eFMI® tutorial part 5 (industry case-study):

eFMI based thermal management system (TMS) development for fuel cell electric vehicles (FCEV)

Presentation by
Daeoh Kang, iVH
CEO

16th International Modelica & FMI Conference, 2025

eFMI® tutorial – Agenda

Part 1: eFMI® motivation and overview (40 min)

Part 2: Running use-case introduction (10 min)

Part 3: Hands-on in Dymola and Software Production Engineering (25 min)

Coffee break (30 min)

Part 3: Hands-on in Dymola and Software Production Engineering (30 min)

Part 4: Advanced demonstrators (20 min)

Part 5 (industry case-study): eFMI based thermal management system (TMS) development for fuel cell electric vehicles (FCEV) (20 min)

Part 6: Outlook and conclusion (5 min)

Tutorial leader:
Christoff Bürger

DASSAULT SYSTEMES

Presenter:
Daeoh Kang

iVH Institute of Vehicle Engineering

efmi Functional Mock-up Interface for embedded systems

Contents

1. Motivation

➢ Challenge for ATV(FCEV) Development

1. Temperature Range

ATV must operate reliably in extreme temperatures, including **very low temperatures (below -30°C)** and **high temperatures (above 50°C)**. This requires optimized heating and cooling systems for the fuel cell stack and vehicle components(Battery etc).

2. Altitude Variation

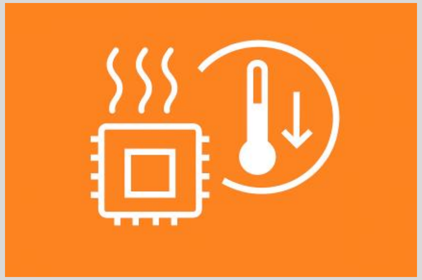
ATV should be able to drive in both high-altitude and low-altitude regions.

3. Road Conditions

ATV must drive well on **paved roads, unpaved roads, snowy surfaces, and icy roads**.

Heat Generation in FCEV Powertrain Systems During **Harsh Driving**

Necessity of a Thermal Management System (TMS)



Ensuring **Optimal Driving Performance** in FCEVs

2. Objective

- **Project Objectives:**
  1. Develop a Thermal Management System (TMS) controller to efficiently operate cooling components in hydrogen-powered light tactical vehicles.
  2. Optimize hardware and software design to meet essential control requirements such as safety, cooperative control, and reliable communication.
- **Technical Objectives:**
  1. Control the temperatures of the fuel cell stack, battery, BOP, and FDC **within ±5°C.**
  2. Maintain stable **thermal balance** under various driving conditions.
  3. Achieve a real-time control cycle of the ECU **within 10ms.**

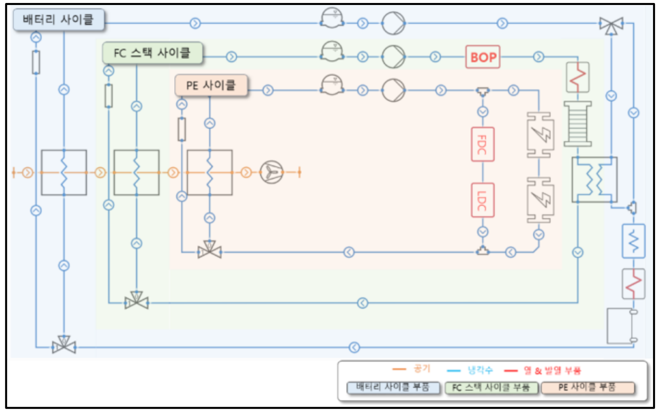
The electrification of existing internal combustion engine-based light tactical vehicles to FCEV vehicle models.

→

The thermal management of the FCEV powertrain is necessary.

→

The development of the FCEV TMS controller.

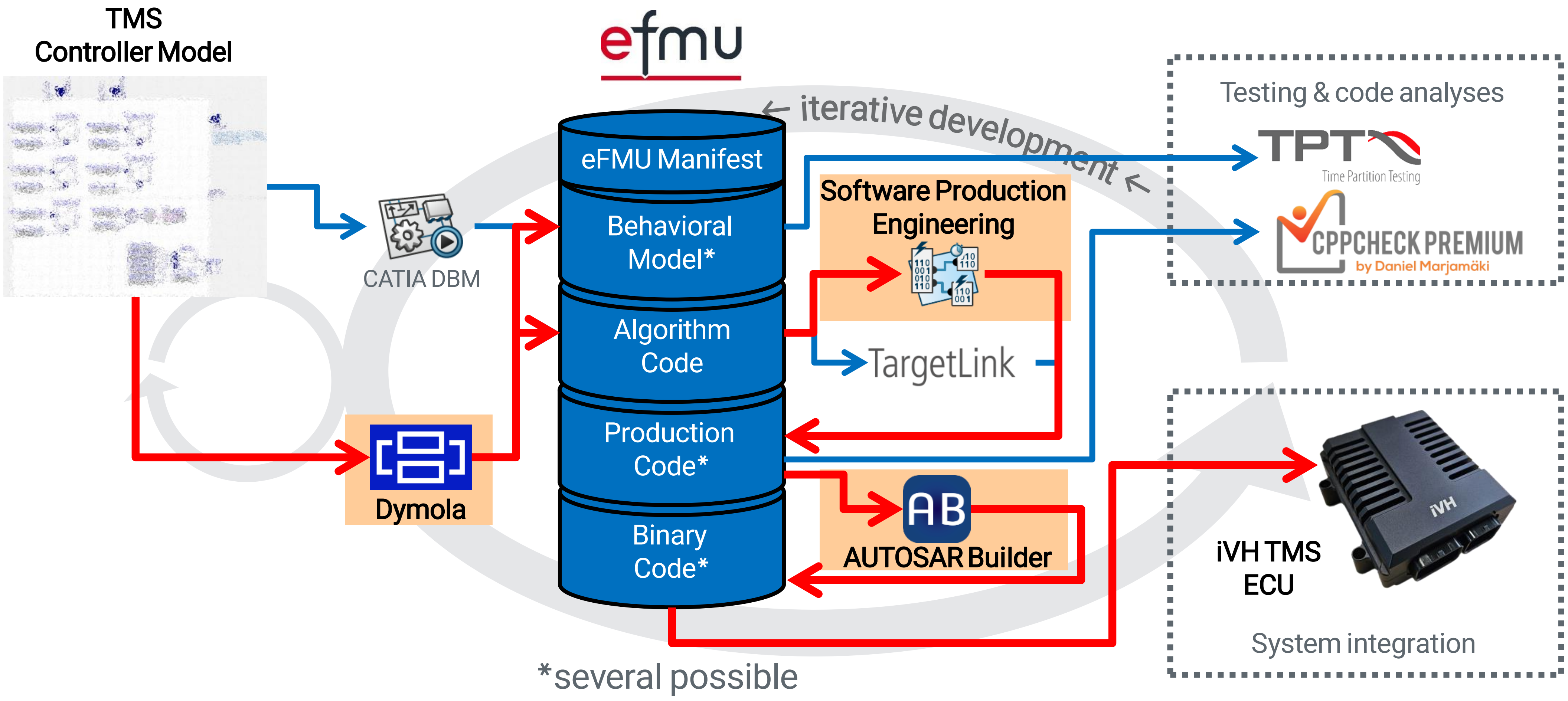


3. Approach

eFMI Workflow

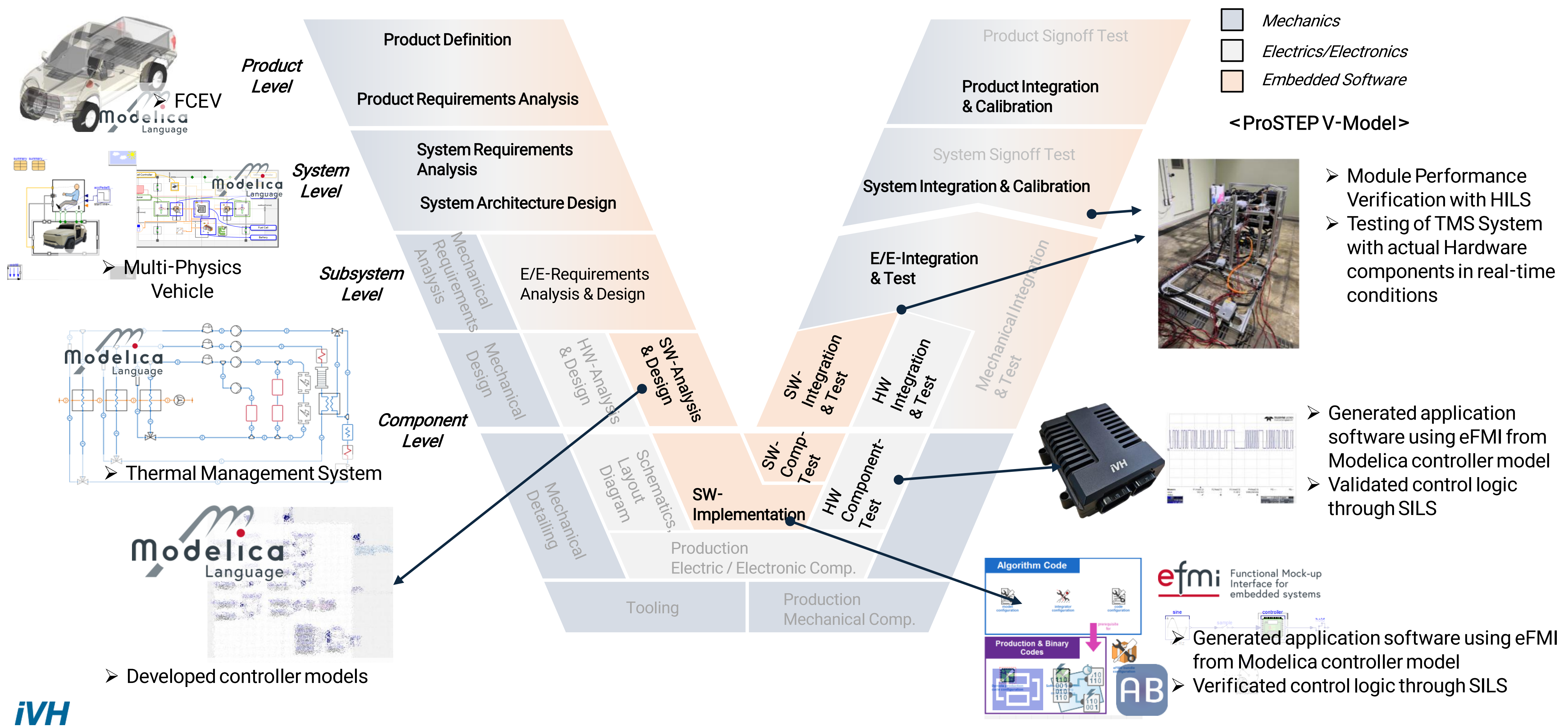
➢ Background

- iVH is a model developer skilled in physics modeling using Modelica, but lacks knowledge and experience in controller code development.
- So, we applied the **eFMI** workflow.



3. Approach

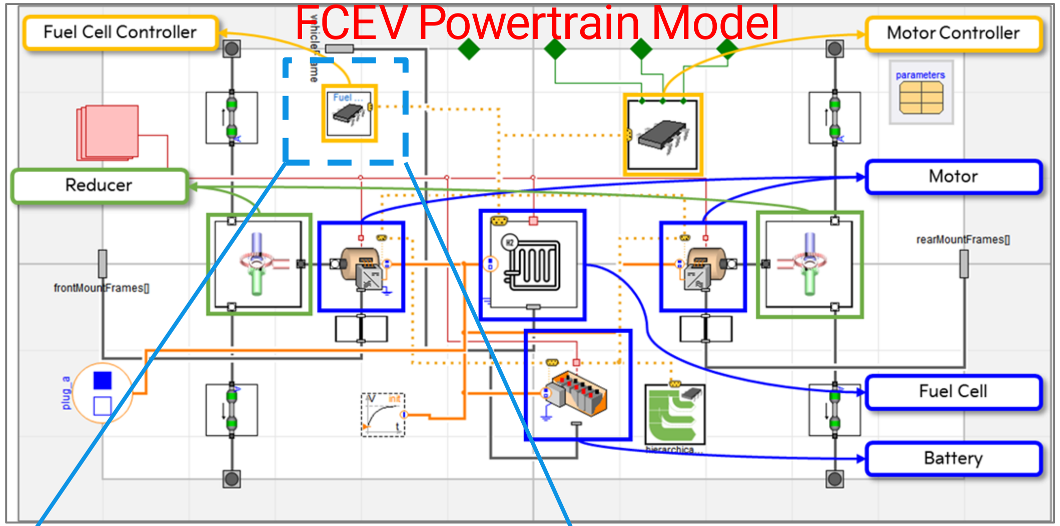
V-Cycle Based Development Process

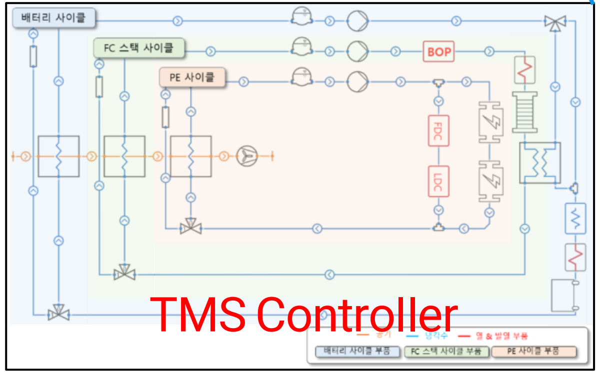


4. Results

Model Configuration & Test Conditions

Simulation In the Loop

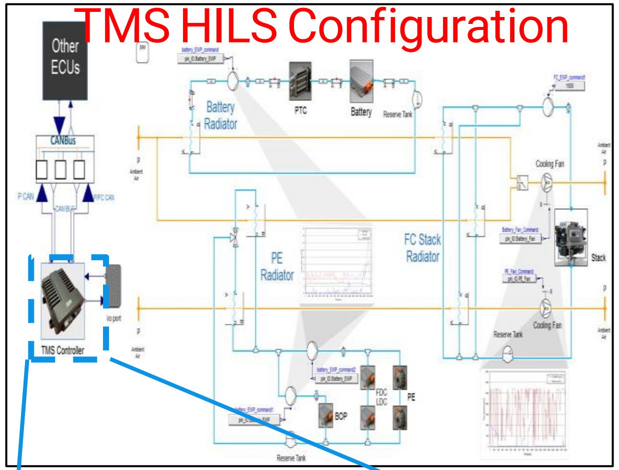


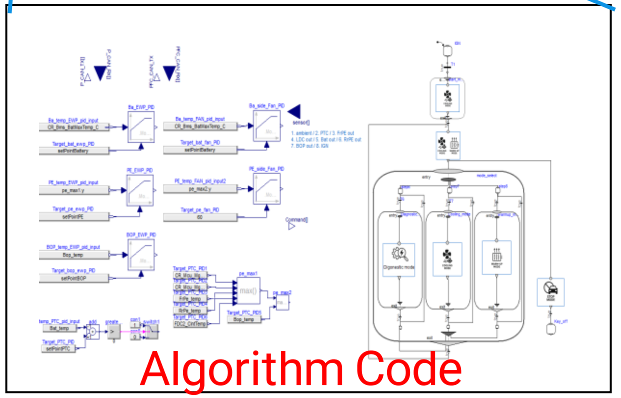


➢ **Simulation Condition**

- Medium : Ethylene Glycol 50%
- Ambient Temperature : 43℃
- Component & Coolant Temperature : 43℃
- Drive Cycle(Heat Cycle) : WLTC 2 Cycle(3600 seconds)

Hardware In the Loop



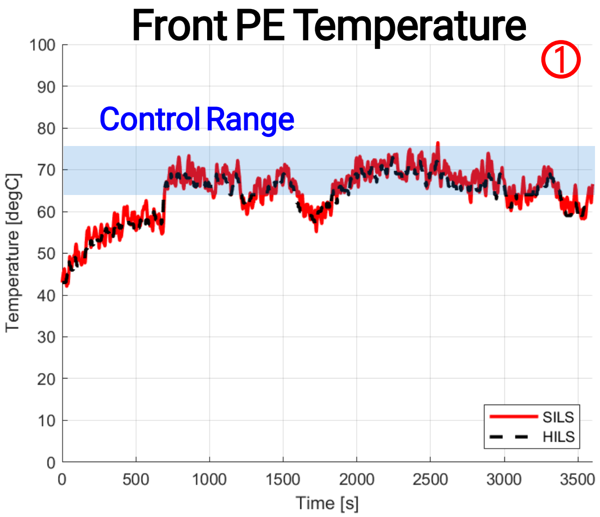


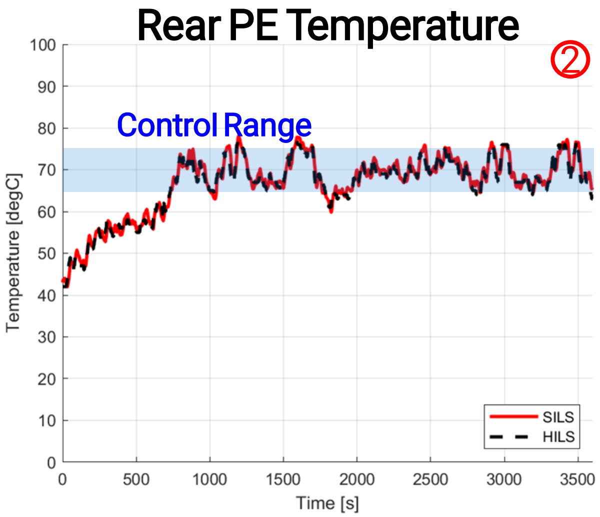
➢ **Test Condition**

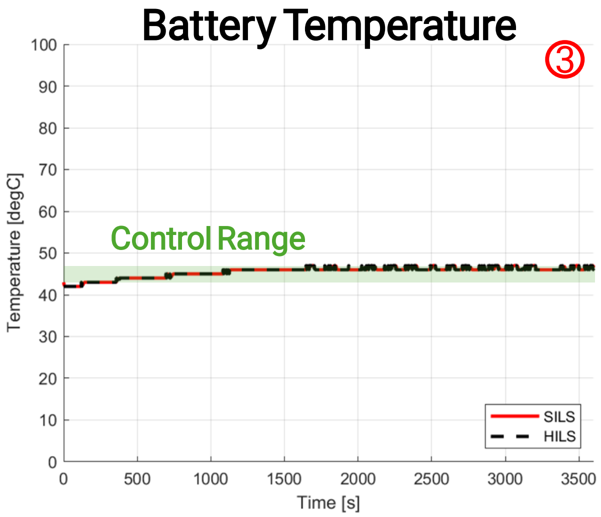
- Medium : Ethylene Glycol 50%
- Ambient Temperature : 43℃
- Component & Coolant Temperature : 43℃
- Drive Cycle(Heat Cycle) : WLTC 2 Cycle(3600 seconds)

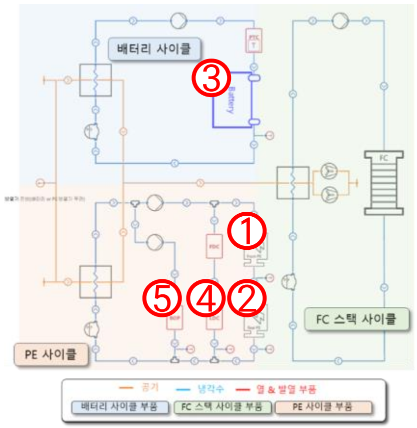
4. Results

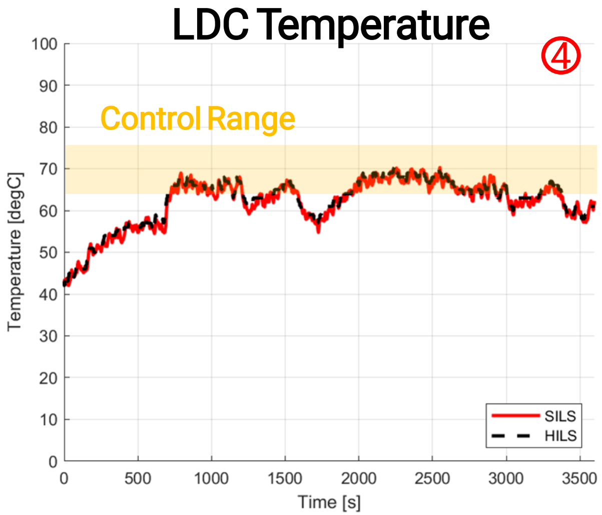
Extreme Hot

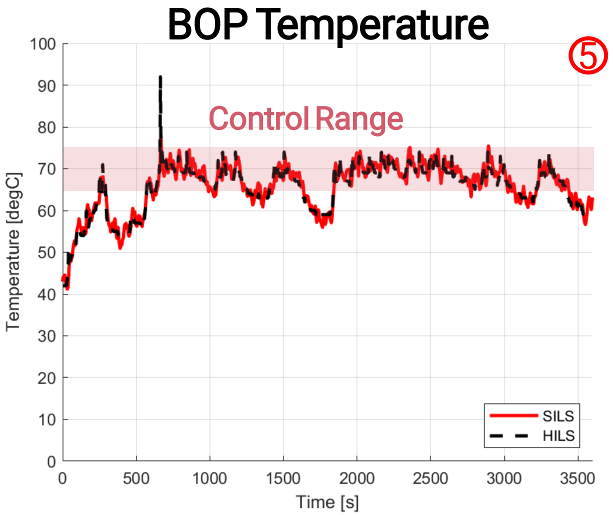












- Each heat source is controlled to maintain temperature within its appropriate **control range**
- The **battery** is cooled via a **cooling cycle**, and its **target temperature is set slightly higher than ambient air**

5. Conclusion

eFMI Success in TMS ECUs

eFMI has proven effective in Thermal Management System ECUs, enabling standardized component communication.

Continuous Validation and Verification

Ongoing testing throughout development increases confidence and reduces project risks.

Comprehensive Integration Approach

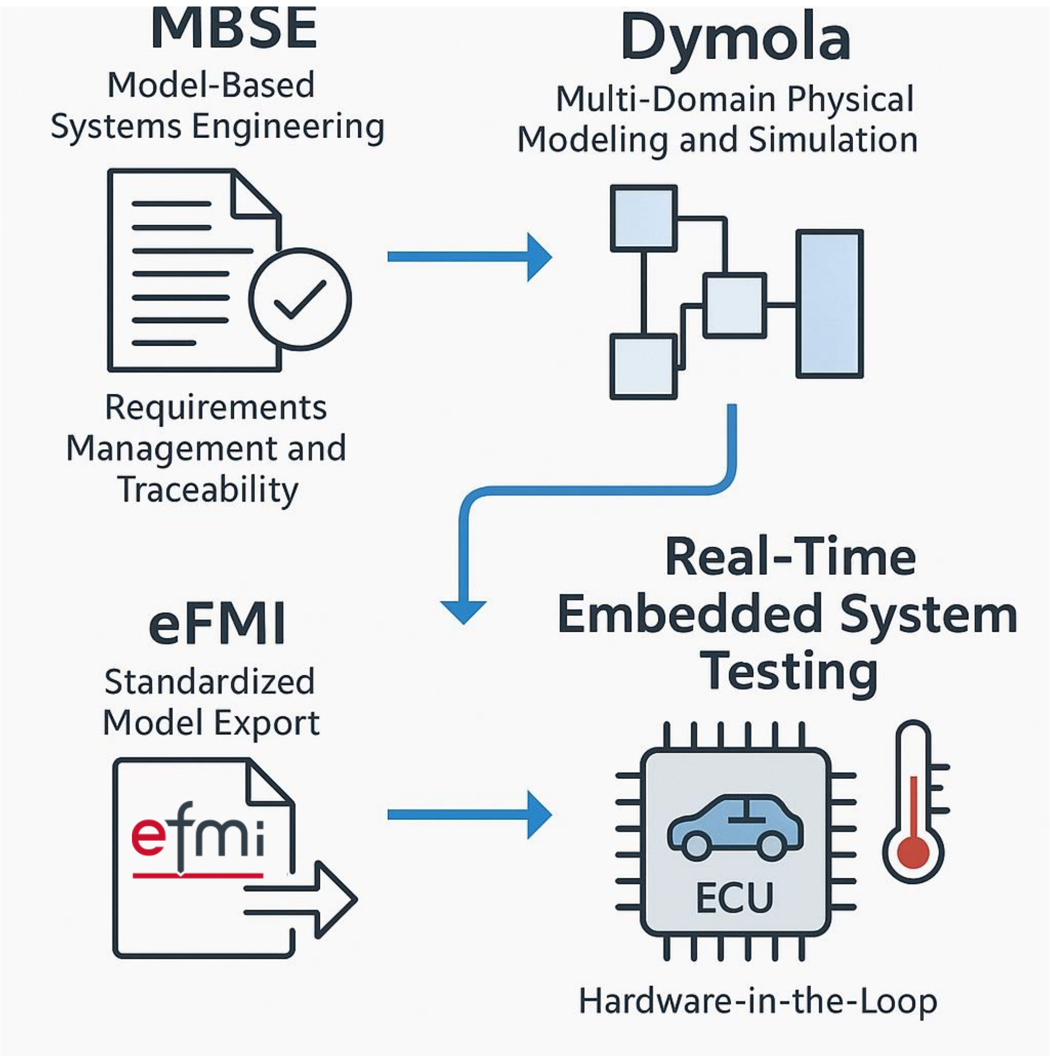
Combining multiple methodologies offers a robust solution to complex ECU development challenges.

Ensuring Efficiency and Quality

This integration promotes improved efficiency and high-quality outcomes in automotive system development.

Future-ready Electrification

Adopting these technologies prepares automotive development for future electric vehicle advancements.



THANK YOU

License for 

https://pixabay.com/illustrations/education-online-school-elearning-5307517/

I create these images with love and like to share them with you. My passion is to provide vintage designs to honor those artists that created something great and timeless. You are most welcome to use it for commercial projects, no need to ask for permission. I only ask that you not resell my images AS IS or claim them as your own creation. As always, a BIG thank you for the coffee donations I received, every dollar is a blessing for my family.

Education Online School royalty-free stock illustration. Free for use & download.

Content License Summary

Welcome to Pixabay! Pixabay is a vibrant community of authors, artists and creators sharing royalty-free images, video, audio and other media. We refer to this collectively as “**Content**”. By accessing and using Content, or by contributing Content, you agree to comply with our Content License.

At Pixabay, we like to keep things as simple as possible. For this reason, we have created this short summary of our Content License which is available in full here. Please keep in mind that only the full Content License is legally binding.

What are you allowed to do with Content?

- Subject to the Prohibited Uses (see below), the Content License allows users to:
- Use Content for free
- Use Content without having to attribute the author (although giving credit is always appreciated by our community!)
- Modify or adapt Content into new works

What are you not allowed to do with Content?

We refer to these as Prohibited Uses which include:

- You cannot sell or distribute Content (either in digital or physical form) on a Standalone basis. Standalone means where no creative effort has been applied to the Content and it remains in substantially the same form as it exists on our website.
- If Content contains any recognisable trademarks, logos or brands, you cannot use that Content for commercial purposes in relation to goods and services. In particular, you cannot print that Content on merchandise or other physical products for sale.
- You cannot use Content in any immoral or illegal way, especially Content which features recognisable people.
- You cannot use Content in a misleading or deceptive way.
- Please be aware that certain Content may be subject to additional intellectual property rights (such as copyrights, trademarks, design rights), moral rights, proprietary rights, property rights, privacy rights or similar. It is your responsibility to check whether you require the consent of a third party or a license to use Content.