
ETAS

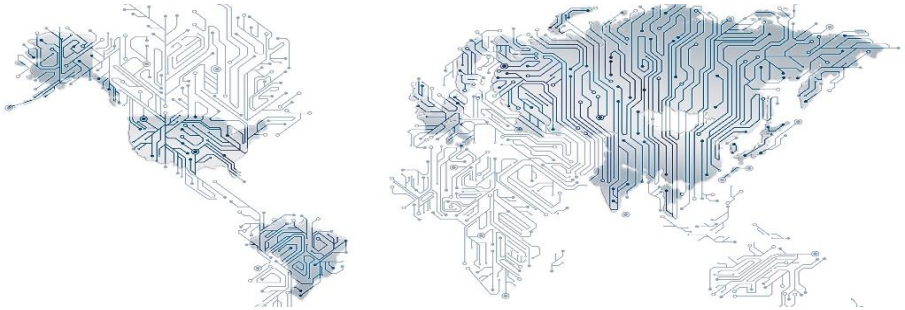
ETAS

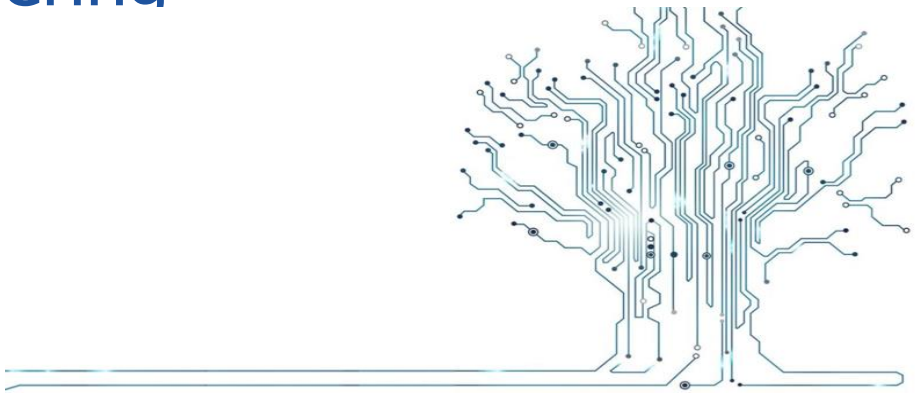
DRIVING EMBEDDED EXCELLENCE

V-Cycle for Automotive SW Engineering

André Pelisser - 2018

V-Cycle for Automotive SW Engineering



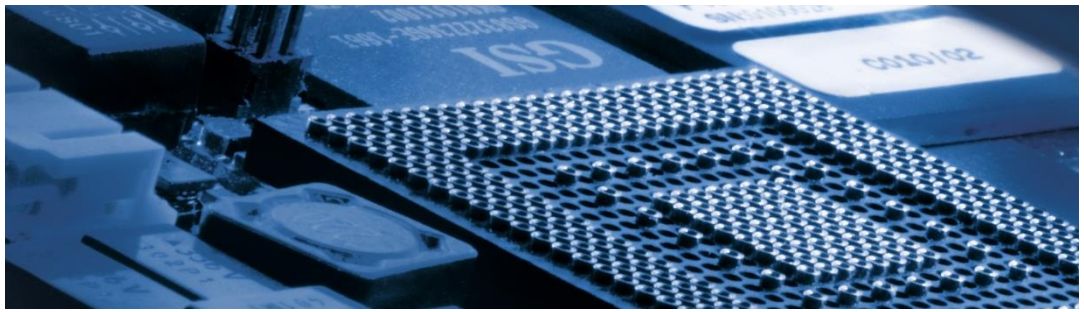


1. ETAS World – Driving Embedded Excellence

- Who are we?
- What we do?
- Where are we?
- Who we work with?

3. The V-Cycle - Control Software Development Metodology

- Basic Control Definition
- Generic V-Cycle fo SE
- V-Cycle – ETAS Solutions



2. Introduction - What is embedded software?

- Why calibration is necessary?
- Basics of calibration
- What is "Real Time?"

4. Software Engineering

- Model Based Development
- Function Design
- Software Architecture
- Software Integration

V-Cycle for Automotive SW Engineering

5. Virtual Testing and Validation

- HiL Motivation
- HiL Concept
- HiL Applications

6. Measurement and Calibration

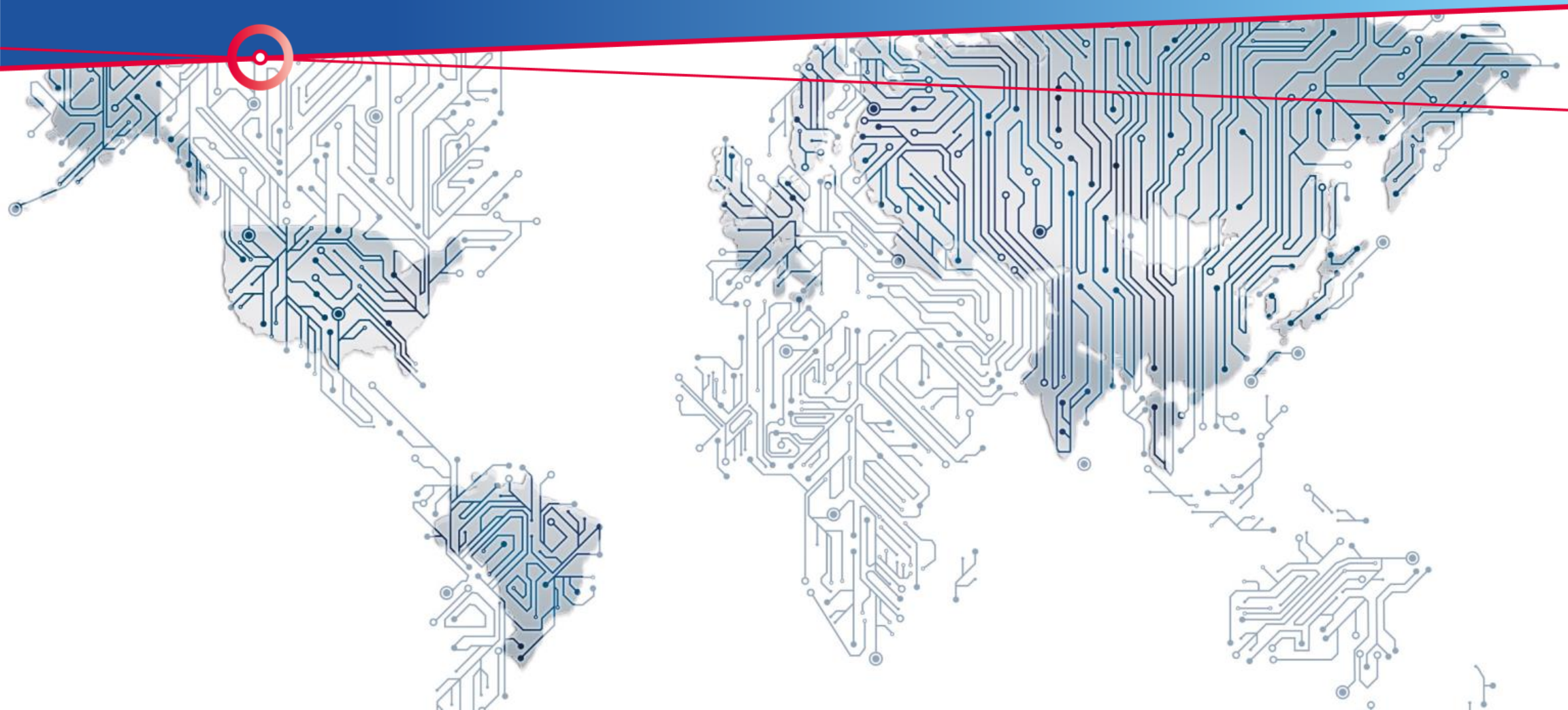
- CAN Bus
- MCD Tools and Tasks
- INCA – The MCD Solution
- ECU Access

7. IPT

- Questions & Answers
- Visit to IPT

The ETAS World

Driving Embedded Excellence



Who are we?

Leading provider of solutions and services for the development of embedded systems

ETAS - Engineering Tools, Applications & Services

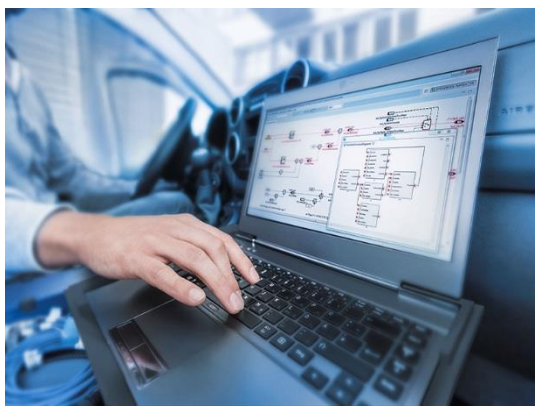
- ETAS was founded in 1994 as a subsidiary of Robert Bosch GmbH;
- Together with its subsidiary ESCRYPT, ETAS employs more than 1,200 associates worldwide;
- ETAS is present at 23 locations in 12 countries; ESCRYPT is present in 8 countries with 12 locations;
- ETAS revenue: 250 million euros in 2017;

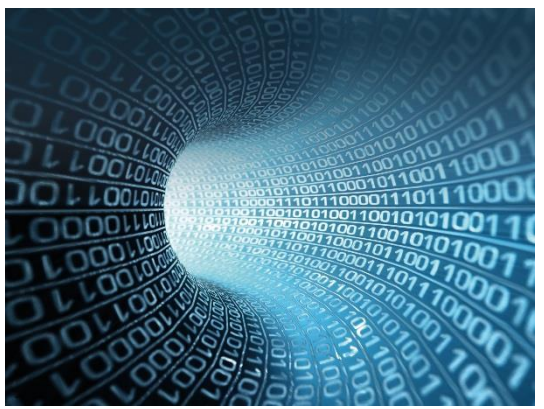
What do we do?

ETAS Solutions Portfolio

Products, Consulting and Engineering Services

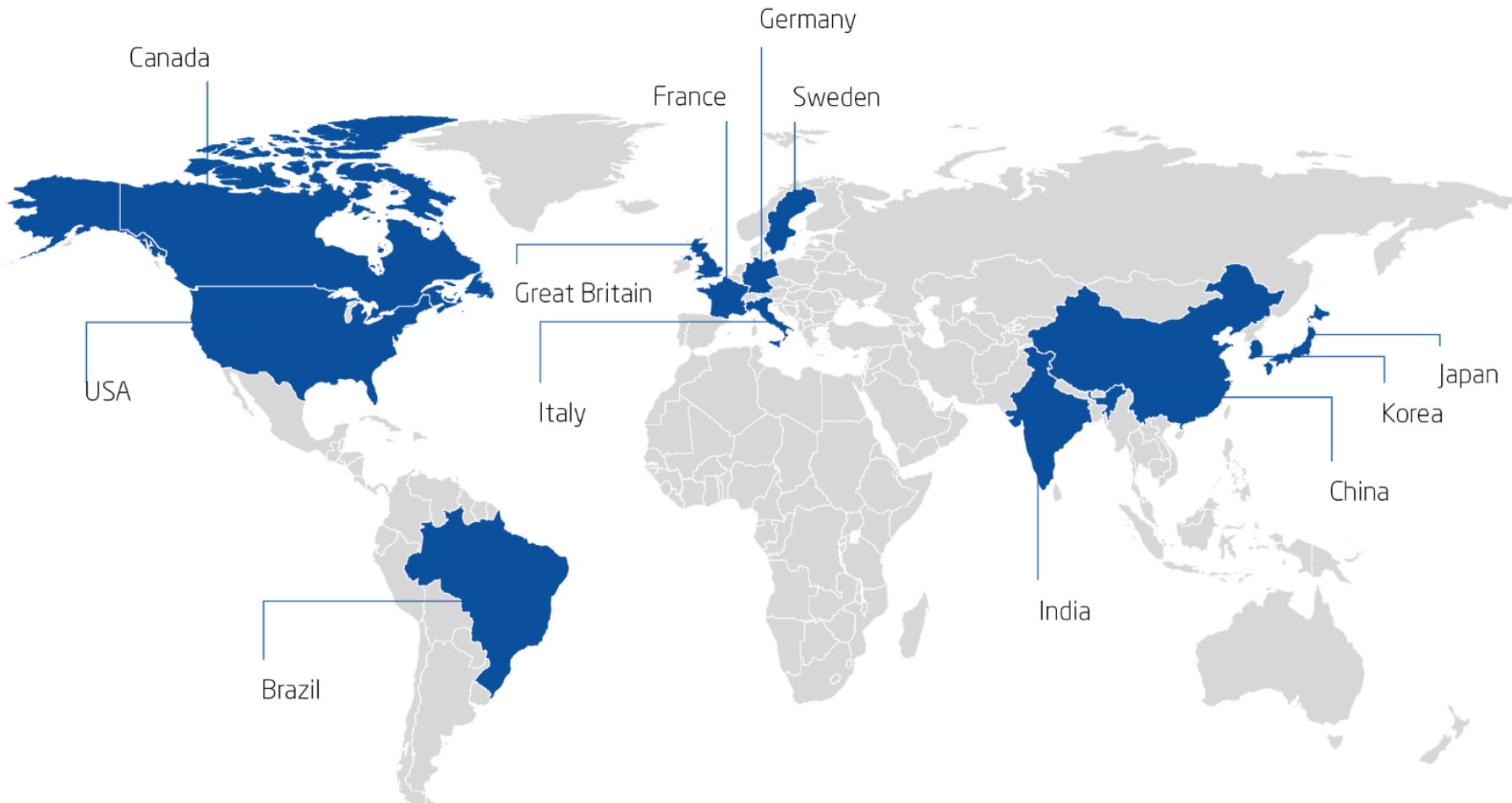
- Software Engineering
- Test and Validation
- Measurement, Calibration, and Diagnostics
- Embedded Security





Where are we?

ETAS is placed where ECU development is being done...



Where are we?

ETAS Brasil Team

- ETAS first came to Brazil on 1 January 2009 in São Paulo as a business unit of Robert Bosch Latin America;
- New office was established on August 2012 in São Bernardo do Campo, major automotive development site in Brazil;

Main contact:

Hermann Klein - Key Account Manager - Sales
R. José Versolato, No 111 – Centro Sala 1814, 18º andar
Torre B, Edifício Domo Business São Bernardo do Campo – SP Brazil Phone: +55 11 2666-0060

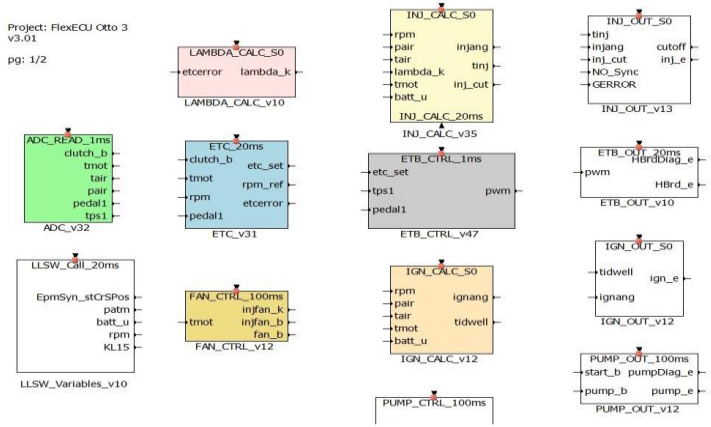
Who we work with?

Extract of our local and international partners & customers

Vehicle Manufacturers (OEM) **ECU Suppliers (Tier 1)** **Engineering Services**

Who we work with?

University Partnerships



FSAE Escola Politécnica da USP

- ICE Management
- Joint Partnership with Bosch
- Measument and Calibration

FSAE Centro Universitário FEI

- Control Engineering
- Electric Motor Management
- Measument and Calibration

GEA Escola Politécnica da USP

- ICE Management
- ECU Software Engineering
- Dynamometer Instrumentation

Introduction

What is embedded software?

What are the specificities of Automotive ECU Software?

Why calibration is important? What is “Real Time”?

Why calibration is necessary?

Same ECU, very different engines...

Equipe Poli Racing – FP09

Type: Monocylinder

Power: 44 HP

Size: 0.45 Liters

JL Racing – Stock Car

Type: 8 Cylinders in V

Power: 550 HP

Size: 6.2 Liters

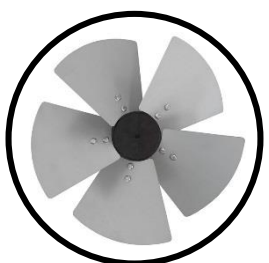
How is that possible?

Basics of Calibration

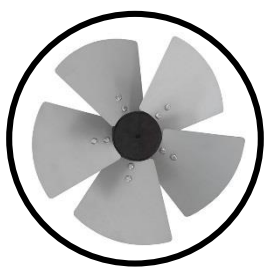
Engine Thermal Manangement - Concept

Is the **Temperature** > 90ºC ?

True



False



Basics of Calibration

Engine Thermal Manangement - Concept

Is the **Temperature** > **Temp_Threshold** ?

True

False

Temp_Threshold = 90ºC

...

Temp_Threshold = 95ºC

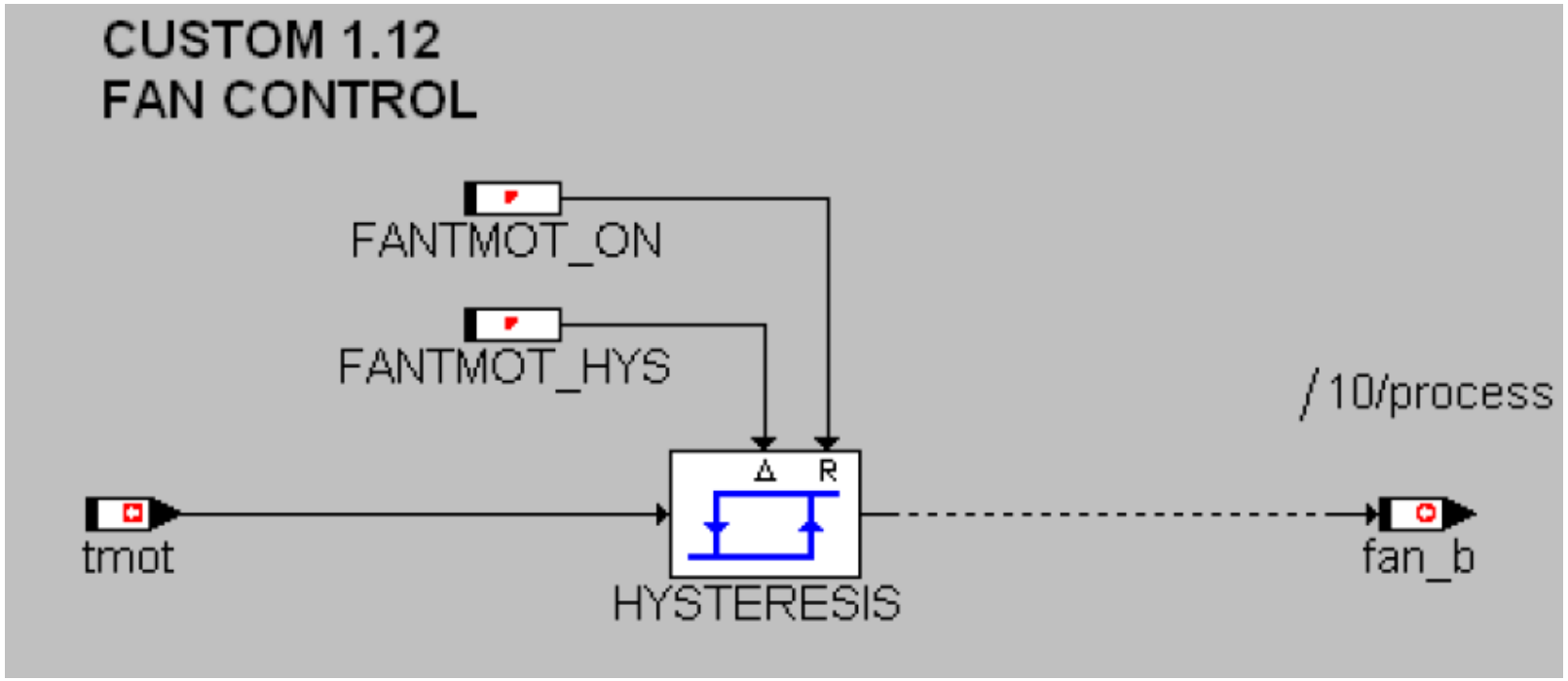
...

Temp_Threshold = 96ºC

This is enabled to be calibrated

Basics of Calibration

Engine Thermal Manangement – Real Application



Each 10ms Do

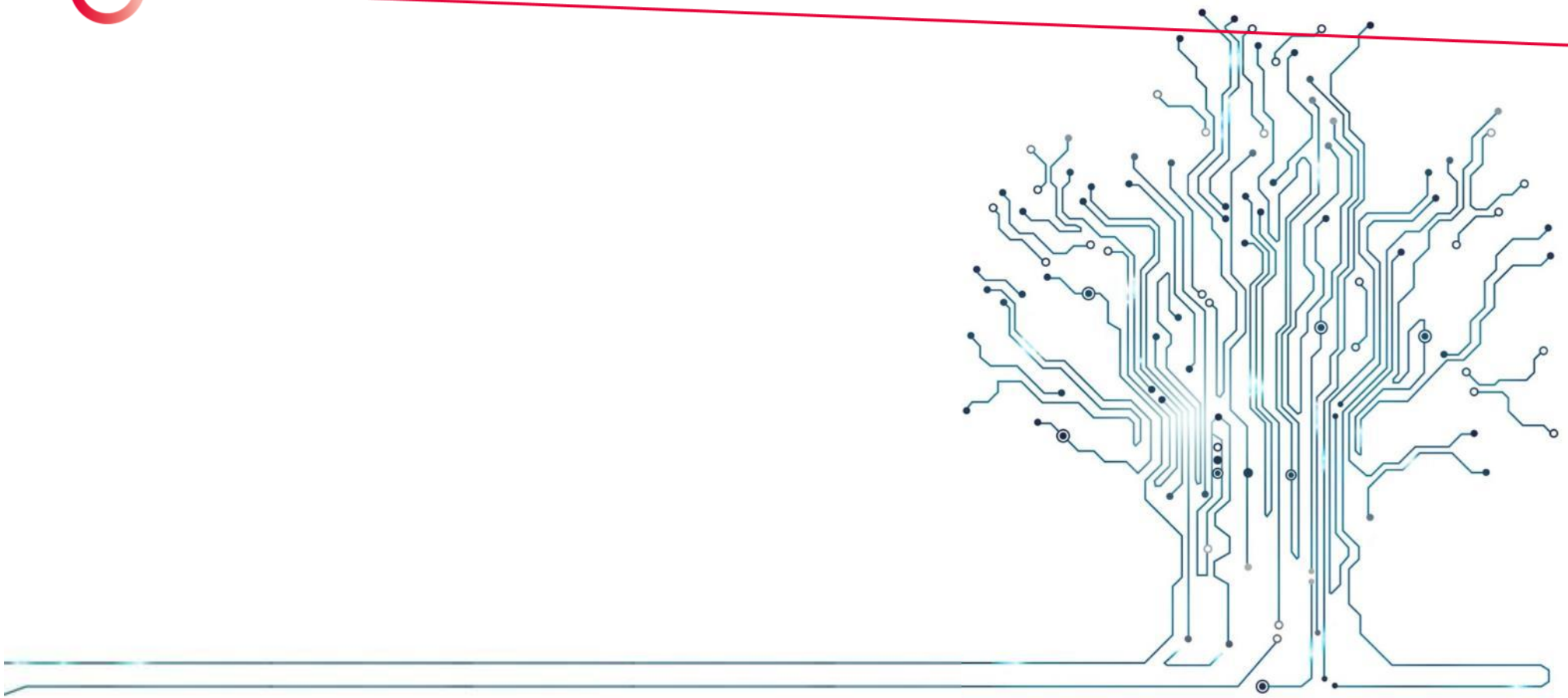
If fan_b == False && tmot > FANTMOT_ON Then fan_b = True

If fan_b == True && tmot < FANTMOT_HYS Then fan_b = False

What is Real Time?

The V-Cycle

Control Software Development Metodology

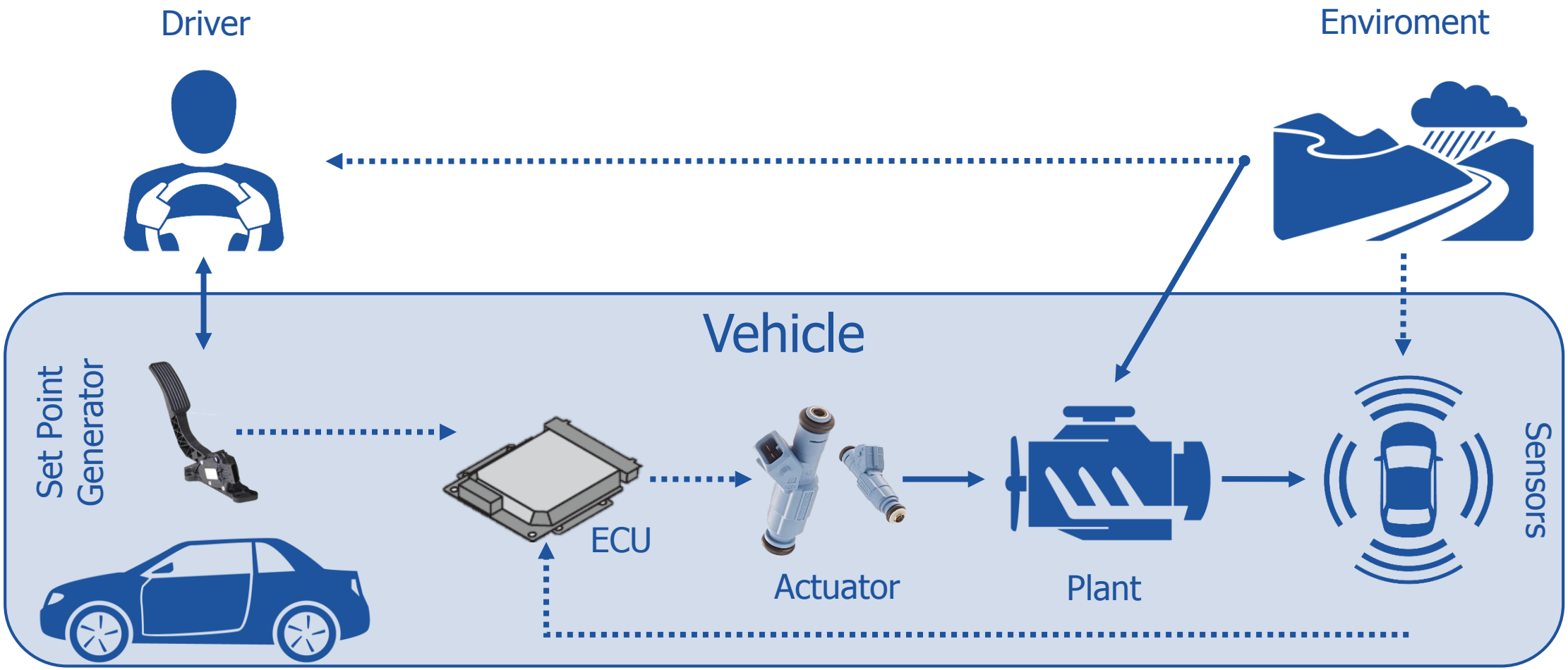


What is a closed loop control system?

Why is it important? How it is conceived?

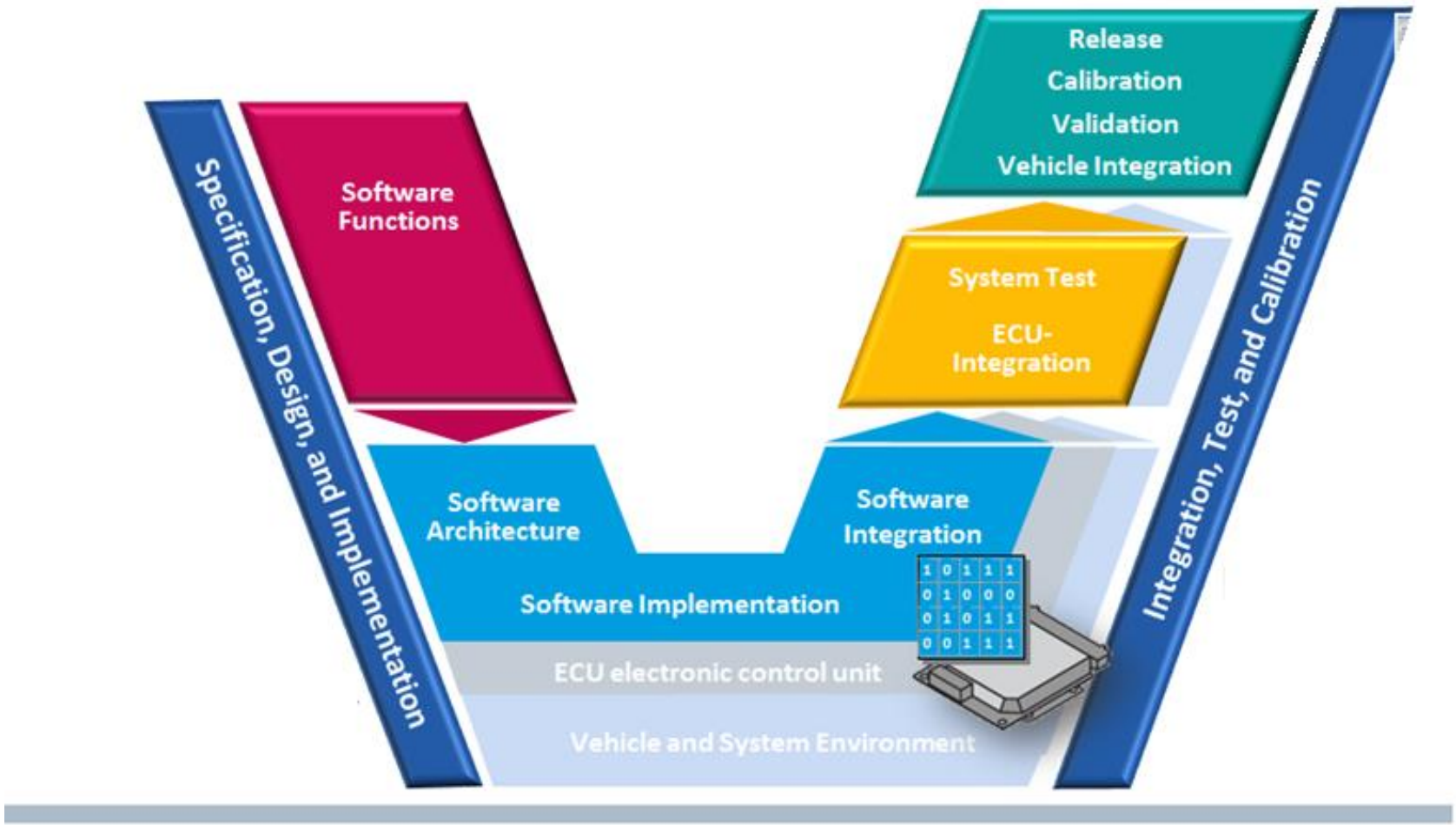
Basic Control Definition

Example - Automotive Closed Loop



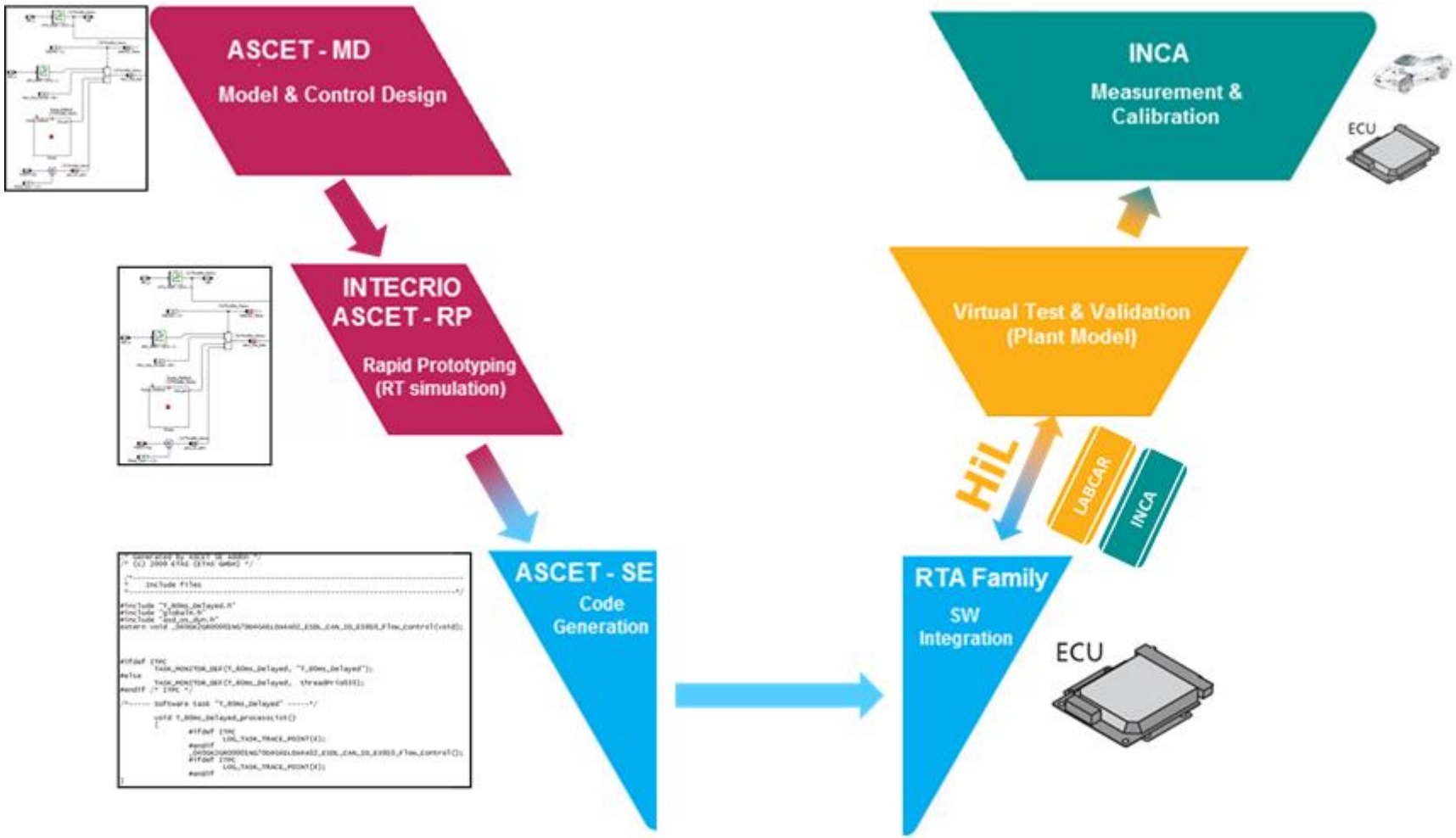
V-Cycle

Generic Embedded Controler V-Cycle



V-Cycle

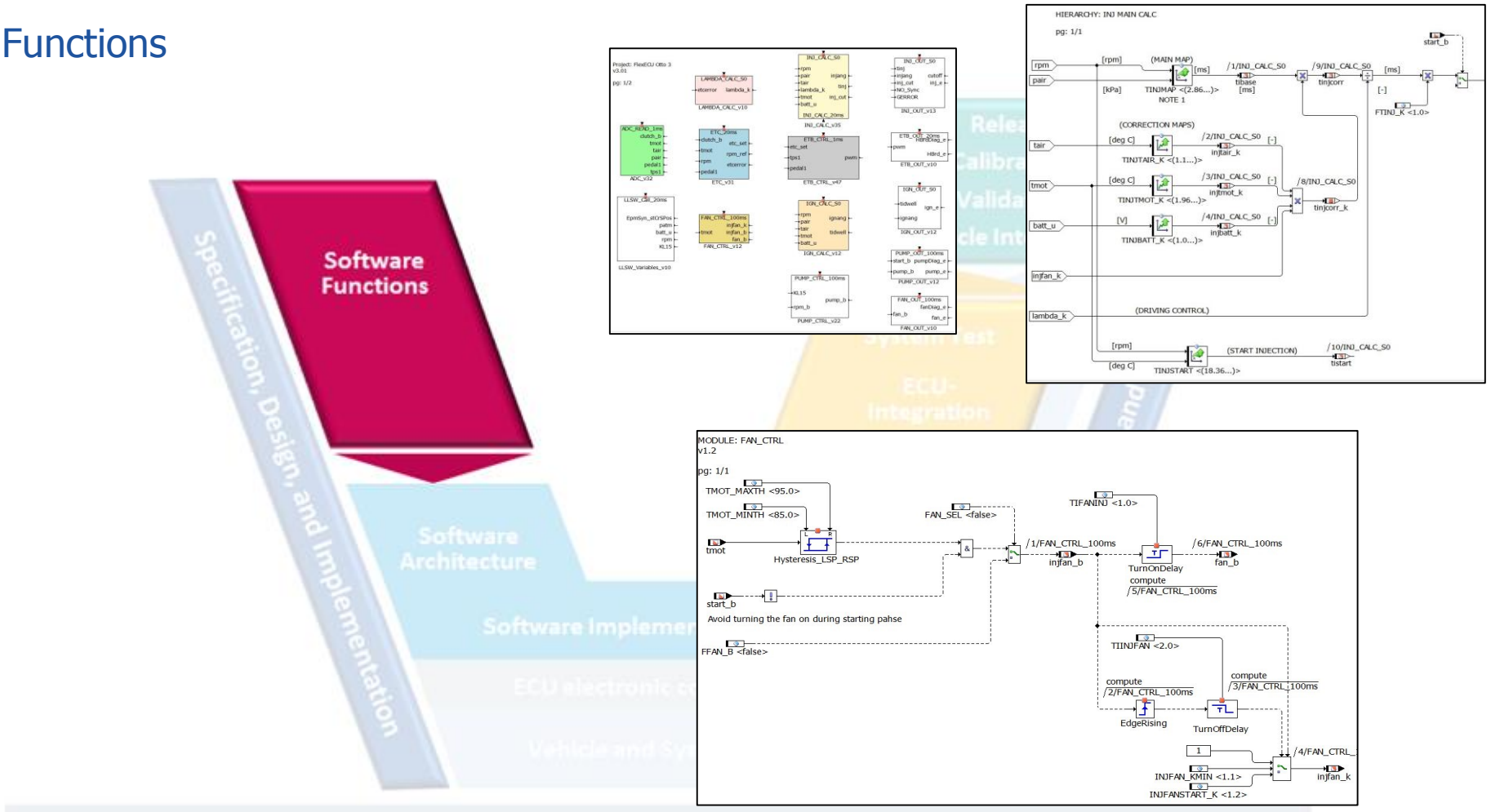
ETAS Solutions



Software Engineering

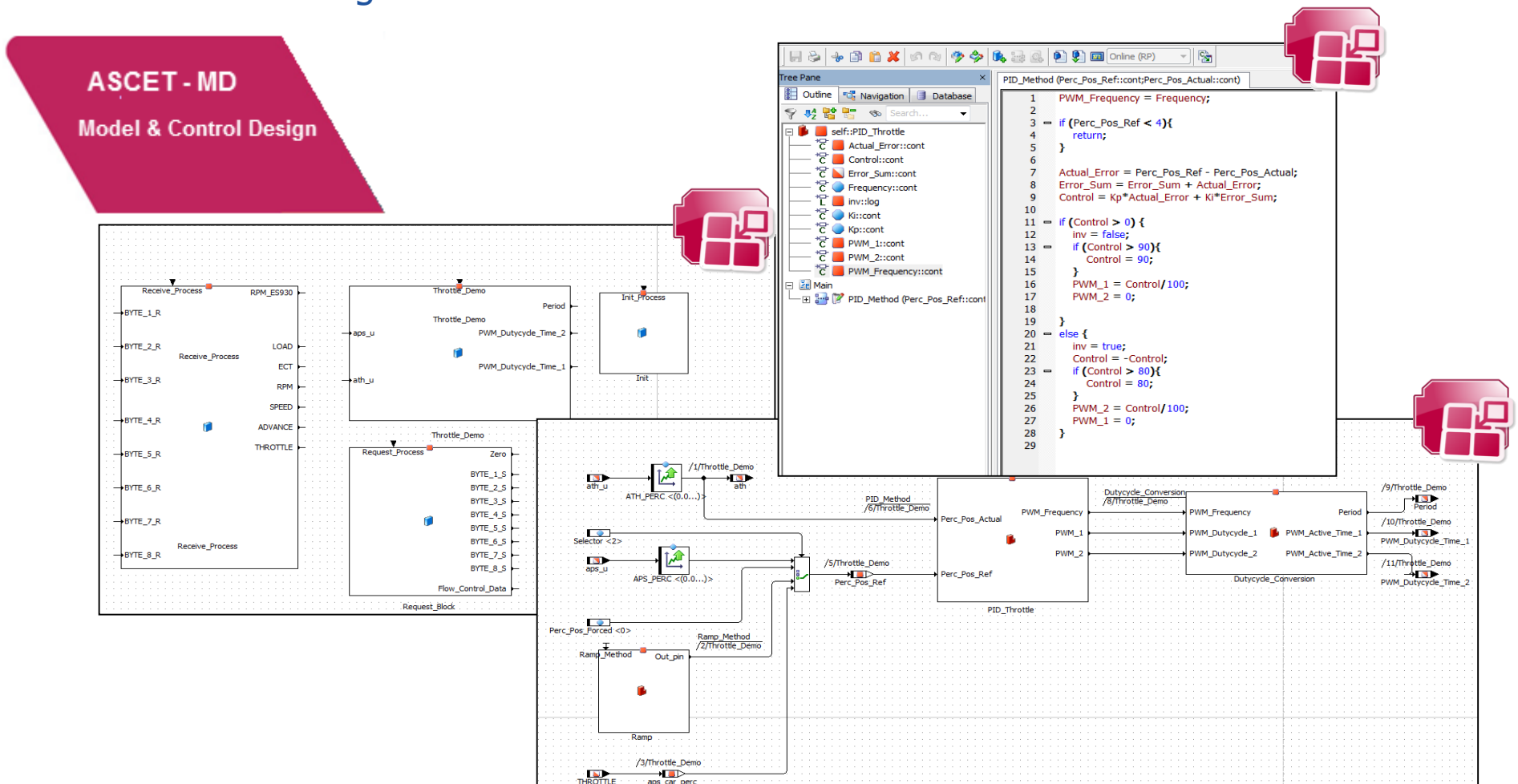
V-Cycle

Software Functions



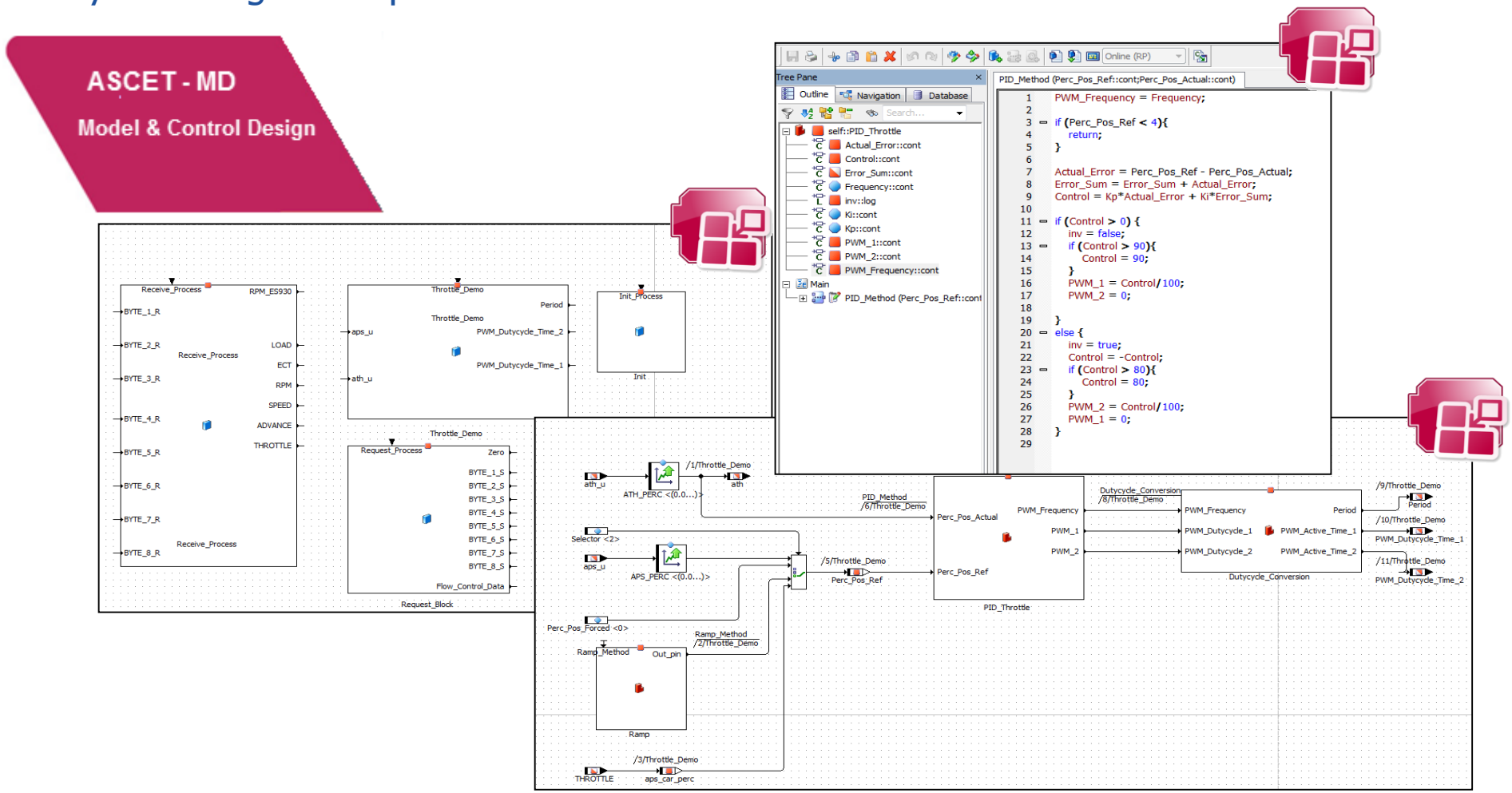
Model Based Development

Model Based ≠ Block Diagram



Model Based Development

Modularity and Target Independence

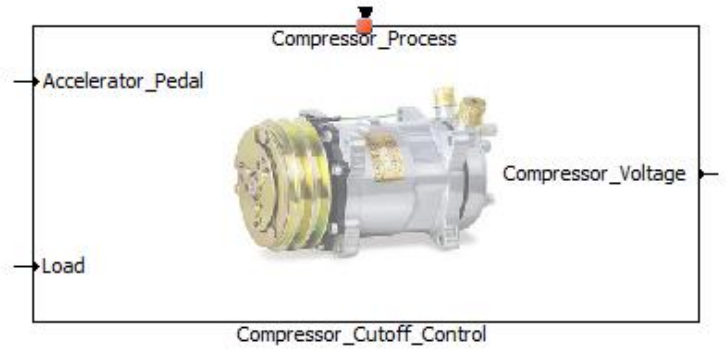


Function Design

Overview and Air Conditioning Example

ASCET - MD

Model & Control Design



Inputs

- Engine Load
- Accelerator Pedal Position

Parameters

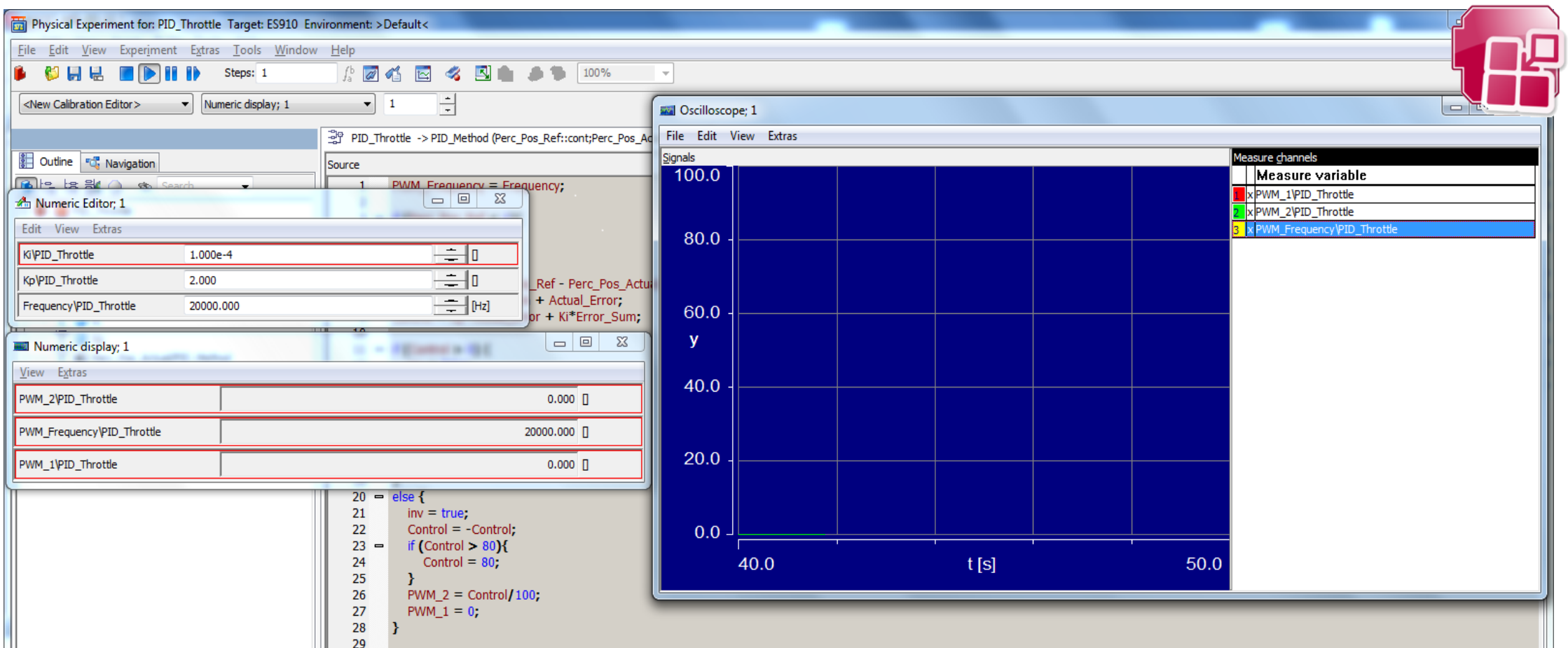
- Load Threshold
- Accelerator Pedal Threshold
- Max Cut-off Time

Outputs

- Compressor Voltage

Function Design

Virtual Simulation – Not real time



Function Design

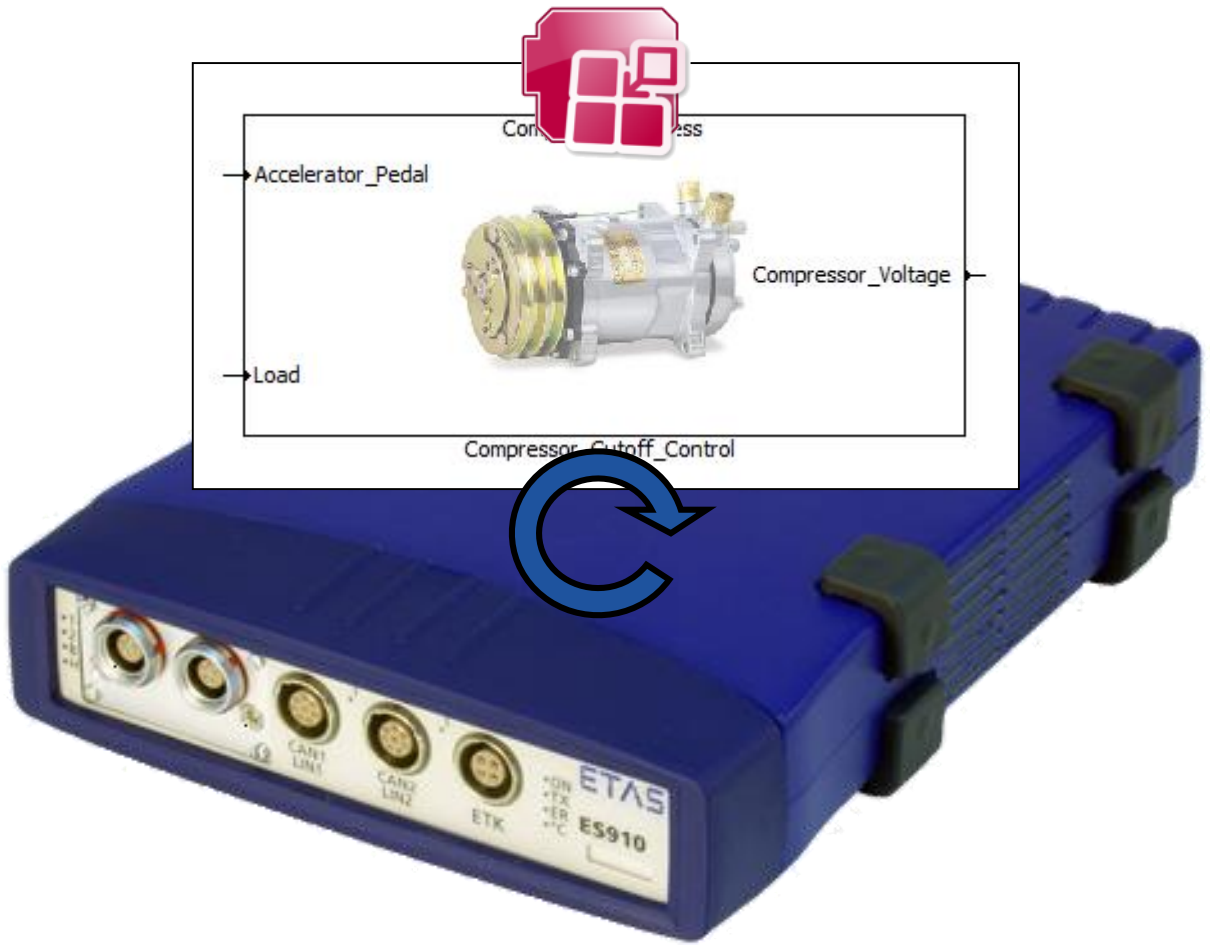
Rapid Prototyping – Real Time Simulation

ASCET - MD

Model & Control Design

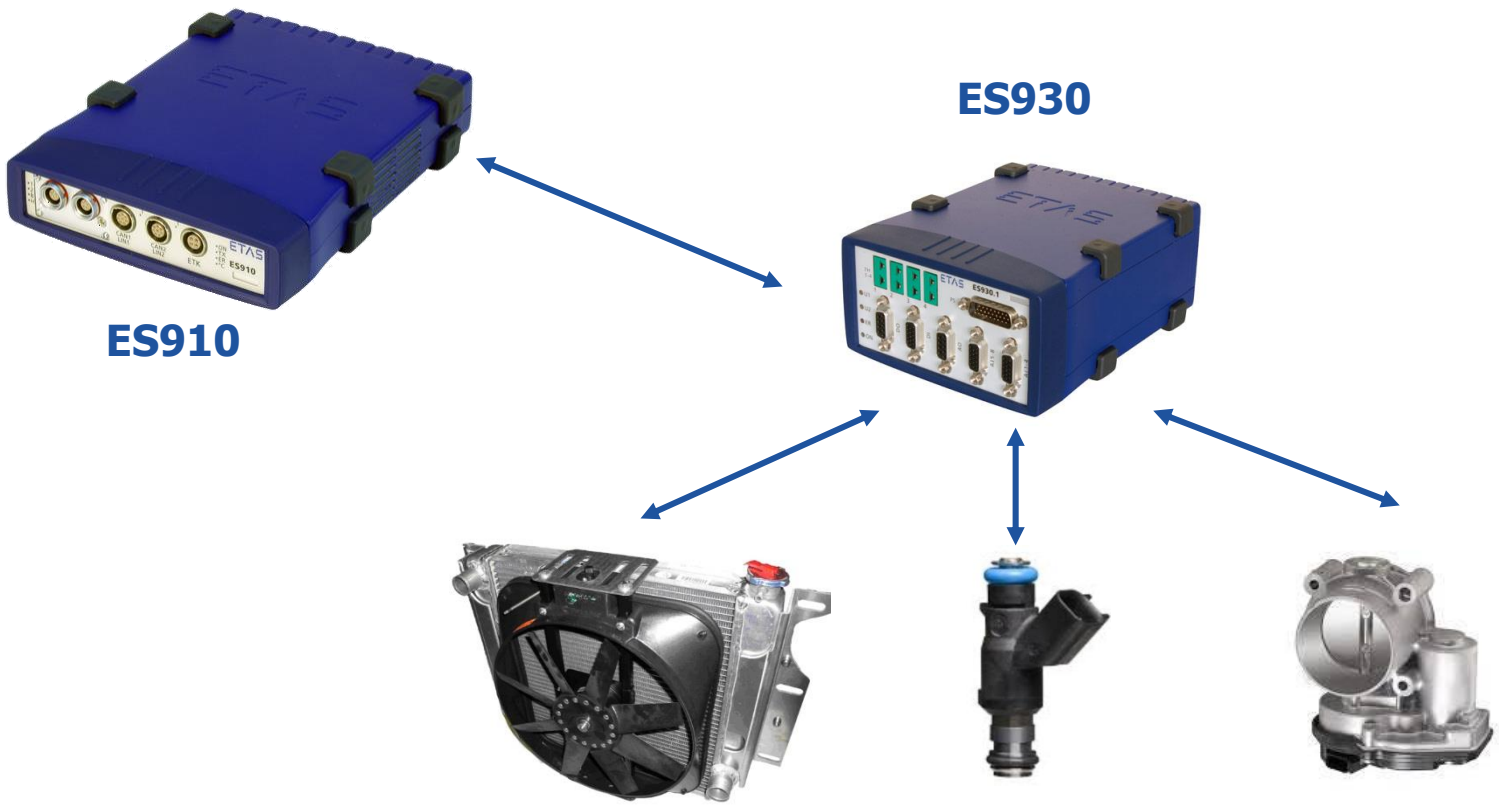
INTECRIO ASCET - RP

Rapid Prototyping (RT simulation)



Function Design

Rapid Prototyping with Real Hardware



Function Integration

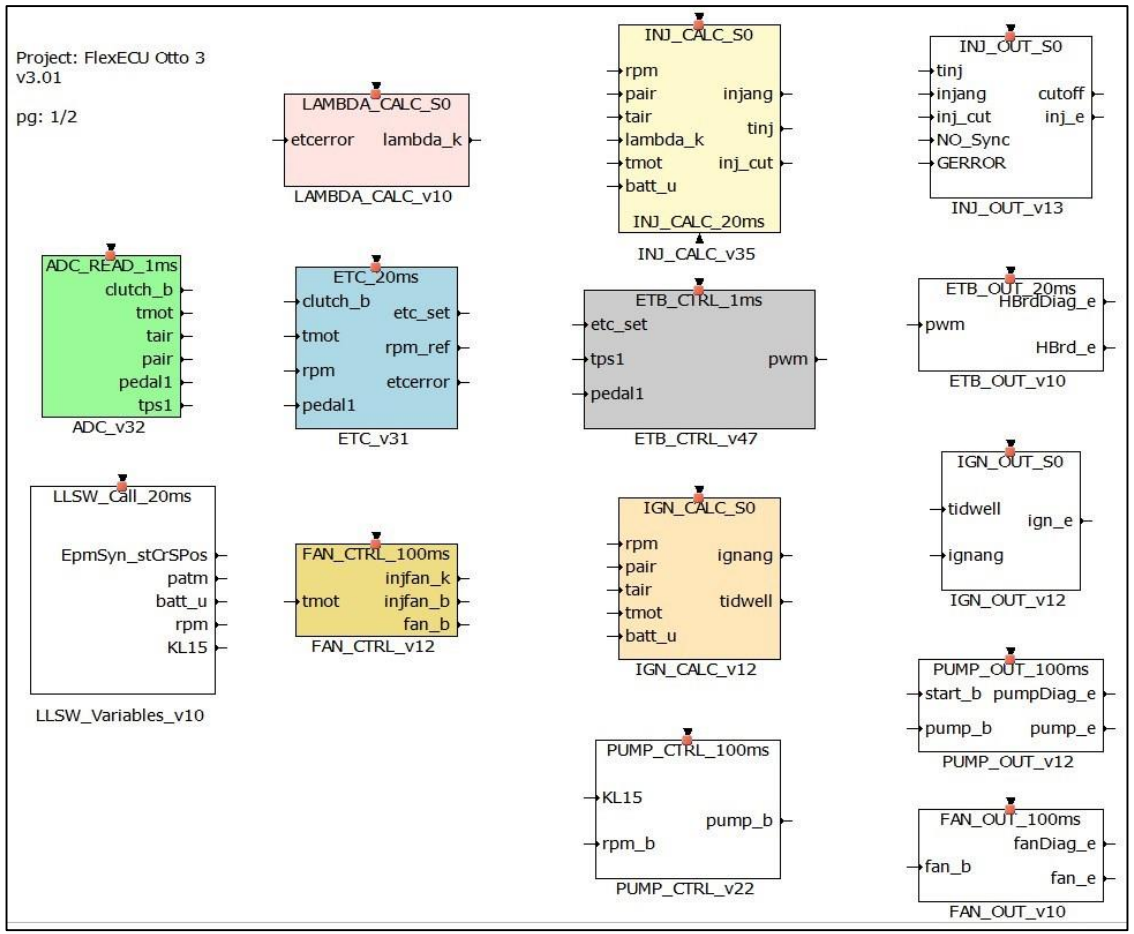
Multiple Functions Simulation

ASCET - MD

Model & Control Design

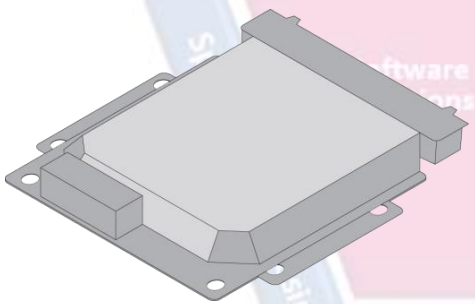
INTECRIO
ASCET - RP

Rapid Prototyping
(RT simulation)



V-Cycle

Software Architecture, Implementation and Integration



ECU

```
/* Generated by ASCET RP AddOn */
/* (c) 2009 ETAS (ETAS GmbH) */

/*-------------------------------------------------------------------------
 *    Include files
 *-------------------------------------------------------------------------*/

#include "T_100ms.h"
#include "globalH.h"
#include "asd_os_dyn.h"
extern void _040SK0DKA58010071C2097C72C800_Proc_100ms(void);
extern void _040SK0DKA58010071C2097E40CH00_ESDL_Daisychain_Inputs_ES930_MIO1_AI_100us(void);
extern void _040SK0DKA58010071C2097E40CH00_ESDL_CAN_IO_CAN_Send(void);



#ifdef ITPC
    TASK_MONITOR_DEF(T_100ms, "T_100ms");
#else
    TASK_MONITOR_DEF(T_100ms,  threadPrio032);
#endif /* ITPC */

/*----- Software task "T_100ms" -----*/

    void T_100ms_processList()
    {
        #ifdef ITPC
            LOG_TASK_TRACE_POINT(1);
        #endif
        _040SK0DKA58010071C2097C72C800_Proc_100ms();
        #ifdef ITPC
            LOG_TASK_TRACE_POINT(1);
        #endif
        _040SK0DKA58010071C2097E40CH00_ESDL_Daisychain_Inputs_ES930_MIO1_AI_100us();
        #ifdef ITPC
            LOG_TASK_TRACE_POINT(1);
        #endif
        _040SK0DKA58010071C2097E40CH00_ESDL_CAN_IO_CAN_Send();
        #ifdef ITPC
            LOG_TASK_TRACE_POINT(1);
        #endif
    }
```

```
:0200000400807A
:20000000FA828ACEFA800400FA800800FA800C00FA801000FA801400FA801800FA801C0046
:20002000FA802000FA802400FA802800FA802C00FA803000FA803400FA803800FA803C0080
:20004000FA804000FA804400FA804800FA804C00FA805000FA805400FA805800FA805C0060
:20006000FA806000FA806400FA806800FA806C00FA807000FA807400FA807800FA8226CBC9
:20008000FA808000FA808400FA808800FA808C00FA82BCE3FA8200F3FA82AAEBFA8276E7EC
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:2000E000FA80E000FA80E400FA80E800FA80EC00FA80F000FA80F400FA80F800FA80FC00C0
:20010000FA800001FA800401FA800801FA800C01FA801001FA801401FA801801FA801C0197
:20012000FA802001FA802401FA802801FA802C01FA803001FA803401FA803801FA803C0177
:20014000FA804001FA8224CBFA8222CBFA804C01FA805001FA805401FA805801FA805C0105
:20016000FA806001FA806401FA806801FA806C01FA807001FA807401FA807801FA807C0137
:20018000FA808001FA808401FA808801FA808C01FA809001FA809401FA809801FA809C0117
:2001A000FA80A001FA80A401FA80A801FA80AC01FA80B001FA80B401FA80B801FA80BC01F7
:2001C000FA80C001FA80C401FA80C801FA80CC01FA80D001FA80D401FA80D801FA80DC01D7
:2001E000FA80E001FA80E401FA80E801FA80EC01FA80F001FA80F401FA80F801FA80FC01B7
```
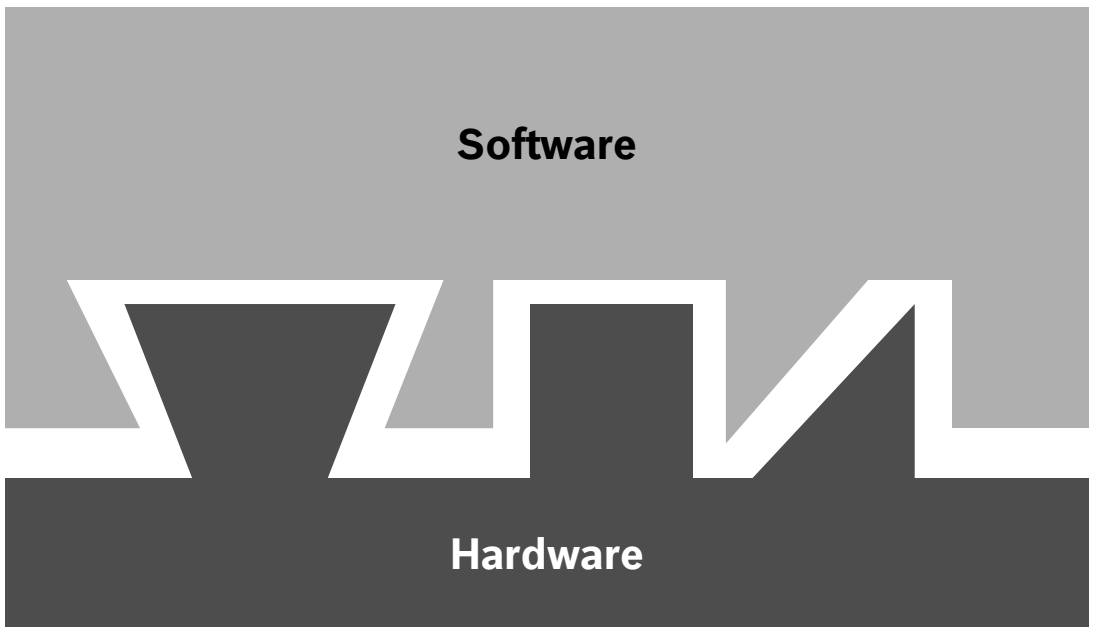
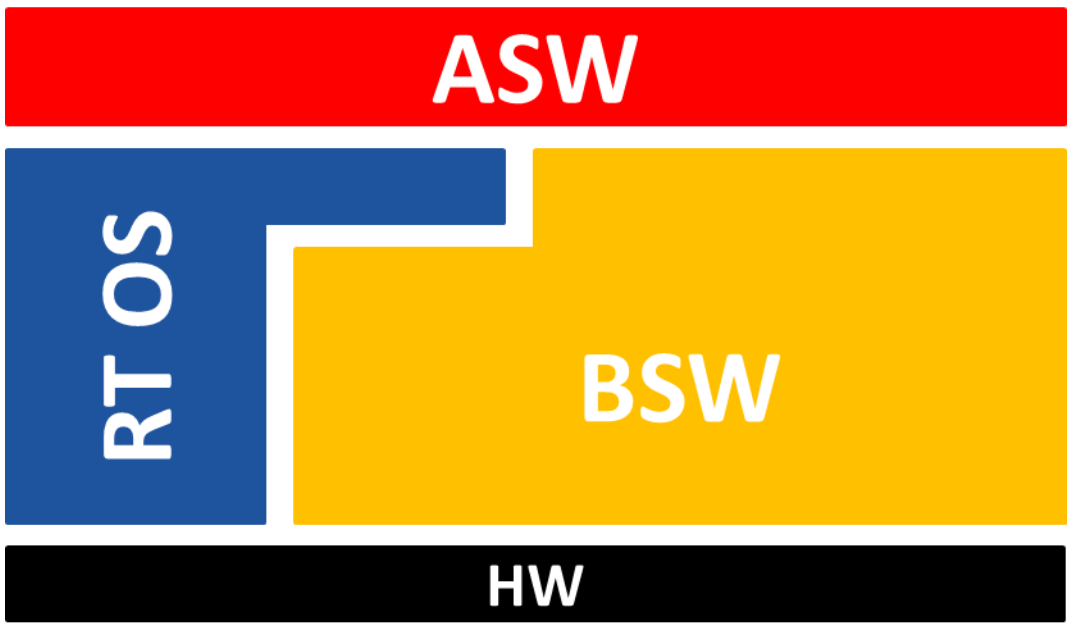

```
/begin CHARACTERISTIC

    UBYTE_Parameter
    "Scalar Parameter for Discrete Calibration Example"
    VALUE
    0x80280123
    Val_uint8
    255
    OneToOne
    0.00
    255

    FORMAT "%3.0"

/end CHARACTERISTIC

/begin MEASUREMENT

    RPM
    "Engine Speed"
    SWORD
    R_N
    1
    100
    0.00
    6500.0

    FORMAT "%5.2"
    ECU_ADDRESS 0xD0001830

/end MEASUREMENT
```

Software Architecture

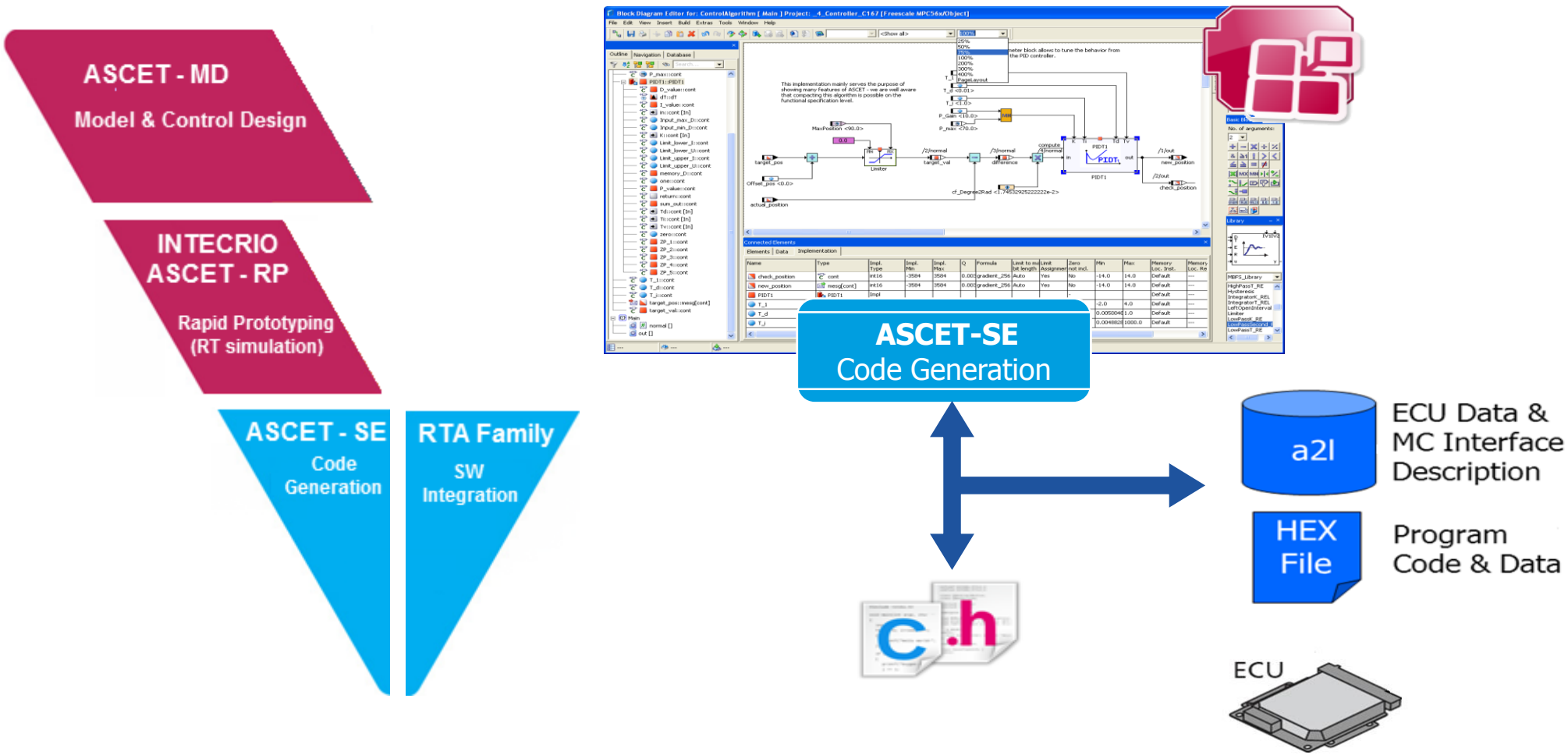
Standard Software x Automotive Software





Software Integration

ASCET Workflow



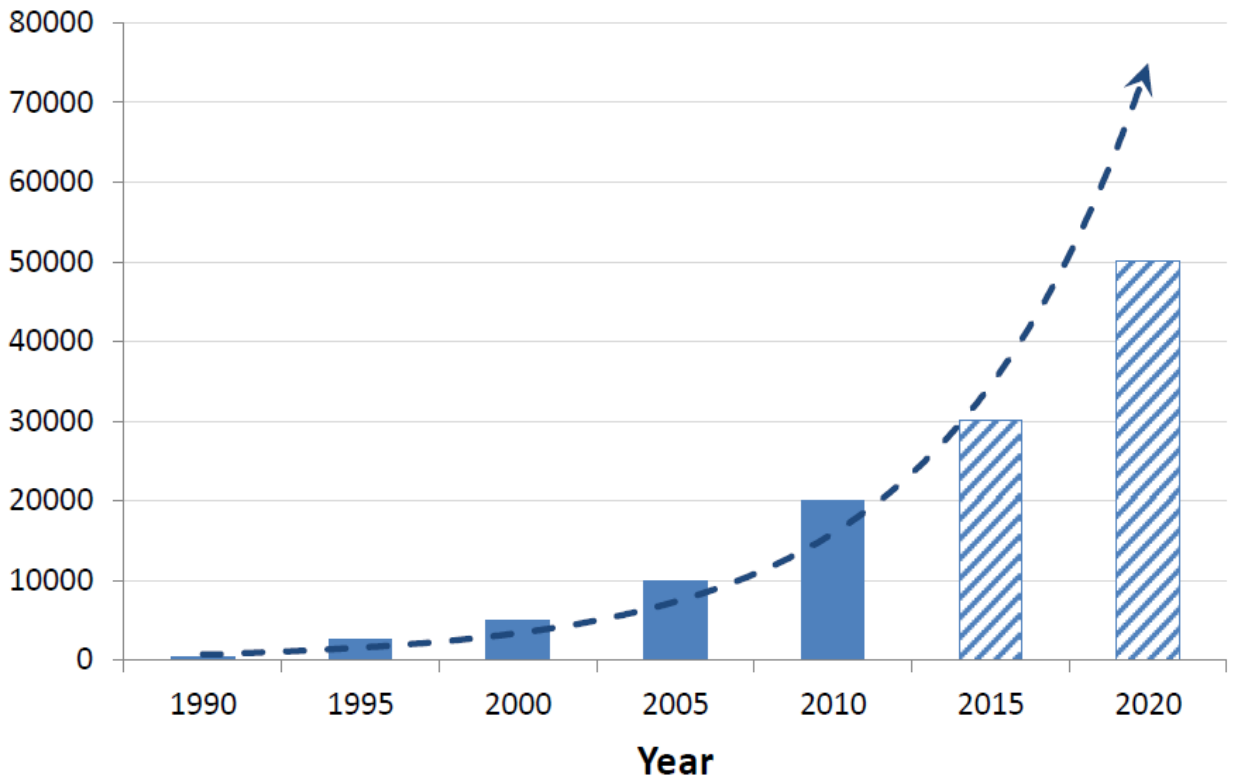
Virtual Testing and Validation

How complicated is to calibrate an engine?

How long does it takes? Why?

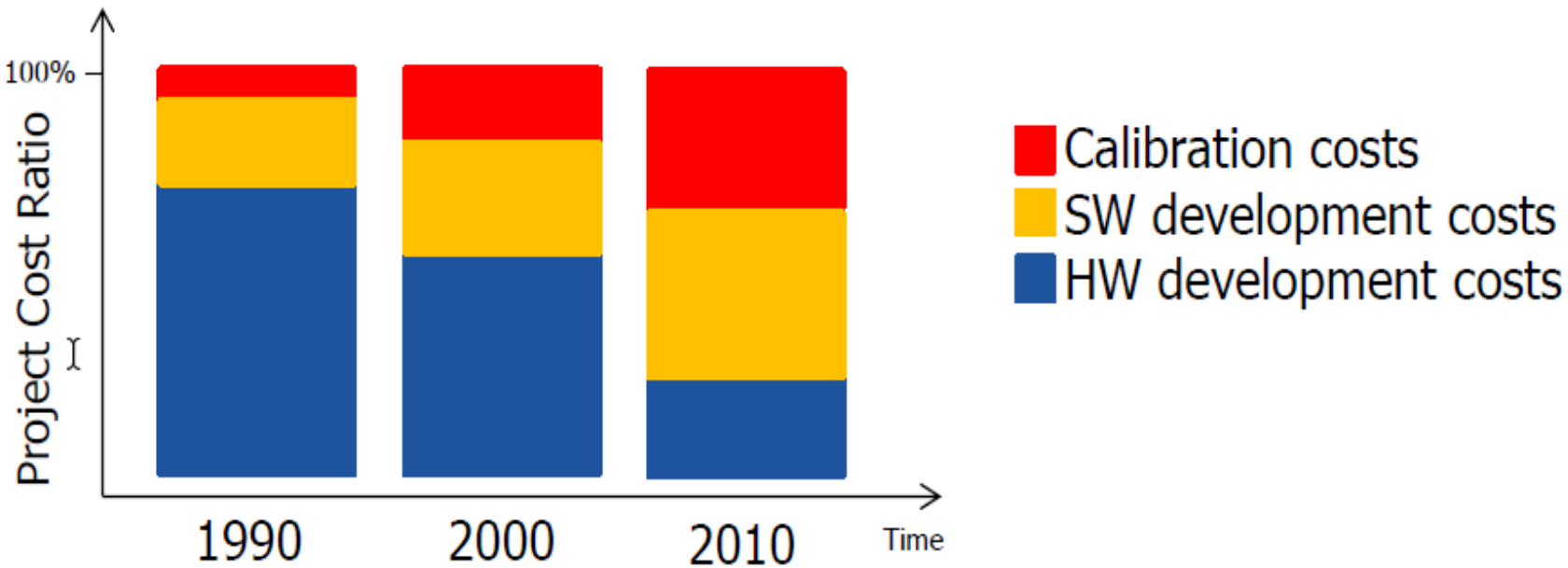
HiL Motivation

Calibration Complexity Evolution – Number of Parameters



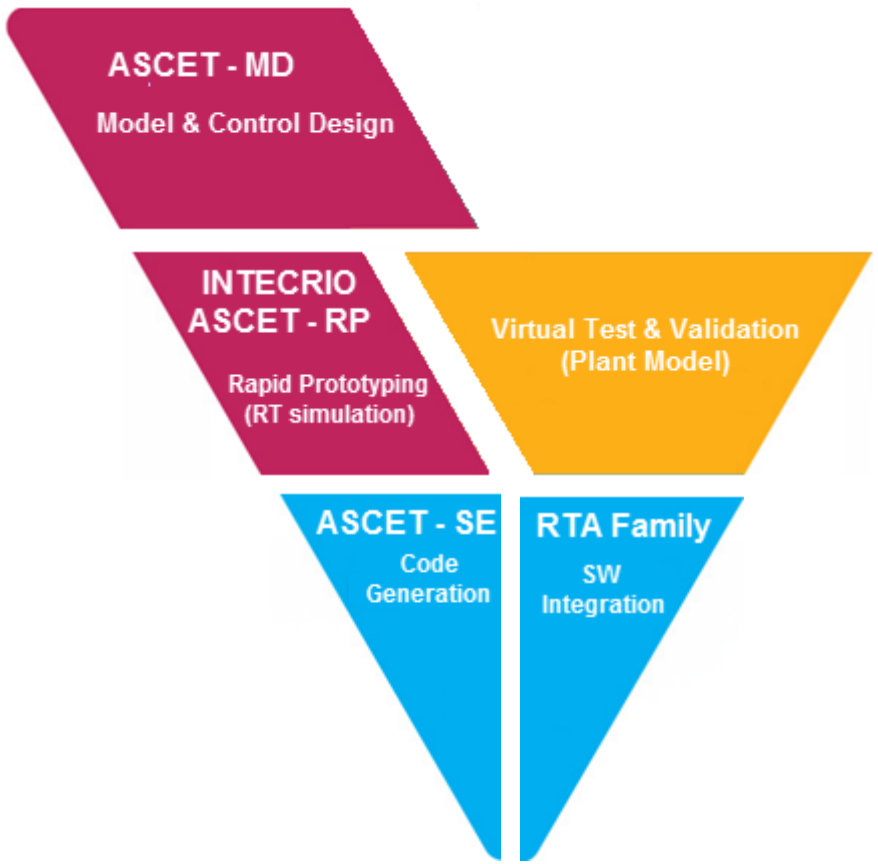
HiL Motivation

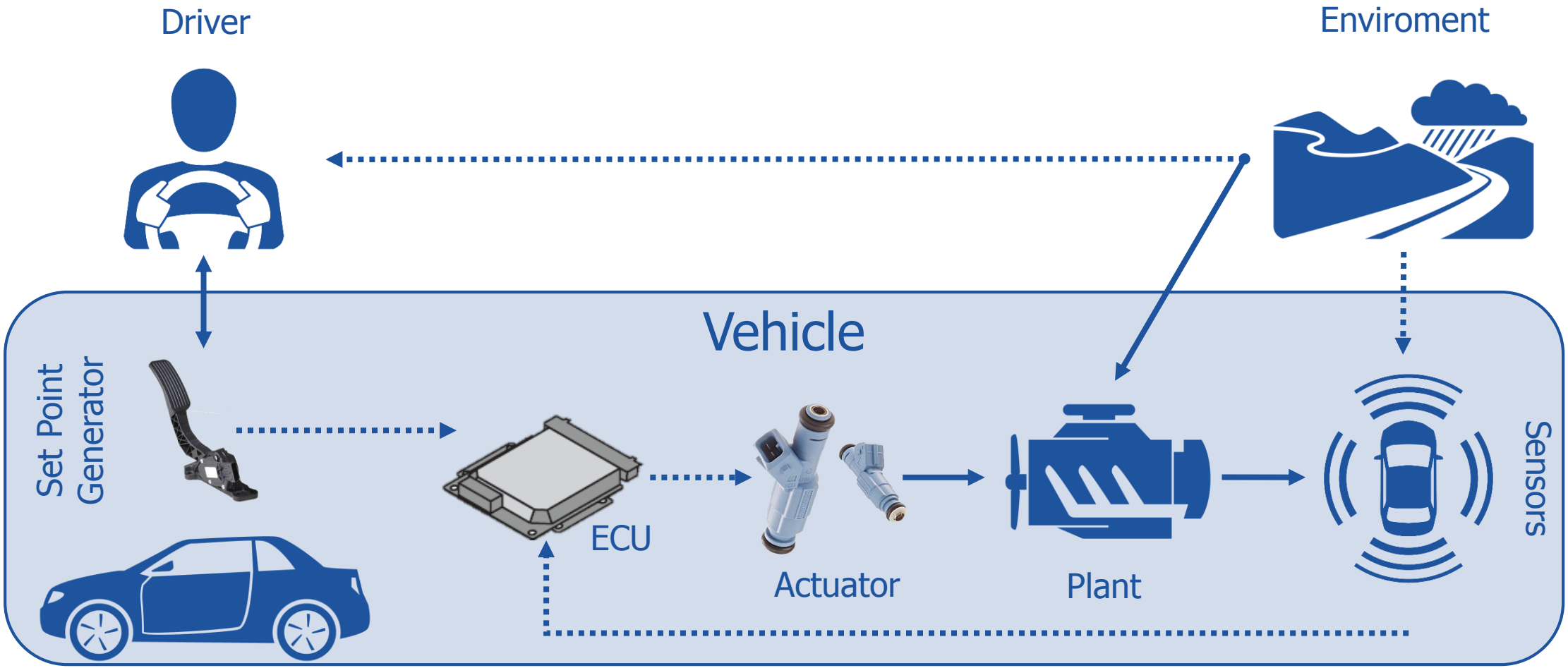
Calibration Complexity Evolution – Cost Share



V-Cycle

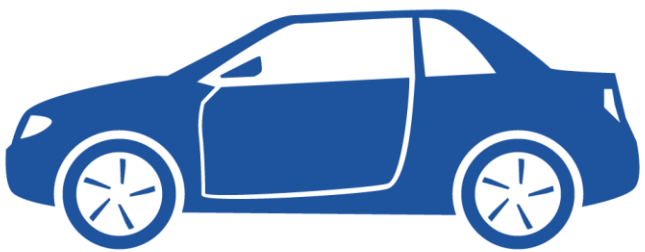
Virtual Testing and Validation





HiL - Concept

Real Car and ECU Communication



Real Vehicle

Real Time Electric Stimuli

ECU

HiL - Concept

Virtual Car – Real Time Eletric Stimuli Emulation

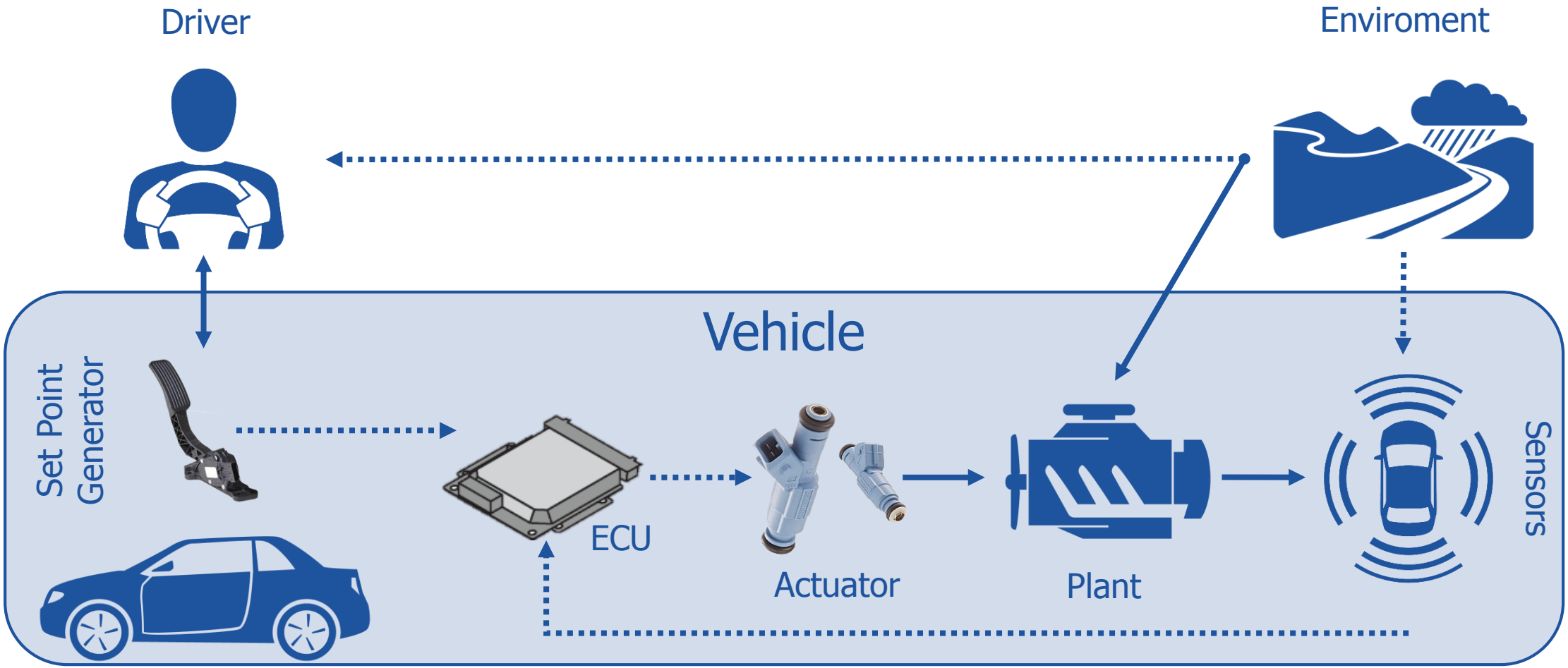
Virtual Vehicle

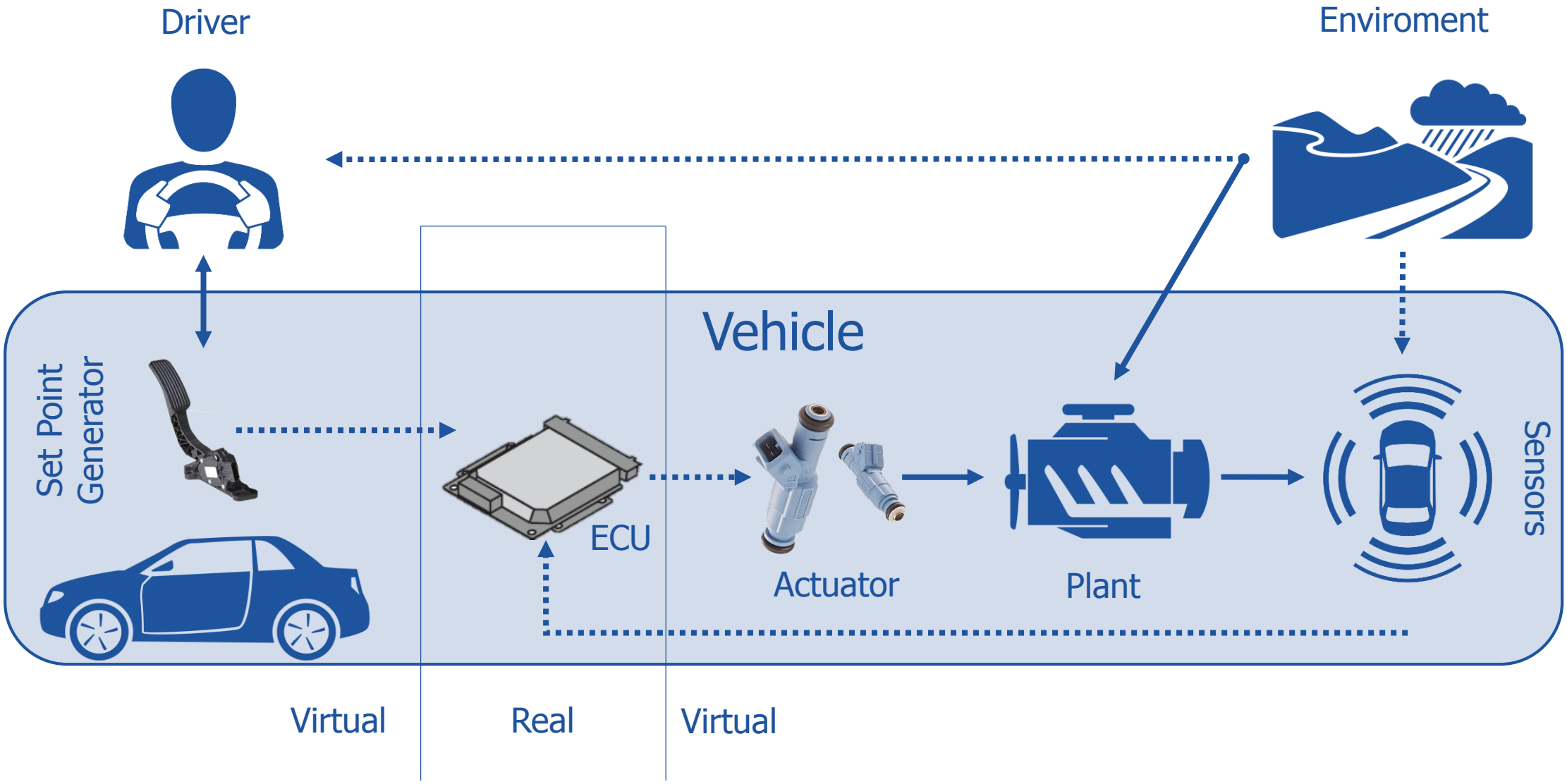
Digital Stimuli

Signal Generation Board

RT Electric Stimuli

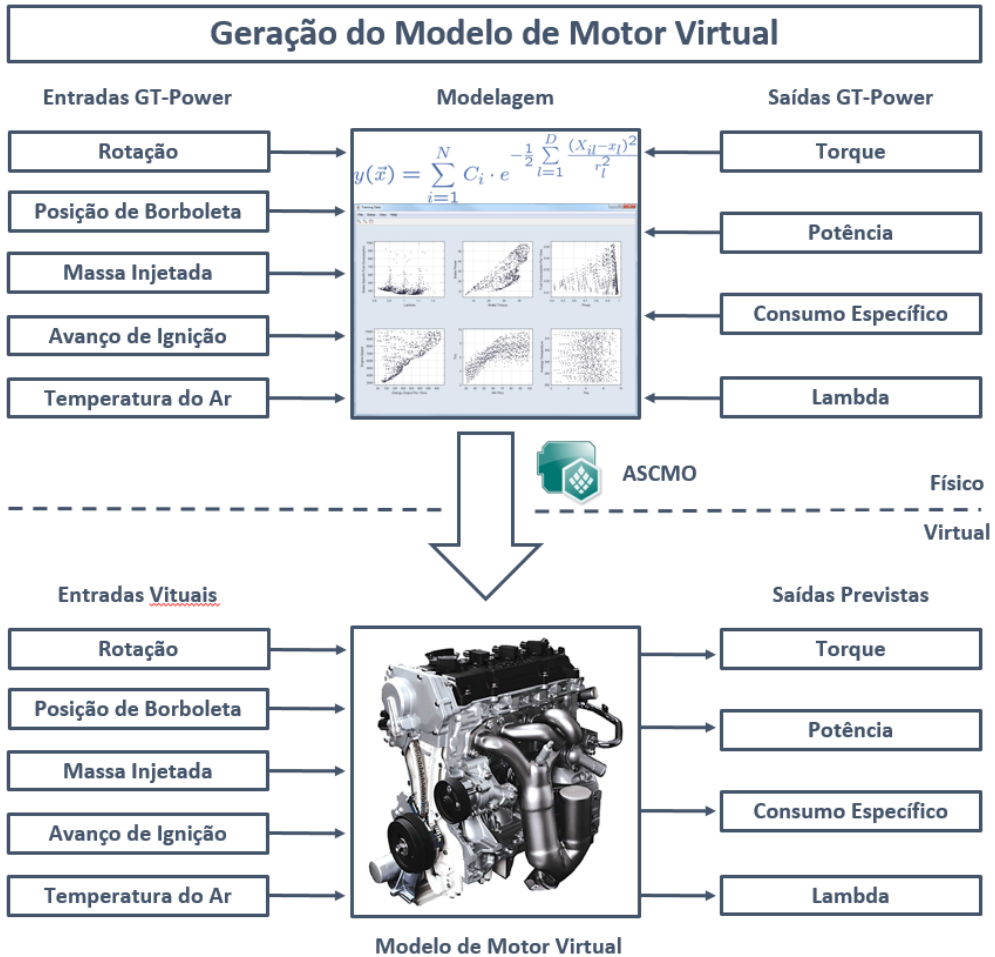
ECU





HiL Applications

Virtual Dyno and Virtual Engine



HiL Applications

Anywhere in the world in just a click!

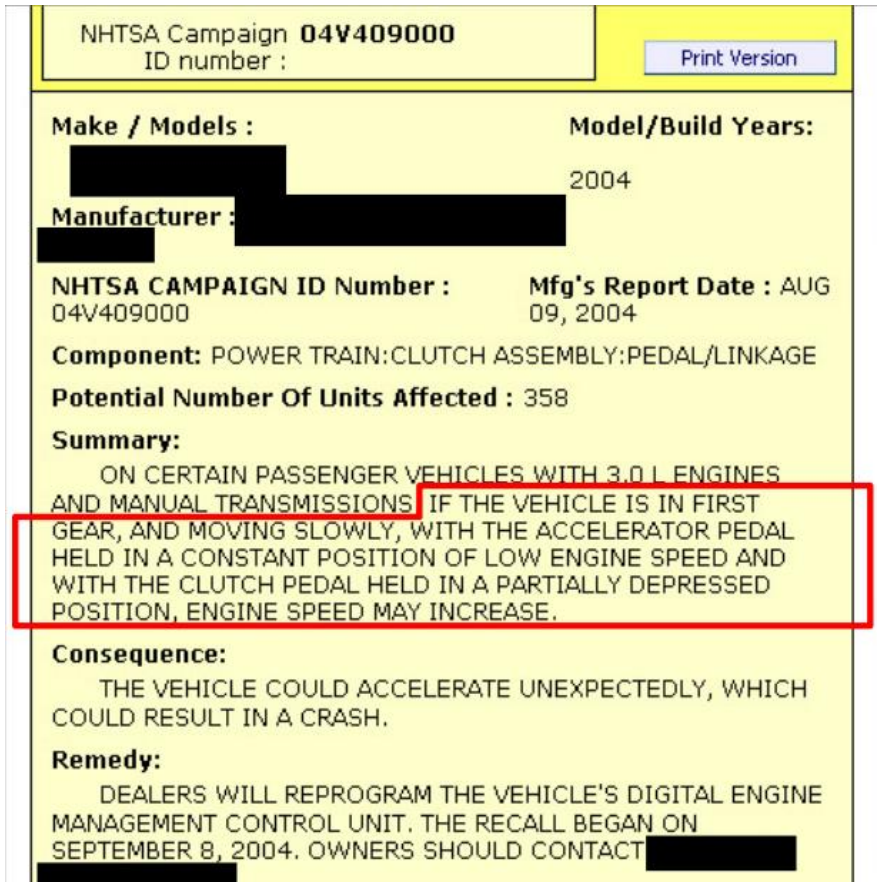
HiL Applications

Scalable Testing

Complete Vehicle HiL Setup

HiL Applications

Field Problem Diagnostics



NHTSA Campaign ID number : **04V409000**

Print Version

Make / Models : [redacted]

Model/Build Years: 2004

Manufacturer : [redacted]

NHTSA CAMPAIGN ID Number : 04V409000

Mfg's Report Date : AUG 09, 2004

Component: POWER TRAIN:CLUTCH ASSEMBLY:PEDAL/LINKAGE

Potential Number Of Units Affected : 358

Summary:

ON CERTAIN PASSENGER VEHICLES WITH 3.0 L ENGINES AND MANUAL TRANSMISSIONS IF THE VEHICLE IS IN FIRST GEAR, AND MOVING SLOWLY, WITH THE ACCELERATOR PEDAL HELD IN A CONSTANT POSITION OF LOW ENGINE SPEED AND WITH THE CLUTCH PEDAL HELD IN A PARTIALLY DEPRESSED POSITION, ENGINE SPEED MAY INCREASE.

Consequence:

THE VEHICLE COULD ACCELERATE UNEXPECTEDLY, WHICH COULD RESULT IN A CRASH.

Remedy:

DEALERS WILL REPROGRAM THE VEHICLE'S DIGITAL ENGINE MANAGEMENT CONTROL UNIT. THE RECALL BEGAN ON SEPTEMBER 8, 2004. OWNERS SHOULD CONTACT [redacted]

Measurement and Calibration

What is the best way to share information in an Automotive Enviroment?

CAN Bus

Motivation

Engine

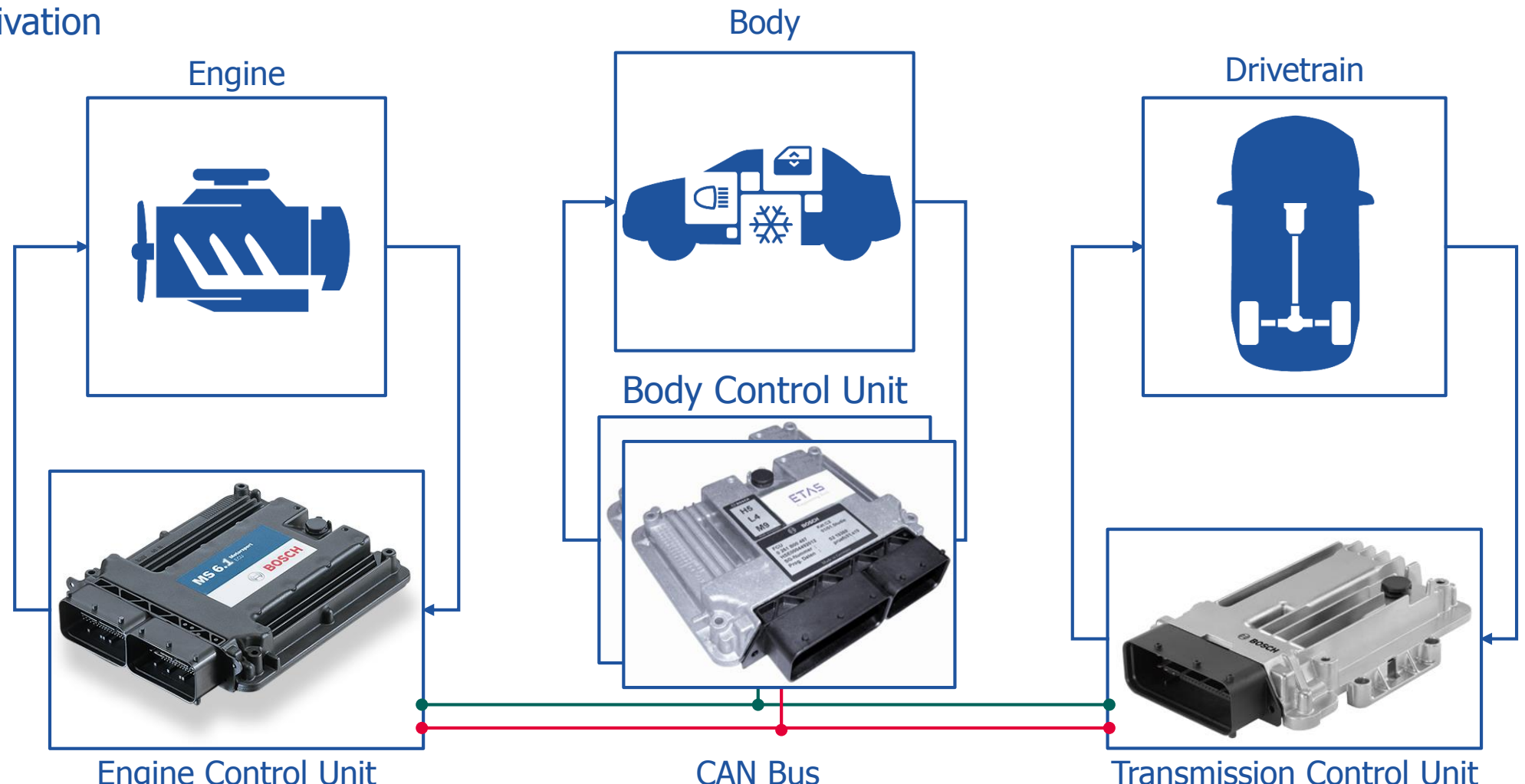
Engine Control Unit

Transmission Control Unit

RPM

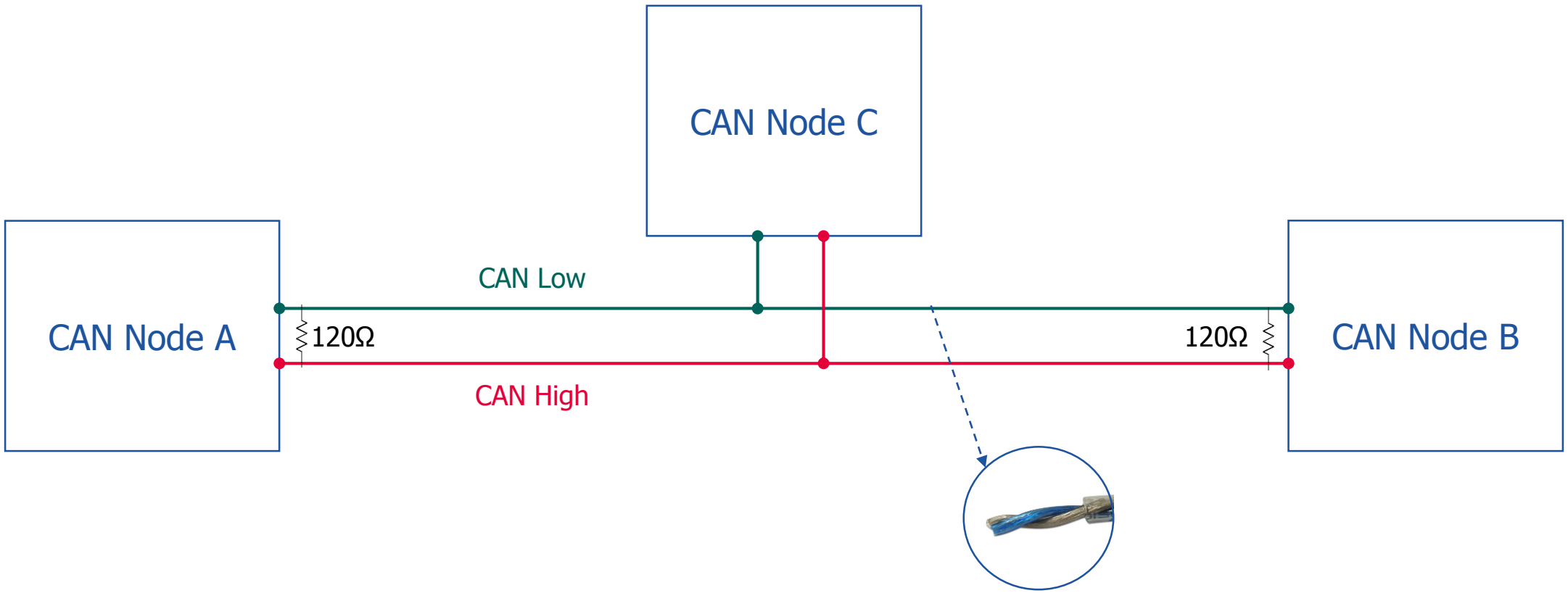
CAN Bus

Motivation



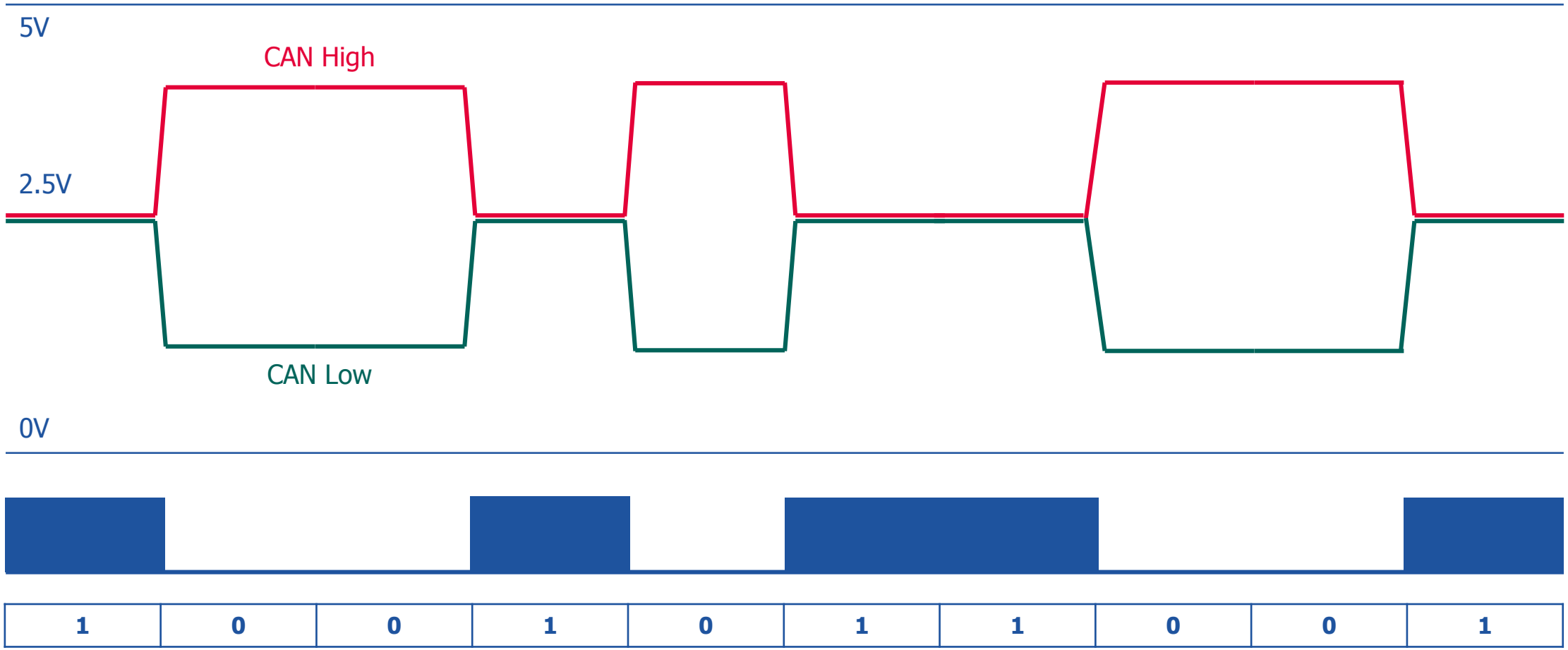
CAN Bus

Network Topology



CAN Bus

Physical Layer

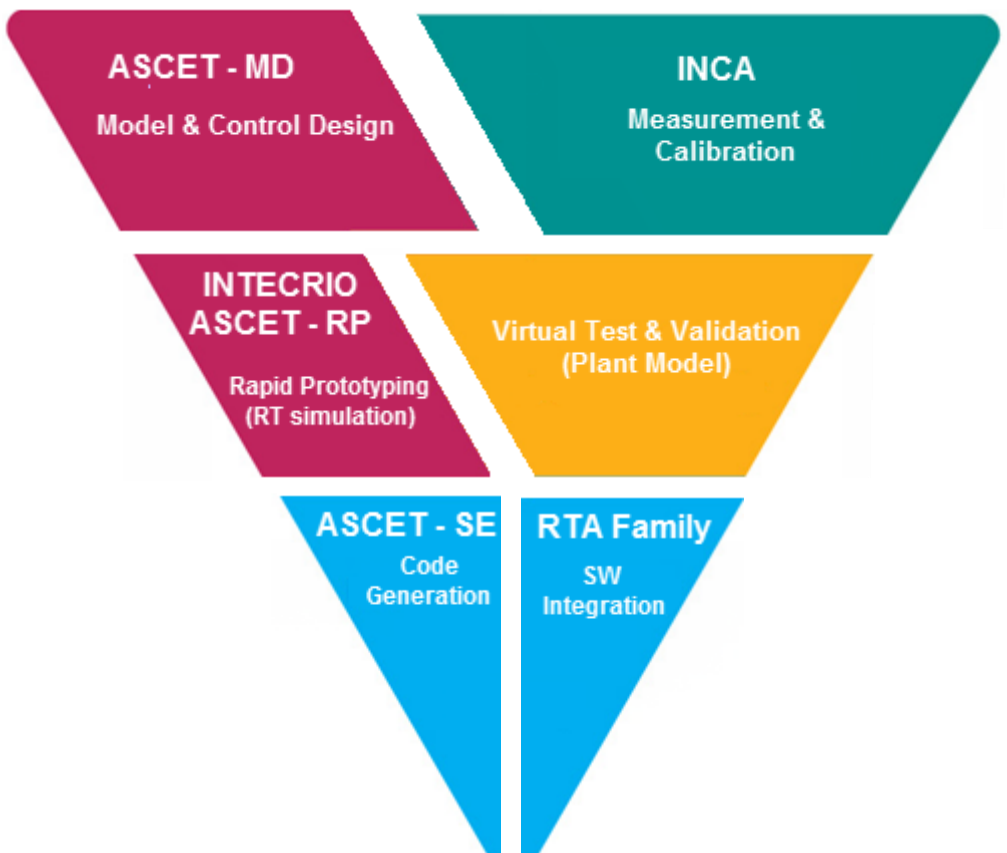


How can an ECU be Accessed and Calibrated ?

What are the calibrator’s tools?

V-Cycle

Measurement and Calibration



Measurement and Calibration

Calibrator Tasks

Base Mapping

Cold Start

ADAS

Emission Testing

Diagnosis

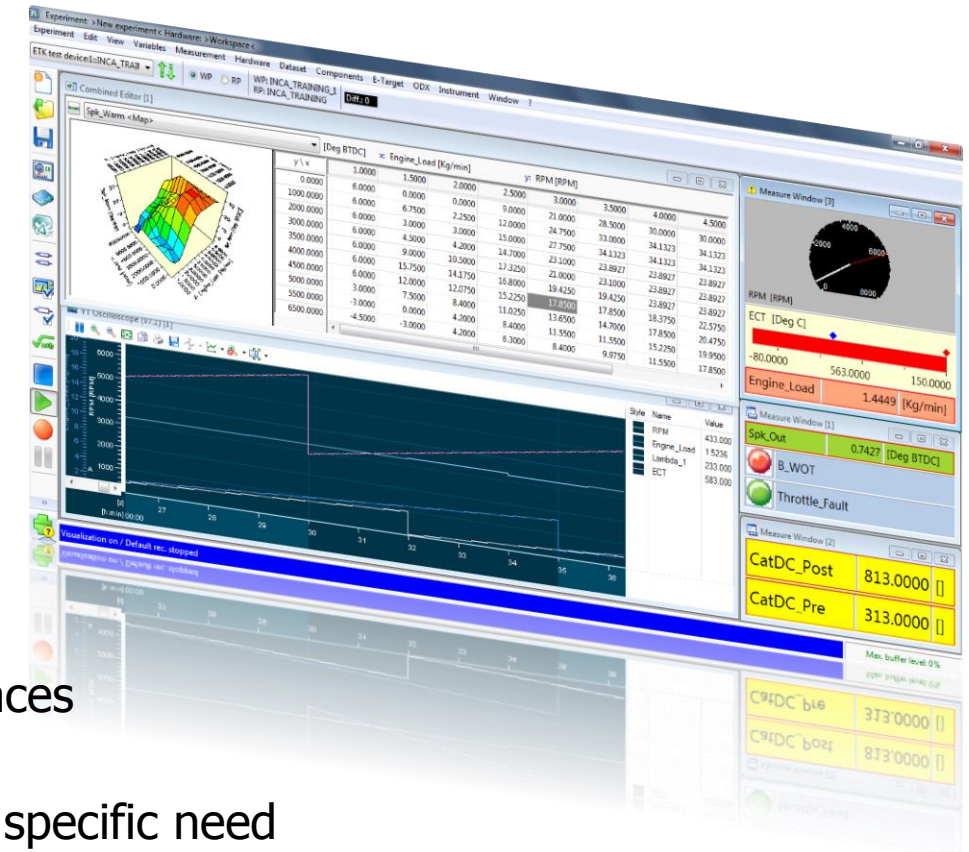
Measurement and Calibration

Calibrator Tools

INCA – The measurement and Calibration Solution

Overview

- ETAS solution for Measurement and Calibration task
- INCA is used by every OEM and most Tier 1
- More than 2000 licenses in Brazil
- INCA is used in all market segments:
  - Chassis
  - Body
  - Powertrain

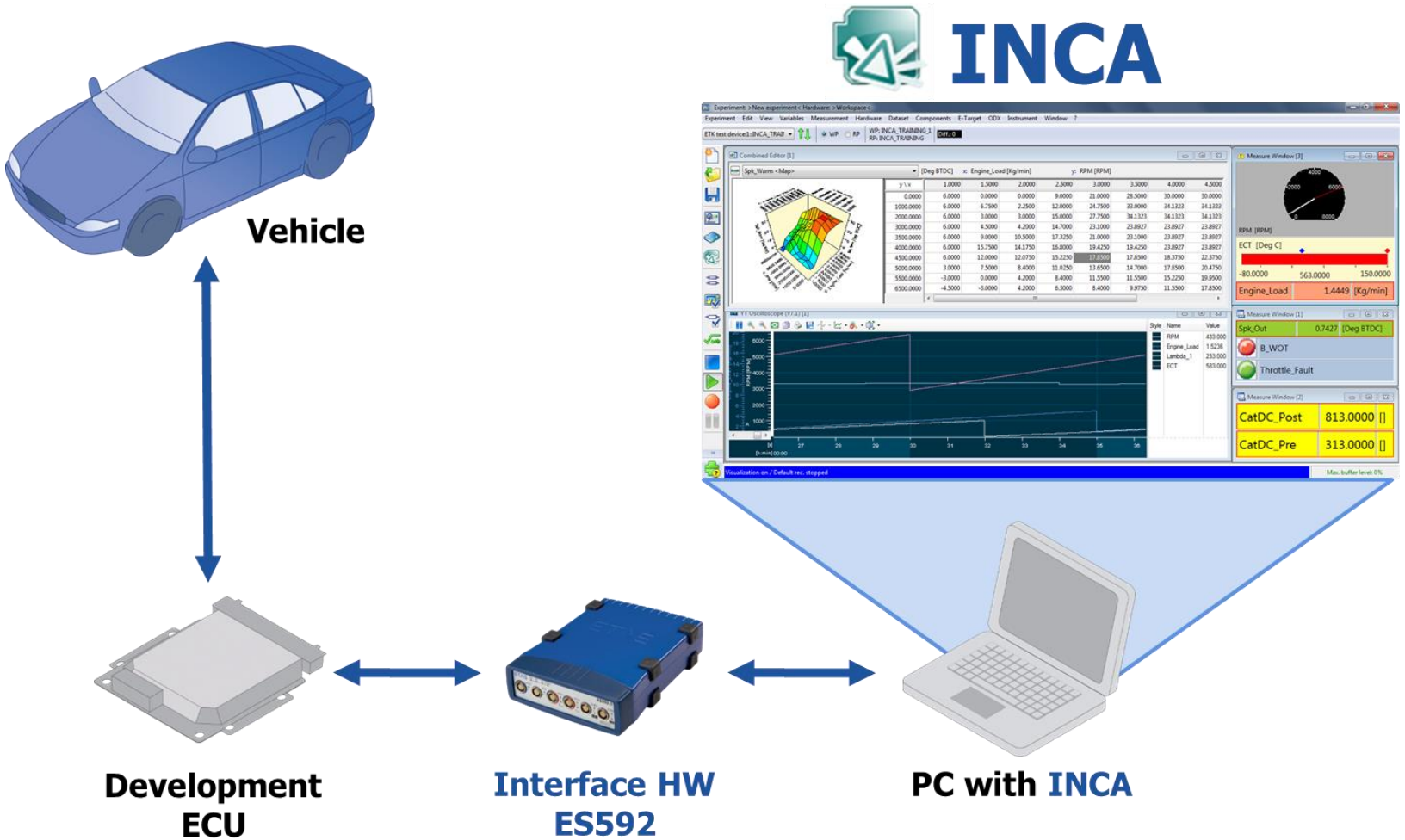


INCA Tasks

- HW Configuration
- Experiment Environment
- Measure Data Analysis
- Calibration Data Manager
- ECU Flashing
- Test Bench Interfaces
- Automation
- Other AddOns for specific need

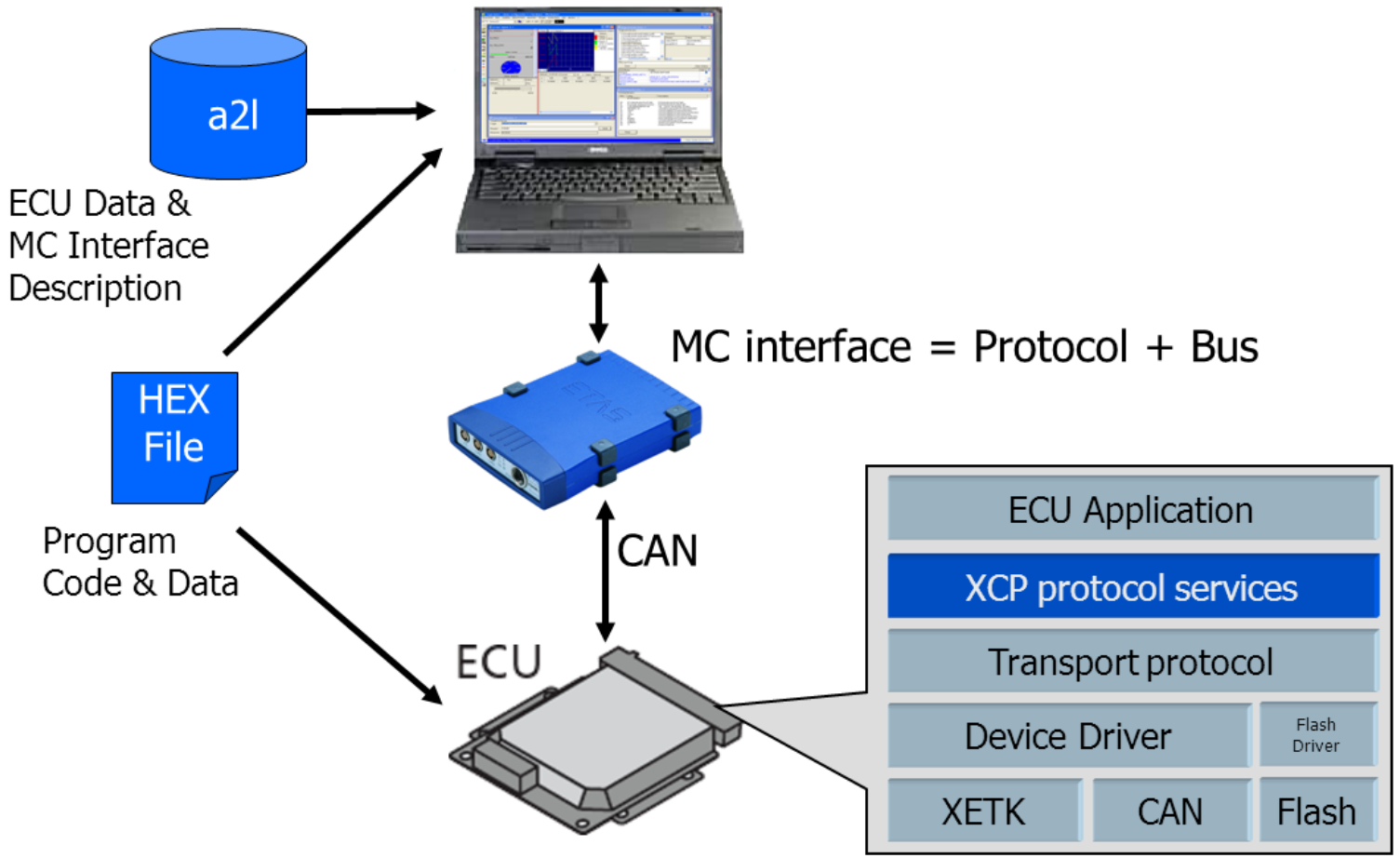
INCA – The measurement and Calibration Solution

Basic Calibration Workflow



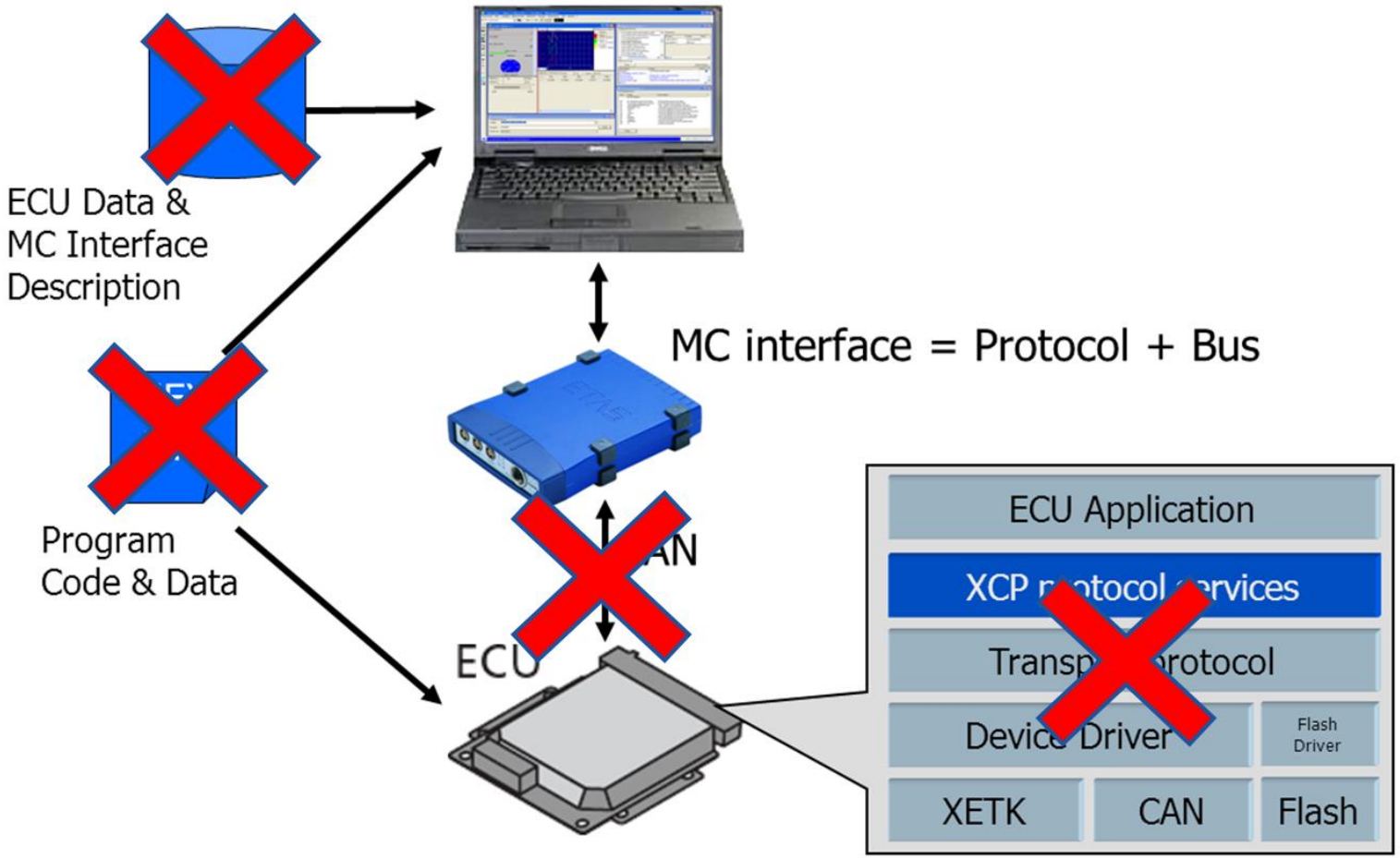
ECU Access

Development ECU



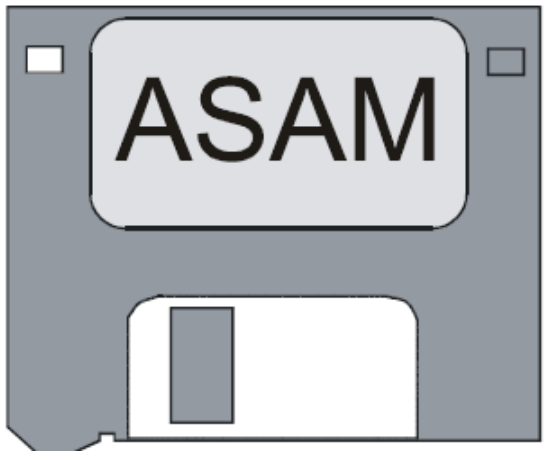
ECU Access

Production ECU

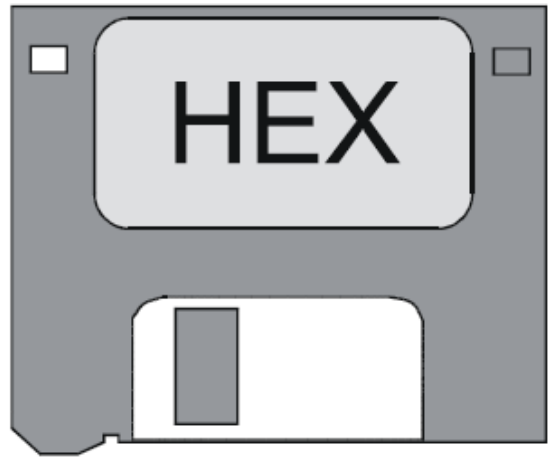


ECU Access

A2l & HEX Files



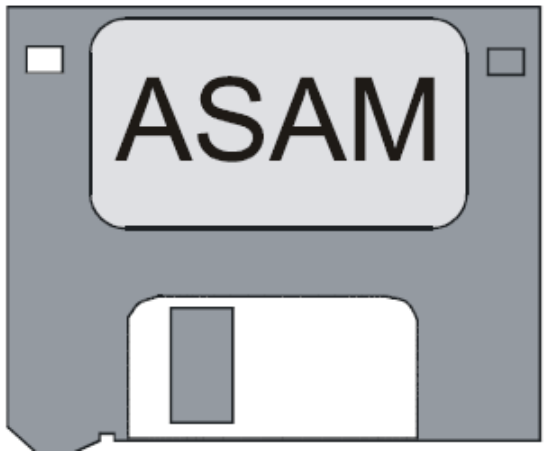
- **ASAM-MCD-2MC (ASAP2) File:**
- Specifies:
  - Variable Names
  - Conversion Formats
  - Memory Address
  - HW Interface
  - Unit
  - ...



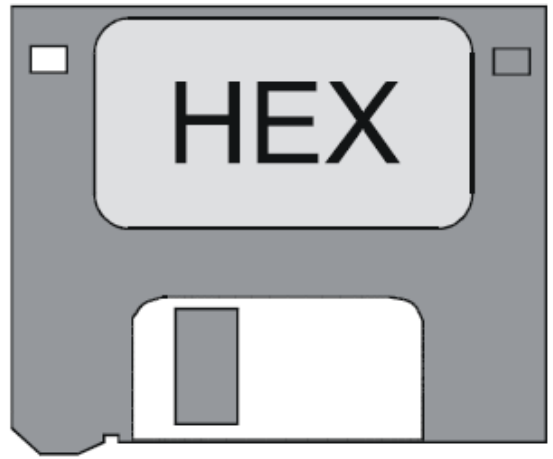
- **HEX File:**
- Contains Compiled Code:
  - Controller Calibration data
  - Controller SW intructions

ECU Access

A2l & HEX Files



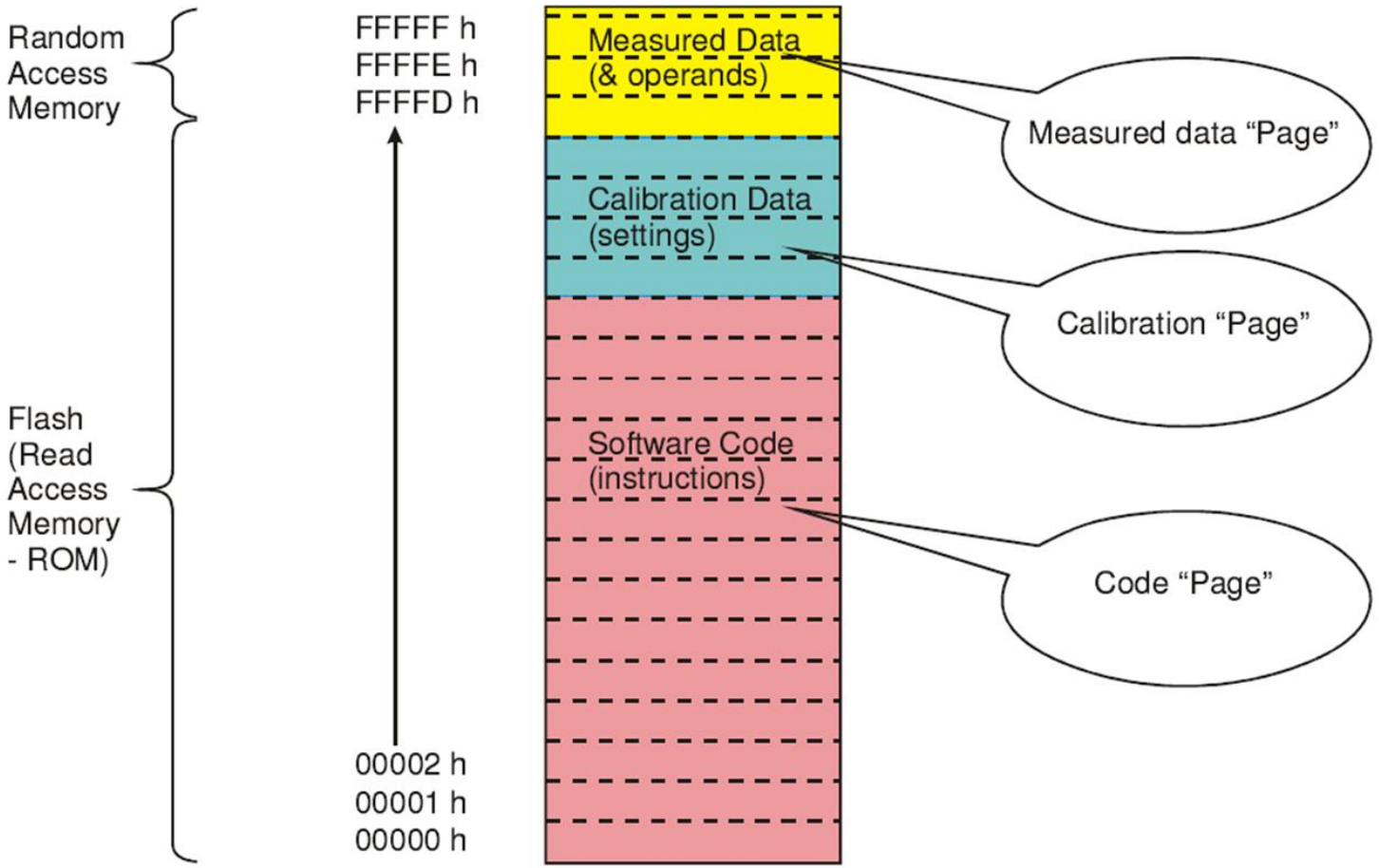

```
/begin MEASUREMENT
    RPM
    "Engine Speed"
    SWORD
    EngN
    1
    100
    0
    6500

    FORMAT "%8.2"
    ECU_ADDRESS 0xD0000076
/end MEASUREMENT
```




```
:0200000480007A
:20000000300000004FD00000000028000FD00800C020080080200800300AFAFAFAFAFAF7B
:20002000AFAFAFAFAFAFAFAFAFAFAF02000000A3AFCE883004020000000080FFFC0080B1
:20004000FECADEFAFEAFFECA0000000074FC008000100000310412007800008003020080C7
:20006000FECADEFAFEAFFECA000000000000000000100000779781BD00000000000000000F
:20008000000000000000000000000000000000000000000000000000000000000000000060
:2000A000000000000000000000000000000000000000000000000000000000000000000040
:2000C000000000000000000000000000000000000000000000000000000000000000000020
:2000E000000000000000000000000000000000000000000000000000000000000000000000
:20010000000000000000000000000000000000000000000000000000000000000000000DF
:20012000000000000000000000000000000000000000000000000000000000000000000BF
:20014000000000000000000000000000000000000000000000000000000000000000009F
:20016000000000000000000000000000000000000000000000000000000000000000007F
:20018000000000000000000000000000000000000000000000000000000000000000005F
:2001A000000000000000000000000000000000000000000000000000000000000000003F
```

ECU Access

ECU Memory Structure - Calibration



ECU Access

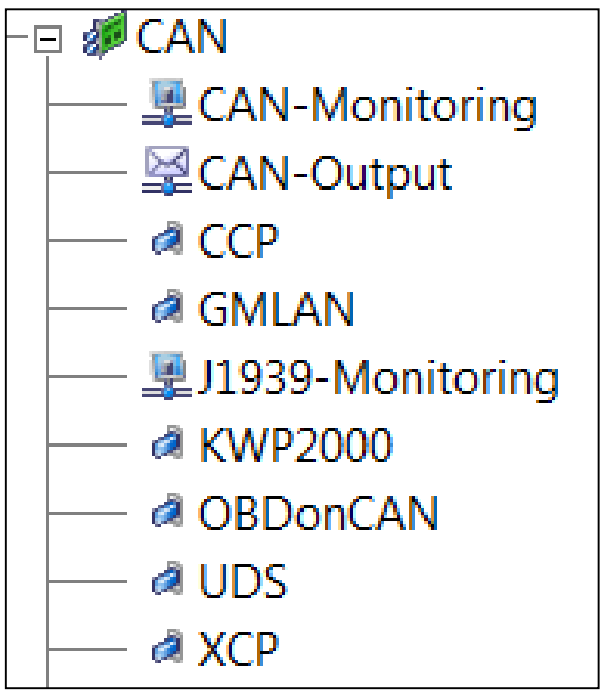
Working Page and Reference Page

Measured Data Page	Volatile (RAM) data that you can record.
Working Page	Calibration data that you can edit (read/write); your “work in progress” calibration.
Reference Page	Calibration data that you cannot edit (read only); your “baseline” or “safe” calibration.
Code Page	Software code; the instructions that your embedded controller executes.

ECU Access

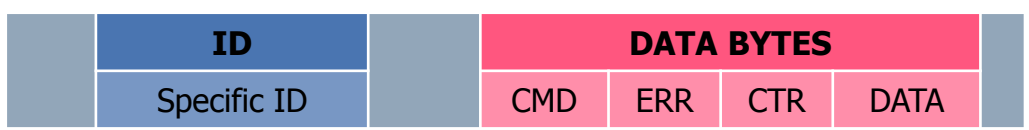
CAN – Possible Protocols

CAN ≠CCP



CAN is the FRAME

CCP is the CONTENT and how it is placed on the CAN Frame

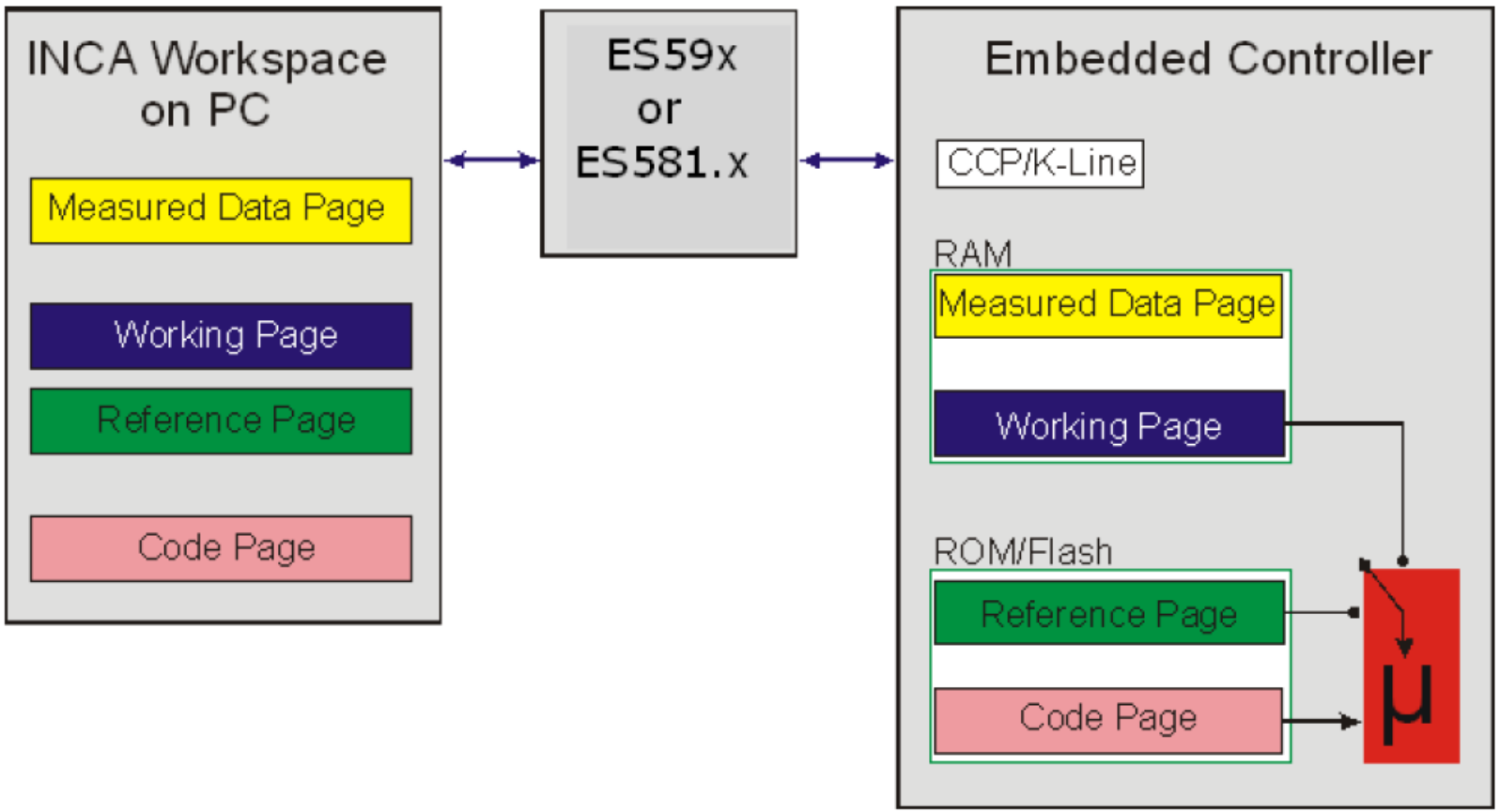


Automotive Protocols

Different Applications

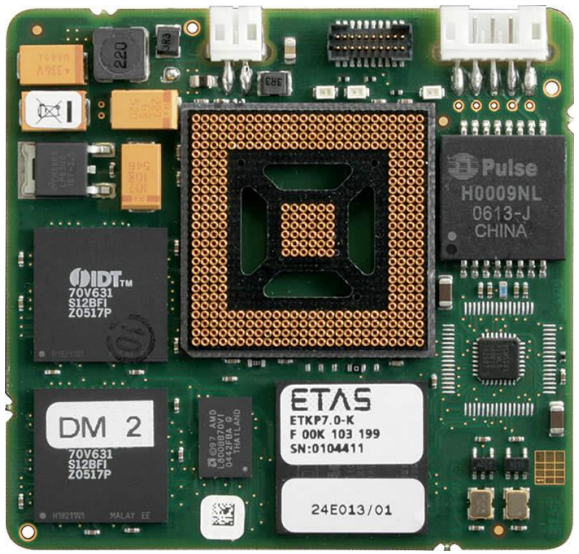
ECU Access

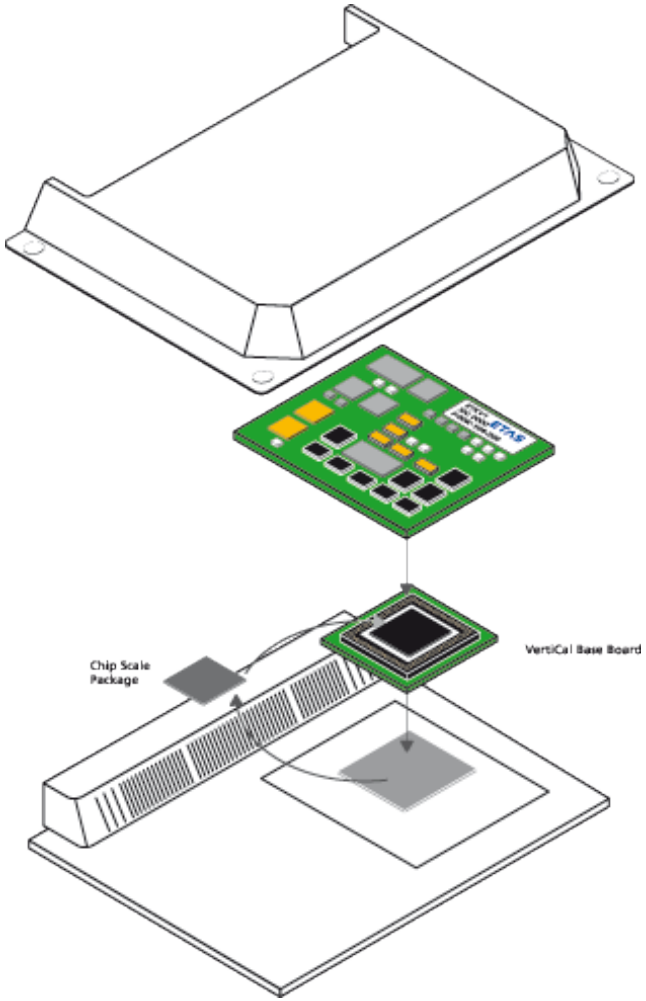
CCP – CAN Calibration Protocol



ECU Access

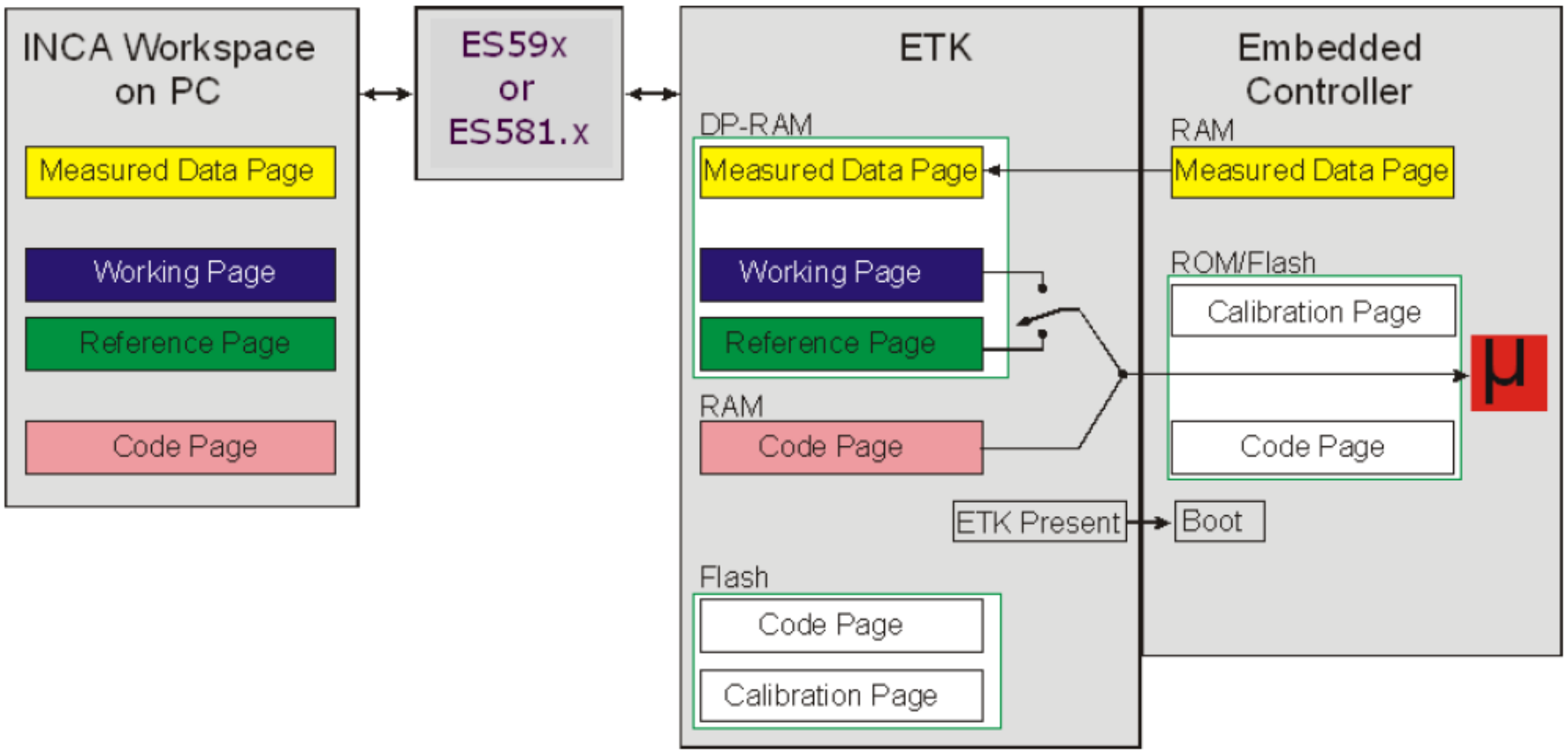
ETK and ETK Protocol





ECU Access

ETK – Memory Layout



ETAS

DRIVING EMBEDDED EXCELLENCE

Thank you!

DRIVING **EMBEDDED EXCELLENCE**

ETAS

André Pelisser

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