



## **Virtual XCU Calibration with Neural Networks** NARX/Sequential Neural Networks for Dynamical Systems

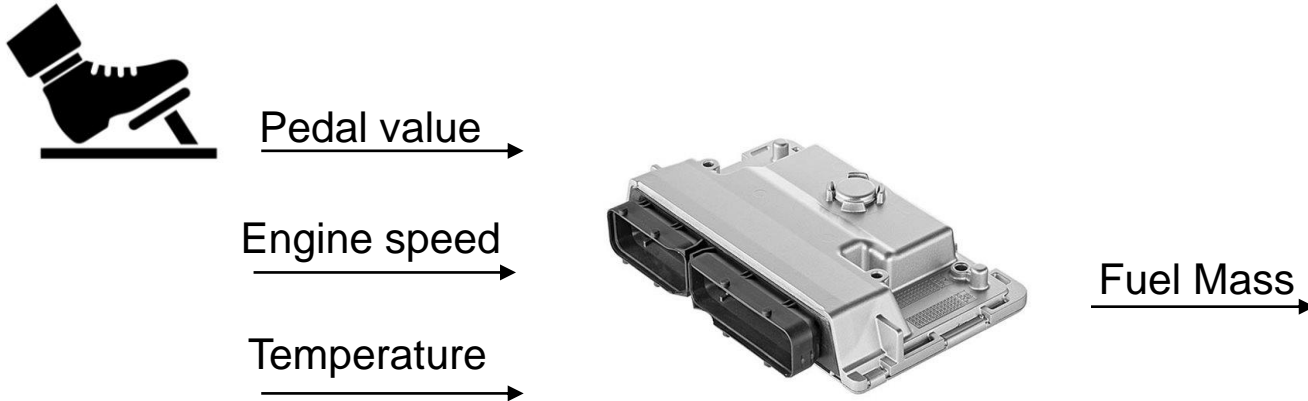
# Agenda

- 1 Classical ECU Functions
- 2 Deep Dynamical Systems
- 3 Deploying AI As Virtual Testbench

# Classical ECU Functions

## What is an ECU Function ?

- › Mapping Input Signals to Output signals

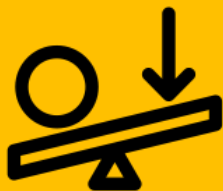


# Classical ECU Functions

## Advantages/Disadvantages

### Advantages

- › Physically motivated
- › High understanding of what's going on (intermediate signals have typically physical units)
- › Enabling “transfer learning” for single HW change



### Disadvantage

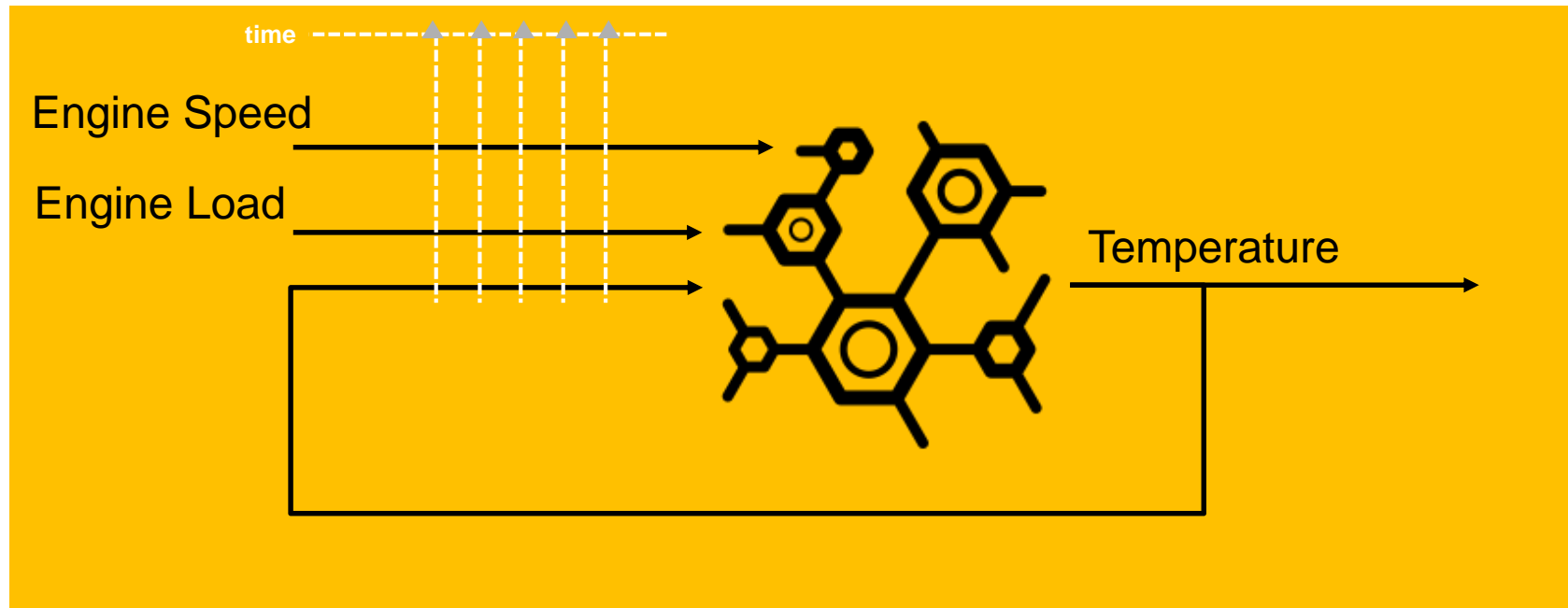
- › Require development (modelling + coding)
- › Require methodology development for calibration = training
- › Require tooling for the training (backpropagation)
- › Require very special measurements from engine test bench



# Deep Dynamical Systems

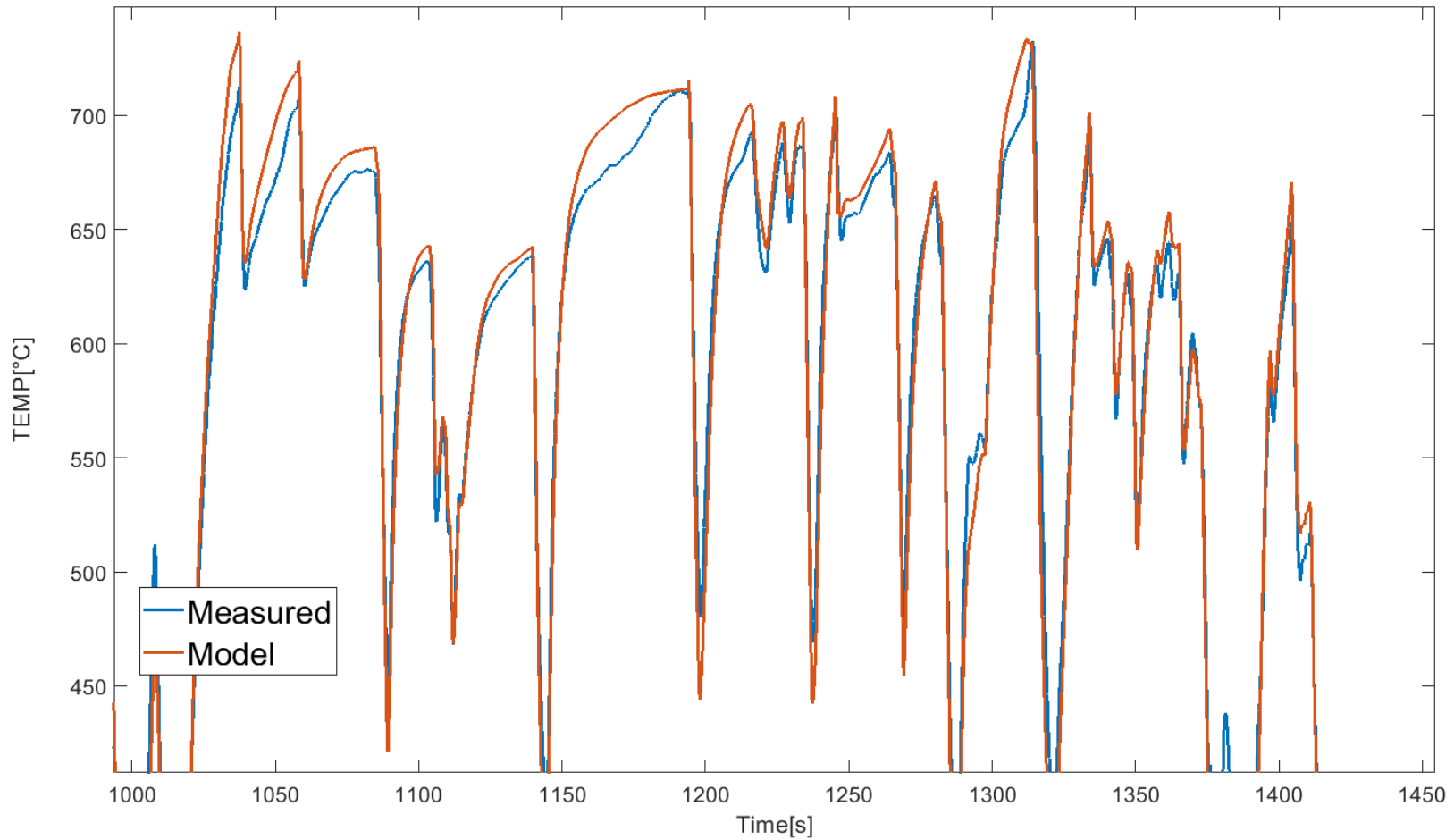
## Network overview

- › No LSTM (Long Short-Term Model)
- › NARX (Nonlinear autoregressive neural network)

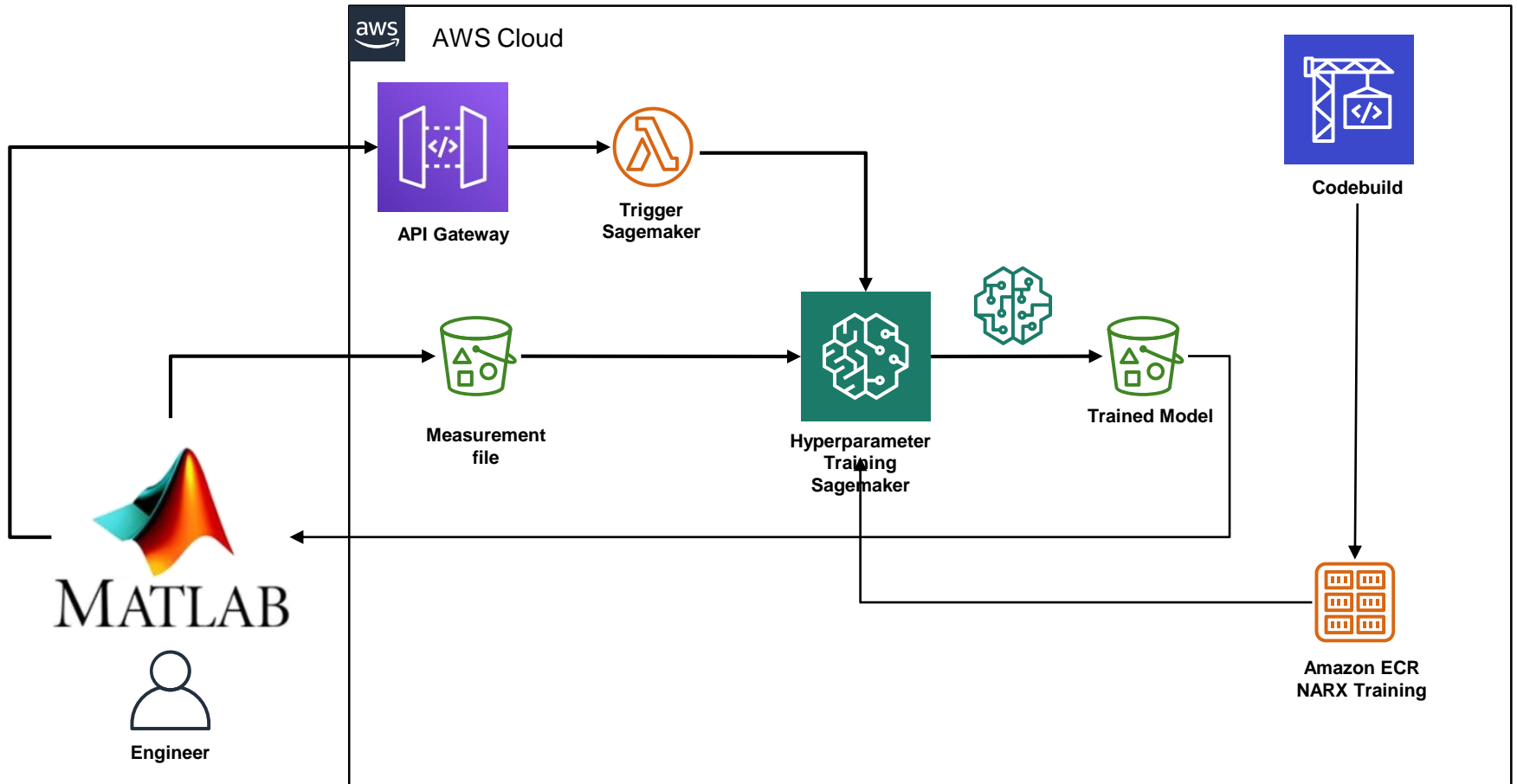


# Deep Dynamical Systems

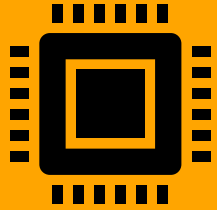
Temperature example 40min of driving (validation)



# Deep Dynamical Systems Training at AWS



# Deep Dynamical Systems Applications



Deploy to ECU



Virtual Testbench



Calibrate Controller for  
Dynamical System

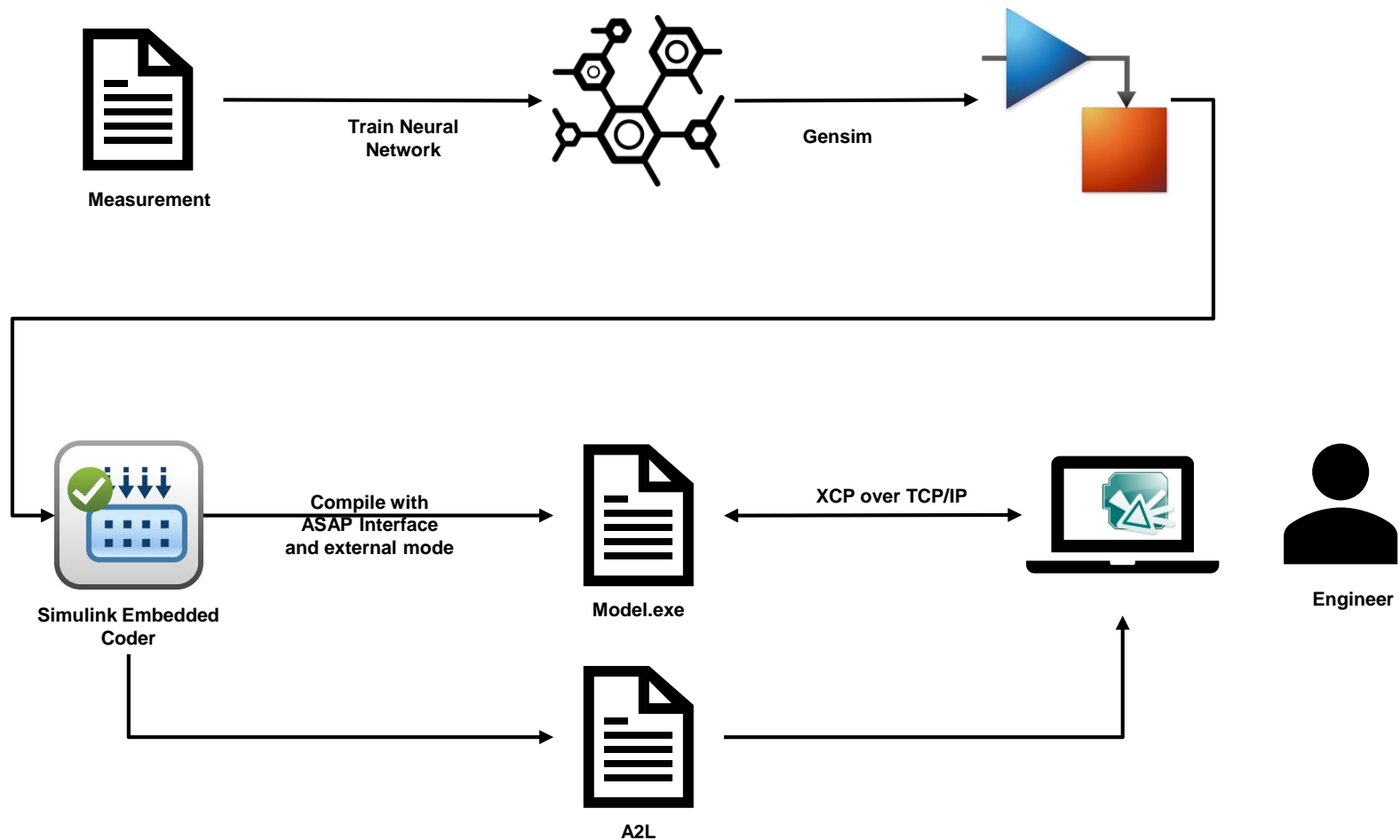


Reinforcement  
Learning



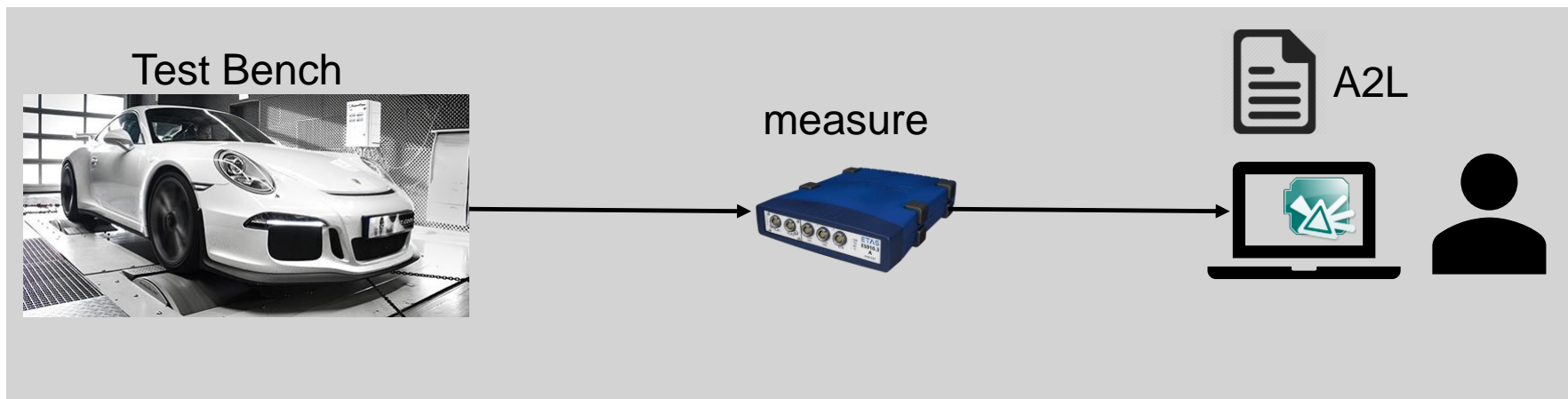
# Deploying Artificial Intelligence As Virtual Testbench

## Matlab/Simulink Workflow



# Deploying Artificial Intelligence As Virtual Testbench

## Measure Neural Network with INCA



# Q & A

