ETAS MCD Tools User Meeting - 2021.06.17

Efforts to automate a real vehicle CDM testing with INCA-FLOW

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1. Background

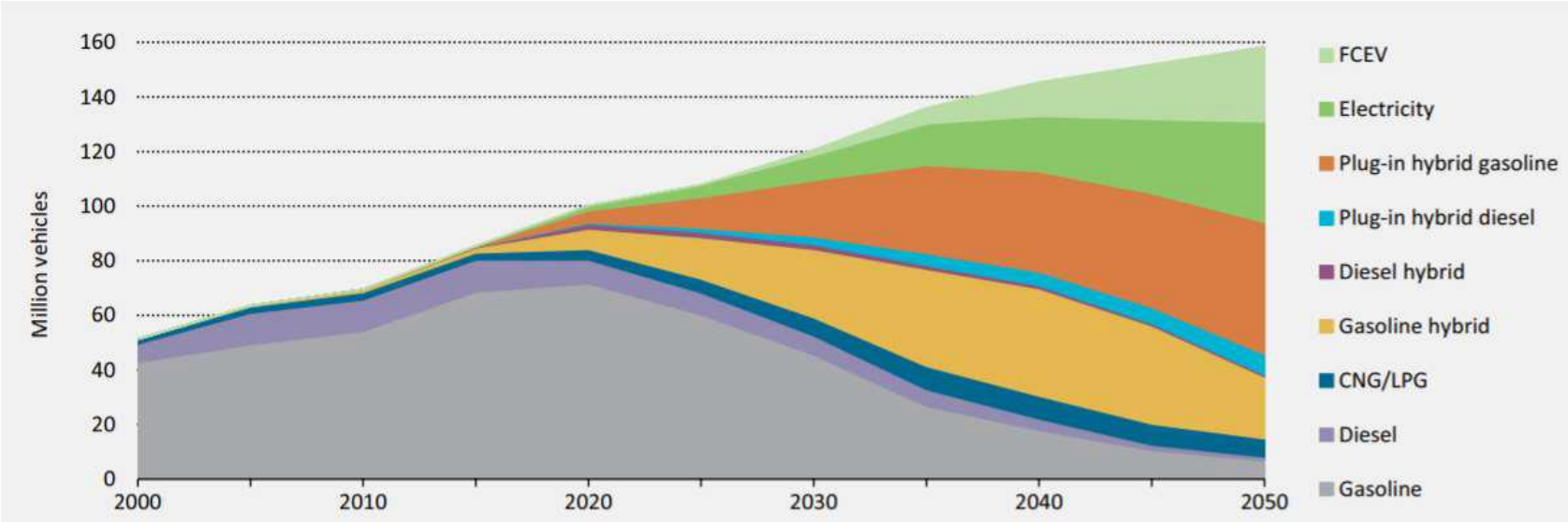
2. Sequence Construction

3. Effect Verification

4. Test Bench Linkage

Automotive Industry Status Quo

Connected **A**utonomous **S**hared&Services **E**lectric

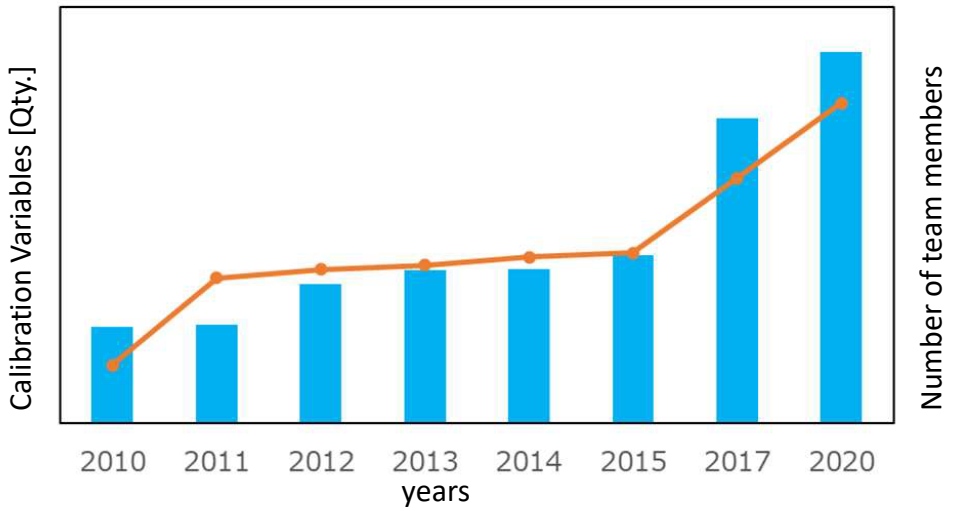


Source：IEA/ETP(Energy Technology Perspectives) 2015

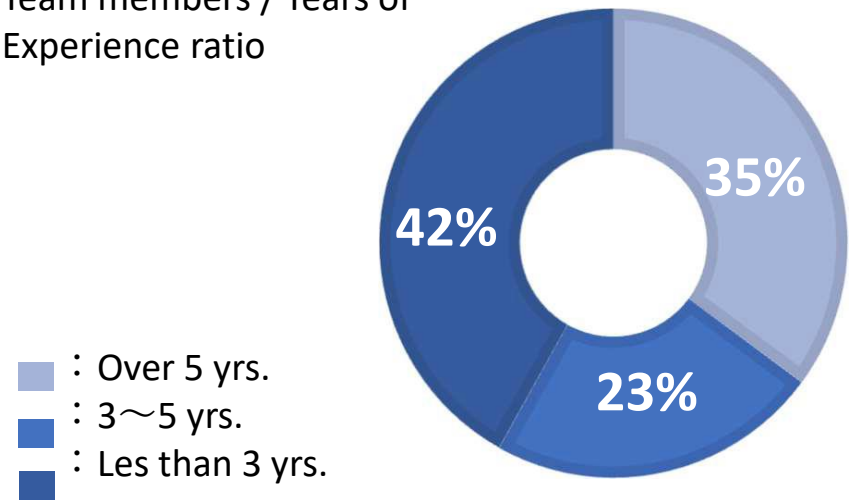
In a “Once in a Century Transformation” the shift to electrification will make unavoidable the reduction of development recourses due to decline of the Internal Combustion Engine, while the sophistication of the Engine Control will accelerate further.

SUBARU Engine Development Site

Calibration Variables / Team members



Team members / Years of Experience ratio



The increase in the calibration variables led to increase in the dedicated team members. However, many of the newly assigned members were inexperienced new employees.

New challenges:

- The test equipment / test vehicles become a bottleneck which leads to development efficiency tie.
- Test results vary widely depending on the calibration variables understanding.

Start improvement by Automation

Safe, efficient and done accurate even by new employees・・・

Would there be such a convenient test method?

Let us introduce an application that standardizes the know-how of skilled engineers and allows anyone to efficiently obtain data.
Would you like to automate your calibration process?

INCA-FLOW

Start improvement by autonomation ~ Goals setting ~

Step0

Consideration and identification of target tests that should be automated

Understanding the current situation

Step1

Anyone can achieve expert like level of accuracy and speed, while maintaining efficiency and safety.

Application in some tests

Step2

Aim for maximum efficiency and full automation.

Link to CDM

Step3

Simultaneous progress of measurement and analysis, immediately reflected in the test plan

Eliminate data loss and retesting safely without mistakes

State of progress

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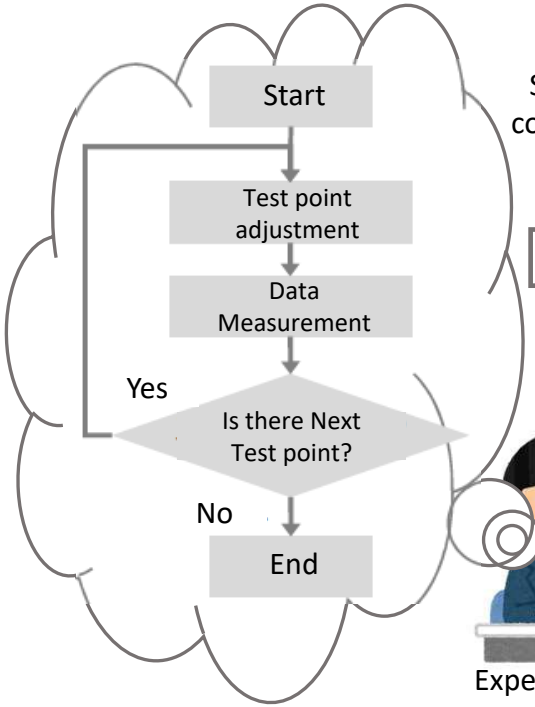
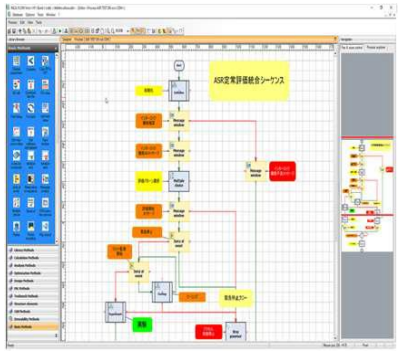
Application introduction

INCA-FLOW

- Overview: Application that can automatically execute tests using INCA by programming the operating procedure in a flowchart format.
- Functionality: Parameter monitoring, manipulation of calibration variables, start / stop of the measurement.



Sequence construction



Test sequence (executable file)

Experienced Engineer

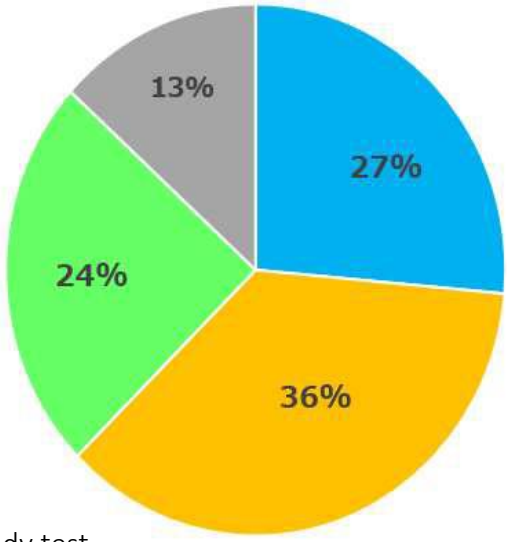
Newly appointed Engineer

Conventional Test Bench

ES59X & ES4XX

Examination of target tests for Autonomation ~ Step0 ~

Test type ratio



ASR steady test
: Constant speed test using vehicle speed control

ALR exhaust gas test

ALR driving test
: 'Real road driving' simulation test by load control

Other tests
: Idle, real road driving, etc.

Main Targets

◆ASR steady test

Characteristics:

Maintaining driving targets and continuously acquire large amounts of data

Voices from the test workshop:

- There are too many parameters to monitor and it is difficult to keep track of them all.
- The test tends to take a long time, and it is physically demanding.
- A lot of redoing due to input errors, duplication, and omission of calibration variables.

◆ALR exhaust gas ・ driving tests

Characteristics:

Add driving resistance values and obtain simulation data.

Voices from the test workshop:

- Driving results vary depending on the tester (driver).
- Mistakes such as calibration variables reflection omissions are very often.

Study of the test sequence ~Step1~

Expected characteristics of the ASR test sequence:

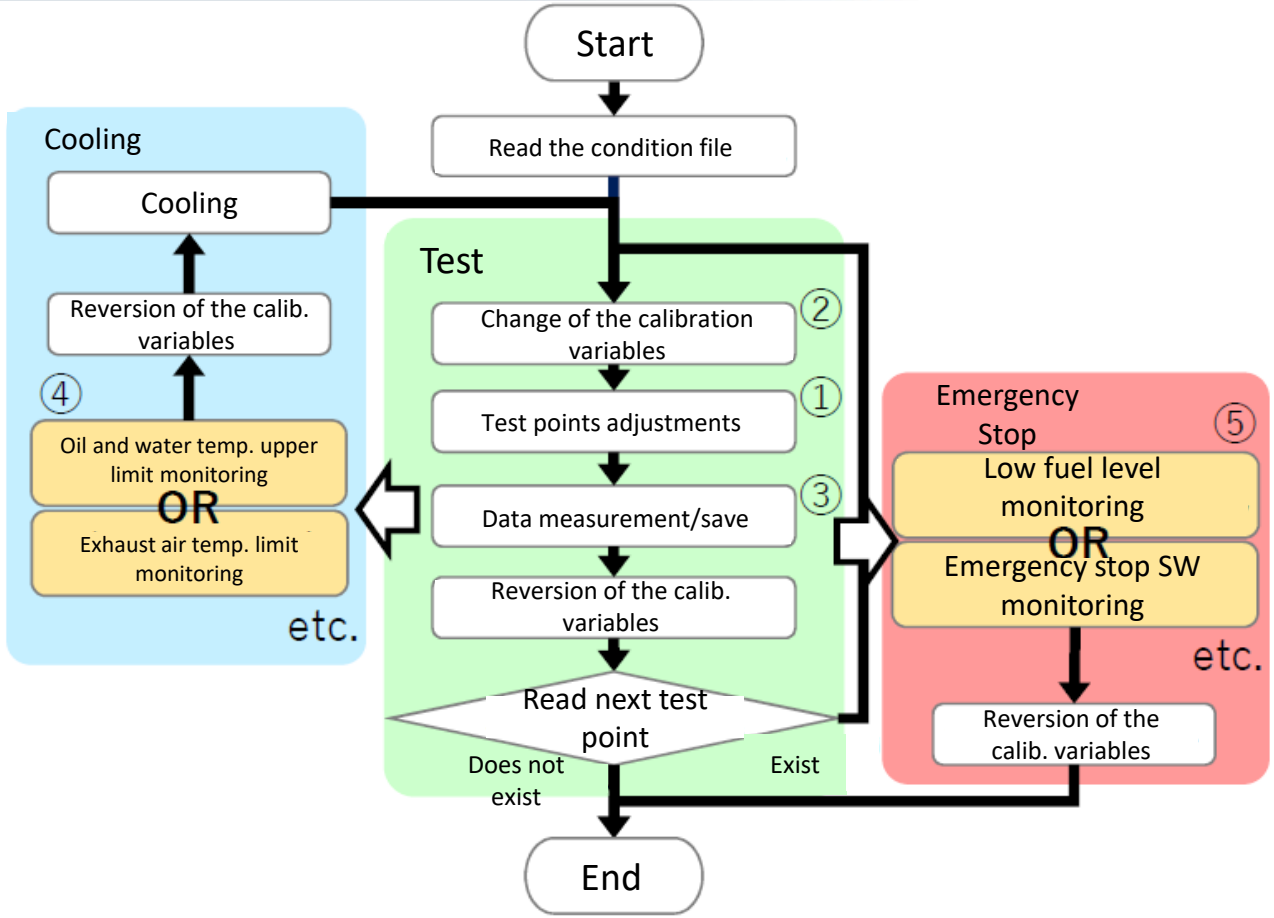
① Align and hold the test driving points

② Change the calibration variables

③ Record and save the measurement data

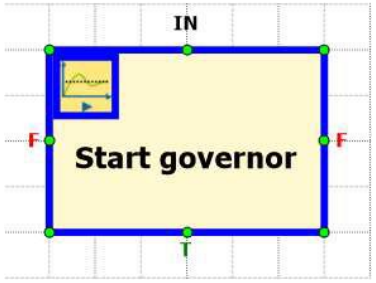
④ Constantly monitor oil water temperature, exhaust temperature, etc.

⑤ To be able to shut down at any time in case of emergency.



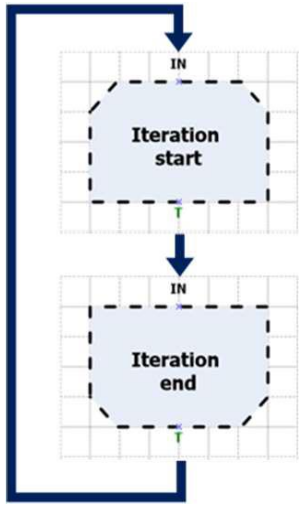
Test Point Adjustment Method

Test Phase ①



Adjust the throttle to **converge to the target test point using PID control** with the "Governor" method.

※Since this method is always active (the yellow block GUI shown), it can absorb the influence from the calibration variables set reflection impact.

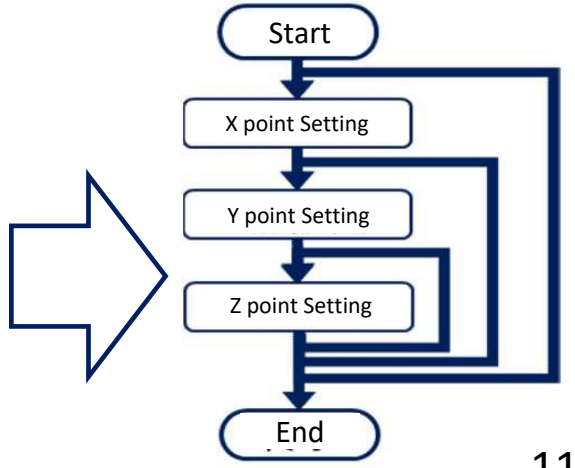


In a 3-axis loop that combines the “Iteration” method, a 3D map measurement sequence can be constructed.

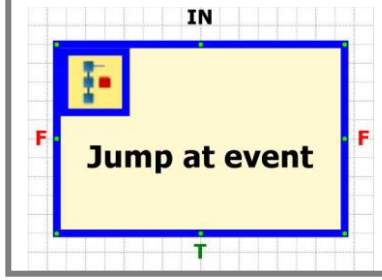
Test Point		Engine load factor (Y)		
		10	50	100
Engine rpm (X)	1000			
	2000			
	3000			
	4000			

×

Constant Set (Z)
Set①
Set②
Set③
Set④



※3-axis: Engine rpm x Load factor x Test calibration variables



Safety is the most important point of Automation

Achieve constant parallel monitoring of critical parameters by using "Jump at Event" method.

Cooling Phase ④

Operating conditions:

- When the engine oil temperature and exhaust temperature exceed the specified values
- When a gear loss is detected
- When there is no operation for a certain period of time, such as when the examiner falls asleep.

Correspondence:

- Throttle fully closed
- Stop fuel injection
- Initialization of the Test variables

Resume the Test:

- Automatic restart from the point of interruption after clearing the conditions

Emergency stop Phase ⑤

Operating conditions:

- If the vehicle speed or engine speed exceeds the specified value
- When the remaining fuel level is below the specified value
- When the examiner presses the emergency stop switch

Correspondence:

- Throttle fully closed
- Stop fuel injection
- Initialization of the Test variables
- Vehicle stop request

Resume the Test: No

Desktop check

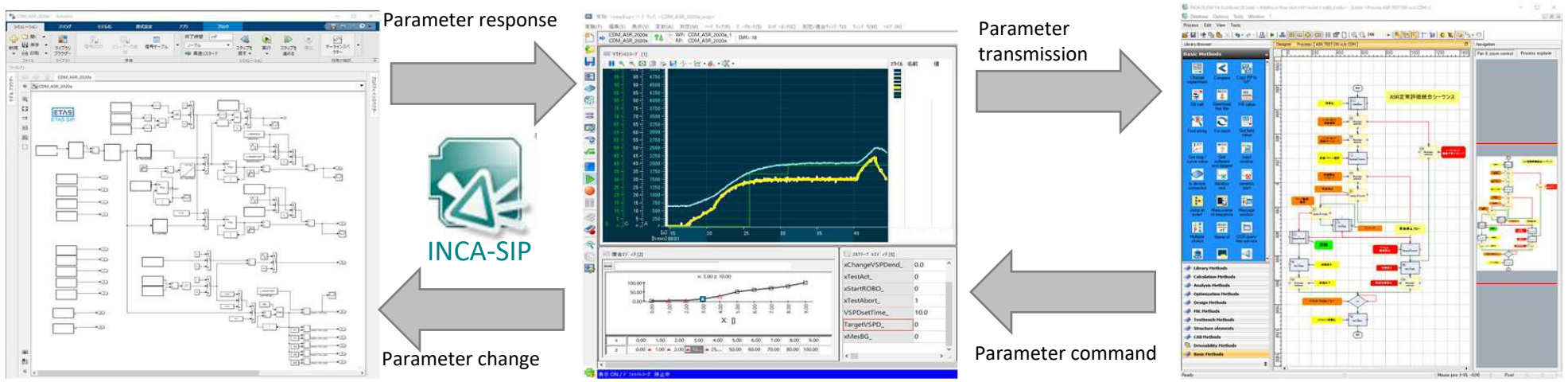
INCA-SIP

Overview: Add-on to realize measurement/calibration by linking Simulink and INCA
Function: To generate A2L/HEX from models and link INCA and Simulink by XCP communication

Simulink response model

INCA experiment monitor

INCA-FLOW



- Debugging evaluation in line with actual tests is possible by creating a simple engine model.
- It is possible to verify items that cannot be implemented from the safety aspect in the actual vehicle

(ex. Erroneous command at vehicle speed - 200km/h)

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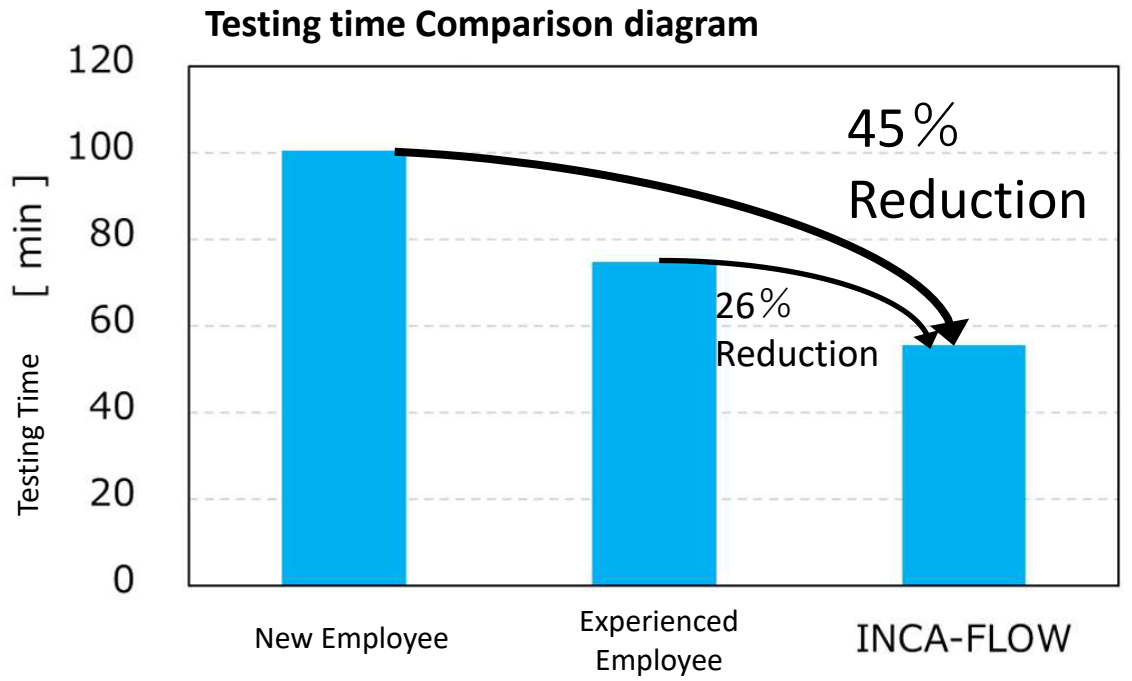
Verification of the test automation effectiveness ~Time efficiency~

Common conditions:

- Test Bench / Vehicle
- 16 measurement points
  (4 Engine speed grids x 4 Load grids)
- Cooling Start/End temperature
- Time measurement from Ready to Stop

Results:

- 26% time reduction for Experienced employees
- **45% time reduction** for New employees



The efficiency of the test automation is enormous,
and anyone can complete the test faster than an experienced employee.

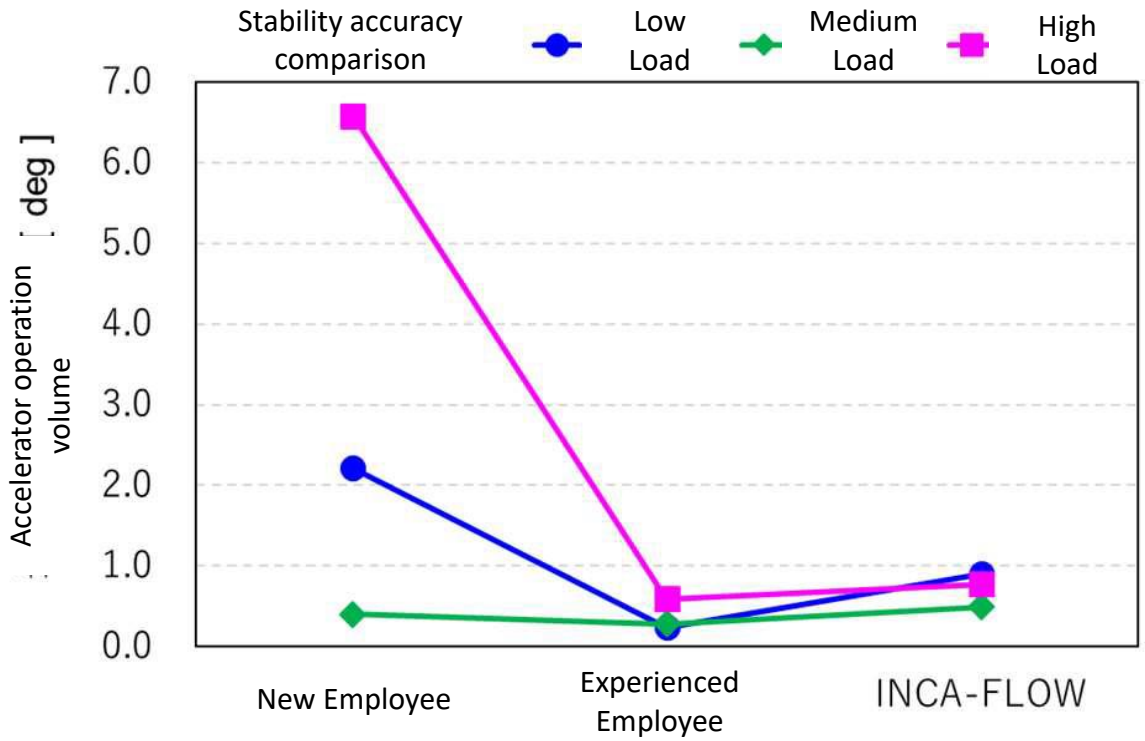
Verification of the test automation effectiveness ~Test accuracy~

Common conditions:

- Test Bench / Vehicle
- 16 measurement points
  (4 Engine speed grids x 4 Load grids)
- Cooling Start/End temperature
- Time measurement from Ready to Stop

Results:

- New employees' accelerator operation has a poor stability accuracy of steady-state operating point
- The experienced employee and INCA-FLOW have high stability accuracy regardless of the engine load



<u>High stability accuracy can be obtained in all areas (any engine load)</u>,
even though experienced employee level is not overpassed.

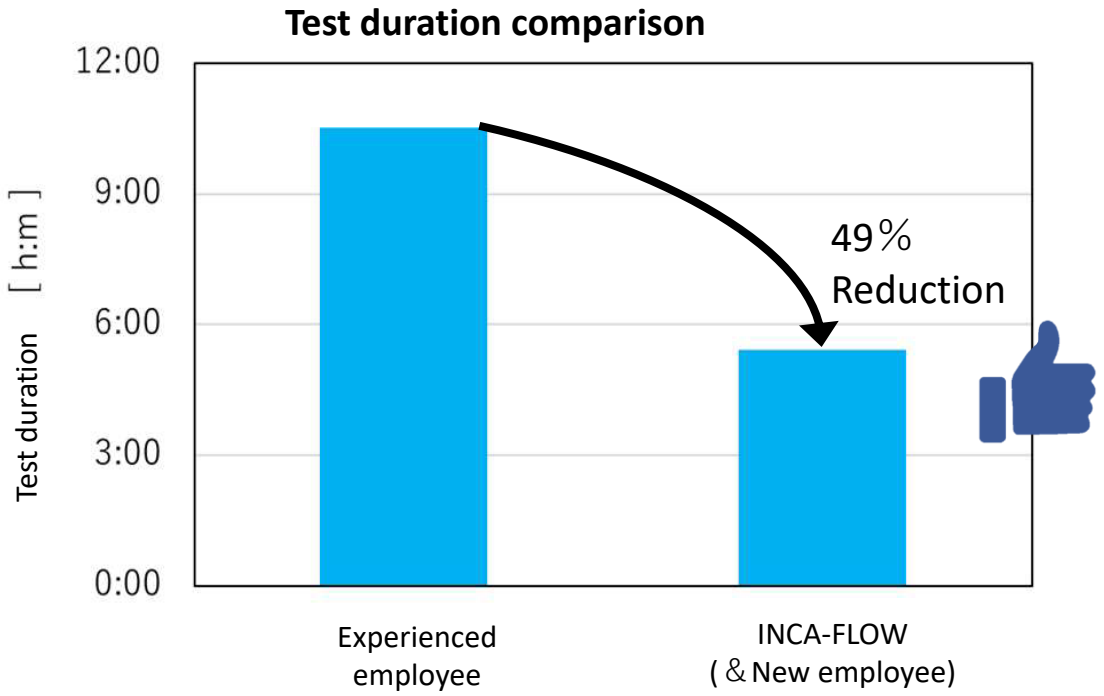
Development and introduction achievements

Test conditions:

- Test plan: 252 points + additional measurement points (9 Engine speed grids x 7 Load grids x 4 sets of variables + extra)

Results:

- Examiner operation results with INCA-FLOW
- **49% time reduction** compared to experienced employees
- Data accuracy is at a similar good level compared to experienced employee



The automation advantage is also valid at mass production development sites.
The longer the test time, the greater the advantage.

Voices from the development workshop

Positive Opinions

- To change variables and hold the test points with the accelerator, while monitoring the status, ...
  All that hard work is gone!
- Redo tests have been greatly reduced because there are no more errors in entering wrong variables or skipping test points.
- Since we need to monitor only the progress of the test, **the long tests has become much easier**

Room for improvement

- I feel uncomfortable with the mismatch between my control and the vehicle's behavior.
- It's a little scary because of the suddenness of the vehicle's movement.
- Even if I want to add test points on the spot, I can't

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Extending the scope of automation ~Step2~

If only the vehicle control is automated...

- The test can’t be terminated automatically when a Test Bench trouble occurs.
- The engine rpm, which depends on the vehicle speed, can’t be adjusted automatically.
  (The test point adjustment function up to this point is only for "engine load")

We want to automatically control the entire Test Bench

New CDM installation project:

SUBARU

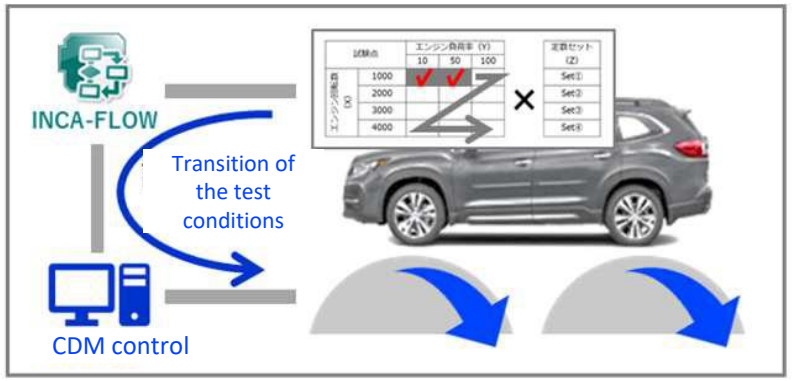
ETAS ： INCA-FLOW control construction

MEIDEN 明電舎 ： CDM control system construction

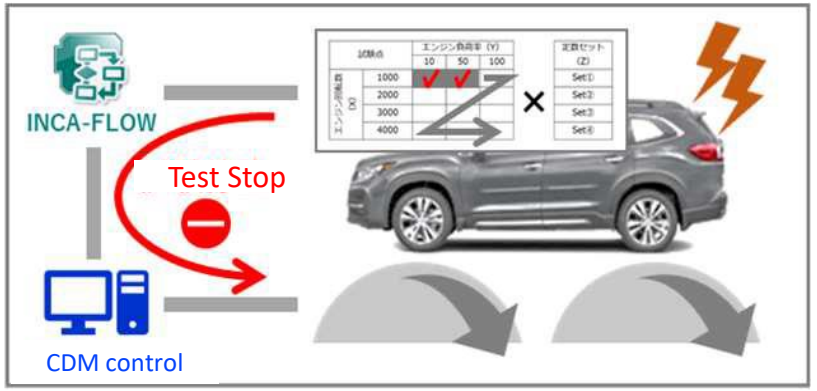
Collaboration in ASR Sequencing

Fully automated ASR testing and constant safety monitoring system in collaboration with CDM facilities

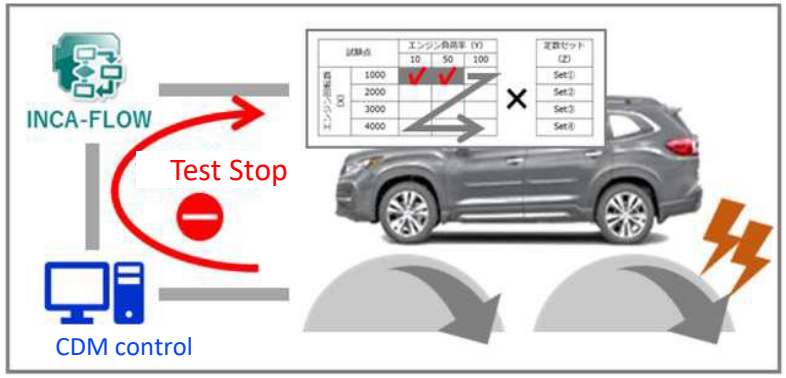
①State of CDM linkage



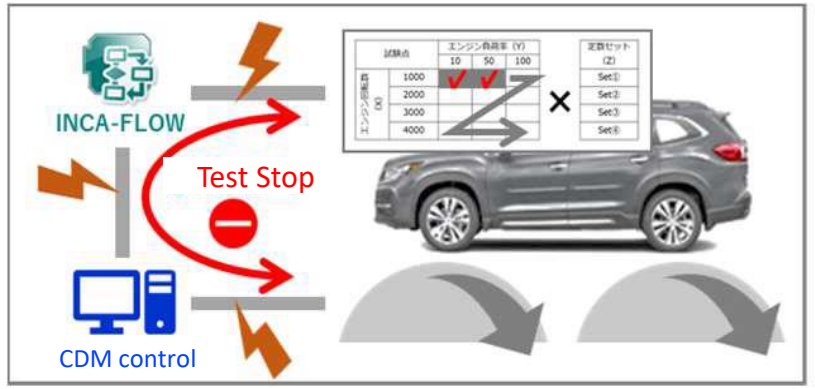
② Emergency stop in case of vehicle malfunction



③ Emergency stop in case of CDM malfunction



④ Emergency stop when communication status is abnormal



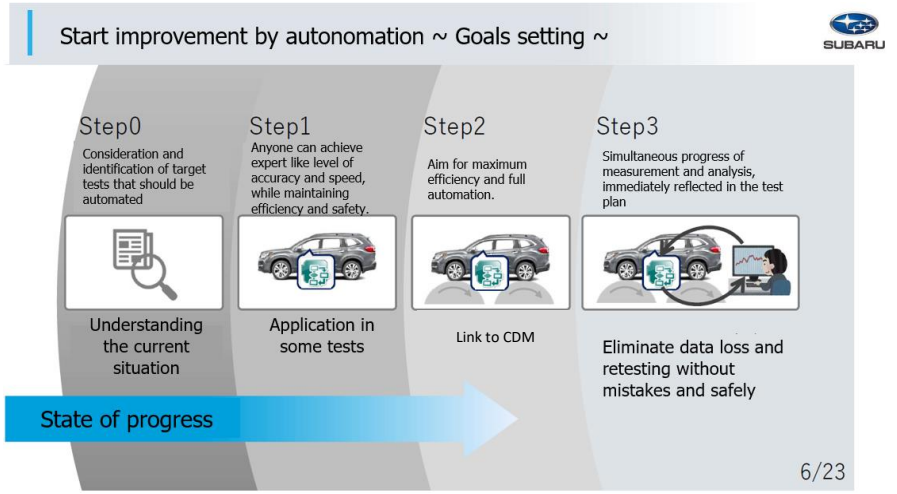
Conclusion and future plans

Step2 – current achievement status summary

- ☑ Time efficiency improvement effect by utilizing INCA-FLOW is over 40%
- ☑ Breaking away from a development style that relies solely on the know-how of experienced employees
- ☑ ASR test is fully automated by equipment collaboration
- ☐ ALR test equipment collaboration

Towards Step3

- ☐ Data measurement and analysis are performed and immediately reflected in the test plan to eliminate errors and re-tests.
- ☐ Expansion of applicable equipment – “Anywhere, Anyone”



ご静聴ありがとうございました

Thank You