset.

Term	Definition
FHWA	Federal Highway Administration. An agency of the U.S. Department of Transportation (DOT). The top-level official at FHWA is the Administrator, who reports directly to the Secretary of Transportation. FHWA is headquartered in Washington, DC, with field offices in every State, the District of Columbia, and Puerto Rico. FHWA is charged with the broad responsibility of ensuring that America's roads and highways continue to be the safest and most technologically up-to-date. Although State, local, and tribal governments own most of the Nation's highways, FHWA provides financial and technical support to them for constructing, improving, and preserving America's highway system.
File Transfer	An information transfer effected between two computers by having one computer write information to a file, moving the file to the other computer and, having the second computer read the file. In the case of a TCIP file transfer, the file is an XML document consisting of a single TCIP message.
FS	See Fare System
FTA	Federal Transit Administration. An agency of the U.S. Department of Transportation DOT headed by an Administrator who is appointed by the President of the United States, FTA functions through a Washington, DC, headquarters office and ten regional offices which assist transit agencies in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, Guam, Northern Mariana Islands, and American Samoa. Public transportation includes buses, subways, light rail, commuter rail, monorail, passenger ferry boats, trolleys, inclined railways, and people movers. The Federal government, through the FTA, provides financial assistance to develop new transit systems and improve, maintain, and operate existing systems. FTA oversees grants to state and local transit providers, primarily through its ten regional offices. FTA is responsible for ensuring that grantees follow Federal mandates along with statutory and administrative requirements.
FTP	File Transfer Protocol. A software standard for transferring computer files between machines with widely different operating systems. It belongs to the application layer of the Internet protocol suite
Garage Revenue System	A business system responsible for managing the collection of revenue and fare related data from public transit vehicles and possibly stop/station based fare/revenue equipment.
Garage Server	A business system responsible for loading and unloading data to/from public transit vehicles-usually over the wireless LAN. The garage server also stages and caches data sets for loading and unloading. A garage server may also contain maintenance and operations information.

Term	Definition
Geography Markup Language	A standard published by the Open Geospatial Consortium that defines an XML schema for conveying geographical and geographically-referenced information.
GIF	Graphics Interchange Format. A file format for exchanging graphical images.
GIS	Geographical Information System. A business system that organizes and processes information based on geographical coordinates as well as other attributes.
GML	See Geography Markup Language.
GPS	Global Positioning System. A system of satellites owned and operated by the U.S. Department of Defense (DoD), that allow receivers on or near the earth to receive signals from the satellites and calculate the receiver's location.
GRS	See Garage Revenue System.
GS	See Garage Server.
Hot Card	This is a smart card that has been lost, stolen or misused. A smart card's status is managed by the organization which issues and owns the card. The hot card status may be modified to deny transactions and eventually physically capture the card. The card may also be referred to as a "negative list" card.
Hot List	See Negative List.
Identifier	A unique number assigned to an item (bus, employee, stop point etc.) to provide a short and uniform way to reference that item, as distinct from all other items of the same type.
IEEE	Institute of Electrical and Electronics Engineers. The IEEE promotes the engineering process of creating, developing, integrating, sharing, and applying knowledge about electro and information technologies and sciences for the benefit of humanity and the profession.
IEEE 1512	IEEE Standard Sets: Communication Framework for Transportation Emergencies. Most TCIP references are to IEEE 1512 "Traffic Incident Management Message sets for Use by Emergency Management Centers."

Term	Definition
IETF	Internet Engineering Task Force. A large open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and the smooth operation of the Internet. It is open to any interested individual. It is the principal body engaged in the development of new Internet standard specifications. The IETF is unusual in that it exists as a collection of happenings, but is not a corporation and has no board of directors, no members, and no dues.
IM	Incident Management. A TCIP business area. See Incident Management.
Implementation	A computer system, component, software application, or business system that includes a TCIP interface.
Incident	1. A non-reoccurring or planned event impacting transportation services. 2. Events that are not planned roadway closures or special events (i.e., events about which there is no advance notice, such as emergencies, accidents, disasters caused by humans, and natural disasters).
Incident Management	A TCIP business area. Incident Management involves reporting, responding to, closing, and coordinating responses to events (incidents) that disrupt transit service.
Inform Customers	A transit business process associated with informing customers about transit services, and maintaining customer relationships. Section 5.8 describes this business process. This business process is closely related to the Passenger Information Business Area.
Information Service Provider	A business system that provides access to information to the public, usually on a fee-basis.
INTEGER	A variable whose values are limited to zero, positive whole numbers, and negative whole numbers. TCIP integer types are further limited to a range of values that allow their storage requirements to be limited to 1, 2, or 4 octets.
Interface	The point of interaction between a business system, subsystem, or component, and any other entity.
IP	Internet Protocol. A data-oriented protocol used by source and destination hosts for communicating data across a packet-switched internetwork.

Term	Definition
ISO	International Organization for Standardization. A network of the national standards institutes of 148 countries, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. Many of its member institutes are part of the governmental structure of their countries, or are mandated by their government. On the other hand, other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations. Therefore, ISO is able to act as a bridging organization in which a consensus can be reached on solutions that meet both the requirements of business and the broader needs of society.
ITE	Institute of Transportation Engineers. An international individual member educational and scientific association, a multimodal professional transportation organization. ITE members are traffic engineers, transportation planners and other professionals who are responsible for meeting society's needs for safe and efficient surface transportation through planning, designing, implementing, operating and maintaining surface transportation systems worldwide.
ITIS Phrase Lists	International Traveler Information System Phrase Lists. Specified by SAE J2540/2. This SAE Standard provides a table of textual messages meeting the requirements for expressing "International Traveler Information Systems" (ITIS) phrases commonly used in the ITS industry. The tables provided follow the rules of SAE J2540 allowing a local representation in various different languages, media expressions, etc. to allow true international use of these phrases.
ITS	Intelligent Transportation Systems. A worldwide initiative to use advanced technologies, and computer-based technologies specifically to enhance the safety and efficiency of transportation systems.
ITU	International Telecommunication Union. Is an international organization headquartered in Geneva, Switzerland within United Nations System where governments and the private sector coordinate global telecom networks and services.
LAN	Local Area Network. A computer network covering a local area, (e.g., transit facility, home, office, or small group of buildings such as a college).
Layer	The visual representation of a feature class in any digital map environment. Conceptually, a layer is a slice or stratum of the geographic reality in a particular area and is more or less equivalent to a legend item on a paper map. On a road map roads, national parks, political boundaries, and rivers are examples of different layers.
Load	Provide a large data message or messages to a vehicle or field device.

Term	Definition
Local Extension	1) A field added to a TCIP message or data frame that conveys information in addition to the information specified by the standard. TCIP specifies which data frames and messages are locally extensible. It is not permissible to add an optional field that conveys the same information as a standard field in lieu of sending that information in the standard format. 2) A code value or values added to an enumerated type data element.
Location Data Source	A sensor that provides a vehicle with current location information. It may be a Global Positioning System Receiver, Dead Reckoning, or other sensor type. It may combine the results of more than one sensor for use on the vehicle.
Logoff	An event wherein a user of a system or component notifies the system or component that an ongoing usage session is to be terminated.
Logon	An event wherein a user of a system or component notifies the system or component that a new usage session is to be initiated. Usually, the logon includes the provision of the user's identification number and possibly security information.
LRMS	Location Referencing Message Specification. See SAE J2266. Standardizes location referencing for ITS applications that require the communication of spatial data references between databases or computer applications.
MDT	See Mobile Data Terminal.
Message	A grouping of data elements and/or data frames intended to be transmitted as a complete package of information in one direction.
Message Wrapper	Any data structure used to enclose a valid TCIP message.
Mobile Data Terminal (MDT)	A component with a key pad and a screen on a transit vehicle to allow the vehicle operator to exchange information with onboard components and systems. Interaction with external systems, e.g.,, a control center, may also be supported. The Mobile Data Terminal may be a separate physical component or may be a part (e.g.,, touch screen) of the Vehicle Logic Unit.
Mode	A transit service type category characterized by specific right-of-way, technological, and operational features.
MPEG-4	A standard promulgated by the Motion Picture Entertainment Group for the distribution of full-motion video images.
Namespace	According to W3C "An XML namespace is a collection of names identified by a URI reference which are used in XML documents as element types and attribute names."

Term	Definition
Narrowband	A communications channel that has limited bandwidth resulting in limited information transfer capacity.
Narrowband Encoding	A means of encoding TCIP information in a compact form for transmission via one or more narrowband communications channels.
Negative List	A list of issued cards that are to be prevented from normal use if presented to any applicable card interface device in the automatic fare collection system.
NEMA	National Electrical Manufacturers Association. Provides a forum for the standardization of electrical equipment, enabling consumers to select from a range of safe, effective, and compatible electrical products.
Network Management	A business system responsible for monitoring and reporting on the health and status of the transit agencies communications infrastructure, and possibly other connected devices, business systems, components etc.
NIA	National ITS Architecture. Provides a common framework for planning, defining, and integrating intelligent transportation systems.
NTCIP	National Transportation Communications for ITS Protocol. A group of standards intended to promote interoperability among ITS components and subsystems.
NTCIP 1211	An NTCIP Standard entitled “Objects for Signal Control Priority.”
NULL	A value assigned to an item to indicate no value or to signify that the item is not present.
Numeric String	A UTF8String consisting exclusively of the characters representing the digits zero through nine.
OAS	See Operator Assignment System.
OB	On board. A TCIP business area. See Onboard
Object	1. A material item that is perceptible by the senses. 2. See TCIP object.
Octet	A group of eight binary bits. Octets are a standard grouping for bits to be transmitted across a communications network.
OCTET STRING	A variable length sequence of octets. This is used to convey unstructured blocks of data. Some of the data elements defined using this type conveys data, which is further defined by another (non-ITS) standard. TCIP data elements defined using OCTET STRING as a base type always specify a limitation on the upper length of the octet string.

Term	Definition
Onboard	A TCIP business area related to interactions among onboard PTV components, and logical entities.
Operator Assignment System	A business system responsible for managing the assignments of Vehicle Operators to specific planned work (runs).
Optional Field	A data field defined in a TCIP message or data frame that may be omitted from the message or data frame when transmitted. Some optional fields are omitted based on functional limitations of the endpoints of the interface. Some optional fields are included or excluded based on conditions at the time the information is generated.
Packed Encoding Rules	A transfer syntax associated with ASN.1 and defined by ISO/IEC 8825-2.
Parking Management	A business system that supports the operations of transit owned and/or operated parking garages.
Passenger Counting	A business system that collects and distributes passenger count information for use by other business systems (e.g.,, planning). This is not to be confused with the Automated Passenger Counter which is an onboard system that collects data for later use by the Passenger Counting business system.
Passenger Information	A TCIP business area. Passenger Information involves the creation, distribution, and dissemination of information that will assist transit users (passengers) in efficiently using the transit system to plan and execute their travel.
Pattern	A path consisting of a series of pattern segments followed by a PTV in executing a scheduled trip.
Pattern Segment	A portion of a path followed by a PTV in executing a scheduled trip. A pattern segment is defined by a series of timepoints and optionally stoppoints. A pattern segment may contain geographical trace points to facilitate mapping.
PC	See Passenger Counting.
PER	Packed Encoding Rules. A transfer syntax associated with ASN.1 and defined by ISO/IEC 8825-2.
Personal Information Access	An element in the NIA physical architecture. This element provides individuals with access to service status, schedules, and other traveler information.
Personnel and Work Assignment Management Process	A transit business process associated with managing transit employees and contractors. Section 5.6 describes this business process.
PI	A TCIP business area. See Passenger Information.

Term	Definition
PICS	See Profile Implementation Conformance Statement.
PID	Passenger Information Display. An electronically changeable information sign that provides transit information to transit passengers. PIDs would typically be located at bus stops, transfer points, and intermodal passenger facilities.
Pixels	The basic unit of the composition of an image on a television screen, computer monitor, or other display.
Polling Controller	A fixed entity that controls access to a TCIP-polled or proprietary-polled data channel and provides an interface to the CAD/AVL System.
Polygon	A closed sequence of vertices that encloses an area feature. For example, an area of hazardous material spill impact or a fare zone.
Positive List	A list of issued cards that are permitted for use if presented to any applicable card interface device in the automatic fare collection system.
Priority	Precedence established based on importance or urgency.
Priority Request	A request to have traffic signal timing temporarily altered at a specified intersection to allow a PTV to operate more efficiently.
Priority Request Generator (PRG)	A logical entity that generates priority requests on behalf of one or more PTV(s).
Priority Request Server (PRS)	A logical entity in the traffic management environment (may be roadside or office based) that determines the disposition of TSP priority requests from the PRG.
PRK	See Parking Management
PRL	See Profile Requirements List
Profile Implementation Conformance Statement (PICS)	A document used to specify the TCIP interface(s) associated with an implementation. The PICS lists the TCIP dialogs, TCIP message file transfers, and options supported by the implementation along with other detailed information about the interface. Section 8 describes the use of a PICS with a TCIP conformant implementation. Section 9 describes the use of a PICS in an ITS procurement. Annex K provides a Sample PICS.
Profile Requirements List (PRL)	A document used to specify an agency's requirements for the TCIP interface(s) associated with a new or upgraded system. The PRL lists the TCIP dialogs, TCIP message file transfers, and options required for the interface along with other detailed interface information. Section 8 describes PRL requirements. Section 9 describes the use of a PRL in an ITS procurement. Annex K provides a sample PRL.

Term	Definition
PTSF	Public Transit Stop/Station Facility. A location or facility where public transit vehicles stop to allow passengers to board and/or alight from the vehicle.
PTSF-ANN	A stoppoint/station based logical entity responsible for managing traveler information dissemination. {Public Transit Stop/station Facility-ANNunciator}
PTSF-FBX	A stoppoint/station based logical entity associated with fare equipment (vending machines, fare gates, etc.). {Public Transit Stop/station Facility – FareBoX}
PTSF-PRK	The logical entity associated with Transit Parking. This is a field-based entity. {Public Transit Stop/station Facility-PaRKing}
PTSF-SEC	A stoppoint/station based logical entity responsible for managing security functions. {Public Transit Stop/station Facitlity-SECurity}
PTV	Public Transit Vehicle. Any vehicle used to provide public transit service.
PTV Operations Process	A transit business process associated with the operations of PTVs, primarily in revenue service. Section 5.3 describes this business process. This business process is closely related to the Control Center and Onboard Business Areas.
PTV-ADH	The logical entity on a public transit vehicle responsible for monitoring and reporting schedule and route adherence. {Public Transit Vehicle-ADHerence}
PTV-ANN	The logical entity on a public transit vehicle responsible for providing information to passengers including announcements. {Public Transit Vehicle-ANNunciator}
PTV-COM	The logical entity on a public transit vehicle that manages the communications links between the PTV and outside entities. {Public Transit Vehicle- COMmunication}
PTV-DAT	The logical entity on a public transit vehicle responsible for data management (within the Vehicle Logic Unit). {Public Transit Vehicle-DATa manager}
PTV-ECU	The logical entity on a public transit vehicle associated with the engine control unit. {Public Transit Vehicle-Engine Control Unit}
PTV-HEL	The logical entity on a public transit vehicle responsible for monitoring and reporting on the health of the PTV and its onboard components. {Public Transit Vehicle-HEaLth}

Term	Definition
PTV-LDS	The logical entity on a public transit vehicle associated with the Location Data Source. {Public Transit Vehicle- Location Determination Source}
PTV-LOC	The logical entity on a public transit vehicle responsible for monitoring and reporting the vehicle's location. {Public Transit Vehicle- LOCation manager}
PTV-OPR	The logical entity on a public transit vehicle associated with interactions with the vehicle operator. {Public Transit Vehicle- OPeRator interface}
PTV-OTH	Any agency-defined logical entity onboard a public transit vehicle. This entity's functions are not defined by the Model Architecture. {Public Transit Vehicle- OTHer}
PTV-PAS	A logical entity onboard a PTV responsible for monitoring and reporting passenger boarding/alighting. {Public Transit Vehicle- PASsenger counter}
PTV-PRI	A logical entity onboard a PTV responsible for managing transit signal priority functions, including the generation of priority requests. {Public Transit Vehicle- PRIority}
PTV-SEC	A logical entity onboard a PTV responsible for managing security functions. {Public Transit Vehicle- SECurity}
Public Safety CAD	A business system within a public safety agency (e.g.,, police, fire, ambulance) that dispatches that agency's fleet.
Publisher	The provider of information in a publication dialog.
Query	A request for information from one business system or component to another.
Queue	1. A line of waiting people, vehicles, or other items. 2. A sequence of stored data, messages, programs, or events awaiting processing in a computer.
Rail Car	A public transit vehicle that operates on rails, and which may comprise a train either on its own, or as part of a sequence of rail cars.
RDPRG	Roadside-based Priority Request Generator. A priority request generator that is installed at a fixed location. See Priority Request Generator.
RDPRS	Roadside-based Priority Request Server. A priority request server that is installed at a fixed location. See Priority Request Server.

Term	Definition
REAL	A simple type whose values are based on the members of the set of real numbers.
Remote Traveler Support	Provision of transit information to travelers using non-transit facilities such as telephone, personal digital assistant, or other internet appliance.
Responsiveness	The conformant fulfillment of all requirements specified in an Agency's TCIP PRL. Responsiveness in TCIP is applicable to a developer's TCIP PICS and to a developer's TCIP implemented interface. In the broader context of an ITS procurement, responsiveness includes fulfillment of other agency functional requirements and business terms and conditions, and the TCIP requirements specified in the PRL.
Revenue and Fare Collection Process	A transit business process associated with managing fare policies, fare collection, and revenue processing. Section 5.4 describes this business process. This business process is closely related to the Fare Collection Business Area.
Revision	An updated instance of an artifact. The revision may be identified by a file identifier, effective date, time last updated, and/or a version number.
RFP	Request for Proposal.
Roster	A grouping of operator work assignments into a weekly package.
Route	A publicly known PTV path over which service is provided- usually on a recurring basis. The pattern of stoppoints and timepoints serviced by PTVs operating on a route may vary by time of day, day of week, etc.
Run	An operator work assignment.
Runcutting	The process of organizing scheduled PTV trips into operator daily work assignments and rosters.
Running Time	The actual, expected, or scheduled time for a public transit vehicle to travel between two specified geographical points.
SAE	Society of Automotive Engineers. A non-profit educational and scientific organization dedicated to advancing mobility technology to better serve humanity. SAE members, develop technical information on all forms of self-propelled vehicles including automobiles, trucks and buses, off-highway equipment, aircraft, aerospace vehicles, marine, rail, and transit systems. SAE disseminates this information through its meetings, books, technical papers, magazines, standards, reports, professional development programs, and electronic databases.
SAE J1587	SAE Standard entitled “Electronic Data Interchange Between Microcomputer Systems in Heavy Duty Vehicle Applications.”

Term	Definition
SAE J1708	SAE Standard entitled "Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications."
SAE J1939	SAE family of standards entitled "Recommended Practice for Truck and Bus Control and Communications Network."
SAE J2266	SAE Standard entitled "Location Referencing Message Standard."
SAE J2354	SAE Standard entitled "Message Sets for Advanced Traveler Information Systems (ATIS)."
SAE J2496	SAE Standard entitled "Transit Area Network Cabling Standard."
SAE J2630	SAE Standard entitled "Converting ATIS Message Standards from ASN.1 to XML".
SCADA	Supervisory Control and Data Acquisition System. A system used to monitor and control a variety of equipment in a transit agency including, pumps, fans, tunnel lights, traction power systems etc.
SCH	See Scheduling, Scheduling System
Schedule	A collection of information that describes the planned movements of public transit vehicles.
Scheduling	A TCIP business area primarily involved with the creation and distribution of transit schedules and closely related information such as operator and vehicle work assignments.
Scheduling Process	A transit business process associated with managing transit schedules. Section 5.5 describes this business process. This business process is closely related to the Scheduling Business Area.
Scheduling System	A business system that creates transit schedules and organizes planned trips within that schedule into operator and vehicle assignments.
SDO	Standards Development Organization.
Security and Incident Management Process	A transit business process associated with ensuring the safety of transit customers, employees, facilities, and equipment, and with managing the recovery and restoral of service following an incident. Informing customers about transit services, and maintaining customer relationships. Section 5.2 describes this business process. This business process is closely related to the Incident Management Business Area.
SEQUENCE	A keyword used in ASN.1 to indicate that a TCIP object (data frame or message) consists of a sequence of other TCIP objects (data frames and/or data elements).

Term	Definition
Service	The provision of transportation, and access to facilities, amenities, and transportation system information to transit customers.
Shape points	Geographical locations that define points along a line, other than its termini, provided for the purpose of defining the shape of the line as other than a straight line.
SNMP	Simple Network Management Protocol. Forms part of the internet protocol suite as defined by the Internet Engineering Task Force. The protocol can support monitoring of network-attached devices for any conditions that warrant administrative attention.
SONET	Synchronous Optical Network. Standard for communicating digital information over optical fiber. It was developed to transport large amounts of telephone and data traffic. It is defined by GR-253-CORE from Telcordia.
SP	Spatial Representation. A TCIP business area. See Spatial Representation.
Spatial Data Management Process	A transit business process associated with managing transit information that includes spatial elements or attributes. Section 5.10 describes this business process. This business process is closely related to the Spatial Representation Business Area.
Spatial Representation (SP)	A TCIP business area. Spatial Representation defines how locations, geographical boundaries, areas, addresses, etc. are defined. SP also defines some units of measure that are used by other TCIP business areas. Effective in TCIP version 2.4, SP data elements and data frames have been replaced by references to the LRMS standard to the extent feasible.
SPV	See Supervisor Portable or Vehicle.
SPV-COM	Supervisor portable or vehicle communications manager entity. {Supervisor Portable of Vehicle – COMmunications}
SPV-DAT	Supervisor portable or vehicle data manager entity. {Supervisor Portable of Vehicle – DATa manager}
SPV-ECU	Supervisor portable or vehicle engine and drive train monitoring entity. {Supervisor Portable of Vehicle – Engine Control Unit}
SPV-HEL	Supervisor portable or vehicle health monitor entity. {Supervisor Portable of Vehicle – HEaLth}
SPV-LDS	Supervisor portable or vehicle location sensor entity. {Supervisor Portable of Vehicle – Location Data Source}

Term	Definition
SPV-LOC	Supervisor portable or vehicle location monitor entity. {Supervisor Portable of Vehicle – LOCation manager}
SPV-OPR	Supervisor portable or vehicle operator interface entities. {Supervisor Portable of Vehicle – OpeRator}
SPV-PRI	Supervisor portable or vehicle TSP manager entity. {Supervisor Portable of Vehicle – PRIority}
SPV-SEC	Supervisor portable or vehicle security manager entity. {Supervisor Portable of Vehicle – SECurity}
State Plane	A coordinate system used in mapping the United States. It divides all fifty states, Puerto Rico, and the Virgin Islands into 120 numbered zones, and each zone number defines the projection parameters for the region. The state plane related data frame is defined in reference [N-4].
STMP	Simple Transportation Management Protocol. A variant of SNMP used to manage ITS assets.
Stoppoint	A location where PTVs normally stop to allow passengers to board and/or alight.
Subscriber	The consumer of information in a Publication dialog.
Subscription	A relationship between an information consumer (subscriber) and an information provider (publisher) in which a contract (subscription) is established governing the information transfer. In TCIP there are three types of subscriptions – query, event, and periodic. These provide information on a one-time-basis, as-changed-basis, and recurring-interval-basis respectively.
Supervisor Portable or Vehicle (SPV)	A component that allows a transit supervisor to exchange data with business systems and other transit components and systems. This component is an element of the TCIP physical architecture and a logical entity within TCIP.
TCIP	Transit Communications Interface Profiles.

Term	Definition
TCIP Business Area	A TCIP defined grouping of business functions. These groupings are artificial, but provide a convenient way to divide TCIP into segments that roughly correspond to areas of expertise of transit employees. All TCIP dialogs, messages, data frames, and data elements are allocated to a TCIP business area. Transit agencies may group the functionality of their business systems very differently from TCIP (i.e., based on the agency ITS architecture) while still using TCIP dialogs and message file transfers to exchange information. TCIP Business Areas: Scheduling, Passenger Information, Incident Management, Onboard Systems, Control Center, Fare Collection, Spatial Representation, Common Public Transportation, and Transit Signal Priority.
TCIP Business Process	A core business process of a transit agency. These Processes are described in the TCIP concept of operations (Section 5). The TCIP Business Processes are: Security and Incident Management Process, PTV Operations Process, Revenue and Fare Collection Process, Scheduling Process, Personnel and Work Assignment Management Process, Asset Management Process, Customer Information Process, Data Repository Operations Process, Spatial Data Management Process, and Transit Signal Priority Process.
TCIP Object	A TCIP data element, data frame, or message.
TCP	Transmission Control Protocol. One of the core protocols of the Internet protocol suite. Using TCP, programs on networked computers can create connections to one another, over which they can send data. The protocol guarantees that data sent by one endpoint will be received in the same order by the other without any pieces missing. It also distinguishes data for different applications (such as a Web server and an email server) on the same computer.
TCP/IP	Transmission Control Protocol/Internet Protocol. The set of communications protocols that implement the protocol stack on which the Internet runs. It is sometimes called the TCP/IP protocol suite, after the two most important protocols in it: the Transmission Control Protocol (TCP) and the Internet Protocol (IP), which were also the first two defined.
TEI	Transit Employee Interface. A device that allows a transit employee to interact with agency data networks. An example is a handheld wireless device used by a supervisor to enter an incident report.
Termini	The “terminating” or end nodes of a line, link, or route.

Term	Definition
Text Take	A segment of text intended to be selected from a list of similar text takes to be inserted into a larger text message. For example, a list of text takes representing bus stop names would be used as the source for the bus stop name to be inserted into a bus stop arrival announcement ("*Now approaching Broad Street Station*").
TFTP	Trivial File Transfer Protocol. A very simple file transfer protocol akin to a basic version of FTP. TFTP is often used to transfer small files between hosts on a network.
Timepoint	A point along a public transit vehicle's route where the vehicle's scheduled time to traverse that point is identified in the schedule. Timepoints may be defined and not used in the schedule, or may be used in more than one route.
TMC	Traffic Management Center. A fixed center from which road (arterial and/or freeway) conditions and traffic are monitored and incidents managed.
TMDD	Traffic Management Data Dictionary. A standard promulgated by ITE/AASHTO as standard number TMI.03.
TMV	Transit Maintenance Vehicle. A vehicle that is part of a transit fleet, but whose primary function is to support maintenance, and/or supervisory functions rather than to transport transit customers.
TMV-COM	Transit maintenance portable or vehicle Communications manager entity. {Transit Maintenance Vehicle – COMmunications}
TMV-DAT	Transit maintenance portable or vehicle Data manager entity. {Transit Maintenance Vehicle – DATa manager}
TMV-ECU	Transit maintenance portable or vehicle Engine and drive train monitoring entity. {Transit Maintenance Vehicle – Engine Control Unit}
TMV-HEL	Transit maintenance portable or vehicle Health monitor entity. {Transit Maintenance Vehicle – HEaLth}
TMV-LDS	Transit maintenance portable or vehicle Location sensor entity. {Transit Maintenance Vehicle – Location Data Source}
TMV-LOC	Transit maintenance portable or vehicle Location monitor entity. {Transit Maintenance Vehicle – LOCation manager}
TMV-OPR	Transit maintenance portable or vehicle operator interface entities. {Transit Maintenance Vehicle –OPeRator Interface}
TMV-PRI	Transit mmaintenance portable or vehicle TSP manager entity. {Transit Maintenance Vehicle – PRIority}

Term	Definition
TMV-SEC	Transit maintenance portable or vehicle Security manager entity. {Transit Maintenance Vehicle – SECurity}
Traffic Management	A business system responsible for monitoring, facilitating, and reporting on the flow of traffic. Usually this business system is external to the transit agency.
Train	One or more rail cars that can operate on a track. A train may contain rail cars that are intended to carry passengers, freight, perform maintenance, or provide infrastructure support services (e.g. trash removal).
Train Detector	A device (usually located along the wayside) that can detect the presence of a train and/or characteristics of the train (such as defects)
Transfer Cluster	A group of stoppoints within an agency-designated area that are used for transfers. A simple example would be a group of stoppoints at an intersection where two routes cross. A more complex example would be a transit center or bus terminal.
Transfer Point	A location where two or more transit routes provide service to the same or very closely located stop points, allowing passengers to conveniently switch between services provided on the various routes.
Transfer	1. An event in a passenger's trip itinerary wherein the passenger must alight from one PTV and board another to switch from service on one route to service on another route. 2. Move data between business systems and/or logical entities. 3. A ticket or other fare product that entitles a traveler to another revenue service.
Transit Maintenance Vehicle (TMV)	A vehicle used by the transit maintenance function, usually to repair, tow etc. public transit vehicles outside of the garage. The vehicle may have an associated computer component which allows the vehicle to exchange data with other transit components and systems. This component is an element of the TCIP physical architecture and a logical entity within TCIP.
Transit Parking	A transit owned or operated parking lot, and the associated components that monitor and report on the lot's status.
Transit Security	A business system responsible for managing transit security, related resources, and incidents.
Transit Signal Priority	A TCIP business area related to obtaining preferential treatment for PTVs at signalized intersections.

Term	Definition
Transit Signal Priority Process	A transit business process associated with obtaining preferential treatment for PTVs at signalized intersections. 5.11 describes this business process. This business process is closely related to the Transit Signal Priority Business Area.
Traveler Information System	A business system that provides information directly to transit travelers via a variety of communications media.
Trigger	1. The initiation of a series of actions (as of a dialog). 2. The event that initiates a series of actions.
Trip	1. A specified series of movements of a transit vehicle between an origin and a destination end point. Trips in revenue service normally involve passing through defined timepoints and providing service at stop points. 2. A single scheduled instance of a PTV providing service on a route in a designated direction. 3.A journey, or a portion of that journey, planned or undertaken by a transit customer.
TRV	See Traveler Information System.
TS	See Transit Security.
TSP	See Transit Signal Priority.
UDP	User Datagram Protocol. One of the core protocols of the Internet protocol suite. Using UDP, programs on networked computers can send short messages known as datagrams to one another. UDP does not provide the reliability and ordering guarantees that TCP does; datagrams may arrive out of order or go missing without notice. However, as a result, UDP is faster and more efficient for many lightweight or time-sensitive purposes.
UDP/IP	User Datagram Protocol/Internet Protocol. A protocol stack consisting of UDP and IP. See UDP and IP.
Unbound	A state of a vehicle or operator work assignment in which the work defined by the assignment has not been associated with the specific vehicle or operator expected to perform the assignment.
Universal Time Coordinated	Time scale maintained by the Bureau Internationale de l'Huere (International Time Bureau) that forms the basis of a coordinated dissemination of standard frequencies and time signals.
Unload	Remove a large data message or messages from a vehicle or field device to a fixed business system.
URI	Universal Resource Identifier. An Internet protocol element consisting of a short string of characters that conform to a certain syntax. The string comprises a name or address that can be used to refer to a resource. It is a fundamental component of the World Wide Web.

Term	Definition
URL	Universal Resource Locator is a standardized address name layout for resources (such as documents or images) on the Internet (or elsewhere).
UTC	See Universal Time Coordinated .
UTF8String	A variable capable of conveying a series of characters, numbers, and special characters. Refer to ISO 8824-1.
Valid PRL	A PRL that meets the requirements for a PRL as specified in TCIP Section 8.
VAN	Vehicle Area Network. A data communications network within PTV, usually conforming to SAE J1708/J1587 or SAE J1939/J1587.
Vehicle Logic Unit (VLU)	A computer on a transit vehicle that coordinates a variety of operational functions that usually include Automatic Vehicle Location and communications.
Version	A particular instance of an artifact. Usually applied to artifacts that are released on a recurring basis. May be identified by version numbers and/or effective date.
VIN	Vehicle Identification Number. Used to uniquely identify motor vehicles. Prior to 1981 there was not an accepted standard for these numbers, so different manufacturers used different formats. Modern day VINs consist of 17 characters that do not include the letters I, O, or Q.
VLU	See Vehicle Logic Unit.
W3C	The World Wide Web Consortium. Develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential. W3C is a forum for information, commerce, communication, and collective understanding.
WAN	Wide Area Network. A computer network covering a wide geographical area, involving a vast array of computers. This is different from personal area networks (PANs), metropolitan area networks (MANs), or local area networks (LANs), which are usually limited to a room, building, or campus. The best example of a WAN is the Internet.
WLAN	Wireless Local Area Network. Uses radio waves as its carrier: the last link with the users is wireless, to give a network connection to all users in the surrounding area. Areas may range from a single room to an entire campus. The backbone network usually uses cables, with one or more wireless access points connecting the wireless users to the wired network.
XML	Extensible Markup Language. W3C defines XML as the “universal format for structured documents and data on the web.”

Term	Definition
XML Schema	Defines the structure of XML documents (or messages in TCIP). W3C states “XML schemas express shared vocabularies and allow machines to carry out rules made by people. They provide a means for defining the content and semantics of XML documents.”
XPATH	XML Path Language. See references [I-28] and [I-29].
XQUERY	XML Query Language. See reference [I-30].
xsd	XML Schema Definition. A file type associated with an XML Schema file.

Commentary : Organizational descriptions are based on information retrieved from the respective organizations websites April 2005.

3. TCIP Building Blocks

TCIP defines the data to be used for transit agency information transfers. For automated interfaces, TCIP defines the sequence of interactions between the interfaced systems in the form of dialogs. TCIP is modular so that each agency can choose the specific standard messages to be exchanged using dialogs or message file transfers to meet that agency's needs. These decisions should be documented in the agency's ITS architecture along with network and protocol definitions and other information allowing them to serve as a baseline and a starting point for RFP development. Figure 3.0 depicts the building block approach to TCIP.

The lowest level items in the TCIP hierarchy are dialog patterns and data elements. Dialog patterns define a type of message exchange in generic form, such as the sequence of actions in a query or a command-response. Data elements define the lowest level TCIP objects and how they are represented. For example, a data element CPT-PersonFirstName is defined as having type NAME30, which is in turn defined to be a string of up to 30 characters.

TCIP data frames build on TCIP data elements by grouping data elements together to describe something meaningful in the real world. For example, an employee description might include other items besides the first name such as the middle and last name, phone number, employee number and address.

TCIP messages build on TCIP data elements and data frames, incorporating them into a meaningful one-way information transfer package. For example, a message defining an incident might incorporate information concerning the employee reporting the incident, vehicles involved, people injured, and incorporate as many data elements and data frames as are required to create a complete one-way information transfer.

TCIP dialogs build on the dialog patterns which define the structure of the interaction (such as a query) and the messages which define the content of the interaction (the information to be exchanged). TCIP file transfer builds on the messages, but not the dialog patterns, because these file transfer mechanisms are defined by developers and agencies, and documented in the PRL and the PICS (see section 8).

The agency ITS architecture builds on the agency's legacy systems, and on TCIP file transfers and dialogs. The agency ITS architecture also needs to consider how the agency fits into the regional ITS architecture, and how the agency and other regional stakeholders plan to evolve their business systems over time. Agency ITS architectures may, <u>but are not required to</u>, build on the TCIP Model Architecture.

To make TCIP data easier to understand, naming conventions have been adopted for TCIP Data Elements, Data Frames, and Messages. Data Elements are identified by a TCIP business area name in all capital letters, followed by a hyphen, followed by the name of the data. Data frames are identified by a TCIP business area name in all capital letters, with no hyphen, followed by the name of that data. Messages are identified by a TCIP business area name with an initial capital letter, followed by the name of the data.

Table 3.0 TCIP Data Naming Conventions

Data Type	Naming Convention	Example
Data Element	BA-DataElement	CPT-PersonFirstName
Data Frame	BADataFrame	SCHPatternInfo
Message	BaMessage	PiNearestStopListSub

In some cases, TCIP imports data frame or data element definitions from other standards such as SAE J2266 Location Referencing Message Specification (LRMS). In these cases, the ASN.1 usage is to identify the data element or data frame using a dot notation with the source specification to the left of the period in capital letters and the name as defined in the source specification to the right, for example, LRMS.GeoLocation. In the XML schema, the equivalent usage is a colon notation with the source name in lower case, for example, lrms:GeoLocation. (The "lrms" represents the namespace of the data frame called GeoLocation.)

The data element, data frame, and message definitions in this document (Annexes A, B and C) include normative specifications, rules, and constraints for the data in English. These definitions also include normative ASN.1 descriptions of the content of each item. TCIP data is intended to be encoded in Extensible Markup Language (XML) format or an agency defined narrowband format such as TCIP Narrowband Encoding (see Annex I). Conformance requirements for TCIP are defined in Section 8.

Commentary: SAE J2630 reference [I-10] was used as a guideline when converting from ASN.1 to XML.

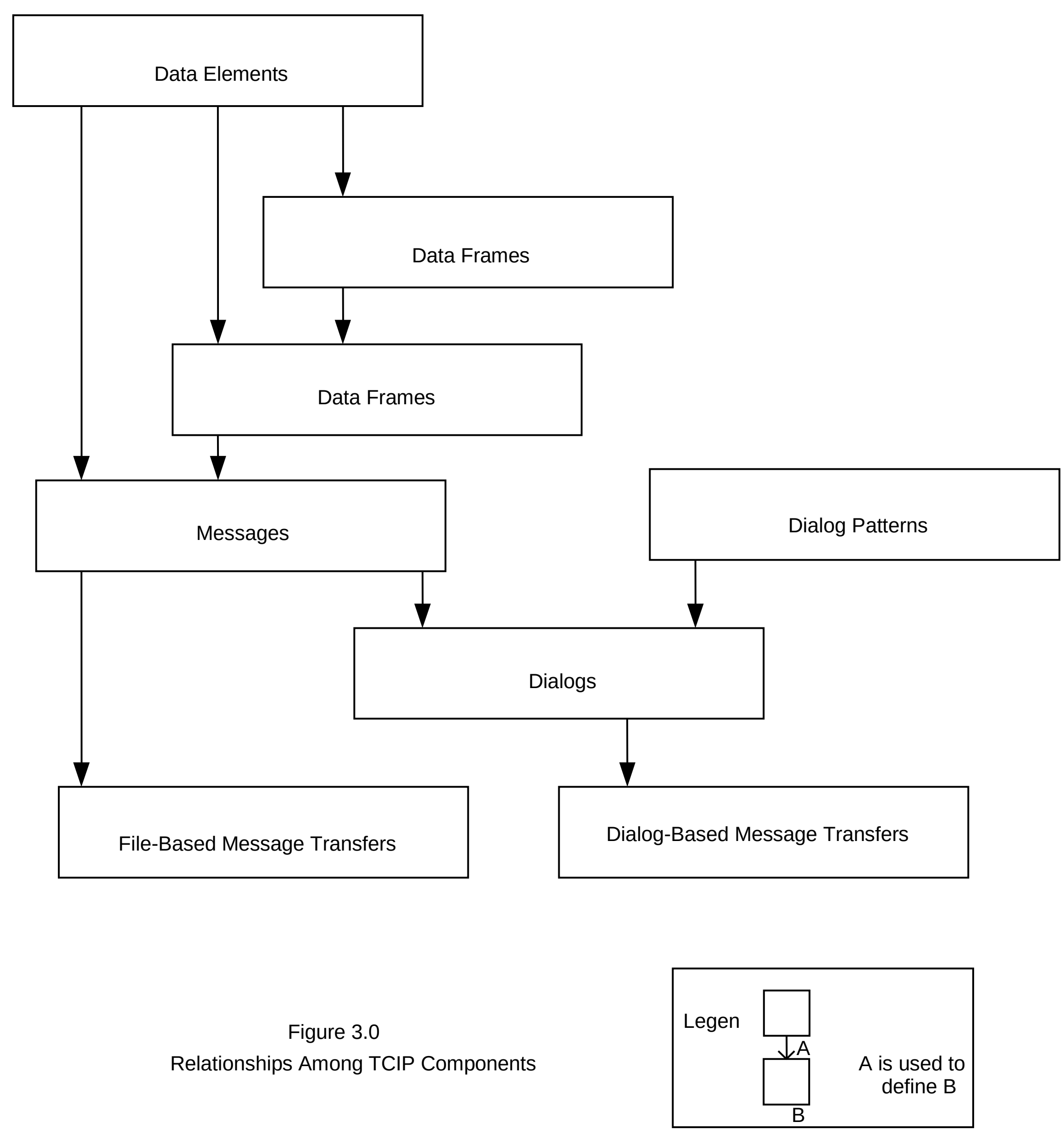


Figure 3.0
Relationships Among TCIP Components

3.1 Data Elements

A data element is an atomic piece of information related to a person, place, thing or concept. For example, CPT-PersonFirstName, and CPT-Footnote are data elements.

TCIP data elements are based on the ASN.1 data types. These base ASN.1 types have been extended to create additional generic data types for use in creating TCIP data elements. The definitions for the base types for TCIP data element definitions are found in Annex H.

TCIP numbers the defined data elements within each TCIP business area.

TCIP data elements are based on the ASN.1 types and the TCIP subtypes defined in Annex H. For example, NAME30 is derived from UTF8String as NAME30::=UTF8String (size(1…30)). TCIP defines data elements based on the NAME30 subtype.

CPT-PersonFirstName::=NAME30.

Finally the data element definition is used to create an XML Schema. The corresponding schema entry for this element is

```
<xsd:simpleType name="CPT-PersonFirstName" >
<xsd:restriction base ="xs:string"/>
<xs:minLength value = “1”/>
<xs:maxLength value = “30”/>
</xsd:simpleType>
```

3.2 TCIP Data Frames

Data frames are groupings of data elements (and/or other data frames) into abstractions necessary to describe more complex concepts. For instance a data frame describing an employee might include name, employee number, and date of employment and/or other information. Depending on the context, the description of an employee might require more or less information. As an example, the employee's middle name might be important to a personnel action, but not relevant to an assignment as an operator for a particular bus run. Consequently similar data frames may be created for use in different contexts, and/or data frames may be created with optional data fields that can be used in some contexts and not others. In some cases two optional fields may be incompatible, requiring explanatory material in the data frame remarks area.

Data Frames may be contained within other data frames. This construct enables data frames to be used to describe abstractions which can be reused within higher level abstractions and so on. For example, the CPTStoppointIden frame uniquely identifies a stoppoint. This frame can be used in a data frame describing a timepoint (SCHTimepointInfo) to identify an associated stoppoint. It can also be used within a data frame describing a stoppoint (CPTStoppoint) to provide the unique identifier for the stoppoint being described.

TCIP also ‘imports’ data frames from other ITS standards such as LRMS. This allows a data concept (e.g.,, GeoLocation) that is defined in another part of ITS to be reused in TCIP. This promotes compatibility when a single ITS system needs to communicate using more than one ITS standard.

Figure 3.2 illustrates the definition of data frames in TCIP.

<u>Example Data Frame Definition in ASN.1</u>

```
SCHPatternInfo ::= SEQUENCE {
                  pattern          SCHPatternIden,
                  pattern-notes    SEQUENCE (SIZE(1..100)) OF SCHNoteIden              OPTIONAL,
                  triggers         SEQUENCE (SIZE(1..200)) OF SCH-ActivationID         OPTIONAL,
Included          mode             CPT-Mode                                            OPTIONAL,    Included Data
  Data            segments         SEQUENCE (SIZE(1..100)) OF SCHPatternSegmentIden,                 Elements
Frames            radio-zones      SEQUENCE (SIZE(1..100)) OF CPTRadioZone             OPTIONAL,
                  events           SEQUENCE (SIZE(1..200)) OF SCHEvent                 OPTIONAL
                  ...  -- # LOCAL_CONTENT
                  }
```

<u>Example Data Frame Definition in XML</u>

```
<xs:complexType name="SCHPatternInfo" >
    <xs:sequence>
      <xs:element name="patternID" type="SCHPatternIden" />
      <xs:element name="pattern-designator" type="SCH-PatternDesignator"  minOccurs="0"/>
      <xs:element name="pattern-name" type="SCH-PatternName"  minOccurs="0"/>
      <xs:element name="pattern-notes"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="100">
            <xs:element name="pattern-note" type="SCHNoteIden" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="triggers"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="200">
            <xs:element name="trigger" type="SCH-ActivationID" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="mode" type="CPT-Mode"  minOccurs="0"/>
      <xs:element name="segments" >
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="100">
            <xs:element name="segment" type="SCHPatternSegmentIden" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="radio-zones"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="100">
            <xs:element name="radio-zone" type="CPTRadioZone" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="events"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="200">
            <xs:element name="event" type="SCHEvent" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="localSCHPatternInfo" type="local:SCHPatternInfo" minOccurs="0"/>
    </xs:sequence>
</xs:complexType>
```

Figure 3.2
Example Data Frame Definitions

3.3 TCIP Messages

Messages are aggregates of data elements and data frames into a larger and more complex structure. Messages are not intended to be combined into larger data structures for communications. Messages are intended to constitute a complete understandable one-way communication, which may consist of data elements and/or data frames conveying metadata and/or information content. Individual message instances (based on the TCIP XML Schema) are included into files and used as the basis of TCIP file transfers. A sequence of one or more messages is used in the definition of each TCIP dialog. These sequences create complete conversations between entities providing two (or more) way communications. The TCIP message identifier uses the TCIP business area abbreviation and an index of 2000 or higher. For example, Figure 3.3 illustrates the definition of TCIP messages with an identifier of pi 2002.

Example TCIP Message Definitions in ASN.1

Included Data Element

Included Data Frames

```
PiGeoZoneListSub::=  SEQUENCE{
        header      CPTSubscriptionHeader,
        points      SEQUENCE(SIZE(1..20)) OF LRMS.PointLocation      OPTIONAL,
        polygon     LRMS.PolygonType                                 OPTIONAL,
        agencies    SEQUENCE(SIZE(1..25)) OF CPT-AgencyID            OPTIONAL,
        zones       SEQUENCE(SIZE(1..1000)) OF PIGeoZoneIden         OPTIONAL,
        zone-defs   SEQUENCE(SIZE(1..1000)) OF PIGeoZone             OPTIONAL
        }
```

Example TCIP Message Definition in XML

```
<xs:complexType name="PiServiceZoneList" >
    <xs:sequence>
      <xs:element name="header" type="CPTSubscriptionHeader" />
      <xs:element name="points"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="20">
            <xs:element name="point" type="lrms:PointLocation" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="polygon" type="lrms:PolygonType"  minOccurs="0"/>
      <xs:element name="agencies"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="25">
            <xs:element name="agency" type="CPT-AgencyID" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="zones"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="1000">
            <xs:element name="zone" type="PIServiceZoneIden" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="zone-defs"  minOccurs="0">
        <xs:complexType>
          <xs:sequence minOccurs="1" maxOccurs="1000">
            <xs:element name="zone-def" type="PIServiceZone" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
</xs:complexType>
```

Figure 3.3
Example TCIP Message Definitions

3.4 TCIP Dialogs

TCIP dialogs define the message sequences exchanged between transit business systems and/or components to achieve a specific information transfer. The dialogs define what messages or conditions initiate, maintain, and terminate the dialog. The dialogs defined in this document are intended to be simple and modular. Simple dialogs perform a single discrete purpose, and do not specify the internal workings of the entities involved in the dialog. Modular dialogs are able to be used in combination to achieve complex interactions or singly to perform their assigned function only. Because they are modular, each agency can specify the dialogs they want implemented. The Profile Requirements List (PRL) documents the agency's dialog selections and the role that each agency business system is to perform in each dialog.

These dialogs specifically exclude the internal actions within the transit agency business systems including:

- How data is stored, translated and manipulated,
- How data is formatted and presented to human users,
- How systems and/or components trigger or initiate dialogs,
- The details of the interactions of components and systems with human users.

3.4.1 Dialog Patterns

Patterns define a sequence of actions in a generic format that can be reused for multiple purposes. For example, a periodic publication dialog pattern allows a subscriber to obtain information from a publisher on a periodic basis. The pattern does not define what is being published (or commanded, reported etc), but rather defines how to publish (or command, report etc) data through a predefined dialog format. This pattern can then be used for multiple disparate purposes such as determining the current locations of specific vehicles periodically, or determining the value of a vehicle health parameter periodically. The use of a small number of dialog patterns to implement a much larger body of dialogs simplifies the implementation process when compared with the approach of creating and standardizing unique control flows for every operational situation.

3.4.2 Dialog Instantiations

Dialogs are the highest level of abstraction in TCIP. A dialog specifies an operational purpose, a dialog pattern to be used, the messages to be used with the specified pattern, and any special conditions or constraints associated with the implementation of this specific dialog. A dialog may also specify relationships with other dialogs, such as an assumption that another dialog was previously executed.

3.5 TCIP File Transfer

Some agencies have a need to transfer data without the use of dialogs. TCIP provides a mechanism to perform these transfers using files. One computer application saves the data in a file, the file is then transferred (possibly manually) to another system where it is loaded and read by another computer application. Such interactions require an agreed-upon data description for the file(s) to be exchanged. TCIP messages provide such a description. The XML format of TCIP messages allows the messages to be saved in text files. TCIP message files contain one TCIP message instance, including attributes as well as data elements. Text files are readable by virtually any type of computer system. TCIP dialogs are not required for file exchanges. Developer-specific procedures govern the process for causing the files to be generated by one application and to be read by another application.

4. Understanding TCIP

4.1 Structure of TCIP

TCIP standardizes information exchanges among transit business systems and components, on a file transfer or message exchange basis. By standardizing and modularizing these interfaces, the intent is to minimize the cost of tailoring interfaces. These costs occur as a result of developer changes to interfaces for an individual agency, or another developer. By standardizing these interfaces, different agencies and developers will be able to reuse the same interfaces. By modularizing these interfaces, each agency will be able to select the specific interactions across the interfaces (dialogs and file transfers) necessary to meet their specific business needs.

The mechanism for conveying an agency's TCIP requirements to a developer is a Profile Requirements List (PRL). The agency creates a PRL as part of their specification for a new or upgraded system. The PRL defines the dialogs, message file transfers, and options associated with the new system. The developer provides a Profile Implementation Conformance Statement (PICS) describing their product as part of the proposal submittal. Comparison of agency PRL requirements with developer PICS claims of conformance allows an agency to determine if the offered TCIP implemented interface will meet the agency's requirements.

Because TCIP is a broad standard encompassing many facets of a transit agency's business, it is convenient to divide TCIP into areas that roughly correspond to areas of expertise of transit staff. These "business areas" are used to group TCIP data and dialogs for identification and review by the transit community. Each business area is associated with a specific TCIP Technical Working Group (TWG) with primary responsibility for reviewing and approving data and dialogs in that business area.

In order to illustrate how TCIP interfaces may be used in a transit agency, Section 5 Concept of Operations of this document describes 10 transit "business processes". These processes are defined based on a generic (or "model") transit ITS architecture. This model architecture describes a non-normative arrangement of field and vehicle-based components and entities as well as a reference set of transit "business systems".

Commentary: *The TCIP Task Force has determined that the Fare Collection business area is not mature enough for balloting and implementation. Consequently dialogs and messages defined in the Fare Collection portion of the standard should be considered as information only as of the publication of this TCIP Version.*

Table 4.1 shows the associations between business areas, TWGs, business process, and business systems.

Business Area	TWG	Associated Business Process(es)	TCIP Data/Message Prefix(es)	Key Business System(s)
Scheduling	1	Scheduling Process	SCH	Scheduling System (SCH) Data Repository (DR)
Passenger Information	2	Customer Information Process	PI	Traveler Information System (TRV) Customer Service System (CSS) Parking Management (PRK)
Incident Management	3	Security & Incident Management Process	IM	Transit Security (TS)
TCIP Tool Support	4	---	---	---
Onboard Systems	5	PTV Operations Process	OB	Garage Server (GS)
Control Center	6	PTV Operations Process	CC	CAD/AVL System (CAD)
Fare Collection	7	Revenue & Fare Collection Process	FC	Fare System (FS) Garage Revenue Server (GRS)
Spatial Representation	8	Spatial Data Management Process	SP	Geographical Information System (GIS)
Common Public Transport	9	---	CPT	---
Transit Signal Priority	10	Transit Signal Priority Process	TSP, SCP	CAD/AVL Data Repository Traffic Management Center*
---	Chairs	Data Repository Operations Process		Data Repository (DR)
---	Chairs	Personnel & Work Assignments Process		Operator Assignment System (OAS) Payroll (PAY)
---	Chairs	Asset Management Process		Asset Management System (AM)

*Usually external to transit agency.

4.2 TCIP Model Architecture

4.2.1 Overview

The TCIP model architecture identifies key transit agency elements pertinent to TCIP and their interfaces. It also provides a useful structure for illustrating the building block approach to interface development provided by the TCIP dialogs and file transfers. ***The model architecture is not intended to represent the actual configuration of any transit agency, nor is it intended to recommend any specific approach to agency or regional ITS architecture development. The sole purpose of the Model Architecture is to provide a conceptual basis for the discussion of agency business processes and interfaces.***

The components of the Model Architecture are:

- Logical Entities – which perform a group of related functions (e.g., PTV-LOC)
- Physical Components – elements in the physical architecture (e.g., farebox)
- Business Systems – fixed computer applications and systems used by an agency to manage or facilitate business processes. Business Systems are elements in both the physical and logical views of the Model Architecture.
- Interfaces to agency equipment (e.g., vehicle, stoppoint, sensors etc.)
- External Systems
- Communications Networks

The top-level TCIP Physical Model Architecture is shown in figure 4.2.1.

The Model Architecture assumes a one-to-one mapping between physical and logical entities within business systems. This is a convenient view for describing a generic agency, however, real agencies may have differently named business systems organized very differently than the Model Architecture arrangement. Such agency ITS architectures are still able to adopt TCIP dialogs and file transfers to exchange information among business systems. The internal architecture of a business system is not addressed by TCIP or by the Model Architecture.

Agency unique business systems may include planning systems, joint agency-local government shared systems, agency developed systems (e.g., financial, analysis, personnel management), project management tools, off the shelf tools for network modeling, operations research packages. Off the shelf applications may be modified or extended by agency IT departments. Agencies may have unique or proprietary systems for developing the CcAnnouncementInfo file containing announcements for stoppoints, destination sign controls, and event-triggered onboard announcements.

TCIP enabled business systems communicate with each other either:

- Via file/document transfers which may be conducted through the transit agency data network, or
- Via physical file/document transfers using removable media, or
- Via dialogs which define message-based conversations between business systems via the transit agency data network.

Some agency architectures include a data repository – usually a large or distributed database management system (DBMS), but may include a formatted or spreadsheet application file. In such agencies, the repository may serve as an intermediary in these conversations between business systems. This allows a business system to produce or consume information asynchronously from other business systems, eliminates the need for an information producing system to communicate with all of the information consumers, and provides a platform for integrating data from multiple sources. Large database management systems generally require technically sophisticated staff to set up and administer, yet with new functions integrated in COTS spreadsheet software, even smaller agencies may be able to implement XML tools that transform data to XML instances.

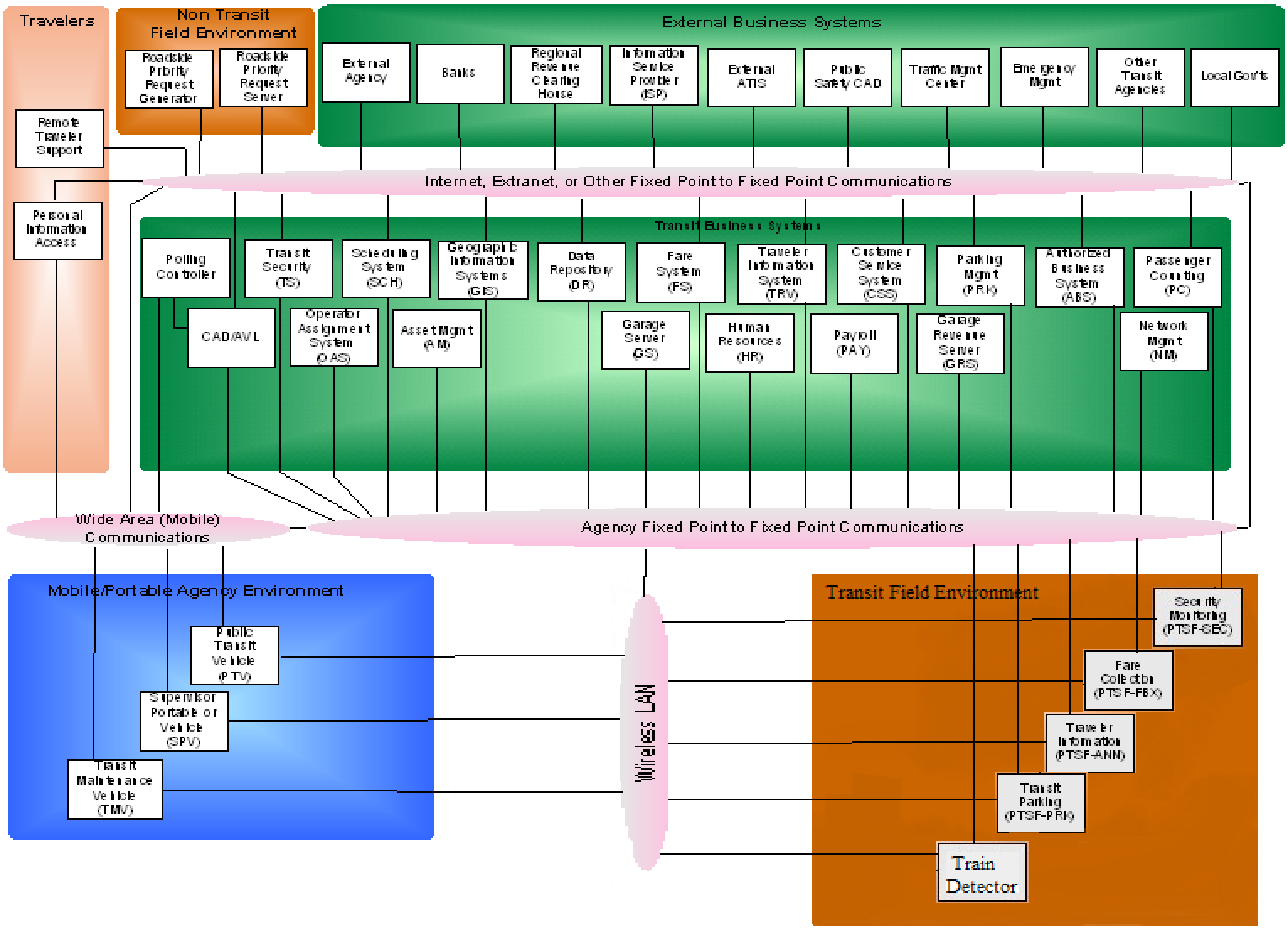
Transit agencies operate a variety of field systems, components, and devices. These may be monitored, controlled, or both. Field equipment includes fare media vending equipment, elevators, escalators, door alarms, passenger information displays, vent fans, and a wide variety of other device types. TCIP provides a limited set of dialogs for communicating with logical entities that act as controllers or managers of these devices. For example, PTSF-SEC may manage a CCTV camera, and TCIP provides dialogs to communicate with PTSF-SEC, but not with the camera itself. The Model Architecture identifies these field device controller/manager entities, but does not specify their physical configuration. These logical entities may be packaged with the field device or may be packaged separately in a unit that controls/manages a group of devices (e.g.,, for a passenger station). Other agency-specified standards and/or proprietary protocols are used to interact with field devices in parallel with TCIP.

Public Transit Vehicles (PTVs) contain a variety of logical functions that are packaged very differently from one agency (or even one bus type within an agency) to another. The Model Architecture identifies these logical entities, and identifies some, but not all, possible physical configurations of these entities. TCIP provides dialogs for communications between PTV logical entities and fixed business systems, and dialogs for some communications between onboard logical entities which are likely to be separately packaged. TCIP recognizes that a significant component of the communications within PTVs occur using non-TCIP data exchanges via the Vehicle Area Network (VAN). VAN communications are defined in the SAE J-1587, J-1708, and J-1939 standards. The Model Architecture assumes that TCIP messages between onboard components are not exchanged on the VAN, but are conveyed over a separate onboard IP/Ethernet-based network referred to as the “Hub”.

Transit business systems also communicate with entities outside of the transit agency itself. These include external Advanced Traveler Information Systems (ATIS), Traffic Management Systems, Information Service Providers, other transit agencies, public safety agencies, traveler-owned Internet appliances, and other systems. These conversations are generally governed by standards promulgated by other industries; however TCIP dialogs do include support for Transit Signal Priority interactions with Traffic Management Systems consistent with NTCIP 1211.

In parallel with the development of TCIP, an effort has been underway to develop a National ITS Architecture (NIA). Since these efforts were conducted independently, there is an imperfect match between TCIP and the NIA. Nonetheless, there is substantial interest in a mapping between NIA and TCIP. A rough mapping is contained in Annex I “TCIP-NIA Mapping”. This Annex maps TCIP logical entities to the closest match NIA ‘Pspec’ and TCIP Dialogs to the closest match NIA data flows. Note that NIA data flows are unidirectional, and dialogs are bi- or multi-directional so dialogs generally map to more than one data flow.

Figure 4.2.1
Top Level Physical TCIP Model Architecture



4.2.2 Business Systems

Transit business systems may be developed by the agencies themselves or by commercial providers. Generally, commercial systems are tailored to some extent for each agency, and agency-developed systems tend to be highly customized. This implies that there may be significant differences in functionality and operation from one agency to another. Furthermore, different agencies and developers package functionality into business systems with different names and groupings. Thus the model architecture and associated assignments of functions to business systems in this model is not normative, and thus not required to achieve TCIP conformance.

TCIP assumes that business systems maintain logs of events and transactions and provide archiving and retrieval capabilities which may be conformant with the National ITS Architecture Archive User Data Service (ADUS). TCIP does not standardize the logging functions of business systems, but does provide some limited functionality for transferring logged information in a standardized format.

Table 4.2.2 summarizes the business systems illustrated in figure 4.2.1, lists their major functions and typical agency architectural variations.

Table 4.2.2

Transit Agency Business Systems

Name	Typical Functions/Contents	Typical Variations
Authorized Business System (ABS)	▪ May be agency designated to participate as a business system in any dialog or file transfer.	Agencies may define any number of ABS for any functions as they see fit. Examples may include planning systems, back office reporting systems and functions described in model architecture business systems which are organized differently in the agency ITS architecture.
CAD/AVL System (CAD)	▪ Track PTVs ▪ Provide Dispatcher Interface ▪ Provide PTV Adherence Monitoring Interface ▪ Provide Alarm Management ▪ Manage Exceptions to Operating Plan ▪ Manage Incidents ▪ Provide Operating Status Information to other Business Systems	This may be designed and/or purchased as separate CAD and AVL systems; however, TCIP does not specify dialogs between the CAD and AVL components in the control center.

Table 4.2.2 Transit Agency Business Systems		
Name	**Typical Functions/Contents**	**Typical Variations**

Customer Service (CSS)	▪ Complaint investigation
	    o Completed trip history
	    o Playback of PTV operations
	▪ Itinerary creation
	▪ Parking information
	▪ Call taking
	▪ Demand (paratransit) trip booking
	▪ Customer eligibility (e.g.,, senior, paratransit)
		Customer Service System and Traveler Information System may be combined.

Data Repository (DR)	▪ PTV Data Load/Unload ▪ Transit Facilities Information Store ▪ Personnel Data Store ▪ Schedule Data Store ▪ Software & Configuration Data Store ▪ Historical Operating Data Store	▪ Data Repository may not be present, & data stores distributed among other Business Systems ▪ DR interactions with PTVs (loads/unloads) may be performed by a Garage Server.
Fare System (FS)	▪ Manage fare zones/fare tables, etc. ▪ Fare data and nightly reconciliation with PTVs/Fare vending machines ▪ Bank reconciliation ▪ Fare type/count/location Tracking & Reporting ▪ Bad card list ▪ Card issuance management	▪ Some or all functions may be performed by regional reconciliation system ▪ Some functions may be contracted out to a commercial services provider
Operator Assignment System (OAS)	▪ Manage pull-outs/pull-ins ▪ Manage fitness for service checks (operators) ▪ Bind available operators to planned trips/runs ▪ Operator 'Pick' management ▪ Rostering (with a-la-carte style pick) ▪ Generate 'extra list' ▪ Manage last minute changes to operator and vehicle assignments	▪ May be combined with Maintenance Management

Table 4.2.2 Transit Agency Business Systems		
Name	**Typical Functions/Contents**	**Typical Variations**
Geographical Information System (GIS)	▪ Transit Facilities Information ▪ Transit Route/Pattern Information ▪ Stoppoint inventory ▪ Fare zone geometry ▪ Ridership history by location ▪ Area maps ▪ Jurisdictional boundaries	▪ GIS may be provided by local or regional government. ▪ Stoppoint inventory may be maintained in a separate bus stop management system.
Asset Management System (AM)	▪ Track all past performed maintenance events ▪ Forecast and plan scheduled maintenance ▪ Forecast and plan vehicle car availability ▪ Track vehicle car work orders ▪ Track/forecast component subsystem performance/reliability ▪ Track/forecast spare parts requirements and requisitions ▪ Manage PTV garage area parking ▪ Bind available vehicles to planned trips/blocks	May be combined with Garage Operations.
Parking Management (PRK)	▪ Transit Agency Operated Parking Garage Management System	
Payroll (PAY)	▪ Payroll calculations	
Scheduling (SCH)	▪ Create Schedule o Define Patterns o Define Trips o Define Timepoints o Define Transfers ▪ Blocking/Runcutting o Define Operator Assignments (unbound) o Define Vehicle Assignments (unbound) o Rostering agencies without a-la-carte picks ▪ Reporting (various output data filters and organizations)	Timepoints and/or stoppoints may be defined in scheduling system, GIS, data repository, or other agency-specified tool.

Table 4.2.2

Transit Agency Business Systems

Name	Typical Functions/Contents	Typical Variations
Traveler Information System (TRV)	▪ Itinerary creation ▪ Parking information ▪ Fare information (for planned trip) ▪ Next Bus information o Timetable o ETA ▪ Passenger Information Display (PID) monitoring & control ▪ Interface to ATIS Systems ▪ Interface to 511 Systems	Traveler Information System and Customer Service System may be combined.
Garage Revenue System (GRS)	▪ Mange collection of cash and data from PTV's and PTSF-based fare components ▪ Provide vault information to Fare System	May be combined with fare system.
Transit Security (TS)	▪ Manage Transit Security Sensors (cameras, alarms, etc.) ▪ Facilitate, monitor and control access to CCTV images ▪ Manage alarms ▪ Incident Management	
Garage Server (GS)	▪ Manage loading of data to PTV's ▪ Mange unloading of data from PTV's ▪ Provide logging and reporting functions	May be combined with Data Repository.
Passenger Counting (PC)	▪ Collect passenger count data from PTV's PTSF equipment and other sources. ▪ Distributes passenger count data to other business systems.	May be combined with Data Repository.

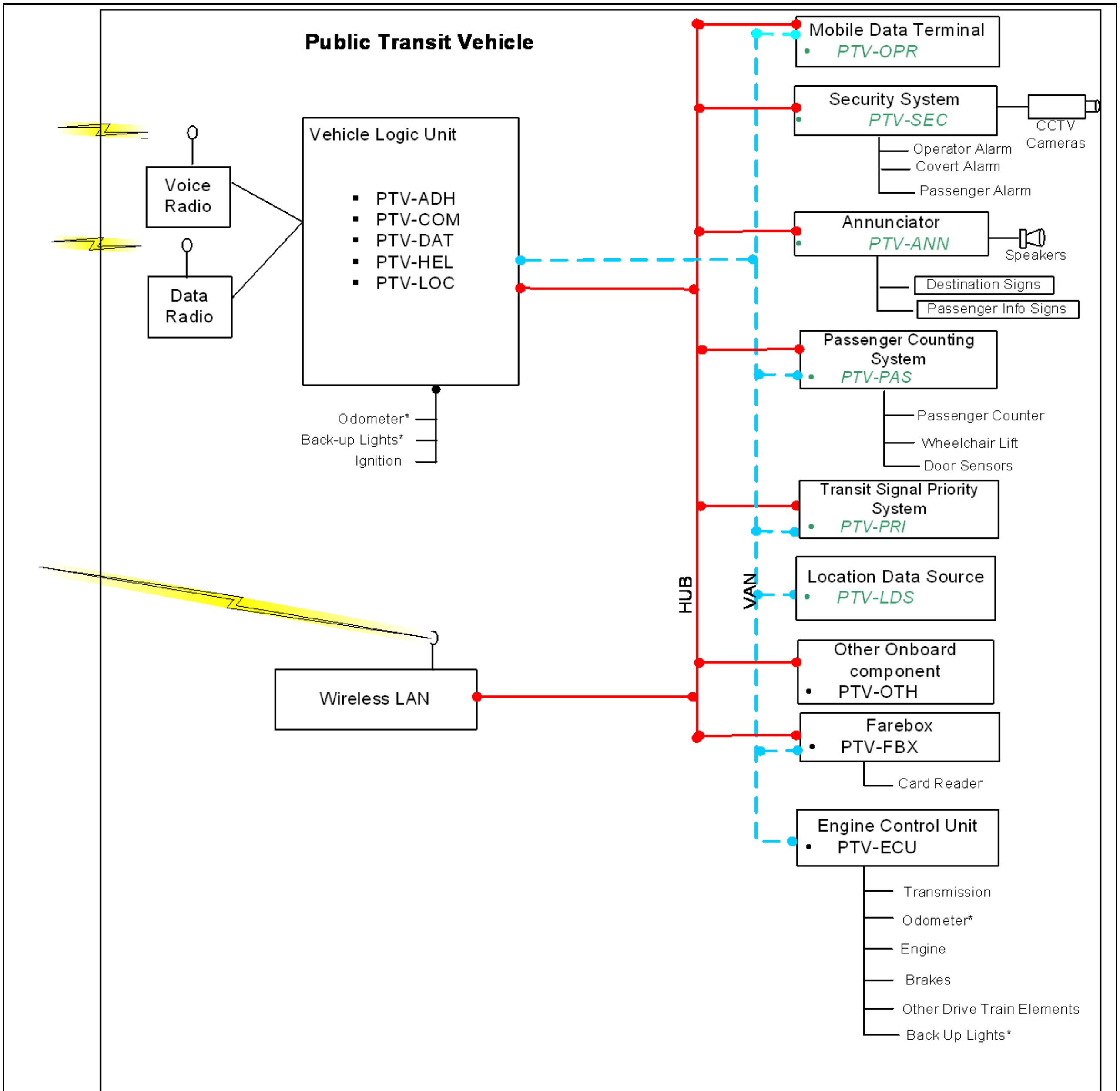
4.2.3 Public Transit Vehicles

Public Transit Vehicles (PTVs) exhibit differing physical architectures from one agency to another, and in many cases between vehicle types or brands within an agency. PTV logical entities perform various business activities onboard the PTV. PTV-HEL, for example, monitors and reports the health of the vehicle, and the subsystems onboard the vehicle. Logical entities on a PTV may communicate with each other and/or with fixed business systems as they carry out their functions. These communications may be TCIP-based via the hub (onboard). They may be TCIP based to fixed business systems via a radio, public network, or wireless LAN. They may include non-TCIP communications via the VAN or via other networks as well.

The PTV Model Architecture is shown in Figure 4.2.3A&B. Figure 4.2.3.A depicts a PTV with its logical entities highly distributed into separate physical components. The Model Architecture assumes that the 5 logical entities shown in the Vehicle Logic Unit are 'core' to that component and are not distributed. Figure 4.2.3.B depicts a PTV with a highly integrated package where more logical entities are consolidated into the Vehicle Logic Unit. These figures are intended to illustrate the range of alternatives available, not to represent all possible permutations of the PTV physical architecture.

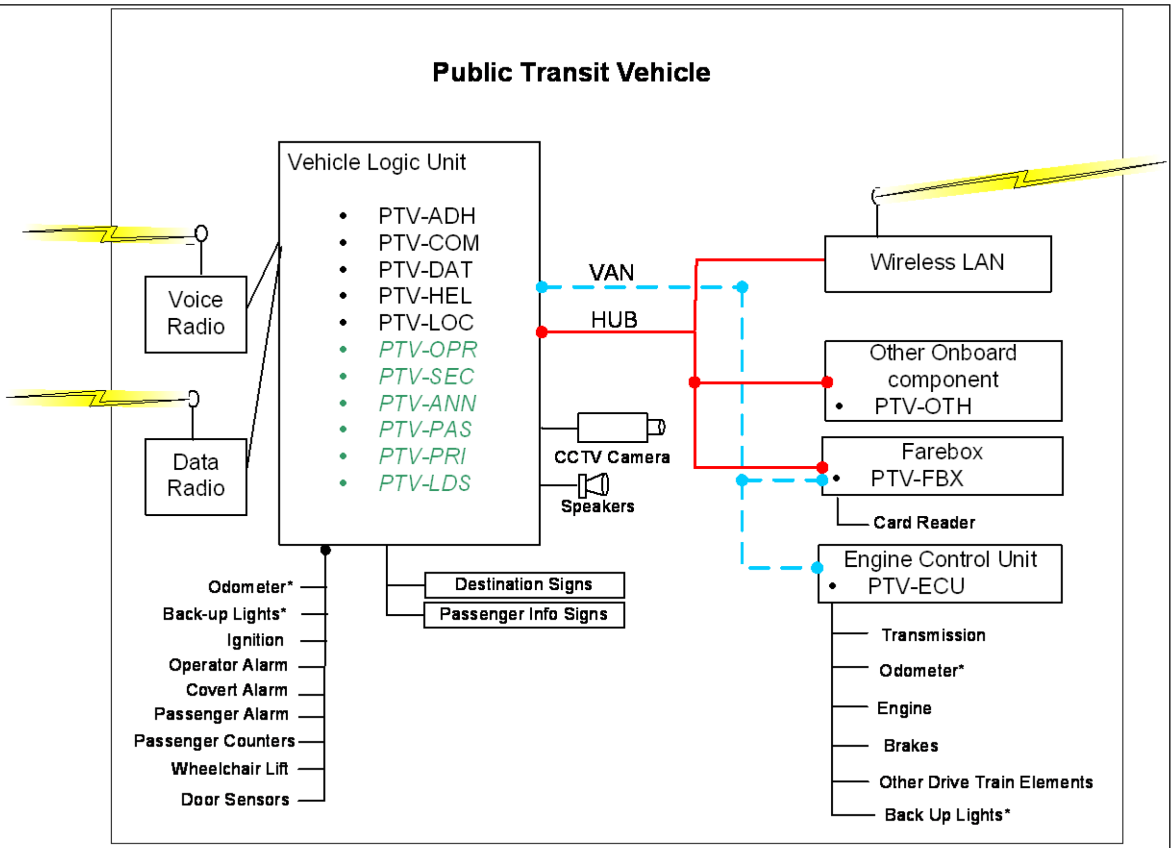
Note that optional discrete connections are shown for operator alarm, covert (silent) alarm, and passenger alarms. These trigger corresponding security-related dialogs.

The farebox optionally incorporates a card reader. This may be a smart card reader, magnetic card reader, paper ticket reader, or other type of portable media reader. This device may also write or act as a vending machine for media depending on the local agency ITS architecture. The device may also be used as the mechanism for PTV operator logins.



Legend:
- Bulleted items represent Model Architecture Logical Entities
- *Bulleted Italic items represent logical entities which may be packaged separately from the VLU or with the VLU*
- Voice Radio & Data may be combined
- Hub, Wireless LAN, and Data Radio messages defined by TCIP
- Hub and wireless LAN communications use XML, and either TCP/IP or UDP/IP communications.
- VAN messages defined by SAE J1587, J1708 and/or J1939
- * May be read via VAN or discrete connection

Figure 4.2.3.A
PTV Model Architecture with Logical Entities Distributed



Legend:
- Bulleted items represent Model Architecture Logical Entities
- *Bulleted Italic items represent logical entities which may be packaged separately from the VLU or with the VLU*
- Voice Radio & Data may be combined
- Hub, Wireless LAN, and Data Radio messages defined by TCIP
- Hub and wireless LAN communications use XML, and either TCP/IP or UDP/IP communications.
- VAN messages defined by SAE J1587, J1708 and/or J1939
- * May be read via VAN or discrete connection

Figure 4.2.3.B
PTV Model Architecture with Logical Entities Consolidated in VLU

Legacy PTV onboard communications are usually based on SAE J1708/J1587 standards. The newer, higher speed SAE J1939 standard may soon be in common use. In either case the VAN network shown in blue dotted lines in Figures 4.2.3.A&B conveys SAE-standardized information. These standards are designed to allow a collection of conformant devices to co-exist on the VAN and to exchange information.

As information technology has progressed, more and more PTVs are being equipped to communicate via high-speed wireless local area networks (WLAN). WLAN communications typically uses the Internet Protocol (IP) at layer 3 with the potential to implement a variety of higher-level protocols as is done with office local area networks. This high-speed connection to the fixed side data networks can be shared by a variety of onboard PTV components using a hub. This hub allows various components to access the WLAN, but also enables hub-connected components to communicate with each other using IP. TCIP onboard dialogs operate over the hub and IP communications infrastructure. Other non-TCIP IP-based communications may coexist with TCIP on the hub/IP network. This capability is represented by the red network in Figure 4.2.3.A&B

PTVs also have data communications with fixed business systems when outside of the Wireless LAN coverage area either through the transit agency's private radio network, or through public networks provided by the common carriers (phone companies). These facilities are generally more expensive and/or capacity limited, and agencies generally avoid sending large data transfers via these mechanisms.

TCIP dialogs specify the conversations to be carried out between:

- Onboard hub-connected components using XML (red network)
- Onboard components communicating to fixed business systems via the Wireless LAN using XML
- Onboard components communicating to fixed business systems via the private or public data network, these communications may use the TCIP narrowband encoding or another agency specified succinct transfer syntax.

TCIP dialogs do not specify the communications occurring on the VAN (blue network); however, the dialogs do note where related VAN communications occur within a dialog's execution.

Table 4.2.3 summarizes the major communicating components on PTV along with their major functions and typical variations.

Table 4.2.3

PTV Logical & Physical Entities

Physical Component Name (Logical Entity)	Typical Functions/Contents	Typical Variations
Engine Control Unit (PTV-ECU)	▪ Monitor drivetrain and other vehicle parameters and distribute their values via VAN	

Table 4.2.3 **PTV Logical & Physical Entities**		
Physical Component Name **(Logical Entity)**	**Typical Functions/Contents**	**Typical Variations**
Farebox (PTV-FBX)	▪ Collect and record fares via various media ▪ Report fare information to fare system for end-of-day reconciliation ▪ Accept login from MDT or provide login to MDT ▪ Provide passenger counts to other onboard entities based on fares collected ▪ Reads and processes smartcards, tickets and/or other agency-specified fare media ▪ Accept passenger counts from other onboard entities to validate number of fares collected.	▪ Login exchanges are not available on all fareboxes ▪ Passenger count information is not provided to the VLU by many fareboxes
Location Data Source (NIA Entity) (PTV-LDS)	Onboard PTV sensor that provides location to vehicle (PTVLOC).	May be packaged with the VLU or separately. May be connected via VAN, or plug into VLU.
Mobile Data Terminal (PTV-OPR)	▪ Provide operator logon/logoff with notification to business systems ▪ Provide relief operator sign on with notification to other entities ▪ Provide two-way operator – dispatcher canned message and text message exchange ▪ Provide operator logon/logoff notification to other onboard components ▪ Provide input/output screen capability for other onboard devices	May be combined with the Vehicle Logic Unit.

Table 4.2.3
PTV Logical & Physical Entities

Physical Component Name (Logical Entity)	Typical Functions/Contents	Typical Variations
VLU Communications Manager (PTV-COM)	This entity controls the PTV radio, provides updates on wireless LAN availability, and performs other communications management activities as specified by the local agency for the VLU.	
Passenger Counting System (PTV-PAS)	Onboard PTV passenger counting entity.	May be packaged with the VLU, Farebox or separately.
VLU- Security Manager (PTV-SEC)	Onboard PTV entity that manages security alarms, CCTV, and emergency activities.	May be packaged with VLU or separately.
PTV Priority Request Manager (PTV-PRI)	Onboard PTV entity responsible for transit signal priority functions, especially the generation of Signal Priority Requests.	May be packaged with VLU or separately.
VLU-Data Manager (PTV-DAT)	This entity is the primary manager for onboard PTV data sharing. It provides a logging function, as well as a schedule, configuration, and software version management function.	
VLU-Adherence Manager (PTV-ADH)	This entity performs the onboard PTV route and schedule adherence monitoring and reporting.	
VLU-Health Monitor (PTV-HEL)	Onboard PTV entity responsible for monitoring & reporting PTV health, other onboard component health, and operational parameters.	
VLU-Location Monitor (PTV-LOC)	Onboard PTV entity for monitoring & reporting PTV location.	

Table 4.2.3 PTV Logical & Physical Entities		
Physical Component Name **(Logical Entity)**	**Typical Functions/Contents**	**Typical Variations**
PTV Other Onboard Component (PTV-OTH)	Onboard PTV component defined by an agency & authorized to participate in onboard dialog(s).	
PTV Passenger Information Annunciation (PTV-ANN)	This entity provides automatic onboard sign updates, automated stop annunciation, and other passenger information functions.	May be packaged separately from the VLU or with the VLU.
Wireless LAN	Provide access to fixed business systems when in range of a WLAN access point.	

4.2.4 Supervisors and Maintenance Vehicles

Transit Field Supervisors perform a variety of tasks that vary from agency to agency depending on a variety of factors including geographical dispersion, operating policies and procedures, degree of technical sophistication, labor agreements, etc. Transit Field Maintenance crews respond to impaired or disabled transit vehicles, traffic accidents involving transit vehicles, other incidents involving transit, and perform other duties as assigned by the agency.

The electronics supporting supervisors and maintenance crews may be packaged as a mobile, portable, or a combination device. Figure 4.2.4 shows these 3 configurations.

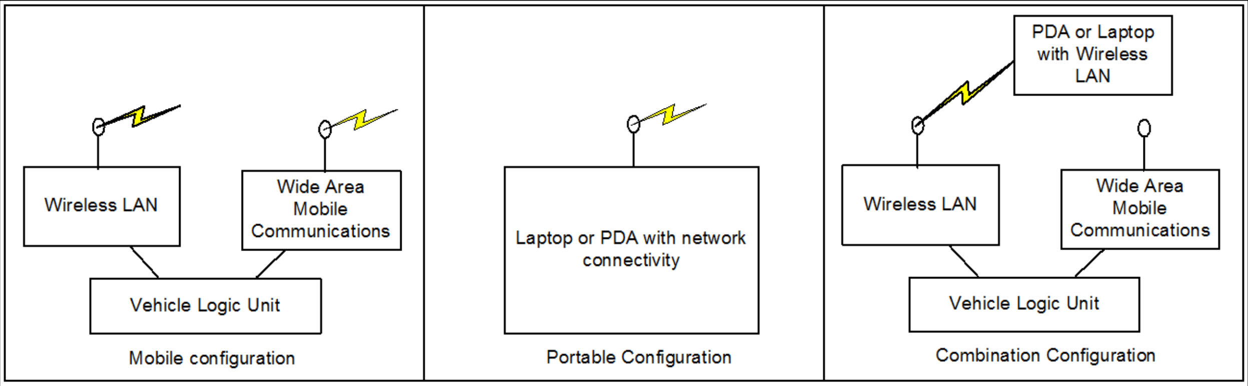


Figure 4.2.4
Alternative Configurations of Supervisor and Maintenance Vehicles

Regardless of the physical configuration, the model architecture defines a set of logical entities associated with these vehicles as shown in Table 4.2.4.

Table 4.2.4

Logical Entities in Supervisor and Maintenance Vehicles

Supervisor Entities	Maintenance Entities	Purpose
SPV-OPR	TMV-OPR	Operator interface entities
SPV-SEC	TMV-SEC	Security manager entity
SPV-COM	TMV-COM	Communications manager entity
SPV-DAT	TMV-DAT	Data manager entity
SPV-HEL	TMV-HEL	Health monitor entity
SPV-LOC	TMV-LOC	Location monitor entity
SPV-LDS	TMV-LDS	Location sensor entity
SPV-ECU	TMV-ECU	Engine and drive train monitoring entity
SPV-PRI	TMV-PRI	TSP manager entity

Note that most maintenance/supervisory vehicles will not have the complete set of logical entities shown in Table 4.2.4.

4.2.5 Transit Field Systems

Field systems exhibit a variety of physical architectures from agency to agency and often from location to location within an agency. The TCIP Model Architecture contains four physical components that represent field equipment. These physical components do not attempt to model the vast variety of field equipment that may be present in the field, but should be conceptually viewed as controllers of front ends that may be present at a location to communicate on behalf of the equipment at that location. For example, the Security Monitoring physical component might be connected to closed circuit television cameras and intrusion alarms. It would interface to this field equipment using whatever legacy protocols, and/or interfaces are appropriate, and would communicate back to the Transit Security business system using TCIP. The physical components at a location may be combined into an integrated field logic unit or distributed as separate components based on the agency's architecture. Table 4.2.5 illustrates the transit field physical and logical entities, and Figure 4.2.5 depicts the model field physical architecture.

Table 4.2.5

Transit Field Entities

Physical Component Name (logical entity)	**Purpose**	**Associated Equipment**	**Associated Business System**
Security Monitoring (PTSF-SEC)	Monitor log and report security activities. Manage alarms and local CCTV cameras.	Intrusion Alarms, CCTV, Traveler Alarms	Transit Security (TS)
Fare Collection (PTSF-FBX)	Manage Revenue collection activities at a station/stoppoint.	Turnstiles, fare vending machines, ticket validators, fare gates, cash box	Fare System (FS)
Traveler Information (PTSF-ANN)	Provide announcements passenger information display updates, and traveler access to information.	Passenger Information Displays, Public Address System, Kiosks.	Traveler Information System (TRV)
Transit Parking (PTSF-PRK)	Monitor, log and report parking lot status including space availability	Occupancy sensors, access gates.	Parking Management (PRK)

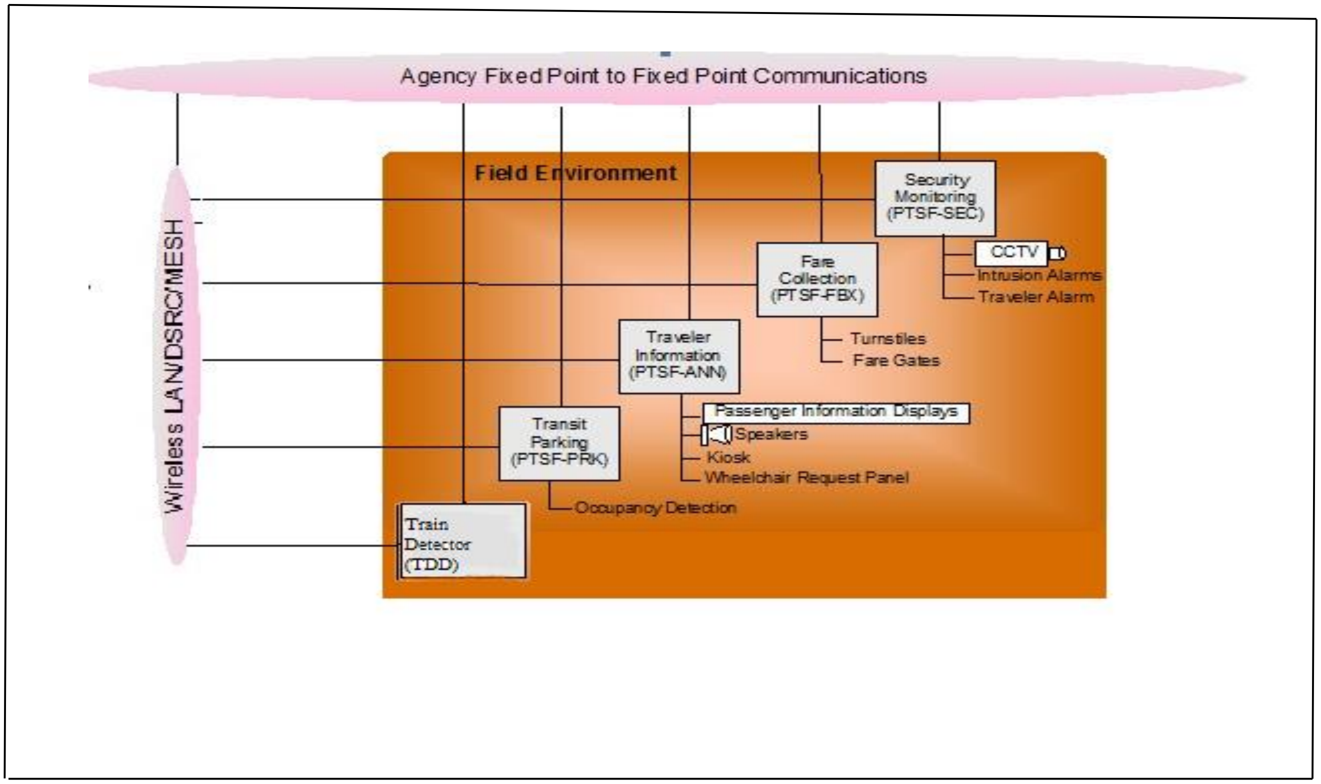


Fig 4.2.5

4.2.6 Transit Agency External Communications

Transit Agencies interact with a variety of external agencies, and private companies. In increasing numbers of cases these interactions are being automated with direct business system to business systems connections. The Model Architecture reflects this reality, although most of these interactions are governed by standards other than TCIP. Figure 4.2.6 depicts the connections between Transit Business Systems and External Business Systems.

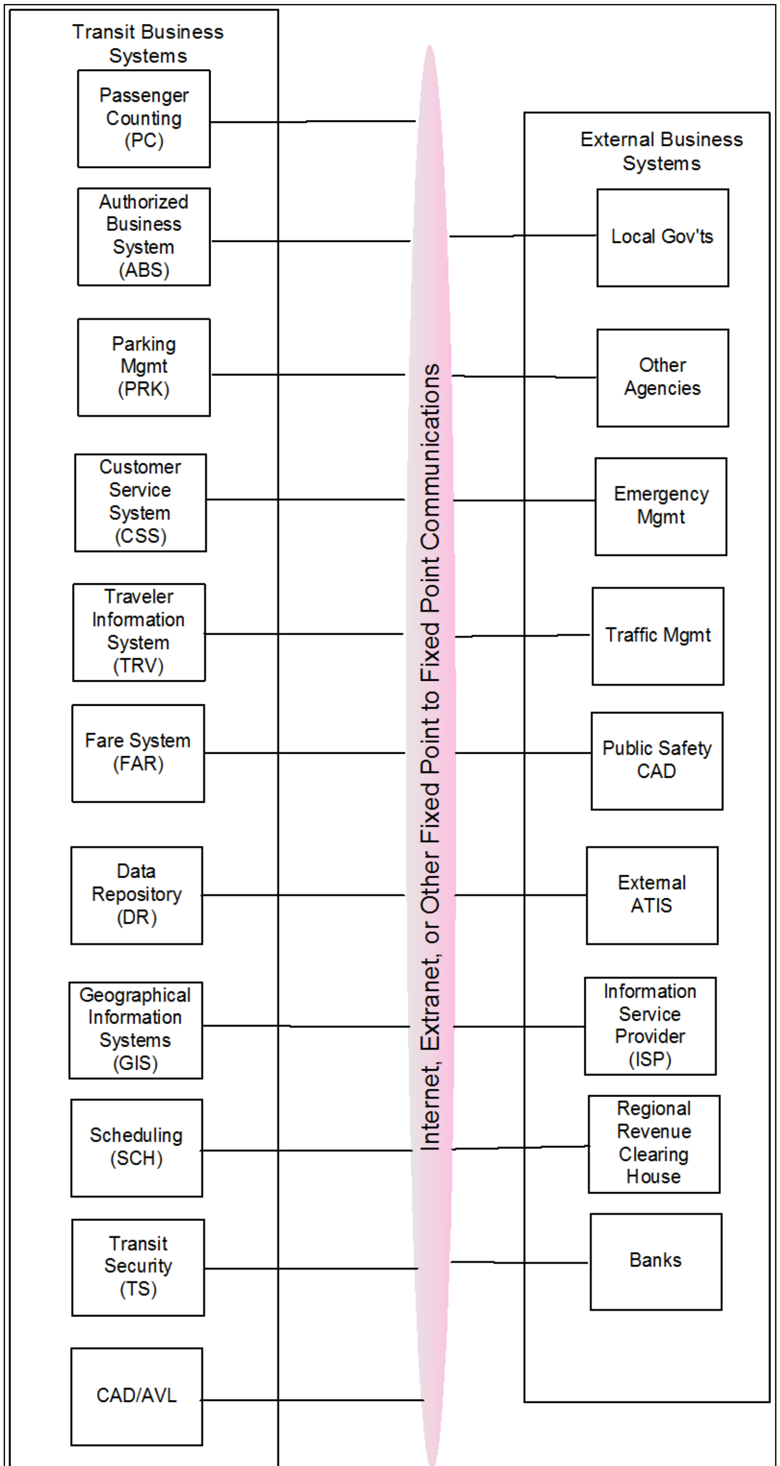


Figure 4.2.6
Transit Agency Interface External Systems

4.2.7 Model Architecture Communications

As with other parts of the Model Architecture, the Communications Network definitions above are non-normative. Transit agencies may adopt a wide variety of communications networks and architectures based on local needs and legacy systems. TCIP dialogs and file transfers will operate over many of these heterogeneous network environments.

The Model Architecture contains 6 communications networks. These are:

- The agency data network – labeled in Figure 4.2.1 as "Agency Fixed Point to Fixed Point Communications". Most agencies have private networks based on Internet Protocols, Ethernet etc. These networks generally convey large volumes of non-TCIP traffic (e.g.,, email) in addition to TCIP message traffic.

- Agency Communications with external entities – labeled in Figure 4.2.1 as "Internet, Extranet, or Other Fixed Point to Fixed Point Communications"

- The Wireless LAN – used to communicate on a broadband basis with field, portable and/or mobile devices. Standard commercial wireless LANs (802.11) are available for this including the emerging 802.11p (DSRC). Proprietary products can also be used to implement this network. Products are currently available which extend the range of broadband coverage using relays.

- The Wide Area (Mobile) Communications network. Some agencies use private (usually polled) data radio networks, while some agencies use public networks (e.g.,, 1XRTT, GPRS). Private data radio networks are usually tied to the agency voice communications and may share the mobile radio. Some of these networks have the capability to convey non-TCIP traffic (e.g.,, short messaging service, and/or email).

- The onboard PTV Vehicle Area Network (VAN) depicted in Figures 4.2.3 A&B. This network exchanges messages defined by SAE Standards J1587/J1708/J1939. TCIP messages are not exchanged on this network.

- The onboard PTV Hub network depicted in Figures 4.2.3 A&B. This network exchanges TCIP messages, and may be used for non-TCIP traffic as well.

Section 10 provides additional information on transit agency communications. This includes information on some possible implementations of these 6 networks.

4.2.8 Dialog and File Transfer Flow Line Conventions

Section 5 (Concept of Operations) of TCIP describes transit business processes and illustrates how TCIP dialogs and file transfers facilitate those processes. Diagrams are used extensively to show the Model Architecture elements and entities involved in each process, as well as the role of TCIP dialogs and file transfers in those processes.

This section defines the conventions used in drawing flow lines (arrows) in the Concept of Operations. The flow lines depict the flow of <u>information</u> between logical entities. A flow line may be labeled with letters signifying dialog flows and/or numbers indicating message file transfer flows. The legend of each drawing will indicate the specific dialog(s) and/or file transfer(s) signified by each letter and number.

File transfers are a simple one-way transmission of a single TCIP message. These are identified in the legend by the name of the TCIP message that defines the file contents.

Dialogs are one-way two-way or more conversations using TCIP messages according to patterns defined in Section 7. Consequently, a convention is required to map dialogs (usually two-way information flows) to flow line arrows that are one-way flows. The approach used is to identify the *direction of primary information flow* within each dialog pattern. Having determined this direction, that direction is used as the convention for assigning dialogs using that pattern to dialog flow lines. Table 4.2.8.A defines the conventions used for assigning directions to dialog flow lines based on the underlying pattern used by the dialog.

A simple example may help to illustrate these conventions. Suppose that the stoppoints are maintained on an agency's Data Repository (DR), and that an agency-defined Authorized Business System (ABS) needs the list of stoppoints and their attributes. The stoppoint list can be moved to the ABS using either the Publish Stoppoint List dialog or using a file transfer based on the CptStoppointList message. Figure 4.2.8 illustrates this scenario.

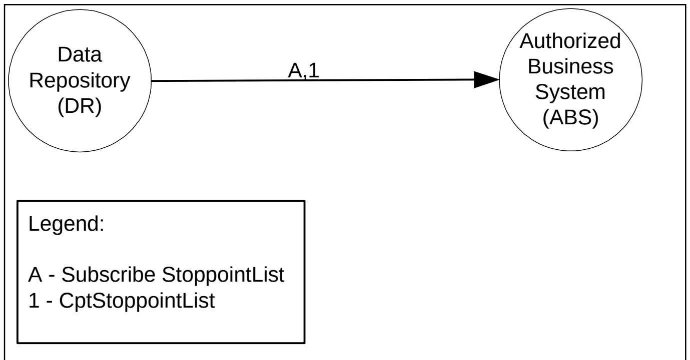


Figure 4.2.8
Flow Line Conventions Illustrated Using a Stoppoint List Transfer

The drawings in section 5 describe much more complex business processes, and thus generally have more flow lines and entities. In some cases a number or letter may represent a group of file transfers or dialogs respectively, as specified in the legend.

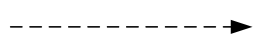
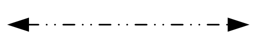
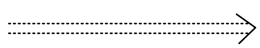
Table 4.2.8.A

Dialog Flow Line Direction Conventions

Pattern	**Flow Source(s)**	**Flow Destination(s)**	**Associated File Transfer**
Publication	Publisher	Subscriber	Sometimes
Report	Reporter	Receiver	Sometimes
Command Response	Controller	Device	No
Silent Alarm	Operator	Dispatcher	No
Load	Source	Destination	Yes
Unload	Source	Destination	Yes
Voice Radio Call	Call Originator	Call Receiver	No
Signal Control & Prioritization	PRG	PRS	No
Blind Notification	Notifier	Receiver	Sometimes

Table 4.2.8.A Dialog Flow Line Direction Conventions			
Pattern	**Flow Source(s)**	**Flow Destination(s)**	**Associated File Transfer**
Push	Sender	Receiver	Yes
Traveler Request	Requester (two way arrow) Central (two way arrow)	Central Provider (PTV)	No

Table 4.2.8.B defines line conventions used for non-TCIP flow lines in the concept of operations. Some lines in diagrams in section 5 may have a more specific meaning, as indicated on the individual figure.

Table 4.2.8.B Line Styles and Meanings in TCIP Concept of Operations Figures	
Line Style	**Meaning**
	Developer or agency defined interface
	Non-TCIP information flow
	Verbal communications
	Verbal communications via telephone
	Physical transfer of an item

4.3 Data Configuration Management

TCIP message definitions specify artifacts which can be conveyed as files or messages. These describe aspects of the transit agency, its resources and operations, and therefore change over time as events take place and as the agency itself evolves. These changes may take place slowly (monthly or quarterly updates), or in near-real time based on current operating conditions.

TCIP provides mechanisms to not only transfer the artifacts among local entities, but also to identify what revision or release of an artifact is being provided, and to provide updates to a previously provided revision.

4.3.1 Identification of Artifacts

TCIP artifacts are identified by:

- The TCIP message name which indicates the type of data contained in the artifact (e.g., stoppoints, stopping pattern, daily PTV operating log). TCIP also provides standard file types and, locally defined file type values to identify agency-specific or developer-specific artifacts based on a numerical identifier.
- An effective date-time which indicates the point in time when the revision of the artifact becomes active. For file types that provide information describing the agency plans, resources etc. the effective date-time is a point at which the artifact takes effect usually superseding a previous artifact revision of the same type. For file types that provide history information (e.g., daily operating data) this indicates the date-time at which the recorded history information begins.
- Version numbers which provide an integer identifier of a version.
- An update date-time indicating the point in time through which all updates to the revision have been included. Updates may include the addition of items, replacement of items, or deletion of items. For history-related artifacts, the update date-time indicates the last instant in time for which history data is included.
- A deactivation date-time. This field is not appropriate for all artifacts, or all agencies. If it is present in an artifact describing resources or plans, it indicates that the artifact is not to be used after the specified time.
- Artifact-specific identifier(s). Some artifacts describe a subset of the information available about a topic. For example, the RouteSchedule contains schedule information specific to a route, so the route identifier defines which route an instance of the artifact describes.

Agencies may elect to identify a file using the version identifier, effective date-time, or both. Some agencies have expressed a preference for the use of effective date time and some for version identifiers. The use of effective date-time provides an intrinsic activation feature, whereas version numbers more readily support a component maintaining multiple revision numbers and executing a 'fallback' to a previously loaded (and not deleted) version.

Artifacts may be transferred using message files, or using a variety of TCIP dialog patterns (see section 7). The Publication dialog pattern allows one entity to retrieve (query) data from another. Depending on the type of artifact the queries may be specified based on version number, date range and/or other criteria appropriate to the type of artifact (e.g., PTVs assigned to a garage).

4.3.2 Rows within Artifacts

Some TCIP artifacts contain lists of data items. For example, the RouteSchedule contains scheduled trips for the route and the Stoppoints list contains stop point descriptions. Following a convention used in relational databases, these list elements are termed "rows". In some cases an artifact may contain more than one list, and hence more than one type of row.

When a revision is updated, the updates are often changes to rows within the artifact. Each row has a unique row identifier which is specific to the row's type, analogous to a primary key for a row in a database table. For example, the rows in the Stop Point List message signify individual stop points. The stoppoint field (of type CPTStoppointIden) is the unique identifier for the row. TCIP provides the following row update operations:

- Add a row
- Replace a row
- Delete a row

Depending on the type of information they contain, rows may include other time-based information. For example, Stoppoints have optional activation and deactivation datetimes. This allows a stoppoint to be defined within a StoppointList and distributed before it is activated, or allows it to be deactivated at a planned datetime without redistributing or updating the Stoppoint List. This temporal information is stored in the row's metadata field (of type CPTRowData).

If a business system issues an update, or becomes out of sync, there are two remedies; use the row based update mechanism to request all changes since the last update, or request the whole version of the artifact. If all changes since the last known change are requested, the result is an update including all changes necessary to come up to date from the specified date-time regardless of how many interim updates may have been missed. If a request for the whole version to be resent is used, an up-to-date complete version will be obtained.

If a business system is storing two (or more) versions of an artifact, these two versions are updated independently. If a row update is applicable to two versions of an artifact, two separate row updates are required.

4.3.3. Relationship to Dialog Patterns and File Transfers

The Load, Unload, Publication, and Push TCIP Dialog Patterns use the artifact identification information to distribute new artifact revisions and row updates. These patterns specify different mechanisms for transferring artifact revisions and updates which are applicable in differing operational conditions.

TCIP also provides for file transfers as a mechanism for conveying TCIP artifacts without using TCIP dialogs. These files convey the same contents as TCIP messages used in dialogs. Consequently the ability to identify artifacts, revisions and updates to revisions are available in file transfers, just as in dialog-based transfers.

4.3.4 Applicability

It frequently occurs that an artifact is produced by a business system and transferred to the Data Repository (DR), Garage Server (GS) or other business system to be subsequently loaded to a group of entities. In some cases the group is all entities of a type (e.g., the schedule may be loaded to all instances of PTV-DAT). In other cases a group is actually a subset of the entities of that type (e.g., all instances of brand X vehicle logic units may receive a software version upgrade).

The optional applicability field in the headers of messages used in Publication load, unload, and push dialogs (see section 7) allow a file to specify the group to which it is applicable. Applicable group types include garages, routes, PTV fleet subsets, and stoppoint subsets.

PTV fleet subsets are assumed to be defined and maintained in the Asset Management System. Arbitrary groupings (which can overlap) may be defined. Examples might include groups for PTV brand and model, common onboard equipment sets, or groups of PTVs involved in a pilot program. Other business systems may obtain the fleet subset group definitions and updates using the Publish Fleet Subset Definitions Dialog. New subset groupings can be created, old subset grouping can be deleted, and the membership in a subset grouping can be changed.

Stoppoint subsets are analogous to fleet subsets in that arbitrary groupings can be created, deleted and modified. Example grouping might be stops serviced by a route, stops with shelters, stops with benches, stops scheduled for an agency defined upgrade program etc. Stoppoint subsets are assumed to be defined in the Data Repository (DR) or GIS. Other business systems may obtain the stoppoint subset grouping definitions and updates using the Publish Stoppoint Subset Definitions dialogs.

4.3.5 Configuration Management Example

To illustrate some of the possibilities for configuration management of information using TCIP, consider the example of an agency with a data repository that is distributing schedule information. The scenarios below have not been endorsed by any agency, but serve to illustrate how TCIP features can be used to manage configuration changes.

4.3.5.1 Scenario 1

The scheduling department is working on developing the new schedule for the next quarter. For the purpose of this example, assume the scheduling department distributes three scheduling artifacts: the timepoints, the patterns and the route schedule. For the purpose of this example we will ignore the distribution of operator assignments, vehicle assignments, and timetables, and assume that the pattern definitions do not include stoppoints.

The scheduling department updates the timepoints, edits the patterns to use the revised timepoint definitions, and defines the trips that are scheduled for each route based on the defined patterns. While large agencies have many routes, for this example we will assume only two routes – red and blue with route numbers 1 and 2 respectively.

The new schedule takes effect 1/10/2010 and the example agency's policy is to assign new version numbers to each artifact with the quarterly release (although TCIP allows artifacts to be identified by effective date alone). The scheduling department releases the timepoints on 11/27/2009, the patterns on 11/30/2009, and the route schedules on 12/17/2009. The Scheduling System transfers the timepoints, patterns, and route schedules to the data repository using the PushTimepoints, Push Patterns, ad Push Route Schedule dialogs, to the Data Repository upon the release of each artifact. All of these artifacts share an effective date time of 1/10/2010 00:00:00. The version numbers assigned are timepoints 12,447, patterns 7,413, Red Route Schedule 9, Blue Route Schedule 11.

On December 14, the GIS department discovers that the geolocations provided for two Timepoints in version 12,447 are erroneous. GIS provides corrected values to the scheduling department, and they are entered into the Scheduling System. The Scheduling System pushes row updates to the timepoints to the Data Repository. These updates use the same version number (12447), and effective date-time 1/10/2010 00:00:00 as the previously loaded timepoints but contains data only for the two updated timepoints. The Patterns and Route Schedules do not need to be transferred again.

4.3.5.2 Scenario 2

In the same agency as Scenario 1, the CAD/AVL system maintains an event-based subscription to the Data Repository using the Publish Master Schedule Version dialog. This subscription allows the CAD/AVL System to become aware of new scheduled releases soon after they are received by the Data Repository. Agency policy in this example requires that the CAD/AVL System import the new schedule and validate it within 24 hours of its release.

The Data Repository based on the new schedule release, sends the new schedule version information to the CAD/AVL System. On the night following the release of the new route schedules (Dec 7), the CAD/AVL System queries for and receives the new timepoints, patterns, and route schedules using the Publish Timepoint List, Publish Pattern List, and Publish Route Schedule dialogs. The CAD/AVL System validates the new schedules, but does not detect the erroneous timepoint locations.

Agency policy does not require the CAD/AVL System to revalidate the schedule based on row updates, so the CAD/AVL system does not retrieve the updated timepoint locations during December.

On the morning of January 9, the CAD/AVL System queries the Data Repositories for all updates to the new timepoints, patterns and route schedules that have occurred since the artifacts were obtained on December 7. The only updates are the row changes reflecting the corrections to the timepoint geo locations, and these are forwarded to the CAD/AVL System. Note that the CAD/AVL System could have queried for the artifacts to be re-transferred in their entirety, but for efficiency reasons only the changes were transferred.

4.3.5.3 Scenario 3

In the same agency as scenarios 1 and 2, the CAD/AVL System has been operating on the new schedule for several weeks. On Feb 10, 2010 the agency decides to add three more morning trips to the Red Route weekday schedule, and to change the timing of four other Red Route weekday trips to establish a regular headway. These changes are entered into the Scheduling System and the Scheduling System transfers row updates to the Route Schedule for the Red Route to the Data Repository. These row updates consist of 3 trip additions and 3 trip replacements. The Data Repository notifies the CAD/AVL System of the update to the Route Schedule based on the ongoing event-based Publish Master Schedule Version dialog. This allows the CAD/AVL System to initiate a query to retrieve the row updates to the Red Route Schedule using the Publish Route Schedule dialog.

On February 14, 2010 a fire in the control center damages the CAD/AVL system and it is offline for two days. On February 16, 2010 the CAD/AVL System is restored using backup media from February 2, 2010. Once the system is restored, it queries for row updates to the timepoints, patterns and both route schedules (since Feb 2), and re-establishes the event query for the Master Schedule Version. The row update query retrieves the trip changes and additions that were initiated on February 10, 2010 and the CAD/AVL System is back up to date on the correct schedule.

Note that the row update retrievals used to catch up after a failure described above would work regardless of whether the changes were to timepoints, patterns, route schedules, or a combination of artifacts. It would also work if updates occurred during the outage period.

4.3.6 TCIP MultiAgency Identifiers

TCIP defines identifiers for a wide variety of data concepts including transit routes, vehicles, transit facilities, operator assignments (runs) and many others. There is a need for such identifiers to be unique, either in a single agency environment, or in the context of regionally integrated transit systems.

This need is met in TCIP using data frames with names ending in ‘Iden’. Iden data frames contain a mandatory alpha numeric identifier (id field), which is unique within a particular transit agency. Important note: id fields shall not contain leading or trailing white space and all comparisons of id fields shall be case insensitive

Iden frames also contain an optional numeric agency-id (ag field) that allows the agency that assigned the unique value to be identified. In a multiagency environment, the inclusion of an agency-id field allows the same identifier value assigned by different agencies to still be unique.

Iden data frames also may include additional optional alphanumeric identifiers, appropriate to the particular data concept. For example, an alphanumeric identifier used for vehicles is the vehicle identification number, and an alphanumeric identifier associated with an operator assignment is a run designator.

Figure 4.3.6 illustrates the ASN.1 definitions for two Iden Data frames

The CPTGenericIden data frame provides a type independent identifier. TCIP Iden frames may be converted to an equivalent data frame of type CPTGenericIden and vice versa. This allows an item identified by an Iden frame to be associated with another item without regard to the type of the identified item. For example, map features may be associated with a generic Iden frame. If the generic Iden frame identifies a timepoint, the feature is associated with timepoint, if the generic frame identifies a stoppoint, the feature is associated with a stoppoint. In this way all features in one layer of a map database can be associated with timepoints, while all features in another layer are associated with stoppoints, and features in yet another layer can be associated with shelters. Table 4.3.6 defines the conversions between various TCIP Iden types and generic Iden types.

```
SCHRouteIden ::= SEQUENCE {
      route-id                      SCH-RouteID,
      agency-id                     CPT-AgencyID OPTIONAL,
      route-designator              SCH-RouteDesignator OPTIONAL,
      route-designatorLangs         CPTAdditionalLanguageContents OPTIONAL,
      route-name                    SCH-RouteName OPTIONAL,
      route-nameLangs               CPTAdditionalLanguageContents OPTIONAL,
      agencydesignator              CPT-AgencyDesignator OPTIONAL,
      agencydesignatorLangs         CPTAdditionalLanguageContents OPTIONAL
}
CPTOperatorIden ::= SEQUENCE {
      id                            CPT-OperatorID,
      ag                            CPT-AgencyID OPTIONAL,
      name                          IM-PersonIdentifier OPTIONAL,
      nameLangs                     CPTAdditionalLanguageContents OPTIONAL,
      desig                         CPT-GenericDesignator OPTIONAL,
      desigLangs                    CPTAdditionalLanguageContents OPTIONAL,
      agdesig                       CPT-AgencyDesignator OPTIONAL,
      agdesigLangs                  CPTAdditionalLanguageContents OPTIONAL,
      ssn                           CPT-SSN OPTIONAL,
      firstName                     CPT-PersonFirstName OPTIONAL,
      firstNameLangs                CPTAdditionalLanguageContents OPTIONAL,
      middleName                    CPT-PersonMiddleName OPTIONAL,
      middleNameLangs               CPTAdditionalLanguageContents OPTIONAL,
      lastName                      CPT-PersonLastName OPTIONAL,
      lastNameLangs                 CPTAdditionalLanguageContents OPTIONAL,
      agdesignator                  CPT-AgencyDesignator OPTIONAL,
      userLoginName                 CPT-Footnote OPTIONAL,
      employee-id                   CPT-EmployeeID OPTIONAL
}
CPTGenericIden ::= SEQUENCE {
      id                            CPT-GenericID,
      numeric-id                    CPT-GenericCounter,
      agency-id                     CPT-AgencyID OPTIONAL,
      name                          CPT-GenericName OPTIONAL,
      nameLangs                     CPTAdditionalLanguageContents OPTIONAL,
      desig                         CPT-GenericDesignator OPTIONAL,
      desigLangs                    CPTAdditionalLanguageContents OPTIONAL,
      agdesig                       CPT-AgencyDesignator OPTIONAL,
      agdesigLangs                  CPTAdditionalLanguageContents OPTIONAL,
      name1                         CPT-GenericName OPTIONAL,
      name1Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name2                         CPT-GenericName OPTIONAL,
      name2Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name3                         CPT-GenericName OPTIONAL,
      name3Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name4                         CPT-GenericName OPTIONAL,
      name4Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name5                         CPT-GenericName OPTIONAL,
      name5Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name6                         CPT-GenericName OPTIONAL,
      name6Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name7                         CPT-GenericName OPTIONAL,
      name7Langs                    CPTAdditionalLanguageContents OPTIONAL,
      name8                         CPT-GenericName OPTIONAL,
      name8Langs                    CPTAdditionalLanguageContents OPTIONAL,
      numeric2                      CPT-GenericCounter OPTIONAL,
      agencydesignator              CPT-AgencyDesignator OPTIONAL,
      agencydesignatorLangs         CPTAdditionalLanguageContents OPTIONAL,
      specific-type                 CPT-FeatureType OPTIONAL
}
```

Fig 4.3.6 ASN.1 Definition for three Iden Data Frames

Table 4.3.6								
SpecificIden – Generic Iden Translations								
GenericIden Fields								
Iden Frame	specific-type	numeric-id	agency-id	name1	name2	name3	name4	numeric2
CPTEmployeeIden	Employee(30)	employee-id	agency-id	name.firstName	name.middleName	name.lastName	---	---
CPTIntersectionIden	intersection(3)	intersection-id	agency-id	tmdd-id	name	---	---	---
CPTOperatorBaseIden	operator-base(3)	base-id	agency-id	Name	---	---	---	---
CPTOperatorIden	operator(32)	operator-id	agency-id	Designator	---	---	---	employee-id
CPTOrganizationalUnitIden	org-unit(33)	unit-id	agency-id	name	---	---	---	---
CPTShelterIden	shelter(10)	shelter-id	agency-id	Name	---	---	---	---
CPTStoppointIden	stoppoint(8)	stoppoint-id	agency-id	Name	---	---	---	---
CPTTransferClusterIden	transfer-cluster(34)	cluster-id	agency-id	cluster-name	---	---	---	---
CPTTransitFacilityIden	transit-facility(24)	facility-id	agency-id	facility-name	base-name	---	---	---
CPTVehicleIden	vehicle(35)	vehicle-id	agency-id	Vin	---	---	---	---
FCFarePolicyIden	fare-policy(36)	policy-id	agency-id	Name	--	---	---	---
FCFareZoneIden	fare-zone(37)	zone-id	agency-id	zone-name	---	---	---	---
IMIncidentIden	incident(17)	incident-id	agency-id	external-id	---	---	---	external-id-agency
PIAmenityIden	amenity(38)	amenity-id	agency-id	Name	---	---	---	---
PIAnnouncmentIden	announcement(39)	announcement-id	agency-id	---	---	---	---	---

Table 4.3.6								
SpecificIden – Generic Iden Translations								
GenericIden Fields								
PISeriveBulletinIden	service-bulletin(40)	serviceBulletin-id	agency-id	serviceBulletin-des	---	---	---	---
PIGeoZoneIden	geo-zone(41)	zone-id	---	zone-name	states*	states*	states*	
PITraverlerIden	traveler(42)	traveler-id	agency-id	traveler-name.firstName	traveler-name. middleName	traveler-name. lastName	---	---
SCHBlockIden	block(43)	block-id	agency-id	bloc-designator	block-name	---	---	---
SCHNoteIden	note(44)	note-id	agency-id	note-des	---	---	---	---
SCHPatternIden	pattern(14)	pattern-id	agency-id	Designator	name	--	---	---
SCHPatternSegmentIden	pattern-segment(15)	segment-id	agency-id	Name	---	---	---	---
SCNRouteIden	route(16)	route-id	agency-id	route-designator	route-name	---	---	---
SCHRunIden	run(45)	run-id	agency-id	Designator	---	---	---	---
SCHTimpointIden	timepoint(9)	timepoint-id	agency-id	Designator	name	---	---	---
SCHTripIden	trip(46)	trip-id	agency-id	Designator	---	---	--	---

*States are two letter state abbreviations for states impacted by the zone. Two letter state abbreviations are stored in name2, name3, name4 (as many as necessary). Name2 holds the first 20 states. Name3 holds the next 20 states, etc.

4.3.7 Schedule Notes

Some transit agencies associate text notes with their schedules, or with parts of the schedule. Some of these notes may be intended for use by employees, and some may be intended for public use. Several TCIP messages provide for the association of schedule notes with items within the message.

This is accomplished by conveying a list of notes (SCHNoteInfo frames) in the message. Items within the message that have associated notes contain one or more SCHNoteIden data frames that indicate what note(s) are associated with that item. A single note can be associated with more than one item, however the SCHNoteInfo frame specifying the note's contents occurs only once in the message.

The SCHNoteInfo data frame contains a Boolean data element named 'public'. This data element indicates whether the note is permitted to be published to the public (e.g.,, with a timetable) or whether the note is intended for internal agency use.

4.3.8 TCIP Releases

As TCIP matures, changes to TCIP data will be identified by the transit industry and incorporated into later versions of TCIP. Such changes, after approval by APTA, will be captured in a 'release' of TCIP. Each release will have a unique number (e.g.,, TCIP 3.0) that identifies that version. The version number will also be identified in the corresponding release of the TCIP XML Schema (e.g.,, tcip_3_0.xsd). Note that all TCIP data will be re-issued in the new release-whether changed or unchanged. Similarly the new schema release will contain all TCIP data definitions changed and unchanged. This approach eliminates issues associated with incremental releases, including ambiguity about what version of a data element is referenced by any message or message file.

4.3.9 Optional Fields

Many TCIP messages and data frames contain optional fields. Fields may be designated as optional for a variety of reasons:

- An optional field may be present to support a functional requirement which is not common to all agencies. For example, a data frame may contain an announcement which can be text audio or both. If the using agency does not use automated audio announcements, the audio field would be unneeded within their agency ITS architecture.

- An optional field may be present to support a capability which is only required in some contexts. For example, an error or warning field in a message may not be needed if there is no error or warning active. Similarly, a field specifying the periodic update interval in a subscription request would not be present if the request was for a single response (query), or for event-driven updates.

- An optional field may be present to convey information which may or may not be available. For example, a stoppoint data frame may provide the ability to convey photographs of the stoppoint. If no photographs or the site are available, the field would not be present. Similarly, a pattern segment in the schedule may be sent from Scheduling to a Data Repository without geographical trace-points, and those trace-points may be subsequently added within the Data Repository prior to downstream distribution.

The tailoring of TCIP at the level of optional field usage within messages is implemented using the PRL and PICS. The agency's PRL defines what optional fields are required or conditionally required for that agency, and the PICs specifies what optional fields are provided/consumed and under what conditions. The PRL provides the facility for an agency to require an implementation to use any field specified as optional within the standard. The comparison of these sections of the PRL and PICs allows the agency to verify that the implemented interface supports the optional fields needed to support the agency's operating requirements.

4.4 Other Standards

TCIP relies on a variety of other standards for a variety of different capabilities. TCIP imports location constructs from the LRMS (Reference [N-4]). TCIP imports phrases and code numbers describing incidents from ITIS (Reference [N-7]). TCIP relies on the IM standard to define incident information exchanges between transit agencies and other agencies such as public safety (Reference [N-9]). TCIP imports itinerary and other passenger information concepts from ATIS (Reference [N-5]). TCIP imports traffic management data concepts from the TMDD (Reference [N-6]). TCIP relies on the SCP standard to define interactions between the transit agency and the traffic control systems for transit signal priority (Reference [N-8]). TCIP relies on the standards published by the worldwide web consortium for the definitions related to XML and XML Schemas (References[N-1], [N-2], and [N-3]).

4.5 Using TCIP Volume II

Volume II of TCIP contains the data element definitions in ASN.1 (Annex A), the data frame definitions in ASN.1 (Annex B), the message definitions in ASN.1 (Annex C), and the dialog definitions (Annex D). In TCIP Version 2.7 and later these Annexes are distributed as Microsoft Word Documents with hyperlinks and tool tips. This section provides information on the proper use of these Volume II capabilities.

Each occurrence of the name of a TCIP object (data element, data frame, or message) is hyperlinked to the ASN.1 definition of that object in Volume II. Depending on the Microsoft Word settings on a particular computer, one can follow the link to the object's definition either by holding down the control key and left clicking on the name, or by left clicking the object without holding the control key.

Each TCIP data frame and data element definition contains a list of TCIP messages and data frames that 'contains' the specified frame or element. These lists provide hyperlinks 'up' the chain of TCIP objects from each data frame and data element to the higher level objects that 'use' or contain them.

Each TCIP dialog, message and data frame contains hyperlinks to lower level objects it 'contains' within its definition. These hyperlinks allow a user of Volume II to follow the chain 'down' from a dialog definition to the lowest level data elements used by that dialog.

Each hyperlink also provides a "tool tip". If the cursor hovers over a hyperlink without clicking on the hyperlink, a tool tip will appear that shows the purpose of the object named by the hyperlink.

Dialog definitions provide hyperlinks to the messages that are used in that dialog (excluding error messages). Messages, however, do not provide links to the dialogs that use them.

Combining the use of the work edit/find feature with hyperlinks and tool tips provides a powerful mechanism for searching and exploring Volume II.

TCIP Volume II is distributed as 3 files:

- TCIP_X_Y_AnnexA.doc
- TCIP_X_Y_AnnexB.doc
- TCIP_X_Y_AnnexCD.doc

"X_Y" represents the TCIP version number of the files (e.g.,, for TCIP version 3.0.1, TCIP_3_0_AnnexA.doc). These files must be stored in the same folder on a computer and must not be renamed in order for the hyperlinks to work correctly. It is not necessary to open all 3 files to get started. For example, to explore the "Publish Stoppoint List" dialog, open AnnexCD, and use the Edit/Find function to search for "Publish Stoppoint List". This search will find the dialog in the table of contents. Control click on the Table of Contents entry to get to the dialog. Click (or control click) on a message in the dialog definition to get to the message. Click (or control click) on a data frame in the message to see the definition of the data frame - note that Annex B opens automatically.

4.6 Schema Files

The TCIP XML Schema depends on external schemas defined by other ITS Standards. Since TCIP and other ITS standards are under configuration control, and evolve over time, a versioning and naming convention has been adopted by the standards developers to ensure that ITS Standard schemas are linked to the correct versions of other schemas. This is accomplished by including the standard acronym and version identifier in the file name. Since many of the ITS standards are locally extensible, and may be released as drafts prior to balloting, some file names have post fix names such as "_DRAFT" or "_Local".

The TCIP XML schema must be used with the correct set of external schemas in order for the schema to validate, and in order for parsers to work correctly. As a best practice for ITS implementations the schema files should all be maintained in a single folder, or directory so the XML parser can find all of the necessary files.

The tcip_X_Y_Local.xsd file may be locally edited to add any required local extensions to the extensible TCIP objects in the TCIP XML schema.

4.7 Multilanguage Support

Beginning with version 3.0.4, TCIP supports the simultaneous use of multiple languages for communicating string variables. Each message that potentially contains multiple language content has an optional CPTLanguageList data frame near the beginning of the message. This frame occurs only once in a message, and specifies what language(s) are used within the message. If this frame is not present, the message shall contain content in English only. If the frame is present, however, any ISO 639 language can be specified as the primary (default) language. Additional ISO 639 languages can also be specified as required by the agency. English is not required to be either the default language, or one of the additional languages if the CPTLanguageList frame is present.

In creating a message or frame the primary language content goes in the field preceding the CPTAdditionalLanguageContents frame. Content in additional languages goes into entries in the corresponding CPTAdditionalLanguageContents frame. If a CPTAdditionalLanguageContents frame is included, the language contents in the CPTAdditionalLanguageContents frame must be included in exactly the same order as the additional languages are specified in the CPTLanguageList near the beginning of the enclosing message. It is an error for a CPTAdditionalLanguageList frame to be included in a message containing a different number of content entries than the number of additional languages specified in the CPTLanguageList frame. It is not an error to omit the CPTAdditionalLanguageContents frame in any context.

Additional language content is specified using the CPTAdditionalLanguageContent data frame. The information is carried in the primary or default language in the base field. The information is optionally carried in the additional languages in the fields of the CPTAdditionalLanguageContent data frame.

Example:

```
CptExampleMessage :: = {
 header CPTSubscriptionHeader,
 languages CPTLanguageList   OPTIONAL,
 direction SCH-RouteDirectionName,
 directionLangs CPTAdditionalLanguageContent OPTIONAL,
}
```

5. Concept of Operations

5.1 General Concepts

TCIP provides a standardized framework for information exchange between:
- Transit agency business systems and components within a transit agency,
- Transit agency business systems in different transit agencies,
- Transit agency business systems and external agency business systems
- Transit agency business systems or components and external agency business systems or components.

In the future new opportunities and challenges will impact TCIP implementations within agencies. These include:
- Data Network Evolution. Rapid expansions of wireline and wireless network capacity is forecasted. The need for narrowband versions of TCIP may diminish – especially in agencies that are early adopters of wide area wideband wireless communications.
- Homeland Security Mandates. The federal government has granted Homeland Security organizations the ability to impose related mandates on transportation agencies including public transit. New mandates may impact communications systems as well as agency ITS architectures.
- New Internet Technologies. New XML-based technologies are under development which may provide new capabilities for TCIP/XML enabled applications.
- Updates to other standards – especially standards referenced by TCIP (e.g.,, XML, LRMS, ATIS).
- ITS development including the Integrated Corridor Management Initiative and the Vehicle Infrastructure Initiative.
- Agency procurements have long timelines which may impact the ability to adopt new technologies. Once implemented some agencies use business systems beyond what might be considered the useful life of the system's components.

The following sub sections of the Concept of Operations describe Transit Core Business Processes and how TCIP can be used to facilitate those processes. These sections are not normative, but are intended to illustrate how TCIP dialogs and file transfers can be used in an agency. For the purpose of illustration, the model architecture described in section 4 is used as a baseline for typical agency ITS architecture.

The key transit business processes described in the following sections are:

- Security and Incident Management Process
- PTV Operations Process
- Revenue and Fare Collection Process
- Scheduling Process
- Personnel and Work Assignment Management Process
- Asset Management Process
- Customer Information Process
- Data Repository Operations Process
- Spatial Data Management Process
- Transit Signal Priority Process

5.2 Security and Incident Management Process

5.2.1 Purpose

The Security and Incident Management Process facilitates the provision of:
- Safe and secure environment for transit employees and customers
- A well thought out response to incidents affecting service and /or posing a potential hazard to transit employees or customers.

The Manage Incidents and Security Business Process Outputs are:
- Prevention of incidents to the extent feasible
- Prompt and effective detection of incidents that do occur
- Prompt and effective responses to incidents that are detected

5.2.2 Overview of Security and Incident Management Process

The Security and Incident Management Process includes 7 stages:
- Planning
- Preparation
- Incident detection, classification, and verification
- Incident notification
- Incident response
- Incident recovery
- Incident follow-up

Key organizations in incident planning process are transit planners, transit operations and maintenance managers, external agencies including public safety agencies, DOTs and other transit agencies. Transit agency contractors may have a role as well in some agencies.

Some challenges relevant to this TCIP business process include:

- Training – Maintaining a high level of employee proficiency in performing tasks which are not performed on regular basis is an issue. Some agencies use drills and recurring incident management procedures and refresher courses to maintain familiarity with seldom used procedures.

- Agency differences – Different types of agencies involved in incident management and response have different operating philosophies, priorities, levels of business system sophistication, and support for IM data exchange standards.

- Conflicting and Duplicate Reports – Incidents often involve a degree of chaos and confusion – especially unplanned incidents in the early stages. This can result in reports of the incident being generated from various sources. These reports may not be consistent or accurate.

- Jurisdictional Boundaries – Jurisdictional boundaries may be different for different types of agencies. For example, police, fire and ambulance services may have response areas that are different. Transit agencies often operate across city and/or county lines resulting in different public safety providers being responsible for incidents on either side of the line. Jurisdictional boundaries may be conditional, the public safety responders to an incident at a given location may vary based on the site of the incident and the responders available at an instant in time.

- Communications – Incident responders form various agencies frequently have incompatible communications systems, especially data and radio systems. When connecting transit business systems to external agency systems for the purpose of exchanging incident data, a key risk is the possibility of one system going down undetected by the other resulting in lost or delayed incident reporting. Consequently a key mitigation strategy is the implementation of an automated “keep alive” system to promptly detect outages.

- Obsolescence – Plans and Procedures which are set up for unplanned incidents may become outdated. Periodic reviews and updates can mitigate this problem.

5.2.3 Primary Architecture Components

The Key TCIP Model Architecture components involved in the Security and Incident Management Process are:

- Transit Security – This business system is used to detect and to manage security incidents.
- CAD/AVL – This business system may include incident management application(s) for use by transit dispatchers, supervisors, managers, etc.
- External Agency Systems – Required for data-based coordination and notifications of incident information and status.
- GIS – This business system maintains the base map, transit features, and may be used as an incident analysis tool.
- Asset Management – This business system deals with scheduling PTV maintenance and repairs, and in PTV assignments including assignment changes which may occur as a result of incidents.
- Operator Assignment System – This business system deals with PTV operator assignments to work (runs) including changes to operator assignments resulting from last minute changes prior to pull outs and changes that occur enroute as a result of incidents.

5.2.4 Security and Incident Management Process Stages

5.2.4.1 Security and Incident Management Planning

The purpose of the planning stage is for the transit agency to determine the types of incidents, hazards, and threats that the agency faces, to assess the risks, and to develop and prioritize mitigation strategies. Agencies use a variety of manual and automated tools and business systems to support the planning effort. Inputs to the process include historical incident information from the agency’s operations, vulnerability assessments, agency infrastructure information, (including maps and drawings), and plans, procedures and policies of other local and regional public agencies, and plans for local or regional events (e.g.,, sporting, entertainment).

The planning process may be divided into a number of sub processes organized by the type of incident or for a single planned event. Planning for some incident types requires extensive coordination with external agencies and/or private companies. These joint planning efforts normally result in the developments of Memorandums of Understand (MOU). MOUs formalize the results of the joint planning efforts so that each participant has a clear understanding of their role when an incident occurs. Items usually covered in an MOU include:

- Initial Incident reporting procedures (interagency)
- Establishment of Transit role in the event of an area evacuation (especially mass evacuation)
- Contact information for each agency (which may be location specific)
- Agreements about what agency will assume the incident commander role under what circumstances
- Specific procedures for handling certain types of incidents and events (e.g.,, notification of road closure, access to agency video feeds)
- Coordination and reporting procedures between representatives of different agencies both at the incident scene and among various command centers
- Safety procedures for working in and around various types of incident hazards (e.g.,, fire, hazmat, downed power lines, weapons)
- Procedures for terminating (clearing) and incident and coordinating the termination between agencies
- Procedures for sharing records of the incident after the fact
- Agreements on interagency post-action reviews (usually only applies to major incidents)

- Procedures and agreements regarding protection and disclosure of confidential information of other agencies
- Restrictions on use of communications (e.g.,, radio/cell phones near bomb threat sites, avoiding passing confidential information on unsecured radio/phone systems)
- Procedures for requesting support and/or resources from other agencies at the scene, or via command centers.
- Variations in procedures based on current homeland security status ("color codes")
- Special procedures related to injured/deceased persons at the scene.
- Procedures related to working at or near a police crime scene
- Procedures related to violent persons at or near the incident scene
- Procedures related to shutting off and restoring power (e.g.,, cantenary or third rail)
- Procedures related to preserving evidence and turning it over to police (e.g.,, chain of custody)
- Procedures related to handling and reporting "trapped" personnel (e.g.,, can't escape from PTV or building)
- Procedures for monitoring and reporting suspicious activity (may be prior to the incident)
- Procedures for notification of an actual, threatened, or suspected weapon of mass destruction
- Tunnel fire, explosion and hazmat procedures
- Procedures for widespread or suspicious power outages
- Agreements on Joint (interagency) training requirements and/or plans including drills.

Generally there are 4 types of planning sub processes:

- Planning for routine operationally disruptive incidents (not scheduled, but anticipated)
- Planning for criminal incidents
- Planning for special events (e.g.,, sporting/entertainment/conventions)
- Planning for disasters and terrorist events (not scheduled, but anticipated)

Planning for routine operationally disruptive incidents is generally based on past experience. These incidents include fires, police investigations, sick customers or employees, snowstorms, PTV breakdowns, traffic congestion, unplanned road closures, etc. Joint planning with responders within or outside the agency may be required. Incident history information is useful in updating plans to compare existing plans and procedures with past incidents to verify that they cover the incidents occurring in the real-world. For anticipated events, (e.g.,, snowstorms) agencies may create alternative schedules by defining a schedule day-type (weekday-snow). This allows trips to individually be scheduled, or omitted from the schedule for that day-type by including or excluding that day-type from the list of day-types on which that trip is run.

Planning for criminal events is similar to routine operationally disruptive events in that coordination with transit and other police agencies is essential, and planning relies heavily on past events. The agency may also evaluate security features in this context and make plans to add security devices or to make infrastructure improvements. Security devices include cameras, intrusion detection alarms access controls, etc. Infrastructure improvements may include closing areas to the public, increased lighting, etc.

Planning for Special Events is somewhat unique in that the specific event's timing and nature are known in advance. Transit schedules may be modified to run additional or special services, or patterns may be changed due to projected traffic patterns, street closures, etc. Alternatively, the schedule may not be modified, and preplanned detours may be implemented to accommodate anticipated conditions surrounding the event. Much of this preplanning information will be exchanged in advance, and much of the information will not be exchanged using TCIP. These preplanning efforts may use work documents, emails, IEEE 1512 messages etc, especially on an interagency basis.

Disaster planning is at the opposite end of the spectrum from special events in that the timing and type of event are unknown in advance requiring planning for a broad spectrum of possible threats with random timing. Planning for these events tends to focus on unique transit requirements that may occur after such an event such as evacuation services, or movements of large groups of injured persons to hospitals or temporary care facilitates. Agencies may create and maintain special purpose schedules to implement in such events.

The primary requirement for interfacing to support incident planning is the ability to obtain transit information. TCIP supports incident planning information transfer needs with the dialogs and file transfers shown in Figures

5.2.4.1 A&B. Other planning documents, drawing, maps, agreements etc. are maintained in agency-specified formats and do not have associated TCIP dialogs or file transfers.

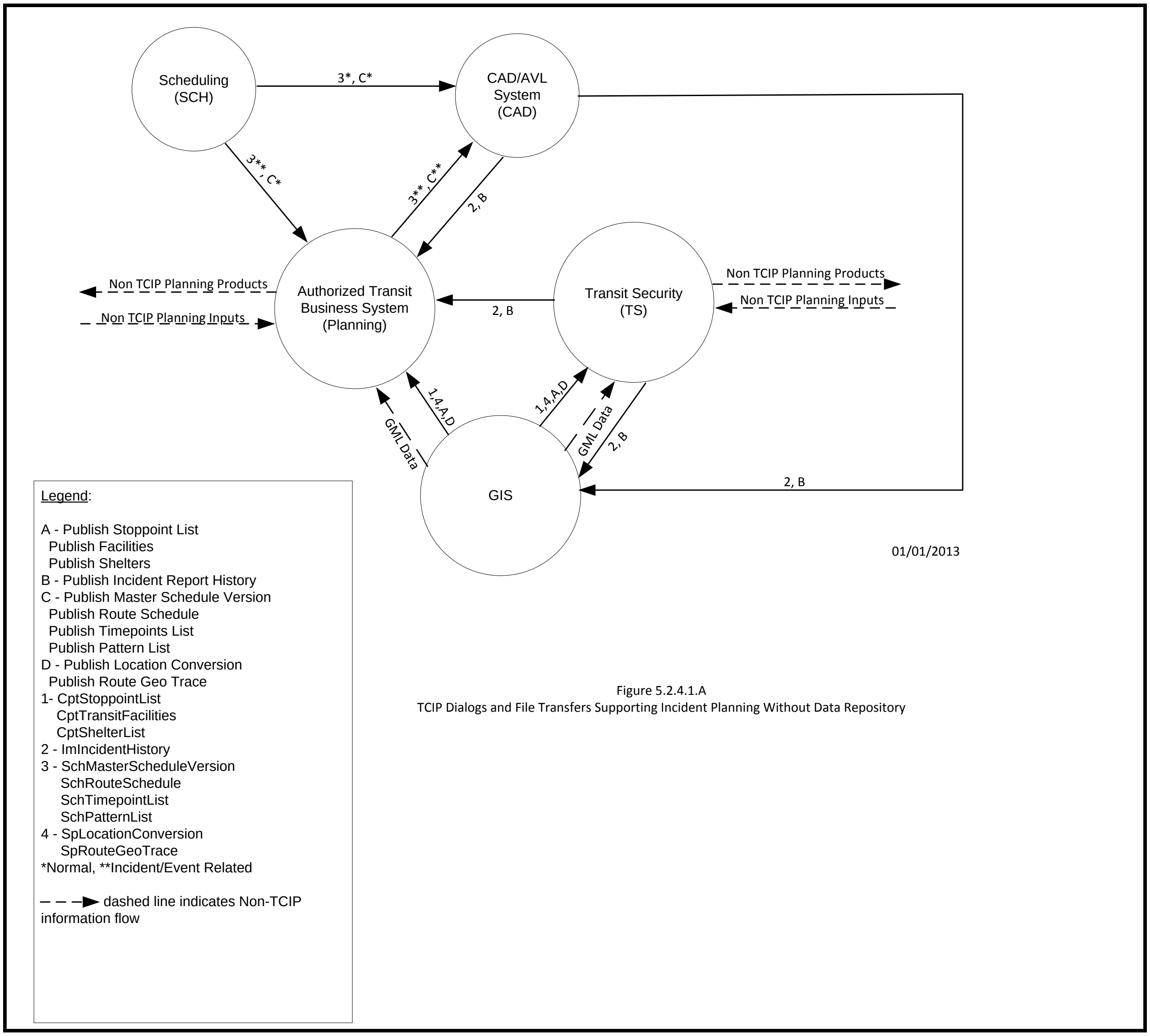


Figure 5.2.4.1.A
TCIP Dialogs and File Transfers Supporting Incident Planning Without Data Repository

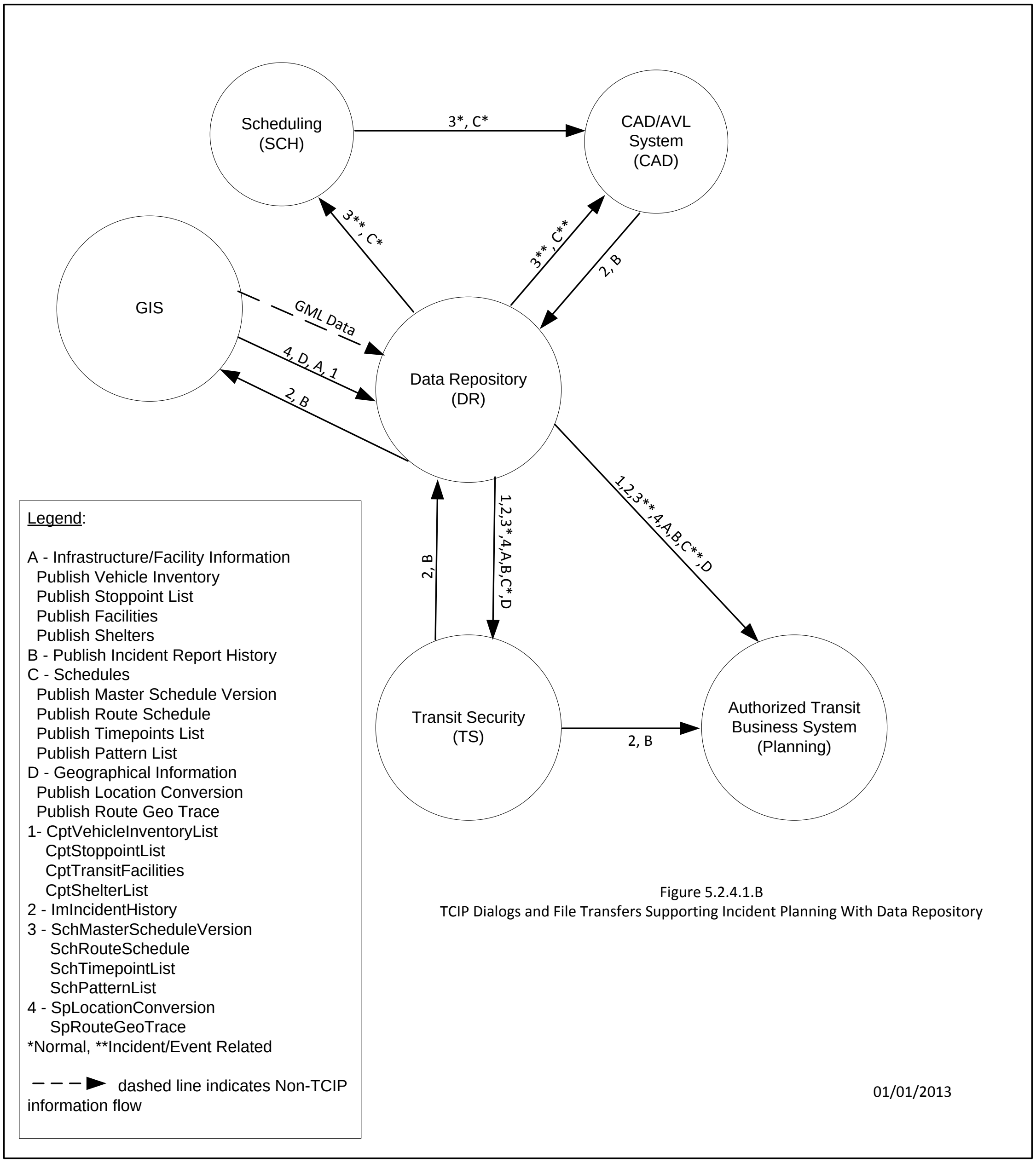


Figure 5.2.4.1.B
TCIP Dialogs and File Transfers Supporting Incident Planning With Data Repository

Figures 5.2.4.1 A&B depict the TCIP information transfers associated with incident planning. The Data Repository or other agency data store may provide infrastructure, past incident, schedule, and/or geographical information to an Authorized Business System used by planners. Alternatively, this information may be retrieved from other sources. The planners may modify schedules within the planning system(s), or alternative schedules may be developed using the Scheduling System. If events are planned for well in advance, then they can be associated with locally defined day-types. Since trips are associated in the schedule with day type(s) on which they are run, the designation of a day-type affect the trips scheduled for the day.

5.2.4.2 Security and Incident Management Process Preparation Stage

During the preparation stage the transit agency takes plans from the planning stage and implements actions to ensure the agency is ready to implement the plans. Activities in this stage include:

- Training - employees on plans and procedures which may include classroom training, drills, etc.
- Construction – including facility and infrastructure upgrades, hardening, installation of cameras, sensors and lighting, modification to PTVs etc.
- Stockpiling – Storing resources in locations where they will be needed in the event of an incident.

No TCIP information transfer requirements have been identified for the preparation stage of the Security and Incident Management Business Process.

5.2.4.3 Security and Incident Management Process Incident Detection, Classification, and Verification Stage

The prompt detection of incidents at the Transit Control Center is often one of the most critical factors in mounting an effective response. Detection occurs in a variety of ways including:

- Voice notifications by telephone or radio from an agency employee, customer or other agency.
- News feeds to the control center
- Data notifications from a variety of sources and methods
    - Incident Notifications from other agencies (transit, highway department, public safety, etc) governed by IEEE 1512
    - Traveler Alarms from stations/Stoppoints (TCIP Report Traveler Alarm dialog) based on activation at a stoppoint by a traveler.
    - Passenger Alarms onboard PTVs (TCIP Report Passenger Alarm dialog) based on an activation on the PTV by a passenger.
    - Operator Alarms from onboard PTVs (TCIP Report Operator Alarm dialog) based on a noncovert alarm activation by the operator.
    - Covert Alarms from onboard PTVs (TCIP Silent Alarm dialog) based on a covert alarm activation by the operator.
    - Health Alarms from onboard PTVs (TCIP Publish PTV Health Alarms dialog)
    - Farebox Alarms from onboard PTVs (TCIP Publish Fare Collection Health dialog)
    - Farebox Alarms from station/stoppoint based fare collection equipment (TCIP Publish Fare Collection Health dialog)
    - Incident Notifications from agency employees (TCIP Report Incident dialog).
    - A text or canned message from a PTV operator.
    - Observation of security cameras at a PTSF or on a PTV

Once the Control Center receives the notification, an incident report is created manually or automatically in the CAD/AVL System, Transit Security, Asset Management, and/or Operator Assignment System. Figure 5.2.4.3.A depicts some alternative the information flows for incident detection.

Each incident may be detected/reported by multiple sources and methods, and consequently different incidents may be opened in one or more business systems. When one or more initially reported incidents are consolidated under on incident identifier, the former independent incidents are termed subsumed-incidents. Generally the agency will designate one business system to have the responsibility to assign incident identifiers and to combine duplicate incidents into a single incident to be managed. While different agencies may choose different business systems for this purpose, this section assumes the CAD/AVL system performs this function.

Depending on the reporting source/method and the nature of the incident, transit agency policy may require that the incident be verified. The purpose of verification is to ensure that the incident is real and that the initial report is substantially correct. Note that details in the initial report may be difficult to corroborate early in the incident. One of the most common verification mechanisms is to have a transit supervisor or manager go to the incident location to inspect and report on the situation. Notifications of the incident (see section 5.2.4.4) are generally held up or strictly limited while a required verification is underway.

Classification of the incident also occurs in this stage. Classification may be performed by the reporter of the incident if the reporter is a trusted entity (e.g.,, supervisor), or classification may be performed in conjunction with verification of the incident if the source of the original report is suspect. During classification and verification, the geographical area affected may need to be determined (e.g.,, for a hazmat spill, public disturbance, major fire etc) and reported via an incident update. Similarly affected entities (agencies, responders, customers) may need to be identified. Figure 5.2.3.4.B illustrates alternative verification information flows.

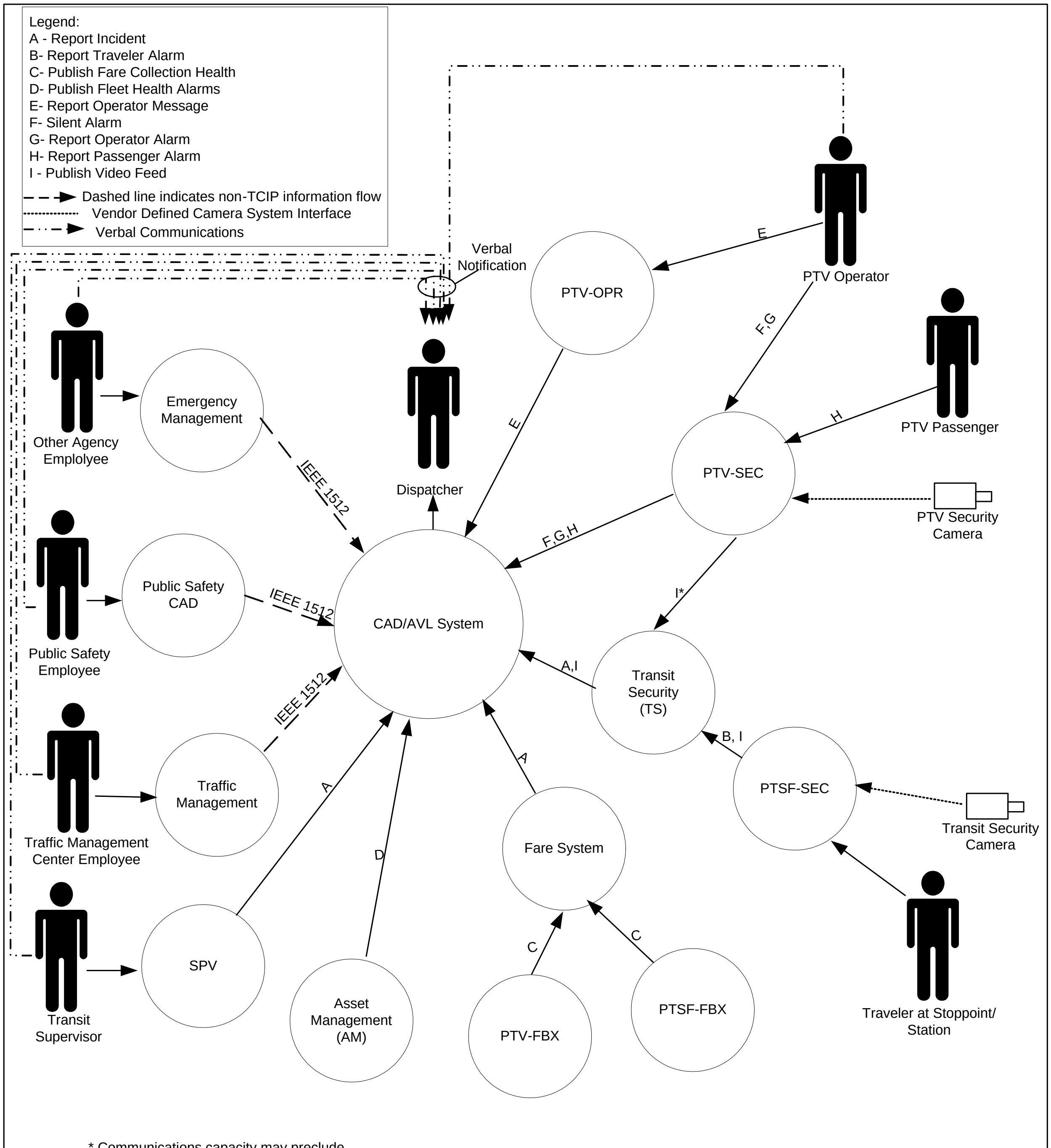


Figure 5.2.4.3.A
Incident Detection Dialog Flows

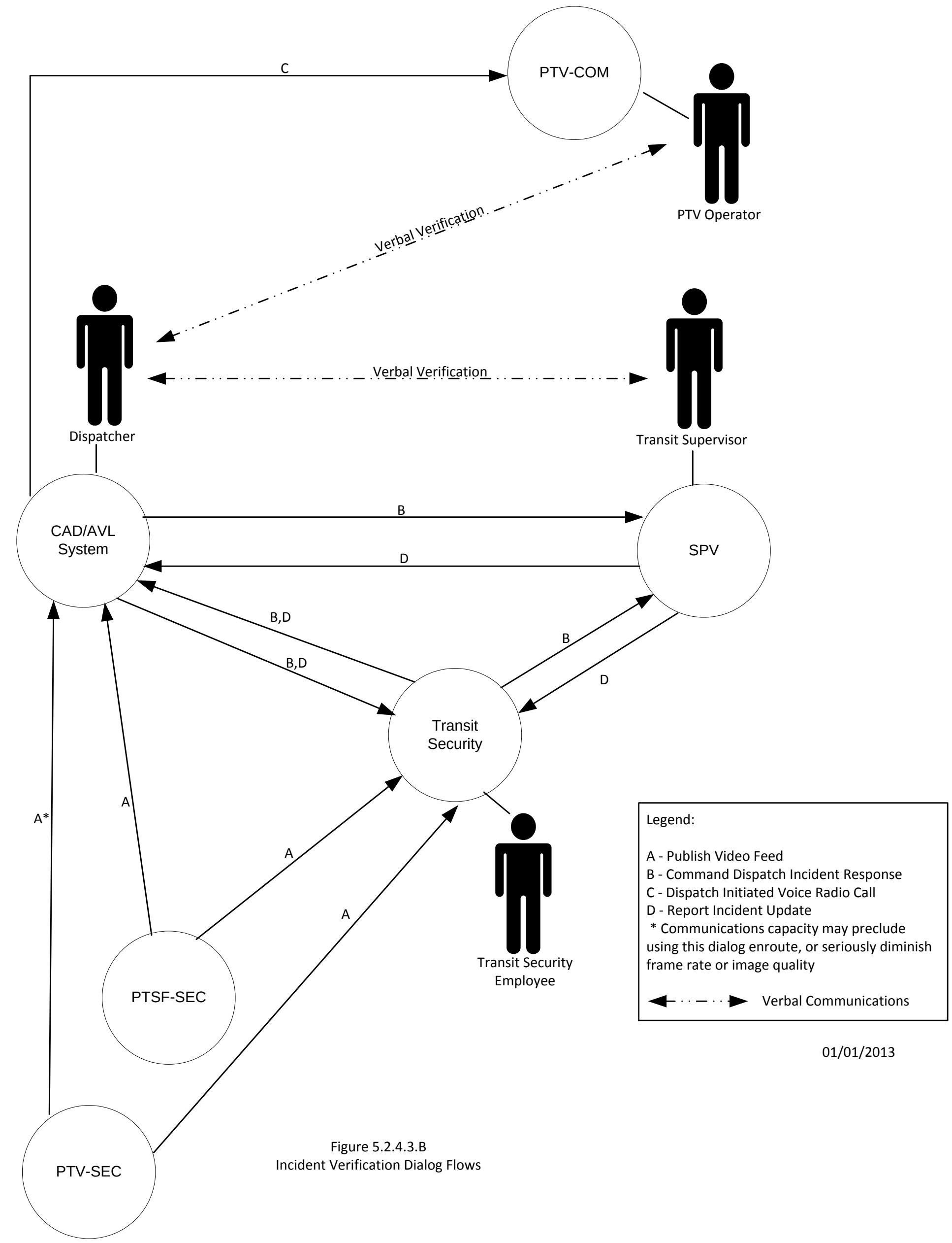


Figure 5.2.4.3.B
Incident Verification Dialog Flows

5.2.4.4 Security and Incident Management Process Notification Stage

Once an incident is reported to the control center, and verified if necessary, the notification stage begins. Various agencies use different approaches to the notification process, but for the purpose of discussion, we assume a verified incident is known to one of these 3 business systems:

- CAD/AVL System
- Transit Security
- Fare System

Planned incidents (e.g.,, major sporting, entertainment or political events) may be notified prior to the onset of the incident. In such cases the agency may begin ‘response’ type activities (e.g.,, pre-positioning PTVs, supervisors, etc.) prior to the incident affecting service.

As discussed in section 5.2.4.3, we assume, for illustrative purposes only, that in the example agency the CAD/AVL system is the central incident notification system. Accordingly incidents which are detected and verified in the Fare System or Transit Security are reported first to the CAD/AVL system and then reported on to additional business systems as appropriate. It is significant that some incidents within the agency are of no interest to other public agencies in the region (e.g.,, engine parameter fault on a PTV), while other incidents require wider notifications (e.g.,, PTV involved in a wreck). Similarly, some incidents may be reported to the public while others are not. In addition to the incident by incident decision to be made on whether to notify other agencies and the public, it is frequently necessary to filter or sanitize incident reports and updates that leave the agency’s control.

Agencies have a variety of different approaches to determining how widely incidents information will be disseminated. Some agencies have designated command center personnel who monitor activities and report appropriate information to Information Service Providers, media , and external agencies manually. Some agencies allow incident information to flow directly to public safety agencies filtered automatically by incident type.

Where incident detection, verification, notification and /or response activities rely heavily on business system to business system data communications, a keep-alive mechanism may be prudent so that the relevant business systems can continually verify that their counter part business system is ‘alive’. TCIP provides a dialog for this purpose “Publish Watchdog Timer”. This dialog is not shown in the information flow diagrams throughout this Concept of Operations, however agencies may elect to incorporate this dialog between business systems which need to be ‘alive’ at all times to respond to emergencies.

Figure 5.2.4.4 illustrates the use of TCIP and non TCIP information flows during the notification stage.

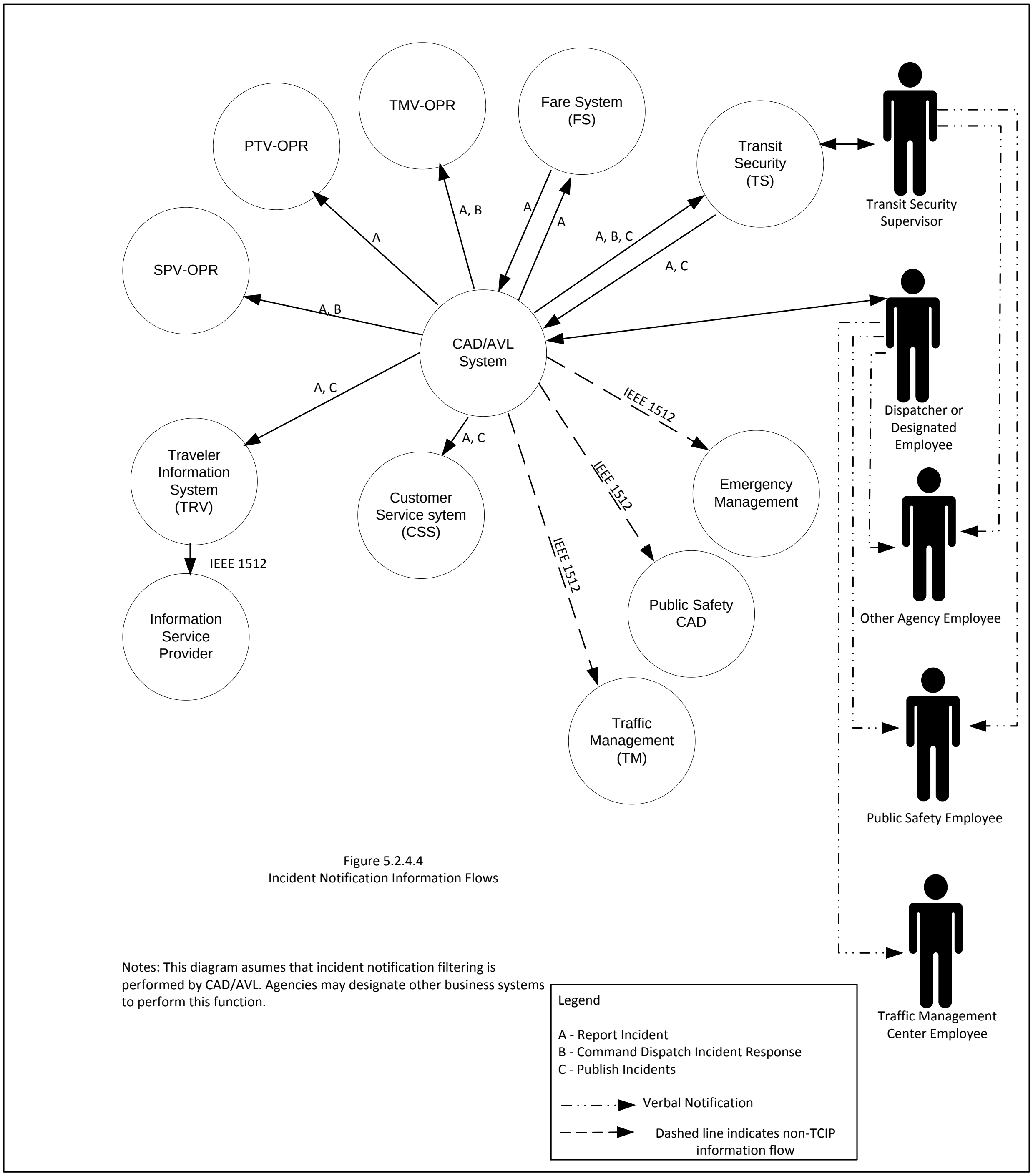


Figure 5.2.4.4
Incident Notification Information Flows

5.2.4.5 Security and Incident Management Process Response Stage

Once the incident is reported to the Control Center, the response stage is executed. In this stage resources are mobilized to resolve, clear and close an incident. During this stage, the Control Center may need to:

- Request/Provide assistance to/from external agencies

- Request/Provide status to/from external agencies
- View video images of events at the incident location
- Receive and distribute incident updates from/to transit employees
- Implement and cancel detours
- Exchange text messages with PTV Operator(s), Transit Supervisors, or Transit Maintenance Vehicle Operators
- Monitor covert audio from a stoppoint or PTV
- Clear/Cancel a silent alarm from a PTV
- Communicate by voice radio with PTV operators or other employees
- Change vehicle or operator assignments
- Dispatch agency responders to the incident (e.g.,, agency owned tow truck)
- Disable/Enable a PTV

The following subsections describe these processes.

5.2.4.5.1 External Agencies

Interactions with external agencies may be by voice (radio or telephone) or by data. Voice communications are based on local or regionally developed plans and procedures. Standardized interagency data exchanges to manage incidents are defined by IEEE 1512. Response stage information flows with external agencies are illustrated in figure 5.2.4.5.1.

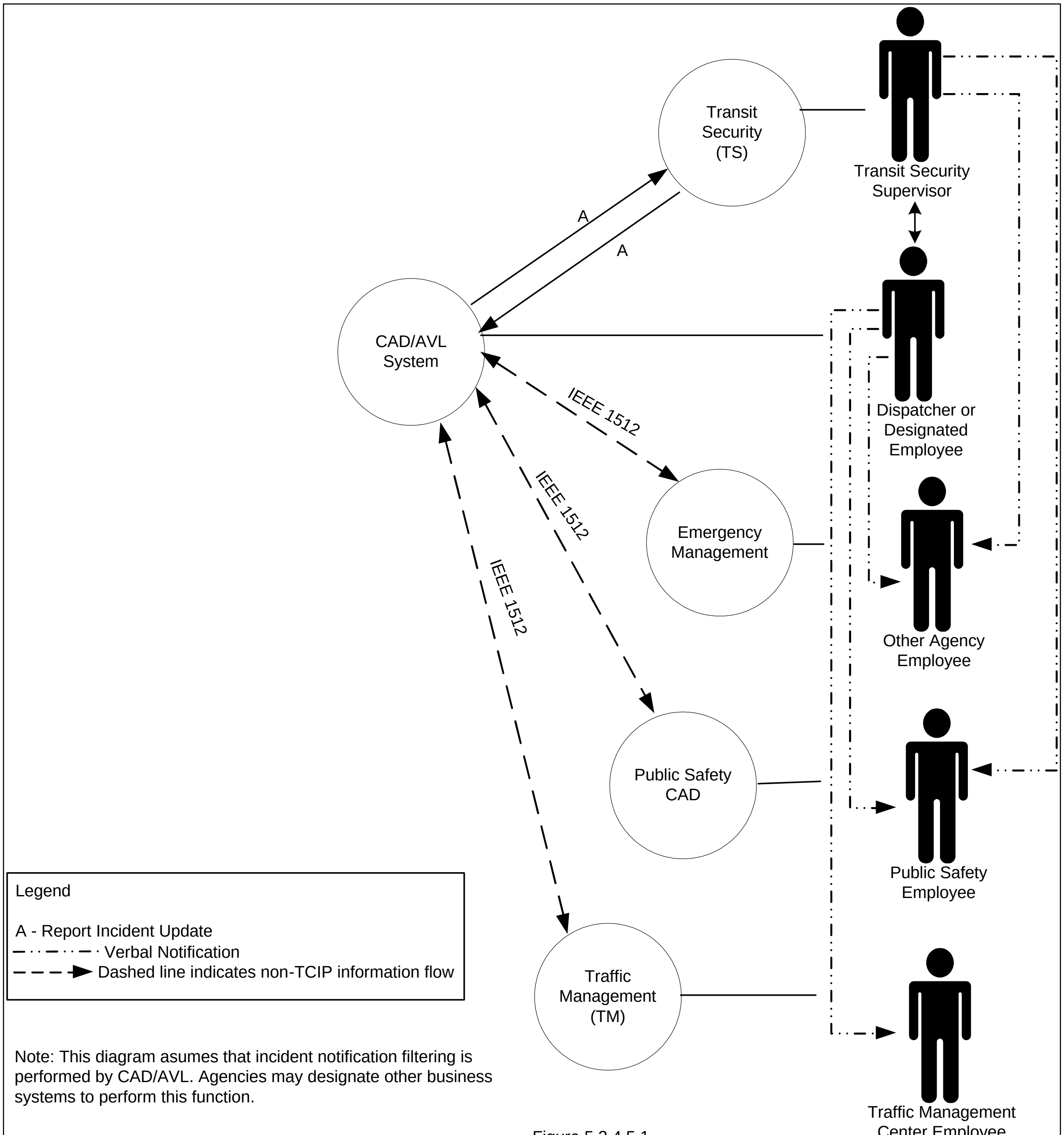


Figure 5.2.4.5.1
Incident Response Stage Information Flows with External Agencies

5.2.4.5.2 View Video Images at the Incident Location

If the infrastructure (communications, bandwidth, and cameras) is in place, the authorized employees may be able to view near-real-time video imagery from the incident scene. It may be possible to present current images from a selected camera or past images (e.g.,, back up to the incidents occurrence) from a PTV or PTSF. The Publish Video Feed dialog supports this capability, as illustrated in figure 5.2.4.5.2.

Agencies may elect to share incident video with external agencies. IEEE 1512 provides the ability to provide a URL to allow an authorized external agency to view agency video from an incident location. Transit Security may authorize such video sharing and may terminate the authorization at any time.

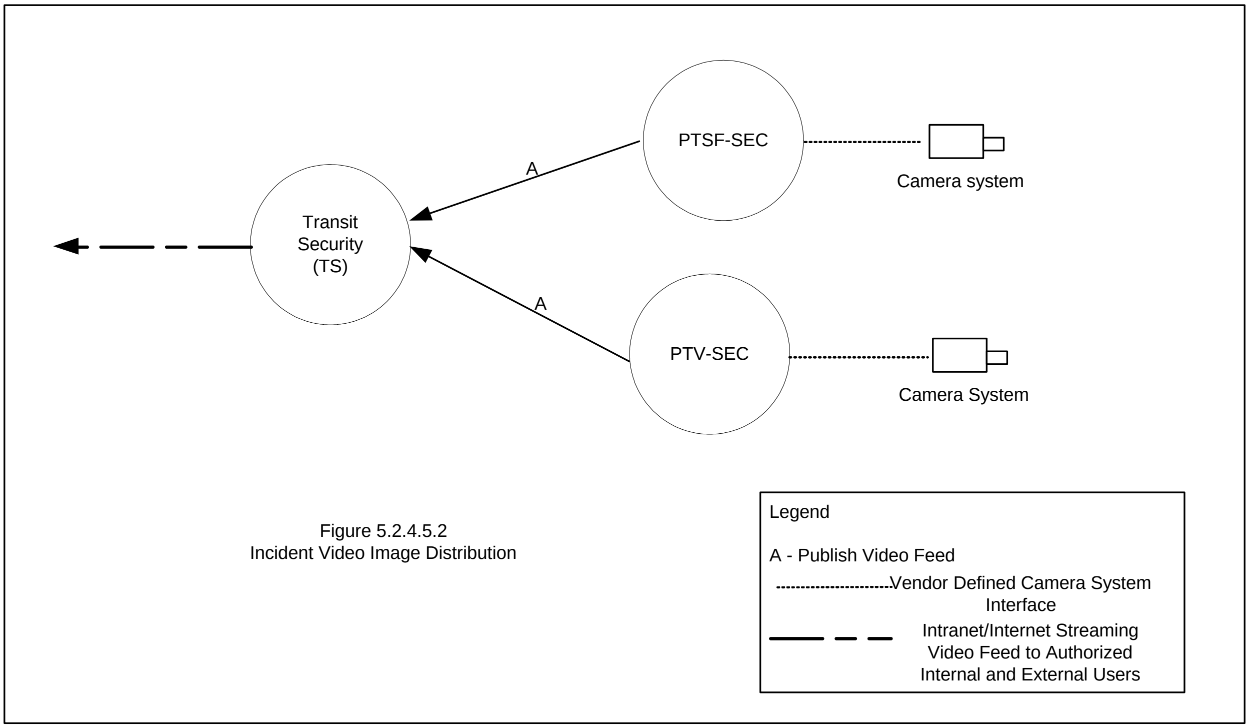


Figure 5.2.4.5.2
Incident Video Image Distribution

5.2.4.5.3 Receiving and Distributing Incident Updates

As the incident progresses, verbal and/or data updates arrive at the control center. Agencies designate an appropriate business system to filter and distribute these updates. Here for discussion purposes, the CAD/AVL system is assumed. Updates are provided to the designated business system which then distributes them to authorized subscribers. Figure 5.2.4.5.3.A depicts the reporting of an incident update. Figure 5.2.4.5.3.B depicts the distribution of the update within the agency.

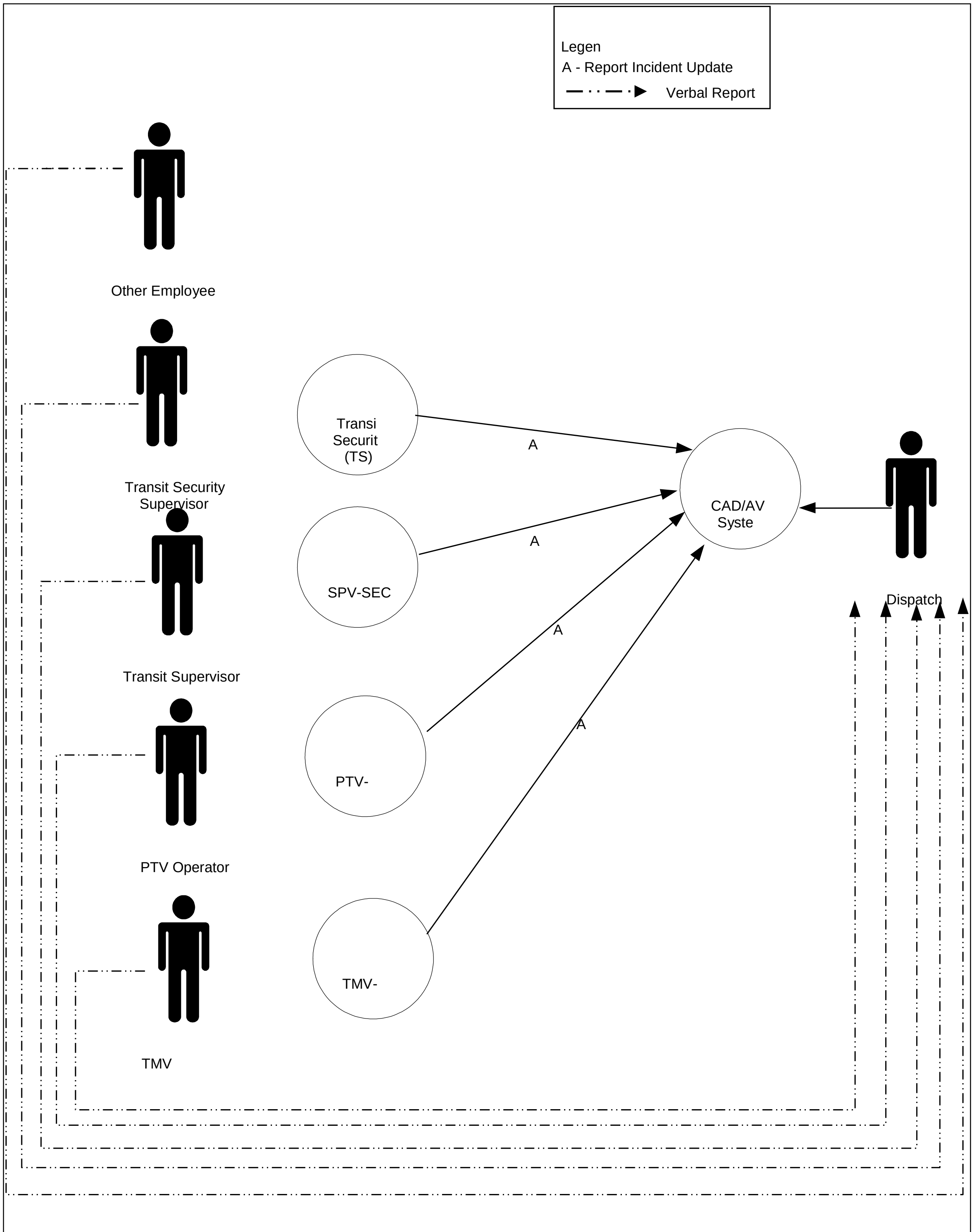


Figure 5.2.4.5.3.A
Incident Update Reporting Within the Transit Agency

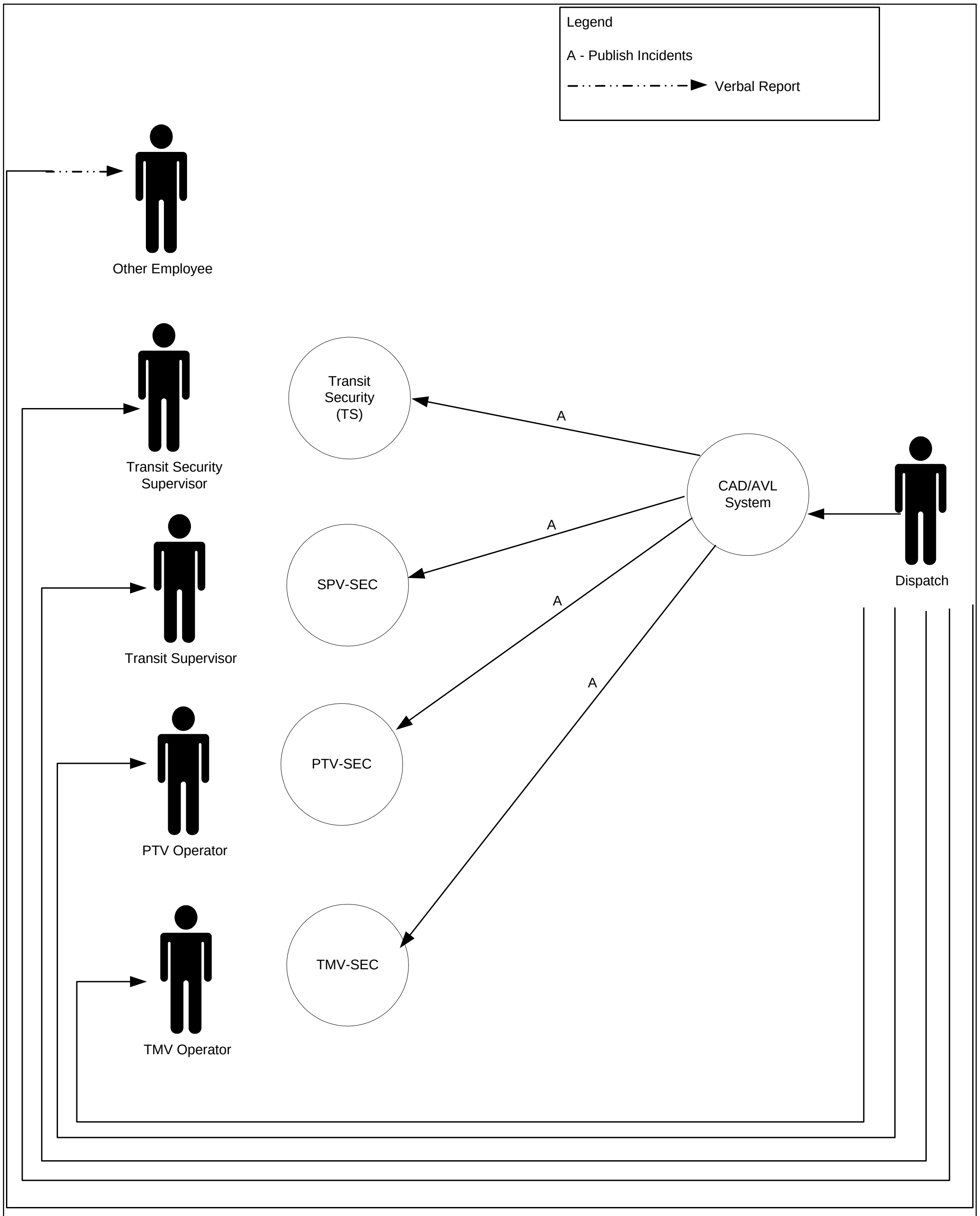


Figure 5.2.4.5.3.B
Incident Update Distribution Within the Transit Agency

5.2.4.5.4 Implement and Cancel Detours

Depending upon the type and nature of the incident, it may be necessary to detour a PTV (or all PTVs on a route) from their normal path.

For detours on long notice, such as a major sporting event, or long duration, such as a major construction project, bus stop and time point data may be updated as follows. After the dispatcher enters the appropriate information into the CAD/AVL System, the Report Detour dialog transfers the detour to the PTV. The Report Detour dialog provides the following features:

- Ability to define way points along the detour
- Ability to add and delete timepoints and stoppoints to/from the trip
- Ability to change PTV's scheduled timepoint arrival times beyond the detour
- Ability to change the PTV's destination sign approaching and on the detour

When the detour is no longer required, the dispatcher enters the appropriate information into the CAD/AVL System and the Report Cancel Detour dialog conveys it to the impacted PTV(s).

For detours of short notice, such as an unplanned street closure, or short duration, such as a brief phase of a construction project, revision of bus stop and time point data is unlikely to be feasible. Transit agencies must fall back on simpler, exception based means of informing drivers and passengers. These include voice radio communication, notices posted at transit garages, payroll exception forms to account for delays, notices posted at bus stops, transit web site messages, and e-mail notification of subscribing customers that a detour is in effect.

The implementation and cancellation of long duration detours is illustrated in Figure 5.2.4.5.4.

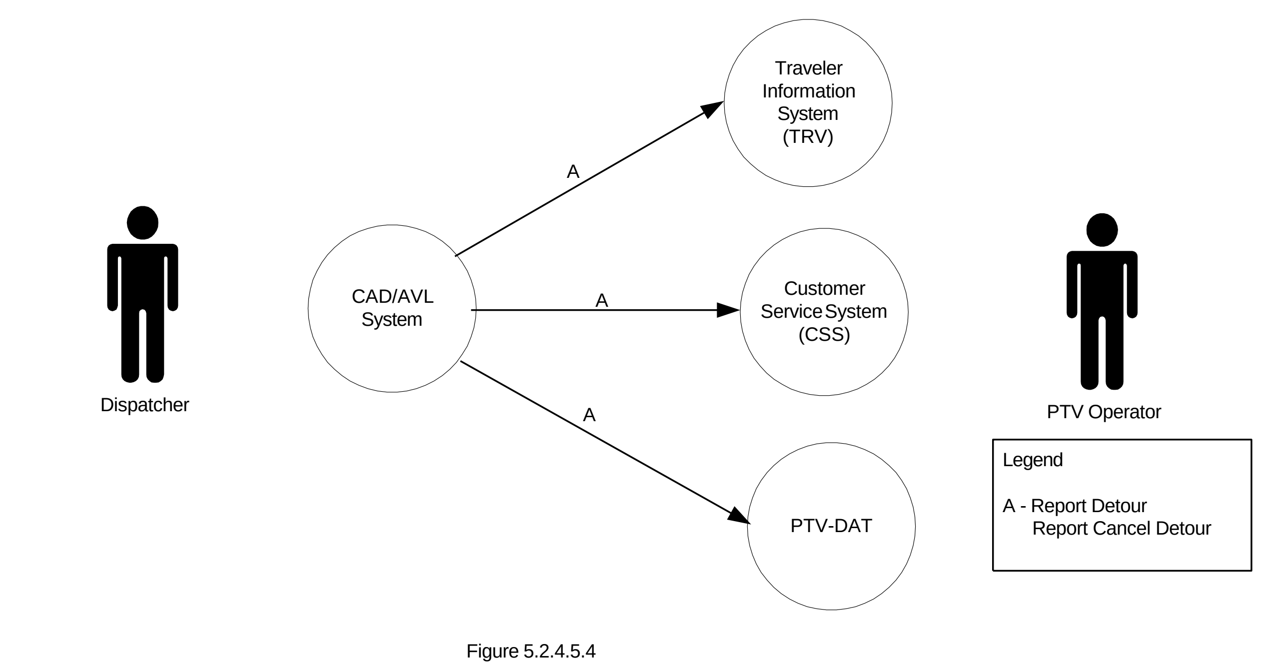


Figure 5.2.4.5.4
Implementing and Cancelling Detours

5.2.4.5.5 Exchange Text Messages

TCIP provides the capability for PTV Operators, Supervisors, TMV Operators, and Dispatchers to exchange canned and/or freeform text messages. This ability allows a dispatcher to provide instructions on how to respond to the incident to operators, and for operators to provide incident status or other information to the dispatcher without tying up the voice radio. These capabilities are provided by the Report Dispatcher Message and Report Operator Message dialogs, as illustrated in Figure 5.2.4.5.5.

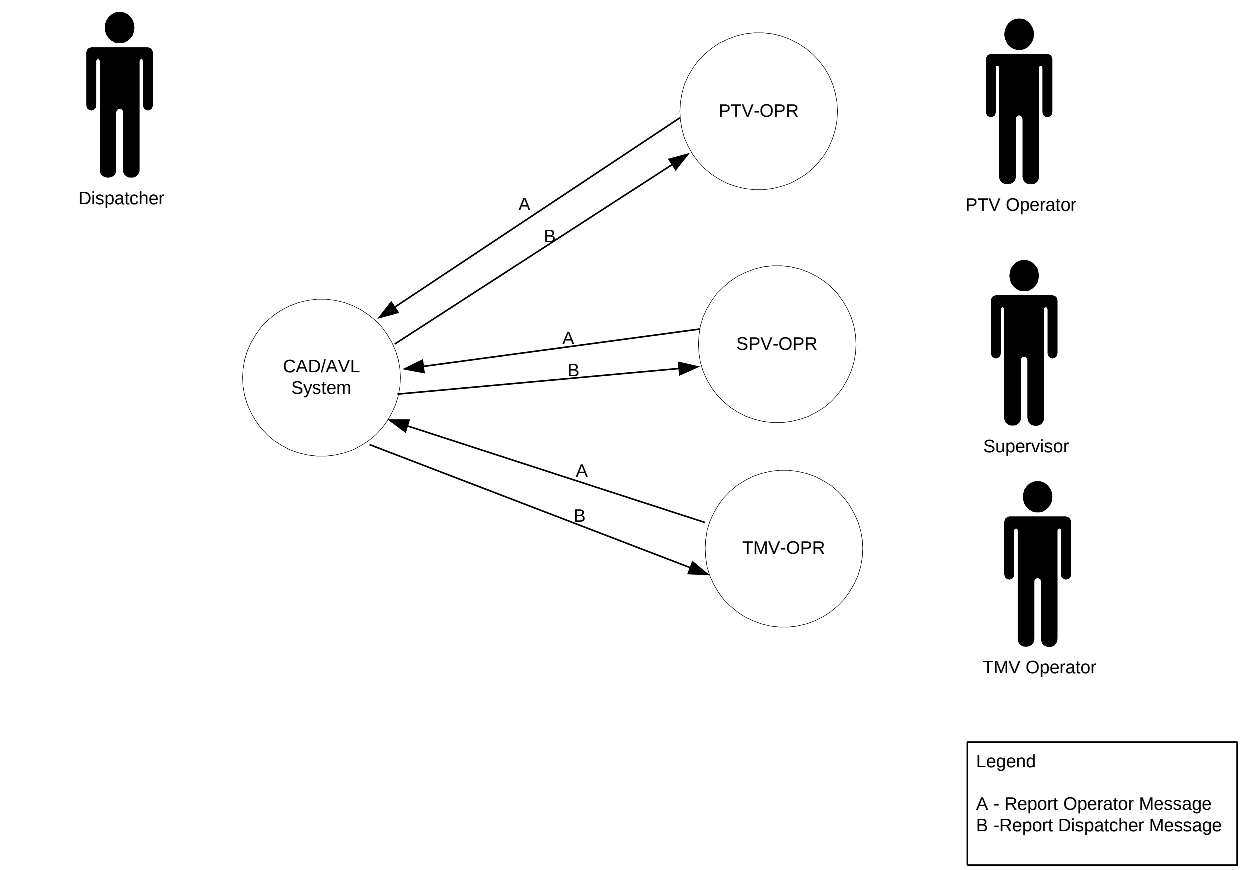


Figure 5.2.4.5.5
Text Message Exchanges Between Dispatchers, Supervisors, and Operators

5.2.4.5.6 Monitor and Cancel Silent Alarms

On appropriately equipped PTVs, the PTV operator can actuate a covert ("silent") alarm. This provides a notification to the dispatcher, and an acknowledgement back to the driver. In some agencies the acknowledgement is generated by the CAD/AVL System as soon as the alarm is received, on other agencies, the acknowledgement is withheld until the dispatcher indicates to the CAD/AVL System that he has seen the alarm. After the alarm is activated, the dispatcher maybe able to monitor events on the PTV using a covert microphone and an audio feed over the voice radio. At some point the operator indicates that the incident is over and cancels the alarm. The alarm remains active however, until the dispatcher confirms the incident closure.

5.2.4.5.7 Voice Communications between Dispatchers and PTV Operators

In the course of an incident it is frequently necessary for the dispatcher and PTV operator to converse on the voice radio. On many agencies a shared voice/data radio is used. Voice Communications can be initiated by either the Dispatcher or the PTV operator, and the PTV Operator may indicate that the need to communicate is urgent. In any case the Dispatcher (through the CAD/AVL System) has the ultimate control over which PTV operators are allowed to enter into voice conversations.

These capabilities are provided by the "Operator-Initiated Voice Radio Call" dialog and the "Dispatcher Initiated Voice Radio Call" dialog.

5.2.4.5.8 Change Vehicle or Operator Assignments

Incidents may force an agency to re-plan its operator and vehicle assignments or to change the trips assigned to a vehicle/operator pair. The changes may be entered by the maintenance or operations supervisors in the garage or the dispatcher may enter these changes into the CAD/AVL System. The "Command Load PTV Trips" dialog and/or the "Command Change Assignments" dialog transfer the new instructions to the PTV. Figure 5.2.4.5.8 depicts these interactions.

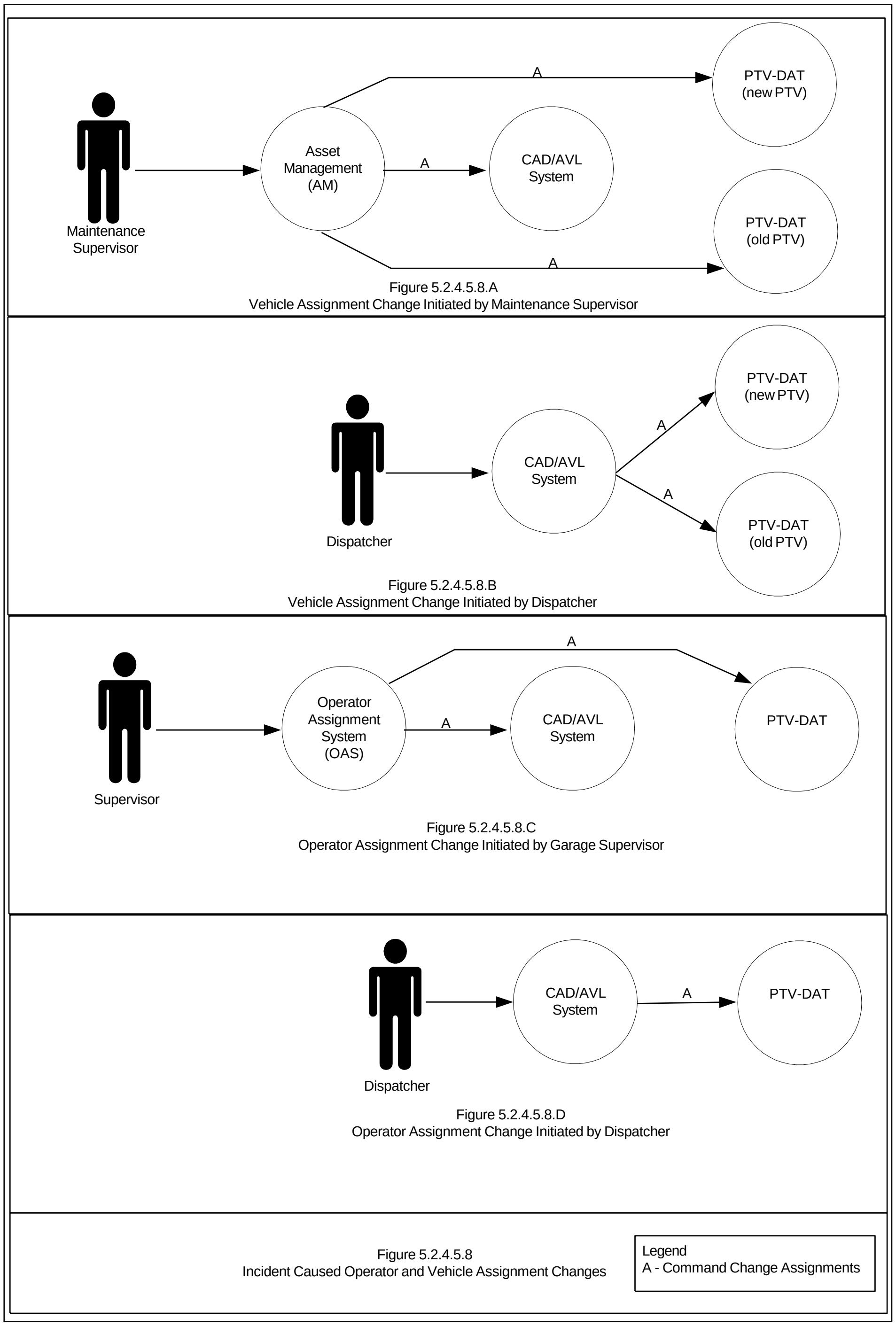


Figure 5.2.4.5.8.A
Vehicle Assignment Change Initiated by Maintenance Supervisor

Figure 5.2.4.5.8.B
Vehicle Assignment Change Initiated by Dispatcher

Figure 5.2.4.5.8.C
Operator Assignment Change Initiated by Garage Supervisor

Figure 5.2.4.5.8.D
Operator Assignment Change Initiated by Dispatcher

Figure 5.2.4.5.8
Incident Caused Operator and Vehicle Assignment Changes

5.2.4.5.9 Dispatch Agency Responders

The dispatcher, upon determining that agency responders are required at an incident location, requests or directs appropriate agency assets to the site. The “Command Dispatch Incident Response” dialog may be used to direct responders, or this may be done via voice communications, email, or using other agency-specified means. Figure 5.2.4.5.9 illustrates alternative scenarios for dispatching transit responders.

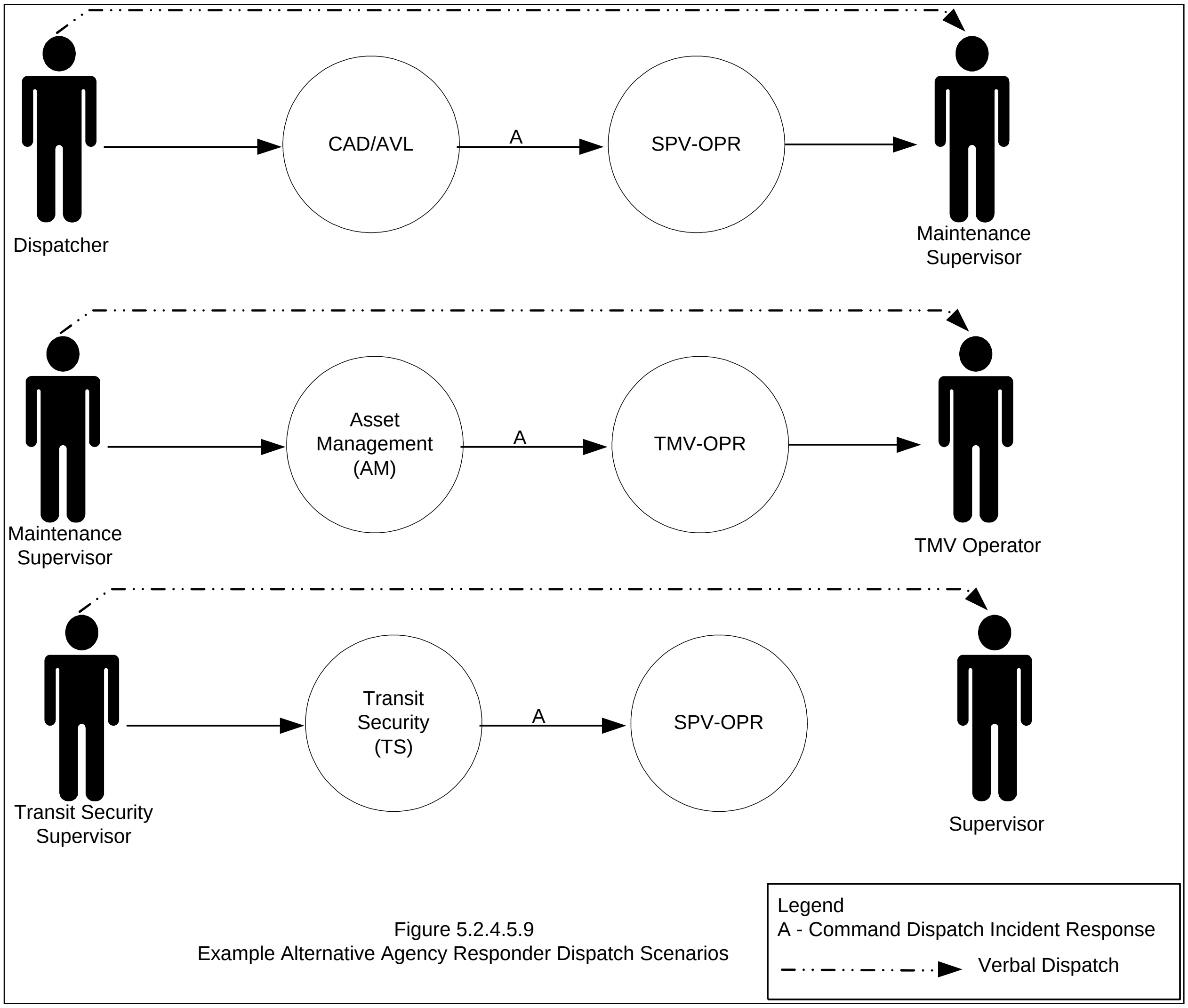


Figure 5.2.4.5.9
Example Alternative Agency Responder Dispatch Scenarios

5.2.4.5.10 Disable a PTV

In some severe circumstances (e.g.,, hijacking), a dispatcher may enter a command into the CAD/AVL System to disable an appropriately equipped PTV. The dialog “Command Remote PTV Disable” conveys the command to the PTV. Enable/Disable commands require a key code to be accepted by the PTV. Agencies may require that the dispatcher’s supervisor approve disabling a PTV due to numerous safety and liability issues involved. Figure 5.2.4.5.10 depicts this scenario.

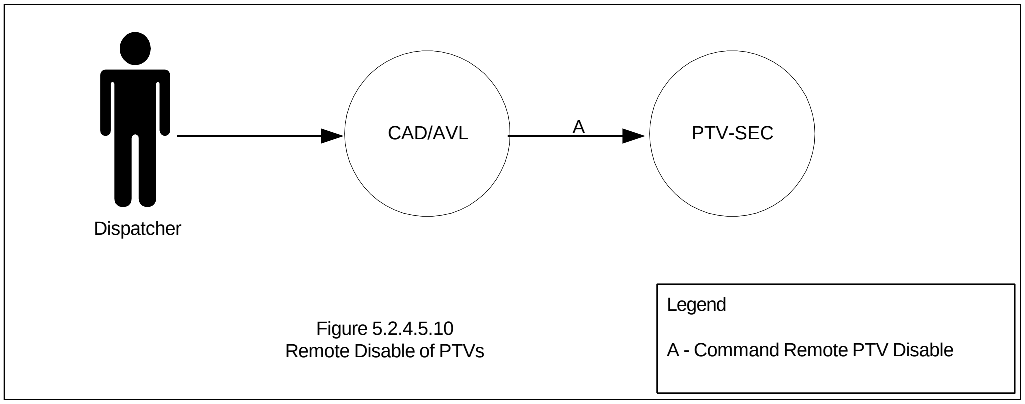


Figure 5.2.4.5.10
Remote Disable of PTVs

5.2.4.5.11 Cancel Trips

An agency may cancel scheduled trips in response to a planned or unplanned incident. Section 5.3.4.3.4 illustrates a trip cancellation scenario.

5.2.4.6 Security and Incident Management Process Recovery Stage

In the recovery stage, the transit agency clears the incident and performs efforts necessary to return to normal service operations. These efforts can be negligible or extensive depending on the nature of the incident and its long term effects.

In the case of an incident involving a single PTV (e.g.,, breakdown, criminal act, accident) the agency may be able to dispatch another PTV and driver to resume the block/run beginning with the next scheduled trip for that PTV. The agency then determines what should be done about the passengers that were riding (or waiting for) the affected PTV. The agency may elect to do nothing and let the next following PTV on the same route pick up the extra passengers, or may dispatch a PTV to fill in the gap.

In the case of an incident resulting in the loss of access to a street, bridge out etc., the agency may be obliged to execute a detour in the short run. The agency may elect to republish the schedule if the outage is long term. Republishing the schedule could impact numerous business systems used for operations, customer service, traveler information etc. It could also cause the agency to republish timetables and other materials describing the affected route.

Figure 5.2.4.6 depicts the canceling of detours and re-enabling a PTV disabled during the response stage.

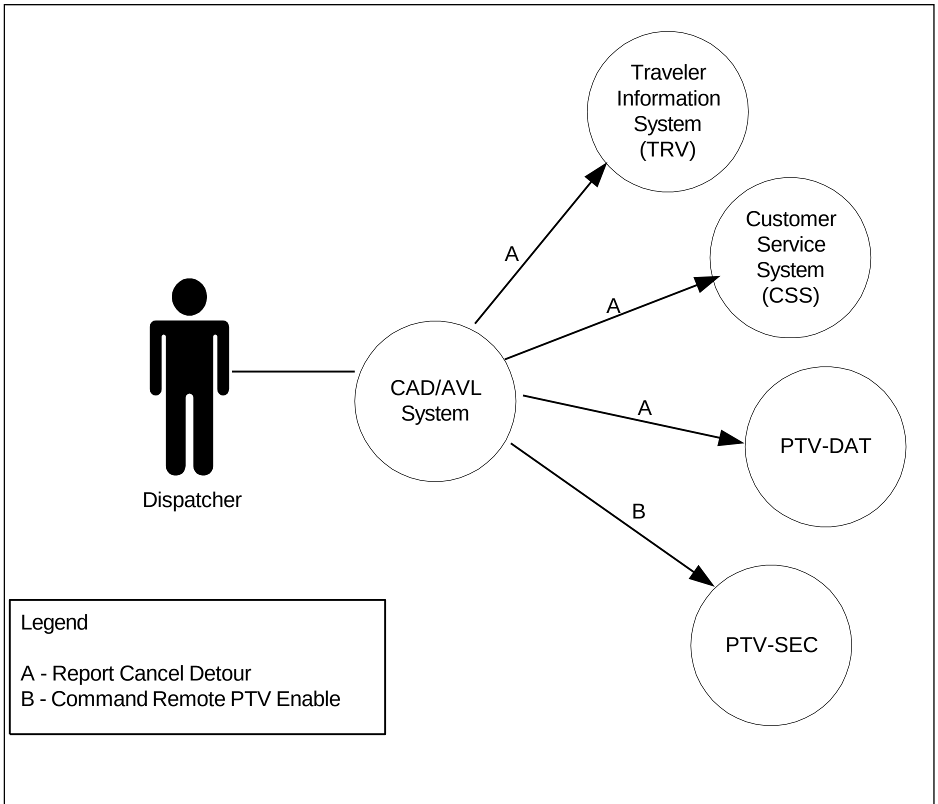


Figure 5.2.4.6
Cancelling Detours and Re-enabling PTVs During Incident Recovery

5.2.4.7 Security and Incident Management Process Follow Up Stage

After an incident is cleared, additional follow-up efforts may be required. Depending upon the type of the incident it may be necessary to gather evidence for a criminal trial, and/or to recreate elements of the incident and the response to the incident as an input into future incident planning.

Video information is captured by cameras installed on PTVs and in PTSFs. This information is periodically unloaded to an archive or data store. During the follow up phase, these images may be retrieved for evaluation or use as evidence.

Business systems create log files of events as they transpire and these log files may provide useful information for recreating or evaluating incidents. Business system log files are not standardized by TCIP.

PTVs maintain logs of operating events while operating and this information is unloaded periodically to a data store or archive. During the follow up phase, these records may be retrieved for evaluation or used as evidence.

Closure of the incident occurs when all follow up actions are completed by all affected departments. Individual departments may send updates reflecting that the incident is closed from their point of view, however operations normally keeps the incident open until all affected departments indicate they are finished with their follow up actions.

Figures 5.2.4.7.A&B illustrate follow-up data collection scenarios with and without a data repository.

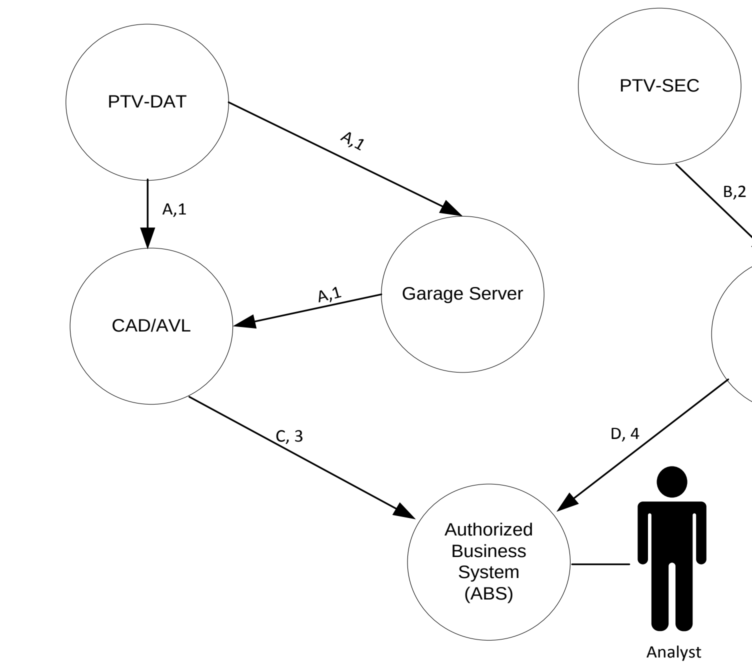


Figure 5.2.4.7.A
Incident Data Collection During Follow Up Without Data Repository

Legend

A - Unload PTV Performance Data
B - Unload Video Images
C - Publish Daily Operating Data
D - Publish Video Images

1 - CcPTVPerformanceData
2 – CcUnloadImages
3 – CcOperatingData
4 - CcVideoImages

01/01/2013

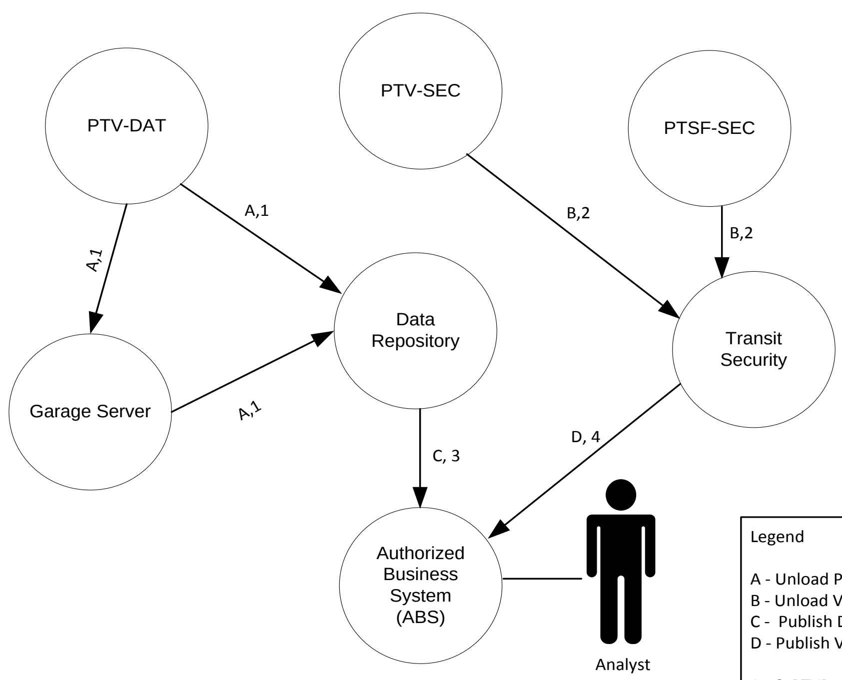


Figure 5.2.4.7.B
Incident Data Collection During Follow Up With Data Repository

Legend

A - Unload PTV Performance Data
B - Unload Video Images
C - Publish Daily Operating Data
D - Publish Video Images

1 - CcPTVPerformanceData
2 – CcUnloadImages
3 – CcOperatingData
4 - CcVideoImages

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5.3 PTV Operations Process

5.3.1 Purpose

The manage PTV Operations business process is the core of the transit business, and the most complex of the business processes defined in TCIP. This process encompasses the actual preparation for service, operations in revenue, training, or ferry service, and the return to base for turnaround. The fundamental purpose of this business process is to transport transit customers.

5.3.2 Overview of PTV Operations Process

The major phases of this business process are:

- Preparation for Vehicle Operations
- Vehicle Operations
- Exceptions to Normal Operations
- Close-Out of Vehicle Operations

The Key organizational participants in this process are:

- Maintenance (Asset Management) who determine what vehicles are ready for service and control the assignment of vehicles to blocks of work.
- Operating Supervisors – who ensure that the pull outs occur in a timely manner, that service is running smoothly and procedures are followed, and who respond to various incidents and exception conditions.
- Dispatchers – who monitor service status and make adjustments based on events in real time throughout the day.

Challenges and constraints associated with this process include the perturbations introduced to smooth service delivery by traffic, incidents, late or sick operators, mechanical failures and other events. The dynamics of PTV movements especially on arterial streets can lead to “bus bunching” whereby PTVs operating on a route become unevenly spaced in time leading to poor service. This problem is most severe with bus service, but can occur with light and heavy rail service as well.

5.3.3 Primary Architecture Components

The key model architecture components related to the PTV Operations Process are:

- PTV onboard entities – performs functions on PTVs
  - PTV-ADH The logical entity on a public transit vehicle responsible for monitoring and reporting schedule and route adherence.
  - PTV-ANN The logical entity on a public transit vehicle responsible for providing information to passengers including announcements.
  - PTV-COM The logical entity on a public transit vehicle that manages the communications links between the PTV and outside entities.
  - PTV-DAT The logical entity on a public transit vehicle responsible for data management (within the Vehicle Logic Unit).
  - PTV-ECU The logical entity on a public transit vehicle associated with the engine control unit.
  - PTV-HEL The logical entity on a public transit vehicle responsible for monitoring and reporting on the health of the PTV and its onboard components.
  - PTV-LDS The logical entity on a public transit vehicle associated with the Location Data Source.
  - PTV-LOC The logical entity on a public transit vehicle responsible for monitoring and reporting the vehicle’s location.
  - PTV-OPR The logical entity on a public transit vehicle associated with interactions with the vehicle operator.
  - PTV-OTH Any agency-defined logical entity onboard a public transit vehicle. This entity’s functions are not defined by the Model Architecture.

- PTV-PAS A logical entity onboard a PTV responsible for monitoring and reporting passenger boarding/alighting.
- PTV-PRI A logical entity onboard a PTV responsible for managing transit signal priority functions, including the generation of priority requests.
- PTV-SEC A logical entity onboard a PTV responsible for managing security

- CAD/AVL – Manage PTVs in-service
- Asset Management (AM) – Get PTVs ready for service
- Operator Assignment System (OAS) – Ensure PTV share operators
- Garage Server (GS) – Load/unload PTV data files

5.3.4 PTV Operations Subprocesses

5.3.4.1 Preparation for Vehicle Operations

This section describes the process of getting a PTV prepared for operations. Although preparation for operation in revenue service is emphasized, most of this discussion is applicable to trips made for training, ferrying of PTVs, and maintenance as well.

5.3.4.1.1 Data Loading

The data loading process can occur at any time when the PTV is located within WLAN coverage or connected to a laptop to other loading device. Most commonly, loads occur when the vehicle returns after completion of a block of work and enters WLAN coverage, or upon power-up of the vehicle electronics. In either case the load pattern-based dialogs provide for the onboard logical entities to contact a designated fixed business system (usually the Garage Server [GS]) and determine if there are files to load. Figures 5.3.4.1.1.A, B & C depict this process.

These data loads include the following items (if required):

- Software (for any onboard components)
- Configuration Data (for any onboard components)
- Fare Data (to PTV-FBX)
- Schedule Data including trips, timepoints, stoppoints, link-maps, patterns
- Operator and Vehicle Assignments which may be for the whole fleet, a subset, or the single PTV being loaded
- Announcement Information (contains announcements, and destination sign contents for PTV-ANN)
- Canned Message Texts to support efficient operator-dispatcher messaging
- Transit Signal Priority Business Rules (Not all PTVs are TSP-capable)
- Alarm Limits and other Parameters and Thresholds
- GIS Map Data. Not all agencies use onboard map data, and the data's geographical scope may not cover all of the PTV operating area.

The Garage Server (GS), Garage Revenue Server (GRS) or other business system designated by the agency, may or may not load the same files to all PTVs. The loads to the GS may specify that they are applicable to only certain PTVs or to certain PTV groups. PTV groups are defined and maintained by Asset Management (AM). The GS and GRS ensure that the correct version and updates are loaded to each PTV.

Although not shown in Figure 5.3.4.1.1, other business systems may subscribe to fleet group definitions. Groups within the fleet may be defined based on the garage, vehicle type, brand/model of VLU, farebox, annunciator etc. Groups are not required to be mutually exclusive, thus an agency can define a group of PTVs with brand X farebox, a group with brand Y farebox, a group with brand A VLU and a group with brand B VLU. A single vehicle might then belong (simultaneously) to groups A and X.

Some load dialogs permit a portion of a file to be updated without loading a new file version. Generally, these dialogs load files that contain a list of data frames (rows) that can be updated individually. The file load messages associated with row-updatable load files contain provisions to delete outdated rows, add new rows or replace existing rows. Row updating can significantly impact the time and communications capacity required to perform file loads to a PTV. Consult individual load dialog specifications in Annex D for information on which files are row-updatable.

The Garage Server (GS), and/or the Garage Revenue Server (GRS) may provide an alarm and or monitoring capability to allow the supervisor to ensure that PTVs that do not have the correct data loads are not allowed to pull out. Based on agency policies, PTVs may be allowed to pull out with outdated data loads, if the operators have been given special instructions or other agency specific procedures are followed.

The VLU may report an invalid schedule load (see section 5.5). The farebox may report an invalid fare set being loaded (see section 5.4). Agency procedures govern the handling of these situations. Note that either the GIS or the Data Repository may be responsible for loading GIS data to the Garage Server.

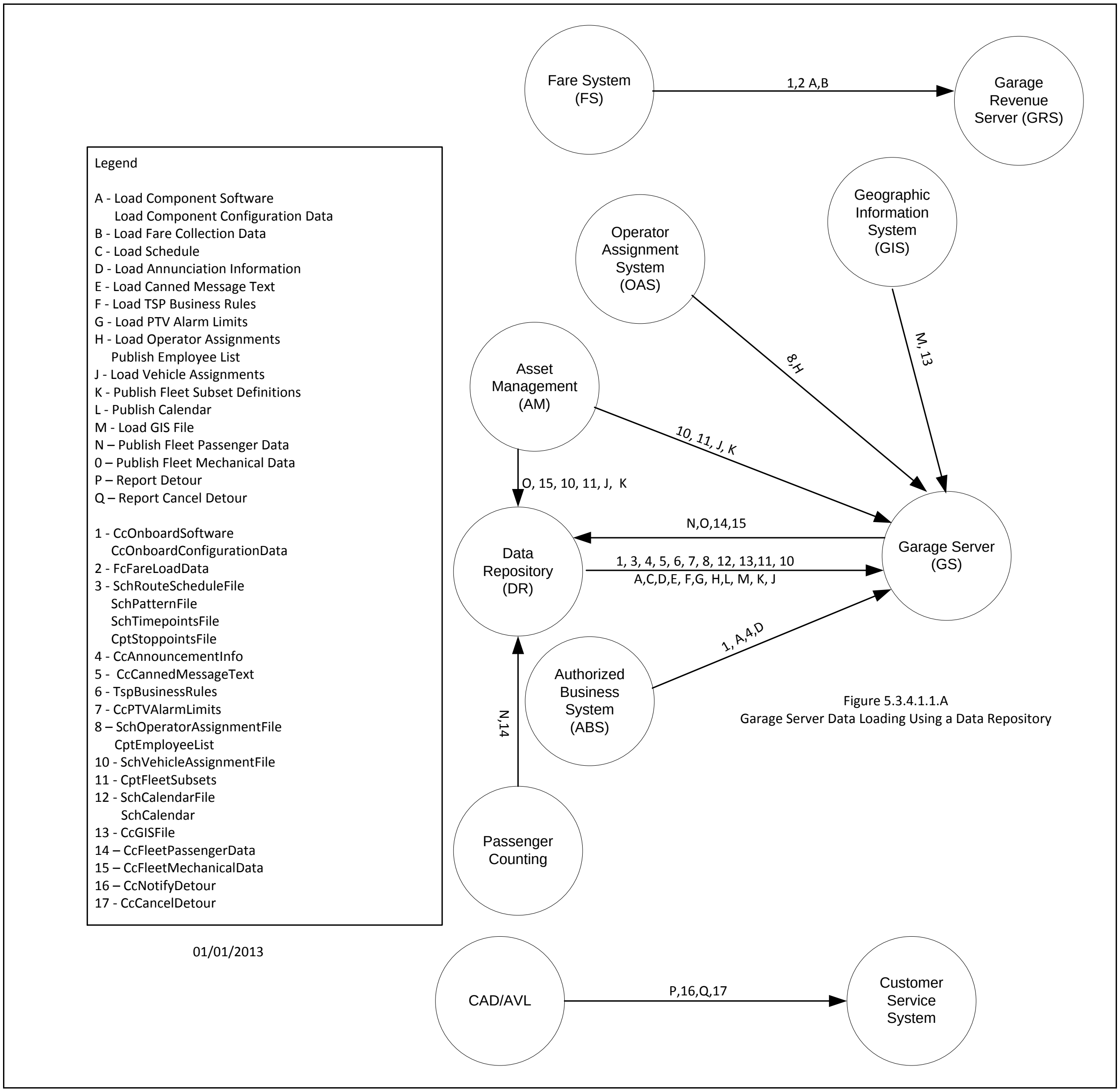


Figure 5.3.4.1.1.A
Garage Server Data Loading Using a Data Repository

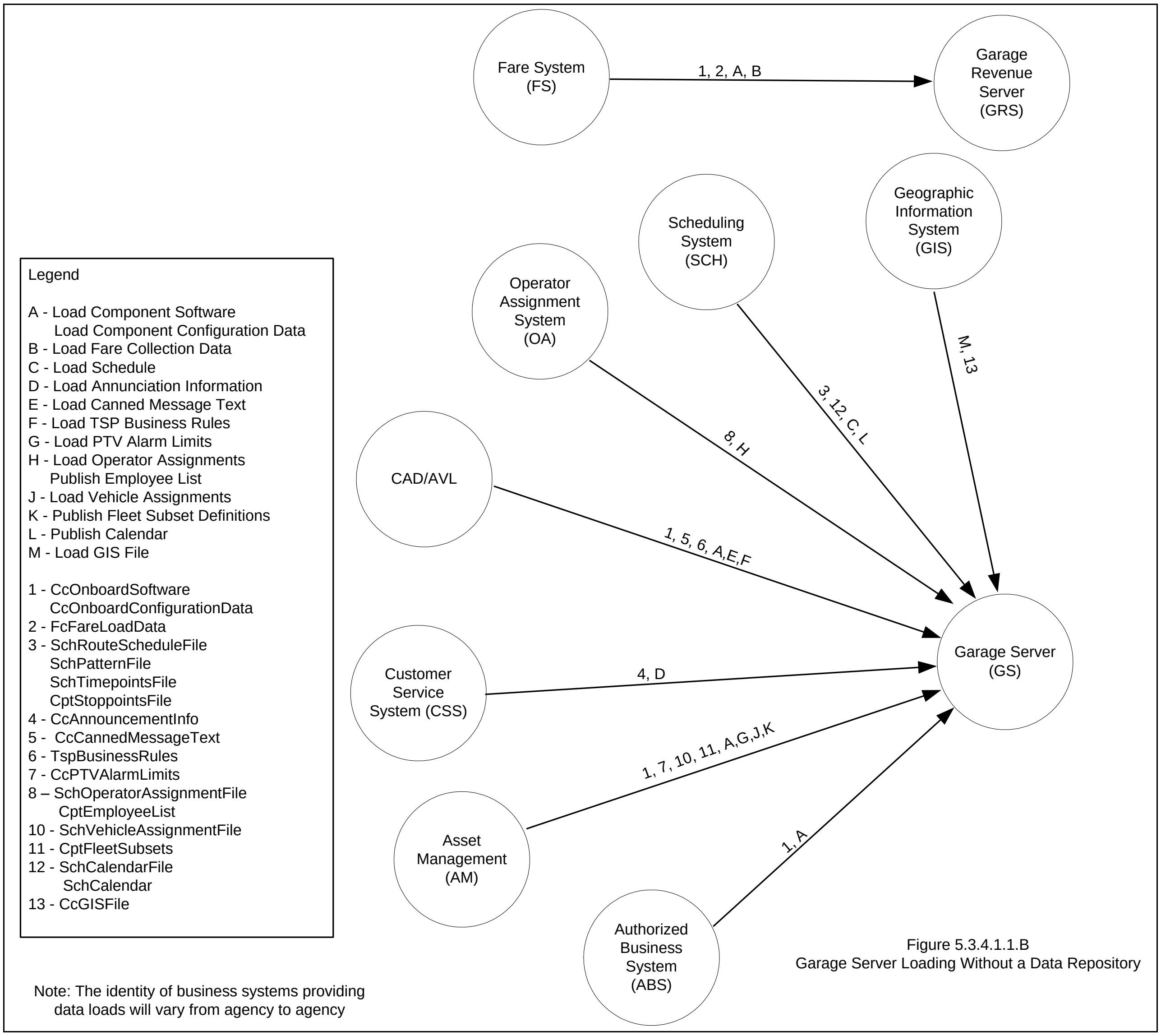
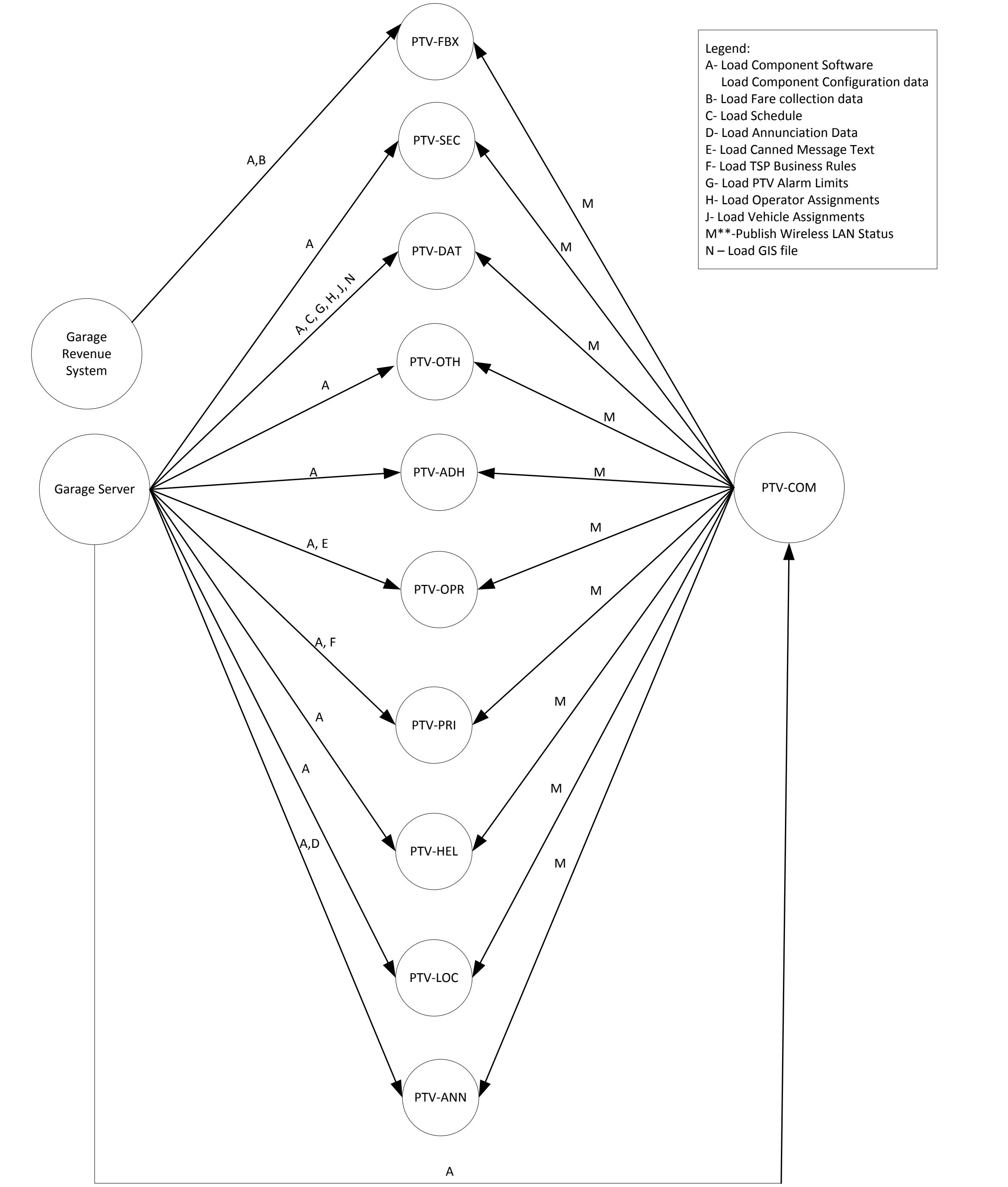


Figure 5.3.4.1.1.B
Garage Server Loading Without a Data Repository



* Any logical entity on the PTV backed with software and/or configuration data using these dialogs
**Any logical entity on the PTV may detect WLAN status using this flow

Fig 5.3.4.1.1.C
PTV Data Wading During the preparation for Vehicle Operations Stage using a Garage Server 01/01/2013

5.3.4.1.2 Vehicle Startup

The PTV Operator starts the vehicle electronics and the PTV's engine. This triggers one or more instances of the Report Start Up Dialog. The PTV electronics run self diagnostics upon startup, which may include verification of the annunciator, engine/drivetrain status etc. The startup notification triggers the Asset Management System (AM) to initiate a Publish PTV Health Alarms dialog. This dialog causes the vehicle electronics to report the health status of the PTV and its onboard equipment. Figure 5.3.4.1.2 depicts this process.

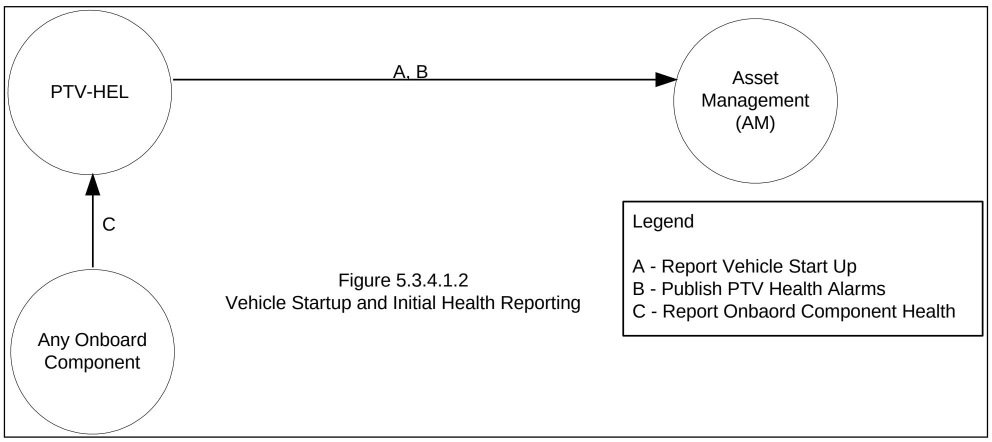


Figure 5.3.4.1.2
Vehicle Startup and Initial Health Reporting

5.3.4.1.3 Operator Sign-On and Inspection

Operators may sign on using a touch screen, key pad, magnetic card swipe, smart card, etc. In the case of a smart card other media, the operator may sign on using a reader connected to the farebox (PTV-FBX) (Figure 5.3.4.1.3.A) rather than the operator interface to the Vehicle Logic Unit (PTV-OPR) (Figure 5.3.4.1.3.B). In either case, the operator inspects the PTV to verify it is service ready. This inspection will include safety checks (e.g.,, tires, wipers, lights), and may include cycling the wheelchair lift/ramp or checking/exercising other agency designated subsystems or components. The inspection results are reported to the Asset Management system (AM).

Operator work assignments (runs) are made prior to the operator's sign on to the PTV at the beginning of the shift. While the operator is already assigned to a run, the binding of the vehicle work block associated with that run to a specific PTV may or may not have occurred. In some agencies the vehicle bindings are performed in advance, and the operator has a specific assigned vehicle to use (Push Approach).

In other agencies the vehicle binding to a work block is deferred until the operator signs on to a PTV; causing the vehicle work block associated with the operator's run to be bound to that vehicle (Pull Approach). In the pull approach the data load normally would contain bound operator assignments for a number of operators (e.g.,, the whole garage), and unbound vehicle assignments for a number of vehicles (e.g.,, vehicles assigned to the garage), and a bound vehicle assignment would be sent to the vehicle for that vehicle only-after the operator signed on. See Figure 5.3.4.1.3.C for an illustration of the pull approach.

Some agencies us a hybrid approach where the assignments are made in advance, but changed automatically if the operator signs on to a different PTV than expected. If the vehicle automated health checks (section 5.3.4.1.2) or the operator's inspection determine that the vehicle is not service-ready, the vehicle assignment may be changed. Figure

5.3.4.1.3.D depicts the change of PTVs in the hybrid approach. Figure 5.3.4.1.3.E depicts a change resulting from an inspection or health failure.

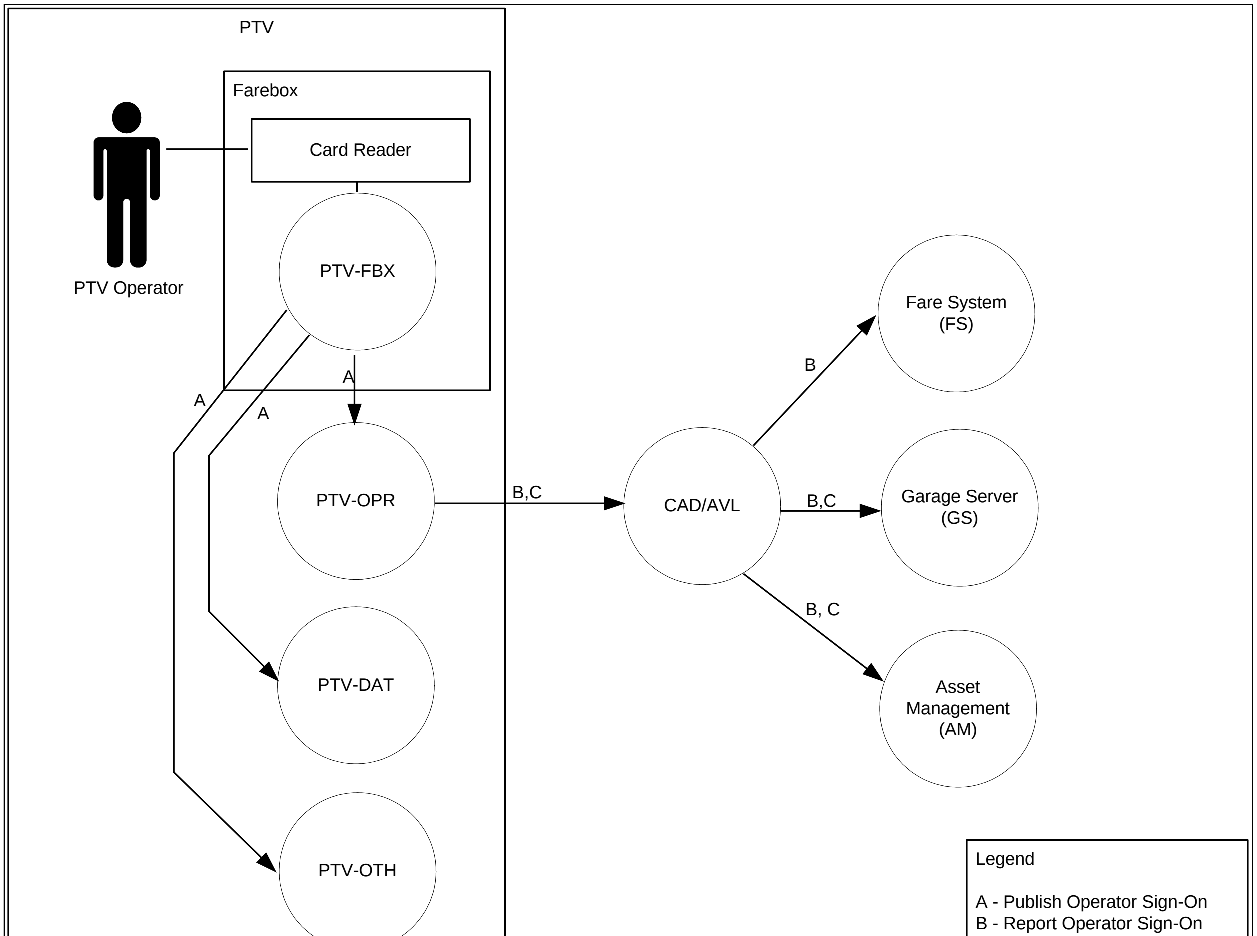


Figure 5.3.4.1.3.A
Operator Sign-On Using Farebox Connected Card Reader

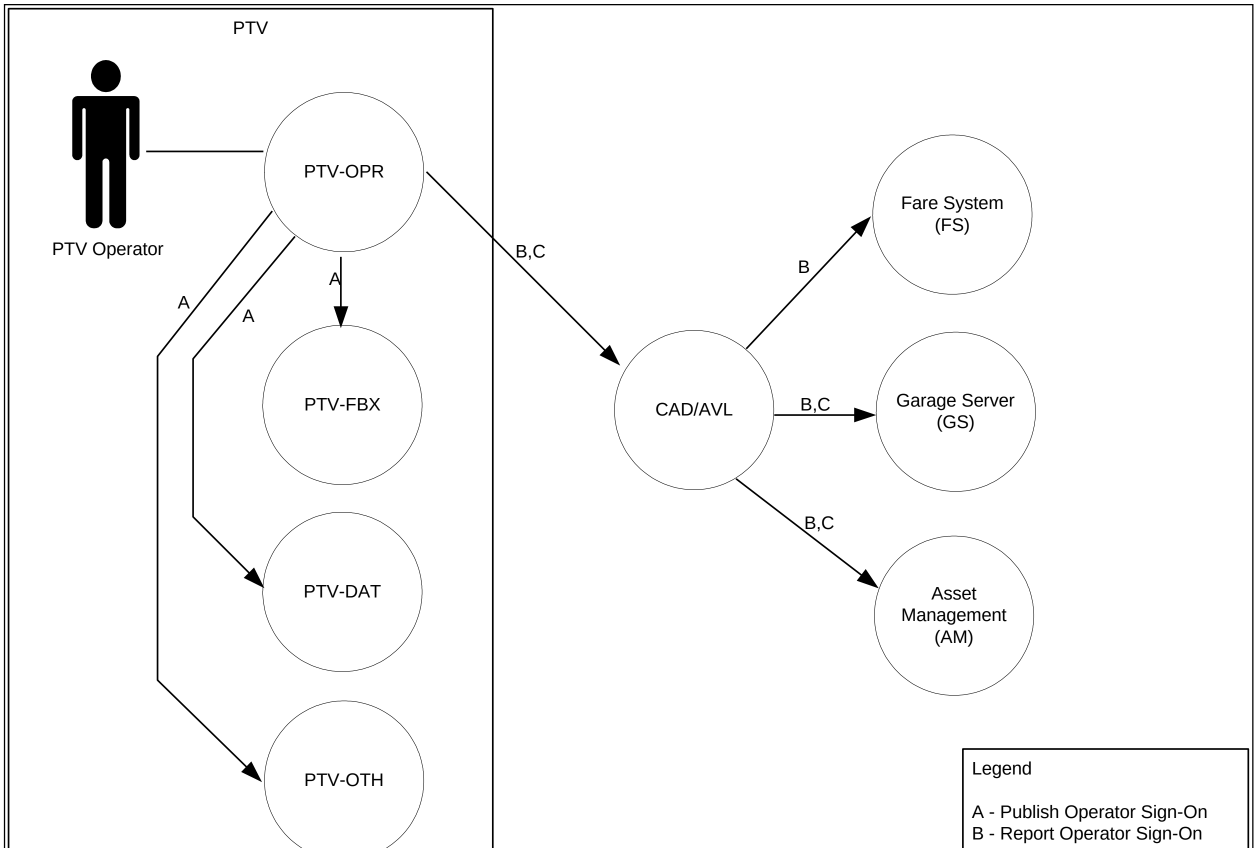


Figure 5.3.4.1.3.B
Operator Sign-On Using VLU Operator Interface

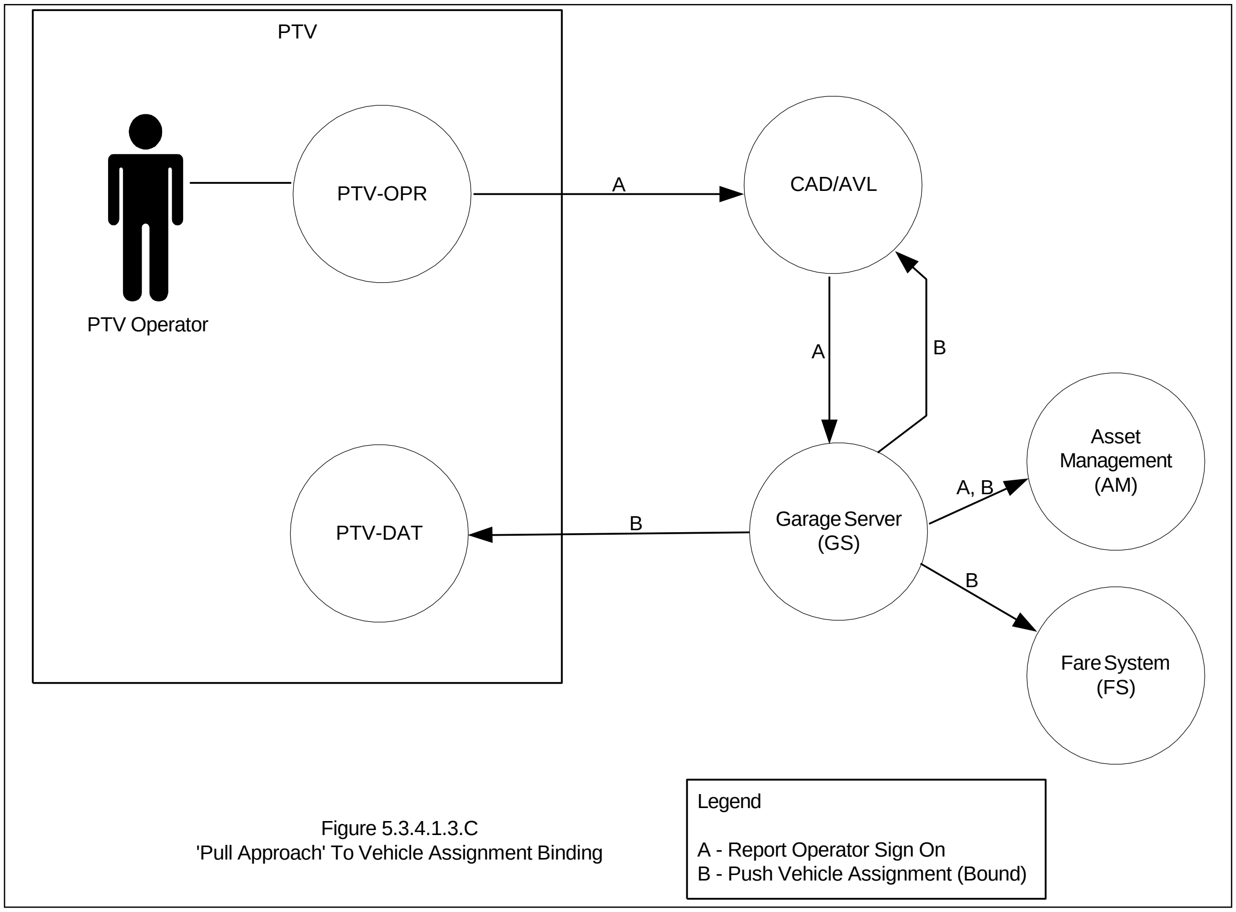


Figure 5.3.4.1.3.C
'Pull Approach' To Vehicle Assignment Binding

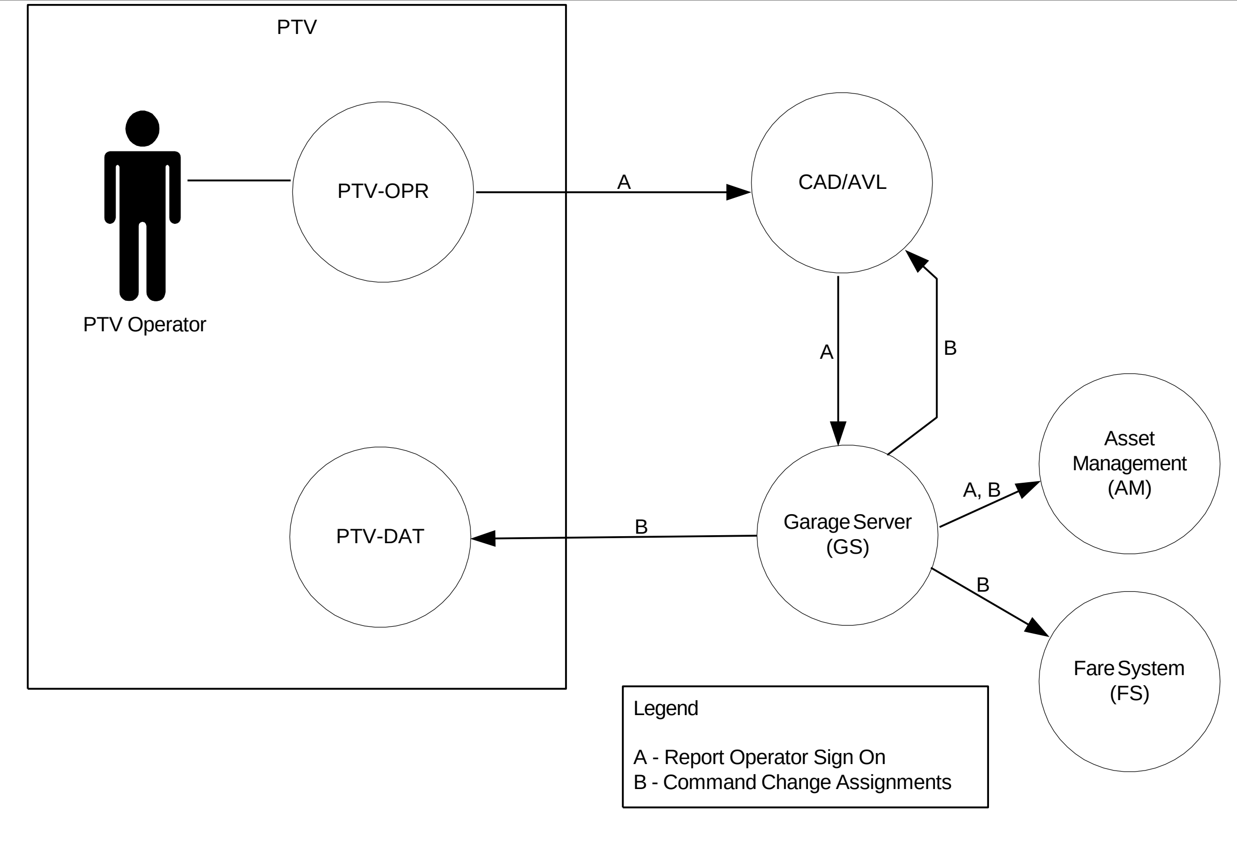


Figure 5.3.4.1.3.D
PTV Assignment Change Resulting from Unexpected Operator Sign-On in Hybrid Assignment Approach

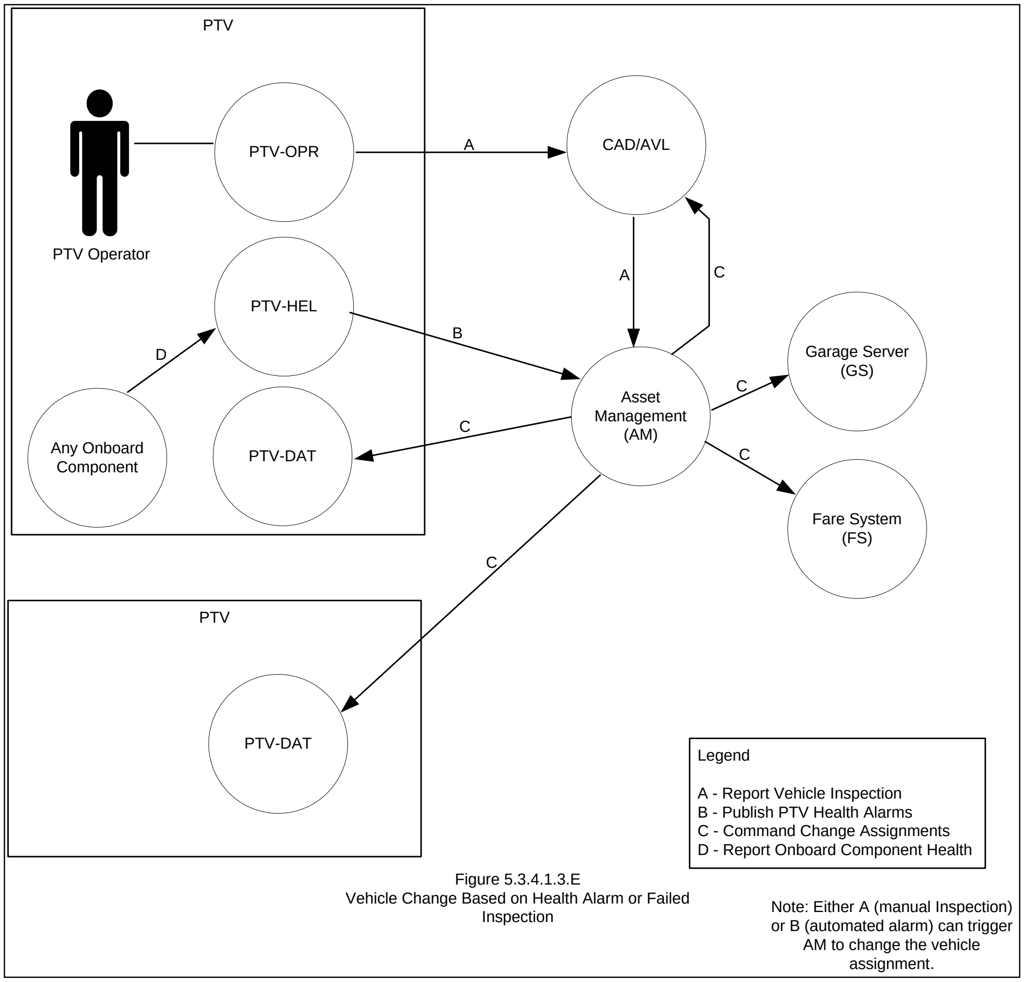


Figure 5.3.4.1.3.E
Vehicle Change Based on Health Alarm or Failed Inspection

5.3.4.1.4 Pull Out

The garage-based supervisor has responsibility for ensuring that the PTV Operator is fit for service (alert, sober, proper uniform, and other agency specified criteria). If the PTV operator is deemed not fit for service, this will normally result in an operator assignment change. If the PTV and the operator are ready for service, the supervisor allows the PTV to leave the garage at the time specified on a pull out list and reports the pull out (see Figures 5.3.4.1.4 A, B&C).

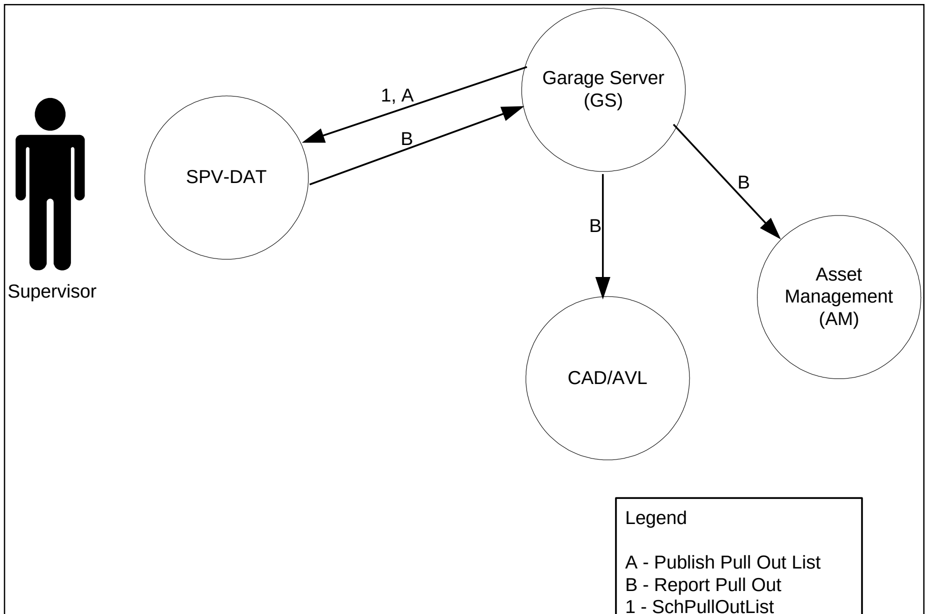


Figure 5.3.4.1.4.A
PTV Pull Out Reporting Using SPV

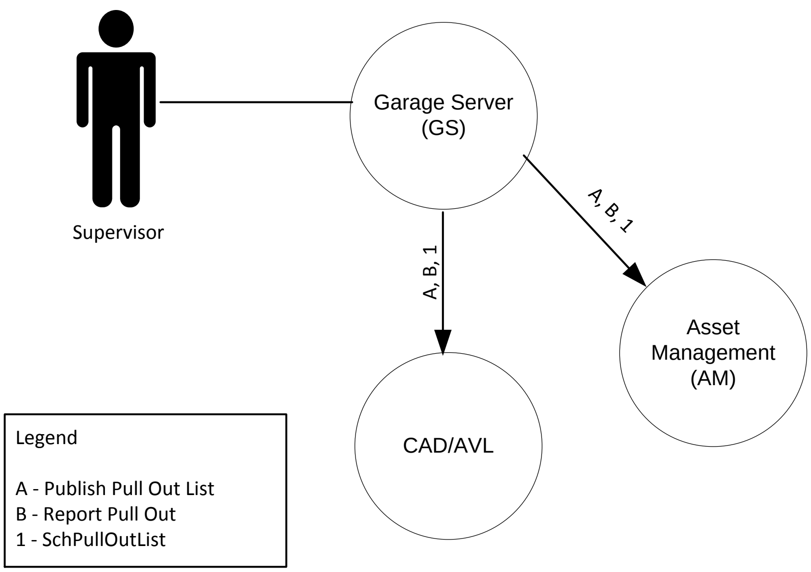


Figure 5.3.4.1.4.B
Pull Out Reporting Using the Garage Server

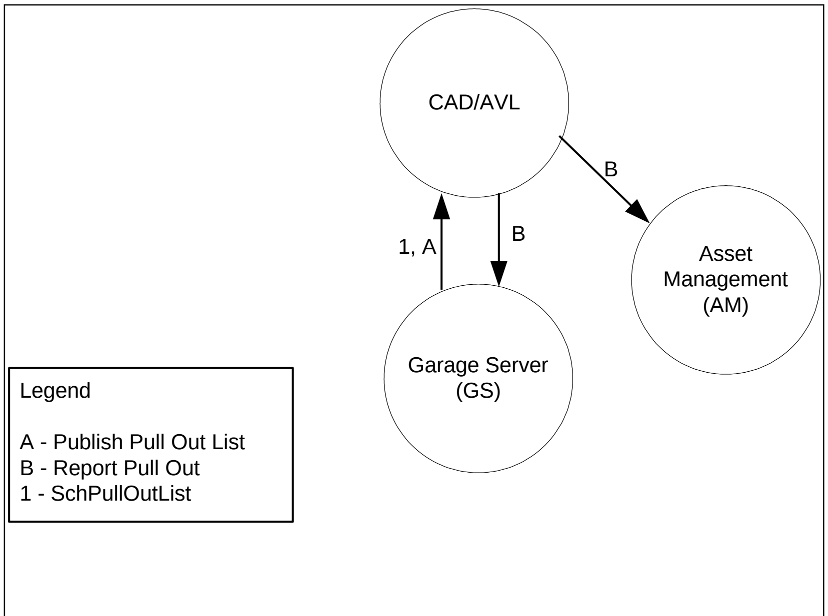


Figure 5.3.4.1.4.C
Automatic CAD/AVL Pull Out Reporting

5.3.4.2 Normal PTV Operations

PTV operations differ significantly between transit agencies. This section describes these operations for a generic agency and illustrates TCIP interactions associated with those operations

5.3.4.2.1 PTV Movements

5.3.4.2.1.1 Deadhead to Initial Terminal

After the PTV leaves the garage, its first trip is usually from the garage to an initial stoppoint. This is reflected by a scheduled out-of-service trip containing two timepoints at the garage and at the first stoppoint. This trip is followed by a second in-service trip that starts with the initial stoppoint followed by a timepoint coincident with the initial stoppoint. The timepoint time associated with this timepoint reflects the scheduled departure time from the initial stoppoint. The PTV waits (usually with doors open) at the initial stoppoint until the scheduled departure time specified for the first timepoint.

5.3.4.2.1.2 In-Service Trips

Agencies may elect to include or omit stoppoint from the pattern segments that constitute the remainder of the revenue trip, however enroute timepoints are needed to establish schedule and route adherence.

If the trip contains a layover (PTV is scheduled to stop and wait for an interval at a stoppoint enroute), this is reflected by using an associated timepoint and stoppoint pair in the pattern for the trip. If the layover occurs mid-trip, there is a timepoint-stoppoint-timepoint sequence in the pattern for that trip using the same timepoint identifier before and after the stoppoint identifier. The timepoint time associated with the first timepoint instance reflects the scheduled arrival at the stoppoint, the timepoint time associated with the second timepoint instance indicates the scheduled departure from the layover stoppoint. This construct may be used to ensure PTVs remain at a stoppoint for a sufficient duration to allow transfers, or for other purposes. If the layover occurs between trips, there is no timepoint-stoppoint-timepoint sequence, but the scheduled ending time for one trip will be different than the starting time of the next trip.

At the end of an in-service trip, the PTV may be scheduled for an out-of-service trip back to the garage, and out-of-service trip to a designated parking area (e.g.,, for an operator break), an out-of-service trip to another agency designated location, an out-of-service trip to the initial stoppoint for the next in-service trip, or may immediately be followed by another in-service trip.

5.3.4.2.1.3 Post In-Service Trips

Scheduled out-of-service trips following an in-service trip are similar to the out-of-service trip to the initial stoppoint. The trip contains a timepoint indicating the start location and time for the out-of-service trip. If the bus is to go to a location and park (e.g.,, for a break), the parking location is reflected by two sequential timepoints at the parking location. The timepoint times associated with the two timepoints at the parking location indicate the scheduled arrival and departure times at that location. A final timepoint in the out-of-service trip's pattern indicates the endpoint for the out-of-service trip. If the out-of-service trip is back to the garage at the end of the PTV's work block, it contains a timepoint for the location where the vehicle left service and a timepoint for the pull-in location. The timepoint times for these timepoints indicate the scheduled out-of-service and pull in times.

5.3.4.2.2 PTV Location Tracking

The current location of PTVs is of interest to a variety of transit entities including onboard entities, the CAD/AVL System, and other agency designated Authorized Business Systems (ABS).

The PTV's raw location heading and speed is determined by the PTV-LDS entity (usually a GPS receiver). This entity reports raw location either directly to the Vehicle Logic Unit PTV-LOC entity, or over the Vehicle Area Network (VAN). If the PTV-LDS reports directly to the VLU, then PTV-LOC relays the information over the VAN to non-TCIP components.

PTV-LOC also obtains adherence information from PTV-ADH, schedule information from PTV-DAT, and provides location data to any other onboard subscriber entities via the "Publish Onboard Location" dialog. This dialog provides location updates:

- Initially on startup
- Periodically
- At the start and end of trips
- Upon arriving and departing stoppoints (if stoppoints are loaded to the PTV)
- At timepoints
- At event-locations specified in the pattern for the trip
- When the adherence status (schedule or route) changes

If PTV-LDS is connected to the VAN, it follows that any other VAN-connected onboard component can obtain location information directly from the VAN without using the "Publish Onboard Location" dialog. Such components will not , however, receive other information published using the "Publish Onboard Location" dialog such as adherence information.

PTV-LOC provides periodic location updates to CAD/AVL. This is accomplished using the "Publish PTV-AVL" dialog over a public or wideband wide area network. Location reporting to CAD/AVL may also be accomplished using the example TCIP Polling Protocol (Annex H), or a proprietary vendor polling protocol. Other business systems that require near-real time PTV location information obtain this information from the CAD/AVL system using the "Publish Fleet Locations" dialog.

Figures 5.3.4.2.2 A&B illustrate the onboard distribution of PTV location. Figures 5.3.4.2.2 C&D illustrate the distribution of PTV location to fixed business systems.

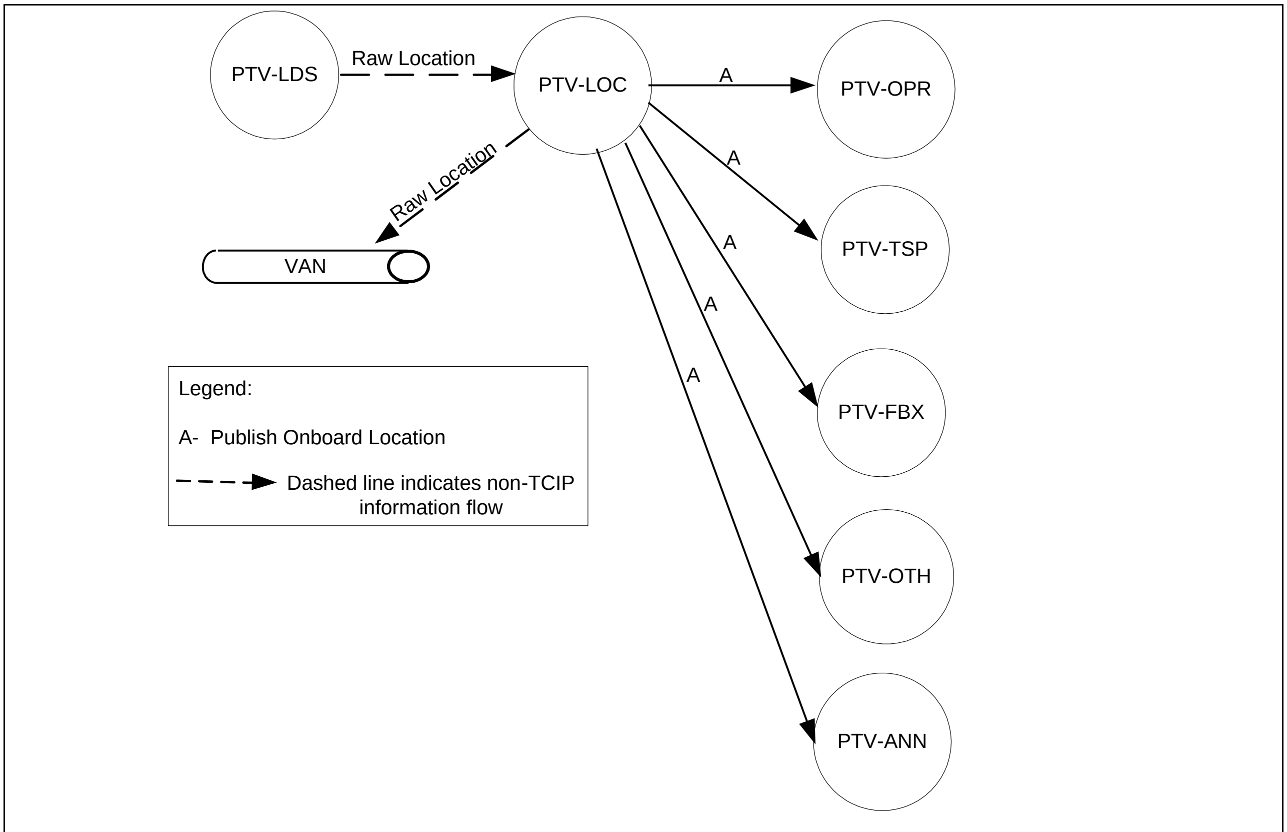


Figure 5.3.4.2.2.A
Onboard Distribution of PTV Location with PTV-LDS Directly Connected to VLU (PTV-LOC)

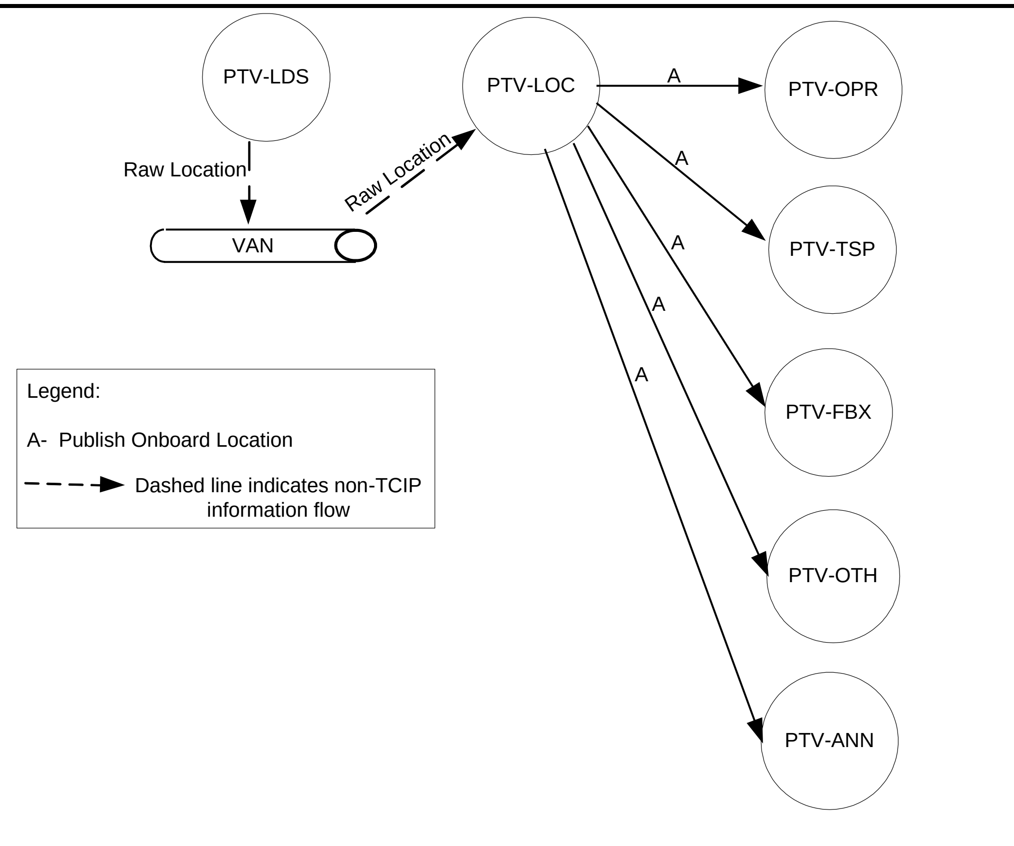


Figure 5.3.4.2.2.B
Onboard Distribution of PTV Location with PTV-LDS Directly Connected to VAN

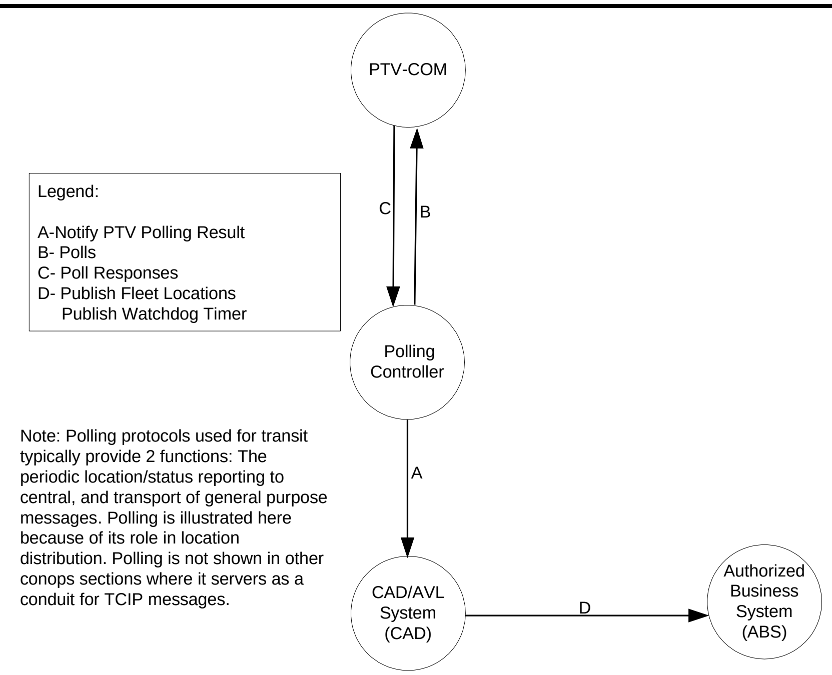


Figure 5.3.4.2.2.C
Distribution of PTV Location to Business Systems Using TCIP or Proprietary Polled Protocol.

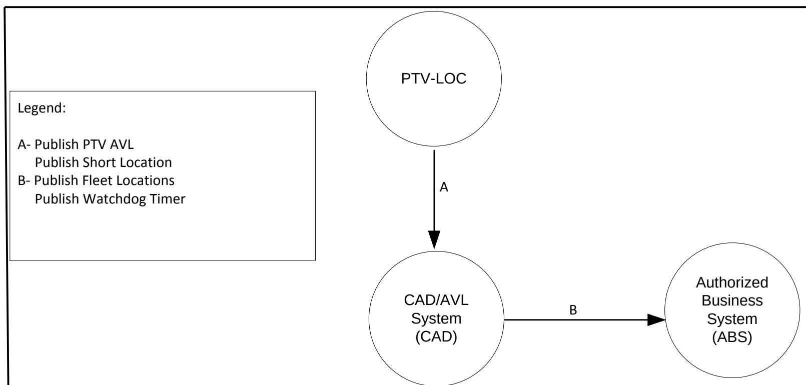


Figure 5.3.4.2.2.D
Distribution of PTV Location to Business Systems Using Public Wireless Networks.

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5.3.4.2.3 PTV Operator Changes

From time to time agencies find it necessary to change PTV operators while the bus is enroute. These changes may be planned or unplanned. Planned (scheduled) changes may occur between trips or at a timepoint within a scheduled trip.

5.3.4.2.3.1 Scheduled Operator Changes

In the case of a scheduled operator change that occurs at the end of a trip, the vehicle assignment will contain a subsequent trip assigned to the PTV, but the operator assignment for the subsequent trip will have a different operator identifier.

If the scheduled operator change occurs mid-trip the pattern for the trip will include one or two timepoints at the operator change location. The old operator assignment will indicate that it ends at that timepoint identifier and the "new" operator assignment will indicate that it begins at that timepoint identifier. The timepoint identifier may be repeated with different timepoint times indicating that the vehicle is scheduled to arrive at the timepoint at the first timepoint time and depart at the other timepoint time. A single timepoint identifier indicates an 'instantaneous' operator charge that has no scheduled duration.

After arriving at the location where the operator change is scheduled, the "old" operator signs off and this is reported to the CAD/AVL System (and optionally to the dispatcher). Similarly the "new" operator signs on and this event is also reported to the CAD/AVL System, and optionally the dispatcher, as illustrated in Figure 5.3.4.2.3.1.

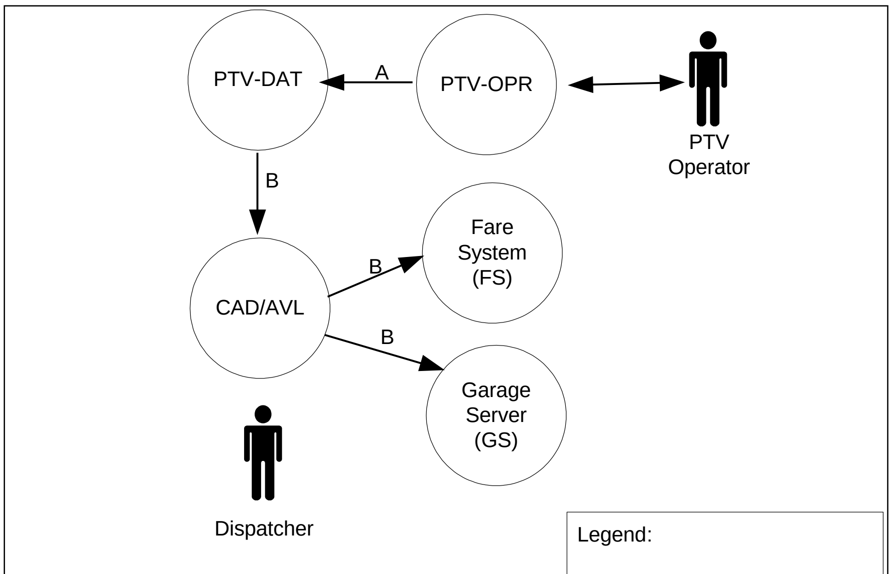


Figure 5.3.4.2.3.1
Dialog Flows for Scheduled PTV Operator Change

5.3.4.2.3.2 Unscheduled Operator Changes

If the operator change is unscheduled, the process of signing off and on is identical; however the notification to the PTV is different. In this case, PTV-DAT already has an operator assignment based on the earlier data load. This assignment is changed by the Supervisor in the Operator Assignment System (OAS) and communicated to the Garage Server (GS), Fare system (FS) PTV-DAT, and to the CAD/AVL System using the Command Change Assignments dialog.

The dialog flows for PTV operator changes are illustrated in Figure 5.3.4.2.3.2.

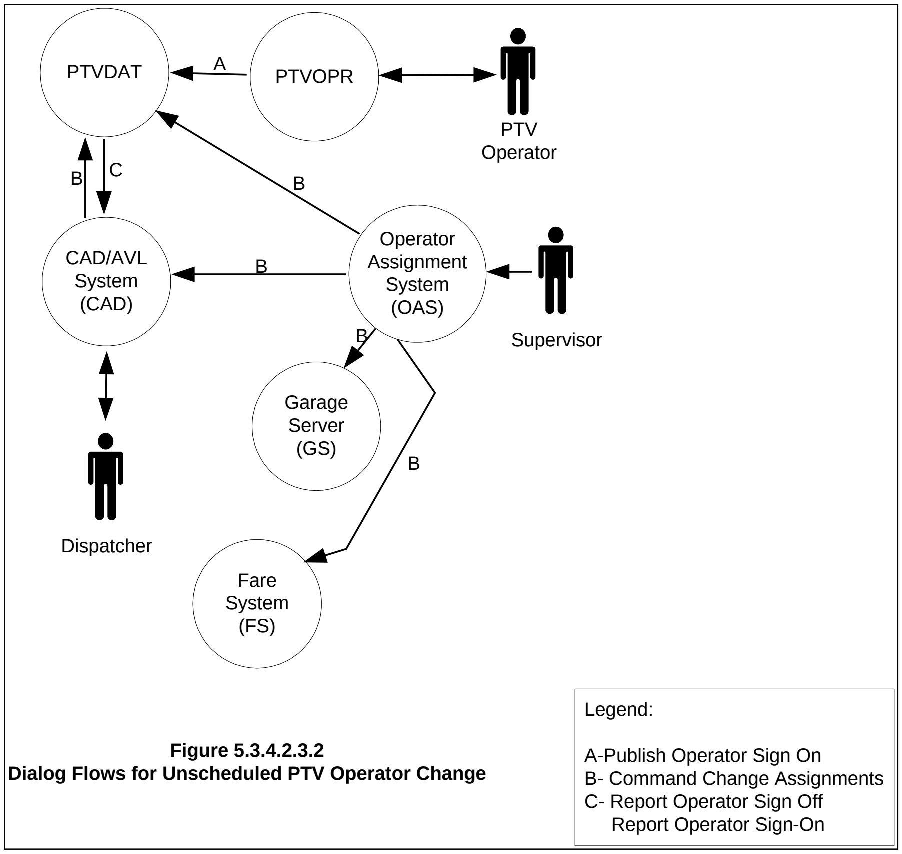


Figure 5.3.4.2.3.2
Dialog Flows for Unscheduled PTV Operator Change

5.3.4.2.4 Enroute Communications with Dispatcher

PTVs often operate for extended intervals without requiring any interaction with dispatchers beyond Automatic Vehicle Location monitoring as described in section 5.3.4.2.2. There are, however, occasions where communications by voice or data are required.

5.3.4.2.4.1 Voice Communications

The two major methods for dispatcher-operator voice communications are via radio or cell phone. PTV Operator Cell Phones are outside the scope of TCIP. Radio conversations may be initiated by the PTV operator or by the Dispatcher. The dispatcher-initiated call can be to the operator or to the annunciator (PTV-ANN) to make a remote announcement.

Operator-initiated calls are shown on the CAD console, and normally must be accepted by the dispatcher prior to the call being set up. Some CAD consoles, however, support "unattended mode". In this mode all operator-initiated calls are automatically accepted. These calls may be forwarded from the dispatch console to the dispatcher via a hand-held radio. In "unattended mode", dispatchers cannot initiate a call back to vehicles. Some CAD consoles also support a fallback mode, wherein calls from PTVs are automatically accepted, and the dispatcher can communicate back to the PTVs on an all-call basis. CAD consoles may automatically revert to normal operations from unattended or fallback mode based on a configurable timer (e.g.,, 2 minutes).

Figures 5.3.4.2.4.1 A-C depicts the TCIP-supported voice call scenarios. Dialog flow lines follow the conventions defined in the model architecture, however supplemental dotted lines show additional message flows defined within the dialogs.

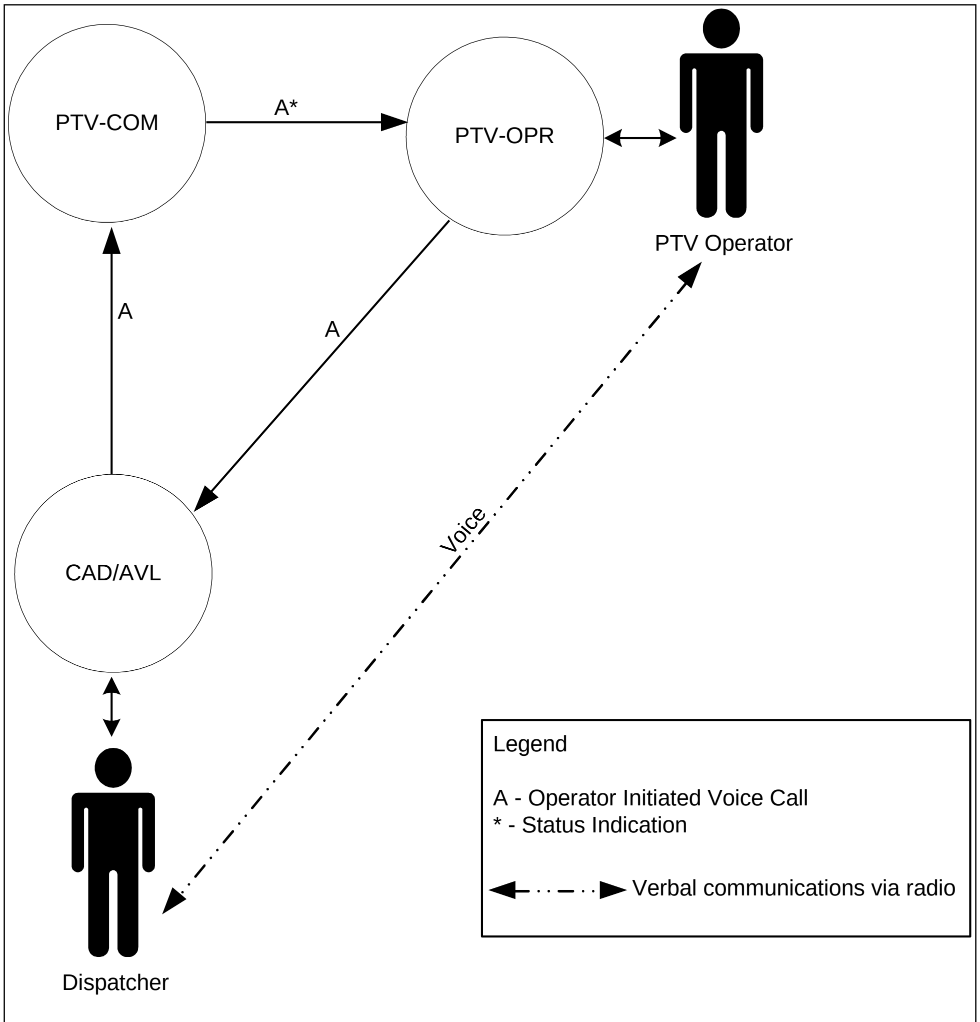


Figure 5.3.4.2.4.1.A
Operator-Initiated Voice Call

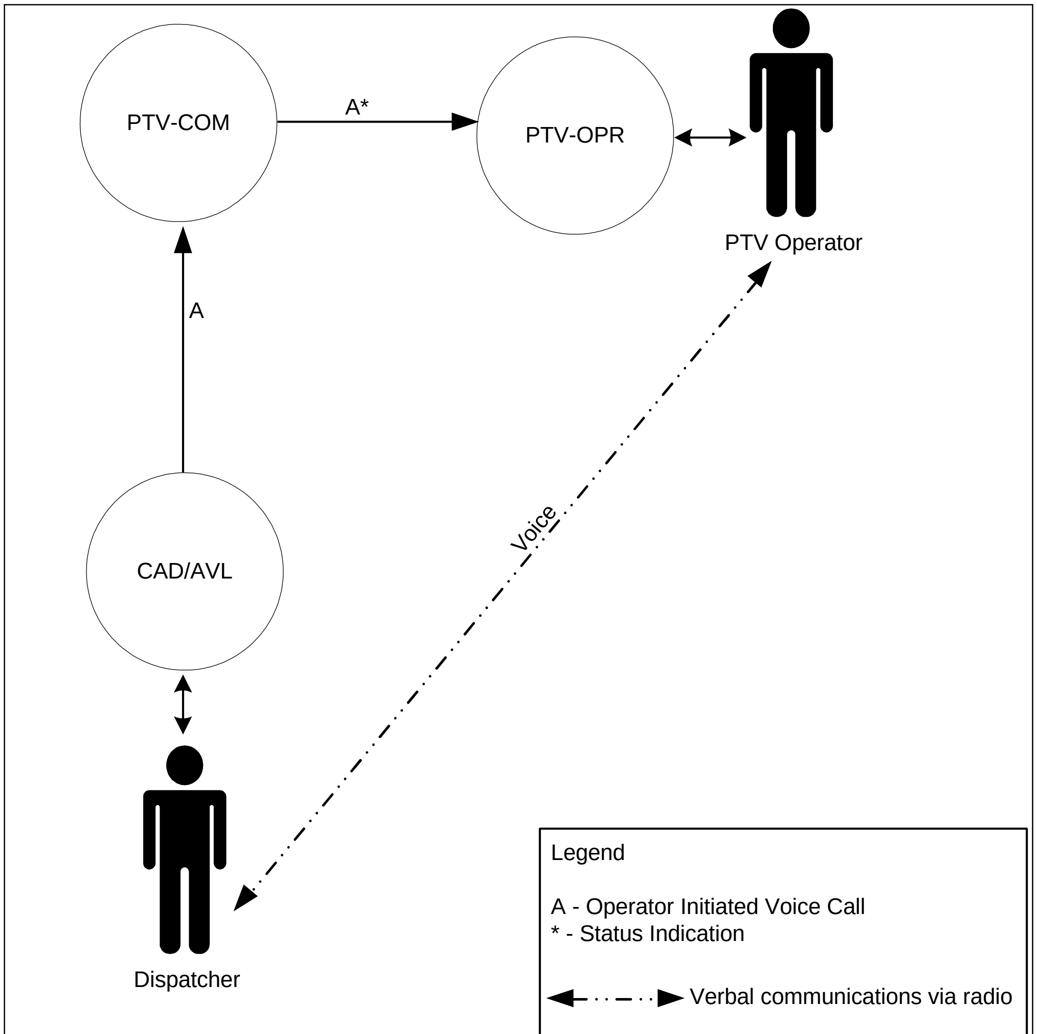


Figure 5.3.4.2.4.1.B
Dispatcher-Initiated Voice Call to PTV Operator

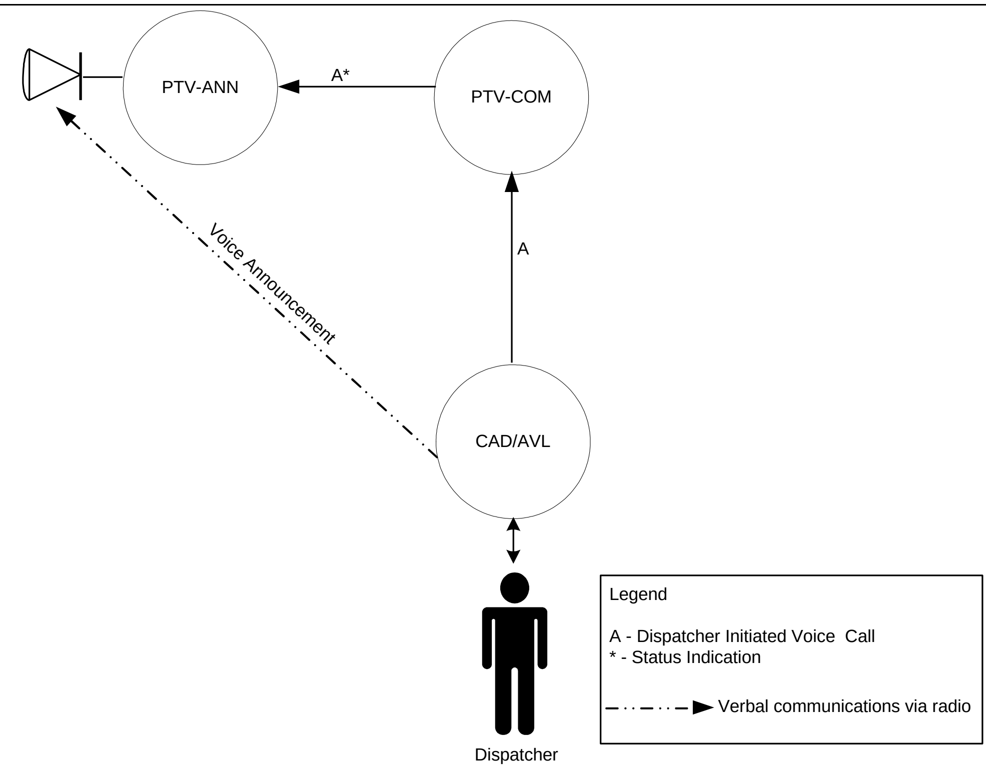


Figure 5.3.4.2.4.1.C
Dispatcher-Initiated Voice Announcement to PTV

5.3.4.2.4.2 Data Communications

Enroute data communications between the operator and dispatcher are possible in either direction. These communications can use prepackaged (canned) messages, which transmit message numbers in a fill in the blank format with blanks filled by entries from numbered lists, this mechanism provides a wireless network-efficient means of text exchange for conversations that are foreseeable. An example use of this capability would be to tell a driver to stop picking up passengers until a specified stoppoint is reached. This type of action might be taken in response to a bus bunching.

Freeform text communications between the driver and dispatcher are also supported by TCIP. These communications require the extra effort to type the message and are not as network-efficient as canned messages, but have the advantage of allowing completely ad-hoc messages to be exchanged.

Figure 5.3.4.2.4.2 A&B depicts dispatcher and operator initiated data messaging.

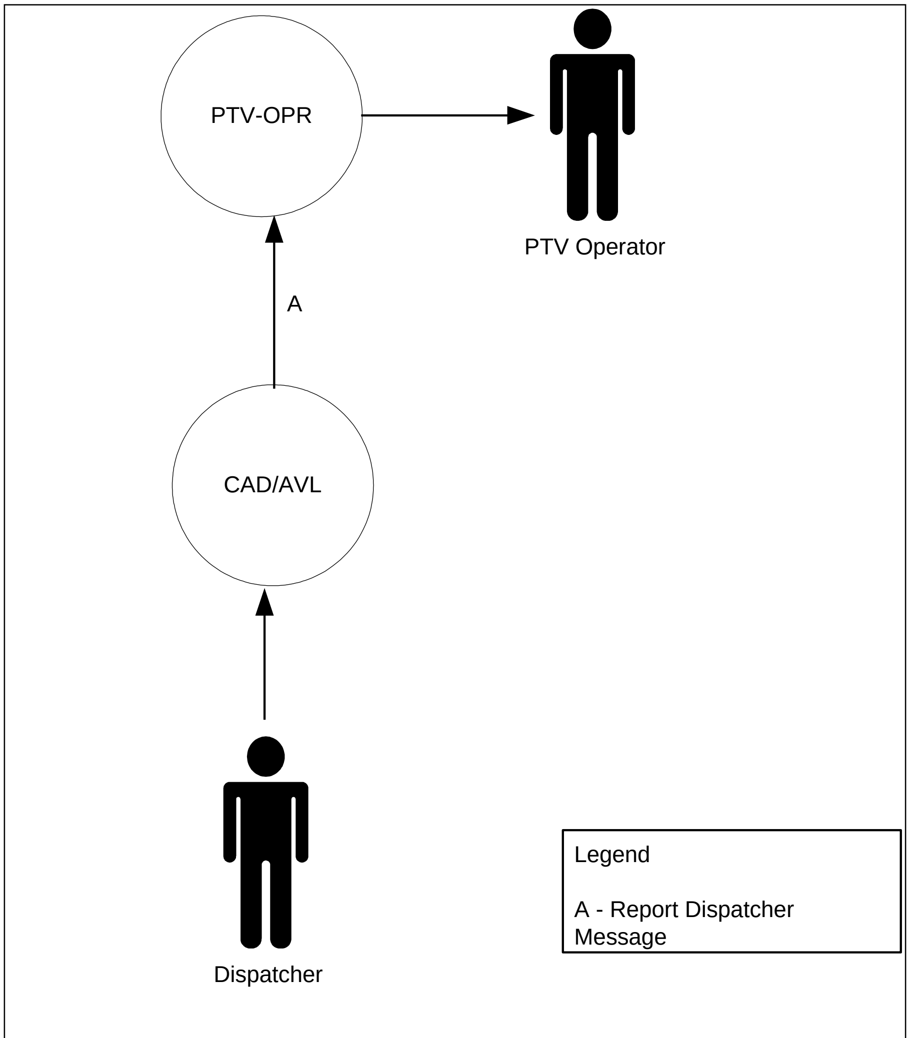


Figure 5.3.4.2.4.2.A
Dispatcher to PTV Operator Freeform or Canned Message Delivery

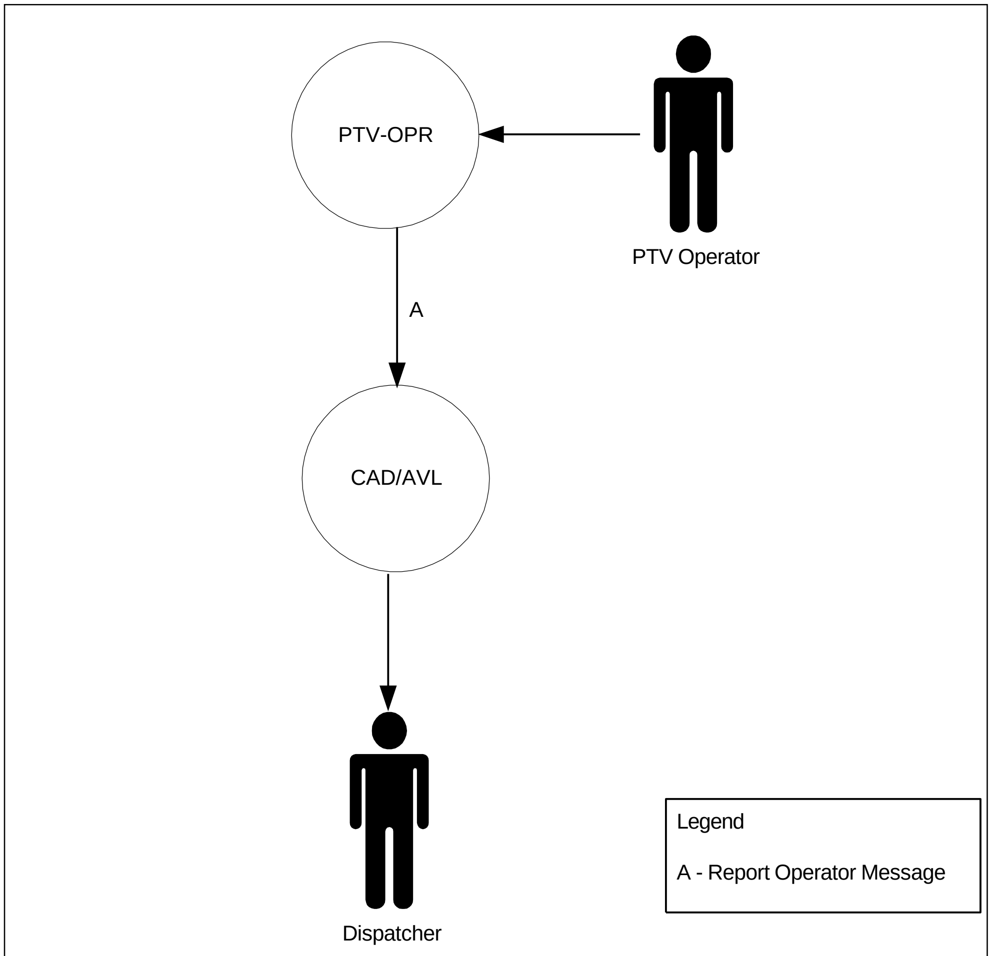


Figure 5.3.4.2.4.2.B
PTV Operator to Dispatcher Freeform or Canned Message Delivery

5.3.4.2.5 PTV Health and Parameter Monitoring

As the PTV progresses enroute, it is necessary to verify that the PTV and its onboard systems are operating normally. TCIP provides health alarm reporting dialogs for the PTV (as a whole) and for the farebox.

The default criteria for alarm generation (parameter ranges) are provided by the “Load PTV Alarm Limits” dialog executed during data loading (section 5.3.4.1.1). These limits can be overridden by parameter limit specifications in individual subscription requests for health alarms.

TCIP also provides a mechanism to subscribe to onboard parameters (e.g.,, water temperature, oil pressure) that are broadcast on the VAN. Normally there will be no active subscriptions to these parameters, however, a subscription can be initiated by a business system in response to an alarm. VAN parameters are defined by SAE J1587. SAE J1587 parameters are conveyed within TCIP using the OBParameterDumpEntry data frame.

Onboard components connected to the hub network report health using the “Report Onboard Component Health” dialog to PTV-HEL, PTV-HEL monitors the VAN and detects exceptions based on information broadcast on the VAN (e.g.,, oil pressure).

Alarm reporting from PTV-HEL can be either to the CAD/AVL or directly to Asset Management (AM). The example TCIP Polling Protocol (Annex H) has health parameter/alarm reporting built into the polling process.

Figure 5.3.4.2.5.A depicts an enroute monitoring and reporting scenario without a reporting mechanism built into the wireless protocol. Figure 5.3.4.2.5.B depicts an enroute monitoring and reporting scenario using a polling protocol with health reporting built into poll responses.

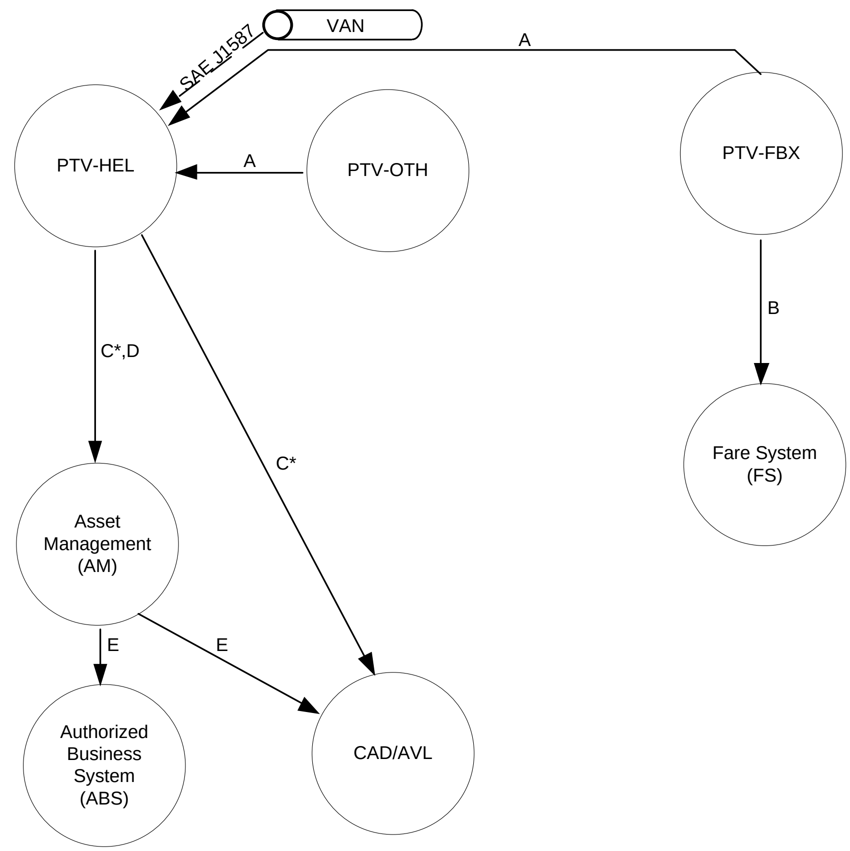


Figure 5.3.4.2.5.A
Dialog-Based Enroute PTV Health and Parameter Monitoring

Legend

A - Report Onboard Component Health
B - Publish Fare Collection Health
C - Publish PTV Parameters
D - Publish PTV Health Alarms and Publish J1939 Fault Codes
E - Publish Fleet Health Alarms
* - CAD/AVL and AM may Publish to different parameters and reporting rates

Dashed line indicates non-TCIP information flow

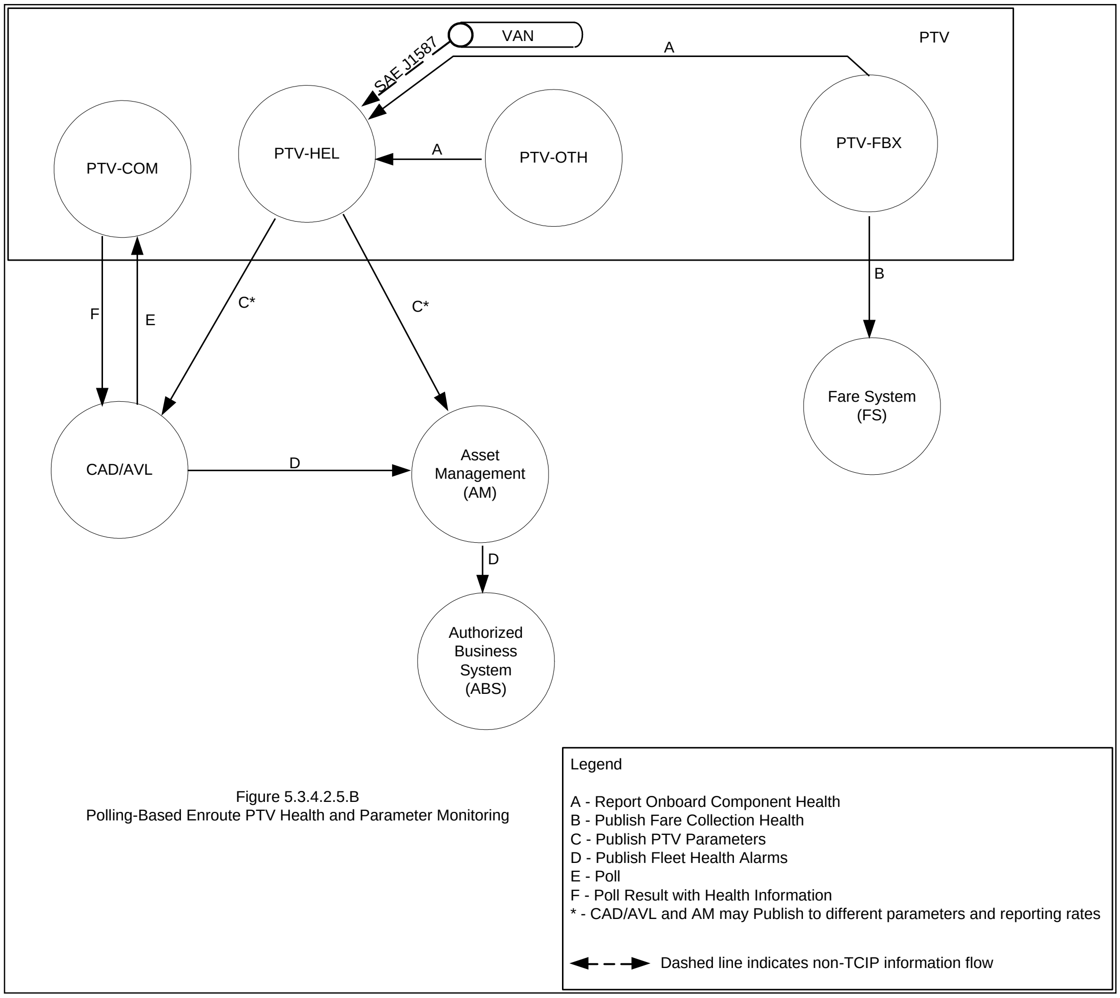


Figure 5.3.4.2.5.B
Polling-Based Enroute PTV Health and Parameter Monitoring

5.3.4.2.6 PTV Annunciator

The PTV annunciator (PTV-ANN) obtains a data load as described in section 5.3.4.1.1. This data load specifies destination sign messages to be displayed along with the corresponding rules. It also specifies destination sign messages, passenger information sign messages and audio announcements to be displayed/played based on stoppoint arrivals and enroute events specified in the pattern for the trip, or specific to a trip.

The PTV annunciator obtains the current location and progress from PTV-LOC (either directly if hosted in the VLU, or via the “Publish Onboard Location” dialog if hosted in a separate component). This information includes start and end of trips, arrival and departure from stop points, and event notification. The PTV-ANN logical entity uses current information to trigger the appropriate announcements and sign updates as the PTV proceeds enroute.

Figure 5.3.4.2.6 illustrates this process.

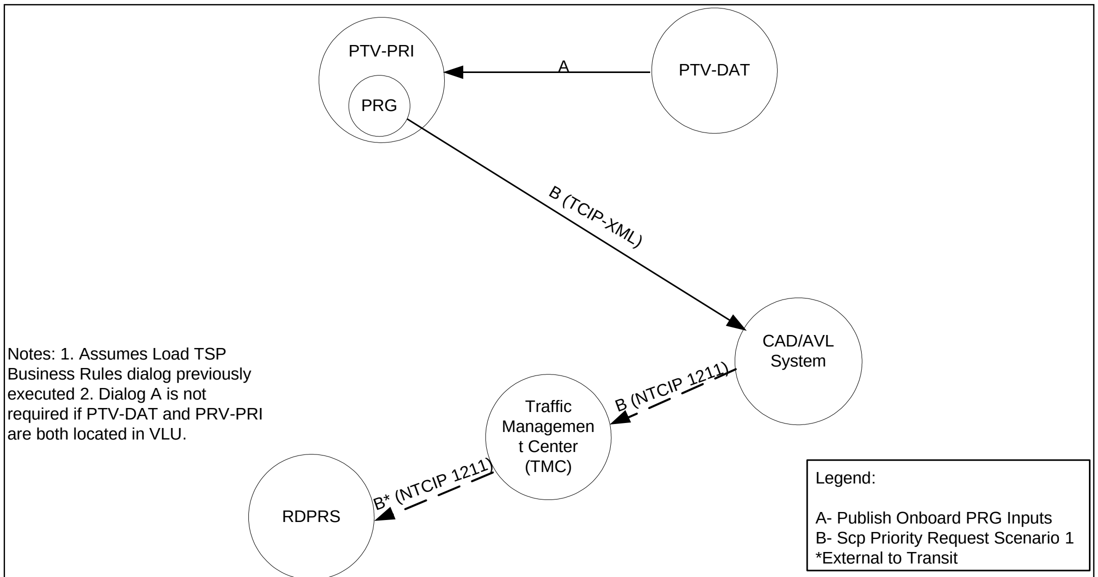


Figure 5.3.4.2.6.1.B
Scp Scenario 1 Dialog Flows - XML Within Transit

5.3.4.2.7 MDT Menu Sharing

As the PTV operates, onboard devices may need to interact with the PTV operator. These interactions may be simply to display a message to the operator and obtain an acknowledgement, or may require the operator to select a response from a list of alternatives (menu). There are two onboard mechanisms to accomplish this: via the VAN and via TCIP.

VAN-based menuing is defined by SAE J1587.

TCIP-based sharing is based on the Report Menu Selection dialog. Figure 5.3.4.2.7 illustrates the dialog flows for these interactions. TCIP includes a priority field in the menuing message to PTV-OPR to allow the order of menu presentation to the operator to be based on the urgency of the content.

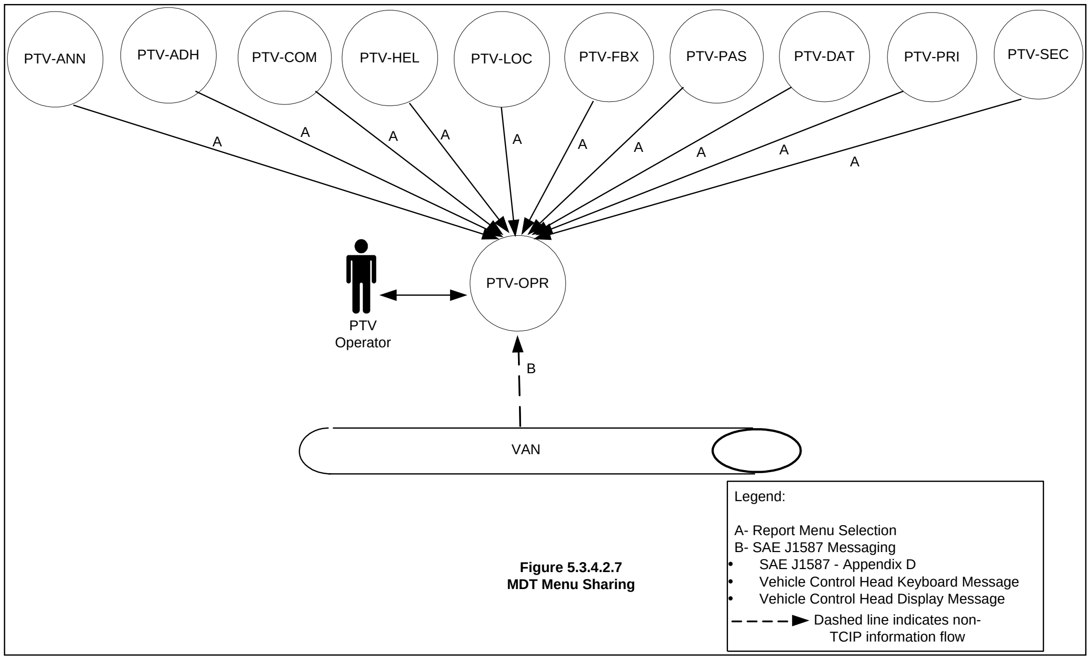


Figure 5.3.4.2.7
MDT Menu Sharing

The potential operating scenarios in which the MDT Menu Sharing may be useful are far too numerous to enumerate, however a few examples are listed below:

- PTV-HEL detects an alarm condition (e.g.,, high oil temperature) and displays an alarm to the operator with an 'OK' button for the operator to acknowledge seeing the alarm condition.
- PTV-ANN provides a selection of operating modes and the operator selects an appropriate mode from the list.
- Any device provides a list of configuration option alternatives, and the operator selects the appropriate setting. This might be available only in an administrator mode.

5.3.4.2.8 Passenger Counting

Some PTVs are equipped with automatic passenger counting equipment. Passenger counts are useful for reporting trips provided, for determining TSP strategies, and for validating fares collected. The logical entity in the TCIP model architecture associated with this function is PTV-PAS. This entity may be packaged in the VLU, farebox or other onboard component. PTV-PAS reports passenger counting results to the VAN (if connected) and to other TCIP entities via the hub network. Normally the report is triggered upon door closure and/or departure from each stoppoint. Figure 5.3.4.2.8 illustrates the onboard dialog flows for passenger counting.

Historical passenger count data is unloaded at the end of the day and provided to the Passenger Counting (PC) business system (see section 5.3.4.4).

The onboard passenger counting entity either subscribes to the onboard location reporting from PTV-LOC (see section 5.3.4.2.2) or if hosted in the VLU obtains location information within the VLU. This information allows the PTV-PAS entity to discern the beginning and end of trips, arrival and departure from stop points schedule adherence and other information. Depending on agency policy, PTV-PAS may automatically set the onboard passenger count value to zero at the end of each trip.

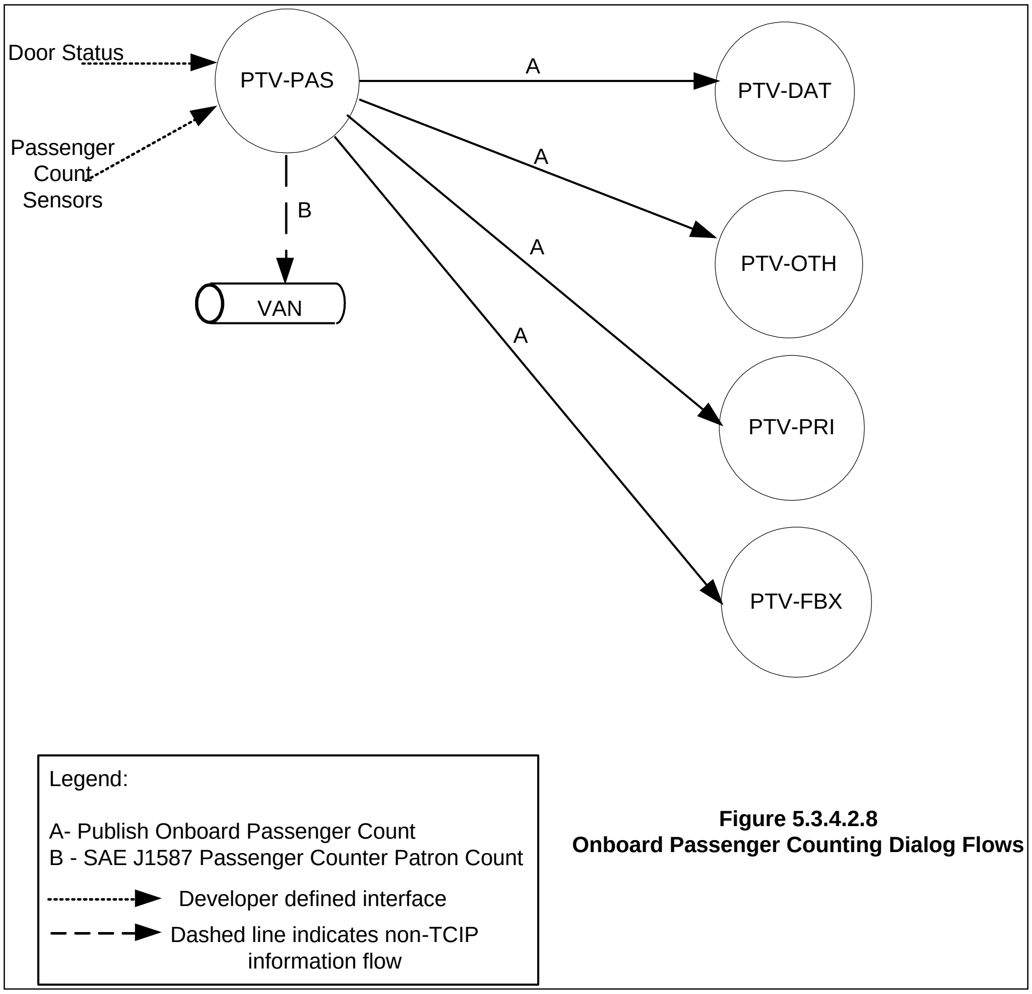


Figure 5.3.4.2.8
Onboard Passenger Counting Dialog Flows

5.3.4.2.9 Traveler Request Inputs into PTV Operations

TCIP supports two mechanisms for travelers to interact in normal PTV Operations:
- Through On Demand Transfer Connection Protection
- Through On Demand Wheelchair Request

5.3.4.2.9.1 Transfer Connection Protection

Agencies may determine that certain scheduled transfers can be 'protected' either routinely or on demand. Routine transfer protections are appropriate where expected demand for a transfer is high (e.g.,, if a bus route stops at a subway station, and subway riders routinely transfer to the bus at that stop). Routine transfer protection can be built into the schedule as a note associated with the Route Schedule or Pattern, or can be provided as special instructions to the PTV Operator.

On Demand Transfer Connection is appropriate where expected demand for a transfer is intermittent and ridership is generally low. An example is late night runs where a missed connection might strand a rider for a prolonged period or overnight.

The Request Transfer Connection Protection dialog allows a traveler on a PTV, at a stoppoint, via the Customer Service or Traveler Information System (TRV) to request that a transfer connection be protected on their behalf. The request goes to the control center (CAD/AVL) where the bus to be held ("Waiter PTV") is identified. The control center may disapprove the request or forward it to the waiter PTV. Upon confirmation from the waiter PTV, the requester is notified of the approval. Upon a disapproval from the control center or a timeout on the confirmation from the waiter PTV a disapproval notice is sent to the requester. The wait instruction sent to the waiter PTV has an associated time limit, so that the waiter PTV is not stranded or excessively delayed by a no-show, or accessibly late requester.

Reasons the request might be disapproved include: Connection Protection System invalid request, and local agency defined denial criteria.

Figure 5.3.4.2.9.1 illustrates the on-demand transfer connection protection dialog flows.

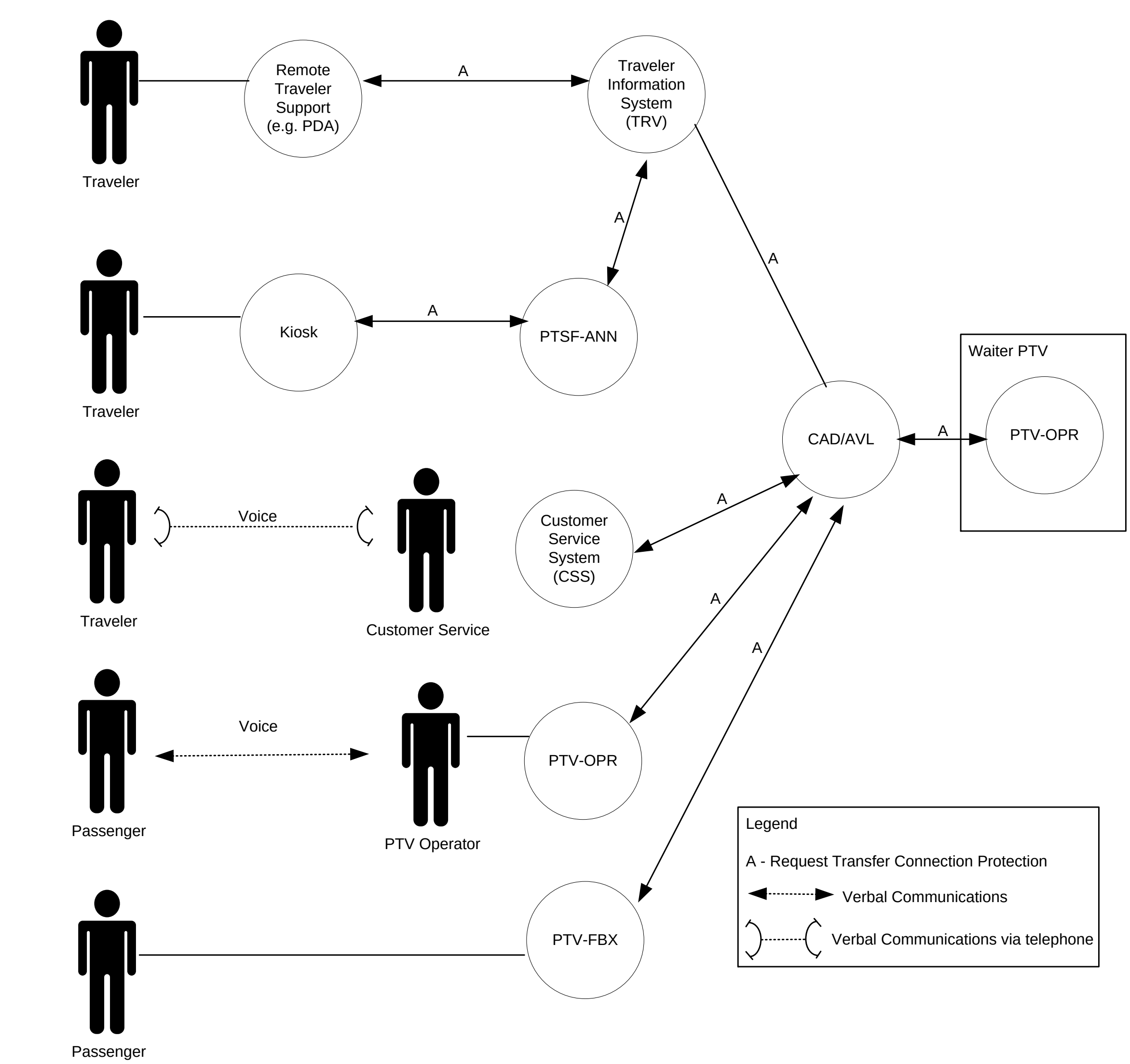


Figure 5.3.4.2.9.1
Transfer Connection Protection Request Flows

5.3.4.2.9.2 On Demand Wheelchair Requests

Agencies may decide to provide a service where travelers request ramp or lift service in advance at selected stoppoints. This request would allow the agency to ensure that a PTV with wheelchair access installed and operational is available to service the traveler, or that the PTV stop at a designated accessible location.

The Request Wheelchair Pickup dialog allows a traveler on a PTV at a stoppoint, via the Customer Service System (CSS), or Traveler Information System (TRV) to request that wheelchair-accessible service be provided and verified. The control center (usually CAD/AVL) can ensure that a selected PTV is able to service the request, and is notified of the need for a wheelchair pickup before sending an approval message to the requester. If the request cannot be honored for any reason the control center notifies the requester of the denial.

Figure 5.3.4.2.9.2 illustrates the on-demand wheelchair request dialog flows.

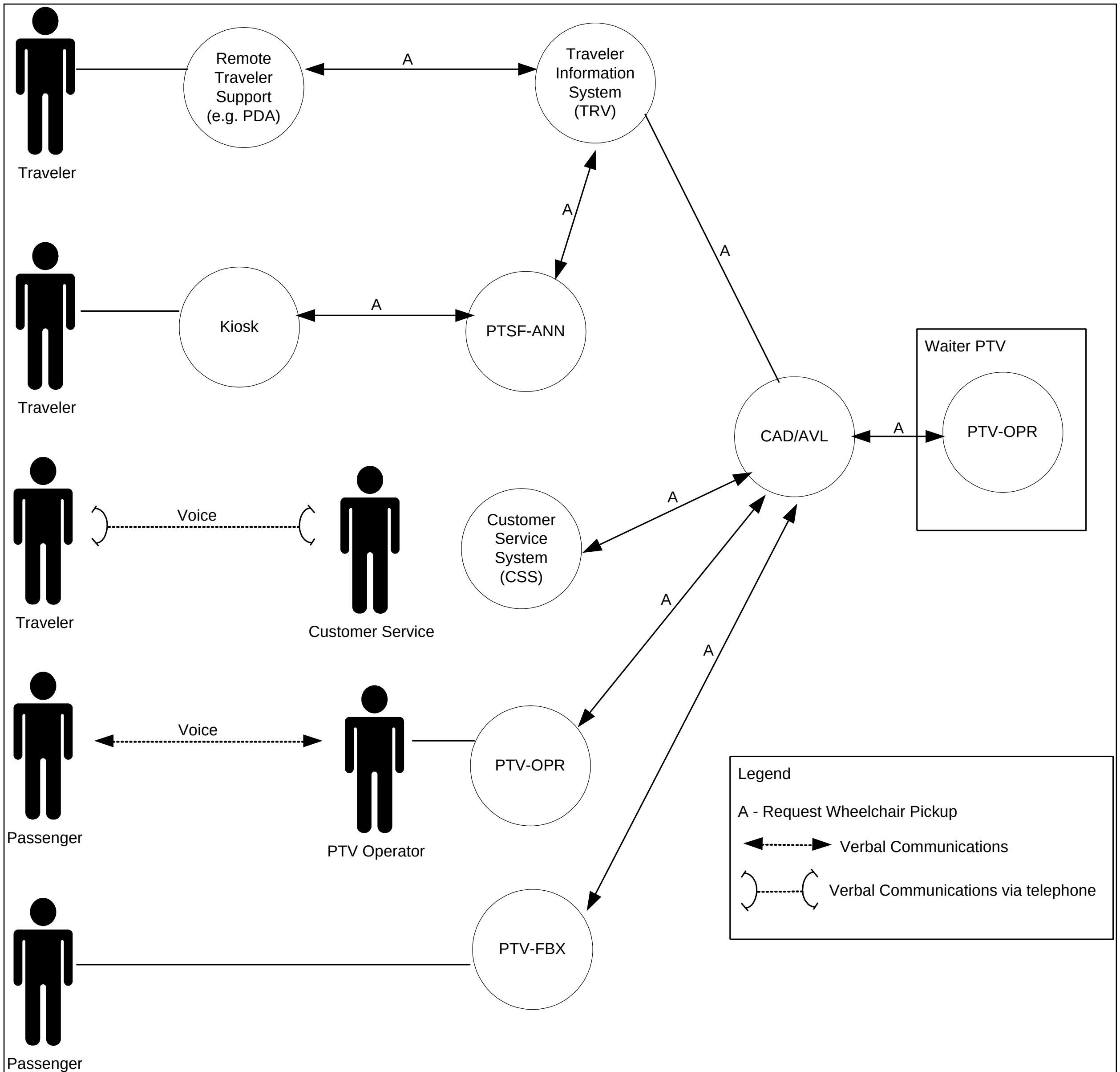


Figure 5.3.4.2.9.2
Wheelchair Pickup Request Flow

5.3.4.2.10 Differential GPS Data Distribution

Timely distribution of GPS correction data can result in significant improvements in effective GPS accuracy. These corrections can be made in real time to allow location reporting and location tagging of data to be more accurate, or can be done in a post-processing made to correct previously reported, but uncorrected data. The choice of which approach to use is made in the context of the Transit Agency ITS Architecture. A key factor in this decision is the attributes of the agency communications network including its available capacity and broadcast capabilities.

TCIP provides two dialogs to facilitate the distribution of GPS correction data: Push Differential Correction Data, and Publish Differential GPS Correction Data. Figure 5.3.4.2.10 depicts the use of these dialogs to distribute DGPS data to PTVs and to transit business systems.

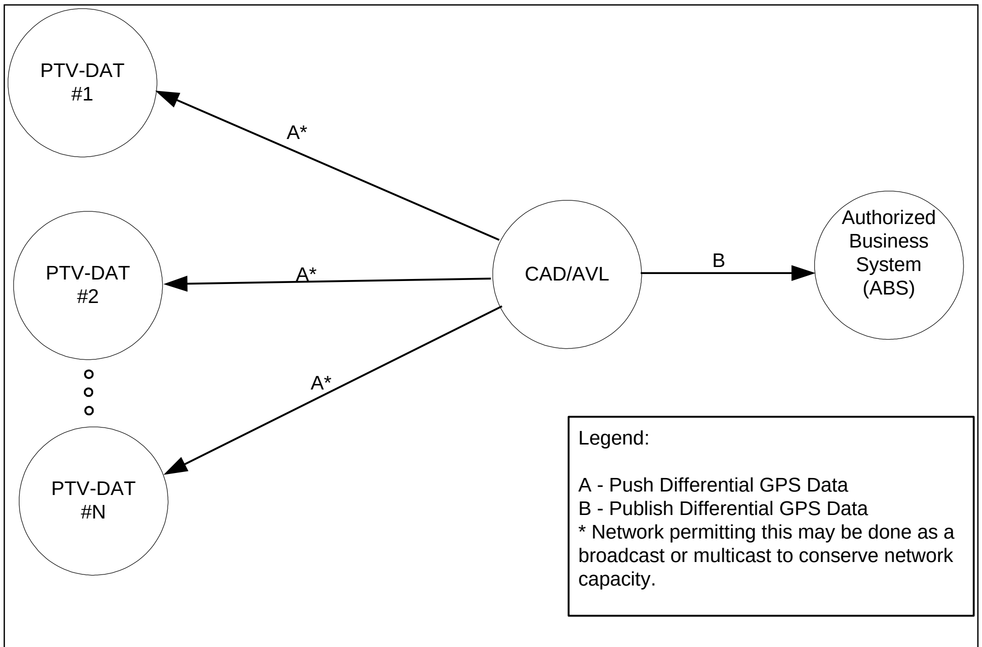


Figure 5.3.4.2.10
Distribution of GPS Correction Data

5.3.4.3 Exceptions to Normal Operations

Section 5.2 discusses incidents including dialog flows associated with incident reporting and management. That discussion includes detours and alarm management (silent, operator, and passenger) and is not replicated here. This section discusses schedule and route adherence exceptions, enroute trip changes, and trip cancellations.

5.3.4.3.1 Route Adherence

The route adherence function monitors and notifies the dispatcher whether a PTV is deviating from its assigned path for its current trip. Route adherence monitoring is performed onboard the PTV by the PTV-ADH entity, or centrally by the CAD/AVL System. The CAD/AVL System can perform this function by comparing vehicle location with the expected vehicle path based on the schedule for the assigned trip.

If the route adherence function is performed onboard, adherence information is provided to the CAD/AVL System either via (TCIP or proprietary) PTV poll responses and the “Notify Polling Result” dialog or the “Publish PTV Adherence” dialog. Default parameters associated with onboard adherence monitoring are provided to the PTV by the “Load PTV Alarm Limits” dialog during the preparation for vehicle operations phase (see section 5.3.4.1).

The frequency of off-route reporting using the “Publish PTV Adherence” dialog is defined by the “Load PTV Alarm Limits” dialog, however, the dispatcher can instruct the CAD/AVL System to send a revised query to PTV-ADH to adjust these parameters (off route distance, and reporting rate) or to cancel the adherence subscription. Note that canceling the adherence subscription impacts schedule adherence reporting as well as route adherence reporting. The dispatcher can effectively disable the route adherence only by setting the minimum off route distance to a large value.

The frequency of off-route reporting using polling is governed by the poll cycle length on the radio channel. The dispatcher may, however, use the CAD/AVL System to put selected PTV(s) in a fast poll mode due to their off-route status. This is accomplished using the "Publish PTV-Polled Parameters" dialog.

The parameters provided in the "Load PTV Alarm Limits" dialog provide ability to specify criteria under which a vehicle is determined to recover from off-route status. These include: transiting a specified number of timepoints or stoppoints along the original route, or returning to within a specified distance of the original route.

Figures 5.3.4.3.1 A-D illustrate route adherence dialog flows in each scenario.

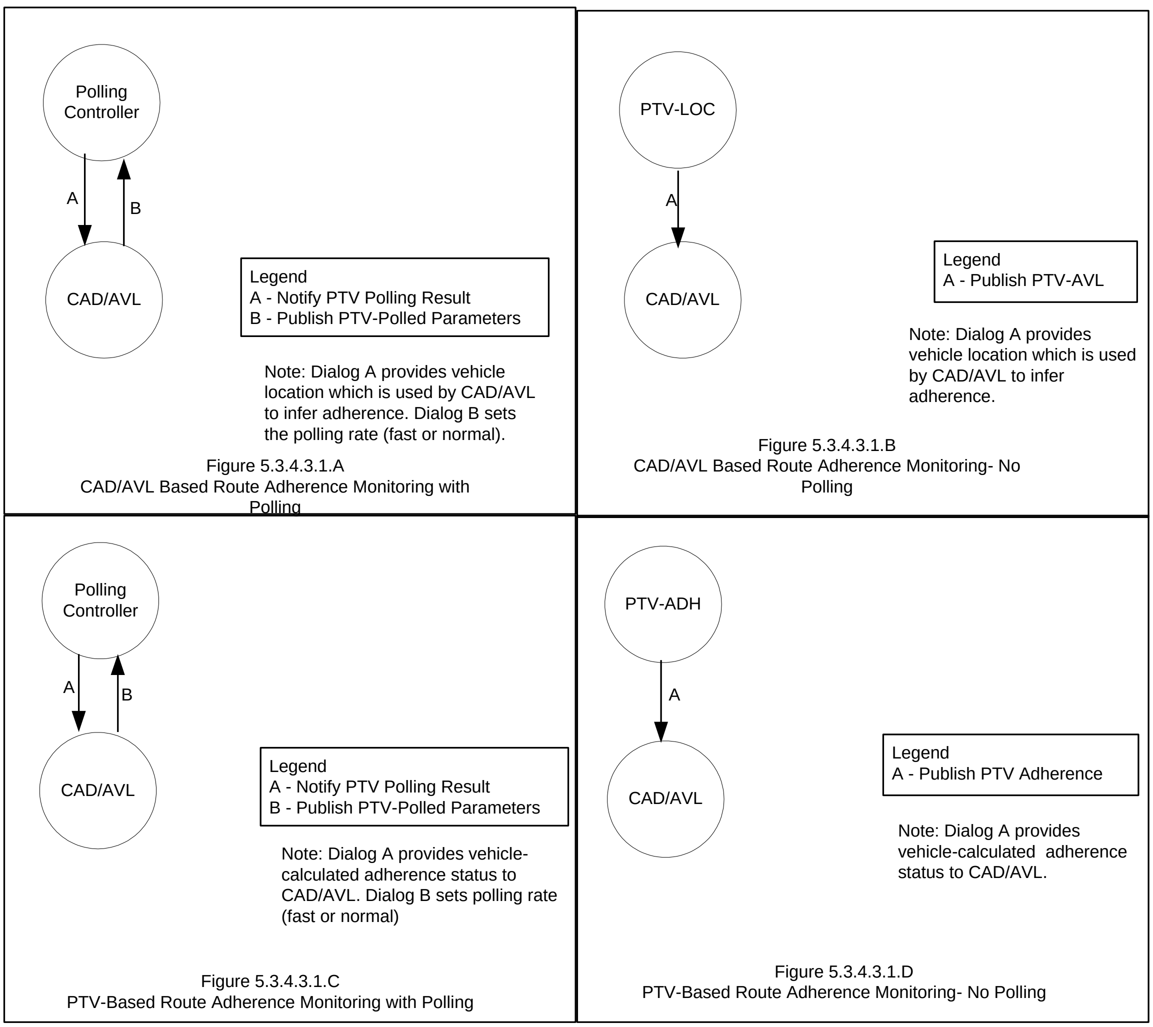


Figure 5.3.4.3.1.A
CAD/AVL Based Route Adherence Monitoring with Polling

Figure 5.3.4.3.1.B
CAD/AVL Based Route Adherence Monitoring- No Polling

Figure 5.3.4.3.1.C
PTV-Based Route Adherence Monitoring with Polling

Figure 5.3.4.3.1.D
PTV-Based Route Adherence Monitoring- No Polling

5.3.4.3.2 Schedule Adherence

The schedule adherence function monitors and notifies the dispatcher whether a PTV is maintaining its assigned schedule for a current trip. Usually schedule adherence is measured by comparing actual and scheduled times at timepoints included in the trip pattern. Schedule adherence monitoring may be performed onboard the PTV by the PTV-ADH entity, or centrally by the CAD/AVL System. The CAD/AVL System can perform this function by comparing vehicle location send times (obtained from the “Notify Polling Result” dialog or the “Publish PTV AVL” dialog), with the scheduled timepoints for the assigned trip.

If the schedule adherence function is performed onboard, adherence information is provided to the CAD/AVL System either via PTV poll responses and the “Notify Polling Result” dialog or the “Publish PTV Adherence” dialog. Default parameters associated with onboard adherence monitoring are provided to the PTV by the “Load PTV Alarm Limits” dialog during the preparation for in-service operations phase.

The schedule adherence criteria using the Publish PTV Adherence dialog is defined by the “Load PTV Alarm Limits” dialog, however, the dispatcher can instruct the CAD/AVL System to send a revised query to PTV-ADH to adjust these parameters, (off schedule early late tolerance) or to cancel the adherence subscription. Note that canceling the subscriptions impacts route adherence reporting as well as schedule adherence reporting. The dispatcher can effectively disable schedule adherence by setting the off schedule tolerance to large values.

The location reporting frequency using polling is governed by the poll cycle length on the radio channel. The dispatcher may, however, use the CAD/AVL System to put selected PTV(s) in a fast poll mode due to their off-route status. This is accomplished using the “Publish PTV-Polled Parameters” dialog.

Figure 5.3.3.2 A-D illustrate schedule adherence dialog flows.

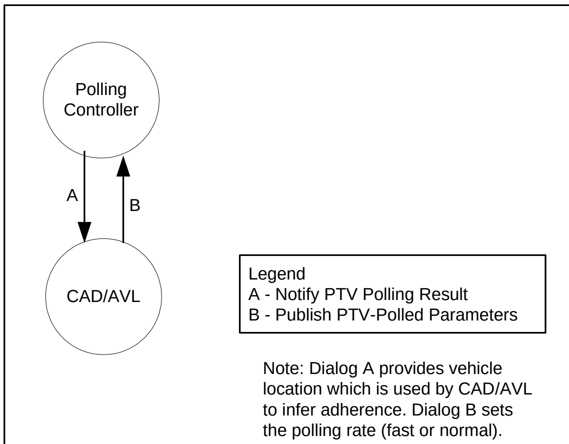


Figure 5.3.4.3.2.A
CAD/AVL Based Schedule Adherence Monitoring with Polling

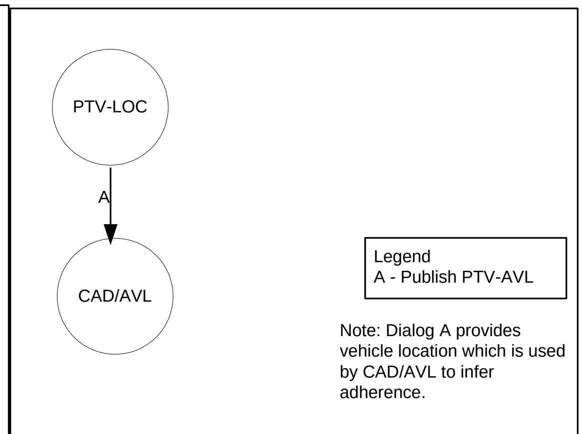


Figure 5.3.4.3.2.B
CAD/AVL Based Schedule Adherence Monitoring- No Polling

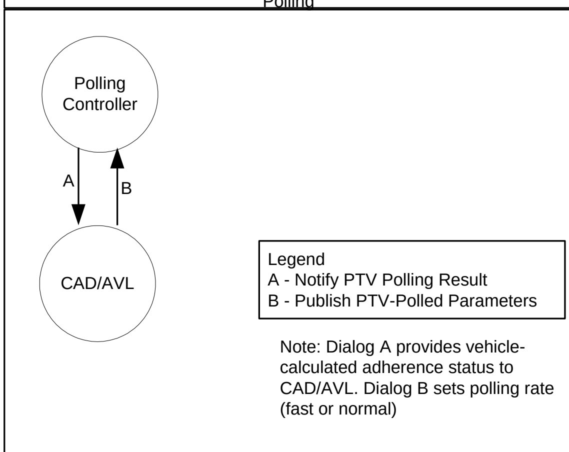


Figure 5.3.4.3.2.C
Onboard Based Schedule Adherence Monitoring with Polling

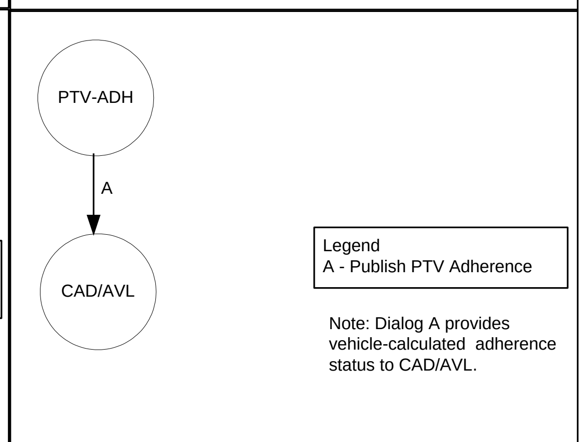


Figure 5.3.4.3.2.D
CAD/AVL Based Schedule Adherence Monitoring- No Polling

5.3.4.3.3 Enroute Trip Changes

Occasionally it becomes necessary to change plans for a PTV after it has departed the garage. Section 5.2.4.5.4 describes the ability for the dispatcher to implement a detour. In some cases it is not appropriate to use a detour, and instead it is necessary to change a PTV's assignment to another scheduled trip or to a newly created trip or set of trips.

If the new trip(s) have already been defined to PTV-DAT using the "Load Schedule" dialog in the preparation for vehicle operations phase, the dispatcher can simply reassign the PTV from one trip to another. The "Command Change Assignments" dialog accomplishes this function. Agency-specific policies and procedures govern the process for moving between assigned trips including discharging passengers, going out-of-service, moving to the appropriate location to begin the newly assigned trip, etc. Normally, this will include a voice conversation between the dispatcher and the PTV operator.

If the new trip has not already been defined to PTV-DAT, then it is necessary to define the trip along with the reassignment. This is accomplished using the "Command Load PTV Trips" dialog. Agencies must use caution in implementing this dialog, as the message to the PTV converting the new trip(s) host the potential to be large and impact the radio link performance, or cause the message to be rejected by the TCIP Polling Controller.

Figures 5.3.4.3.3 A-B illustrate the dialog flows for enroute trip changes.

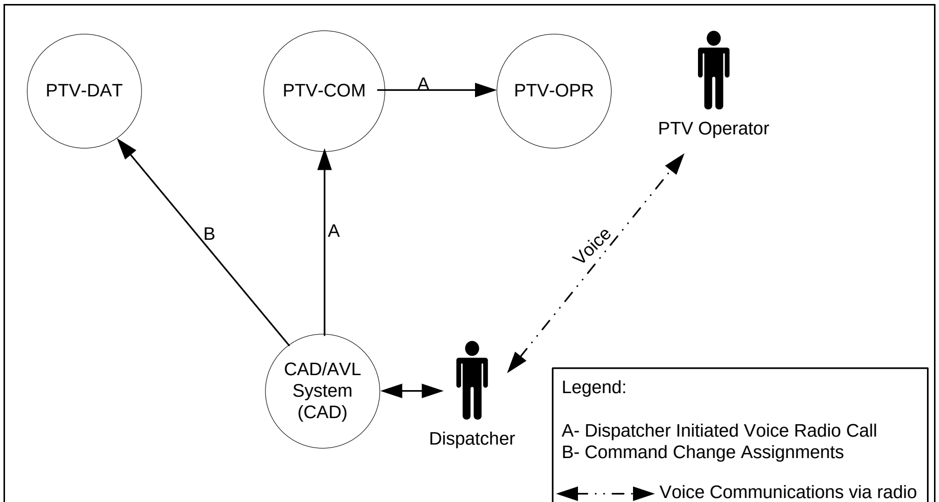


Figure 5.3.4.3.3 A
Enroute Trip Change - New Trip Previously Loaded

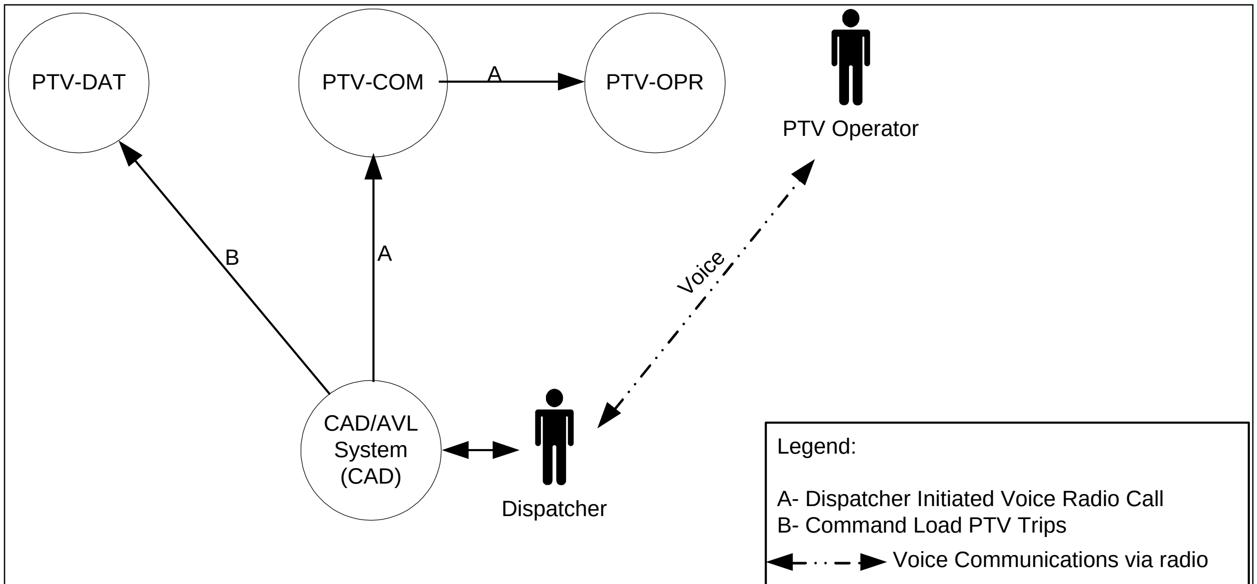


Figure 5.3.4.3.3 B
Enroute Trip Change - New Trip Not Previously Loaded

5.3.4.3.4 Canceling Scheduled Trips

From time to time it becomes necessary to cancel scheduled trips for operational reasons due to unplanned schedule changes, etc. TCIP provides two mechanisms to accomplish this action:

Schedule Updates – If the cancellation is known far enough in advance, row updates can be performed on the schedule to add, modify, or delete trips from the schedule. This occurs via the schedule distribution process discussed in section 5.5, and the loading processes (to PTVs) discussed in section 5.3.4.1.1.

Cancellations Without Schedule Updates – If the cancellation is not known in advance, or the agency does not want to wait to perform a schedule update, the cancellations may be performed using the “Notify Trip Cancellations” dialog.

The “Notify Trip Cancellations” dialog allows the control center to specify that groups of trips will be cancelled for:

- The current day
- A list of specified days
- A list of specified day-types

Figure 5.3.4.3.4 illustrates the use of the "Notify Trip Cancellations" dialog.

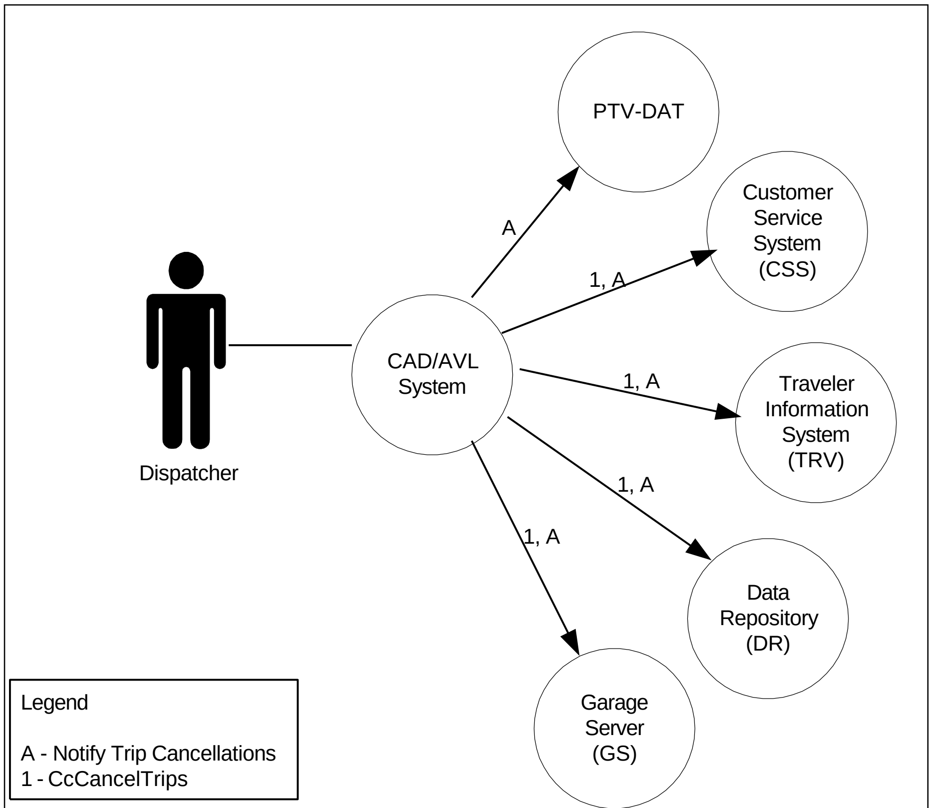


Figure 5.3.4.3.4
Cancellation of Trips Without a Schedule Update

5.3.4.3.5 Reporting Service Events

A PTV operator may encounter a variety of events while providing service, such as noticing damage or graffiti at stoppoints, gang activity, sick passengers, etc.

Figure 5.3.4.3.5 depicts the reporting of these types of events, with a data repository.

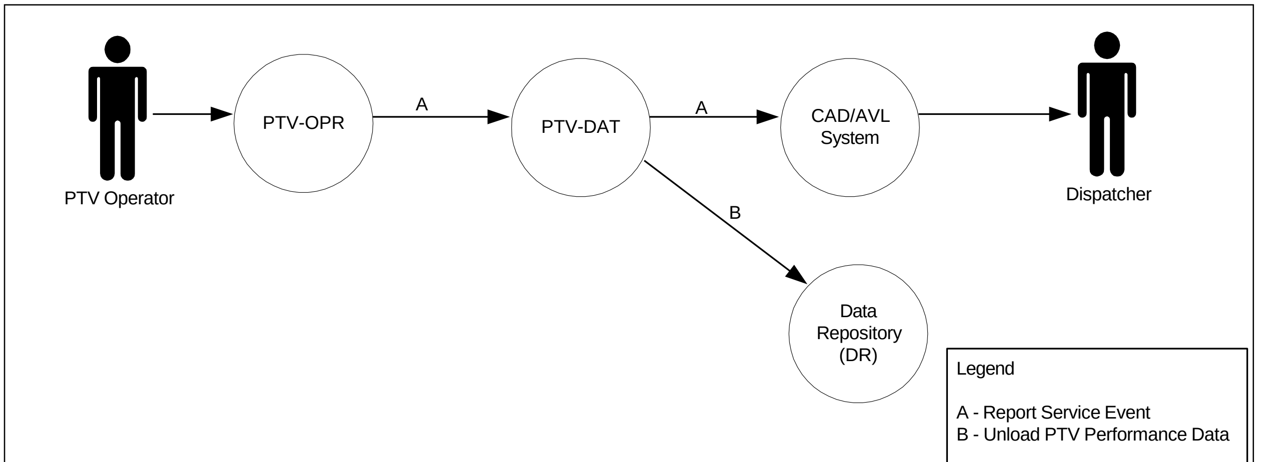


Figure 5.3.4.3.5
Reporting and Logging Service Events

5.3.4.4 Close Out of Normal Operations

After completing service the PTV normally returns to the bus garage. A variety of post service activities may take place including:

- Recording the pull-in to the garage
- Removing cash and tokens from the farebox
- Unloading data from the PTV
- Logoff and shutdown

In addition to the individual PTV closeout operations, there is a closeout with the Traffic Management Center, and another closeout with PTSF entities. These closeouts may occur on a daily or other periodic basis specified by local policies.

5.3.4.4.1 Recording the Pull-In

The PTV's final trip of the day will normally be an out-of-service trip containing a final timepoint at the garage. The scheduled timepoint time for this final timepoint and the scheduled pull-in time will correspond.

The garage-supervisor may obtain a list of scheduled pull-ins from the Garage Server (GS), using a Supervisor Portable or vehicle (SPV). The supervisor will report the pull in, along with the actual pull-in time. Pull-In times may be significant to an agency due to overtime liability, labor agreements, etc.

Other Pull in scenarios include housing the supervisor report directly to the Garage Server (GS), or having pull-ins detected automatically by the CAD/AVL System.

Figure 5.3.4.4.1 A-C illustrate the Pull in reporting process.

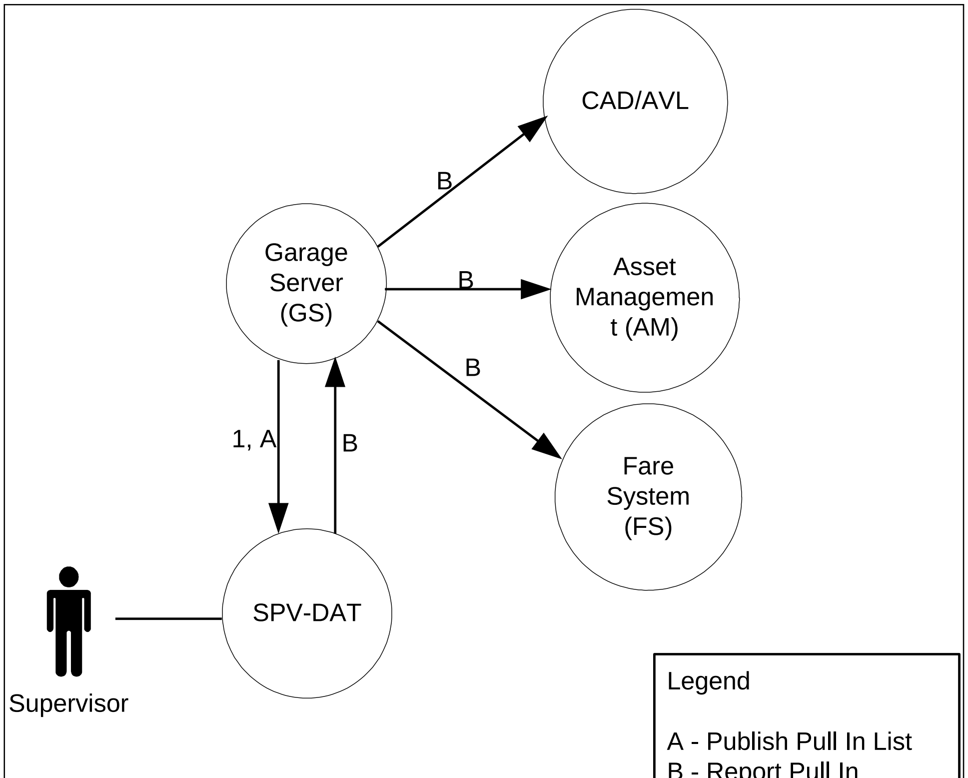
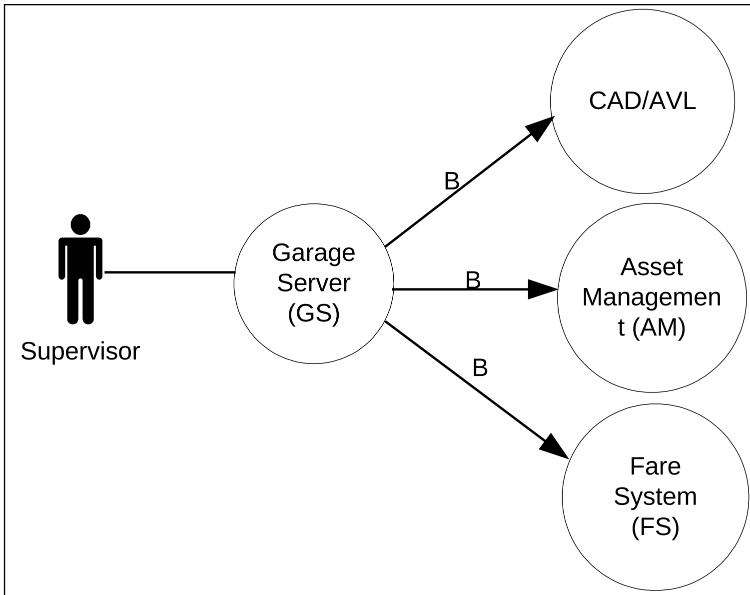


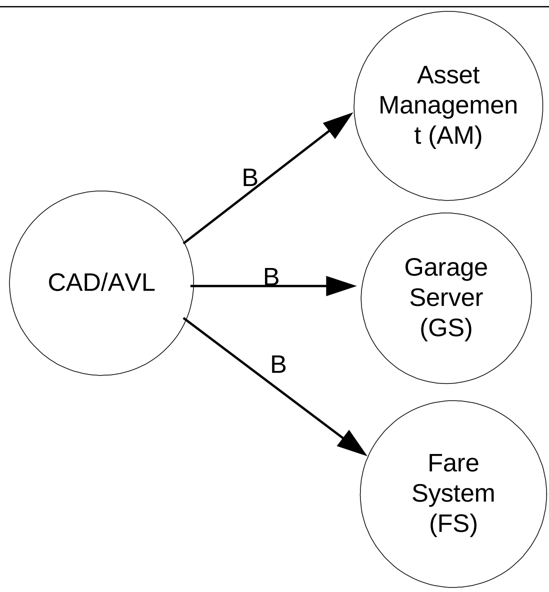
Figure 5.3.4.4.1.A
Recording the Pull In to the Garage Using an SPV



Legend

A - Publish Pull In List
B - Report Pull In
1 - SchPullInList

Figure 5.3.4.4.1..B
Recording the Pull In to the Garage Using the Garage Server



Legend

A - Publish Pull In List
B - Report Pull In
1 - SchPullInList

Figure 5.3.4.4.1..C
Automatic CAD/AVL-Based Pull In Reporting

5.3.4.4.2 Removing Cash and Tokens

The cashbox and tokens may be removed at the garage, or the bus may go to a separate location to have the cashbox removed. Cashboxes may be removed nightly, or allowed to remain on the PTV for a period of days depending on local agency policies. When the cashbox is removed by an authorized employee, the event and the cashbox contents are reported by the PTV to the Garage Revenue System (GRS) and the Fare System (see Figure 5.3.4.4.2). Additional information about fare reporting is described in section 5.4.

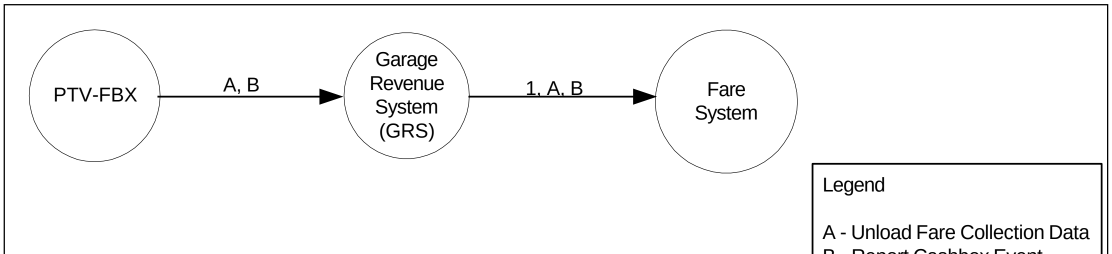


Figure 5.3.4.4.2
Reporting the Cashbox Removal and Unloading Fare Data

5.3.4.4.3 Unloading Data from the PTV

The logical entities onboard the PTV collect and log data throughout the work assignments. When the PTV returns to wireless LAN coverage, this information needs to be removed (unloaded) from the PTV to a longer term data store. Local agency ITS architectures may define variations on the business systems shown as data stores in this section.

Data to be unloaded includes:

- Fare Collection Data
- PTV Performance Data which includes vehicle time/motion information as well as vehicle health and alarm information
- Transit Signal Priority Data (PRG Event Log)
- Video Images captured onboard the PTV

Passenger count data is included in the PTV Performance data unload. This information is required by the Passenger Counting (PC) business system. The Garage Server (GS) extracts this information and provides it to the Passenger Counting business system. The Passenger Counting (PC) business system provides passenger count information to other authorized business systems that require it. (e.g.,, planning, GIS).

Similarly vehicle health/mechanical data is included in the PTV Performance Data unload to the Garage Server (GS). The Garage Server extracts this information and provides it to the Asset Management System (AM).

Figures 5.3.4.4.3 A&B illustrate the unloading of data from the PTV with and without a Data Repository.

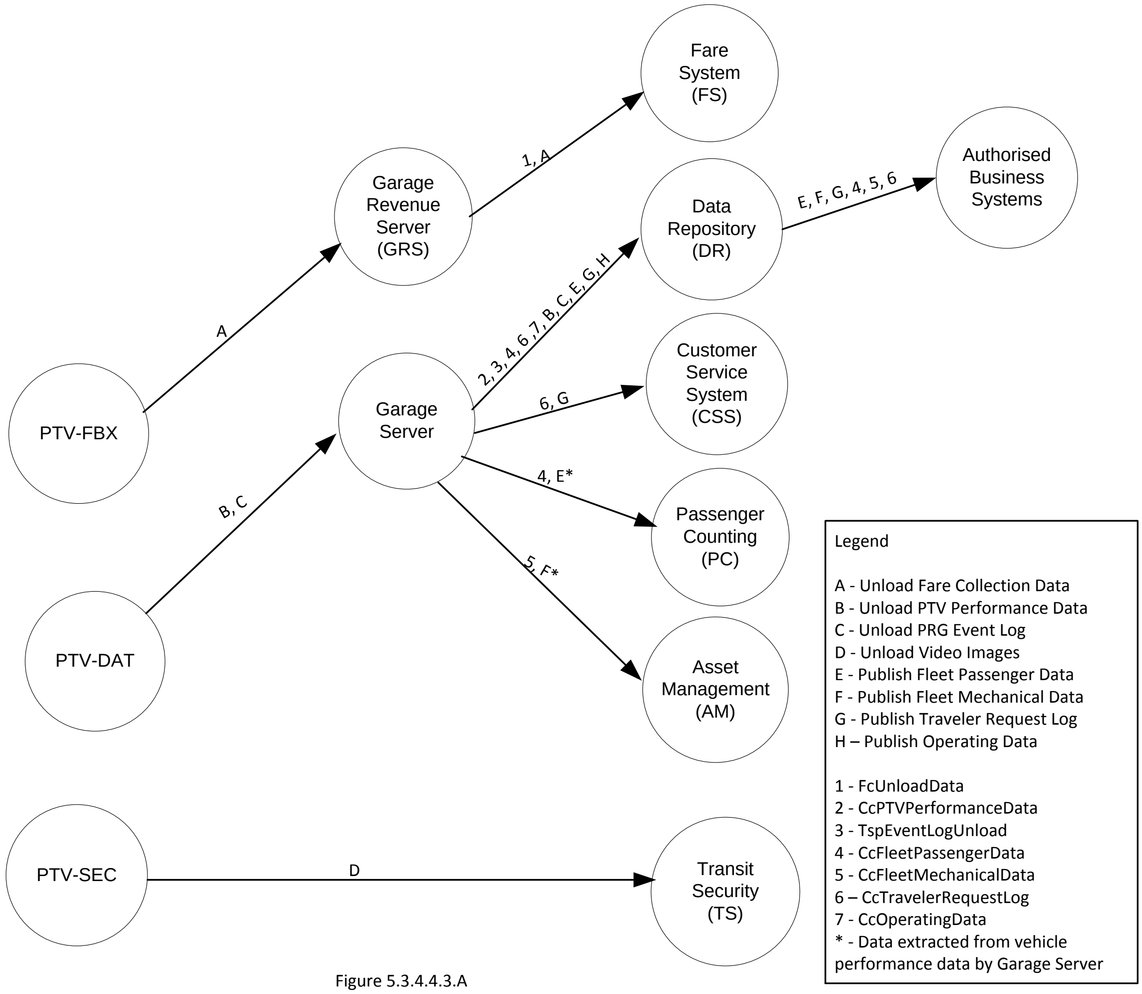


Figure 5.3.4.4.3.A
Unloading Data from the PTV With a Data Repository

01/01/2013

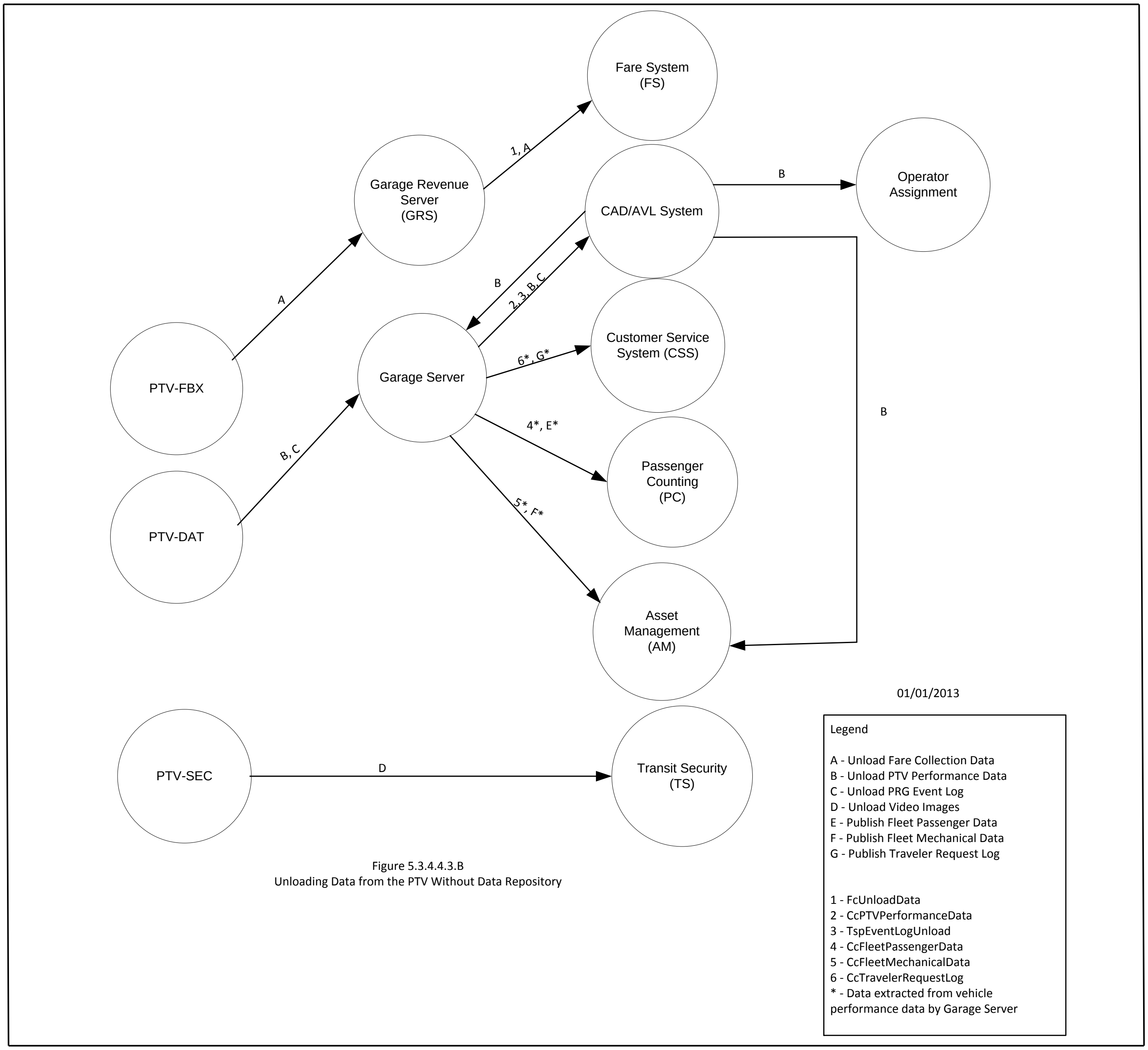


Figure 5.3.4.4.3.B
Unloading Data from the PTV Without Data Repository

5.3.4.4.4 Logoff and Shutdown

The final events of a work day from a PTV perspective, are the sign off by the PTV Operator and possibly a PTV Shutdown. Note that some agencies do not shutdown PTVs after a work block-especially in colder climates. Also, many implementations do not shutdown the computers onboard a PTV promptly when the engine is shut off. This may allow data unloads to complete prior to computers shutting down and effectively disabling the various PTV logical entities. The operator may also report vehicle defects at the end of the day. This is accomplished using the same dialog used for the pre-trip inspection (Report Vehicle Inspection). Figure 5.3.4.4.4 illustrates these activities.

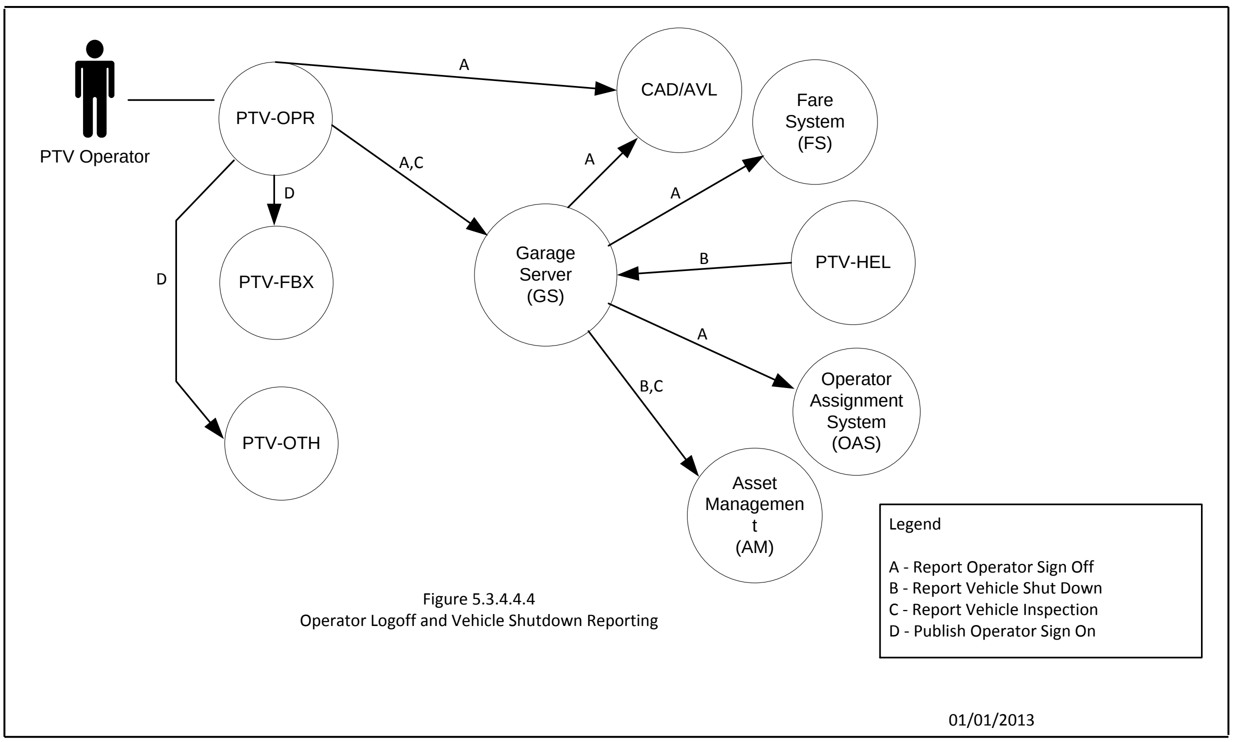


Figure 5.3.4.4.4
Operator Logoff and Vehicle Shutdown Reporting

5.3.4.4.5 Non PTV Closeouts

In addition to the data obtained from the PTV at the end of the day, other operating data is obtained from fixed entities as well.

The periodic closeout with the traffic management area obtains TSP history data from TMC and field based PRG(s) and/or PRS(s). This provides a basis for evaluating the effectiveness of the TSP System(s) installed.

The periodic closeout with the stoppoint of station entities includes cashbox event reporting, fare collection data unloading and video image recovery from PTSF-FBX and PTSF-SEC.

The periodic closeout of traveler requests (for connection protection and/or wheelchair pickups) involves data pushed from CAD/AVL and TRV to the CSS.

Figure 5.3.4.4.5 illustrates these processes.

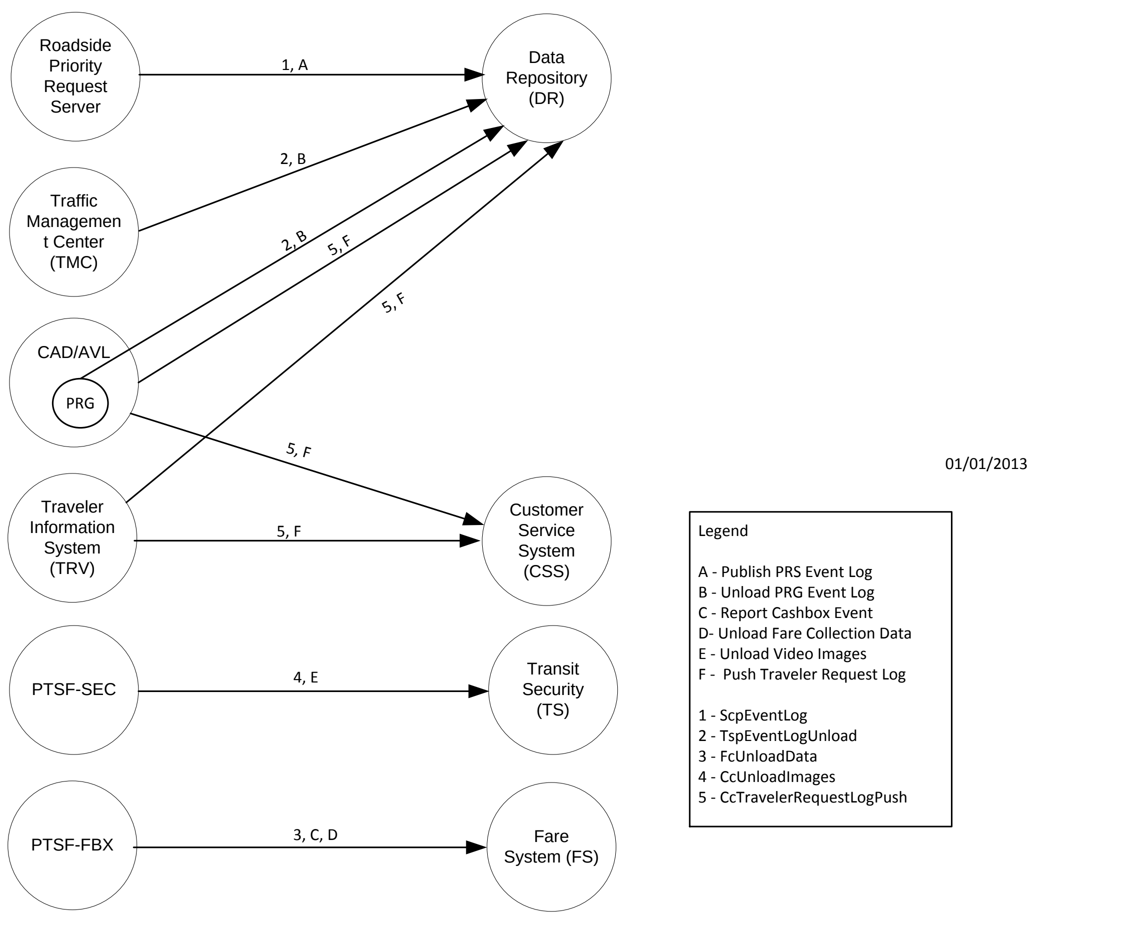


Figure 5.3.4.4.5
Closeout of Non-PTV Entities

5.4 Revenue and Fare Collection Process

5.4.1 Purpose of Revenue and Fare Collection Process

The Manage Revenue and Fare Collection business process deals with all aspects of a transit agency's fare policies and operations. These include determining fares, collecting fares, handling exception conditions, managing media and cash, and dealing with security and accounting reconciliation issues.

Fare policies are locally determined based on a complex process involving local and regional political considerations, agency revenue needs and sources, ridership forecasts and other factors. Since fare policies are highly agency dependent, TCIP provides some basic capabilities which may be tailored to individual agency needs.

The transit industry is currently developing a Universal Transit Farecard Standard (UTFS), sometimes called a smartcard. Many aspects of the Revenue Management and Fare Collection business process will fall under the UTFS standardization umbrella including back office communications with financial institutions, farecard content, validation security requirements, and reader/writer requirements.

5.4.2 Overview of Revenue and Fare Collection Process

The Manage Revenue and Fare Collection business process consists of 8 major sub processes:

- Fare Policy
- Fare Media Sales/Vending
- Revenue/Media Collection
- Revenue Reconciliation
- Banking
- Security
- System Maintenance
- System Configuration

TCIP does not define:

- Regional clearing house functions
- Regional integration of backend fare and financial systems
- Interfaces to banks
- Interfaces to merchants (e.g.,, commercial fare media vendors)
- Fare media
    - Content
    - Form factor
    - Communications/reader protocol
- Encryption schemes

TCIP does define:

- A mechanism to transfer ("load") software and/or manufacturer-defined configuration data to fareboxes and other fare equipment.
- A mechanism to load fare policies, fare zones, etc to fareboxes fare vending equipment.
- A mechanism to remotely disable/enable fareboxes or fare equipment.
- A mechanism to report cash box and vaulting events and contents.
- A mechanism to report the log of farebox or fare equipment events.
- A mechanism to report farebox and fare equipment health alarms and/or security alarms.
- A mechanism to report the fare(s) associated with a planned itinerary.

These mechanisms are intended to support a wide array of agency fare policies and procedures, but may need to be extended to support some locally defined requirements.

Some key challenges and constraints associated with fare collection and revenue management include:

Fare Policy Complexity – Fare policy is driven by a wide variety of local business and political concerns. This results in widely divergent fare policies from one agency to another. Some agencies define very large numbers (>1000) different fare variations within a single agency.

Agency Differences – Agencies adopt significantly different approaches to fare policy including but not limited to paying by ride by distance, by zone, by customer class, etc. Some agencies use cash only, but increasingly agencies are adopting a variety of different fare media.

Regional Policy Coordination – Agencies benefit (through increased ridership) by making it convenient for customers to transfer between transit systems, and modes within a regional area. This results in a need for regional coordination of fare policies and procedures. This is especially true when agencies implement smart card technologies and allow the card to be used on an interagency basis.

Security/Theft/Fraud – Agencies experience ongoing attempts by customers, employees and others to improperly extract cash, monetary transfers, and free service from the agency through a wide variety of techniques including burglary, embezzlement, robbery, fraud and forgery. Agencies must diligently and continuously implement and execute security processes and procedures to counter these threats.

Small Market – The marketplace for transit fare equipment is small compared to the market for other manufactured devices. This problem is exacerbated by different fare policies which result in equipment designs which are not universally applicable across the transit industry. This fragments an already small market. The small market limits commercial investment in research and development of fare equipment for transit, and drives up costs.

Culture – Partially due to the need for security, and partially due to human nature, fare and revenue organizations in transit agencies and the vendors for those agencies tend to be very reluctant to provide open interfaces to fare/revenue systems and equipment. This drives the industry towards stovepipe solutions, inhibits data sharing, and adds complexity to operations (e.g.,, multiple PTV operator logons).

Communications Security – There is a need to ensure that communications conveying revenue-critical information are adequately protected. This may require some communications to be encrypted, authenticated, or otherwise protected and/or authenticated.

Future issues to be addressed in the fare collection and revenue management area include:

Integration Across Modes – Increasingly agencies require the ability to ‘seamlessly’ transfer among transit modes. This presents particular challenges when fare procedures differ by mode. For example, subway systems generally collect fares in stations and control access using turnstiles or fare gates, whereas bus systems often collect fares at boarding. BRT systems may collect fares at the station and issue a ticket as proof of payment. Paratransit customers may pay on boarding or be billed separately from the trip (e.g.,, monthly credit card billing).

Non Transit Cards – The use of non-transit fare media is popular with transit riders, but presents challenges for transit agencies. These cards include commercial credit cards (American Express®, Discover®, Visa®, MasterCard®, etc.), and corresponding band-branded smart cards issued by the banking industry. Additionally government agencies are issuing a variety of magnetic and smartcards which can be used as identification, or as a transit fare media. Non transit cards may require separate fare reconciliation mechanisms, as well as different procedures for loading cards and for obtaining reimbursement for transit services provided. Issuers of these cards may charge a fee deducted from the fare reimbursement for the use of these cards.

Parking Garage Management – Agencies often provide park and ride services where commuters drive from their home to a commuter facility, park their cars in a parking lot or garage and then board a transit vehicle. The parking facilities may be operated by the transit agency, a private contractor (concessions), or by a completely distinct private company. Commuters would prefer to use the same media to pay for fares and parking.

ITS Initiatives – The Intelligent Transportation Systems initiatives continue to evolve over time. The Integrated Transportation Corridor Initiative and the Mobility Services for all Americans Initiative may impact fare collection and revenue management approaches in the future.

CEN Fare Management System Architecture (FMSA). The European Committee for Standardization (CEN) has developed a standard on architectures for fare management systems. Since fare system vendors may sell equipment both in the US and Europe, this standard may impact US fare systems in the future.

APTA Universal Transit Farecard Standard (UTFS) – APTA is developing a standard for fare media and for a variety or related fare/revenue processing activities. This standard will impact the development of smart card and magnetic card systems in the US. UTFS is expected to handle the bulk of the requirements for fare media standardization (particularly card and content specifications), and as a result TCIP does not provide requirements in these areas. UTFS is also working on a set of fare/revenue security guidelines for transit.

5.4.3 Primary Architectural Components

The Key components of the Model Architecture involved in the Revenue and Fare Collection Process are:

Fare System – This is the agency business system that manages fare policies, fare reconciliation, interfaces to the regional clearinghouse, banks, etc.

Garage Revenue Server – This business system provides the link to PTV-based fare equipment and to the garage-based vault. It manages loads and unloads of data from vehicles, cash box events, etc. It also accumulates fare data from the fleet to be provided to the Fare System.

Farebox – This component includes the farebox, cashbox, card readers/writers, and onboard fare vending equipment, etc. It is represented in information flow diagrams by the logical entity PTV-FBX.

Station Equipment – Agencies use a variety of station fare equipment or in some cases none at all. This equipment may include turnstiles, fare media, vending machines, fare media readers/validators, etc. The station equipment is represented in flow diagrams by the logical entity PTSF-FBX.

Regional Fare/Revenue Clearinghouse – This allows agencies to settle up for media sold and trips provided when a multiagency fare system is in place.

Banks – Ultimately the revenue collected, whether directly or indirectly, needs to get into the agency's bank account (s). Banks are also involved directly in transactions involving commercial credit/debit/smart cards.

5.4.4 Manage Revenue and Fare Collection Subprocesses

5.4.4.1 Fare Policy

Agencies develop and evolve fare policies under complex agency-specific conditions that consider:

- Basic Fare Approach (Zone based, distance based, flat fares etc)

- Revenue projections
- Fraud Potential
- Political Environment
- Introduction of Technical Advances (e.g.,, smartcards)
- Other factors

TCIP Provides Policy definition capabilities for:

- Fare media sales
- Allowed transfers
- Fares to be charged/collected
- Fare media 'loading'
- Parking

TCIP fare policy definitions allow a policy to be defined considering the following policy dimensions:

- User/vehicle type
- Fare type (distance, zone etc.)
- Time (expiration of media, valid periods for fares etc)
- Multiple trips (e.g.,, 10 trip card)
- Media types (cash, smartcard, ticket, etc.)
- Day-types (weekday, weekend, holiday, etc)
- Restrictions
- Value/cost
- Discounts and promotions

These fare policies can be pushed from one business system to another using the TCIP Push Fare Policy dialog.

In some agencies, a closely related concept for fare policies are fare zones. TCIP allows fare zones to be defined and transferred from one business system to another. For example, fare zones may be defined in the GIS and transferred to the Fare System, or vice versa, Fare Zone definitions can be loaded to station and PTV based equipment as part of the fare data load process.

Figure 5.4.4.1.A depicts the exchange of fare policy and fare zone information using TCIP.

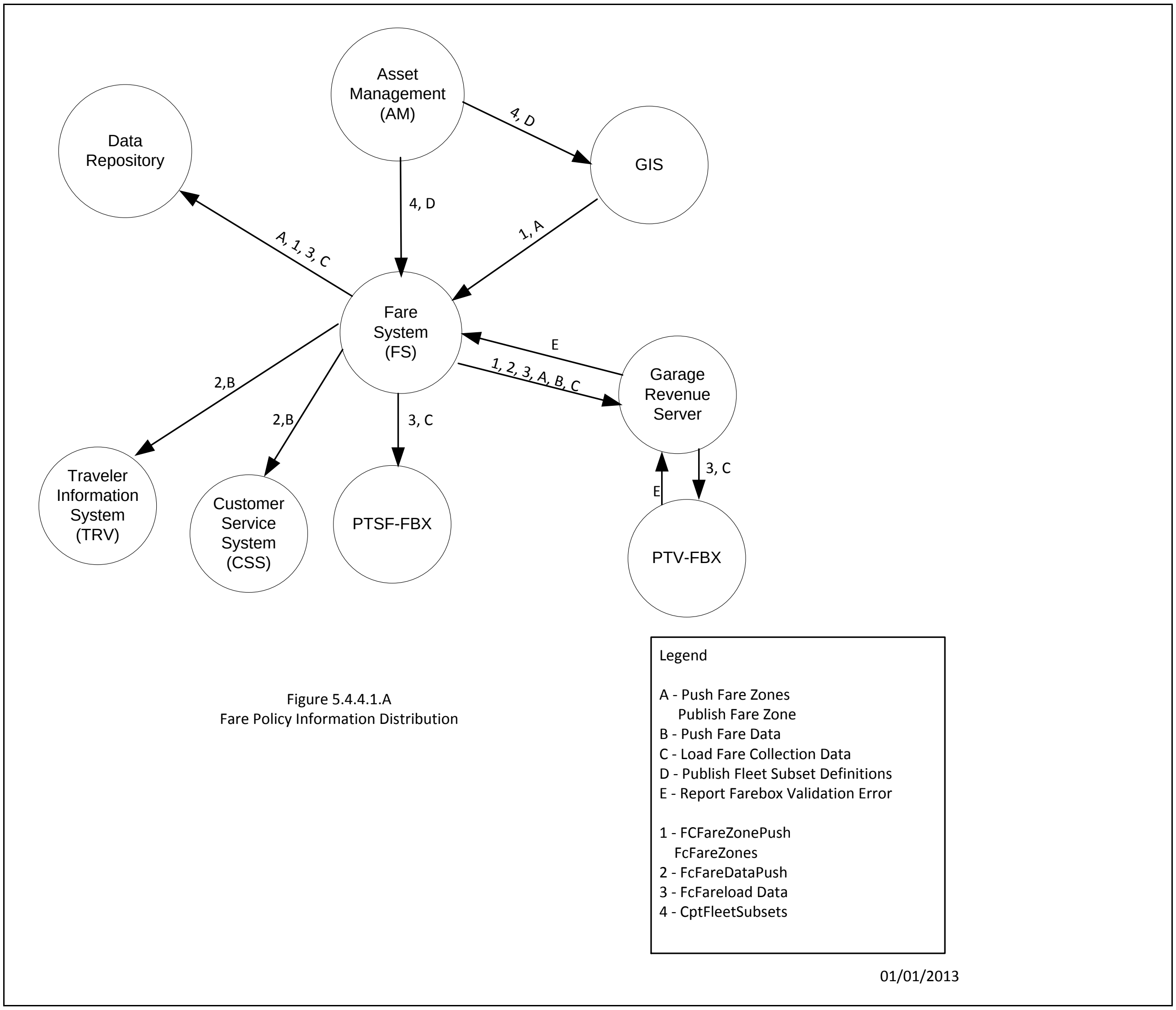


Figure 5.4.4.1.A
Fare Policy Information Distribution

Some agencies may determine that fare policies are not to be loaded to the Customer Service Systems (CSS) and/or the Traveler Information Systems, as shown in Figure 5.4.4.1.A. In this case TCIP provides a mechanism to allow these business systems to query the Fare System (FS) for the fare for a defined itinerary, as shown in Figure 5.4.4.1.B.

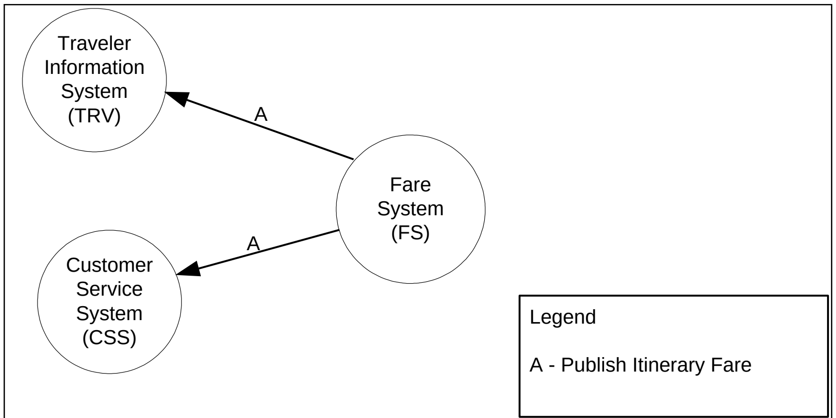


Figure 5.4.4.1.B
Providing Individual Itinerary Fares to Customer Information Systems

5.4.4.2 Fare Media Sales/Vending

Fare Media sales are a key component of the Fare Collection/Revenue Management business process. These sales may occur:

- Using transit agency employees
- Using station/stoppoint based vending machines (PTSF-FBX)
- Using PTV fare boxes (PTV-FBX)
- Using external vendors and/or banks

In addition to sales of fare media, transactions may occur with some media types to:

- Trade in medium for sale on a new medium
- Move value or rides between ‘purses’ on a medium
- Add value to a medium (loading)
- Extract value from the medium for a non-fare sale (e.g.,, newspaper purchase at stoppoint concession)

TCIP does not provide mechanisms to support individual sales transactions (e.g.,, loading a smartcard, validating a credit card). TCIP does include mechanisms for reporting the transactions as part of the unload of fare data from the PTV farebox or station/stoppoint vending equipment for reconciliation at the end of the day.

5.4.4.3 Revenue/Media Collection

Fares may be collected in cash, with a bankcard by collecting a fare medium (e.g.,, ticket/token), by swiping or reading a fare medium which contains stored value (denomination in rides or currency) or by reading a fare medium that results in a later back office ride or value deduction from an account. Customers may have a pass which is read or examined in lieu of fare payment – examples include employee passes, school passes, and monthly passes.

Some agencies sell fare media in the station/stoppoint which must be “validated” by a piece of equipment on the PTV. The ‘validation’ dates the media so that it cannot be reused, or deducts a ride from its value.

As with fare media sales TCIP does not provide mechanisms to collect fares or revenue. TCIP does, however, provide a mechanism for the station/stoppoint equipment or PTV farebox to report transactions in a file unload for reconciliation. (See section 5.4.4.4).

TCIP also provides a mechanism to disable/enable fare equipment in the station/stoppoint or onboard a PTV. The disable command conveys a field that indicates whether it is intended to turn off one or more pieces or equipment, or whether it is to make the system 'free' at that stoppoint or on that PTV. Figure 5.4.4.3 illustrates the dialog flows for these processes.

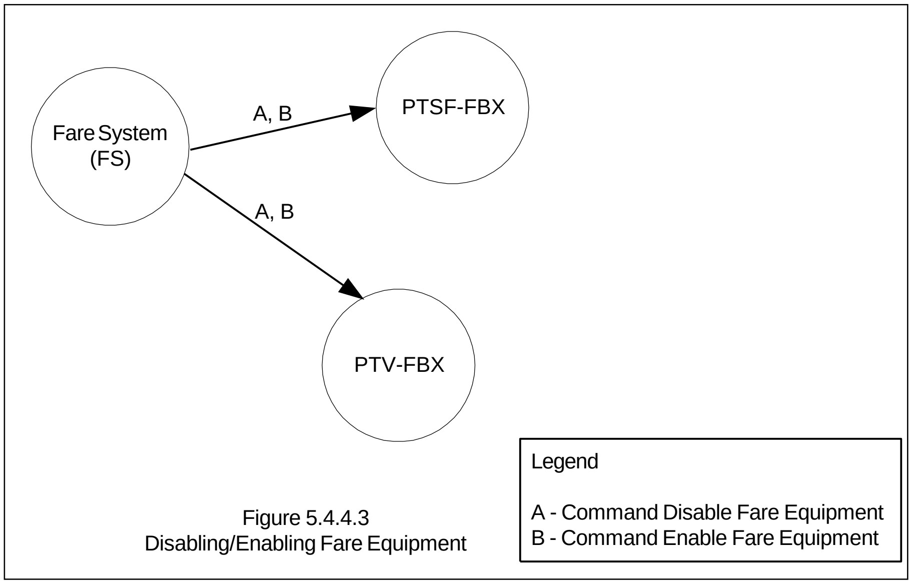


Figure 5.4.4.3
Disabling/Enabling Fare Equipment

5.4.4.4 Revenue Reconciliation

At the end of the operating day (or other agency-determined interval), the data, media, and cash collected at each stoppoint, and PTV are collected and reconciled. Some agencies perform this function in a single location. Some agencies perform this function at various garages and/or administrative locations. Some agencies perform all vending and collection activities on the PTV, some perform all vending/collection activities at stations/stoppoints, some distribute the collection and vending activities, perhaps including commercial merchants.

TCIP provides no mechanism for interacting with commercial merchants, TCIP does provide some mechanisms to support data transfers related to the end of data collection and reconciliation of revenue.

Two examples will serve to TCIP mechanisms provided to support this process phase.

Example 1
In Example 1, consider an agency which performs all of its fare collection and media sales onboard the PTV. The agency may have several garages, each with a cash vault and a Garage Revenue Server (GRS).

At the end of the operating day, the PTV returns to the garage. The PTV's farebox data is unloaded to the GRS. The cashbox is removed and transported to the vault. The removal of the cashbox from the PTV triggers a report to GRS that the cashbox was removed, including the expected contents of the cashbox. Once the cashbox reaches the vault, its contents are compared (reconciled) with the reported cashbox contents and the fare data unloaded from the PTV. GRS generates a cashbox reconciliation report and sends it to the Fare System. Note that the physical process for removing the cashbox contents is not standardized. Some agencies use physical removal of the cashbox from the PTV, while some agencies use automated extraction equipment that does not require and actual farebox removal.

At some point in time, the agency determines that the vaults contents should be collected and reconciled. When the vault is removed, GRS sends a report of the vault event and expected contents to the Fare System. When the vault arrives at the central location its contents are counted and reconciled against its expected contents. The Fare System may produce a variety or reconciliation reports as a result of this process. The fare system may also extract passenger count information from the data provided by the PTVs. This extracted passenger information may be provided to the Passenger Counting (PC) business system, Data Repository, or other Authorized Business system (ABS).

Figure 5.4.4.4.A illustrates the reconciliation information flows example 1.

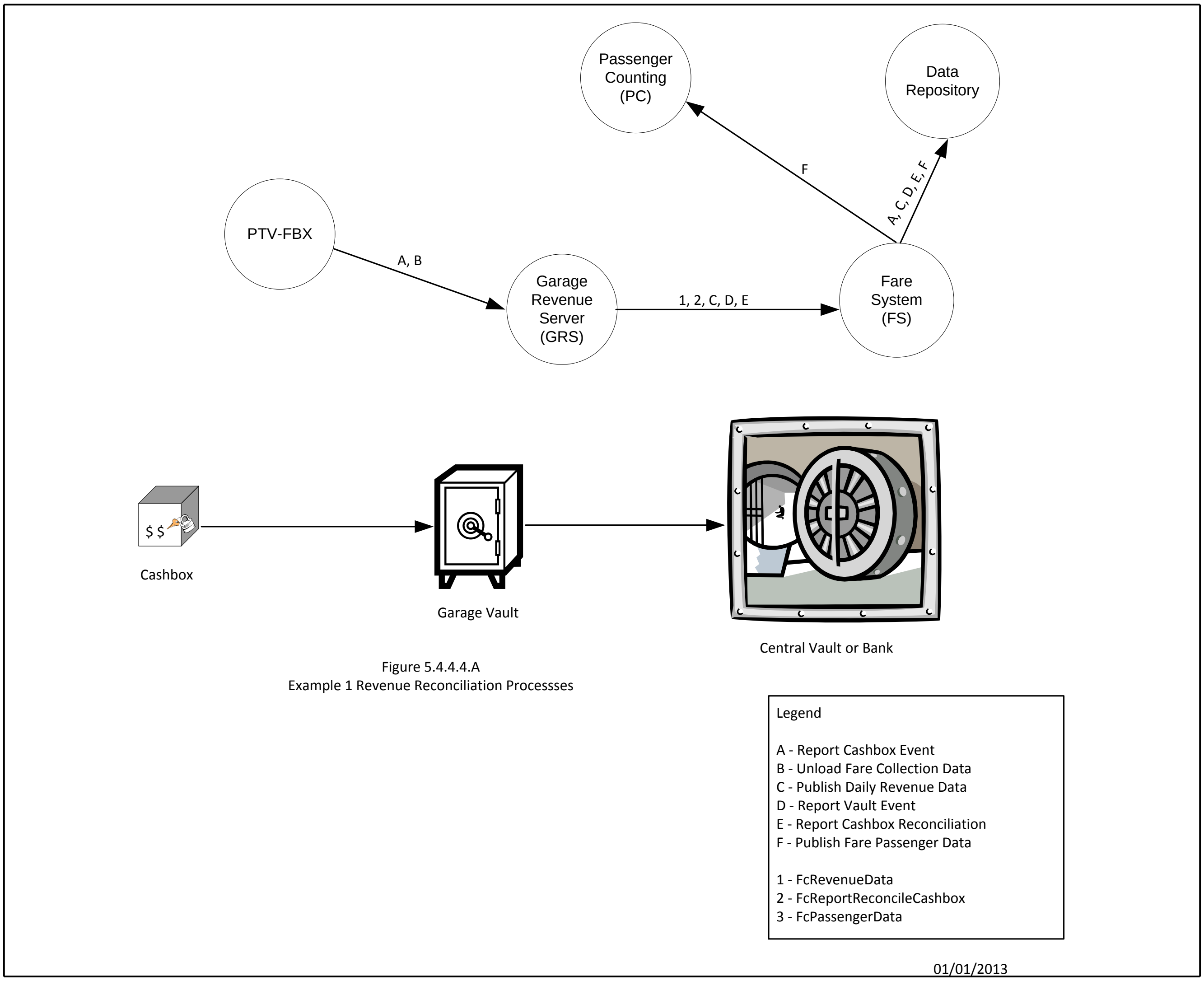


Figure 5.4.4.4.A
Example 1 Revenue Reconciliation Processses

<u>Example 2</u>

In example 2 consider an agency that performs all of its fare collection and media sales at the station/stoppoint. This agency is assumed to have only one central vault facility and no Garage Revenue Server (GRS).

At the end of the operating day, the cashbox is collected from the station/stoppoint. A station/stoppoint may have several fare vending machines and several cashboxes. The Agency ITS architecture determines whether on PTSF-FBX logical entity (station controller) 'manages' all of the station/stoppoint equipment, or whether each separate fare equipment item acts as its own logical entity. The removal and replacement of each cashbox is reported as a cashbox event to the Fare System (FS). Separately, and possibly at a different time, the data is unloaded from the station/stoppoint fare equipment.

Figure 5.4.4.4.B illustrates the reconciliation information flows example 2.
The cashbox(es) are transported to the central facility where the contents are transferred to the central vault. The contents of the cashbox are reconciled with the expected contents from the farebox event report and the unloaded fare data. As with example 1, the unloaded fare data can be used to extract passenger counts to be reported to the Passenger Counting (PC) business system.

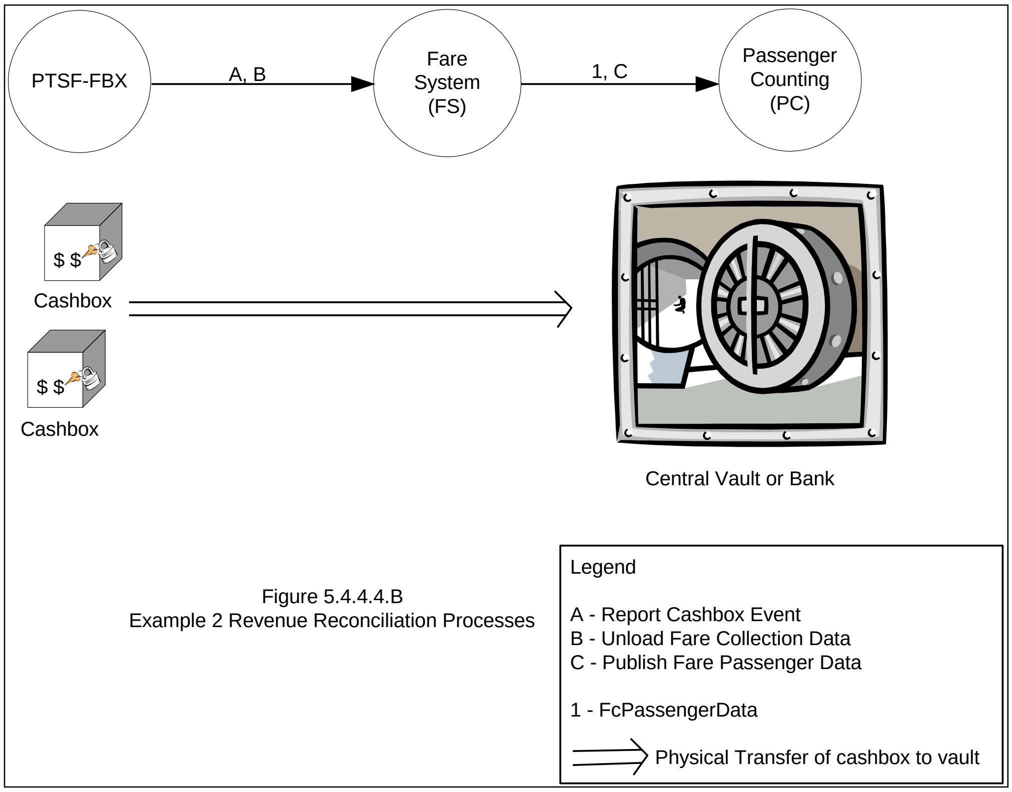


Figure 5.4.4.4.B
Example 2 Revenue Reconciliation Processes

5.4.4.5 Banking

The Fare Collection and Revenue Management business process may have several interfaces to the banking system depending on agency and regional architectures. If bank credit, debit, or smart cards are used for fare payments or to load smartcards or prepaid accounts, this will require an interface to perform card validations. If a regional clearinghouse is used, an interface will normally be required to exchange transaction data with the regional clearinghouse, and one or more agency bank accounts will be required. If external entities (banks or merchants) sell or load fare media on behalf of the transit agency, interfaces to obtain data on these transactions, to reconcile the transactions with funds transfers, and to conduct funds transfers may be required.

TCIP does not specify interfaces to regional clearinghouses, banks, or external commercial entities. The expectation is that banking industry standards based interfaces will be negotiated between local agencies, the regional clearinghouse and the bank(s) involved.

5.4.4.6 Fare Collection and Revenue Management Security

Security in this business process has two major components: physical security and information security. TCIP does not provide information security, however TCIP messages can be exchanged over encrypted links or through virtual private networks or other tunnel-based encryption mechanisms.

Physical security requires a multipronged approach including surveillance, locks, alarms, barriers and other techniques. TCIP defines mechanisms for conveying security camera images (real time or archived) TCIP also provides notifications of cashbox events (see section 5.4.4) which aid management in keeping track of the status and contents of cashboxes. Finally TCIP provides farebox health alarms (see section 5.4.4.7) which include break-in alarms to assist transit security and management in detecting events which may indicate a security incident.

5.4.4.7 Fare/Revenue System Maintenance

Fare collection equipment requires a responsive maintenance capability as failed collection equipment may result in:

- Lost revenue – (can't collect fares)
- Safety problems (e.g.,, jammed turnstile or faregate)
- Security/theft problems
- Exposure to fraud
- Service delays

TCIP provides a mechanism for reporting of farebox and other fare equipment failures and other problems via the Publish Fare Collection Health dialog. Some health alarms may be an indication that routine maintenance is needed. Figure 5.4.4.7 illustrates health reporting to the Fare System, and the creation of a related incident report due to a security problem. The health reporting mechanism also reports serial numbers of reporting device(s) which can aid in configuration management.

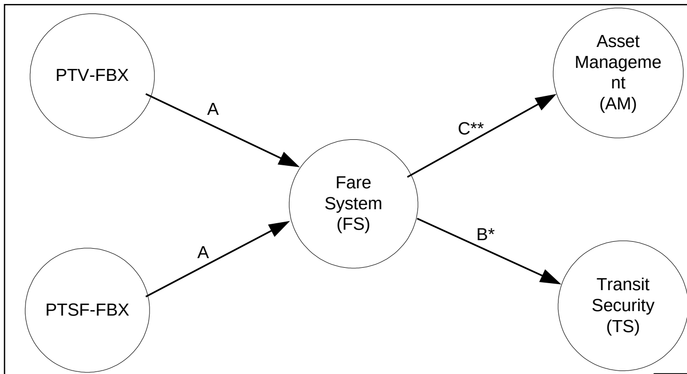


Figure 5.4.4.7.
Health Reporting of Fare Collection Equipment with Possible Security Incident Detection

Legend

A - Publish Fare Collection Health
B - Report Incident
C - Command Open Work Order
* Only occurs when a health report indicates a security problem, may be subject to verification by transit employee.
** Only occurs if Asset Management manages fare equipment maintenance.

5.4.4.8 Fare System Configuration

Fare equipment configuration consists of 3 types of updates:

- Software updates – loading new executable software or firmware
- Standardized Fare Data Updates – loading new fares, fare zones, fare policies
- Manufacturer Configuration Data – loading manufacturer-defined configuration data specific to the equipment brand and model.

TCIP provides mechanisms to update all three types of configuration information. Configuration information can be directed to specific agency defined groups of equipment. The load dialog pattern provides a mechanism to request the correct version of loaded files for a given piece of equipment, however the source of the load must 'know' the correct configuration items to be loaded to that piece of equipment. Figure 5.4.4.8 illustrates the information flows for loading fare configuration data.

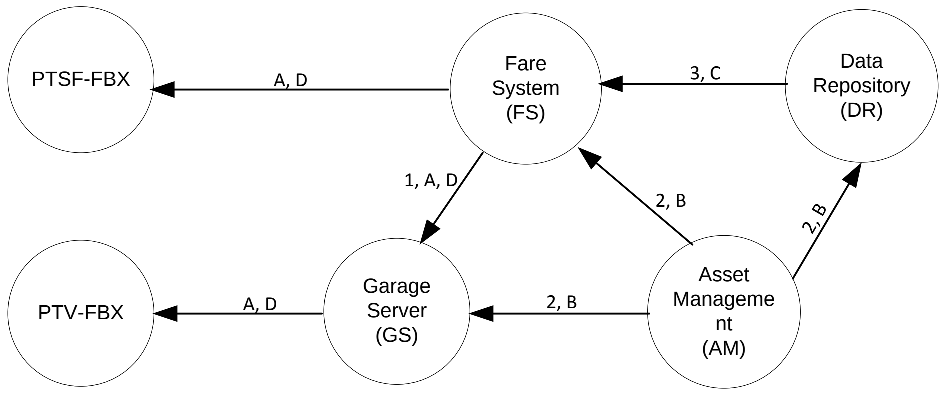


Figure 5.4.4.8
Configuration of Fare Collection Equipment

Legend

A - Load Component Software
Load Fare Collection Data
Load Component Configuration Data
B - Publish Fare Equipment Subset Definitions
Publish Fleet Subset Definitions
C - Publish Stoppoint Subset Definitions
D - Command Set Time

1 - CcOnboardSoftware
CcOnboardConfigurationData
FcFareLoadData
2 - FcEquipmentSubsets
CptFleetSubsets
3 - CptStoppointSubsets

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Although TCIP provides mechanisms to convey configuration information to fare collection equipment on a PTV or in a station/stoppoint, significant configuration issues can still arise. These include configuration errors due to:

- Configuration information sent to wrong equipment
- Equipment location different than indicated by configuration information (e.g.,at wrong stoppoint)
- Incorrect or incomplete equipment inventory
- Incorrect definition of equipment groupings

The Asset Management System (AM) is assumed to maintain equipment inventories in TCIP. Agencies may elect to maintain fare equipment inventories in another business system as part of their agency ITS architecture. The Publish Fare Equipment Subset Definitions allows fare equipment inventories to be divided into groups (which can overlap). Similarly the PTV fleet may have group definitions. These group definitions allow configuration information to be directed to agency defined equipment groupings (e.g.,, all model xyz turnstiles). Thus the Fare System can receive a new software load that applies only to model xyz turnstiles. Assuming that a group definition exists for xyz turnstiles, the Fare System can use the group definition to direct the software only to the impacted turnstiles. Similar group definitions allow groups of PTVs and stations to be defined, and for loads to be directed to specific station group(s) or vehicle group(s).

5.5 Scheduling Process

5.5.1 Purpose of the Scheduling Process

This business process develops transit schedule products and distributes those products to a data repository or to other business systems that need them.

Scheduling products include information for a variety of customer information systems, and schedule-related data for internal management systems that are used to make daily vehicle and operator assignments, manage service, and perform other management processes.

Scheduling products are distributed to the other Transit Business Systems via automatically scheduled or on-demand update processes, either directly from the Scheduling system or from a central repository. Transit Business Systems receiving schedule data may use the data substantially "as is," or may add new information to it in order to perform their function, and may redistribute the data to Public Transit Vehicles, Field Systems, and External Systems.

The frequency with which new schedules and schedule updates are distributed is determined by each agency's business needs and the needs of the users of each system that receives scheduling data.

Scheduling defines the transportation services that will be delivered to agency customers. This process creates an agency's routes, determines when they will operate, defines their length and frequency of operation, identifies the vehicle types that will operate the service, and creates regular operator and vehicle assignments. Customer information is generated from data that originates in the Scheduling process.

In producing schedules and schedule-related information, the Scheduling process is a fundamental agency mechanism for implementing and controlling a transit agency's operating budget. Agency productivity, measured in terms of ridership and revenue, is determined by the efficiency of the services delivered and the cost factors that apply to the delivery of that service. Examples of these cost factors include service characteristics such as route length and frequency of operation, as well as labor contract rules that may determine how operator assignments are created and managed on a daily basis. Many policy decisions are made manifest in the way a transit agency organizes, schedules and delivers its service.

The Scheduling process also has a significant impact on an agency's capital budget, by determining the number of vehicles that are required to deliver an agency's service. Fleet size and vehicle characteristics, in turn, are determining factors for an agency's capital facilities requirements, such as parking space, maintenance capacity and the number of staff required to support vehicle maintenance requirements. The size and number of customer facilities and amenities needed, such as bus stops, transit centers and park and ride lots, are also affected by the scale and complexity of an agency's operation, as defined in its schedules.

Scheduling data form the baseline template for the daily delivery of service. Many operational decisions, such as the assignment of spare vehicles and extra operators, are guided by scheduling data, which is used to determine what recovery strategies may be exercised when service is interrupted by adverse weather, road conditions, accidents, incidents and other operational realities.

5.5.2 Overview of the Scheduling Process

The major subprocesses within this business process are summarized below, and described in more detail in Section 5.5.4.

Gather Data for Schedule Writing

The task of writing a transit schedule typically starts with an analysis of the current schedule, to determine where or how it needs to be changed and updated. This process is assisted by the collection of data from whatever sources are available for analysis, such as ridership information, schedule adherence data, and agency plans for service adjustments or new service. Agencies may have several sources of data available to them for this process depending on the systems they have deployed and how they are used.

Policy decisions are a primary source of guidance to the schedule writer, as revised policy goals or new management objectives will often determine the parameters of a major service change, or set constraints on the resources that are available to accomplish them. Quality control is also an important part of the schedule writing process, especially in current transit environments where automated systems depend on the accuracy of underlying data in order to perform as expected. Users of the current version of the schedule may have reported missing or mismatched data elements that must be fixed in the next release of the schedule. Schedule validation errors may be reported by automated processes, or by anecdotal problem reports that require additional investigation and analysis.

Develop Scheduling Products

This process includes three key sub-functions: schedule writing, block building and run-cutting. These functions define transit service and produce the three products that are distributed from the Scheduling Process.

- Schedule writing produces the Route Schedule, which is used to create customer information in a variety of formats, and is the foundation for the following two sub-processes.
- Block-building is the process of combining scheduled trips in sequences that can logically and efficiently be operated by transit vehicles. The primary output of this process is a set of Unbound Vehicle Assignments that comprise the vehicle sign-out list for each type of operating day; e.g., weekday, Saturday, Sunday or holiday.
- Run-cutting is the process that takes vehicle assignments and "cuts" them – and also combines them – into a set of Unbound Operator Assignments appropriate for each type of operating day for the service change, as required by the agency's weekday, Saturday, Sunday, or holiday operation. The parameters applied during run-cutting are largely determined by an agency's labor policies or labor contract.

Distribute Scheduling Products

Once the scheduling products are created, they must be distributed to the other business systems that require them. The process of distributing schedule products will vary depending on agency ITS architecture and the requirements of the business systems receiving the data. Scheduling data may be distributed directly from an agency scheduling system to client systems, or from the scheduling system to a central repository which then serves as the central distribution point.

Timing is an important element of the distribution process. Some transit business systems require a much longer lead time than others, in order to accommodate internal processes that must occur before a new schedule is put into production. The Operator Assignment System, for example, typically needs a lead time of several weeks with the new schedule in order to set up and conduct an operator pick process and ensure that all operators are trained on their new route assignments, before the schedule becomes effective. Similarly, a Timetable Production System may need several weeks to produce timetable layouts and to print and distribute the paper timetables. Other systems, such as CAD/AVL, may need the new schedule data just a few days before its effective date, in order to complete system loading and error-checking processes.

The schedule distribution process may be set up as an automated "publish and subscribe" process, whereby the publication process will automatically "push" the new data out to subscribing systems. Or the process may be set up to give the receiving systems an extra level of control, so that they are able to initiate a process to "pull" the new data into their system when they are ready for it, as in the cases mentioned above. TCIP supports both types of processing.

Agency ITS architectures also will determine whether schedule distribution is a wholesale update of the entire schedule, or just a distribution of the elements that have changed. Many systems are not capable of handling just incremental updates, and so must receive a complete dataset each time a new version of the schedule is distributed.

Organizational players in the Scheduling process include the following:

- A Planning work group often develops the new service plan and defines the general parameters that will apply to the service. These include guidance on the frequency and span of service to be provided, as well as guidance on the routing to be used. Often, the Planning group is responsible for obtaining the management and policy-level approvals for the proposed service plan.
- The Scheduling workgroup works with client groups to refine the agency's scheduling requirements, creates the scheduling products, and distributes the scheduling products.
- Due to the technical nature of Geographic Information Systems (GIS), many agencies have a specialized workgroup that creates and maintains digital maps of the service area, route overlays, bus stop data and other layers of GIS data. Other agencies use the built-in GIS features of a developer's scheduling product.
- An Information Technology workgroup provides essential support for the maintenance of servers, databases, applications and processes that support the creation and distribution of Scheduling products. Sometimes this group also provides GIS support.
- The Customer Services workgroup is a major consumer of Scheduling products and often provides feedback on customer-requested changes and improvements to the schedule.
- The Operations workgroup, similarly, is a major consumer of scheduling data in a variety of forms, including data for daily operator assignments and the databases for critical management systems such as CAD/AVL.
- The Vehicle Maintenance workgroup uses Scheduling products to assign vehicles and manage fleet requirements.

Since TCIP was created to establish interface standards for communications between transit information systems, a fundamental assumption in TCIP is that certain core systems are available to produce transit data in those formats. While many elements of TCIP, such as real-time PTV arrival information or automated on-board stop announcements, are optional, the scheduling system is a required building block that must be present before any core set of TCIP-conformant systems and dialogs can be deployed.

Since scheduling information is used in many ways throughout a transit agency, the Scheduling business process must try to balance the needs of all those users in order to provide a consistent product. Schedulers are often constrained by the agency's operating budget, since adding or changing running times may affect operator pay, or may result in changes to the blocking process that result in less efficient vehicle assignments. If there is a labor agreement, it may include any number of requirements on how operators' work may be defined, such as breaks or lunch periods, which can affect the schedule writing and blocking as well as the runcutting process.

All of the large transit agencies and most of the medium-sized transit agencies have deployed some form of computerized scheduling system, as have many of the smaller agencies. However, there is a much wider variation in whether agencies have fully integrated Geographic Information Systems into their environments, and whether they have developed and maintained the data elements and attributes that are part of GIS. This aspect of system development is important because accurate geographic data, including an up-to-date base map and layers of transit-related data elements, are required building blocks for the deployment of many advanced features of modern transit information systems.

Although many agencies have incorporated the concept of a data repository, there is a wide variety in how these repositories are defined and maintained, and what granularity of processes and reporting are available from them. While not providing absolute requirements for the definition of these repositories, TCIP will help to standardize them by providing structured definitions for the inputs to them and outputs from them. Section 5.9 describes the data repository in more detail.

More transit agencies will seek to deploy advanced technologies such as automatic vehicle location, automated on-board stop announcements and displays, and real-time customer information updates delivered by a variety of channels.

The need for more responsive service will mean that Scheduling will have shorter cycles for making changes and distributing updates.

More performance data being gathered from a variety of sources (ridership, on time performance, traffic conditions, etc) means that more advanced analysis tools will be required to properly analyze that data.

5.5.3 Primary Model Architecture Components

The model architecture assumes that the Scheduling, Blocking and Runcutting functions are performed in a single business system. These functions may be allocated to different components in an agency ITS architecture, and may be performed at different points in time.

The model architecture deals with architectures that may or may not include a data repository. Schedule distribution requirements are somewhat different for these 2 cases.

The key entities in the model architecture for the Scheduling Process are:

- Scheduling System (SCH) – this business system performs the scheduling/blocking/runcutting.
- Data Repository (DR) - If present in the agency ITS architecture, this business system receives schedules from the scheduling system and distributes them to other business systems. The DR may also fuse data from other sources with the schedule.
- Geographical Information System (GIS) – If present this system is used to maintain geographical information about transit facilities and operations, as well as map information. This business system may also provide conversions between location referencing schemes (e.g.,, address to latitude-longitude), and geographical traces for series of points (e.g.,, a pattern).

5.5.4 Scheduling Subprocesses

This section describes the major subprocesses of this business process.

5.5.4.1 Data Gathering for Schedule Writing

The goal of this process is to collect and analyze all possible sources of relevant data as an aid to refining and revising schedules for a future update. The number of sources and amount of data available is dependent on the agency's local architecture, but may include one or more of the following:

- Ridership data helps Schedulers evaluate whether the frequency of service is appropriate, or the correct vehicle type is assigned to each trip on the route. These data may come from a combination of the following sources:
    - A registering farebox – cash fares, tokens and tickets may be counted and categorized by a registering farebox system. These data are later summarized at the trip or route level to evaluate ridership.
    - An electronic fare payment system, using either contact or contactless "smart cards" may collect electronic payments or count rides that are authorized by electronic passes. These data also may be summarized by trip or route to evaluate ridership.
    - An Automatic Passenger Counting (APC) system may be used on a portion of the fleet or the entire fleet in order to count customer boarding and deboarding. APC systems have an advantage over most fare payment systems in that they are able to determine peak passenger loading, since they capture both the boarding as well as deboarding points.
    - Survey data – some agencies use staff to count riders, by riding along on selected trips, or by observations at key locations on the route. Some survey data may be gathered by transit operators in the form of count cards which are later tallied.
- Schedule adherence data may be collected from a variety of sources, such as:
    - An Automatic Vehicle Location system collects on-time performance data in the form of actual arrival and leave times at scheduled timepoints. Sometimes schedule adherence data are also collected by an APC system.

- A Transit Signal Priority system also collects on-time performance data.
- The Incident Management system may provide information on certain operational trends that are not readily apparent or understood from looking just at automated sources such as AVL or APC data.
- Survey Data – Staff employed as mentioned above under Ridership may also collect observations of schedule performance on selected trips or at key locations (check points) along the route.

- Other sources
  - Customer feedback from a Customer Information System may provide information on problem areas or requested service improvements
  - Operator input in the form of service reports may be used in making schedule adjustments.
  - Error reports from systems and users of scheduling data may identify the need for corrections or revisions that should be included in the next release.

Figure 5.5.4.1 depicts the process of gathering data into the Scheduling System to use in the schedule writing process. Not all of these information flows will be used by all agencies and agencies may have other locally defined information flows that are used. For example, this figure implies actual running times being extracted from operating data by the DR, and provided to GIS, and the GIS in turn provides new scheduled running times to scheduling. Other agencies may analyze and re-plan running times in the scheduling system without involving the GIS. Actual running times may be collected by the CAD/AVL System, by post processing CAD/AVL data by supervisors or by other mechanisms such as post processing toll tag reader data.

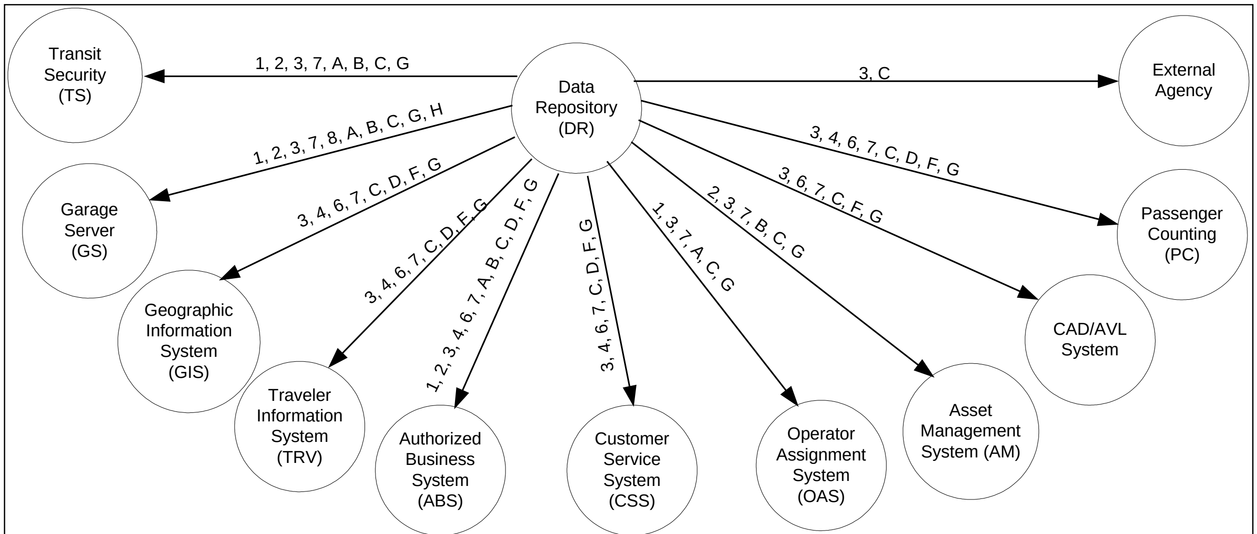


Figure 5.5.4.3.C
Schedule Artifact Distribution by Data Repository

Note:
1. GS will either use schedule load, or subscriptions but not both.
2. Schedule Distribution to PTVs is done by GS - see section 5.3.4.1

Legend

A - Publish Operator Assignments
Publish Roster
B- Publish Vehicle Assignments
C - Publish Master Schedule Version
Publish Route Schedule
Publish Trip Detail
Publish Block Schedule
Publish Run Schedule
Publish Pattern List
Publish Timepoint List
D - Publish Stoppoint List
F - Publish Running Times
G -Publish Calendar
H - Load Schedule

1 - SchPushOperatorAssignments
SchPushRoster
2 – SchPushVehicleAssignments
SchVehicleAssignmentList
3 - SchPushMasterScheduleVersion
SchPushRouteSchedule
SchTripDetailList
SchPushPatterns
SchPushTimepoints
4 - CptStoppointList
6 - SchPushRunningTimes
7 - SchPushCalendar
8 - SchRouteScheduleFile
SchRunScheduleFile
SchBlockScheduleFile
SchPatternFile
SchTimepointsFile
SchCalendarFile
CptStoppointsFile

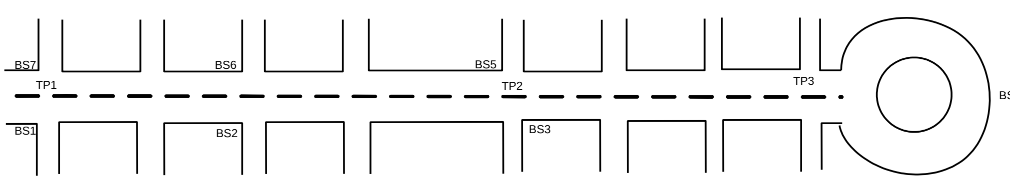
5.5.4.2 Developing Scheduling Products

Schedule writing is the process of creating a route and defining the service that will operate that route. A route is defined by one or more patterns – the geographic paths over which trips travel. Patterns may contain many types of points and events, including timepoints, bus stops, transfer points, fare zone changes, destination sign changes, transit signal priority triggers, operator road relief points, automated announcements to passengers and other messages to the operator. In TCIP, each trip is assigned a unique number within a schedule release.

Route Schedules define the scheduled trips on a route in both directions. Trips are defined in terms of the patterns they are to follow and the times that the vehicle is scheduled to arrive at (or depart from) timepoints within the pattern. Route Schedules reference patterns that define the movements of vehicles along a route. A pattern is defined as a sequence of pattern segments. Pattern segments in turn define the timepoints, stoppoints and layovers associated with the vehicles movement. A pattern may also define other events that are scheduled enroute (e.g.,, destination sign changes). Patterns and pattern segments can be shared by more than one trip. Timepoints define locations at which the PTV's progress is measured against schedule. In addition to in-service, or revenue, trips – some agencies also schedule 'dead head' trips, garage transfer trips, and other trips for administrative purposes. Some agencies exclude administrative trips from the schedule.

Pattern Segments may be defined by timepoints alone or by the timepoints and stoppoints included in the pattern segment. This convention was adopted to accommodate the widest possible variety of scheduling system designs, however not all transit business systems and components can accommodate pattern definitions that lack stoppoint data.

There are cases where a scheduling system produces patterns without stoppoint information, and downstream businesses require stoppoints as part of the pattern definition. For example, a VLU may require stop information to correctly attribute passenger counts to stoppoints. Stoppoints may be added to the pattern segment definitions downstream of the scheduling system in an external business system such as a data repository or bus stop management system. This process is termed "stop sequencing". Stop Sequencing may be done in a different department and on a different release schedule than baseline schedules. For example, this may occur upon approval of a new bus stop by a local government. Consequently systems that use patterns containing stop information (e.g., VLUs on PTVs) may need pattern updates more frequently than schedules are released from the scheduling department.



Example of Patterns with Bus Stops Preceding and Following Timepoints
Figure 5.5.4.2

Careful consideration must be given to stoppoints that appear in a pattern segment prior to the first timepoint in the pattern or following the last timepoint in a pattern. Stop sequencing must consider factors other than the proximity of a stop to the mapped GIS pattern of streets between mapped time points. Such factors include:

- Whether a stop is included by its association with the first or last time point on a route even though it is beyond a mapped pattern that begins and ends at mapped time points in the center of intersections.
- Whether a stop is excluded due to express or skip stop operation or turning movement.

Consider, for example, Figure 5.5.4.2. A pattern is defined from left to right containing timepoints TP1, TP2 and TP3, and another pattern from right to left containing the same timepoints in reverse order. In both cases bus stops must be added to the pattern during stop sequencing that are "outside" the timepoint sequence. Also note that if BS4 is used as a layover/turnback point, it will need to be added to both patterns.

Some agencies may require that layover times be associated with a stoppoint such as BS4 in Figure 5.5.4.2. TCIP provides several possibilities for this. One approach is to include a timepoint associated with BS4 and to include the timepoint in both the right to left and left to right patterns. Thus the timepoint at the end of the pattern signifies scheduled completion of that pattern and the timepoint at the beginning of the pattern signifies scheduled beginning of that pattern. An alternative approach is to schedule times in both patterns for TP3 without a timepoint associated with BS4. In this case the departure from BS4 to begin the new trip must be appropriately in advance of the scheduled time at TP3 to account for the movement to that intersection. Schedule notes may be used to document layover information for use by operators, supervisors and other transit employees.

Another consideration is the relationship between timepoints and stoppoints. One or more stoppoints may be associated with a timepoint. Frequently, timepoints are georeferenced to the center of an intersection, whereas stoppoints are georeferenced to the right side of the street and before ('nearside stops") or after ("farside stops") the intersection. Agency policy dictates when a timepoint is considered to be traversed for schedule adherence purposes. These policies may include:

- Timepoints are traversed when the PTV reaches the center of the intersection
- Timepoint is traversed when bus stops at or passes an associated nearside stop
- Timepoint is traversed when a bus closes its doors and departs or passes an associated nearside stop
- Timepoint is traversed when a bus arrives at or passes an associated farside stop
- Timepoint is traversed at the intersection center for nearside stops, but upon passing or stopping at an associated farside stop
- Timepoint is traversed for schedule adherence purposes when the PTV arrives within an agency-specified distance of the timepoint location, and is considered 'departed' from the timepoint when it reaches an agency specified distance from the timepoint.

TCIP does not endorse, or preclude any of these policies.

Each trip in the route schedule, is defined not only by the pattern it follows, but by the scheduled times at timepoints for the PTV. Timepoints may be shared by more than one pattern or pattern segment. Transfers define opportunities for transit passengers to switch from one PTV and trip to another – usually between PTVs operating on different routes. The transfers specified in this output from the scheduling process generally do not include all available transfers, but are limited to a subset that the agency determines to be of particular interest. Transfers may be protected or unprotected. A protected transfer implies that the agency may hold the departing PTV to wait for the arriving PTV so that transferring passengers can make the connection. Agency policies limit the duration and circumstances of such holds. Transfers may also be intermodal (e.g.,, light rail or subway to bus or vice versa.) or interagency. Transfers may be defined by the scheduling system, or inferred and added by a downstream system such as a Data Repository, Customer Service System, or traveler information system. Transfer definitions are optional in TCIP and may be omitted from the schedule entirely, based on agency profiles.

The schedule may be distributed to other business systems at this stage of the development process (see section 5.5.4.3), as the definitions of the trips to be run and transfers to be made available to customers may be useful to other transit business systems. Based on agency policy the distribution at this time may or may not contain trip times (e.g.,, Route Schedule). Some agencies adjust trip times to achieve efficiencies in blocking and runcutting. The schedule group can then work on the remainder of the scheduling products (see below) in parallel with work done in other areas using the new schedule (e.g.,, develop printed timetables).

Once schedules are written, the block building process combines trips into optimized vehicle assignments such that the number of PTVs and platform hours are minimized. A block, also known as a vehicle assignment, includes everything a PTV is assigned to do from the time it pulls out of the garage until it pulls in. Different vehicle types are assigned to specific trips or routes based on ridership requirements or other characteristics of the route. The block building process determines the amount of layover or recovery time that a PTV will have between scheduled revenue trips. This is also the process that identifies the deadhead trips that might be needed to move a PTV from one route to another so that all trips are operated efficiently.

Vehicle assignments (or "blocks") defining the daily work assignment for vehicles are the output of the blocking process. Scheduling creates the work assignments but does not assign this work to individual vehicles. The term unbound indicates that specific vehicles have not been paired (bound) with the work assignments. The assignment of specific vehicles to blocks is the responsibility of the "Garage Management System".

Run-cutting is the final step in the scheduling process, in which vehicle assignments are cut into optimized operator assignments. A short vehicle assignment may require just one operator, while longer vehicle assignments may require several operators throughout the day. Some pieces of work may be combined to create a split shift assignment for a guaranteed 8-hour day. The goal of the run-cutting process is to efficiently distribute the work so that overall costs are minimized given union contract rules, pay rates, work rules and management requirements.

Operator assignments (or "runs") defining a regular set of operator work assignments are the output of the runcutting process. As with Vehicle Assignments, the Scheduling process creates the work assignments but does not assign the work to individual operators. The term "unbound" indicates that specific operators have not been paired with a run. Runs generally consist of a series of assigned trips, however some agencies end/begin runs mid-trip. Therefore runs may begin or end or switch to a different trip at any agency-designated timepoint on any trip. Operator assignments may be collected into weekly groupings called rosters by the scheduling system and distributed to other business systems (e.g.,, Operator Assignment System). Some agencies conduct "a-la-carte picks" in which operators pick their work assignments, based not on aggregated rosters, but instead on individual daily assignments. In such cases the roster is created by the OAS during the pick process rather than as part of the schedule development process.

The most significant variation to this phase is whether the Scheduling work group will use the developer-provided GIS functions internal to the Scheduling system, or use a separate agency GIS, to create, edit and maintain the geographic data elements related to the schedule.

Even if an agency uses an external data repository for the subsequent schedule distribution process, schedule writers typically will use the database internal to the scheduling system to perform the functions of this phase.

5.5.4.3 Distributing Scheduling Products

This process is intended to ensure that all parts of the transit agency are working from the "same sheet of music" to deliver transit service. In other words, operators must be trained, assigned, and available to drive vehicles that are fueled, repaired and assigned, in time to operate the service that customers have been informed to expect to arrive on time. Errors or failures in this process can result in failures to deliver the service that customers have been led to expect.

The outputs from the Scheduling business processes are:

- Master Schedule Version – Defines the appropriate revisions of selected schedule products in terms of effective date, updated time (includes all updates through a specified time), expiration date, and optionally version number. This allows agencies to publish a schedule, a 'next' schedule and row updates to artifacts related to either schedule. This can be important if a business system crashes and needs to obtain the current schedule for a restart, as well as for day to day schedule configuration management. Section 4.3 Data Configuration Management describes how information is identified and updated in TCIP. This information is not replicated in this section, but is relevant to the distribution of scheduling products as described below.

- Route Schedule – Defines the scheduled transfers and trips on a route in both directions. Trips are defined in terms of the patterns they are to follow and the times that the PTV is scheduled to arrive at (or depart from) timepoints within the pattern. Each direction for each route a specifies a pattern that trips on that route in that direction follow by default. Since not all trips follow the same pattern, each trip contains an optional field that allows the default pattern on a route in a given direction to be overridden on a trip by trip basis. The same data elements are used to define patterns for the default and override cases. Every trip must have an assigned pattern, either the default pattern for the route and direction or a pattern explicitly allocated to that trip. Transfers define opportunities for transit passengers to switch from one PTV and trip to another – usually between PTVs operating on different routes. The transfers specified in this output from the scheduling process generally do not include all available transfers, but are limited to a subset that the agency determines to be of particular interest. Transfers may be protected or unprotected. A protected transfer implies that the agency may hold the departing PTV to wait for the arriving PTV so that transferring passengers can make the connection. Agency policies limit the duration and circumstances of such holds. Transfers may also be intermodal (e.g.,, light rail or subway to bus or vice versa), or interagency.

- Block Schedule – defines the scheduled trips to be run organized by block (vehicle assignment), rather than by route.
- Run Schedule – defines the scheduled trips to be run organized by run (operator assignment) rather than by route.
- Running Times - Running times define the scheduled time for a PTV to move from one timepoint to another. These may vary based on time of day, day of week, route, and other factors. Other business systems may require this information to predict arrival times, or for other purposes.
- Patterns- Patterns define the movements of PTVs along a route. A pattern is defined as a sequence of pattern segments. Pattern segments in turn define the timepoints, stoppoints and way points associated with the PTV's movement. A pattern may also define other event(s) that are scheduled enroute (e.g.,, destination sign changes). Patterns and pattern segments can be shared by more than one trip.
- Timepoints – Timepoints define locations at which the PTV's progress is measured against schedule. Each trip in the route schedule is defined not only by the pattern it follows, but by the scheduled times at timepoints for the PTV. Timepoints may be shared by more than one pattern or pattern segment.
- Operator Assignments (unbound) – Operator assignments (or "runs") define daily work assignments for PTV operators. At this stage in the process individual operators have not been paired (bound) with the work assignments, consequently the assignments are termed "unbound". A run generally consists of a series of assigned trips, however some agencies end/begin runs mid-trip. TCIP accommodates this requirement by allowing a run to begin or end or switch to a different trip at any timepoint on any trip.
- Vehicle Assignments (unbound) – Vehicle assignments (or "blocks") define a daily work assignment for a PTV. At this stage in the process, specific PTVs have not been paired (bound) with the work assignments, consequently the assignments are termed "unbound".

The outputs of the scheduling process all have an effective date. Optionally, these outputs or artifacts also have an assigned version number. An agency may elect to use push dialogs and/or Publication dialogs and/or message file transfers to distribute schedule information. In some cases, particularly when distribution is via Publication dialogs, it is useful to know the effective dates and/or version numbers in use at various points in time. This information can be used in generating a query for new artifacts, or to verify that an artifact is the correct version number of effective date. In such cases, the Publish Master Schedule Version dialog allows a business system to determine what artifacts are to be used at what points in time.

For example, a business system that wants to determine what schedule artifacts should be used on May 27 can query using Publish Master Schedule Version for the schedules in effect on that day and obtain a response providing the effective revisions to be used. Alternatively, an event-based query can be used with the same Publish Master Schedule Version dialog. In this case the subscriber will be notified of schedule changes as they are released.

The schedule distribution may be directly to business systems or to a Data Repository (DR). In the case of a Data Repository (DR), the schedule information may be transferred to the DR using Publication dialogs to 'pull' the information from the Scheduling System (SCH), using push dialogs to push the information from SCH to DR, or using file transfers based on the Publication or push messages. Figures 5.5.4.3 A & B depict these transfers to the DR.

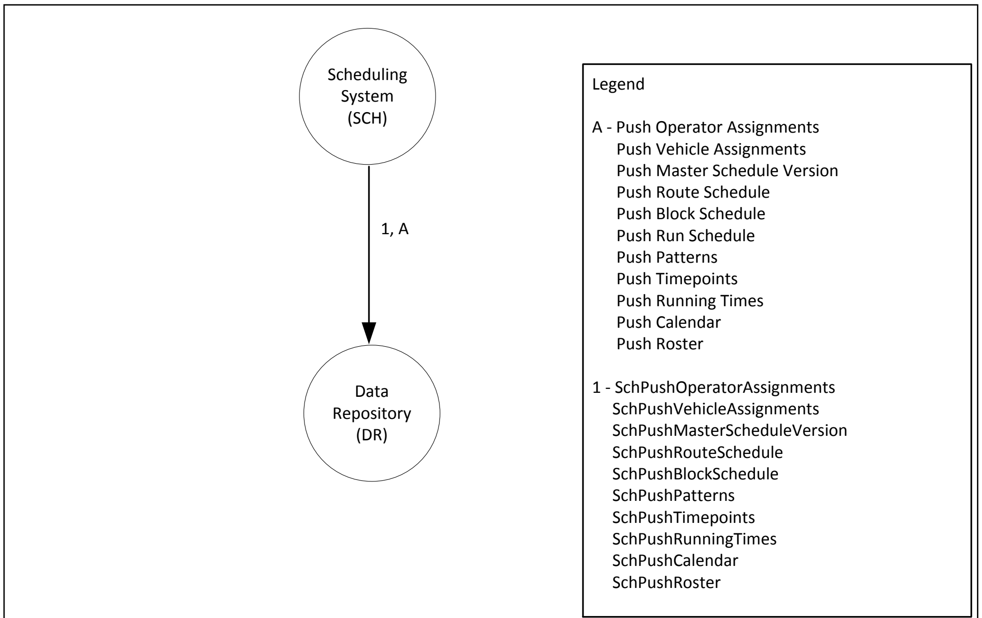


Figure 5.5.4.3.B
Schedule Information Transfer to a Data Repository Based on Push Dialogs or File Transfers.

Once the DR has the scheduling artifacts, it distributes those artifacts to business systems that require them. This may occur using Publication dialogs or related file transfers. Figure 5.5.4.3.C depicts this process.

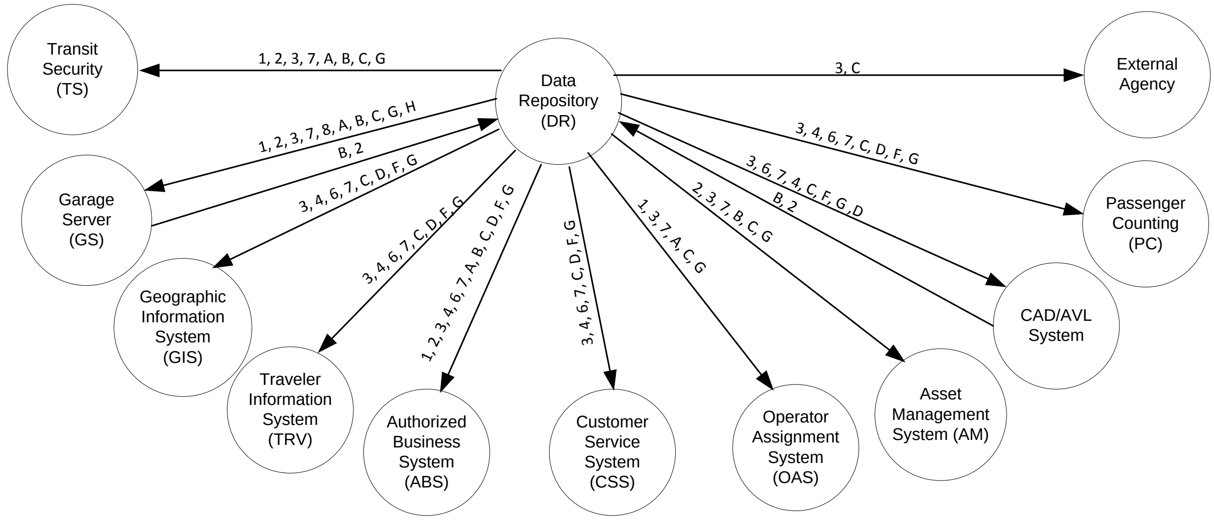


Figure 5.5.4.3.C
Schedule Artifact Distribution by Data Repository

Note:
1. GS will either use schedule load, or subscriptions but not both.
2. Schedule Distribution to PTVs is done by GS - see section 5.3.4.1

Legend

A - Publish Operator Assignments
Publish Roster
B- Publish Vehicle Assignments
C - Publish Master Schedule Version
Publish Route Schedule
Publish Trip Detail
Publish Block Schedule
Publish Run Schedule
Publish Pattern List
Publish Timepoint List
Publish Block Subset Definition
D - Publish Stoppoint List
F - Publish Running Times
G -Publish Calendar
H - Load Schedule

1 - SchPushOperatorAssignments
SchPushRoster
2 – SchPushVehicleAssignments
SchVehicleAssignmentList
3 - SchPushMasterScheduleVersion
SchPushRouteSchedule
SchTripDetailList
SchPushPatterns
SchPushTimepoints
4 - CptStoppointList
6 - SchPushRunningTimes
7 - SchPushCalendar
8 - SchRouteScheduleFile
SchRunScheduleFile
SchBlockScheduleFile
SchPatternFile
SchTimepointsFile
SchCalendarFile
CptStoppointsFile

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If the agency ITS architecture does not include a DR, agencies may have individual business systems subscribe directly to SCH, or may employ file transfers from the Scheduling System to each business system or may have another business system act as the distributor. Figure 5.5.4.3.D depicts the case of the Scheduling System distributing schedules directly to business systems.

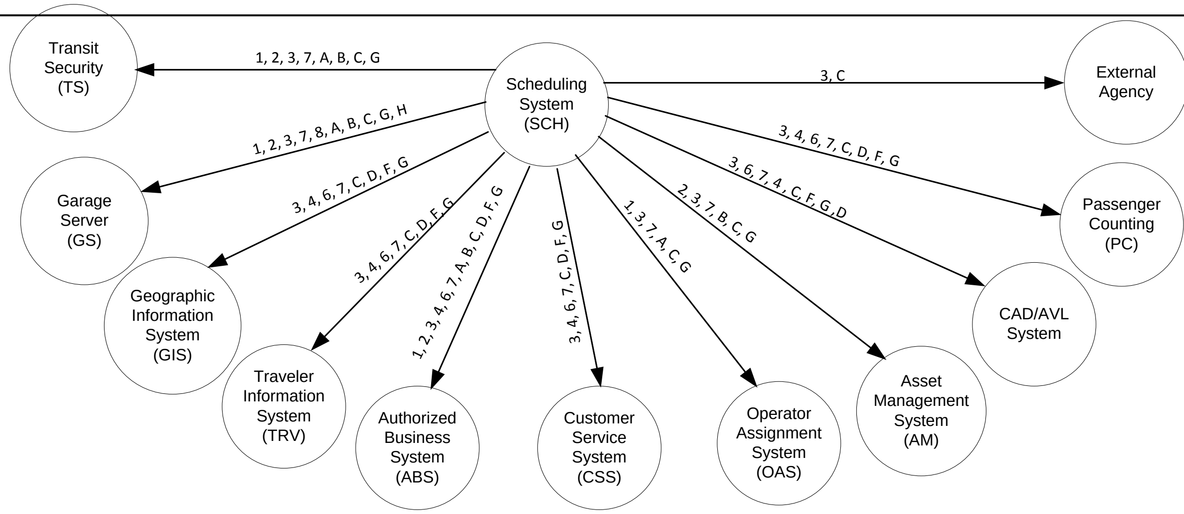

Figure 5.5.4.3.D
Schedule Artifact Distribution Without Data Repository

Note:
1. GS will either use schedule load, or subscriptions but not both.
2. Schedule Distribution to PTVs is done by GS - see section 5.3.4.1

Legend

A - Publish Operator Assignments
B- Publish Vehicle Assignments
C - Publish Master Schedule Version
Publish Route Schedule
Publish Trip Detail
Publish Block Schedule
Publish Run Schedule
Publish Pattern List
Publish Timepoint List
D - Publish Stoppoint List
F - Publish Running Times
G -Publish Calendar
H - Load Schedule

1 - SchPushOperatorAssignments
SchPushRoster
2 – SchPushVehicleAssignments
SchVehicleAssignmentList
3 - SchPushMasterScheduleVersion
SchPushRouteSchedule
SchTripDetailList
SchPushBlockSchedule
SchPushRunSchedule
SchPushPatterns
SchPushTimepoints
4 - CptStoppointList
6 - SchPushRunningTimes
7 - SchPushCalendar
8 - SchRouteScheduleFile
SchPatternFile
SchTimepointsFile
SchCalendarFile
CptStoppointsFile

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In addition for the products produced by the scheduling system, transit agencies produce a plethora of derived products using the schedule. Some of these products are extracts from the schedule products, and some are produced by fusing schedule products together, or with other information.

The DR can be the focal point for the creation and distribution of derived products. Figure 5.5.4.3.E depicts the distribution of derived products by DR. Distribution flows for derived products without a DR are highly dependent on the agency ITS architecture.

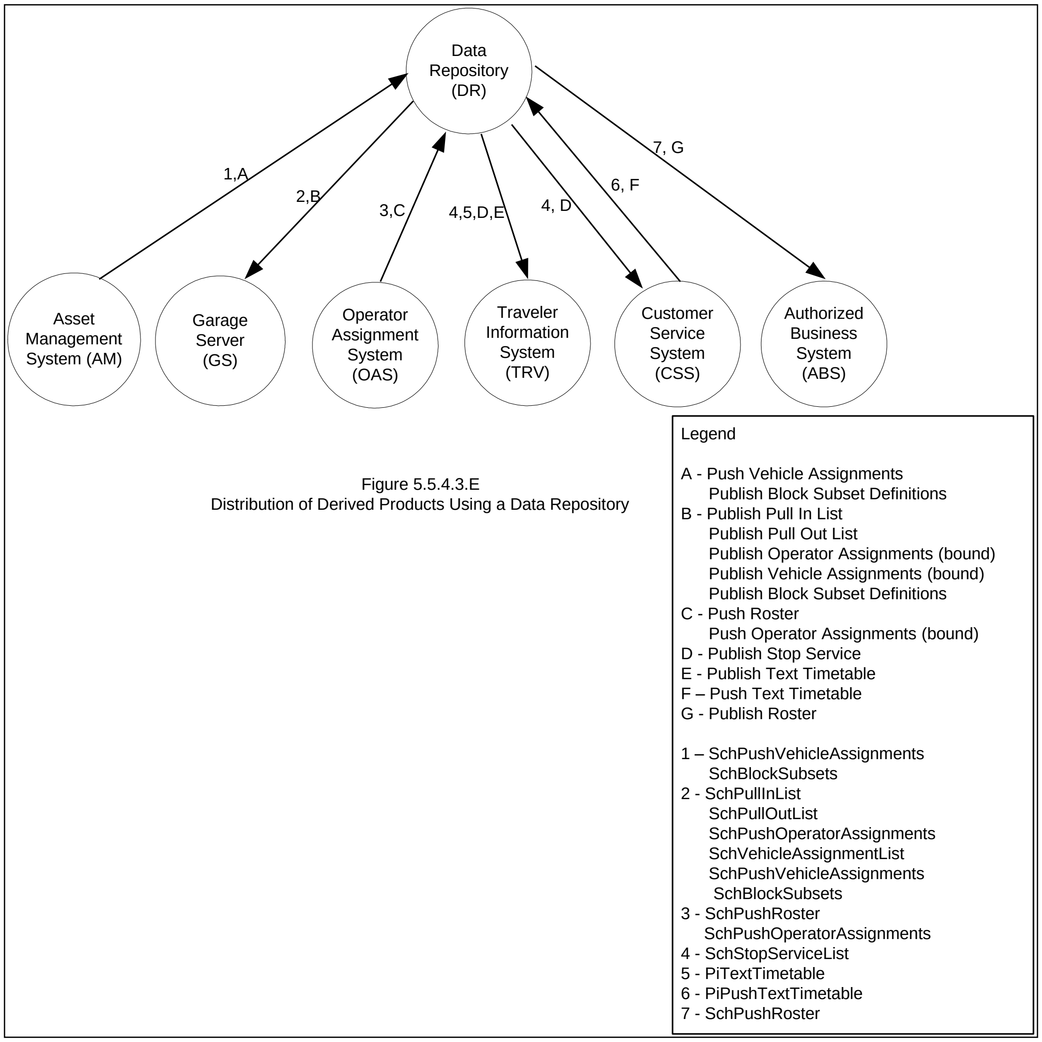

Figure 5.5.4.3.E
Distribution of Derived Products Using a Data Repository

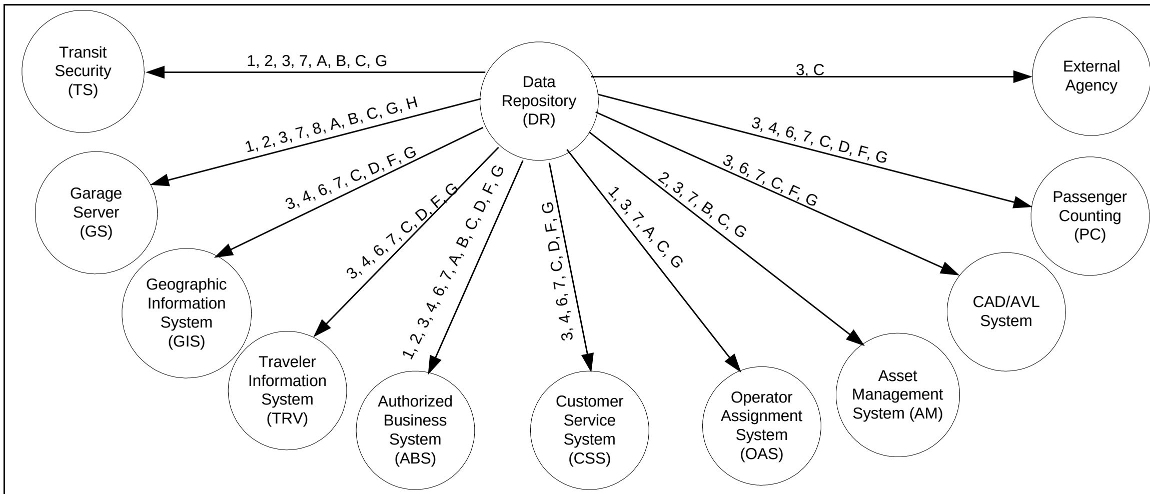

Figure 5.5.4.3.C
Schedule Artifact Distribution by Data Repository

Note:
1. GS will either use schedule load, or subscriptions but not both.
2. Schedule Distribution to PTVs is done by GS - see section 5.3.4.1

Legend

A - Publish Operator Assignments
    Publish Roster
B- Publish Vehicle Assignments
C - Publish Master Schedule Version
    Publish Route Schedule
    Publish Trip Detail
    Publish Block Schedule
    Publish Run Schedule
    Publish Pattern List
    Publish Timepoint List
D - Publish Stoppoint List
F - Publish Running Times
G -Publish Calendar
H - Load Schedule

1 - SchPushOperatorAssignments
    SchPushRoster
2 – SchPushVehicleAssignments
    SchVehicleAssignmentList
3 - SchPushMasterScheduleVersion
    SchPushRouteSchedule
    SchTripDetailList
    SchPushPatterns
    SchPushTimepoints
4 - CptStoppointList
6 - SchPushRunningTimeList
7 - SchPushCalendar
8 - SchRouteScheduleFile
    SchRunScheduleFile
    SchBlockScheduleFile
    SchPatternFile
    SchTimepointsFile
    SchCalendarFile
    CptStoppointsFile

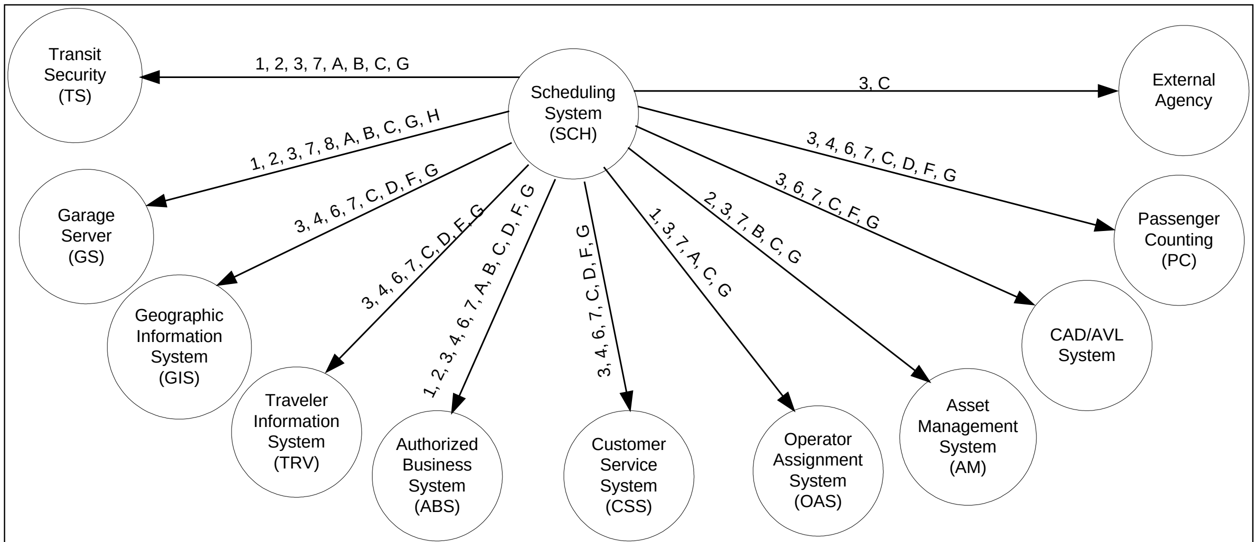

Figure 5.5.4.3.D
Schedule Artifact Distribution Without Data Repository

Note:
1. GS will either use schedule load, or subscriptions but not both.
2. Schedule Distribution to PTVs is done by GS - see section 5.3.4.1

Legend

A - Publish Operator Assignments
B- Publish Vehicle Assignments
C - Publish Master Schedule Version
Publish Route Schedule
Publish Trip Detail
Publish Block Schedule
Publish Run Schedule
Publish Pattern List
Publish Timepoint List
D - Publish Stoppoint List
F - Publish Running Times
G -Publish Calendar
H - Load Schedule

1 - SchPushOperatorAssignments
SchPushRoster
2 – SchPushVehicleAssignments
SchVehicleAssignmentList
3 - SchPushMasterScheduleVersion
SchPushRouteSchedule
SchTripDetailList
SchPushBlockSchedule
SchPushRunSchedule
SchPushPattern
SchPushTimepoints
4 - CptStoppointList
6 - SchPushRunningTimeList
7 - SchPushCalendar
8 - SchRouteScheduleFile
SchPatternFile
SchTimepointsFile
SchCalendarFile
CptStoppointsFile

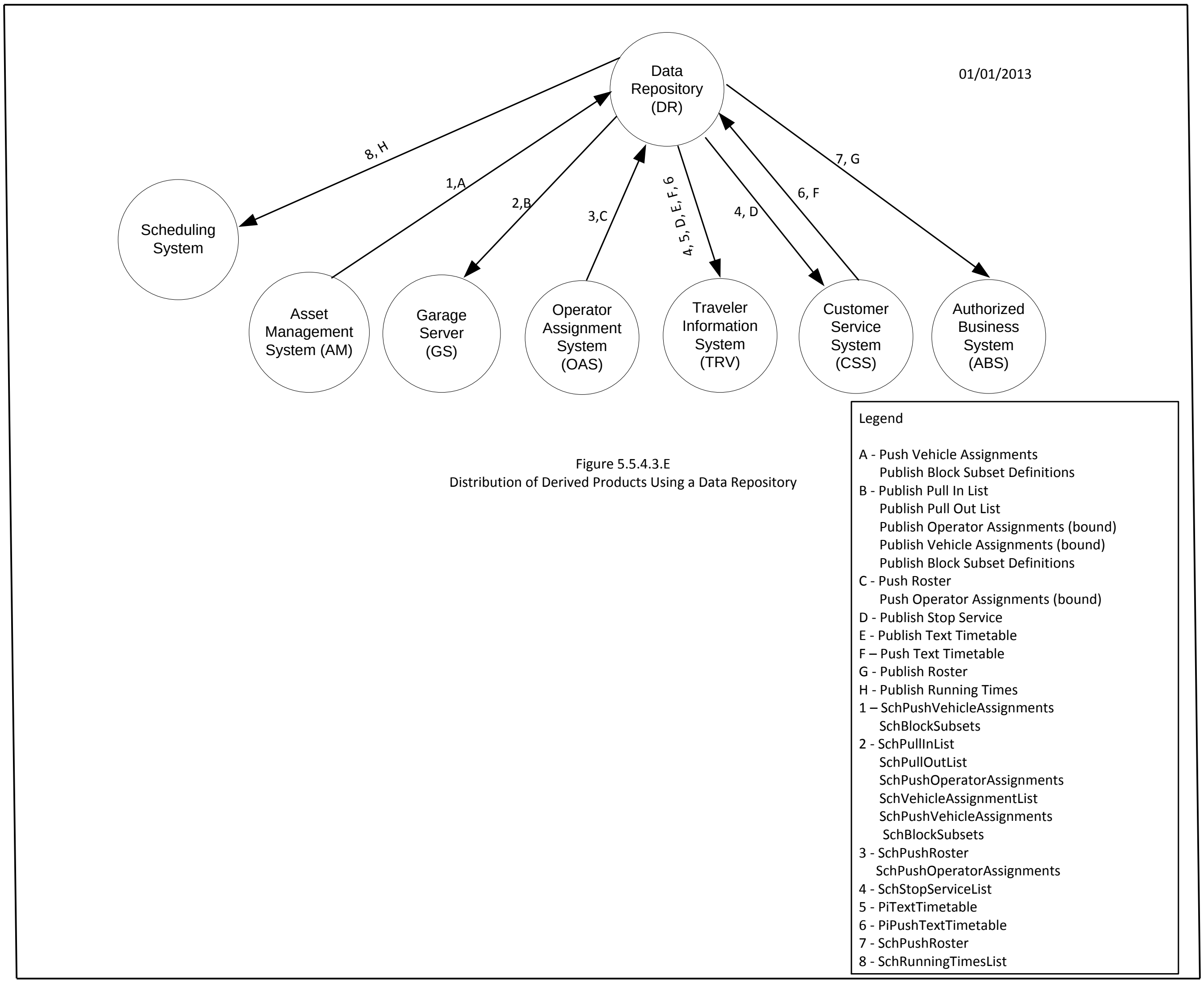

Figure 5.5.4.3.E
Distribution of Derived Products Using a Data Repository

The most significant architecture variation relevant to this phase is whether an agency distributes scheduling data directly from the scheduling system or uses an intermediate data repository.

5.6 Personnel and Work Assignment Management Process

5.6.1 Purpose

The Personnel and Work Assignment Management Process ensures that service-ready PTV operators, and other employees are available to provide and manage scheduled service, and assigns specific people to work assignments including qualified PTV operators to work assignments (runs) defined by the Scheduling System (SCH).

5.6.2 Overview of Personnel and Work Assignment Management Process

Schedule Operator Assignments (runs) are combined into rosters which define weekly groupings of work assignments. This combination may be performed by the Scheduling System and provided to the Operator Assignment System (OAS), or may be done as part of a pick process (see below).

In some agencies, union agreements govern a “pick” process by which PTV operators choose their work on a monthly or quarterly basis. The results of the pick process are a preliminary set of bindings between scheduled work and specific PTV operators expected to perform that work. The pick process also results in the production of extra lists which indicate what PTV operators are available for duty on each day that do not have work assigned. When the combination of runs into rosters is conducted as part of the pick process, it is known as an ‘a-la-carte pick’.

This business process also deals with changes to operator assignments due to operator unavailability (e.g.,, illness, leave), or changes due to incidents.

Some challenges and constraints related to this business process include:
- Union agreements and rules constrain agency policies and procedures. Changes to these agreements and rules may impact agency software.
- Actual availability of operators changes from day to day requiring adjustments to planned assignments.
- Incidents and events occur to operators and PTVs after they are dispatched requiring assignments to be changed.

5.6.3 Primary Architecture Component

The key architectural element for this business process is the Operator Assignment System (OAS). This business system manages the pick process as well as daily assignment changes. The Garage Server (GS) is also involved in providing these assignments to the PTVs.

5.6.4 Manage Personnel and Work Assignment Management Subprocesses

5.6.4.1 Operator Assignment Definition

The first step in the operator assignment process is the development of daily operator work assignments (runs) tied to the scheduled service. If the agency does not employ a-la-carte picks, the Scheduling System (SCH) will distribute these unbound assignments along with the corresponding rosters to the Operator Assignment System (OAS). Figure 5.6.4.1 depicts this process with and without a Data Repository (DR).

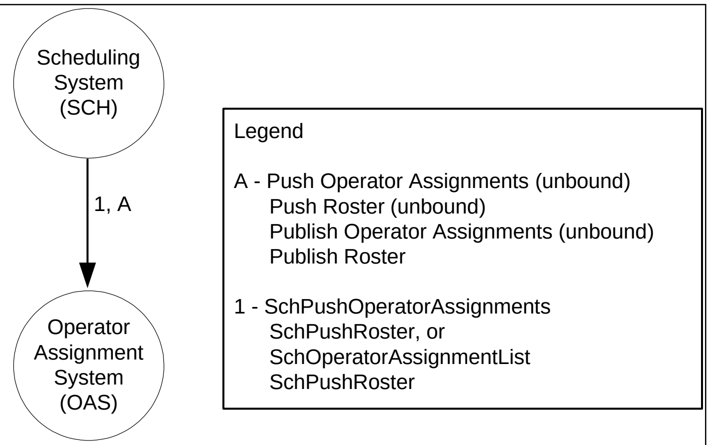

Figure 5.6.4.1.A
Distribution of Unbound Operator Assignments Without a Data Repository (No A-la-Carte Pick)

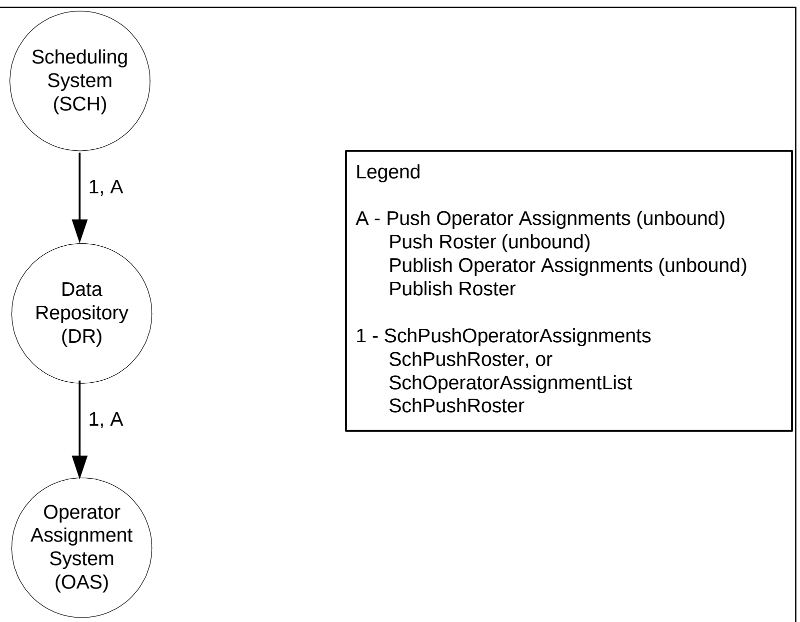

Figure 5.6.4.1.B
Distribution of Unbound Operator Assignments With a Data Repository

5.6.4.2 Pick Process

Once the Operator Assignment System (OAS) has the unbound operator assignments and the rosters, it is possible to execute the pick. Normally the schedule and procedure of the pick is known well in advance. The pick process is usually related in some way to the seniority of PTV Operators and is tightly coupled with union agreements.

When the pick is completed, the Operator Assignment System (OAS) has the information necessary to produce a list of (preliminary) bound assignments for any given day. These preliminary bindings may be changed numerous times within the OAS between the time of the pick and the time of the next pick.

5.6.4.3 Distribution of Bound Assignments

The Operator Assignment System (OAS) on a daily basis provides the bound operator assignments to the Garage Server (GS). The Garage Server (GS) may fuse the bound operator assignments with the bound vehicle assignments received from the Asset Management System (AM). The Garage Server (GS) loads the bound assignments to the PTVs. Figure 5.6.4.3 depicts this process.

Note: Operator assignments are described here using a “push” approach to daily assignments. For a discussion of an alternative “pull” approach see section 5.3.4.1.

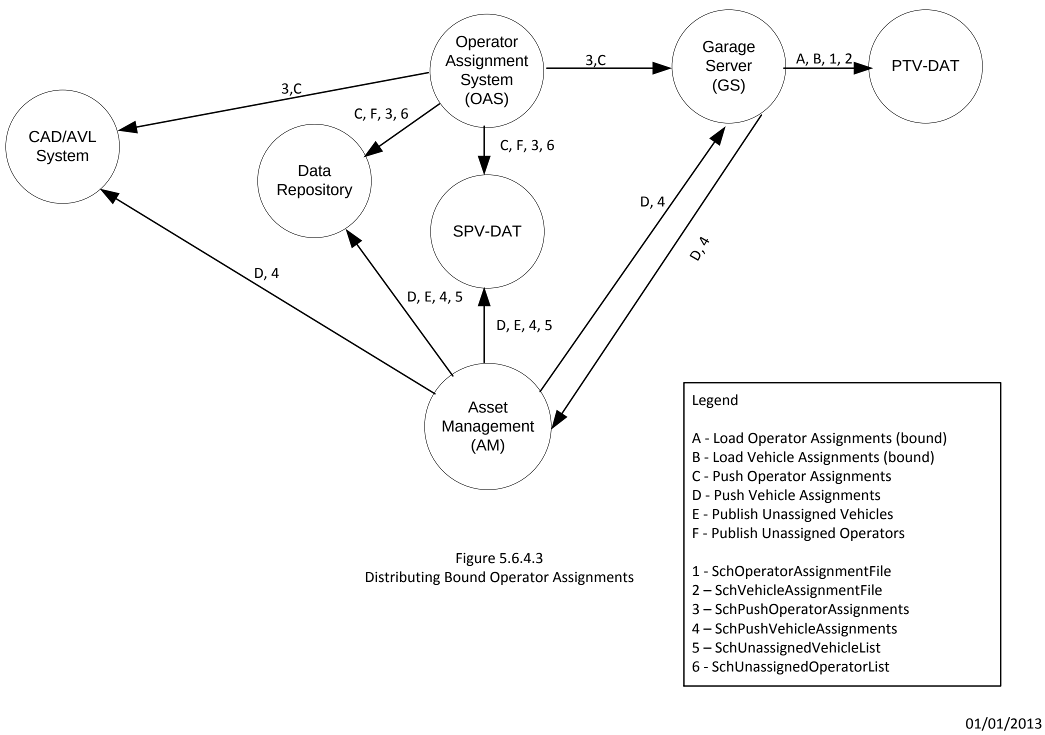

Figure 5.6.4.3
Distributing Bound Operator Assignments

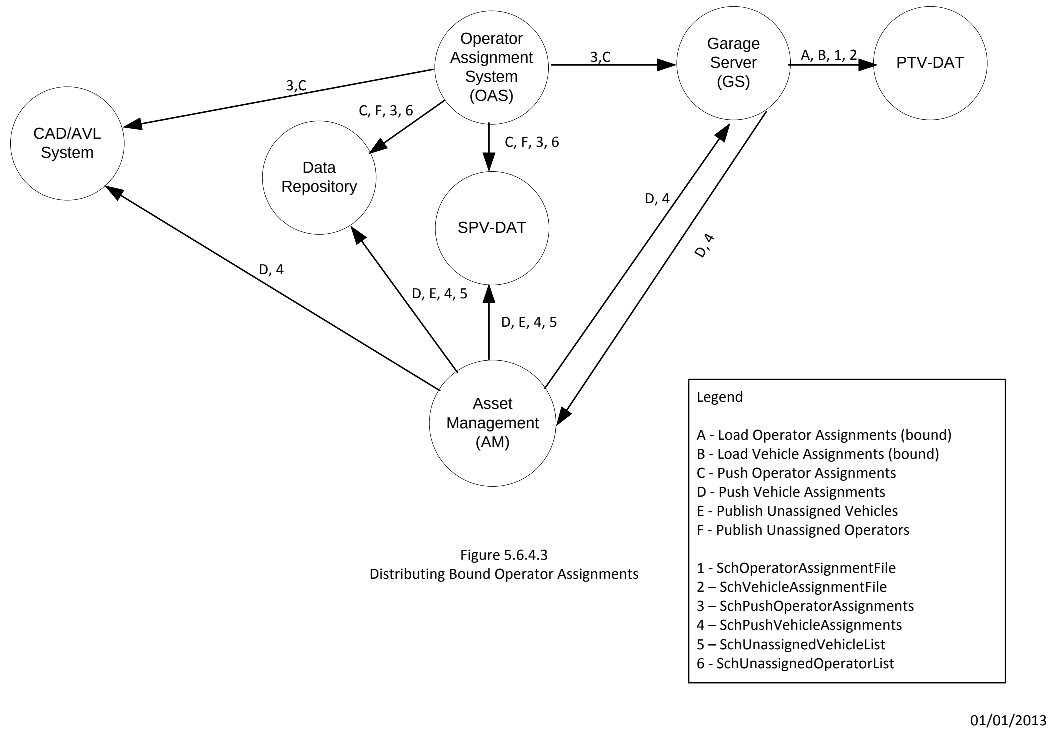

Figure 5.6.4.3
Distributing Bound Operator Assignments

5.6.4.4 Changes to Operator Assignments

Changes to operator assignments may be occasioned by operator unavailability, incidents or other reasons. If the change to the operator assignment occurs before the distribution of the bound assignments from the OAS to other business systems the change is made within the OAS.

If an assignment change occurs after the bound assignment is distributed to other business systems, then OAS updates the assignments to each impacted business system using the Command Change Assignments dialog. Sections 5.2.4 and 5.3.4 discuss this process in more detail.

5.7 Asset Management Process

5.7.1 Purpose of the Asset Management Process

The Asset Management Process ensures that service-ready PTVs are available to provide scheduled service and assigns specific PTVs to work assignments (blocks) defined by the Scheduling System (SCH).

The Asset Management System (AM) maintains a history and schedule of PTV service. This provides the basis for maintenance planning, parts demand forecasts and vehicle availability planning, parts demand forecasts and vehicle availability planning. The Asset Management System also tracks PTV faults alarms and incidents or PTV service failures as inputs to the maintenance planning process.

The Asset Management System may also maintain the agency's PTV inventory, or this function may be performed by the Data Repository (DR), or other agency Authorized Business System (ABS).

The following list summarizes the activities included in the Asset Management business process:

- Monitor vehicle mechanical health
- Diagnose defects
- Predict failures
- Monitor fuel and fluids consumption
- Manage vehicle configuration
- Track vehicle miles/hours/idle time/duty cycle
- Schedule vehicles for service and bind vehicles to assignments (Blocks and trips) (Vehicle assignment policies may seek to balance miles and/or maintain a consistent pairing of specific vehicles with specific operators)
- Schedule maintenance activities, vehicle inspections and servicing
- Manage spare parts inventory (typically included in Materials Management Subsystem)
- Manage maintenance work orders, technician assignments and maintenance personnel schedules
- Manage garage parking for revenue vehicles
- Manage tool inventory (typically included in Materials Management Subsystem)
- Monitor/calibrate/ and manage testing and shop equipment
- Performance management and Reporting

5.7.2 Overview of the Asset Management Process

The Manage Assets business process encompasses 11 areas. One of these areas (farebox vaulting) is discussed in section 5.4.4.4 (Revenue Reconciliation). The remaining 10 areas are:

- Pull In
- Fuelling
- Cleaning/Washing
- Service/Inspection/Scheduled Maintenance
- Unscheduled Maintenance
- Overhaul/Contractor/Manufacturer Maintenance
- Garage Parking Management & Vehicle Assignments
- Pull Out
- En-route
- Synchronization/Calibration (May be included in fixed facilities management system)

The garage maintenance management and technician staff are the key organizational entities involved in this process. The key challenge in this area is to consistently and reliably provide clean, service-ready PTVs on a daily basis in adequate numbers and types to meet service requirements while maintaining a very low rate of in-service failures.

5.7.3 Primary Model Architecture Components

The central architectural component in the Asset Management Process is the Asset Management System (AM). AM maintains the vehicle maintenance records for both scheduled and unscheduled activities, as well as the vehicle assignments on a daily basis. AM may also provide tools for managing the parking of PTV's in the garage area.

5.7.4 Asset Management Subprocesses

5.7.4.1 PTV Pull In to Garage

This process deals with activities related to the PTV returning to the garage after a trip. The trip may be in-service, but may also be a ferry move, training trip etc.

The vehicle pull-in is reported by a supervisor or may be detected automatically. This report may be via a supervisor's portable device or directly into the Garage Server (GS). The Garage Server (GS) reports the Pull-In to AM.

When the PTV enters the garage area, it may detect the availability of the wireless LAN. This triggers onboard entities to initiate data loads and unloads to the Garage Server (GS) and Garage Revenue Server (GRS). These loads and unloads are described in sections 5.3.4.1.1 (loading) and 5.3.4.4.3 (unloading).

Upon entering the garage area the operator may report defects concerning the vehicle, after which the operator will log off of the PTV, and may shut down the vehicle. These processes are illustrated in section 5.3.4.4.4.

The pull-in report and/or the inspection report may trigger AM to update parking and/or maintenance plans for the vehicle. Based on the plans for that vehicle, a technician or bolster may log onto and off of the vehicle for various purposes and/or may start up or shut off the vehicle and/or its onboard electronics. These logon/off and startup/shutdown events are handled in the same manner as operator initiated logon/logoff and startup/shutdown events (see sections 5.3.4.1.2, 5.3.4.1.3, 5.3.4.4.4). Note that when the VLU is started up, it triggers another attempt to load and unload data, so any startup may be the trigger for an update to loaded/unloaded data. Data is only loaded/unloaded if required.

5.7.4.2 Fuelling/Servicing

This process may or may not occur daily, depending on agency fueling policies, fuel tank capacity, and daily fuel consumption. This process may be initiated routinely by transit staff, or be triggered by calculations of fuel and/or fluid requirements by AM.

The vehicle may be driven to the fueling area by the operator or by a hostler. Prior to or upon entering the fueling area, a set of agency defined safety checks are performed. Depending on the agency ITS architecture, data loads/unloads may occur specifically in the fueling area, rather than at any location within the garage facility.

The actual fueling and fluid replenishment is conducted by the technician, and the amount of fuel and other fluids used is recorded in AM. AM may audit the fuel and fluids taken against an expected value based on vehicle type, mileage etc. AM may generate discrepancy reports for unusually high or low fluid/fuel consumption.

At the end of the fueling cycle a technician, inspector, or supervisor may be required by agency policy to conduct and record additional safety and/or leak checks, and an area inspection.

5.7.4.3 Cleaning

PTV cleaning normally occurs on an agency-specified periodic bases. It includes both interior and exterior vehicle cleaning. Additional unscheduled cleaning events may be inserted if the vehicle becomes excessively dirty, salt covered, etc. Agencies may have a daily minimal cleaning event (e.g.,, sweep out) for PTVs that do not receive a complete daily interior and exterior cleaning.

The PTV is pulled into a vacuum area and to a wash rack. Depending on agency facility design there may be a multistage process with a station for each stage of the process. At the end of the process a cleaner or supervisor inspects the PTV and records the results in the Asset Management System.

Some PTVs (e.g.,, commuter buses) have public toilet facilities onboard. Draining the septic tank for these PTVs and refilling the related expendable commodities (water, soap, etc) may be done in conjunction with the cleaning cycle, the fueling cycle or as an independent process.

5.7.4.4 Scheduled Service and Inspections

PTVs require periodic service and inspections. The Asset Management System (AM) monitors the intervals between service actions and schedules PTVs to receive service and inspections. When scheduled for service and inspection, AM generates a work order for the activity. A hostler, or a technician brings the PTV to a service bay, and the technician logs in the start time and vehicle ID for the periodic service.

AM provides the technician with an inspection/service checklist which may be customized based on:
- Vehicle type
- Time/mileage since last service
- Age of routinely replaced components
- Inspection reports provided by operator or supervisors

The technician performs the required service and inspection, and may enter tools or parts requests into AM. If the required actions cannot be completed due to lack of tools or parts, a deferred maintenance record maybe generated; otherwise the technician completes the service activity.

AM generates an update to the warranty and/or other maintenance records for the PTV, and if warranty-covered services where required may generate claims forms etc. AM generates a request for a supervisor or quality assurance inspection or the work.

The supervisor, or quality control inspector verifies the work and enters the results of the check into AM. AM updates the appropriate records for the vehicle.

Finally the vehicle is removed from the bay by the technician or hostler. If AM has parking management capabilities, it may provide instructions on where to move the vehicle to stage it for its next assignment.

5.7.4.5 Unscheduled Maintenance

Unscheduled maintenance occurs as a result of a manually, or automatically generated report of a vehicle fault, or out of tolerance condition. Manual reports are provided:

- As a result of AM monitoring vehicle parameters on the PTV (Publish PTV Parameters) or,
- As a result of AM subscribing to vehicle fault reports (Publish J1939 Fault Codes) or,

- As a result of AM subscribing to health alarms for the PTV fleet (Publish Fleet Health Alarms) or,
- As a result of AM subscribing to health alarms from individual PTVs (Publish PTV Health Alarms)

Section 5.3.4.2.5 depicts automatically detected enroute reporting scenarios.

Once AM becomes aware of the problem, it updates the vehicle status (in-service/available for service/operable non-revenue only/ in operable). If the vehicle failed in-service, this event is managed as an incident as described in section 5.2. AM opens a work order for the vehicle.

The vehicle at some point in time is scheduled to be brought in for service. A hostler or technician brings the vehicle into the bay, and the technician logs in the start time and vehicle ID for the unscheduled service.

AM generates a service/inspection checklist based on the reported fault, and possibly including other routine items to be inspected/repaired/replaced. The technician performs the required service and inspection, and may enter tools or parts requests into AM. If the required actions cannot be completed, a deferred maintenance record may be generated; otherwise the technician completes the service activity.

AM generates an update to the warranty and/or other maintenance records for the PTV, and if warranty-covered services where required may generate claims forms etc. AM generates a request for a supervisor or quality assurance inspection or the work.

The supervisor, or quality control inspector verifies the work and enters the results of the check into AM. AM updates the appropriate records for the vehicle.

Finally the vehicle is removed from the bay by the technician or hostler. If AM has parking management capabilities, it may provide instructions on where to move the vehicle to stage it for its next assignment.

5.7.4.6 Overhaul/Contractor/Manufacturer Maintenance

This process covers contractor or manufacturer performed maintenance. This is includes major maintenance actions such as recalls, overhauls, or other substantial upgrades.

This process begins with the generation of an overhaul or contractor request. This may be done manually, or recommended by AM software based on reliability software analyses. When the request is approved, the vehicle's status is updated by a manager or technician in AM. The new status may be "out-of-service", "transferred-central-shop", "transferred-contractor", "transferred-manufacturer" etc.

AM updates the vehicle's maintenance records upon transferring the vehicle out and upon receiving it back. These updates may impact warranty records, major subassembly records (serial number change, initial mileage charge etc).

When the vehicle is returned, AM provides an inspection checklist for the supervisor or quality control inspector. The inspection checklist may include acceptance criteria, and may require acceptance testing, when the vehicle passes the inspection, the vehicle's records are again updated and the vehicle returned to service.

5.7.4.7 Garage Parking Management & Vehicle Assignment

This process deals with the allocation of ready-for-service vehicles to vehicle work assignments, and the allocation or vehicles to parking spaces in the vicinity of the garage. Asset Management Systems may not provide all of the functionality described here, or the functionality may be supplied as separate modules or subsystems within the Asset Management framework.

AM receives the vehicle work assignments (blocks) from the Data Repository (DR) or the Scheduling System (SCH). In addition AM maintains an inventory of the vehicles along with their current and scheduled maintenance status. If AM contains a parking management component, then AM also maintains a schedule of parking space allocations for PTVs that are ready for service, as well as for vehicles that are awaiting service, inspections, fueling, cleaning etc.

Based on the blocks of work scheduled for the coming day, and the expected set of service ready vehicles, AM establishes preliminary vehicle assignments for the coming day's work. Similarly other vehicles may be assigned to maintenance for all or part of the coming day. Vehicles may also be assigned to queues within AM for cleaning a fueling.

Based on the assignments and determinations made in the previous paragraph, AM establishes parking space assignments for vehicles that will facilitate efficient pullouts and efficient hostling of vehicles for cleaning, fueling, and service.

In advance of the morning pull outs, AM provides the daily bound vehicle assignments, and pull outs to other business systems, and specifically to the Garage Server. The pullout lists contain parking space assignments indicating where the vehicle (hopefully) will be found.

In the Garage Server (GS) the pull out list provided by AM is combined with information received from the Operator Assignment System (OAS). This allows GS to provide a pullout list to the supervisor in charge of pullouts that combines the vehicleID, parking location, operator, pullout time and pullout trip (initial trip). This information facilitates the effective management of the pull-out process. Figure 5.7.4.7.A depicts these processes.

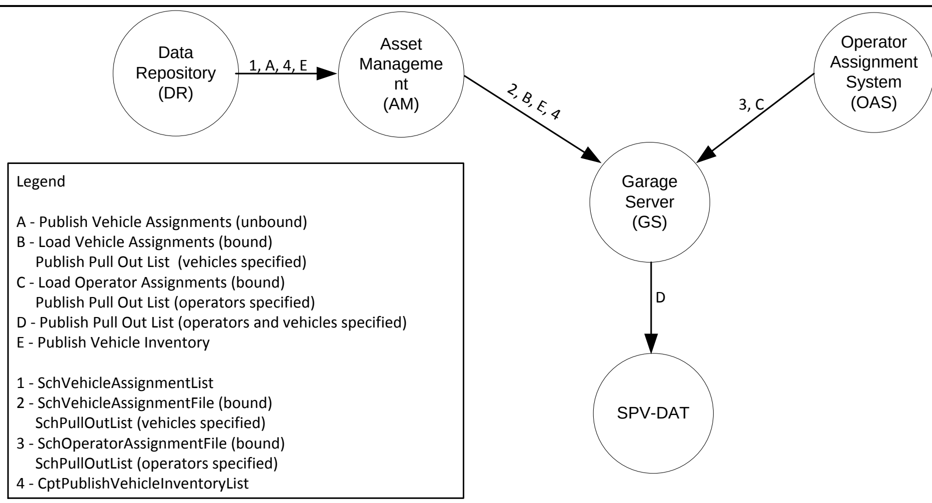

Figure 5.7.4.7.A
Pull Out Information Fusion During the Parking Management and Vehicle Assignment Process

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At the end of the day, based on the preliminary schedule for activities for the following day – AM provides pull-in information to the Garage Server for use by the supervisor managing pull-ins. These lists contain parking space assignments for vehicles based on whether they are going to be fueled, cleaned, serviced or returned to service the following day. Figure 5.7.4.7.B depicts this process.

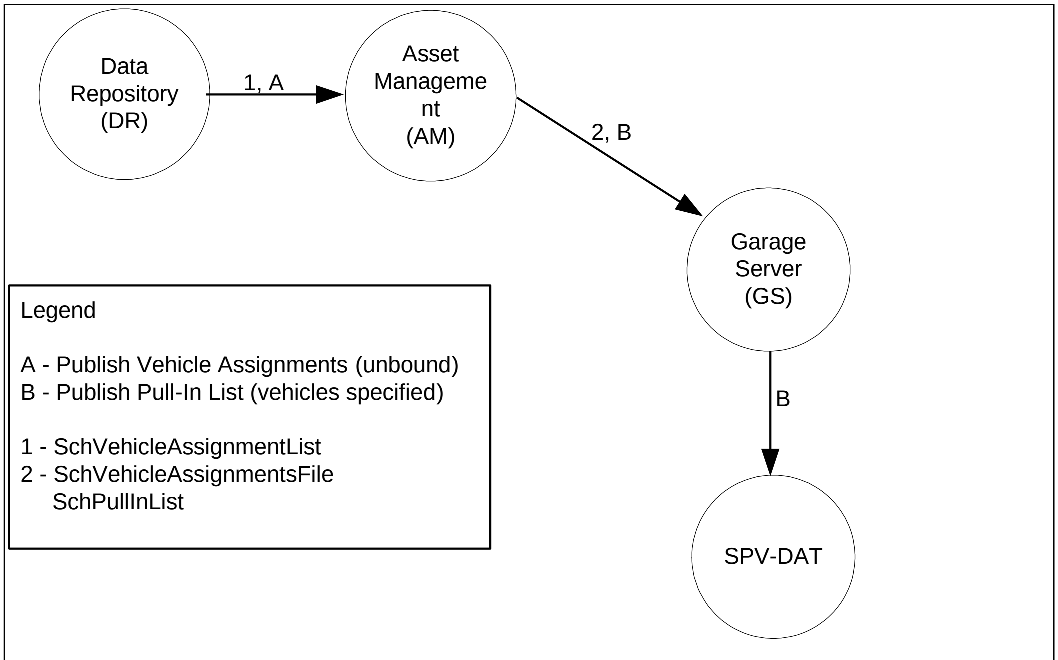

Figure 5.7.4.7.B
Pull-In Information During Parking Mangement and Vehicle Assignment Process

5.7.4.8 Pull Out Subprocess

The pull out process involves getting the ready-for-service assigned operator paired with the ready-for-service assigned PTV and having them leave the garage at the appointed time. The operator reports to a supervisor who verifies that the operator is ready for service, and then to the PTV. The operator inspects the PTV, starts it and logs on to the PTV. If the PTV starts up in wireless LAN coverage, onboard components interact with the Garage Server (GS), and the Garage Revenue server (GRS) to verify that there are no new or updated files to load.

The data loading process is described in section 5.3.4.1.1. Vehicle startup is described in section 5.3.4.1.2. The Operator sign-on and inspection process is described in section 5.3.4.1.3.

Once the operator and PTV are ready to go and the scheduled pull out time occurs, the supervisor reports the pull out to the Garage Server (GS) using the SPV or directly to the Garage Server (GS). Depending on the agency ITS architecture, pullouts may be detected automatically by the CAD/AVL System and reported to the Garage Server. Section 5.3.4.1.4 describes this process.

Based on the reported pull out, AM updates the parking allocation (frees the assigned space) and status of the PTV (in-service).

5.7.4.9 En Route Failures

Section 5.7.4.5 discussed unscheduled maintenance. This section describes a special case of unscheduled maintenance – an en route failure. PTV faults and failures enroute include amenity failures (e.g., wheelchair lift, air conditioning), electronics faults and failures (e.g., VLU, radio), drivetrain faults and failures (e.g., engine, transmission), and safety equipment faults and failures (e.g., mirrors, tires, brakes).

Enroute failures may constitute an incident. The incident management process is described in section 5.2. This section focuses on the process for recovering and repairing the PTV.

Notification of an enroute failure may occur:

- Via voice radio from the operator to the dispatcher, with a dispatcher call or email to notify the garage,
- Via text messaging from the operator to the dispatcher, with a dispatcher call to the garage.
- Via automatic health alarm or vehicle parameter reporting.

Agency policy and physical constraints govern the reaction to an enroute failure. Failures that involve severe safety problems (e.g.,, loss of brakes) or inability to move under the PTVs own power normally result in the vehicle being towed back to the garage for repairs. Other less severe, scenarios may allow for the PTV to discharge passengers and proceed on its own power to the garage. Even less severe scenarios may allow the PTV to remain in-service.

If the PTV requires immediate attention, a maintainer is dispatched via voice or via the Asset Management System and the TMV. Transit Management may elect to send a new PTV and an ‘extra’ list operator to pick up discharged passengers, or to take on the faulty PTV’s assigned work. If the replacement PTV is not assigned +0 pick up the discharged passengers, it may proceed to a timepoint further along the faulty PTV’s trip, or to the start point for the next assigned trip.

AM processing of the information related to the failure is described in section 5.7.4.5. Figure 5.7.4.9 illustrates information flows related to EnRoute Failures.

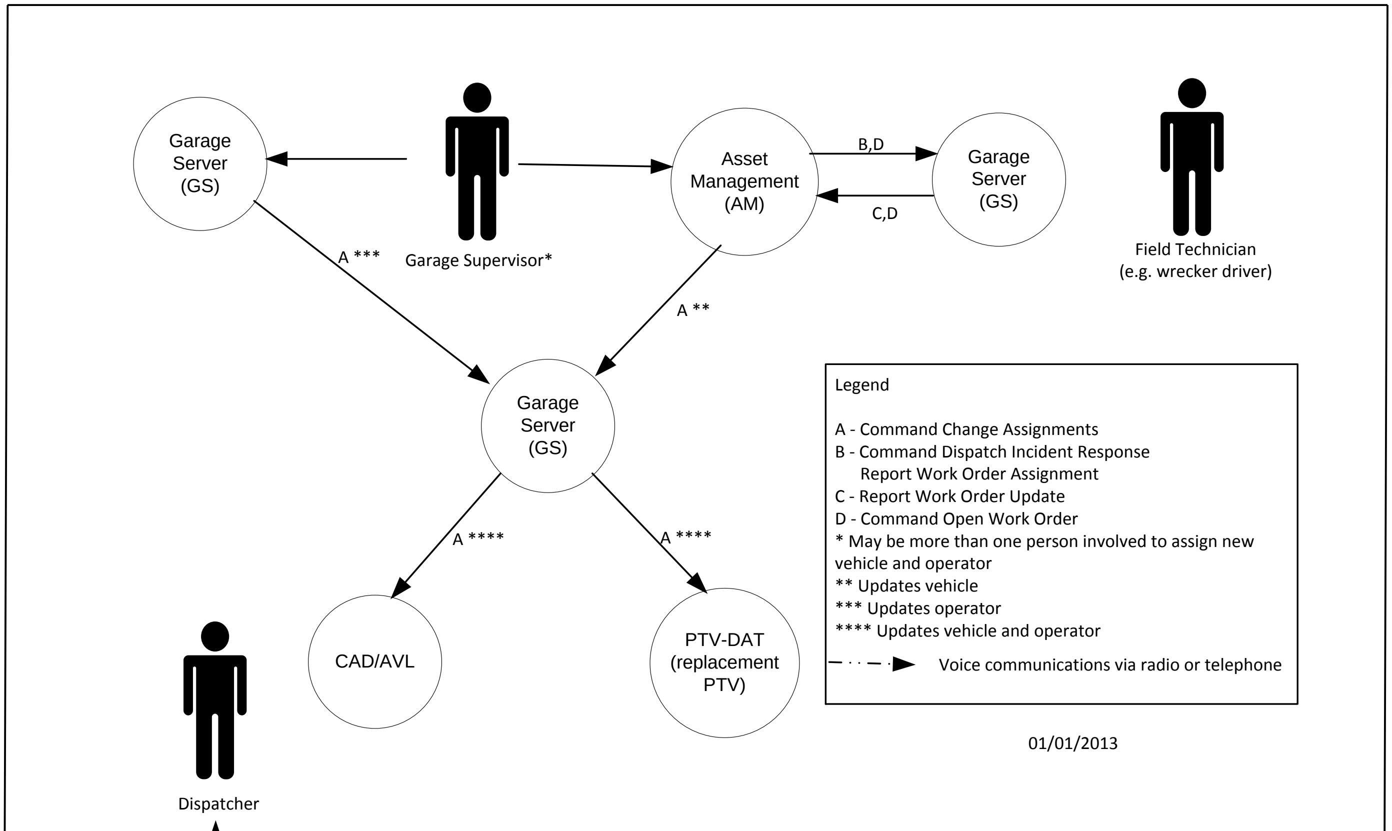

Figure 5.7.4.9
Possible Response Scenario to En Route PTV Failure

5.7.4.10 Synchronization/Calibration

The Synchronization and calibration process ensures that instruments and equipment used by technicians remains within prescribed tolerances, allowing it to be used for its prescribed purpose. The Asset Management System (AM) maintains an inventory of devices/equipment that requires periodic calibration or synchronization. Associated with each type of item or equipment requiring calibration/synchronization, AM maintains a file describing the required protocols for calibrating/synchronizing the device/equipment. These protocols may include procedures, drawings, and verification test procedures.

For devices and equipment requiring time synchronization, AM may maintain configuration files recording time delays and required offsets. For example, in an equipment clock is to be set, and the time to send a message to the device and have it processed is 30 milliseconds, then a time set command should be sent to the device with a time 30 ms in the future. Similarly in verifying that the time is set correctly, the latency from the time the clock is read in the device being synchronized to the time it is compared with the reference clock must be considered.

AM also maintains a schedule of calibration and synchronization due dates/times and notifies technicians of devices equipment schedule for calibration or synchronization. Performance of calibration and synchronization activities by technicians are reported to AM and logged, enabling AM to calculate the next required calibration or synchronization.

5.8 Customer Information Process

5.8.1 Purpose of the Customer Information Process

The Customer Information Business Process deals with all aspects of communicating with transit customers. This includes assisting customers in determining the availability of transit services, providing transit literature (e.g.,, maps, guides for the handicapped) notifying the status of service, providing itineraries and providing customers with information while on the transit agency's property. It also includes managing persistent information about customers and collecting, and processing information necessary to investigate and resolve customer complaints.

5.8.2 Overview of the Customer Information Process

The key people in the Customer Information Process are the customers themselves and the customer service representatives. Customers are the focus of each phase of this process, as the process exists to provide them useful information. Customers in this section are variously referred to as "customers" at any stage in the process, or "travelers" while in the transit property but not on a PTV, and "passengers" while boarding/alighting or onboard a PTV.

Customer Service Representatives may interact with customers via telephone at any stage of the journey. Customer Service may also initiate announcements and/or displayed messages on signs on PTVs or at stoppoints.

The customer information business process can be broken into several processes, based on the status of a customer's journey:

- The Pretrip Planning Process provides support to a customer planning to make a journey involving public transit. In many cases this requires information to be provided to the customer at their home or work location, however because plans may change enroute it may also support replanning at any stage in a journey.
- The Station/Stop Process provides information to customers (travelers) while they are at a transit station or stoppoint. Examples include real-time service information, gate/bay assignments, destinations, and scheduled departure times.
- The Passenger Process provides information to customers (passengers) while they are onboard a PTV. The most prevalent information in this phase is real time information about the PTV's progress (e.g.,, next stop announcements).
- The Ongoing Process provides information at times and locations independent of the customer's actual or planned travel. This includes information related to complaint resolution, maintenance of customer profiles, and event-driven service information distribution.

The current state of customer information varies widely among agencies. Some agencies have only customer service telephone support and printed materials, while others have begun implementing real-time information via kiosks, web pages, web-enabled cell phones, PDAs etc. Some stoppoints, usually in high-density areas, are equipped with automated next bus information.

The emergence of low-cost solar powered wireless signs may begin to allow next bus information to be available at a larger number of locations in the future. In the meantime, the availability of capital and operating funds constrains the deployment to low-density locations.

5.8.3 Primary Model Architecture Component Roles in the Customer Information Process

Customer Communications are primarily supported by two model architecture business systems: Customer Service Systems (CSS) and Traveler Information Systems (TRV). These systems may be organized and/or named differently in individual agency ITS architectures.
Customer Service systems support transit agency customer interactions via call centers and mail including:

- Itinerary creation for customer service call takers
- Mailing management for printed material
- Customer information profile management
- Complaint management and resolution
- Timetable creation
- Trip duration estimates based on scheduled running times
- Service bulletin creation and dissemination
- Lost and found

Traveler Information Systems (TRV) support online interactions with customers via Passenger Information Displays, Traveler Internet Appliances, Kiosks, and Information Service Providers (ISP). Travelers can obtain the following via Internet Appliances, Kiosks, and ISPs:

- Nearest Transit service and parking information
- Transit Itineraries and Fares
- Landmark Locations
- Text timetables
- Stoppoint shelter and amenity information
- Transfer Opportunities
- Service Bulletins
- Maps

The TRV and CSS obtain information from a variety of sources. Some of this information is obtained in advance of a customer's need (e.g.,, schedules) and used repeatedly until superseded. Other information may be queried for on an as-needed basis (e.g.,, itineraries), or be provided on an ongoing basis using a persistent event driven or periodic Publication (e.g.,, next bus information).

Agencies can provide a variety of information to customers via stoppoint and PTV-based Passenger Information Displays which may provide audible as well as visual announcements including:

- Next bus information at stoppoint, which may include destination, route, and/or gate/bay assignment.
- Next stop information on PTVs
- Route and Destination information on PTVs
- Advertising and public service announcements on PTVs or stoppoints

Either the Traveler Information System (TRV) or Customer Service System (CSS) may serve as an Itinerary Generator for the other, or each may have its own internal itinerary generator. The CSS creates timetables from the schedule and provides those to the TRV. The TRV and/or the CSS may communicate with external Advanced Traveler Information Systems (ATIS) using SAE J2354 to obtain multimodal itineraries, itineraries including other transit agencies, weather information, etc, or to provide transit itineraries to external ATIS.

The TRV and CSS may be provided fares for transit itineraries by the Fare System, or the TRV may maintain fare information internally. The CAD/AVL System may provide on demand service status information. The CAD/AVL System also provides stoppoint ETA information which allows the TRV to provide next bus information at stoppoints. The CAD/AVL System provides service bulletins to CSS directly or via the Data Repository, similarly the Scheduling/Blocking/Runcutting System provides schedule information directly to CSS and TRV or via a Data Repository.

Schedule, facilities, and map data are assumed to be stored in the Traveler Information System (TRV), and in the Customer Service System (CSS). The transfer of schedule information is discussed in section 5.5. The transfer of map data (in addition to the map information included with the schedule) is discussed in section 5.10. Figure 5.8.3 A&B depict the transfer of schedule, facilities, and map data to the TRV and CSS.

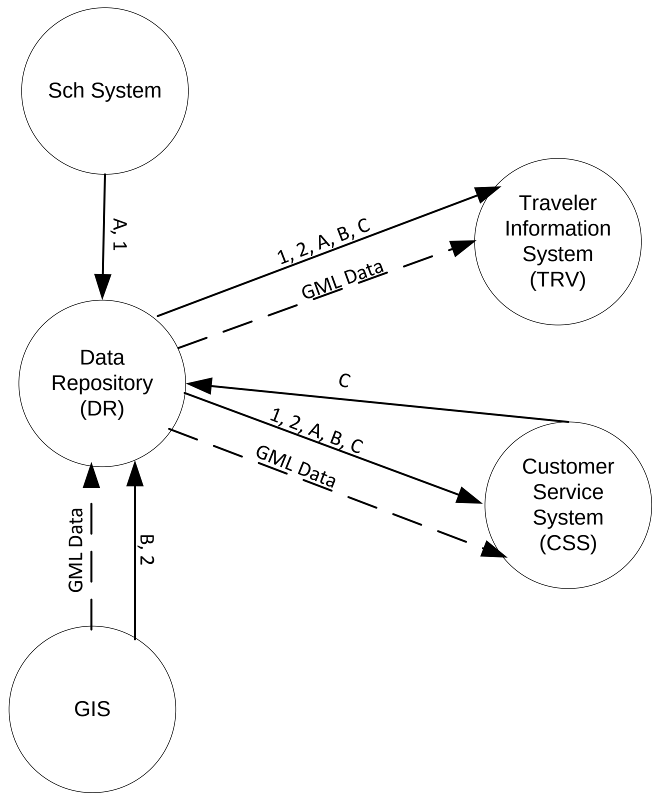

Figure 5.8.3.A
Transfer of Information to TRV and CSS with Data Repository

Legend

A - Publish Master Schedule Version
Publish Route Schedule
Publish Trip Detail
Publish Timepoint List
Publish Pattern List
B - Publish Landmarks List
Publish Stoppoints List
Publish Facilities
Publish Shelters
Publish Transfer Cluster List
Publish Amenities
C - Publish Available Mailings

1 - SchPushMasterScheduleVersion
SchPushRouteSchedule
SchTripDetailList
SchPushTimepoints
SchPushPatterns
2 – PiLandmarksList
PiAmenitiesList
CptStoppointList
CptTransitFacilities
CptShelterList
CptTransferClusterList

Dashed line indicates non-TCIP information flow

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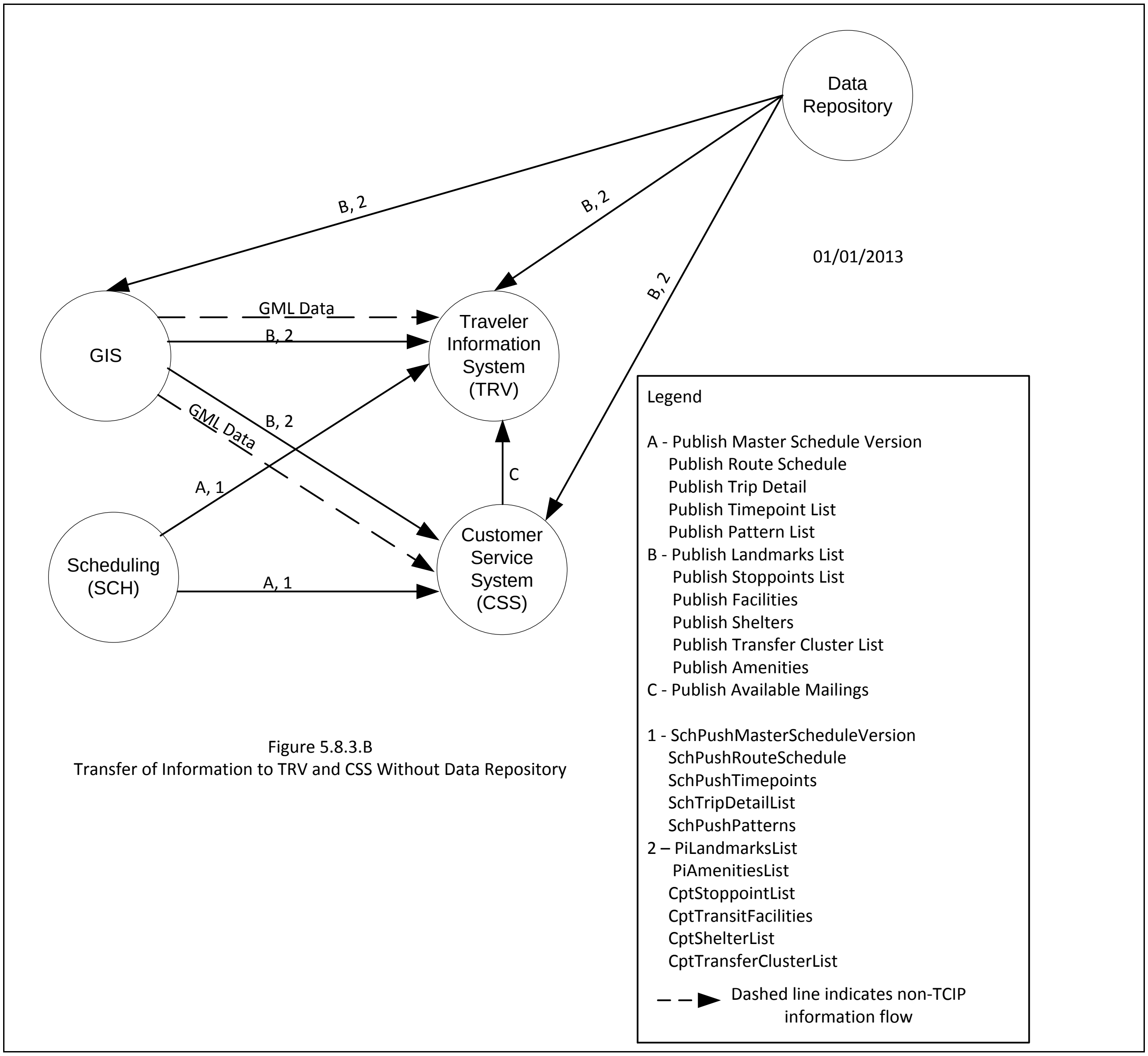


Figure 5.8.3.B
Transfer of Information to TRV and CSS Without Data Repository

The CSS supports complaint resolution processes. Complaint investigations may require the investigator to review logs of vehicle movements from the CAD/AVL System, logs of operating data from PTVs or video images collected by cameras in PTVs or PTSFs and stored for later use.

Customer inquiries may use a variety of mechanisms to specify locations- particularly origins and destinations. Since customers generally do not know the latitude/longitude of their origin, destination or present location, the Publish Location Conversion dialog allows a business system to subscribe to translations of addresses, landmark names, etc. to latitude/longitude from another business system.

Customer Service Systems (CSS) and Traveler Information Systems (TRV) generate substantial quantities of important information on usage of transit transportation services, as well as on customer support and information service. This information is logged within these business systems and may be used for analyses of usage patterns etc. TCIP does not standardize the format of these logs, or their transfer, however.

5.8.4 Customer Information Subprocesses

5.8.4.1 Customer Pretrip Planning

In the planning process the customer has determined that he/she may be making a journey or journeys involving transit. The journey may be imminent or some time in the future, it may be a one time occurrence, or a new planned commuting pattern.

During the planning process, the customer will generally need information on service availability at the time of the planned trip. If the customer is unfamiliar with the transit system, they may start by asking for stoppoint locations near their origin and destination. They may need information on the availability of parking, shelters, handicap accessibility, or other amenities at the stoppoints of interest. The customer will usually want to know the fare, and the schedule for service at the stoppoints of interest around the expected travel time. Additionally, if the trip involves transfers, the customer may want information related to transfer opportunities, transfer clusters, transfer times, etc.

The communications with the customer may take the form of a series of questions or queries, or the customer may prefer to submit a request to have a complete itinerary created, and receive back a completed itinerary or series of alternative itineraries. These itineraries may also include maps. In cases where the journey is not imminent, the customer may want information mailed to them to support their own planning efforts. The list of available mailings can be transferred from the data repository to the CSS at this time as well (if the list is not maintained in the CSS itself).

If the customer's interaction is online, through an ISP, kiosk, or Internet appliance, the required information is provided by the Traveler Information System (TRV). If the customer calls the customer service telephone support service the required information is provided by the Customer Service System (CSS), usually based on information previously obtained from other business systems.

Individual agencies may implement a number of variations of the model architecture, including but not limited to:

- Implementation with or without a data repository
- Combining the TRV and CSS into a single business system, or segmenting the functionality of these systems differently.
- Use of the GIS, Data Repository, or other Authorized Business System as the source of stoppoint, landmark, location conversion or other information.

5.8.4.1.1 Itinerary Generation

Itinerary requests may originate from kiosks, internet appliance, Interactive Voice Response (IVR) system (e.g.,, 511 system) or other external (to the transit agency) business systems. The Traveler Information System (TRV) accepts these requests as TCIP messages or as SAE J2354 ATIS messages. Note that TCIP messages act as a container for an ATIS message – so the data is easily exchangeable with and without the TCIP container message.

Itinerary requests may also come by telephone to the Customer Service Call Center and be entered into the Customer Service System (CSS) by the customer service call taker. For illustrative purposes, we assume that itinerary generation is done in the Traveler Information System (TRV).

The TRV may be able to create an itinerary based solely on information it has stored internally, however it may also need to obtain information from other sources, such as the TRV from another transit agency, or external ATIS, or ISPs supporting other modes (taxi, highway, air transport). The TRV may obtain weather information using SAE ATIS messages from an ISP, or may receive weather from a specialized weather information service provider in a provider-defined format.

Although TCIP does not include the Paratransit Business Area, the itineraries requested and provided by TCIP may support paratransit service. Similarly the Publish Itinerary Map and Publish Itinerary Fare dialogs may be used with paratransit itineraries.

The itinerary generation process may provide no itinerary because the requirements of the request can not be met or because the request is invalid. Real-time information including weather, service bulletins, and active detours may be used to alter the itinerary or may be associated with the itinerary if the request is made with an intended travel time in the near future. Maps of the itinerary route may be provided with the itinerary.

Fares associated with the itinerary may be calculated by the Traveler Information System (TRV) if it has been loaded with the agency's fare policies. If the agency ITS architecture does not include transferring fare policies to TRV, then itinerary fares may be obtained on an itinerary-by-itinerary basis from the Fare System. This scenario is illustrated in Figure 5.8.4.1.1.

Similarly to fares, the TRV may have the capability to render a map for an itinerary, or the TRV may be reliant on the GIS to create a custom map on an itinerary-by-itinerary basis. The latter scenario is illustrated in Figure 5.8.4.1.1.

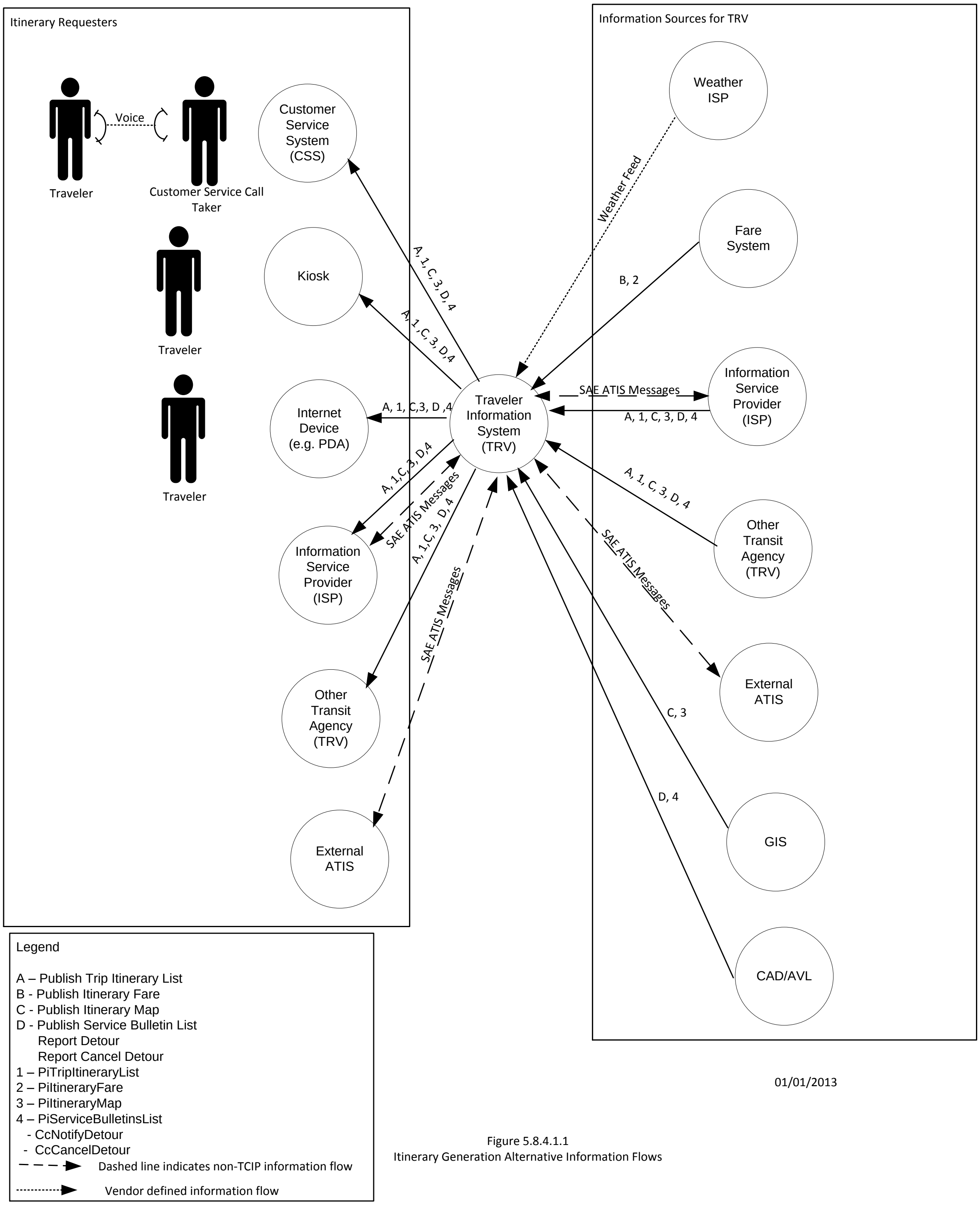


Figure 5.8.4.1.1
Itinerary Generation Alternative Information Flows

5.8.4.1.2 Other Planning Data

Travelers may also need other information in planning their journey. This information might include:

- Determination of the nearest transit stop to an origin or destination of a trip.
- Determination of the landmarks in a vicinity e.g.,, near a transit stop.
- Determination as to whether parking is available at a transit stop, or where parking is available convenient to a specified location. Both of these features are provided by the Publish Stoppoint Parking Dialog.
- Determination as to whether a shelter or other amenity is available at a transit stop or group of transit stops.
- Obtaining a text (printable) timetable for a route.
- Determination of the current or planned service bulletins in effect.
- Information about service detours in effect.
- Agency profile information – including service area, name, contact information, etc.
- Agency Static Files – publicly available files published by the agency which may include any type of schedule or service information, general fare information, agency history, etc. in commercial-off-the-shelf file formats.
- Locally-Defined Geographical Zones – Locally or regionally defined zones which may be based on city, county, town or state lines, or on other locally determined criteria.
- Accessibility – includes information on service accessibility for bicycles, surfboards, handicap access, etc.
- Service Types – includes the types and modes of available transit service for a point or area.
- Route Information – information about a specified transit route or routes.
- Announcements – public announcements published by an agency.
- Location Map – map of a specified location, usually highlighting transit facilities.
- Directions – instructions on how to get between two points which may be indoors, or outdoors. Such directions may include a transit itinerary and/or walking directions

Based on local policy, related information may be included with the responses to these queries. For example, a request for the nearest stop to a location of landmark might automatically return service bulletins in effect near the stop(s) and parking information for the stop(s) identified.

Agencies may elect not to report detours in effect to TRV and CSS, but instead to include this information only in the form of service bulletins, however both information flows are included in Figure 5.8.4.1.2. Service bulletins and other service information may also be provided using Passenger Information Displays (PIDS).

Figure 5.8.4.1.2 depicts the information flows for providing other planning data.

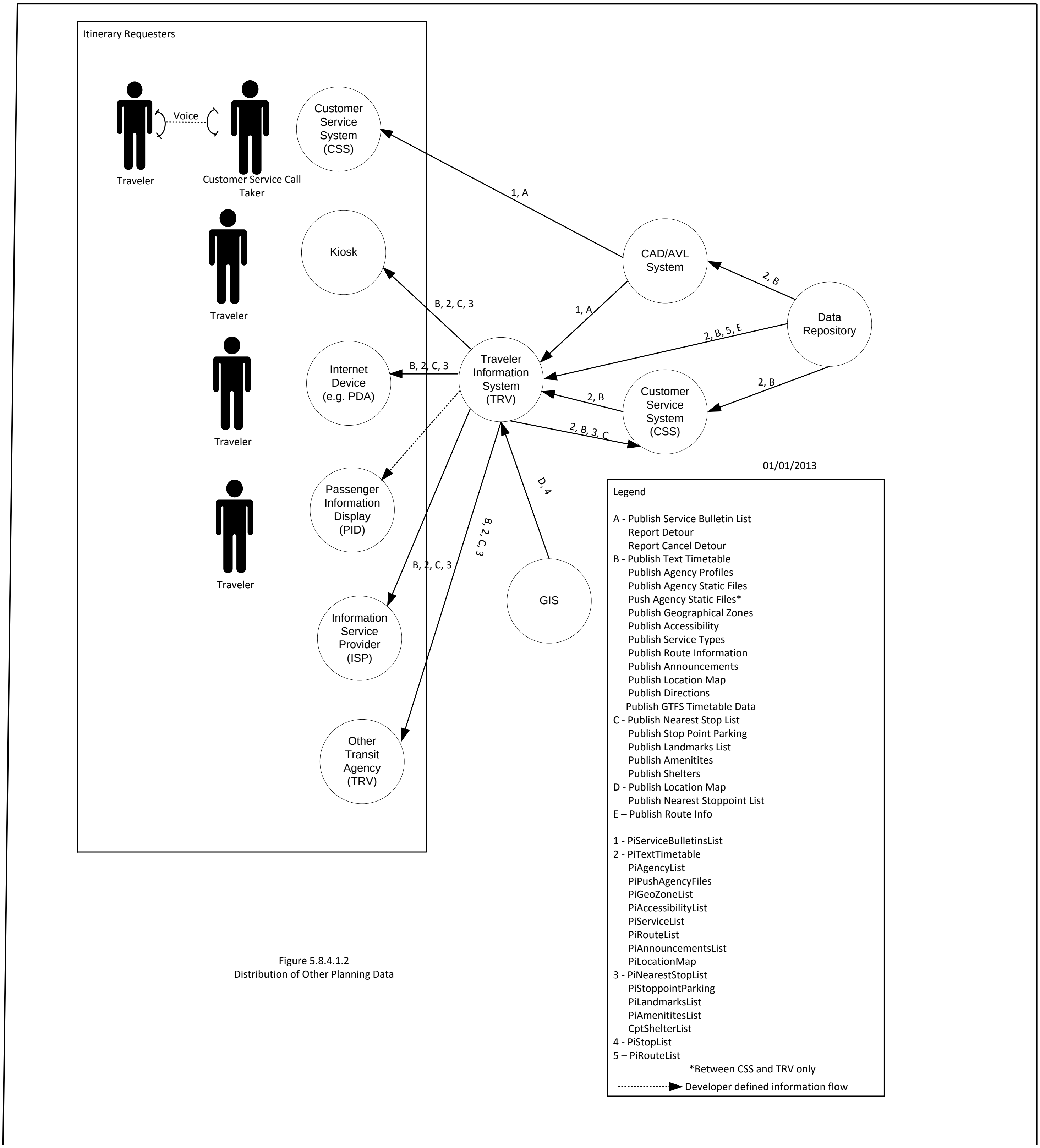


Figure 5.8.4.1.2
Distribution of Other Planning Data

5.8.4.1.3 Printed Planning Material

Many transit agencies maintain hardcopy printed materials (maps, timetables, etc.) for use by their customers. Customers usually can pick these materials up at designated transit agency locations. Customer service call takers may be able to mail these materials to customers upon request. Customers may also be able to order these materials online or via a kiosk.

The system that manages the mailing process may be the Customer Service System (CSS), or another Authorized Business system. The list of available mailing may be maintained by the CSS, another Authorized Business System (ABS), or the Data Repository. For illustrative purposes we assume a separate ABS-Mailing system and that the list of available mailings is maintained in the Data Repository (DR).

Figure 5.8.4.1.3 depicts the mailing process.

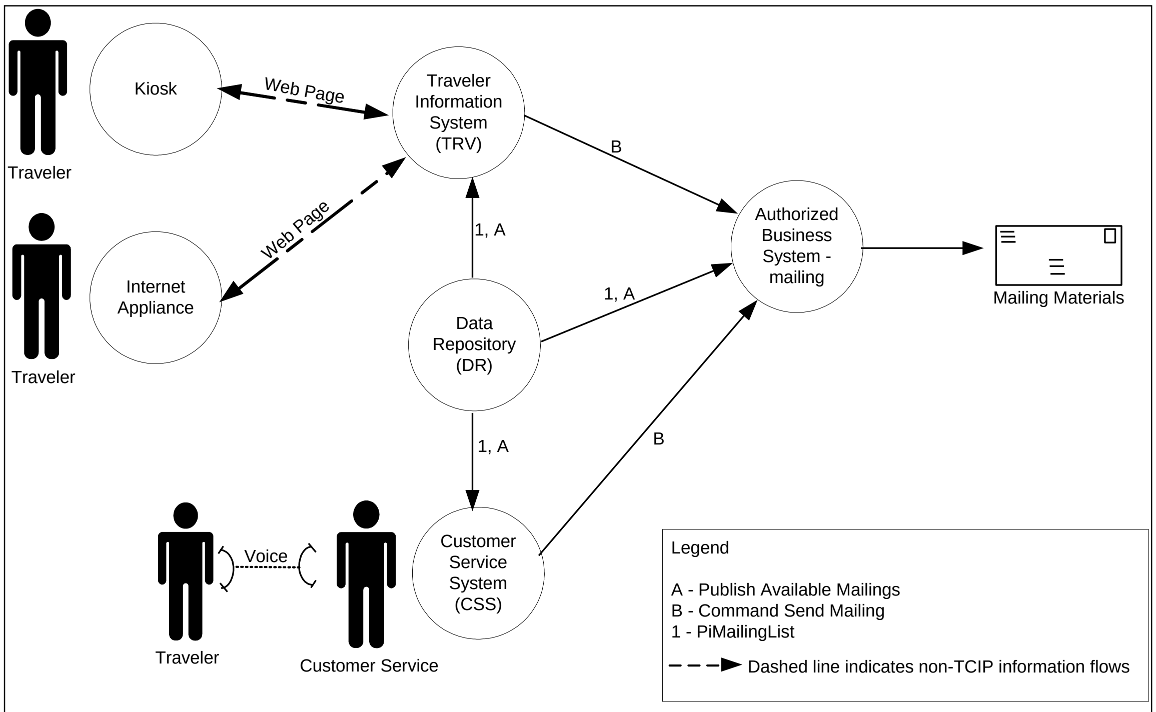


Figure 5.8.4.1.3
Printed Mailing Materials Processing

5.8.4.2 Customer Information-Station/Stop Subprocess

Most customer journeys that include transit involve passage through a transit center, station or stoppoint. This process involves communications with travelers while they are at or in one of these facilities.

Stoppoints may be as simple as a sign on the side of the road, or may be elaborate multimodal facilities. All stoppoints have provisions for displaying static information of the stoppoint location which may include servicing routes and timetable information. Some facilities will have provisions to communicate variable information to the customer using dynamic message signs or public address announcements.

The most common variable information to be provided at a stoppoint is next bus information. In some cases next bus information may be accompanied by service bulletins, special announcements, advertising and other agency-defined information. Agencies may provide the capability for live announcers to initiate audio and/or visual announcements.

TCIP provides the capability to convey next bus arrival information and service bulletins which may be used by TRV in operating these services.

TCIP provides the ability to query service status at a stop (e.g., next bus eta, schedule deviation) from a kiosk or Internet appliance.

Figure 5.8.4.2 A, B & C depict the Inform Customers Station/Stop Process TCIP information flows.

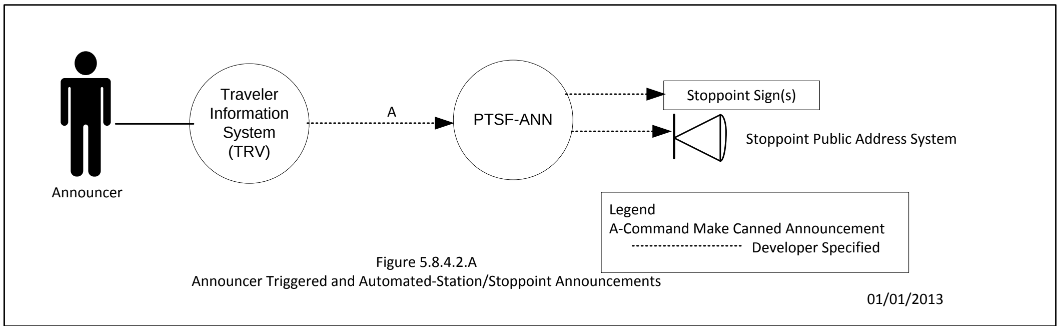


Figure 5.8.4.2.A
Announcer Triggered and Automated-Station/Stoppoint Announcements

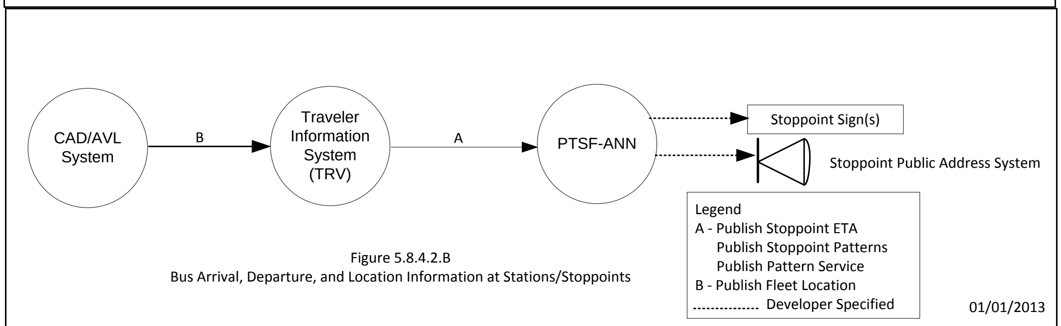


Figure 5.8.4.2.B
Bus Arrival, Departure, and Location Information at Stations/Stoppoints

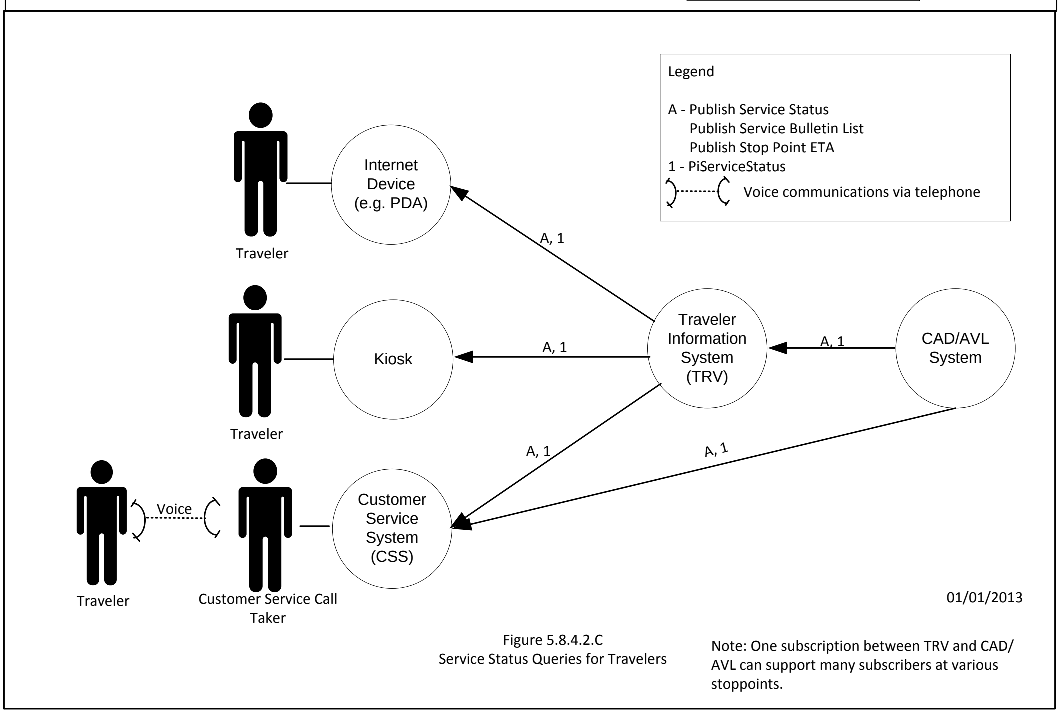


Figure 5.8.4.2.C
Service Status Queries for Travelers

5.8.4.3 Inform Passengers Subprocess

The Inform Passengers process involves the provision of information to a customer while they are onboard – or in some cases boarding/alighting a PTV. Key information to be provided includes Route Id, Destination, Express/Local information, Stop Announcements, Landmark Announcements, En route Announcements (including fare zone boundary announcements if so configured).

Route, Destination, and Express/Local information are generally provided on destination signs, and possibly on other signs on other parts of the PTV as well. Stop announcements and other en route announcements may be made by the driver or automatically, and may be accompanied by messages on Passenger Information Displays on the PTVs. Additionally, in some transit agencies, the dispatcher has the capability to remotely make live or canned announcement on the bus using the radio system.

Announcements may be visual, audio or both, and may be displayed/played internally to the PTV, externally or both. Announcements may be triggered by arrival at a designated location (event), occurrence of a time of day (event), approach to a stoppoint, or arrival at a stoppoint.

Announcements, text messages, destination sign messages and rules, and event-based announcements are loaded to the PTV (PTV-ANN) during the preparation for vehicle operations. This process is described in section 5.3.4.1.1.

Figure 5.8.4.3 A-E depicts the TCIP Information flows for the Passenger Phase of the Inform Customers Business Process.

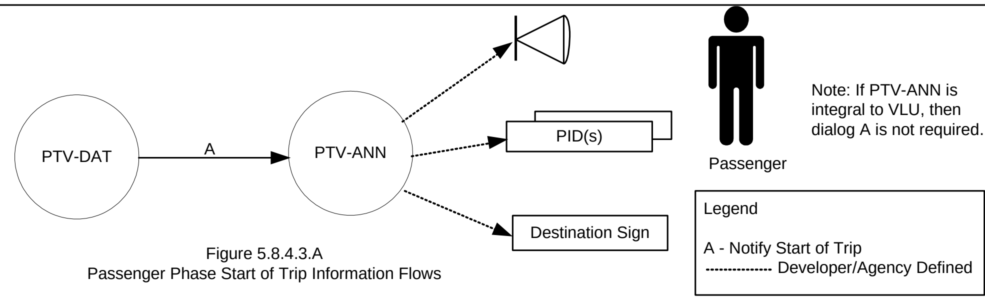


Figure 5.8.4.3.A
Passenger Phase Start of Trip Information Flows

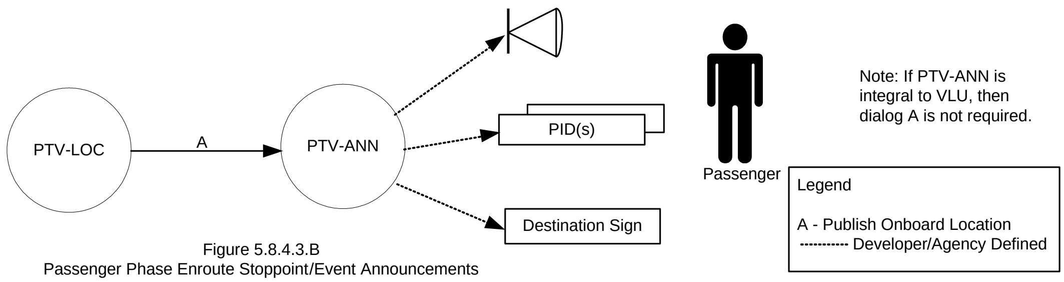


Figure 5.8.4.3.B
Passenger Phase Enroute Stoppoint/Event Announcements

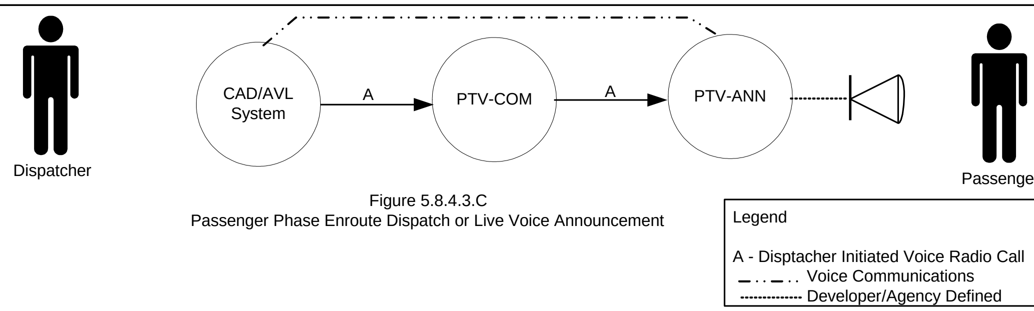


Figure 5.8.4.3.C
Passenger Phase Enroute Dispatch or Live Voice Announcement

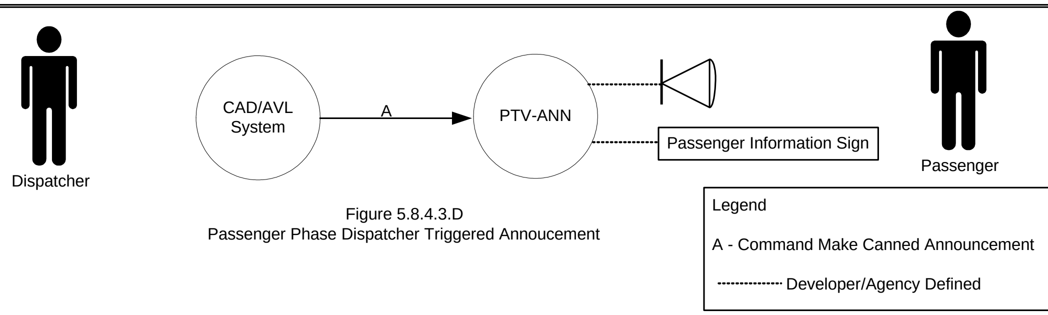


Figure 5.8.4.3.D
Passenger Phase Dispatcher Triggered Annoucement

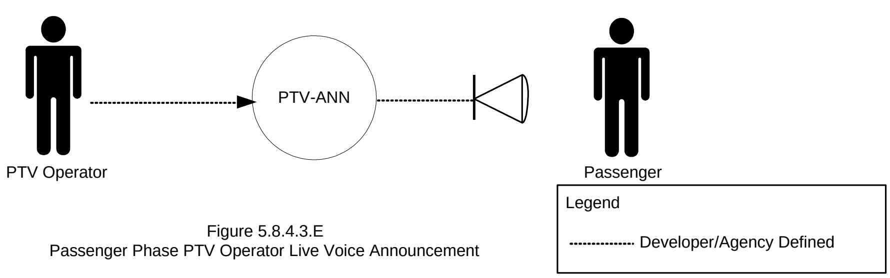


Figure 5.8.4.3.E
Passenger Phase PTV Operator Live Voice Announcement

5.8.4.4 Customer Information – Ongoing Subprocess

This phase of the Inform Customers process involves activities that are outside the planning and execution of a trip. The Customer Service System (CSS) maintains customer profiles which may be used for mailings, determination of ADA eligibility etc. The CSS also participates in the investigation of customer complaints and provides the capability for a Customer Service Representative to look at historical data including: video archives from cameras at stoppoints and/or on PTVs service history based on historical data unloaded from PTVs when they return to the garage at the end of a block of work. Ongoing activities of the Customer Service group also include operation of a lost and found.

5.8.4.4.1 Customer Complaints

Figure 5.8.4.4.1 Summarizes the complaint investigation process. Agencies may use other systems besides the DR as the storage location for the video images and operating data.

Daily operating data is used to verify where PTV's were and at what time. Video images (if available) provide a powerful tool for recreating events surrounding the complaint. Historical incident reports provide official records, produced during and following an incident. The traveler request logs help determine whether requests for wheelchair pickups were honored and if not, why not.

A complaint form or report will normally be created by a customer service representative when the complaint is first lodged. The report is maintained in the Customer Service System (CSS), and may be updated numerous times in the course of a complaint investigation. A complaint report will normally contain:

- Date/Time Complaint Lodged
- Customer Information (name, phone number, address, etc.)
- Complaint Number
- Customer Service Representative ID (could be more than one)
- Problem Description
- Date/Time of Problem/Incident
- Location of Problem/Incident
- RouteID (optional)
- VehicleID (could be zero, one or several)
- Operator ID (could be zero, one or several)
- Run Number (optional)
- Associated Incident ID #
- Associated Traveler Request (Requester ID, Control Center ID)
- Witness Reports or Interviews
- Closeout Information
- Response to complaint originator (content of phone call, letter, etc.

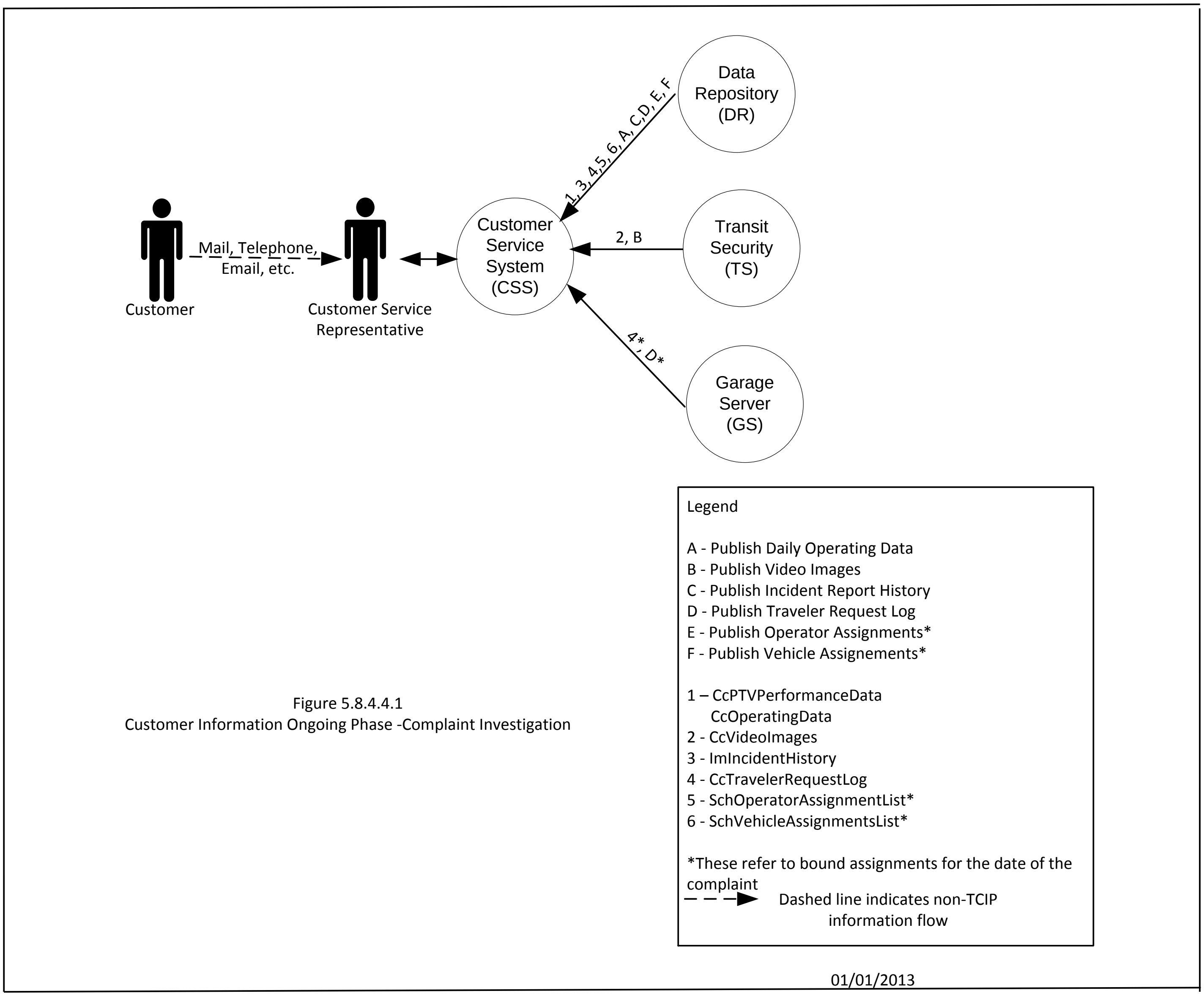


Figure 5.8.4.4.1
Customer Information Ongoing Phase -Complaint Investigation

5.8.4.4.2 Inform Customers Ongoing Subprocess – Lost and Found

The lost and found process involves reporting and storing found items, reporting lost items, matching lost and found items and returning items to their owners. In some cases found items may be subject to special procedures (guns, explosives, animals, etc), and such items may be turned over to other public agencies. Figures 5.8.4.4.2 A-D illustrates alternatives in each stage of this process.

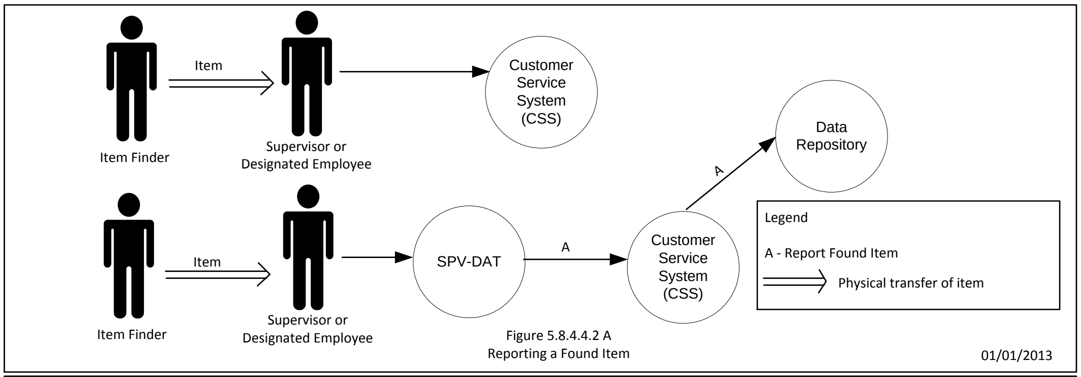


Figure 5.8.4.4.2 A
Reporting a Found Item

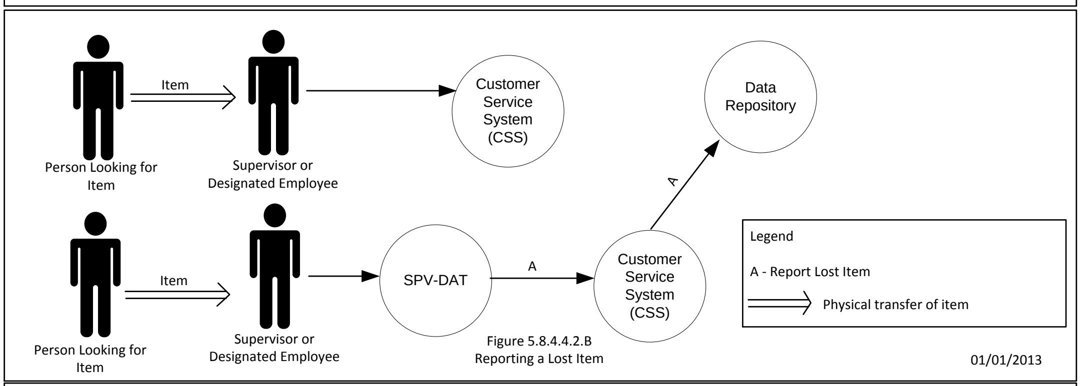


Figure 5.8.4.4.2.B
Reporting a Lost Item

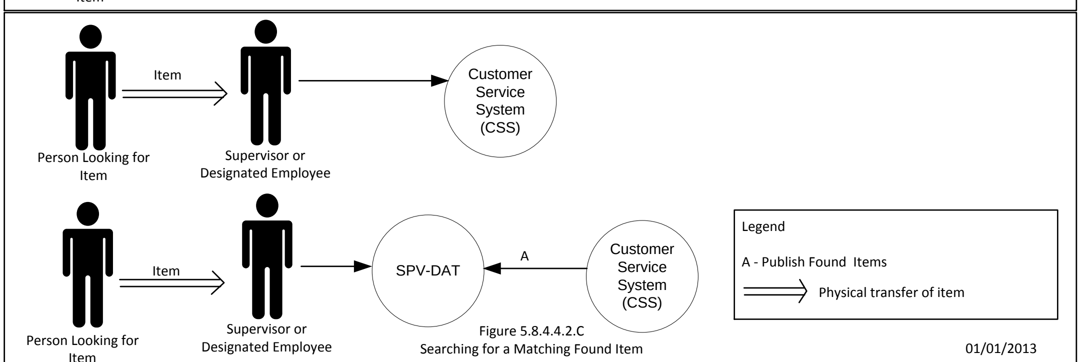


Figure 5.8.4.4.2.C
Searching for a Matching Found Item

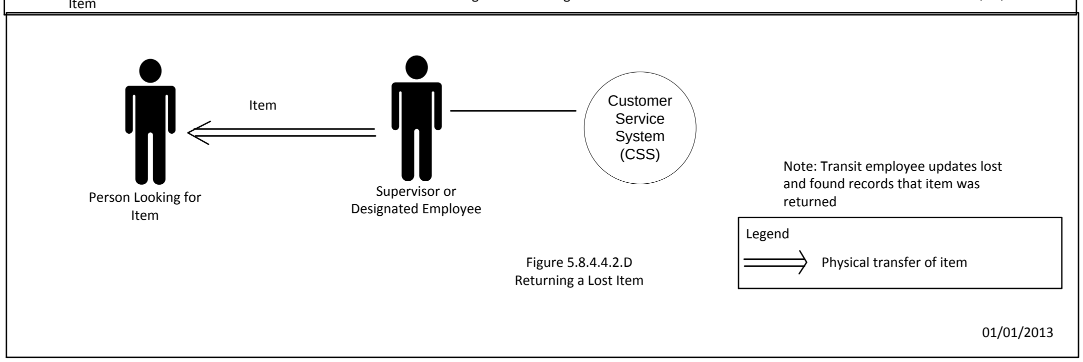


Figure 5.8.4.4.2.D
Returning a Lost Item

5.8.4.4.3 Customer Information Ongoing Subprocess – Customer Subscriptions and Profiles

Customer Profiles and Subscriptions facilitate a variety of customer communications and services that would not otherwise be feasible including:

- Distributing Commuter Bulletins to commuters via mail or email
- Distributing Newsletters & press releases directly to customers via mail or email
- Distributing notifications of service changes including detours, trip cancellations, etc.
- Distributing real-time service information to commuters (e.g., route xyz westbound experiencing delays from abc to def)
- Demand-Response services

In general these customer communications use methods other than TCIP to distribute information to customers based on the stored profile.

Figure 5.8.4.4.3.A illustrates the process of establishing and updating profiles and subscriptions. A customer must first establish a profile through customer service or online. Once a profile is created it can be updated (e.g.,, change of address). To facilitate updates, the list of existing profiles can be queried by profile number, name, address, etc.

Once a profile exists, it can have associated subscriptions created/added/deleted/modified using the Report Update Customer Subscription dialog. Agencies may require security (e.g.,, VPN connection) for online profile/subscription queries and updates.

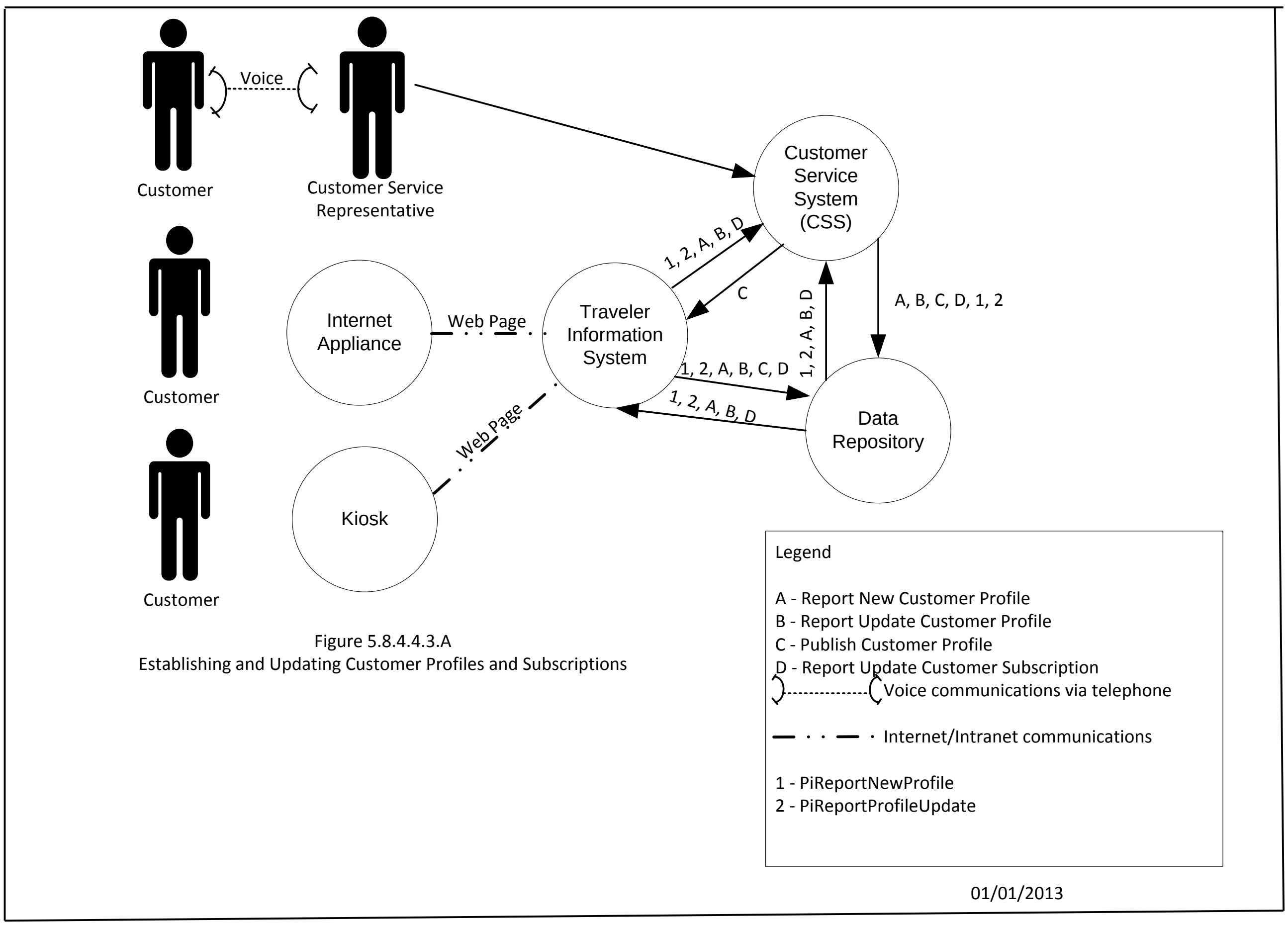


Figure 5.8.4.4.3.A
Establishing and Updating Customer Profiles and Subscriptions

As illustrated in figure 5.8.4.4.3.B, the CSS may use a variety of mechanisms to inform the customer based on a profile:

- Send mail to the customer describing planned changes to service, service bulletins, newsletters, or other information relevant to that customer.
- Provide stored customer profile information to a customer service call center representative servicing the customer.
- Push information relevant to the customer's use of transit via email or an Internet appliance.
- Push information relevant to the customer's use of transit to the customer's cell phone using short message service (sometimes called text messaging).
- Make an automated outgoing telephone call to the customer to provide the customer with information relevant to the customer's use of transit.

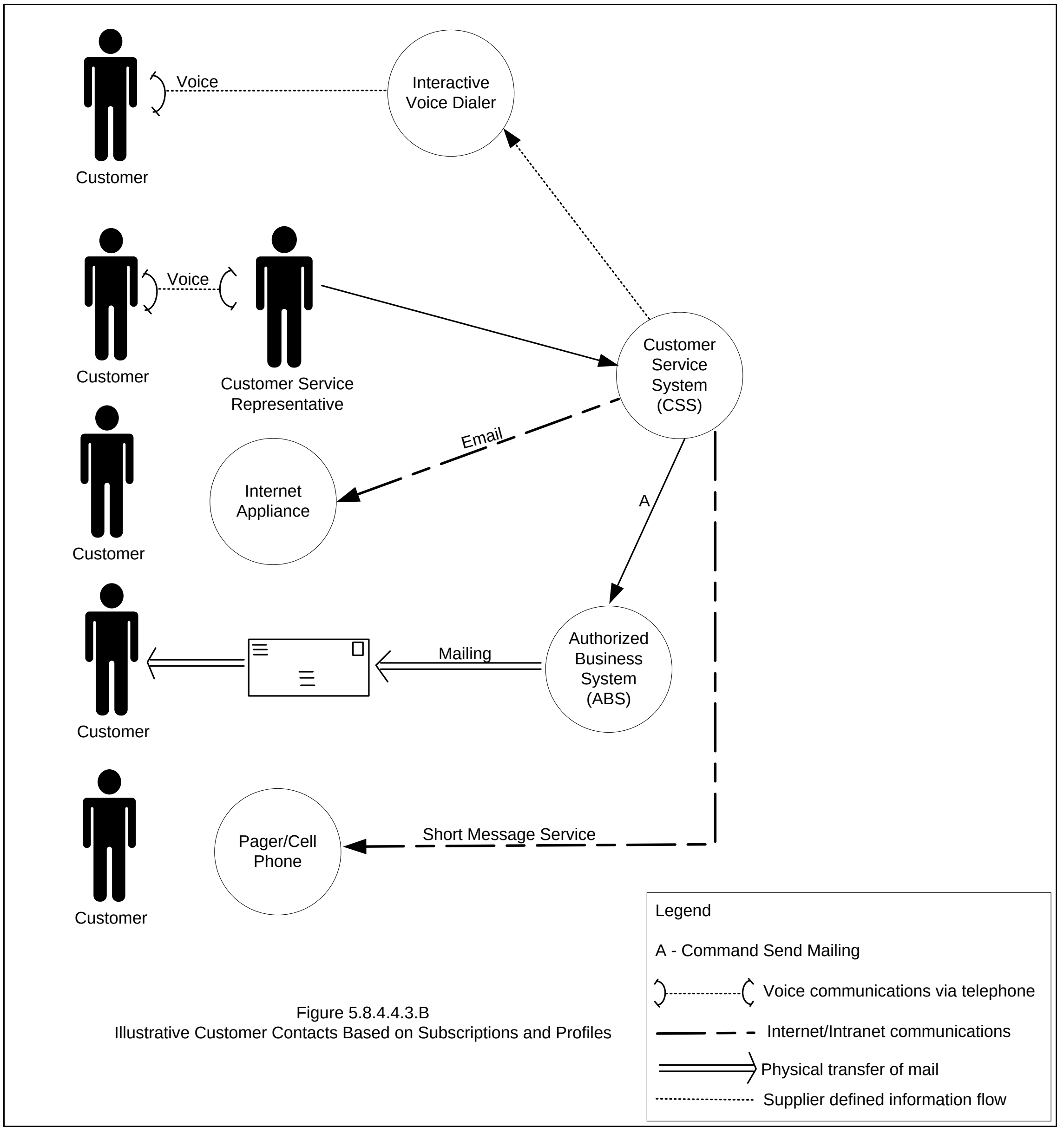


Figure 5.8.4.4.3.B
Illustrative Customer Contacts Based on Subscriptions and Profiles

5.9 Data Repository Operations Process

5.9.1 Purpose of the Data Repository

The Transit Data Repository serves as a central location for storing and maintaining transit agency data. The data repository may be a relational data base, a group of linked relational databases, and may include data warehouse application(s).

Data Repositories may receive data from one business system and later distribute the data to other business systems. This asynchronous distribution of data provides significant advantages in an agency ITS architecture. Specifically, it:

- Allows the originating business system (application) to remain unchanged when new users of its outputs are added.
- Allows data to be output from an originating business system when destination business system(s) are inactive or not in the operating mode to receive the data.
- Allows data to be stored and merged ("fused") with other data from other sources prior to distribution to "downstream" business systems
- Allows ad-hoc reports to be generated which rely on data from multiple sources.

The TCIP data definitions (data elements, data frames, and messages) may serve as a guide in defining the data repository's internal data definitions (e.g., rows in tables). Alternatively the data repository may have its own "native" data elements and organization with translations to and from related TCIP data concepts. TCIP does not mandate the Data Repository's internal data representations or its internal workings.

5.9.2 Overview of Data Repository Operations Process

The Data Repository Operations Process has 9 main subprocesses included in its operations:

- Data Storage – receipt and storage of data from other entities
- Metadata Management – Store and maintain data about the data in the repository
- Validation of data from business systems
- Security- Set permissions controlling what users (machines or people) have the right to view, receive, modify, store or perform other operations on the data
- Data Integration – combining and integrating data from multiple sources
- Reporting – generation of predefined or ad-hoc reports using data in the repository
- Archiving – protecting data in long term storage. The ADUS in the National ITS Architecture provides additional insight into archive requirements for ITS data.
- Data Distribution – making data available to entities that need it.
- Data Translation – Translating data between TCIP and formats provided or required by legacy business systems

The degree of sophistication and the amount of functionality built into a data repository varies *substantially* from agency to agency. These range from a grouping of linked relational databases and data warehouses with associated applications and complex business rules, to simple manually maintained data stores.

The more sophisticated data repositories require specialized IT staff to develop and maintain. These staff members may include database administrators, analysts, software developers etc. Staffing constraints may lead some agencies to elect to include less sophisticated Data Repositories in their agency, or to devise agency ITS architectures that do not include a separate data repository. Some agencies use the development and evolution of their data repository as a framework to define and refine the relationships among core transit data concepts.

Agencies may elect to include sophisticated data validation tools and/or business rules into their data repositories, or may have these rules and validation processes distributed into various business systems. Including validation processes and business rules into the Data Repository can help ensure agency defined business rules are enforced and can reduce the rate of occurrences of validation errors reported by “downstream” business systems. The existence of data validation processes within the Data Repository may not eliminate the data validation processes incorporated into these downstream business systems. Similarly the implementation and/or enforcement of business rules within the Data Repository may result in higher quality data reaching downstream business systems, but may not eliminate the need for developer and agency specific business rules to be implemented in those downstream systems.

Agencies may include tools with their Data Repositories to enable analysts to perform various “what if” analyses using historical data and various service strategy and other scenarios.

TCIP is applicable to agencies that elect to implement simple Data Repositories, complex Data Repositories, or that have no separate Data Repository.

5.9.3 Primary Model Architecture Component

Agency Data Repositories may be designed within the context of a single application (e.g., COTS database engine) or may be a distributed, cooperating set of databases and/or data warehouses. The TCIP Model Architecture treats the Data Repository as a single optional business system. The internal architecture and design of the Data Repository is agency-specific and not defined by TCIP.

5.9.4 Data Repository Operations Subprocesses

The following subsections describe each of the Data Repository constituent processes. These subsections do not illustrate all of the possible dialogs and file transfers in and out of the Data Repository as these are described in other parts of this Concept of Operations.

5.9.4.1 Data Storage

The Data Repository may receive data for storage from agency business systems, external agency (e.g., other regional transit, local government, DOT business systems) or other logical entities in a variety of fashions including:

- TCIP-XML File Transfers from business systems
- TCIP Publication Dialogs (Query, Periodic or Event-Driven)
- TCIP Unload Dialogs (from field or mobile entities)
- TCIP Push Dialogs (unsolicited data transfers from external entities)
- TCIP Blind Notification Dialogs (unsolicited, unacknowledged notifications from external systems)
- Non TCIP Legacy Transfers
- Other non-TCIP transfers such as GML transfers of spatial data based on Open Geospatial Consortium Standards.

TCIP-XML file transfers from external systems may be executed using a file transfer protocol (such as FTP or TFTP), or via removable physical media. This transfer mechanism is applicable where the source providing the data has been converted to TCIP, or has a TCIP translator, but the source does not support TCIP dialog(s) that perform the data transfer automatically.

TCIP Publication Dialogs provide an automated transfer from the source to the Data Repository. These dialogs allow transfers to be executed on a one-shot basis, or to use an initial query followed by later queries for updates, or for the data repository to request an event-driven subscription to obtain the initial information along with automatic updates, or an initial transfer with periodic updates. Although the Data Repository must initiate a subscription, event-driven Publications allow the source to initiate the transfer of updates once the subscription is established.

TCIP Unload Dialogs allow transfers of data from mobiles or the field to the Data Repository. Unload Dialogs may also be used to move data from the Garage Server to the Data Repository. Unload Dialogs are generally used to transfer information about actions occurring in the field (including stations/stoppoints) and/or Public Transit Vehicles (PTVs) to the Data Repository for archival, reporting and analysis. Agencies may elect to:

- unload data directly from the field location or vehicle to a Data Repository
- unload to an intermediate device (e.g.,, Garage Server) and then to unload the Garage Server to the Data Repository
- unload from a field device or a mobile device directly to a business system.

TCIP Push Dialogs allow a source to initiate the transfer of data to the Data Repository without a prior subscription request from the Data Repository. Push Dialogs contain acknowledgements which allow the source to initiate recovery processes in the event the Data Repository does not receive the data, or rejects the data.

TCIP Blind Notification Dialogs allow a source to initiate a transfer of data to the Data Repository without a prior subscription request from the Data Repository and without any error recovery in the event the transfer fails or the data is rejected. This type of transfer may be employed where the data is transient, where the source needs to notify several destinations, where there is no feasible error recovery mechanism, or where the return of a response to the notification is impractical or undesirable.

Non TCIP Legacy transfers allow a source to transfer data to the Data Repository in a non TCIP format using legacy defined transfer mechanism(s). This type of transfer is applicable when a legacy application has no translation capability to TCIP, but has data that needs to be moved to the Data Repository. In this case the data may be translated to TCIP within the Data Repository, or may be translated directly from the legacy format to the internal representation used by the Data Repository.

Transit agency data contains significant temporal content. These temporal features may be associated with the metadata – e.g., when the data was received, or updated. Some temporal information may be integral to the data itself – e.g., the actual location of a PTV at an instant in time, or the time at which the PTV executing a scheduled trip is scheduled to traverse a timepoint. This temporal aspect of agency data has many significant implications for the internal design and operation or a data repository. A complete discussion of these implications is beyond the scope of this discussion, however a few items are worth mentioning specifically; temporal data may be required for:

- Reporting on the state of the agency and its assets at a point in time or for a specified interval of time.
- Replaying the sequence of events as they occurred based on historical data.
- Forecasting the future state of the agency and its assets based on historical trends and future projections and plans. Using historical temporal data for forecasting purposes may require the data to be aggregated, filtered, or otherwise processed prior to use in the forecasting model.
- Updating business systems based on changes to previously provided data (e.g., give me all changes to stoppoint data since a specified date-time)
- Rolling back a database to recreate the data as it appeared at a specified moment in the past. This maybe performed due to corruption, or as part of an investigation or analysis.

Transit agency data also contains significant spatial content. Spatial content is used to define point locations such as current vehicle location, stoppoint location, timepoint location etc. Spatial data also defines area and linear features such as fare zones and transit routes. Spatial data may be expressed in a variety of formats or reference systems including latitude-longitude, state-plane, and link-node. The data repository may employ an interface to a spatial data repository, or GIS or may include an integrated spatial data repository to manage spatial data. Section 5.10 describes transit agency spatial data management in more detail.

Figure 5.9.4.1 illustrates the variety of mechanisms available to transfer data to the Data Repository.

The diagram illustrates the following types of data transfers to the Data Repository:

- The transfer from ABS1 illustrates a transfer where the originating business system translates the internal data to TCIP format and transfers the data to the Repository using a TCIP file transfer.

- The transfer from ABS2 illustrates a similar file transfer where the originating business system uses TCIP formatted data internally.
- The transfer from ABS3 illustrates a non TCIP transfer. The Data Repository translates the legacy data to an internal format for storage.
- The transfers from ABS4, ABS5 and ABS7 illustrate transfers to the Data Repository using TCIP formatted data using TCIP dialogs.
- The transfer from ABS6 illustrates a transfer using a translator within the originating business system to convert the data to TCIP format before a transfer using a TCIP dialog.
- The transfer from ABS8 illustrates a legacy transfer using SQL and the Data Repository's native internal data format.

Note: Any TCIP dialog pattern or file transfer can be used with a translator at either, neither or both ends of the transfer.

5.9.4.2 Data Validation

The Data Repository may from time to time receive data for storage which is discernibly erroneous, corrupt, incomplete or invalid. The Data Repository may contain algorithms to detect these problems and to initiate reporting of the problems. This validation within the Data Repository provides an opportunity for an agency to prevent "bad" data from propagating to downstream business systems and creating additional problems. Validation may also occur in downstream business systems, as most business system developers include their own business rules for ensuring data validity. TCIP provides a general purpose data validity reporting mechanism that can be used by either the data repository, or downstream business systems to report a data validity problem. It is not expected that a report of a data validation failure results in any 'automatic' recovery by the upstream data source, but rather that the upstream system is provided with information that will be useful to a human that intervenes to resolve the 'bad' data.

Faulty data reporting may take several forms:

- Validation Error Dialogs (where they have been defined) may be used to report the error to the data source or to another agency-designated business system.
- Alarm Reporting. If the Data Repository contains its own online or batch alarm reporting capabilities, data problems may be reported using these mechanisms.
- Event Log. The Data Repository may incorporate an event log where records of data problems can be recorded and maintained.

The Data Repository may also distribute data to external entities that in turn determine that the data has a problem. Such entities may use validation error dialogs to report the error to the Data Repository or other agency-designated business system.

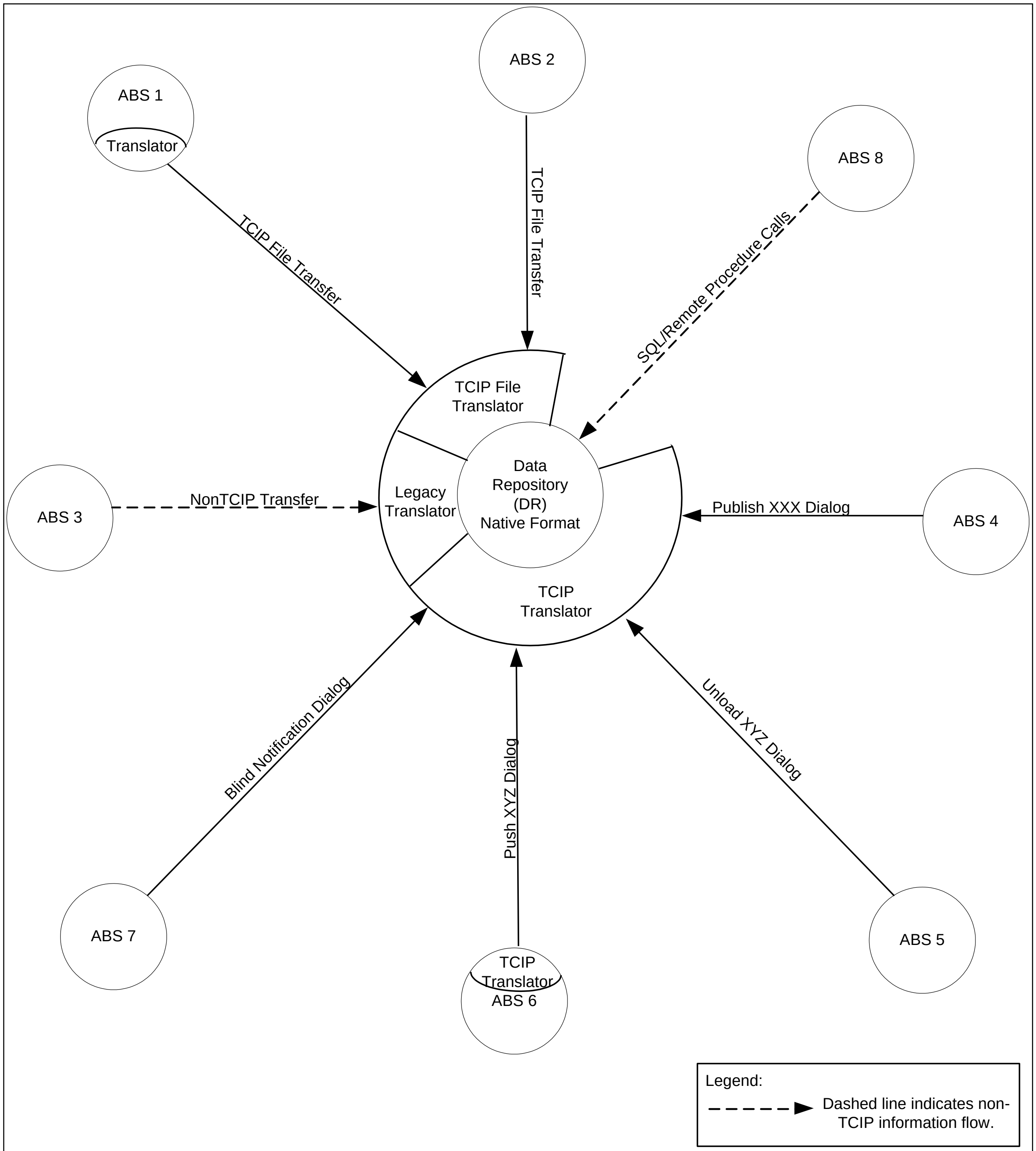


Figure 5.9.4.1
A Data Repository May Receive Data for Storage Using a Variety of Transfer Methods.

Figure 5.9.4.2 depicts the variety of Data Repository data validation failure scenarios.

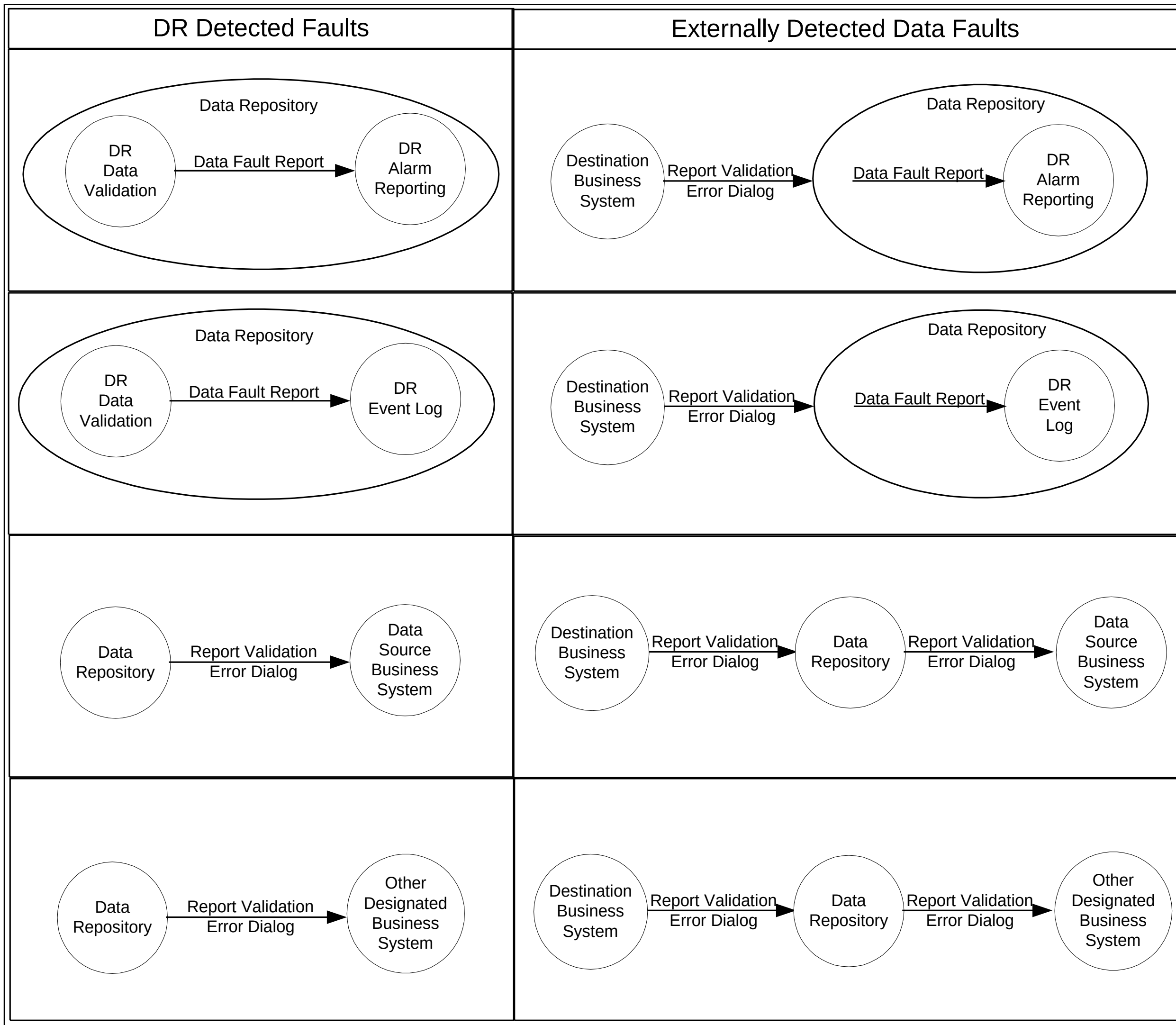


Figure 5.9.4.2
Data Repository Data Validation Error Reporting Scenarios

5.9.4.3 Data Integration

The Data Repository can be used to combine data from a number of sources to create improved and more useful "joined" data. Spatial Information provided by the GIS Business System may be combined with patterns provided by the Scheduling Business System, for example. Data integration may require identifiers and records from disparate sources to be correlated and mapped; business rules may apply regarding what data from what source can be updated under what circumstances; data types may need to be converted to enable comparisons of data provided using different representations or data may need to be normalized to reflect 1:N relationships, for example.

The Data Repository may participate either or both of two data integration processes:

- Internal Data Integration
- External Update Integration

Internal Data Integration is a process where by the Data Repository receives data asynchronously from two or more sources. The Data Repository includes business rules that recognize the relationship between the various received data sets, and uses this knowledge to update the data. For example, a new dataset maybe used to populate an optional field in a table in the Data Repository that was formerly not populated or to create another instance or a piece of data with a different period of validity.

As an example the Scheduling System provides the set of patterns used in creating a schedule, but not containing any spatial data for those patterns. Separately, the GIS provides spatial data which includes street layouts, and the locations of timepoints and stoppoints occurring in the pattern. The Data Repository combines the data from both sources and when it passes the pattern list to the AVL System (or any other business system) it now includes the spatial data associated with each pattern. Figure 5.9.4.3.A depicts the internal data integration process.

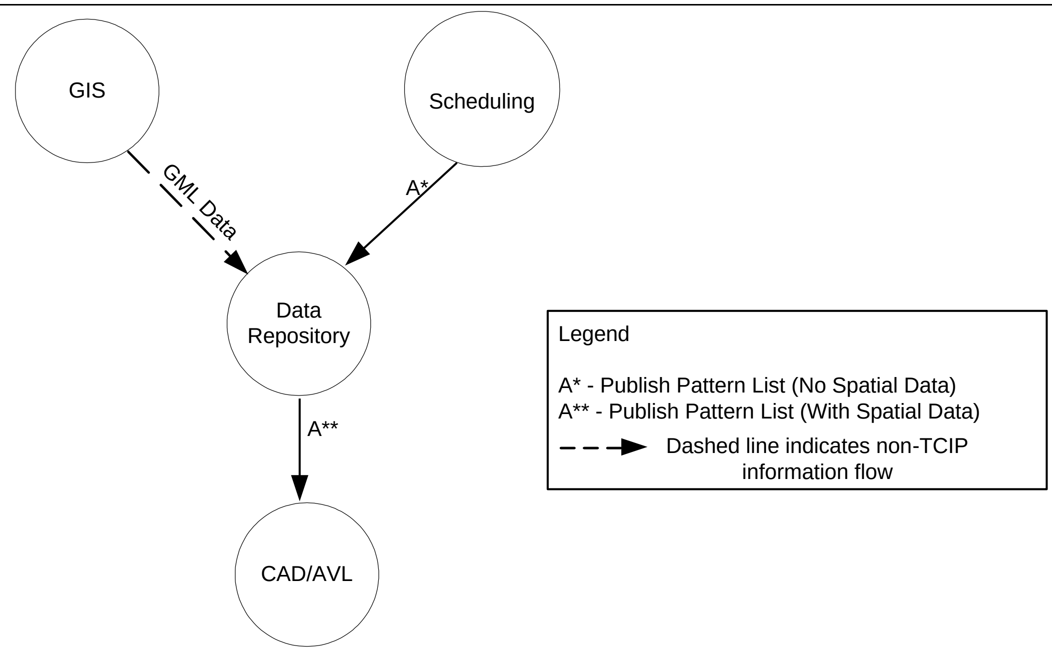


Figure 5.9.4.3.A
Internal Data Integration in Data Repository

As another example, consider a Data Repository that has information on the stoppoints for each pattern. The scheduling system sends a set of patterns defining the timepoints for each pattern segment, but not the stoppoints. The Data Repository adds the stoppoints to the pattern segment definitions. The Data Repository can now provide authorized subscribers with pattern definitions with or without stoppoints included. Note: The SchPatternListSub message allows a subscriber to request the inclusion of stoppoints in pattern-segments using the stoppoints-needed field.

External Update Integration is a process whereby the Data Repository provides data to an external entity, and that entity updates the data, possibly by populating formerly unpopulated optional fields, and then provides the data back to the Data Repository. This may be done with “interlocking” Publication dialogs. Figure 5.9.4.3.B depicts the external data integration process.

In this example, the Scheduling System provides the unbound operator assignments (runs) to the Data Repository. The Data Repository later on request provides those unbound assignments to the Operator Assignment System (OAS). After the pick, or after any update within the OAS, the OAS pushes the bound assignments back to the Data

Repository. On request the Data Repository provides bound assignments to the CAD/AVL or other business systems that require them. Two key items are illustrated here: first, that the Data Repository enables the external data integration by providing the ability for other business systems to obtain and provide data asynchronously, and by implementing the business rules necessary to manage the data updates from different sources: second, that the operator assignment information can be pulled using the Publication dialog or pushed using the push dialog, as appropriate for each case within the agency ITS architecture.

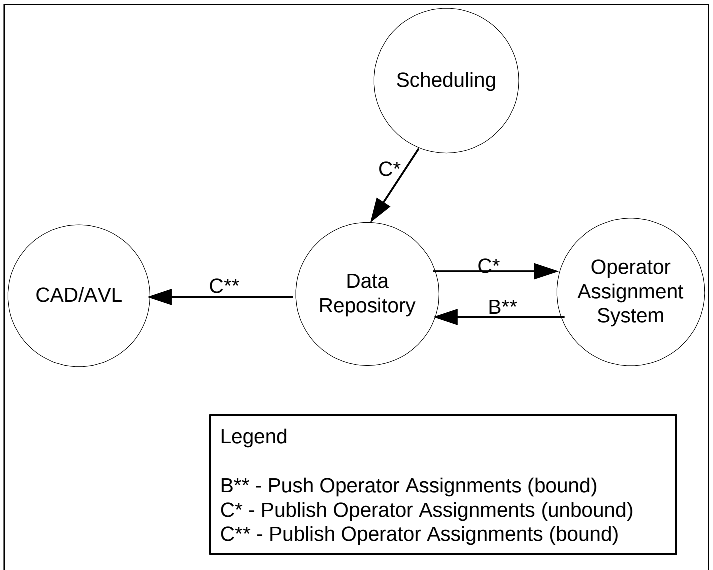


Figure 5.9.4.3.B
External Update Data Integration

5.9.4.4 Reporting and Archiving

A Data Repository contains an extremely useful cross section of the transit agency’s data including data on facilities (e.g.,, stoppoints), operating plans (e.g.,, schedule, operator assignments), and records of past operations (log files, other historical data). This data can be used by agency analysts to generate reports which can in turn be used to plan future operations, justify future expenditures, to review past actions etc.

Data Repositories will generally contain an off-the-shelf ad-hoc report generating capability. The capabilities vary based on the database package(s) and other commercial packages used by the agency within the data repository.

The Data Repository will generally contain a mechanism for archiving important data for long term storage, as well as for retrieving archived data when needed.

TCIP does not specify requirements for reporting and archiving within the Data Repository. The Archived Data User Service (ADUS) defined in the National ITS Architecture provides some guidance for archiving in ITS applications. Agencies may use ADUS guidance in developing archival services. (See reference I-25).

Commentary: Setting up a sophisticated data repository with reporting and archiving abilities can be labor-intensive, and require access to skilled IT personnel.

5.9.4.5 Data Distribution

The Data Repository may distribute data to a variety or agency business systems or other logical entities in a variety of fashions including:

- TCIP-XML File Transfers to external systems
- TCIP Publication Dialogs (Query, Periodic, or Event-Driven)
- TCIP Load Dialogs (to a proxy such as a Garage Server or directly to field or mobile entities)
- Non TCIP Legacy Transfers

TCIP-XML file transfers are applicable for transferring data to systems that are TCIP data-compatible, but which do not implement TCIP dialogs.

TCIP dialogs provide for automated transfers of TCIP data from the data repository to appropriately provisioned external entities.

Non TCIP data transfers are appropriate when the data repository must transfer data to a legacy application which has not, or cannot be upgraded to TCIP. Agencies sometimes will have such applications which are not feasible or cost effective to upgrade to TCIP, requiring legacy transfer mechanisms and formats to be used until the application is replaced.

Figure 5.9.4.5 illustrates the data repository alternative data distribution methods. The diagram illustrates the following types of data distribution from the Data Repository to other business systems:

- The transfer to ABS1 illustrates a TCIP file transfer to move the data to ABS1 where a translator is used to convert the data to the format used internally by ABS1.
- The transfer to ABS2 illustrates a TCIP file transfer to move the data ABS2, where the TCIP formatted data is used without translation by ABS2.
- The transfer to ABS3 illustrates a non-TCIP transfer to a legacy system with the translation to the legacy format and legacy transfer mechanism performed within the Data Repository.
- The transfer to ABS4 illustrates a TCIP dialog-based transfer, where the TCIP formatted data is used without translation by ABS4.
- The transfer to ABS5 illustrates a TCIP dialog-based transfer, where a translator is used to convert the data to the format used internally by ABS5.
- The transfer to ABS6 illustrates a legacy transfer using SQL and the DR’s native data format.

Note: Any TCIP dialog pattern or file transfer can be used with a translator at either, neither or both ends of the transfer.

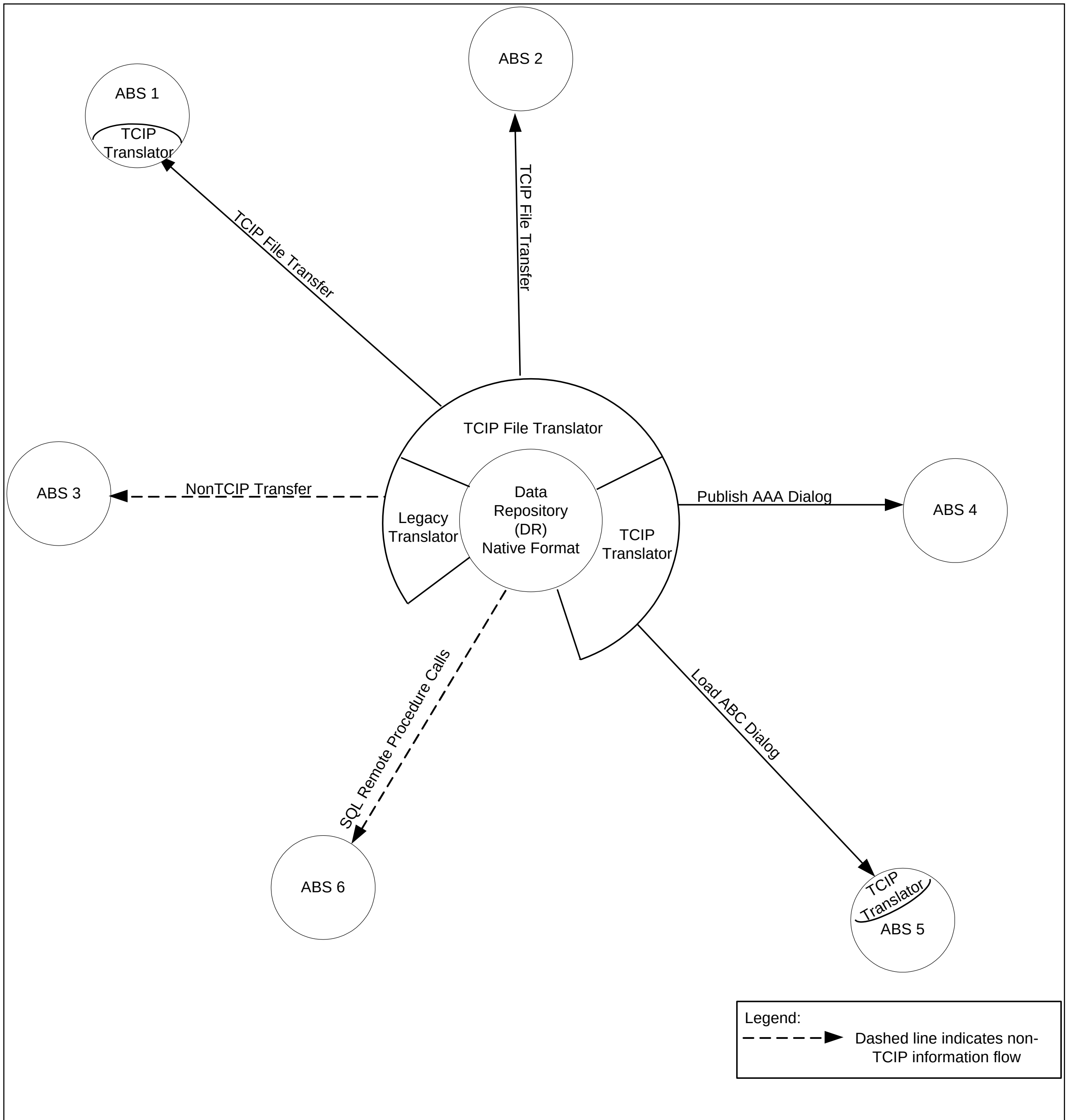


Figure 5.9.4.5
A Data Repository May Distribute Data Using a Variety of Transfer Methods.

5.10 Spatial Data Management Process

5.10.1 Purpose of the Spatial Data Management Process

The ability to achieve transit's mission and to provide timely transportation services and accurate customer information is dependent on the availability of accurate spatial data. For transit agencies to be efficient and effective, they need to know where their customers are located, where they want to go, where transit vehicles and employees are, where facilities are located and a wide range of other answers to geographic-related questions.

Virtually all transit business processes depend on some form of spatial data or output from a Geographic Information System (GIS), such as maps, finding the location of addresses, the analysis and display of types of incidents or any number of other analyses. With the advent of Intelligent Transportation Systems (ITS) applications, many transit business systems also depend on spatial data to operate. For example, the spatial location of bus stops is one of many spatial elements that Trip Planning systems and Automated Passenger Counter systems need to be able to function and provide answers for transit.

Some of the transit software functions that are fundamental to providing efficient transit service and timely customer information are included below, with an example of a question they answer that requires spatial data.

- Trip Planning – How do I get from here to there using transit?
- Paratransit – Where are the trip origins and destinations for customized transit services?
- Rideshare or Carpool Matching – Where can people meet to facilitate multiple-occupancy car trips?
- Planning/Scheduling – When and where should service be made available?
- Automate Vehicle Location (AVLs) – Where's the vehicle when a security incident has occurred?
- Automated Passenger Counters (APCs) – Which routes are too crowded or underutilized?
- Real-Time Display – Where are the transit vehicles right now?
- Transit Forecasting – Where are we likely to need service in the future?

A more comprehensive listing of uses of spatial data and geographic analyses in transit is included in the Federal Transit Administration sponsored guidebook, titled "Best Practices for Using Geographic Data in Transit: A Location Referencing Guidebook."

Transit agencies use a wide range of spatial data, including both transit and non-transit spatial data. Examples of transit spatial data include bus stops, routes, fare zones and service areas. Many of the transit planning and ITS applications also need spatial information about roadways, landmarks, political boundaries, waterways and other spatial data sets. In addition, ITS applications create spatial data such as the location of incidents and trip itineraries.

A Geographic Information System or GIS is necessary to provide spatial data management, geographic functions and analyses needed by transit staff, customers and information systems. Often, the spatial data generated within a transit agency's information systems must be spatially analyzed in the context of data from other applications. GIS is a natural solution to this problem and best practices include maintaining and managing spatial data in a GIS.

As a result of its wide spread use and critical importance, spatial data is a fundamental part of transit's information technology infrastructure. Like all portions of transit's infrastructure, the spatial data infrastructure requires management and maintenance. This Concept of Operations for Spatial Data Management addresses some of the key elements and issues pertaining to spatial data management and how it relates to transit and the TCIP standard.

5.10.2 Overview of the Spatial Data Management Process

This section provides an overview of some key spatial data management issues that should be considered when planning to implement TCIP. Additional detail about the architectural elements necessary for spatial data management is provided in Section 5.10.3. The spatial data management processes and TCIP dialogs and message file transfers associated with them are described in Section 5.10.4.

5.10.2.1 Documents Referenced for Spatial Data Management

The references listed below provide background information relevant to managing spatial data and implementing GIS in the transit environment.

- Geographic Information Framework Data Content Standards, Transportation: Transit, Reference [I-3]

- Best Practices for Using Geographic Data in Transit: A Location Referencing Guidebook, Reference [I-5]
- Location Referencing Message Specification (LRMS), Reference [N-4]
- Bus Stop Inventory Best Practices and Recommended Procedures, Reference [I-8]
- Geography Markup Language (GML), Reference [I-4]

5.10.2.2 Assumptions

Spatial data management practices vary in their level of sophistication across transit agencies, as do GIS implementations. In some transit agencies spatial data is stored solely in a GIS. Agencies that have more integrated data and systems may have their DBMS and GIS working hand-in-hand. The spatial data may be managed by the GIS and stored in the DBMS. As a result, TCIP dialogs and/or message file transfers may have different sources and/or destinations for the same information.

Spatial data that flows between systems may require some processing (clean-up, aggregation, combination/analysis) which is best performed by a GIS. In addition, spatial analyses and the creation of new spatially based data objects are often performed in a GIS. In some cases, data requests may require additional analyses before information can be returned.

Implementing best practices pertaining to GIS and spatial data provides many benefits to transit and simplifies the implementation of TCIP. In general, these best practices have to do with reducing the number of systems and data sources to simplify the interfaces needed and to reduce duplication and unnecessary data reconciliation. Some key best practices to consider in the transit agency ITS Architecture include:

- Have a single agency GIS. This does not rule out the presence or use of imbedded mapping applications in other systems, such as in a Scheduling system. The agency GIS, however, would perform the spatial data management, maintain the spatial geometry, and perform geographic analyses for the transit agency.
- Have a single point of authority for core data. In this model, responsibility for the data creation and maintenance is clearly delineated. All systems and users can take the "official" version of the data and use or manipulate it as needed.
- Have a single agency base map as a source. The updating of streets and other crucial data should only be done once for an agency and distributed to other applications.

For additional best practices, see the Bus Stop Inventory Guidebook and the Location Referencing Guidebook.

Transit agencies require specialized software applications to provide efficient and economical transportation services to an increasingly diverse and widely dispersed population. Some of these applications may have embedded mapping functions, which are not sufficiently comprehensive or complete to facilitate centralized database architectures or to serve as a GIS. In addition, each application can have a unique way of storing spatial data and each business area can have different requirements regarding the positional accuracy of the data, reporting functions, and data validity. In the absence of an agency-wide GIS approach, transit agencies may expend resources synchronizing data stored in these separate systems. Cross-functional analysis of spatial data is also more difficult when the data is dispersed and in multiple formats. When designing the agency architecture, consideration must be given as to the best place to access and retrieve valid and accurate spatial data, whether it is the GIS, the DBMS, or an ABS.

5.10.2.3 Temporal Data and Synchronization

The temporal element of transit data and its association with the geographic location makes it both unique and complex. Transit agencies need to know where things are and when, such as passengers and vehicles. Temporal data are further complicated by the need to distinguish between current, planned and historical route, schedule and service information. Often, more than one of these data sets must be retained in transit business systems simultaneously. As a result, TCIP data communications must allow for accurate specification of the actual data needed, whether it is future, current or past and whether it was planned or actual.

A relational database is the most effective tool to perform the sophisticated analyses and complex queries associated with AVL and APC data generation and analyses that rely heavily on spatial data. In the absence of a data repository, the CAD/AVL and PC business systems may internally provide a relational database structure. In addition, route patterns change with time, which makes historical data management, an important aspect of spatial data management.

An awareness of data synchronization issues is critical when combining spatial data with other data elements or requesting spatial analyses and maps. Knowledge of metadata, age of data and data dependencies is important, particularly when data originates from different databases. An information requester cannot assume that information maintained by one workgroup is not dependent upon the information maintained by another workgroup. For example, a bus stop may include attributes such as on street, cross street, distance from the cross street, bearing, side of street, GPS coordinates and other attributes that may be entered by one workgroup. This information may then be used by another workgroup to actually place the stop in a GIS. These two sets of information describing location may then need to be joined to produce a publishable dataset for use in information systems throughout the agency. Also, when one set of information is changed by one workgroup, the other workgroup must be notified so that their information can be updated. Best practices should facilitate linkages between databases to eliminate complex load processes and the need for synchronization. In addition, communication between data maintainers should be facilitated specifically with regard to new, updated, or deleted objects.

5.10.2.4 Ownership

Spatial information about particular transit features (e.g., stops, time points, routes, streets) can be maintained in different ways by different workgroups within a transit agency. For some transit agencies, maintenance of all the attributes of a transit object resides solely within a single workgroup. As a preferred practice, data are best maintained by workgroups that have the greatest stake in ensuring the data's integrity. Furthermore, it may be the case that a transit agency uses information maintained by external agencies such as streets, landmarks, property information, or political districts.

Because of the possible distributed maintenance of spatial data, TCIP provides for direct linkages between spatial information maintained in a GIS and non-spatial attribute information maintained in a DBMS or in other software. For example, scheduling software should have access to the GIS and some of the functionality within that system. Conversely, GIS requires data from the scheduling system to generate the route geometry. To maintain data integrity, transactional updates should be synchronous messages, not asynchronous.

For more information on data management using TCIP, refer to Section 4.3 Configuration Management.

5.10.2.5 Staged Data Publication

Spatial data in many agencies undergoes a very frequent or even continual maintenance and upgrade process. Consequently, not all data in a business system, particularly a GIS, is ready for publication to downstream systems at any instant in time.

An agency's data publication approach should allow for a two-stage release of information, when appropriate, and may be addressed in the Agency ITS architecture. The first stage makes data available to other data maintainers. The second stage makes data available to the entire agency and is achieved only when all work is complete. Business systems used for spatial data maintenance should provide information to data maintainers about missing attributes that should prevent an object from being published. The possibility of multiple stages of "data readiness" should be considered before selecting a data source in the agency ITS Architecture.

5.10.2.6 Relation to Other Standards

TCIP spatial data frames and data elements are used within TCIP messages in all TCIP business areas. Although there are many spatial feature transfers that are not within the scope of TCIP, there are other related and consistent industry standards that provide the interfaces necessary for a transit agency to implement a robust spatial data management process. For example, large-scale spatial data exchanges and feature set updates may be performed using other standards such as Geography Markup Language (GML) and GeoSpatial One Stop (GOS). Furthermore, there are different levels of representation that are supported by different standards. These standards are described as follows:

Geography Markup Language (GML): Promulgated by the Open Geospatial Consortium (OGC), this standard describes geospatial feature relationships and formats that may be used to compose a transportation network and/or location references associated with spatial features (e.g., bus stops, route segment paths, etc.) GML is a specialization of XML, and specifies the "tags" that describe spatial feature type formats. It contains geospatial descriptions for a variety of layers including hydrology, cadastral, and transportation. It is used in a wide variety of environments and industries, and includes support by most GIS products. Rather than TCIP, GML should be used for base map transfers and updates, feature set transfers and updates, and for web services supporting ABS to ABS transfers.

GeoSpatial One Stop (GOS): Defines the representation of geospatial data, their definition, format and relationship including feature sets for various geospatial domains including hydrology, transportation (roads, rail, air, waterways, and transit). Transit is a part of the transportation network that is integrated into a GOS data model. Transit features incorporated into the model include transit points such as timepoints and stops, multimodal connection junctions, transit paths such as route segments and patterns. GOS describes data type definitions for vehicle and operator assignments, trips, routes, transfer points, amenities and more. The model may be used to create an XML Schema using GML or TCIP/LRMS,

The GOS program includes the specification of web services for publishing, searching and viewing geospatial feature sets. The web services are implemented using the GML description of the GOS model. Because it supports the complex relations among transit features, the GeoSpatial One Stop (GOS) may be more appropriate for systems that need information on feature relationships such as a data repository. A TCIP data transfer can work with the GOS data model if the necessary data mapping is performed.

Location Referencing Method Specification (LRMS): The LRMS standard describes the data elements and frames necessary to describe location references using a variety of geographical, addresses, and linear reference methods as it relates to a transportation network. Also based on XML, LRMS describes more types of linear and attribute (i.e., address) referencing methods for transportation then GML, however, the relationship among the spatial features are assumed from a given transportation network. LRMS is used in TCIP primarily to define data elements and frames that provide many of the spatial data concepts that are used throughout TCIP and other ITS Standards. LRMS spatial data concepts support a variety of representations for geo-spatial data including address-based, latitude-longitude, and state plane coordinates.

TCIP may be used for transactional updates to the data or to transfer datasets. For example, multi-modal and multi-agency trip planning requires complex data from varying source datasets that include an ordered sequence of points. This data could be provided in a format that could then be converted to TCIP, however care should be taken whenever data is transferred from one data source to another, the source dataset quality may not align precisely with the target dataset quality.

5.10.2.7 GIS and Information Technology

An information system requires people trained with the appropriate skill set to support the system throughout its useful life. A GIS is no exception and requires a broader range of skill sets than most – hardware support, database support, software support, application support, and data support. It is rare if not impossible to find all these skills within a single individual. It may be necessary for a larger agency to acquire portions of several individuals time, each with some of the necessary skills to achieve the desired mix required to provide support.

Close affiliation with an Information Technology department can often provide adequate staff to support the hardware and databases, although these individuals should have additional GIS training. The advantage to using existing IT staff is that they often already have the basic skills necessary to maintain the databases and hardware. Similarly, many GIS Software technologies now support common application development languages permitting the GIS developer to embed “maps in their apps”. The advantage here is the ability to more easily find developers familiar with these languages that need only training in GIS. The deployment of GIS software does not require any special skills, but its use does. Vendor training classes are often available in the use of their software as well as GIS hardware system support, application development, and spatial database management.

Despite the potential disparate location of all the necessary support staff within the agency’s physical or political structure, those individuals involved with spatial data support should work closely together to understand how data are used, how to effectively deploy applications, how to efficiently store data, and anticipated hardware requirements. Minor changes in the database, the application, hardware, network connectivity, or the data itself can lead to performance problems for end-users. In larger agencies, many of these individuals work as a team within the same work unit, and are organized and supported themselves by a program manager.

5.10.2.8 Summary

Spatial data and its uses in transit are complex and a number of issues must be kept in mind when creating, managing, analyzing and distributing spatial data. The TCIP standard can be used to support the communication of spatial information using dialogs and/or message file transfers. The transit agency ITS architecture is an appropriate repository to capture the results of the agency’s deliberations concerning what data should be transferred, between what systems, and under what conditions.

5.10.3 Architectural Components of a GIS

Geospatial information is a key component of most transit business systems. Transit requires a spatial framework to know where a bus is supposed to be and a temporal framework to know when the bus is supposed to be at that location. Scheduling provides the temporal framework and GIS provides the spatial framework. Thus, unlike many other business systems in transit that are largely *consumers* of information, GIS and scheduling provide the two critical pieces of information *infrastructure* used throughout the agency.

Transit business systems do not all share the same needs regarding spatial data accuracy, currency, or features that need to be located. Further, some systems require spatial data, some require specific applications, and some require geospatial services. The delivery of these data, applications, and services requires specific hardware, software, and knowledgeable staff who understand the business of transit and who understand GIS. GIS Support Services involve: training; application and tool development; hardware/software purchases and installations; management of data sharing and service level agreements. GIS is not just an off-the-shelf vendor application or a “map”, but a complex information system comprised of key components. Spatial data management involves much more than a simple mapping application and some data.

The five architectural components described below, in addition to people trained with the appropriate skills, comprise the necessary elements of a GIS. Together these components provide decision support capabilities within an agency and facilitate spatial data management through the processes discussed in section 5.10.4. As a best practice, a transit agency should consider each of these components when implementing a GIS, as elements of each are required to provide the minimum capabilities necessary for spatial data management. TCIP implementation will be facilitated if spatial data management is considered in the agency ITS architecture, and is treated as an integral part of the agency’s core infrastructure

5.10.3.1 Data

A GIS provides the unique capability to associate descriptive information about an object with its geographic location. This allows you to explore both kinds of information together – for example, identifying all bus stops with shelters to create optimal paths to be followed by a shelter cleaning crew. It also facilitates combining geographic data in different map layers together – for example, identifying nearby homeowners and residents to target for a mass mailing regarding improvements at a park and ride. Map layers are digital representations of real world features all of the same type. For example, all park and rides might make up a single map layer. The attributes of park and rides would allow you to symbolize them differently on a paper map. For example, park and rides *owned* by the agency might be shown with a different symbol from those that are *leased*.

The essential map layers for transit are the transportation network, bus routes (including timepoints), and bus stops. Many transit business systems will require at least one or all of these layers. Supplementary data also useful for a variety of transit applications include various transit facilities (e.g., park and rides, transit centers, garages), boundary layers (e.g., fare zones, cities, zip codes), and others (e.g., incident locations, landmarks, aerial photography).

Geospatial data might be initially acquired from a variety of sources both public and private (e.g., national map vendors, regional consortia, other transportation agencies, public utility districts). As a transit agency identifies key layers, consideration should be given to their ongoing maintenance. These layers need to be updated for a variety of reasons, including:

- Incremental changes to the data from the original source.
- Changes to the map made by the agency to reflect missing or incorrect features.
- Major updates of the data from the original source.

Although it may seem expedient to regularly purchase updated data layers or data maintenance services from outside the agency, update cycles from external sources may not coincide with the business needs of the agency. Also, external non-transit agencies may not understand the business of transit or the requirements of TCIP, and they may make assumptions regarding data maintenance that limit capabilities for the agency.

Many vendor-based non-GIS transit applications with spatial data needs (e.g.,, Trip Planning, AVL) now embed map layers internal to the application rather than reading these directly out of the agency GIS. This can result in several issues that must be mitigated. Updates made within these applications get overwritten the next time the layers are updated from GIS to these systems. It may not be possible to transmit a single map layer to these systems since transit features such as routes and bus stops are usually geographically referenced to the transportation network – in such cases all layers must be transmitted together. Where possible, it is more efficient to require that vendor systems use data directly from the spatial data repository so that the latest updates are available to their systems without the need for regular mass transfers of data layers. Transfers of map layers are not facilitated by TCIP, although the Geography Markup Language (GML) promulgated by the Open GIS Consortium provides an open XML-based extensible mechanism for exchanging map layers.

5.10.3.2 Databases

Transit agencies require a place to put data just as any other business – a data repository. This can be as simple as a directory of flat files, spreadsheets, and other tabular data or as complex as a database management system. The primary purpose of a repository is to bring together data from separate and potentially disparate sources into a well-defined, cohesive data structure for use by multiple applications. This is most effectively achieved through a database management system. A key objective is to make the data in the database more than the sum of its parts. It's not simply a dumping ground of data. It's more of a community of data where each dataset enrolled must be made aware of its relationship to other member datasets. Once the community of data is achieved, its utility to applications using it as a source is greatly enhanced. Users and systems that provide data to the repository are known as publishers.

Spatial data management requires a place to store and maintain data. Historically, spatial data was maintained and stored in proprietary databases associated with a GIS. But this is beginning to change with the advent of GIS technologies that permit storing, retrieving, and managing spatial data in common off-the-shelf database management systems. This has the advantage of allowing the management of spatial data along side other business data, facilitating integration and validation of these data during maintenance and also permitting the development of complete data maintenance information systems. For example, bus stop location, attributes, and sequencing within routes can all be maintained within a single application.

Another key function of the database is to make its contents available to users and information systems throughout the agency. Database management systems allow the agency to deliver the same data to different systems in different formats without duplicating the data, and TCIP provides a mechanism to standardize this delivery. It may also be necessary to publish data into a separate area from data maintenance activity to provide broader user access and to permit restructuring the data to make it easier to use by data subscribers.

In the design and implementation of a spatial database, the agency should keep in mind the requirements of both publishers and subscribers. Requirements for accuracy can differ, so if the most stringent accuracy requirements are met, business systems throughout the agency can use it and this will avoid duplication of data sets. Consideration should also be given to providing integrated data management solutions for both spatial and non-spatial data.

5.10.3.3 Software

Although spatial data can be stored outside of a GIS in database management systems, agencies frequently do not find it convenient to manage and maintain the data in that environment. GIS software provides tools to maintain spatial data, spatial relationships, and associated non-spatial data. It also provides powerful tools for end-users to analyze spatial data and to make maps. Off-the-shelf GIS products for spatial data management are comprehensive and include core software that can be used “out of the box” including, add-ons to manage spatial data within a database management system, application development tools including those for the web, and technologies necessary to host maps on the internet. GIS software can usually be customized with additional extensions that provide business area specific functionality. Extensions may also be available to use TCIP dialogs and/or message file transfers to exchange data with other transit business systems, external agencies, or vendors.

Although many GIS software packages are significantly more user friendly compared to earlier versions, they cannot be used without training. Further, as with any complex software, users who are trained must make use of the software regularly or they will likely lose their ability to use it. Typically, the GIS support staff and power users receive the vendor product, whereas others receive customized applications with specifically designed and targeted functionality.

5.10.3.4 Applications

GIS Software is designed to support every kind of GIS user in all disciplines. This makes for software that has a wide variety of functions, many of which are rarely if at all used in any one industry. Thus, best practices warrant the development of specifically targeted applications for spatial data management and use. These tools could serve as extensions to core GIS software, or they could be stand-alone applications. End-user applications are best developed for use within a browser to facilitate deployment and maintenance. Targeted spatial data management tools will likely be client-server as the technology to develop these types of tools for the internet is currently limited and expensive to implement.

5.10.3.5 Hardware

Spatial data management requires the capability to manipulate enormous amounts of data typically within commercially available or in house developed client server applications. More powerful hardware is usually required for end users, GIS analysts, and servers then traditionally expected for other transit staff. Large display devices, higher memory, greater disk space capacity, and faster network speeds are typical requirements for most agency staff involved in spatial data management and use. Minimum hardware requirements are available from GIS software vendors.

A primary output for spatial data are maps. High-quality output devices for both small and large formats will be required in staff accessible areas. These include color laser printers and high-speed plotters. Although agency staff can be expected to replace consumable supplies (i.e., paper, ink), vendor support contracts will be necessary to ensure these devices remain in working order.

5.10.4 Spatial Data Management Processes

5.10.4.1 Data Creation or Collection

Creating new data and objects that did not exist before can be accomplished with a variety of methods including map digitizing, geocoded locations, file of points from lat/longs, or GPS data collection. Spatial Data can also be imported from other business systems or from other agencies. Non-spatial data can also be geoprocessed to generate a spatial component.

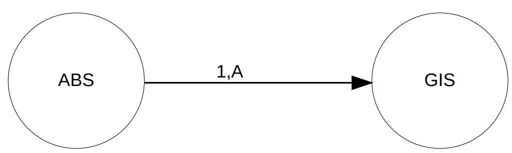


Figure 5.10.4.1.A
Spatial Data or Non-Spatial Data Collected from an Authorized Business System (ABS).

Legend:

1 - Push Geolocation Data
A - SpGeolocationData

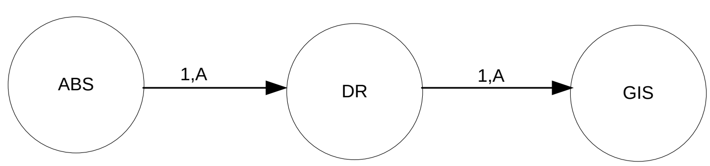


Figure 5.10.4.1.B
Spatial Data or Non-Spatial Data Collected from an Authorized Business System (ABS) to a Data Repository (DR) and Geoprocessed by the GIS

Legend:

1 - Push Geolocation Data
A - SpGeolocationData

5.10.4.2 Maintenance and Management of Spatial Data

After the collection of spatial data, it must be maintained and managed for geoprocessing and spatial queries. The emergence of the ability to store spatial data in a relational database now allows for centralized spatial and non-spatial data management and distributed data maintenance. This facilitates data consistency within the agency and allows the users access to the most current information. Data security and user permissions can be managed at the database level.

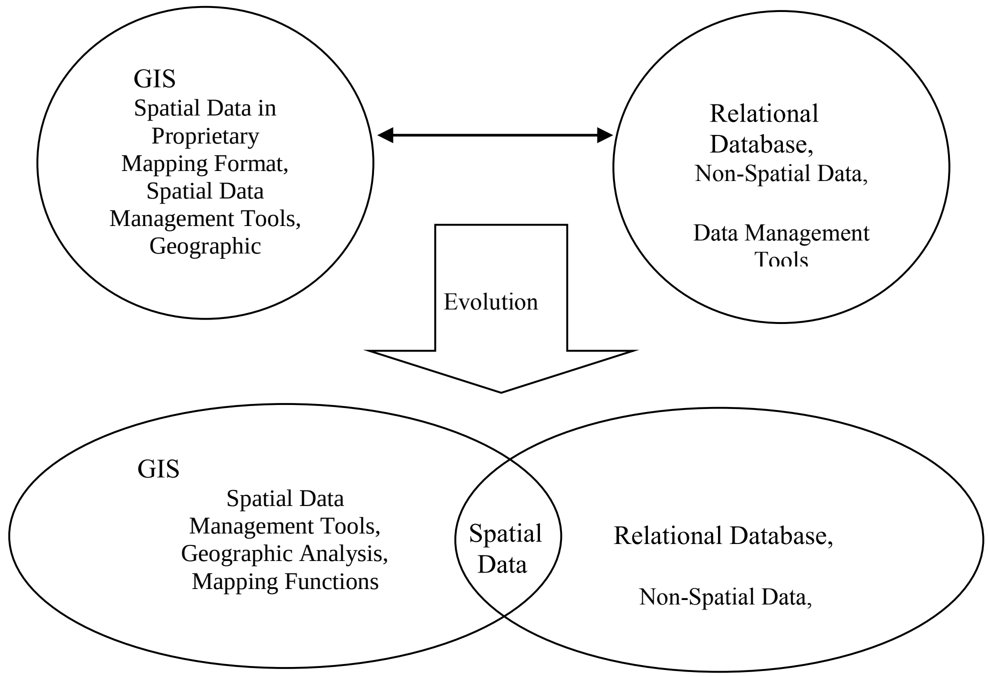


Figure 5.10.4.2.A

Spatial Data Management Evolution

There are geographic tools that sit on top of the relational database to manage spatial data and their relationships. This infrastructure does not allow TCIP to communicate directly with the relational database. A conceptual view of this relationship is shown below in Figure 5.10.4.2.B.

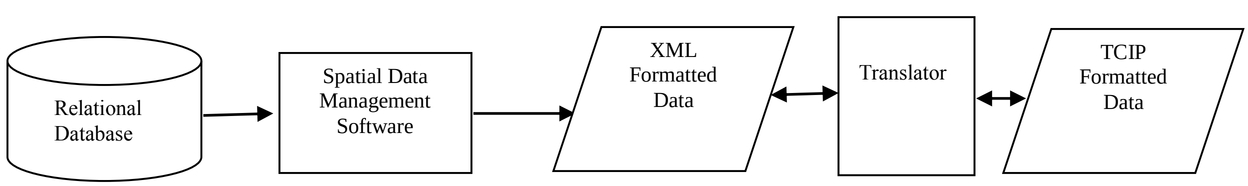


Figure 5.10.4.2.B
Message Flow for Spatial Data in an DBMS

5.10.4.3 Geoprocessing

One of the main internal functions of a GIS is geoprocessing, which includes the following:

- Spatial analysis and queries
- Buffering
- Geocoding

- Generation of driving instructions
- Generation of topology (point, line, polygon, route)
- Generation of distance calculations
- Generation of linear referencing system
- Generation of area and length
- Query for optimal route between an origin and destination
- Projection of data

Transit agencies must ensure that the quality of the data used by geoprocessing functions is adequate for the function being performed. For example, driving instructions may be incorrect (or illegal) if the quality of the street map data is inadequate.

5.10.4.4 Data Output and Distribution

Data distribution can require a data export to a specified format or direct access to the spatial database. The main recipients of transit data are as follows:

- End Users
- Business Systems, including ITS applications and Data Repositories
- External agency distribution (i.e. regional trip planning)

The outputs from the GIS vary and each has an appropriate method of data transfer for distribution.

- Paper Maps – no data output
- Map Images – TCIP Dialog can be used (e.g., Publish Map Image)
- New mapping layer – GML or agency specified mapping format
- Tabular and statistical data – TCIP or specified data format (e.g., Publish Location Conversion, Publish Geographic Zone)

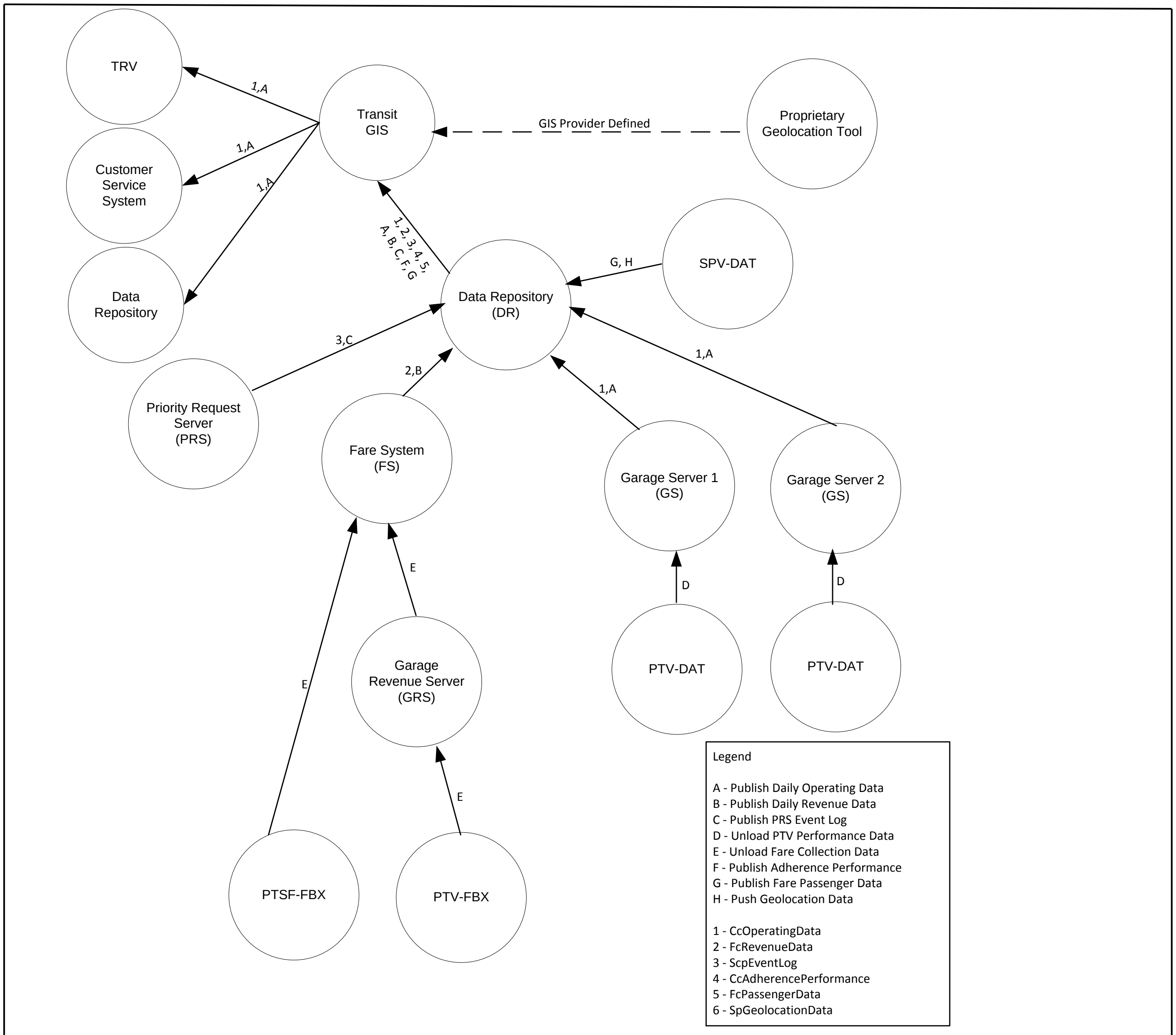


Figure 5.10.4.3.A
Importing Operating and Geolocation Data into GIS Using a Data Repository

A GIS requires data from the Scheduling system for the generation of the route geometry and for the ordered sequencing of point IDs (stops, timepoints, shapepoints) or street segment Ids. This will require data from Scheduling that may include: pattern segment, pattern, trip, block, and any other arbitrary path defined by two points such as two bus stops or walking path/directions. The extract from the scheduling software would require a "constant" pattern ID which could be used to link to the GIS. The output needs to be an ordered set of potentially any one of the following: links, shapepoints, timepoints or bus stops.

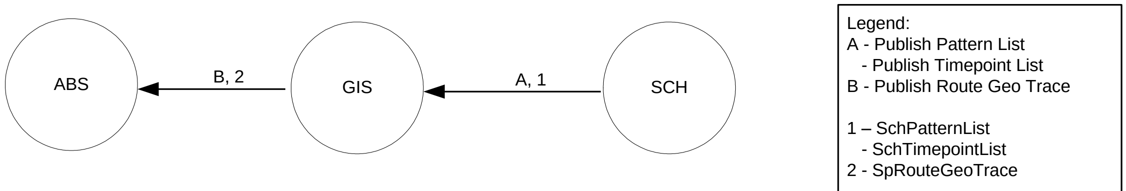


Figure 5.10.4.3.B
Authorized Business System (ABS) Obtaining Information Requiring Geoprocessing With Data from Scheduling (SCH).

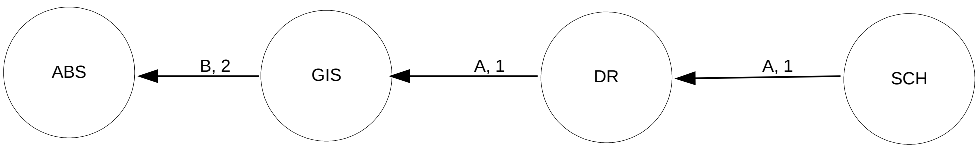


Figure 5.10.4.3.C
Business System (ABS) Obtaining Information Requiring Geoprocessing With Data from Scheduling using a Data Repository.

Legend:
A - Publish Pattern List
- Publish Timepoint List
B - Publish Route Geo Trace

1 – SchPatternList
- SchTimepointList
2 - SpRouteGeoTrace

The following diagrams illustrate the different ways in which an Authorized Business System (ABS) can subscribe to a map image.

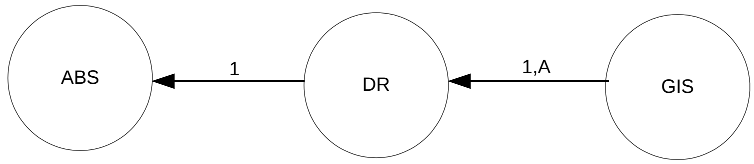


Figure 5.10.4.3.D
Authorized Business System (ABS) Subscribing to Map Images Generated in a GIS and Stored in a Data Repository.

Legend:

1 - Publish Map Image
A - SpMapImage

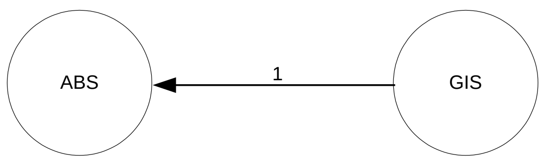


Figure 5.10.4.3.E
Authorized Business System (ABS) Subscribing to a Map Image Generated in a GIS Dynamically Using a Predetermined Map Template.

Legend:

1 - Publish Map Image

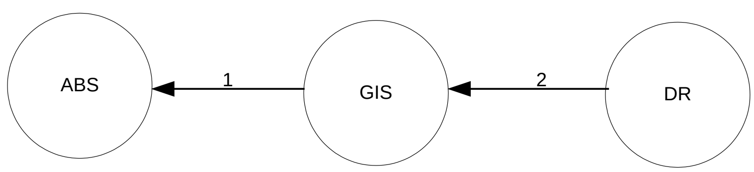


Figure 5.10.4.3.F
Business System Subscribing to a Map Image Generated in a GIS Dynamically. Using a Map Template. GIS may Utilize Non-Spatial or Spatial Information Stored in the Data Repository (DR).

Legend:

1 - Publish Map Image
2 - PublishPatternList
 - PublishTimepointList
 - Publish Shelters
 - Publish Stoppoint List
 - Publish Facilities

TCIP provides a basic mechanism to transfer feature spatial data organized into layers. The primary purpose of this capability is to provide data for mobile applications, however business systems with constrained data requirements can use this capability as well. The following diagram illustrates the distribution of basic GIS layers to business systems in a transit agency using TCIP. More complex transfers of GIS information may use GML or other standards.

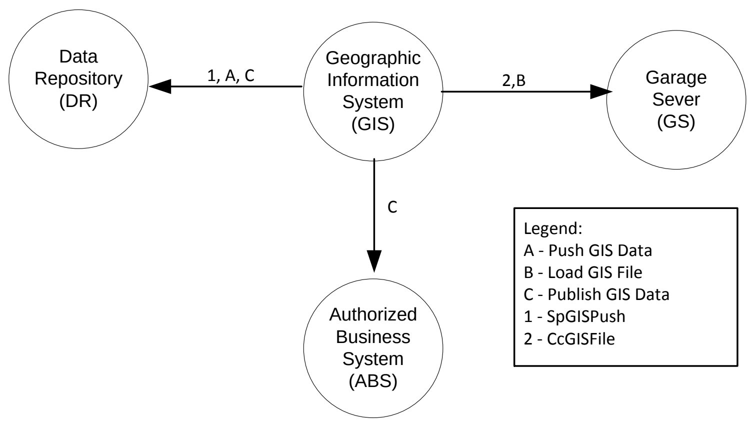


Figure 5.10.4.3.G
Distribution of Simple GIS Layers Using TCIP

01/01/2013

5.11 Transit Signal Priority (TSP) Process

5.11.1 Purpose of the Transit Signal Priority Process

As the PTV operates on its trips it may encounter intersections that are equipped to provide priority treatment to PTVs (e.g., early green, extended green, phase rotation) to allow the PTV to operate more efficiently. Equipping intersections and agreeing on acceptable strategies for TSP requires extensive coordination between transit agencies, traffic management, and traffic engineering. Although a Priority Request Generator may request priority treatment; the traffic management system is not obliged to, and may not, grant it.

5.11.2 Overview of the Transit Signal Priority Process

The Transit Signal Priority Process and related TSP business area draw heavily from dialogs, data and concepts defined in NTCIP 1211. This includes the Priority Request Generator (PRG), Priority Request Server (PRS), and all items defined in TCIP beginning with 'SCP'. NTCIP 1211 requires that all communications to/from the PRS use SNMP. However, requests from the PRG need not necessarily be in SNMP format provided that a translator converts between SNMP and the alternative format – so that all communications to/from the PRS are SNMP formatted.

Priority Request Generators may consider any or all of the following in creating a priority request (based on data available to the PRG at the time the request is generated):

- Business Rules
- Schedule Adherence Status of PTV
- Time of Day
- Equipment Type at Intersection
- Passenger Loading on PTV
- Scheduled time for PTV's current trip to arrive intersection (many agencies do not schedule to this level)

NTCIP 1211 defines four scenarios for TSP operation. In addition TCIP recognizes an additional Scenario #5. These scenarios vary according to the physical location of the Priority Request Generator, and the path by which the priority request and its precursor information flow toward the Priority Request Server.

Note that this figure includes the loading/unloading of information whereas the dialog flows later in this section only cover enroute operations. Loading dialog flows are included in section 5.3.4.1.1 and unloading dialog flows are included in section 5.3.4.4.3. Accordingly, the remainder of this section assumes that any required loading of information to the PTV was conducted during the preparation (pre-departure) stage.

TSP history data collections from both PRS and PRGs are required at the end of the operating day, or other locally specified interval. Section 5.3.4.4 discusses the closeout and collection of TSP and other operating data.

Note that network and server delays may cause priority requests to become "stale" before they can be processed. Implementing agencies should closely consider latency issues when implementing TSP. Figure 5.11.2 provides a conceptual overview of the entire TSP process, independent of scenario numbers.

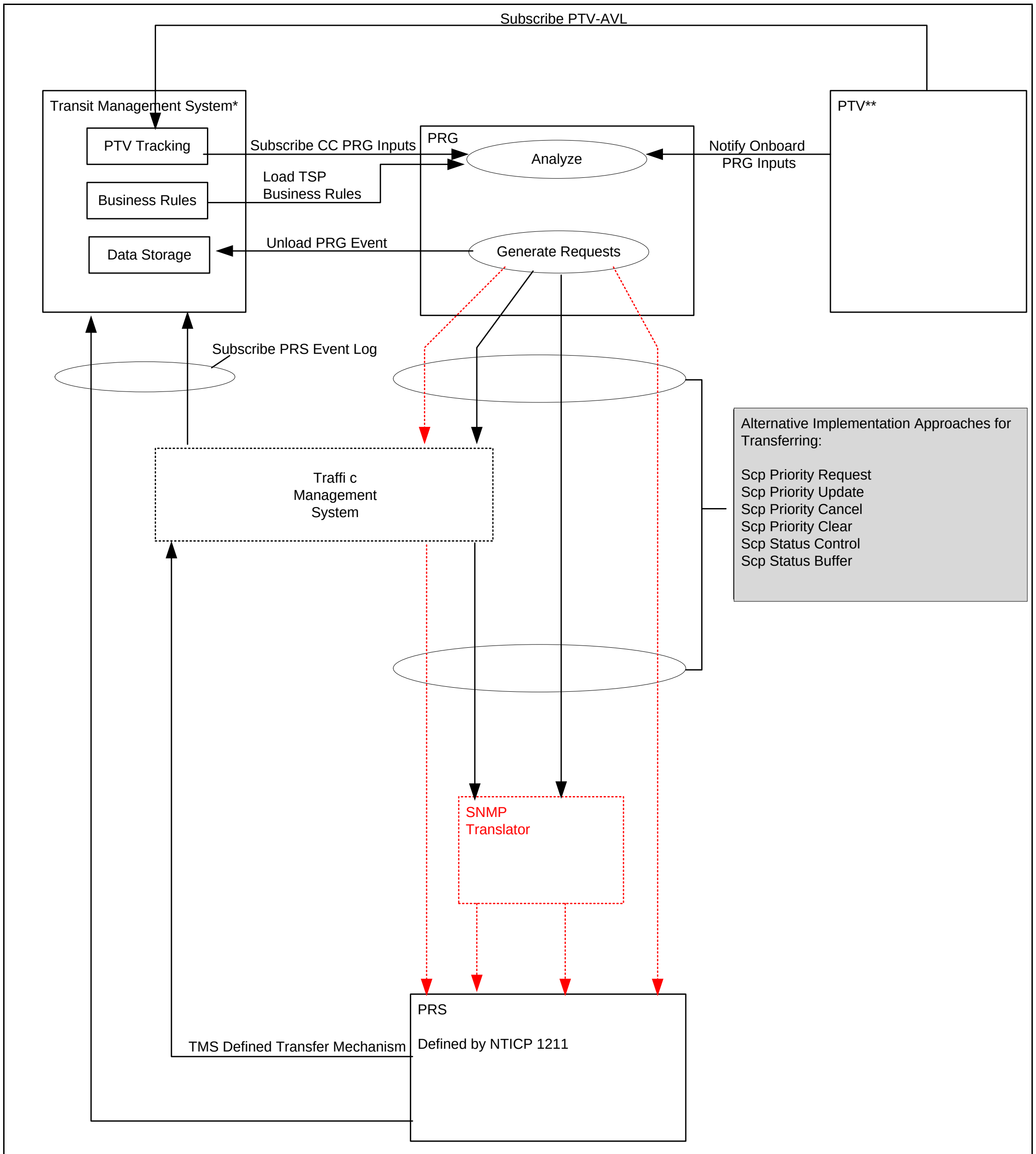
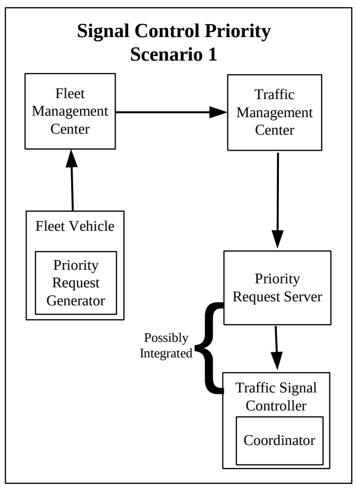
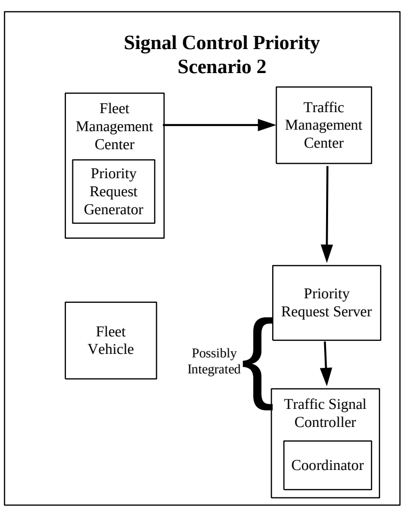


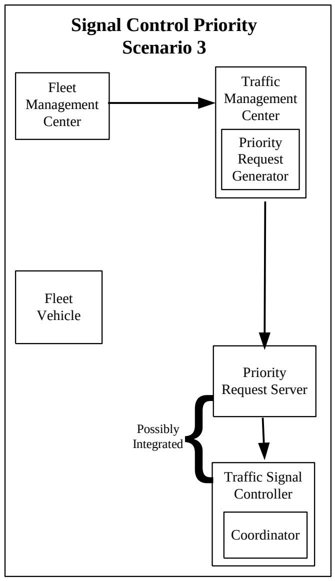
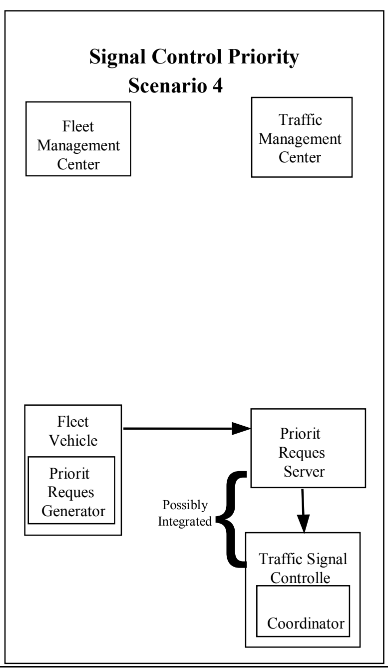
Figure 5.11.2
Scenario Independent Overview of Transit Signal Priority

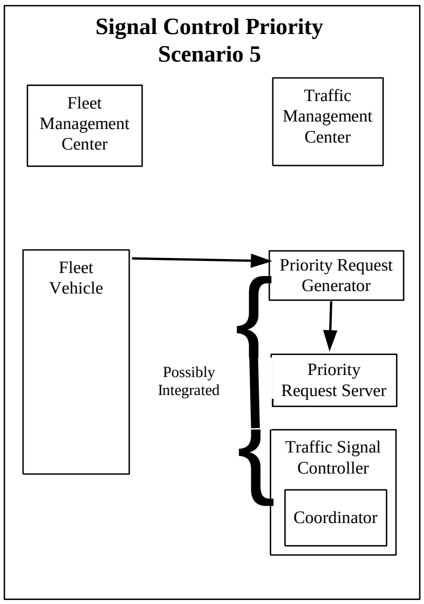
Legend:
TCIP XML or Narrowband Message
TCIP/NTCIP 1211 SNMP Message
* May be implemented by Data Repository and/or CAD/AVL.
** Contains multiple internal logical entities

5.11.3 Overview of Transit Signal Priority Scenarios

Table 5.11.3 summarizes the various TSP scenarios.

Signal Priority Scenarios		
Table 5.11.3		
Scenario	**Figure**	**Description**
1		The transit fleet vehicle carries a Priority Request Generator (PRG). Priority requests are sent through the transit fleet management center (control center) to the Traffic Management Center and onward to the Priority Request server in the field for processing. Response messages follow the reverse path. The onboard PRG is implemented by the TCIP logical entity PTV-PRI.
2		The Transit Fleet Management Center (control center) generates Priority requests which are sent through the Traffic Management Center to the Priority Request Server. Response messages follow the reverse path. The Transit Vehicle is not directly involved in the exchange.

Signal Priority Scenarios		
Table 5.11.3		
Scenario	**Figure**	**Description**
3		The Transit Fleet Management Center (control center) sends information about the transit fleet operations to the Traffic Management Center which generates priority requests to the Priority Request Server. Neither the transit vehicles nor the Transit control center are directly involved in the processing of priority requests or responses.
4		The transit fleet vehicle carries a Priority Request Generator (PRG). Priority requests are sent directly to the Priority Request server in the field. Response messages follow the reverse path. Neither the transit control center, nor the Traffic Management Center is directly involved in the processing of priority requests or responses. The onboard PRG is implemented by the TCIP logical entity PTV-PRI.

Signal Priority Scenarios		
Table 5.11.3		
Scenario	**Figure**	**Description**
5		The transit fleet vehicle conveys inputs to the request generation process to a roadside-based PRG. Neither the Transit Control Center nor the Traffic Management Center is directly involved in the processing of requests or responses.

5.11.4 Transit Signal Priority Processes by Scenario

5.11.4.1 Priority Request Scenario 1

The first priority request scenario is specified by NTCIP 1211 to include an onboard PTV Priority Request Generator (PRG). The request is generated onboard and transferred from the PTV to the CAD/AVL System, onward to the Traffic Management Center and then to the Priority Request Server.

In this scenario, PTV-PRI must have been loaded with the "Load TSP Business Rules" dialog. If PTV-PRI is in a component separate from the Vehicle Logic Unit (VLU), it receives real-time input from PTV-DAT via the Notify Onboard PRG Inputs dialog. Based on this dialog, or on information transferred within the VLU PTV-PRI detects the PTV's approach to an intersection, selects a request strategy based on the business rules, and decides to send a signal priority request to the CAD/AVL System to be forwarded via the TMS to the PRS.

Implementation of this scenario requires close attention, by the transit agency as well as the traffic management agency, to ensure that cumulative network and server latencies do not excessively delay the priority request.

The communications from PTV-PRI may use TCIP narrowband or another agency-designated narrowband encoding, or XML to communicate the CAD/AVL System. The communications between the TMC and the CAD/AVL system must be SNMP as per NTCIP 1211. Figure 5.11.4.1 depicts Scenario #1.

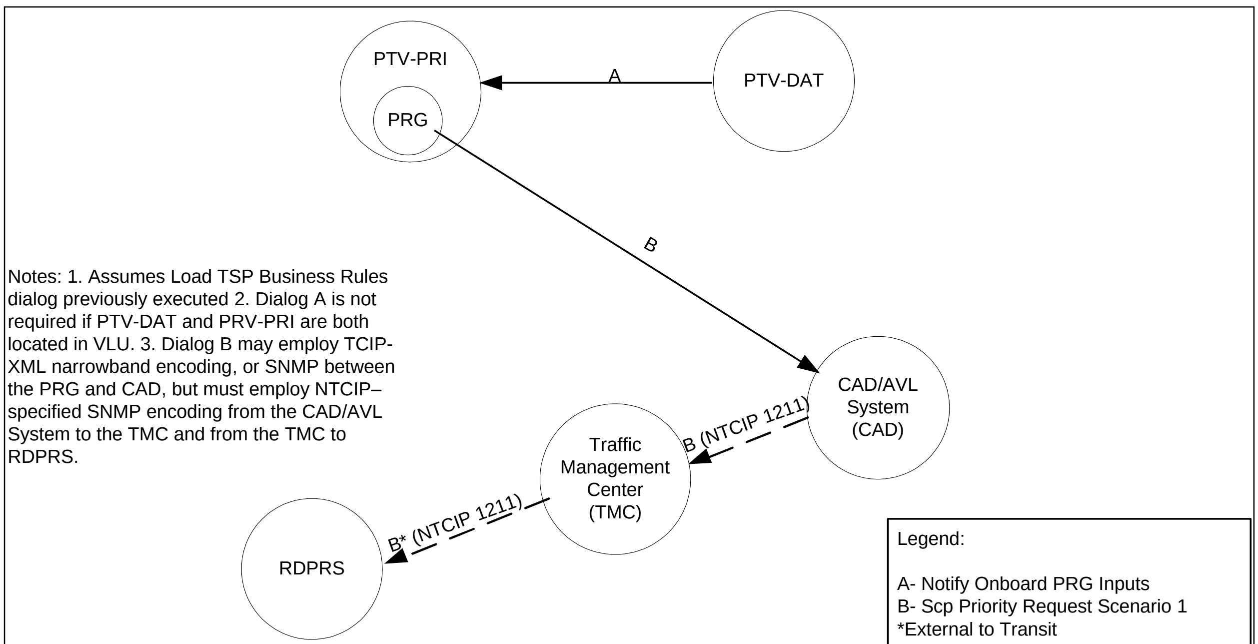


Figure 5.11.4.1
Scp Scenario 1 Dialog Flows - All SNMP

5.11.4.2 Priority Request Scenario 2

This request scenario is specified by NTCIP 1211 to include the Priority Request Generator in the "Fleet Management Center". This equates to the CAD/AVL System in the TCIP Model Architecture. The priority requests are sent to the Priority Request Server via the Traffic Management Center (TMC). The effect is that this scenario looks like scenario #1 to the TMC.

The CAD/AVL System determines the vehicle is approaching an intersection based on vehicle location determined as described in section 5.3.4.2.2. The CAD/AVL system has the business rules necessary to determine the appropriate priority request strategy and to forward that request to the TMC.

The “Scp Priority Request Scenario 2” dialog uses NTCIP 1211 SNMP-encoded messages. Figure 5.11.4.2 illustrates the dialog flows for scenario #2.

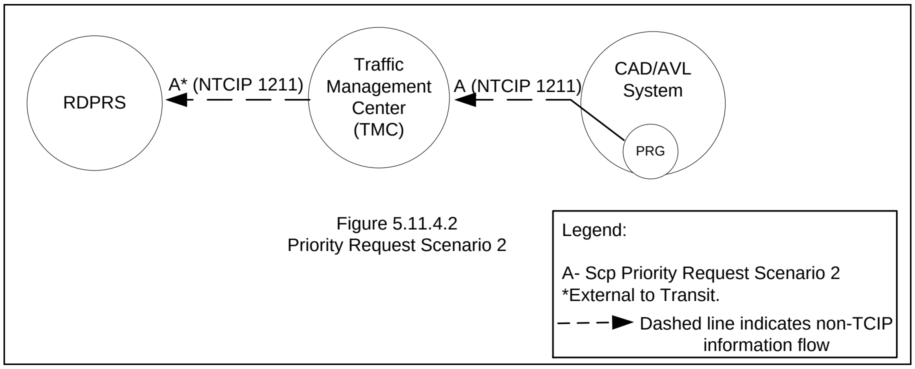


Figure 5.11.4.2
Priority Request Scenario 2

5.11.4.3 Priority Request Scenario 3

This request scenario is specified by NTICP 1211 to include the Priority Request Generator in the Traffic Management Center. Information to support the creation of a priority request is sent to the TMC by the CAD/AVL System based on location reporting from the PTV. Note that the “Publish CC PRG Inputs” dialog does not use SNMP encoding. The TMC has business rules to determine the appropriate priority request strategy and to forward that request to the PRS. Figure 5.11.4.3 illustrates the dialog flows for scenario #3.

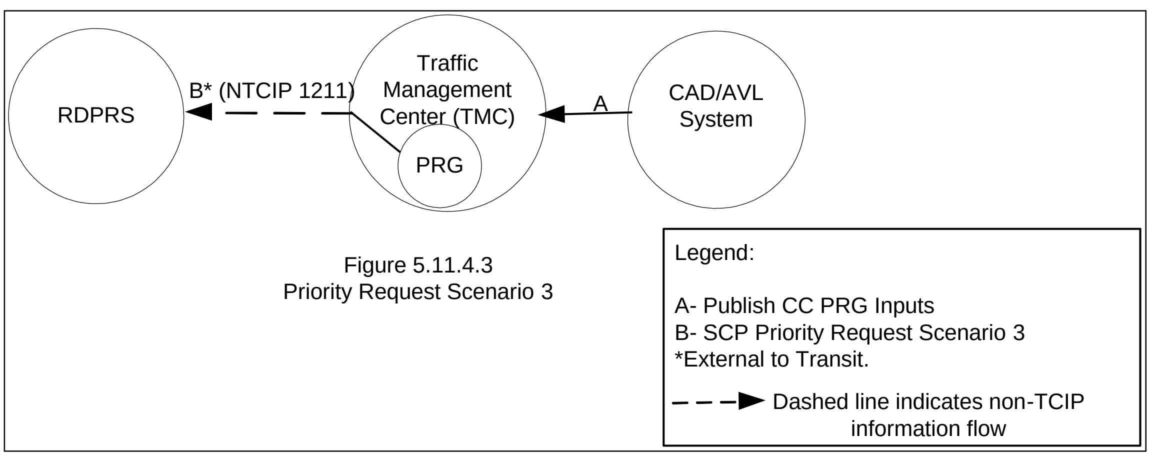


Figure 5.11.4.3
Priority Request Scenario 3

5.11.4.4 Priority Request Scenario 4

Scenario 4 is implemented with a PTV-based Priority Request Generator (PRG) that sends priority requests to the roadside Priority Request Server (PRS). PTV-PRI is loaded with business rules during the preparation for vehicle operations phase. These business rules allow the PRG within PTV-PRI to determine when to request priority.

The PRG within the PTV-PRI determines the appropriate priority request strategy to use and sends the priority request based on the business rules. Figure 5.11.4. 4 illustrates the dialog flows for Priority Request Scenario 4.

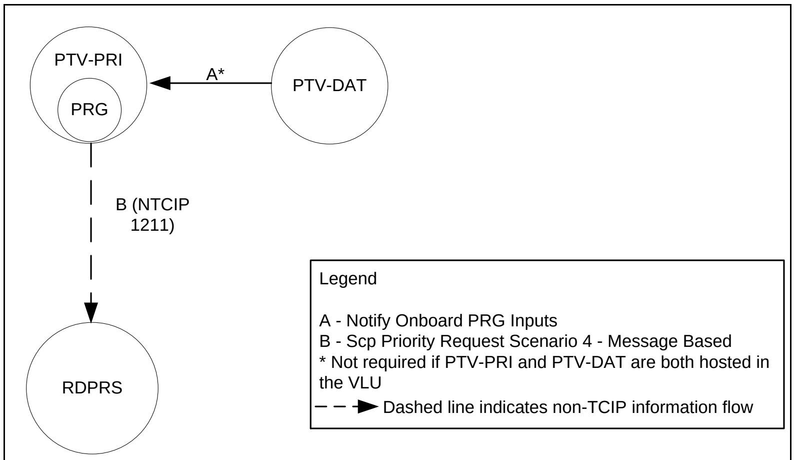


Figure 5.11.4.4
Priority Request Scenario 4

5.11.4.5 Priority Request Scenario 5

Scenario 5 was added to the NTCIP 1211 defined scenarios to accommodate implementations where the PTV communicates directly to the roadside, but does not generate priority requests onboard. In this case, PTV-PRI sends priority request precursor information to a roadside-based PRG which may generate a priority request to the PRS. The roadside PRG contains necessary business rules to generate the request. Figure 5.11.4.5 illustrates the dialog flows for Scenario 5.

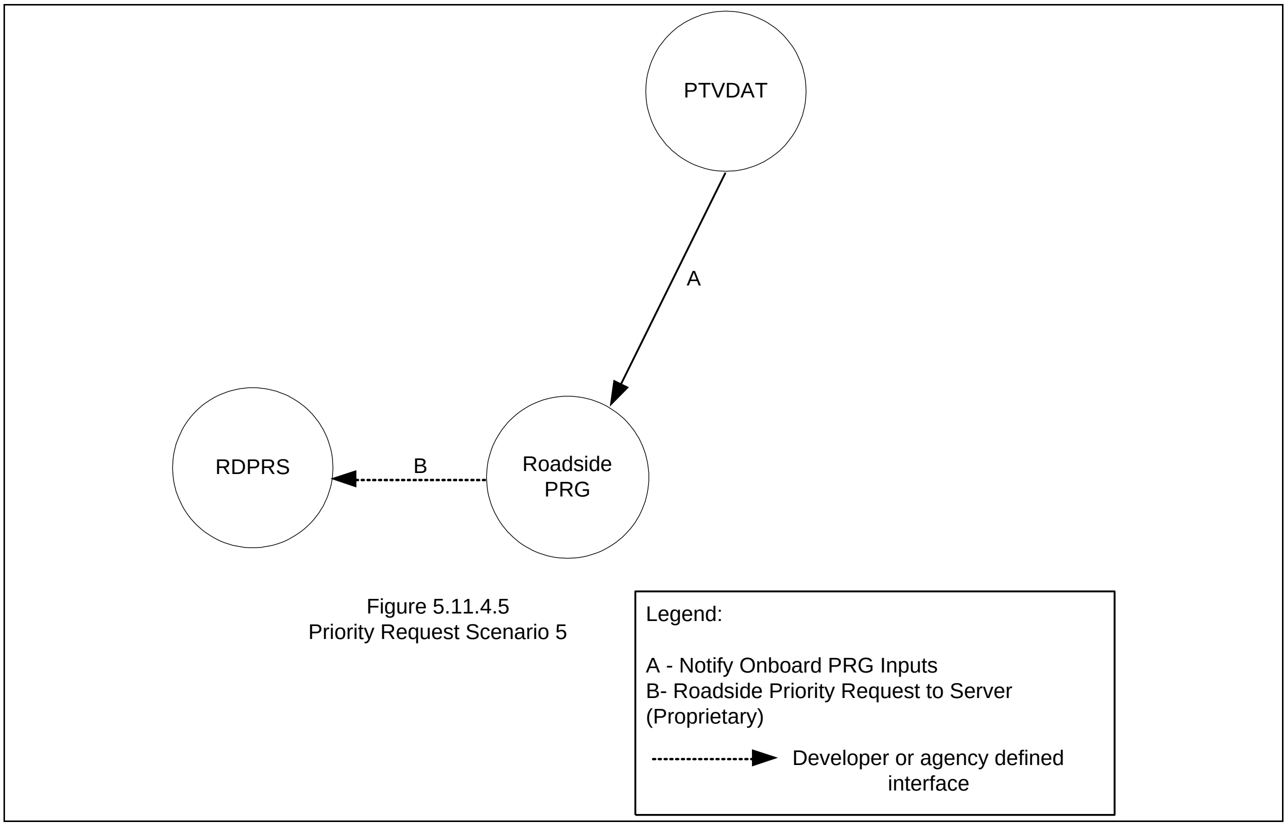


Figure 5.11.4.5
Priority Request Scenario 5

5.12 Rail Operations Process

The Rail Operations Process deals with the unique aspects of rail operations within a transit agency. Many TCIP messages and data frames contain optional fields that allow rail-specific data to be conveyed in the same messages that are used for rubber-tired service.

5.12.1 Consist Changes

One of the most significant differences between rail and rubber-tired service id that rail based PTVs have the ability to be joined into train consists, and to be split back up into separate PTVs. These changes can occur in the yard, at terminals, and in some cases in the course of a revenue trip.

TCIP provides the ability to schedule such consist changes at the trip, pattern segment, and pattern levels. This is accomplished using events. Events tied to trips, segments, or patterns specify the location for an event to take place and a series of triggers that identify activities that should take place as a result of the event's detection by the vehicle.

Scheduled consist changes may be conveyed in Block, Run and Route Schedule messages. Entries in these lists of train consist changes are linked to the events by the triggers specified in those events.

Changes to the scheduled consist changes may be conveyed to the vehicle by the Load Schedule dialog(SchEventChangeFile Message).

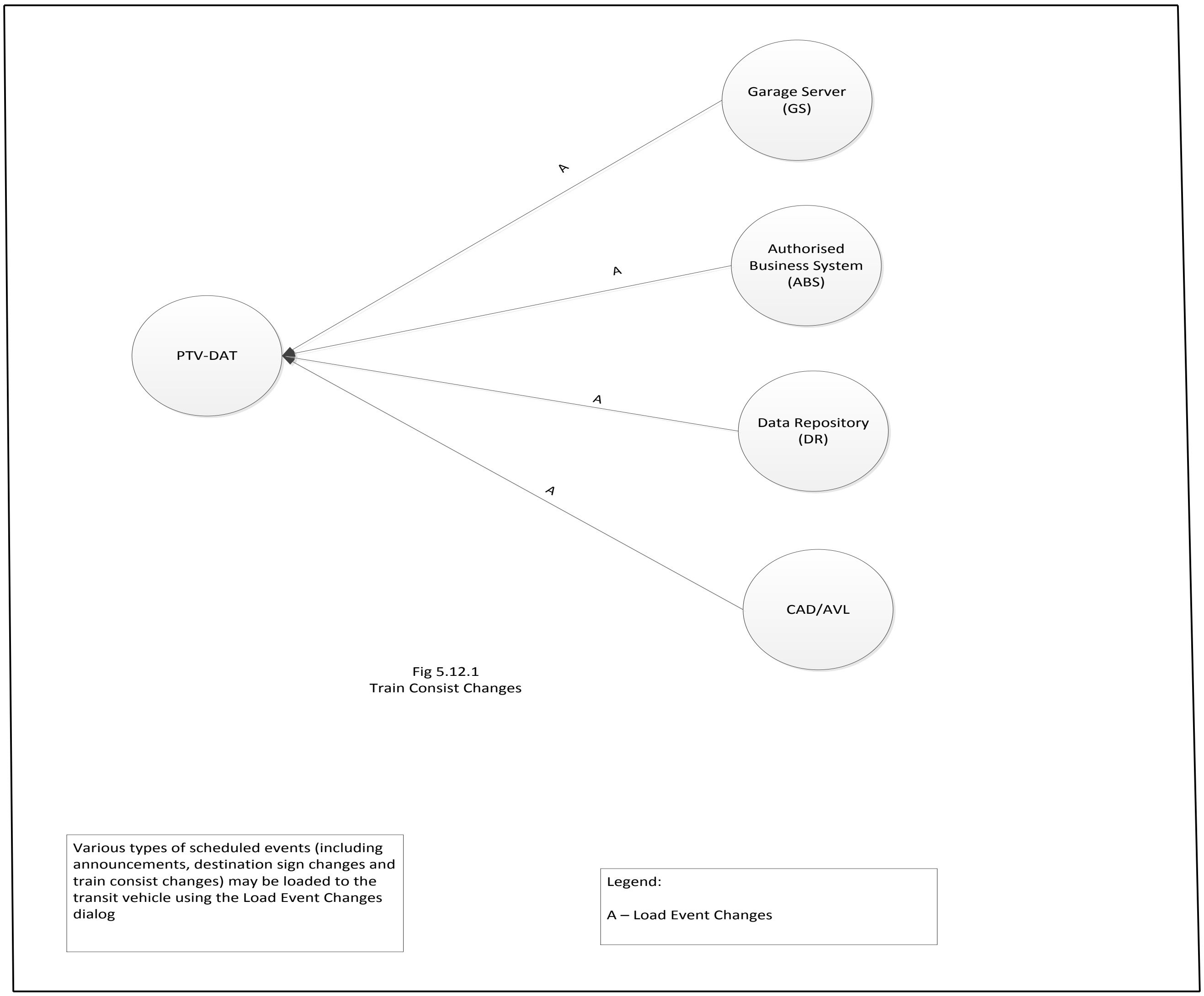


Fig 5.12.1
Train Consist Changes

5.12.2 Train Initialization & Termination

Once a train is formed with the necessary car consist, and is ready to be operated on the agency's rail network, its train ID may need to be entered manually so that the train can be uniquely identified on the network. Some systems use thumbwheels to identify the train, or an operator logon.

Similarly when the train has completed its work, its identity as a train needs to be ended and a similar process may be used to dissociate the cars in the train from the train id.

Both initialization and termination can occur at any location on the rail network. In the case of a consist change, a deadhead train may enter the mainline from the yard, then meet up with a train in service, and connect to the in service train at a designated location on the network. In such a case the deadhead train would terminate and the revenue train would have a consist change.

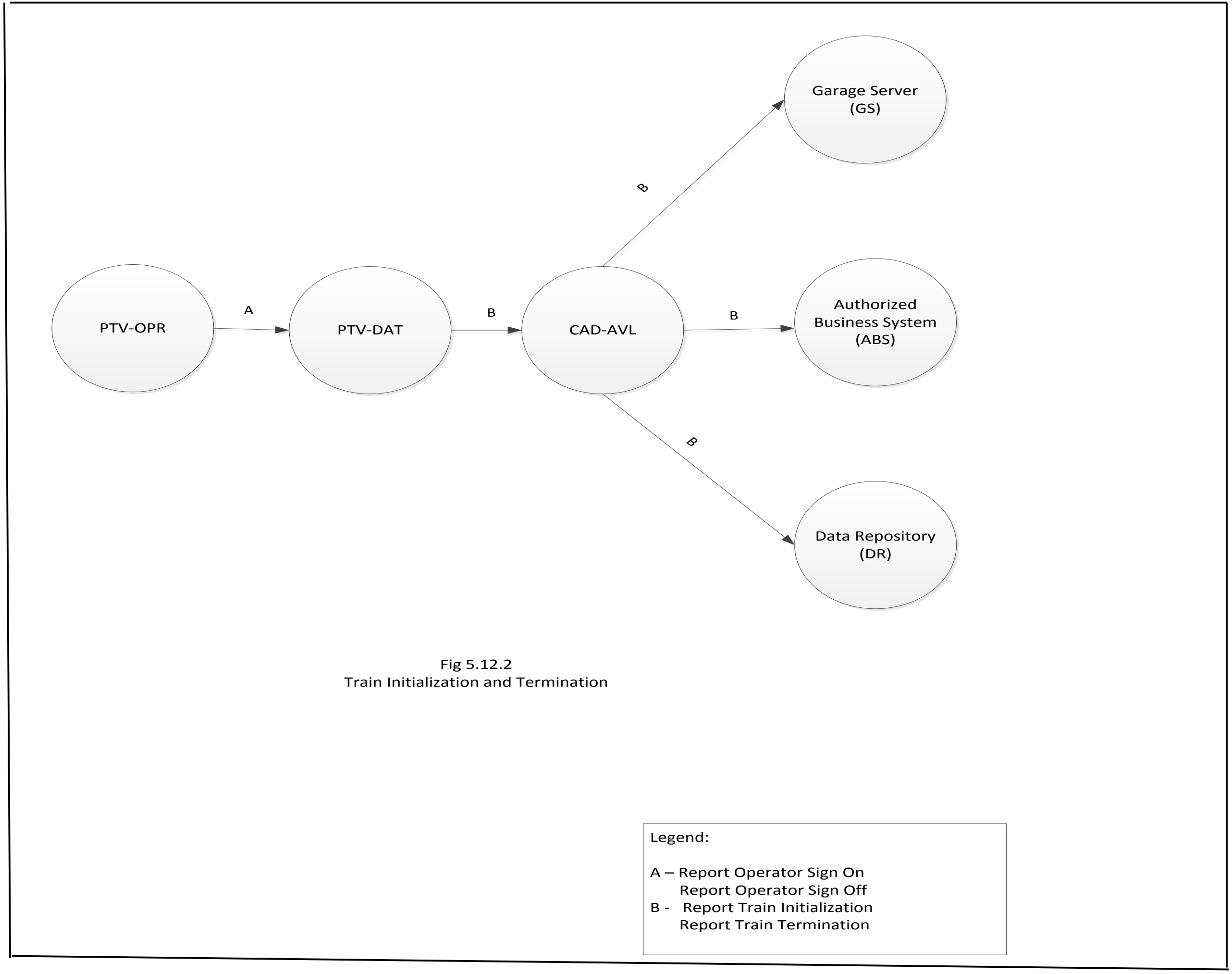


Fig 5.12.2
Train Initialization and Termination

5.12.3 Train Detection

Rail systems sometimes employ fixed location train detectors along the rail network. These detectors may be used to verify the train's consist, notify central of the train's passage by a point, or notify central of defects found on the train.

The simplest type of detection is a track circuit. Such circuits report the presence of a train when there is an electrical shunt between the running rails. Track circuits generally do not recognize the train's identity, but only recognize the presence or absence of shunting. In some cases track circuits will report a rail discontinuity (e.g. broken rail) as a train presence. Since the signal system will not normally authorize a train into an occupied section of track, this provides a rudimentary form of broken rail detection. Since track circuits are integrated with the signal and/or SCADA system on a real-time basis, TCIP does not provide messaging to report track circuit state transitions.

More complex train detectors may include sensors to 'read' the identity of the cars in a train consist, or event the train identification itself. Some of these detectors have sensors that monitor the health of passing trains using infrared, acoustic or other technologies. Items to be monitored include flat wheels, overheated bearings, and equipment that cannot fit through a tunnel. TCIP provides a dialog to allow such sensors to report their findings to the central office.

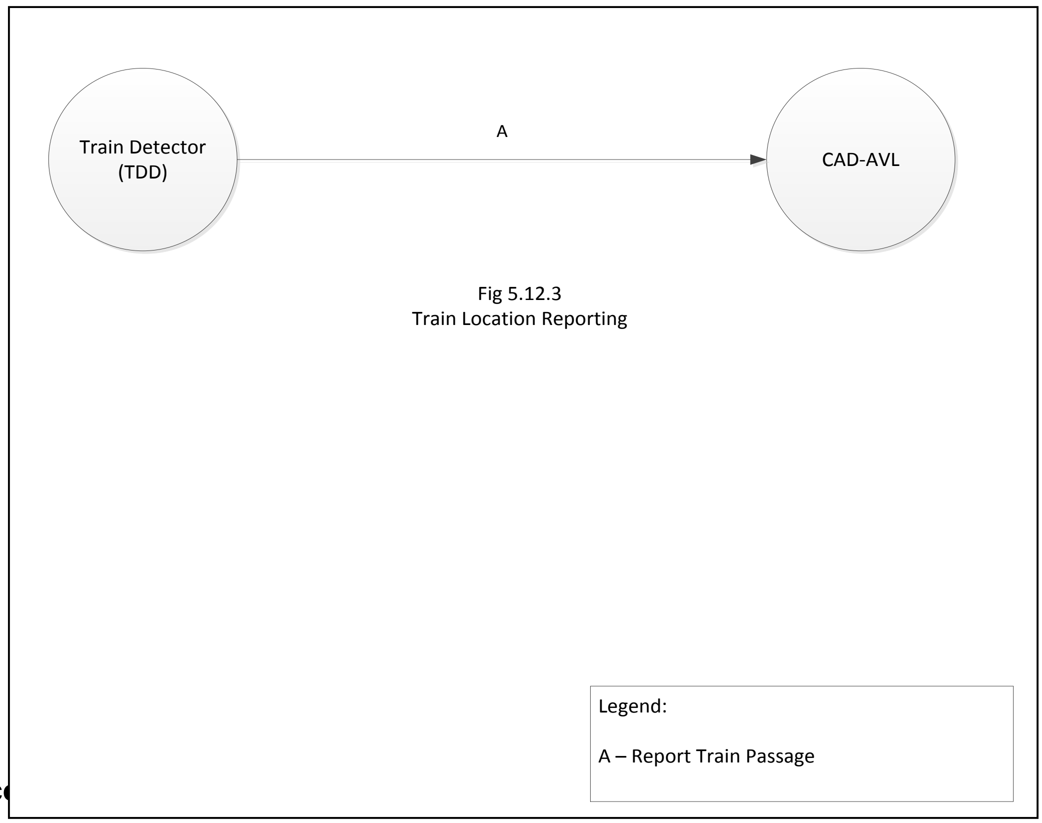


Fig 5.12.3
Train Location Reporting

6 TCIP

6.1 Enc

TCIP supports two types of message encoding for communications Extensible Markup Language (XML), and narrowband.

XML encoding requirements are provided by the W3C requirements for XML Schemas and XML instances (references N-I, N-2, N-3) and the TCIP XML Schema (Annex E). Additional requirements for each message specified in the remarks sections of the message, frame and data element definitions (and copied into the documentation areas of the XML Schema) also apply.

Narrowband encoding schemes may be specified by the individual agency. Possible schemes to use are ASN.1 Packed Encoding rules, "Zipped" or compressed XML encoded documents, or TCIP Narrowband encoding as defined in Annex I. Narrowband encoded messages (using any scheme) shall adhere to TCIP requirements regarding required versus optional fields in messages and data frames, and the requirements specified in the usage sections of the message, frame, and data element definitions.

7. TCIP Dialog Patterns

As discussed in Section 3.4, TCIP dialogs define message sequences exchanged between transit business systems and/or components to achieve a specific information transfer.

This section specifies dialog patterns. Dialog patterns generically define a message exchange sequence without regard to the specific information content to be exchanged. These patterns can then be revised in different dialogs with different messages to exchange different information, using the same rules. For example, a subscription-query a can be used to query for and obtain stoppoint information, or operator assignment information using the Publish Stoppoint List and Publish Operator Assignments dialogs. The dialog definitions in Annex D use the patterns defined in this section as part of the specification of each dialog. These dialog definitions specify the messages to be used with the pattern, as well as any assumptions, processing requirements, pre or post conditions etc. associated with the specific dialog.

The dialog patterns defined in this section include:

- Publication Pattern (Query, Periodic and Event)
- Command Response Pattern
- Report Pattern
- Silent Alarm Pattern
- Load Pattern
- Unload Pattern
- Voice Radio Call Patterns (Operator-Initiated, and Dispatch Initiated)
- Signal Control & Prioritization Pattern
- Blind Notification Pattern
- Push Pattern
- Traveler Service Request Pattern

7.1 Publication Pattern

A Publication dialog is a three (3) message dialog pattern. The pattern defines the conversation between a subscriber and a publisher. The publisher is the owner/producer/provider of information required by the subscriber who requires the information. The three messages are a subscription request, a subscription response, and an error notice. The subscription request message and the subscription response message are unique to the individual dialog, however both contain a CPTSubscriptionHeader data frame. The error message is common to all Publication dialogs and is defined as CptSubErrorNotice. If the publisher sends a CptSubErrorNotice at any time, the dialog shall immediately end with no further data exchanges. **Receipt of a CptSubErrorNotice, or a failure to communicate, or to receive an expected response shall be recovered by a developer specified process within the component (subscriber or publisher).**

The subscription request message name has the form AaaXxxSub where:

- Aaa indicates the business area (e.g., Cpt, Sch) where the message is defined.
- Xxx indicates the name of the subscription (e.g., RouteList).
- Sub indicates that the message is a subscription request message.

The subscription response message name has the form AaaXxx where:

- Aaa indicates the business area (e.g., Cpt, Sch) where the message is defined.
- Xxx indicates the name of the subscription (e.g., RouteList).

The CPTSubscriptionHeader contains a data element defined as CPT-SubscriptionType (see figure 7.1.A) which allows a Publication dialog to assume 3 forms:

- The first form is a basic query. The subscriber requests the information and the publisher provides it on a one-time basis.
- The second form is the periodic subscription. The subscriber requests the information and the publisher provides it initially and on a recurring basis at intervals specified in the subscription request.
- The third form is the event-driven subscription. The subscriber requests the information and the publisher provides it initially and provides new versions of the information based on events that change the information.

The CPT-SubscriptionType (see Figure 7.1.A) also provides the capability for the subscriber to cancel a periodic or event-driven subscription. In the event that the publisher receives a subscription request message (AaaXxxSub) with a subscription header data frame indicating that the subscription is to be cancelled, the publisher shall cease sending the matching AaaXxx messages for the indicated subscription(s). Note that the cancellation message may request the cancellation of a single dialog only with a matching subscription number, or all dialogs for that subscriber of type AaaXxx.

```
CPT-SubscriptionType ::=   ENUMERATED
                    Query
                    Periodic (2),
                    Event (3),
                    Cancel (99),
                    CancelAll (100),
                    --        4-98
                    --        101-255
                    }
```

Figure 7.1.A
ASN.1 Definition of CPT-SubscriptionType Data Element

The CPTSubscriptionHeader provides identifiers for the subscriber and the publisher in the fields subscriberIdentifier and hostIdentifier. These fields are of the type CPT-ApplicationID, which is an agency-assigned unique identifier for computer applications within the agency's architecture. Agencies will need to coordinate with other agencies with whom they share data to ensure uniqueness of these identifiers (e.g., within a metropolitan area).

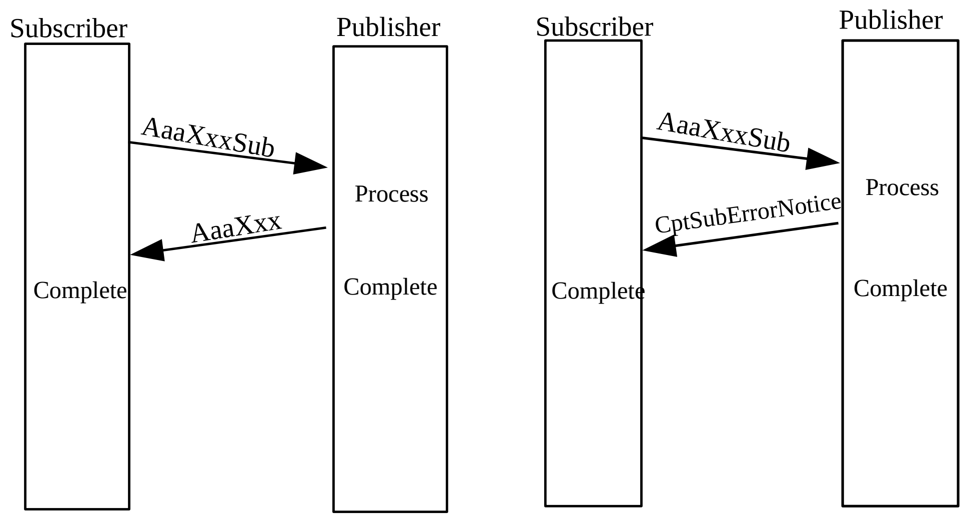
The CPTSubscriptionHeader provides an identifier for each subscription of type CPT-RequestIdentifier. This identifier allows multiple subscriptions between a subscriber-publisher pair to exist simultaneously and operate independently. Figure 7.1.B depicts the CPTSubscriptionHeader.

```
CPTSubscriptionHeade ::=   SEQUENCE
requestedType          CPT-SubscriptionType,
expirationDat          CPT-DeactivationDate, -- for the subscription
expirationTime         CPT-DeactivationTime, -- for the subscription
reportInterval         CPT-TimeInterval        OPTIONAL,
requestIdentifier      CPT-RequestIdentifier,
subscriberIdentifier   CPT-ApplicationID,
publisherIdentifie     CPT-ApplicationID
applicability          CPTFileApplicabilit     OPTIONAL
}
```

Figure 7.1.B
ASN.1 Definition of CPTSubcriptionHeader Data Frame

In the event that a periodic, or event driven subscription request arrives at a publisher and the expiration time for the request has already passed, the publisher shall immediately downgrade the request to a basic query, provide a single response to the subscriber (assuming the request is valid) and end the dialog. In the event that the expired request is also invalid for other reasons, the publisher shall respond with a CptSubError notice.

Figures 7.1.C through 7.1.E depict the variations of the Publication pattern.



Normal Execution of Query Publication Dialog

Error Response to Query Publication Dialog

Figure 7.1.C
Query Version of the Publication Dialog Pattern

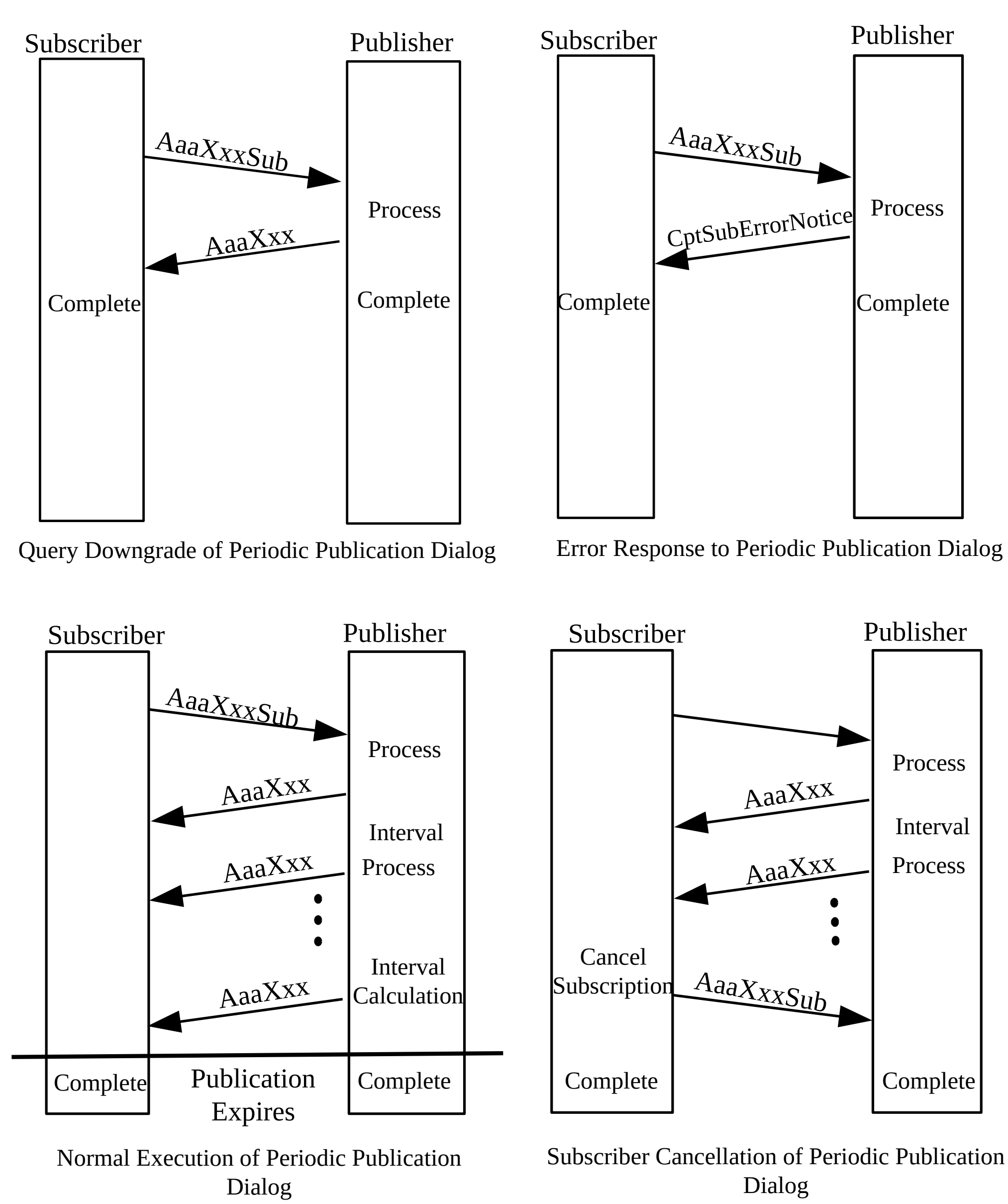


Figure 7.1.D
Periodic Version of the Publication Dialog Pattern

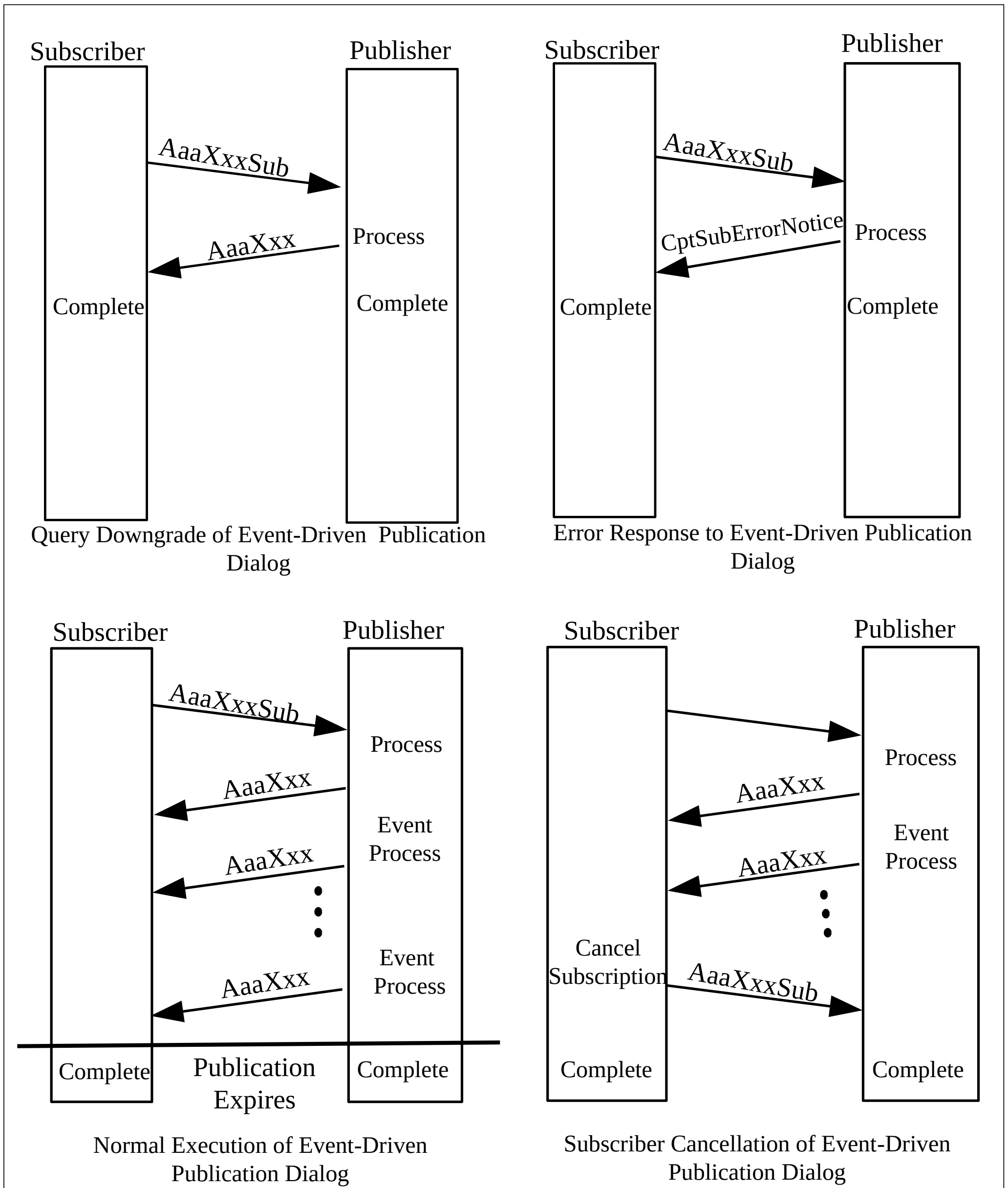


Figure 7.1.E
Event Driven Version of the Publication Dialog Pattern

Although the subscriber requests the form of the subscription in CPTSubscriptionHeader, the publisher may change (downgrade) the request in the response. The allowed changes by the publisher are:

- Periodic request changed to Query response.
- Event-Driven Request changed to Query Response.
- Periodic Request changed to a longer reporting interval. For example, if a subscriber requested information updates every second to the bus stop inventory the provider might change it to daily or weekly.
- Subscription expiration date/time changed to an earlier date/time. For example, if the subscriber requested a 100 year subscription, the provider might limit the subscription to six months.

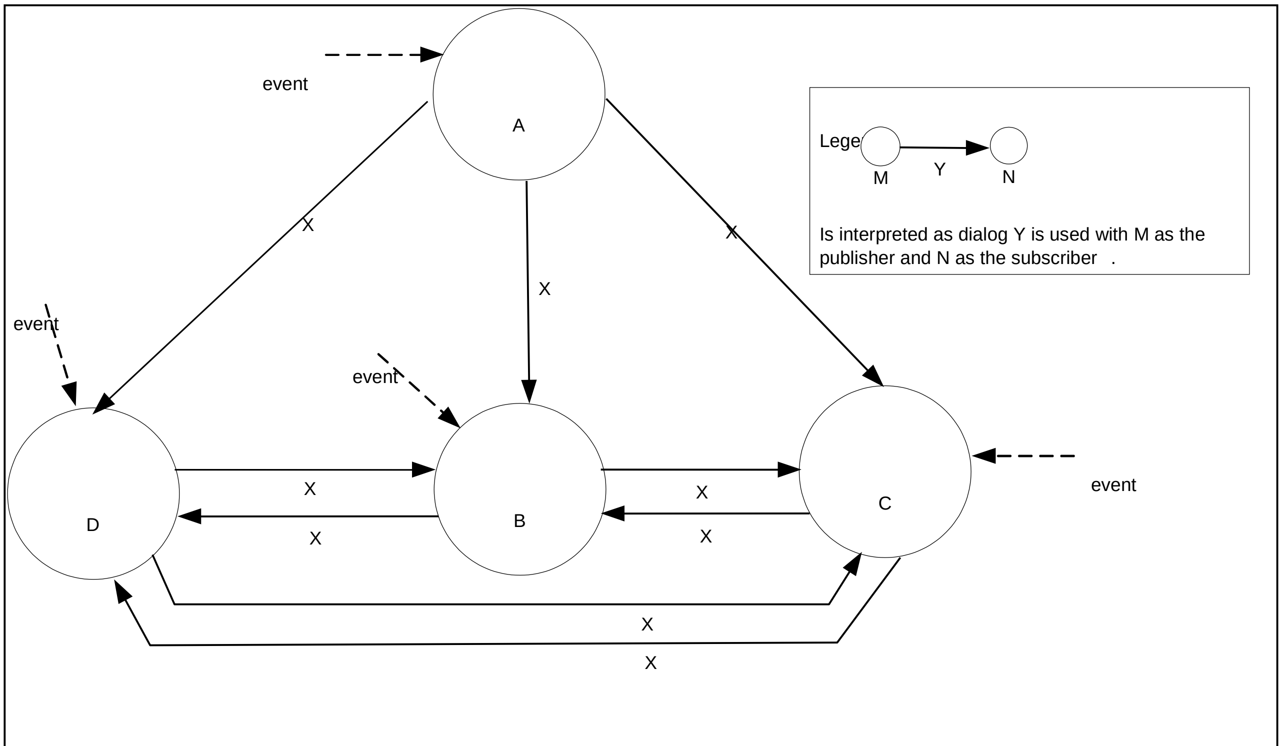
The publisher shall notify the subscriber of the downgrade by updating the fields from the subscription requests that are replicated in the response message.

In addition to the request information provided in CPTSubscriptionHeader, the subscription request generally contains additional specifications on the data to be provided that is dialog-specific. There may be dialog-specific limitations on the data in the response. For example, if the planned schedule is requested for the next year, but has only been defined for the next six months, the publisher might have a dialog specific option to reduce the scope to the data that actually exists.

A procuring agency may limit the allowable downgrades for any specific Publication dialog. For example, if an agency is procuring a passenger information system that subscribes to bus locations on a periodic basis from a CAD/AVL System, the agency may require the CAD/AVL system provider to service the periodic subscription, and not downgrade it to a query.

Some Publication dialogs are used to exchange large data sets usually expressed as lists that may have small, but frequent changes. Such dialogs may implement query or event-based “row versioning”. In query-based row versioning, the subscriber shall send a query with a field indicating that only data that has changes since a specified date & time should be included in the response from the publisher. In event-based row versioning, the initial query shall cause the publisher to send the entire dataset, however updates to the dataset shall trigger the publisher to send event messages to the subscriber indicating that the message contains only updates since a specified date & time. In either case the message to the subscriber may contain a list of deleted items as well as a list of new or updated items in the list.

In some cases, business systems act as both the publisher and subscriber of the same event-based information. When this occurs, receipt of an event-based update as a subscriber, may cause a business system to send an event update as a publisher. Caution should be exercised when establishing such arrangements. These arrangements have the potential to create circulating messages or event explosions. If two business systems subscribe to the same event information from each other, receipt of an event notice by a subscriber shall not result in the receiver publishing the same event information back to its source. This requirement is necessary, but not sufficient, to prevent circulating messages or event explosions. Consider the case of Figure 7.1.F. An event occurring at A will result in 3 circulating messages among B,C and D. An event occurring at B,C, or D will result in a pair of circulating messages among B, C and D. As more and more events occur more and more circulating messages are created until the system fails.



Figur 7.1.F
Distribution of Event Notifications Using Publication Dialogs with a Potential for Event Explosions

Prudent planning of the agency ITS architecture can preclude the problems described above. Consider the case where the agency designates a single business system as the 'owner' of the information. The owner becomes the sole source for downstream distribution of the information. In Figure 7.1.G, business system A is designated the 'owner'. All events occurring in business systems B,C, or D result in updates to business system A, which generates updates to the remaining two business systems but not back to its source. In this scenario, no event explosion is possible.

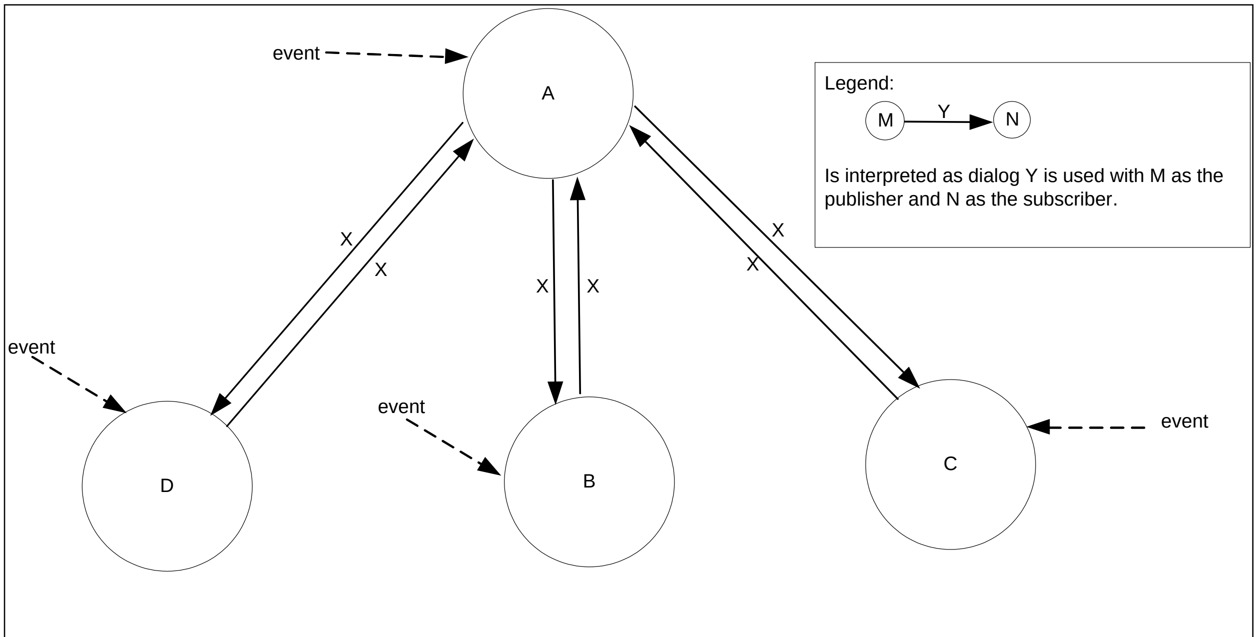


Figure 7.1.G
Distribution of Event Notifications Using Publication Dialogs and a Designated Owner

Publication Dialog Definitions

Publication dialogs derived from the Publication Dialog Pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the word "Subscribe"
2. TCIP business area
3. Dialog Purpose – Defines the purpose of the Publication dialog. Generally this is to convey a particular type of information from a publisher to a subscriber.
4. Subscription Types – Subscriptions may be query, event driven or periodic. Some Publication dialogs support more than one subscription type.
5. Row Updates Supported – If row updates are supported specifies the type(s) of rows (data frames) in the response message that are supported.
6. Subscription Request and Response Messages
7. Dialog Specific Assumptions and Notes
8. Associated file Transfer – Indicates that there is a file transfer that may be used in lieu of the subscription by specifying the name of the response message or "none" indicating that there is no associated file transfer.
9. Events – If the Publication dialog supports event- driven, defines the type(s) of events that trigger updates.

7.2 Command-Response Pattern

A Command Response dialog is a two (2) message pattern. The pattern defines the conversation between a controlling entity (controller) and a controlled entity (device). The device performs actions or provides services in response to commands from the controller. The two messages are a command message and a response message. Command Response dialogs correlate commands and responses using the command identifier.

The controller shall initiate all command response dialogs by sending a command message. The usual case is that the device attempts to perform the command and replies with a response message indicating whether or not the command was executed successfully. A command identifier number of type CPT-CommandID assigned by the controller and conveyed to the device in the command message shall be returned to the controller in the response message from the device allowing the controller to match the response with the previously issued command.

Some dialogs specify the use of the Command Response dialog pattern with one of two variations

- In the first variation the dialog specifies that the device only sends a response if a designated field in the command message asks for a specific response. Fields of the type are generally of type CPT-Boolean and have names like verifyCommand, or responseRequired.

- In the second variation, the dialog specifies that the device never sends a response, in this case a corresponding response message will not be specified for that dialog.

Some dialogs may specify that the command must be executed within a specified time frame or abandoned. The time frames may be specified in the dialog definition or in the command message. Such dialogs shall specify a response message containing a data element of type CPT-ErrorCode which can be used to indicate that the command was not executed due to a timeout.

Figure 7.2 depicts the execution of the Command Response dialog pattern.

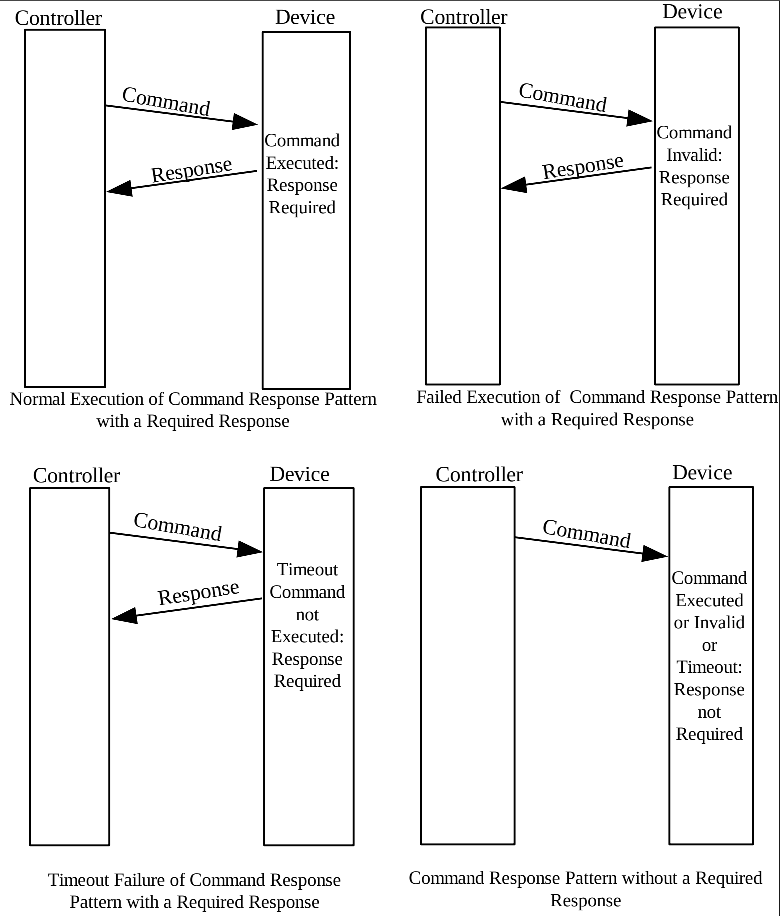


Figure 7.2
Command Response Dialog Pattern

<u>Command Response Dialog Definitions</u>

Command-response dialogs derived from the Command-Response Dialog Pattern shall each specify:

1. <u>Dialog Name</u>- A unique name for the dialog beginning with the word "Command"
2. <u>TCIP business area</u>
3. <u>Dialog Purpose</u> – Defines the purpose of the command response dialog
4. <u>Response Type</u> – One of "No Response Required", "Command Elicited" (indicates a response is required only if requested in the command message), or "Response Required"
5. <u>Command and Response Messages</u>
6. <u>Dialog Specific Assumptions and Notes</u>

7.3 Report Pattern

A Report Dialog is a two (2) message pattern. The pattern defines the conversation between a reporter entity, (such as a field, or mobile based employee computer), and a receiving entity such as a supervisor hand held device, dispatch system, or Maintenance Management System. Report dialogs correlate reports and report acknowledgements using the reporting time.

The reporter entity shall generate the report based on actual conditions, or human input, not based on a query or subscription request from the receiving entity. Because reports are generated on an ad-hoc basis and from a variety of sources, the reports shall be given unique identifiers by combining their source identifier with the date-time of the report.

The report pattern is not intended to broadcast notifications to a wide distribution list, and the receiver shall acknowledge receipt of the report. Developer/Agency defined recovery procedures shall be executed by the reporter if the acknowledgement is not received by the reporter. Such procedures may include retrying the transmission, generating an alarm, notifying the operator (if applicable), or aborting the dialog.

Figure 7.3 depicts the execution of the Report dialog pattern.

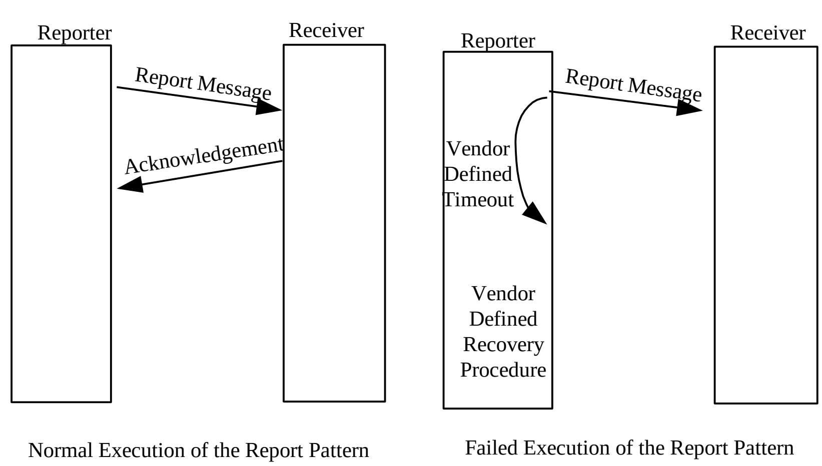


Figure 7.3
Report Dialog Pattern

<u>Report Dialog Definitions</u>

Report dialogs derived from the Report Dialog Pattern shall each specify:

1. <u>Dialog Name</u> – A unique name for the dialog beginning with the word "Report"
2. <u>TCIP business area</u>
3. <u>Dialog Purpose</u> – Defines the purpose of the report dialog
4. <u>Report and Acknowledgement Messages</u>
5. <u>Dialog Specific Assumptions and Notes</u>

7.4 Silent Alarm Pattern

The Silent Alarm pattern is a unique pattern specifically intended for use with transit vehicles with a silent alarm feature. The dialog shall be initiated by the vehicle computer when the alarm is triggered, and the vehicle computer shall send a ImSilentAlarm message to the dispatch computer system. The vehicle computer may perform other agency/developer defined actions as a result of the trigger.

After an agency/developer defined notification and acknowledgment between the dispatch computer and the dispatcher, the dispatch computer shall provide an acknowledgment (ImSilentAlarmAck) to the vehicle. The dispatcher and/or the dispatch computer may initiate other developer/agency defined actions as a result of the notifications. For example, this may include changing the location reporting update rate for the vehicle. Upon receipt of the acknowledgement, the vehicle computer shall use a developer/agency defined covert signal to notify the driver that the acknowledgement has been received.

Optionally, the operator may use the Mobile Data Terminal to cause an ImAlarmCancel message to the dispatch computer to notify the dispatcher of a request to terminate the alarm condition, however this message shall not itself cause the alarm condition to be reset or closed, nor shall it end the SilentAlarm Dialog.

The dialog shall end when the dispatcher determines that the alarm was false or that the incident requiring the alarm has concluded, and enters this into the dispatch computer. The dispatch computer shall send a closing message (ImSilentAlarmClose) to the vehicle computer. The dispatch computer may reset other agency/developer defined states related to the alarm based on the dispatcher's decision to close the alarm.

The vehicle computer upon receipt of the closing message, shall reset any developer/agency defined states (e.g., Mobile Data Terminal icon changes) and shall close out the alarm.

Figure 7.4 depicts the execution of the Silent Alarm dialog pattern.

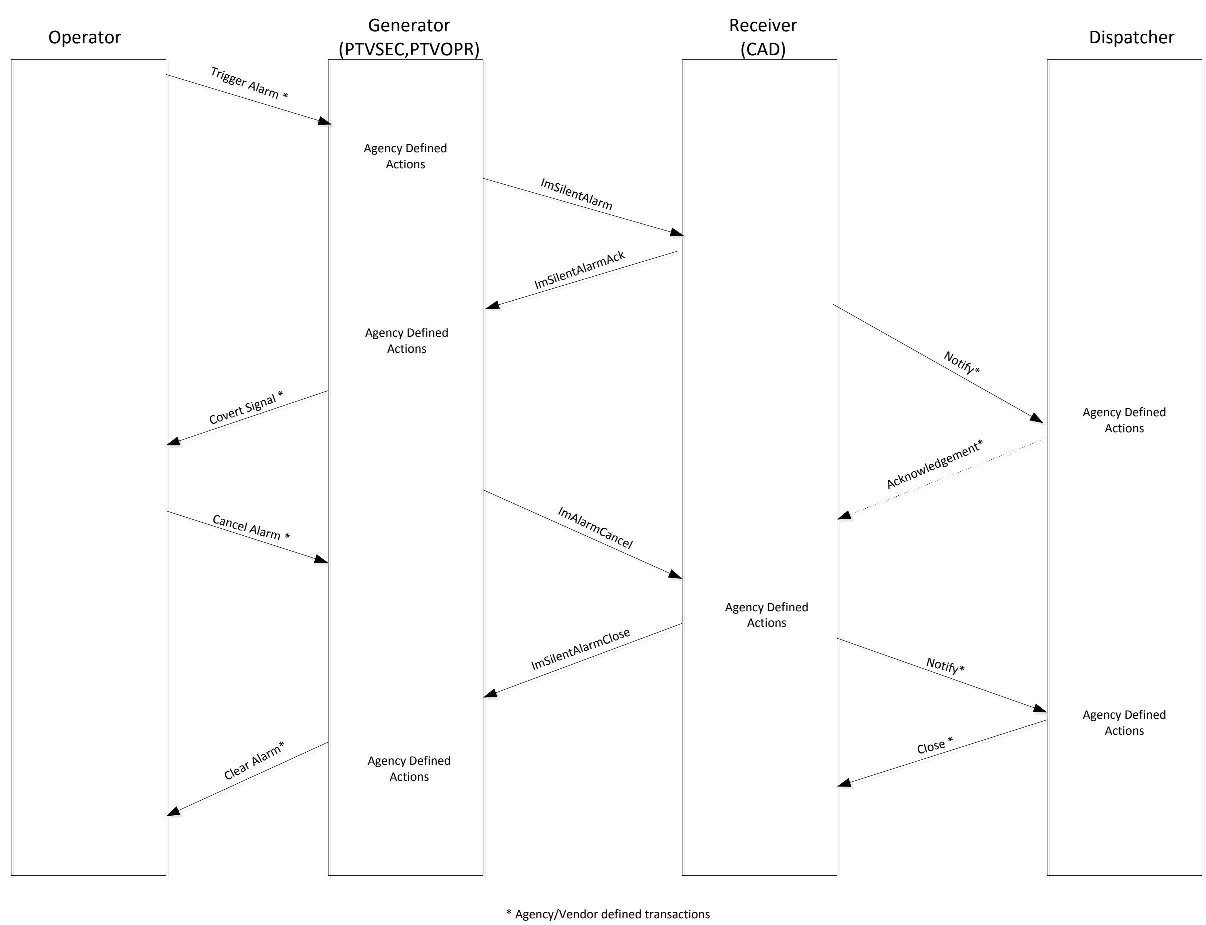


Fig 7.4 Normal Execution of the Silent Alarm Dialog

Silent Alarm Dialog Definition

Because the Silent Alarm Pattern is only used to define the Silent Alarm dialog, there are no requirements for the derivation of new dialogs from this pattern.

7.5 Load Pattern

This pattern is intended to load large files from a fixed business system source to a corresponding onboard component, field component, or a business system acting as a proxy for one or more field or onboard components (destination). As an example a Garage Server may serve as a proxy for the Vehicle Logic Units (VLUs) on a group of PTVs. Other business systems can load files onto the proxy using this dialog and the proxy can then use the same dialog to load the files onto the appropriate VLUs when they are available (in WLAN coverage). Thus a proxy would act as a destination in one instance of the dialog and as a source in another instance of the same dialog.

Files may include configuration information, software applications or other information. Loads may be performed using a laptop computer, or a wireless LAN or other network connection. Loads may also be performed using portable media such as flash cards or CDs. This dialog pattern is applicable to loads performed over a network connection or a laptop plugged into the onboard/field component. Normally loads will not be performed over narrowband radio networks.

The source component (laptop or source business system) shall be responsible for maintaining configuration control over the files to be loaded. The source component shall be responsible for keeping track of the correct version number(s) and/or effective dates of the loaded file(s) as appropriate for the destination component. The correct current version number and/or effective dates for an onboard component may be the same for all vehicles in the fleet or different by class of vehicle, garage-base, or by individual vehicle. Similarly, the correct version number and/or effective date for a field component may be the same for all stoppoints, field locations etc., or may be tailored on a site by site or component by component basis.

The applicability field in the load file's header shall indicate the specific PTVs, stoppoints etc. to which a file applies. This field is not necessary when loading a file or files to a specific onboard or field component, but is required when loading a proxy component. The proxy shall use the applicability field to determine what files to load to what PTVs, stoppoints etc.

The destination component shall be responsible for keeping track of the version number(s) and/or effective dates of the load files it has stored. Destination components may or may not keep multiple versions of the same load file depending on internal memory size and file management capabilities. In addition to the version number and/or effective date, some files are row-updatable. The destination shall keep track of the most recent update date-time on hand. The source shall keep track of all updates and when they are applied. Upon receipt of a request for updates, the source shall transfer only the changes to a version of a file that is already on hand at the destination.

Destination components shall ensure that if a file is incompletely loaded (e.g., due to network failures or loss of wireless LAN availability) that the destination component remains usable.

The load initiation shall always performed by the destination component by sending a CptOnboardVersionNotice message to the source component, however the source component may trigger the destination component to initiate the load by sending a CptForceLoad message. Note that an load initiation may not result in an actual file transfer, as the initial exchange of messages (CptOnboardVersionNotice, and CptVersionInfo between the destination and source components may result in a determination that the correct up-to date file versions are already on hand in the destination component.

The destination component shall initiate a load upon:

- Receipt of a CptForceLoad message from the source component.
- Receipt of a notification (via the "Publish Wireless LAN Status" Dialog) that the wireless LAN has become available and the minimum load request interval (see below) has elapsed since the last load initiation. Normally this trigger applies to mobile (e.g., PTV-based) destination components.

- Determination that the maximum load request interval (see below) has expired and the wireless LAN or another high-capacity communications path is available.

The minimum load request interval is a parameter that prevents the onboard destination components from continuously initiating loads when in marginal wireless LAN coverage. In this situation it is possible for the "Publish Wireless LAN" Dialog to frequently indicate failures and recoveries of the wireless LAN. Instead of having the onboard component interpret each recovery as a new visit to the garage, this parameter governs how long the onboard component must wait before initiating a new load request. This interval shall be overridden by receipt of a CptForceLoad message. The value of this parameter is locally defined. A recommended initial default interval is 60 minutes.

The maximum load request interval is a parameter that prevents the destination components from failing to initiate new loads due to a prolonged continuous period of wireless LAN or other communications path availability. If the communications path is always available, the "Publish Wireless LAN" Dialog will not send event-driven notifications of wireless LAN availability resulting in the destination components failing to obtain new loads. If the component's communications path remains available coverage for a period exceeding this interval, the destination component shall initiate a new load. The value of the maximum load request interval is locally defined. A recommended initial default interval is 240 minutes (4 hours).

The dialog pattern executes as follows:

1. The onboard or field component shall initiate the dialog based on one of the three criteria described above and send a CptOnboardVersion Notice message to the source component. This message informs the source component of the current version(s) effective dates and/or update times of the load files stored in the destination component.
2. The source component upon receipt of the CptOnboardVersionNotice shall send a CptCurrentVersionNotice to the destination component. This message informs the destination component of the file version(s) that should be stored by the destination component, and optionally provides a list of files to delete.
3. The destination component shall determine:
   A. The files that need to be loaded
   B. Whether there will be room to store the files to be loaded (allowing for space freed up by file deletions)
   C. Whether the files specified in the CptCurrentVersionNotice message are files that the destination component should have (e.g., farebox doesn't use VLU software files).
4. The destination component shall send a CptLoadControl message to the source component ending the load dialog or requesting the first file to be loaded. The dialog can be ended at this point due to:
   A. Invalid information in the CptCurrentVersionNotice message
   B. Insufficient storage in the destination component
   C. All files are current
5. If a valid file load was requested, the source component shall send the requested file or file update. If the file request is invalid, the source component shall send a CptBadLoadRequest message and the dialog shall end.
6. Upon receipt of the file or file update the destination component shall validate the file (manufacturer defined but including a verification of file length at a minimum), and shall determine whether additional files are needed. The destination component shall send a CptLoadControl message to the source component ending the dialog or requesting the next file. If a file is requested, go to step 5 above.

Figure 7.5 A-B depicts the execution of the Load dialog pattern.

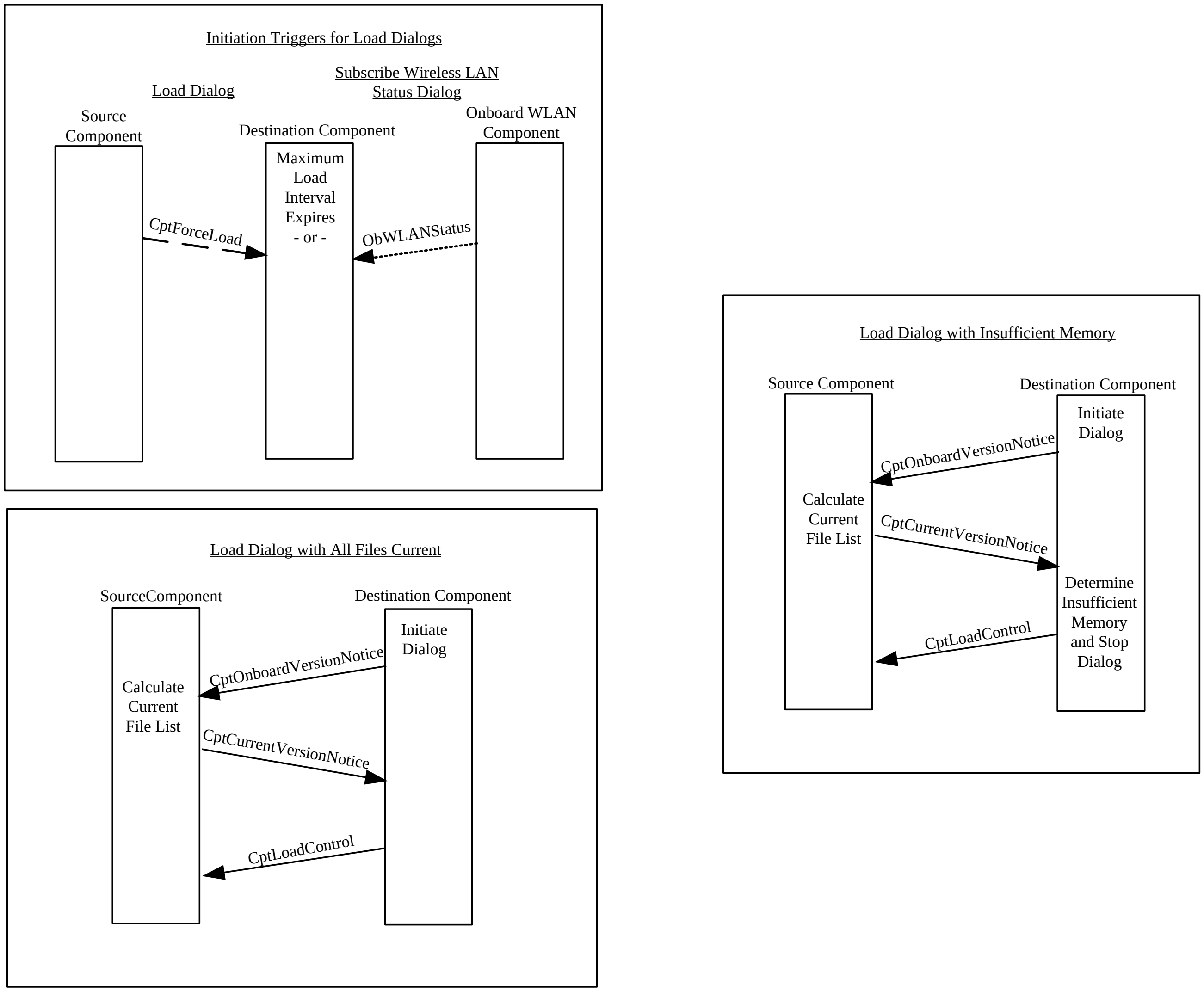


Figure 7.5.A
The Execution of the Load Dialog Pattern

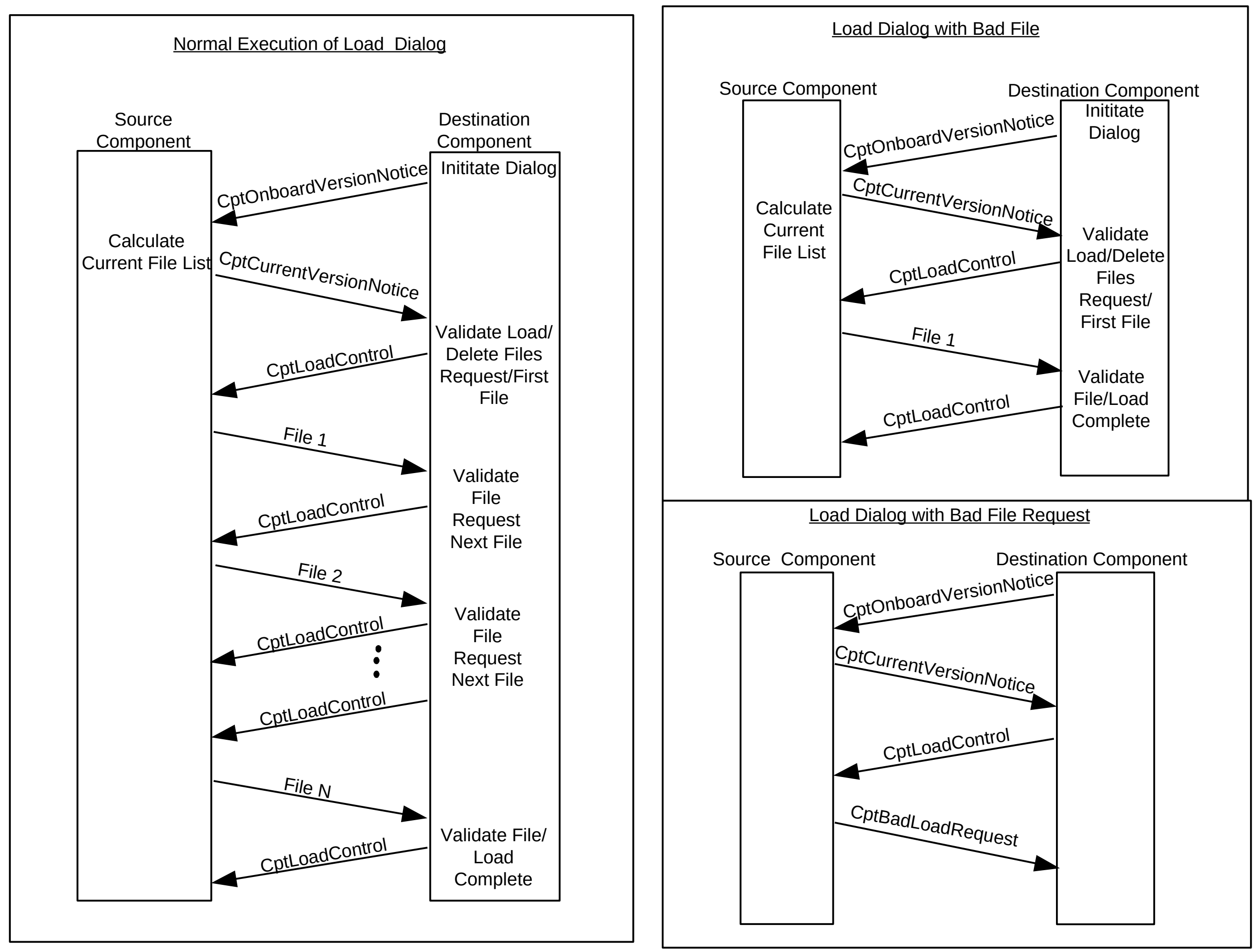


Figure 7.5.B
Execution of the Load Dialog Pattern

Load Dialog Definitions

Load dialogs derived from the Load Dialog Pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the word "Load"
2. TCIP business area
3. Dialog Purpose – defines the purpose of the load dialog. Generally this is to transfer a file or list of files from a source to a destination – if required.
4. Row Updates Supported – Fore each file (message) that supports row updates, specify the message and the type(s) of rows (data frames) in the file that are supported.
5. Load File Messages
6. Dialog Specific Assumptions and Notes
7. Associated File Transfers – Indicates what loaded files may be moved using a file transfer in lieu of the load dialog. Note that this substitution may be appropriate between business systems, but usually not between a business system and an onboard or field entity. This section will indicate "None" if there are no associated file transfers.

7.6 Unload Pattern

This pattern is intended to unload large files to a destination (usually fixed) business system from a corresponding source (usually onboard or field) component. If files are unloaded to a proxy server (e.g., Garage Server), the unload dialog(s) may also be used to transfer the unloaded files to another business system (e.g., Data Repository). Files may include configuration information, fare collection data, schedule adherence and other operator performance data or other information. Unloads may be performed using a laptop computer, or a wireless LAN or other network connection. Unloads may also be performed using portable media such as flash cards or CDs (batch mode). This dialog pattern is applicable to unloads performed over a network connection or a laptop plugged into the source component. Normally unloads will not be performed over narrowband radio networks.

The destination component (laptop or fixed business system) shall be responsible for maintaining configuration control over the unloaded files. The source component shall be responsible for storing the files to be unloaded until the file is listed for deletion in a CptUnloadControl message or until the source component is forced to delete the file due to lack of storage capacity. The rules governing file deletion due to lack of storage capacity shall be manufacturer defined.

The unload initiation shall be always performed by the source component by sending a CptFilesToUnload message to the destination component. Note that a unload initiation may not result in an actual file transfer.

The source component shall initiate a unload based upon:

- Receipt of a notification (via the "Publish Wireless LAN Status" Dialog) that the wireless LAN has become available and there are stored files waiting to be unloaded. This trigger usually applies only to mobile (PTV-based) sources.
- Determination the wireless LAN or other high-capacity communications link is available, and a new file has become ready to unload.
- Receipt of a CptForceUnload message from the destination component. This message exists primarily to trigger the unload to a laptop plugged into the source. It can also be used to elicit an unload from one business system (proxy) to a destination business system.

The dialog pattern executes as follows:

1. The source component shall initiate the dialog based on one of the 3 criteria described above and shall send a CptFilesToUnload message to the destination component. This message informs the destination component of the begin and end times for the data contained in the file, file type(s), version number(s) and/or effective dates of the files stored in the source component awaiting a unload.
2. The destination component upon receipt of the CptFilesToUnload message shall send a CptUnloadControl message to the source component. This message informs the source component of the next file to unload (if applicable) and any files to be deleted.
3. The source component shall determine:

   A. If an available file was requested in the CptUnloadControl message

   B. Whether any files are to be deleted without unloading them. For example, the destination component may have successfully received an unload on a previous attempt, but been unable to notify the source component due to a loss of WLAN coverage.
4. The source component shall delete any files specified to be deleted, and if an unload was requested (that is available), shall initiate sending the file. If no files are requested, the dialog ends.
5. If a file is specified for deletion by the destination component, and is not on hand in the source component, the deletion request shall be ignored by the source component.

6. If a file is specified for unloading by the destination component and the file is not on hand, the source component shall send a CptUnloadRequestError message to the destination component and shall terminate the dialog. The source component may re-initiate the dialog immediately if the WLAN is still available and there are still files to unload.
7. Upon receipt of an unloaded file, the destination component shall send a CptUnloadControl message to the source component, and the dialog goes to step 3 above. The destination end shall be responsible for including the successfully unloaded file in the files to delete section of the CptUnloadControl message.

Figure 7.6 depicts the execution of the unload dialog pattern.

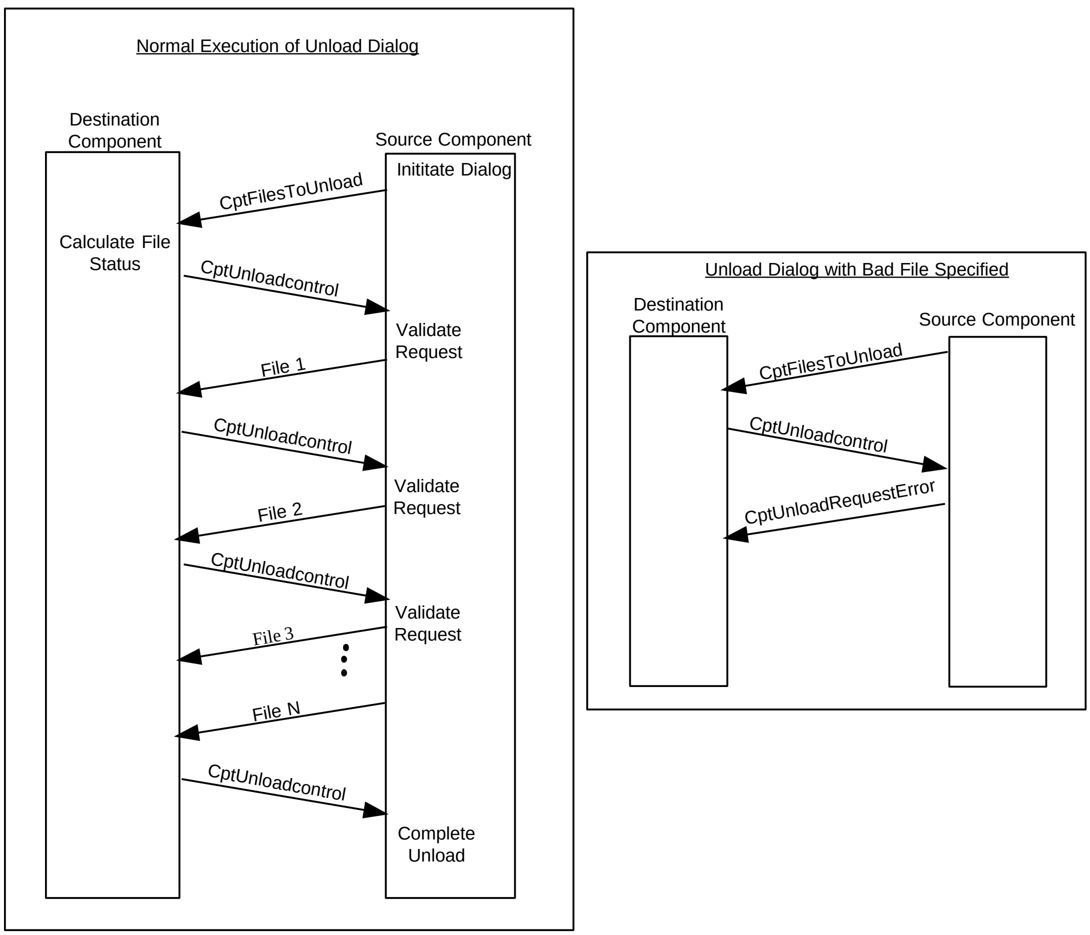


Figure 7.6
Unload Dialog Pattern

Unload Dialog Definitions

Unload dialogs derived from the Publication Dialog Pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the word "Unload"
2. TCIP business area

3. Dialog Purpose – Define the purpose of the unload dialog. Generally this is to convey a particular type of historical information from a source to a destination.
4. Unload Files Messages – the names of the unload file message(s) transferred by the dialog.
5. Dialog Specific Assumptions and Notes
6. Associated File Transfer(s) – Lists the file transfers that (by message name of unloaded file) that may be used in lieu of this dialog. Usually this substitution is applicable between business systems and not when transferring files from onboard or field components.

7.7 Voice Radio Call Patterns

Two patterns define voice radio calls between mobiles, and central: the Operator Initiated Voice Radio Call Pattern, and the Dispatcher-Initiated Voice Radio Call Pattern. These patterns define the interactions among the VLU/MDT, the annunciator and the CAD/AVL System in establishing and terminating voice radio calls. These patterns do not specify the radio control protocol. These patterns do not describe the human machine interfaces used by the operator or dispatcher to access the radio.

These dialogs are intended to operate with a variety of one and two bus radio solutions, and thus do not assume that data messaging between the CAD/AVL System and the VLU/MDT is available while voice calls are in effect.

Voice Radio Call Dialog Definitions

The patterns defined in this section are used in unique dialogs. As other dialogs are not derived from these patterns, there are no requirements for defining such derivative dialogs.

7.7.1 Operator Initiated Voice Call Pattern

This pattern defines the sequence of events in a dialog where the vehicle operator requests a voice conversation with the dispatcher. This includes the case where the operator activated a covert microphone. The operator requests the voice call via developer-specific mechanism such as an MDT transaction, punching a button etc. If the VLU and MDT are separate components connected by a messaging interface, and the request is made via the MDT; the MDT shall send the ObVoiceRequest message to notify the VLU of the request. Other onboard architectures may not need this message.

The VLU/MDT shall send a CcOperatorCallRequest message to the CAD/AVL System. The CAD/AVL System shall notify the dispatcher of the request using developer defined mechanisms. The dispatcher decides to accept or deny the call, and notifies the CAD/AVL of the result using developer-defined mechanisms.

If the dispatcher denies the call, the CAD/AVL System shall send a CcDenyCallRequest message to the VLU/MDT. The VLU/MDT shall inform the operator that the call request was denied and the dialog shall end. If the VLU and MDT are separate components connected by a messaging interface; the VLU shall send the ObVoiceRequestProgress message to notify the MDT of the denial.

Commentary: Some agencies will not use the call deny feature. Such agencies may direct developers to disable the call denial capability within the CAD/AVL System.

If the dispatcher accepts the call, then the CAD/AVL System shall notify the radio system of the call to be set up using developer-specific mechanisms. The radio system may provide a channel number to be conveyed to the vehicle for the voice call. The CAD/AVL System shall send a CcAcceptCallRequest message to the VLU/MDT. The VLU/MDT shall provide an indication that the call was accepted to the operator. If the VLU and MDT are separate components connected by a messaging interface; the VLU shall send the ObVoiceRequestProgress message to notify the MDT of the acceptance. The VLU/MDT shall use a developer-specific means to indicate the call setup to the voice radio. If the call requires the annunciation system (e.g., covert microphone call) the VLU shall send a CcAnnunciationCallSetup message to the annunciation system. At this point the voice call is established.

The operator-initiated voice call is terminated by the dispatcher who provides a developer-specific indication to the CAD/AVL System that the call should be terminated. The CAD/AVL System shall use a developer-specific mechanism to notify the radio system that the call should be terminated. The radio system terminates the voice radio connection, and shall provide a developer-specific indication to the VLU/MDT that the call has ended.

The VLU/MDT shall notify the operator that the call has ended. If the VLU and MDT are separate components connected by a messaging interface; the VLU shall send the ObVoiceRequestProgress message to notify the MDT of the call termination. If the annunciation system was included in the call, the VLU shall send a CcCallTermination message to the annunciator.

Figure 7.7.1 A-B depicts the operator initiated voice call.

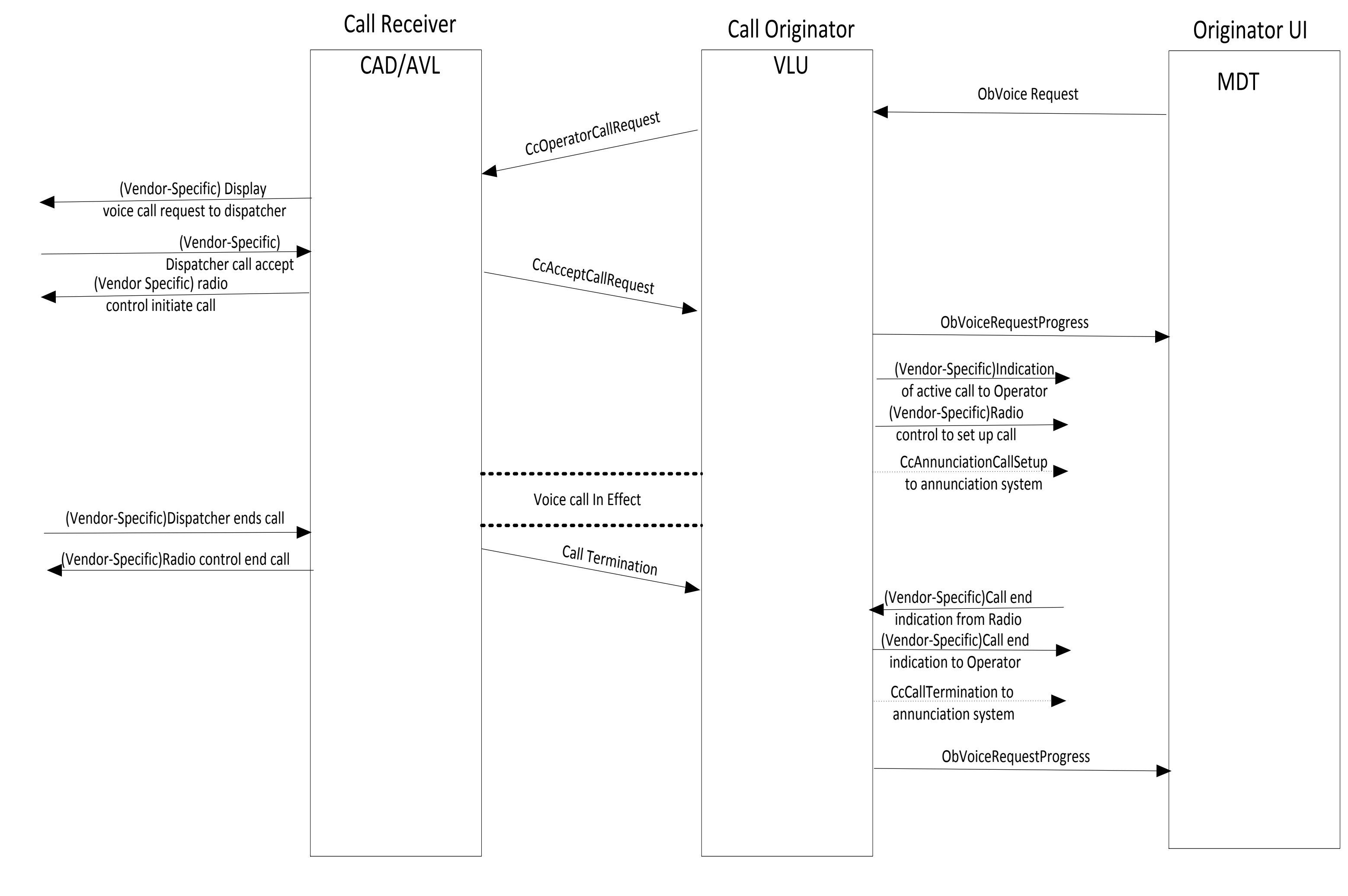


Fig 7.7.1.A Operator Initiated Voice Call Pattern Accepted

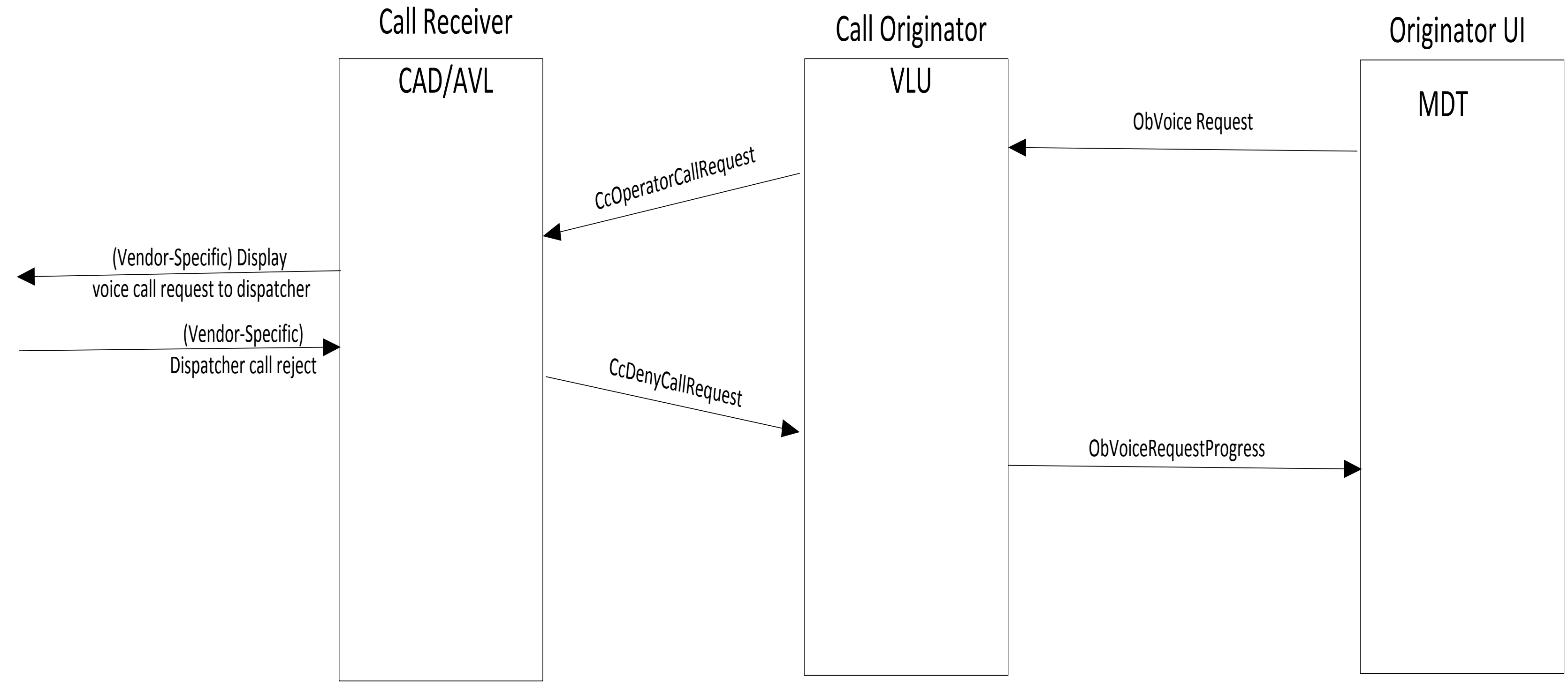


Fig 7.7.1.B Operator Initiated Voice Call Pattern Rejected

7.7.2 Dispatcher Initiated Voice Call Pattern

This pattern defines a sequence of events in a dialog where the dispatcher initiates a voice conversation with the vehicle. This includes the case where the dispatcher remotely makes a voice announcement through the onboard annunciation system. The dispatcher requests the voice call via developer-specific mechanism. The radio system may provide a channel number to be conveyed to the vehicle for the voice call. The CAD/AVL System shall send a CcDispatchCallSetup message to the VLU. The VLU/MDT notifies the operator via developer-specific mechanism of the call setup. If the VLU and MDT are separate components connected by a messaging interface, the VLU shall send the CcNotifyIncomingCall message to notify the MDT of the call setup. The VLU shall notify the radio to set up the call using developer-specific mechanisms. If the annunciation system is to be used for the call (e.g., for a dispatcher-made remote announcement), the VLU shall send a CcAnnunciatorCallSetup message to the annunciator. At this point the voice call is in effect.

The call is terminated by the dispatcher similarly to the operator initiated call. The CAD/AVL System shall notify the radio system to terminate the call. The onboard radio notifies the VLU of the call termination using developer-specific mechanisms. The VLU/MDT shall notify the operator of the call termination. The VLU shall send a CcDispatchCallEnd message to the MDT if the VLU and MDT are separate components connected by a messaging interface. If the annunciation system was included in the call, the VLU shall send a CcCallTermination message to the annunciator.

Figure 7.7.2 depicts the dispatcher-initiated voice sequence of events.

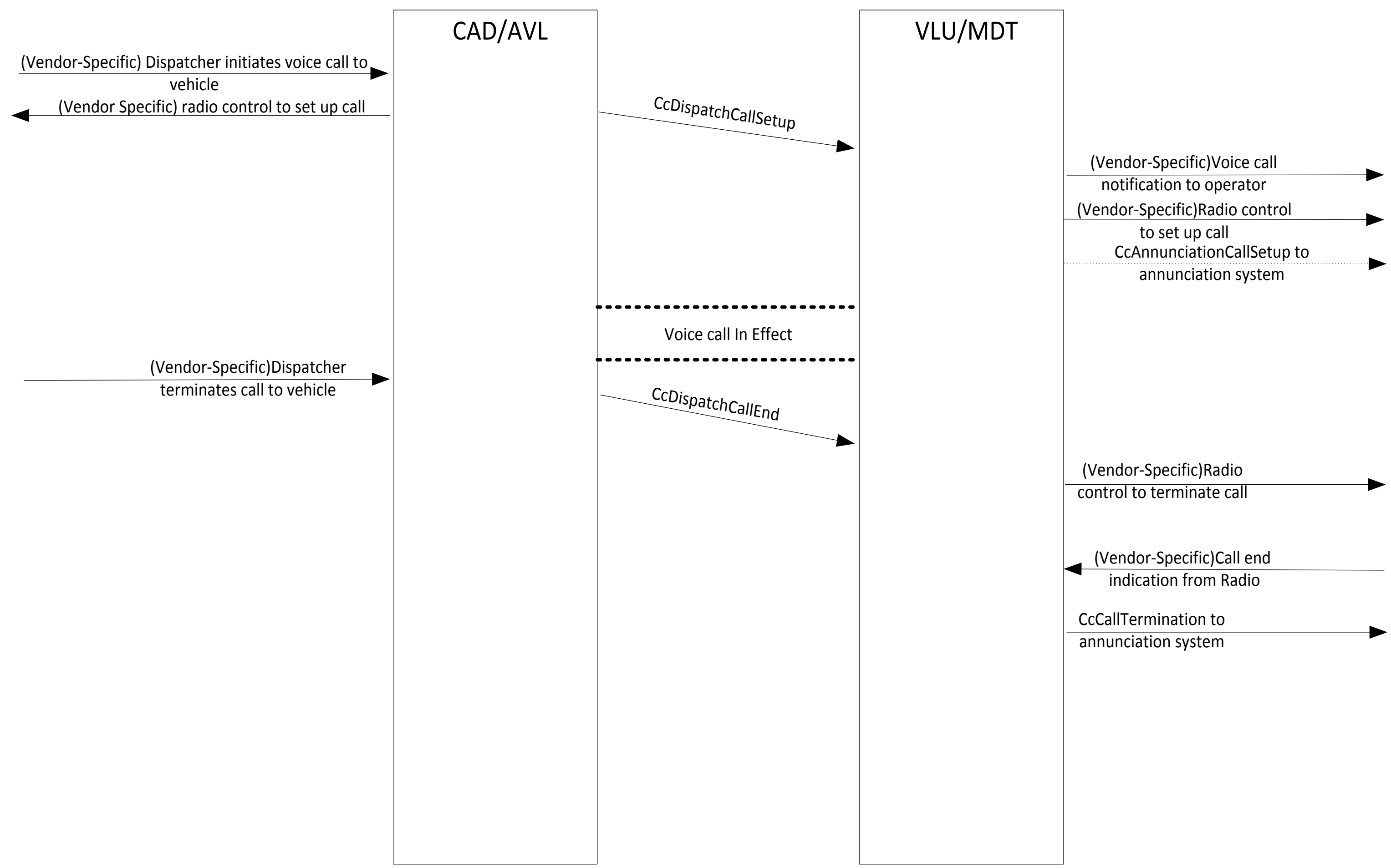


Fig 7.7.2 Dispatcher Initiated Voice Call Pattern

7.8 Signal Control & Prioritization Dialog Pattern

This pattern supports the conversations between a Priority Request Generator (PRG) that initiates requests for preferential treatment from the traffic signal system, and a Priority Request Server (PRS) which processes those requests. There may be one or more intermediaries in the dialog which receive, process, and forward the messages used to request, update, status, and cancel priority requests. Intermediaries can be the Transit Control Center, the Traffic Management Center or both. This pattern is used with NTCIP 1211 Scenarios 1, 2, and 4.

In accordance with NTCIP 1211, all conversations between the PRG and PRS take place using the Simple Network Management Protocol (SNMP). Two basic SNMP processes are used in NTCIP 1211: 1) The SET procedure, which sends a value for a variable to be assigned from the PRG to the PRS. The SET procedure can also cause a variable to be allocated within the PRS if it doesn't already exist. 2) The GET procedure, which obtains the value of a variable on the PRS and returns the value to the PRG.

NTCIP 1211 defines 6 transactions for SCP as shown in Table 7.8

SCP Transactions
Table 7.8

Transaction	SNMP Type	Message	Response	Purpose
Priority Request	SET	ScpPriorityRequest	ScpPriorityRequestAck	Request a priority strategy from the PRS on behalf of a transit vehicle.
Priority Update	SET	ScpPriorityUpdate	ScpPriorityUpdateAck	Request that a previously sent priority request be modified.
Priority Status Control	SET	ScpStatusControl	ScpStatusControlAck	Prepare the PRS to receive an inquiry regarding the status of a previously sent priority request.
Priority Status Buffer	GET	ScpStatusBuffer	ScpStatusBufferResponse	Provide the status of a previously sent priority request from the PRS to PRG.
Priority Cancel	SET	ScpPriorityCancel	ScpPriorityCancelAck	Cancel a previously send priority request that is no longer required.

SCP Transactions Table 7.8				
Transaction	**SNMP Type**	**Message**	**Response**	**Purpose**
Priority Clear	SET	ScpPriorityClear	ScpPriorityClearAck	Clear a completed priority request from the PRS.

The priority request is the most fundamental SCP transaction. The PRG shall determine a strategy to request from the PRS, and shall send the request.

The PRG shall use the priority update to revise the requested strategy, arrival time or other parameters related to the priority request. This transaction only occurs when changing conditions, detectable by the PRG, warrant alteration of the active request.

The PRG shall use the priority status control to condition the PRS to receive a priority status buffer. This transaction only occurs if the PRG determines it needs to obtain the current status of an active priority request.

The PRG shall use the priority status buffer transaction to retrieve the priority request status from the PRS after successful execution of a priority status control.

The PRG shall use the priority cancel when operational circumstances, detectable by the PRG, change such that the priority request is no longer appropriate.

The PRG shall use the priority clear when the transit vehicle has cleared the intersection for which priority was requested. This transaction may (by local agreement) not be initiated by the transit vehicle to conserve communications network capacity. If the PRG does not generate a priority clear, the PRS will timeout and clear the request automatically.

Figure 7.8 depicts the dialog pattern for Signal Control and Prioritization. Dotted lines indicate transactions within the dialog that do not occur in every instance of the dialog's execution. Housekeeping activities by the intermediary (if one exists) generally include maintenance of a log of SCP actions, and may include maintenance of an SCP real-time display.

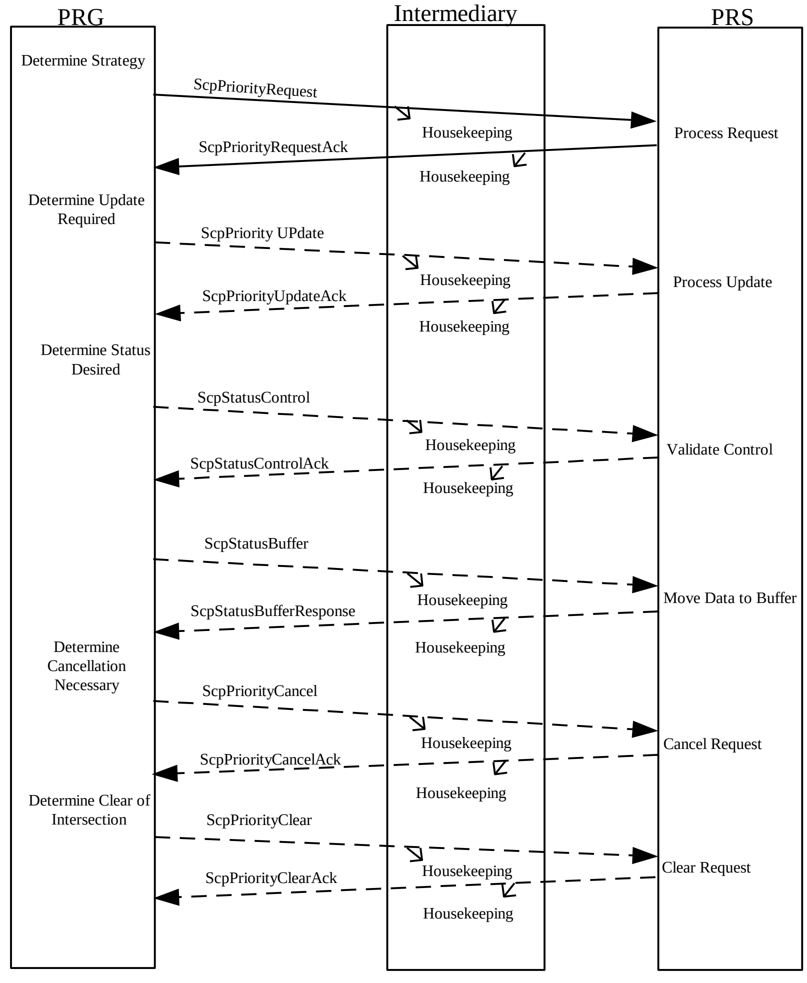


Figure 7.8
Signal Control & Prioritization Dialog Pattern

<u>Signal Control & Prioritization (SCP) Dialog Definition</u>

SCP dialogs derived from the SCP Dialog Pattern shall each specify:

1. <u>Dialog Name</u> – A unique name for the dialog beginning with the words "SCP Priority Request"
2. <u>TCIP business area</u> – Always "TSP"
3. <u>Dialog Purpose</u> – Define the purpose of the specific SCP dialog
4. <u>Priority Request Generator Location & Description</u>
5. <u>Priority Request Communications Path and Encoding Scheme(s)</u>

6. Dialog Specific Assumptions and Notes

7.9 Blind Notification Pattern

This is a one message pattern that provides for a notifier to send information to a receiver, without an expected response. The notifier shall not implement any error recovery if the message is not delivered successfully. Figure 7.9 depicts the execution of the Blind Notification Pattern.

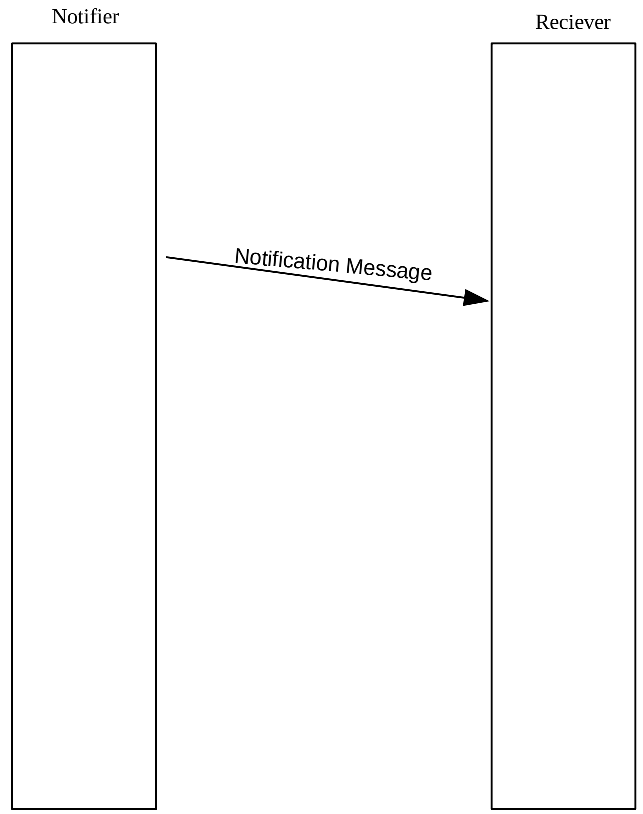


Figure 7.9
Blind Notification Pattern

<u>Blind Notification Dialog Definition</u>

Notification dialogs derived from the Blind Notification dialog pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the word “Notify”
2. TCIP business area
3. Dialog Purpose – Defines the purpose of the dialog
4. Notification Message
5. Associated File Transfer – Notification message name or “Name”
6. Dialog Specific Assumptions and Notes

7.10 Push Pattern

This is a 3 message pattern that provides for a sender of a message (usually a large file) to initiate the transfer to a receiver. The pattern provides for a reliable transfer (in contrast to the Blind Notification Pattern) by providing feedback to the sender.

The sender shall detect the failure of the push attempt via internal timeout, or the receipt of a CptPushFailure message. The sender shall implement manufacturer defined recovery mechanisms in the event of a failure. These mechanisms may include alarm generation, retry at a later time, etc.

The receiver shall accept and validate the push message. The validation is manufacturer-defined. If the message is invalid, or cannot be accepted for any reason, the receiver shall send a CptPushFailure message to the sender. If the message is valid and accepted, the receiver shall send a CptPushSuccess message to the sender.

Figure 7.10.1 depicts a successful execution of the Push Pattern.

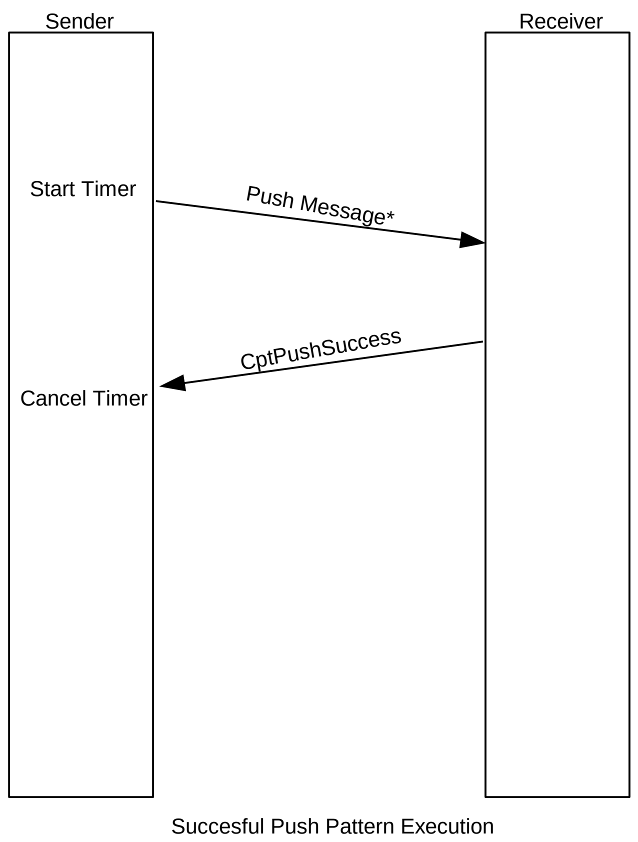


Figure 7.10.1
*Message Containing the Information to be Transferred with a Push Header.

Figure 7.10.2 depicts unsuccessful execution of the Push Pattern. Note that if the receiver is not operational, the push can fail with no response from the receiver. The sender detects and recovers from this failure using an internal timer. The duration of the timer as well as the specific recovery actions are implementation-specific.

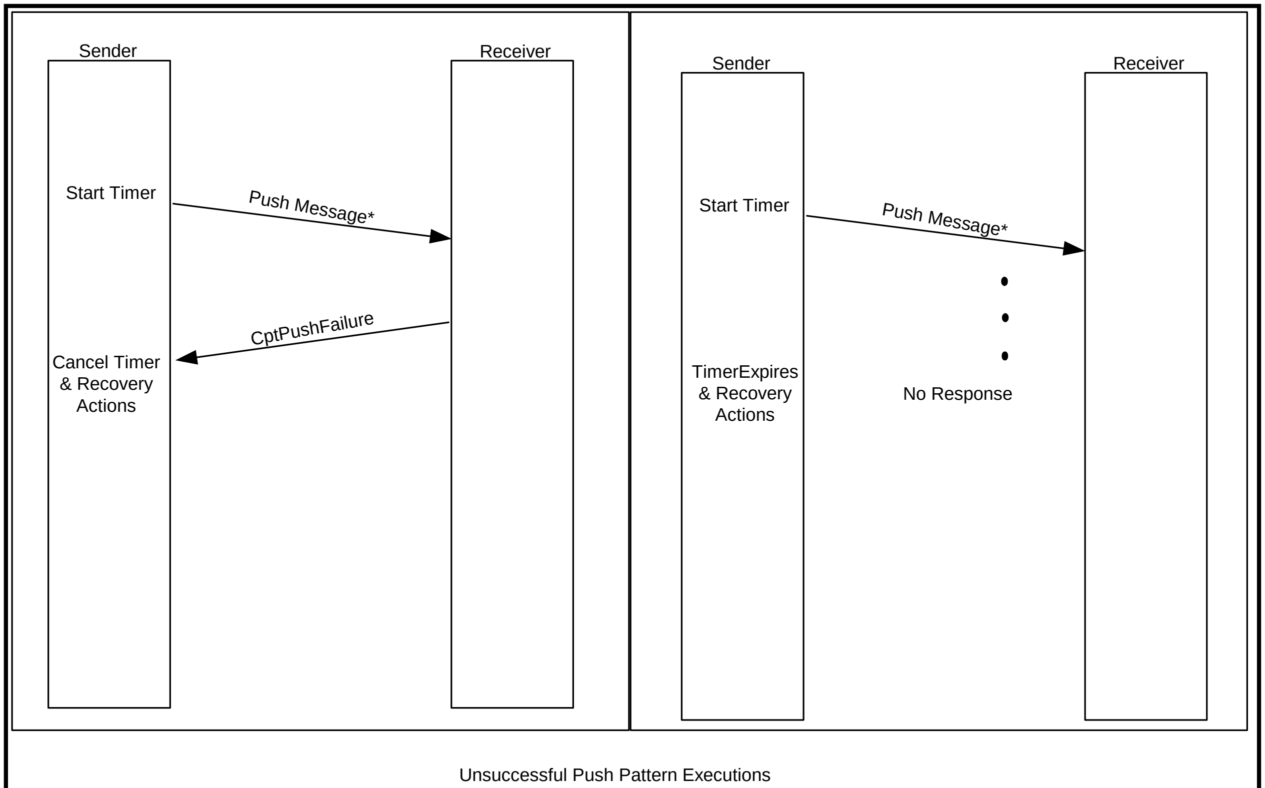


Figure 7.10.2
* Message Containing Information to be Transferred and a Header

Push Dialog Definition

Push dialogs derived from the Push Dialog Pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the word "Push"
2. TCIP business area
3. Dialog Purpose – Defines the purpose of the push dialog. Generally this is to convey a particular type of information from a Notifier to a Receiver.
4. Row Updates Supported – If row updates are supported, specifies the type(s) of rows (data frames) in the message that are supported.
5. Push Message Name

6. Associated File Transfers – “None” or Push Message Name
7. Dialog Specific Assumptions and Notes.

7.11 Traveler Service Request Pattern

The traveler service request pattern defines a dialog to allow a transit traveler or passenger to request that a PTV provide an amenity at a stoppoint (e.g., wheelchair lift, transfer connection protection). All requests are subject to concurrence by a central entity (usually the CAD/AVL system), and to a limited hold time. Hold time refers to the maximum delay that may be added to a PTV’s trip to accommodate a request. The dispatcher may ‘turn off’ these services resulting in all requests being denied. Agencies may specify that services are to be turned on/off on a granular basis resulting in the ability to turn on/off these services by routes, zone, time of day, etc.

The traveler service request process proceeds as follows:

1. Request Initiation – The request may originate from a traveler at a stoppoint, a PTV passenger (e.g., when transfer is issued), from the Customer Service System, or from the Traveler Information System (e.g., traveler using a kiosk). The requester entity shall assign a unique identifier (for the requester entity) to the request and shall send a request message to central.

2. Request Disposition – The central entity shall assign a unique identifier (for the central entity) and shall return determine if the request can be honored, and if so what PTV should be instructed to service the request.
    a. If the request cannot be honored, the central entity shall return a Deny message to the requester entity, and the dialog shall end.
    b. If the request can be honored, the central entity shall send an Instruction message to the PTV that is to provide the amenity (provider entity). The provider entity shall display the instruction to the PTV Operator. Depending on a local agency configuration, the provider entity shall either:
        - Send an acknowledgement to the central entity automatically upon displaying the instruction, or
        - obtain an acknowledgement from the operator before sending an acknowledgement to the central entity.
    c. The central entity shall wait for an agency-specified time for an Acknowledgment Response from the provider entity. If no response is received, the central entity shall cancel the request and send a deny message to the requester entity.
    d. If the central entity receives the acknowledgement message before the timeout, then the central entity shall send an approval message to the requester entity, and the dialog shall end. The instruction message, and the approval message both contain a maximum wait date-time, beyond which the provider entity is not expected to provide the amenity. The central entity is not apprised as to whether the person making the original request received the amenity. Agency policy may dictate that the ‘promised’ wait-until time in the approval message is earlier than the ‘directed’ wait-until time in the Instruction message by a small interval to reduce the incidence of customer complaints.

The provider entity and the central entity shall log the request and its disposition. Via separate dialogs these logs are made available to business systems that require this historical information. The messages used in this dialog pattern and in the associated historical logs contain the identifiers assigned by the requester entity and the central entity which allow transactions to be correlated when post processing historical information.

Figure 7.11 illustrates the traveler service request dialog pattern.

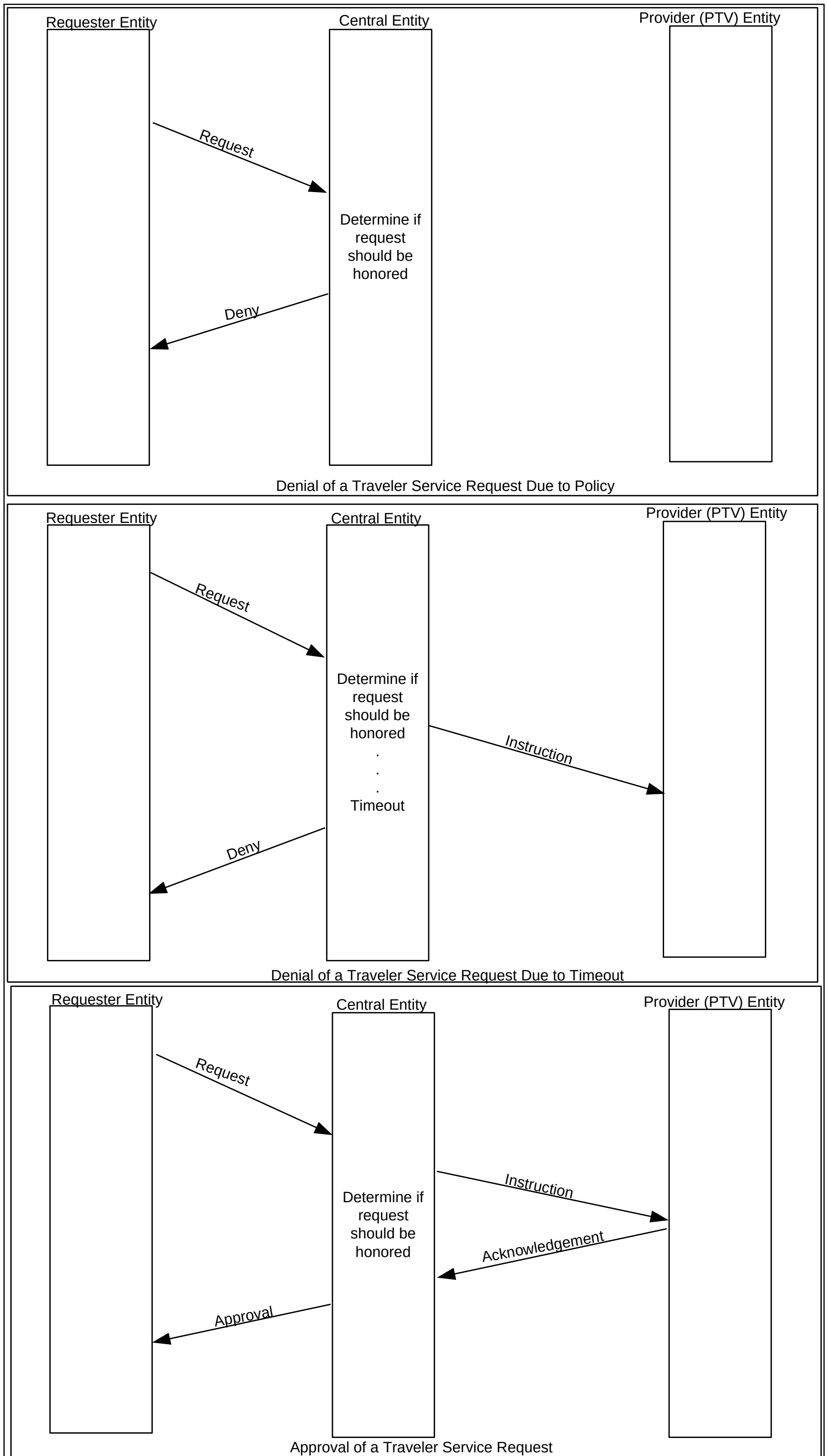


Figure 7.11
Traveler Service Request Pattern

Traveler Service Request Dialog Definitions

Traveler service request dialogs derived from the Traveler Service Request Dialog Pattern shall each specify:

1. Dialog Name – A unique name for the dialog beginning with the "Request"
2. TCIP business area
3. Dialog Purpose – Defines the purpose of the traveler request dialog
4. Messages Used – Specifies the request, instruction, acknowledgement, approval and denial messages.
5. Dialog Specific Assumptions and Notes

8. Conformance

This section defines the minimum requirements that shall be met by a Profile Implementation Conformance Statement (PICS), or an interface to claim TCIP conformance. This section also defines the minimum requirements for the creation of a valid Profile Requirements List (PRL). TCIP is an interface standard and not a functional specification for agency business systems, components, or logical entities. Consequently, the fact that an interface is TCIP conformant will not in and of itself, ensure that agency functional requirements are met.

An implementation can be considered TCIP conformant, even though it's interfaces support only some of the dialogs and/or message files defined by TCIP. TCIP provides a modular conformance approach that allows a transit agency to choose the dialogs, file transfers, and classes of conformance that provide interfaces that best meet the agency's needs. Thus an agency can select a group of dialogs to be supported by a Class 1A interface, and/or a group of message files to be consumed via a Class 2A interface, and/or a group of message files to be produced by a Class 2B interface. The agency can specify that all of these selections shall be supported by a single implementation.

A transit agency defines its TCIP interface requirements using a Profile Requirements List (PRL). A product developer specifies a product's conformance to TCIP using a Profile Implementation Conformance Statement (PICS). The formats of these documents are intended to be very similar to allow convenient side-by-side comparisons of a product's capabilities with an agency's requirements.

8.1 Basic Conformance Requirements

An Interface is defined as the point of interaction between a business system, subsystem, or component and any other entity.

A Profile Requirements List (PRL) defines a transit agency's TCIP requirements for TCIP implemented interfaces associated with a product to be procured (or developed) by the agency. A valid PRL is a PRL which meets all of the requirements specified in Section 8.4.

A Profile Implementation Conformance Statement (PICS) defines what parts of TCIP a product's interfaces support. When a product developer wishes to state that one of its products is TCIP conformant, the developer shall provide one or more Profile Implementation Conformance Statements (PICS) to describe the product's conformance.

When one or more of a product's interfaces conforms to all of the provisions stated in the PICS that accompany the product documentation, then the product is considered a TCIP Implementation, and the interface(s) that conform to the PICS are considered TCIP Implemented Interfaces. Specifically, TCIP conformance is achieved when the product's interface(s):

- Have PICS that conforms to the criteria in Section 8.3
- Conform in every respect with its PICS.
- Conform with all requirements associated with each conformance class for which conformance is claimed in the PICS.

A product's interface is responsive to an agency's TCIP requirements if the interface is conformant as described above and conforms to a valid agency PRL.

Note that it is possible for a product to be considered a TCIP Implementation having TCIP Implemented Interfaces, and at the same time for the product to also support interfaces that are not described in this standard. Put another way, TCIP conformance compliance does not restrict a product from also providing additional non-TCIP conformant interfaces. For example, one could envision an onboard product that provides TCIP conformant interfaces as well as SAE J1708/J1587 interfaces.

Product developers shall provide assurances in their PICS that any provided non-TCIP interface(s) in an implementation cannot cause a fault condition, or a nonconformance in the TCIP interface(s) provided by that implementation. Agencies may require that developers define how the TCIP and non-TCIP interfaces are separated in the design as part of their proposal and/or design documentation.

8.2 TCIP Conformance Classes and Requirements

TCIP conformant interfaces shall support a specific listed Conformance Class and will be referred to as TCIP Implemented Interfaces. TCIP shall have only the listed conformance classes:

- Class 1A – Dialog Based Interface with TCIP XML Encoded Messages.
- Class 1B – Dialog based Interface with narrowband encoded messages. Selection of Narrowband encoding schemes are a local agency decision.
- Class 2A – File Based Interface consuming TCIP XML Encoded Message Files
- Class 2B – File Based Interface producing TCIP XML Encoded Message Files

8.2.1 Class 1 (Dialog) Conformance Requirements

All Class 1A and Class 1B TCIP Implemented Interfaces shall:

- Implement all dialog requirements listed in the dialog definition (as specified in Annex D), for each dialog listed in the PICS.
- Conform in every respect with each dialog's associated Dialog Pattern definition (as specified in Section 7) for each dialog listed in the PICS.
- Provide all required fields in every transmitted TCIP message. Any field in a TCIP message or TCIP data frame which is not specified as 'OPTIONAL' is required.
- Conform with any "WITH COMPONENTS" fields present in the ASN.1 definition of any transmitted TCIP message.
- Conform in every respect with the 'Remarks' field in the ASN.1 definition of any transmitted or received TCIP message (Annex C), including the remarks sections of included data frames and data elements (Annexes B and A).
- Provide internal recovery mechanisms from any error state (e.g., lost/bad messages, no response etc.) generated by each dialog listed in the PICS.
- Accept all required and/or optional fields in any message instance of any message defined to be received by the TCIP Implemented Interface based on the dialogs identified in the PICS.
- Accept maximum length message instances for all messages defined to be received by the TCIP Implemented Interface in any dialog identified in the PICS.

8.2.1.1 Class 1 A Conformance Requirements

All Class 1A TCIP Implemented interfaces shall:

- For any TCIP message identified by the PICS to be received by the TCIP Implemented Interface, accept any specified message instance that conforms to the appropriate version of tcip.xsd (e.g., tcip_2_7.xsd)..
- For any TCIP message instance transmitted by the TCIP Implemented Interface, include the minimum set of XML message instance attributes as specified in section 8.4.2.1
- For any TCIP XML message instance transmitted by the TCIP Implemented Interface, shall be well-formed, valid, and conformant with the version of the TCIP XML Schema identified by the PICS for the interface. The terms "well-formed" and "valid" shall be interpreted in accordance with Reference [N-3].

8.2.1.2 Class 1 B Conformance Requirements

All Class 1B TCIP Implemented Interfaces shall:

- Conform in every respect with the PICS-defined encoding scheme.

- Implement an encoding/decoding process which in every respect maintains the integrity of the message according to the data definitions provided for TCIP messages in Annexes A-C. Commentary: This requirement is intended to preclude the use of 'lossy' compression schemes of any type for TCIP message encoding.

8.2.2 Class 2 A Conformance Requirements

A Class 2A TCIP Implemented Interface shall:

- For any TCIP message file identified by the PICS to be received by the TCIP Implemented Interface, accept any specified message file instance that conforms to the appropriate version of tcip.xsd (e.g., tcip_2_7.xsd).

8.2.3 Class 2 B Conformance Requirements

A Class 2B TCIP Implemented Interface shall:

- For any XML message file instance produced by the TCIP Implemented Interface, the message in the file shall be well-formed and valid. The terms "well-formed" and "valid" shall be interpreted in accordance with Reference [N-3].
- For any produced TCIP message file, include the minimum set of XML message instance attributes as specified in section 8.4.2.1 and conform with the appropriate version of tcip.xsd (e.g., tcip_2_7.xsd).
- For any produced TCIP message file conform in every respect with the 'Remarks' field in the ASN.1 definition of the message (Annex A), including the remarks field of included data frames and data elements (Annexes B and A).
- Include exactly one TCIP message per message file.

8.3 PICS Requirements

A sample PICS is included in the Annex K.

A TCIP PICS shall meet the following requirements:

8.3.1 TCIP Version

PICS Requirement: The PICS shall specify the TCIP Version or Versions supported by the implementation for each supported dialog and/or message file.

Examples:

Conformance Class 1A: Supported Dialogs			
Project Component: Example CAD System			
External Component: Example Data Warehouse			
Dialog Name	**Role**	**TCIP Version**	**PICS Annex**
Notify Trip Cancellations	Notifier	3.0.2	1A.1
Publish Block Schedule	Subscriber	3.0.2	1A.2

Conformance Class 1A: Supported Dialogs			
Publish Calendar	Subscriber	3.0.2	1A.3
Publish Master Schedule Version	Subscriber	3.0.2	1A.4
Publish Run Schedule	Subscriber	3.0.2	1A.5
Publish Route Schedule	Subscriber	3.0.2	1A.6
Publish Pattern List (with spatial data)	Subscriber	3.0.2	1A.7
Publish Operator Assignments (bound)	Subscriber	3.0.2	1A.8
Publish Timepoint List	Subscriber	3.0.2	1A.9

TCIP Message Name	**TCIP Version**	**PICS Annex**
SchPushRunningTimes	3.0.1	2A.1

8.3.2 Conformance Class(es)

PICS Requirement: The PICS shall specify the TCIP Conformance Class(es) supported by the implementation. For class 1 the PICS shall identify the dialogs and roles supported by the implementation. For class 2 the PICS shall identify the messages produced or consumed by the implementation.

Examples:

Conformance Class 1A: Supported Dialogs			
Project Component: Example CAD System			
External Component: Example Data Warehouse			
Dialog Name	**Role**	**TCIP Version**	**PICS Annex**
Notify Trip Cancellations	Notifier	3.0.2	1A.1
Publish Block Schedule	Subscriber	3.0.2	1A.2
Publish Calendar	Subscriber	3.0.2	1A.3
Publish Master Schedule Version	Subscriber	3.0.2	1A.4
Publish Run Schedule	Subscriber	3.0.2	1A.5
Publish Route Schedule	Subscriber	3.0.2	1A.6
Publish Pattern List (with spatial data)	Subscriber	3.0.2	1A.7
Publish Operator Assignments (bound)	Subscriber	3.0.2	1A.8
Publish Timepoint List	Subscriber	3.0.2	1A.9

Conformance Class 2A: TCIP Message Files Accepted		
Project Component: Example CAD System		
External Component: Example Data Warehouse		
File Import Procedure: With the CAD application running, go to the File Menu & Select Import. Browse to the file to be imported. Select the appropriate file type from the drop-down list.		
File Attributes & Limitations: Message files cannot exceed 2MB.		
TCIP Message Name	**TCIP Version**	**PICS Annex**
SchPushRunningTimes	3.0.1	2A.1

Conformance Class 2B: TCIP Message Files Generated	**TCIP Version**	**PICS Annex**

Project Component: Example CAD System **External Component:** Example Data Warehouse **File Export Procedure:** With the CAD application running, go to the File Menu & Select Export. In the dialog box specify the folder and file name to be created. Select the appropriate file type from the drop-down list. FIll in the dates in the text boxes provided. Click on Export. **File Attributes & Limitations:** Message files must not exceed 1MB. **TCIP Message Name**		
TspEventLogUnload	3.0.1	2B.1

8.3.3 Network Address

PICS Requirement: The PICS shall specify the configuration mechanism for IP addresses and port numbers or alternative network and transport addressing parameters used by the implementation, both to identify itself and to identify other interfaces with which it communicates.

Example:

Profile Implementation Conformance Statement (PICS)		
Project Name: Example CAD		
Agency/Company Name: Greater Richmond Transit Company	**Agency ID:** 3006	**Agency Model:** Multi
Project Component:		
Example CAD System		
External Component:		
Example Data Warehouse		
Network Configuration: The Example CAD System uses TCP/IP communications for all supported TCIP dialogs.		
Non TCIP Interfaces Supported: Example CAD provides a daily archive data set to the warehouse using an agency-specified transfer mechanism.		
Exceptions to TCIP Requirements: None		

8.3.4 Non-conformant TCIP Features and Non-TCIP Interfaces

PICS Requirement: The PICS shall state or describe any manner in which the interface does not conform to the TCIP requirements. Failure to list a non-conformant feature or attribute of the interface shall render the interface non-conformant in its entirety. The PICS shall identify any non-TCIP interfaces included with the implementation, and the standard or interface definition(s) to which said interface(s) conform.

Commentary: Generally, anything listed here is considered a non-conformant feature. The intent is to ensure that non-conformances are clearly identified by developers so that developers of interfacing products can determine whether non-conformant features are acceptable in their environment, and agencies can determine whether the non-conformant aspects of the interface are acceptable.

The reasoning here is that early TCIP adopters may be less than 100% conformant. A mechanism is needed to document these non-conformant features so they are known to the agency, to the developer of distant end interfaces, and documented for use in generating comments on future revisions of TCIP. Eventually such non-conformant features may become part of TCIP, may be replaced by TCIP conformant features, or may be eliminated. Since failure to identify a non-conformant feature in the PICS renders the entire interface non-conformant; a developer may not claim that an interface, that whose PICS fails to disclose a non-conformant feature, is in any respect a TCIP conformant interface.

Example:

Profile Implementation Conformance Statement (PICS)		
Project Name: Example CAD		
Agency/Company Name: Greater Richmond Transit Company	**Agency ID:** 3006	**Agency Model:** Multi
Project Component:		
Example CAD System		
External Component:		
Example Data Warehouse		
Network Configuration: The Example CAD System uses TCP/IP communications for all supported TCIP dialogs.		
Non TCIP Interfaces Supported: Example CAD provides a daily archive data set to the warehouse using an agency-specified transfer mechanism.		
Exceptions to TCIP Requirements: None		

8.3.5 Optional Fields for Messages and Message Files

PICS Requirement: The PICS shall specify what optional fields are supported for each TCIP message or message file supported. This requirement includes optional fields in the message definition, as well as optional fields within frames contained in the message, or message file.

Each optional field in received messages or message files shall be specified as one of:

- U Used by and/or stored by the receiving implementation if present
- R Required by the receiving implementation
- I Ignored by the receiving implementation if present

Each optional field in produced messages or message files shall be specified as one of:

- A Always included in the message produced by the implementation
- N Never included in the message produced by the implementation
- C Conditionally included in the message produced by the implementation

For any optional field in a message or message file, (or data frame within a message or message file), which is specified to be conditionally included in the message, the PICS shall specify the conditions under which the optional field is included. The enumeration of the usage status of optional fields in a message need not include the contents (children) of any frame that is specified as Ignore on receipt, or is specified as Never sent.

Note: Although a field may be specified as optional in TCIP, the information in that field may be critical to the function of a specific implementation. For example, an implementation may require that patterns in a schedule be named, as well as numbered, whereas TCIP requires numbers and specifies that names are optional.

Examples:

Annex 1A.1 - Message 1 (CcCancelTrips)	
PICS Dialog Requirements	
Project Component: Example CAD System	
External Component: Example Data Warehouse	
Dialog Name: Notify Trip Cancellations	
Dialog Role: Notifier	
Send Message Name: CcCancelTrips	
Optional Send Field Support Codes: 'A' - Field shall always be sent. 'N' - Field shall never be sent. 'C' - Field shall conditionally be sent.	
Field	**Code**
cancel-records.cancelled-trips.agency-id	A

Annex 1A.1 - Message 1 (CcCancelTrips)		
cancel-records.cancelled-trips.designator	N	
cancel-records.day-types	C[1]	
cancel-records.specific-dates	C[2]	
Local Field Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Type**	**Code**
No local field extensions are defined for this message.		
Local Code Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Data Element**	**Local Code**
No local code extensions are defined for this message.		

Annex 1A.2 - Message 2 (SchBlockScheduleList)	
PICS Dialog Requirements	
Project Component: Example CAD System	
External Component: Example Data Warehouse	
Dialog Name: Publish Block Schedule	
Dialog Role: Subscriber	
Receive Message Name: SchBlockScheduleList	
Optional Receive Field Support Codes: 'U' - Field shall be used or stored if present. 'R' - Field required by implementation. 'I' - Field may be ignored if present.	
Field	**Code**
subscriptionInfo.reportInterval	U
subscriptionInfo.applicability	I
specific-garages	U
specific-garages.agency-id	R
specific-garages.facility-name	U
specific-garages.base-name	U
specific-blocks	U
specific-blocks.agency-id	R
specific-blocks.block-designator	I
specific-blocks.block-name	U
update-since	U
sched-blocks	U
sched-blocks.block.agency-id	R
sched-blocks.block.block-designator	I
sched-blocks.block.block-name	U
sched-blocks.metadata.created	U
sched-blocks.metadata.effective	U
sched-blocks.metadata.expiration	U
sched-blocks.metadata.activation	U
sched-blocks.metadata.deactivation	U
sched-blocks.trip-details.trip.agency-id	R
sched-blocks.trip-details.trip.designator	I
sched-blocks.trip-details.route.agency-id	R

Annex 1A.2 - Message 2 (SchBlockScheduleList)	
sched-blocks.trip-details.route.route-designator	I
sched-blocks.trip-details.route.route-name	U
sched-blocks.trip-details.direction	U
sched-blocks.trip-details.pattern	U
sched-blocks.trip-details.pattern.agency-id	R
sched-blocks.trip-details.pattern.designator	I
sched-blocks.trip-details.pattern.name	U
sched-blocks.trip-details.run	U
sched-blocks.trip-details.run.agency-id	R
sched-blocks.trip-details.run.designator	I
sched-blocks.trip-details.block	U
sched-blocks.trip-details.block.agency-id	R
sched-blocks.trip-details.block.block-designator	I
sched-blocks.trip-details.block.block-name	U
sched-blocks.trip-details.trip-type-name	U
sched-blocks.trip-details.events	U
sched-blocks.trip-details.events.time-begin	U
sched-blocks.trip-details.events.point	U
sched-blocks.trip-details.events.proximity	U
sched-blocks.trip-details.events.fare-zone-id	U
sched-blocks.trip-details.events.fare-zone-id.agency-id	R
sched-blocks.trip-details.events.fare-zone-id.zone-name	U
sched-blocks.trip-details.events.radio-zone-id	U
sched-blocks.trip-details.notes	U
sched-blocks.trip-details.notes.agency-id	R
sched-blocks.trip-details.notes.note-des	I
sched-blocks.trip-details.op-time-type	U
sched-blocks.begin-timepoint	U
sched-blocks.begin-timepoint.agency-id	R
sched-blocks.begin-timepoint.designator	I
sched-blocks.begin-timepoint.name	U
sched-blocks.end-timepoint	U
sched-blocks.end-timepoint.agency-id	R
sched-blocks.end-timepoint.designator	I
sched-blocks.end-timepoint.name	U
deleted-blocks	U
deleted-blocks.agency-id	R
deleted-blocks.block-designator	I
deleted-blocks.block-name	U

Annex 1A.2 - Message 2 (SchBlockScheduleList)		
Local Field Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Type**	**Code**
No local field extensions are defined for this message.		
Local Code Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Data Element**	**Local Code**
No local code extensions are defined for this message.		

Annex 2A.1 (SchPushRunningTimes)	
PICS Receive Message File Requirements	
Project Component: Example CAD System	
External Component: Example Data Warehouse	
Receive Message Name: SchPushRunningTimes	
Optional Receive Field Support Codes: 'U' - Field shall be used or stored if present. 'R' - Field required by implementation. 'I' - Field may be ignored if present.	
Field	**Code**
push-header.sched-version	U
push-header.version-number	U
push-header.updates-since	U
push-header.applicability	U
push-header.applicability.applicable-routes	R
push-header.applicability.applicable-routes.agency-id	R
push-header.applicability.applicable-routes.route-designator	I
push-header.applicability.applicable-routes.route-name	U
push-header.applicability.applicable-ptvs	I
push-header.applicability.applicable-stops	I
push-header.applicability.applicable-facilities	I
push-header.applicability.applicable-garages	I
push-header.applicability.applicable-fleet-subsets	I
push-header.applicability.applicable-stoppoint-subsets	I

Annex 2A.1 (SchPushRunningTimes)		
push-header.applicability.applicable-fare-subsets	I	
running-times.period-name	U	
running-times.service-types	U	
running-times.earliest-time	U	
running-times.latest-time	U	
running-times.day-types	U	
running-times.stoppointA	U	
running-times.stoppointA.agency-id	R	
running-times.stoppointA.name	U	
running-times.stoppointB	U	
running-times.stoppointB.agency-id	R	
running-times.stoppointB.name	U	
running-times.timepointA	U	
running-times.timepointA.agency-id	R	
running-times.timepointA.designator	I	
running-times.timepointA.name	U	
running-times.timepointB	U	
running-times.timepointB.agency-id	R	
running-times.timepointB.designator	I	
running-times.timepointB.name	U	
running-times.pattern	U	
running-times.pattern.agency-id	R	
running-times.pattern.designator	I	
running-times.pattern.name	U	
running-times.pattern-segment	U	
running-times.pattern-segment.agency-id	R	
running-times.pattern-segment.name	U	
running-times.waiting-times	U	
running-times.waiting-times.stoppoint	R	
running-times.waiting-times.stoppoint.agency-id	R	
running-times.waiting-times.stoppoint.name	U	
running-times.waiting-times.other-location	I	
Local Field Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Type**	**Code**
No local field extensions are defined for this message.		

Annex 2A.1 (SchPushRunningTimes)		
Local Code Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Data Element**	**Local Code**
No local code extensions are defined for this message.		

File Import Procedure:
With the CAD application running, go to the File Menu & Select Import. Browse to the file to be imported. Select the appropriate file type from the drop-down list.

File Attributes & Limitations:
Message files cannot exceed 2MB.

8.3.6 Locally Defined Extensions

PICS Requirement: The PICS shall specify any supported locally defined extensions to TCIP messages and/or message files sent or received by the implementation. Local extension field support shall be documented in the same manner as optional fields in Section 8.3.5 above.

Example:

Local Extension Fields Defined in tcip_2_7_local.xsd			
Field			**Code**
alarms.nyct-alarm-descriptor			R
Local Code Extensions Defined in tcip_2_7_local.xsd			
Field	**Data Element**	**Local Codes**	**Code**
alarms.other-alarms	CC-AlarmCode	nyct-breaker-trip(128)	U
alarms.other-alarms	CC-AlarmCode	nyct-door-alarm(129)	U

8.3.7 Conformance Class 1B Specific PICS Requirements

PICS Requirement: The PICS for a Class 1B Conformant TCIP Interface Implementation shall specify the narrowband encoding scheme supported by the interface including any implementation specific limitations:

Examples:

Conformance Class 1B: TCIP Narrowband Encoded Dialogs
Message Encoding Specification: This implementation supports ASN.1 PER for encoding TCIP messages.
Message Encoding Limitations: This implementation supports a maximum PER-encoded message length of 512 Octets.
Conformance Class 1B: TCIP Narrowband Encoded Dialogs
Message Encoding Specification: This implementation supports TCIP Narrowband encoding as defined in TCIP Version 2.7 Annex I.
Message Encoding Limitations: This Implementation supports a maximum TCIP Narrowband-encoded message length of 512 Octets.

8.3.8 Conformance Class 2A Specific PICS Requirements

PICS Requirement: The PICS for a Class 2A Conformant TCIP Interface Implementation shall:

- Specify the file naming convention(s) for the file(s) to be consumed by the Implementation.
- Specify any implementation operating system dependencies, and/or operating system file specific attributes.
- Specify the procedure for importing the file from another system

Example:

File Import Procedure: With the CAD application running, go to the File Menu & Select Import. Browse to the file to be imported. Select the appropriate file type from the drop-down list.
File Attributes & Limitations: Message files cannot exceed 2MB.

8.3.9 Conformance Class 2B Specific PICS Requirements

PICS Requirement: The PICS for a Class 2B Conformant TCIP Interface Implementation shall:

- Specify the file naming convention(s) for the file(s) to be produced by the Implementation.
- Specify any implementation operating system dependencies, and/or operating system file specific attributes.
- Specify the procedure for exporting the file to another system

Example:

File Export Procedure: With the CAD application running, go to the File Menu & Select Export. In the dialog box specify the folder and file name to be created. Select the appropriate file type from the drop-down list. FIll in the dates in the text boxes provided. Click on Export.
File Attributes & Limitations: Message files must not exceed 1MB.

8.3.10 PICS Protocol Requirements

The PICS shall define the communications protocol(s) supported by the implementation.

8.3.11 PICS WSDL Requirements

The PICS shall specify whether the implementation provides port definitions using Web Services Design Language (WSDL).

8.4 PRL Requirements

A sample PRL is included in Annex K.

8.4.1 TCIP Version

PRL Requirement: The PRL shall specify the TCIP version or versions to be supported by the implementation for each required dialog and/or message file.

Examples

Conformance Class 2A: TCIP Message Files Accepted		
Project Component: Example CAD System		
External Component: Example Data Warehouse		
File Attributes & Limitations: Message files cannot exceed 2MB.		
TCIP Message Name	**TCIP Version**	**PICS Annex**
SchPushRunningTimes	3.0.2	2A.1

Conformance Class 1A: Supported Dialogs			
Project Component: Example CAD System			
External Component: Example Data Warehouse			
Dialog Name	**Role**	**TCIP Version**	**PRL Annex**
Notify Trip Cancellations	Notifier	3.0.2	1A.1
Publish Block Schedule	Subscriber	3.0.2	1A.2
Publish Calendar	Subscriber	3.0.2	1A.3
Publish Master Schedule Version	Subscriber	3.0.2	1A.4
Publish Run Schedule	Subscriber	3.0.2	1A.5
Publish Route Schedule	Subscriber	3.0.2	1A.6
Publish Pattern List (with spatial data)	Subscriber	3.0.2	1A.7
Publish Operator Assignments (bound)	Subscriber	3.0.2	1A.8
Publish Timepoint List	Subscriber	3.0.2	1A.9

Conformance Class 2B: TCIP Message Files Generated	TCIP Version	PICS Annex
Project Component: Example CAD System		
External Component: Example Data Warehouse		
File Attributes & Limitations: Message files are not generated by this implementation.		
TCIP Message Name		
TspEventLogUnload	3.0.2	2B.1

8.4.2 Conformance Class(s)

PRL Requirement: The PRL shall specify the required TCIP Conformance class(es) to be supported by the implementation. For class 1 the PRL shall specify the dialogs and roles to be supported by the implementation. For class 2 the PRL shall specify the messages to be consumed and/or produced.

Examples

Conformance Class 2A: TCIP Message Files Accepted		
Project Component: Example CAD System		
External Component: Example Data Warehouse		
File Attributes & Limitations: Message files cannot exceed 2MB.		
TCIP Message Name	**TCIP Version**	**PICS Annex**
SchPushRunningTimes	3.0.2	2A.1

Table 0-1

Conformance Class 2B: TCIP Message Files Generated	TCIP Version	PICS Annex
Project Component: Example CAD System		
External Component: Example Data Warehouse		

File Attributes & Limitations: Message files are not generated by this implementation.		
TCIP Message Name		
TspEventLogUnload	3.0.2	2B.1

8.4.3 Network Address

PRL Requirement: The PRL shall specify the IP addresses and port numbers or alternative network and 325transport addressing parameters assigned by the transit agency for use by the implementation, both to identify itself and to identify other interfaces with which it communicates.

Example:

Project Name: Example CAD		
Agency/Company Name: Greater Richmond Transit Company	**Agency ID:** 3006	**Agency Model:** Multi
Project Component:	**IP/Network Address:**	**Port/Transport Address:**
Example CAD System	10.5.3.7	8088
External Component:	**IP/Network Address:**	**Port/Transport Address:**
Example Data Warehouse	10.5.2.2	8088

8.4.4 Non-conformant TCIP Features and Non-TCIP Interfaces

PRL Requirement: The PRL shall specify any non-TCIP interfaces required for the implementation. The PRL shall specify any deviations from the TCIP standard required to adapt TCIP interface(s) to legacy systems which are not fully TCIP conformant.

Example:

Non TCIP Interfaces Supported: Example CAD provides a daily archive data set to the warehouse using an agency-specified transfer mechanism.
Exceptions to TCIP Requirements: None

8.4.5 Optional Fields for Messages

PRL Requirement: The PRL shall specify what optional fields defined in the TCIP standard shall be supported by the implementation. This requirement includes optional fields in the message definition, as well as optional fields within frames contained in the message.

Each optional field in received messages or message files shall be specified as one of :

- U – Field shall be used and/or stored by the implementation if present
- R – Field shall be used and/or stored by the implementation if present, and may be regarded as an error condition if the field is absent
- I – Field may be ignored by the implementation if present, however presence or absence of the field shall not cause an error condition.

Each optional field in produced messages or message files shall be specified as one of :

- A – Field shall always be included by the implementation.
- N- Field shall never be included by the implementation.
- C- Field shall be included by the implementation under specified conditions.
- D – Field may or may not be included by the implementation (don't care).

If an optional field in a produced message or message file is specified as 'C', then the PRL shall specify the conditions under which the implementation must include the field. The enumeration of the usage status of optional fields in a message need not include the contents (children) of any frame that is specified as Ignore on receipt, or is specified as Never sent.

Examples:

<table>
<tr><td colspan="2">PRL Dialog Requirements</td><td rowspan="11">C[1]</td></tr>
<tr><td colspan="2">Project Component:
Example CAD System</td></tr>
<tr><td colspan="2">External Component:
Example Data Warehouse</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Dialog Name:
Notify Trip Cancellations</td></tr>
<tr><td colspan="2">Dialog Role:
Notifier</td></tr>
<tr><td colspan="2">Send Message Name:
CcCancelTrips</td></tr>
<tr><td colspan="2">Optional Send Field Support Codes:
'A' - Field shall always be sent.
'N' - Field shall never be sent.
'C' - Field shall conditionally be sent.</td></tr>
<tr><td>Field</td><td>Code</td></tr>
<tr><td>cancel-records.cancelled-trips.agency-id</td><td>A</td></tr>
<tr><td>cancel-records.cancelled-trips.designator</td><td>N</td></tr>
</table>

cancel-records.day-types	
cancel-records.specific-dates	C[2]

Annex 2A.1 (SchPushRunningTimes)	
PRL Receive Message File Requirements	
Project Component: Example CAD System	
External Component: Example Data Warehouse	
Receive Message Name: SchPushRunningTimes	
Optional Receive Field Support Codes: 'U' - Field shall be used or stored if present. 'R' - Field required by implementation. 'I' - Field may be ignored if present.	
Field	**Code**
push-header.sched-version	U
push-header.version-number	U
push-header.updates-since	U
push-header.applicability	U
push-header.applicability.applicable-routes	R
push-header.applicability.applicable-routes.agency-id	R
push-header.applicability.applicable-routes.route-designator	I
push-header.applicability.applicable-routes.route-name	U
push-header.applicability.applicable-ptvs	I
push-header.applicability.applicable-stops	I
push-header.applicability.applicable-facilities	I
push-header.applicability.applicable-garages	I
push-header.applicability.applicable-fleet-subsets	I
push-header.applicability.applicable-stoppoint-subsets	I
push-header.applicability.applicable-fare-subsets	I
running-times.period-name	U
running-times.service-types	U
running-times.earliest-time	U
running-times.latest-time	U
running-times.day-types	U
running-times.stoppointA	U
running-times.stoppointA.agency-id	R

Annex 2A.1 (SchPushRunningTimes)		
running-times.stoppointA.name	U	
running-times.stoppointB	U	
running-times.stoppointB.agency-id	R	
running-times.stoppointB.name	U	
running-times.timepointA	U	
running-times.timepointA.agency-id	R	
running-times.timepointA.designator	I	
running-times.timepointA.name	U	
running-times.timepointB	U	
running-times.timepointB.agency-id	R	
running-times.timepointB.designator	I	
running-times.timepointB.name	U	
running-times.pattern	U	
running-times.pattern.agency-id	R	
running-times.pattern.designator	I	
running-times.pattern.name	U	
running-times.pattern-segment	U	
running-times.pattern-segment.agency-id	R	
running-times.pattern-segment.name	U	
running-times.waiting-times	U	
running-times.waiting-times.stoppoint	R	
running-times.waiting-times.stoppoint.agency-id	R	
running-times.waiting-times.stoppoint.name	U	
running-times.waiting-times.other-location	I	
Local Field Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Type**	**Code**
No local field extensions are defined for this message.		
Local Code Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Data Element**	**Local Code**
No local code extensions are defined for this message.		

Annex 2B.1 (TspEventLogUnload)
PRL Generated Message File Requirements
Project Component: Example CAD System

Annex 2B.1 (TspEventLogUnload)	
External Component: Example Data Warehouse	
Send Message Name: TspEventLogUnload	
Optional Send Field Support Codes: 'A' - Field shall always be sent. 'N' - Field shall never be sent. 'C' - Field shall conditionally be sent.	
Field	**Code**
fileHeader.vehicle	C[1]
fileHeader.vehicle.agency-id	A
fileHeader.vehicle.vin	C[2]
fileHeader.component-identifier	C[3]
fileHeader.component-IP	C[4]
fileHeader.component-Port	C[5]
fileHeader.stoppoint	C[6]
fileHeader.stoppoint.agency-id	A
fileHeader.stoppoint.name	C[7]
fileHeader.field-address	C[8]
fileHeader.field-port	C[9]
fileHeader.applicability	C[10]
fileHeader.applicability.applicable-routes	A
fileHeader.applicability.applicable-routes.agency-id	A
fileHeader.applicability.applicable-routes.route-designator	N
fileHeader.applicability.applicable-routes.route-name	C[11]
fileHeader.applicability.applicable-ptvs	N
fileHeader.applicability.applicable-stops	N
fileHeader.applicability.applicable-facilities	N
fileHeader.applicability.applicable-garages	N
fileHeader.applicability.applicable-fleet-subsets	N
fileHeader.applicability.applicable-stoppoint-subsets	N
fileHeader.applicability.applicable-fare-subsets	N
event-log.intersection.agency-id	A
event-log.intersection.tmdd-id	C[12]
event-log.intersection.name	C[13]
event-log.requestID	C[14]
event-log.request-time	C[15]
event-log.disposition	C[16]

Annex 2B.1 (TspEventLogUnload)		
event-log.disposition-time	C[17]	
event-log.granted	C[18]	
event-log.grant-duration	C[19]	
event-log.grant-records	C[20]	
event-log.vin	C[21]	
event-log.vehicleClassType	C[22]	
event-log.serviceStrategyNumber	C[23]	
event-log.timeOfServiceDesired	C[24]	
event-log.timeOfEstimatedDeparture	C[25]	
event-log.preemption-vehicle	C[26]	
event-log.actual-wait-time	C[27]	
event-log.strategyEmployed	C[28]	
Local Field Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Type**	**Code**
No local field extensions are defined for this message.		
Local Code Extensions Defined in tcip_3_0_1_local.xsd		
Field	**Data Element**	**Local Code**
No local code extensions are defined for this message.		

8.4.6 Locally Defined Extensions

PRL Requirement: The PRL shall specify any locally defined extensions to TCIP messages and/or message files to be sent or received by the implementation. Local extension requirements shall be documented in the same manner as optional fields in 8.4.5 above.

Example:

Local Extension Fields Defined in tcip_3_0_2_local.xsd			
Field			**Code**
alarms.nyct_alarm_descriptor			R
Local Code Extensions Defined in tcip_3_0_2_local.xsd			
Field	**Data Element**	**Local Codes**	**Code**
alarms.other-alarms	CC-AlarmCode	nyct-breaker-trip (128)	U
alarms.other-alarms	CC-AlarmCode	nyct-door-alarm (129)	U

8.4.7 Conformance Class 1B Specific PRL Requirements

PRL Requirement: The PRL for a class 1B TCIP interface shall specify the narrowband encoding scheme to be supported by the interface, including any known limitations.

Examples:

Conformance Class 1B: TCIP Narrowband Encoded Dialogs
Message Encoding Specification: The implementation shall support ASN.1 PER for encoding TCIP messages.
Message Encoding Limitations: The implementation shall support a minimum PER-encoded message length of 500 Octets.

Conformance Class 1B: TCIP Narrowband Encoded Dialogs
Message Encoding Specification: The implementation shall support TCIP Narrowband encoding as defined in TCIP Version 2.7 Annex I.
Message Encoding Limitations: The Implementation shall support a minimum TCIP Narrowband-encoded message length of 500 Octets.

8.4.8 Conformance Class 2 Specific PRL Requirements

PRL Requirement: The PRL for a class 2 (A or B) TCIP interface shall

- Specify the file naming convention to be used by the producing and consuming implementations.
- Specify any required operating system dependencies and/or operating system file specific attributes required of the implementation(s).

Example:

Conformance Class 2A: TCIP Message Files Accepted
Project Component: Example CAD System
External Component: Example Data Warehouse
File Attributes & Limitations: Message files cannot exceed 2MB.

Conformance Class 2B: TCIP Message Files Generated
Project Component:

Conformance Class 2B: TCIP Message Files Generated
Example CAD System
External Component: Example Data Warehouse
File Attributes & Limitations: Message files are not generated by this implementation.

8.4.9 PRL Protocol Requirements

The PRL shall define the communications protocols to be used in the implementation.

8.4.10 PRL WSDL Requirements

The PRL shall specify whether the agency requires port definitions using Web Services Design Language (WSDL).

8.5 XML Encoding Conformance Requirements

TCIP XML messages and message files produced by the TCIP Implemented Interfaces (Conformance Classes 1A, and 2B) shall meet the requirements in the following subsections.

8.5.1 TCIP XML Schema

8.5.1.1 XML Namespace

The Namespace for the TCIP XML Schema shall be:

<xs:schema_ targetNamespace=http://www.tcip-address
xmlns="http://www.tcip-address">

Conventional XML namespace prefixes are used throughout the listings in this standard to stand for their respective namespaces. In addition, imported ITS data dictionary objects use the prefixes as follows:

- The prefix atis: stands for the Advanced Transportation Information System namespace [N-5]
- The prefix tmdd: stands for the Traffic Management Data Dictionary namespace [N-6]
- The prefix lrms: stands for the Location Reference Message Specification namespace [N-4]
- The prefix im: stands for the Incident Management Specification namespace [N-9]. This is not to be confused with the TCIP IM TCIP business area.
- The prefix itis: stands for the International Traveler Information Systems Phrase List namespace [N-7].

[Editor's Note*:* As of the release of TCIP Version 2.7, the ITS standards community was still discussing alternative namespace definition and schema file naming conventions. These conventions may therefore change in subsequent TCIP releases.]

8.5.1.2 Versioning

The TCIP XML Schema has a version number inherited from the version of the TCIP standard in which it is defined. The schema version number shall be conveyed as an attribute in each XML instance file and/or message (example: **schversion= “TCIP 2.7”**). The schema version is conveyed as an attribute in the schema file (example: **version= “TCIP 2.7”**).

8.5.1.3 Schema Generation

The TCIP data elements, frames and messages as described in the Data Description Language (DDL) of the Abstract Syntax Notation One (ASN.1) are translated to a TCIP XML Schema using the ITSware Mini-Edit utility. The XML translations performed by this utility generally conform to the SAE “Converting ATIS Message Standards from ASN.1 to XML Rev. 1.0” [I-10]. The TCIP XML Schema is included in Annex E. The schema creation date and time is included in the schema as a comment.

8.5.2 XML Message and Message File Instances

8.5.2.1 XML Message and Message File Instance Attributes

All TCIP XML Message and Message File instances produced by Conformance Class 1A or 2B Implemented Interfaces may include the attributes listed in Table 8.5.2.1. The attributes shall be conveyed using the “tcipMsgAttributes” attribute group defined in the schema. TCIP Implemented Interfaces that generate messages/files may provide additional attributes. Agencies may require additional attributes to be included in any purchased TCIP Implemented Interfaces. Agencies specify the sourceip and sourceport values in the PRL. Agencies that use non-IP networks may specify alternate content for the sourceip and source port fields in the PRL.

Table 8.5.2.1

Optional Attributes in TCIP XML Message and File Instances

Attribute Name	**Type**	**Example**
created	xs:datetime	created= “2006-10-04T19:59:01”
schversion	xs:string	schversion = “TCIP 2.7”
sourceapp	xs:string	sourceapp= “SampleTran Data Repository”
sourceip	xs:string	sourceip= “130.102.103.115”
noNameSpaceSchema Location	xs:string	noNamespaceSchemaLocation= “tcip_2_7.xsd”

8.5.2.2 XML Message Instance Recommended File Naming Conventions

When more than one TCIP XML Message File instance is produced for use in file-based information exchanges, the recommended naming convention for the files shall be:

TCIP_Message_Name_x_y.xml

Where

Message_Name refers to the formal message name;
x refers to the file number; and
y refers to the total number of files

For example, if a scheduling system produced 3 SchRouteSchedule files they would be named:

TCIP_SchRouteSchedule_1_3.xml
TCIP_SchRouteSchedule_2_3.xml
TCIP_SchRouteSchedule_3_3.xml

Agencies that require files to be maintained in the same folder, may specify that the datetime of the file creation be added in the form:

_YR_MO_DY_HR_MN_SC

where YR is the Year, MO is the Month number, DY is the day of the month, HR is the Hour of the day, MN is the Minutes of the hour, and SC is the Second of the minute. If these same files had been produced on October, 4, 2004, at 2:03:26 PM, under this convention they would be named:

TCIP_SchRouteSchedule_1_3_04_10_04_14_03_26.xml
TCIP_SchRouteSchedule_2_3_04_10_04_14_03_26.xml
TCIP_SchRouteSchedule_3_3_04_10_04_14_03_26.xml

Internal XML instance attributes of each file may provide further details.

8.6 TCIP Narrowband Encoding

TCIP defines an example narrowband message encoding scheme in Annex I of this document. This protocol may be used to exchange TCIP messages across a communications medium with limited capacity. Agencies are NOT obligated to use this encoding scheme to achieve Class 1B conformance, other agency defined (or designated) protocols are available and may be used for this purpose.

If an agency does elect to use the TCIP Narrowband Encoding to implement a Class 1B conformant interface, the Implemented Interface shall meet all requirements defined in Annex I in order to be designated a TCIP conformant implementation.

8.7 TCIP Polling

TCIP defines an example polling protocol in Annex J. This protocol may be used in conjunction with the TCIP narrowband encoding to provide TCIP communications across an agency private radio link. Agencies are NOT obligated to use this protocol to achieve TCIP conformance.

If an agency does elect to use the TCIP Polling protocol, then the implementation of the VLU and the Polling Controller shall meet all of the requirements of Annex J in order to be designated a TCIP Polling Protocol conformant implementation.

8.8 Subset XML Schemas

An agency may elect to use a subset TCIP schema that only includes those data elements, data frames, and messages which may be sent or received by an implementation. This approach provides for faster message parsing and validation, but incurs some risk of additional cost and effort in schema maintenance. If a subset schema is used, the schema file name should contain the post fix "__ Partial". For example, if "TCIP_3_0_FINAL.xsd" was subsetted, the file name would become "TCIP_3_0_0_Partial.xsd.

9.0 Procuring TCIP Conformant Systems

9.1 Agency ITS Architecture

The foundation of successful agency procurements for Intelligent Transportation Systems (ITS) is the transit agency ITS architecture. An agency ITS architecture is the repository for capturing and documenting the agency's legacy and planned business systems, legacy interfaces, as well as the TCIP interfaces. The agency ITS architecture may specify a series of development phases for the agency's ITS systems. The architecture characterizes the agency's current and planned Intelligent Transportation Systems (ITS). It includes the identification of business systems, field components, mobile components as well as external business systems with which the agency interacts.

Ideally the architecture provides a roadmap of the planned evolution of the agency's systems over an extended planning horizon (e.g., 15 years). The agency ITS architecture cannot, however be developed in isolation. The agency may need to participate in planning the regional ITS architecture which incorporates planning from other transit agencies, other modes and public safety agencies. The agency ITS architecture needs to be consistent with the agency's business plans and funding constraints. This may include consideration of facilities being built or remodeled, fleet (or fleet subset) purchases, new routes to be added to (or routes to be deleted from) the agency network.

The agency ITS architecture also identifies the interfaces among ITS components, agency business systems, and external business systems. These interfaces may be TCIP interfaces, other standards-based interfaces (e.g., SAE J1939/J1587) or proprietary legacy interfaces. As the agency evolves its ITS systems according to its architecture, some of these interfaces will be replaced, upgraded, and new interfaces may be added. In each case TCIP may be the right answer for the new or upgraded interface.

For example, an agency might transfer schedules from its scheduling system to its CAD/AVL system using a floppy disk with a file in a proprietary format. When the agency replaces the scheduling system it may upgrade to a TCIP interface which may be based on file transfers or dialogs. The CAD/AVL System would either have its interface upgraded along with the scheduling system, or a translator might be used to convert the TCIP messages to the legacy format until the CAD/AVL System is replaced, by a new CAD/AVL System with TCIP capabilities.

Another example is that annunciator information (e.g., announcement audio and text) might be loaded to the PTV using flash cards, or a laptop in a proprietary format. At some point in time the annunciator might be upgraded with a translator that allows the file transfers to be done using TCIP message files rather than a proprietary format. A later upgrade might occur to allow the annunciator to load the information using a TCIP dialog when a wireless LAN is installed, reducing the labor and time required to update the announcements on a fleetwide basis.

The agency ITS architecture may or may not resemble the TCIP Model Architecture described in Section 4. Agency ITS architectures will define the allocation of functions to components and business systems as deemed appropriate for each agency. Agency ITS architectures can then map the provided TCIP dialogs and file transfers to the interfaces identified in their architecture.

9.2 Agency RFPs

The process for procuring ITS Business Systems and components is usually based on a Request for Proposal (RFP). An RFP specifies the technical, business, legal and project management requirements for a system being procured by an agency. The business and legal requirements for an ITS procurement are usually based on the agencies policies and standard practices. The technical and project management areas of the RFP are driven by the agency ITS architecture and business plans.

In developing the technical specifications for the new system, the starting point is the description of the system in the agency ITS architecture. The description of the system in the agency ITS architecture is expanded to include more detailed operational and functional requirements. These elaborated requirements allow the agency to then further elaborate the details of the TCIP interfaces identified for the new system. The agency's elaborated requirements for TCIP interfaces are documented in an agency's Profile Requirements List (PRL), which is included with the RFP Technical Specification. The agency PRL defines the specific TCIP file transfers and/or dialogs that the agency requires to be supported by the new system. A PRL is also an appropriate means for an agency to capture their requirements for an interface upgrade (e.g., for a change order to upgrade an existing system to TCIP).

Agencies often have substantial amounts of existing legacy data which may not be in TCIP format. Agencies may also have legacy business systems which use data in non-TCIP formats. In developing the Technical Specifications for the RFP, agencies should identify this information and document the relationships between the legacy data and the TCIP equivalents. Alternatively, the agency may provide their legacy data definitions with the RFP, and require the developer to map the legacy data to TCIP. In general, agencies can expect to discover that legacy data is expressed using different data elements then TCIP, (e.g., may use code numbers different from TCIP, may have different units of measure, miles-per-hour versus feet-per-second, etc. Agencies may also expect to find that the data structures (data frames and messages in TCIP) are differently organized than their legacy data.

Developers may also have legacy implementations which may contain proprietary interfaces and data models. The agency RFP may indicate the extent to which proprietary interface protocols, data elements and messages are acceptable to the agency. If such interfaces are permitted, the RFP should indicate the extent to which the agency requires those interface definitions to be disclosed to the agency and/or placed into the public domain by the developer.

Agencies may determine in the course of the analysis of their legacy data that some legacy data elements or messages are appropriate for addition to the TCIP Standard. Agencies may submit comment forms to APTA proposing the addition of these items to the next release of the standard.

Figure 9.2 depicts the elements of TCIP in the context of agency procurements.

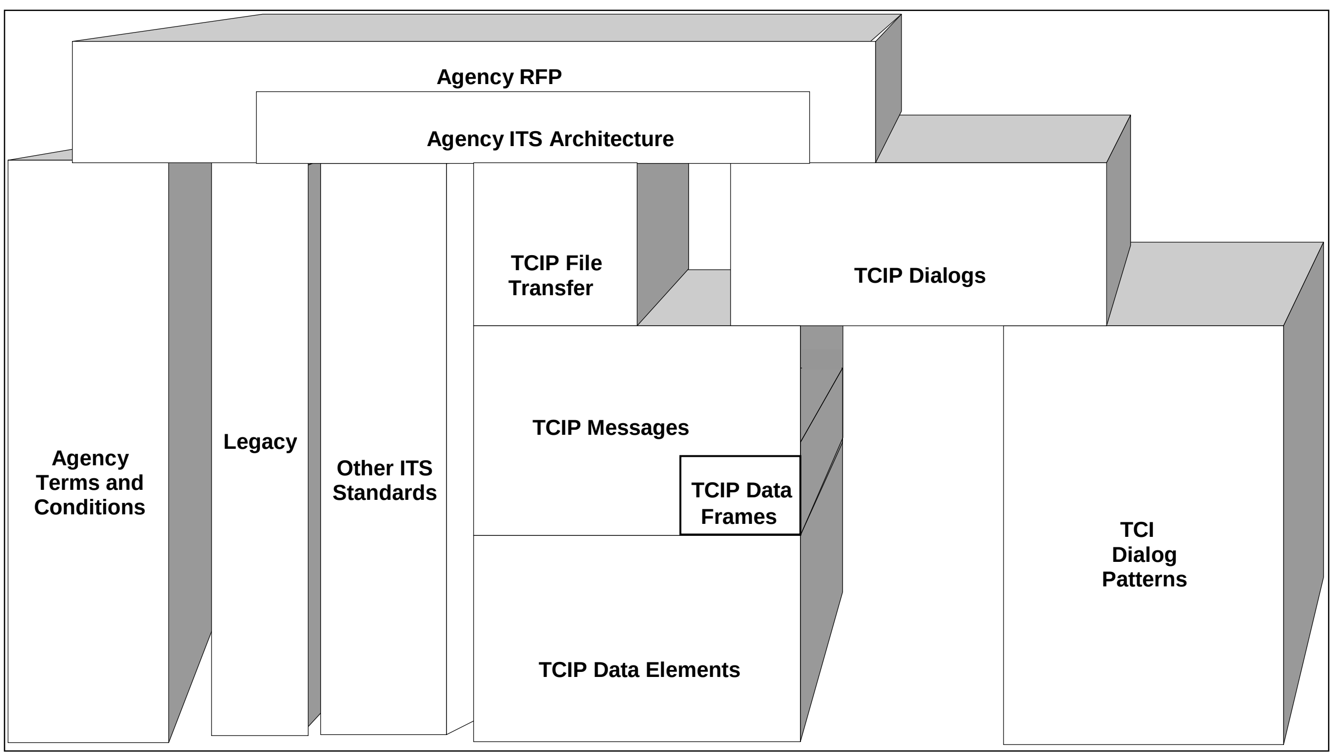


Figure 9.2 TCIP Provides the Building Blocks for Agency ITS architectures and RFPs

9.3 Proposals

The agency RFP normally specifies proposal requirements to ensure that all of the received proposals cover the same topics so that a meaningful comparison can be made between competing developer offerings. This provides an opportunity for the agency to specify that the developer provide the PICS and test plans for the TCIP interfaces to be provided as part of the proposal.

The agency may require that the PICS be provided in a matching format with the agency PRL to facilitate comparisons between the two documents. Annex K provides an example of a PRL and PICS in matching formats.

The test plans provided in the proposal should specify:

- How the developer will demonstrate/prove to the agency that the supplied interface meets every requirement in the agency PRL and every applicable requirement in this standard (refer to section 8 for TCIP conformance requirements).
- How the developer will record test results and provide these results in an understandable form to the agency.
- How the developer will demonstrate/prove to the agency that the required (either by the standard or by the PICS) fields in the TCIP messages are present (sender) and used (receiver), and that proprietary information flows or developer added proprietary fields have not been used to supplant TCIP data fields.
- If the other end of a required interface is not available when the system is delivered, how the developer will emulate the missing component and demonstrate the correct operation or the provided ‘end’ of the interface.

The developer’s PICS define the interfaces that the developer proposes to provide. Ideally the developer PICS should demonstrate that the developer will deliver a superset of the interface requirements defined in the agency PICS. The developer PICS may demonstrate, on the other hand, that the developer proposes to provide less than what the agency required in their PICS. In such cases, the agency will need to determine whether to ask the developer to correct the deficiency, declare the developer non-responsive, rate the developer’s proposal as technically interior to competitors, or accept the deficiency.

9.4 Design Phase

After contract award for an ITS project, the successful bidder normally begins a design phase. During this phase final details of the project are worked out and documented. This normally includes obtaining additional detailed information from the agency that was not provided in the RFP, and designing hardware and/or software customizations to the product specific to the application. This includes changes to interfaces to allow the supplied system to communicate with other agency systems.

During the design phase, the developer provides detailed designs and test procedures for the TCIP interfaces to the agency for approval. Design documents should reflect the implementation-applicable requirements from the PRL, the developer’s PICS (submitted with the proposal), the RFP and the TCIP Standard. Design documentation normally also includes drawings and plans for equipment installations in the agency facilities. Test procedures should define the step by step process for setting up and conducting the tests, and any special equipment required (e.g., test equipment), initial and post test conditions, and pass/fail criteria for each test.

9.5 Factory Acceptance Test (FAT)

After the design phase of the project, the developer implements the agency-approved design. Once the product(s) are implemented, the developer sets up the ITS system-usually in a laboratory at the factory location, and invites agency representatives to observe the operation of the product. FAT may be performed with less than the full complement of peripheral equipment, so some interfaces may be connected to a test environment that emulates the agency's infrastructure.

During FAT, the developer executes all or most of the test procedures approved in the design phase. Some tests may be deferred until the installation or system acceptance test phases.

9.6 Installation Test

After successful completion of the FAT, the developer ships the ITS equipment to the customer site, and installs it according to the installation design approved in the design phase. The developer tests the equipment, with agency representative(s) observing, to verify that the equipment functions as intended when installed at the agency site. If the equipment is dispersed at numerous locations (e.g., installed on PTVs or at stoppoints), there may be a series of installation tests, on per location basis.

The installation tests are usually an agreed-upon subset of the suite of tests defined during the design phase. Interface testing is to test the supplied equipment connected to its 'real' interfaces, as opposed to test equipment and/or emulators.

9.7 System Acceptance Test

After the installation is completed, the developer performs a set of end-to-end system tests intended to verify that all of the required system functionality is present and working. This includes all interfaces. Note that some interfaces may have been completely or partially tested during the installation test, however retesting during the acceptance test phase ensures that the system works with everything installed, up and running.

The System Acceptance Test normally also includes a reliability test in which the system must function for an extended period (e.g., 30 days) with a limited number of faults. Faults may be segmented into categories as part of the test procedure definitions. For example, in installing a large closed circuit television system, some defined limited number of camera failures may be 'allowed' during the reliability test, whereas no failures of the central server during the 30 day period would be allowed.

10 TCIP Communications

10.1 Overview

TCIP communications are the realizations of the 6 networks defined in section 4.2. These networks generally fall into four major categories:

- Fixed point to fixed point communications
- Wireless wideband communications
- Wide area (mobile) communications – public networks
- Wide area (mobile) communications – private networks

Agencies may implement many variations on these networks without impacting TCIP conformance. The descriptions below of these four network types are generalized and informative only.

10.2 Fixed Point to Point Communications

These communications are both wide-area and local-area, and usually tied to Internet technologies. Local area networks are usually based on TCP/IP or UDP/IP over Ethernet or token ring networks. Local area networks may be extended over a wide area (between facilities) using a variety of fiber optic and wire-based technologies, or using leased communications from public carriers (phone companies). Figure 10.2 depicts a typical fixed point to point communications networks.

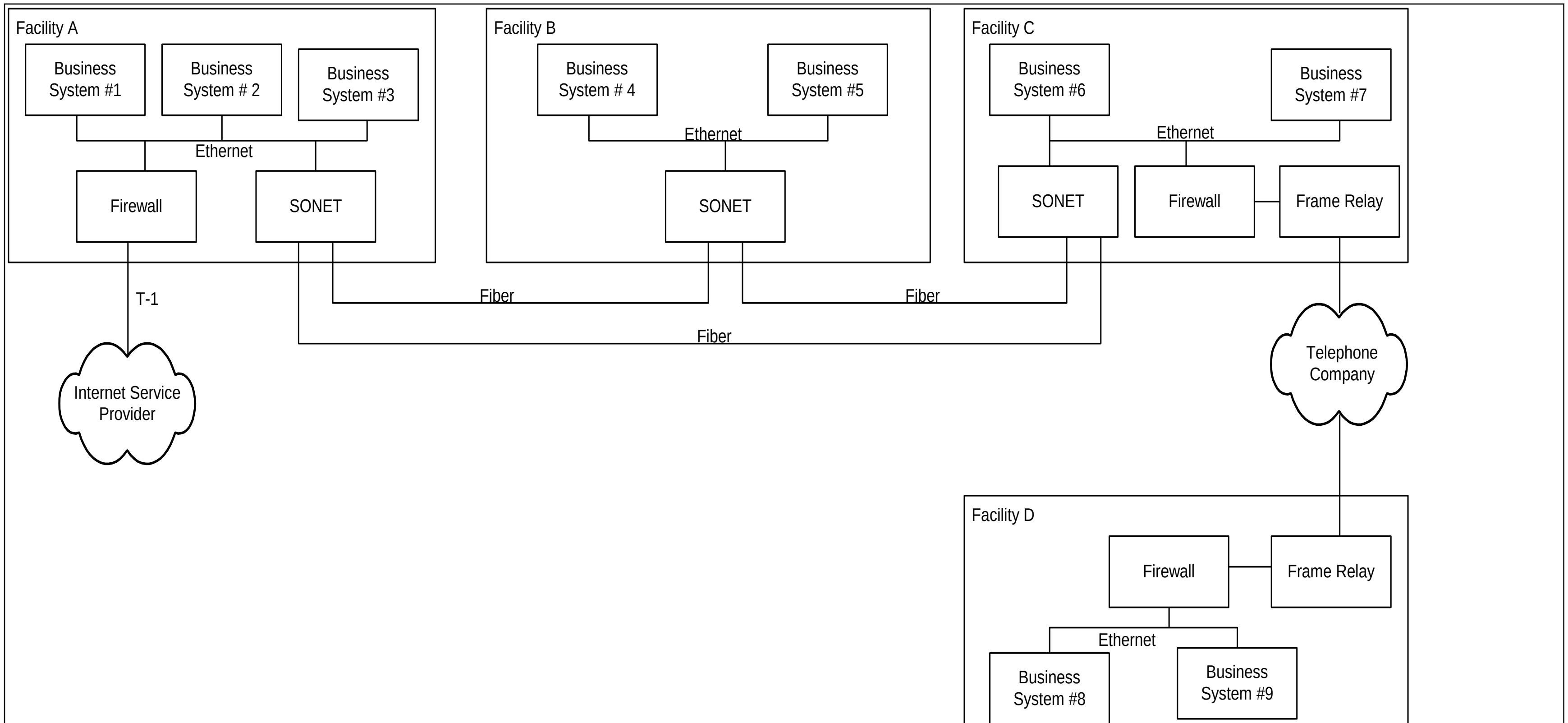


Figure 10.2
Generic Transit Agency Fixed Point to Point Network

Figure 10.2 depicts an agency which provides access to its business systems via the Internet via a single firewall in facility A. Facilities A-C are connected by a SONET fiber loop which provides a level of redundancy, and protection against fiber failures. Communications within each facility use Ethernet LANs, however the example could have used token ring communications instead. Communications to/from facility D are via a telephone company provided frame relay connection. Each LAN in the diagram could have workstations connected (not shown) along with a variety of hubs, routers, and switches within the Ethernet LAN.

TCIP communications, as well as data communications defined by other standards, can be exchanged over all of this fixed communications infrastructure. For example, Business Systems 1 and 8 could be executing a TCIP dialog, while business systems 3 and 5 are performing a TCIP file transfer, and email could simultaneously being sent between workstations and business system #4 functioning as a mail server. Similarly customers using internet appliances might be accessing one of the business systems using an Internet appliance.

10.3 Wireless Wideband Communications

A variety of wireless wideband technologies are available in the market today. Most of these offerings extend high-speed TCP/IP or UDP/IP communications from a LAN to a workstation, computer or another LAN over a wireless link. Most of these products provide short range communications (less than 1 mile). These communications networks are often termed “wireless LANs”.

Wireless LANs provide portable and mobile users with high-speed access to agency business systems which facilitates the unteathered use of applications requiring large verbose data transfers (such as XML). Transit agencies use this technology extensively in and around garage areas. In these areas, wireless LANs enable data loads and unloads to/from PTVs, SPVs, and TMVs.

Figure 10.3 depicts a Wireless LAN configuration.

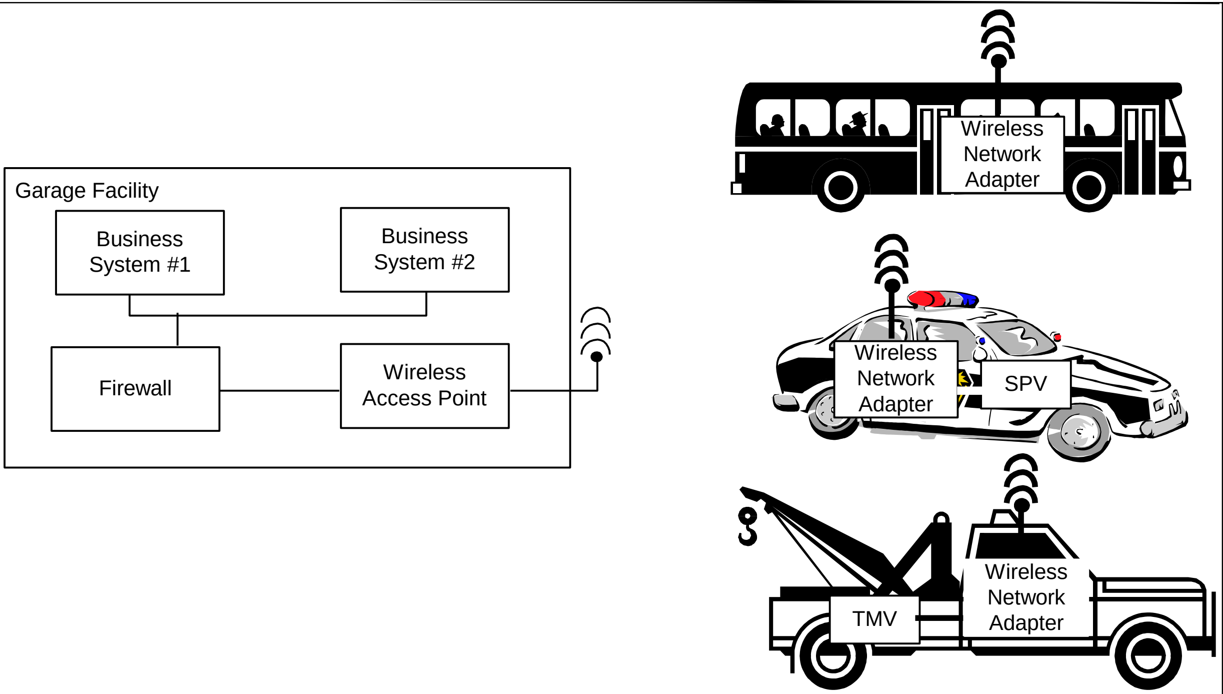


Figure 10.3
Transit Agency Wireless LAN Typical Configuration

10.4 Wide Area (Mobile) Communications – Public Networks

Transit agencies require data communications with enroute PTVs, SPVs, and TMVs. The communications may be provided via private networks (see section 10.5), or via a public network. Public networks generally offer a connection for TCP/IP or UDP/IP traffic over a wide area. The public network is shared with other non-transit users. The predominant public networks are based on cell phone technology. Public wireless service is provided on a for-fee basis. The calculation of fees varies widely by carrier, geographical area, and 'plan' offered by the carrier.

Agencies electing to use public networks gain the advantages of not needing to develop and maintain their own wireless infrastructure, but have little control over the performance or operations of those networks.

Figure 10.4 depicts a typical agency configuration using a public network.

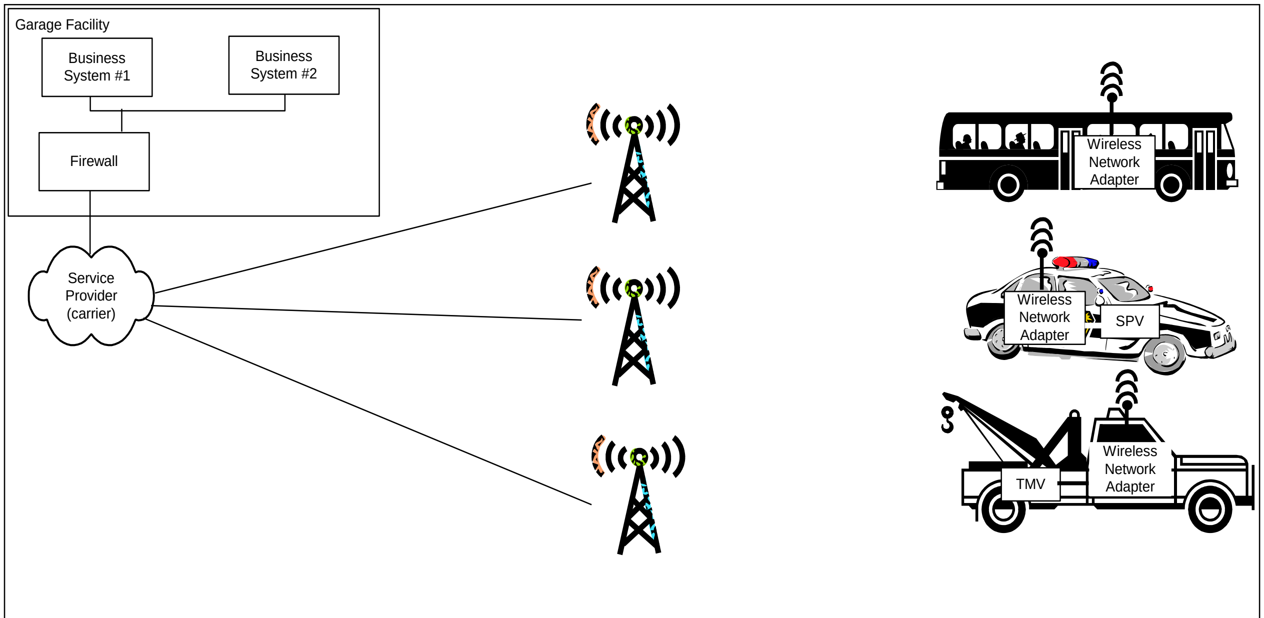


Figure 10.4

Transit Agency Public Network Typical Configuration

10.5 Wide Area (Mobile) Communications – Private Networks

Private data networks are usually comprised of:

- Agency-owned base and mobile radios
- Radio modems associated with each radio
- Communications circuits linking base stations with central
- Centrally located communications manager and/or polling controller
- Agency licensed radio channels

Agency-owned private radio networks allow the agency to exercise significant control over their wide area mobile networks. Agencies can adjust antenna types, aim and configuration, power levels, etc. Agency-owned networks are maintained by the agency or contractor, providing some control over this aspect of the network as well.

Transit agency private data radio networks are usually polled networks. The mobile radio may be shared between voice and data necessitating a mode change when switching between voice and data. Due to limited private radio channel allocations from the FCC, it is necessary to optimize the communications for a limited capacity network shared by many users within the transit agency. Typically messages are sent in some type of compressed or packed format across the radio channel. The communications protocol itself may be tailored to provide frequently changing information in an efficient format. Annex J defines such a protocol for transit. This protocol is available for use by interested agencies, but is NOT required to achieve TCIP conformance. Figure 10.5 A-B depicts a private radio system with separate data and voice radios.

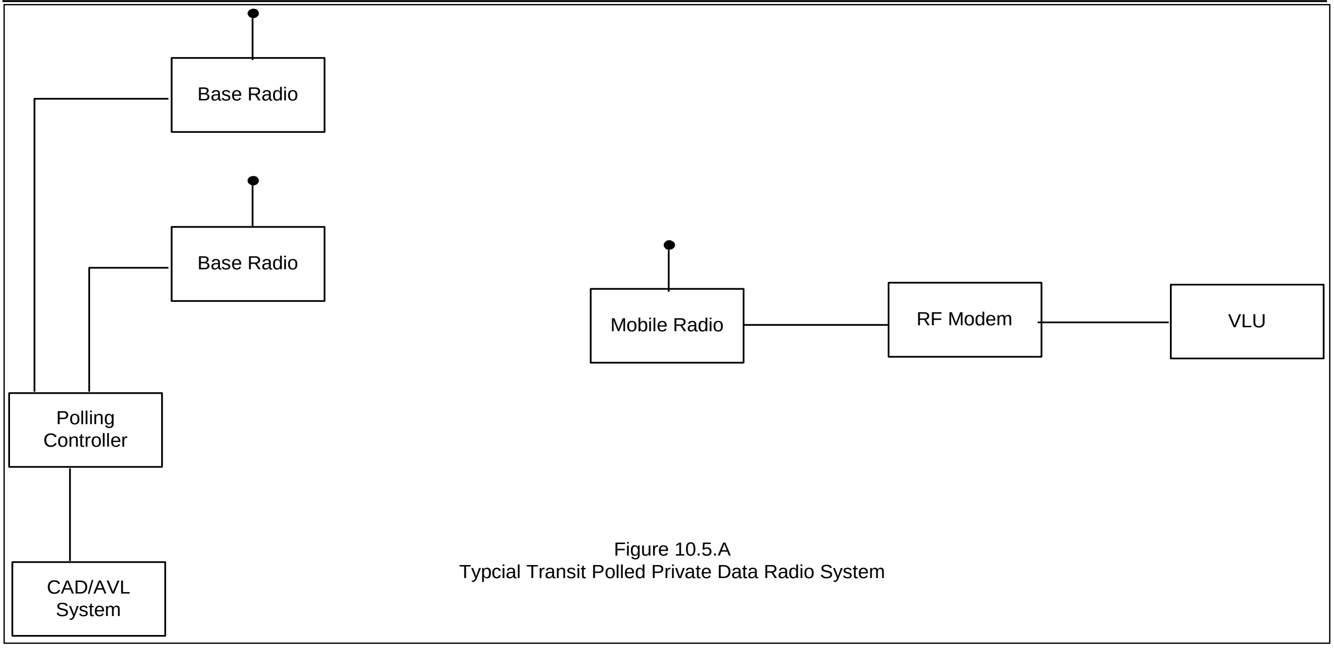


Figure 10.5.A
Typcial Transit Polled Private Data Radio System

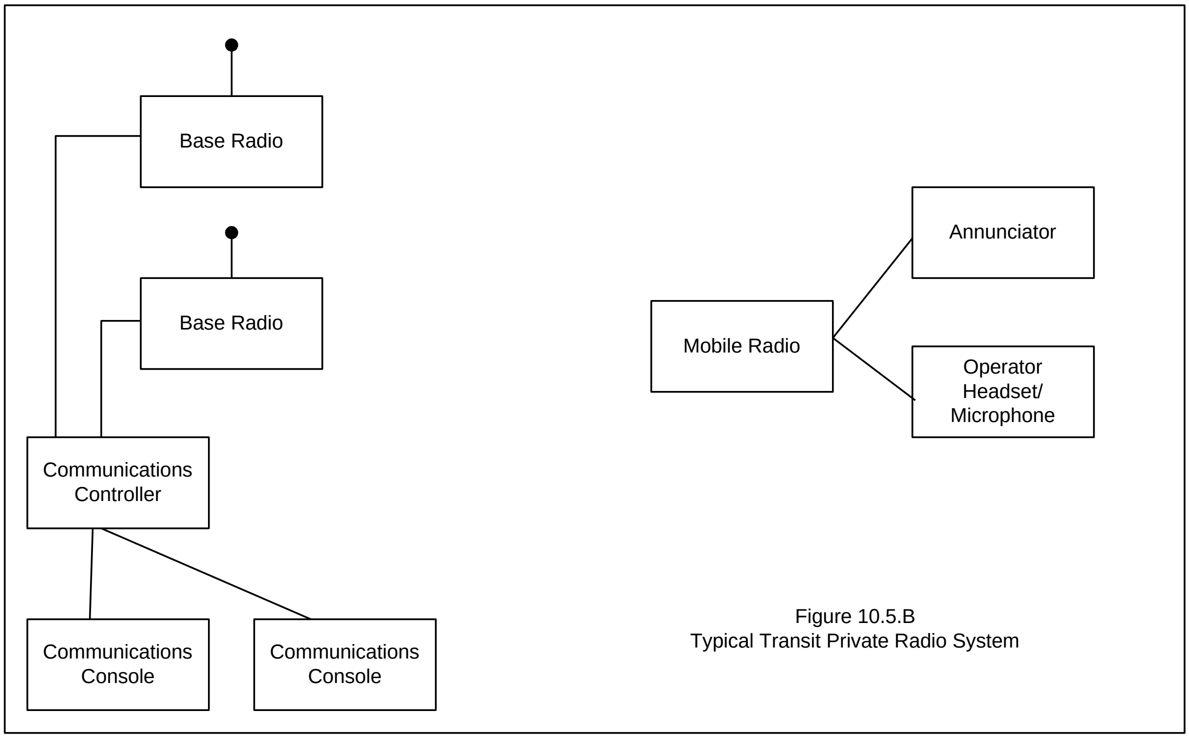


Figure 10.5.B
Typical Transit Private Radio System