V2X – Emerging Technologies Comparison in the United States, Europe, and Japan



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October 4, 2012

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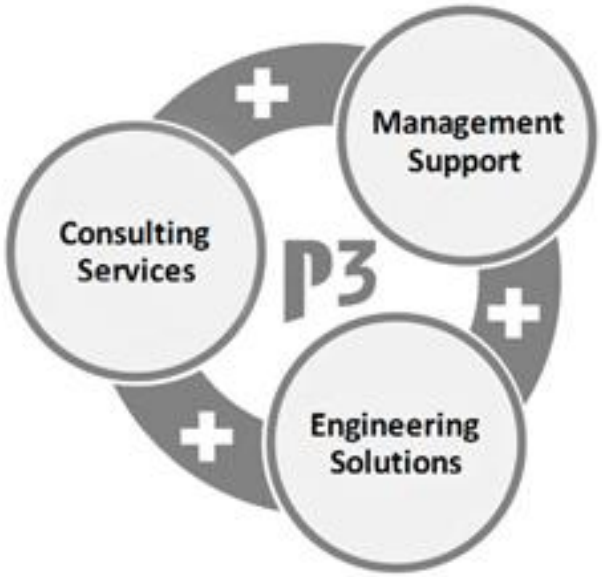

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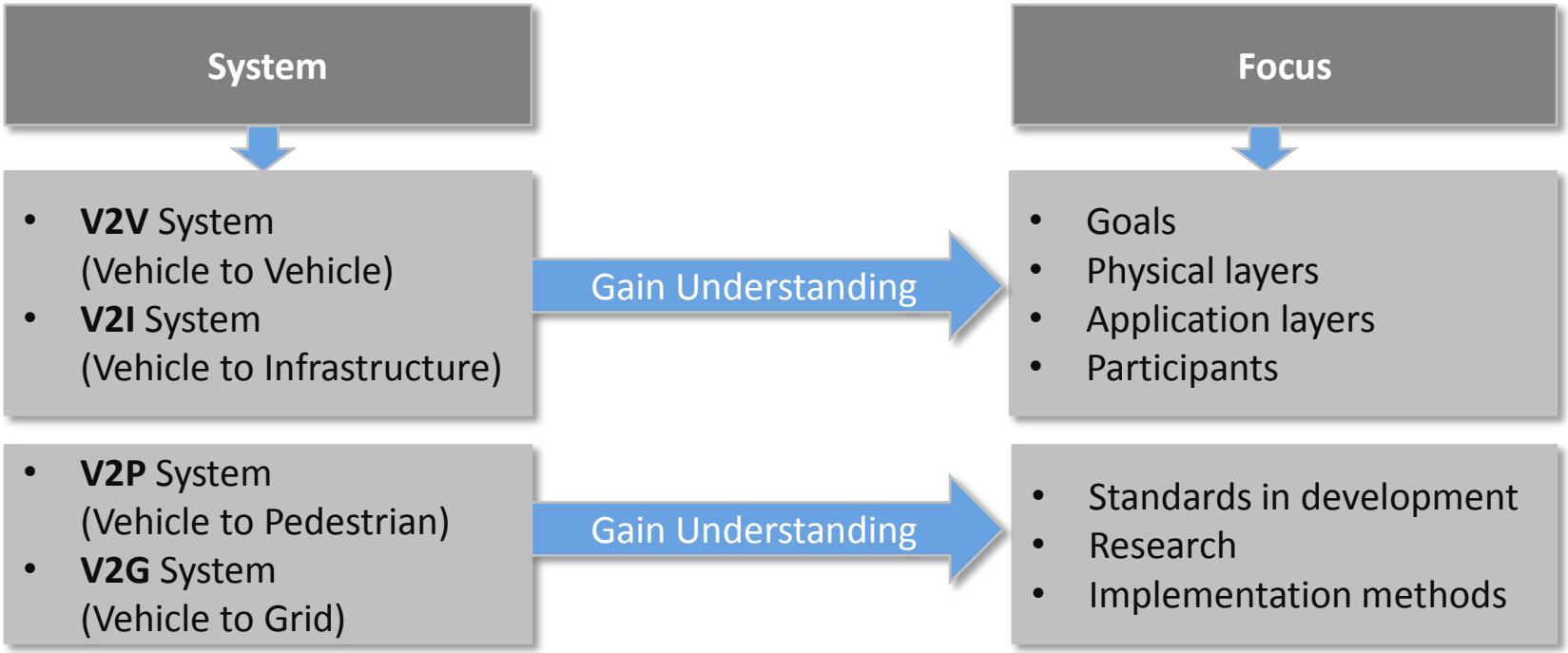
Overview of Presentation

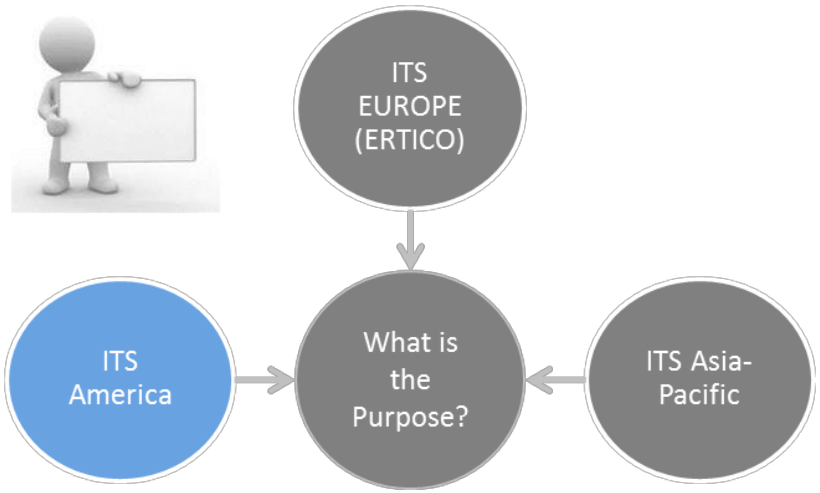
Motivation

To highlight the collaboration, differences, and similarities in the four Intelligent Transportation System (ITS) Technologies



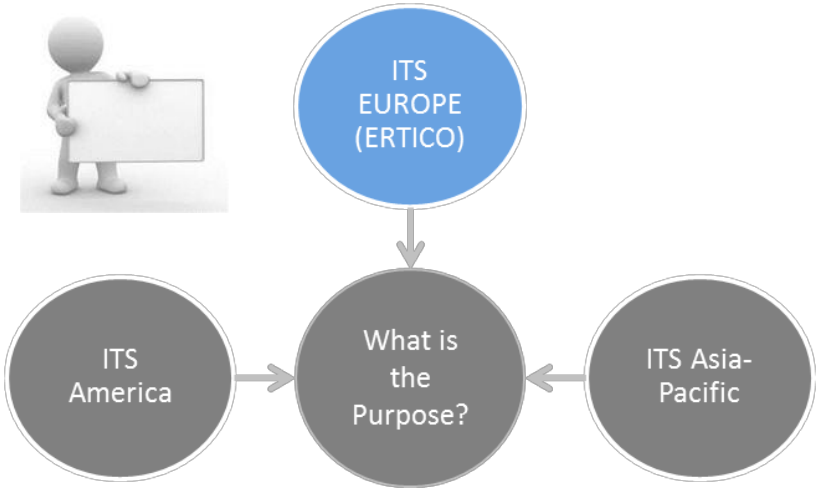
Mission Summary for ITS in America[1]

- To address transportation system challenges such as congested roadways and deteriorating infrastructure
- To build smarter infrastructure to meet future demands and enhance transportation network
- To deploy technologies to save lives, time, money, and to sustain the environment



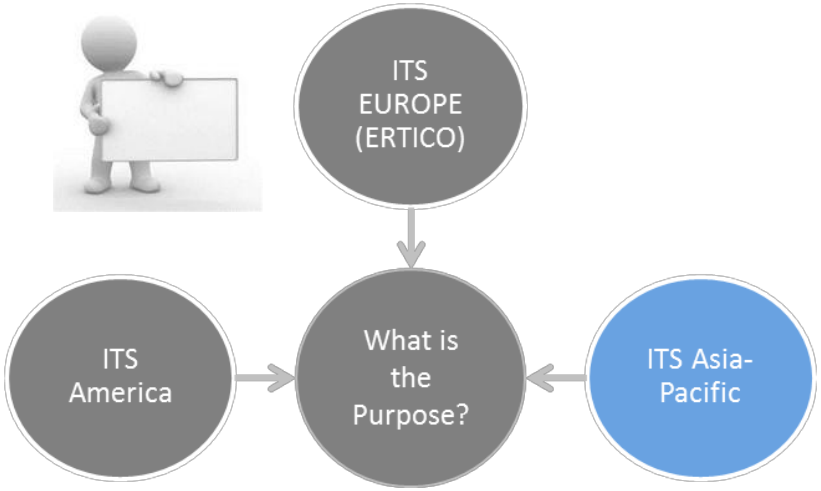
Mission Summary for ITS in Europe (ERTICO) [2]

- **Cooperative mobility-** to focus on Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication
- **Cooperative monitoring-** to provide real-time vehicle-based data
- **Cooperative safety applications-** to provide local hazard alerts, the safe intersection and wrong-way driver warning
- **Cooperative traffic management-** to use vehicles as "virtual loop detectors" and provide vehicle-traffic control interaction

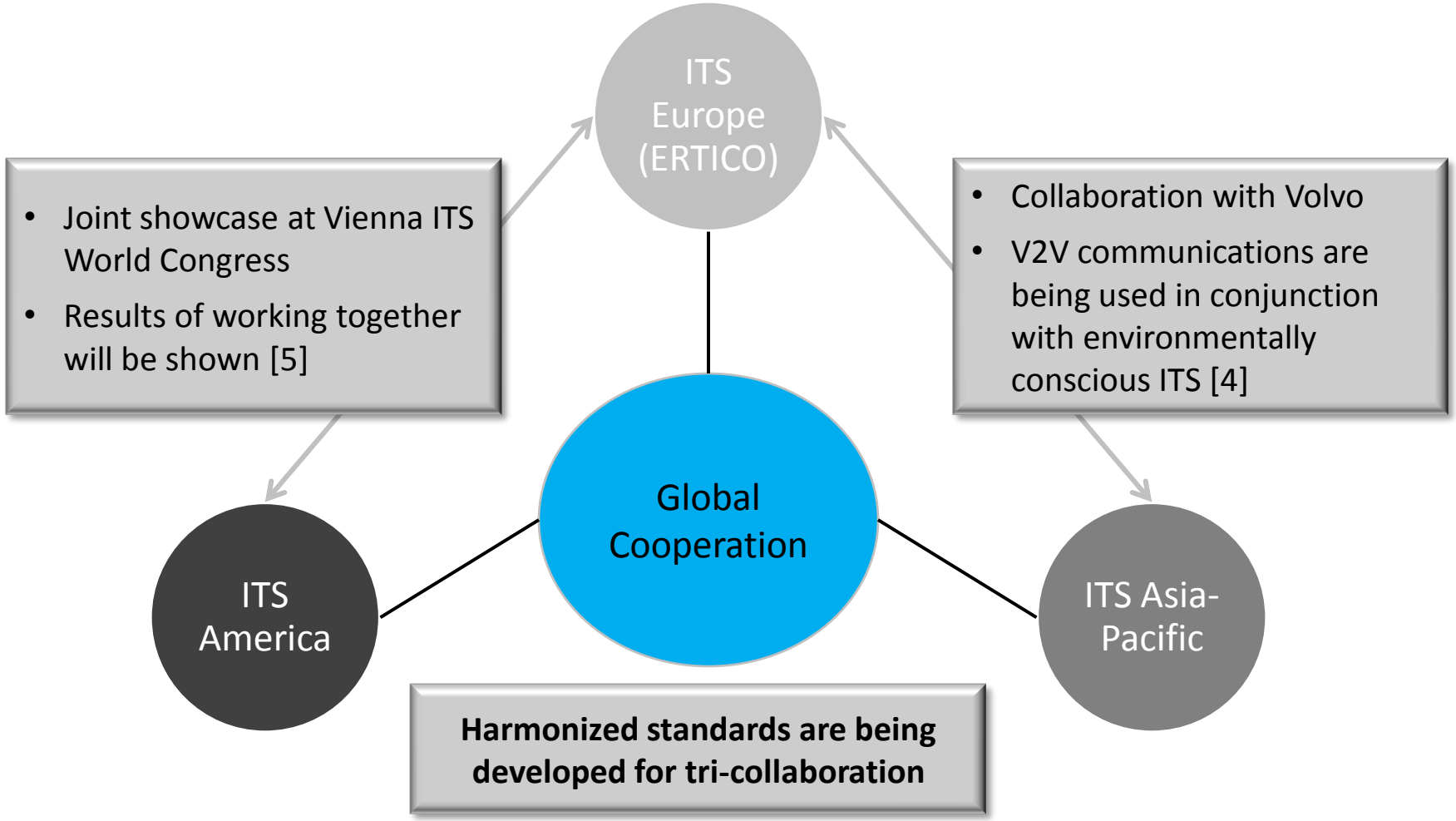


Mission Summary for ITS in Japan [3]

- To solve various transportation issues to include traffic accidents, congestion and environmental pollution
- To create ideal traffic conditions, reducing accidents and congestion while saving energy and protecting the environment
- To provide intelligent road solutions to incorporate railroad, aviation and marine
- To evolve national level project to improve system of societies, creating new industries and markets



Collaboration – Global View



Example: Communication for eSafety (COMeSafety) Collaboration and Benefit [6]

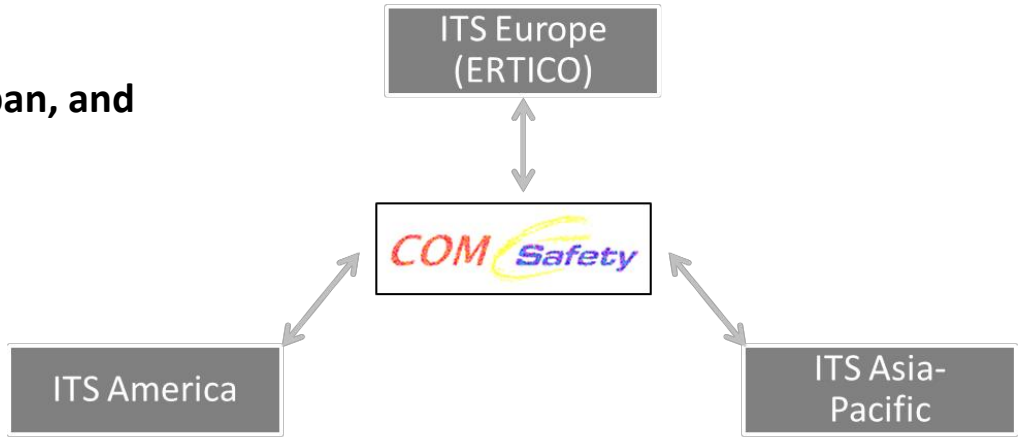
European centric project with collaboration between United States and Japan

Project Goals:

- Worldwide harmonization (US/EU/Japan)
- Coordination and consolidation of research
- Support for standardization and frequency allocation
- Deployment preparation

Collaboration between United States, Japan, and Europe allows for a much wider range of:

- Test Fields
- Applications
- Results



System Focus & Implementation – Primary Focus Differs Between Global Regions

System Focus	**V2V**	**V2I**	**V2V / V2I**
Primary Target	Improving Safety	Improving Mobility	Improving Mobility & Safety concurrently

V2V- Vehicle to Vehicle

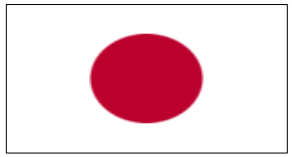
V2V System – Goals

Per *European Car2Car Consortium* [8], improve upon:

- Safety
- Mobility, traffic management, and flow
- Ecological management
- Economical management

Per *US Department of Transportation RITA* [7], improve upon:

- Safety
- Connected vehicle environment
- Mobility, traffic management, and flow
- Environmental performance



Per Japan's *Ministry of Land, Infrastructure, Transport, and Tourism* [9], improve upon:

- Safety
- Comfort
- Transport efficiency
- Environmental conservation

V2V System – Physical Layer [7], [23]

Broadcasting Frequency: 5.9 GHz, 70 MHz Spectrum

- Entire Bandwidth spectrum available for application usage
- Broken into seven 10 MHz bands
- Two of the 10 MHz bands can be combined to form 20 MHz bands

Wireless Protocol: IEEE Standard 802.11p

DSRC Protocol: IEEE 1609

Transmission Range: 300 – 1000 Meter

Messaging isolated to receiving vehicles within the transmitting vehicles radius

Three basic transmission schemes:

Uni-Casting / Geo-Casting	Single Node-to-Single Node	Node-to-Core for Retransmission
Single source node to a group of available destination nodes to access	Data can transmitted from one source node to destination node through specific addressing	Data can be sent to the core which retransmits to a group of available destination nodes

V2V System – Physical Layer [8]

Broadcasting Frequency: 5.9 GHz, 70 MHz Spectrum

- Portions of Bandwidth spectrum assigned to specific applications for use in 10 MHz channels:

5.855 – 5.875	5.875 – 5.885	5.885 – 5.895	5.895 – 5.905	5.905 – 5.915	5.915 – 5.925
Non-safety related Car to Roadside and Car to Car applications	Road Safety Traffic Efficiency	Network Control Critical Safety App	Critical Safety Applications	Road Safety Traffic Efficiency	Road Safety Traffic Efficiency

Wireless Protocol: IEEE Standard 802.11p

DSRC Protocol: IEEE 1609

Transmission Range: 1000 Meters within one-hop

Messaging range is increased using forwarding algorithms to transmit from vehicle to vehicle

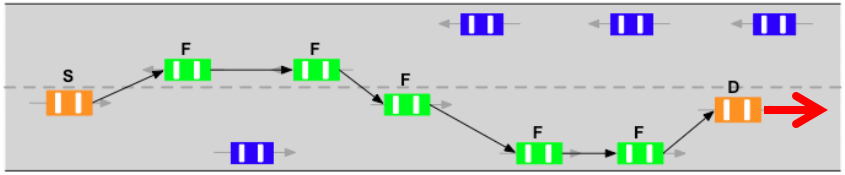
- Vehicles act as nodes and are defined by individual addresses and geographical positions
- Types of nodes: source, forwarding, destination, and forwarding / destination

Messaging transmission is higher when necessary, slower when not needed

V2V European Physical Layer Forwarding Algorithm Methodology: Four types of message forwarding methods [8]

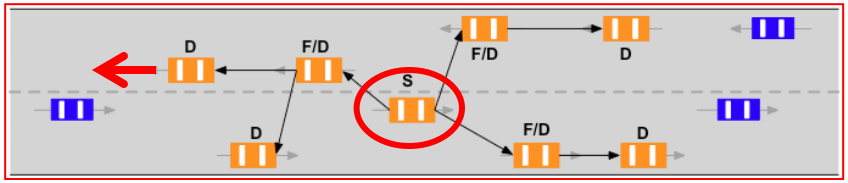
Geographical Unicast

- Single source node to single destination node
- Direct communication or multi-hops
- Addresses: Node ID, geographic position, time



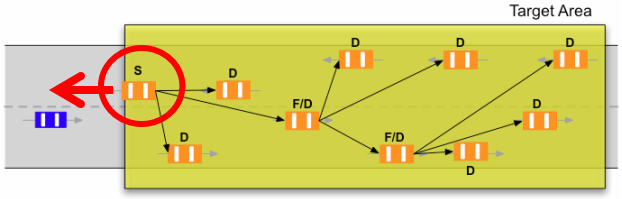
Topologically-Scoped Broadcast (TSB)

- Single source node to all nodes in coverage area
- Region is defined by broadcast data-link layers
- Restricted by allotted number of wireless hops



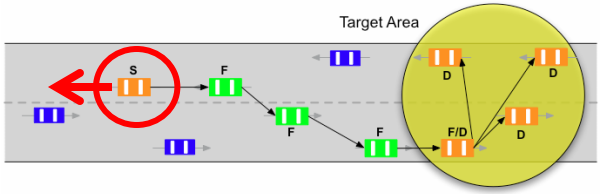
Geographically-Scoped Broadcast

- Single source node to nodes within defined region
- Region is defined geographically
- Source node can be inside or outside of region



Geographical Anycast

- Source node to nodes within geographic region
- Message is not forwarded inside region (unlike geographically-scoped broadcast)



Images courtesy of Car-2-Car Consortium Manifesto [8]

V2V System – Physical Layer [10]

Broadcasting Frequency: 5.8 GHz

- 5.8 GHz spectrum is licensed to ITS Japan for use

Wireless Protocol: IEEE Standard 802.11p

DSRC Protocol: ARIB STD-T75

Transmission Range:

- ~400 Meters forward and reverse
- 25 Meters in lateral directions

Messages sent to vehicles in transmission zone

- Types (per DSRC Standard):
  - Single source node to single destination node
  - Single source node to multiple destination nodes
- Repeaters used to increase signal strength

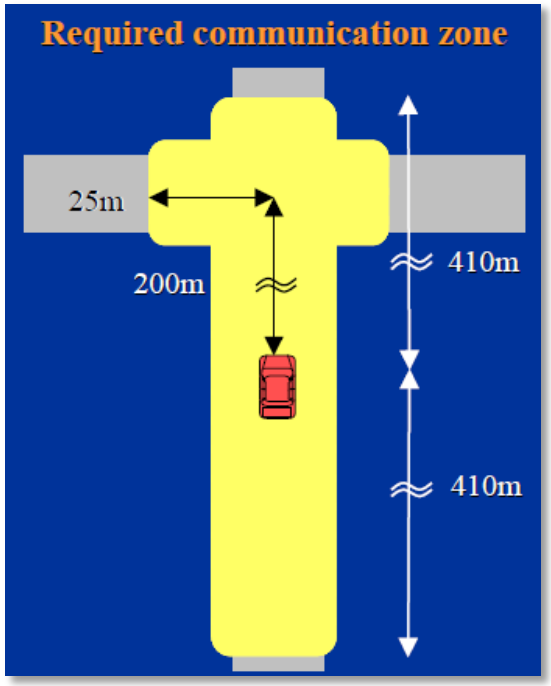


Image courtesy of [10]

V2V System – Application Layer

[8]

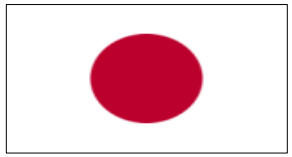
Message Standard:
ETSI TS 102 637

- Cooperative collision avoidance / mitigation (1 Application)
- Road hazard warning
- Traffic management optimization
- Comfort and entertainment
- Efficiency in road management
- Economical / Ecological efficiency management
- Vehicle / Service life cycle management

[24]

Message Standard:
SAE J2735 Safety Messages

- Cooperative collision avoidance / mitigation (7 Applications)
- Road hazard warning
- Traffic management optimization
- Efficiency in road management
- Economical / Ecological efficiency management
- Real-time data capture and management



[9],[11]

Message Standard:
Road Communication Standard

- Cooperative collision avoidance / mitigation
- Advances in navigation systems
- Traffic management optimization
- Efficiency in road management
- Support for pedestrians
- Support for public transport and emergency vehicles
- Efficiency in commercial vehicle operations

V2V System – some of the participants

Audi
BMW
HONDA
DAIMLER
VOLVO
OPEL
ARADA SYSTEMS
CohdaWireless Mobile Broadband
PSA PEUGEOT CITROËN
RENAULT
HITACHI Inspire the Next
Continental
DELPHI
RENESAS
MAN
DENSO
BOSCH
vector

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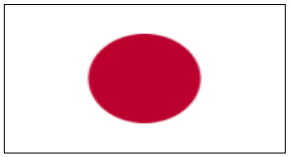
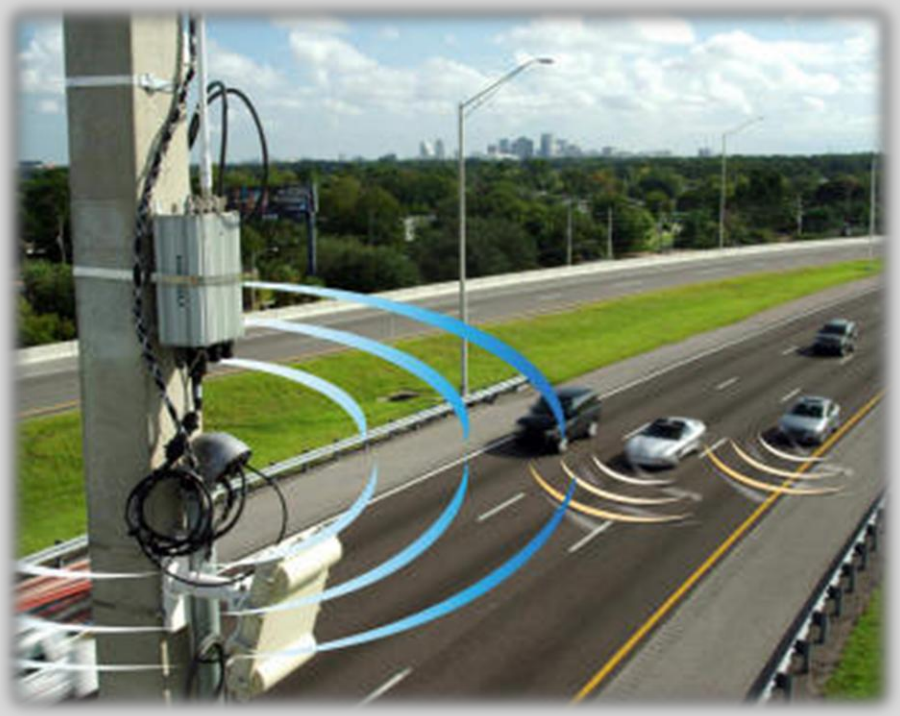
HONDA
Ford
GM
Mercedes-Benz
NISSAN
U.S. Department of Transportation
Volkswagen
TOYOTA
RITA
HYUNDAI
KIA MOTORS
U.S. Department of Transportation Federal Highway Administration
DENSO
NHTSA www.nhtsa.gov
Virginia Tech Transportation Institute



HONDA
TOYOTA
DENSO
HITACHI Inspire the Next
MITSUBISHI
OKI
NICT National Institute of Information and Communications Technology
ITOCHU



V2I- Vehicle to Infrastructure

V2I System - Goals

 [8]

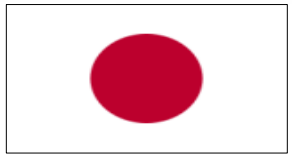
Per *European Car2Car Consortium,* improve upon:

- Collision avoidance / mitigation
- Mobility, traffic management, and flow
- Ecological / Economical management

 [12],[13]

Per *US Department of Transportation RITA,* improve upon:

- Collision avoidance / mitigation
- Mobility, traffic management, and flow
- Ecological / Economical management

 [14]

Per *ITS Japan*, improve upon:

- Collision avoidance / mitigation
- Elimination of congestion
- Ecological / Economical management
- Meet regional needs via information to the infrastructure

V2I System – Physical Layer


[8]

Broadcasting Frequency:
5.9 GHz, 70 MHz

V2I Enabling Technologies:

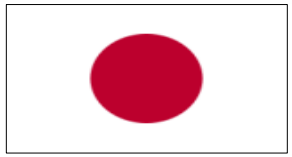
- Infrastructure to provide and maintain information
- Roadside units to transfer/receive information to/from passing vehicles
- Signalized intersection transmission
- Mapping and security


[15]

Broadcasting Frequency:
5.9 GHz, 70 MHz

V2I Enabling Technologies:

- Signal Phase and Timing (SPaT)
- Communications and positioning
- Roadside units to transfer/receive information to/from passing vehicles
- Mapping and security


[14]

Broadcasting Frequency:
5.8 GHz

V2I Enabling Technologies:

- Vehicle Information and Communication System (VICS)
- Electronic Toll Collection (ETC) system
- Sensors to detect traffic congestion at accident prone locations
- Mapping and security

V2I System – Application Layer


[8]

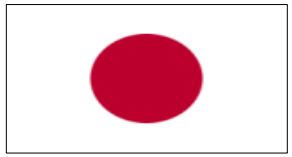
Message Standard:
ETSI TS 102 637

- Enhanced route guidance and navigation
- Cooperative awareness and collision avoidance / mitigation
- Road hazard warnings
- Optimal speed advisories
- Traffic management
- Economical / Ecological efficiency management


[16]

Message Standard:
SAE J2735 Safety Messages

- Intersection safety
- Roadway departure prevention
- Optimal speed advisories
- Priority assignment for emergency vehicles
- Commercial / transit vehicle enforcement and operations
- At-grade rail crossing operations
- Transit safety and operations


[14]

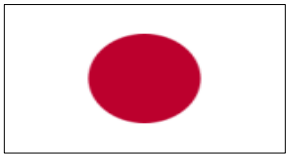
Message Standard:
Road Communication Standard

- Traffic congestion notifications
- Cooperative awareness and collision avoidance / mitigation
- Electronic toll collection
- Electronic fee collection
- Information gathering to support regional needs
- Support for public transit
- Real-time hazard warnings

V2I System – some of the participants

Audi BMW HONDA
DAIMLER
VOLVO
OPEL
CohdaWireless Mobile Broadband
ARADA SYSTEMS
PSA PEUGEOT CITROËN
RENAULT
HITACHI Inspire the Next
Continental
DELPHI
vector
RENESAS
DENSO
BOSCH

DENSO
ARADA SYSTEMS
Savari
NHTSA www.nhtsa.gov
U.S. Department of Transportation
AASHTO THE VOICE OF TRANSPORTATION
SIEMENS
kapsch
CohdaWireless Mobile Broadband



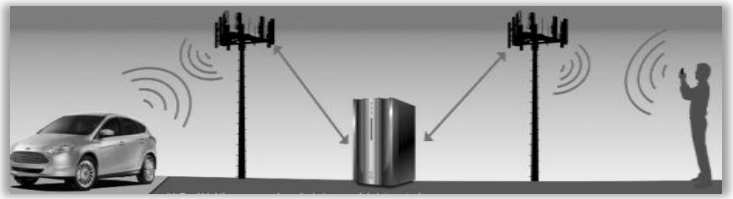
HITACHI Inspire the Next
DENSO
JEITA
OKI
MLIT Ministry of Land, Infrastructure, Transport and Tourism

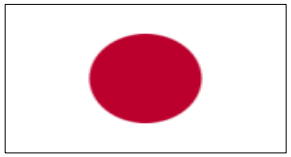
V2P- Vehicle to Pedestrian

V2P Technology

According to recent GM findings [19]**, implementation of V2P technologies can be done in several ways:**

- Standalone devices (i.e. GPS)
- Smartphones
- Aftermarket devices
- Embedded OEM systems





Japan's "New IT Reform Strategy" [18] **states:**

"Working to realize the safest and most people-friendly society on earth through the effective utilization of IT" [17]

V2P technology will help to meet this goal by making vehicles more aware of their surroundings (i.e. pedestrians, cyclists) [18]

V2G- Vehicle to Grid

V2G Technology

Standards currently being developed by SAE:

- ISO / IEC 15118-4: Road Vehicles – Vehicle to grid communication interface – Part 4: Network and application protocol conformance test
  - Status is under development in stage 10.99
- J2931/5 Telematics Protocol – potentially impactful, approvals in progress

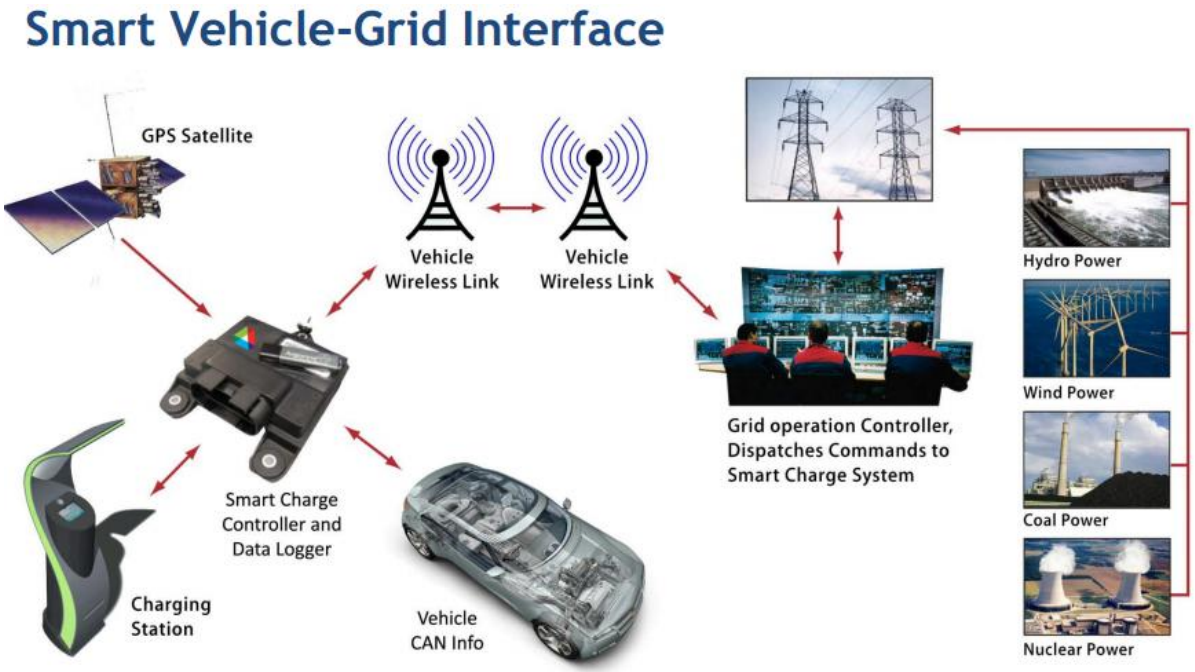


Image courtesy of: *http://www.gaccom.org/fileadmin/ahk_chicago/Dokumente/Hannover_InfoV_Presentations/Lohse-Busch_Smart_Grid.pdf*

Implementation – USA: Safety Pilot Model Deployment [20]

Location: Ann Arbor, MI

Coordination: UMTRI and the US DOT

Mission: Benchmarking process for current connected vehicle & safety applications with volunteer participants

Implementation:

- Scaled-down version of vehicle connectivity
- Necessary components installed in vehicle at no cost
- Data is collected every three months
- Participation lasts 12 months

U.S. Department of Transportation

University of Michigan Transportation Research Institute
Advancing Safe and Sustainable Transportation

Vehicle Awareness Device (VAD)

ASD + Data Acquisition System (DAS)

Aftermarket Safety Device (ASD)

Images courtesy of [20]

Implementation – Europe:
Safe and Intelligent Mobility Test Field Germany (sim^{TD}) [21]

Location: Frankfurt, Germany

Coordination: Testing and validation of technology is being performed

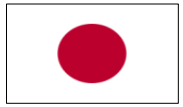
What is being Tested?	**How** is it being Tested?
• Vehicle technology • Traffic technology • Communication technology	• Motorways • Rural roads • Urban roads • ITS central station • Test fleet
Interaction and readiness of the technologies	Real world scenarios are created for analysis and benchmarking

sim^{TD} Research Mission:
ITS Technology System Integration and connected vehicle application assessment

What are the **Applications**?

- Driving assistance
- Local danger alert
- Traffic management
- Monitoring of traffic situation and information
- Internet access and local information services

Implementation – Japan:
Smartway Project – Co-operative Vehicle Highway Systems [22]



Location: Tokyo, Nagoya, Kyoto, Osaka, Kobe

Coordination: Testing

Mission:

Gather information on implemented safety measures and validate initial effect

Implementation:

- On-board units
- Connected vehicle services
- Testing and study methods

Challenges for V2X Rollout and Success

Security

- No decision on how the system will be defined (i.e. certificates versus keys)
- No clear path on how anything will be shared (i.e. cell network versus V2I)

Scalability

- Bandwidth limitations, processing power, transmission frequency

Business Case

- V2I requires massive deployment of compatible RSUs
- Currently limited by deployment scale and funding

Security

- Our research shows limited activity in this area when compared to the United States

Domination

- No single dominant automaker in the EU that could create significant market penetration

Government

- No government involvement
- Consortium based

Legality and Insurance Concerns [25]

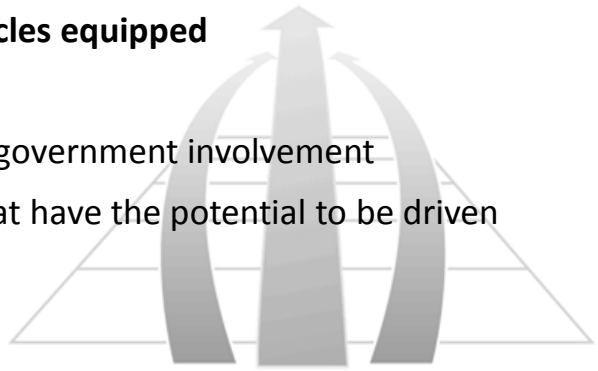
- In the event of an accident, V2X enabled vehicles are subject to potential legal action
- Insurance premiums will change with the addition of V2X technology

Based on our analysis and experience…
Three main drivers will shape V2X

1. **Protocol Standard – success will rely on industry leading organizations finding a common standard across the world**
   - Current focus in the US is on a single channel implementation with transmission at a periodic rate
   - Current focus in Europe is on a multi-channel implementation that can support periodic transmission for short range threats and additional data transmission with an event is detected

2. **Application Orientations – applications drive consumer value**
   - Safety applications provide opportunity for a low cost implementation of ADAS
   - Mobility applications will provide drivers with better situational awareness

3. **Critical Mass – value of V2X systems is limited by the number of vehicles equipped with the systems**
   - Europe is developing the technology in a consortium with limited government involvement
   - United States and Japan are involved in government led efforts that have the potential to be driven into the industry quickly



P3 Insight: V2V will lead the industry

1

A Harmonization layer needs to be created

- Needs to be flexible to handle various intentions of parties throughout the world

2

Flexible protocol in Europe provides stronger baseline for the world

- Provides potential for implementation of safety and mobility applications
- Algorithms being developed in Europe have a good potential for real world scalability

3

Safety is main driver for industry

- To provide lower cost options to ADAS technology in market, creating immediate value

4

V2V systems will lead industry into deployment of V2X technologies

- Provides lower cost ADAS system compared to competing technologies
- This will allow consumers and governments to understand the value of V2X technology

5

Development of ASDs is essential to gaining critical mass in industry

- Market penetration will be slow through release of new systems in new vehicles

Your P3 Contacts for Questions referring to Vehicle Connectivity

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Questions & Answers

References

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