Dedicated Short Range Communication: What, Why and How?

Imran Hayee

EE Department, University of Minnesota Duluth

Connected Vehicles Research Lab

(http://www.d.umn.edu/ee/cvrl/index.html)

Outline

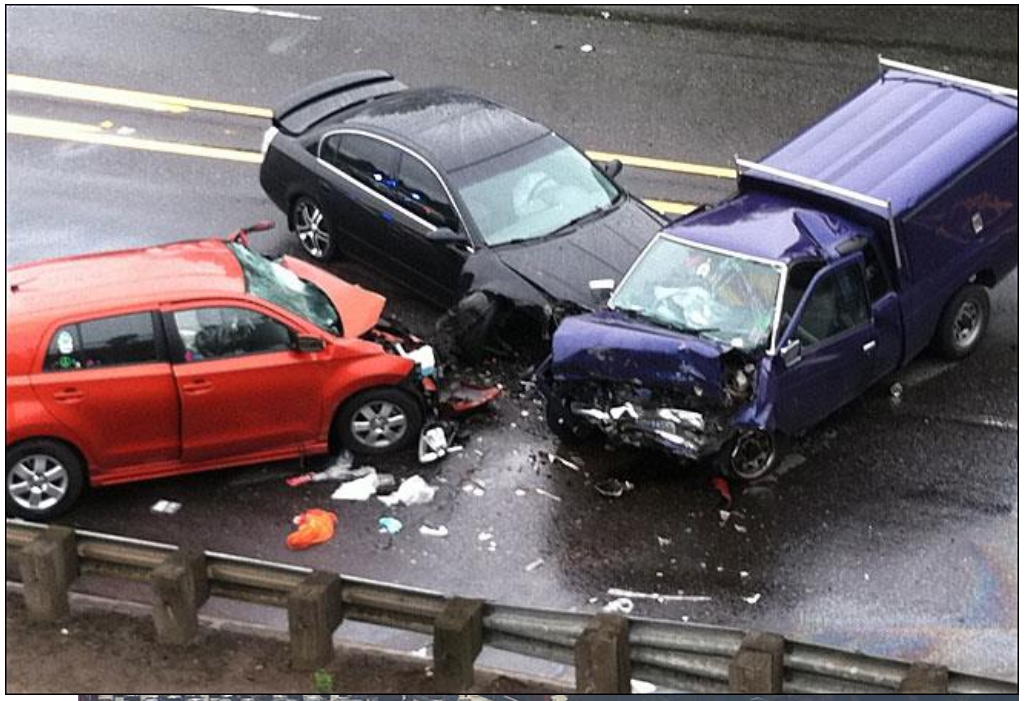
- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

Outline

- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

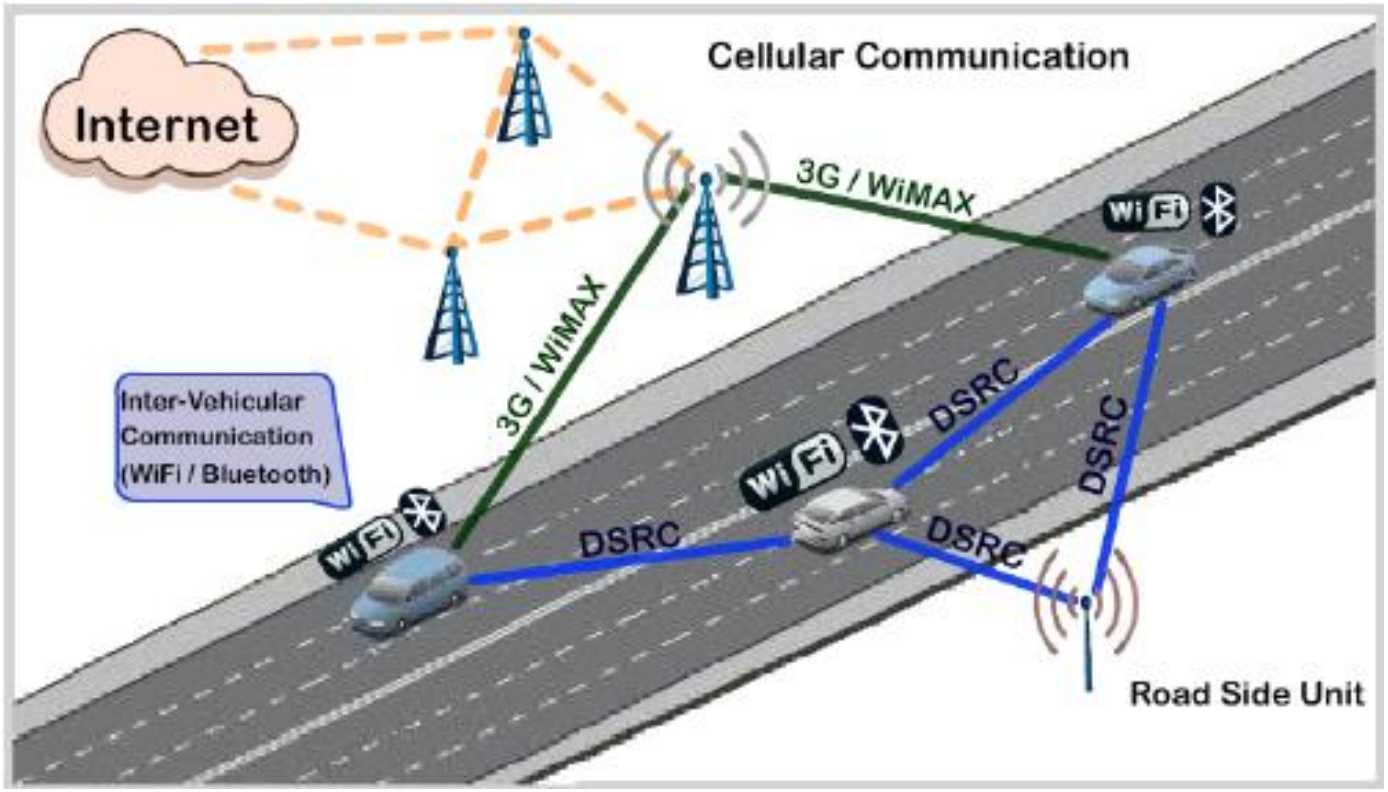
Problem

- Safety
  - > 5 Million Crashes/year
  - > 2 Million injuries
  - > 30,000 deaths/year
  - Leading cause of death in ages 4 to 34
- Mobility
  - > 5 billion hours of travel delay
  - > $100 billion cost of urban congestion
- Environment
  - > 3 billion gallons of wasted fuel



Can Technology help?

- Dedicated Short Range Communication
- DSRC communication can **“reduce, mitigate, or prevent 80% of crashes by unimpaired drivers”** – US DOT

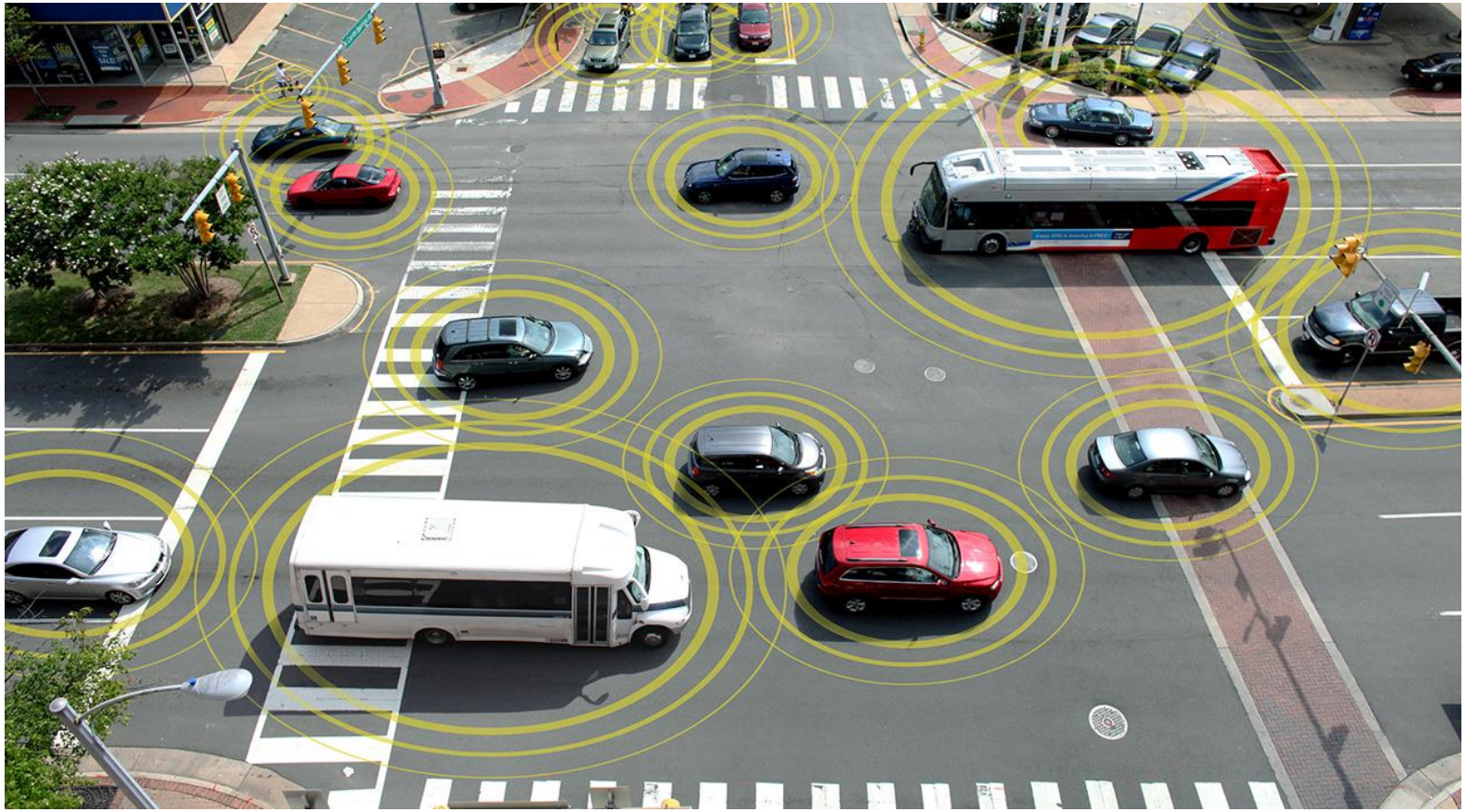


Outline

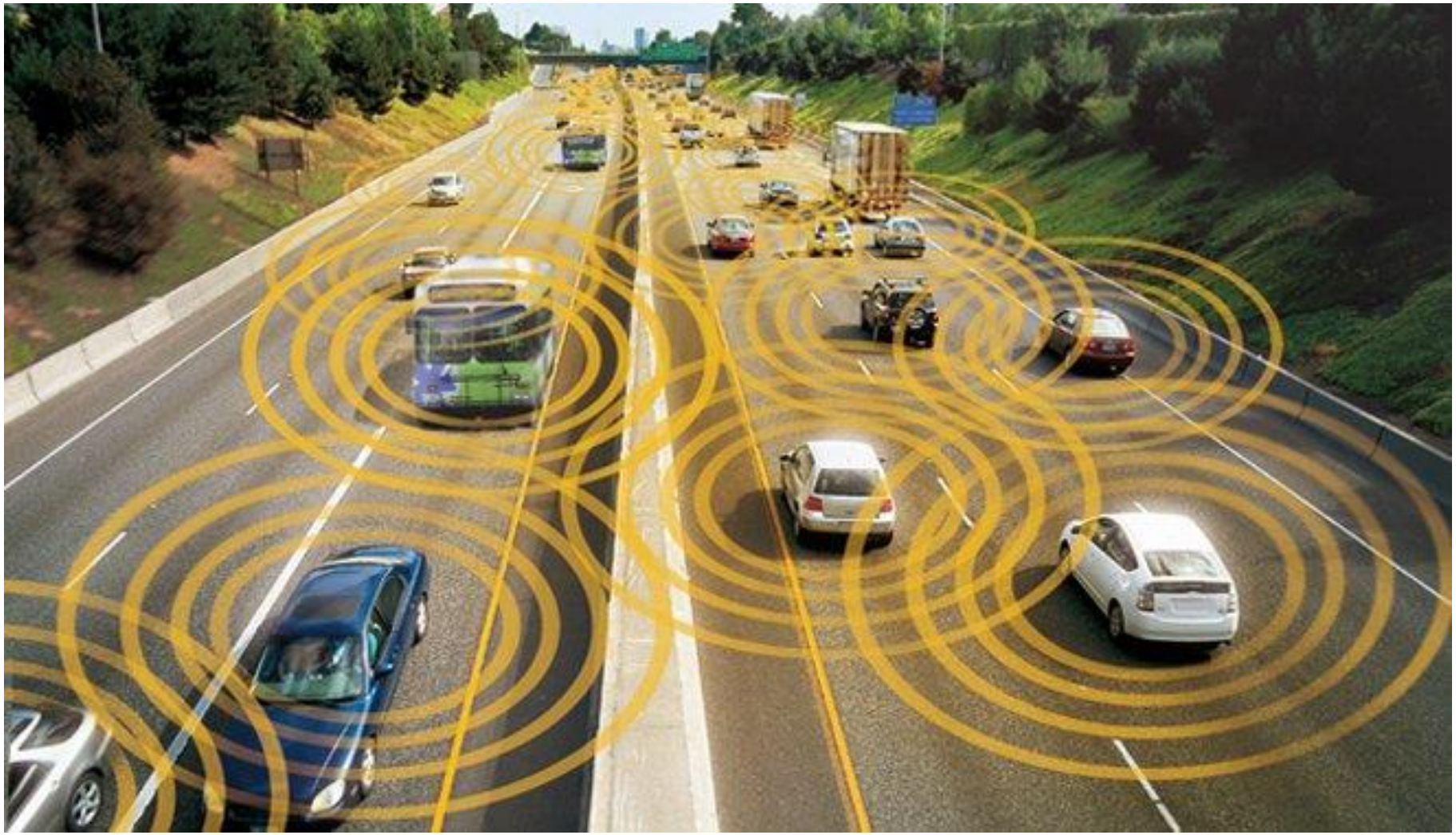
- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

DSRC Overview

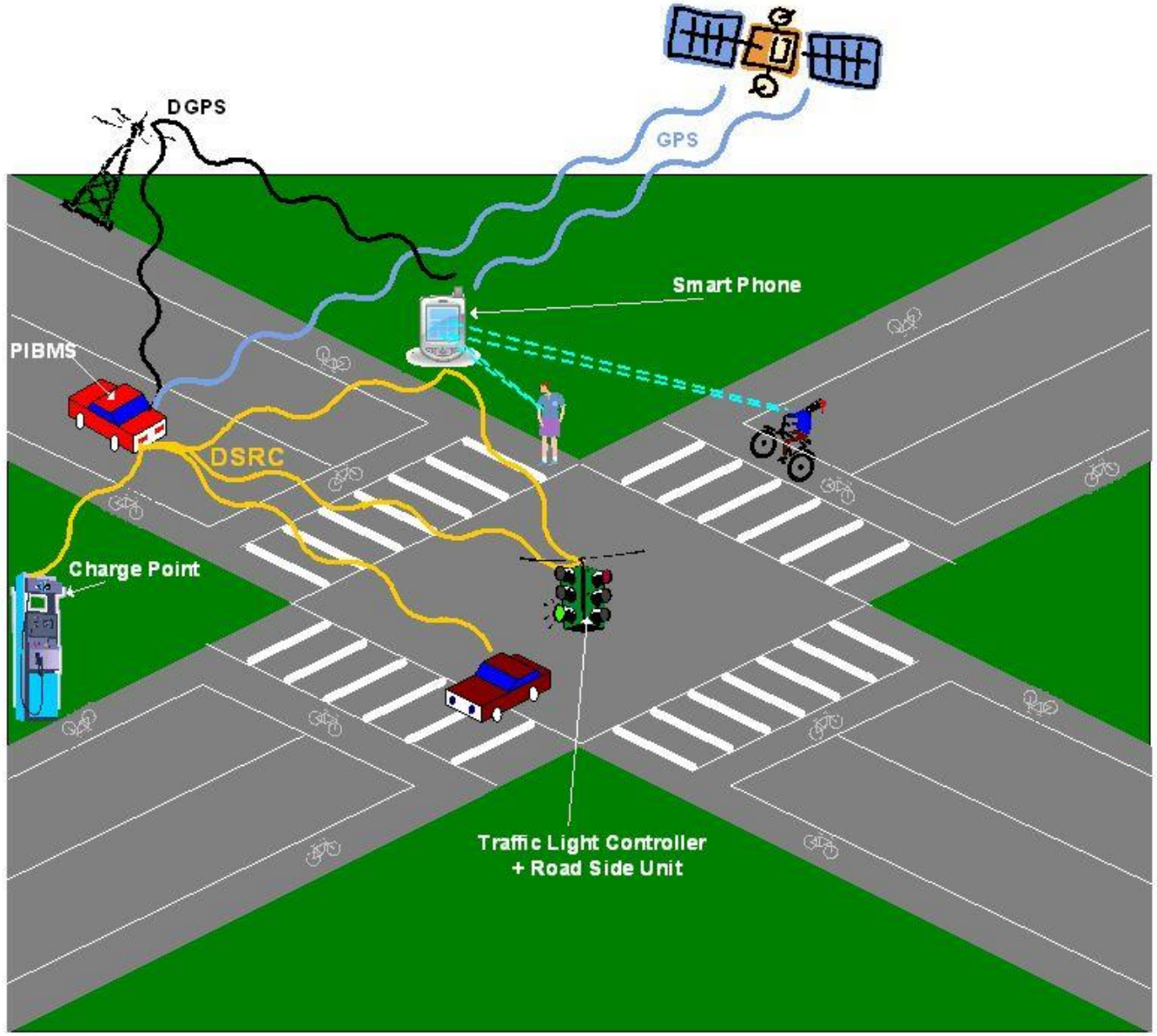
- FCC has authorized 75 MHz of spectrum (5.850 - 5.925 GHz) for DSRC
- Supports both public safety and private operations
- Operates in both vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication environments



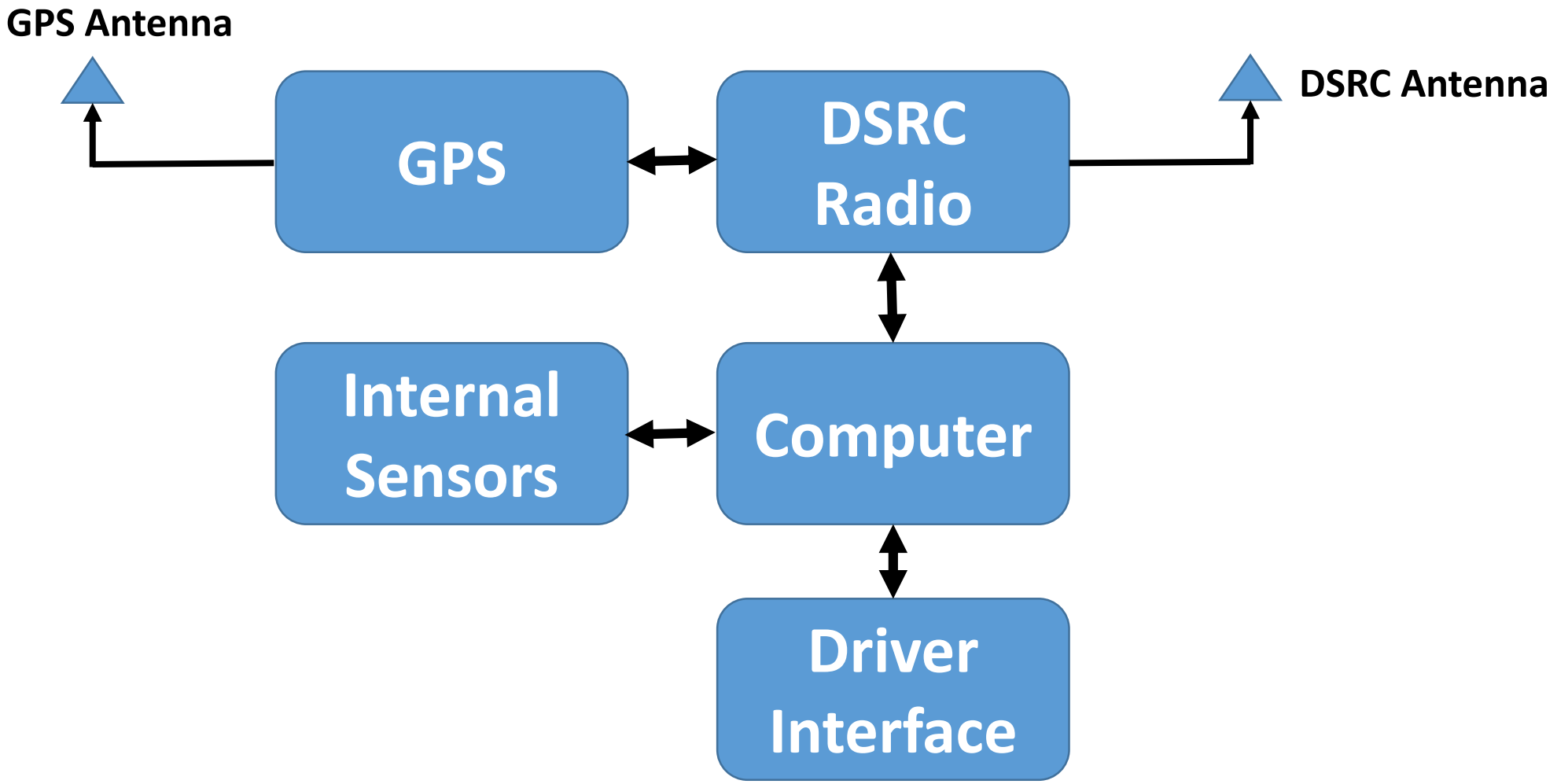
Vehicle to Vehicle (V2V) environment



Vehicle to Infrastructure (V2I) environment



DSRC Infrastructure



DSRC Message Types (SAE J2735)

- Basic Safety Message (BSM)
- Probe Vehicle Data Message (PVD)

Vehicle

- Traveler Information Message (TIM)
- Map Data Message (MAP)
- Signal Phase and Timing Message (SPaT)

Infrastructure

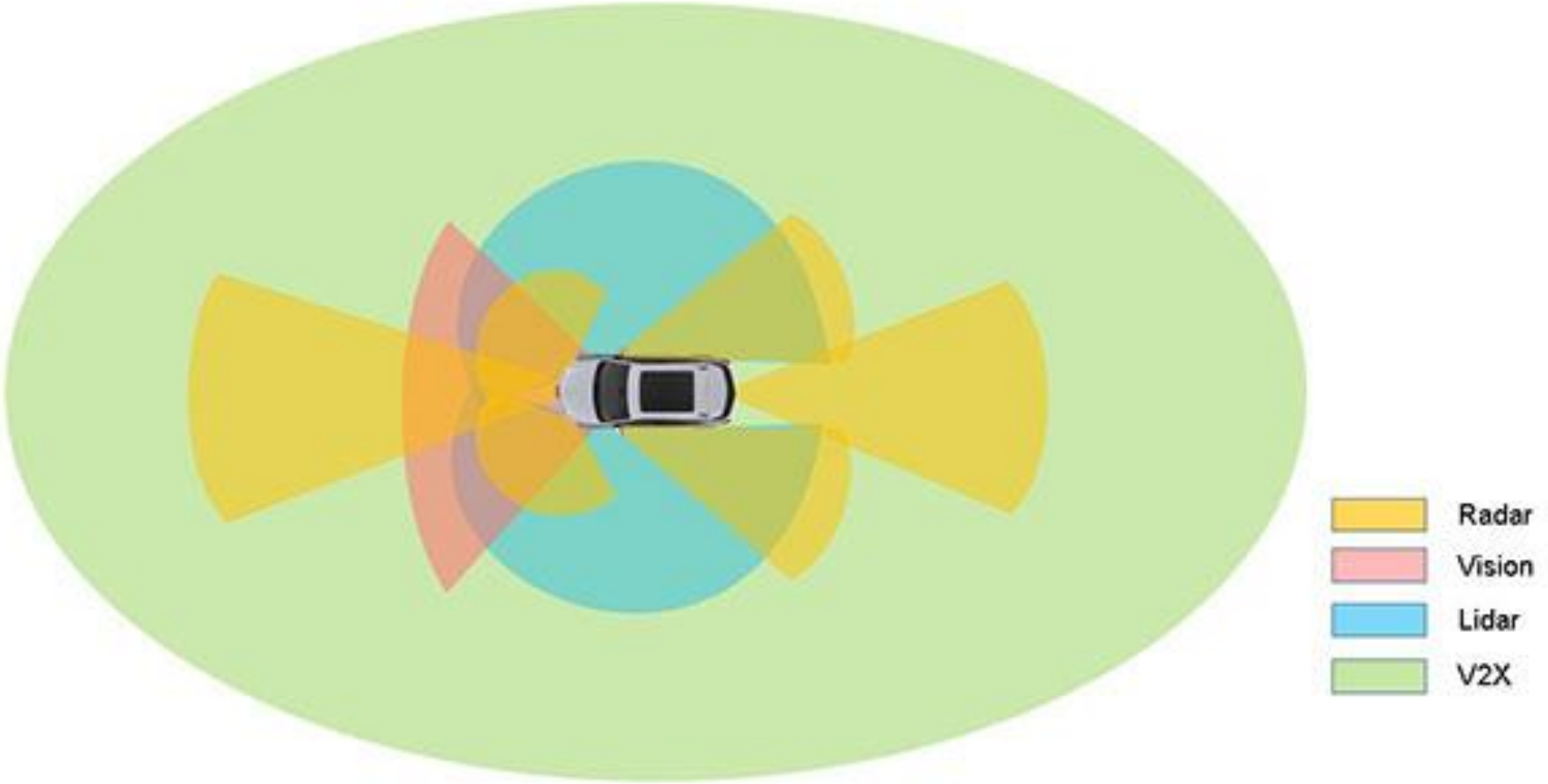
Outline

- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

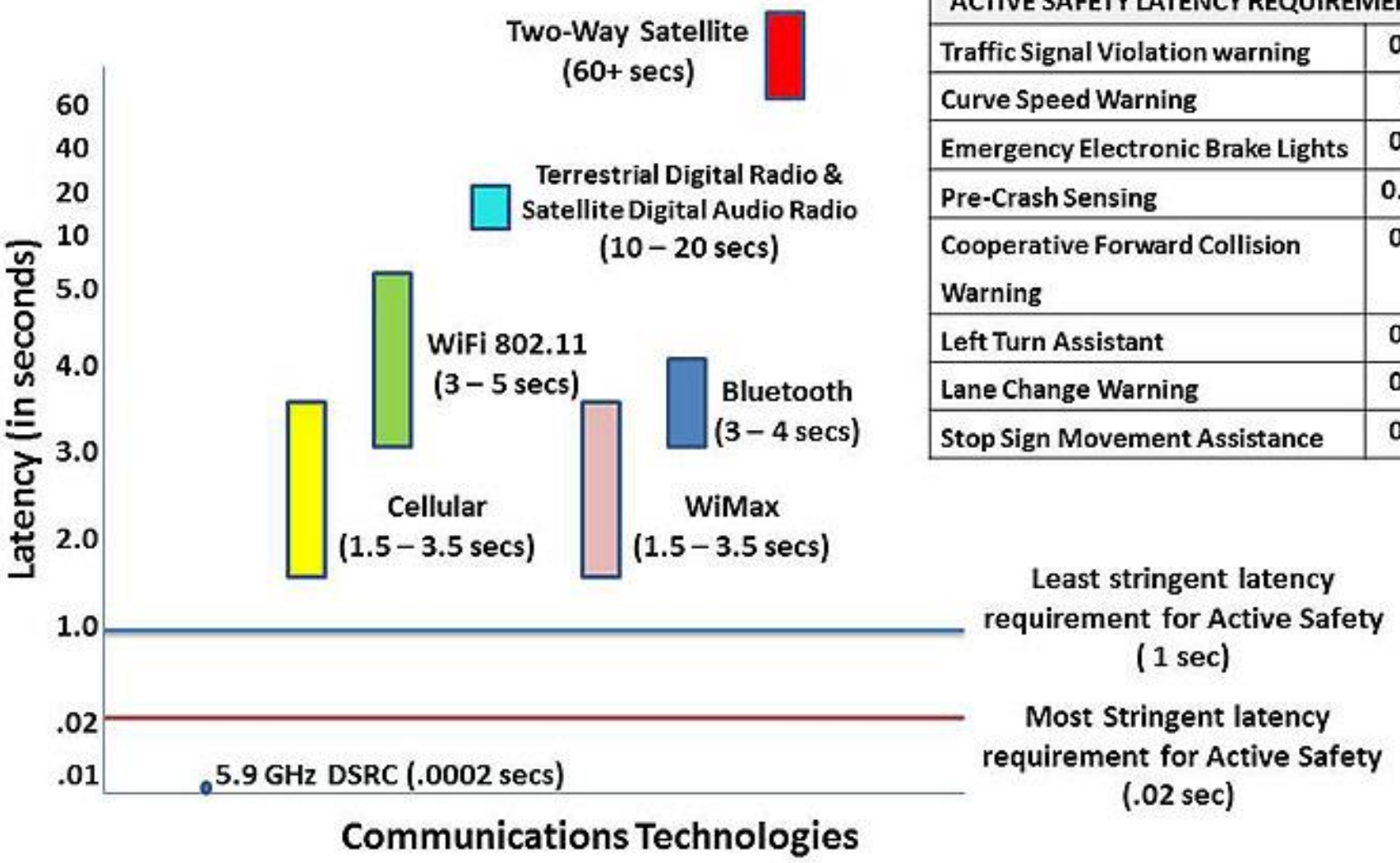
Unique Benefits

- Dedicated 75 MHz of spectrum @ 5.9 GHz
- Key Benefits
  - 802.11p technology similar to 802.11a
  - Low latency communication (<< 50 ms)
  - High data transfer rates (3 – 27 Mbps)
  - Line-of-sight, up to 1000 m and 360º
  - Low power message reception (< -90 dBm)

Range



Latency



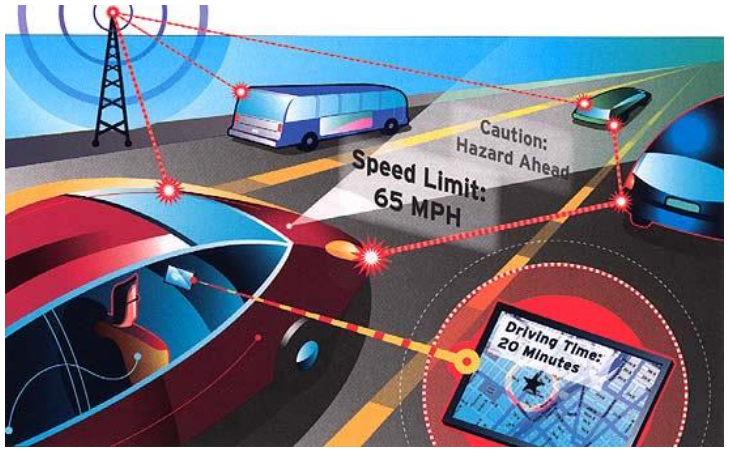
ACTIVE SAFETY LATENCY REQUIREMENTS	
Traffic Signal Violation warning	0.1s
Curve Speed Warning	1s
Emergency Electronic Brake Lights	0.1s
Pre-Crash Sensing	0.02s
Cooperative Forward Collision Warning	0.1s
Left Turn Assistant	0.1s
Lane Change Warning	0.1s
Stop Sign Movement Assistance	0.1s

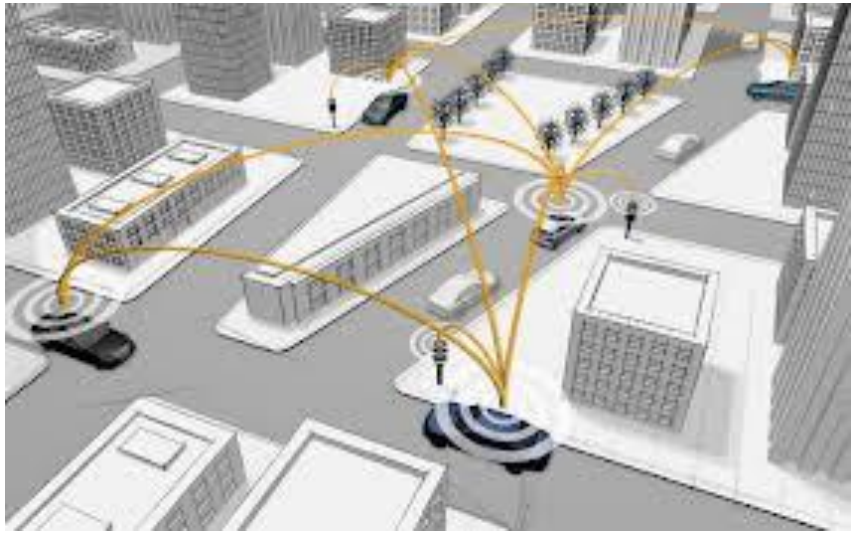
Outline

- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

DSRC Applications

- V2V Safety
- V2I Safety
- CVO
- Private



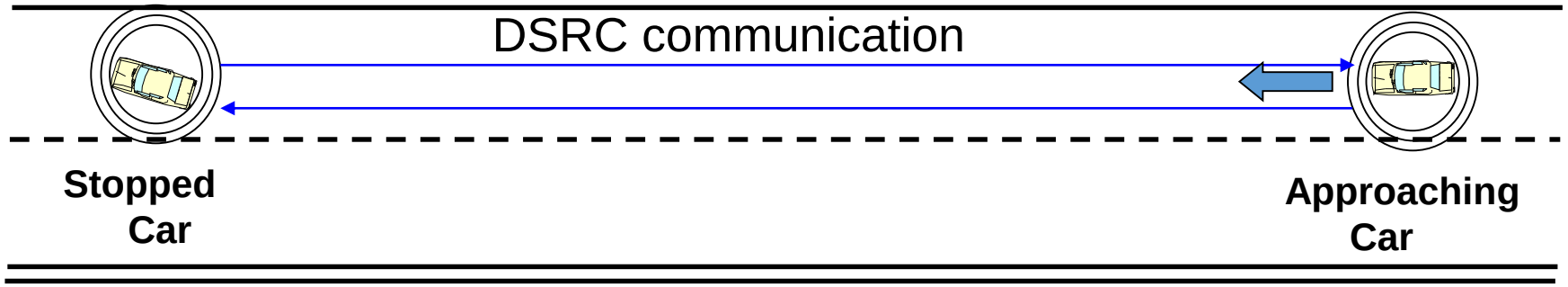


V2V Safety Applications

Applications Enabled by BSM

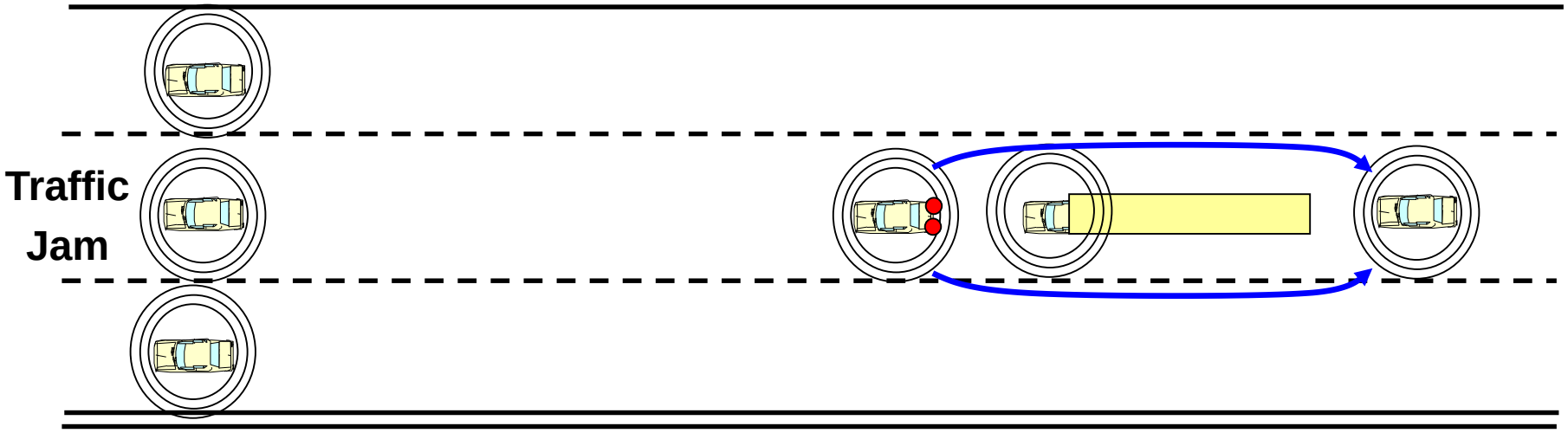
• Forward Collision Avoidance	FCA
• Emergency Electronic Brake Lights	EEBL
• Blind Spot Warning	BSW
• Lane Change Assist	LCA
• Do Not Pass Warning	DNPW
• Intersection Collision Warning	ICA
• Wrong Way Driver Warning	WWDW
• Cooperative Adaptive Cruise Control	CACC

Forward Collision Warning (FCW)



If driver of approaching vehicle does not stop, or slow down, a warning is issued within the vehicle.

Emergency Electronic Brake Lights (EEBL)



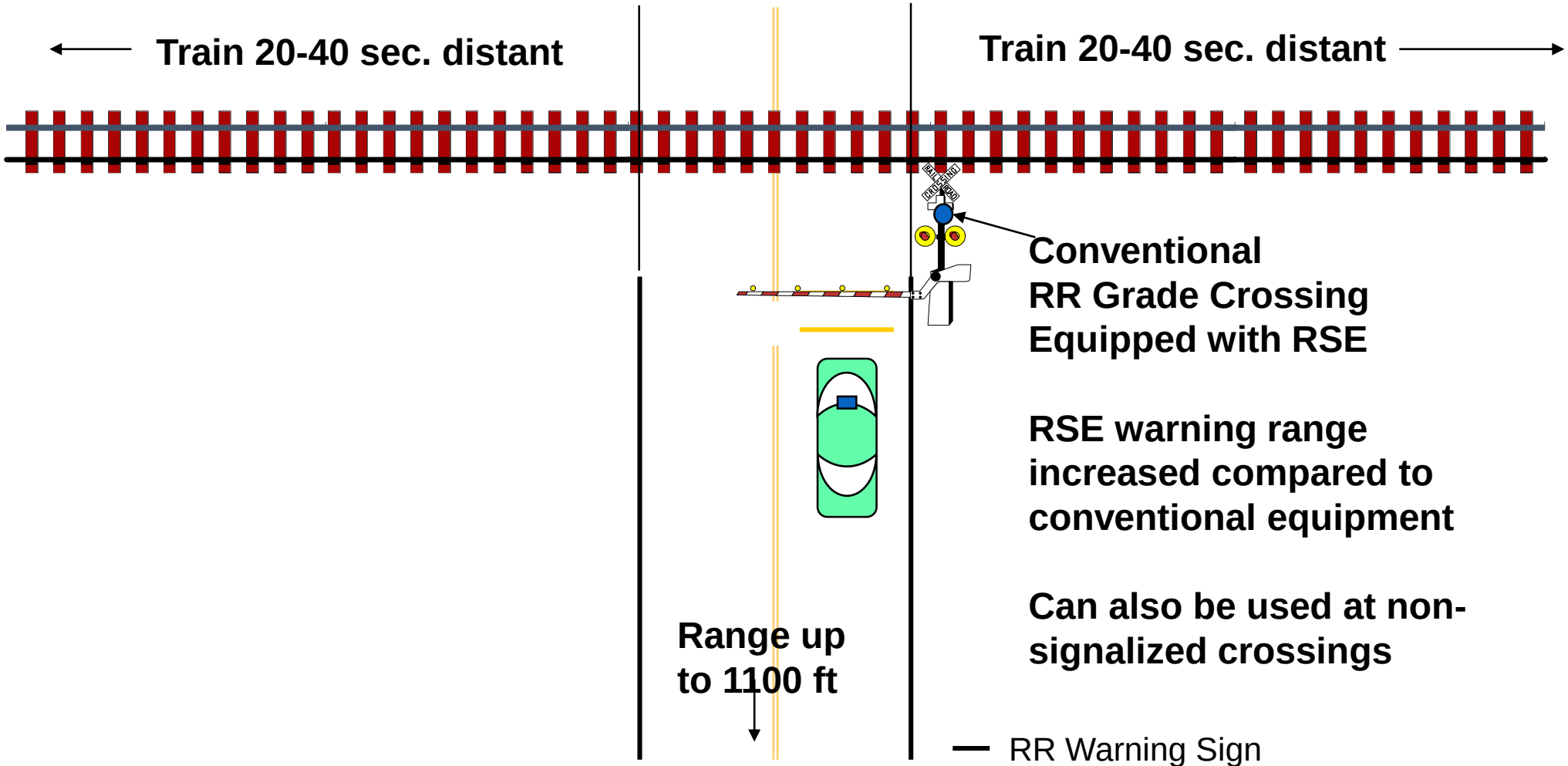
- **High deceleration by vehicle approaching jam**
- **Trailing vehicle Informed via DSRC within 100 msec.**

V2I Safety Applications

Applications enabled by SPaT/MAP

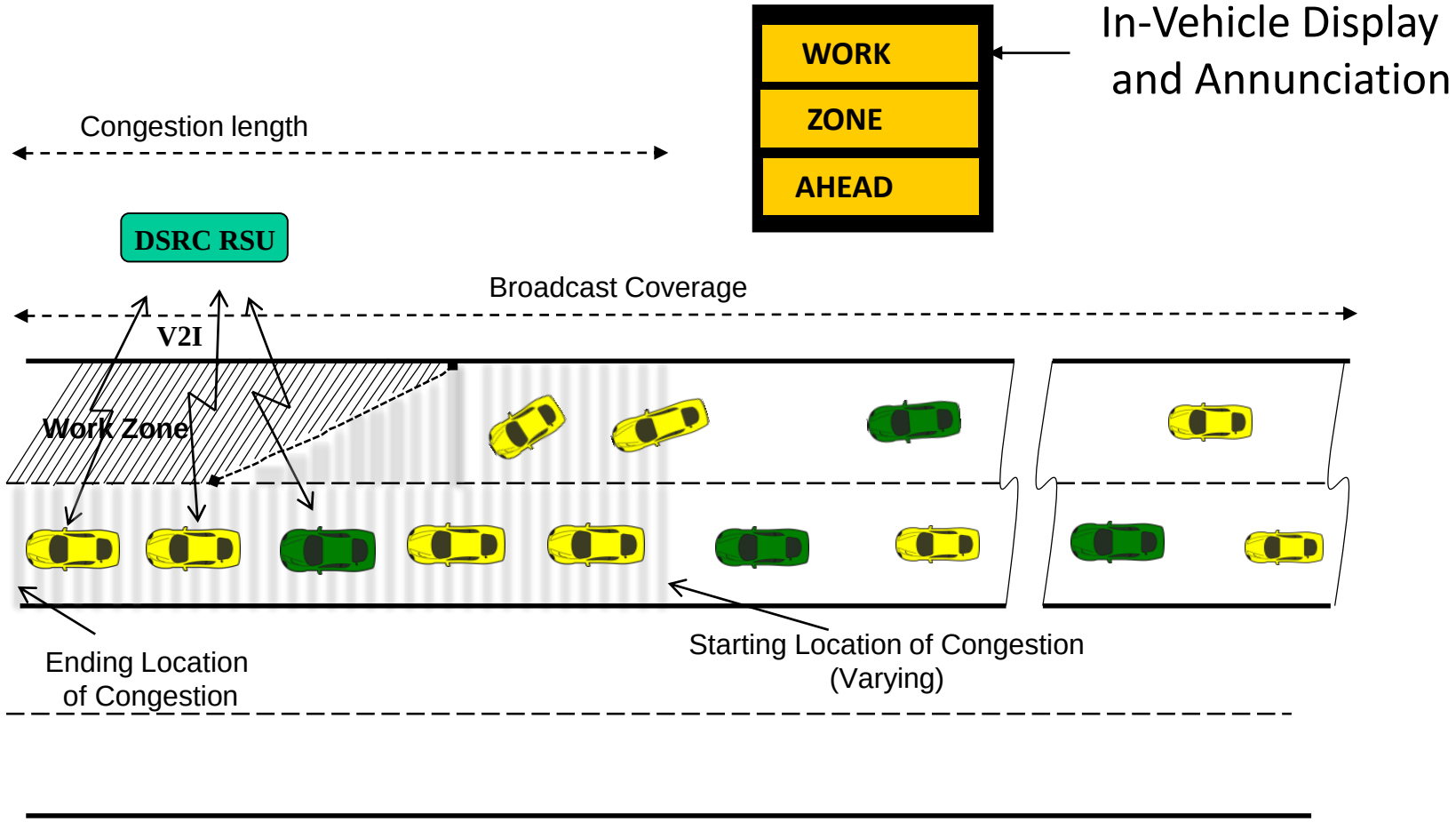
• Red Light Running	RLR
• Left Turn Assist	LTA
• Right Turn Assist	RTA
• Pedestrian Signal Assist	PED-SIG
• Emergency Vehicle Preempt	PREEMPT
• Transit Signal Priority	TSP
• Freight Signal Priority	FSP
• Rail Crossing	RCA

Rail Road Grade Crossing



Source: John Kenney, Toyota Info Technology Center

Work Zone Warning



CVO Applications

V2I and V2V applications

- Border Crossing
- Control Loss Warning
- Driver Log
- Fleet Management
- Freight, Inventory & Container Management
- Wireless Inspection
- Vehicle Diagnostics
- Weigh in Motion (WIM) Stations

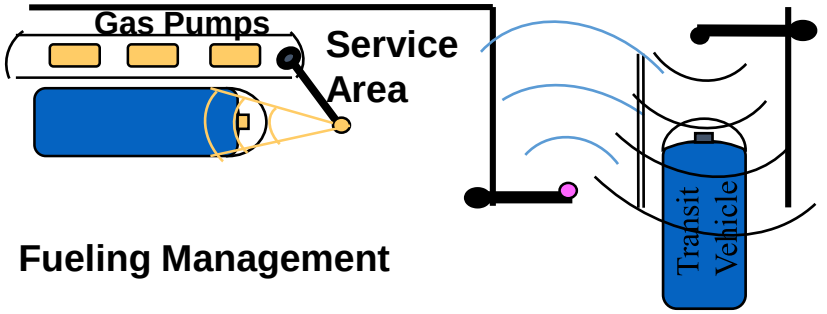
Unique to CVO Driver & Vehicle

- **Vehicle Size**
- **Cab Environment**
- **Workload**
- **Duration**

Private Applications

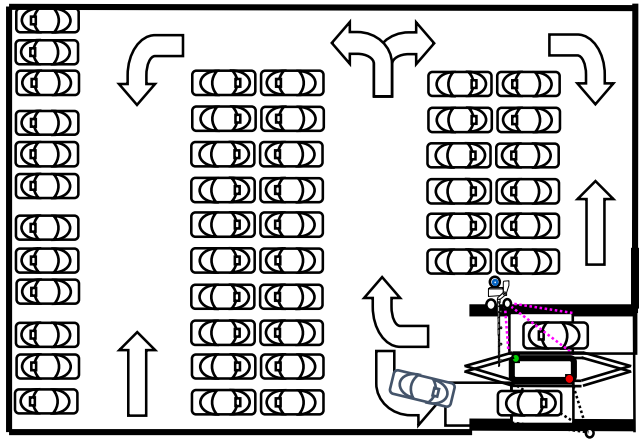
V2I and V2V applications

- Access Control
- Probe Data / Traffic Information
- Fuel / Drive-thru Management
- Parking Management
- Rental Car Transactions
- Service Record
- Vehicle Diagnostics
- Advanced TIS



Fueling Management

Access Exit Control



Parking Management & Payment

Automated Vehicles

Google Car

- **Two million miles**
- **90% of scenarios**

Connected and Automated Vehicles

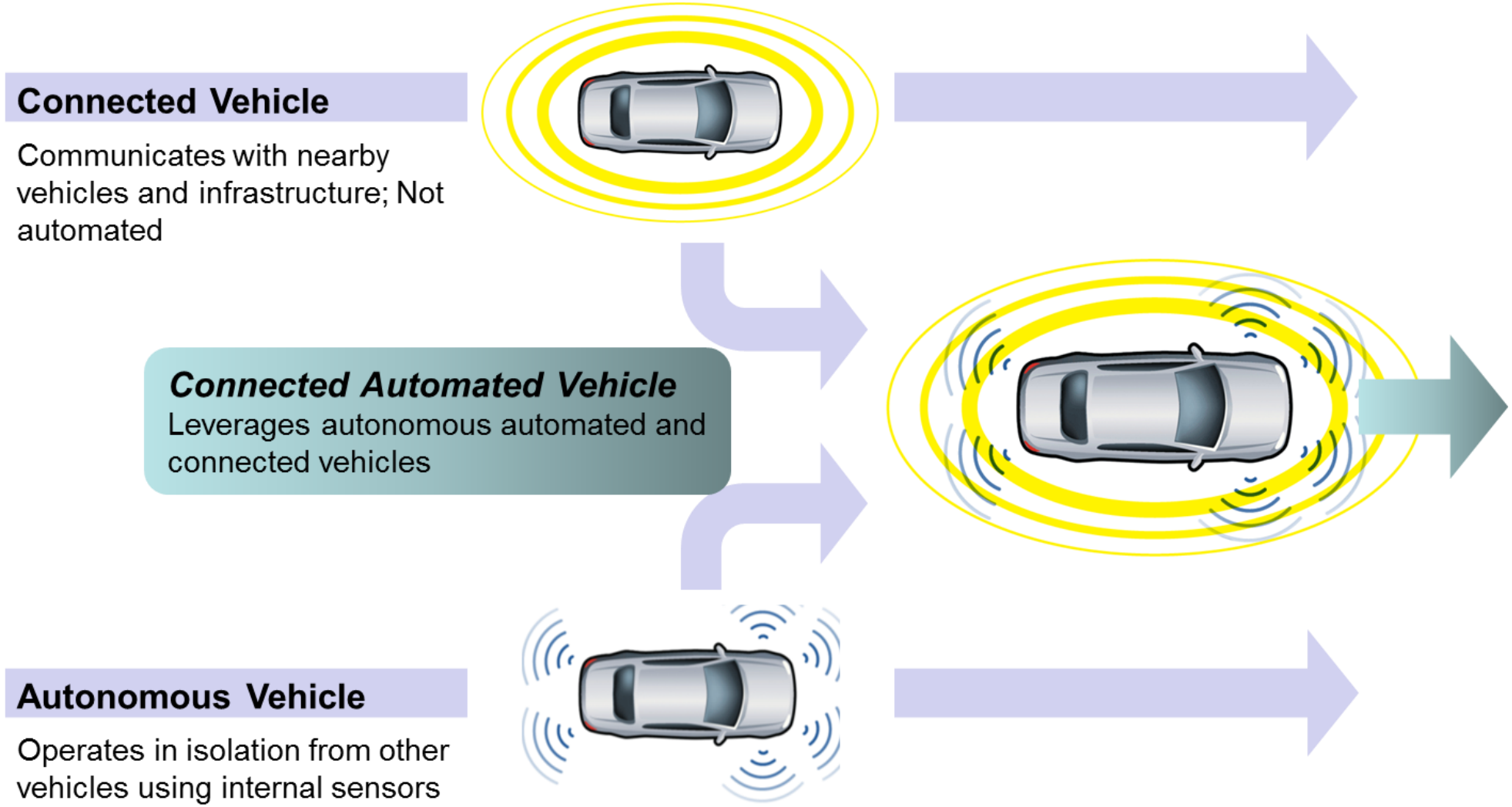


Image Source: Thinkstock/USDoT

Outline

- Background
- What is DSRC?
- Why DSRC?
- Applications (V2I and V2V)
- Widespread Deployment Issues
- Summary

Widespread Deployment Concerns

- Privacy
- Security
- Positioning
- Scalability

Privacy

Privacy Concerns

- Information is abused
- Any 3rd party could track vehicle
- Authorities could track vehicle

Privacy is key element of V2X security

- No data tracking or trajectory logging of an individual vehicle
- Identifiers (certificates, MAC, etc.) changed every few minutes
- 1609.2 supports pseudonymous certificates – not linked to car

Security Concerns

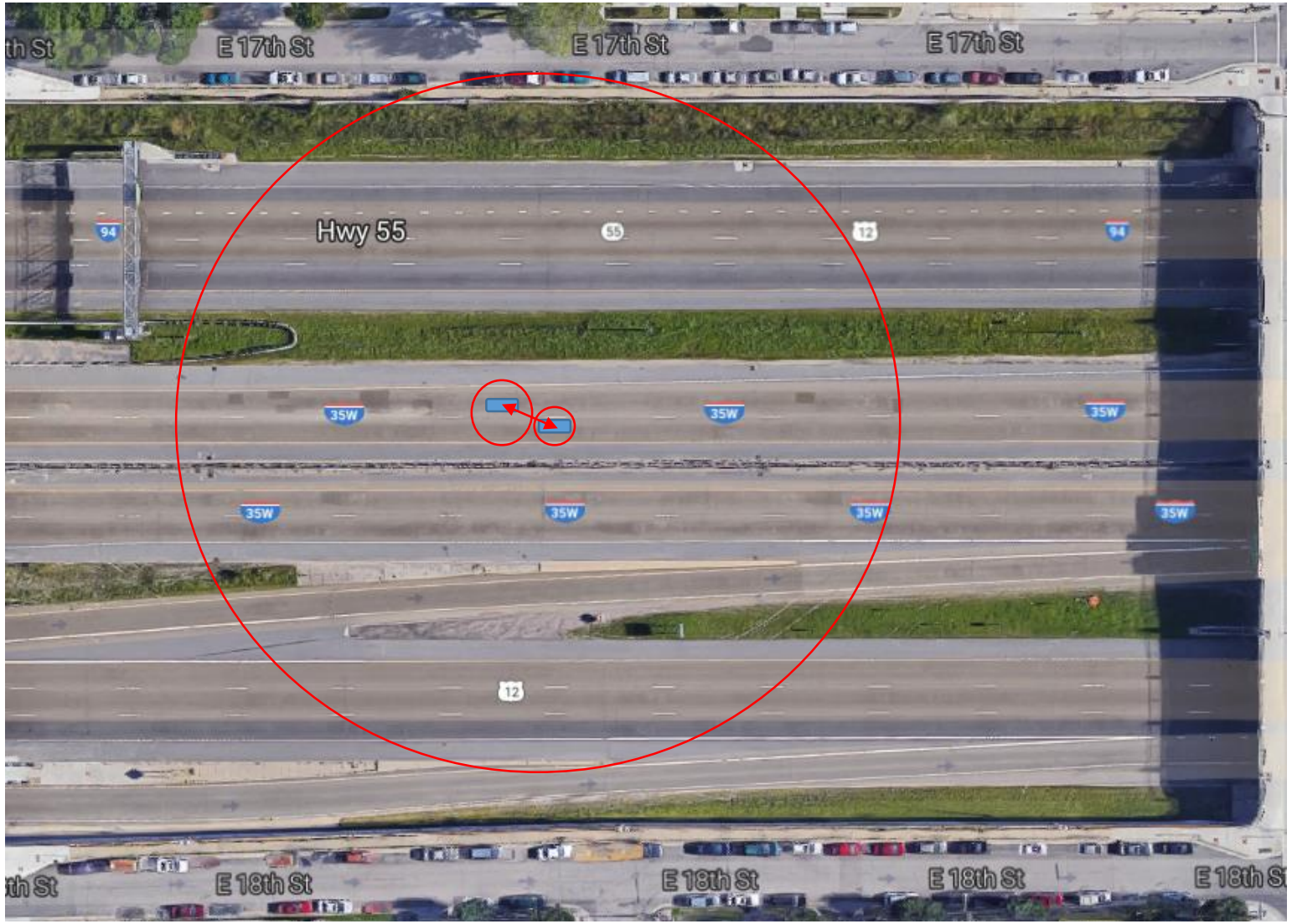
Security Concerns

- Terrorists inject false messages or hack server, and people will be hurt
- There will be plethora of hoax or spam messages

Security is built into design

- Authentication – Shows sender is authorized and data not altered
- Encryption – keeps data secret

Positioning



- Which Road?
- Which Lane?
- Where in Lane?
- Relative Distance?

Scalability

Will all this work here?

Summary

- Technology can help in future generation transportation systems
- DSRC has unique characteristics to enable future generation intelligent transportation systems
- DSRC works both in V2I and V2V environments providing many safety and mobility applications
- DSRC will facilitate connected autonomous vehicles
- There are some concerns in widespread deployment but the progress in technology and anticipated benefits will make it happen

Time for Questions?