Introduction plan for implementing safety requirements of micro mobility

8 – 12 May 2017
Background

Demand for micro mobility increased due to changes in the social environment

- Small vehicle
  - Light and small vehicles accounted for 7.57%, and large vehicles accounted for 6.76% in 2014.
  - Deepening polarization of preferred cars for small and large vehicles.

- Large vehicle
  - Eco-friendly vehicle
    - Strengthen CO2 emission requirements.
    - Continuing government policies such as tax reduction on eco-friendly vehicles.

- People as City Car
  - City car emerged as a means of short-distance transportation and complementary means of public transportation.
  - Car sharing service was increased due to metropolitanization.

- Advanced vehicle
  - GM plans to develop a micro mobility with autonomous driving function.
  - Efforts of Europe, Japan, etc. to strengthen safety of micro mobility.
Research and safety requirement trend in other countries

Europe

Micro mobility which is “car-like” was classified as category L.

Vehicle regulations of L7 were strengthened to Regulation (EU) No. 168/2013” from Directive 2002/24/EC” in 2013.

EU Regulation 168/2013, safety requirements on L7 category were added and strengthened.

For example, “vehicle occupant protection” requirement was newly established and “rearward visibility” requirement was improved.

In Dec. 2016, the WP29 addressed the need to improve the safety regulations of the L7 category.

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>L7 Heavy Quadricycle</td>
<td>4 wheels, Mass ( \leq 450\text{kg} ) (transport of passengers), ( 600\text{kg} ) (transport of goods), Seating positions ( \leq 2 ), ( V_{\text{max}} \leq 90\text{km/h} ), ( P_{\text{max}} \leq 15\text{kW} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47 items for type approval.</td>
<td>This regulation was amended in Jan 2013, effective from Jan, 2017.</td>
</tr>
<tr>
<td></td>
<td>In this directive, 25 items were mandatory.</td>
<td>36 items are mandatory.</td>
</tr>
<tr>
<td></td>
<td>L6 (Light quadricycle) category is the same as L2 category requirements.</td>
<td>Safety requirements were added and strengthened.</td>
</tr>
<tr>
<td></td>
<td>L7 (Quadricycle) category is the same as L5 requirements.</td>
<td></td>
</tr>
</tbody>
</table>
Micro mobility was called as "Ultra small mobility". In several local governments, pilot projects are under progress. Through the pilot projects, the usability and safety of ultra small mobility will be evaluated.

<table>
<thead>
<tr>
<th>Kei car</th>
<th>Ultra Small Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Max. Power ≥ 15kW</td>
<td>• Included the Kei car sub-category.</td>
</tr>
<tr>
<td>• Provisions to gradually meet the regulations of category M1.</td>
<td>• Carrying out the pilot projects to evaluate the usability and safety.</td>
</tr>
<tr>
<td>• Apply the 40km/h frontal impact requirement from 1994.</td>
<td>• No safety provisions for Ultra small mobility.</td>
</tr>
<tr>
<td>• Apply the 50km/h frontal impact and side impact requirements from 1998.</td>
<td>• Ultra small mobility definition</td>
</tr>
<tr>
<td>• Kei-car accounted for 32% of the entire auto market in 2012, therefore the number of Kei car traffic accidents increased.</td>
<td>✓ Length, width, height &lt; Kei car</td>
</tr>
<tr>
<td>• Need to strengthen the Kei-car safety requirements.</td>
<td>✓ Seating positions ≤ 2</td>
</tr>
<tr>
<td>✓ Max. Power ≤ 8kW</td>
<td>✓ Max. Velocity ≤ 90km/h</td>
</tr>
<tr>
<td>✓ No roads dedicated exclusively for Ultra small mobility</td>
<td>✓ Compulsory system: Pedestrian alert system, belt, Rear view mirror, Steering wheel</td>
</tr>
</tbody>
</table>

A possible Fiat Kei-Car?

- Toyota iQ
Research outline

Selecting test vehicle
Select a test vehicle that are available in Korea

Researching regulations
Review of overseas regulations that are applicable in Korea

Testing as following regulations
Tested according to the reviewed regulations

Implementing regulations
Establish micro mobility regulations in Korea

• Passive safety test
  Seat, Safety-belt, Occupant protection, Frontal impact, etc.

• General safety test
  Protective structure, Load platform, etc.

• Active safety test
  Braking, Lamps, Steerability, etc.

• Performance test
  Battery, EMC, Fuel consumption, etc.

• Safety regulations
  Safety regulations by sector of general safety, passive safety, active safety and performance.
Selection of test vehicle

Investigation of development and sales status

- Development plan of domestic and foreign manufacturers
  - 5 OEMs: No plan except for Renault-Samsung(Twizy).
  - 6 medium-sized companies: 2 manufacturers undergoing development,
    4 manufactures considering development plan.
  - Foreign manufacturers (from KAIDA): No sales plan in Korea.
  - Foreign manufacturers’ development and sales plan (from Literature search): 15 vehicles.

- Selection of test vehicle
  - Renault “Twizy”.
  - Only Twizy is available in Korea.
  - Domestic brand vehicle will not be available within our research period.
## Regulations

### Review of EU regulations that are applicable in Korea

<table>
<thead>
<tr>
<th>Directive 2002/24/EC</th>
<th>47 items for type approval. In this Directive, 25 items were mandatory. L6 (Light quadricycle) category is the same as L2 category requirements. L7 (Quadricycle) category is the same as L5 requirements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU Reg. 168/2013</td>
<td>This regulation was amended in Jan, 2013, effective from Jan, 2017. 36 items are mandatory. Safety requirements were added and strengthened.</td>
</tr>
</tbody>
</table>

### Test item for establishing micro mobility safety regulation in Korea based on EU Reg. 168/2013

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number of item</th>
<th>Added item for strengthening safety</th>
</tr>
</thead>
</table>
| General Safety       | ◆ 6 items  
Mass and dimension, Protective structure, Fuel storage, Load platform, Devices to prevent unauthorized use, Coupling device                                                                                  | Speedometer                        |
| Active Safety        | ◆ 2 items  
Braking, Steerability                                                                                                                                                                                    | Frontal Impact, Pedestrian, Steering wheel impact, Door lock, Electrical safety |
| Passive Safety       | ◆ 4 items  
Rollover, Safety belt, Occupant Protection, Seats                                                                                                                                                        | REESS safety, QRTV                 |
| Performance          | ◆ 9 items  
Audible warning device, Glazing, Lamp, Rearward visibility, Tire, EMC, Fuel consumption, Engine power, Wipers                                                                                           |                                    |
| Total                | 21 items                                                                                                                                       | 8 items                            |
## Tests

Tests are conducted according to the reviewed EU regulation 68/2013.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Test items</th>
<th>Test results and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Safety</td>
<td>◆ 6 items&lt;br&gt;Mass and dimension, Protective structure, Fuel storage, Load platform, Devices to prevent unauthorized use, Coupling device</td>
<td>- Mass and dimension&lt;br&gt;- In case of the dimension, considering the application of light passenger vehicle regulation in KMVSS.&lt;br&gt;- For mass, gross vehicle weight 550kg including battery.&lt;br&gt;- Other items: Be able to apply of passenger vehicle(M1) regulations.</td>
</tr>
<tr>
<td>Active Safety</td>
<td>◆ 3 items&lt;br&gt;Braking, Steerability, Speedometer</td>
<td>- Braking&lt;br&gt;- Applying a form derived from two-wheeled motor vehicle braking system.&lt;br&gt;- Need to apply of secondary braking system like a M1 category braking system.&lt;br&gt;- Need to develop exclusively Micro mobility ABS.&lt;br&gt;- Steerability: Equivalent to M1 category regulations.&lt;br&gt;- Speedometer: Be able to apply passenger vehicle regulations.</td>
</tr>
<tr>
<td>Passive Safety</td>
<td>◆ 9 items&lt;br&gt;Rollover, Safety belt, Occupant Protection, Seats, Frontal impact, Pedestrian, Steering wheel impact, Door lock, Electrical safety</td>
<td>- Rollover: Apply roof crush requirement of KMVSS.&lt;br&gt;- Safety belt: Need to strengthen the applying forces.&lt;br&gt;- Occupant protection&lt;br&gt;- Similar to the requirement for checking radius of curvature.&lt;br&gt;- For other vehicles, no requirement of curvature radius in KMVSS.&lt;br&gt;- Steering wheel impact: Considering this requirement in case of non-applying frontal impact regulations.&lt;br&gt;- Pedestrian&lt;br&gt;- Expecting the high frequency of exposure to pedestrian.&lt;br&gt;- Door lock, Frontal impact and Electrical safety are not assessed yet.</td>
</tr>
</tbody>
</table>
Tests

Tests according to the reviewed EU regulation 68/2013

<table>
<thead>
<tr>
<th>Sector</th>
<th>Test items</th>
<th>Test results and remarks</th>
</tr>
</thead>
</table>
| Performance | ◆ 9 items  
Audible warning device, Glazing, Lamp, Rearward visibility, Tire, EMC, Fuel consumption, Engine power, Wipers, REESS safety, QRTV | • Lamp  
- Mandatory: Head lamps, Direction indicators, Position lamps, Stop lamps, Reversing lamps, Rear registrations plate lamps.  
- Fuel consumption  
- Need a additional research for the test cycle.  
- FTP Mode(Passenger vehicle) or WMTC mode(Two-wheeled motor cycle)  
• Wiper  
- Need the mandatory installation requirements of wiper system with compulsory side door and window pane installation requirement applied.  
• REESS safety  
- the tests carried out according to UN R.136.  
• QRTV: Be able to apply passenger vehicle(M1) regulations. |
Examples of performed test

Passive safety tests

- Pedestrian
  - Headform impact
  - Doorlock

- Occupant Protection
  - Headform impact

- Rollover
  - Before test

- Seat belt
  - Belt anchorage

Active safety tests

- Braking
  - Test equipment
  - Test result

- Steerability
  - Test equipment
  - Test result

- Speedometer

Performance tests

- Fuel consumption

- Lamp

- Rearview visibility

- Wiper

- Audible warning

- REESS

- EMC
Issues related to crash worthiness

Heat and Safety belt anchorage requirement

<table>
<thead>
<tr>
<th>Applied regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Based on EU R.168/2013 and KMVSS 97 and 103.</td>
</tr>
<tr>
<td>• The loaded force on the safety belt anchorage is stronger (about twice times) in KMVSS than EU Regulation.</td>
</tr>
<tr>
<td>Tractive force in EU R: 675 daN</td>
</tr>
<tr>
<td>Tractive force in KMVSS: 1,078 daN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performed test</th>
</tr>
</thead>
<tbody>
<tr>
<td>• First test results subject to application of the EU R. are met the requirement.</td>
</tr>
<tr>
<td>• In second test according to KMVSS, safety belt anchorages withstood.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Issue 1. <strong>Strengthened the loaded force</strong></td>
</tr>
<tr>
<td>In full frontal crash test result, the loaded force value on safety belt was about 800~900 daN.</td>
</tr>
<tr>
<td>We need to strengthen the applied load on the safety belt anchorages.</td>
</tr>
<tr>
<td>According to test results, there is no problem that the test vehicle meets the strengthened requirements from now.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implementing regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Considering the implementation of strengthened regulations in K</td>
</tr>
</tbody>
</table>
### Issues related to crash worthiness

#### Door Lock system requirement

<table>
<thead>
<tr>
<th>Applied regulations</th>
<th>Performed test</th>
<th>Test results</th>
</tr>
</thead>
</table>
| • Based on EU R.168/2013 and KMOVSS 104 (equivalent to GTR 1).  
• For evaluating the safety of door lock systems, the test procedures of KMOVSS are different from those of EU R.  
| • First test results met the requirements of EU R.  
• In second test according to KMOVSS, the door lock systems withstood the load and inertial test.  
| • Issue 1.  
**Strengthened the regulation.**  
Door lock systems are very important in vehicle accidents because the door locks will prevent passengers from being ejected from the car accident.  
According to test results, there is no problem that the test vehicles meet the strengthened requirements from now.  

#### Implementing regulations

• Considering the implementation of strengthened regulations in KMOVSS.
### Pedestrian safety

**Applied regulations**

- Based on K MVSS 102-2 (equivalent to GTR No.9) Pedestrian Protection

  - **Head Test Condition**
    - Impactor: Adult Headform(65°), Child Headform(50°)
    - Impact Speed: 35 km/h
    - Injury Criteria: ≤ HIC 1000/1700
    - Location: Worst / Typical area

- **Leg Test Condition**
  - Impactor: Flex-PLI
  - Impact Speed: 40 km/h
  - Injury Criteria
    1. ACL/PCL: ≤ 13 mm
    2. MCL: ≤ 22 mm
    3. T Bending Moment: ≤ 340 Nm
  - Location: CTR, Corner

**Performed test**

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>HIC</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WAD1900(CTR)</td>
<td>591.60</td>
<td>○</td>
</tr>
<tr>
<td>2</td>
<td>WAD1670(CTR)</td>
<td>340.98</td>
<td>○</td>
</tr>
<tr>
<td>3</td>
<td>A-plr RH</td>
<td>1712.78</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Hood Corner</td>
<td>1990.99</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>WAD 1000(CTR)</td>
<td>1307.07</td>
<td>Δ</td>
</tr>
<tr>
<td>6</td>
<td>Wiper</td>
<td>1365.93</td>
<td>Δ</td>
</tr>
<tr>
<td>7</td>
<td>A-plr LH</td>
<td>2007.53</td>
<td>X</td>
</tr>
</tbody>
</table>

**Test results**

- **Issue 1: Head form Test**
  - Not adequate Test Area, or Extremely Narrow Test Area
  - Due to the short front
  - Not effective assessment (by the current regulation)

- **Issue 2: Identification of Bumper/Hood**
  - Hard to distinguish bumper/hood
  - Due to the distinctive design (exposed tire, small front cover)
  - Not effective test area (if exemption zone is considered)

**Implementing regulations**

- Need to consider the new regulations of micro vehicles for pedestrian protection, if necessary.
## Issues related to crash worthiness

### Crash safety

**Applied regulations**

- Based on KMVSS 102, UN R.94 and UN R.95 (KMVSS 102 similar to UN R.137)
- **KMVSS 102 (Full frontal)**
  - Test speed: 48 km/h
  - Rigid barrier impact test
  - Dummy: Hybrid III 50%ile
  - Injury measurement:
    - Head, Neck, Chest, Leg
- **UN R.94 (Offset)**
  - Test speed: 56 km/h
  - 40% Offset
  - Honeycomb block impact test
  - Dummy: Hybrid III 50%ile
  - Injury measurement:
    - Head, Neck, Chest, Leg
- **UN R.95 (Side)**
  - Test speed: 50 km/h
  - Movable barrier impact test
  - Dummy: EuroSID II
  - Injury measurement:
    - Head, Chest, Pelvis

### Performed test and results

<table>
<thead>
<tr>
<th>Sector</th>
<th>Injury</th>
<th>Requirement</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Full frontal</td>
</tr>
<tr>
<td>Head</td>
<td>HIC36</td>
<td>1000</td>
<td>860</td>
</tr>
<tr>
<td></td>
<td>Acceleration</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>Shear force</td>
<td>3.1</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>Tension force</td>
<td>3.3</td>
<td>1.56</td>
</tr>
<tr>
<td></td>
<td>Moment</td>
<td>57</td>
<td>48.2</td>
</tr>
<tr>
<td>Chest</td>
<td>Deflection</td>
<td>50 / 42</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>VC</td>
<td>1.0</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Acceleration</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>T12</td>
<td>Compression force</td>
<td>2.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Moment</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Abdominal peak force</td>
<td>2.5</td>
<td>-</td>
</tr>
<tr>
<td>Pelvis</td>
<td>Pubic symphysis force</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Femur</td>
<td>Compression force</td>
<td>9.07</td>
<td>L: 3.12 / R: 4.83</td>
</tr>
<tr>
<td>Tibia</td>
<td>Compression force</td>
<td>8.0</td>
<td>L: 4.5 / R: 6.4</td>
</tr>
</tbody>
</table>
Issues related to crash worthiness

1. Head impact
   - 0ms
   - 20ms
   - 40ms
   - 60ms
   - 100ms
   - 150ms

2. Roof impact
   - 0ms
   - 56ms
   - 86ms
   - 150ms
   - 200ms

3. Seat impact
   - 0ms
   - 50ms
   - 80ms: Head contact to the roof in vehicle
   - 100ms
Comparing KATRI crash test results with 2014 EuroNCAP test results

Frontal impact test results

- Head and neck injuries of 2014 EuroNCAP are similar to 2017 KATRI test.
- In the case of chest injuries, the result of chest deflection in KATRI test improved significantly compared with those in 2014 EuroNCAP.
- Femur force value improved.

Side impact test results

- In 2017 research, dummy head contacted the roof of vehicle and HIC value exceeded 1000.
- Lower chest deflections improved significantly in 2017 KATRI research.
- But, chest acceleration results was worse.
- T1 and T12 injuries of spine in 2014 EuroNCAP were similar to those in 2017 KATRI research.

Remarks and issues

- The comparison of crash tests showed that some areas of the test vehicle in 2017 KATRI research improved over 2014 EuroNCAP.
- Based on KATRI test results Korea is considering the strengthening of crashworthiness requirements.
## Implementing regulations in Korea

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Application</th>
</tr>
</thead>
</table>
| ◆ 43 items amendment in KMVSS  
  • General safety: 20 items including mass and dimension, control and tell-tale signs, fuel storage, etc.  
  • Active safety: 3 items including braking, steerability, speedometer.  
  • Passive safety: 4 items including safety-belt, Door lock, etc.  
  • Performance: 16 items including tire, glasses, fuel consumption, lamps, etc. |

<table>
<thead>
<tr>
<th>Phase 2</th>
<th>Application</th>
</tr>
</thead>
</table>
| ◆ 4 items  
  • Frontal impact  
  • Side impact  
  • Pedestrian safety  
  • Braking(ABS) |
Thank you for your attention.