CI Implementation Guidance
System Design Details Walkthrough

March 8 – March 11

(11:00 AM – 5:30 PM EST)

Anti-Trust Guidance (Narla)

- The Institute of Transportation Engineers is committed to compliance with antitrust laws and all meetings will be conducted in strict compliance with these antitrust guidelines. Further if an item comes up for which you have conflict of interest, please declare that you have a conflict of interest on the matter and recuse yourself from action on that item.
- The following discussions and/or exchanges of information by or among competitors concerning are prohibited:
  - Prices, price changes, price quotations, pricing policies, discounts, payment terms, credit, allowances or terms or conditions of sale;
  - Profits, profit margins or cost data;
  - Market shares, sales territories or markets;
  - The allocation of customer territories;
  - Selection, rejection or termination of customers or suppliers;
  - Restricting the territory or markets in which a company may sell services or products;
  - Restricting the customers to whom a company may sell;
  - Unreasonable restrictions on the development or use of technologies; or
  - Any matter which is inconsistent with the proposition that each company must exercise its independent business judgement in pricing its service or products, dealing with its customers and suppliers and choosing the markets in which it will compete.

Agenda (Goudy, Thai)

1. Call to Order
2. Anti-Trust Guidelines & Logistics
3. Roll Call
4. Project Overview
5. USDOT Remakrs
6. Review of the Walkthrough Process
7. Walkthrough – System Design Details
8. Next Steps

Roll Call of Committee Members

Affiliation	First Name	Last Name	Organization	Alternate
OEM	Roy	Goudy	Nissan	
ITE	John	Thai	City of Anaheim	-
AASHTO	Raj	Ponnaluri	Florida DOT	Derek Vollmer
AASHTO	Christina	Spindler	Wyoming DOT	Ali Ragan
AASHTO	Ray	Starr	Minnesota DOT	Kevin Chan
ITE	Ed	Seymour	Texas A&M Transportation Institute	Kevin Balke
ITE	Faisal	Saleem	AZ McDOT Maricopa County	April Wire
NEMA	Whitney	Nottage	Q-Free/Intelight	Douglas Tarico
NEMA	Steve	Bowles	360 Network Solutions	Billy Stalcup
NEMA	Mike	Schagrin	McCain	Jesus Ruiz
OEM	Mike	Shulman	Ford Motors	Michael Maile
OEM	Vivek	Vijayakumar	General Motors	Bo Yu
V2X	Michael	Stelts	Panasonic	Mateusz Malinowski
V2X	Jim	Misener	Qualcomm	William Whyte
V2X	Doug	Schmidt	Aptiv	Chris Hedges
CAMP	Jay	Parikh	CAMP/IOO-OEM Forum	
Mobile Services	Steve	Sprouffske	Kapsch	Imran Inamdar
IEEE 1609/SAE	Justin	McNew	JMC Rota Inc.	Masoud Motammedi

Project Overview (Goudy, Thai)

- Committee Scope
  - The scope of the Connected Intersections (CI) Committee is to develop and publish document(s) that defines the minimum requirements a connected intersection must support to ensure national interoperability among road users, equipped devices/vehicles and connected intersections.
- Project Scope
  - The project purpose is to develop and publish a CI implementation guide that standardizes the key capabilities and interfaces for a connected intersection. …the [guide] should address the ambiguities and gaps identified by early deployers and provide enough guidance to generate messages and develop applications for signalized intersections that are truly interoperable across the United States, especially for automated transportation systems.

Project Overview (Goudy, Thai)

Task Force	Co-Chairs	SDO	SME Consultant
SPaT/MAP	Ray Starr (MnDOT)/Michael Maile	AASHTO	Patrick Chan Jay Parikh
Testing/ Conformity	Jay Parikh (CAMP)/Christina Spindler (Wyoming DOT)	AASHTO	Manny Insignares Randy Roebuck
Security	William Whyte (Qualcomm)/Jimmy Upton (ISS)	NEMA Alt: ITE	Wolfgang Buckel Michaela Vanderveen
Positioning	Jim Misener (Qualcomm)/Justin McNew (JMC Rota)	NEMA	Steve Sprouffske
Traffic Controller Issues	Roy Goudy (Nissan)/Kevin Balke (TTI)	ITE	Ralph Boaz Chris Poe

Project Overview (Goudy, Thai)

- Each Task Force meets regularly (weekly or every 2 weeks)
  - 200 participants on the mailing list
    - Participants per task force vary from 28 to 67
    - Representatives from many industries: OEMs, mobile users, CAMP, private sector, state DOTs, local DOTs, researchers
- Also coordinating with other groups
  - Crash Avoidance Metrics Partners (CAMP)
  - IOO/OEM Forum
  - Connected Vehicles Pooled Fund Study (CVPFS)
- Task Force Chairs and Subject Matter Experts (SMEs) meet every Friday for progress and coordination

Project Overview (Goudy, Thai)

- Achievements to date:
  - Developed a draft systems design details document (SDD), based on the systems engineering process
    - Includes a Concept of Operations and requirements document
  - 15 letters (13 organizations, including 1 Canadian) received volunteering to be a validation site
    - Objective 1: Verify requirements and design details for SPaT, MAP, and RTCMcorrections messages are unambiguous and complete
    - Objective 2: Document test site readiness and lessons learned regarding the Agency's experience in the design, implementation, operation and maintenance of its CI
    - Objective 3: Document the expected date of readiness and the technical and institutional challenges/lessons learned in preparing for CI deployment

Project Overview (Goudy, Thai)

- Oct. 8, 2019 - Project Begins
- Apr. 8, 2020 – First CI Committee Meeting
- Aug. 31- Sept. 2, 2020 - ConOps Walkthrough
- Sept. 3 2020 – Started work on Functional Requirements
- Oct. 30, 2020 - ConOps Submitted
- Dec 7 – 10, 2020 - Requirements Walkthrough
- December 2020 – Started work on Design Details
- January 25 – Requirements Submitted
- February 26 – SDD draft distributed

USDOT Remarks

Review of the Walkthrough Process (Goudy, Thai)

- Purpose:
  - Solicit input from participants and additional stakeholders on the draft CI Implementation Guidance System Design Details (SDD) from a functional, technical, management, Systems Engineering Process (SEP) and implementation perspective.

  - Prior to the walkthrough, a draft SDD document and walkthrough workbook (with request for written input prior to the walkthrough) was distributed. During the walkthrough, a walkthrough workbook will guide review, and be updated in real-time based on participant input.

Project Overview (Goudy, Thai)

- Objectives
  - Provide sufficient guidance for the consultants to complete the design details section
  - Identify anomalies and gaps
  - Consider alternatives
  - Verify traceability between user needs, requirements and design details

Review of the Walkthrough Process (Goudy, Thai)

Meeting Rules

- Robert's Rules of Order
- Close decisions and follow up
  - Make sure decisions are supported by the group, otherwise they won't be acted on.
  - Note pending issues and schedule follow up actions/meetings as needed.
  - Identify actions based on decisions made, and follow up actions assigned to you.
- Record outcomes and share
  - Record issues discussed, decisions made, and tasks assigned.

Roles and Responsibilities (Chan)

The roles and responsibilities for the participants during the SDD walkthrough follow.

a) Walkthrough Leader (Chan): Lead walkthrough/guide discussion

b) Recorder (Chan/Lahiri): Record all revisions with basis of revisions (anomalies)

c) Author (consultant team/task force): Subject Matter Experts on the design details with overview of Standard

d) Review Team (All others): Identify anomalies, discuss, propose and agree to appropriate resolutions

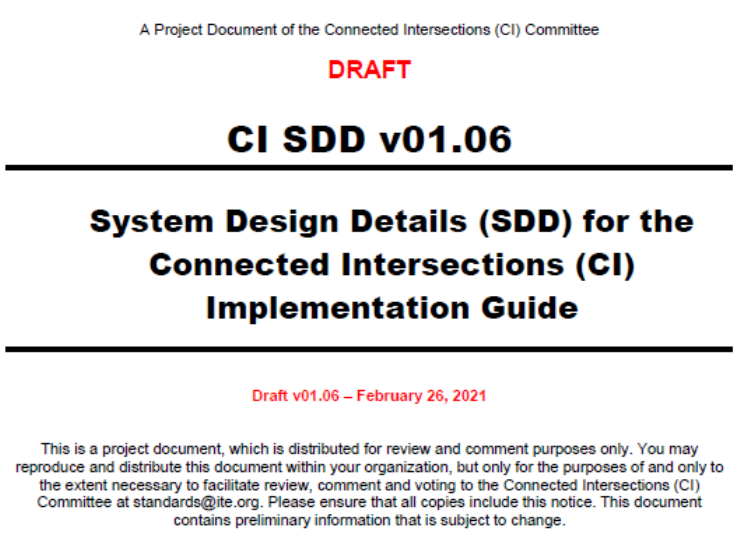
Entry Inputs (Chan)

The inputs to be used during the walkthrough.

a) Draft SDD Document

b) Inputs (proposed revisions) on the Draft SDD Document

c) SDD Walkthrough Workbook



A Project Document of the Connected Intersections (CI) Committee

DRAFT

CI SDD v01.06

System Design Details (SDD) for the Connected Intersections (CI) Implementation Guide

Draft v01.06 – February 26, 2021

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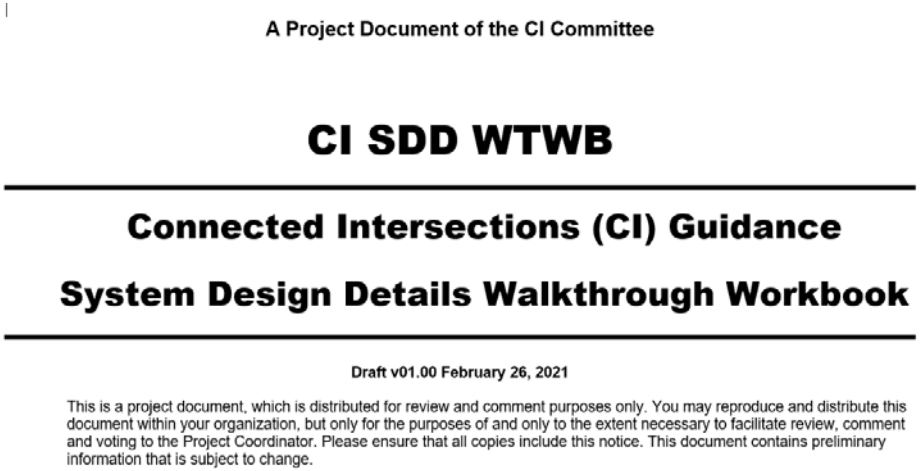

A Project Document of the CI Committee

CI SDD WTWB

Connected Intersections (CI) Guidance

System Design Details Walkthrough Workbook

Draft v01.00 February 26, 2021

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Walkthrough Criteria

Evaluation

– Each design element (individually and as a group, where appropriate) is evaluated as follows, to determine whether the Functional Requirement is fulfilled by the proposed design elements
  - **Verify design traceability:** Is the design element properly associated with the requirement?
  - **Verify design logical consistency:** Is the design element logically consistent with the requirement?
  - **Verify design completeness:** Does it fully fulfill the requirement?
  - **Verify design correctness:** Are there any errors in the design elements presented.

Well-Written User Need Criteria

The criteria used to determine if a need is well-written follow.

a) **Uniquely Identifiable:** Each need must be uniquely identified that is each need shall be assigned a unique number and title.

b) **Major Desired Capability (MDC):** Each need shall express a major desired capability (corridor level) in the system, regardless of whether the capability exists in the current system or situation or is a gap.

c) **Solution Free:** Each need shall be solution free, thus giving designers flexibility and latitude to produce the best feasible solution.

d) **Capture Rationale:** Each need shall capture the rationale or intent as to why the capability is needed in the system.

Pattern for Well-Formed Requirements

Well-formed requirements should be:

a) **Necessary:** Must be useful (traceable to needs)

b) **Unambiguous:** Susceptible to only one interpretation

c) **Concise:** Stated in declarative language (“shall statements”)

d) **Consistent:** Does not contradict itself, nor any other stated requirement

e) **Complete:** The requirement is stated completely in one place. (Requirements may be grouped.)

f) **Attainable:** Realistic to achieve within available resources and time

g) **Testable:** Must be able to determine that the requirement has been met through one of four possible methods (inspection, analysis, demonstration, or test)

Pattern for Well-Formed Requirements

- Good requirements will generally take the form: [Actor] [Action] [Target] [Constraint] [Localization]. The localization and constraint portions are important, but not all requirements will have both. The constraint identifies how you will measure success or failure of the requirement. The localization identifies the circumstances under which the requirement applies.
- For example: The System [Actor] shall generate [Action] event reports [Target] containing the following information [Constraint] on a scheduled interval [localization]. If a requirement can't be stated in this simple format, you probably need to define the functionality using multiple requirements.

Walkthrough Criteria

Walkthrough Procedures

Perform detailed review of draft SDD document by using the SDD Walkthrough Workbook

- Use the walkthrough workbook to guide discussion and review during the walkthrough, specifically to ensure that each user need, requirement and design element are logically consistent
- Answer questions and comments throughout the walkthrough workbook and resolve those questions and comments for each user need, requirement, and design element.
- Capture comments in ‘real time’ in the walkthrough workbook, and as needed/appropriate in the draft SDD document to reflect inputs from walkthrough participants.

Walkthrough Criteria

Exit Outputs

The outputs of the walkthrough follow.

a) A marked-up walkthrough workbook, indicating which user needs, requirements and design elements were reviewed, the result of the evaluation of, and input provided during the walkthrough that may result in a revision

b) ITE will deliver an SDD comment resolution report which identifies inputs received during the SDD walkthrough, using track changes in a copy of the SDD walkthrough workbook, and the resolution of those comments

c) ITE will deliver an updated, revised SDD document to reflect revisions resulting from walkthrough input

SDD Walkthrough

4 Q: Traceable? Logical Consist? Complete Design? Correct Design?					
UN FR ID	**Text**	**Design ID**	**Design Concept**	**Conformance**	**Additional Specifications**
2.4	**Needs**				
2.4.1	**Architectural Needs** A connected intersection needs to use a communications technology to exchange data with the applications on an OBU/MU in a timely manner. This feature allows an application on an OBU/MU to receive data, such as signal timing information, with enough low latency so the application can properly process the data from the CI and react to the dynamic situation at the intersection. The reaction may include providing warnings or alerts to the driver or Vulnerable Road Users (VRUs), or taking an appropriate action.			M	
3.3.1.1	**IEEE 802.11 (DSRC)** A connected intersection shall exchange data with OBUs/MUs using IEEE 802.11 (operating outside the context of a BSS) in the 5.895 to 5.925 GHz band on channels 180, 182, and 184. Selection of channel is deployment dependent. NOTE: Subject to change. This requirement is applicable only in the United States. The United States Federal Communications Commission (FCC) ruled only the upper 30 MHz will be available as of November 2020.			O.1 (1..*)	
			See IEEE 802.11		
3.3.1.2	**3GPP PC5 Mode 4 (Release 14 or 15 (C-V2X)** A connected intersection shall exchange data with OBUs/MUs using 3GPP PC5 Mode 4 (V2X Sidelink) in the 5.905 to 5.925 GHz band with 20 MHz channel width (one channel – Channel 183).			O.1 (1..*)	
			See 3GPP TS 23.285		
2.4.2	**Traffic Signal Controller Infrastructure Data** The traffic signal controller (TSC) infrastructure provides and serves as the source for the signal phase and timing information to the RSU. The TSC infrastructure needs follow.			M	
2.4.2.1	**Provide Signal Timing Data to an RSU** A TSC infrastructure needs to provide signal timing data to an RSU so the RSU can forward that information to OBUs/MUs.				
3.3.2.1.1.1	**NTCIP 1202 v03 SPaT Information** A TSC infrastructure shall transmit a SPaT information message to an RSU in conformance with the applicable requirements in NTCIP 1202 v03A, Section 3.5.4.			O.2 (1)	
		4.3.2.1.1.1	**NTCIP 1202 v03 SPaT Information** The design details to use NTCIP 1202 v03A to transmit a SPaT information message are as follows. NTCIP 1202 v03A defines data objects that provide the information needed by a RSU to generate a UPER-encoded SPaT message. The requirements for generating the SPaT message can be found in Section 3.5.4 of NTCIP 1202 v03A. The RSU then uses this information to generate a UPER-encoded SAE J2735 SPaT message.		

SDD Walkthrough Schedule

- Monday, March 8 (All times EST)
  - 11:00 AM – 5:00 PM Traffic Controller Issues/SPaT Design Details
- Tuesday, March 9:
  - 11:00 AM – 12:30 PM Traffic Controller Issues/SPaT Design Details (if needed)
  - 3:30 – 5:30 PM Testing and Conformity
- Wednesday, March 10:
  - 12:00 – 5:00 PM Security
- Thursday, March 11:
  - 11:00 AM – 5:00 PM Positioning/MAP
- Friday, March 12:
  - 11:00 AM – 2:30 PM: If needed

SDD Walkthrough Notes

- Due to time constraints, we may not walk through every requirement during this walkthrough
  - Focus on known gaps or inconsistencies between the Task Force inputs
- Due to resource and time constraints, may not address every potential issue or gap in this first CI Implementation Guide
  - CI Implementation Guide to be published by September 2021
  - The CI Implementation Guide creates a framework for future revisions
  - Created a “parking lot” for future consideration (See Annex F)
    - No clear need
    - No consensus on the design details

Next Steps

- SDD Walkthrough – March 8-11 (11:00 AM - 5:30 PM EST)
- Updated Draft SDD Document – distribute by March 19 for a 2-week comment period.
  - Comments due April 2, 2021
- Final SDD Document – expected April 6, 2021
- Start Validation Phase

Traffic Controller Issues/SPaT Design Details

Figure 2

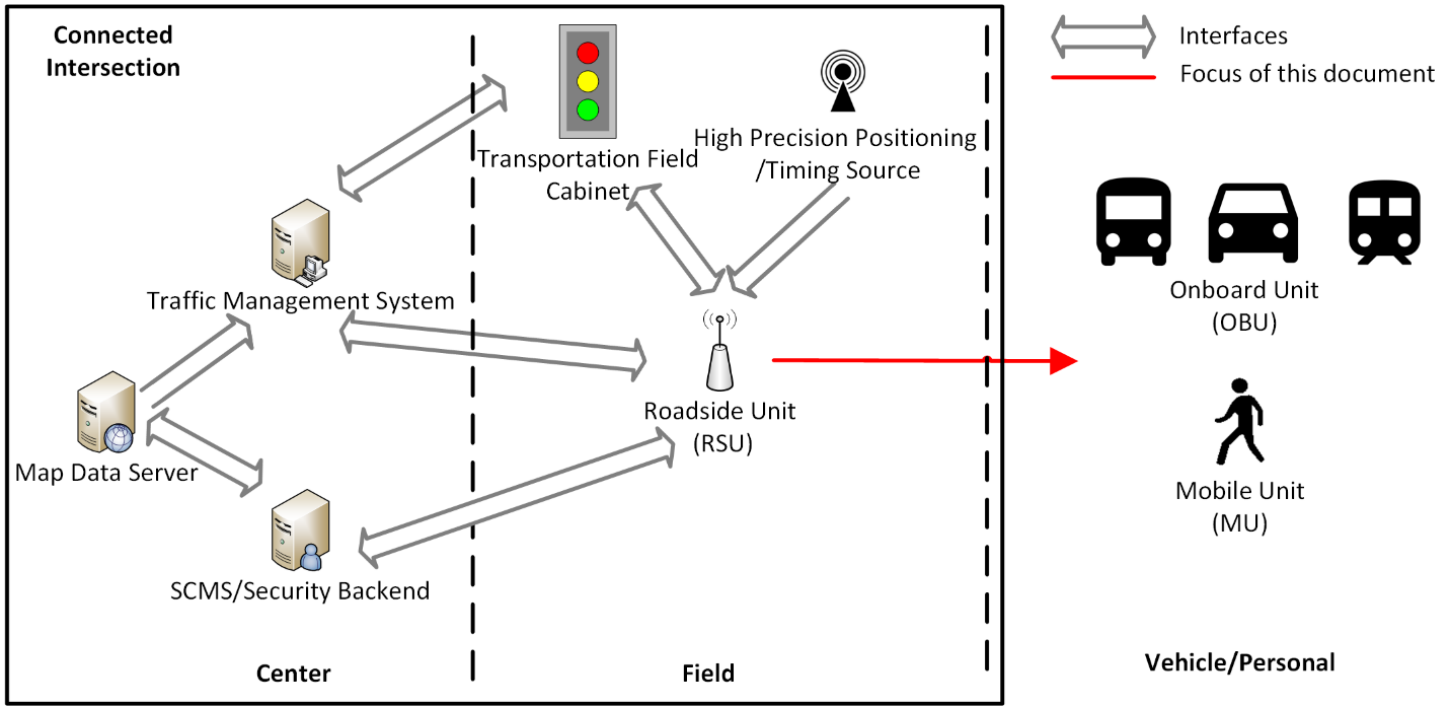

Figure 11

Traffic Controller Issues/SPaT Design Details

Table 7

SAE J2735 Data Frames and Data Elements	SAE J2735 Standard	CI Implementation
messageId=DE_DSRC_MessageID=19 (SPAT UPER)	M	M
timeStamp=DE_MinuteOfTheYear	O	M
intersections=DF_IntersectionStateList	M	M
id=DF_IntersectionReferenceID	M	M
region=DE_RoadRegulatorID	O	M
id=DE_IntersectionID	M	M
revision=DE_MsgCount	M	M
status=DE_IntersectionStatusObject	M	M
timeStamp=DE_Dsecond	O	M
enabledLanes=DF_EnabledLaneList=1 to 16 x DE_LaneID	O	C (if a revocable lane is active ("enabled") - See Section 4.3.3.3.7)
states=DF_MovementList=1 to 255 x DF_MovementState	M	M
signalGroup=DE_SignalGroupID	M	M
state-time-speed=DF_MovementEventList	M	M
eventState=DE_MovementPhaseState	M	M
timing=DF_TimeChangeDetails	O	M
startTime=DE_TimeMark	O	C (If available - See Sections 4.3.3.3.5.7 and 4.3.3.3.5.8)
minEndTime=DE_TimeMark	M	M
maxEndTime=DE_TimeMark	O	M
nextTime=DE_TimeMark	O	C (If available - See Sections 4.3.3.3.5.7 and 4.3.3.3.6.1)

Traffic Controller Issues/SPaT Design Details

Table 8

SAE J2735 Data Element	SPaT Information Message		
	J2735 SPaT Message	NTCIP 1202 v03A	TSCBM
timeStamp (DE_MinuteOfTheYear)	See 4.3.3.2.3	To be completed	Generated by the RSU
id=DF_IntersectionReferenceID	See 4.3.3.3.1	To be completed	Mapped in the RSU
region=DE_RoadRegulatorID	See 4.3.3.3.1.2	To be completed	Mapped in the RSU
id=DE_IntersectionID	See 4.3.3.3.1.3	To be completed	Mapped in the RSU
revision=DE_MsgCount	See 4.3.3.2.2.1	To be completed	Generated by the RSU?
status=DE_IntersectionStatusObject	See 4.3.3.3.2	To be completed	To be completed
timeStamp=DE_Dsecond	See 4.3.3.2.3.2	Provided as ticks to the RSU	
enabledLanes=DF_EnabledLaneList	See 4.3.3.3.7	To be completed	Generated by the RSU?
states=DF_MovementList	See 4.3.3.3.3	To be completed	To be completed
signalGroup=DE_SignalGroupID	See 4.3.3.3.3.1	To be completed	Mapped in the RSU
state-time-speed=DF_MovementEventList		To be completed	To be completed
eventState=DE_MovementPhaseState (Current Movement)	See 4.3.3.3.3	To be completed	To be completed
eventState=DE_MovementPhaseState (Next Movement)	See 4.3.3.3.4	To be completed	To be completed
timing=DF_TimeChangeDetails	See 4.3.3.3.5	To be completed	Generated by the RSU
startTime=DE_TimeMark	See 4.3.3.3.5.7, 4.3.3.3.5.8	Unsupported	Generated by the RSU
minEndTime=DE_TimeMark	See 4.3.3.3.5.3	Provided as ticks to the RSU	Generated by the RSU
maxEndTime=DE_TimeMark	See 4.3.3.3.5.4	Provided as ticks to the RSU	Generated by the RSU
nextTime=DE_TimeMark	See 4.3.3.3.6.1	Provided as ticks to the RSU	Generated by the RSU

Traffic Controller Issues/SPaT Design Details

- Plan
  - Review of Annex A – CI Traffic Controller Issues & Recommendations
  - Review Architectural Needs
  - Review of TSC – RSU interface
    - NTCIP 1202 v03A
    - V2I Hub ICD SPaT Information (TSCBM)
    - UPER-encoded SAE J2735 SPaT message
  - RLVW Support
    - Annex B – Assured Green Period Use Cases
  - SPaT Messages
  - Security
    - Annex C.1 – Security Profile for SPaT Messages
  - Annex G – Recommendation to SDOs

Traffic Controller Issues/SPaT Design Details

6.50 Data Frame: DF_MovementEventList

Use: The MovementEventList data frame consists of a list of MovementEvent entries.

ASN.1 Representation:

```
MovementEventList ::= SEQUENCE (SIZE(1..16)) OF MovementEvent
```

Used By: This entry is used directly by one other data structure in this standard, a DF called DF_MovementState <ASN>. In addition, this item may be used by data structures in other ITS standards.

6.51 Data Frame: DF_MovementEvent

Use: The MovementEvent data frame contains details about a single movement. It is used by the movement state to convey one of number of movements (typically occurring over a sequence of times) for a SignalGroupID.

ASN.1 Representation:

```
MovementEvent ::= SEQUENCE {
   eventState    MovementPhaseState,
                 -- Consisting of:
                 -- Phase state (the basic 11 states)
                 -- Directional, protected, or permissive state

   timing        TimeChangeDetails OPTIONAL,
                 -- Timing Data in UTC time stamps for event
                 -- includes start and min/max end times of phase
                 -- confidence and estimated next occurrence

   speeds        AdvisorySpeedList OPTIONAL,
                 -- various speed advisories for use by
                 -- general and specific types of vehicles
                 -- supporting green-wave and other flow needs
                 -- See Section 11 for converting and translating
                 -- speed expressed in mph into units of m/s
```

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Adjourn

– Thank you!