Development of Traffic Information Systems Using DSRC Technology for the Work-Zone Environment

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May 8, 2013

Idea of Connected Vehicles

Mission: **Intelligent Transportation Systems (ITS)**

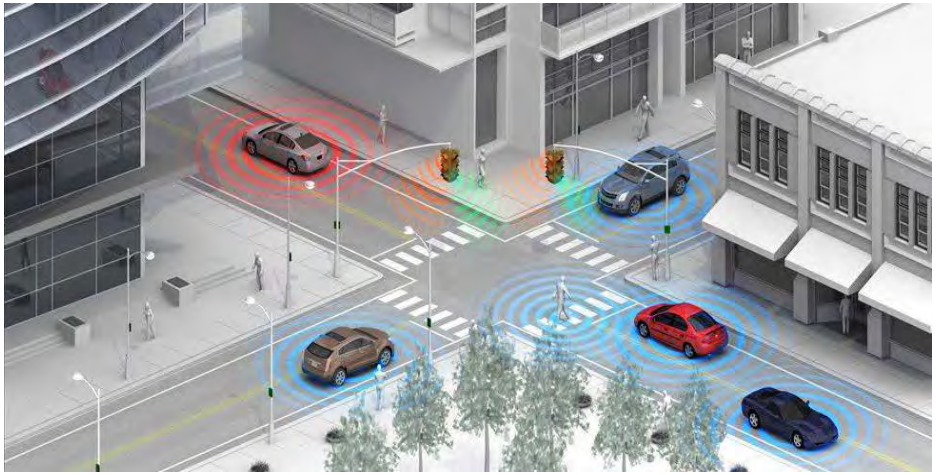
Objectives: **Safety, Mobility and Efficiency**

Outline

- **Introduction**
  - DSRC Technology Overview
  - Applications
  - Work Zone Environment
- **V2I Traffic Information System**
  - System Architecture and Design
  - Field Demonstration
- **V2V Assisted V2I System**
  - System Architecture and Design
  - V2V Protocol
  - Field Demonstration
- **VMS Integration**
  - Need
  - Demonstration
- **V2V System – Ongoing Work**
- **Summary / Questions**

DSRC Technology Overview

A short to medium range wireless communications protocol specifically designed for automotive use to promote traffic safety, efficiency and mobility. It incorporates both Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) communication.

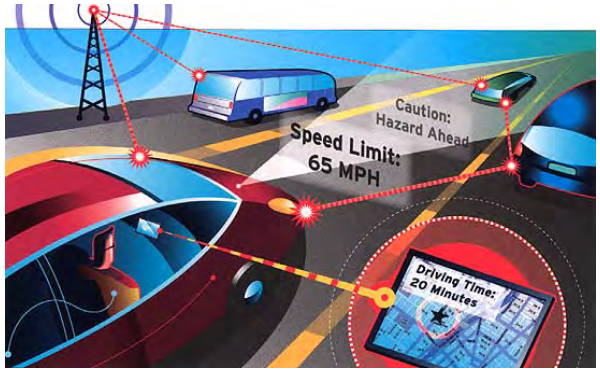


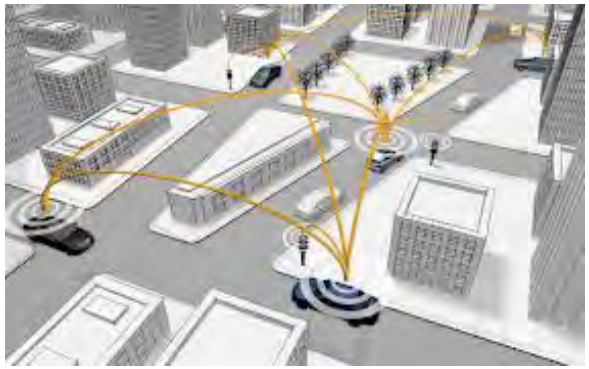
Technical Specifications:

- **5.9 GHz**
- **Range up to 1000 meters**
- **Data rate 6 to 27 mbps**
- **7 licensed channels**
- **Vehicle speed up to 100MPH**

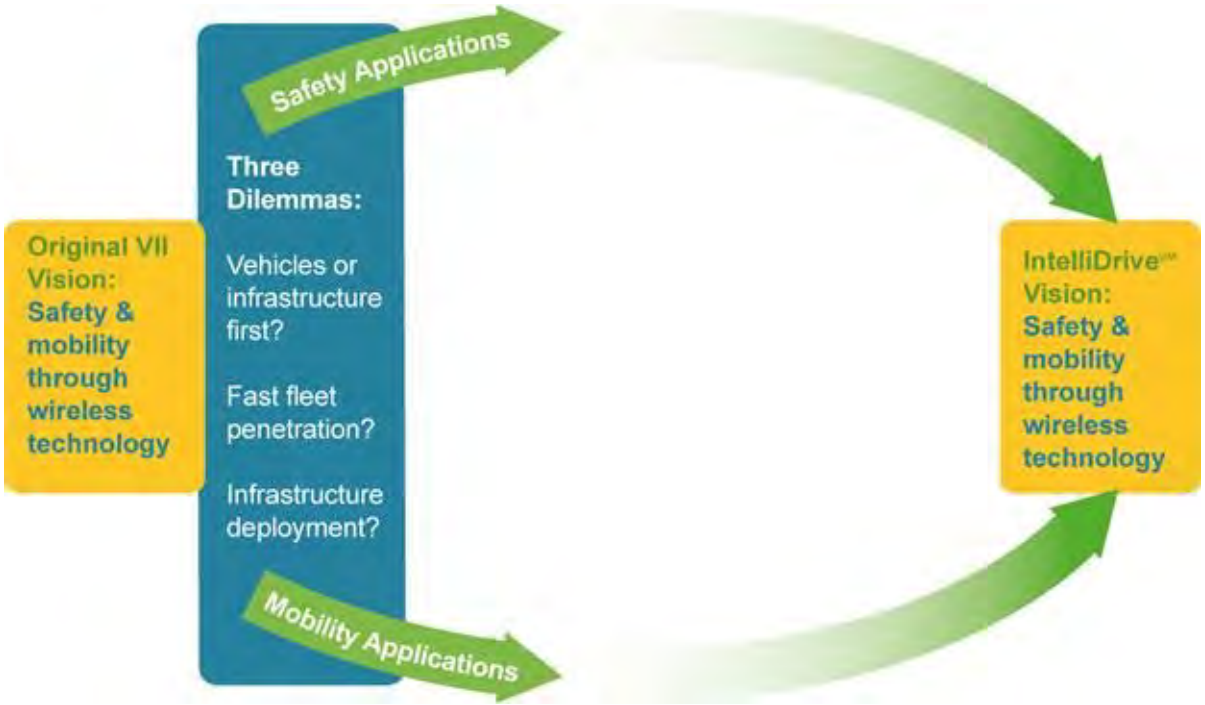
DSRC Potential Applications

- Traffic Information Systems
- Emergency Vehicle Signal Preemption
- Approaching emergency vehicle warning
- Weather and road conditions warning
- Curve speed warning
- Do not pass warnings
- Cooperative Adaptive Cruise Control
- Cooperative Forward Collision Warning
- Left Turn Assist
- Merge Assist





Obstacles to Adoption of DSRC Technology



- **The Chicken and Egg Dilemma**
- **Market Penetration**
- **Infrastructure Support**

Work Zone Environment

Total Work Zone Related Fatalities

Year	Work Zone Related Fatalities
2011	587
2010	576
2009	680
2008	720
2007	831
2006	1,004

Source: Fatality Analysis Reporting System (FARS) - Final, NHTSA

Current Approach to Reduce Fatalities

Estimate travel time and communicate to the drivers

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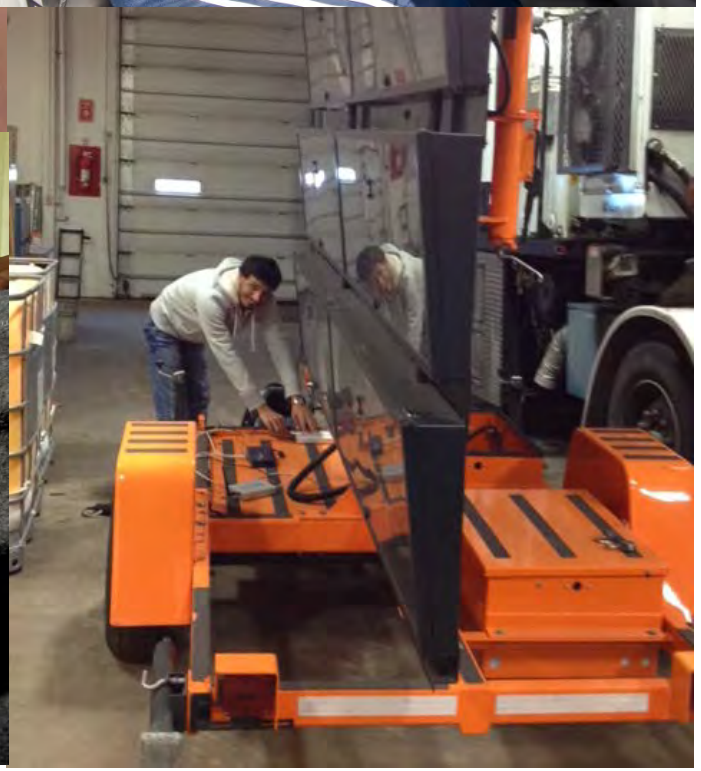
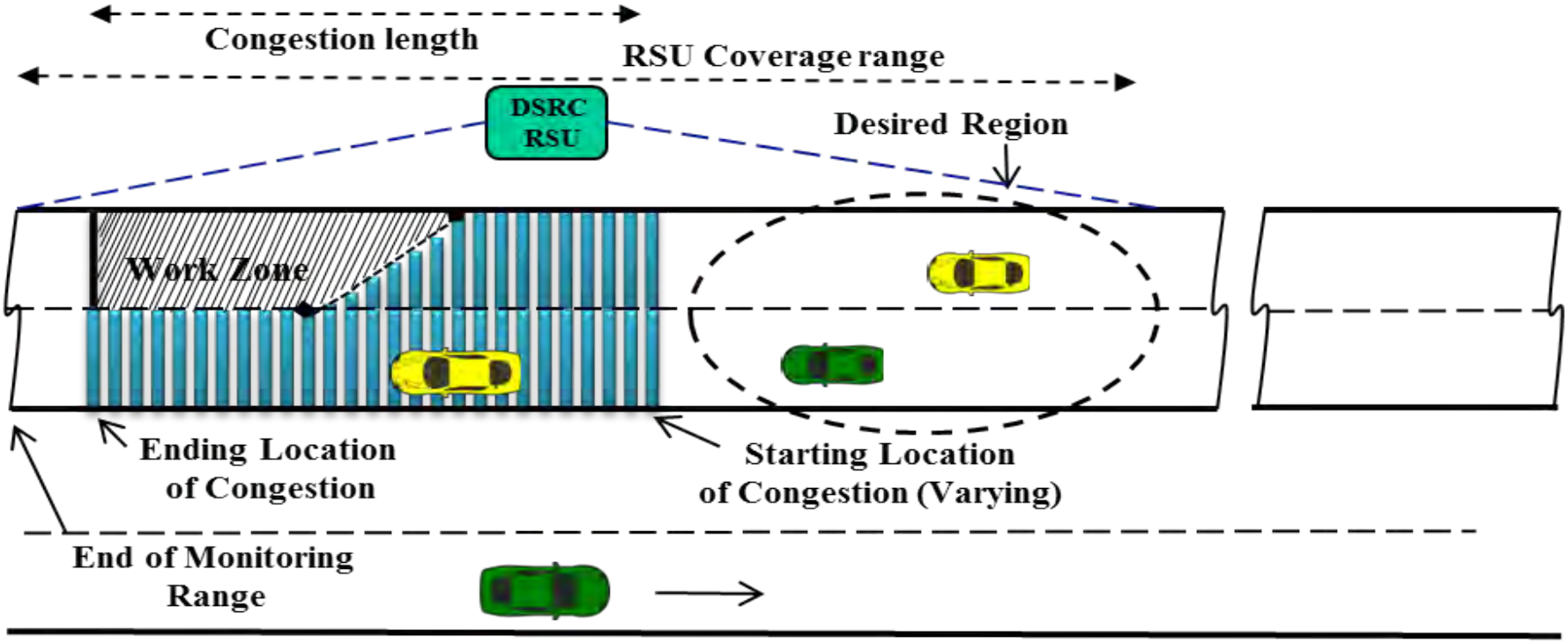
Student In Action

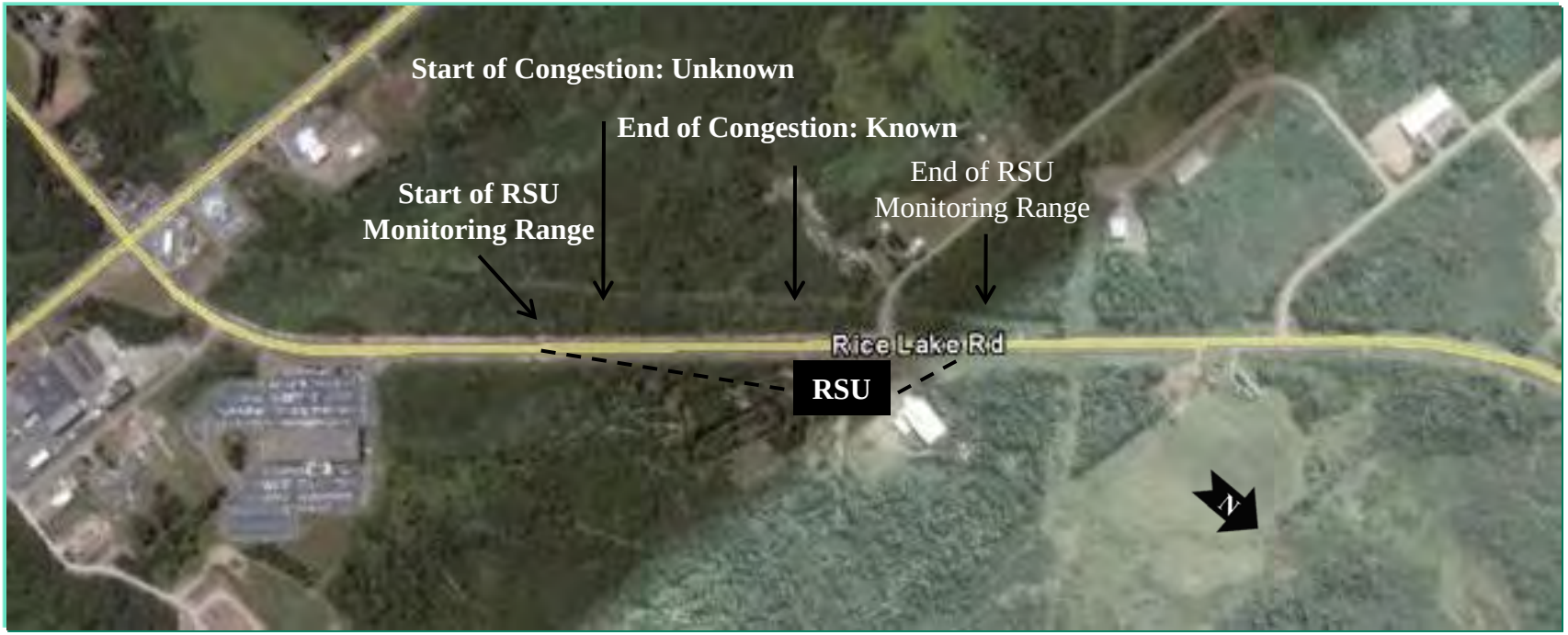


V2I System Architecture



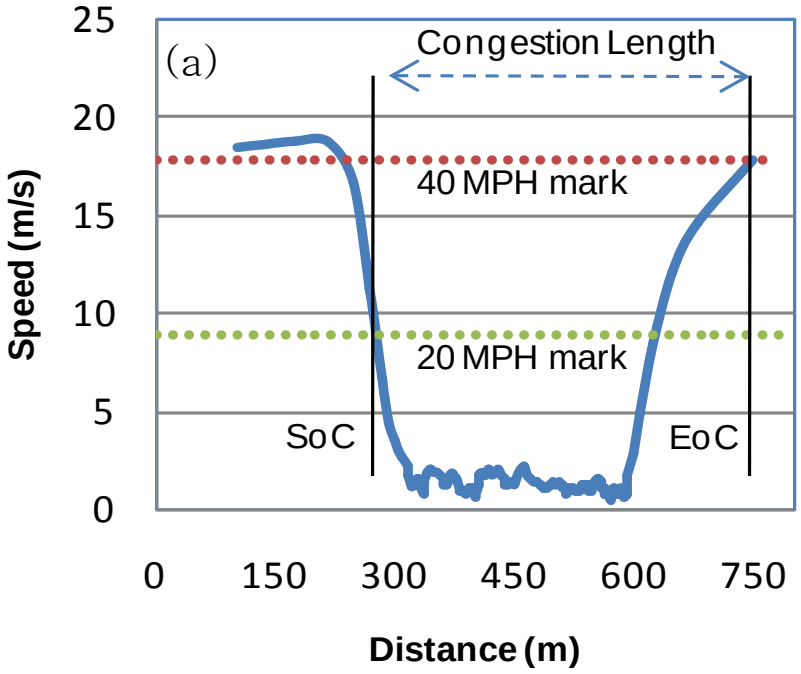
- **RSU is placed such that RSU monitoring range aligns with the end of the congestion.**
- **At periodic intervals, an OBU participation is requested by the RSU to monitor a vehicle's speed and position through a congestion area.**
- **RSU sends traffic alert message to all OBUs indicating travel time through monitoring area.**

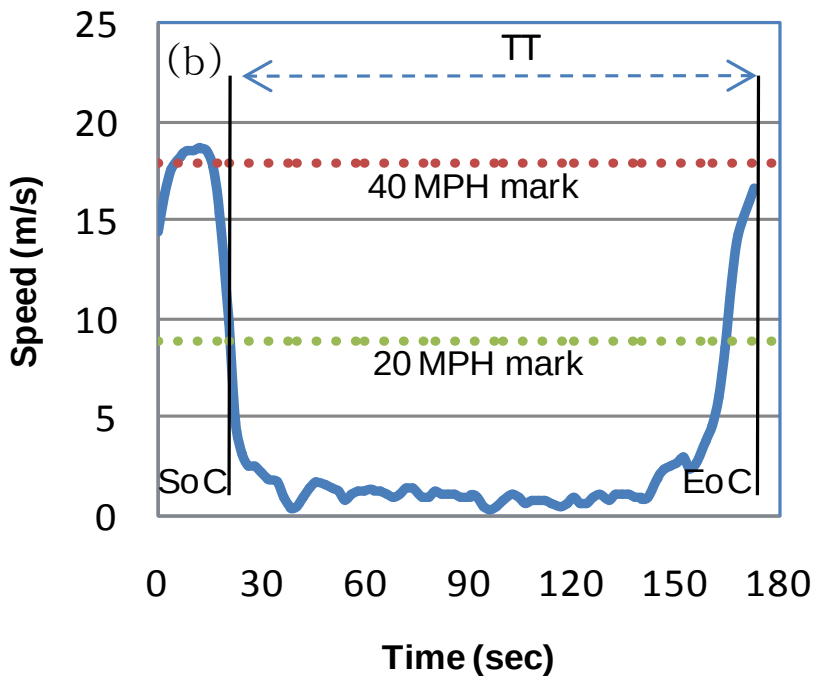
Field Demonstration



- **The field demonstration site was chosen at Rice Lake Rd, Duluth MN with the focus on providing a clear line of sight between RSU and the OBU.**
- **The RSU is placed near the congestion end due to reduced range on one side due to signal blocking by back of the vehicle.**

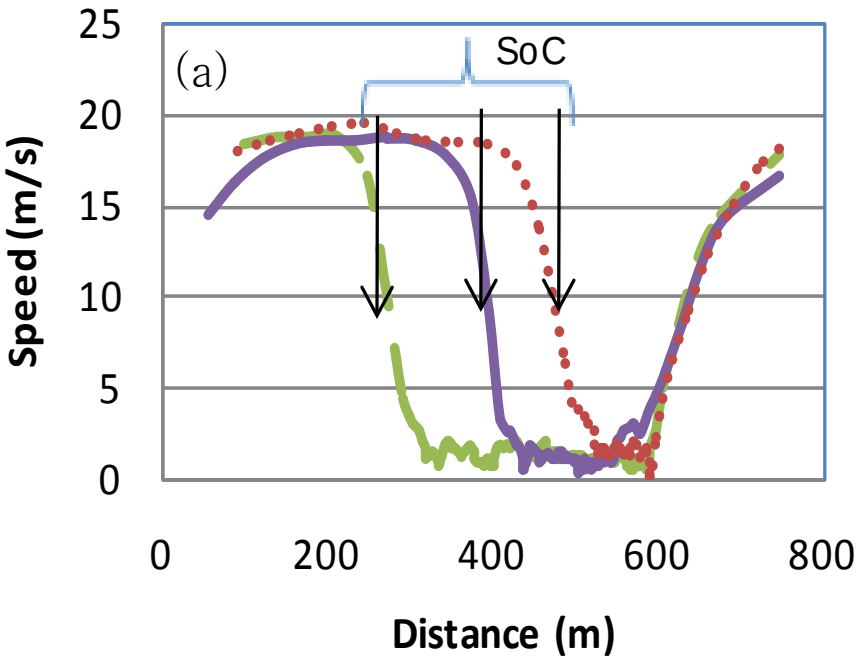
Results – Traffic Safety Parameters

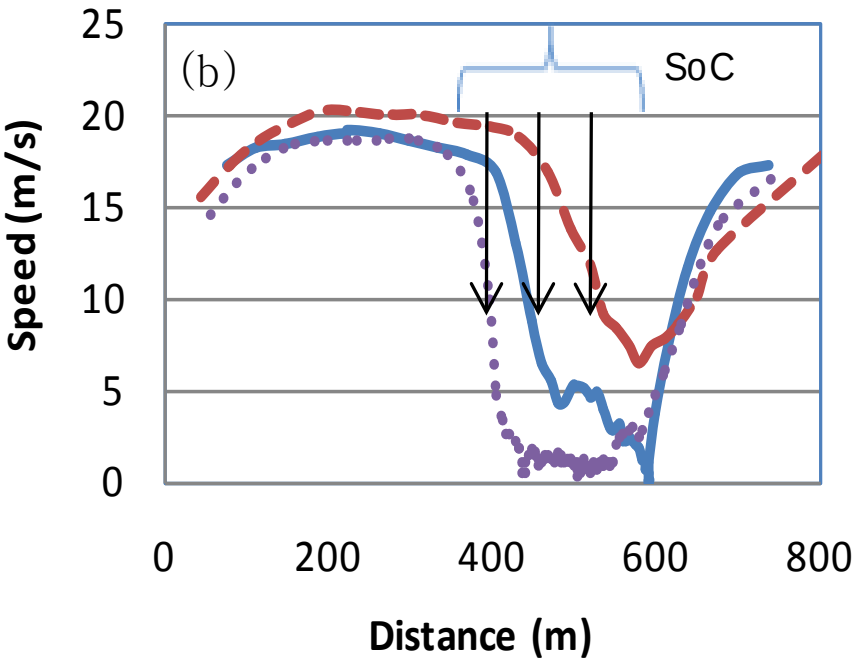




The traffic parameters - Start of Congestion location and the Travel Time are determined by RSU and communicated to all the OBUs in range

Varying the Length and Depth of Congestion





Congestion scenarios of varying start of congestion location and congestion depth were tested for different vehicle speeds

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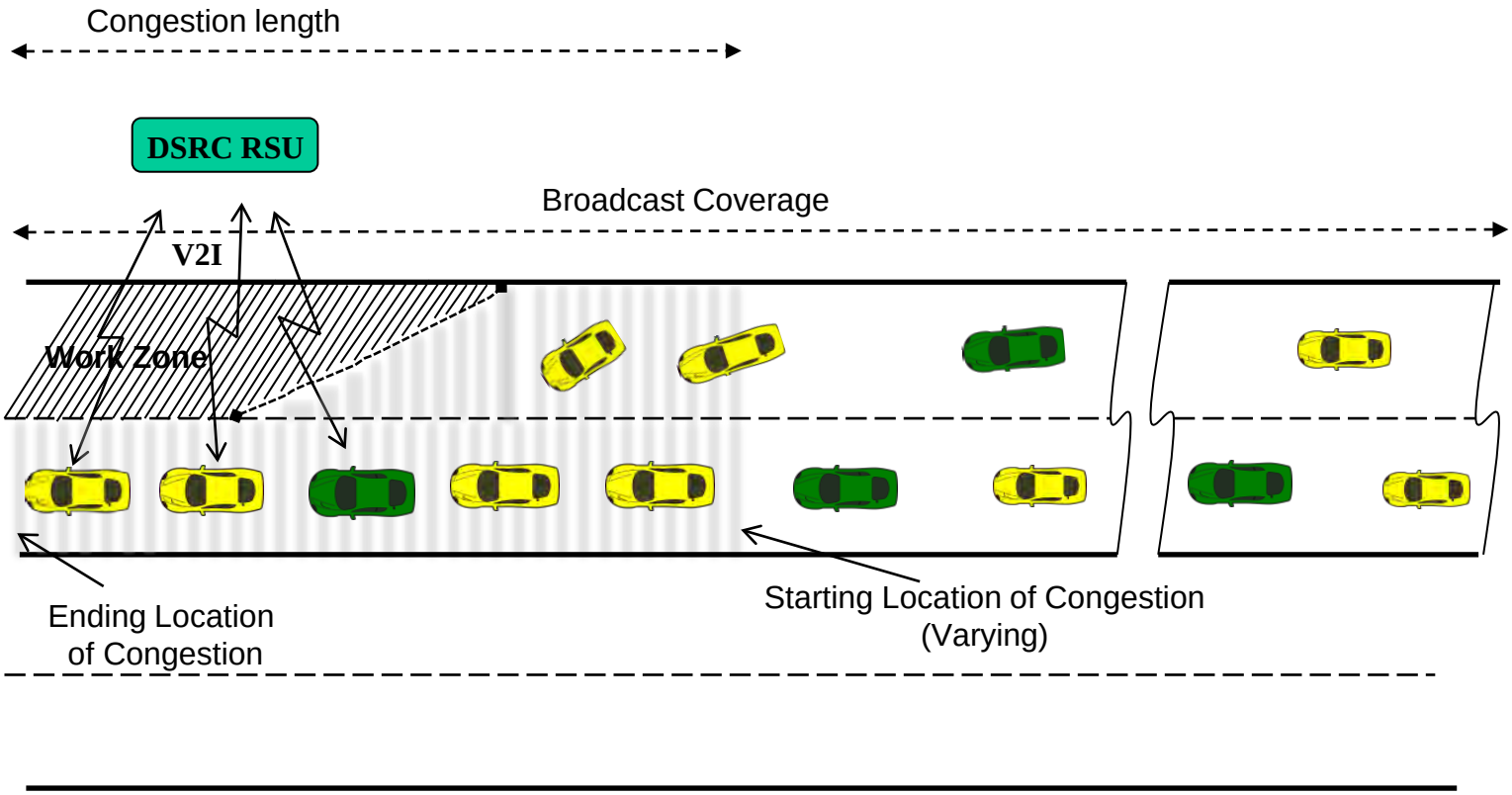
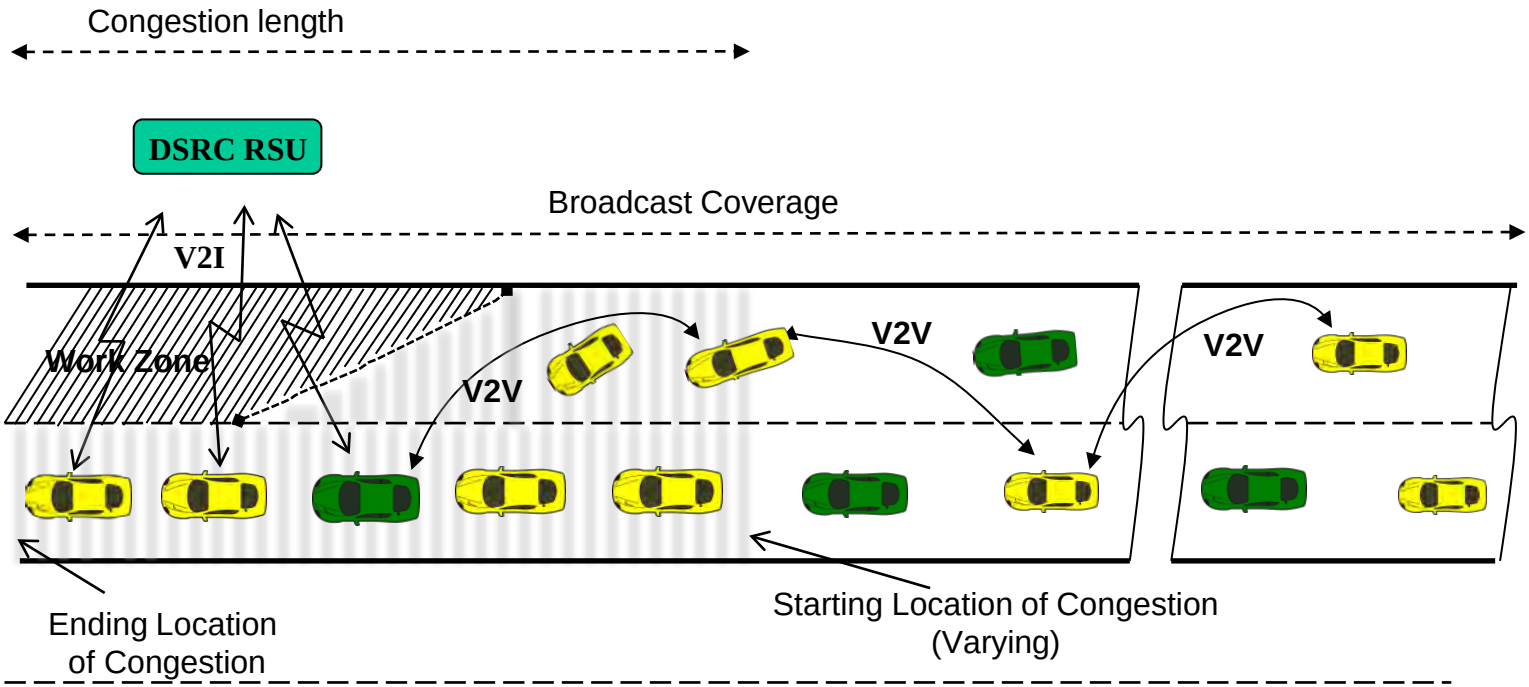
V2V-Assisted V2I System

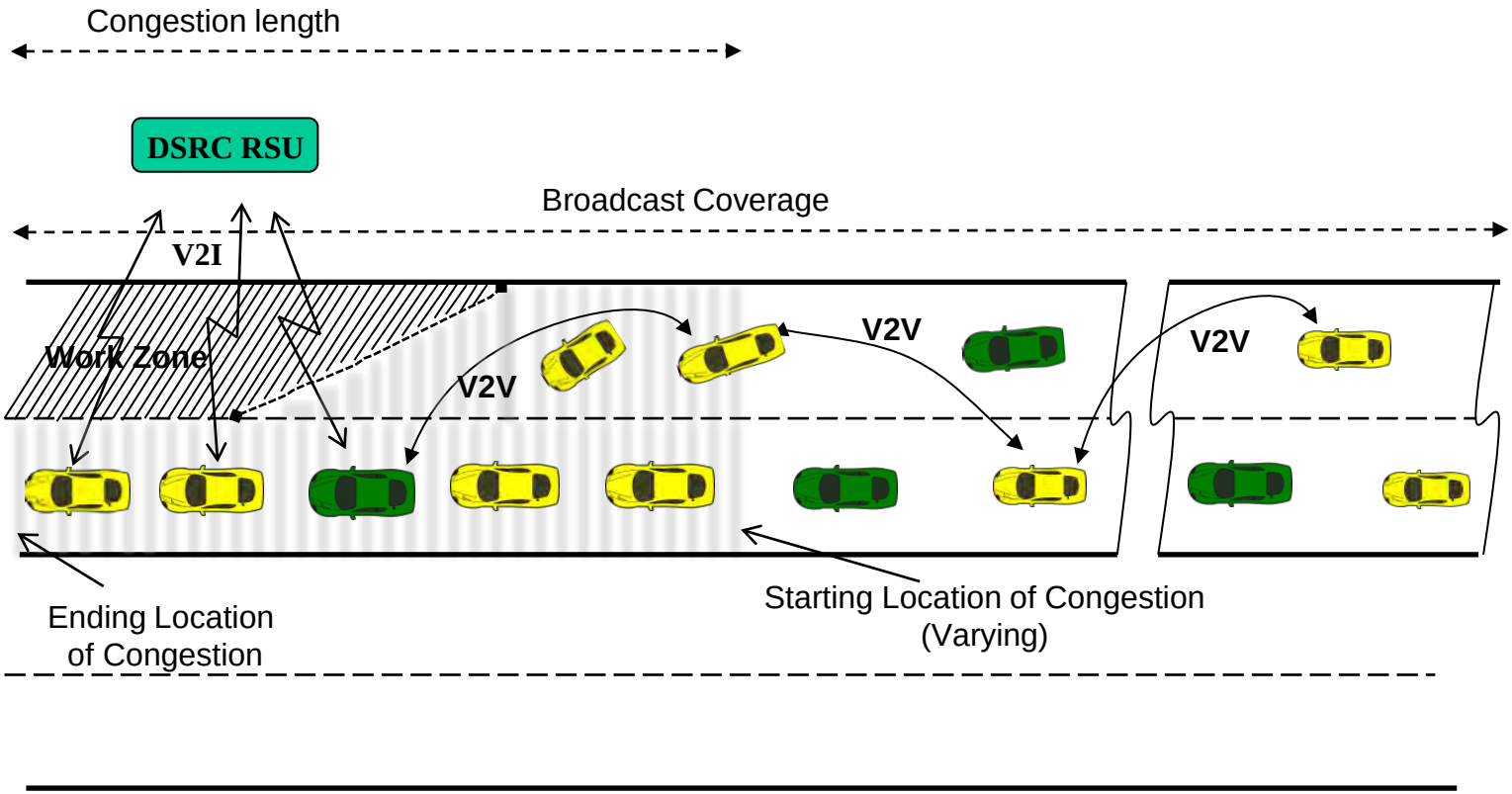


V2V Message Relaying



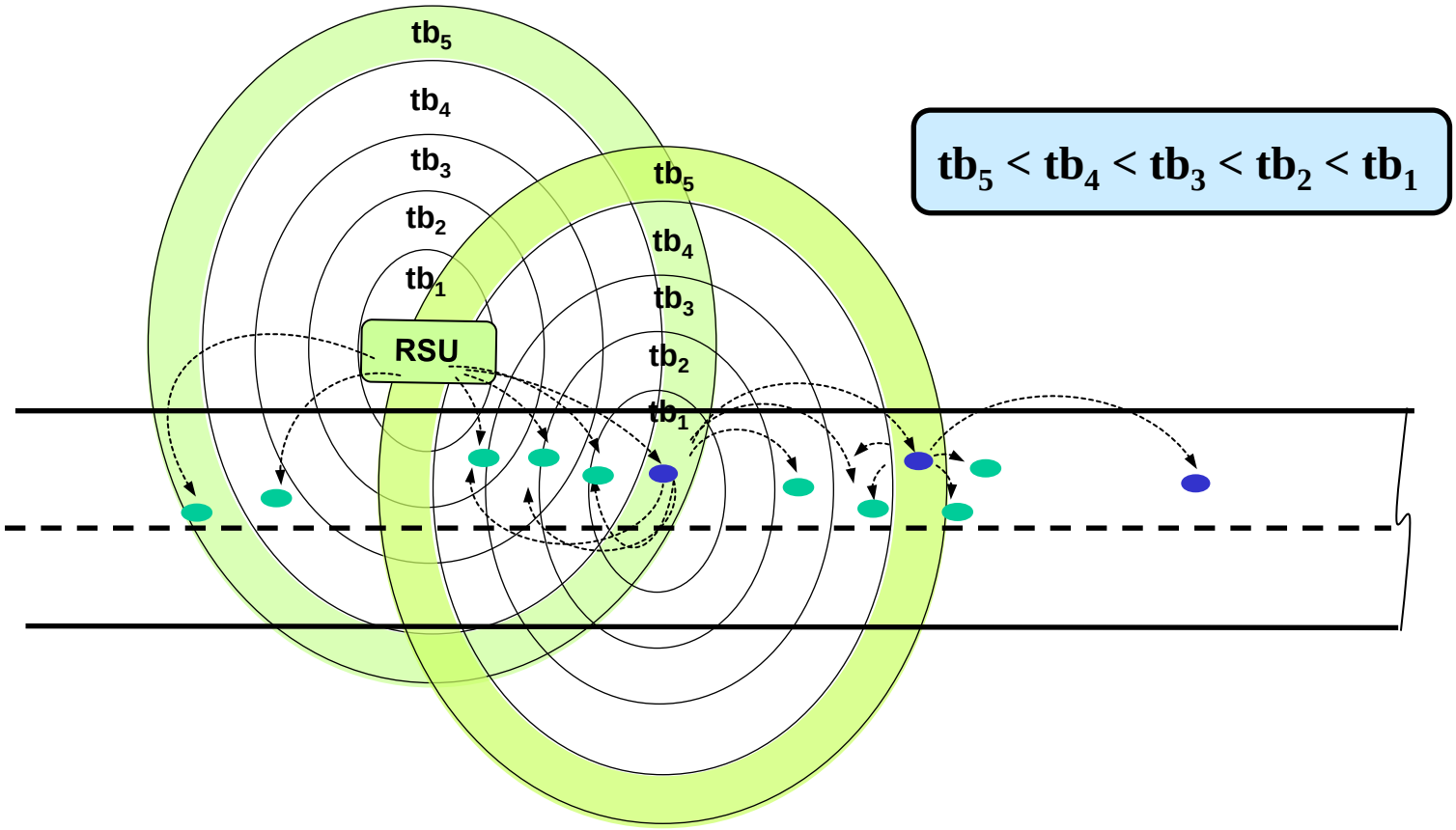
- **Increased message broadcast range usingV2V-assisted DSRC communication.**
- **Much longer congestion coverage beyond the access range of one portable roadside DSRC unit.**

V2V Message Relaying



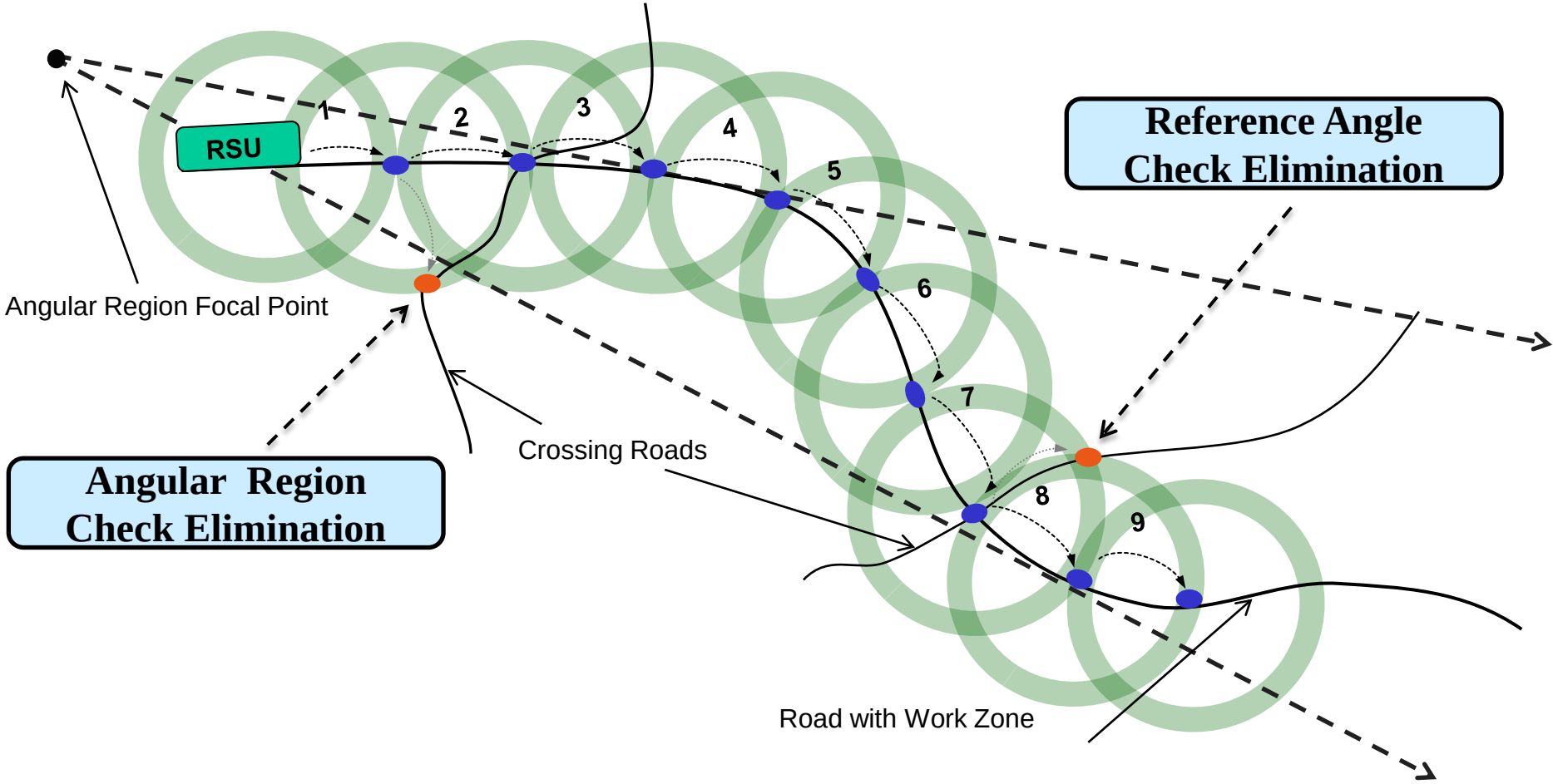
- **Selective Relay**
- **Directive Relay**

Selective Relay



- **Only one of the vehicles should relay the message forward.**
- **Selection should be such that the number of hops can be minimized.**

Directive Relay

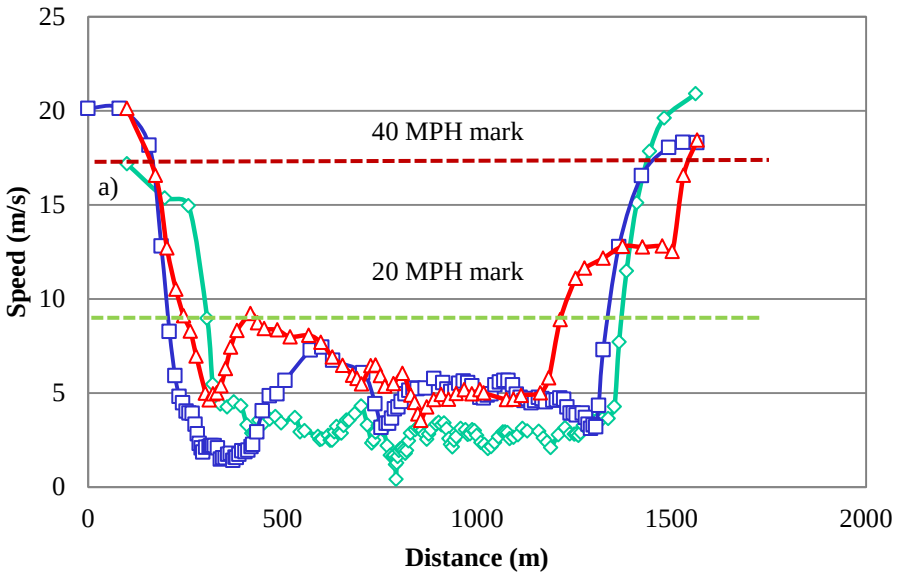


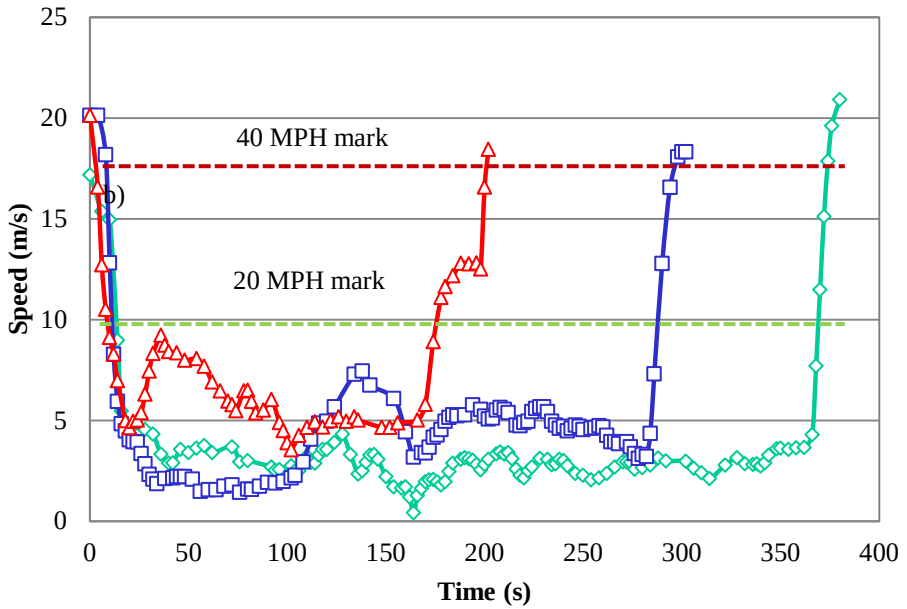
Message should be relayed towards the direction of the road from which the vehicles are approaching towards the congestion.

Field Demonstration Setup - V2V

- **The field demonstration site was chosen at Rice Lake Rd, Duluth MN with the focus on providing a clear line of sight between RSU and the OBU.**
- **The RSU is placed nearer to the congestion end due to reduced range on one side from the signal being blocked.**

Results





- **Increased congestion coverage range**
- **Increased message broadcast range**

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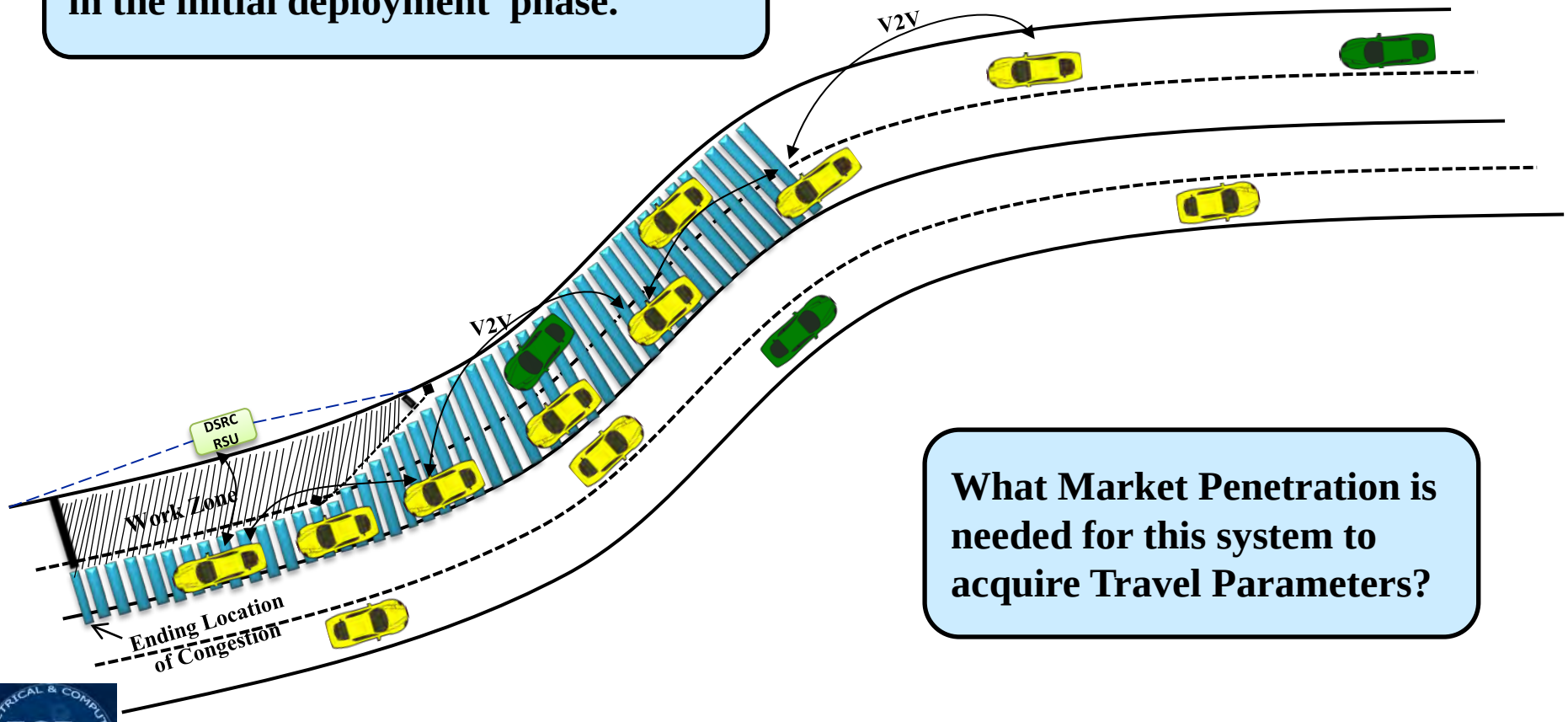
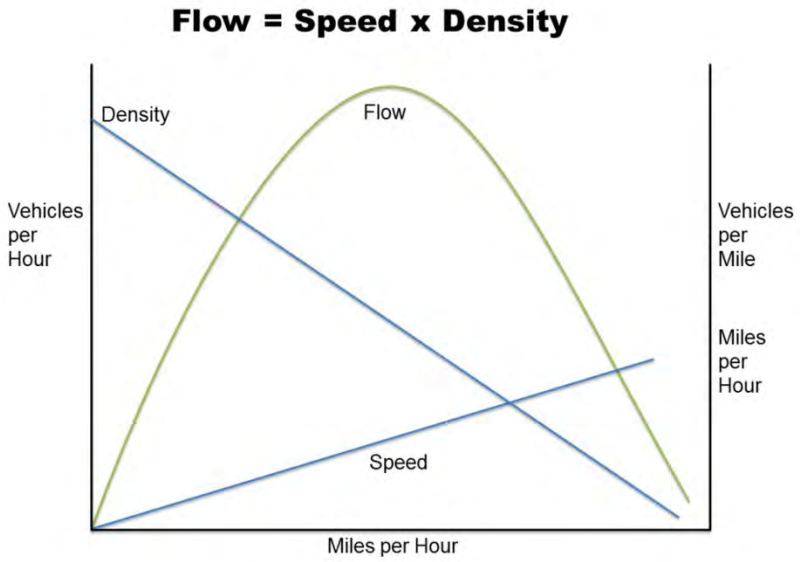
Need for Variable Message Sign (VMS) Integration with the Developed System

Not all vehicles will be DSRC equipped in the initial deployment phase.

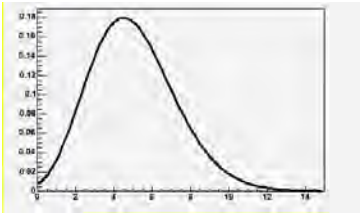


What Market Penetration is needed for this system to acquire Travel Parameters?

DSRC Market Penetration Rate Requirement Analysis

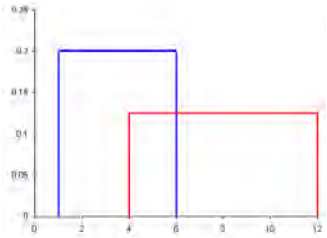


Poisson Distribution



Light Traffic Flow and Density

Uniform Distribution



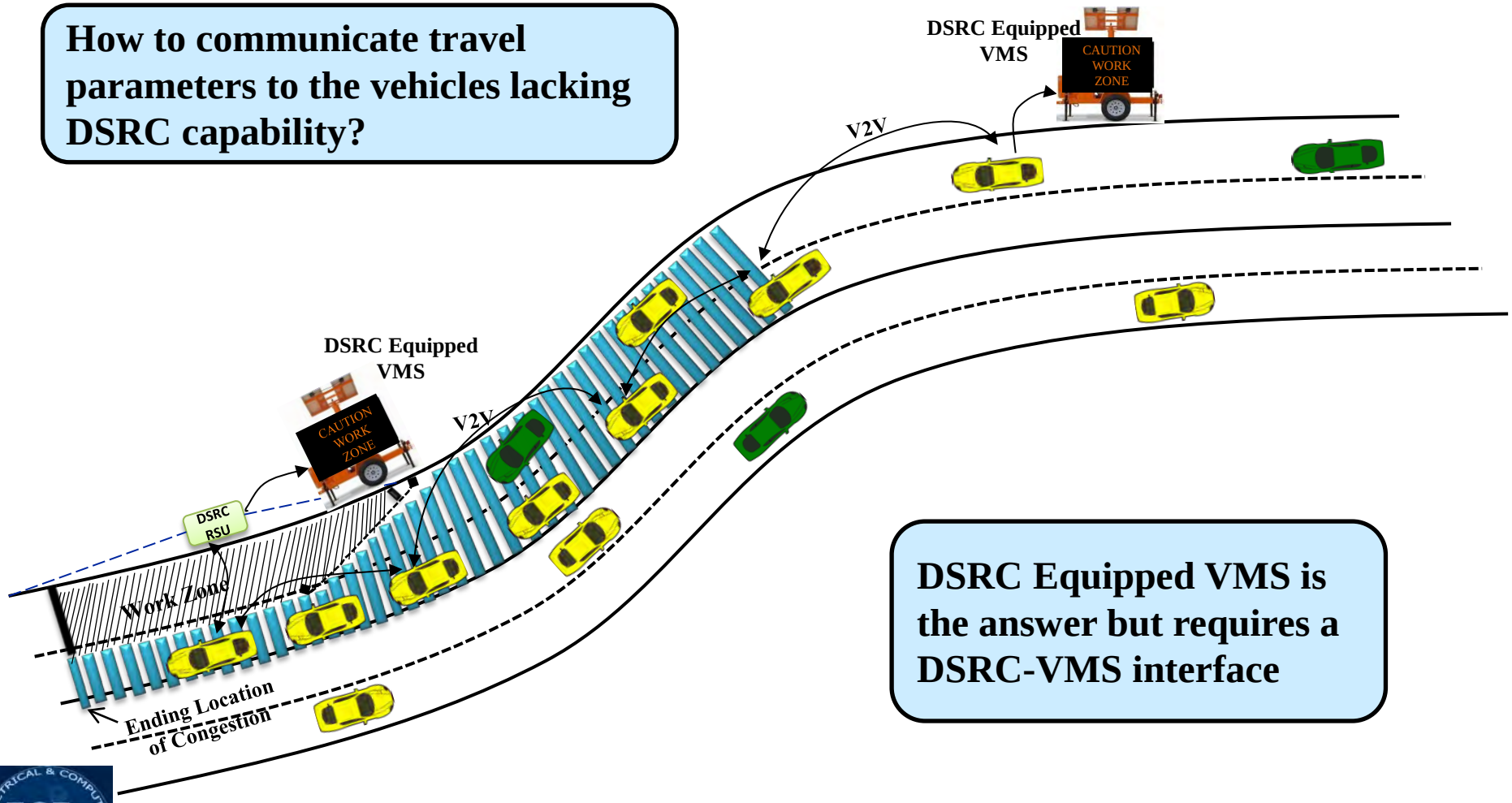
Heavy Traffic Flow and Density

Analysis suggests that successful functionality

- Requires a minimum DSRC penetration rate of 35% during non-rush hour traffic situation.
- Requires a minimum DSRC penetration rate of 20% during rush-hour traffic situation.

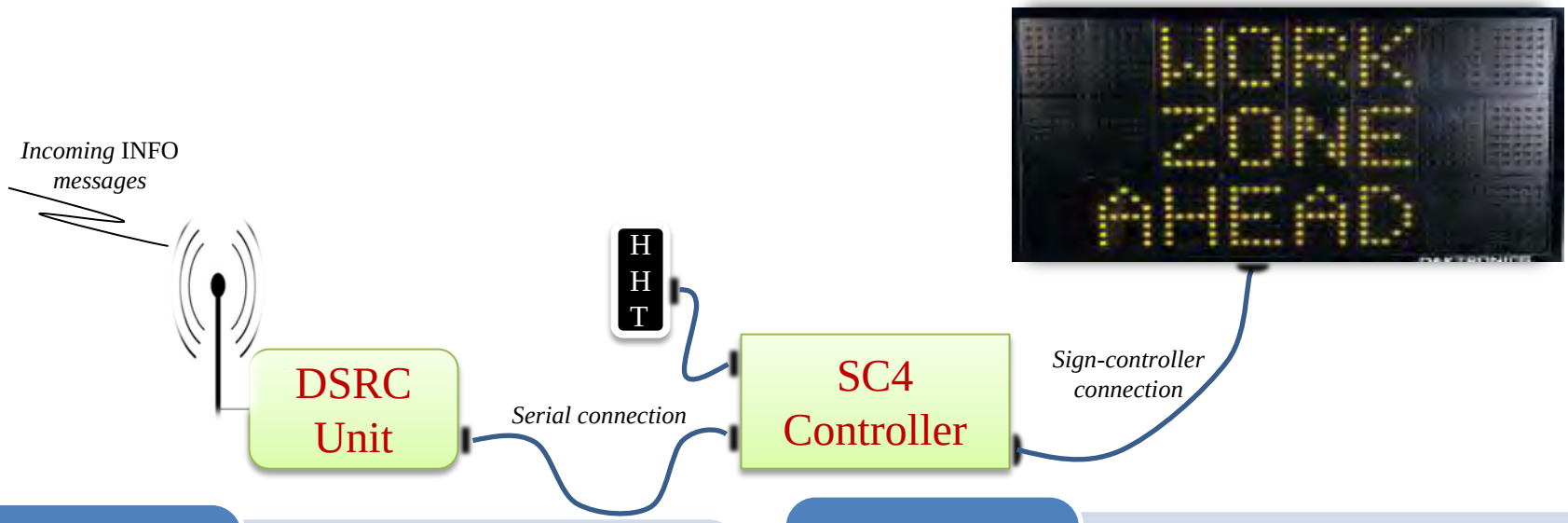
Acquisition vs. Dissemination

How to communicate travel parameters to the vehicles lacking DSRC capability?



DSRC Equipped VMS is the answer but requires a DSRC-VMS interface

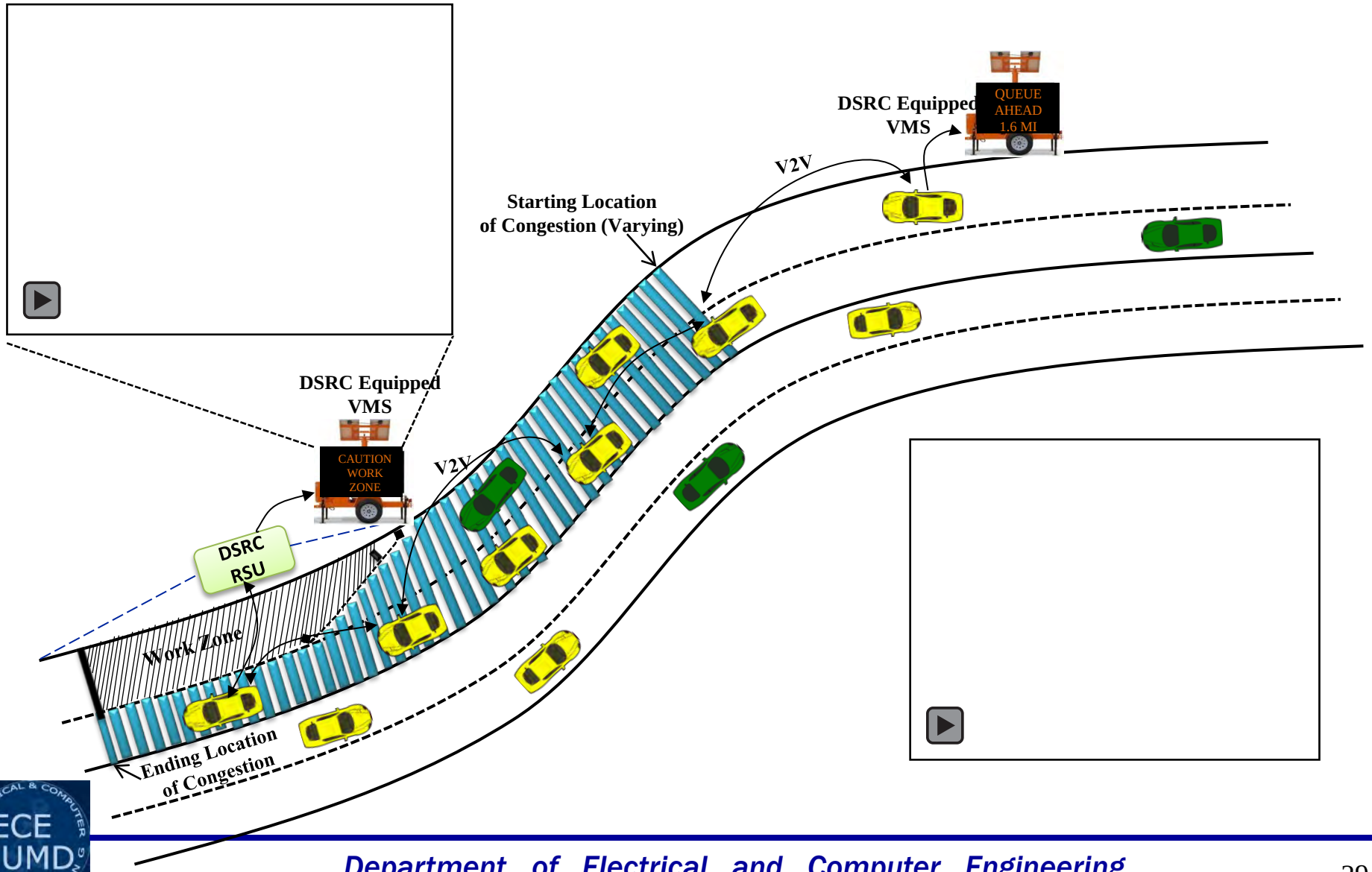
DSRC–VMS Interface Design



Receive	• Looks for an updated information (INFO) message and receives whenever available
Process	• Extracts the TT & SLOC coordinates, then calculates distance to SLOC & TT through the work zone.
Communicate	• TT and distance to SLOC, if different, is formatted for VMS and transferred to SC4 controller using serial port.

Receive	• Receives HDLC packet containing updated TT and distance to SLOC, through the serial port.
Process	• Blanks the message sign before displaying the updated information.
Communicate	• Displays the Queue length and Travel Time on the message sign continuously until another update arrives.

DSRC-VMS Interface Demonstration



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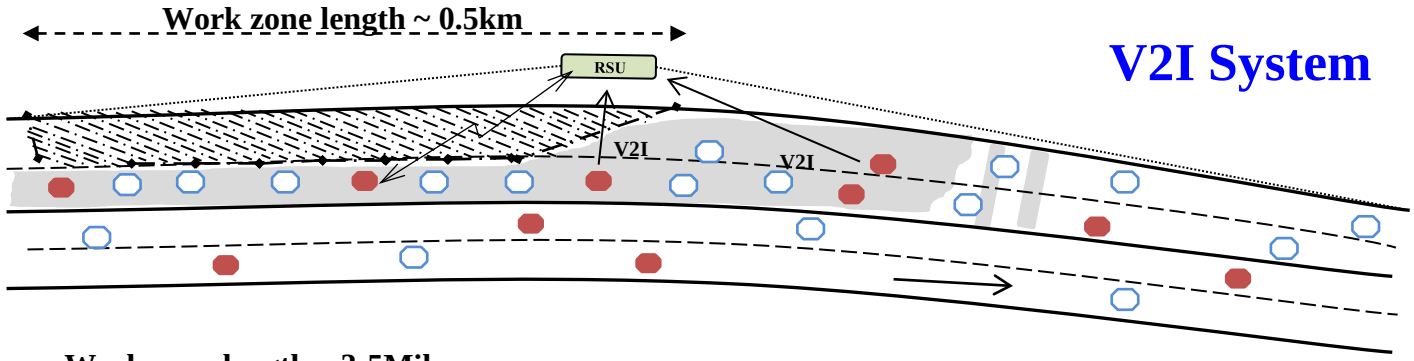
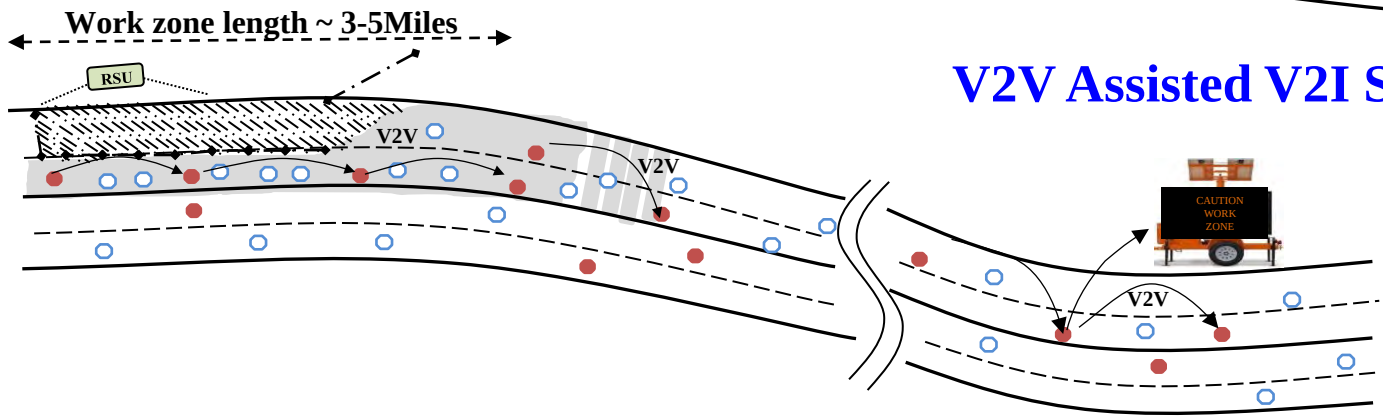
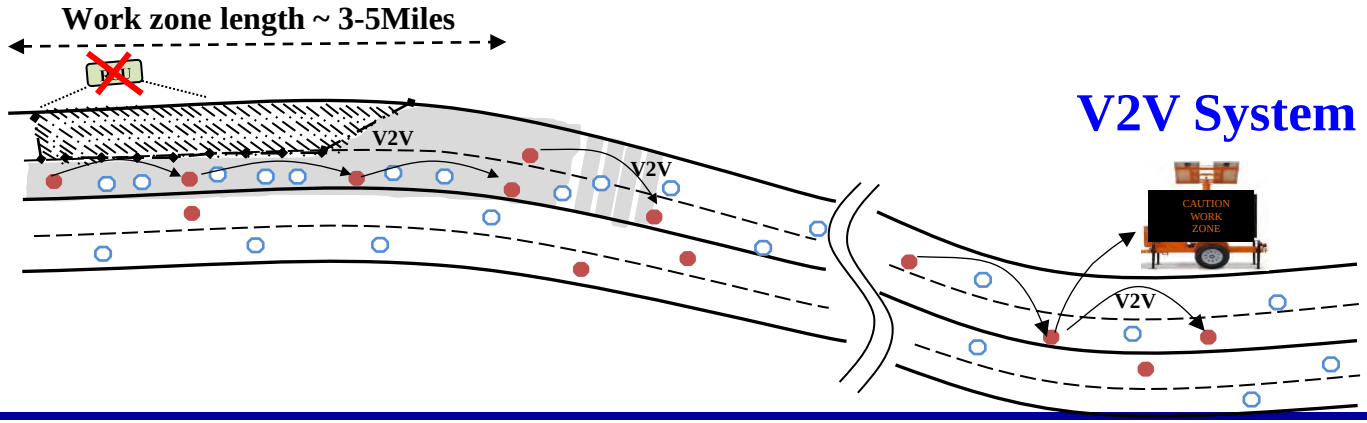
Current Work



V2I System

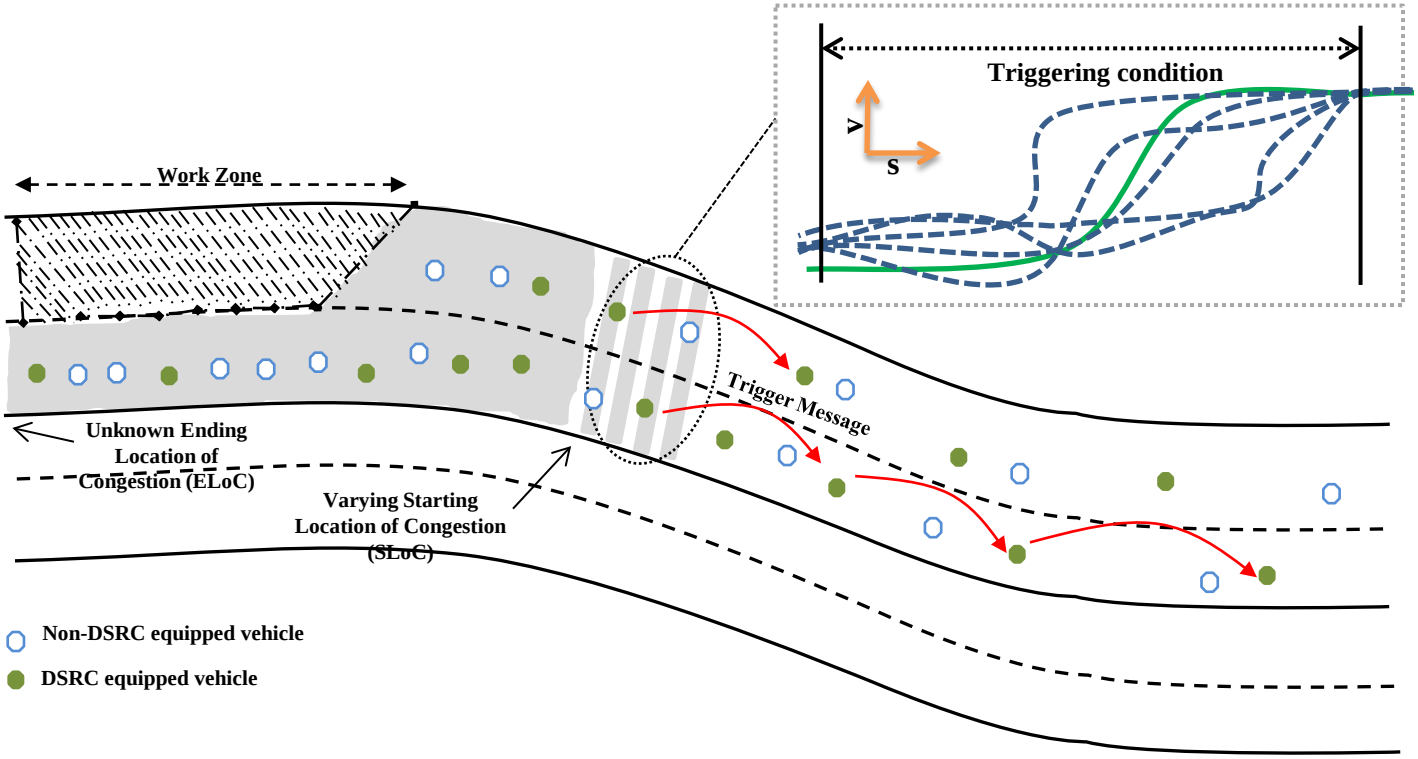


V2V Assisted V2I System



V2V System

Proposed System Architecture with Only V2V Communication



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