a Korea’s Test-bed for Automated Vehicles: Focusing on the facilities and test scenarios

July 11, 2017

Speaker: Dr. Taehyung Kim, Research Fellow at KOTI

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2) Chief Director of the National Transport Technology R&D Center, The Korea Transport Institute
3) Chief Director of the Automated Vehicle Center, Korea Automobile Testing & Research Institute
# Overview of the K-City R&D Project

**Title:** Development of technologies for assessing the safety of Autonomous Vehicles

<table>
<thead>
<tr>
<th>Objective</th>
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<tr>
<td>To establish technologies for assessing safety and to establish verification facilities for ensuring safety of Autonomous Vehicles</td>
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<table>
<thead>
<tr>
<th>Project overview</th>
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<tbody>
<tr>
<td>• Study period: 2016. 6. 29 - 2018. 12. 31 (2 years and 6 months)</td>
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<tr>
<td>• Total study cost: 17.4 M Dollars</td>
</tr>
<tr>
<td>• Participants: 15 public &amp; private organizations including KATECH, KOTI, Seoul National University, MOBIS, and SKT, etc.</td>
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Overview of the K-City R&D Project

**Test bed development**
- Insufficient research infrastructure with Level 2 test environment
- Unital and limited test environment
- Using test roads for individual performance

**Safety test technology**
- Test criteria of Level s 0 to 1 ADAS technology
  *ABS, ESC, BAS, FCW, LDW, ACC, AEB, BSD, LKAS, etc.*
- Concern for accidents caused by system failure, unexpected situations, and road conditions

**Provision of infrastructure**
- Improved research capabilities by developing Level 3 test environment
- Autonomous driving through integrated technology tests
- Development of dedicated autonomous driving experiment city (K-City)

**Test criteria of Level s2 to 3 autonomous driving technology**
*LGS+ACC, PAS, V/Parking, T/J/Assist, H/pilot, etc.*
- Reliability through verification
- Improved safety against failures and dangerous situations

Dr. Jaehyun (Jason) So | The Korea Transport Institute | July 11, 2017
K-City Design and Establishment

**Motorway**
Dedicated road for high-speed driving

**Urban area**
Environment of urban-center road traffic

**Community / autonomous parking**
Pedestrian-centric road and parking facilities.

**Rural road**
Rural road where infrastructure is insufficient
### Evaluation Scenarios Development - Motorway

#### Scenarios

<table>
<thead>
<tr>
<th>Location</th>
<th>Maneuver</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Mainline</td>
<td>Normal Decel.</td>
<td>Normal deceleration by speed limit change</td>
</tr>
<tr>
<td>Mainline</td>
<td>Normal Accel.</td>
<td>Normal acceleration by speed limit change</td>
</tr>
<tr>
<td>Mainline</td>
<td>Normal Takeover</td>
<td>Takeover due to a leading-crawling vehicle or any recognized obstacle</td>
</tr>
<tr>
<td>Mainline</td>
<td>Sudden Decel.</td>
<td>Sudden deceleration after incident recognition</td>
</tr>
<tr>
<td>Mainline</td>
<td>Sudden Decel. &amp; LC</td>
<td>Sudden deceleration and lane-change after incident recognition</td>
</tr>
<tr>
<td>Weaving</td>
<td>Merging</td>
<td>Merging to a mainline</td>
</tr>
<tr>
<td>Weaving</td>
<td>Diverging</td>
<td>Diverging from a mainline</td>
</tr>
<tr>
<td>Weaving</td>
<td>Merging &amp; Diverging</td>
<td>Weaving by merging-and diverging vehicles</td>
</tr>
<tr>
<td>Toll-lanes</td>
<td>Normal Decel. &amp; LC</td>
<td>Normal deceleration and lane-change to enter a toll gate</td>
</tr>
<tr>
<td>Toll-lanes</td>
<td>Normal Accel. &amp; LC</td>
<td>Normal acceleration and lane-change after a toll gate</td>
</tr>
</tbody>
</table>

**Normal deceleration by speed limit change**

![Diagram of normal deceleration by speed limit change]

**Weaving by merging-and diverging vehicles**

![Diagram of weaving by merging-and diverging vehicles]

**Deceleration and lane-change on toll-lanes**

![Diagram of deceleration and lane-change on toll-lanes]
Future Plans

Construction of road sections
- K-City fully opens in December 2018 (Motorway section opening in October 2017)
- K-City is the largest test-bed for automated vehicles - 320,000 m².
- Motorway, urban roadway, community roads, rural road

Development of evaluation scenarios
- Motorway test scenarios: developed in 2016 (Completed)
- Scenarios for the other road sections: will be developed in December 2017

Acquisition of AV
- 6 AVs will be delivered through the study period.

Safety assessment technologies
- Under investigation, and will be completed in December 2017.
This research was supported by a grant (No. 17TLRP-B117133-02) from transportation logistics research program funded by Ministry of Land, Infrastructure and Transport of Korean government.

Thank you.

KOTI enriches the future by securing harmony among people, the environment and transport

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## Cases of Autonomous Vehicle test beds

<table>
<thead>
<tr>
<th></th>
<th>M-City (USA)</th>
<th>MIRA City Circuit (UK)</th>
<th>J-Town (Japan)</th>
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<tbody>
<tr>
<td><strong>Established in</strong></td>
<td>2015.7</td>
<td>2009</td>
<td>2017.4</td>
</tr>
<tr>
<td><strong>Operated by</strong></td>
<td>Michigan University</td>
<td>HORIBA MIRA</td>
<td>Japan Automotive Research Institute (JARI)</td>
</tr>
<tr>
<td><strong>Establishment cost</strong></td>
<td>Approximately KRW 13.2 billion</td>
<td>-</td>
<td>Approximately KRW 37.2 billion</td>
</tr>
<tr>
<td><strong>Area</strong></td>
<td>130,000㎡</td>
<td>240,000㎡</td>
<td>150,000㎡</td>
</tr>
</tbody>
</table>
| **Characteristics**  | - Test bed established on campus  
- Various assessment environment realized  
  - Urban, and suburbs areas realized  
- **Differentiated membership**  
  - Leadership circle  
  \( 16 \) members including LG Electronics  
  - Affiliate membership  
  \( 52 \) members including Mobis  
- **Evaluation of communications dead spots through operating communication dead spot control facilities (S/S) (structure not installed)**  
- Central-controlled P.G. Management System  
- Precision video-taking and analysis of car driving with 3D motion-capture cameras  
- Adverse, urban, and multi-purpose testing environment created  
  - Adverse environment tests: Testing for bad weather and lighting condition  
  - Urban environment tests: Testing for signal verification/identification, and recognition by others  
- Multi-purpose test: Testing for lane-keeping performance, and cross-road running |
| **Overview**         | ![M-City (USA)](image1) | ![MIRA City Circuit (UK)](image2) | ![J-Town (Japan)](image3) |
Iowa Automated Vehicle Proving Ground (Iowa AVPG)

Daniel McGehee, Director, University of Iowa
Omar Ahmad, Deputy Director, University of Iowa
Ashley McDonald, Project Manager, University of Iowa

Tom Banta, Iowa City Area Development Group

July 11, 2017

Session: CAV Testing Facilities Showcase at Automated Vehicles Symposium
University of Iowa: Rich History and Experience

Full Suite of Research Vehicles and Instrumented Vehicles

AV Virtual Testing Ground – Springfield, USA

285 Square miles
A Collaboration Between...

Iowa Automated Vehicle Proving Grounds
Why are we doing this?

**Connected and Automated Vehicles**

**Improve Safety**
- Reduce crashes using higher levels of automation/control
- Improve roadway utilization and efficiency

**Broaden Mobility**
- Increase transportation options
- Connect rural communities to urban centers

**Enhance Movement of Goods**
- Improve efficiency
- Increase competitiveness of agricultural and commercial trucking sectors
- Grow the economic base
Our Guiding Principles: address the 94% of car crashes caused by human error
Moving Forward

2017
- Engaging with Proving Ground Stakeholders
- High level visioning of our Proving Ground
- Iowa DOT AV Hazard Alert Demonstration

2018
- Iowa DOT AV High Definition Map Vehicle Demonstration

2019
- Exploring opportunities in the rural landscape
  - Stopped school buses
  - Slow moving tractors
Florida’s CAV Initiatives

Michael Shannon, P.E.
Director of Transportation Development
Florida’s Turnpike Enterprise
Central Florida AV Partnership

Simulation and Testing

Controlled Environments

Open Environments
Designed for Evolution

**SunTrax**

*Infrastructure*  
Rich Facility

*Reconfigurable Environments*

*Supply-Chain Logistics*

**Infield Concept**

- **Land Use**
  - Urban & Community Simulation Zone 57 ACRES
  - Dynamic Pad Network & Virtual Simulation 54 ACRES
  - Straight Track & Warehousing 16 ACRES
  - Admin Centers, Shared Services & Environmental Testing 40 ACRES

**Florida Department of Transportation**
Other Initiatives

- AV/CV Impacts on Traditional Planning
- Infrastructure Innovations
- Corridor of the Future

- 483 Mile Toll Facility
- 143 Mile Pilot Project
  - Tandem Trailers
  - 3 Service Plazas
  - 17 interchanges
Questions?

MICHAEL SHANNON, P.E.
Director of Transportation Development
Florida’s Turnpike Enterprise

Michael.Shannon@dot.state.fl.us  407-264-3628
Breakout Session # 12 Testing Connected and Automated Vehicles

Summary of Key Findings and Lessons Learned

- CAV testing is necessary, global, and all encompassing
- It cannot be "done" or solved by one company or team, or at one site or simulation
- There is great potential in testing collaboration
- We recognize strong interest in this critical aspect of CAV
Breakout Session # 12 Testing Connected and Automated Vehicles

**Recommended Action Items**

- Focus on unifying goal of SAFETY
- Define roles to facilitate collaboration
- Look for opportunities to share
  - Integrated Data Exchange
  - near crash data
  - crash data
- Draft Global Test Bed Collaboration Plan