Update of ITS Research and Development in Japan

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1. ETC2.0 system

2. “Next-generation C-ITS”

3. Low Speed Automated Driving (LSAD) Services in Rural and Mountainous Areas
1. ETC2.0 SYSTEM
1.1. ITS Development in Japan

**VICS**: Vehicle Information and Communication System

- **1990’**
  - Car navigation
  - VICS
  - ETC
  - 70 million units shipped (March 2016)
  - 50 million units shipped (March 2016)
  - 53 million units shipped (March 2016)

- **1996**
  - VICS
  - ETC
  - 50 million units shipped (March 2016)

- **2000**
  - VICS
  - ETC

- **2011**
  - VICS
  - ETC
  - ITS Spot
    - Various applications by a single onboard unit (OBU)
    - • Dynamic route guidance
    - • Safety driving support
    - • ETC etc.

- **2015**
  - VICS
  - ETC

**ETC 2.0**

- **Upgrade of existing services**
  - Evolved
- **New services**
  - • Smart investment based on big data
  - • Smart tolls that reduce congestion and accidents
  - • Smart toll gate with ETC basically
  - • Smart logistics that improve productivity

VICS: Vehicle Information and Communication System
1.2. Overview of ETC2.0 system

**V2I Communication**

- **Roadside units (RSU)**
  - Expressways: 1,700 +
  - National Highways directly administered: 1,900 +

- **On-board units (OBU)**
  - 2+ million

**Basic Information Provision**

- **Congestion Avoidance**
  - Wide-area traffic information
  - Beware of rear-end collisions.
  - Snow on the road, ahead.

- **Safe Driving Support**
  - Warning of accident-prone locations, Warning of dangerous situations (e.g. congestion around blind curves)

**Vehicle**

- ETC 2.0 compatible navigation system

**Road**

- ETC 2.0 on-board unit

**Roadside unit**

- 5.8GHz DSRC (Active)
1.3. Probe data collection

- Probe data is accumulated in on-board units and collected when vehicles pass under roadside units.

Data collected

- **Travel Record**: Time, Positional data, Speed, etc.
  → Recorded at every 200 m of driving distance or when the direction of travel has changed 45°.

- **Behavior Record**: Time, Acceleration, etc.
  → Recorded when acceleration is 0.25 G or more.
1.4. Various Applications

(1) Smart investment based on “big data” (community roads)

- View is obstructed by plant
- Hazardous short cut

(2) Smart Tolls (Phased Revision of Toll System in Tokyo Metropolitan Area)

- Changes depending on congestion status

(3) Service improvement using ETC 2.0

- To use nearby facilities without additional toll.

(4) Highly productive “smart” logistics

- ETC 2.0 probe data helps to improve the productivity of logistics operations.

(5) Map of passable routes after disasters

(6) V2I communications to support automated driving

- GPS
- 17:30 - 18:40
2. “NEXT-GENERATION C-ITS” (cooperative)
2.1. Concept of next-generation C-ITS

- enable vehicles and road administrators to share data and fill in the gaps with their information.

Safer and more convenient automated driving

Look ahead information (congestion, accidents, obstacles, etc.)

More efficient road management
- More various Information

Probe data, road work schedule, traffic regulations, etc.

Information for road management (abnormal weather conditions, obstacles, pavement damage etc.)
2.2.1. Public–Private Joint Research Project (1)

**Phase 1: to create a common understanding on overview of C-ITS**
- Period: September 2012 - December 2013
- Investigated architecture and systems used in C-ITS
- Investigated C-ITS concepts using the architecture
  - Selected 196 C-ITS services
  - Selected 35 services prioritized for more detailed examination

**Phase 2: to narrow down the scope for realizing automated driving**
- Period: April 2015 - March 2017
- Investigated the practical use of C-ITS based on the results of Phase 1
  - The four services are examined (requirements and definitions) by focusing on automated driving on expressways:
    1. “Look ahead information provision service"
    2. “Merging support service”
    3. “Diversing support service”
    4. “Wrong-way prevention service”
### 2.2.2. Participants in joint research

- **17 participants in Phase 2**

<table>
<thead>
<tr>
<th>Category</th>
<th>TOYOTA</th>
<th>NISSAN</th>
<th>HONDA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Automobile manufacturers (3)</strong></td>
<td>TOYOTA MOTOR CORPORATION</td>
<td>HONDA</td>
<td></td>
</tr>
<tr>
<td><strong>Electronic equipment manufacturers (6)</strong></td>
<td>OKI</td>
<td>DENSO Hitachi Kokusai Electric</td>
<td>NEC</td>
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<tr>
<td><strong>Map companies (2)</strong></td>
<td>ZENRIN</td>
<td>DRM</td>
<td></td>
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<tr>
<td><strong>Road administrators (3)</strong></td>
<td>NELIM</td>
<td>NEXCO East</td>
<td>NEXCO Central</td>
</tr>
<tr>
<td><strong>Other (3)</strong></td>
<td>JARTIC</td>
<td>HIDO</td>
<td>Pacific Consultants</td>
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</table>
Autonomous cars cannot go independently through merging sections or when there are obstacles ahead.

V2I communication will improve automated driving to higher stage for safe and comfortable driving.

Difficult situation for autonomous cars

- Merging locations
  - Traffic status on the main road is unknown, so unable to merge safely and smoothly.

- Obstacles on road
  - Unable to detect obstacles until just before reaching them, so there is no time to change lanes safely.

Merging support started in Dec 2017.

- Merging support
- Look ahead information provision
- Advanced road management using vehicles’ data
Providing traffic conditions on mainline helps drivers and AD vehicles merge smoothly.
2.4.2. Look Ahead Information (LAI) Provision Service

LAI* helps drivers or AD vehicles take safer maneuver.

* LAI (Look Ahead Information): Information of anticipated events which can’t be detected by on-board-sensors.
Vehicle data, such as brake and turn signal operation, can enhance road management. Ex. Early detection and quick response
3. LOW SPEED AUTOMATED DRIVING (LSAD) SERVICES IN RURAL MOUNTAINOUS AREAS
3.1. Issues in rural mountainous areas

- It gets difficult to maintain daily-life services.

**Rapidly aging population**
Ratio of the population over 65 years old to the total population (2010)

- *Japan:* 23%
- *rural mountainous areas:* 31%

**Abolishment of public transport to go shopping and/or to clinics**
Length of bus routes abolished

- Total 13,108km (2009)

**Rapid increase of elderly people who cannot drive**
Number of returned driving licenses from people over 65 years old

- Approx. 330,000
- 17 times

**Shortage of truck drivers who deliver goods**
Age group of truck drivers

- About 40% of truck drivers are over 50 years old.
3.2. Automated driving services in rural area

- expected for ensuring both people’s daily transport and maintain the flow of goods, and further local revitalization.
- A series of pilot project with autonomous cars was started in 2017.

- V2I Cooperation will be considered as well (e.g. guide cables)
3.3. Test sites

Community centers ("Michi-no-Eki"s)

- designated by MLIT for technical verification
- designated by public offer for business model

Feasibility Study
### 3.4. Test vehicles

<table>
<thead>
<tr>
<th>Bus type</th>
<th>Passenger-car type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1) DeNA Co., Ltd.</strong></td>
<td><strong>3) Yamaha Motor Co., Ltd.</strong></td>
</tr>
<tr>
<td><img src="image1.jpg" alt="DeNA Co., Ltd." /></td>
<td><img src="image2.jpg" alt="Yamaha Motor Co., Ltd." /></td>
</tr>
<tr>
<td><strong>Autonomous technology</strong></td>
<td><strong>V2I technology</strong></td>
</tr>
<tr>
<td>• Identify own position by GPS and IMU.</td>
<td>• Drive a predetermined route by following embedded magnetic-induction lines.</td>
</tr>
<tr>
<td>• Drive according to a predetermined route.</td>
<td>Capacity:  <strong>Approx. 4–6 people</strong></td>
</tr>
<tr>
<td>• Acquire point-group data.</td>
<td>Speed: Automated:  <strong>Approx. 12km/h</strong></td>
</tr>
<tr>
<td>Capacity: <strong>6 people (seated)</strong> (Total 10 people seated and standing)</td>
<td>Manual: &lt;20km/h</td>
</tr>
<tr>
<td>Speed: <strong>Approx. 10km/h</strong> (Max: 40km/h)</td>
<td></td>
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| **2) Advanced Smart Mobility Co., Ltd.**      | **4) Aisan Technology Co., Ltd.**                        |
| ![Advanced Smart Mobility Co., Ltd.](image3.jpg) | ![Aisan Technology Co., Ltd.](image4.jpg)               |
| **V2I technology**                            | **Autonomous technology**                                |
| • Identify own position and drive a predetermined route using GPS, magnetic markers and gyro sensors. | • Drive a predetermined route using a high-precision 3D map. |
| Capacity: **20 people**                        | • Detect surrounding conditions by LIDAR.                |
| Speed: **Approx. 35km/h** (Max: 40km/h)        | Capacity: **4 people**                                    |

GPS: Global Positioning System
IMU: Inertial Measurement Unit
LIDAR: Light/Laser Imaging Detection and Ranging

*Note: Vehicle speed responds to the posted speed limit of each road.*
3.5. V2I cooperation technologies for rural areas

Environmental condition is severe in rural area. e.g. AD vehicle cannot catch GPS signal due to forest. Performance of Lidar sensors decrease in snowy condition.

Some of the AD vehicle providers use low-tech but robust technology against severe weather, so that vehicles can identify their own location accurately.

**Magnetic markers** *(Advanced Smart Mobility Co., Ltd)*

**Magnetic-induction lines** *(Yamaha Motor Co., Ltd.)*

You can see this technology in Japan booth!!
### 3.6. Evaluation viewpoint

<table>
<thead>
<tr>
<th>1) Roads and traffic</th>
<th>2) Environmental conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Road structure (Straightness, grade, etc.)</td>
<td>1) Weather conditions (rain, snow, etc.)</td>
</tr>
<tr>
<td>2) Road management (demarcation lines, planted trees, etc.)</td>
<td>2) Communication conditions (GPS reception)</td>
</tr>
<tr>
<td>3) Support for mixed traffic</td>
<td>4) Public acceptance</td>
</tr>
<tr>
<td>4) Space required</td>
<td>5) Beneficial effects on regions</td>
</tr>
</tbody>
</table>

#### 3) Costs
- e.g., Installation magnetic induction lines
- 1) Costs for vehicles
- 2) Costs for others

#### 4) Public acceptance
- 1) Comfort (speed, psychological impact, etc.)
- 2) Convenience (routes, frequency of service, etc.)

#### 5) Beneficial effects on regions
- e.g., Combined transport of passengers and cargo
- 1) Opportunity for elderly to go out
- 2) Collection and shipping of agricultural produce, etc.
Some of the issues to be solved

Speed difference btw. AD vehicles and normal vehicles

On-board-camera view of an AD

Poor maintenance of rural road

On-board-camera view of an AD

Following vehicle overtook AD vehicle in “No overtaking” section.

Appropriate passing place should be provided.

Roadside bushes are detected as obstacles on the route.

Appropriate maintenance level should be considered.
Summary and Future Works

1. ETC2.0 system
   • Enrich its services with an increase of data

2. “Next-generation C-ITS”
   • Discussion about more concrete data requirements and methodologies for Look Ahead Information Provision Service and Merging Support Service

3. Low Speed Automated Driving (LSAD) Services in Rural and Mountainous Areas
   • FOTs and its evaluation from technical viewpoints for installing LSAD services in rural areas

Thank you for your attention!