VSC development in Japan

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Outline

• Introduction

• Activities in Japan
  – ITS Info-communications Forum/ “Inter-Vehicle Communications Systems Expert Group”
  – JARI/ ITSC
  – AHSRA

• Personal view on vehicle safety and communication

• Conclusions
Introduction

• Vehicle safety and communication
• ITS and business
• Safety is a public matter or a private matter?

• [Terminology] Dedicated Short Range Communications
  – Vehicle-to-Vehicle Communication
    (Inter-vehicle Communication)
  – Roadside-to-Vehicle Communication
  – V-R-V Communication
  – Vehicle Data Sharing
Communication systems from the viewpoint of ITS architecture (USA)
Communication systems from the viewpoint of ITS architecture (Japan)

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VSC activities in Japan

• ITS Info-communications Forum/ "Inter-Vehicle Communications Systems Expert Group"

• JARI/ ITSC (Japan Automobile Research Institute / ITS Center)

• AHSRA (Advanced Cruise-Assist Highway System Research Association)
ITs Info-communications Forum

Inter-Vehicle Communications Systems Expert Group(1)

• Study Approach of Vehicle-to-Vehicle Communications
ITS Info-communications Forum
Inter-Vehicle Communications Systems Expert Group(2)

• Study Approach(v1.3)

< START >

Business model & Scenario

User Requirements

Applications

Guideline

< GOAL >

Validation

Power Budget

Other Applications

Channel Plan

Mod/Demo & Access scheme

Interference

Communication Spec.
### Example of vehicle communication systems

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Description</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive cruise</td>
<td>Automatically stop and go smoothly, when cars are in traffic jam.</td>
<td><img src="example1.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Cooperative driving</td>
<td>Cooperative driving by exchanging respective cruising data.</td>
<td><img src="example2.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Hazard warning</td>
<td>Obstacle warning, Stopped vehicle warning, Slowing down vehicle warning.</td>
<td><img src="example3.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Merging &amp; lane change warning</td>
<td>Cars of main line and a car merging communicate for safe and smooth line change.</td>
<td><img src="example4.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Intersection &amp; winding curve</td>
<td>Collision warning, Cars out of sight communicate for safe and smooth cruise.</td>
<td><img src="example5.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Inter/intra-platoon communication</td>
<td>Ad Hoc communication between cars.</td>
<td><img src="example6.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>
### ITS Info-communications Forum

Inter-Vehicle Communications Systems Expert Group(4)

- Communication specifications

<table>
<thead>
<tr>
<th></th>
<th>Stop &amp; Go</th>
<th>Intersection Collision Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Band</td>
<td>60 GHz</td>
<td>5.8 GHz</td>
</tr>
<tr>
<td>Modulation</td>
<td>FSK</td>
<td>√ /4-QPSK(ASK)</td>
</tr>
<tr>
<td>Modulation Speed</td>
<td>512 Kbps/128 kbps</td>
<td>640 kbps/4 Mbps</td>
</tr>
<tr>
<td>Media Access</td>
<td>CSMA</td>
<td>CSMA</td>
</tr>
<tr>
<td>Emission Power</td>
<td>less than 10 mW</td>
<td>less than 10 mW</td>
</tr>
</tbody>
</table>
ITS Info-communications Forum
Inter-Vehicle Communications Systems Expert Group(5)

- IVC Mapping

<table>
<thead>
<tr>
<th>type</th>
<th>for</th>
<th>Safety</th>
<th>Convenience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td></td>
<td>&lt; Our Forum&gt;</td>
<td>&lt; EU&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop&amp; Go</td>
<td></td>
</tr>
<tr>
<td>1:n</td>
<td></td>
<td>Intersection</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fleming</td>
<td></td>
</tr>
<tr>
<td>n:n</td>
<td></td>
<td>&lt; North America&gt;</td>
<td></td>
</tr>
</tbody>
</table>

IVC: Inter-Vehicle Communication
AVCSS: Advanced Vehicle Control and Safety Systems

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• V2V Deployment Scenarios

< Scenario 1 >

ACC

Associated ACC

Enhancement

Stop & Go

Point to point link for Safety

< Scenario 2 >

Multi-purpose DSRC

ETC

Spin off

Interception Collision Warning

Point to multi-point link for Safety

Ad-hoc Network
JARI ITS-Center(1)

- JARI ITS-Center was established on July 1st 2003
- It takes over the activities of JSK (integrated into new-JARI)

- There are two main fields of activity:
  - Research (pre-competitive phase)
  - International standardization (ISO/TC204)
JARI ITS-Center(2)

- JSK started Inter-vehicle Communication study in the early 1980s.
- In 90s, the study was focused on IVC for cooperative driving.
- The study result was shown in Demo2000.
- JARI ITS-Center (Ex-JSK) started IVC standardization activity in 2003.
JARI  ITS-Center(3)

• Two main subjects of 2002:
  – Construct “Concept Reference Model for IVC”
  – Acquire DSRC field data on Intersection Collision Warning Application

• IVC is expected to support various VS (Vehicle Safety) applications.
• IVC standardization is inevitable to realize VS applications.
# Profile of AHSRA(1)

<table>
<thead>
<tr>
<th>Name</th>
<th>Advanced Cruise-Assist Highway System Research Association (AHSRA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leading Ministry</td>
<td>Ministry of Land, Infrastructure and Transport (MLIT)</td>
</tr>
<tr>
<td>Research Trust</td>
<td>National Institute for Land and Infrastructure Managements (NILIM)</td>
</tr>
<tr>
<td>Objective</td>
<td>The purpose of AHSRA is to develop the Advanced Cruise-Assist Highway Systems (AHS), which will achieve significant improvements in road traffic safety and efficiency by applying information technology (IT) to road infrastructure.</td>
</tr>
</tbody>
</table>
Profile of AHSRA(2)

<table>
<thead>
<tr>
<th>Established</th>
<th>September 25, 1996, based on the Mining research Association law and with approval from the Minister of Construction (since renamed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Members</td>
<td>18 Japanese Private Companies</td>
</tr>
<tr>
<td>Associate Members</td>
<td>350 Organizations and Persons</td>
</tr>
</tbody>
</table>
Positioning of AHSRA
Cooperation between Public and Private

- The MLIT (Ministry of Land, Infrastructure and Transport) establishes top policy for AHS.
- The NILIM (National Institute for Land and Infrastructure Management) of the Ministry of Land, Infrastructure and Transport carries out R&D of AHS in cooperation with AHSRA.

<table>
<thead>
<tr>
<th>NILIM</th>
<th>AHSRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determination of concept</td>
<td>R&amp;D of systems</td>
</tr>
<tr>
<td>Establishment of requirements</td>
<td>Assessment and analysis of field operation test</td>
</tr>
<tr>
<td>Evaluation of practical application</td>
<td>etc.</td>
</tr>
</tbody>
</table>

Cooperation
Cooperative Driver Assistance System

Real-time Driver Assistance by Road & Vehicle cooperation

Smartcar (ASV)  Smart Gateway  Smartway (AHS)

R&D on Intelligent Vehicle   R&D on Intelligent Road

ASV: Advanced Safety Vehicle
AHS: Advanced cruise-assist Highway System
Basic Concepts of AHS

- **Infrastructure**
  - Takes charge of the range that is difficult or impossible to perceive by drivers and/or vehicles.

- **Vehicle**
  - Vehicle side takes charge of portions that can be perceived by drivers and/or vehicle sensors.

Example at blind curve

Information detected by infrastructure is transmitted to vehicles via DSRC

Road condition detection sensor

Example at blind curve

Vehicle side detects portions that can be perceived by drivers and/or vehicles.

Roadside equipment

DSRC
Proving tests on actual roads were conducted for AHS using DSRC at 6 test sites.

- Route 246
- Higashi-Meihan Expressway
- Route 25
- Metropolitan Expressway
- Tomei Expressway

Support for prevention of collisions with forward obstacles
Support for prevention of overshooting on curve
Support for road surface condition information

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Personal view on vehicle safety and communication

• Today’s Theme
  – Vehicle safety and communication
Effect of VSC from results of our simulations(1)

- Vehicle density property (10km, three lanes)

![Graph showing the effect of vehicle density on mean accident interval. The x-axis represents vehicle density in [Veh./km/lane], and the y-axis represents mean accident interval in [hour]. The graph shows a decrease in mean accident interval as vehicle density increases.](image-url)
Effect of VSC from results of our simulations(2)

- Two types of VSC evaluation indexes
  - From the viewpoint of road administrators
    Accidents frequency within an area
  - From the viewpoint of drivers
    Accidents frequency for each driver
Effect of VSC from results of our simulations(3)

- Equipped ratio property
Effect of VSC from results of our simulations(4)

- Equipped ratio property (from the viewpoint of drivers)
My plain definition of ITS

• Human and objects transport systems sophisticated by IT

• Road, Human, Vehicle, Train, Airplane  □
  Mobility of human and objects
ITS Pentagon

• Systems’ objectives in order, and concretization of systems’ positioning
Systems Innovation

- Functions
  - I/O

- Costs
  - B by C
  - Neither “seeds oriented” nor “needs oriented”, but “Platform oriented”
  - Not “limited number” but “infinite number” of applications on the platform
  - common functions provided by the platform

- Migration
  - Migration of the platform itself
  - Migration of sub-platforms -> 2G to 3G, GPS receivers
  - Migration of our life styles -> many pedestrians and vehicles will have cameras
End-user Triangle

- End-user taxonomy (non-exclusive)
- Correspondence end-users to systems
Driving assistance system

• Incident avoidance
  – Vehicle control / Automated driving
  – Information / warning

• Functions
  – Positioning
  – Communication
    (- HMI)

• Different level (QoS) requirements
  – Precision, delay, robustness
First and Second Category ITS Platforms

First Category ITS Platform
(Realtime seamless communication and realtime precise positioning)

Second Category ITS Platform
(Quasi-realtime seamless communication and quasi-realtime precise positioning)

Third Category ITS Platform
(RFID-Tag system’s positioning and communication)
Construction of ITS Platform

- Example of construction from 50 ITS applications
Evolutional Ubiquitous Platform for ITS (EUPITS)

- Architecture of EUPITS

(Medium selection depending on QoS and other conditions)
“M-CubITS” Positioning System

- Elements of M-sequence Multimodal Marker for ITS (M$^3$ for ITS; M-cubed for ITS; M-CubITS)

(ref.: PNCMM)
M-CubITS and Application Image(1)

- On the street (Pedestrian/Vehicle/Motor bike)

- For vehicles
  - Using the lane keeping system by white line detection, realization of realtime precise positioning without additional hardware.
M-CubITS and Application Image(2)

• For pedestrians
  – Photo-oriented direct suggestion of the direction for a pedestrian → WYSIWYAS pedestrian navigation system. (assumption of Mobile phone terminal or PDA with a camera)

(WYSIWYG:
What You See Is What You Get

As the corresponding concept,

WYSIWHAS:
What You See Is What You Are Suggested)
M-CubITS and Application Image(3)

- At basement car park or tiered parking lot, on the street
  - Besides determination of position and direction at GPS invalid area, empty space visual guidance in the large parking lot (using local positioning and communication functions)

-> WYSIWYAS Navigation
Discussion(1)

- First category and Second category
  (Different requirements for sub-systems)
- Determination of position and direction
- Communication
- WYSIWYAS navigation HMI

- Is a killer application needed?

- Effectiveness of communications for safety depends on not only the communication function itself but also other functions such as positioning or sensing functions.
Discussion(2)

- **Realization methods of unusual situation detection**
  - Monitoring by roadside cameras
  - **Realtime precise positioning and communications (probe car)**
    - Event driven communications of abnormal trajectory
    - Fulltime communications of trajectory
Discussion(3)

- Communication range in IVC
- Migration of the communication paradigm
  - Telephone network: Particular point – Particular point
  - Mobile phone: Particular terminal / General area
  - ITS infor-com.: + General terminal / Particular area
Discussion(4)

- Communication sub-platform and positioning sub-platform

- Next Gen. DSRC
- Wireless LAN
- PHS
- Mobile phone
- Marker
- GPS
Discussion(4)

- DSRC: R2VC and IVC
- Data sharing
- Integration of IVC and R2VC
Conclusions

• Vehicle safety activities in Japan
  – ITS Info-communications Forum/ “Inter-Vehicle Communications Systems Expert Group”
  – JARI/ ITSC
  – AHSRA

• My personal view and discussion on vehicle safety and communication
  – Safety driving assistance (first and second categories)
  – Communication and positioning (not-separately, by a platform)

  – B by C (Platform oriented) (material and unmaterial)
  – Systems Innovation (functions, costs, migration)
  – System oriented (safety and elemental techniques such as communication, positioning, HMI etc.)
  – Safety and data sharing
  – Integrated thinking way of systems technology toward safety and elemental technology (communication, positioning, HMI etc.)