Integrated ADAS HIL System with the Combination of CarMaker and Various ADAS Test Benches

Jinjong Lee, Konrad Yu-Mi Song, Hyundai-Autron
Agenda

Part1. ADAS Sensor Fusion HILS Trend
  1.1 The trend of ADAS ECU development.
  1.2 HILS Architecture for ADAS
  1.3 Test Scenario Sync with Target Simulation
  1.4 Cutting edge target simulation

Part2. Usecase of Chassis/ADAS HILS
  2.1 Development of Chassis/ADAS HILS
  2.2 Demo Video
  2.3 Conclusion
ADAS Sensor Fusion
HILS Trend

Jinjong Lee
Principle Engineer of Automotive HILS
The trend of ADAS ECU development.

• Many OEM chooses the domain controller concept for their ADAS system development with new network Architecture.

• **ADAS Domain Control ECU** has the functionalities for sensing all data from the sensor network and request vehicle dynamic control to relevant ECUs such as EPS and ESP.

• To validate the ADAS Domain Control ECU in the virtual world, the **sensor fusion HILS** is many choices from the OEM.
How many applications with limited resource?
Smart working

Centralized Sensor Information to recognize targets
The major role of ADAS Domain Controller
General Architecture for vehicle

- Vehicle Network Architecture

Central Gateway

<table>
<thead>
<tr>
<th>POWER TRAIN</th>
<th>CHASSIS</th>
<th>ADAS</th>
<th>BODY</th>
<th>INFORTAINMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Management</td>
<td>Stability Control</td>
<td>ACC AEB</td>
<td>Body Control</td>
<td>Navi</td>
</tr>
<tr>
<td>Transmission Management</td>
<td>Steering Control</td>
<td>MFC</td>
<td>Door..</td>
<td>Cluster</td>
</tr>
<tr>
<td>CANFD</td>
<td>CANFD</td>
<td>CANFD</td>
<td>CAN</td>
<td>Ethernet</td>
</tr>
</tbody>
</table>
Understanding of integration testing

• Validate Fusion Functions with All ECUs together
HILS Architecture for AEB sensor Fusion

Sensor Fusion HILS Architecture to validate Fusion ECU specification
HILS Architecture for ADAS Domain Controller

HIL System
- PXI – VeriStand Synchronisation
  - Vehicle Model
  - Road Model
  - Driver Model
  - Traffic Model
- Signal Conditioning

Target Simulation
- Radar
- LIDAR
- Camera
- Ultrason
- Comm. V2X
- Sim. GNSS

Fusion ECU
- Fusion Functionality Validation with Chassis and ADAS ECU
- FIU
- Fusion Functionality Validation with Chassis and ADAS ECU

ISO 26262, Fault Insertion
- CAN / Flexray / LIN / etc.
- DIO
- Analog

Test Case Management
Test Scenario Sync with Target Simulation

Radar, Lidar and Camera Target Simulation over the air.
Cutting edge target simulation
Usecase of Hyundai Autron Chassis/ADAS HILS

Yu-Mi Song
Leading Research Engineer
2.1 Development of Chassis/ADAS HILS

**Hyundai-Autron Integrated Chassis/ADAS HILS**

**Components**

<table>
<thead>
<tr>
<th>No</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>HILS</td>
<td>Radar Target Simulator</td>
<td>Camera Bench</td>
<td>VSD</td>
<td>EPS Test Bench</td>
<td>GNSS Simulator</td>
</tr>
<tr>
<td>Main Function</td>
<td>Measure and Insert ECU In/Out signal</td>
<td>Generate radar signal</td>
<td>Play movie</td>
<td>Measure solenoid valve signal</td>
<td>Generate resistance force from road</td>
<td>Generate RF signal</td>
</tr>
<tr>
<td>Related ECU</td>
<td>All</td>
<td>1. Front Radar 2. Rear-Side Radar</td>
<td>CAMERA</td>
<td>ESC</td>
<td>EPS</td>
<td>Navigation</td>
</tr>
</tbody>
</table>
2.1 Development of Chassis/ADAS HILS

- Hyundai-Autron Integrated Chassis/ADAS HILS

Host PC - NI VeriStand - IPG CarMaker (Vehicle Model)  
Real-time HILS - NI PXI RT HW - IPG CarMaker (Movie etc.)

- Sensor CAN
- Vehicle CAN
- Target Vehicle Info. (Relative Speed, Distance, RCS)
- Road, Target Movie
- Sensor CAN
- GPS Coordinates (rd5)
- GPS Coordinates from rd5
- Wheel Speed, Cylinder Pressure, Valve Detect
- ESC with VSD

- EPS with Bench
- GPS Coordinates from rd5
- Steering Wheel Angle, Torque from Bench
- Hydraulics Model
- Steering Model

- RF Signal
- Navigation
- GNSS Simulator
- EPS with Bench
- ESC with VSD
- SENSOR FUSION
- RADAR Target Simulator
- RADAR
- SCREEN
2.1 Development Procedure

Development of Tool Chain

- System Definition File
  - HW/SW Configuration
- Workspace
  - Manual Test
- Diagnostic Tool
- Automation Program
  - Editor
  - Report

In/Out Signal Modeling

- Simulation Model
  - Sensor
  - Restbus Simulation
- Scaling
  - Engine Torque
- Mapping
  - CarMaker
  - Simulation Model
  - Restbus Simulation
  - CAN Message
  - ECU, Testbench

Integration

- ECU
  - RADAR
  - CAMERA
  - BRAKE
  - STEER
  - NAVIGATION
  - HMI

- Test Bench
  - RTS
  - CAMERA Bench
  - VSD
  - EPB Test Bench

Validation

- Function
  - ACC
  - LKAS
  - ABS
  - TCS
  - VDC
  - VSM
2.1.1 Development of Tool Chain

- Set up the entire tool chain for test with NI VeriStand and IPG CarMaker:
  - HW Configuration,
  - Vehicle Dynamics Model as a custom device,
  - Diagnostic Tool,
  - Test Automation.
2.1.2 In/Out Signal Modeling

- Signal Modeling for real ECUs
  - Simulation models ↔ Real ECU CAN models or HW I/O Pin

Vehicle Dynamics → Custom Device IO

Braking Model → Valve and Pump → CAN, Measure valve position → CAN,HW

Steering Model → Steering → CAN, Measure torque from Bench → CAN,HW

Sensor Model → Sensor Information → CAN Model → Target Info

Target Model → Distance, Speed → CAN Model → CRC

Road Model → Urban,Speed Limit Sign → CAN Model

Driver → Maneuver → CAN Model

Power Train → RPM, Torque,Gear → CAN Model

- CAN, HW
- ESC
- IMU
- EPS
- RTS
- SCC
- Camera
- EMS
- TCU
- SPAS
- Temp,Fuel
- Engine, CRC
- Transmission CRC
- Counter, CRC

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2.1.3 Integration

- Check the basic functions of each ECU with Test bench
  : Test the basic function and fail-safe in various driving conditions

**Manual basic function test**

- Create Test Scenario
  - Ego-vehicle Maneuver
  - Target-vehicle Maneuver
  - Road (Length, Line, Mu etc)
  - Signs (Speed limit)

- Input in driving condition
  - Switch
  - Fault (Open, Short)

- Check/Measure ECU output
  - CAN Signal
  - Analog/Digital Signal

**Test Automation Program with Script**

- Input in driving condition
  - Switch
  - Fault (Open, Short)

- Check ECU status
  - DTC
  - DTC Status
2.1.4 Scenario with Evaluation Criteria_Function

- **LKA (Lane Keeping Assist)**
  - Vehicle drives at 80kph and goes close to the right line
  - Camera requests EPS to control steering torque and Cluster to show the warning display to the driver

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Maneuver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>Vehicle Speed</td>
</tr>
<tr>
<td>Normal Surface</td>
<td>0 → 80kph</td>
</tr>
<tr>
<td>Straight</td>
<td></td>
</tr>
<tr>
<td>Dot lines</td>
<td></td>
</tr>
</tbody>
</table>

**Evaluation ECUs**: Camera, EPS, Cluster

<table>
<thead>
<tr>
<th>CAN Signal</th>
<th>HMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>LKA Active</td>
<td>DISPLAY</td>
</tr>
<tr>
<td>LKA RH Warn</td>
<td>Lane Keep Asst</td>
</tr>
<tr>
<td>LKA Request Torque</td>
<td>Lane Keep Asst</td>
</tr>
<tr>
<td>EPS Torque Active</td>
<td></td>
</tr>
</tbody>
</table>

**VEHICLE SPEED**: 80kph

**WARNING**: X

**Right Warning**
### 2.1.4 Scenario with Evaluation Criteria_FUNCTION

- **SCC (Smart Cruise Control)**
  - Ego-vehicle sets the target speed at 60kph
  - Controls the distance between Ego-vehicle and Low speed Target-vehicle in front

#### Scenario vs Maneuver

<table>
<thead>
<tr>
<th>Road</th>
<th>Ego-Vehicle Speed</th>
<th>Target-Vehicle Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Surface, Straight</td>
<td>60kph (← Set Speed)</td>
<td>30kph → 80kph</td>
</tr>
</tbody>
</table>

#### Evaluation

- **CAN Signal**
- **HMI**
  - DISPLAY
    - SET SPEED: 60kph
  - TARGET DETECT: X → O
  - DISTANCE: 4th Level

※ Evaluation ECUs: Radar, ESC, Cluster
2.2 Demo Video

- Video for Basic functions of Chassis/ADAS ECUs
  - Lane Keeping Assist, Smart Cruise Control
2.3 Conclusion

- Develop Integrated HILS for validation of ADAS Sensor-Fusion function
  - Radar, Camera, ESC, ESP, Navigation, Cluster(HMI)
  - Conduct testing distributed functions in the mass-produced vehicles with HMC

- Build-up Automated Test Tool Chain
  - HILS with NI VeriStand and IPG CarMaker
  - Test Automation developed by NI LabView

- Further Development
  - High Definition Video For The Movie
  - V2X
Thank you