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# **Connected Intersections (CI) Plenary Meeting**

Monday October 19 (02:00 PM – 5:00 PM EDT)

Virtual Meeting

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# Meeting Agenda

1. Call to Order
2. Anti-Trust Guidelines
3. Roll Call
4. Plenary Meeting Purpose
5. Project Overview
6. Task Force Presentations (15-18 minutes each)
7. Project Schedule
8. Validation Sites
9. Participation
10. Closing Remarks
11. Adjourn

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## Anti-Trust Guidance (Narla) – 1 minute

- 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.

# Roll Call (Goudy)

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

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## Plenary Meeting Purpose (Thai)

- Quarterly plenary meeting
- Update the stakeholder community about the progress and accomplishments of the CI project

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## Project Overview (Thai)

### – ITE Project Website

- <https://www.ite.org/technical-resources/standards/connected-intersections/>
- Meeting minutes/presentations

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## Project Overview (Chan)

- Systems Engineering Process
- Concept of Operations (Summary)
  - Describes the scope, the current problem and the needs
  - Needs were developed by each of the 5 task forces
  - Operational Scenarios also developed
  - ConOps Walkthrough: August 31 – September 2
  - Draft Final ConOps document distributed September 15
  - 2 week comment period
  - 39 comments received

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# Project Overview (Chan)

## – Concept of Operations

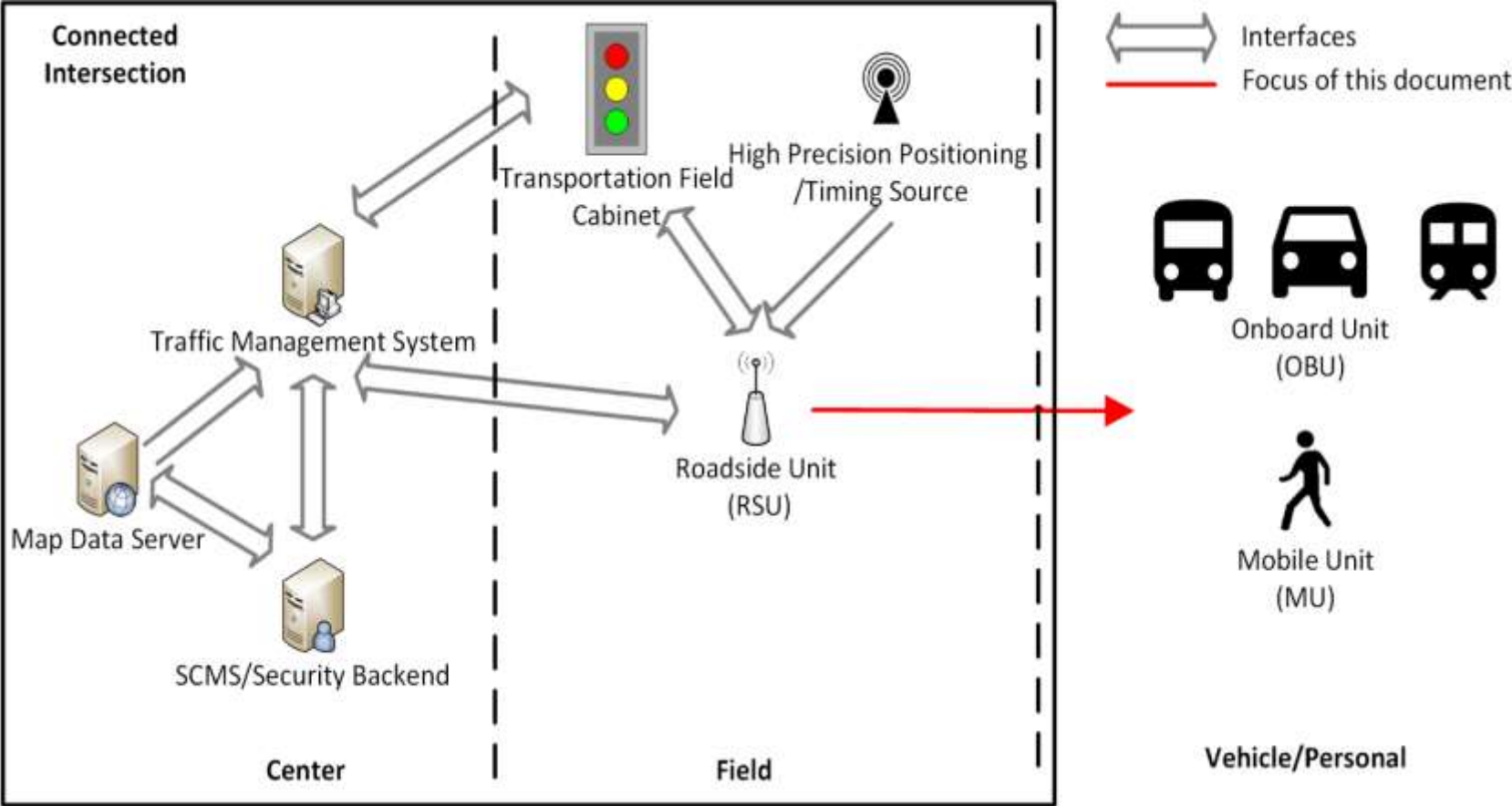
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# Project Overview (Chan)

## – Concept of Operations



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## Project Overview (Chan)

- Concept of Operations (Needs)
  - Architectural Needs
  - Messages
    - Performance
    - Generic Message Data Needs
    - Signal Timing Data Needs
    - Roadway Geometry Data Needs
    - Positioning Data Needs

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## Project Overview (Chan)

- Concept of Operations (Needs)
  - Security
    - Correct Operations
    - Data Flow
    - Network Monitoring
    - Credential Management
- Operational Policies and Constraints
- Operational Scenarios
- Relationship to the ITS National Architecture

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## Project Overview (Chan)

- Testing and Conformity Verification Management
  - Testing and Conformance (Needs)
  - Test Methodology
  - Message Level Testing
  - Test Documentation
  - Requirements Verification Methods
  - Test Cases
  - Test Coverage
  - Test Procedures
  - Identify Existing Test Documentation
  - Identify Existing Test Tools
  - Configuration and Change Management Needs

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## Project Overview (Chan)

### – Requirements

- Each test force developing requirements derived from the needs identified
  - Requirements will be traced to the user needs
- Coordination between task forces for some requirements
- First draft of the requirements by Friday, November 13

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## **SPaT/MAP Task Force**

**Michael Maile / Ray Starr, co-chairs**

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## **SPaT/MAP Task Force**

1. Highlight SPaT/MAP Needs from ConOps
2. Highlight SPaT/MAP Draft Requirements to Date
3. Ongoing Collaboration with Other Task Forces
4. Items Considered and Not Needed or Required
5. Next Steps
6. Q&A

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## SPaT/MAP Task Force

Select Needs from ConOps for SPaT

1. Data Coverage
2. Timestamp / Revision
3. Intersection Status
4. Current / Next Movement State – Including Peds
5. Time Change Details
6. Next Green
7. Revocable / Enabled Lanes



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## SPaT/MAP Task Force

Select Needs from ConOps for MAP

1. Concise Messages
2. Intersection Geometry
3. Lane Attributes
4. Allowed Maneuvers for the Lane
5. Connections Between Lanes
6. Approach Speed Limits
7. Synchronization with SPaT

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## **SPaT/MAP Task Force**

### Select Draft Requirements for SPaT

1. Protected vs Permissive States
2. Next Movement State Enumeration
3. Current / Next Movement Start Time
4. Minimum / Maximum End Time
5. Time of Next Green

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## **SPaT/MAP Task Force**

### Select Draft Requirements for MAP

1. Road Regulator Identifier – Proposed Numbering
2. Intersection Reference Point
3. Lane Width
4. Speed Limit
5. Center of Lane – Vehicle, Crosswalk, Landing

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## **SPaT/MAP Task Force**

### Ongoing Collaboration with Other Task Forces

1. End of Green / Minimum Assured Time
2. Intersection Status
3. Start Time for Current State
4. Node Point Accuracy

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## SPaT/MAP Task Force

### Things Considered and NOT Required

1. Likely Time / Confidence – Still TBD
2. Maneuver Assist
  - Queue Length
  - Ped / Bike in Crosswalk
3. Approach IDs
4. Real Time Monitoring

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# **SPaT/MAP Task Force**

## Next Steps

1. Density of Nodes
2. MAP Extent
3. MAP Node Representation
4. MAP Computed Lane Data Elements
5. Lane Connections
6. Revocable Lanes

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# SPaT/MAP Task Force

Q&A

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## **Positioning Task Force**

**Justin McNew / Jim Misener, co-chairs**



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## Positioning Task Force

- Meet every other Monday at 1 PM Eastern
- Last met October 12
- Milestones
  - Iterated on and agreed to CIC user needs

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## Positioning Task Force

- Agreed that intersection transmits RTK per RTCM10403.2
  - Some detail: includes Multiple Signals Messages (MSM). MSM 7 addresses all pertinent constellations (GPS, GLONASS, Galileo, QZSS, BeiDou, SBAS)
  - Latest version (3.2, MSM7) is recommendation RSU requirement. Pending:
    - Technical validation – TF needs to see paid standard → Action item is request to SDOs (NEMA in this interest) to establish relationship with RTCM
    - Potential survey of OEMs and suppliers, e.g., How is RTK used? How is PPP used?

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## Positioning Task Force

- Next meeting (26 Oct)
  - Will address map accuracy, drift and other issues and coordinate with SPaT/MAP TF → drives location accuracy needs
  - Review CAMP-created ConOps

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# Positioning Task Force

Q&A

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## **Security Task Force**

**Jimmy Upton / William Whyte, co-chairs**

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## Security Task Force

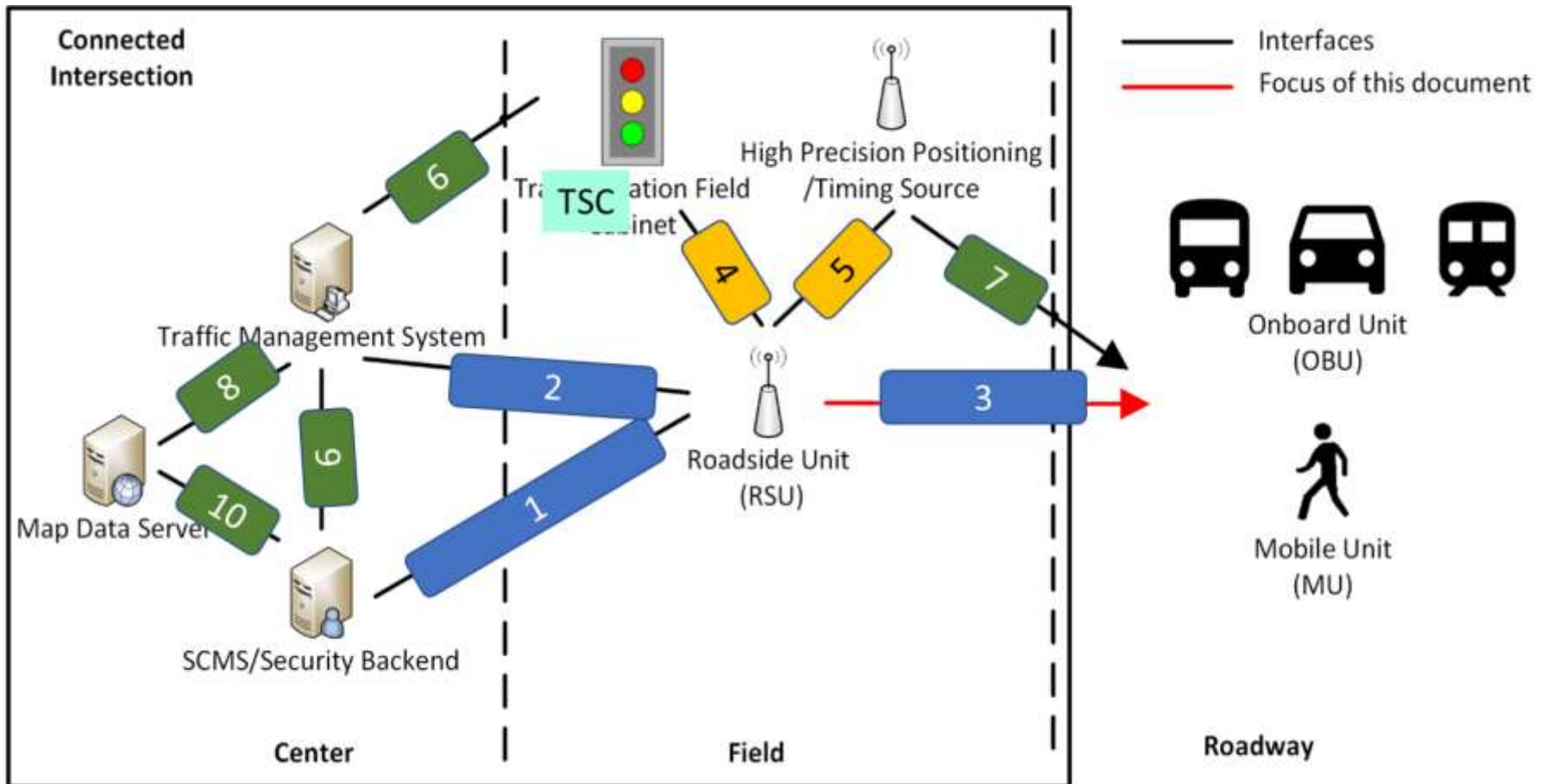
- How can we enable devices to create SPaTs and MAPs to a sufficiently high quality that OEMs will enable production vehicles to trust them?
- Purpose:
  - Address gaps, ambiguities and interoperability issues with security across the V2X interface, including minimum requirements.

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## Security TF Activities

- Completed ConOps material for review and supported walkthrough
- Started work on requirements
- Current tasks / focuses
  - Understand existing data flows that support SPaT and MAP to ensure that security requirements are tailored to them
    - Especially MAP data flows from MAP center to RSU
  - Complete resolution of outstanding comments on security part of ConOps document
  - Establish correct model for security requirements other than on the RSU
    - Want to accommodate existing deployments if they can be shown to be secure enough

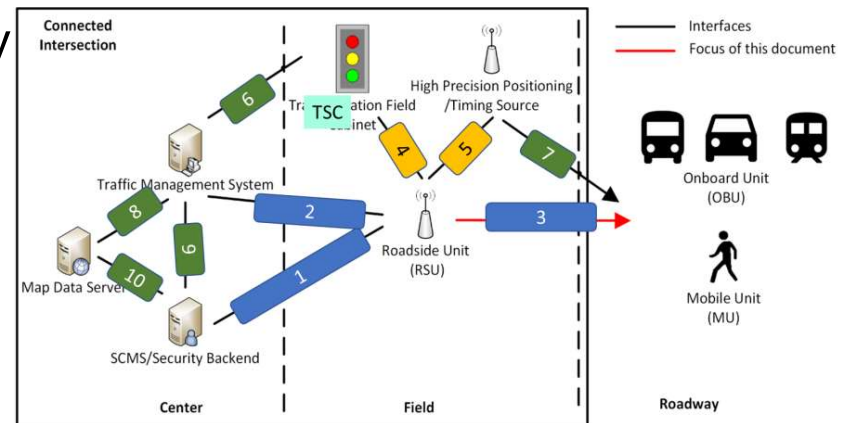
# Requirements Model





# Requirements Model

- Interfaces 1, 2, 3: Can be fully specified in design phase
  - Interface 3 basically is already fully
  - RSU Spec is close to fully specifying 1 and 2
- Interfaces 4, 5: Can specify requirements and (in design phase) give a list of approved mechanisms based on existing supported techniques
- Interfaces 6, 8, 9, 10: do not intend to specify mechanisms on these but to specify requirements
  - Maybe give examples of mechanisms that satisfy requirements but not mandatory



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## Security certification model for traffic management network

- CI documents state requirements for the internal traffic management network
  - Interfaces 6, 8, 9, 10
  - Common Criteria “Protection Profile” analogy
- Deployment sites write a doc specifying how their internal network meets those requirements
  - Common Criteria “Security Target” analogy
    - This could be done simply by saying the site uses the mechanisms given as examples in the CI Guidance docs
    - But sites with legacy mechanisms or other mechanisms could still be validated

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# Security certification model for traffic management network

## – SCMS Operator

- Reviews the “Security Target” doc and determines that, if true, it would meet the requirements
- Evaluates the deployment site to determine that the Security Target doc correctly describes it
- Issues certificates for SPaT (and, if managed by the deployment, MAP) only if those requirements are met

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## **Testing/Conformity Task Force**

**Jay Parikh / Christina Spindler, co-chairs**

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# Testing / Conformity Task Force

## – Purpose

- Define test requirements and criteria for verifying conformity to the CI Implementation Guidance

## – Co-Chairs

- Jay Parikh (CAMP)
- Christina Spindler (Wyoming DOT)

## – SDO Support

- Venkat Nallamotheu (AASHTO)

## – Consultant Support

- Manny Insignares (ConSysTec)
- Randy Roebuck (OmniAir)

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## T&C TF Topics

1. Testing & Conformity User Needs
2. Testing Scope
3. Test Plan Requirements
4. Testing Methodology
5. Next Steps

# CI Testing & Conformity User Needs

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- Infrastructure Testing Needs
  - Need to test/verify message data to vehicle (OBU) / MU
  - Need to test/verify referential integrity of message data (e.g., Intersection IDs in SPaT and MAP)
  - Need to manage configuration and changes
- Testing Methodology
  - Need to describe methods and approach to testing
  - Need to test/verify data format, structure, and content of Messages
    - From signal controller and RSU
  - Need to describe and test:
    - positive outcomes when correct inputs are provided to a CI
    - test error condition handling when incorrect inputs are provided to a CI
    - test boundary conditions/values provided to a CI

# CI Testing & Conformity User Needs – Test Methodology

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## – Testing Methodology

- Describe methods of data collection for analysis-based testing
  - For example, through message packet capture
- Develop test documentation to guide comprehensive testing
- Describe methods of requirements verification (test cases and test procedures)
- Describe test environment for comprehensive and consistent testing
- Information regarding available testing tools



# CI Testing Scope – Identifies Testing Needs and Requirements of Various Interfaces

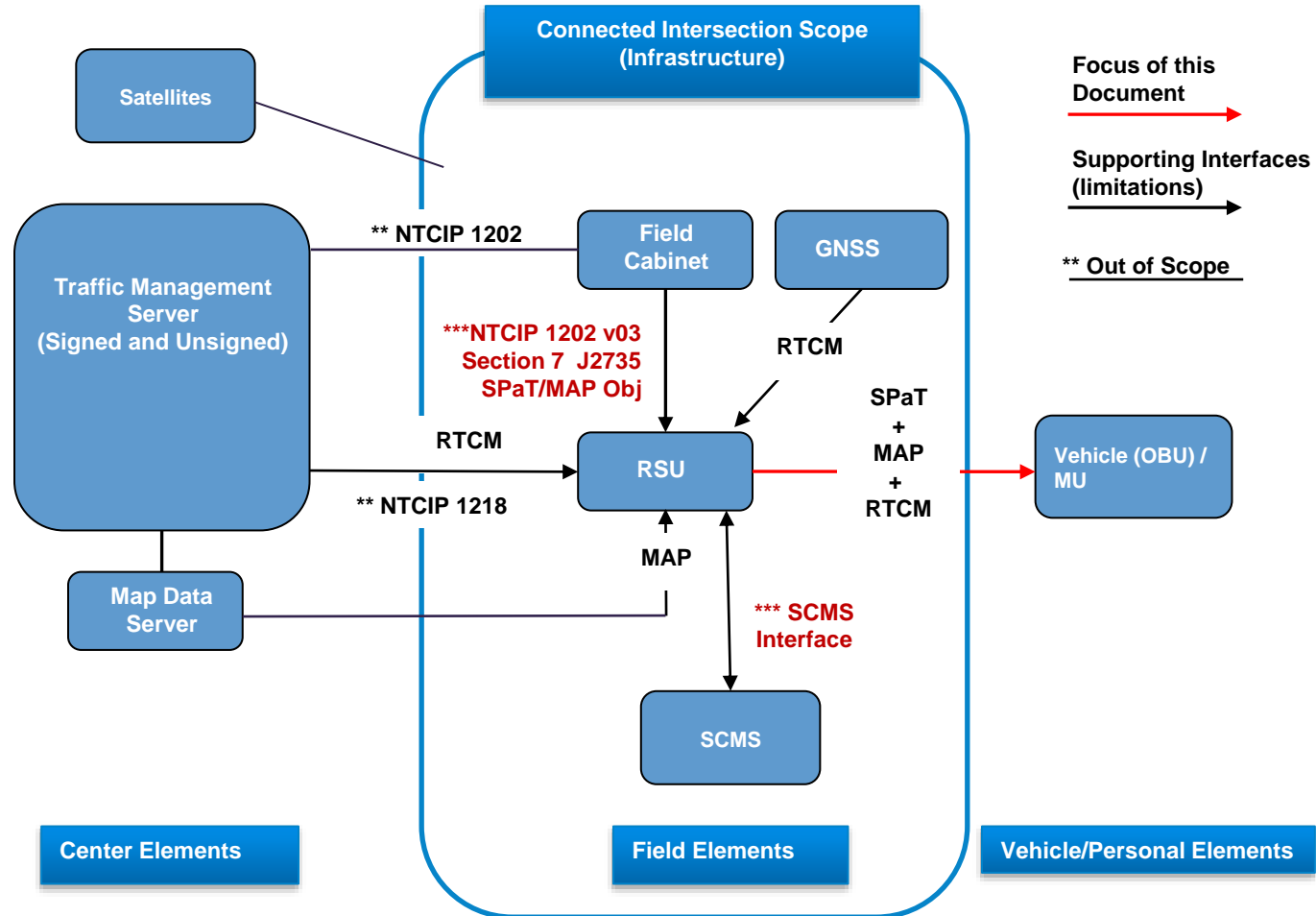
Note: RSU HSM needs to be located where the message is being signed.

## In Scope Interfaces

1. SPaT
2. MAP
3. RTCM

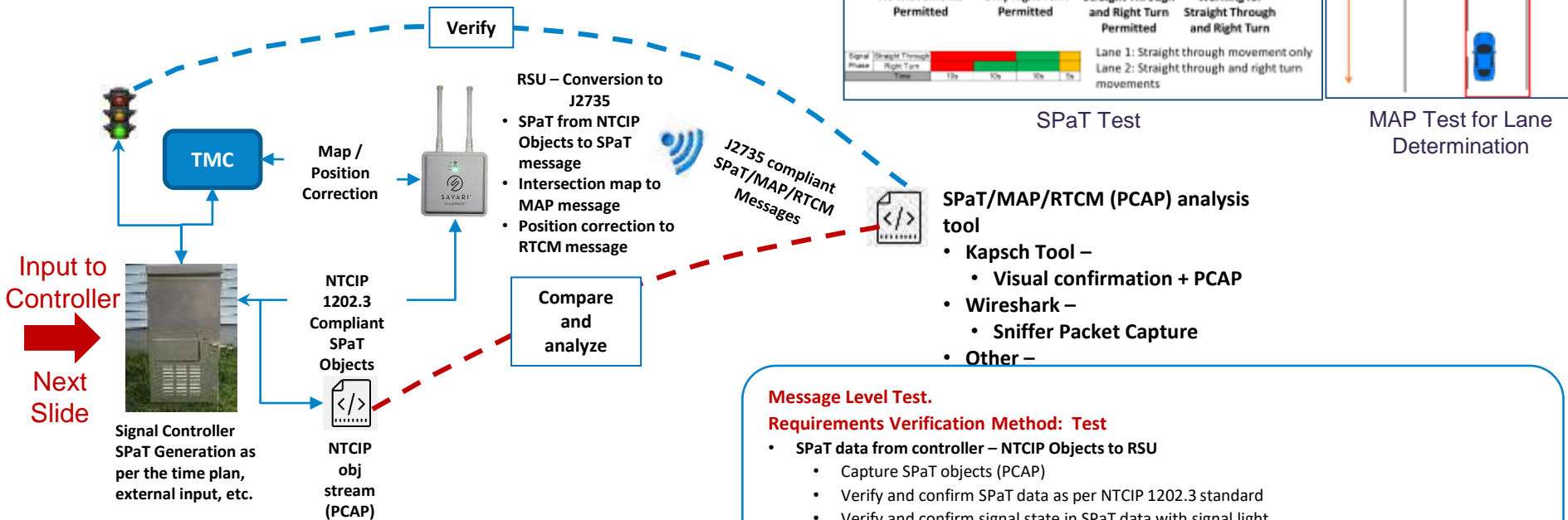
\*\* Indicates Out of Scope.

\*\*\* Indicates limited to what is minimally necessary to accomplish testing.



# CI Test Environment – Identifies Test Points and Test Methodology

## Field Test



### Out of scope:

- Physical h/w mounting/testing of field equipment
- Wireless comm, protocol and message transmission
- Stress test (RSU, Controller, etc.)
  - Physical and interface
- Gap, ambiguity, etc. in other standards
  - NTCIP 1218, NTCIP 1202.xx, NEMA TE-2, etc.

### Message Level Test.

#### Requirements Verification Method: Test

- SPaT data from controller – NTCIP Objects to RSU
  - Capture SPaT objects (PCAP)
  - Verify and confirm SPaT data as per NTCIP 1202.3 standard
  - Verify and confirm signal state in SPaT data with signal light
- SPaT/MAP/RTCM message broadcast from RSU
  - Capture SPaT/MAP/RTCM messages
  - Verify and confirm message transformation and data as per:
    - Required and optional elements for RLVW
    - J2735 structure and format and CCI guideline
    - Correctness of data in the message (verify against NTCIP objects for transformation check)
      - TimeMark, signal phase/time as generated by the controller
    - Correlate data in SPaT/MAP for the intersection (e.g. intersection ID, signal group and lane IDs, etc.)

#### End-to-End Test. (Test-point to Test-point)

#### Requirements Verification Method: Data Collection and Analysis

- Compare and analyze data values in PCAP (packet capture) streams.
- Field test (Ref. Implementation)

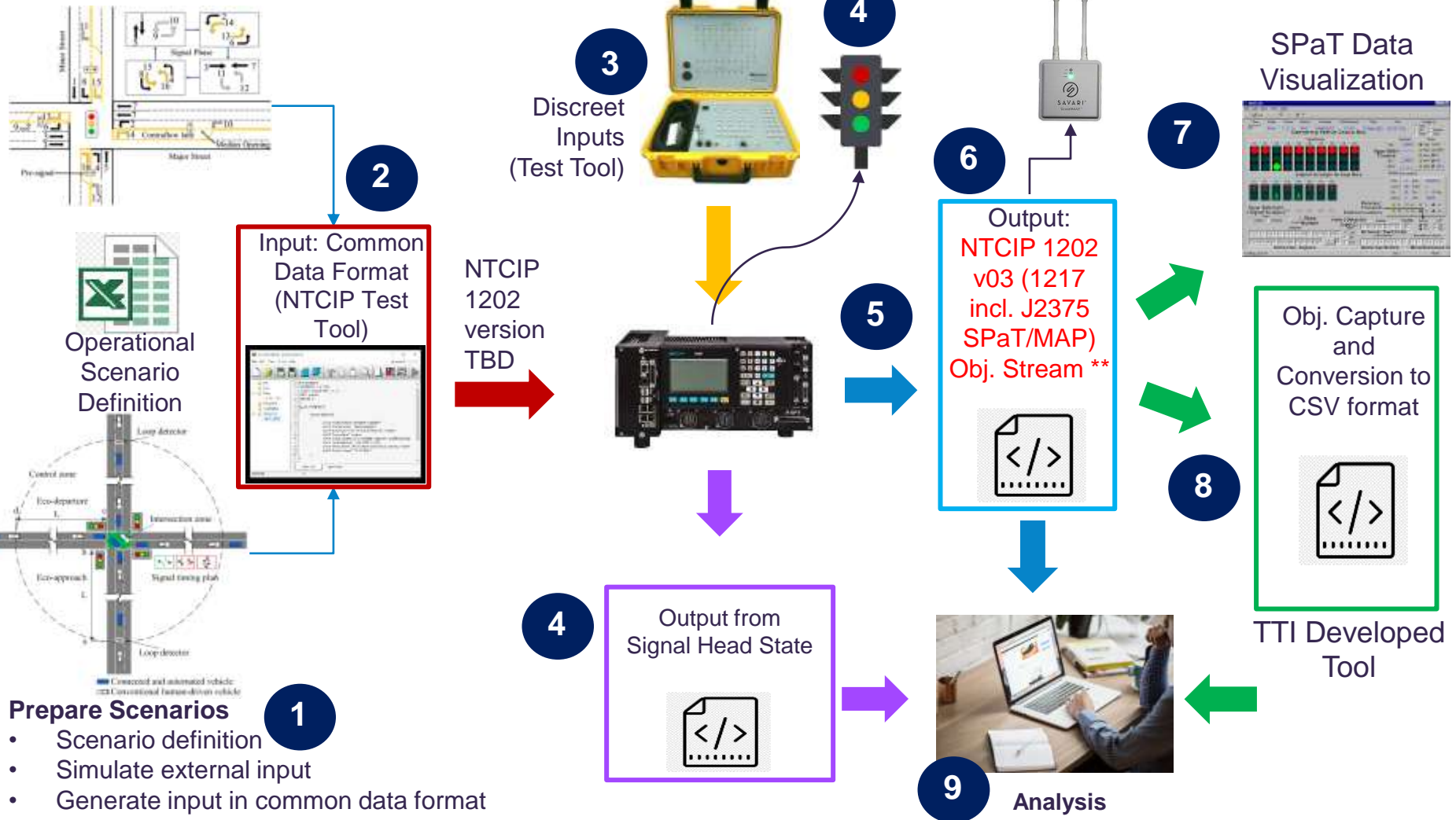
# Steps for Signal Controller Test – Bench Test

- T&C TF define this diagram as a Bench Test Environment, SPaT specific

## Discreet Inputs:

- Time based control (Fixed Time)
- Actuated
- Coordinated

- Preemption
- External Inputs
  - Ped xwalk activation
  - Vehicle detection



# End-to-End Test Procedure Steps for Controller (Overview)

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1. Develop operational test scenarios
2. NTCIP Test tool input to signal controller (e.g. From Laptop)
3. Test tool to generate discreet inputs to Controller
  - E.g. Ped xwalk activation, vehicle detection, side street actuation, priority/preemption, etc.
4. Controller output to Signal Head and to a file (CSV format)
  - Signal light verification (as per the phase indication from controller)
5. Simultaneous with Step 4, controller output in NTCIP 1202 v03 (SPaT Data (1217)) to RSU
6. Capture controller output from Step 5 in a PCAP file
7. Simultaneous with Step 6, a visualization tool:
  - Controller SPaT information output visualization
8. Test tool (e.g., TTI Test Tool) converted byte-oriented SPaT information or NTCIP 1202 v03 packets to a CSV file
9. Analysis
  - Collect the output data capture from the controller
  - Time synchronize the data
  - Verify controller outputs for the given set of operational inputs defined in steps 1, 2, and 3



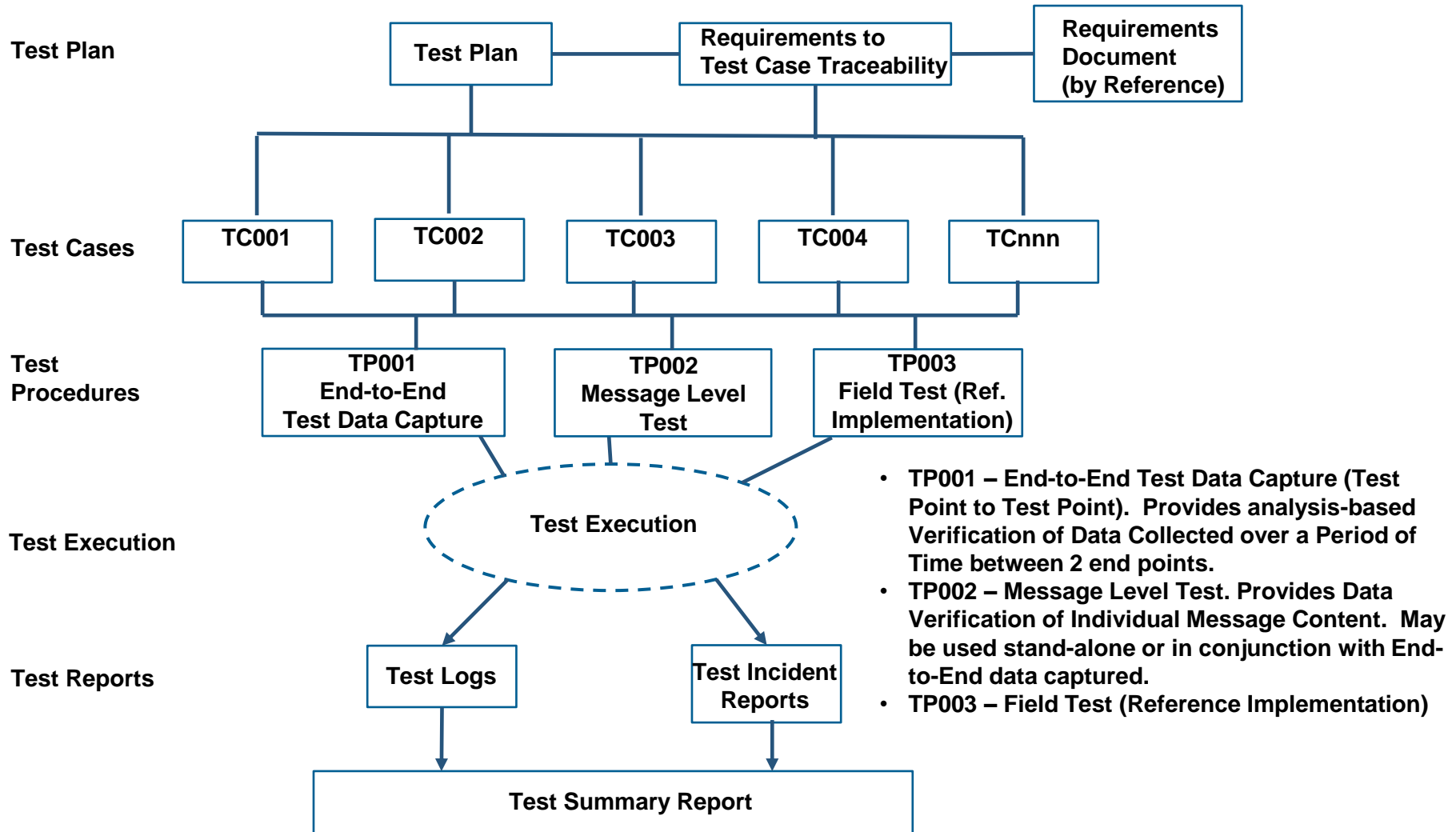
# End-to-End Test Procedure Steps for RSU (Overview)

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1. Controller: SPaT data output to RSU as defined in NTCIP 1217 (inc. in 1202v03)
  - Simultaneously:
    - Capture controller output in a file for conversion to CSV format
    - Controller output of signal phase to signal head
  - 1a: RSU: Receive MAP/RTCM data from TMC
2. RSU: Convert SPaT, MAP and RTCM data to J2735 UPER encoded messages with proper security and broadcast at:
  - SPaT @ 10Hz
  - MAP @ 1Hz
  - RTCM @ xHz (Message type dependent)
  - Test receiver device: Receive OTA messages and capture packets in a file
  - Convert captured packets to CSV format for processing
3. Analysis Tool: Testing and conformity analysis
  - 3a: Conduct conformance as per J2735 for SPaT/MAP/RTCM
  - 3a: Conduct analysis of SPaT data from controller(step 1) and SPaT message from RSU (step 2)
  - 3a: Generate test report

# DRAFT Connected Intersections Test Documentation Organization Based on Review of Existing Test Documentation gathered.

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# Next Step

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- Test Plan Outline
  - Identification of requirements
  - Requirements to Test Case Traceability Matrix
  - Test Methods (Procedures)
    - Message Level Testing
    - Field Level Testing (Ref. Impl.)
  - Operational scenarios for testing
  - Potential Test Location(s)
  - Test Equipment Setup
    - Pre-test Equipment Setup and Verification of Configuration
  - Data Collection Management
    - Start Time / End Time
    - Frequency of Collection
    - Data Format (specification) of Logged Data
    - Data synchronization time markers to match test point data
  - Analysis Steps
    - Calculations
    - Pass/Fail Determination



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# Testing & Conformity Task Force

Q&A

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## **Traffic Controller Issue Task Force**

**Kevin Balke / Roy Goudy, co-chairs**

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## Our Focus

- Issues that have to do with Traffic Controllers and Traffic Control Operations
  - Resolving gaps and ambiguities that have already occurred
  - Identifying and documenting traffic operational scenarios that are potentially problematic
  - Make recommendations, identify needs, develop requirements, and specifying design to provide SPaT data in a consistent manner across traffic controller manufacturers

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## **Traffic Controller Issues Task Force**

1. Accomplishments since July Plenary Meeting
2. Traffic Operational Scenarios
3. User Needs
4. Traffic Controller Manufacturers Subcommittee
5. Confidence Factor Subcommittee
6. Red Light Violation Warning (RLVW)
7. Next Steps
8. Q&A

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## Accomplishments since the July Plenary Meeting

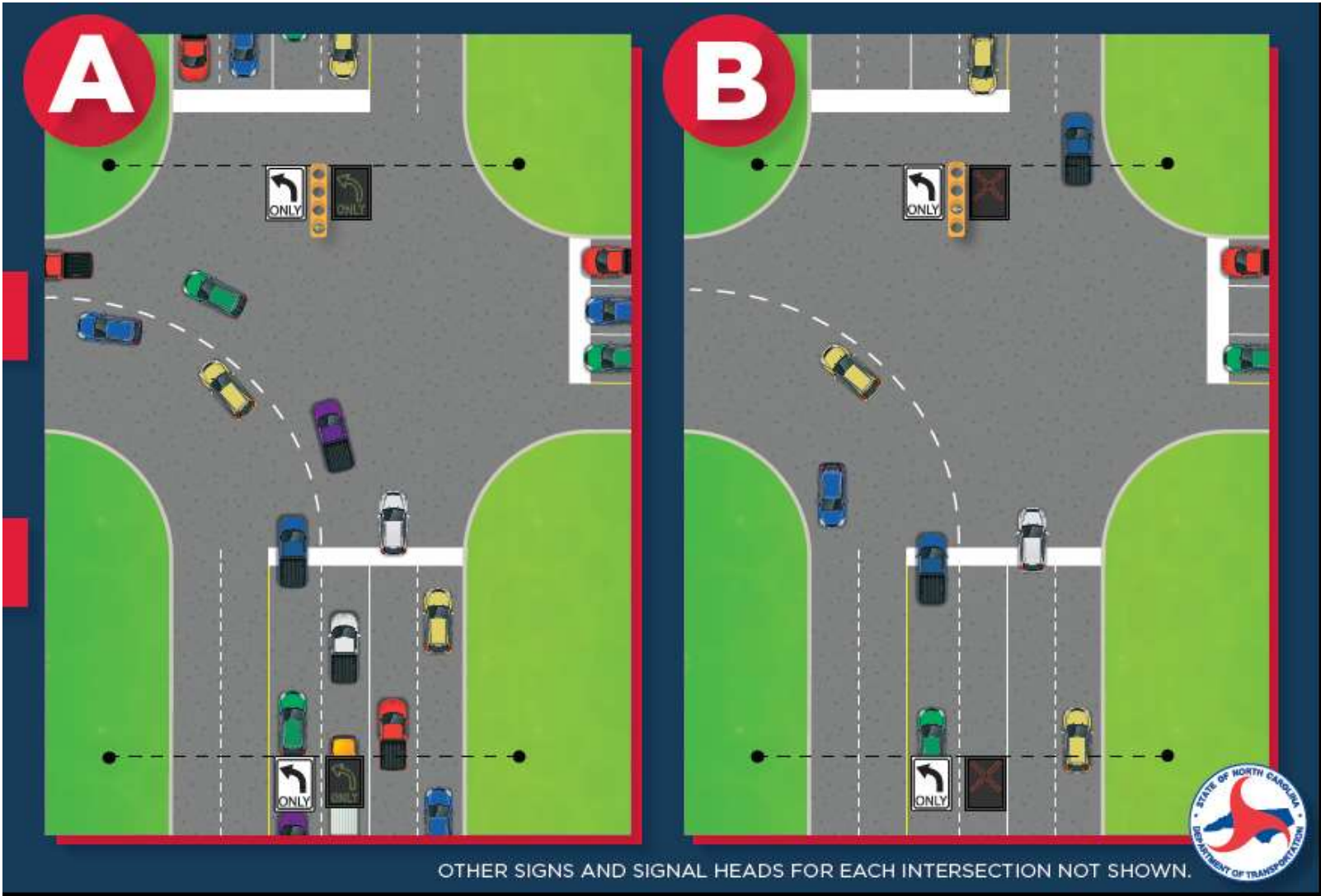
- Held 12 Task Force Meetings
  - Developed Traffic Operational Scenarios
  - Developed User Needs based on gaps, ambiguities and issues that have occurred
  - Created a Traffic Controller Manufacturers Subcommittee
  - Created a Confidence Factor Subcommittee
  - Produced SPaT Interpretation Document
  - Produced Red Light Violation Warning (RLVW) Description Document

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## Traffic Operational Scenarios

- Developed to expose gaps in SPaT and MAP messaging for signalized intersections
- May be used as test cases for proposed changes to SPaT and MAP messaging
- The Traffic Operational Scenarios written so far:
  - Two intersections operated by a single controller
  - Texas Diamond Operation
  - Florida T Intersection
  - High-intensity Activated crossWalk (HAWK) Beacons
  - Intersections with External Logic
  - Intersection with Dynamic Lane Use
- 9 other intersection issues identified

# Example – Dynamic Left Turn Intersection



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# Traffic Controller Issues TF User Needs - Examples

## 1 Uniform

All connected intersection needs to provide a consistent (or uniform) representation of the situation and operating conditions. Uniform data fields increase interoperability between the infrastructure components and the applications that use the data to aid drivers and VRUs.

## 2 Robustness

The connected intersection needs to be robust. When subject to anomalous data and commands, the connected intersection and its components function properly and are not corrupted. The connected intersection and its components also function properly under the maximum simultaneous data traffic possible on all communications interfaces. Applications depend on continuous and proper operation under extreme demands on the system.



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## Traffic Controller Manufacturers Subcommittee

- Subcommittee made up of technical representatives from all six of the major US traffic controller manufacturers (and a few invited guests)
- Initial work was in cleaning up SPaT interpretation – Document produced
- Gained agreement from all manufacturers on base assumptions and timing calculation methods for fields used in the SPaT message
  - Includes what to do in special cases such as flash conditions
- Developed RLVW document and merged with SPaT interpretation document
  - Subcommittee now reviewing

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## Confidence Factor Subcommittee

- Held 2 Meetings
- Goal to find a workable solution for a confidence factor for predicting the next change in signal indications
- Determined that for safety applications such as RLVW, nearly 100% confidence is required
- Developed draft document describing RLVW needs
- Suspended Confidence Factor meetings to engage Task Force on RLVW
- Whether we will use a confidence factor from within the traffic controller is still TBD
  - Confidence factor may be something applied externally by a monitoring system

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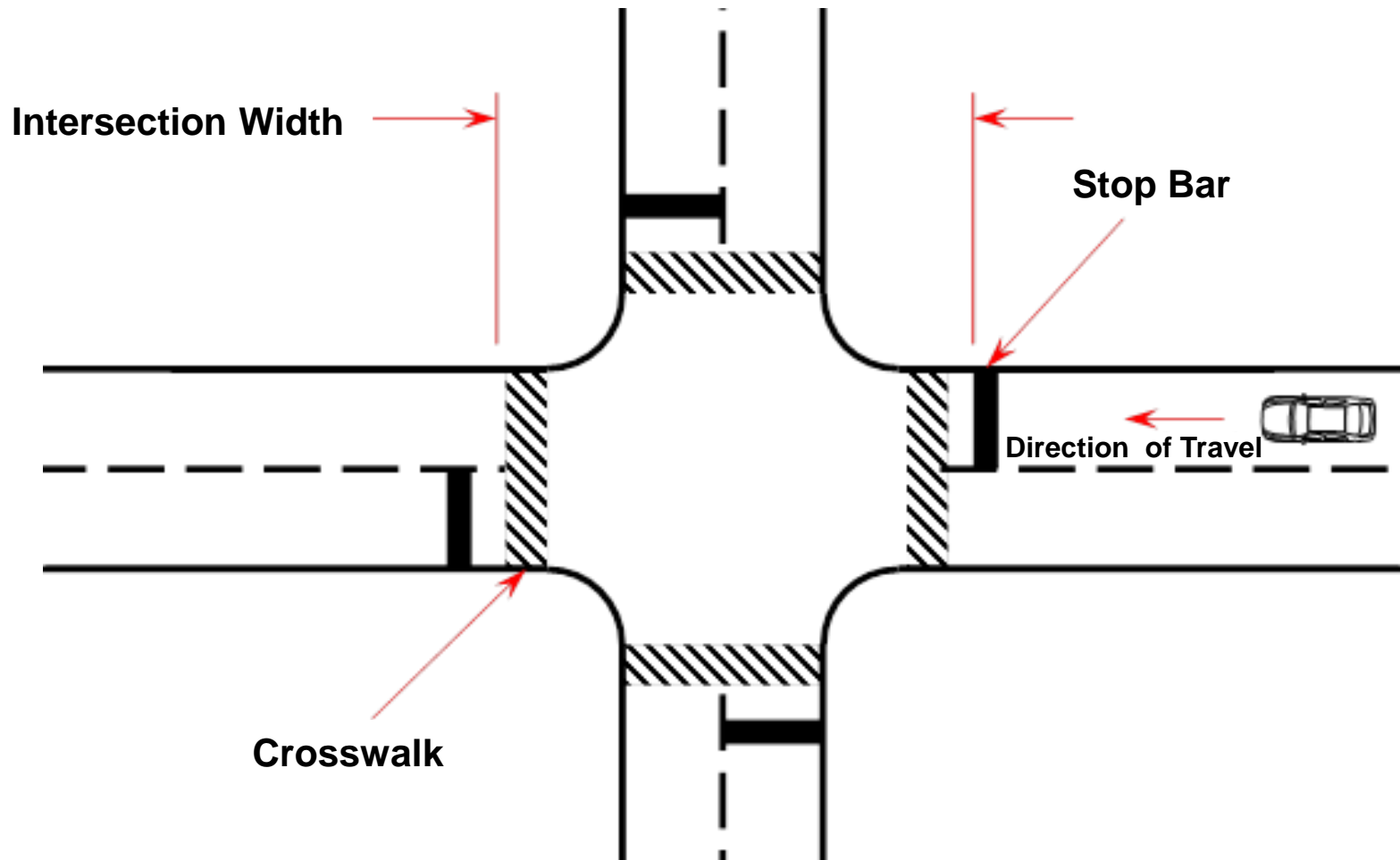
## Red Light Violation Warning (RLVW)

- Traffic signal controllers allow traffic engineers to program them to safely maximize traffic flow
- Under fully actuated signal operation:
  - Termination of green time is not an event that can be predicted with any certainty
  - Yellow change interval timing has a high confidence/certainty (nearly 100%)
- Yellow change interval timings are generally set to allow driver to:
  - Stop before entering the intersection or
  - Enter during yellow but allow signal to change to red while vehicle is still intersection

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## Red Light Violation Warning (RLVW) (cont.)

- Based on RLVW document, the need is to provide an alert so the driver may clear the intersection while in yellow



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## Red Light Violation Warning (RLVW) (cont.)

- This means:
  - A time mark is needed for the imminent termination of green at approximately two seconds before the actual green termination in the field
  - Referring to this as Advance Warning of End of Green (AWEG)
- RLVW based on yellow change interval time + AWEG will provide time for drivers to:
  - Stop before entering the intersection or
  - Enter and clear intersection while signal is in yellow

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## Red Light Violation Warning (RLVW) (cont.)

- TCI TF is seeking to offer some level of AWEG support
- Need different methodologies to accommodate high variability in intersection geometries, control strategies, and existent infrastructure
- Develop a set of recommended changes for CIs based on the local factors
- Provide the maximum amount of AWEG feasible without a negative impact to the intersection safety and efficiency

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## **Red Light Violation Warning (RLVW) (cont.)**

- Original RLVW document has been updated
- Draft contains proposed methods for AWEG under various conditions
- Draft AWEG description document produced under the TCI Task Force
- Now RLVW/AWEG and SPaT interpretation documents merged and being reviewed by TC Manufacturers Subcommittee

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## Next Steps for the TCI Task Force

- Gain consensus support by TC Manufacturers Subcommittee for RLVW/AWEG and SPaT interpretation documents
- Formalize requirements
- Make recommendations for changes in signal software, traffic operations for CI, and changes in existing standards



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# Traffic Controller Issues Task Force

Q&A

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## **Questions & Answer Session**

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## Next Steps (Thai)

### – Project Schedule

- Requirements Walkthrough (early December)
- Requirements Document (early January 2021)
- Draft Implementation Guidance Document (Complete April 2021)
- Validation (to be determined April – June 2021)
- Publish Final Implementation Guidance Document (Complete September 2021)

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## Validation Sites (Goudy)

### – Potential Validation Sites

- Developing a checklist of minimum requirements for a reference implementation setup with the USDOT.

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## Participation

- If interested in participating in a Task Force, send an e-mail to:
  - [standards@ite.org](mailto:standards@ite.org)
- Please indicate which task force(s) in the e-mail
- Participation limited to no more than 3 task forces

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## Closing Remarks

- USDOT
- Standards Development Organizations (SDOs)
  - AASHTO
  - ITE
  - NEMA

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# Adjourn

– Thank you!