A312b: Specifying Requirements for Transportation Sensor Systems (TSS) Based on NTCIP 1209 Standard

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1. Introduction/Purpose

A312b: Specifying Requirements for Transportation Sensor Systems (TSS) Based on NTCIP 1209 Standard is the second of two modules of the Professional Capacity Building (PCB) program on using NTCIP communications with transportation sensor systems and/or devices. A312b describes the requirements in the NTCIP 1209 Standard v02, it shows how to use a protocol requirements list and requirements traceability matrix (RTM) to specify a TSS interface, it demonstrates when and how to extend the standard, and it describes the Simple Network Management Protocol (SNMP) interface and dialogs used in NTCIP 1209 v02.

2. Strengths and Weaknesses of Commercially Available Sensor Technologies

(From FHWA Detector Handbook)

Technology	Strengths	Weaknesses
Inductive loop	• Flexible design to satisfy large variety of applications. • Mature, well understood technology. • Large experience base. • Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap). • Insensitive to inclement weather such as rain, fog, and snow. • Provides best accuracy for count data as compared with other commonly used techniques. • Common standard for obtaining accurate occupancy measurements. • High frequency excitation models provide classification data.	• Installation requires pavement cut. • Improper installation decreases pavement life. • Installation and maintenance require lane closure. • Wire loops subject to stresses of traffic and temperature. • Multiple loops usually required to monitor a location. • Detection accuracy may decrease when design requires detection of a large variety of vehicle classes.
Magnetometer (two-axis fluxgate magnetometer)	• Less susceptible than loops to stresses of traffic. • Insensitive to inclement weather such as snow, rain, and fog. • Some models transmit data over wireless radio frequency (RF) link.	• Installation requires pavement cut. • Improper installation decreases pavement life. • Installation and maintenance require lane closure. • Models with small detection zones require multiple units for full lane detection.

Technology	Strengths	Weaknesses
Magnetic (induction or search coil magnetometer)	• Can be used where loops are not feasible (e.g., bridge decks). • Some models are installed under roadway without need for pavement cuts. However, boring under roadway is required. • Insensitive to inclement weather such as snow, rain, and fog. • Less susceptible than loops to stresses of traffic.	• Installation requires pavement cut or boring under roadway. • Cannot detect stopped vehicles unless special sensor layouts and signal processing software are used.
Microwave radar	• Typically insensitive to inclement weather at the relatively short ranges encountered in traffic management applications. • Direct measurement of speed. • Multiple lane operation available.	• Continuous wave (CW) Doppler sensors cannot detect stopped vehicles
Active infrared (laser radar)	• Transmits multiple beams for accurate measurement of vehicle position, speed, and class. • Multiple lane operation available.	• Operation may be affected by fog when visibility is less than appximately 20 feet (ft) (6 m) or blowing snow is present. • Installation and maintenance, including periodic lens cleaning, requires lane closure.
Passive infrared	• Multizone passive sensors measure speed.	• Passive sensor may have reduced vehicle sensitivity in heavy rain, snow, and dense fog. • Some models not recommended for presence detection.
Ultrasonic	• Multiple lane operation available • Capable of overheight vehicle detection. • Large Japanese experience base.	• Environmental conditions such as temperature change and extreme air turbulence can affect performance. Temperature compensation is built into some models. • Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles traveling at moderate to high speeds.

Technology	Strengths	Weaknesses
Acoustic	• Passive detection. • Insensitive to precipitation. • Multiple lane operation available in some models.	• Cold temperatures may affect vehicle count accuracy. • Specific models are not recommended with slow-moving vehicles in stop-and-go traffic.
Video image processor	• Monitors multiple lanes and multiple detection zones/lane. • Easy to add and modify detection zones. • Rich array of data available. • Provides wide-area detection when information gathered at one camera location can be linked to another.	• Installation and maintenance, including periodic lens cleaning, requires lane closure when camera is mounted over roadway (lane closure may not be required when camera is mounted at side of roadway) • Performance affected by inclement weather such as fog, rain, and snow; vehicle shadows; vehicle projection into adjacent lanes; occlusion; day-to-night transition; vehicle/road contrast; and water, salt grime, icicles, and cobwebs on camera lens. • Reliable nighttime signal actuation requires street lighting. • Requires 30- to 50-ft. (9- to 15-m) camera mounting height (in a side-mounting configuration) for optimum presence detection and speed measurement. • Some models susceptible to camera motion caused by strong winds or vibration of camera mounting structure. • Generally cost effective when many detection zones within the camera field of view or specialized data are required.

3. Federal Highway Administration (FHWA) 13 Vehicle Classifications

Class 1 – Motorcycles: All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handle bars rather than wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheeled motorcycles.

Class 2 – Passenger Cars: All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.

Class 3 – Other Two-Axle, Four-Tire, Single Unit Vehicles: All two-axle, four-tire, vehicles other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single unit vehicles pulling recreational or other light trailers are included in this classification.

Class 4 – Buses: All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be trucks and be appropriately classified.

Note: In reporting information on trucks the following criteria should be used:
a. Truck tractor units traveling without a trailer will be considered single unit trucks.
b. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered as one single unit truck and will be defined only by axles on the pulling unit.
c. Vehicles shall be defined by the number of axles in contact with the roadway. Therefore, "floating" axles are counted only when in the down position.
d. The term "trailer" includes both semi- and full trailers.

Class 5 – Two-Axle, Six-Tire, Single Unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.

Class 6 – Three-axle Single unit Trucks: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.

Class 7 – Four or More Axle Single Unit Trucks: All trucks on a single frame with four or more axles.

Class 8 – Four or Less Axle Single Trailer Trucks: All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power unit.

Class 9 – Five-Axle Single Trailer Trucks: All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.

Class 10 – Six or More Axle Single Trailer Trucks: All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.

Class 11 – Five or Less Axle Multi-Trailer Trucks: All vehicles with five or less axles consisting of three or more units, one of which is a tractor or straight truck power unit.

Class 12 – Six-Axle Multi-Trailer Trucks: All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.

Class 13 – Seven or More Axle Multi-Trailer Trucks: All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

4. Glossary

Term	Definition
Agency Specification	A document that has been prepared by an agency to define requirements for a subject item or process when procured by the agency.
ASC	Actuated Signal Control
Arming Enable	A selected state of an arming input bit or Arming Pin of the TSS that can be used to modify its operation.
Arming Input Bit	An external event that is reported to the TSS using this protocol and used to modify its operation.
Arming Pin	A physical input to the TSS that can be monitored and used to modify its operation.
class	A subdivision of collected historical sample data.
compatibility	Two or more systems or components perform their required functions while sharing the same environment
compliance	A condition that exists when an item meets all of the requirements of an agency specification.
conformance	A condition that exists when an item meets all of the mandatory requirements as defined by the standard. It can be measured on the standard as a whole, which means that it meets all mandatory (and applicable conditional) requirements of the standard or on a feature level (i.e., it conforms to feature X as defined in section X.X.X), which means that it meets all mandatory (and applicable conditional) requirements of the feature.
ConOps	Concept of Operations
delay	A feature that allows the detection output from a TSS detector to be deferred for a user set time period.
deprecated	In the context of a MIB, 'deprecated' is an object STATUS value that indicates the object is valid in limited circumstances and may have been replaced by another.
DST	Daylight Saving Time
extension	A feature that allows the detection output from a TSS detector to be lengthened for a user set time period.

Term	Definition
Fail-Safe Mode	Capable of compensating automatically and safely for a failure, as a mechanism or power source.
feature	A service provided by or behavior of the TSS.
Firmware Version	A manufacturer specified description for identifying the software currently embedded in the TSS.
Hardware Version	A manufacturer specified description for identifying the electronic components that comprise the TSS
ICD	Interface Control Document
interchangeability	A condition that exists when two or more items possess such functional and physical characteristics as to be equivalent in performance and durability, and are capable of being exchanged one for the other without alteration of the items themselves, or adjoining items, except for adjustment, and without selection for fit and performance. (National Telecommunications and Information Administration, U.S. Department of Commerce)
interoperability	The ability of two or more systems or components to exchange information and use the information that has been exchanged.
Live Data	A specific operational network configuration between the management station and the TSS where the information exchange can be performed without the need for initiating and terminating a physical network connection between the management station and TSS. From a network perspective, this configuration is an 'always on' connection, where the management station has access to the 'current' information available in the TSS.
Management Information Base (MIB)	A structured collection or database of related managed objects defined using Abstract Syntax Notation One (ASN.1).
Management Station	A remote computer (e.g., Traffic Management Center), local computer (e.g., Laptop), or local controller (e.g., Traffic Controller).
MVI	Multi-Version Interoperability (backward compatibility)
Near Real-Time Data	Data that depicts an event as it existed at the current time less the processing time. The data varies from real time data because it is dependent on the type and speed of transmission. This data is useable for identifying changes in traffic flows.
NTCIP	National Transportation Communication for ITS Protocol
normalized	Process of reducing sample data to a common denominator to accommodate comparison of the measured data.
occupancy	A measurement of vehicle presence within a zone of detection, expressed in seconds of time a given point or area is occupied by a vehicle.
output	The condition of an on/off status generated by a change of state.

Term	Definition
Output Mode	There are two common modes, Presence and Pulse. In the presence output mode, a detection of a vehicle is output constantly while the vehicle is in the zone. In the pulse output mode, a detection is output for 125 milliseconds (± 25 milliseconds) and then the zone is retuned.
PRL	Protocol Requirements List
protocol	A specific set of rules, procedures, and conventions defining the format and timing of data transmissions between devices that are accepted and used to understand each other.
Protocol Version	A standardized description for identifying the version of the TSS standard to which the TSS is designed to conform.
Requirement	A condition or capability to which a system must conform, either derived directly from the user needs, or stated in a contract, standard, specification, or other formally imposed document. A desired feature, property, or behavior of a system.
Requirements Traceability	The ability to follow or study the logical progression among the needs, requirements, and design details in a step-by-step fashion.
RTC	Real Time Clock
RTM	Requirements Traceability Matrix
Sample Period	Duration of time in seconds when data for the zone is being collected.
Sensitivity	The ability of the TSS to react to incoming signals, expressed as the minimum input signal required to produce an output signal.
Sensitivity Mode	A characteristic of the loop detector being used. It is defined as either $\Delta L/L$, $\Delta L/\sqrt{L}$, or ΔL.
Sensor	A physical device used for sensing traffic.
SEP	Systems Engineering Process
SNMP	Simple Network Management Protocol
SRS	Software Requirements Specification
Transportation Sensor System (TSS)	Any system capable of sensing and communicating near real-time traffic parameters using NTCIP.
User	A person who will utilize the system that is developed.
User Need	The business or operational problem (opportunity) that must be fulfilled in order to justify purchase or use. While this is termed a 'user need' within the NTCIP community, it reflects needs of all stakeholders.

Term	Definition
Virtual Zone	A logical combination of one or more zones to create a new zone with its own conditioning and Arming Enables. This is useful in combining zones to a single zone to provide one output from many zones. This can also be used to alias a zone so that the same zone can provide multiple outputs, each with different conditioning parameters, sample periods, and/or trigger usage.
volume	The number of vehicles crossing a section of road per unit time at a selected period.
Zone	An area in which traffic parameters can be measured and/or traffic data can be generated.
Zone Options	Special settings for controlling the behavior of zones.

5. Reference to Other Standards

- Institute of Electrical and Electronics Engineers, *IEEE 830-1988 Recommended Practice for Software Requirements Specifications*. IEEE, 1998. http://standards.ieee.org/findstds/standard/830-1998.html

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- NTCIP Joint Committee, *National Transportation Communications for ITS Protocol Object Definitions for Actuated Traffic Signal Controller Units Version 02*. NTCIP Joint Committee, 2005. http://www.ntcip.org/library/documents/

- NTCIP Joint Committee, *National Transportation Communications for ITS Protocol Object Definitions for Transportation Sensor Systems (TSS) Version 02*. NTCIP Joint Committee. NTCIP JC Recommended Standard in process of publication. http://www.ntcip.org/library/documents/

6. References

- Alexander, Ian and Ljerka Beus-Dukic. *Discovering Requirements*. Wiley, 2009.

- ITS PCB Training http://www.pcb.its.dot.gov

- United States Department of Transportation Federal Highway Administration. *Systems Engineering Guidebook for Intelligent Transportation Systems Version 3.0*. November 2009. http://www.fhwa.dot.gov/cadiv/segb/

- United States Department of Transportation Federal Highway Administration. *Traffic Detector Handbook: Third Edition—Volume I*. October 2006. http://www.fhwa.dot.gov/publications/research/operations/its/06108/

7. Participant Questions Included in Presentation

1) **What tool is used to show the relationship of objects and dialogs within the standard?**
   a) Object Tree
   b) Protocol Requirements List (PRL)
   c) Requirements Traceability Matrix (RTM)
   d) Dialogs

2) **Which of the following is not a major group of requirements in NTCIP 1209 v02?**
   a) Manage the TSS Configuration
   b) Manage the Camera
   c) Collect Sample Data
   d) Multi-Version Interoperability (Backward Compatibility)

3) **If Video:O.2 is used in the conformance column of the TSS PRL, what does it mean?**
   a) It's the second of 20 optional Video requirements in the standard
   b) It identifies the second highest priority optional Video requirement
   c) Says that if one Video:O.2 optional requirement is used in the project, all Video:O.2 requirements must be used
   d) None of the above

4) **Which statement is TRUE in regards to achieving interchangeability for TSS equipment using NTCIP 1209 v02?**
   a) Using user needs from the standard guarantees interchangeability
   b) Using only requirements, data elements, and dialogs from the standard guarantees interchangeability
   c) Adding communications data elements that are not in the standard makes interchangeability impossible
   d) Using only requirements, data elements, and dialogs from the standard makes interchangeability a possibility

5) **Which statement is TRUE in regards to the RTM in NTCIP 1209 v02?**
   a) Shows relationship of requirements to the specific design items of the TSS interface
   b) Shows relationship of user needs to the specific design items of the TSS interface
   c) Should always be included in an agency specification
   d) Not used until integration of the system and the TSS device

6) Which of the following is the best occasion to extend the standard with a new feature?

a) When you are not worried about interoperability or interchangeability
b) After you have weighed the risk of making interoperability and interchangeability more difficult against the benefit of the feature
c) When you want to disqualify a second vendor because you have done business with another in the past
d) When a proprietary method to accomplish a feature is more familiar over the method used in the standard

7) Which statement is TRUE concerning Dialogs used in defining a TSS interface?

a) A Dialog is best defined by graphical pictures
b) A Dialog is not necessary when adding features outside of the standard
c) A Dialog is only necessary if there are several exchanges of messages
d) A Dialog is important to defining the exchange of messages to accomplish a requirement