5G Communication based Automated Vehicle Test-bed

K-City
01 Overview of K-City

Location of KATRI

Located at the Automated Vehicle R&D center of Korea

- Permanent-standing companies (6)
  : GM Korea, Ssangyong Motors, Renault Samsung, Mando, Bosch Korea, and Jatco

- Annually, the cars are jointly used by 88 organizations (in 2017)
  including Manufactures, research institutes, IT, Commutation company, and universities.
Overview of K-City

Proving Ground
Advanced tracks

Test track layout features
- Natural drain through existing reservoir
- Maintain original topography
- Increase Vehicle safety & Minimize R&D test track
- Easy access to every track (close entrance)
- Maximize efficiency of Test facility management
- Economic and easy to construct

Test Facility
10 of the Facility

- Construction Equipment
- Inspect Facility
- General Test Facility
- Environmental Test Facility
- Driving and Braking Test Facility
- Impact Test Facility
- Crash Test Facility
- Noise&EMC Test Facility
- Advanced Vehicle Test Facility
- Tire Assessment Test Facility
- Construction Equipment
- Safety Defect Test Facility

Total cost $1.242bn
Total length 28.5km
Overview of K-City

Overview of the establishment

- **(Goal)** Provision of various on-road environments (road, traffic, and communications)
  - Simulated testing of possible accidents (crashing) that may happen during the driving
    - Simulate real world and simulation to support technologies development
    - Verify safety of automated vehicles
- **(Location)** KATRI P.G. (Hwaseong City, Gyeonggi Province)
  - The area of the current ITS testing circuit is 360,000 m² out of the total area of 2,150,000 km²
- **(Budget)** Total 1.9M$ (Government 1.7M$, Private 0.2M$)
  - K-City Construction costs 1.1M$
- **(Schedule)** Aug. of ’17, Groundbreaking for K-City
  - Nov. of ‘17, Motorway Open
  - Nov of ‘18, entire sections Open

- 14 testing roads were established in the largest scale in Korea (2013)
* It is expected that the establishment schedule and cost will be saved through utilizing the existing roads and facilities.
Establishment of K-City

K-City: Test-bed for Autonomous Vehicles

Junctions and Acceleration Lanes
Test the vehicle's ability to use an acceleration lane and to join the main lane.

Building Facet
Test the impact of environmental recognition by exterior sides of a building (portable, different heights).

Main Line
Test the driving in a high-speed driving environment and the function of ADAS (Advanced Driving Assistance Systems).

Road Facilities
Test the ability to recognize road environments such as road facilities (noise barriers, guardrails, and medians).

Bus-only lane
Test a vehicle if it can recognize bus-only lanes (median and road side), and evaluate the effect of buses.

Bus and Taxi Stop
Test a vehicle whether it can manage the situation when buses and taxis stop and go.

School Zone
Test a vehicle how it can manage the collision with the pedestrian when at a school zone.

Autonomous Parking Facility
Test perpendicular/parallel angle parking modes. Evaluate the ability to stop with the lane.

Outdoor Parking Facility
Test parallel parking ability.

Roundabout
Test a vehicle's ability to recognize a roundabout, to decide priority among cars, and to cope with collisions.

Asphalt / Concrete Roads
Recognition and judgment of road environments, depending on the quality of the road surface.

Bike lane / Sidewalk
Test the conflicts between cyclists (bike lane) and pedestrians (sidewalk).

Tree-Lined Street
Test a vehicle if its recognition of environment is affected by street trees.

Unpaved road
Test the recognition and judgment of road environments, depending on unpaved road conditions.

Signalized Intersection
Test a vehicle whether it can recognize intersections, crosswalks, and traffic signals. Test the vehicle in a situation where vehicles and pedestrians collide.

Narrow Road
Test the recognition of a two-way undivided road, and road responses to traffic conflicts.

Tunnel
Test the ability to recognize the environment despite the contrast between light and darkness.
Establishment of K-City

Establishment of on-road assessment environment

- Road, traffic, and communications environment similar to the actual road conditions will be established.

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

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

**Community & Automated parking**
Pedestrian-centric road and parking facilities.

**Rural road**
rural road where infrastructure is insufficient
Establishment of K-City

- Opened at Motorway
  - (date) 17.11.07.
  - (facilities) main lane (5th lane), merging/ demerging section, guiderail, tollgate, median, sound proof wall, bus only lane (total 7 item)
Establishment of K-City

Establishment of various communications systems

- Various communications systems for 5G, 4G(LTE), WAVE, and Wi-Fi

**5G**
- Realization of ultra-high speed/large-capacity data collection

  - [Reference] 5G demonstration (KT)
  - [Reference] 5G demonstration (SK Telecom)

**4G(LTE)**
- Collection of position-based vehicle information

**WAVE**
- Provision of traffic information
- Provision of region-specific information

  - [Reference] C-ITS service (WAVE-based)

**Wi-Fi**
- Synchronization of assessment systems
- Synchronization of Automated Vehicles

  - [Reference] Communications for Automated Vehicle assessment systems (Wi-Fi)
Establishment of 5G Network and Data Support Center

- Center controls automated vehicles by means of 5G network and a vehicle-specific platform
- Its utilization will be improved in the future in linkage with the C-ITS infrastructure of the K-City

**Video wall of the automated vehicle control system**

Track and driving situation | Event and in-driving vehicle
Vehicle view info. | Driving record | Vehicle condition |
| Video call | On-vehicle camera (CCTV) | HD-Map
03 Event of related K-City & Autonomous Vehicles

(February 5, 2018) World’s first demonstration of the inter-vehicle operating technologies of automated vehicles that utilize 5G communications

- “automated vehicles make dialog with 5G technologies: They stop within 0.001 s upon the ‘child detected’ warning”
- (Key attendants) Kim Hyunmi, Minister of the Land, Infrastructure, and Transport
How to utilize the K-City

Building K-City

Safety performance assessment technologies

Test bed establishment

Utilization method

National certification facilities for Automated Vehicles
- Verification of car safety criteria
- Assessment of car safety levels
- Safety criteria harmonized with international criteria

Research infrastructure
- Utilized by manufacturers, universities, etc. in technical development
- Support for technical development utilizing the test bed

→ Preparation of various operating support methods including a K-City Partnership program.
  - Provision of opportunities to industries, research institutes, and the academia for direct utilization
  - Implementation of joint researches with industries, research institutes, and the academia