V2V Interoperability Project

USDOT ITS Connected Vehicle Workshop

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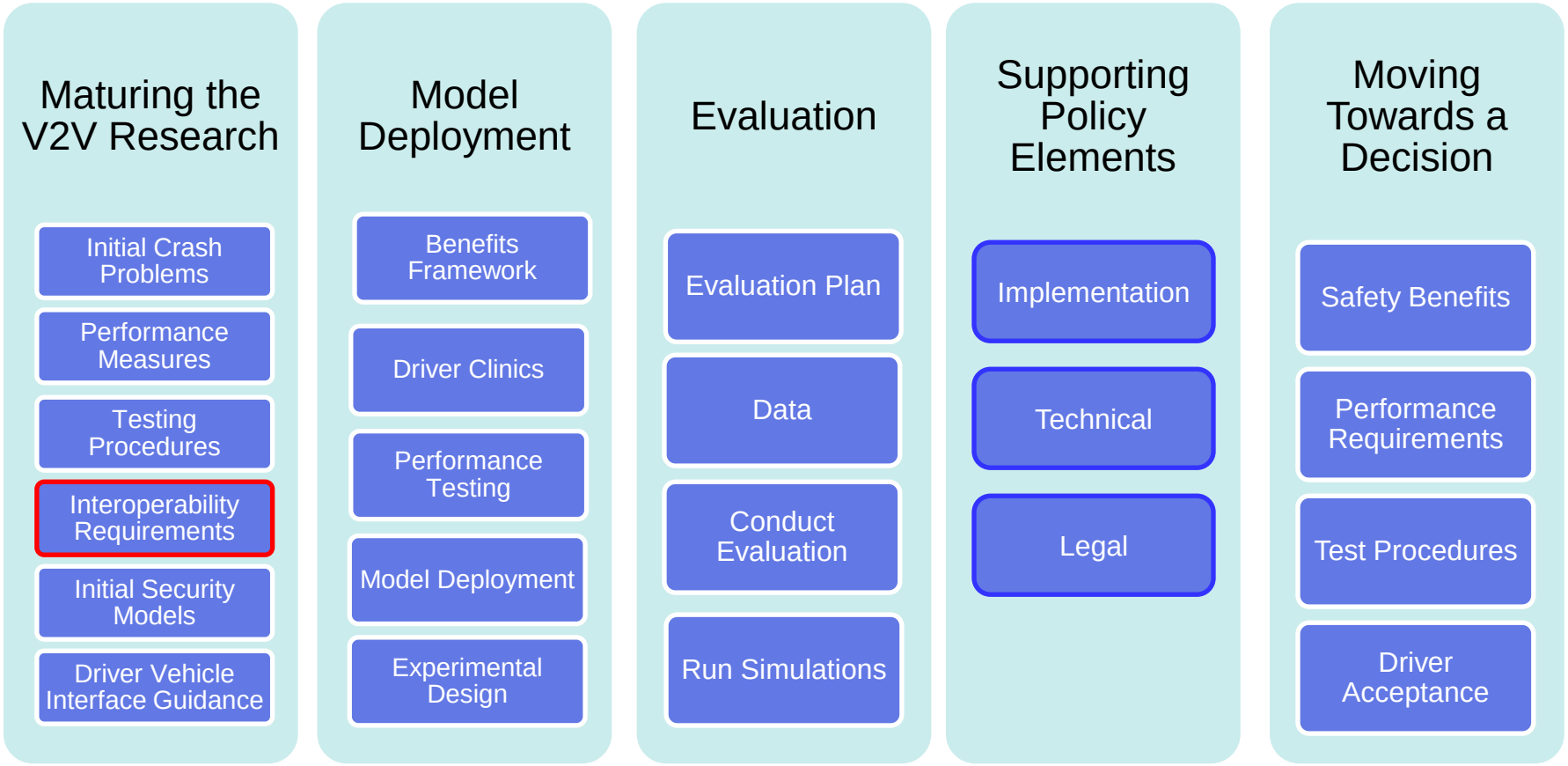
V2V Safety Framework



OVERVIEW

What is V2V Interoperability?

- The ability for V2V safety systems to successfully function across any, and all, equipped vehicles regardless of make/model or model year

V2V-Interoperability Project:

- Follow-on project to CAMP-VSC 2 / US DOT VSC-A project (2006-2009)
- Project Duration:
  - Phase I: 30 month project - January 2010 - June 2012
  - Phase II: 21 month extension through March 2014
- Collaborative effort between 8 Automotive OEMs and US DOT

CAMP
Vehicle Safety Communications 3
Mercedes-Benz Research & Development North America, Inc.
GM
TOYOTA
HONDA
Honda R&D Americas
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NISSAN
HYUNDAI·KIA MOTORS
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Research and Innovative Technology Administration
Volpe National Transportation Systems Center

PROJECT OBJECTIVES

- Address 5.9 GHz DSRC technical issues related to interoperability, scalability, security, and data integrity / reliability
- Provide necessary inputs into the relevant standards development and related efforts, as required, in order to ensure a deployable standards-based system

V2V Safety Communications Interoperability

- Task Goal
  - To achieve V2V safety communications and security interoperability between On Board Equipment (OBE) systems from different manufacturers
- Accomplishments
  - Specified preliminary minimum device requirements for V2V safety communications and security
  - Worked with 4 suppliers to develop On-Board Equipment (OBEs) to meet requirements
  - Conducted interoperability testing and analyzed interoperability test results
  - Developed and implemented remediation recommendations for device requirements and industry standards
  - Achieved device level Vehicle-to-Vehicle (V2V) safety communications and security interoperability between OBEs from different manufacturers

V2V Safety Communications Scalability

- Task Goal
  - Identify a transmission control protocol for scalable V2V safety communications that will preserve the performance of V2V safety applications in both congested as well as un-congested communication environments.
- Primary Transmit Test Configurations to Address the Goal
  - Baseline 1 – 10 Hz fixed BSM transmit rate
  - Baseline 2 – 5 Hz fixed BSM transmit rate
  - Algorithm X – Adaptive control of the BSM transmission rate and transmission power based on a host vehicle position tracking error estimation and channel utilization assessment
  - Algorithm Y – Adaptive control of the BSM transmission rate based on reported channel utilization assessments from neighboring vehicles and that measured by the host vehicle

V2V Safety Communications Scalability

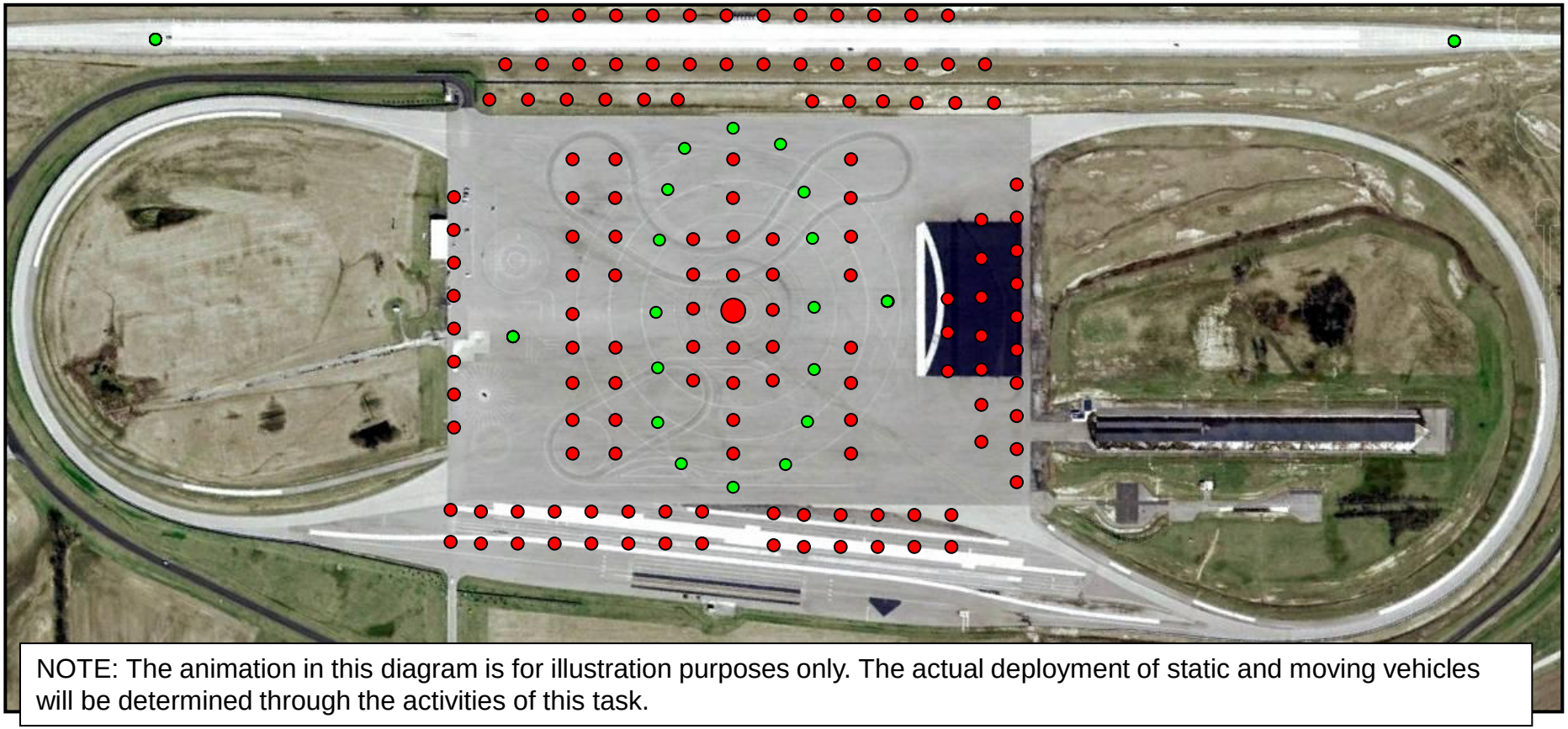
- Metrics for analyzing transmit test configuration performance
  - Packet Error Rate (PER): Ratio of the number of missed packets at a receiver from a particular transmitter and total number of packets sent by that transmitter
  - Inter Packet Gap (IPG): Time between successive successful packet receptions from a particular transmitter
  - Position Tracking Error (TE): Difference between a transmitter's position and a receiver's estimate of the transmitter's position
  - Channel Busy Percentage (CBP): Ratio of the time during which the wireless channel is busy (energy level is higher than carrier sensing threshold) to the period of time over which CBP is being measured
  - Vehicle Safety Application Range Error: Threat range error in actual warning range versus the nominal warning range assuming fixed speed and acceleration

V2V Safety Communications Scalability

- Testing Increments and Locations
  - 50 Vehicle Test
    - Transportation Research Center (TRC) from November 11 - 18, 2011
  - 100 Vehicle Test
    - Naval Air Station Alameda from January 24 - 31, 2012
  - 200 Vehicle Test
    - TRC from March 24 – April 3, 2012
- 200 Vehicle Test
  - 6 primary driving configurations encompassing 8 driving scenarios
    - Highway – 2 Scenarios
    - Intersection – 1 Scenario
    - V2V Safety Application – 1 Scalability Scenario w/ 3 Safety Application Scenarios
    - High Dynamics Winding Road – 1 Scenario
    - Hidden Node – 2 Scenarios
    - Sudden Loading Effect – 1 Scenario
  - 3 OBE scaling increments: 100, 150, & 200 OBEs

Scalability Testing

As an animation…



NOTE: The animation in this diagram is for illustration purposes only. The actual deployment of static and moving vehicles will be determined through the activities of this task.

SCALABILITY TESTING

…and in reality

V2V Safety Communications Scalability

- Preliminary observations from the 200 vehicle test scenarios:
  - The channel congestion level was highest for the Baseline 10 Hz configuration but was not to the point of being fully saturated
  - For all configurations and scenarios, there was no evidence of significant degradation of the communication performance that would seem to result in degradation of the vehicle safety applications for 200 vehicles
  - Algorithm X and Algorithm Y show promising communication performance that may result in good performance of the vehicle safety applications for 200 vehicles while reducing the channel utilization to lower values in comparison to the baseline 10 Hz configuration
- Next Steps – Finalize V2V safety communication technique(s) that will support large-scale deployment level of vehicles while preserving the performance of V2V safety applications (Phase II)
  - Calibration of communication simulation environments
  - Algorithm refinement and, if necessary, development of alternate approaches
  - Field testing
  - Incorporate recommendations into standards

SECURITY MANAGEMENT

- Task Goal
  - Develop technical requirements and build a prototype security system, test this system, and utilize it within the scalability testing
- Accomplishments:
  - Developed enhanced OBE security software, a prototype infrastructure security server, and Security Framework Access Devices (SFADs)
  - Equipped 4 OBEs (2 each from two suppliers) with the enhanced security software and provisioned them with SFADs to communicate with the CAMP VSC3 prototype security server
  - Tested the OBEs in the scalability environment at TRC in close proximity with 196 other units broadcasting BSMs on channel 172
  - Demonstrated that the OBEs were able to request and receive security credentials from the Registration Authority (RA) located in the CAMP VSC3 lab, receive batches of certificates, and verify certificates from other OBEs for the following channel configurations:
    - Channel 174 (adjacent channel to the other 196 units)
    - Channel 172 (same as 196 units)
    - Cellular 3G

Data Integrity and Reliability Certification

- Goal:
  - Define and assess the requirements necessary for vehicles to trust the accuracy of the data in the OTA messages and to ensure proper functionality of the safety applications
- Accomplishments:
  - Developed the SP BSM Minimum Performance Requirements
  - Developed initial draft of objective test procedures and test plan for:
    - Vehicle Awareness Device (VAD) / Aftermarket Safety Device (ASD) Minimum Performance Requirements (MPR) certification for MD
    - ASD application certification for MD
  - Determined differences in the outcome of the preliminary objective tests when the sensor data are varied within the currently expected accuracy ranges using simulation
  - Assessed aftermarket units (with no, or limited, connection with vehicle networks) in terms of capabilities and ability to meet preliminary certification procedures
  - Follow-up work is being conducted in V2V-MD Project

COORDINATION W/ OTHER USDOT PROGRAMS

- For Standards Development
  - Active participation in IEEE 802.11, IEEE 1609.x, and SAE J2735
  - Well-positioned for SAE J2945 development
- For Safety Pilot Model Deployment (SPMD)
  - Knowledge transfer of preliminary technical requirements from V2V-Interoperability research for consideration in USDOT SPMD activities
  - Coordination subsequently transferred to CAMP VSC3 V2V-MD Project
- With Vehicle Infrastructure Integration Consortium (VIIC)
  - Security technical inputs related to security policy considerations
  - Close coordination for initial deployment model identification activities
  - Technical cooperation on EU-US harmonization
- For US-EU Standards Harmonization
  - Basic Safety Message (BSM) / Cooperative Awareness Message (CAM) harmonization at the data element level
  - Harmonization on minimum performance requirements on hold pending further input from V2V-MD Project

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