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# V2X Technology and Mobility Application Development of ITRI, Taiwan

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Division for Telematics and Vehicular Control System  
Information and Communication Lab., ITRI

Sept. 26, 2013



# Agenda

- ITRI Overview
- ITRI V2X Development
  - WAVE/DSRC Unit R&D
  - WAVE/DSRC V&V and Trial Technology R&D
  - V2R Mobility Applications
  - V2X Mobility Applications
- Concluding Remarks



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# ITRI OVERVIEW



# ITRI at A Glance



Total Staffs: 5,813

Ph.D. : 1,379 (24%)

Master : 3,147 (54%)

Alumni : 21,937+

Total Patents

**18,546**

Start-ups

Spin-off : 71

Incubated : 154

**UMC**

1983



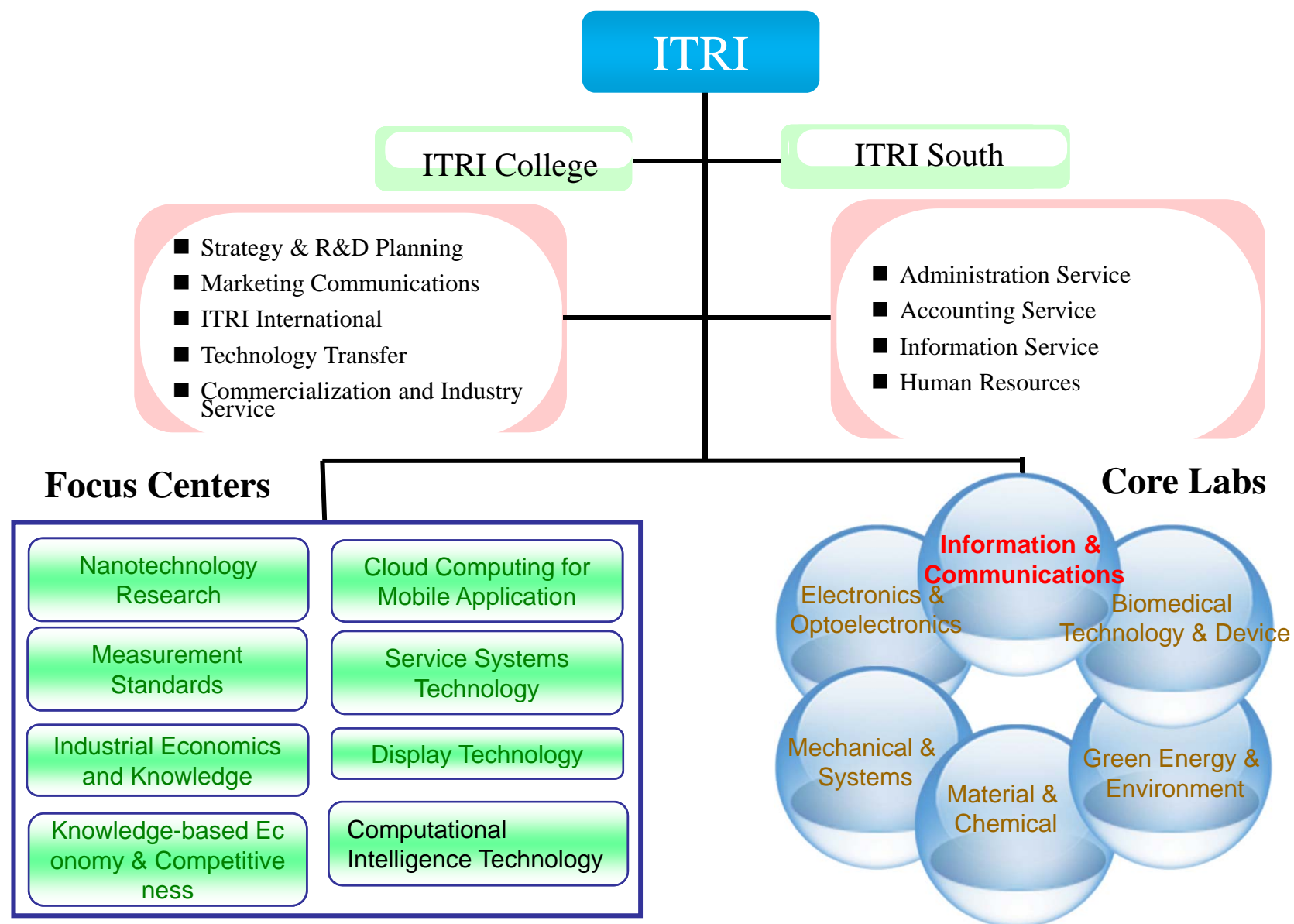
1987



1994

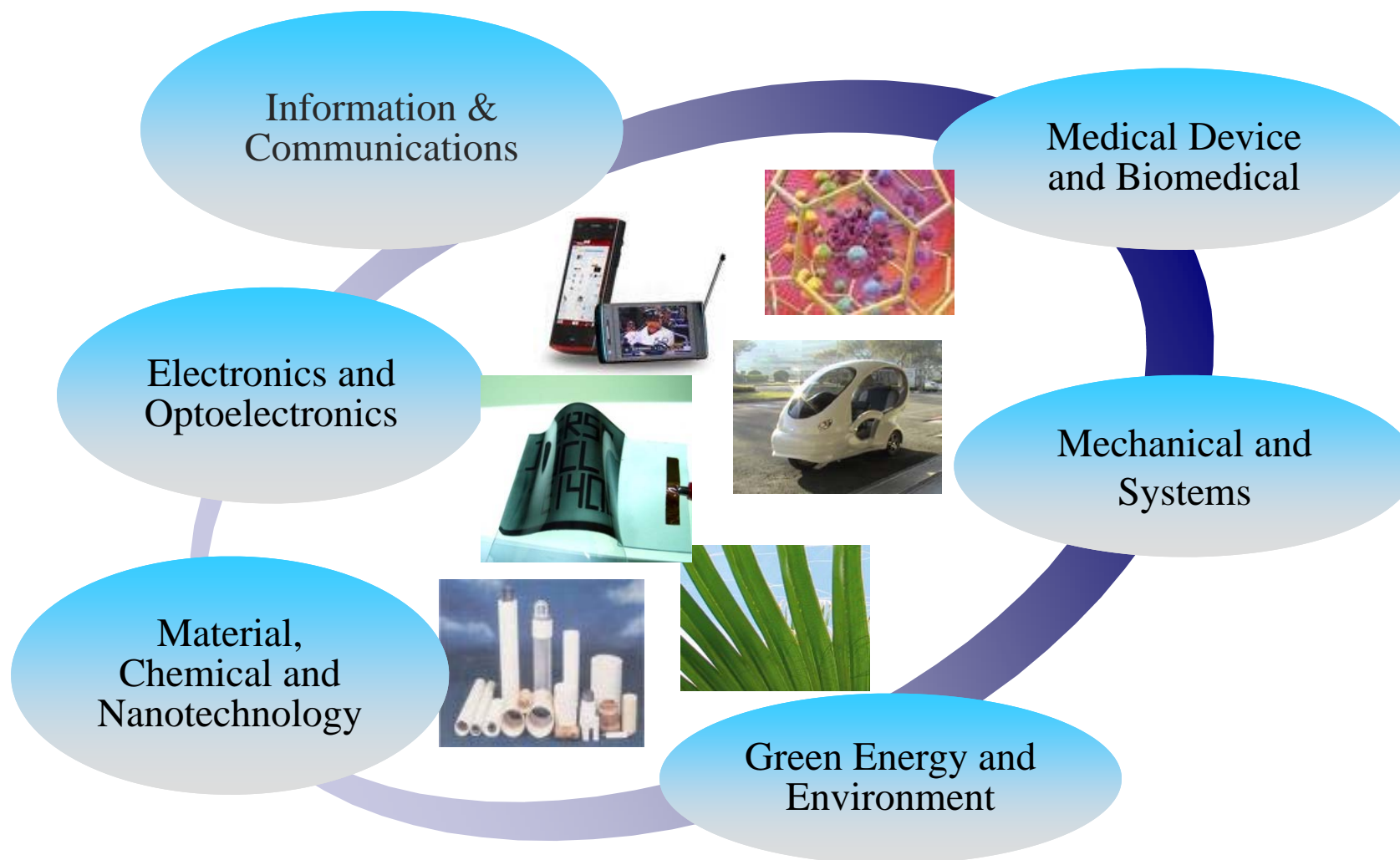


# ITRI Organization





# R&D Focus Areas

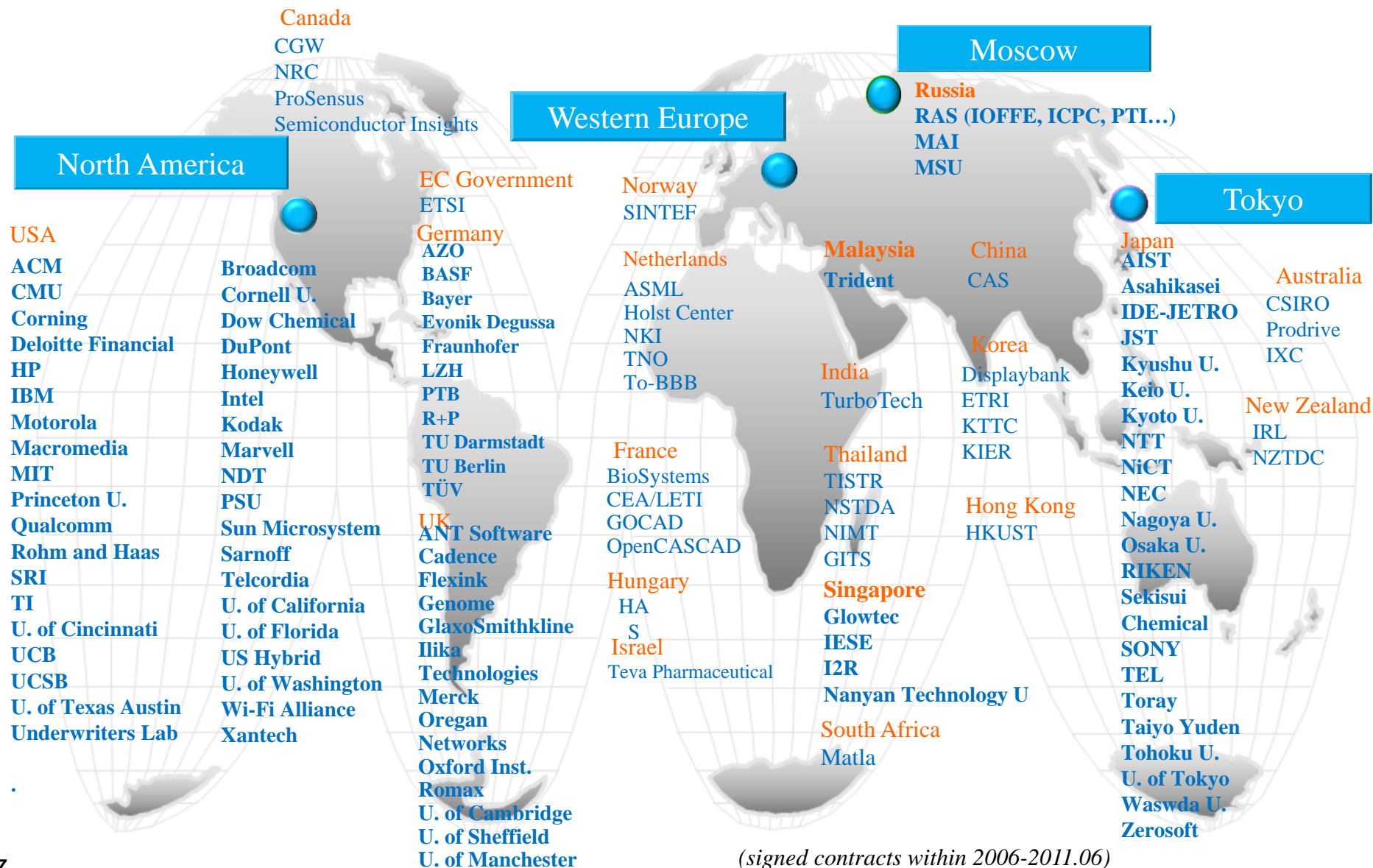


Advanced Technology Research • Industrial Services • IP Business and New Venture





# ITRI Worldwide Offices & Global Partners



(signed contracts within 2006-2011.06)



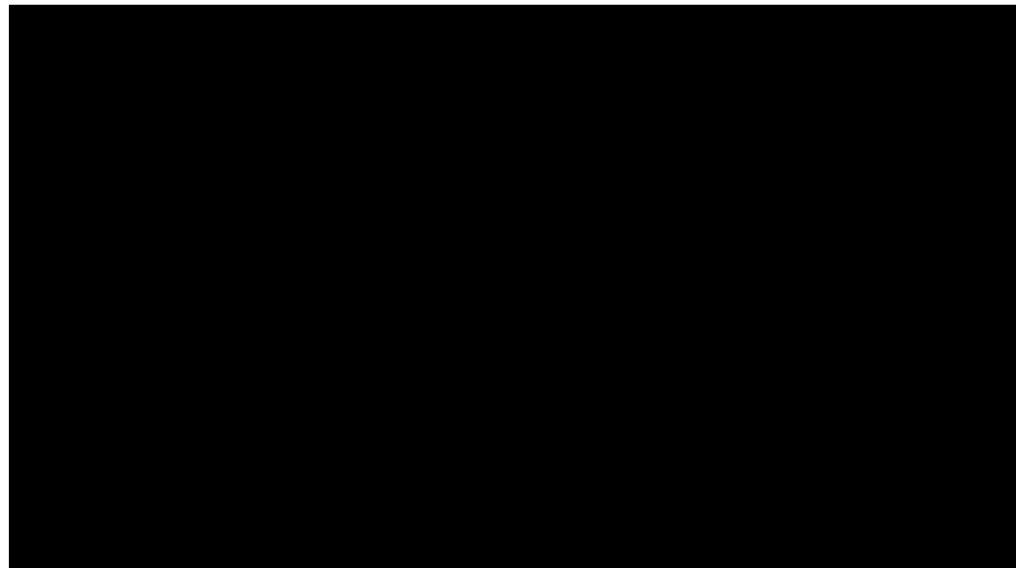
# ITRI V2X DEVELOPMENT V2V GROUP COMMUNICATION





## ITRI V2X Development Demo Video (1/2)

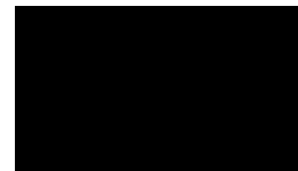
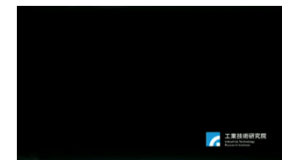
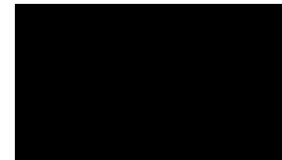
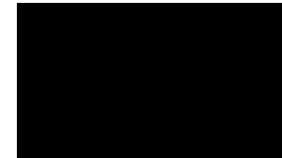
- Geo-networking Application
- Scenario-aware HMI Development
- Cooperative Road Condition Recognition and Warning
- Radar-assisted V2V Emergency Brake Warning





## ITRI V2X Development Demo Video (2/2)

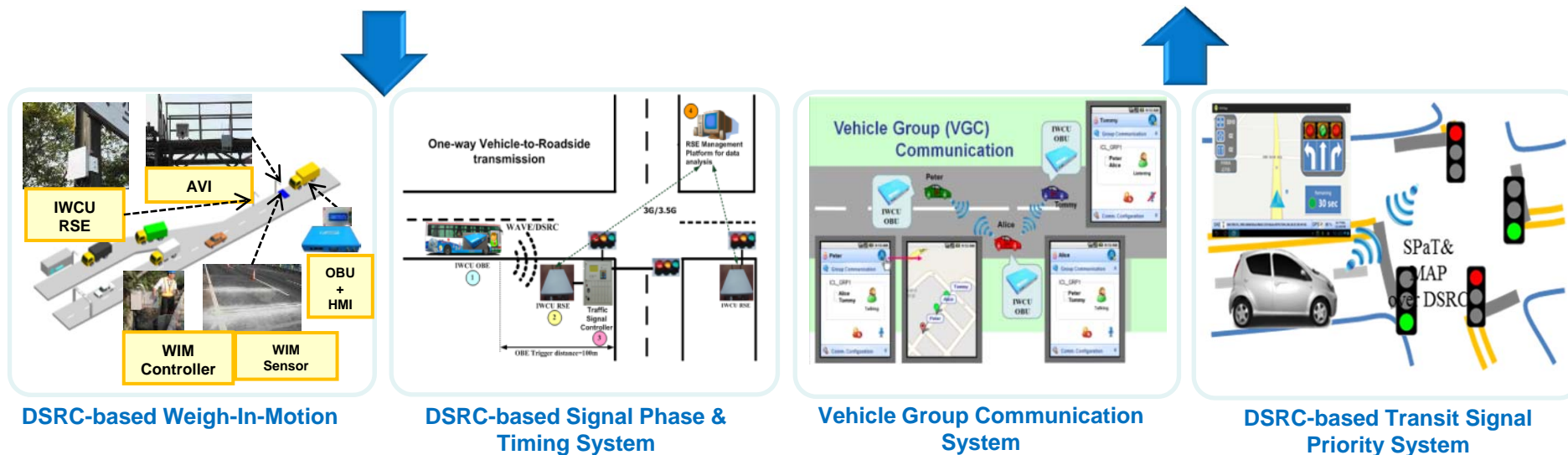
- Center for Telematics Technology (CTT)
- WAVE/DSRC Weigh-In-Motion (WIM) for Trucks
- WAVE/DSRC Transit Signal Priority (TSP)
- Mobile Radar Precision Measurement System





## WAVE/DSRC Communication Unit

## CTT\_WAVE/DSRC Validation & Verification





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# WAVE/DSRC UNIT R&D

# ITRI WAVE/DSRC Communication Unit (IWCU)

**Taiwan's First WAVE/DSRC Unit:** With ITRI's connected vehicle research power, IWCU is an integrated wireless communication system designed for deploying Intelligent Transportation Systems (ITS) Vehicle-to-Vehicle (V2V), Vehicle-to-Roadside (V2R) and Vehicle-to-Infrastructure (V2I), or called V2X applications and improving driving safety and convenience on the roadways

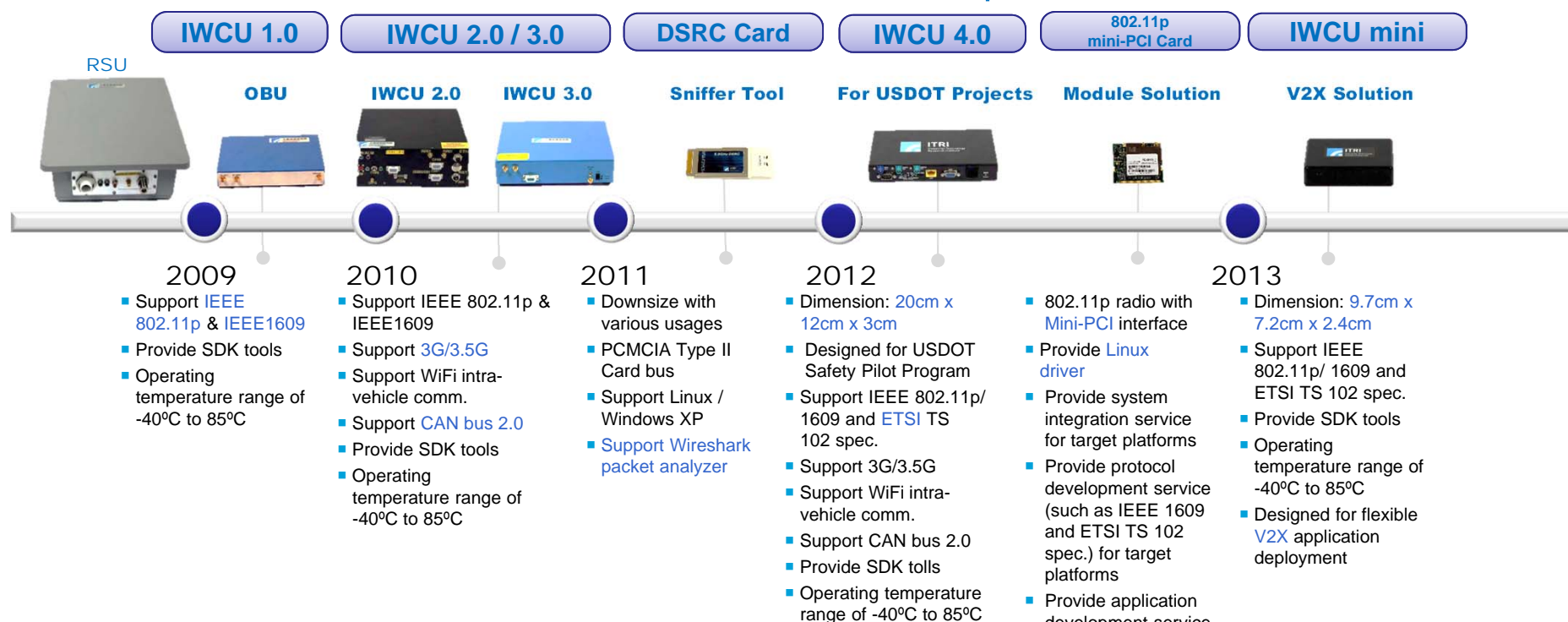
\* WAVE/DSRC: Vehicular Environments / Dedicated Short Range Communications

## Standards Compliance

- IEEE 802.11p/1609 WAVE/DSRC Standards
- SAE J2735 Message Set Dictionary Standards
- ETSI TC-ITS European Standards



## IWCU Roadmap





## ITRI's RSE Entered USDOT Research Qualified Product List (rQPL)

**RITA** U.S. Department of Transportation  
Research and Innovative Technology Administration

**Intelligent Transportation Systems  
Joint Program Office**

**RESEARCH**

- Connected Vehicle Research
- Short Term Intermodal Research
- Cross-Cutting Research
- Exploratory Research
- Research Planning
- ITS Research Success Stories

**Safety Pilot**

**The U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office Selects Firms to Provide Roadside Equipment for the Connected Vehicle Safety Pilot Model Deployment and other Test Bed Installations**

The following firms passed the U.S. DOT's acceptance criteria for placement on the research qualified products list (rQPL)

- Arada Systems
- Cohda Wireless/Cisco Systems
- Kapsch TrafficCom, Inc.
- Savari Networks
- Industrial Technology Research Institute.**

Product testing for the RSEs was conducted from February 20 through March 2, 2012. In addition to other factors such as cost and timing, devices were evaluated based on the following standards.

**IntelliDrive**  
Safer. Smarter. Greener.

Site sponsored by the U.S. Department of Transportation  
Research and Innovative Technology Administration (RITA)

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**NEWS**

**All News**

**ITS-JPO Selects Eight Firms to Develop and Produce V2V and V2I Communications Devices**

Awards have been made to the following contractors:

- AutoTalks Ltd
- Cohda Wireless
- Cohda Wireless/TomTom
- Denso International America, Inc.
- DGE Inc.
- Industrial Technology Research Institute**
- Savari
- Siemens Industry Inc.

**ITRI's OBE is  
Selected by USDOT  
IntelliDrive  
Program**





# WAVE/DSRC V&V AND TRIAL TECHNOLOGY R&D

**Center for Telematics Technology (CTT):** ITRI has built Taiwan's first WAVE/DSRC testing facility that provides integrated indoor verification & validation and outdoor field trial environment for flexibly and dynamically creating test scenarios on roads.

## Features:

- Standard testing procedures
- Integrated testing environment
- Product validation and verification
- Significantly time and costs reducing

## Facilities:

- RF spectrum analyzer
- US ITS conformance testing tool
- ETSI ITS conformance testing tool
- Interoperability testing environment
- Performance evaluation system

## Standard Procedures



## CTT Testing Equipments



Center for Telematics Technology



Conformance Testing Facility



RF Spectrum Analyzer



Interoperability Testing Environment



Performance Evaluation System

# Outdoor Testing Suite of CTT

Outdoor Field Trial: Establish the Taiwan's first WAVE/DSRC testing vehicle, mobile RSE, and OBU operation platform for the outdoor testing environment. The vehicle equips several OBU platform to remote control and deploy services through the RSU management platform. After testing completed, the remote experimental data can be real-time analyzed.

## Achievements:

- Weight in Motion (WIM) @ National Highway No. 3
- Bus Rapid Transit (BRT) @ Jhubei City, Hsinchu County

## Facilities:

- Mobile RSE x8
- RSE management platform
- WAVE/DSRC demo vehicle
- OBU operation platform



WAVE/DSRC Testing Vehicle



Mobile RSE



OBU Operation Platform



RSE Management Platform



Outdoor Field Tests



# V2R MOBILITY APPLICATION

- **WAVE/DSRC-BASED WEIGH-IN-MOTION**
- **WAVE/DSRC-BASED TRANSIT SIGNAL PRIORITY**
- **WAVE/DSRC-BASED SPAT**

# WAVE/DSRC-based Weigh-In-Motion System Solution

## Needs & Goals

- Taiwan Freeway will adopt ETC system to fully replace toll stations in late 2013. All vehicles will not need to stop at toll stations for payment.
- Current Commercial Vehicle (CV) weigh service, however, requires trucks stopped at weigh stations for weighting, wasting time and fuel energy.
- To enhance weighing service for CVs, ITRI uses the WAVE/DSRC technology to integrate Weigh-in-Motion (WIM) sensors, Weigh stations and CVs to provide a new weighing service, allowing CVs to be weighed during movement.



Current Weigh Station



Next-generation  
WAVE/DSRC-based WIM System

## Benefit

Create a new (NT\$) 960-million WIM-DSRC Transponder product market

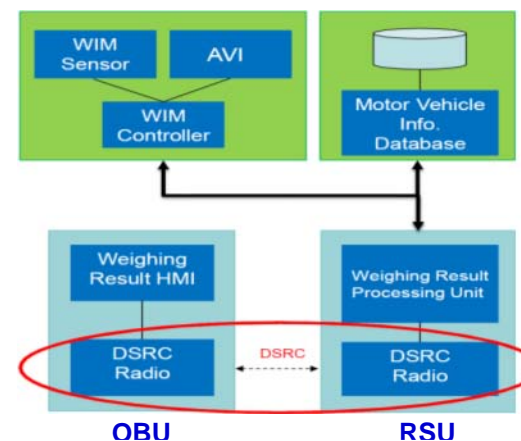
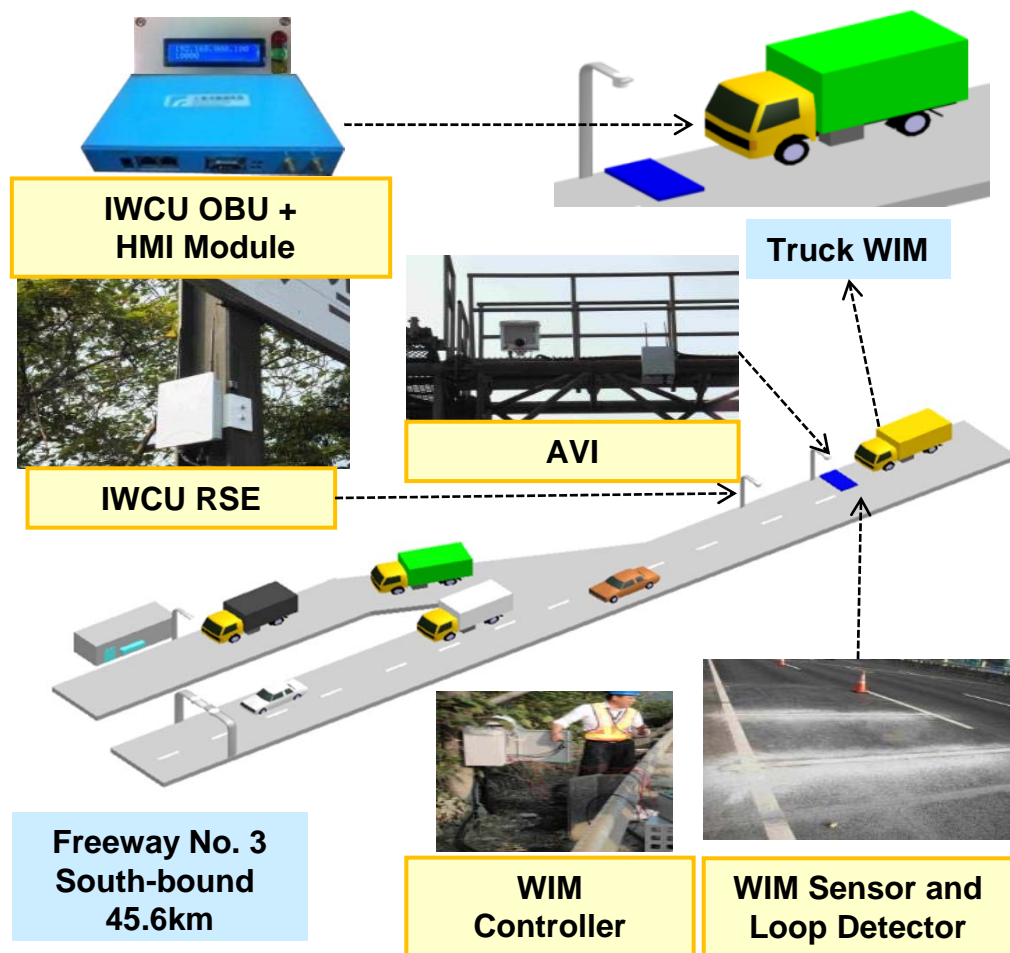
Save travel times of CVs passing through freeways; both time cost and fuel wastage can be reduced

Extend the lifetime of freeway road surface by reducing number of over-weighted CVs



## System Operation on Freeway No.3, Taiwan

- Collaborated with National Freeway Bureau (MOTC, Taiwan) and Taiwan large logistics companies including the HCT Logistics and CPC (the Tao-Yuan Division)
- The second WAVE/DSRC-based WIM system test site in the world



## Features

- Bidirectional HMI without causing driver distraction
- Extensible for future V2I application/service and fleet management
- Simplify the inspection process for the police



# DSRC-based Transit Signal Priority System Solution

## Needs & Goals

- A growing interest in the use of transit signal priority to promote transit ridership and reduce urban congestion In recent years
- ITRI uses the WAVE/DSRC communication technology for Bus Priority Signal Control to improve service and reduce travel times for mass transit vehicles at intersections controlled by traffic signals.
- Design real-time control logics dedicated to bus priority that constitute green signal extensions and early green recalls.
- Compatible with current traffic control systems that have been deployed



ITRI RSU Deployment in  
Chupei, Hsinchu, Taiwan



ITRI OBU Deployment  
on the Transit Bus

## Benefit

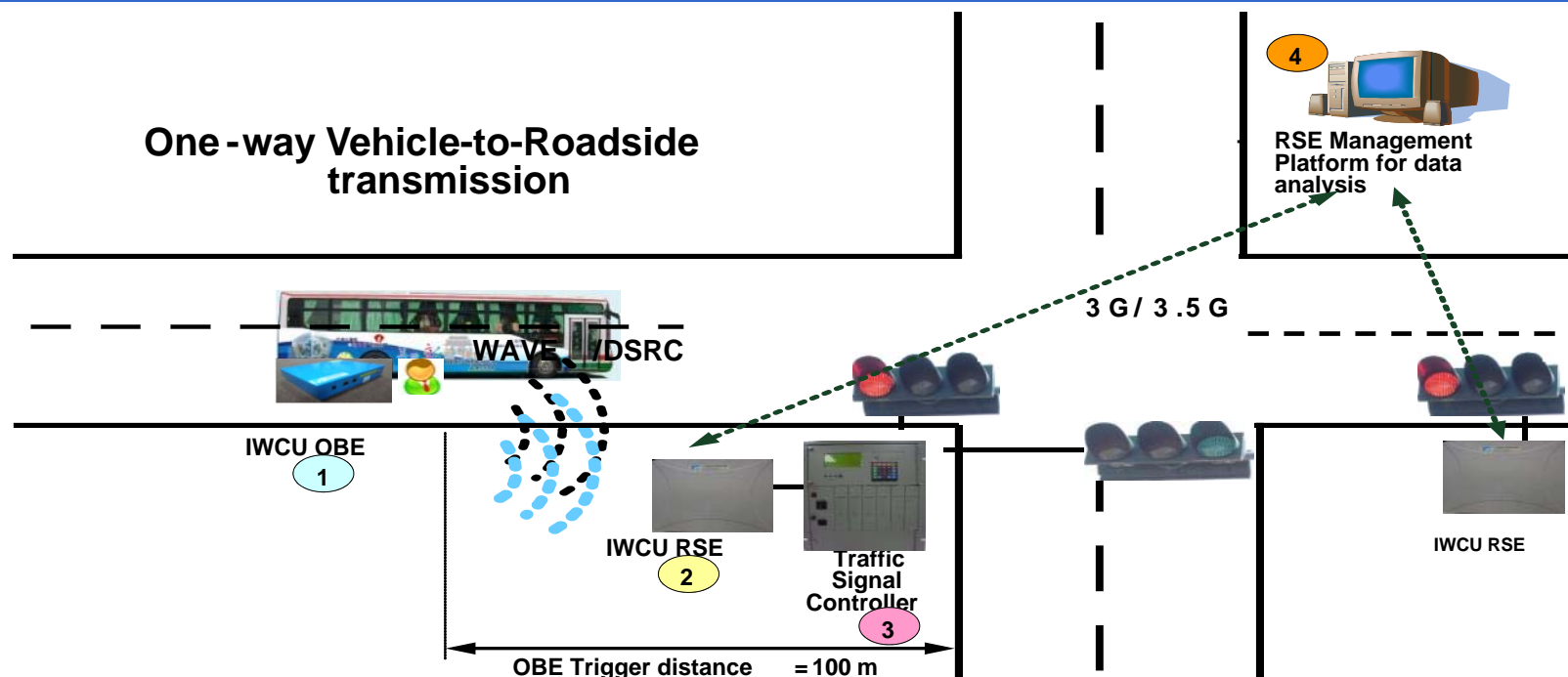
Reduce travel time, waiting time, and headway deviation experienced by bus passengers

Improve fuel efficiency, bus utilization, service quality and maintenance costs of relative operators

Served as base for future emergency services, such as ambulance police car, with priority signal control

## System Operation in Hsinchu, Taiwan

- The first WAVE/DSRC-based Bus Priority Signal Control system test site
- Collaborated with department of Transportation and Tourism, Hsinchu Country Government, Taiwan
- The system is composed of four parts: 1) the OBE; 2) the RSE; 3) the Traffic signal controller; and 4) the RSE management platform.
- The OBE/RSE supports Bus Priority Signal Control module,
- RSU Includes two control logic for bus priority



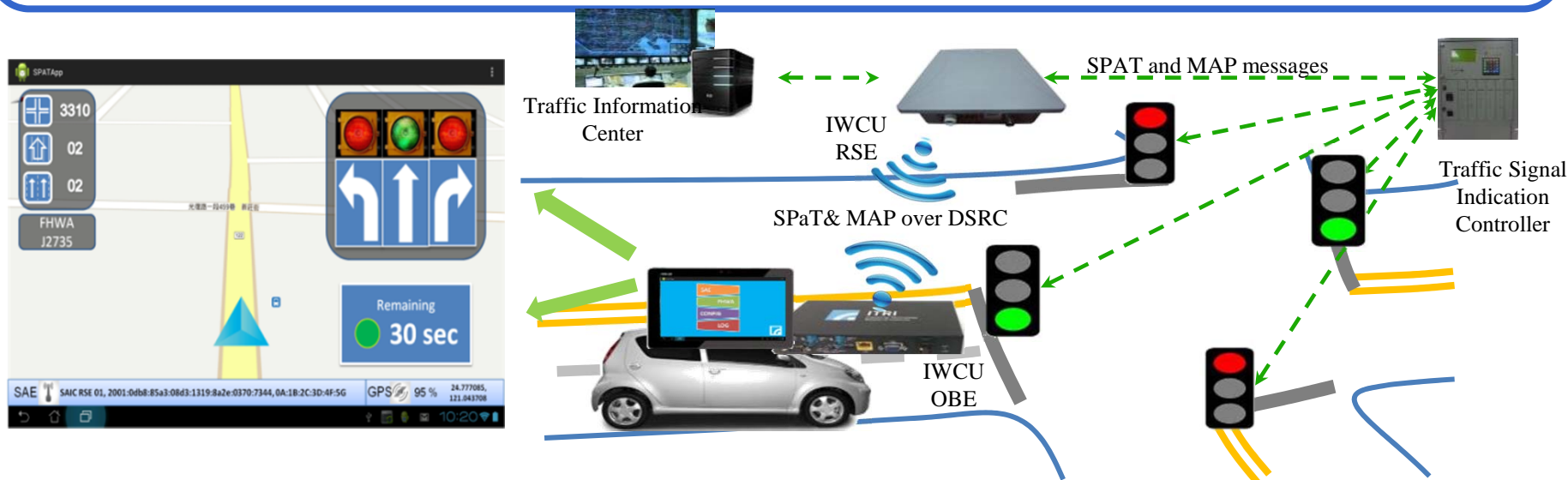
## Features

- Control logic strategy: green signal extensions and early green recalls
- Approaching buses are detected at a user-specified distance (e.g., 100m) upstream of the signal stop line, to trigger the control logic
- Detailed system logs for performance analysis and future improvements

# DSRC-based Signal Phase & Timing (SPaT) System Solution

## Need & Goal

- A growing need for integration system of traffic signal indication control and driver notification
- To achieve a real intelligence traffic management system
- To provide a simple and clear view of traffic signal indication
- Real time transmission , no latency
- To comply with International standards



## Features

- One-way Roadside-to-Vehicle transmission
- Fully comply with IEEE 1609
- Comply with SAE J2735
- Easy to traffic system integration
- Enable to log all incoming messages

## Benefits

- Improve road safety and traffic management efficiency
- Reduce the driver's response time
- Easy to inter-operate with other traffic device

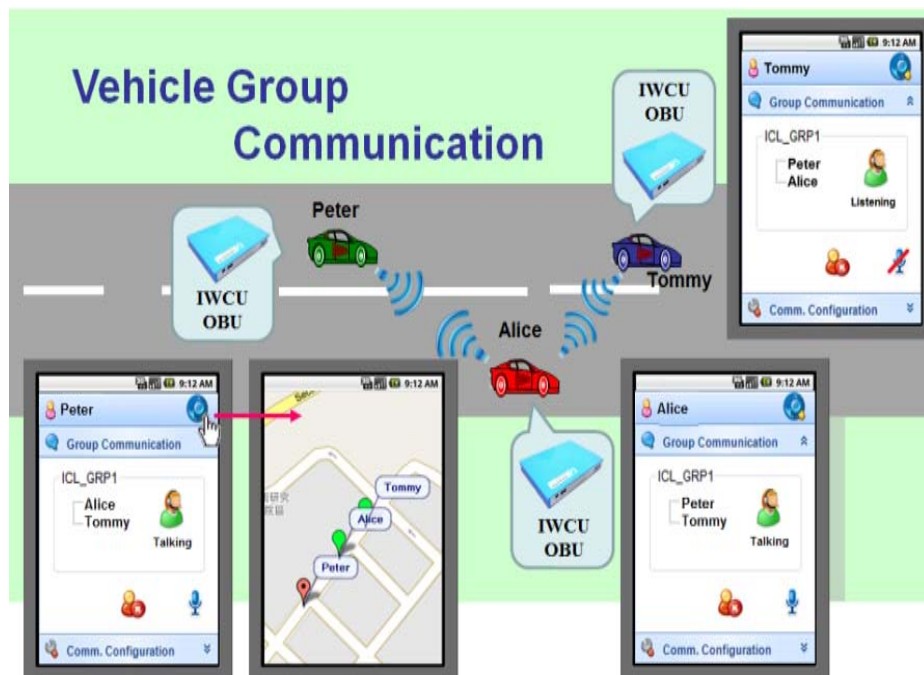


# V2X MOBILITY APPLICATION

- **V2V GROUP COMMUNICATIONS**
- **CELLULAR-BASED MOBILITY APPLICATION**
- **BACK OFFICE SOLUTION**

# Vehicle Group Communication

- WAVE/DSRC-based V2V video and voice group communication
- Full-duplex communication
- Simultaneous conversation among all group members



Voice Communication Trial

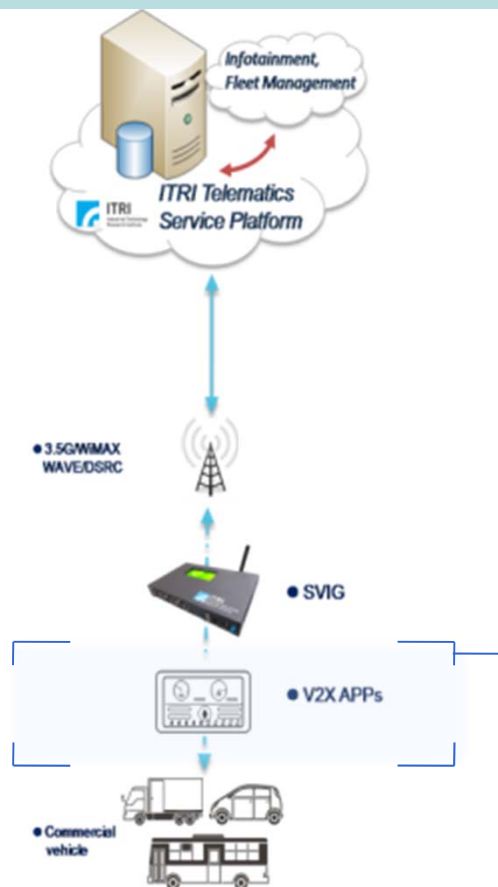






# ITRI Cellular-based Mobility Application

- **Smart Vehicle Information Gateway (SVIG) and ITRI Telematics Service Platform (iTSP) construct ITRI's cellular-based solution.**
- Mobility applications for commercial fleet operation (e.g., Taxi Fleets)
- **Live Trial: 40 taxis equipped with the ITRI commercial fleet solution participates in trials in Taipei city**

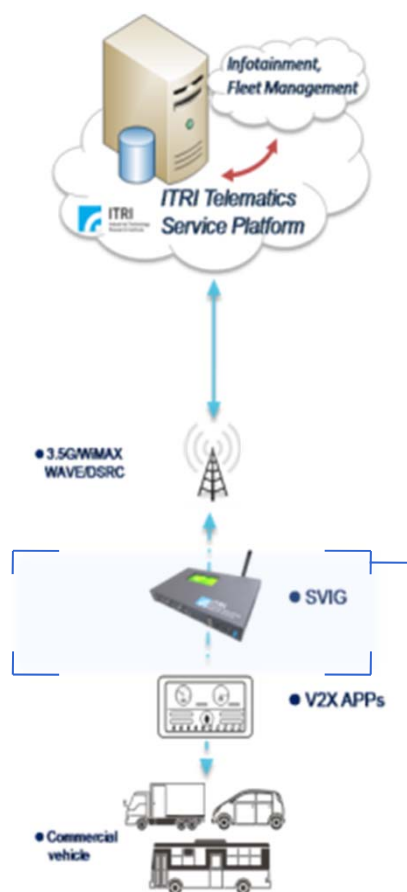


<b>Video / Audio On-demand</b> 	<b>Drive Through (e-payment)</b> 	<b>Parking Lots Guiding</b> 
<b>POI Publication</b> 	<b>Traffic Information</b> 	<b>Local news broadcasting</b> 





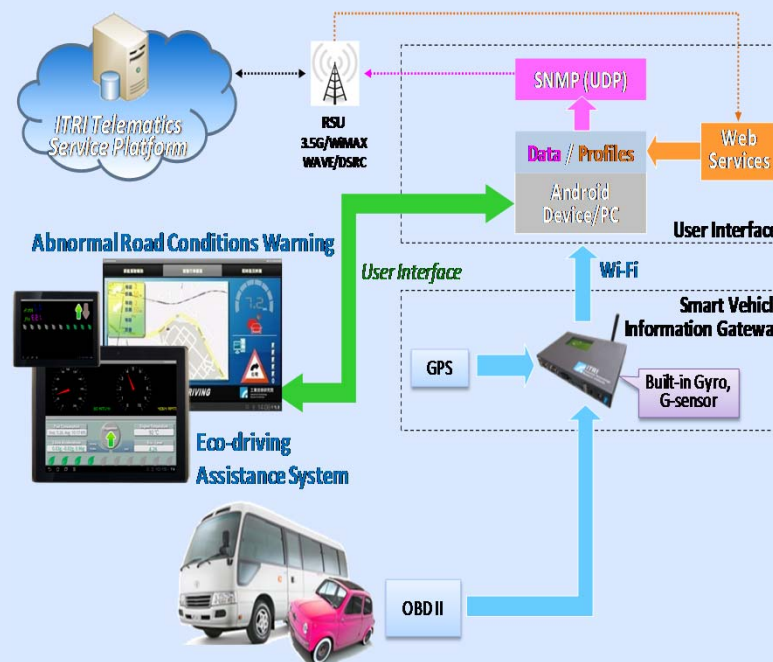
- SVIG provides economic and safe driving assistances via mobile devices to enhance the daily routines for both fleet and driver.
  - On-board diagnostic II (OBD II) interface and information retrieval
  - Connected with the ITRI Telematics Service Platform (iTSP) to realize V2X mobility applications



## Human Machine Interface



## System Architecture





# ITRI Telematics Service Platform (iTSP)

## Features

- Can cooperates with SVIG
- Open to all vehicles and car makers
- Compatible with NGTP 2.0
- Modulated system for easy maintenance
- Extensible architecture

## Provide functions:

- Real-time driver behavior monitoring
- Abnormal road condition analysis
- Fleet asset tracking
- On-board services usage statistic



### Personalized Driving Behavior Monitoring



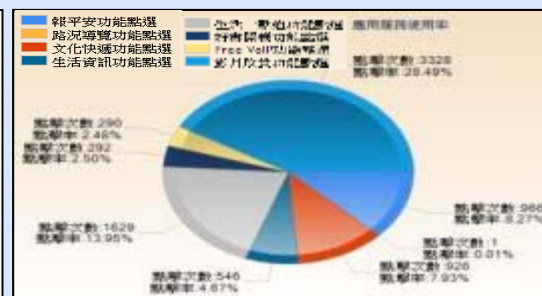
### Abnormal Road Condition Analysis



### Real-time Vehicle Tracking and Route Plotting



### Service Usage Statistic and Plotting



## Concluding Remarks (1/2)

- WAVE/DSRC will become a new key ingredient to the Connected Vehicle world
- Mobility applications with WAVE/DSRC are important to facilitate market acceptance of this new technology
- ITRI has invested R&D energy into V2X technology and Applications
  - WAVE/DSRC Core Technology and Application
  - 3G/4G-based Service

## Concluding Remarks (2/2)

- ITRI targets at mobility applications from real-world needs
  - WIM
  - TSP/SPaT
  - V2V Group Communication
  - Cellular-based V2X application and back-office solution
- ITRI's development approach highlights both the core tech. and the system deployment
  - Core Tech:
    - Standardization Activity
    - ITRI WAVE/DSRC Communication Unit Product Line
    - ITRI WAVE/DSRC V&V Solution
  - Field Deployment:
    - ITRI DSRC-WIM Highway Testbed
    - ITRI DSRC-based Signal Control City Testbed
  - Live Showcase
    - ITRI iTaxi Service Trial operated in Taipei city for 2 years



# APPENDIX: INTRODUCTION TO THE WAVE/DSRC TECHNOLOGY



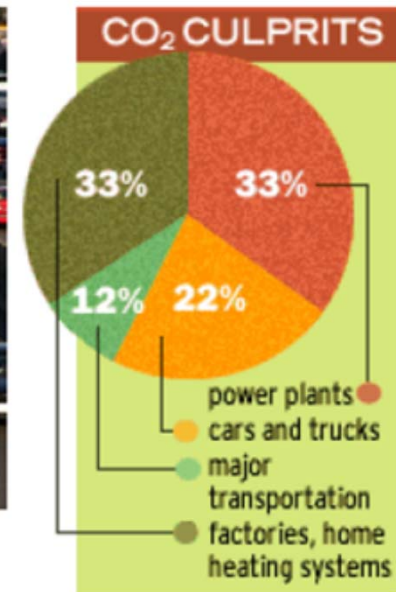


# Problems People Faced Today

- Safety
  - 32,885 highway deaths in 2010
  - 5400000 crashes/year
  - Leading cause of death for ages 4-34
- Mobility
  - 4,200,000,000 hours of travel delay
  - \$80,000,000,000 cost of urban congestion
- Environment
  - 2,900,000,000 gallons of wasted fuel



**New major issues drive  
development of new technologies**



Data source: USDOT, NHTSA, CDC, TTI, Photo Source: ThinkStock





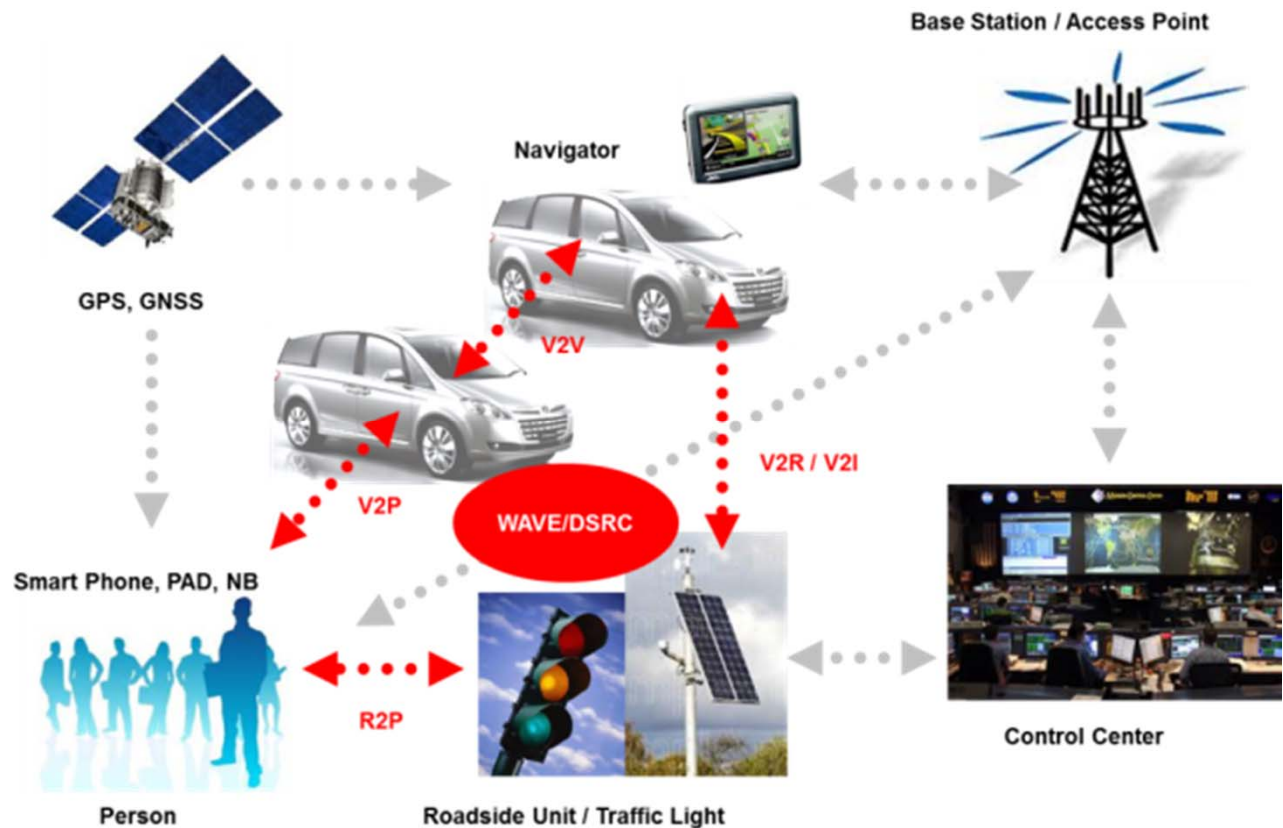
# New Demands to V2X Communication Technology

## What do We Need?

**We already got vehicles connected.**

**But, we can't get them connected in real time now!**

- Existing Communications for vehicular network
  - Cellular
  - Satellite
  - V2X
- How to construct a vehicular network?
  - Vehicles are equipped with *sensing, computing and wireless devices*
  - Vehicles talk to *road-side infrastructure* (V2I) and other vehicles (V2V)
  - Information can flow from end to end within proper tolerance





## Technology Requirement from New Applications(1/2)

### Safety

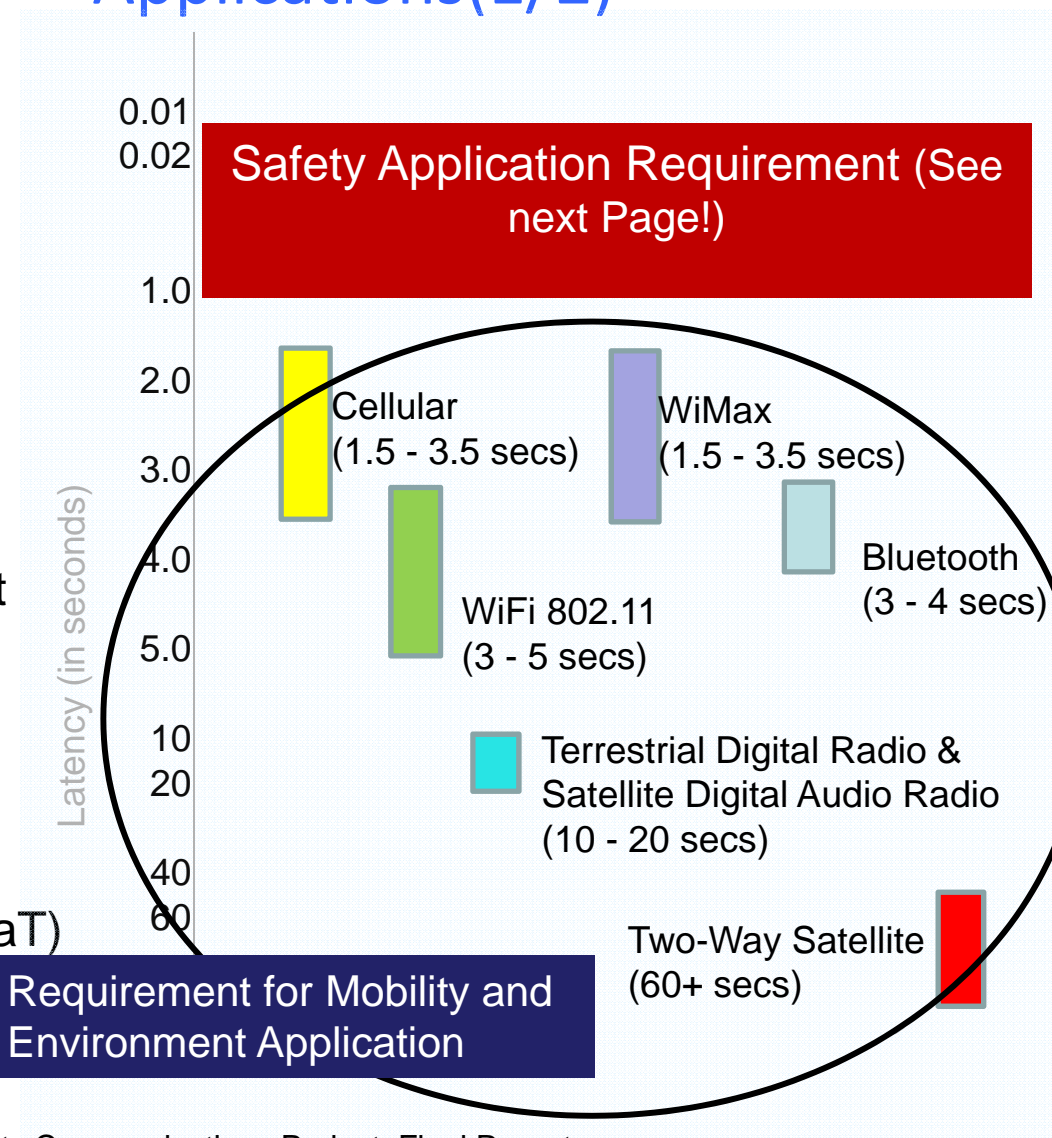
- Collision Avoidance Warning
- Blind Spot Warning
- Emergency Electronic Brake Light (EEBL)

### Mobility

- Navigation
- Vehicle Tracking
- Fleet Management
- Mobile Data and Management
- Customer Relationship Management (CRM)
- Auto Insurance

### Environment

- Signal Phase and Timing (SPaT)
- Transit Signal Priority (TSP)



Data source: Vehicle Safety Communications Project-Final Report



## Technology Requirement from New Applications (2/2)

- Vehicular safety application requires very low latency for communication
  - Existing Technology cannot satisfy such needs
  - Require a new communication technology
    - WAVE/DSRC (IEEE 1609/802.11p) is created for this goal!

Applications	Comm. Latency Requirement (sec)
Traffic Signal Violation Warning	0.1
Curve Speed Warning	1.0
Emergency Electronic Brake Lights	0.1
Pre-Crash Sensing	0.02
Cooperative Forward Collision Warning	0.1
Left Turn Assistant	0.1
Lane Change Warning	0.1
Stop Sign Movement Assistance	0.1

Data source: Vehicle Safety Communications Project–Final Report



# Emergence of WAVE/DSRC

- **WAVE/DSRC** stands for:
  - **W**ireless **A**ccess in **V**ehicular **E**nvironment/**D**edicated **S**hort **R**ange **C**ommunication
- Core Protocol Stack:
  - IEEE 802.11p
    - 5.9GHz
    - OFDM
    - CSMA/CA
    - No association and authentication with APs
  - IEEE 1609 protocol family
    - Multi-channel operation
    - Simple broadcast mode (e.g. WSM = Wave Short Message)
    - V2V/V2I security framework
  - Finalized in 2013
  - Minimized transmission latency:
    - 0.002 sec
  - Suitable for supporting active safety

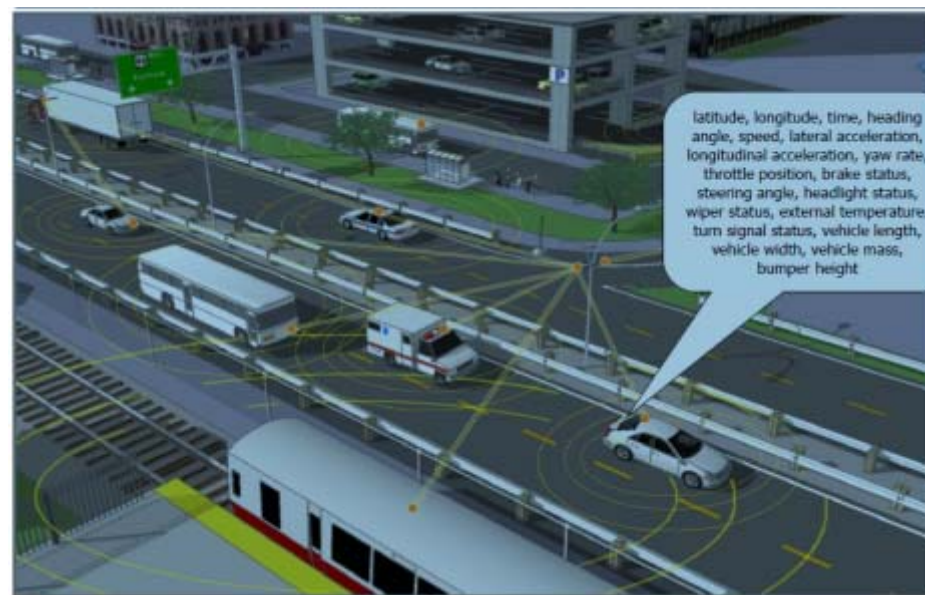
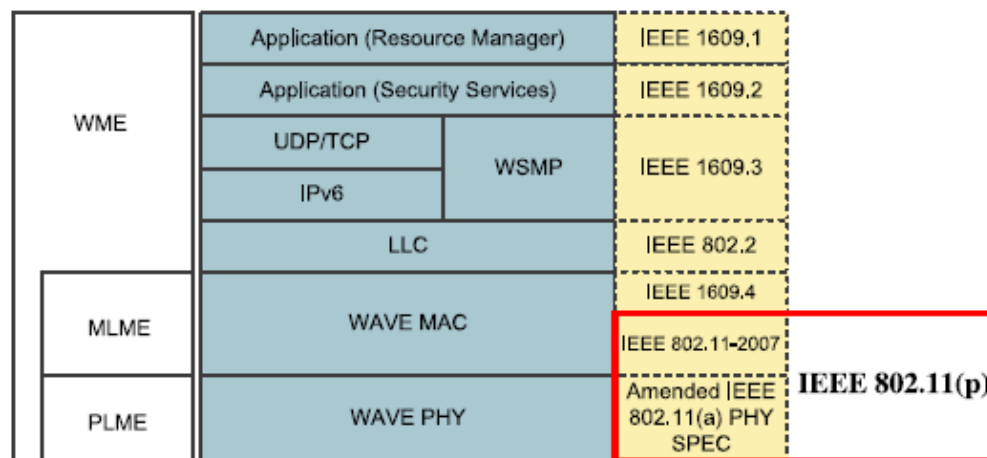


Image: U.S. DOT

Photo source: "On the Performances of Forwarding Multihop Unicast Traffic in WBSS-based 802.11(p)/1609 Networks"

Photo Source: USDOT



# WAVE/DSRC Protocol Stack

- WAVE/DSRC protocol stack

