

HYUNDAI

MOTOR GROUP

EUROPEAN TECHNICAL CENTER

How to deploy AI based functions into rapid control prototyping for real time vehicle applications

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MathWorks
**AUTOMOTIVE
CONFERENCE 2024**

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Agenda

- H.M.E.T.C. Introduction
- Motivation & Benefits of applied AI
- Function Development workflow
- Summary of challenges
- Results
- Conclusions

Hyundai Motor Europe Technical Center GmbH

European R&D Center for Hyundai Motor Company

- Locations: Ruesselsheim / Nuerburgring



- Main activities:
 - Electrified Propulsion Development
 - Vehicle Development
 - Electronics Systems Development
 - Commercial Vehicles
 - Design

- Brands: Hyundai / Kia / Genesis



Motivation & Benefits of applied AI

Function Personalization
(Driver characterization)

Enhanced Driver Experience
(Speed prediction)

Reduce Complexity
(SOC Prediction)

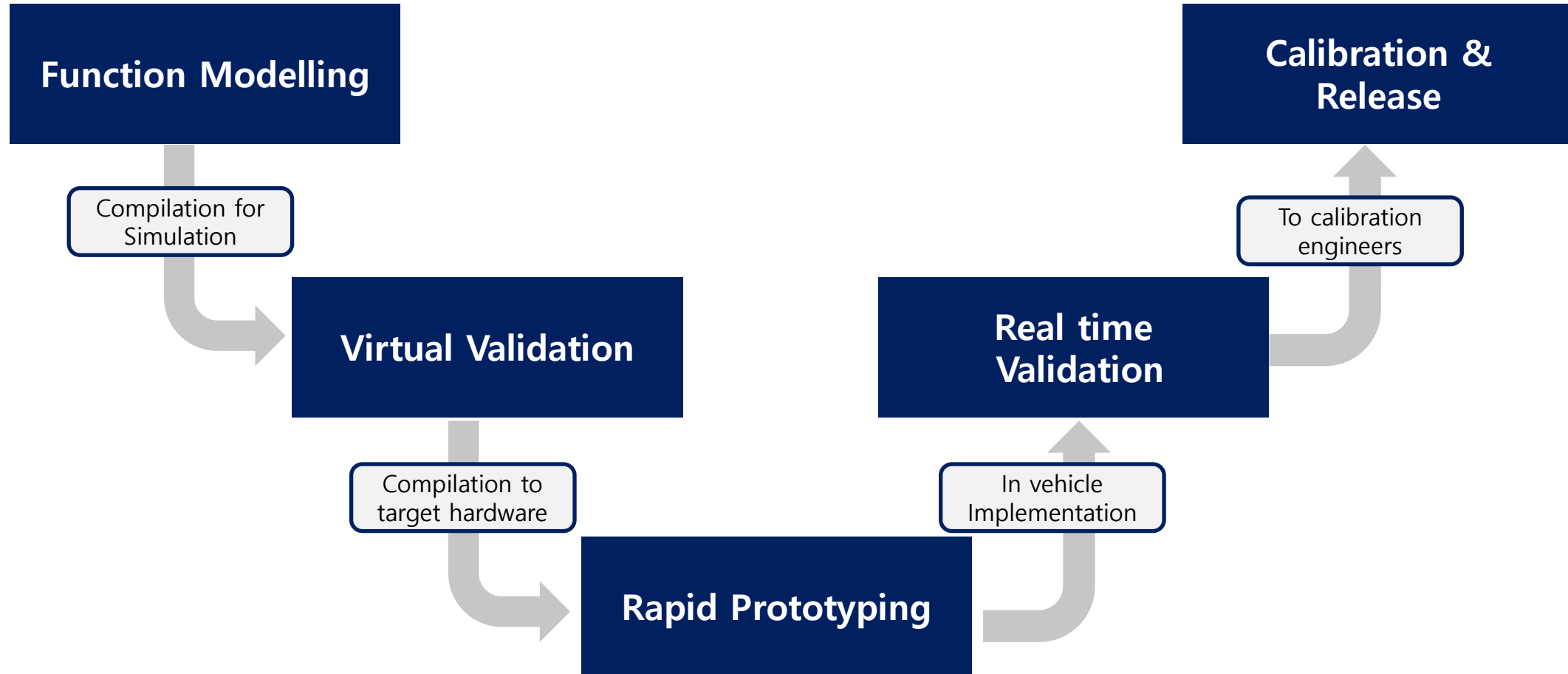
Forecasting conditions
(Torque prediction)

Higher Energy Efficiency
(Powertrain configuration)

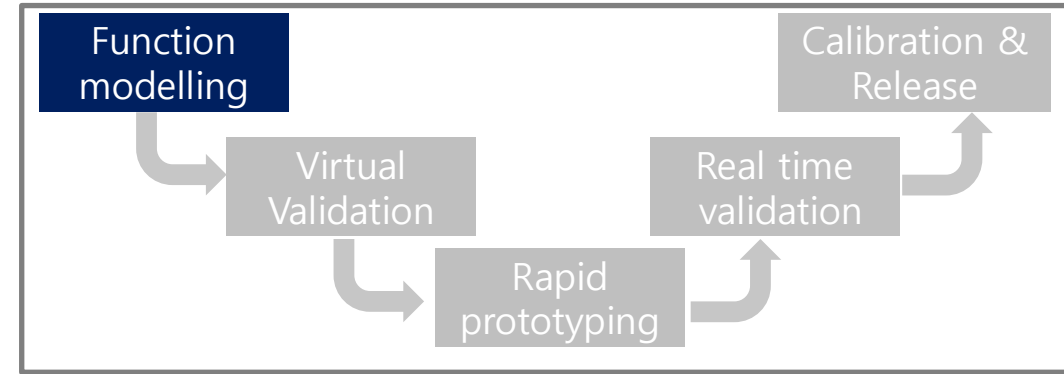
Fast integration of functions into the vehicle

“Driving AI”

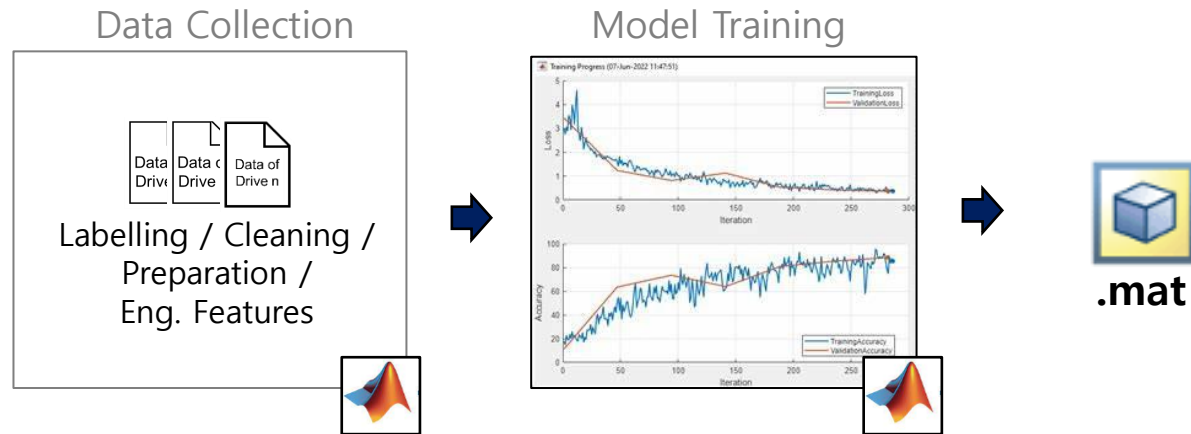
Function Development workflow



Function Development workflow

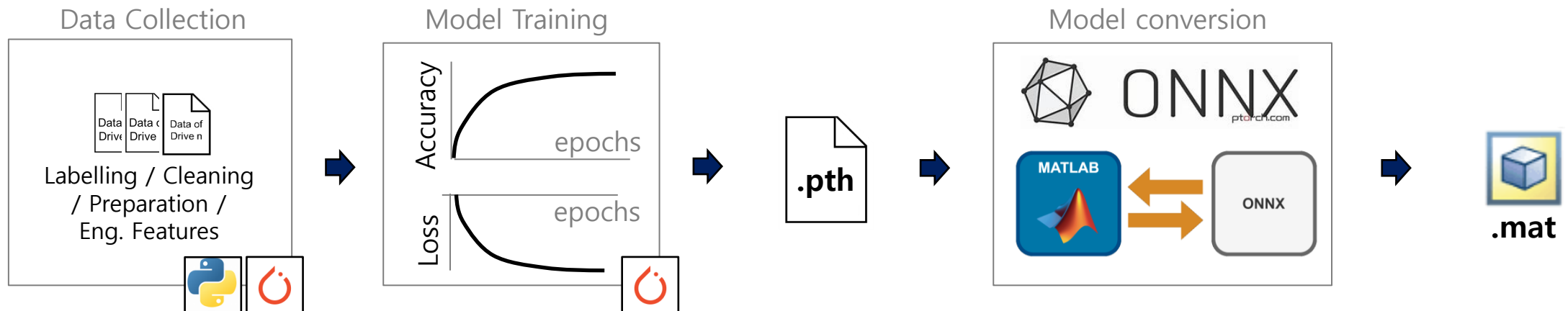


• Case 1: Matlab based

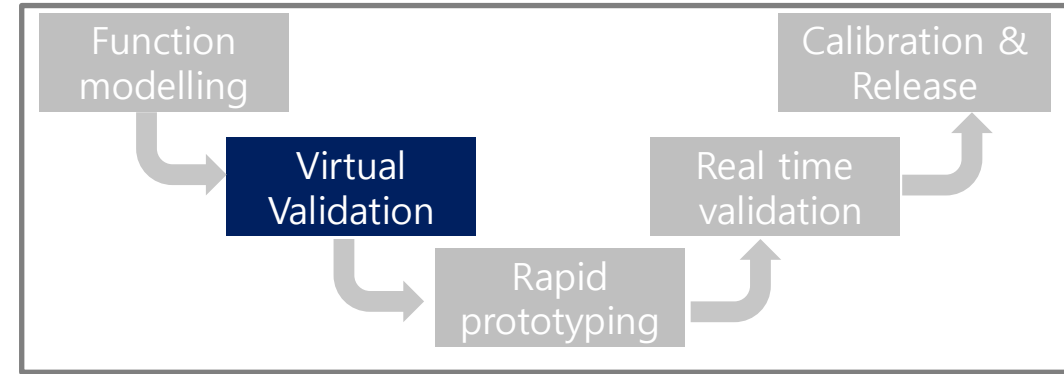


- Model training results in **.mat** or **.pth**
- Use existing models from Python / Pytorch
- **.mat** needed for the deep learning block in Simulink

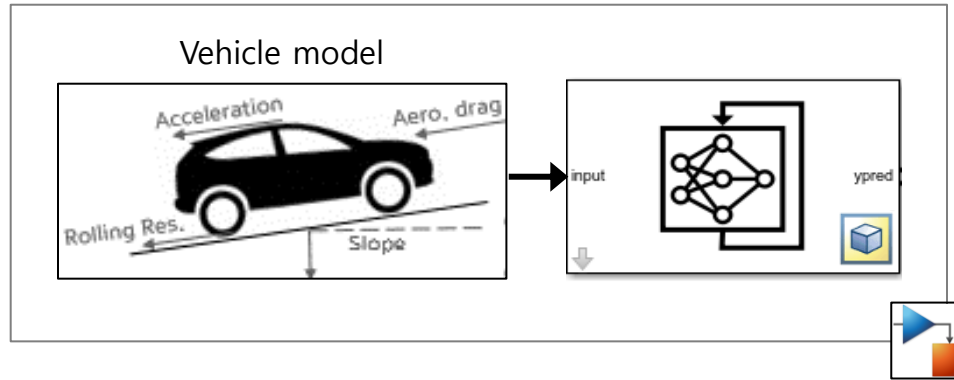
• Case 2: Pytorch to Matlab



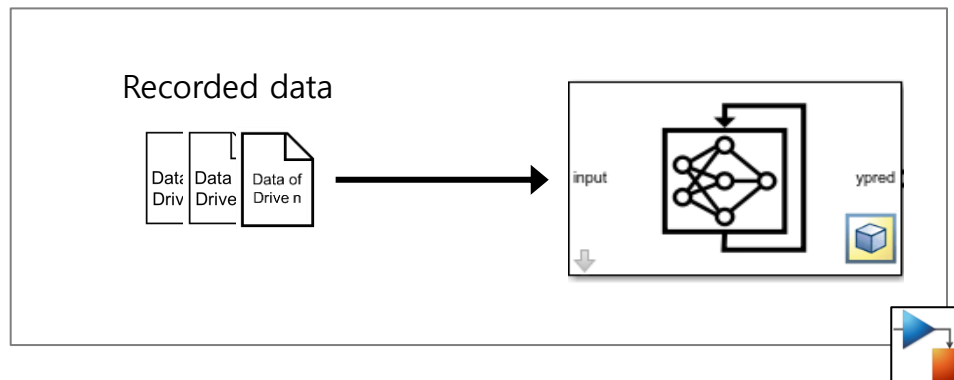
Function Development workflow



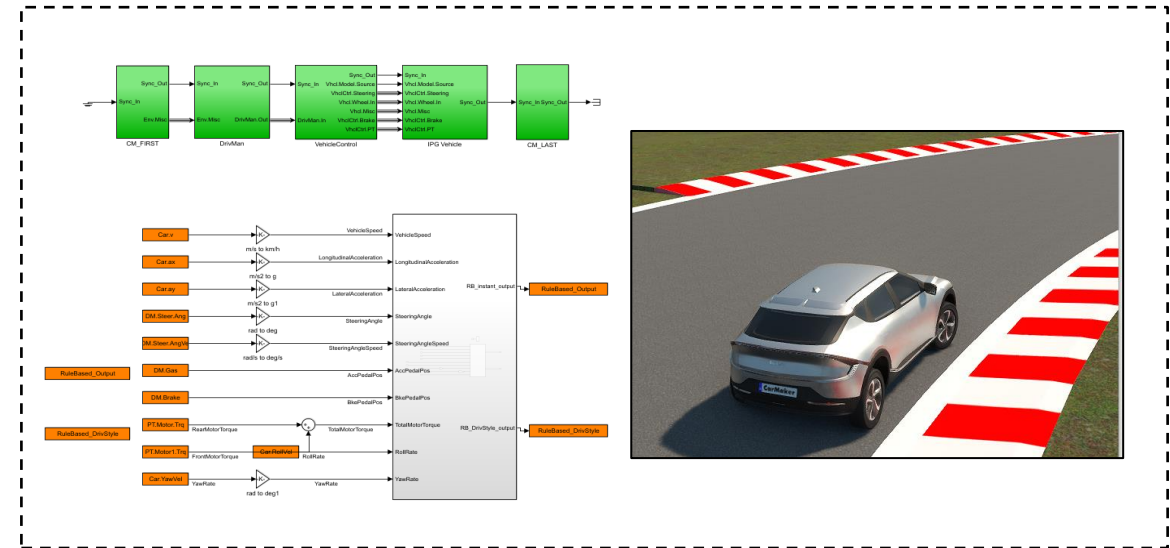
- Case 1: Matlab based**



- Case 2: Pytorch to Matlab**



Model Running in Simulink



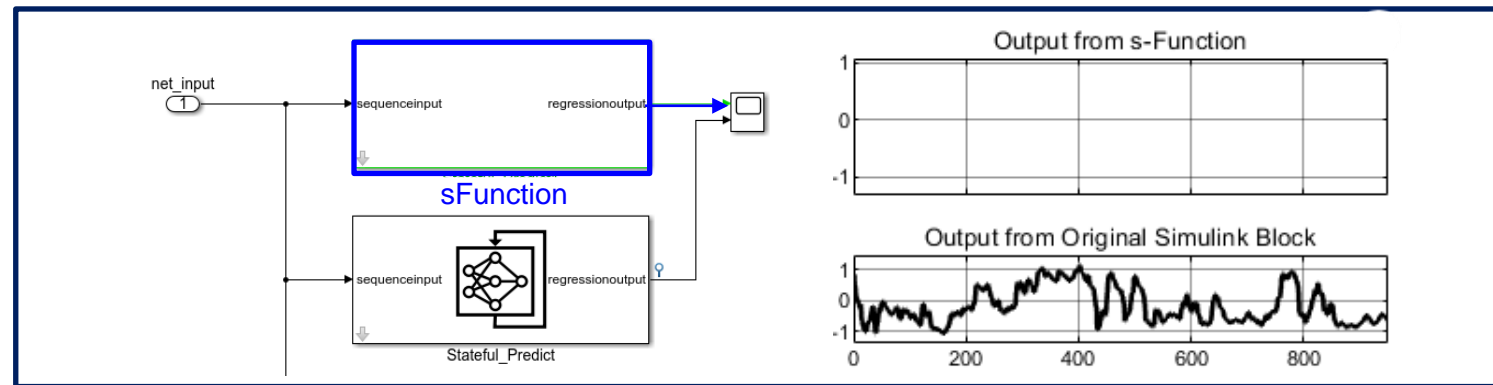
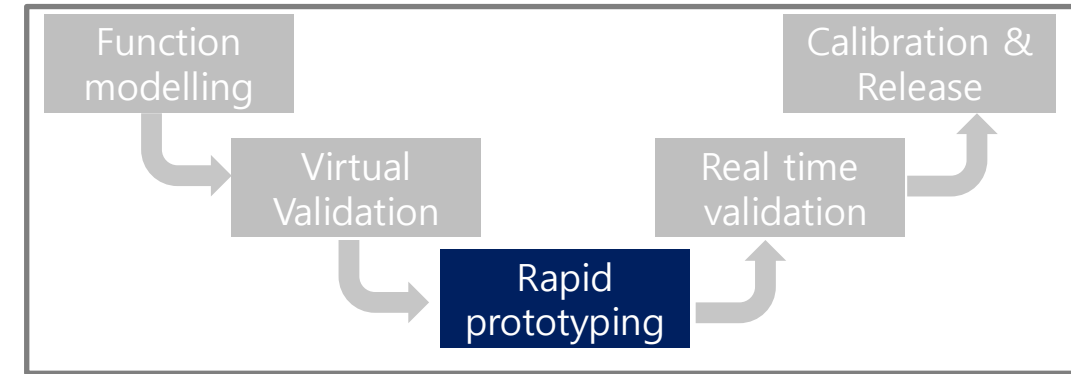
Usable with any other tool compatible with Simulink

Function Development workflow

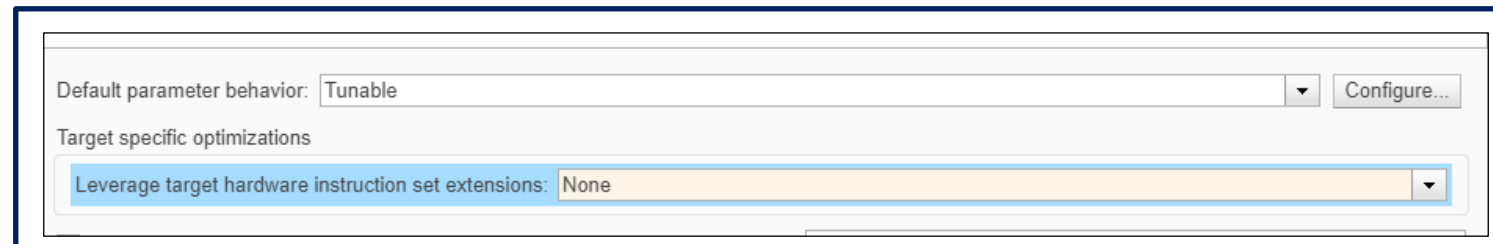
• Case 1: Matlab based



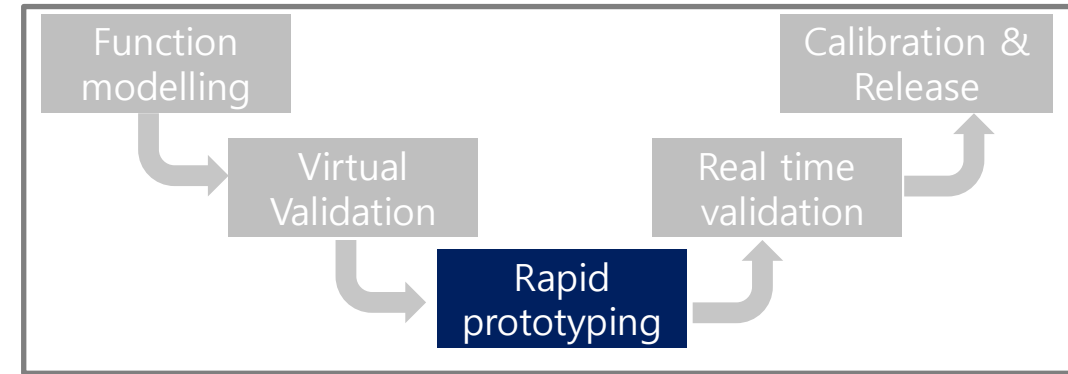
- Target hardware limitation to older Matlab versions
- sFunction output \neq Deep Learning Block






- Instruction set extension limitation from target hardware compiler

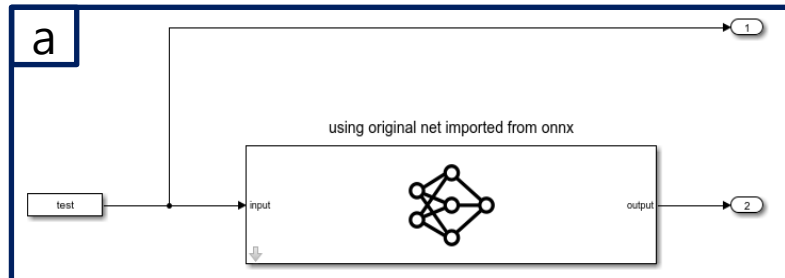


Function Development workflow

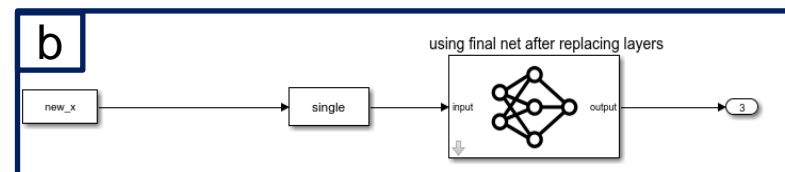


- **Case 2: Pytorch to Matlab**   
 - 1D Convolutional layer** not supported for code generation
 - Fix implies usage of **dlnetwork**, not supported by Matlab 2021b
 - dlnetwork** supported by Matlab 2023a

Import from ONNX



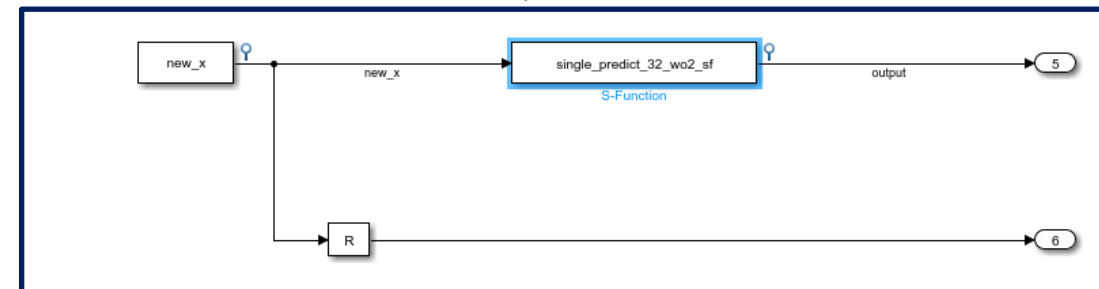
Replacement of unsupported layer



sFunction generation in 2023a

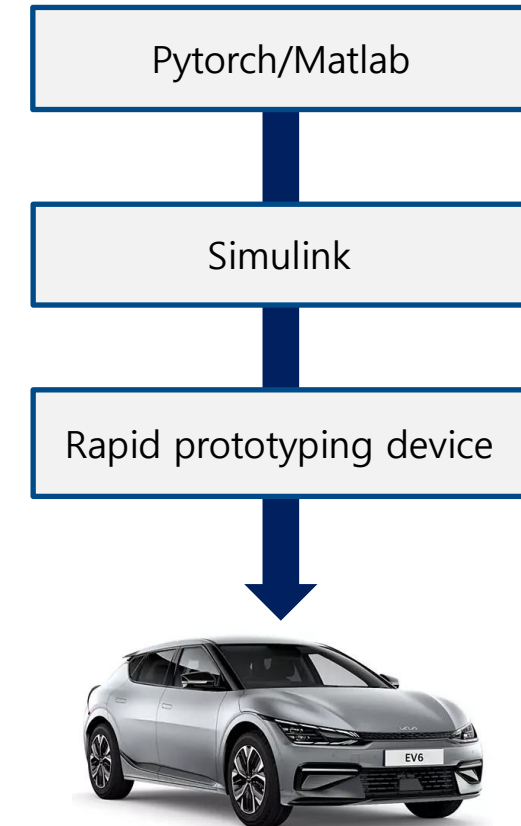
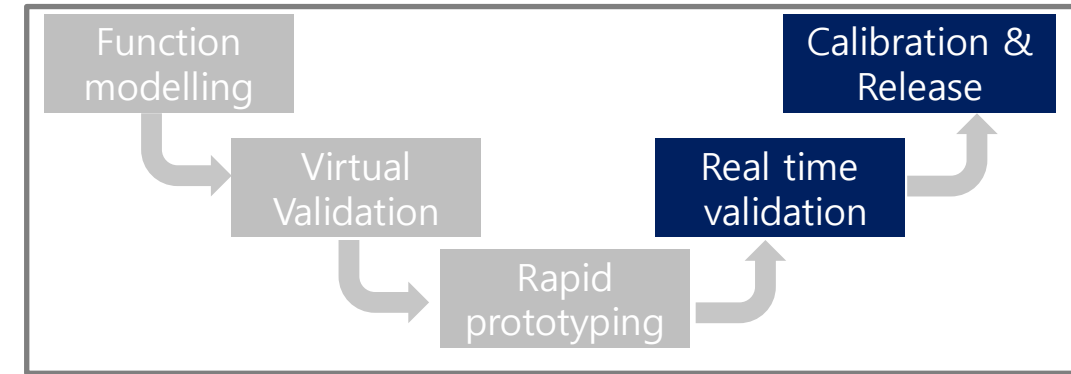
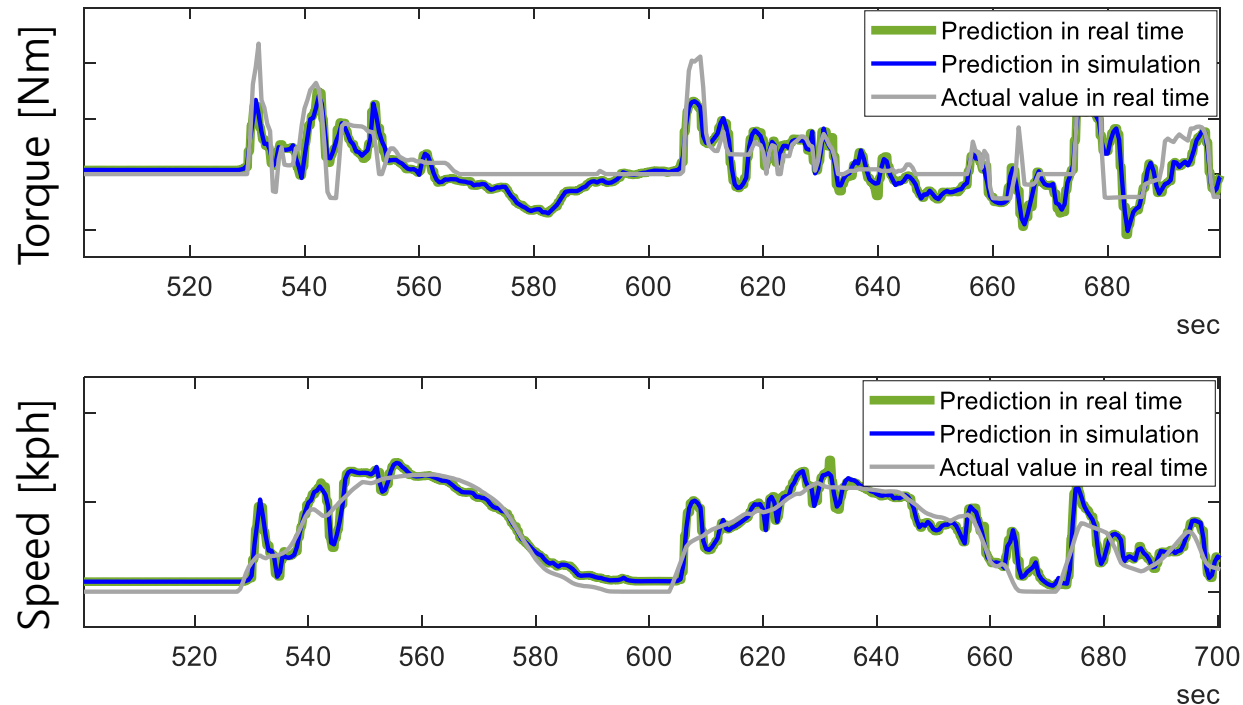


sFunction import into 2021b



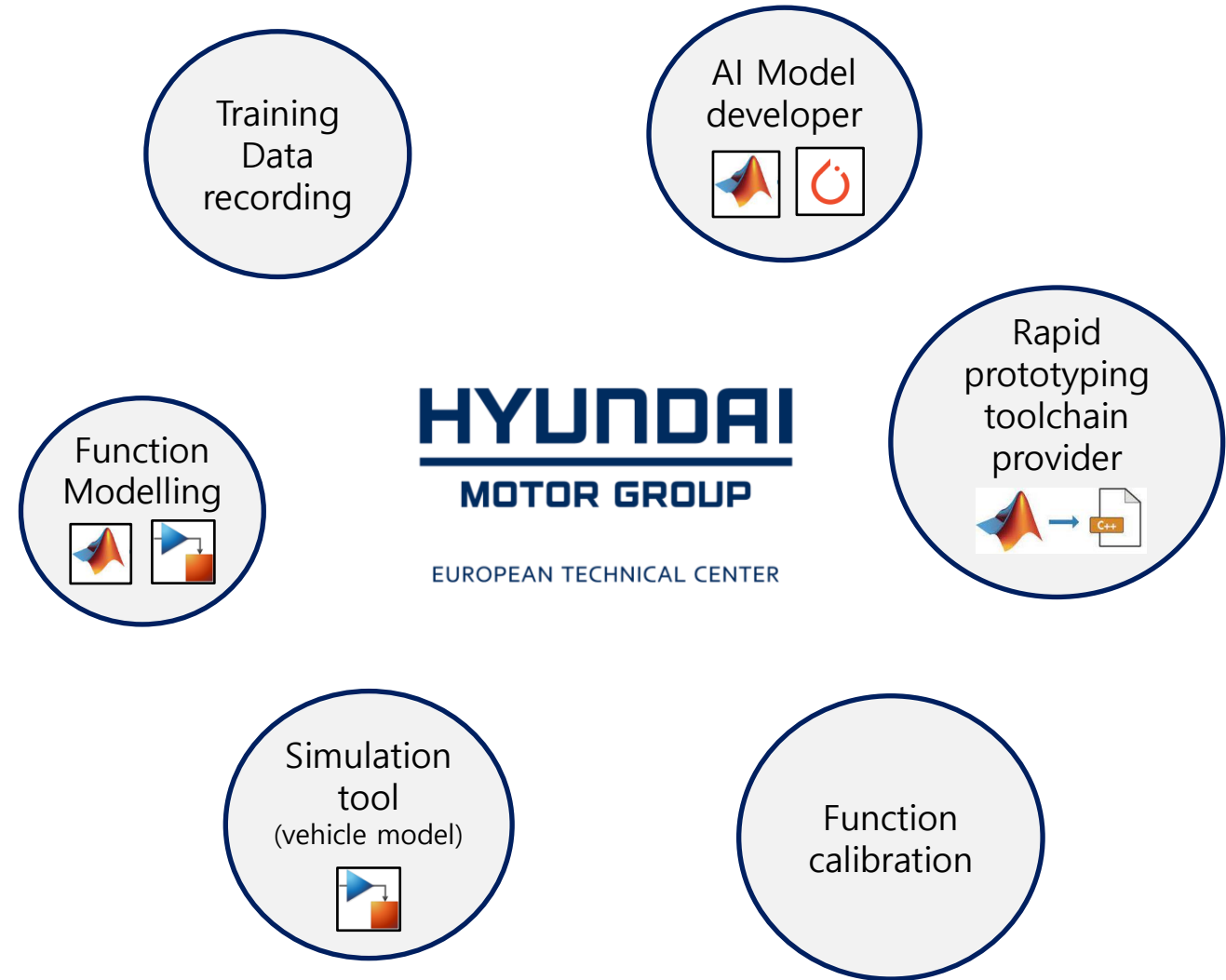
Function Development workflow

- ✓ All issues solved with Mathworks support
- ✓ Simulink models running in target hardware
- ✓ Test drive evaluations started



Summary of challenges

- Compatibilities among different parties
- Limitation to older Matlab versions
- Matlab code generation limitations for our specific AI model characteristics.
(1D Convolutional layer from Pytorch)
- Function validation in real time



Results



Driver characterization



Speed prediction



Torque Prediction



SOC Prediction

Research intention

- Enhance driver to vehicle collaboration
- Adapt driving performance: eco / sport

Evaluation of AI approach

- Good capabilities for subjective driver characterization
- Complex predictions solved by AI



Conclusions

- Successful deployment of AI models from Simulink into existing toolchain
 - Matlab
 - Pytorch
- Matlab AI capabilities for real time demonstrated
- Process is manual in a great extent due to the specific SW/HW setup of Project
 - Solutions found with Mathworks support for each specific case
- Other approaches offer tailored Simulink/Hardware combinations
 - Newer Matlab versions + Specific target hardware

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