Improving ECU Test Environment from the Ground Up

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Gowtham Pulikonda, Project Engineer
Aisin Technical Center of America
Body dept. ECU Systems group
Outline

- Introduction
- Background
- Approach
- Solution of Validation
- Solution of Verification
- Case Study
- Summary
We are Total Vehicle System Supplier

**Engine**
- Variable Valve Timing
- Oil / Water Pump
- Intake Manifold
- Casting parts
- Piston

**Chassis**
- Electric Tilt/Telescopic Steering Column

**Body**
- Door Components, PSD/PBD
- Sunroof
- Seat Components, Occupant Weight Sensing system
- Exterior (Door Frame, Moldings)

**Electronics**
- Height Sensor
- Smart Entry Antenna
- Seat Position Sensor
- T/M Revolution Sensor
- ABS Wheel Speed Sensor
- Advanced Driver Assist System
- OCS for Passenger Air Bag
- Memory Seat ECU

**Drivetrain**
- Automatic Transmission
- Forklift Transmission
- Manual Transmission/Transaxle
- Transfer Case
Global Supplier

Aisin Seiki

Aisin Technical Center of America

Europe
11 companies
Approx. 2,500 employees

China
37 companies
Approx. 15,700 employees

Japan
83 companies
Approx. 64,200 employees

North America
36 companies
Approx. 14,300 employees

Asia & Others
11 companies
Approx. 17,700 employees

India
8 companies

Thailand
20

South Africa**
1 company

Australia**
1 company

Brazil**
3 companies

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Background

1. Software design localization aiming to OEM satisfaction
   Quick response, Cost reduction, Delivery saving

Development V process
Background

2. Insufficient test environment with inexperienced engineers

**Validation**

- Indirect measurement data analysis
- Inefficient tuning method
  - Exported them to Excel file
  - Merged offline
  - Graphed and analyzed manually
- Insufficient number of data
  - It is difficult to judge the behavior

**Verification**

- Manual operation
  - Test script/case management
  - Maintenance of traceability

Test time consuming...
Approach from Ground Up

1. De facto Standard Tool
   ✓ Meet OEM requirements
   ✓ Support open-standard file formats
   ✓ Provide a seamless path to the next technologies such as CAN-FD

2. Rich Tool Chain
   ✓ True efficiency is not an improvement of a single tool
   ✓ How tools are combined to build a tool chain that is flexible for both technology
trends and user extensibility

3. Vendor that can provide global support
   ✓ AISIN Group is a global company that supports customers all over the world
   ✓ A tool vendor that can provide local support for all AISIN locations worldwide is a
   requirement for broad deployment of testing solutions
Growth Plan

Improving ECU Test Environment

Approach
1. De facto standard tool
2. Rich tool chain
3. Vendor that can provide global support

Aiming to acquire cutting-edge design capability

Software development

Good

Software development

Software test
(Vehicle test / HILS)

Parameter change
(Software study)

Liaison
(Specification study)

Design capability

Case of Liaison continuation
Focus on...

Euro and US OEMs

Focused area

Validation
Vehicle test

Verification
HILS test

ISO 26262 2nd edition is issued in 2018

<table>
<thead>
<tr>
<th>Test of the embedded SW</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIL environment</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>ECU network environment</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Vehicle environment</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

+: Recommended
++: Strong Recommended
Solution for Validation Issue

- Measurement
- Diagnosis
- Calibration

**CANape**
- XCP on Ethernet
- A/D
- Ram, CAN

**VECTOR VX1000**
- RAM, CAN

**CSM ADMM**
- Analog signal
- Configurated from CANape
- IP67 (Dustproof and Waterproof)

**CSM CNTMM**
- Mechanical Load Cell
- Target ECU

**ATCA**
## Improved Test Capability - CANape

<table>
<thead>
<tr>
<th>Before</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement Capability</td>
</tr>
<tr>
<td>Analog ECU outputs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog ECU outputs + Sensor Pulse (A/D) + Communication data (CAN) + ECU internal data (RAM) + Camera data (Video) + G-Sensor, Current, Force etc.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis Capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-flexible analysis No data export Visual judgement only Manual report creation</td>
</tr>
</tbody>
</table>

| + Flexible data analysis + Measured data export + Parameter calibration + Automated result judgement + Report auto generation, etc. |
Advantage of CANape: Our Experience

**Synchronization**
- All relevant data **measured at the same time** directly from the ECU RAM and external input signals.

**Noise Elimination**
- High possibility of noise generation in the analog signals, **converting it to CAN by applying the CSM modules like ADMM and CNTMM eliminates noise**.

**Make Excel Analysis Obsolete**
- The analysis of the measurement result can be done freely with **CASL (CANape Scripting Languages)**. Thus, manual analysis is no longer necessary.

**A2L file format**
- The configuration file for calibration adopts **A2L format (ASAM*¹ standard)**. This gives compatibility to all tools of the development process chain and consistency in data exchange.

*¹ Association for Standardization of Automation and Measuring Systems
Solution for Verification Issue

VECTOR > vTESTstudio
CANoe

VECTOR > VT-System (HILS)

Target ECU

Test Table Editor

Diagram Editor

Classification tree

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Classification Tree - vTESTstudio

✓ Tree structure Decision table
✓ Generate input pattern combination
Improved Test Capability - vTESTstudio

Before

- Test script coding by CAPL
- Manual traceability

After

- Create test case using **graphical** elements
- **Direct access** to VT-System environment variables
- Create **combination of test cases easily**
- Simplify **reusability**
- **Automatic bi-directional traceability** maintenance of OEM requirements, both test case and test result
Advantage of vTESTstudio: Our Experience

Test case creation
- Even with little programming skill, it is possible to create test cases and those test cases can be easily shared with others
- vTESTstudio can be used in conjunction with the conventional CAPL function

Test case management
- Data driven test executes multiple patterns by changing input data for one test script
- It is easy to maintain because the test script and input data are separated
  - Test script is created by “Test case definition” in vTESTstudio
  - Input test data is created parameter list in vTESTstudio

Traceability
- Identify relationship between OEM requirements and test cases
Traceability Overview

- REQM/TDM system
  - IBM Rational DOORS 9.6
  - Requirement file - Requirement ID
  - Test Report - Requirement ID - Test ID - Pass/Fail

- vTESTstudio
  - Test cases creation
  - Test ID creation
  - Traceability creation

- CANoe
  - Test execution
  - Report creation

- Traceability Matrix
  - Traceability Matrix - vTESTstudio
  - Requirement ID
  - Test case file
  - XML

- HILS
  - Requirement file
  - Requirement ID

- ECU
  - VT System
### Traceability Matrix - vTESTstudio

#### Requirement

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Test case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look by velocity and open</td>
<td></td>
</tr>
<tr>
<td>Look by increasing velocity</td>
<td></td>
</tr>
<tr>
<td>Lock with car moving/going forward</td>
<td></td>
</tr>
<tr>
<td>Crash detection when car is moving</td>
<td></td>
</tr>
<tr>
<td>No lock by increasing velocity</td>
<td></td>
</tr>
<tr>
<td>No lock by slowing down</td>
<td></td>
</tr>
<tr>
<td>Crash detection while engine is running</td>
<td></td>
</tr>
</tbody>
</table>

#### Coverage

<table>
<thead>
<tr>
<th>Variant Properties</th>
<th>Test Cases</th>
<th>Design Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Test cases total: 33</td>
<td>Trace items total: 5</td>
</tr>
<tr>
<td>Region</td>
<td>Test cases linked: 14</td>
<td>Trace items linked: 4</td>
</tr>
<tr>
<td>Coverage</td>
<td>Test cases not linked: 19</td>
<td>Trace items not linked: 1</td>
</tr>
<tr>
<td>Car Variant</td>
<td>Active test cases (filtered): 27</td>
<td>Design coverage of trace items: 80%</td>
</tr>
<tr>
<td>Feature_KeylessGo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feature_SmartTrunkOpener</td>
<td>not available</td>
<td></td>
</tr>
</tbody>
</table>
## Case study - Vehicle Test

**Target**: Sunroof ECU  
**Location**: Customer test track in USA and Euro

<table>
<thead>
<tr>
<th>Situation</th>
<th>Issues / Risk</th>
<th>Solution</th>
</tr>
</thead>
</table>
| ✓ Many test cases  
(Over 100 test cases in 3 days)  
✓ Customer test vehicle is shared by multiple suppliers | ✓ No time to re-test  
✓ Limited time for set up | ✓ CANape  
- Record template  
- CASL  
- Trigger setting  
- Data mining |
| ✓ Less test experience  
✓ Multiple design locations  
(USA, Japan H/Q) | ✓ Lack of measurement data  
✓ Misjudgment | ✓ Fix test equipment |
| ✓ Frequent high vibration | ✓ Fail to measure data  
✓ Safety issue | |

**The Result**: Completion of all test cases in three days with no error
CANape Screen

**Numeric window**
- RAM
- Motor current
- Motor pulse

**Calibration parameter**

**System Overview**
- Console
- GPS
- Communication bus log

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**ATCA**

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Fix Test Equipment - G-Box

Before

After

Trunk / Cargo area
$ Payback

Vehicle test cost

CANape Installation cost + 75%

Saved cost 62%/year
Test environment overview

Validation

CANape
- Measurement
- Diagnosis
- Calibration

Vector Network Interface
- CAN bus

VECTOR Base module
- POD (Plug-on-device)

VECTOR Serial cable
- JTAG cable

CSM ADMM
- Mechanical load cell

CSM CNTMM

Verification

CANoe
- CANoe.XCP
- CANoe.Diva

VECTOR Ethernet
- VT-System
  - Digital
  - General-Purpose Analog I/O
  - Stimulation
  - Load and Measurement
  - General-Purpose Relay
  - Network
  - Real-time

VT System
- CAN bus

Traceability

MDF
- Test report.xml
- Req ID file.xml

vTESTstudio

ATCA

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Next step

Euro and US OEMs

Focus area
High Efficiency

- Unit/integration test with **Continuous Integration**
- Measurement data **Cloud**

**SCM system**  **CI environment**

1. Coding
2. Check-in
3. Compiling
4. Unit test
5. Integration test

**Jenkins**

**Vector vMDM**

**Data mining**

**Integration test**

**Validation Verification**

**Unit test**

**VectorCAST**

**Compiler**
Summary

- Achieved software design localization from ground up
- Resolved issues of V&V by suitable tools with approach

For better test environment
- Priority: **1st Environment ⇒ 2nd Engineers ⇒ 3rd Processes**
- Tool has to be ‘pre-approved’ by OEMs
  - Saves project time vs New tool certification
- Should not focus on **one particular tool** improvement
- **Suitable toolchain** that Combine the strength of vTESTstudio, CANoe, CANape and VectorCAST
- **Maintain the test capability** to accommodate test technology environmental changes
3. Each tool chain, Aisin believes, that pure efficiency was an improvement of a single tool, but how tools are combined to build a toolchain is flexible with respect to both technology trends and user experience.

USP that can provide global support

The Aisin Group is a global company that supports customers all over the world. A tool vendor that can provide local support for all of its locations worldwide is a requirement for broad deployment of testing solutions. Considering these three key attributes, ATCA selected the following solutions:

- Vector measurement and calibration toolchain: CAIS with Vector VEH000 and CMTM measurement modules for the vehicle test/Calibration environment.
- Vector VTESTstudio as the requirements verification software tool and for the existing Vector Calibration test environment.

Benefits and Advantages Detailed

Measurement with CAIS and VEH000 modules

The Vector VEH000 GUI interface allows for all relevant data to be measured at the same time directly from the ECU channel and external inputs.

C. Calibration of the ECU team mentioned that the ability to collect all relevant data in a single measurement is very convenient. This provides the capability to quickly extract and analyze select outputs with ease after measurement to create the measured and validated parameter set for analysis. The need to manually export and copy measurement data for analysis in Excel has been eliminated. Analysts can perform data analysis directly on the measurement data using calculations implemented with the CAIS, supporting language in CAIS. Often the Excel spreadsheets that are difficult to debug and crash with specific test runs. Over are the errors often experienced with complex Excel calculation macros.

In order to ECU RAM (MEMORY) and CAN bus (BCD) it was necessary to synchronize with external input signals like frequency and current.

The ECU RAM and CAN bus measurement modules could solve this problem. These measurement modules have excellent flexibility and integration with CAIS. All settings of the CAIS measurement modules can be managed and applied directly in ATCA. CAN bus modules transfer sensor data to CAIS or CAN, effectively eliminating time and effort between the measurement hardware and the measurement software. The combined CAIS measurement module and CAIS measurement module provide easy access to the limited space available inside the vehicle.

O.化石 investors the ECU team says that by observing the mechanical movement is parallel using both a reference sensor connected to CAIS and synchronizing the video with the measurement data, it is possible to combine mechanical movement and software signal change as a single measurement. This combined measurement concept is very desirable when investigating unsteady system behavior. Accurate sensor data can be simultaneously and the cause of the problem can be easily identified.

Calibration with CAIS and VEH000 modules
The ECU calibration interface is configured with a 3-2-1 sequence for the ECU and software which gives compatibility to all tests of the development process chain and consistency in data exchange. The compatibility and data exchange is a top priority for working effectively with ATCA’s vehicle OEM customers.

Chapter 3: System overview
It is an advantage to have the calibration data to be shared between CAIS and VEH000 for the benefit of work with software and hardware. The software can then be used in the test environment to support the test. The CAIS has real-time collaboration and the ability to maintain the ECU response incrementally. It also allows for efficiency improvement that measured data and calculated results can be confirmed at the same time using CAIS.

Vehicle Test / Collaboration

Vehicle Test / Collaboration

CAIS

VEH000

Target ECU

Mesh

Vector VTESTstudio

Figure 5: Test environment summary

Requirements Verification

Automated ECU test were executed using the CAPL scripting language in the Vector Calibration tool. While the effective testing parameters, key change in the ECU, sensor data update cycle, CAN bus speeds, etc., were monitored using a variety of test tools.

The solution

Due to the opportunity to improve the test environment for a new development project, ATCA adopted the following:

- ECU based standard test
- Modern calibration software with support from the manufacturer, and provided a seamless path to future technologies such as Live ECUs.
Thank you for your attention