

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>)

The screenshot shows the top portion of the CVRL website. At the top is the University of Minnesota Duluth logo and name, with the slogan "Driven to Discover". Below this is a yellow navigation bar with links for "myUMD", "Search", "People", "Departments", "Events", and "News". A second yellow bar identifies the "Swenson College of Science and Engineering". The main header features the CVRL logo and the text "Connected Vehicles Research Laboratory". Below the header is a grey navigation menu with buttons for "HOME", "RESEARCH", "PERSONNEL", "PUBLICATIONS", "OUTREACH", "LINKS", and "CONTACT". Two large images are displayed: the CVRL logo on the left and a 3D visualization of a city street with cars and communication signals on the right.

[Dept. of Electrical Engineering Home](#) [CVRL Home](#)

CONNECTED VEHICLES RESEARCH LABORATORY

The Connected Vehicles Research Lab (CVRL) is located in the electrical engineering (EE) department of the University of Minnesota Duluth (UMD). The CVRL is involved in the state of the art research to improve driver safety and traffic mobility using vehicle to vehicle (V2V) or vehicle to infrastructure (V2I) wireless communication which is commonly known as the connected vehicles technology. The CVRL has previously worked on projects funded by the Northland Advanced Transportation Systems Research Laboratory (NATSRL), the Intelligent Transportation Systems (ITS) Institute, and the Center for Transportation Studies (CTS) of the University of Minnesota. Currently, CVRL is working in collaboration with Roadway Safety Institute (RSI) of CTS, and [Savari Networks](#) on two different projects funded by United States Department of Transportation (DOT). The CVRL is also working on a workzone safety project funded by [Minnesota Department of Transportation](#). To find out the details on current and past research projects, please [click here](#).

Outline

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

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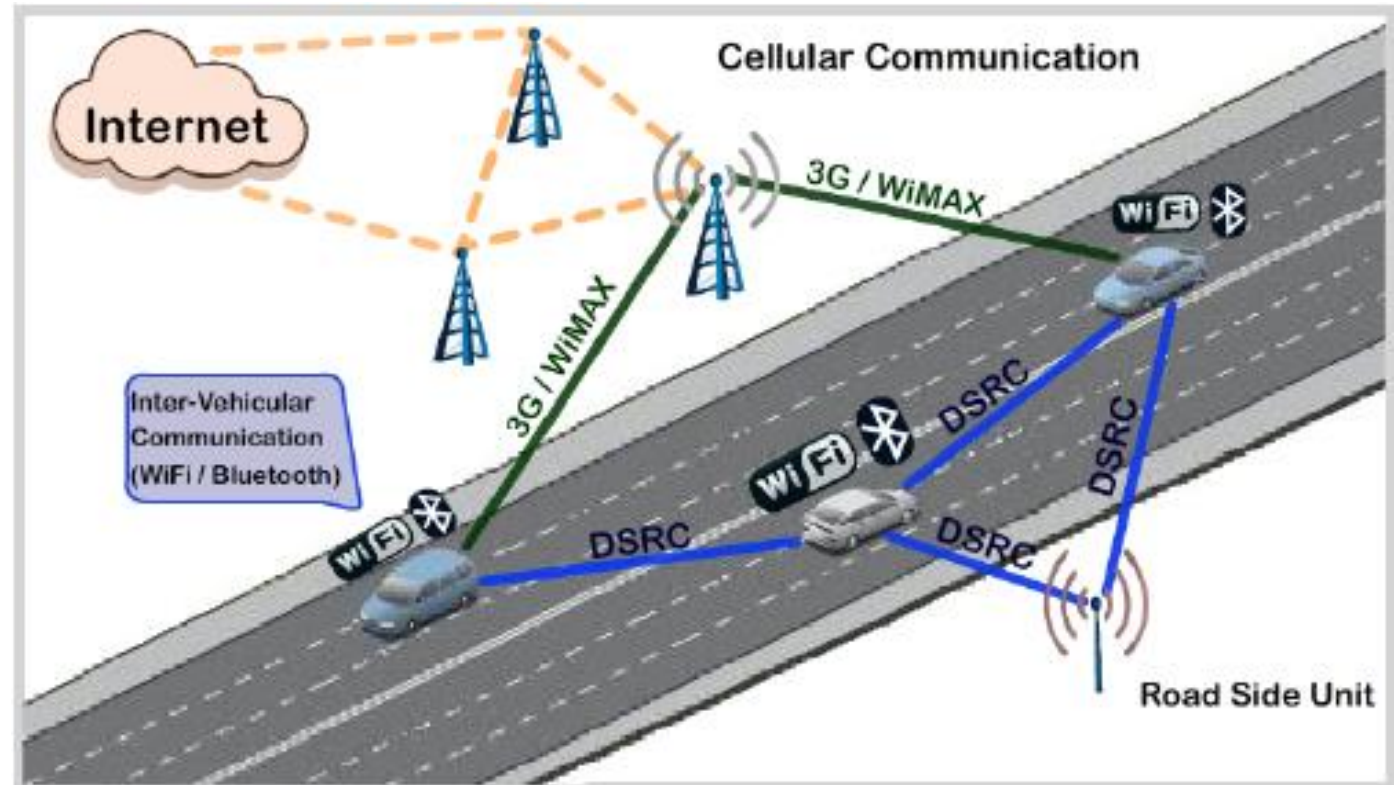
Problem

- 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

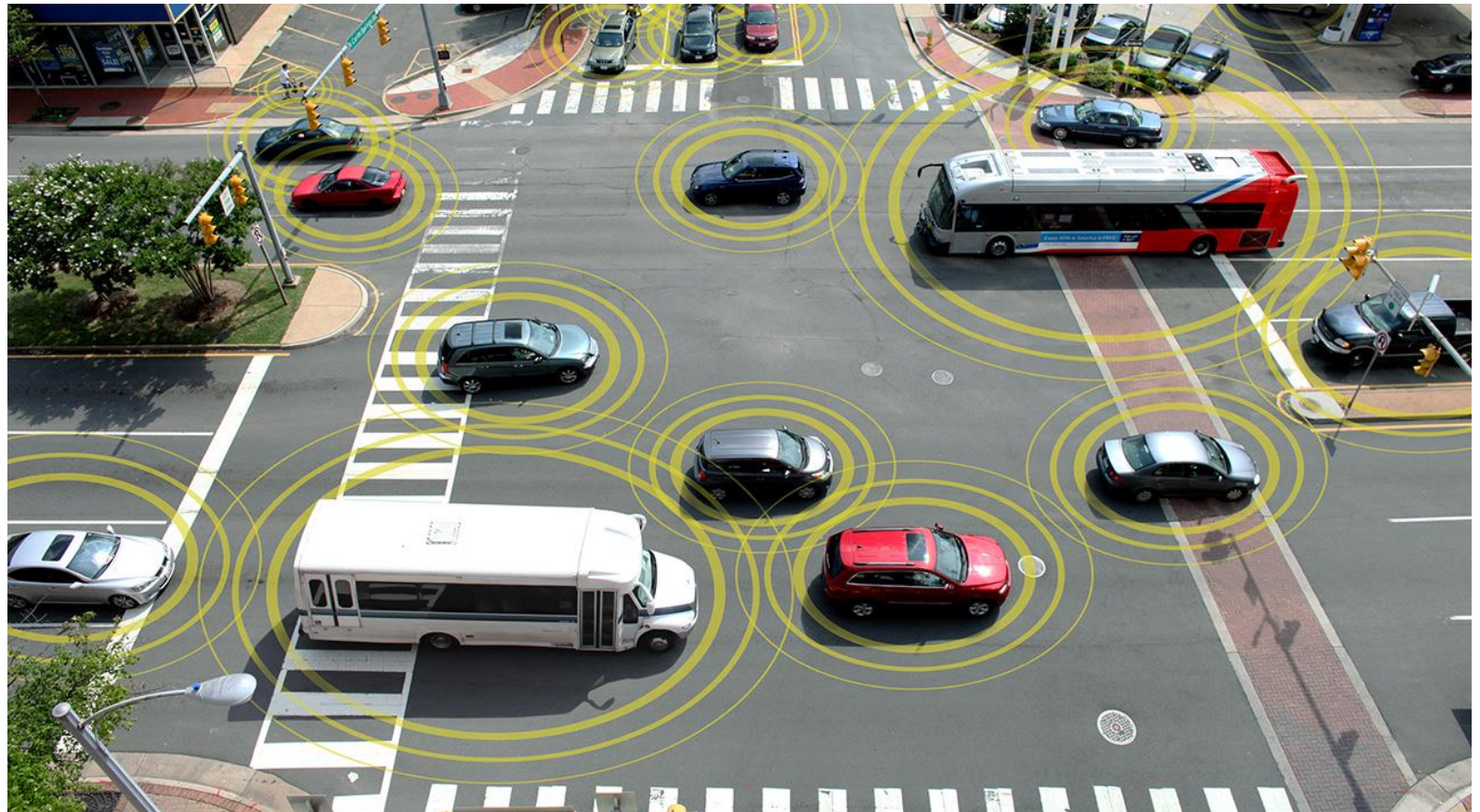


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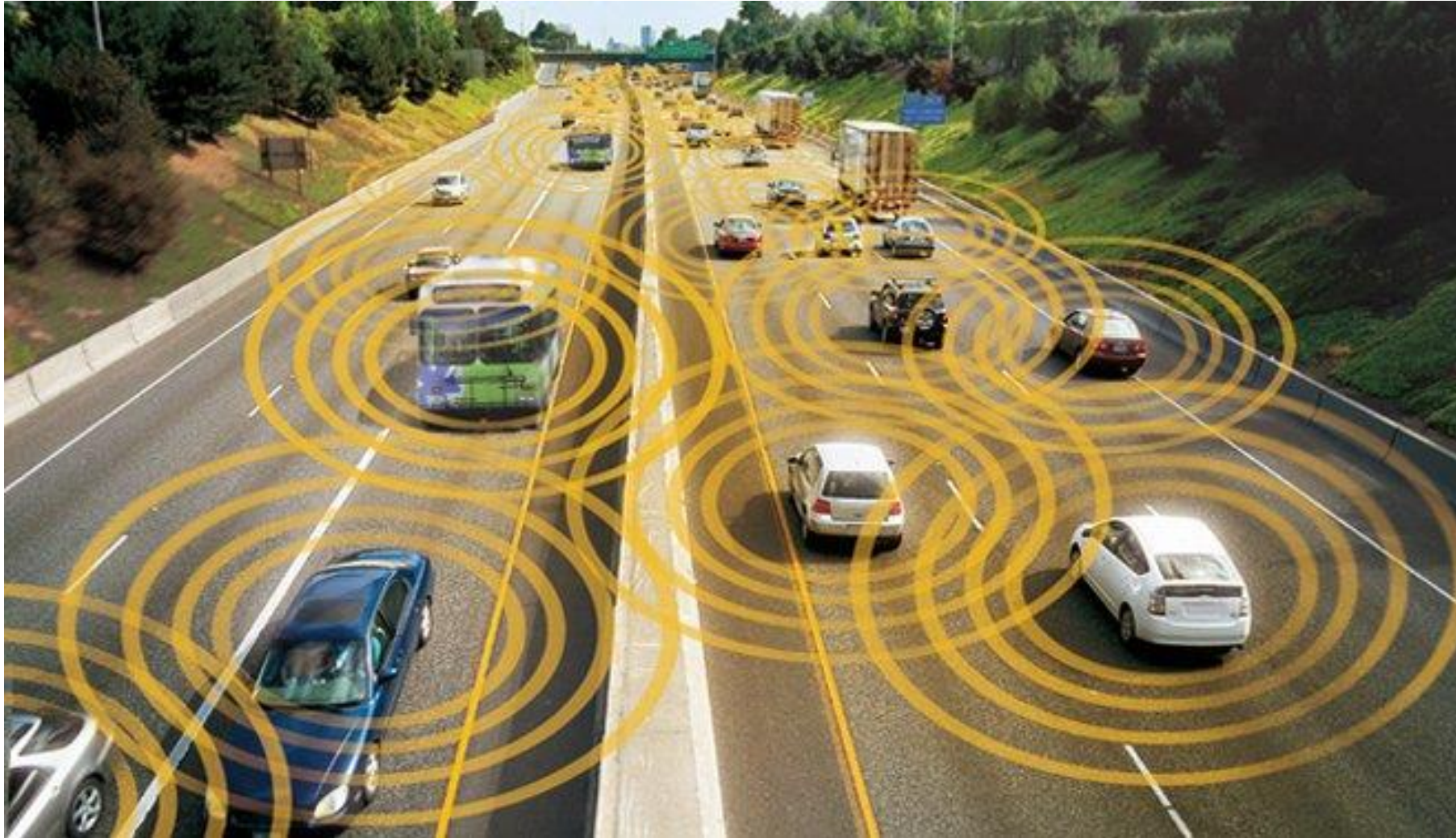
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DSRC Overview

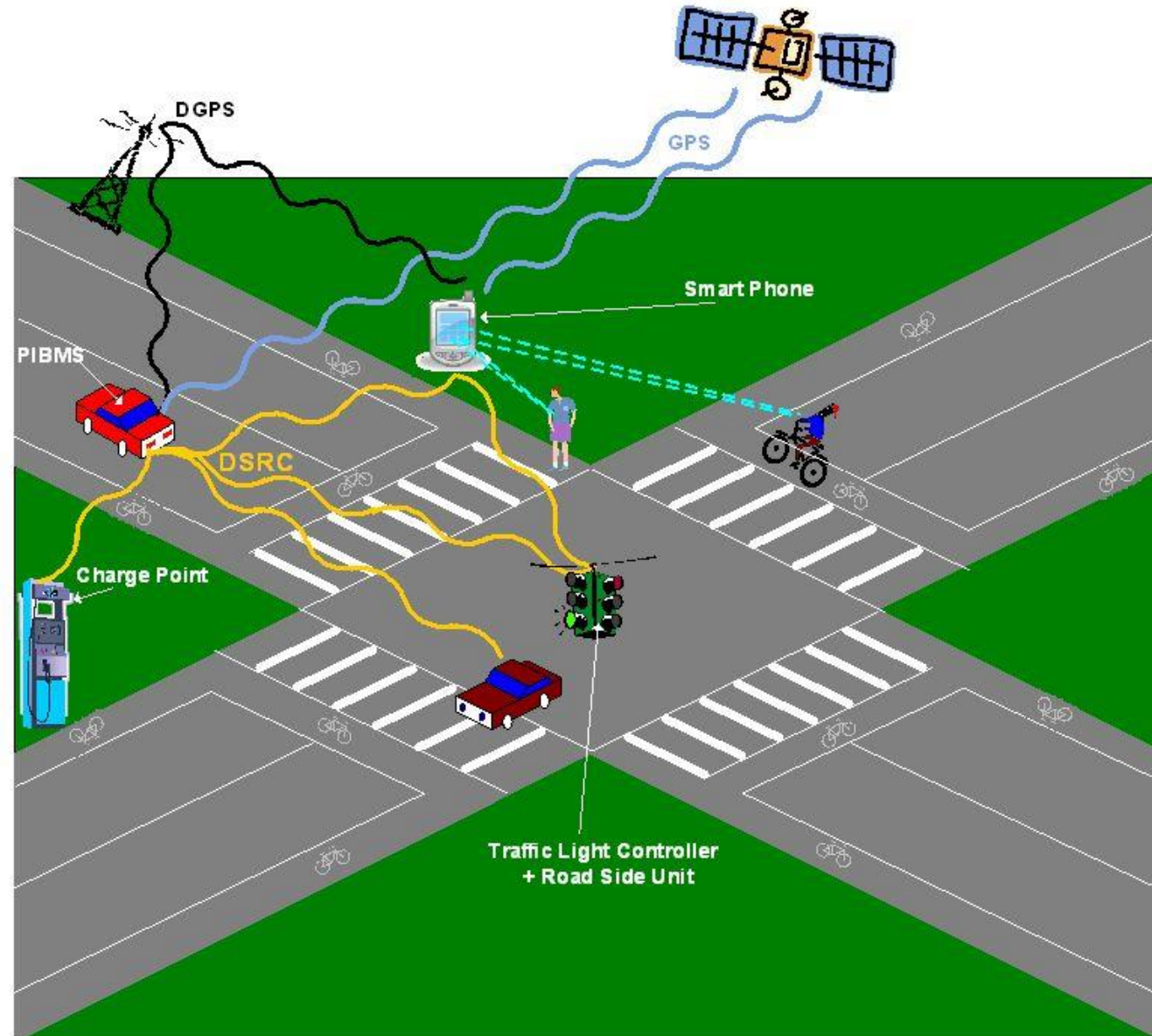
- FCC has authorized 75 MHz of spectrum (5.850 - 5.925 GHz) for DSRC
- Supports both public safety and private operations
- Operates in both vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication environments



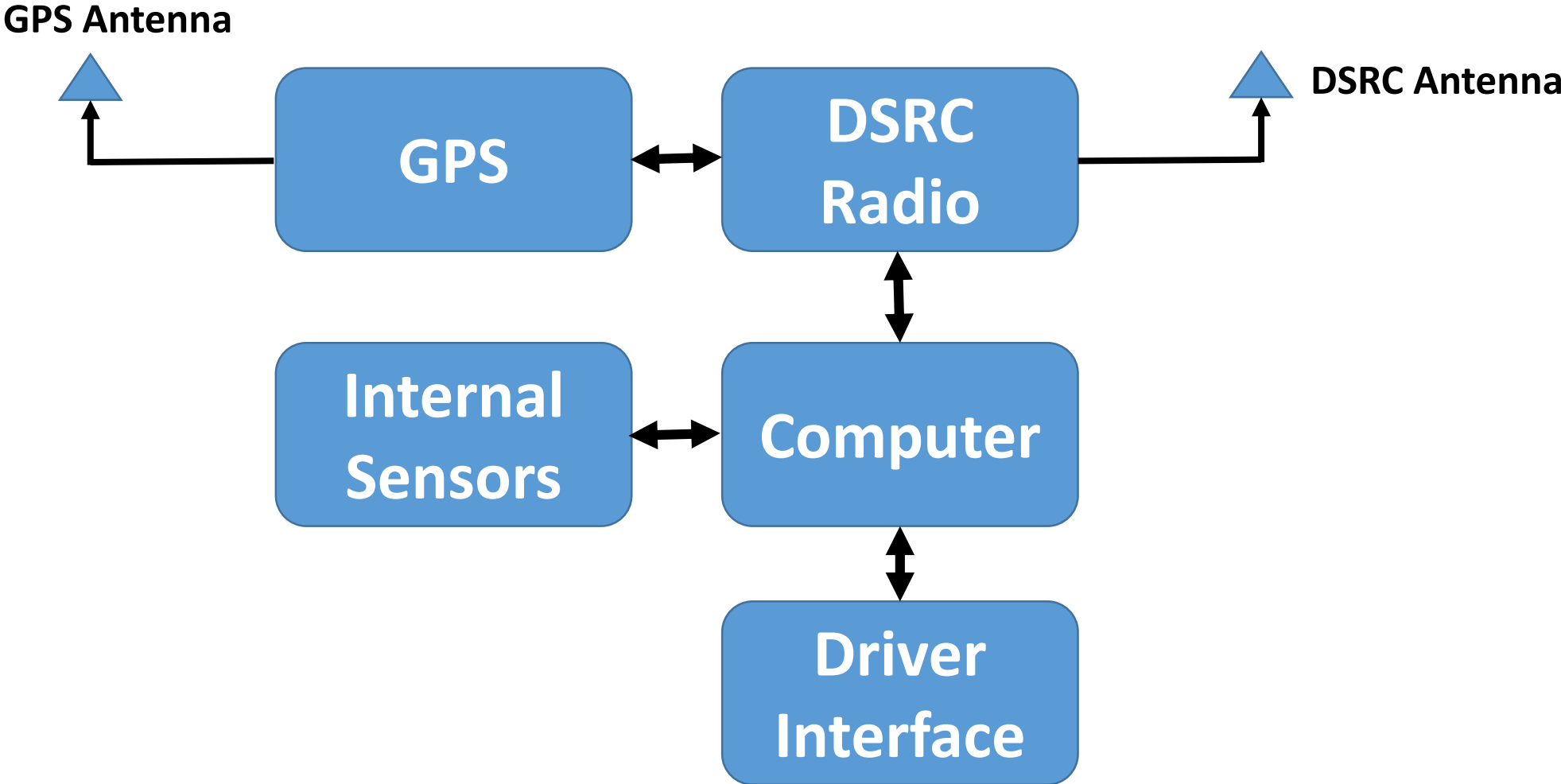
Vehicle to Vehicle (V2V) environment



Vehicle to Infrastructure (V2I) environment



DSRC Infrastructure



DSRC Message Types (SAE J2735)

- Basic Safety Message (BSM)
 - Probe Vehicle Data Message (PVD)
 - Traveler Information Message (TIM)
 - Map Data Message (MAP)
 - Signal Phase and Timing Message (SPaT)
- } Vehicle
- } Infrastructure

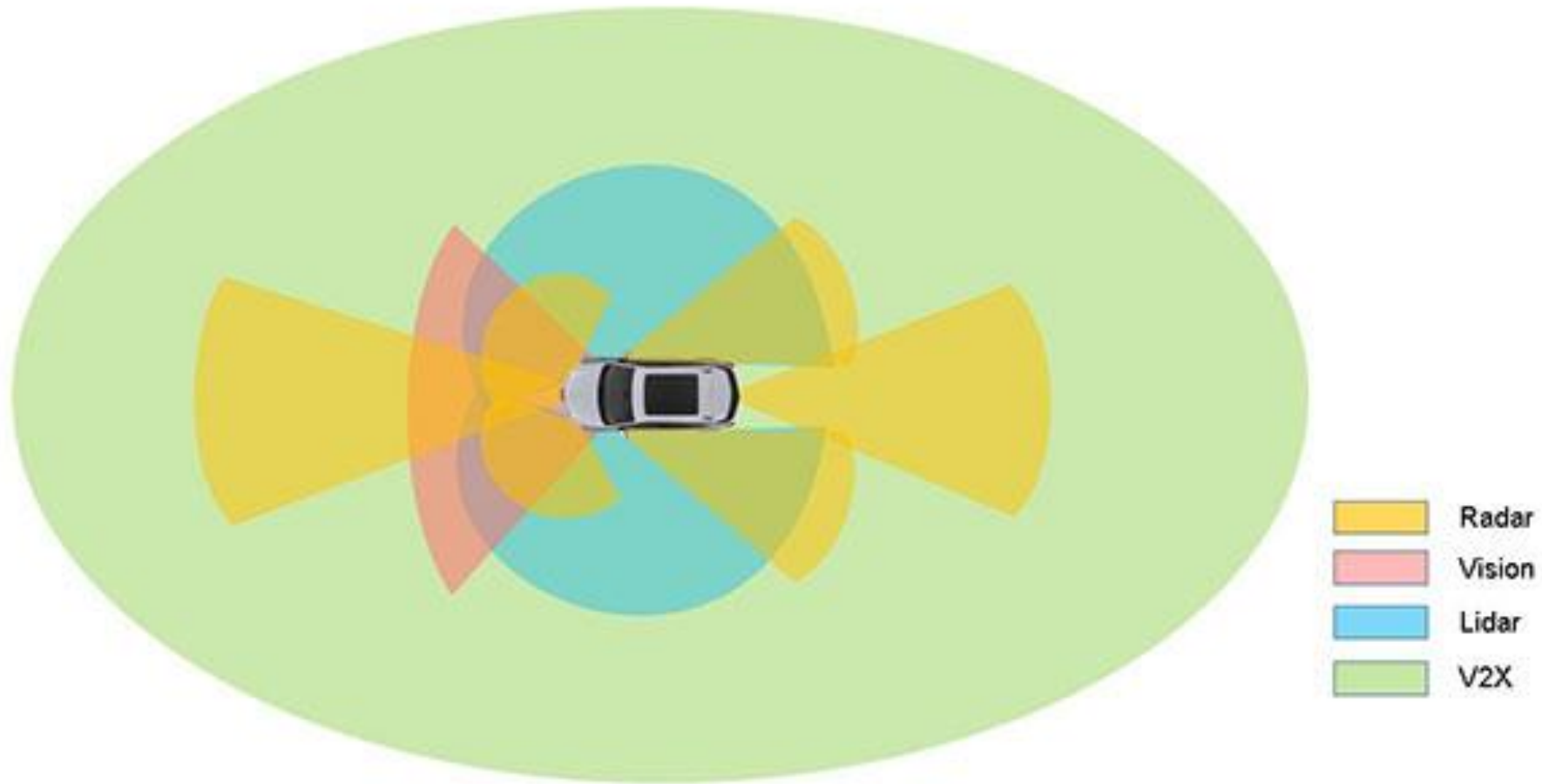
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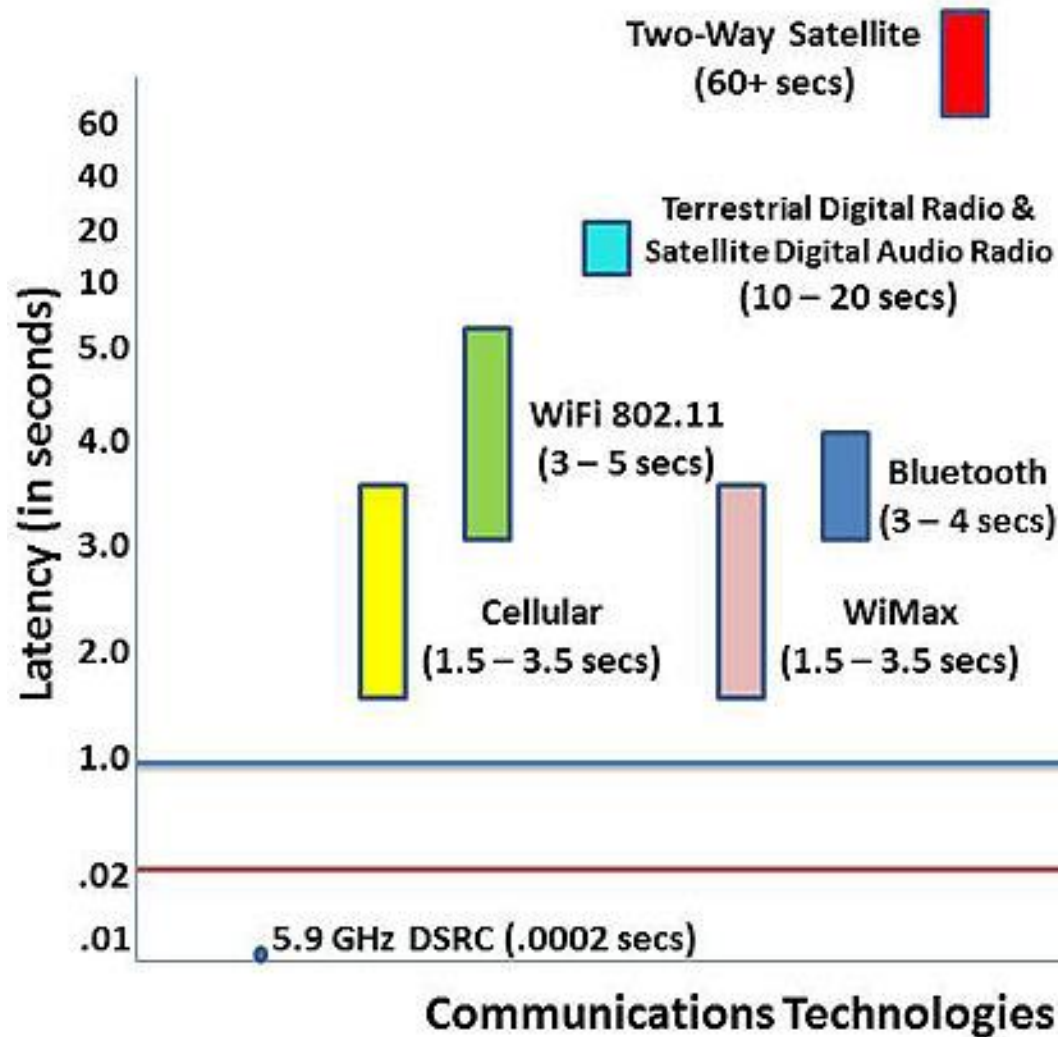
Unique Benefits

- Dedicated 75 MHz of spectrum @ 5.9 GHz
- Key Benefits
 - 802.11p technology similar to 802.11a
 - Low latency communication ($\ll 50$ ms)
 - High data transfer rates (3 – 27 Mbps)
 - Line-of-sight, up to 1000 m and 360°
 - 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

Least stringent latency requirement for Active Safety (1 sec)

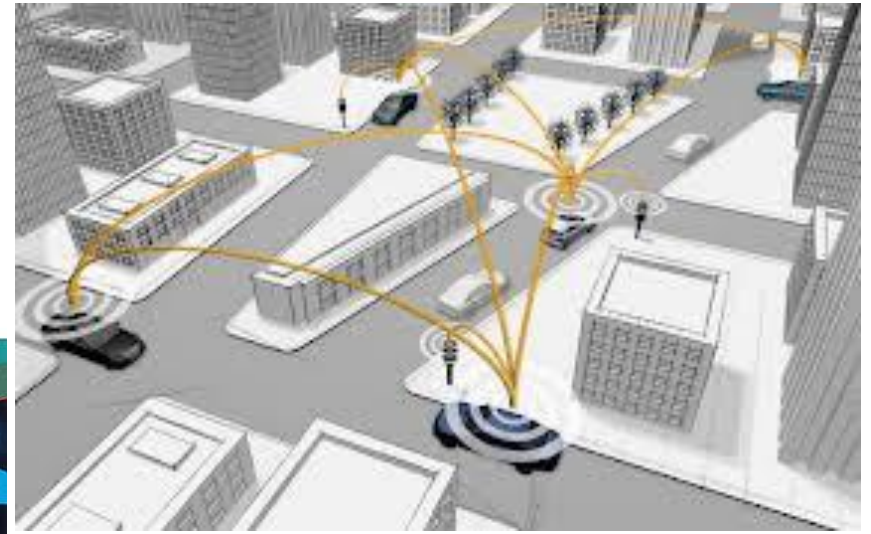
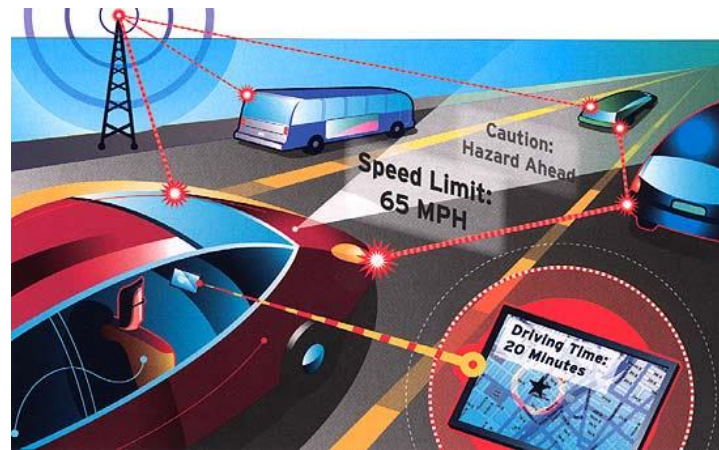
Most Stringent latency requirement for Active Safety (.02 sec)

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DSRC Applications

- V2V Safety
- V2I Safety
- CVO
- Private

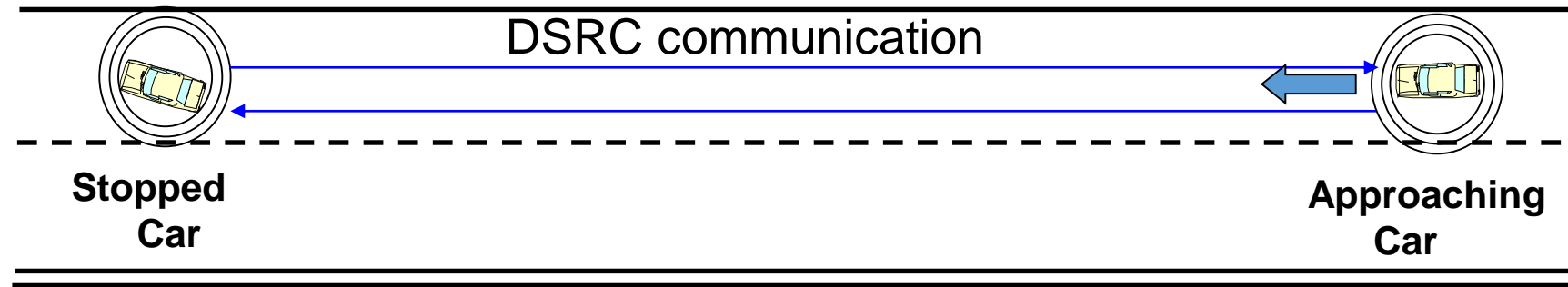


V2V Safety Applications

Applications Enabled by BSM

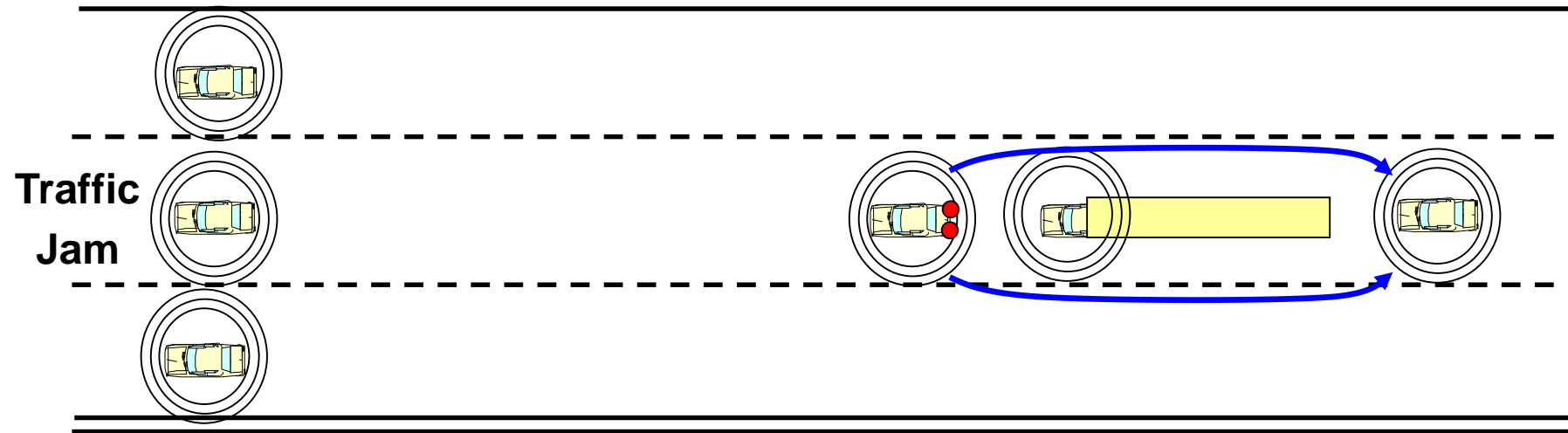
- Forward Collision Avoidance FCA
- Emergency Electronic Brake Lights EEBL
- Blind Spot Warning BSW
- Lane Change Assist LCA
- Do Not Pass Warning DNPW
- Intersection Collision Warning ICA
- Wrong Way Driver Warning WWDW
- Cooperative Adaptive Cruise Control CACC

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)



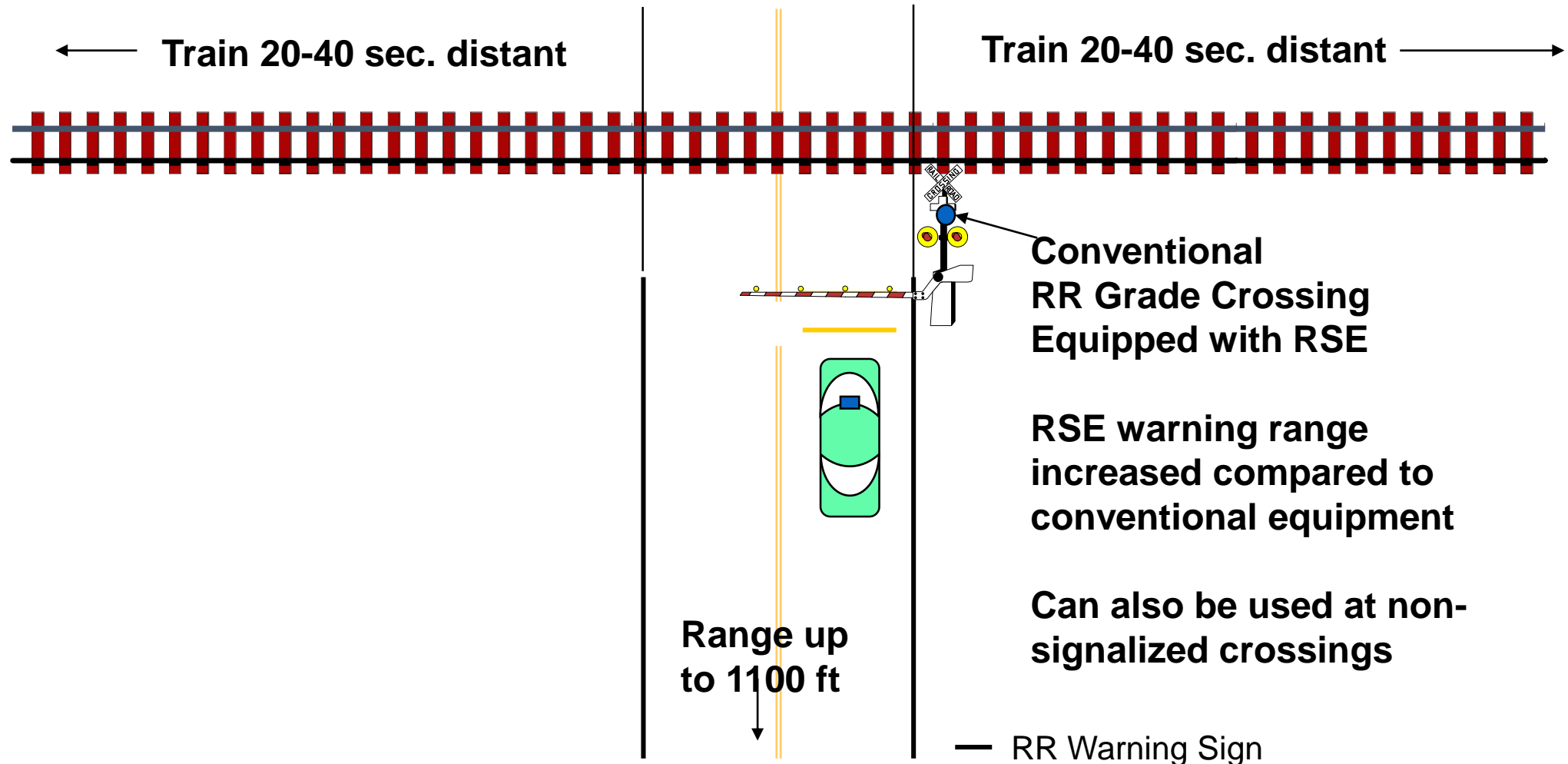
- High deceleration by vehicle approaching jam
- Trailing vehicle Informed via DSRC within 100 msec.

V2I Safety Applications

Applications enabled by SPaT/MAP

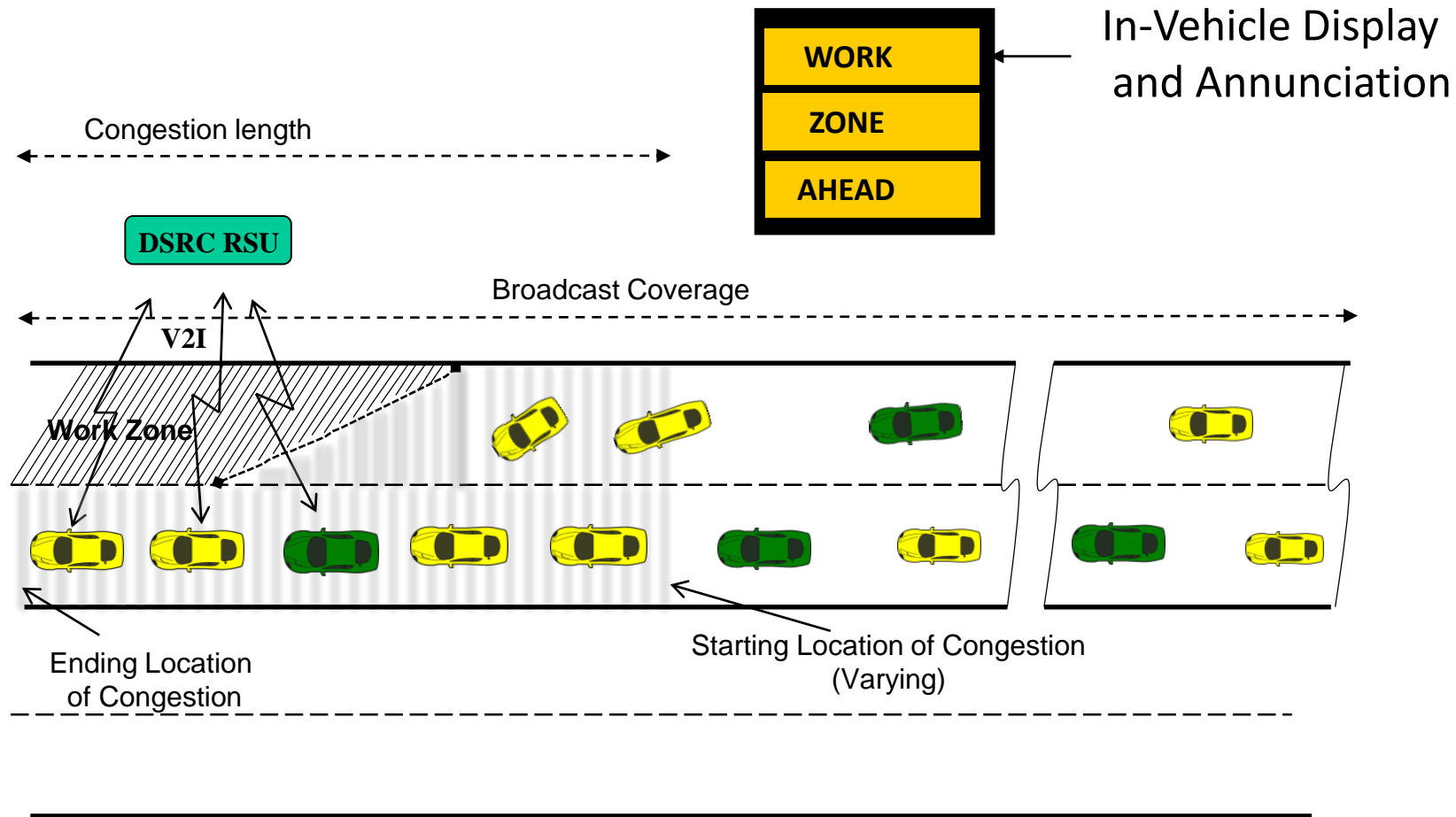
- Red Light Running RLR
- Left Turn Assist LTA
- Right Turn Assist RTA
- Pedestrian Signal Assist PED-SIG
- Emergency Vehicle Preempt PREEMPT
- Transit Signal Priority TSP
- Freight Signal Priority FSP
- Rail Crossing RCA

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



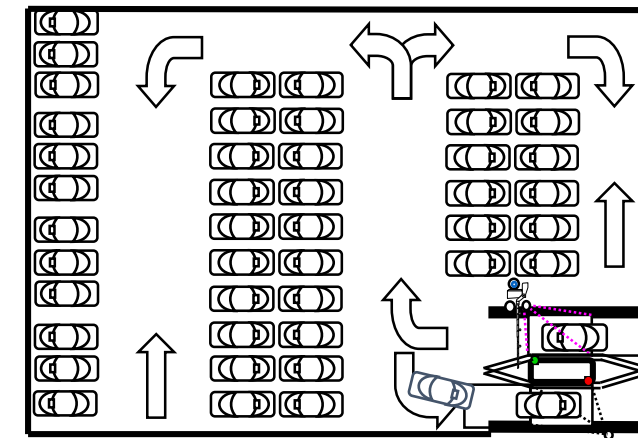
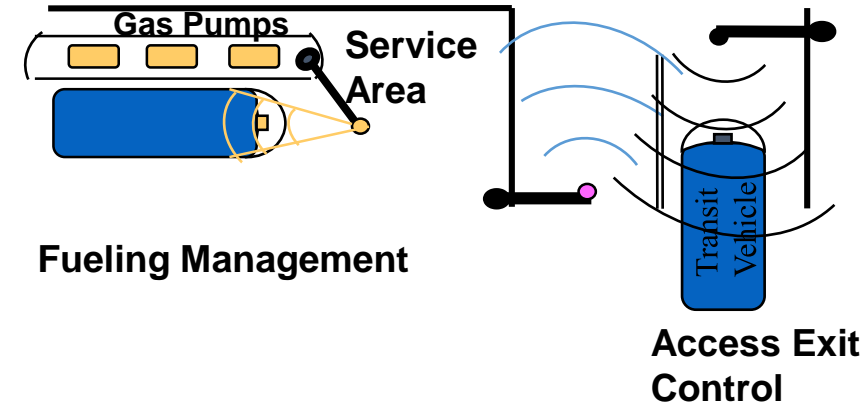
Unique to CVO
Driver & Vehicle

- **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



Parking Management & Payment

Automated Vehicles



Google Car

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



Connected and Automated Vehicles

Connected Vehicle

Communicates with nearby vehicles and infrastructure; Not automated



Connected Automated Vehicle

Leverages autonomous automated and connected vehicles



Autonomous Vehicle

Operates in isolation from other vehicles using internal sensors



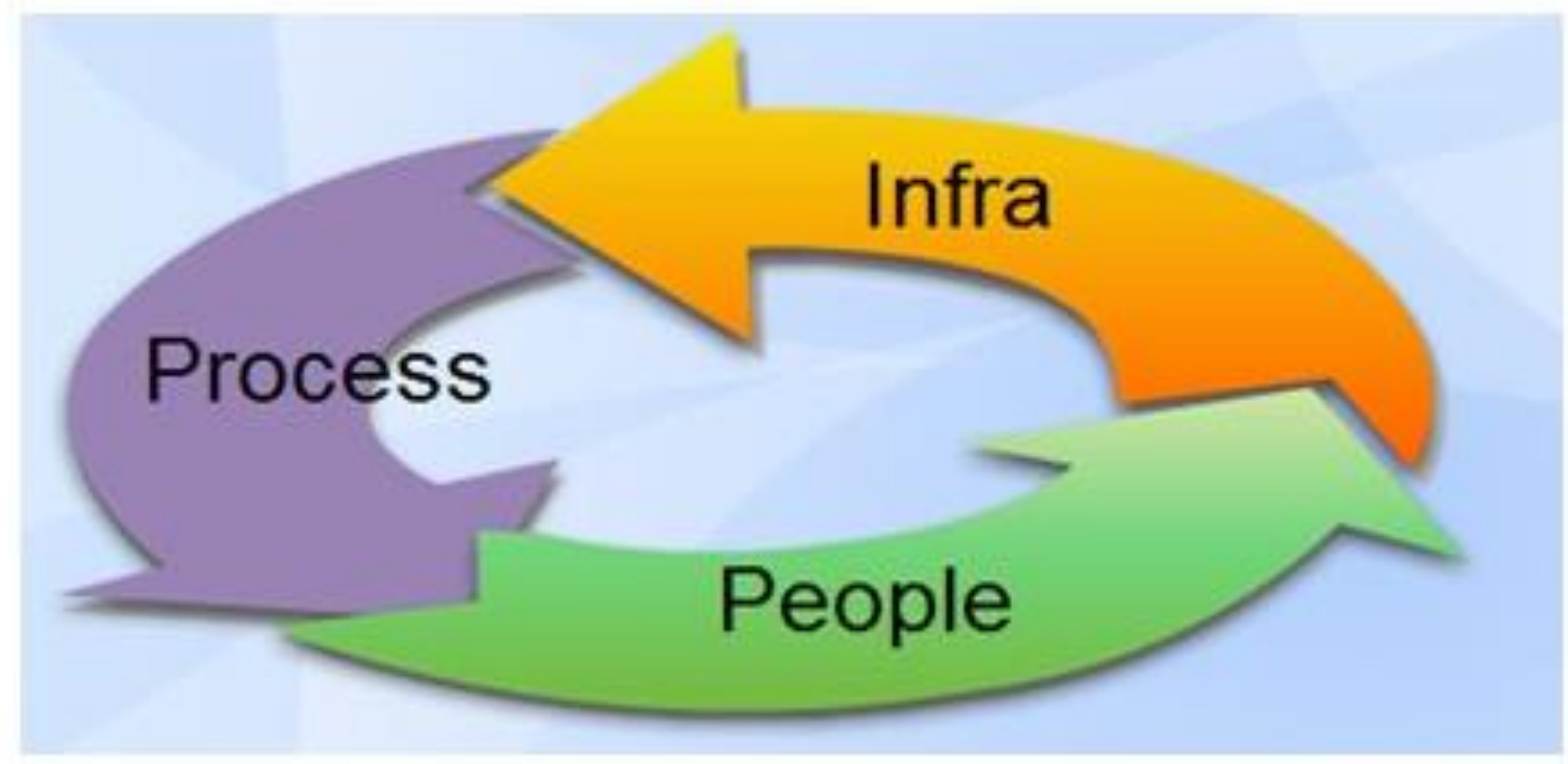
Image Source: Thinkstock/USDoT

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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?