



Vehicle Communications

V2X

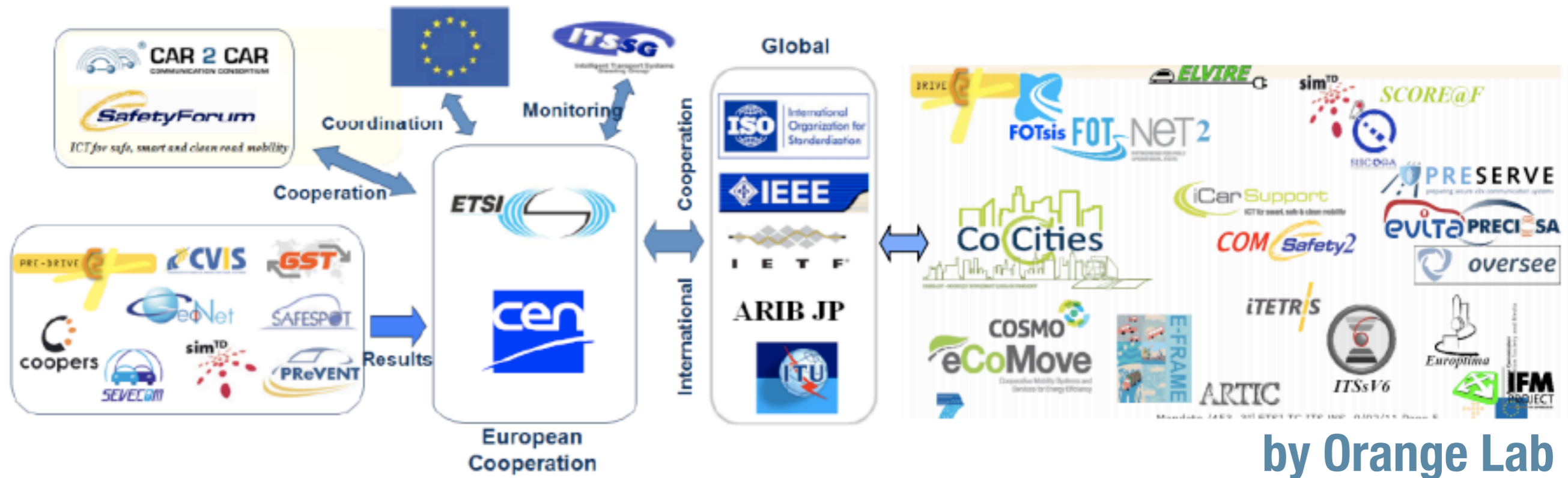
การสื่อสาร V2X

- * V2V (Vehicle to Vehicle), V2I (V to Infrastructure) and V2D (V to device) = V2X (Vehicle to Anything)
- * เพื่อลดอุบัติเหตุ เพิ่มประสิทธิภาพการเดินทาง ลดมลภาวะและพลังงาน
- * เทคโนโลยี m2m, Internet of Things (IoT), DSRC, Radar, Wi-Fi, 3G, LTE, Zigbee, and etc ใช้ใน V2X
- * มาตรฐาน: ISO CALM, IEEE 802.11p (WAVE), ETSI, ARIB.



Pictures from DENSO

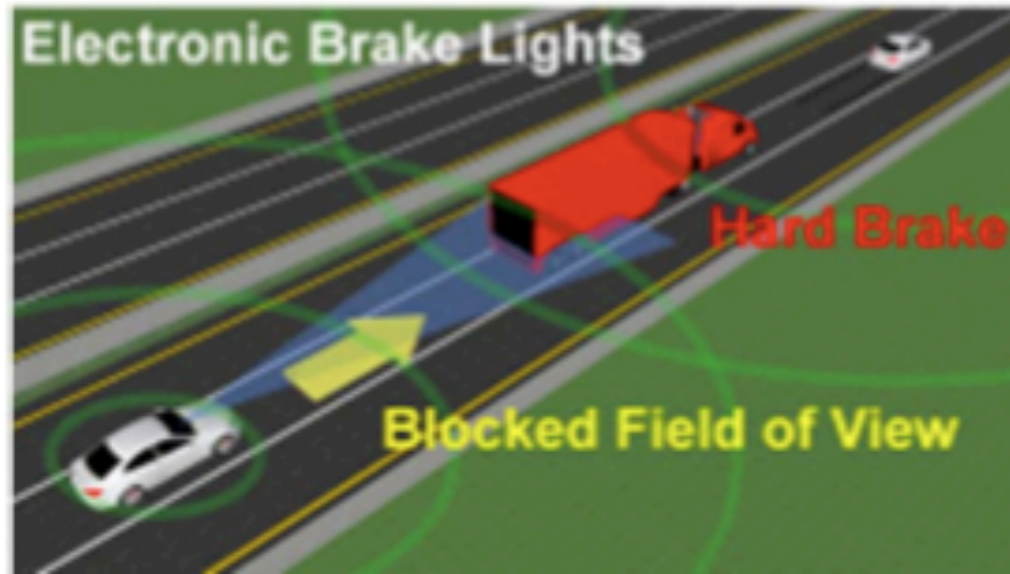
Known Projects/Standards



by Orange Lab

V2V

WAVE



V2I

WAVE

3G

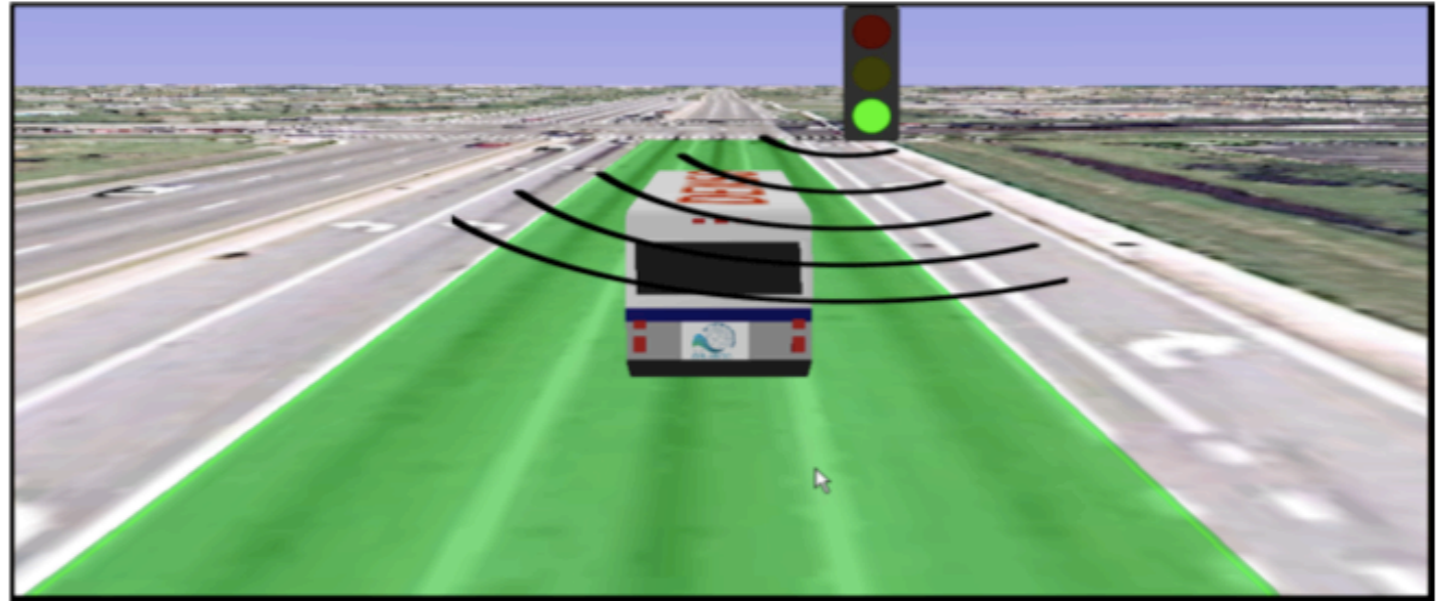
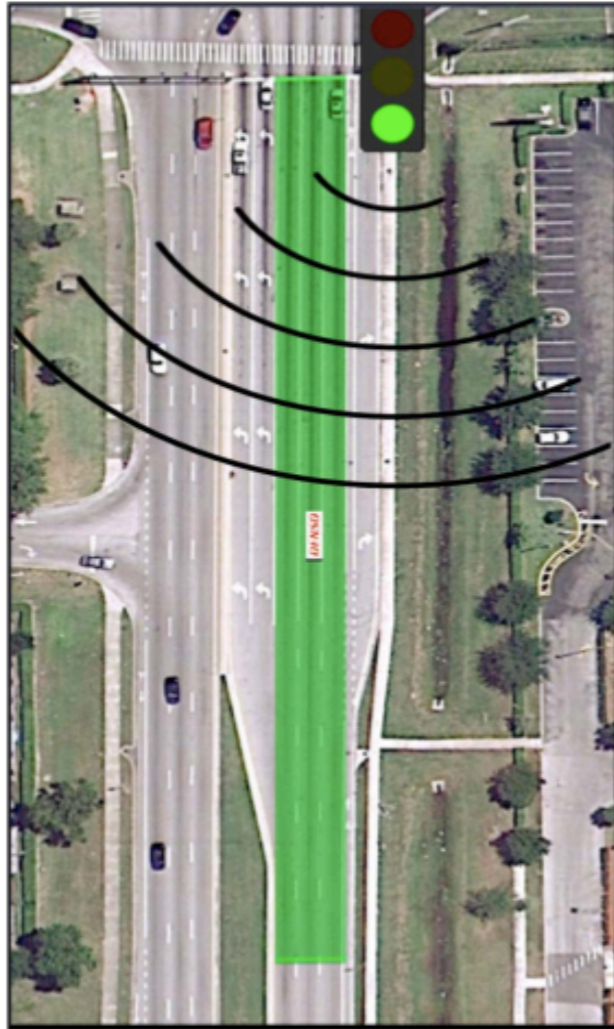
Wi-Fi

Milimeter-
wave

IR

802.11a/n

LTE



"Green Carpet Ride" uses signal phase & timing data broadcast by roadside equipment and allows driver to adjust speed to "catch the green light"

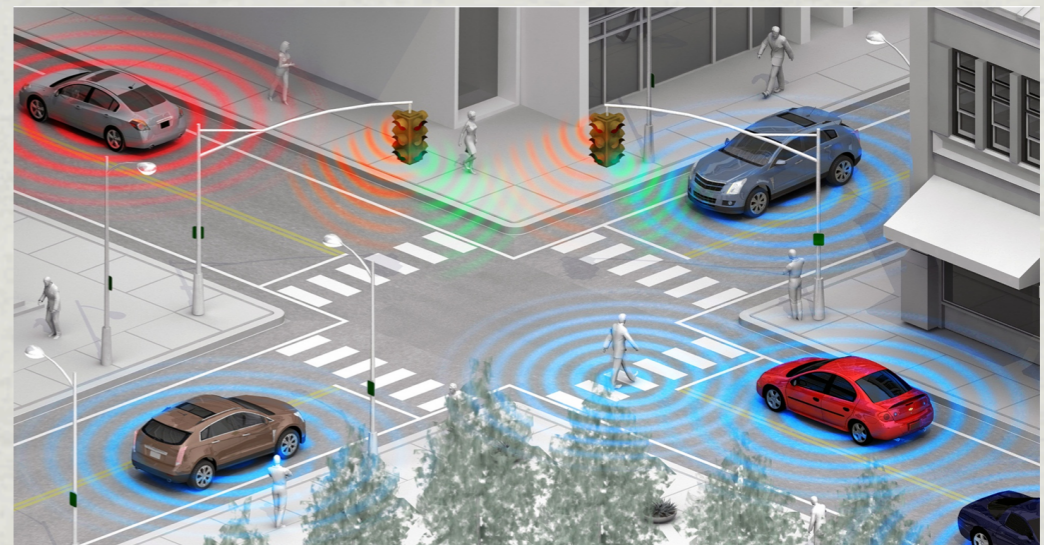
**INTERSECTION SAFETY
ROADWAY DEPARTURE PREVENTION
SPEED MANAGEMENT
TRANSIT SAFETY AND OPERATIONS
COMMERCIAL VEHICLE ENFORCEMENT AND OPERATIONS
AT-GRADE RAIL CROSSING OPERATIONS
PRIORITY ASSIGNMENT FOR EMERGENCY VEHICLES**

Safety

- * Warnings on entering intersections.
- * Warnings on departing the highways
- * Obstacle discovery
- * Sudden halts warnings
- * Reporting accidents
- * Lane change warnings

Traffic Management

- * Variable speed limits
- * Adaptable traffic lights
Automated traffic intersection control
- * Accommodating ambulances, fire trucks, and police cars



Driver assistance systems

- ✱ Parking a vehicle
- ✱ Cruise control
- ✱ Lane keeping assistance
- ✱ Road-sign recognition



POLICING AND ENFORCEMENT
PRICING AND PAYMENTS
DIRECTION AND ROUTE OPTIMIZATION
TRAVEL-RELATED INFORMATION
GENERAL INFORMATION SERVICES

V2X World-class Projects



<http://www.worldstandardscooperation.org/fnc2013.html>

- * “Fully Networked Car 2013 – The Future of Vehicles” is being held 6 March 2013 Geneva International Motor Show by IEC ISO and ITU



- * Connected Vehicle Research

http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm






✿ Car 2 Car Communication Consortium (C2CCC)



The communication technology for cooperative ITS and Car-2-Car Communication is derived from the standard IEEE 802.11, also known as Wireless LAN and a frequency spectrum in the 5.9 GHz range has been allocated on a harmonized basis in Europe in line with similar allocations in USA.

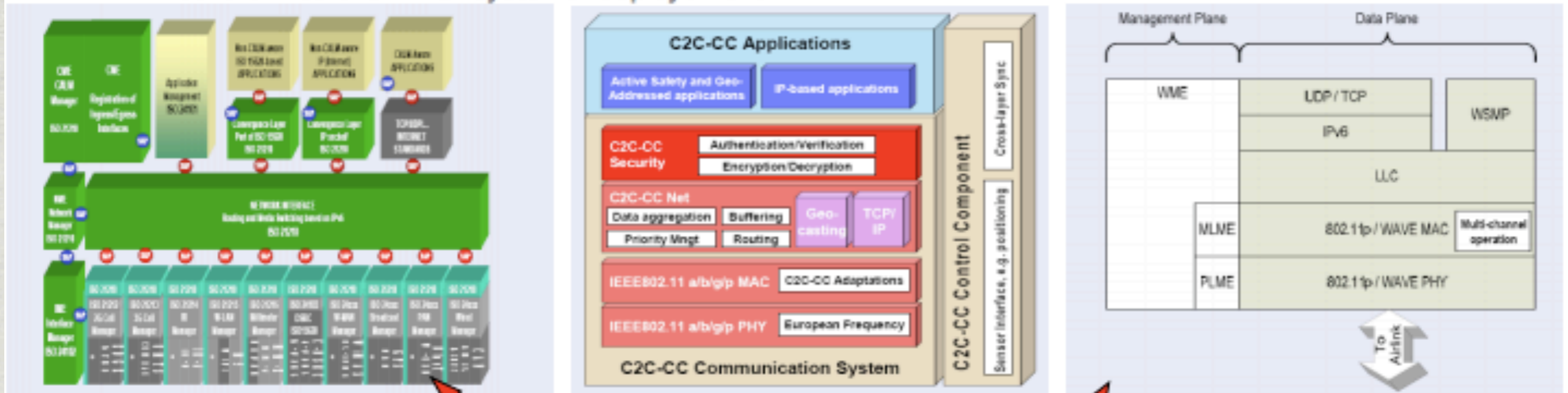
<http://www.car-2-car.org>

V2X Standards

	 Japan	 US	 Europe
Standard	ARIB STD T109	IEEE802.11p/1609.x draft	C2CCC/ETSI ES202 663 draft
Frequency	755~765MHz	5.850~5.925GHz	5.875~5.905MHz
Transmission Power	20dBm(@RF connector)	23~33dBm(EIRP)	
# of channels	10MHz × 1ch	10MHz × 7ch (20MHz is optional)	10MHz × 3ch
Modulation	Orthogonal Frequency Division Multiplexing (OFDM)		
Data rate	3~18Mbit/s	3~27Mbit/s(10MHz) / 6~54Mbit/s(20MHz)	3~27Mbit/s
Access control	CSMA/CA		
Enhanced access function	DCF (Distributed Coordination Function)	DCF PCF (Point Coordination Function) is under discussion	
Communication type	Broadcast	Broadcast, Multicast, Unicast	

V2V Standardization initiatives

at the heart of ITS systems deployment

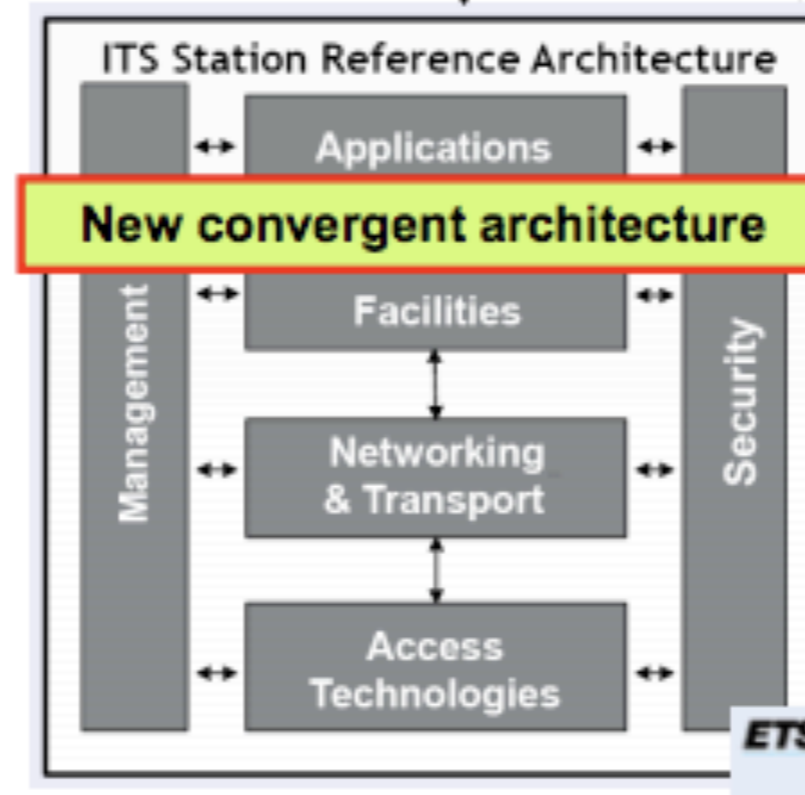


3 Standardisation bodies :

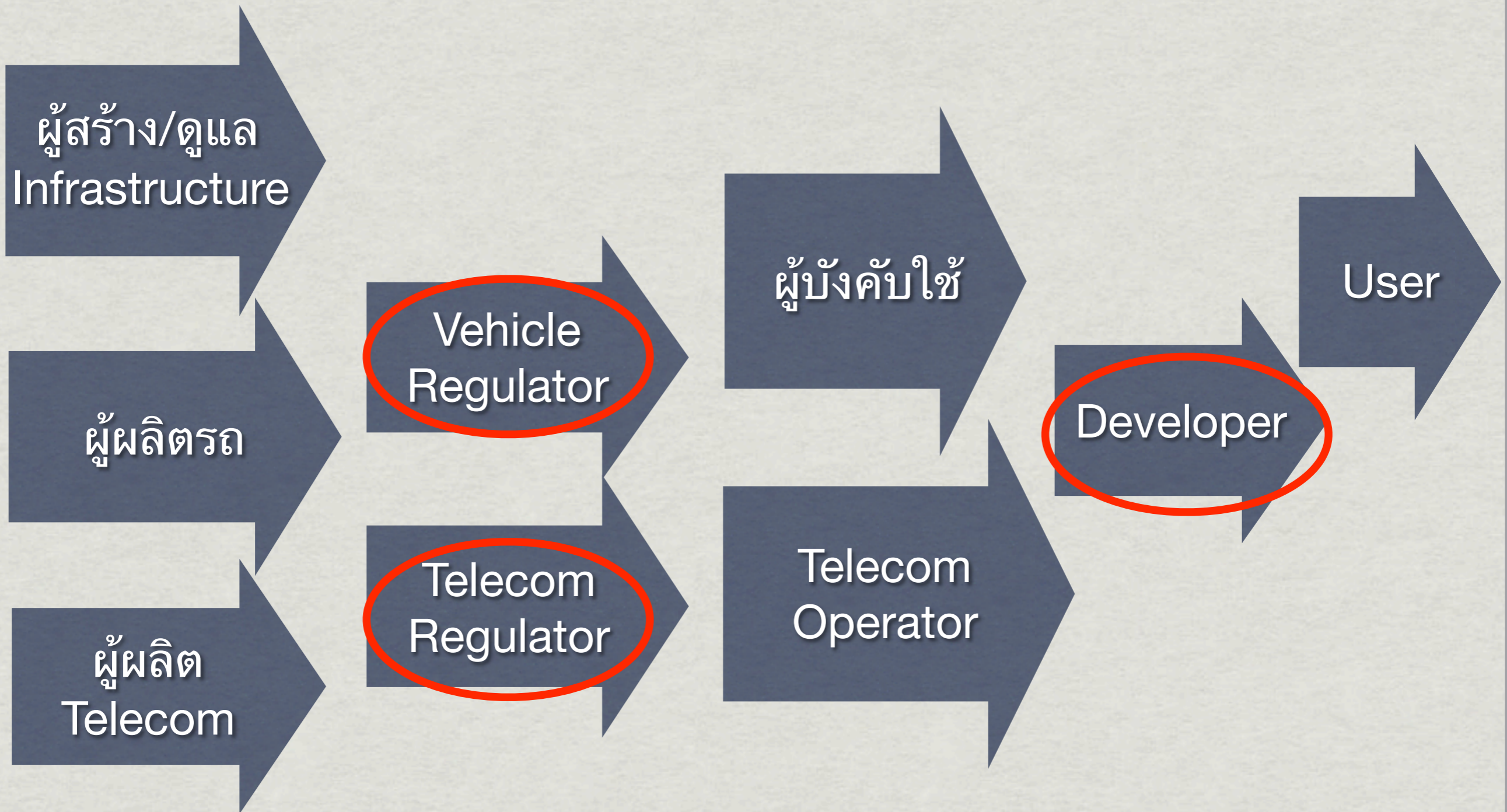
ISO TC 204 WG 16 : Started in 2001, WG16 of the International Technical committee 204 developed architecture **CALM (Communications Access for Land Mobiles)**

ETSI ITS TC : founded in 2007, ETSI involved in EC Mandate M453 to develop a minimum common set of standards for European needs and deployment.

IEEE WAVE 1609 : American WG created since 2006 developing **WAVE (Wireless Access in Vehicular Environment)** architecture based exclusively on top of IEEE 802.11p and ASTM1609



V2X Stakeholder



manufacture

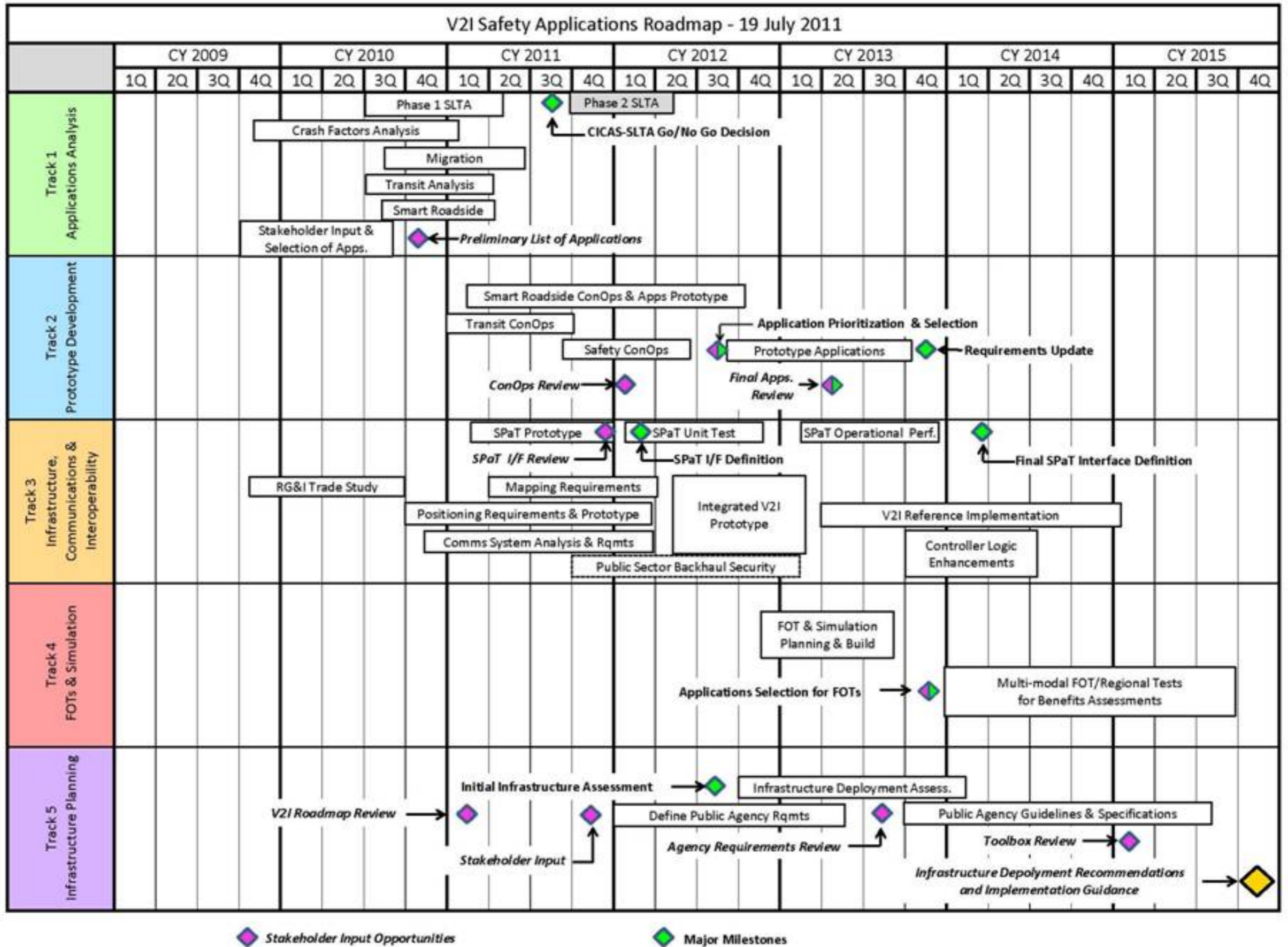
regulate

operate

develop

use

V2I Safety Applications Roadmap - 19 July 2011



NEED

New paradigm to solve road safety and traffic congestion problems.

SOLUTION

Wireless Communication between vehicle and others under v2x standard.

DIFFERENT

Wireless communication in vehicle environment is different from Wi-Fi and mobile phone environment.

BENEFIT

Reduce accident and increase transport performance in a smart and effective way.

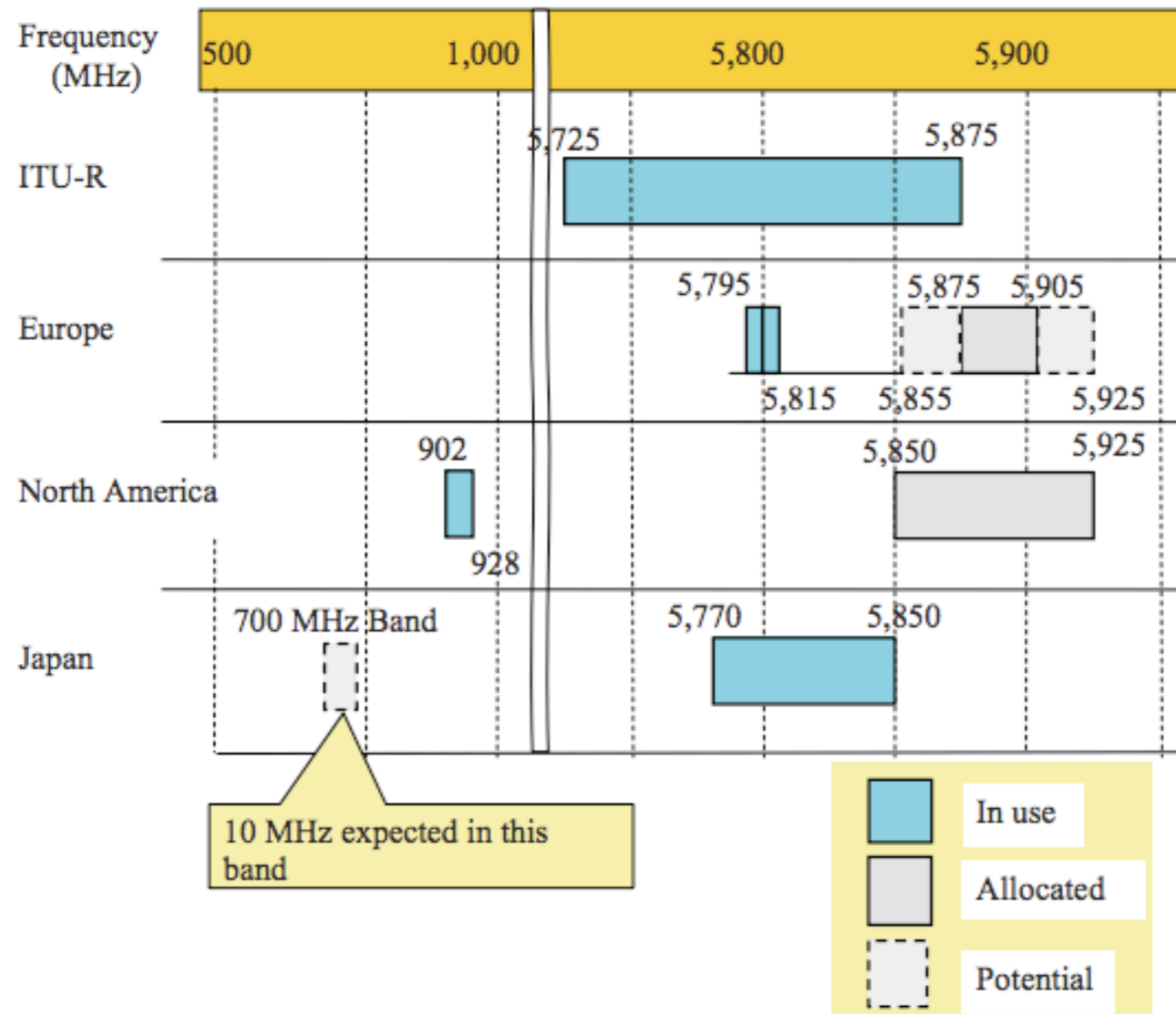
ประเทศไทยกับ V2X



- * ทั่วโลกมุ่ง V2X ไปที่ Road Safety ซึ่งโจทย์แต่ละประเทศต่างกัน จำเป็นต้องมีการศึกษาวิจัยเฉพาะพื้นที่
- * V2X คาบเกี่ยว ก.อุตสาหกรรม ก.คมนาคม ก.ICT ก.วิทย์ฯ รวมทั้ง กสทช.และภาคเอกชน เป็น Value Chain ขนาดใหญ่ ต้องมีหน่วยงานกลางประสาน ขับเคลื่อน
- * V2X กับมาตรฐานในประเทศไทยควรจะเป็น IEEE 802.11p และความถี่ 5.9 GHz
- * V2X เป็นโอกาสสร้างนวัตกรรม ITS ตอบโจทย์ประเทศ และก้าวสู่ผู้นำในตลาด ASEAN

Back up Slides

Radio Spectrum



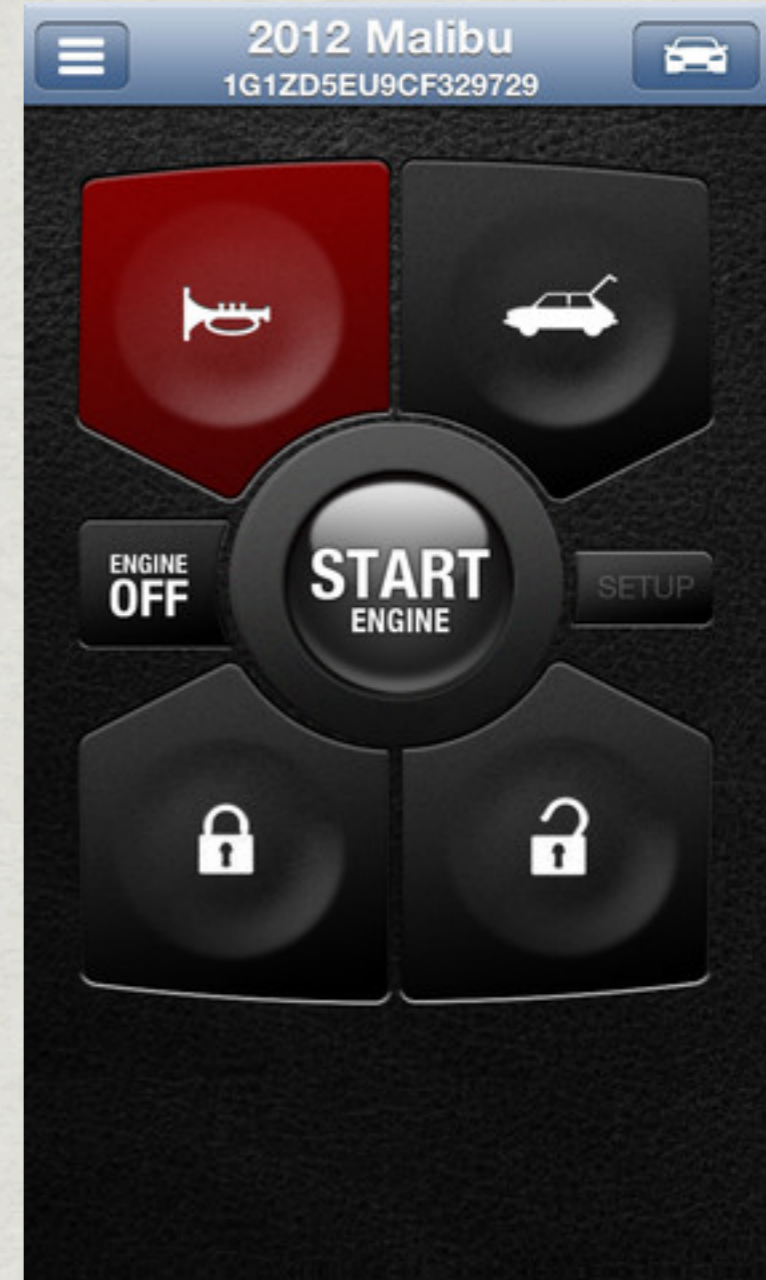
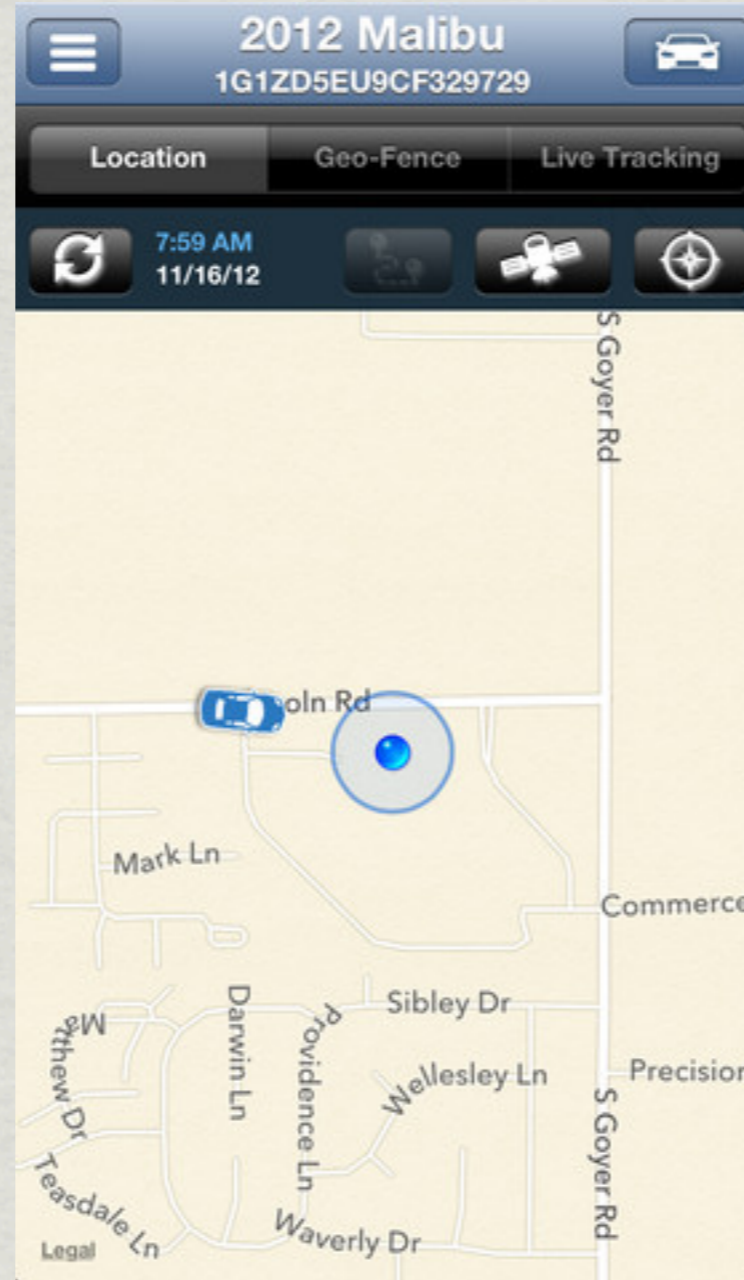
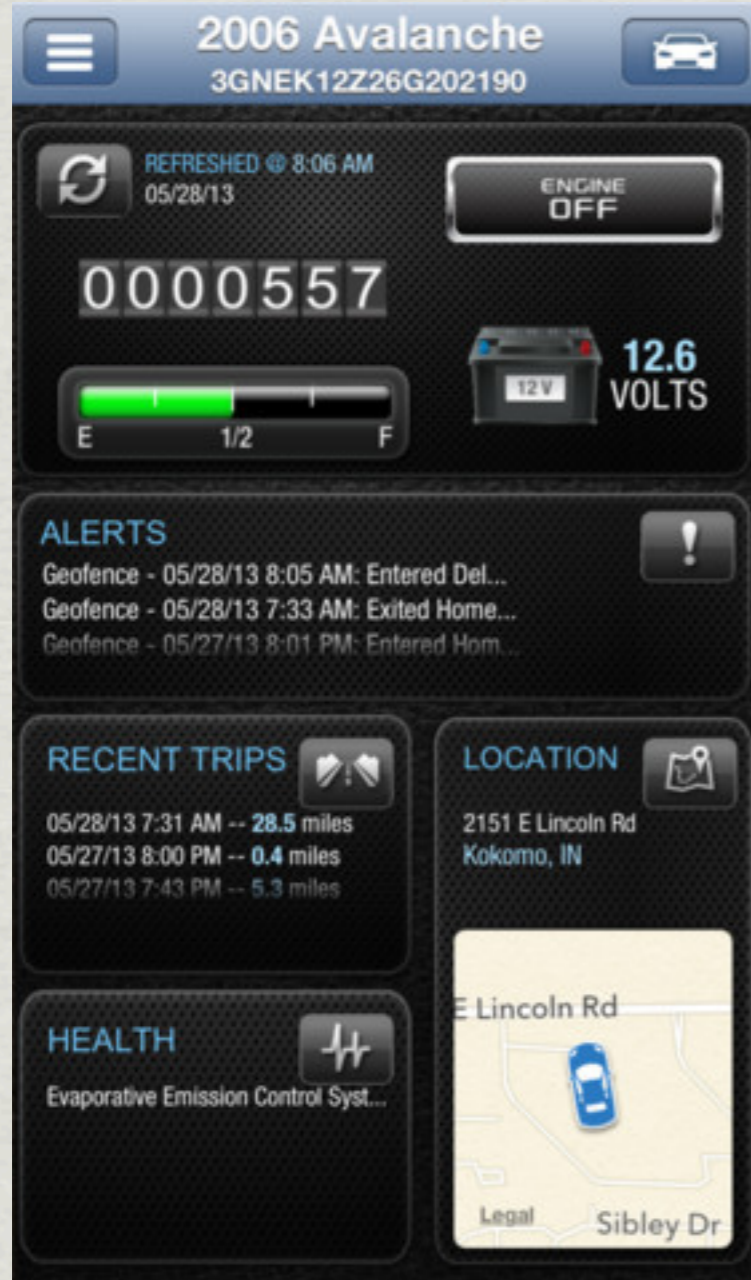
Radio Spectrum

- * 5.85-5.925 GHz
 - * FIXED
 - * FIXED SATELLITE (Earth-to-space)
 - * MOBILE
 - * Radiolocation
- * 5.725-5.875 (center freq 5.800 MHz) is ISM.
- * Thailand: 5.725-5.875 GHz 10mW e.i.r.p Radar (license exempted)

5 Trends for Road Safety.

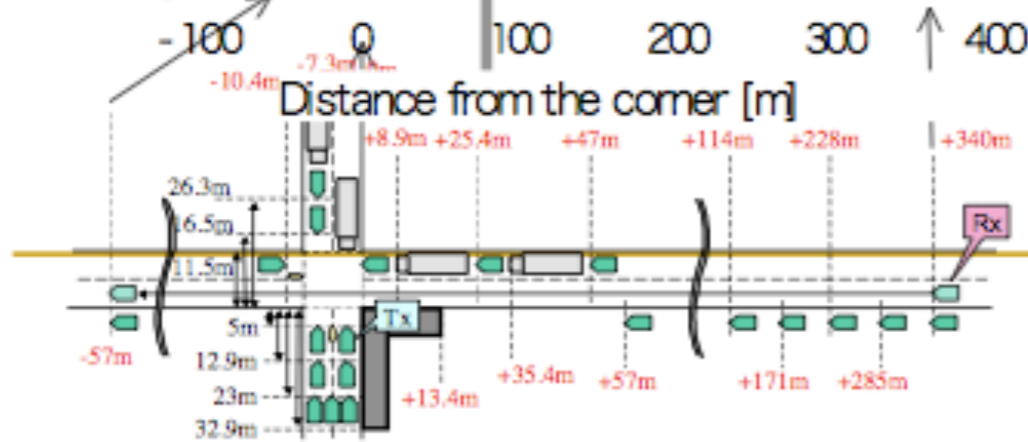
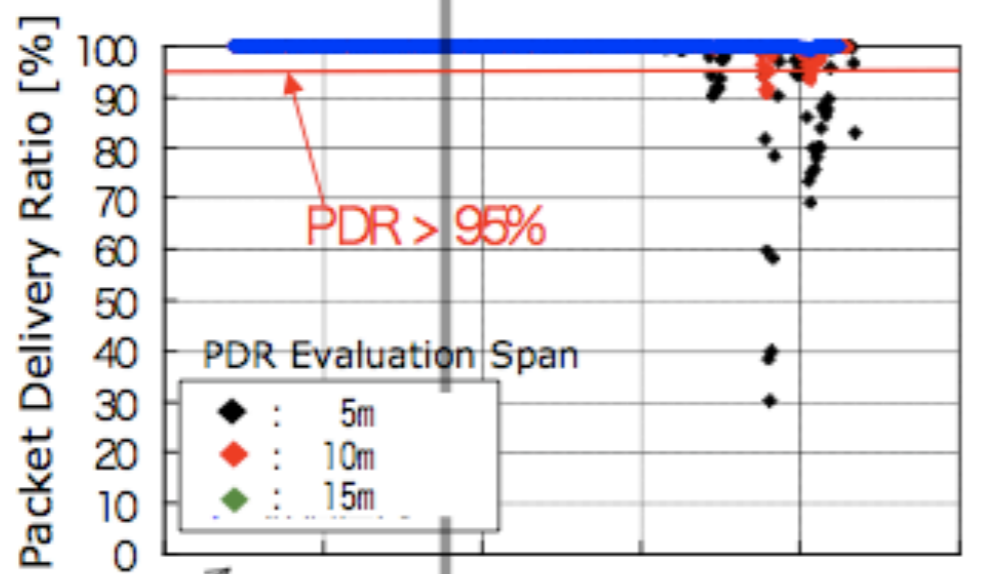
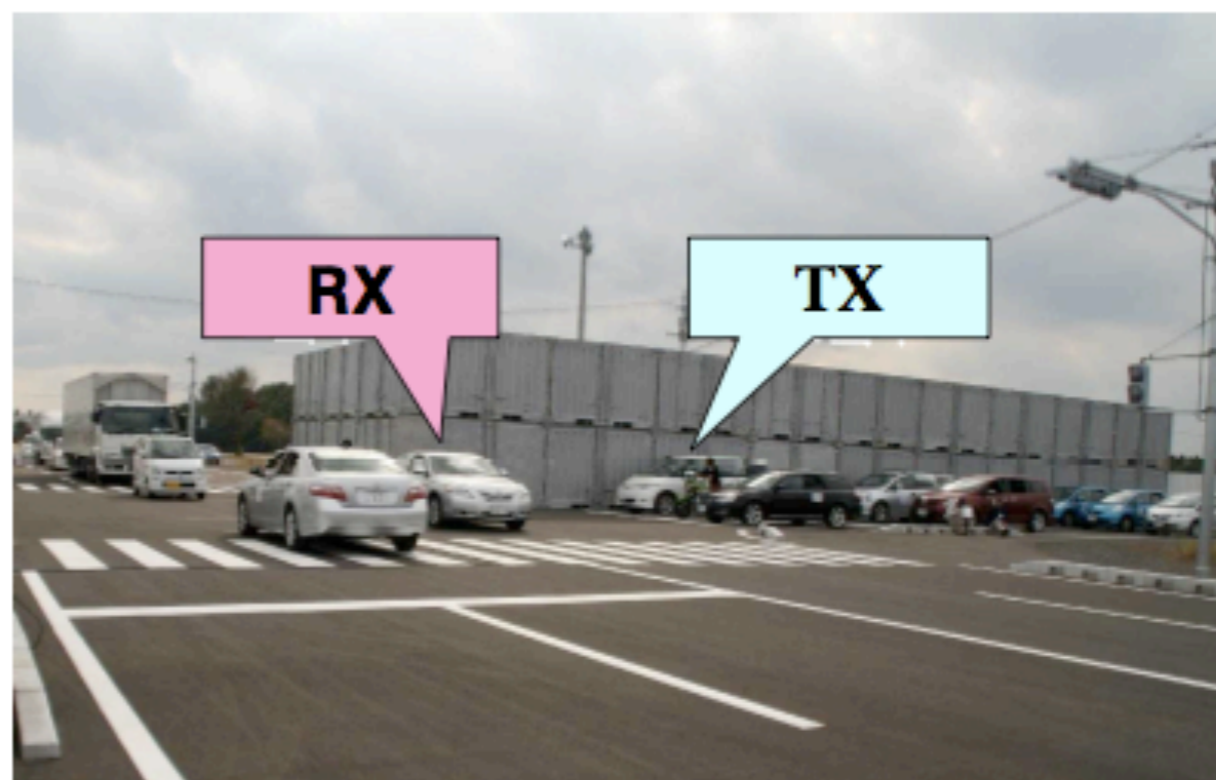
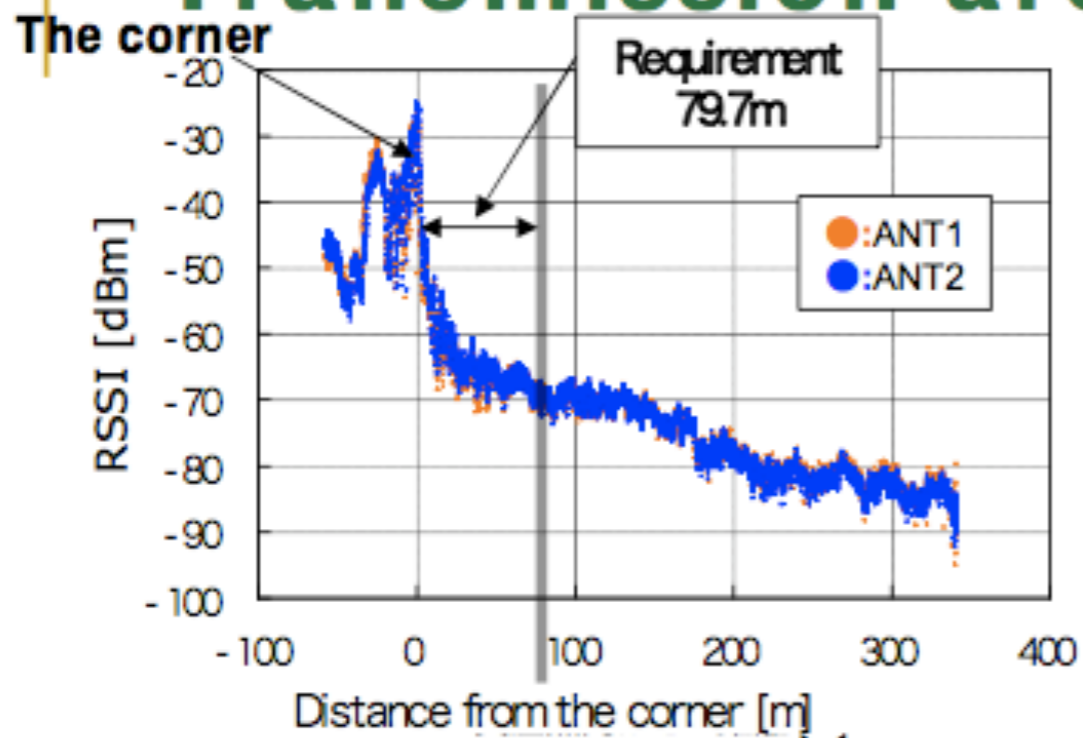
1. Less Distracted Driving
2. Gamification and Augmented Reality
3. Autonomous Emergency Braking systems (AEBs)
4. Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communication systems
5. Remove the Human Driver – Autonomous Vehicles

Mobile app



Delphi Connected Car
โดย Delphi Automotive Systems, LLC

Transmission around the blind corner

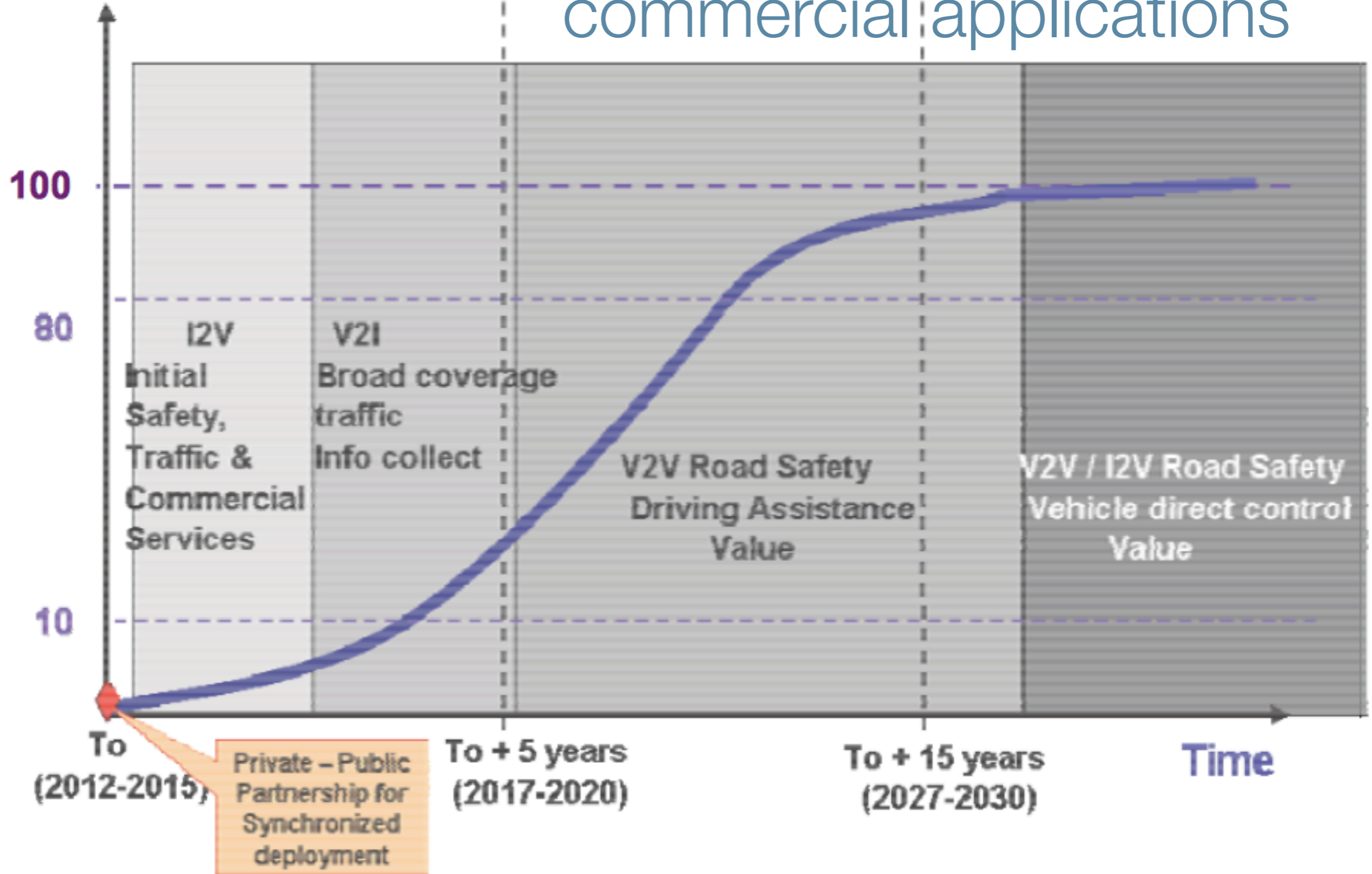


Verified to meet the requirement:

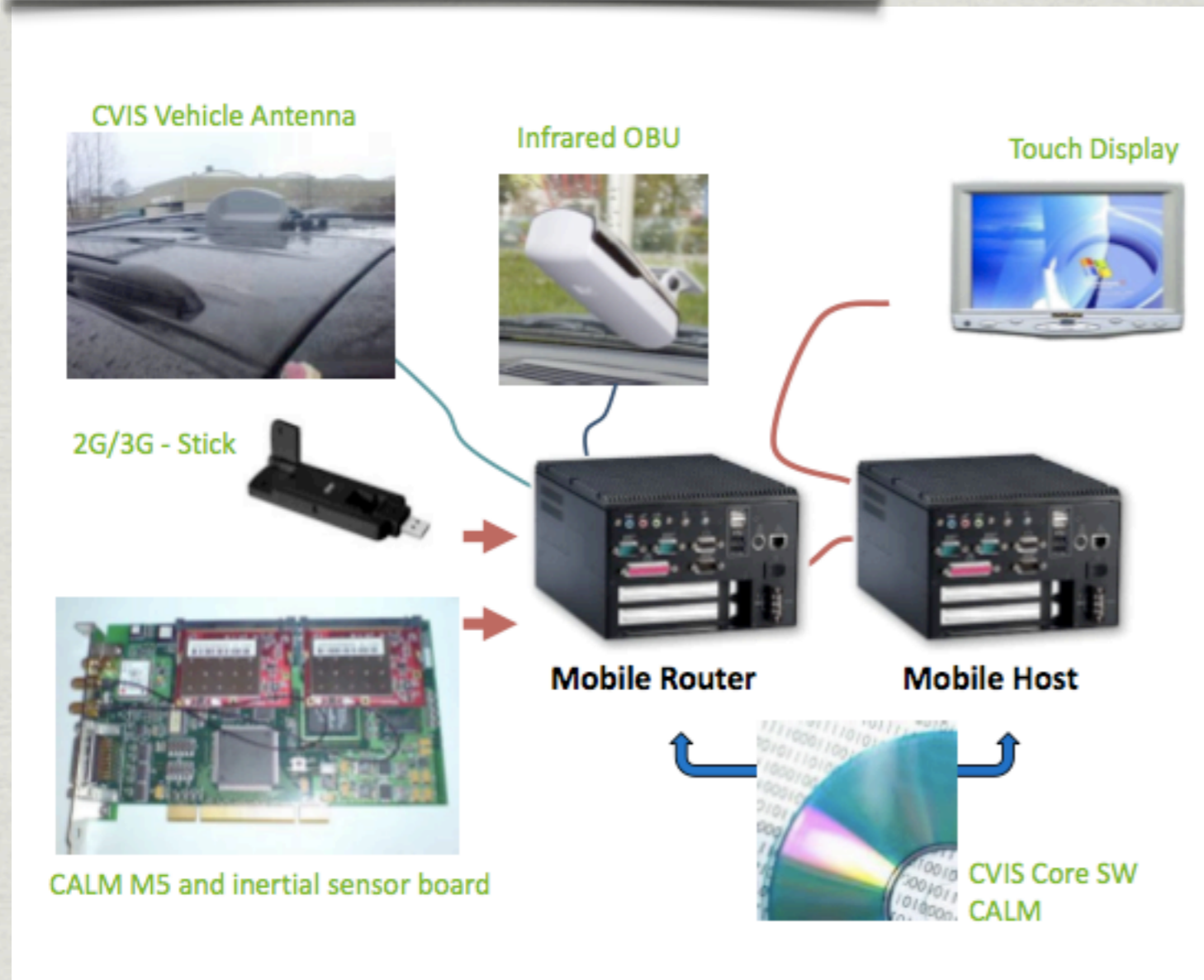
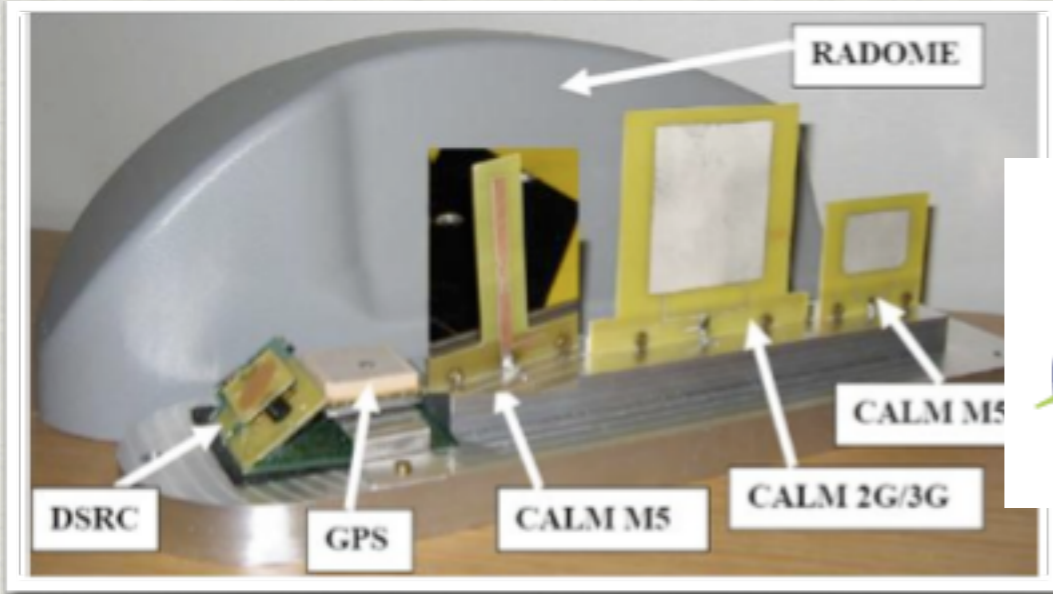
PDR > 95% at 79.7m from the center of the corner

Time to value for societal and commercial applications

% of In Service vehicles



ปิดโครงการ มกราคม 2010



Comparison

Technology	IEEE 802.11n	IEEE 802.11p	3G/HSPA	LTE
Capacity	50-100Mbps (MIMO)	3 to 5 Mbps	14Mbps	100Mbps in 20MHz channel (MIMO)
Speed	High speed capacity	High speed capacity (doppler spread sensitive)	High speed capacity	High speed capacity
Coverage distance	A few km in open field	500m	A few km in open field	A few km in open field
Type of communications	V2I	V2V	V2I	V2I
QoS	EDCA parameters (802.11 e)	EDCA parameters (802.11 e)	RAB and radio resource allocation	SAE Bearer: GBR, MBR...delay, PER
security	WPA2	PKI with cryptography	USIM card, authentication, cryptography	USIM card Authentication AKA encryption
E2E delay	<250ms	<100ms	<a few hundred of ms depending on the cell load	100ms

WAVE vs others

	DSRC/WAVE	Wi-Fi	Cellular	Mobile WiMAX5
Data rate	3-27Mbps	6-54Mbps	< 2 Mbps	1-32 Mbps
Latency	< 50ms	Seconds	Seconds	?
Range	< 1km	< 100m	< 10km	< 15km
Mobility	> 60 mph	< 5mph	> 60 mph	> 60 mph
Nominal Bandwidth	10MHz	20MHz	< 3MHz	< 10MHz
Operating Band	5.86-5.92GHz (ITS-RS)	2.4GHz, 5.2GHz (ISM)	800MHz, 1.9GHz	2.5 GHz
IEEE std.	802.11p (WAVE)	802.11a	N/A	802.16e

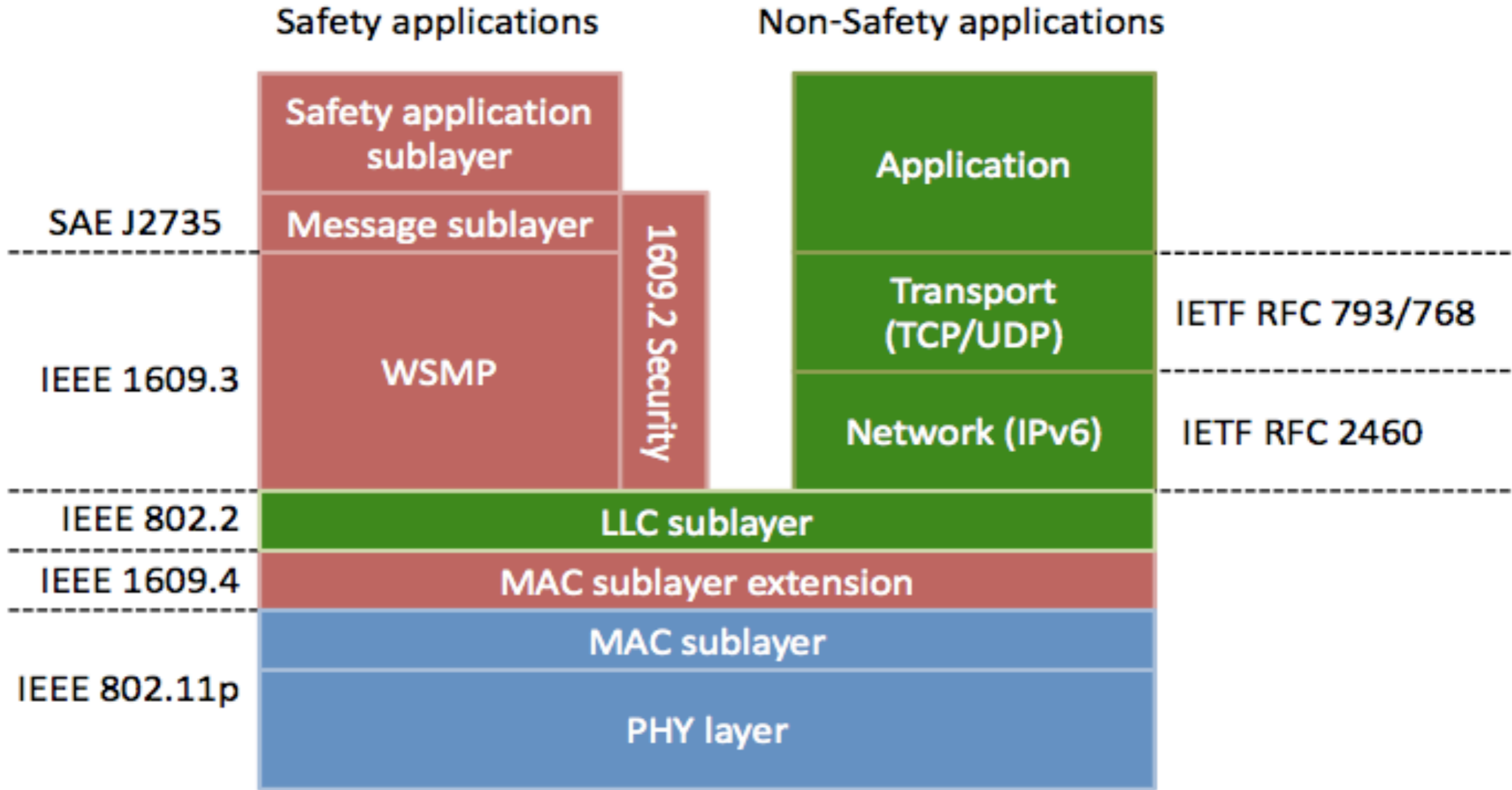
IEEE 802.11p unlike 802.11a

- * 5.9 GHz (US), e.i.r.p up to 44.8 dBm (30W).
- * 75 MHz is divided into seven 10 MHz (reduce Doppler spread effect).
- * Control channel (safety message) and Service channel (lower priority).
- * Use double guard bands to reduce Inter Symbol Interference caused by multi-path propagation.

Why WAVE?

- * Highly dynamic topology
- * Frequently disconnect network
- * Highly delay constraint
- * Road environment (tall building)
- * Provide mobile-mobile as well as mobile-roadside communication

IEEE and SAE standards (USA)



WAVE

- * Two types of devices: Road Side Unit (RSU) and On-Board Unit (OBU).
- * OFDM, multiple of 3 up to 27 Mbps in 10 MHz channel.
- * MAC layer (IEEE P1609.4) is multi-channel operation standard.
- * CCH (Control CHannel for safety) and SCH (Service CHannel).
- * Support IPv6 and WAVE Short Message Protocol (WSMP).

Control Channel (CCH)

- * Broadcast communication
- * Dedicated to short, high-priority, data and management frames
- * Safety-critical communication with low latencies
- * Initialization of two-way communication on SCH

Service Channel (SCH)

- * Two-way communication between RSU and OBU or between OBUs
- * For specific applications, e.g. tolling, internet access
- * Different kinds of applications can be executed in parallel on different service channels

WAVE safety and non-safety

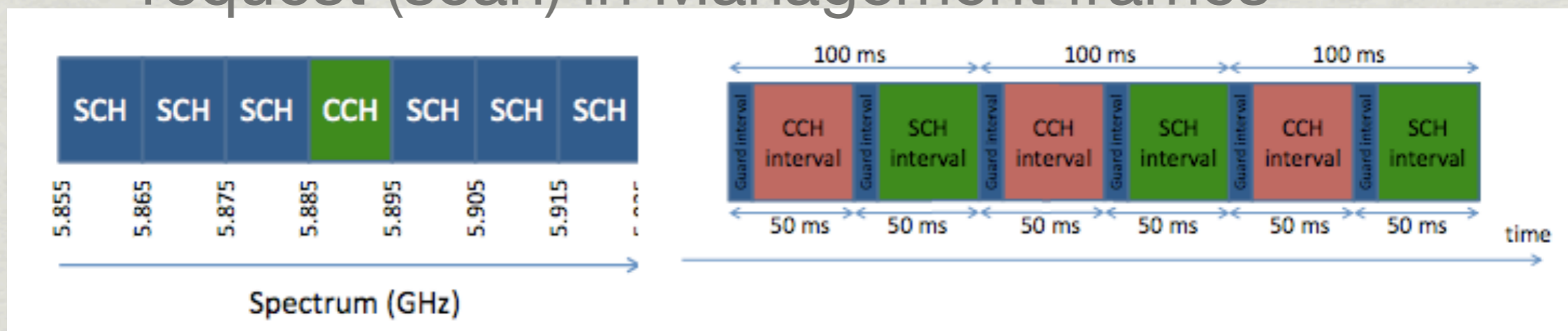
- * WAVE Short Message Protocol (WSMP)
 - * Used on both Control and Service Channels
 - * No setup required
 - * Limited to 1400 bytes
 - * Limited to WAVE-aware devices
- * IPv6
 - * Used on Service Channels only
 - * Allows access to generic applications and networks

WAVE PHY layer

- * IEEE 802.11p
 - * PHY: IEEE 802.11a: OFDM (3 to 27 Mbps) at 5.9 GHz
 - * MAC: IEEE 802.11e (CSMA/CA) for QoS, No access point functionality
 - * Introduces a random local MAC address
 - * Allows communications either with or without a WAVE Basic Service Set (WBSS)

WAVE MAC layer

- * IEEE 1609.4
 - * Multichannel operation: CCHs
 - * Provides frequency band coordination and management within the MAC layer
 - * Time-division channel coordination
 - * No more association, authentication, probe request (scan) in Management frames



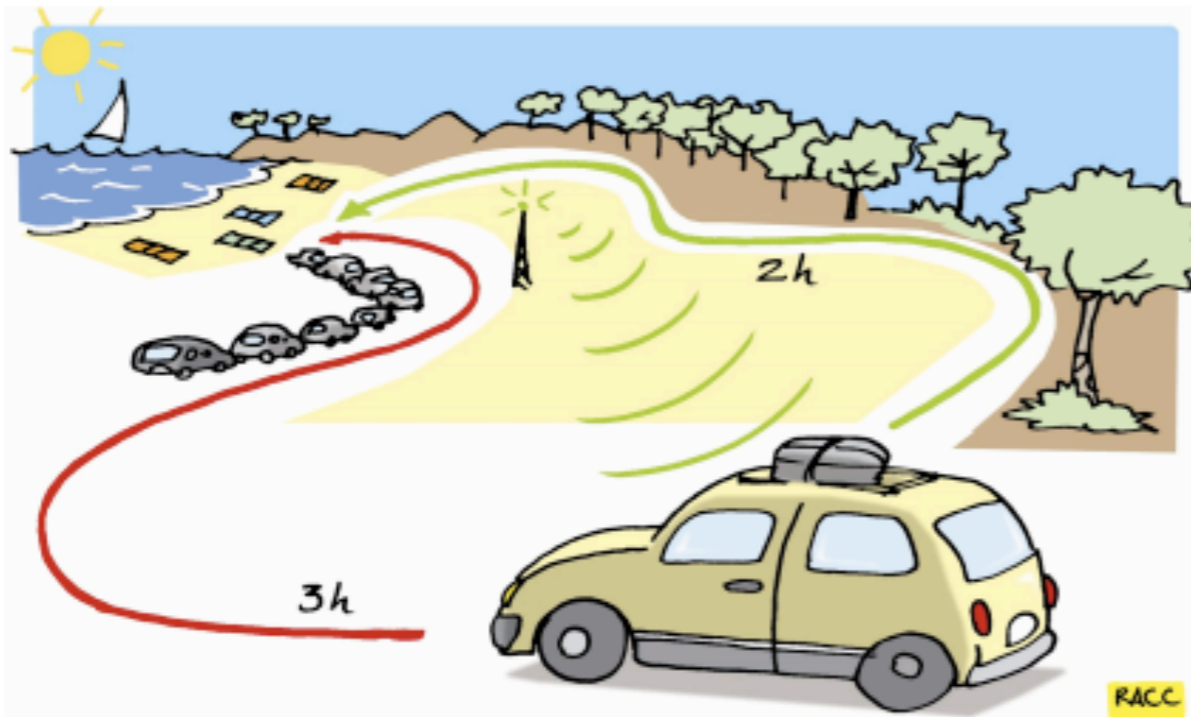
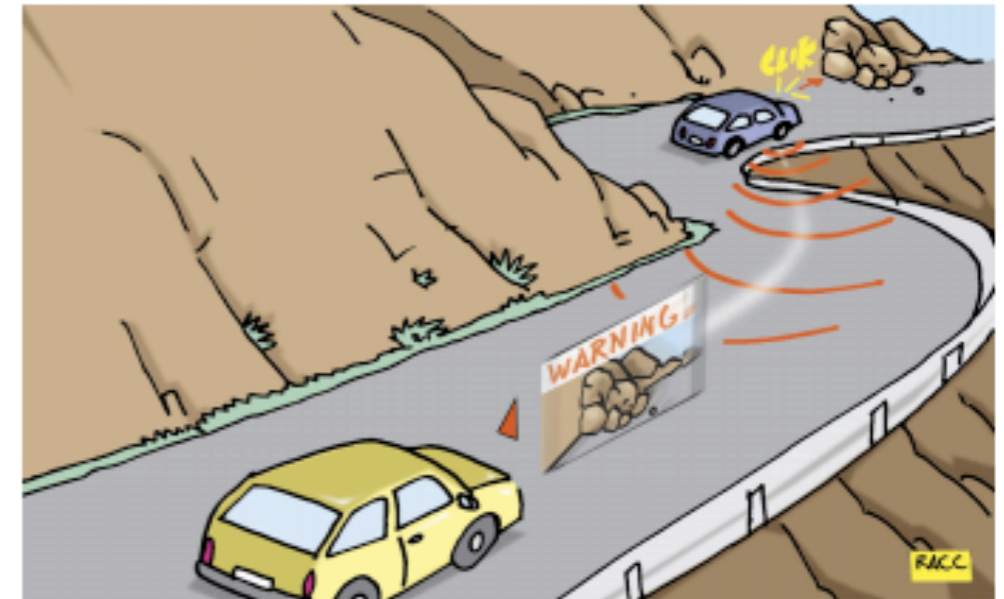
WSMP

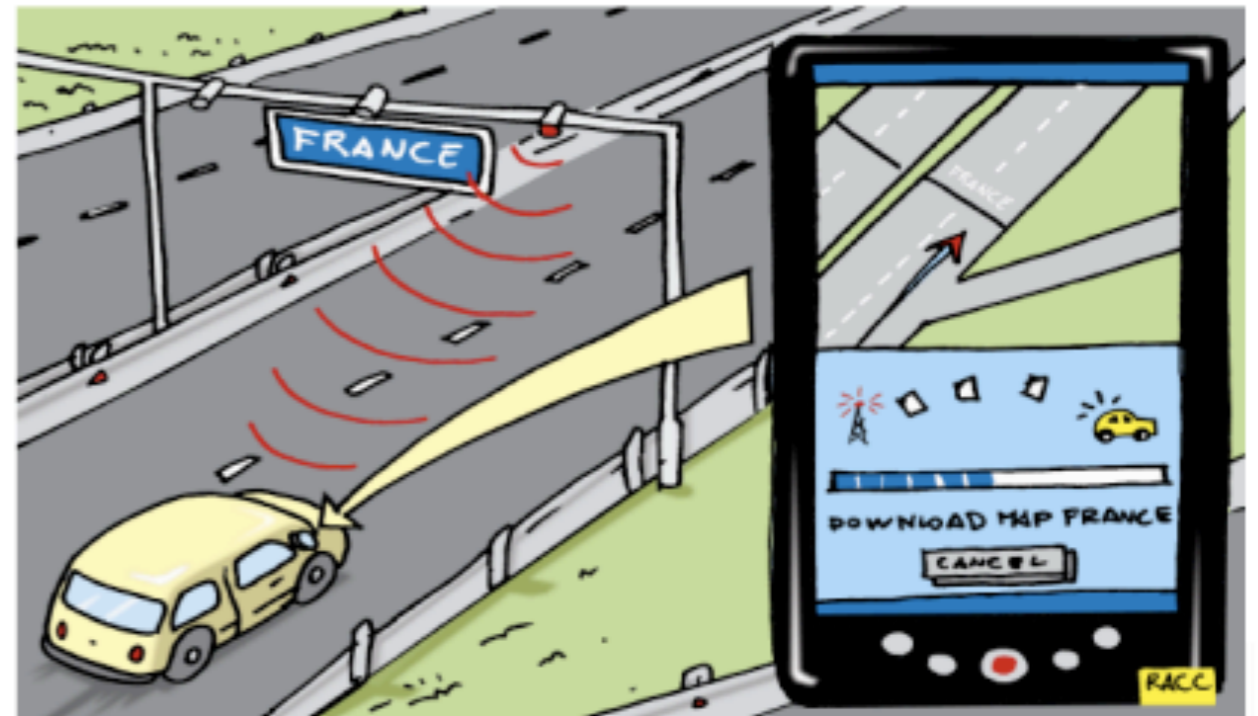
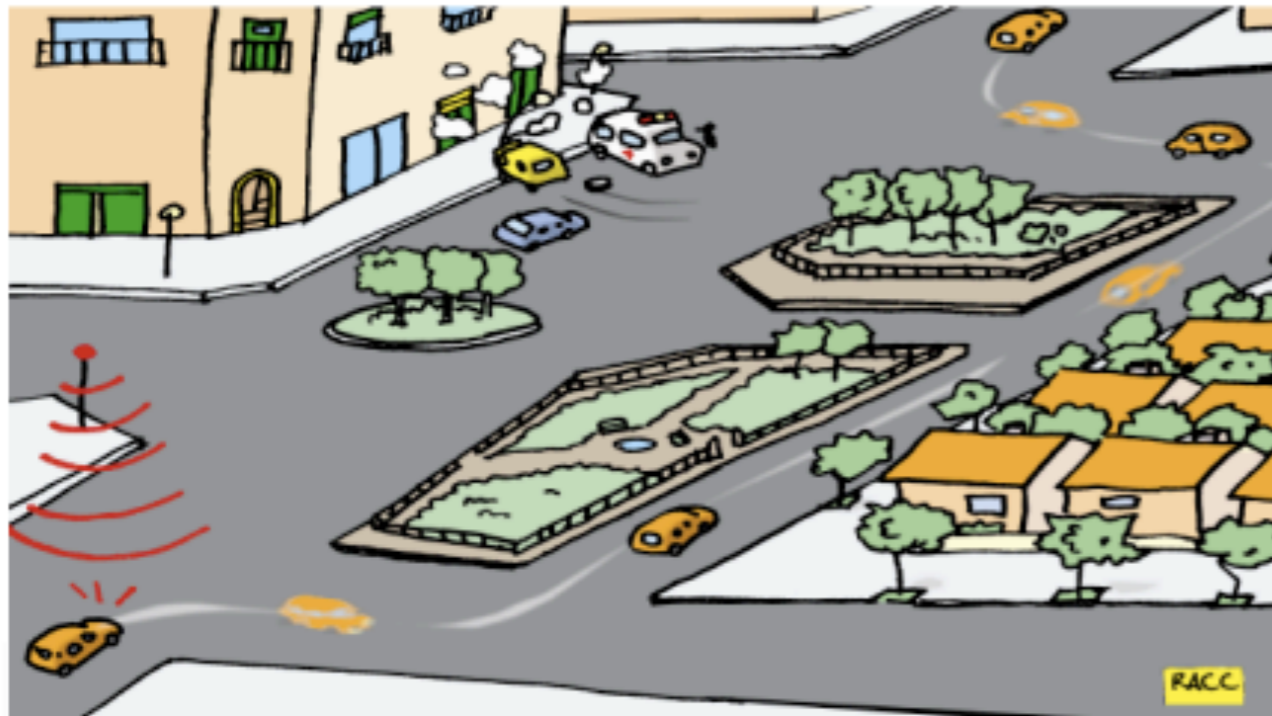
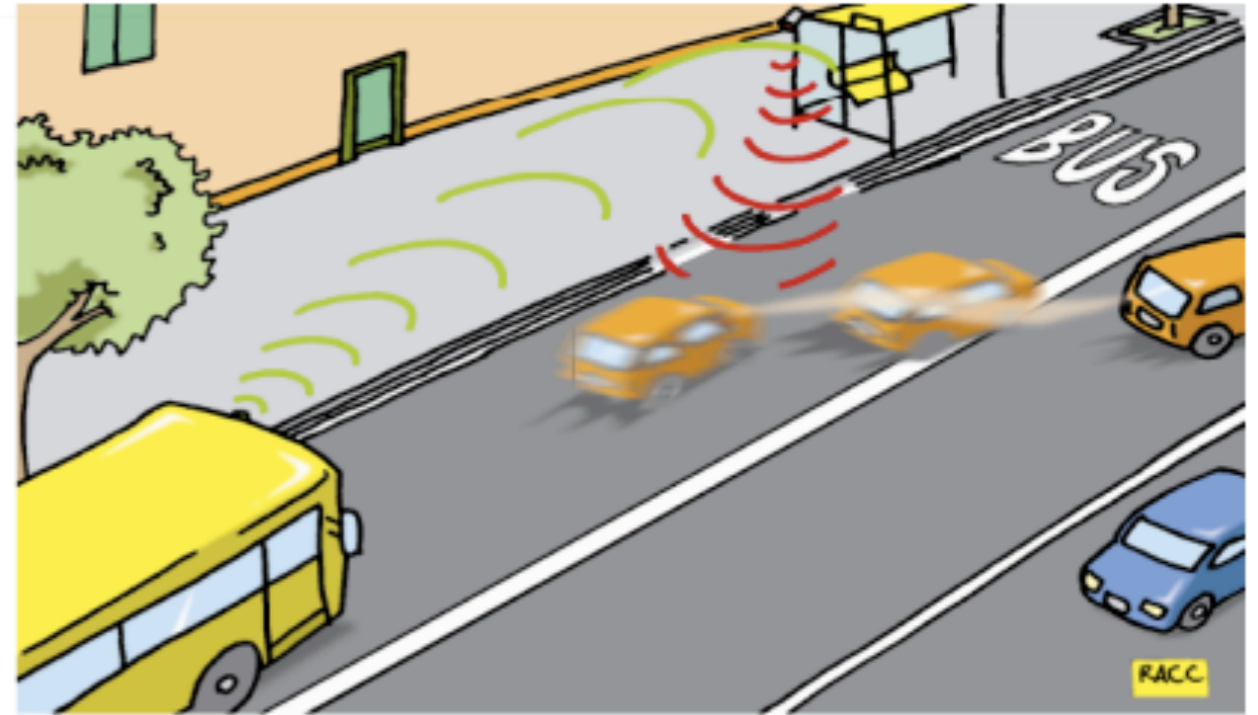
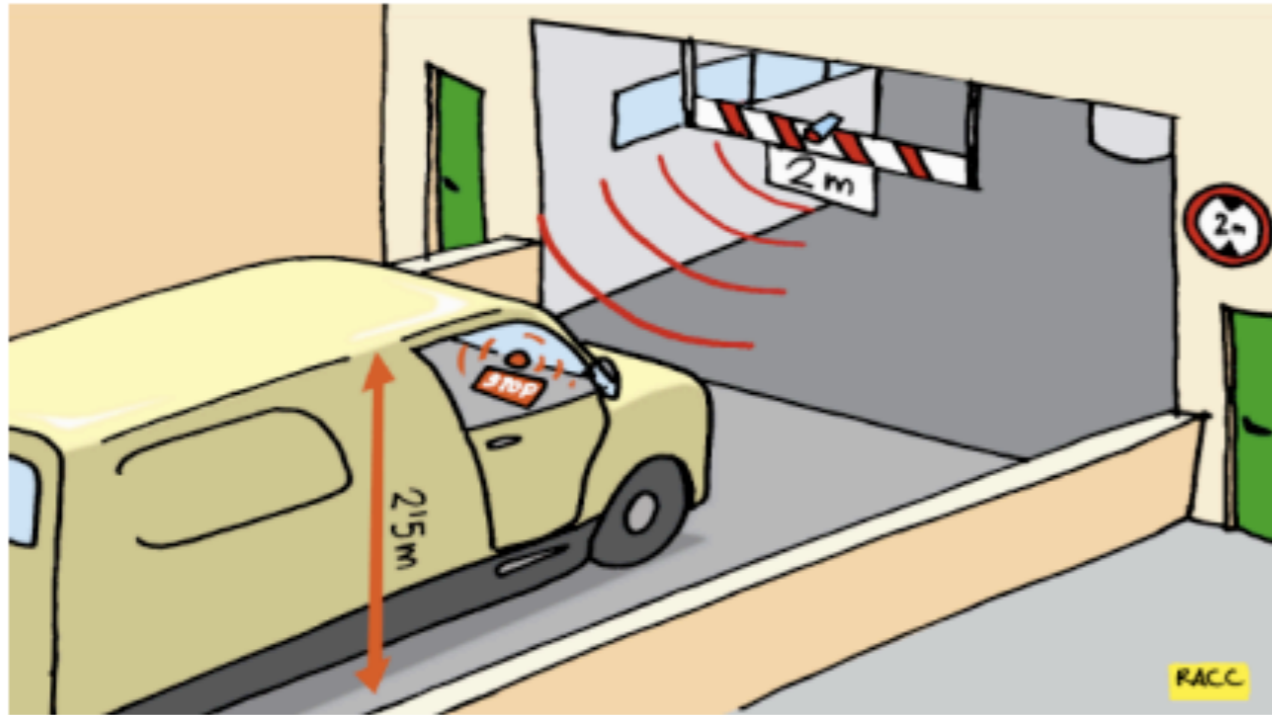
- * IEEE 1609.3 WSMP (WAVE short message protocol) for safety application
- * Reduced overhead: WSMP has 11 bytes of overhead
- * Allows applications directly control lower-layer parameters

WSM Version (1 Octet)	Security Type (1 Octet)	Channel Number (1 Octet)	Data Rate (1 Octet)	TX Power (1 Octet)	PSID (4 Octets)	Length (2 Octets)	WSM Data (Variable)
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ITS Applications

- Road safety applications
- Traffic efficiency applications
- Infotainment applications





ITS standards developing organizations (SDO)

- Regularity constraints (e.g., radio frequency) are different depending on the country/region.
- Standardization activities
 - USA: **IEEE**, **SAE** (Society of Automotive Engineers)
 - Japan: ITS Info-Communications Forum, **ARIB** (Association for radio industry and business), ISO
 - Europe: CEN (European committee for standardization), **ETSI** (European telecommunications standards Institute), ISO

