Accelerating EV Thermal Controller Development Using Rapid Control Prototyping on Speedgoat.

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ELECTRIC ORIGIN SUVs

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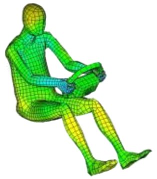
Content

1 Introduction

Core of EV success

Electric vehicles achieving maximum range is prime requirement

Maintaining temperature of the batteries in EV is highest priority



Huge Energy is consumed by HVAC System to maintain cabin temperatures

E-drive temperatures to be maintained in all weather conditions

Maximum efficiency of all consuming components while achieving best performance is core of EV success

Image Credits: Mahindra & Mahindra

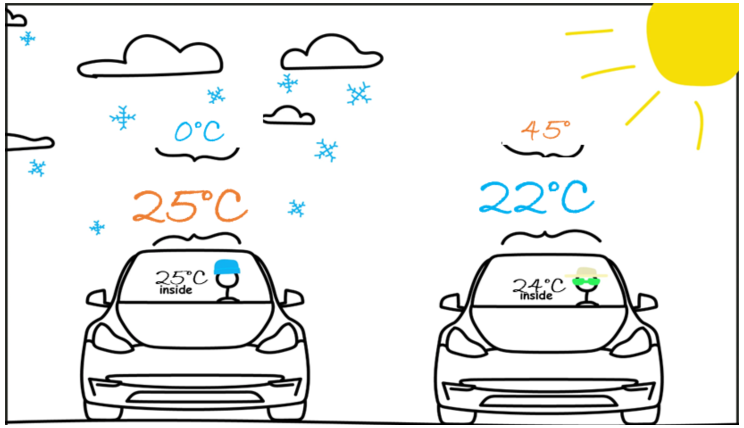
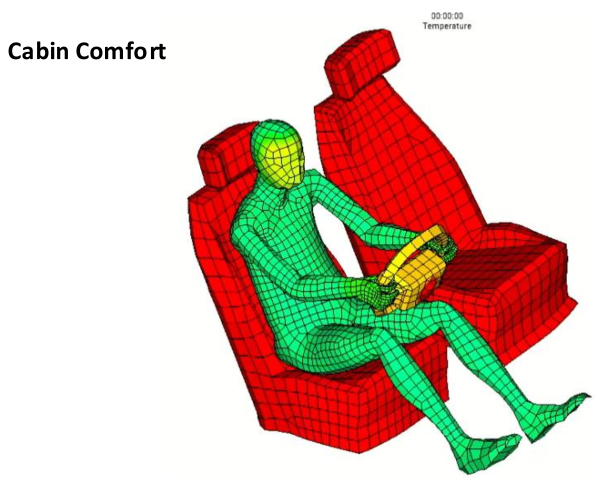


Image Credits: @advancefleetmanagementtube3879

Introduction to EV Thermal Management

➢ Multiple closed loop systems working simultaneously for achieving the requirements



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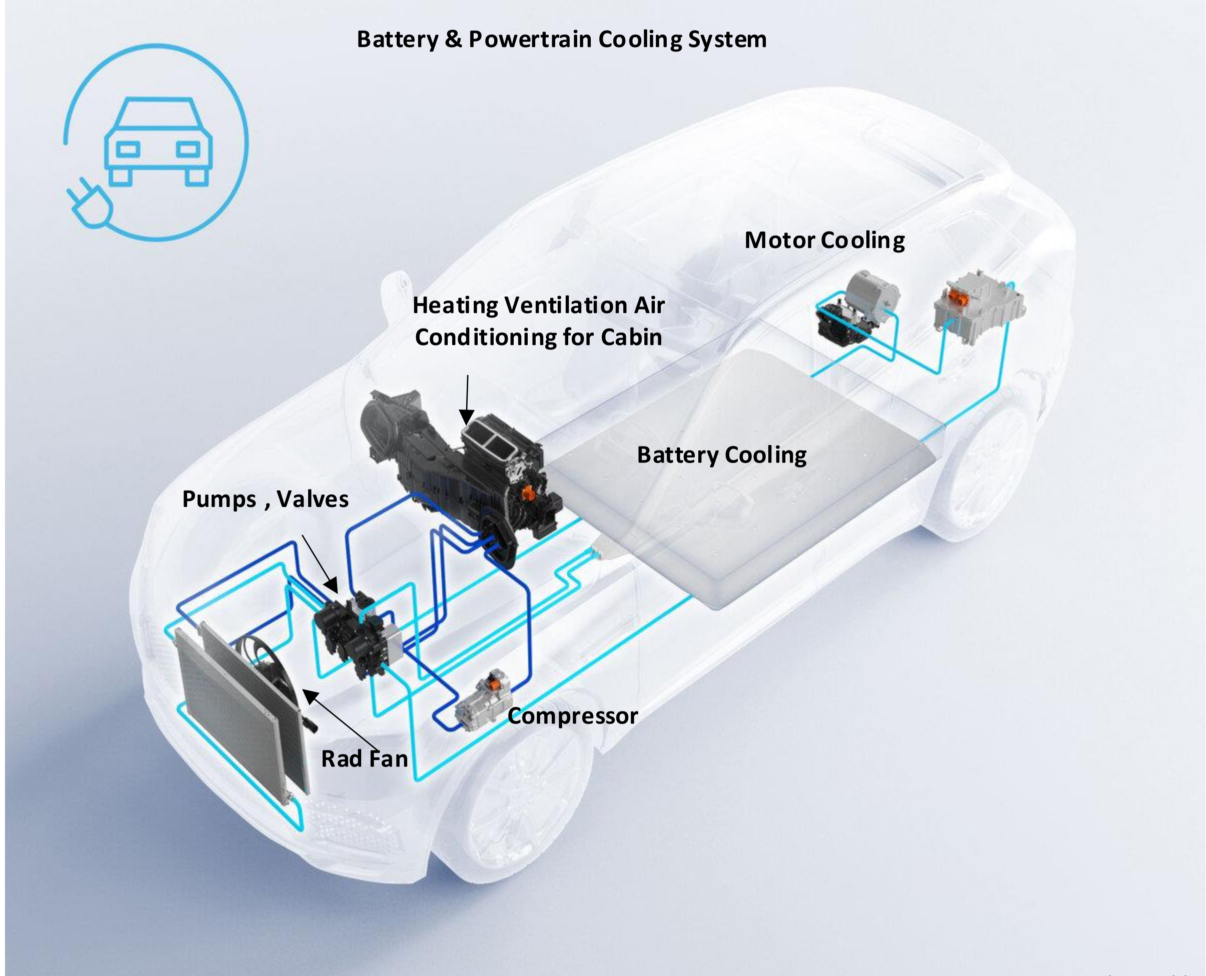

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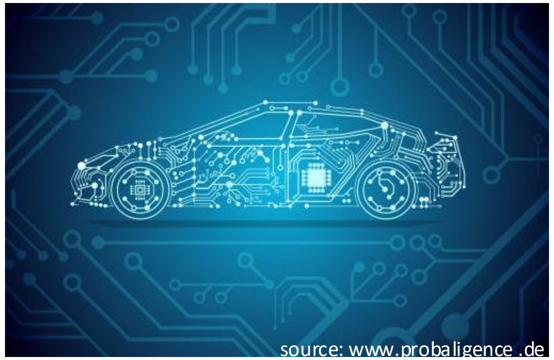
Challenges in EV Thermal System Development

Challenges in EV Thermal System Development

Electronics & Software dependency increase for efficiency



Reduced time to market

Multiple strategies & ideas for efficiency improvement to be tested

- Lack of availability of all ECUs during early stages of vehicle development.

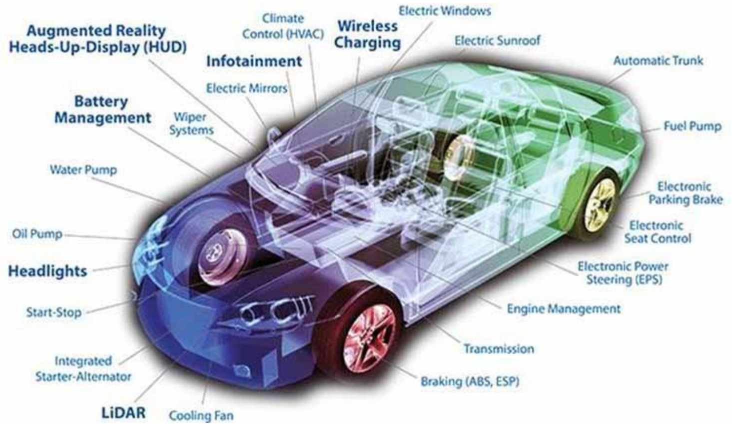


Image source: https://www.linkedin.com/pulse/automotive-microcontrollers-mcu-market-2023-2030-growth-vhanmane/

Multiple architecture require one software

- Controller Hardware configurations Constraints

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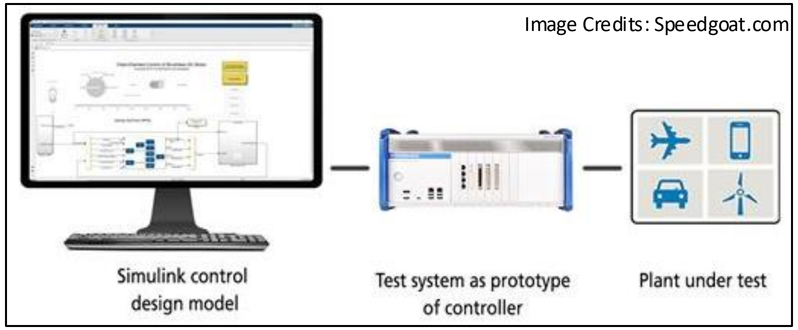
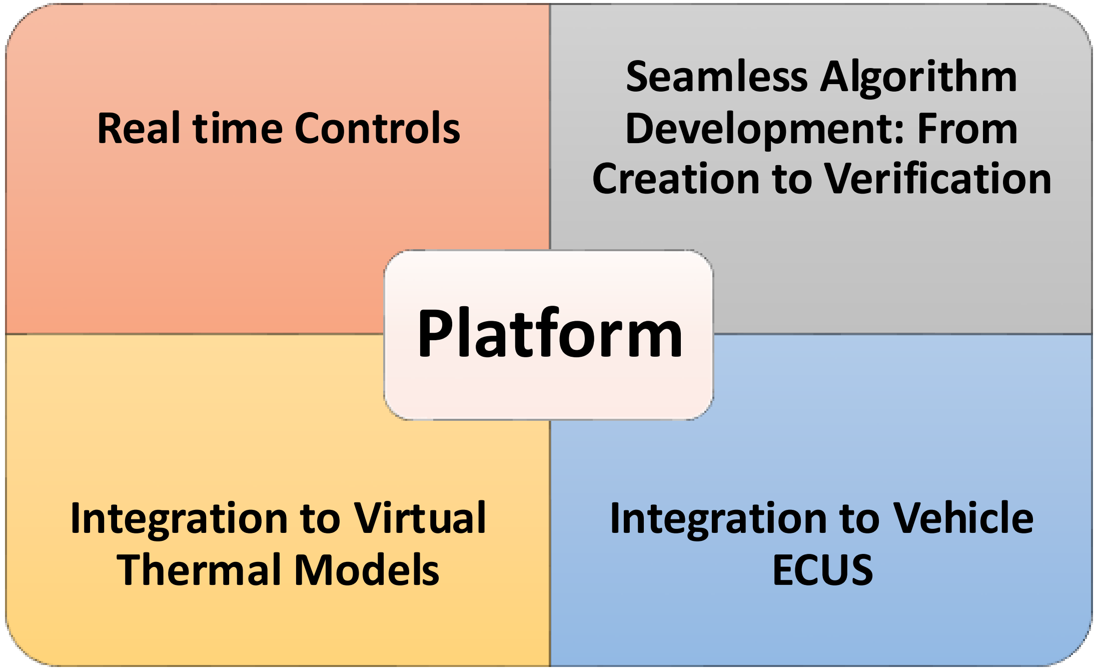
Requirements of Platform which can take over challenges

Platform Requirements





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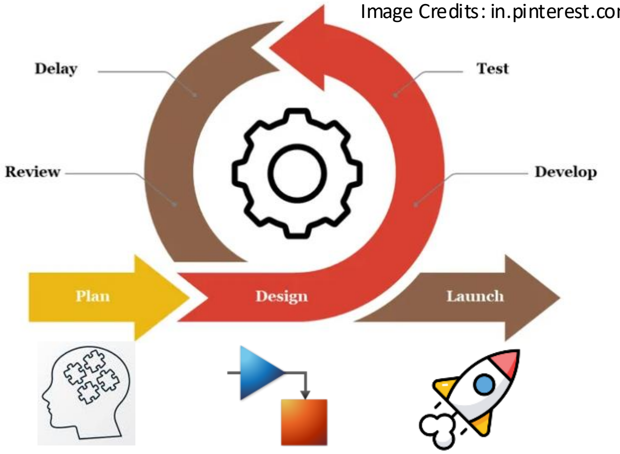

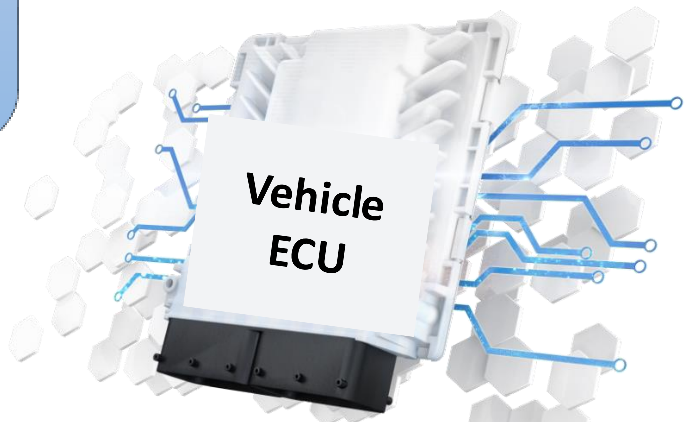

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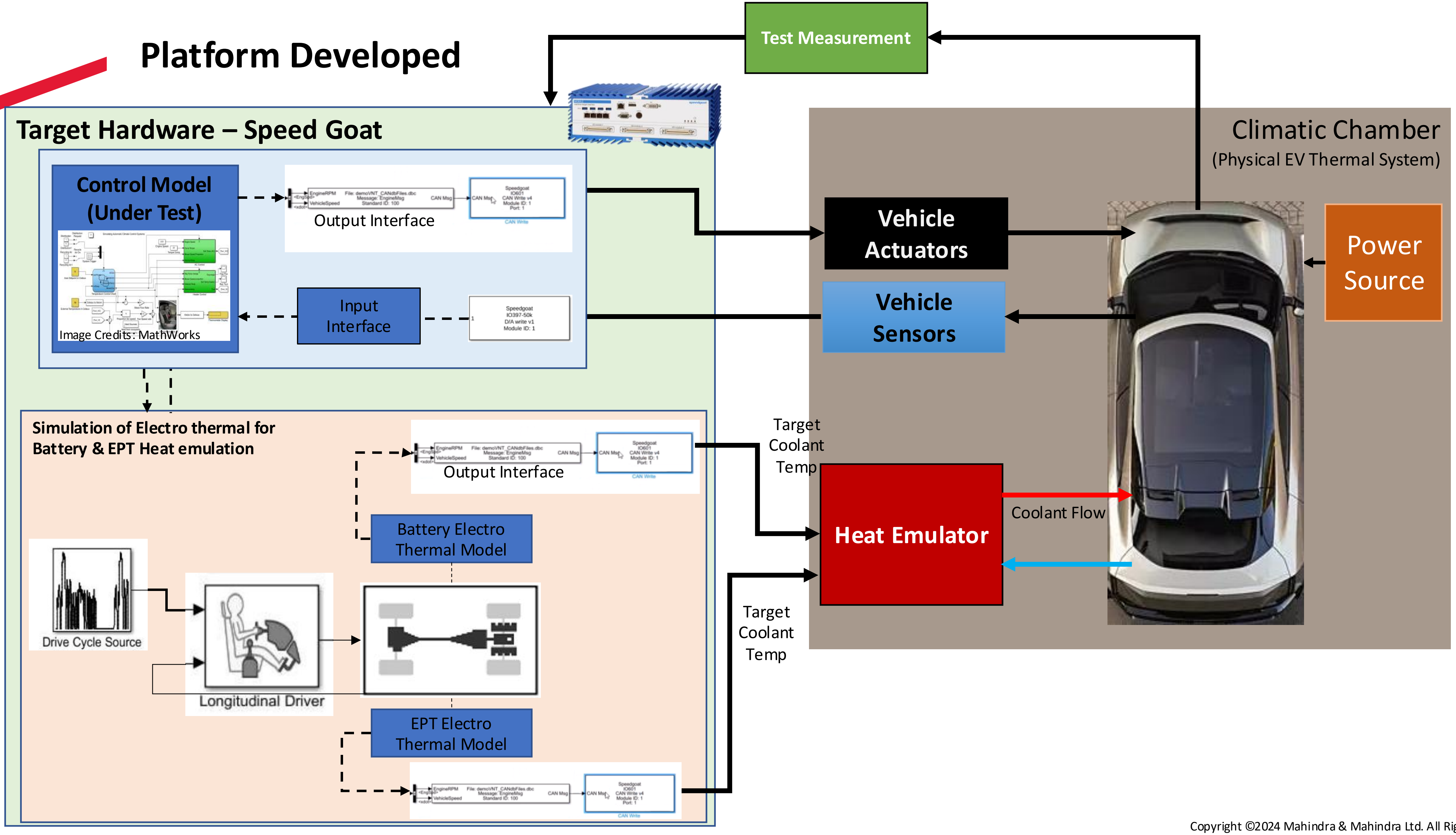
Platform Developed

Platform Developed



Leveraging Rapid Control Prototyping

Accelerated process of controller development

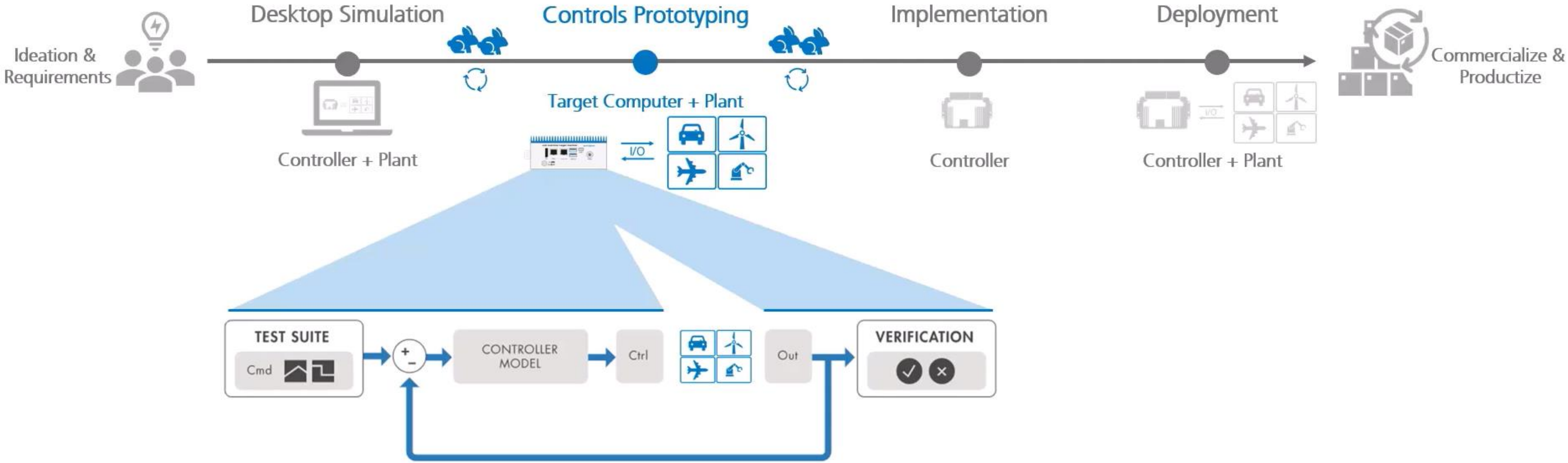


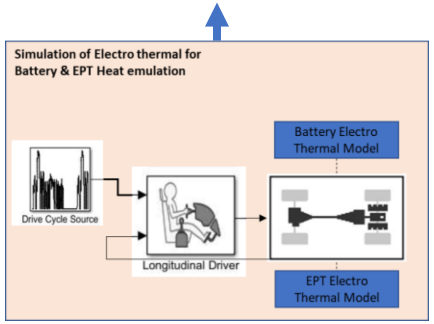
Image Credits: Speedgoat.com

Realtime target machine for Control Prototyping

Development Computer
MATLAB, Simulink, Simscape & SLRT

Image Credits: Mahindra & Mahindra

Physical System
Hardware under test with sensor and actuator interfaces

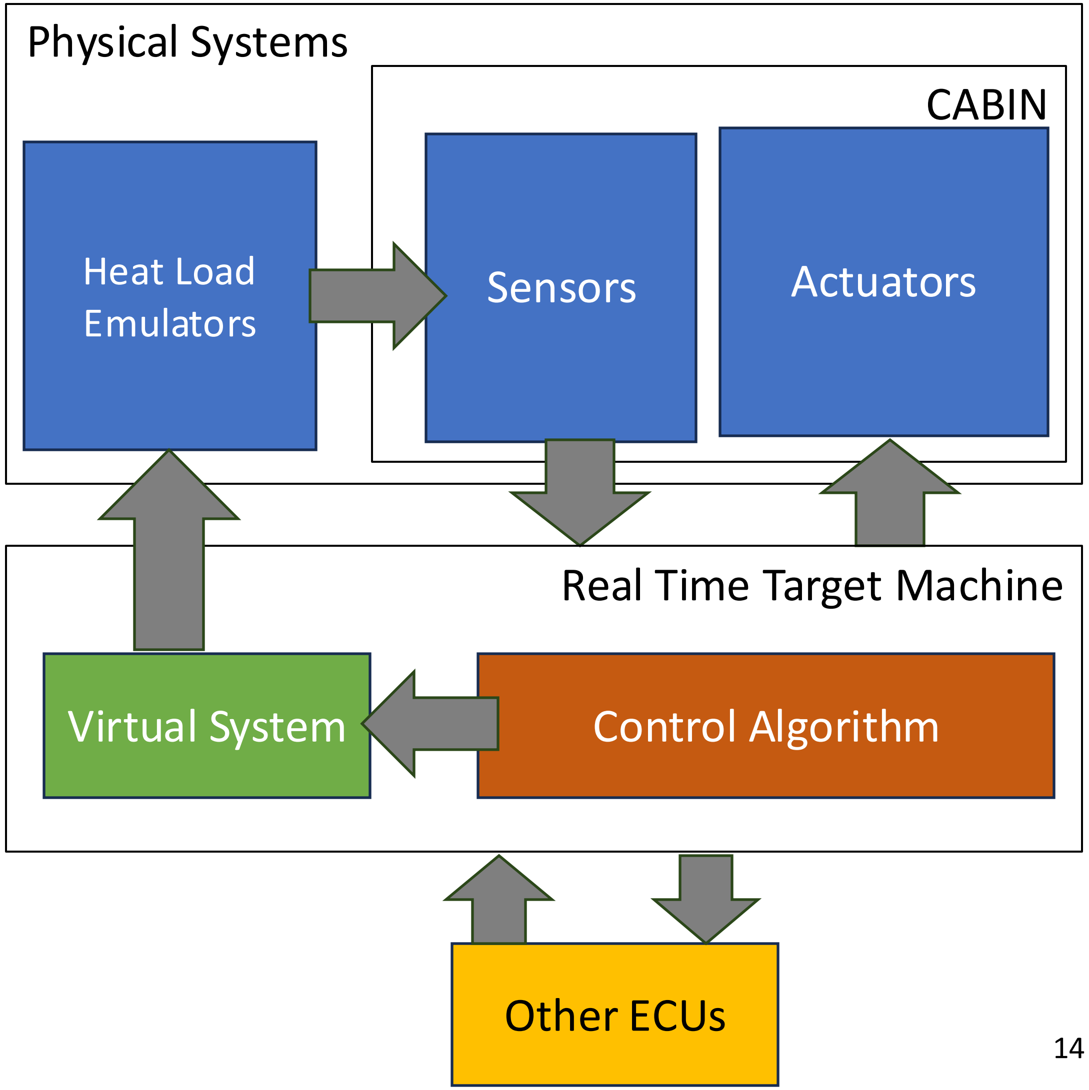


Simulated System
Hardware not available simulated in Simscape on target computer

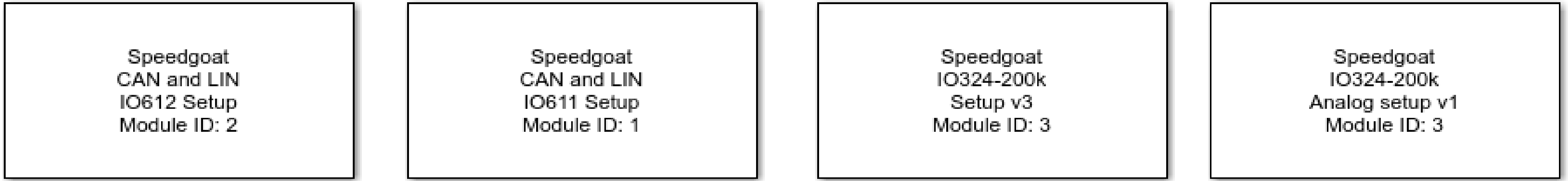
Image Credits: Speedgoat.com

Synthesis of the Platform

Physical Systems			Virtual Systems
Sensors	Actuators	Critical Components	
• Pressure and Temperature Sensors of Refrigerant loop • Temperature Sensors of Coolant Loop • Additional coolant Flow sensors for Better control	• LIN • CAN • SPI • PWM • Switches (On/OFF)	• Compressor and Pumps • Heat Exchangers • Cabin • Valves	• Battery, powertrain Heat Loads • Auxiliary heat loads • BMS, VCU , HMI, Front Zonal



RCP setup using Speed Goat



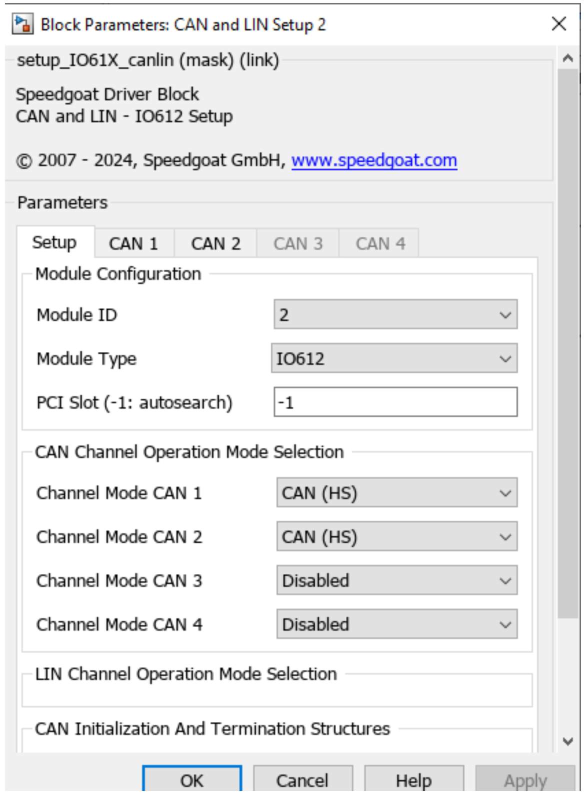
RCP Machine : Performance Realtime Target Machine

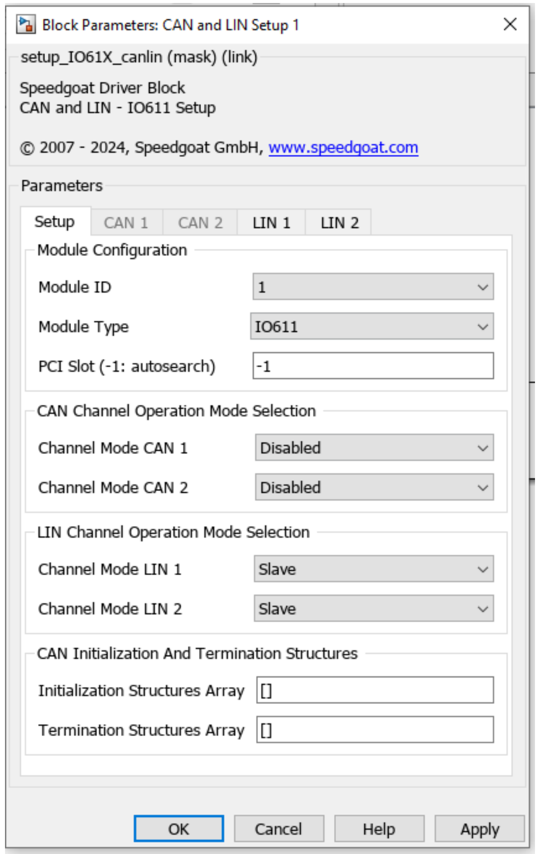
Cards used

- CAN network – IO612
- LIN network – IO611
- Analaog –IO324
- SPI – IO324
- PWM-IO324
- Digital –IO324

Note

- Relevant LDF and DBC files from actual vehicles used
- Analog Card used for Sensor Inputs through Voltage Divider Circuits





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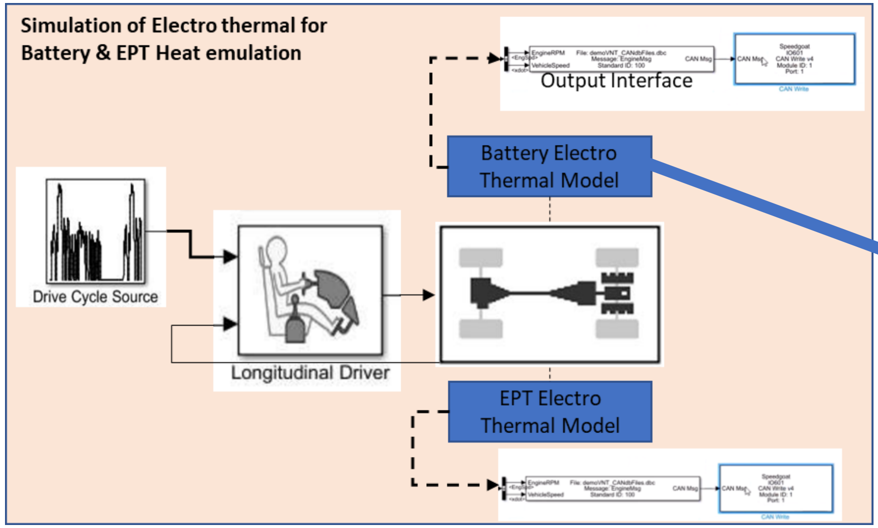
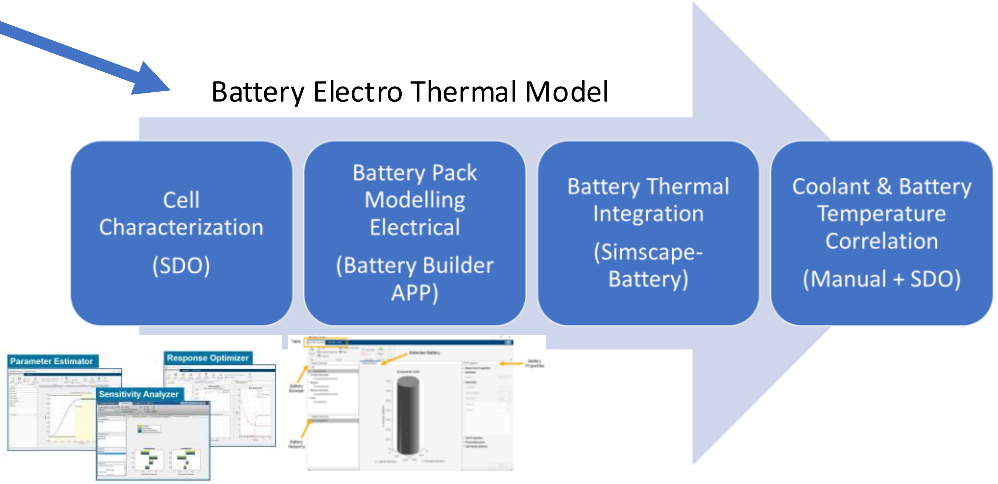
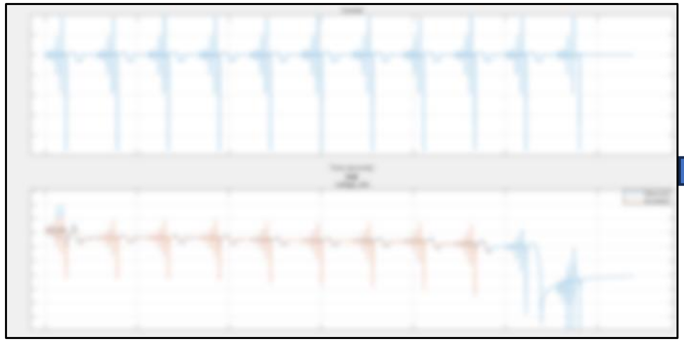
5 Simulated Plant

Electro Thermal Modeling with Simscape Battery

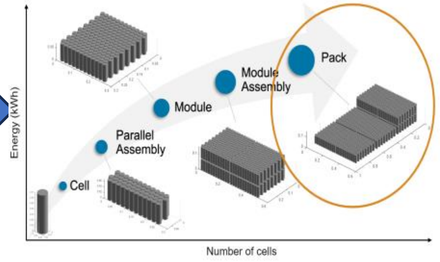




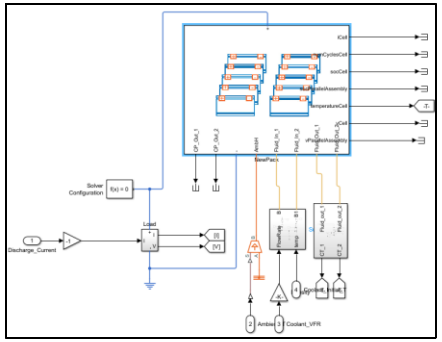
Cell Characterization from HPPC



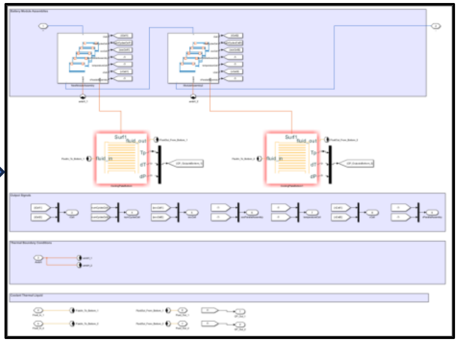
Cell to Pack Modeling



Thermal Integration



Battery Electro Thermal Model



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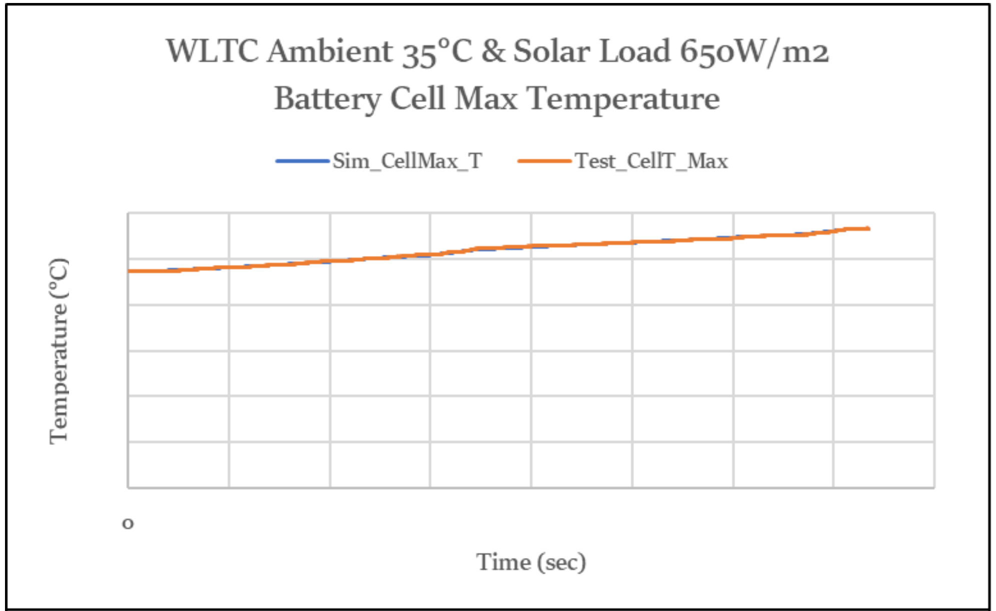
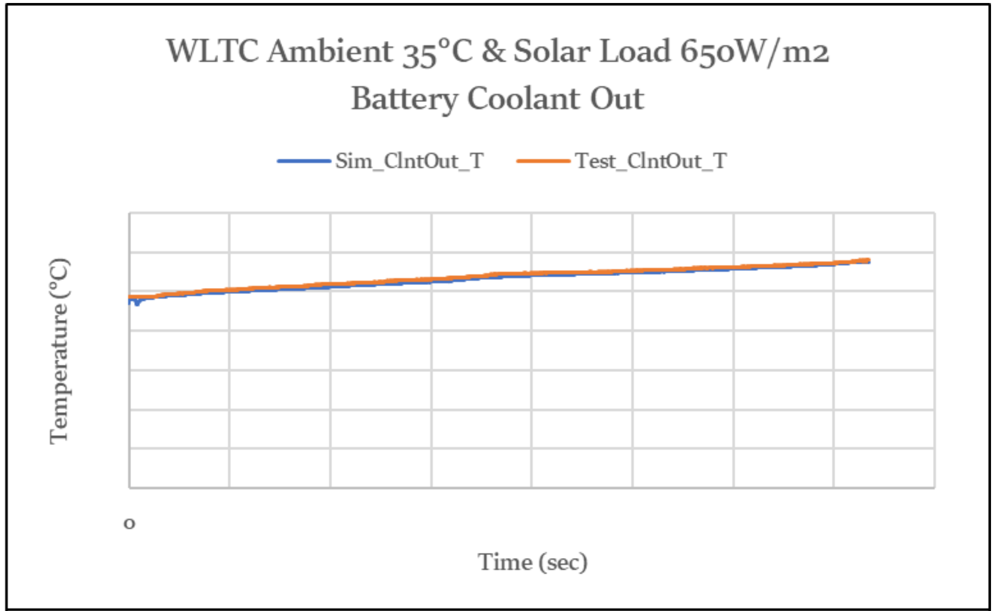
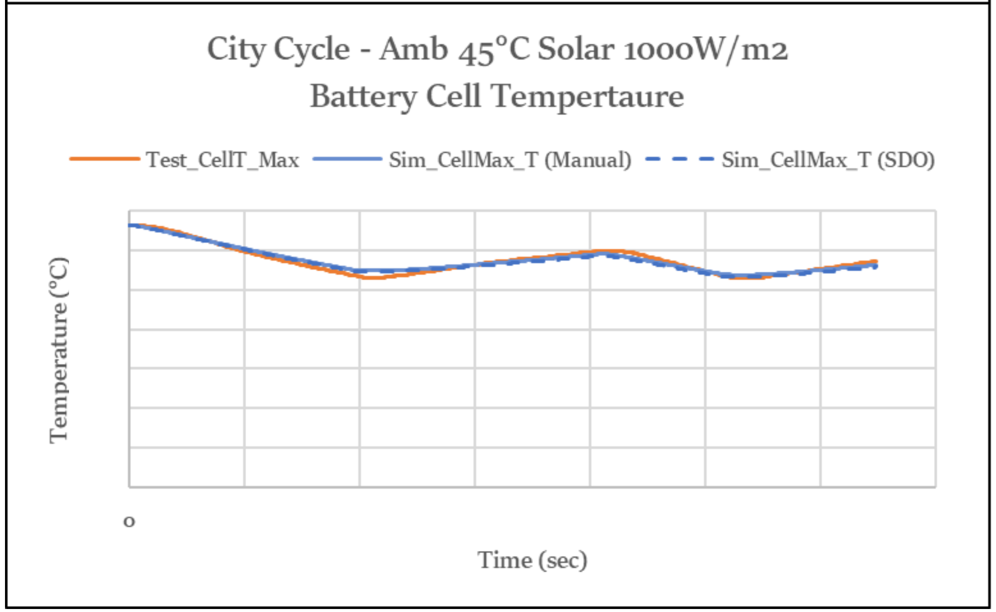
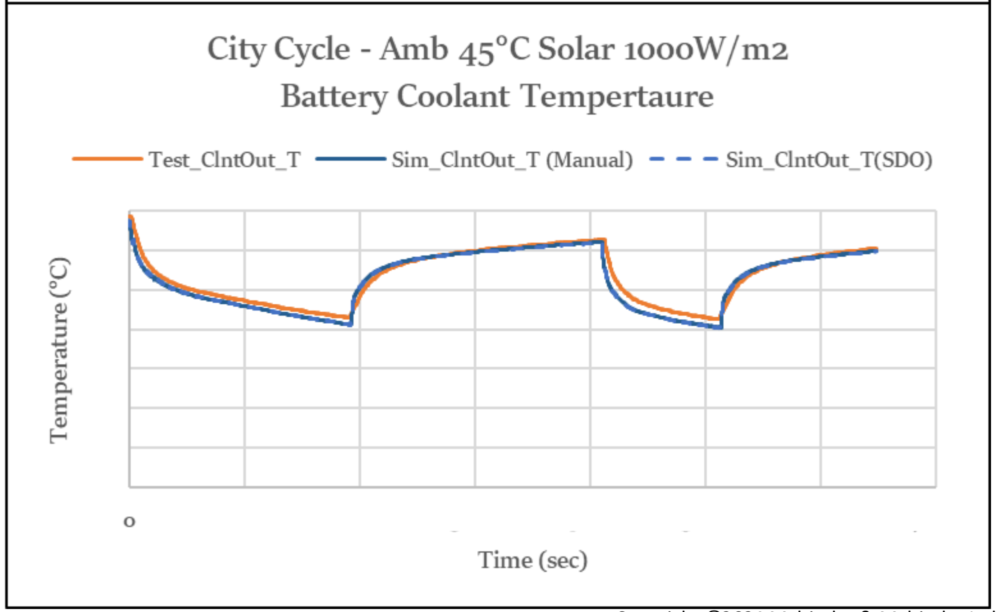
Coolant & Battery Temperature Correlation









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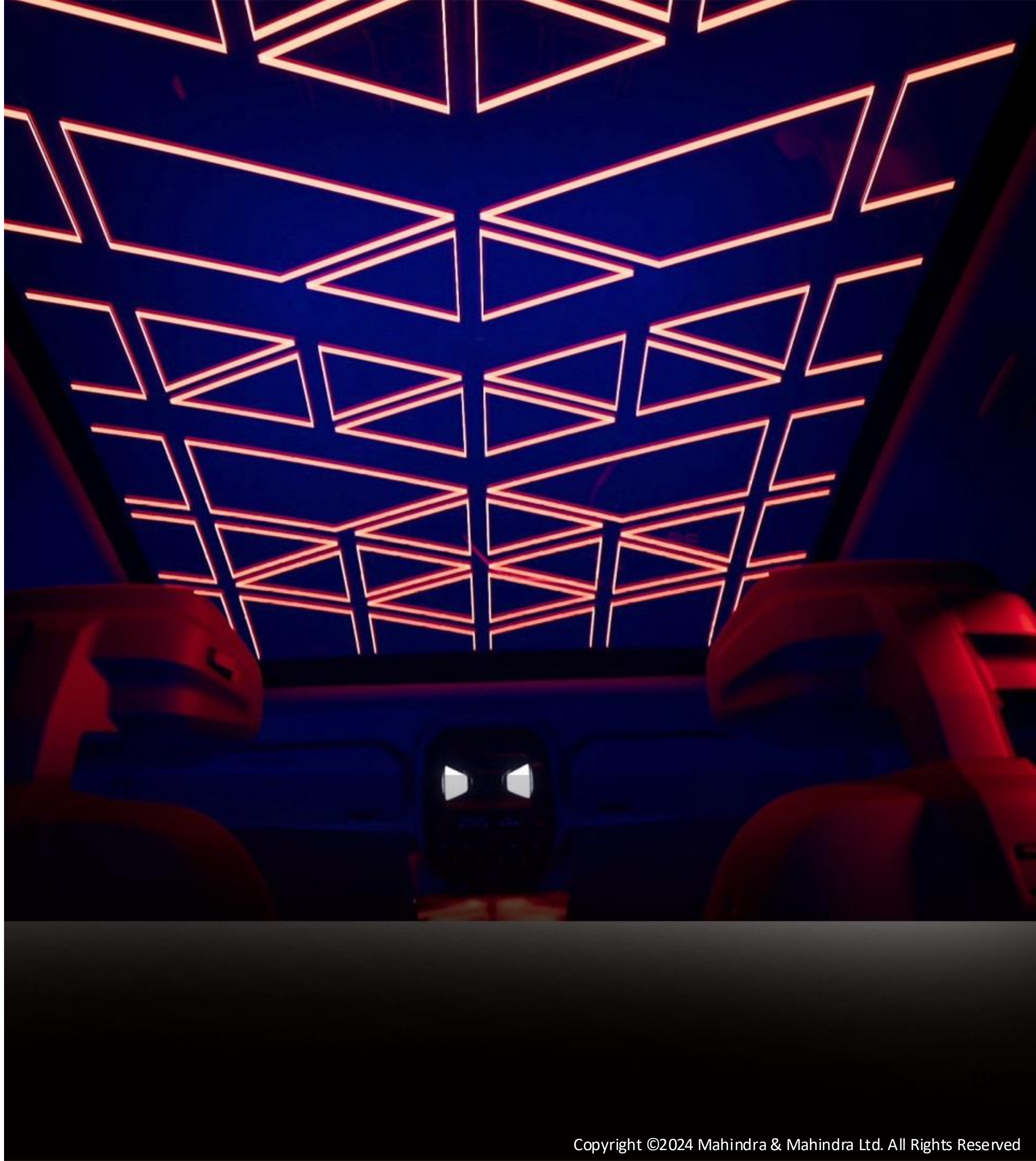
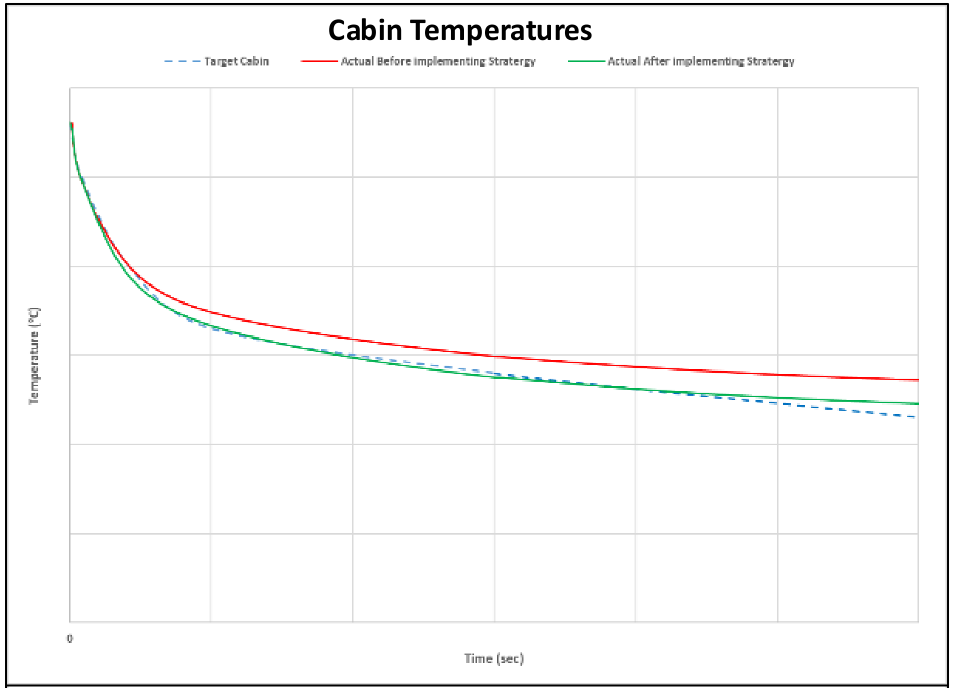
Use Case & Results

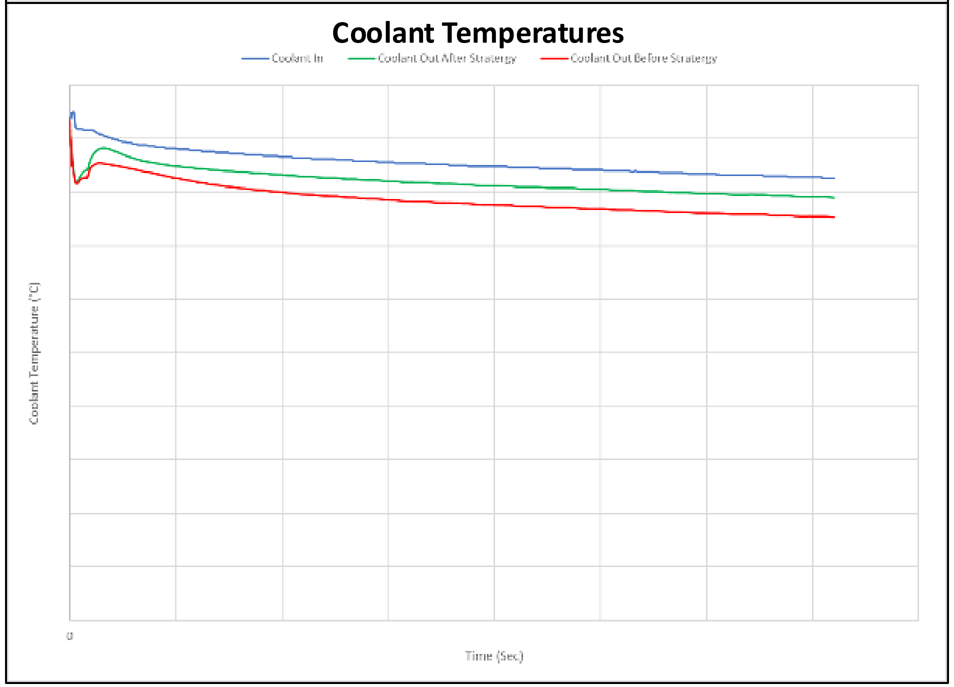


Use Case

- In severe hot conditions, system requires prioritization
- When System comes to capacity limit, challenges is to balance the need

- For verifying & tuning the logics, require to have developed controllers like CCM, BMS & VCU
- But with the RCP approach it can be able to test without having either of ECU's





7 Conclusion

Conclusion

- Summary of Key Points:
  - Reduced timeline for development of Electric Vehicle
  - Tough to test strategies without having developed ECU and achieving maximum efficiency
  - Platform developed for testing strategies & logics without having developed ECU’s by leveraging R C P
  - Plant comprises physical as well as simulation enviornment.
- Benefits to OEMs and Industry
  - Simplified verification approach
  - Improved thermal management and energy efficiency.
  - Faster time-to-market.
  - Reduced development costs.
- Future Work:
  - Process to be established from this Experimented RCP approach

Any Questions?

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