P2C

CONTROL SYSTEMS

Automotive Electronic Control Systems

Pure Power Control S.r.l

HPEGROUP

HPE GROUP

HPE
ENGINEERING SOLUTIONS

COXA
MACHINING AND METAL ADDITIVE

P2C
CONTROL SYSTEMS

AT
MOTORS

Luigi Di Marco - Technical Director

EDUCATION AND TRAINING

- L'Aquila University

Master Degree in Mathematics

- Rome Tre University

PhD studies in Mathematics

- Alma Mater Studiorum – Bologna University - Department of Mathematics (2004)

II level Master degree in "Applied Mathematics"

WORK EXPERIENCE

- MARELLI POWERTRAIN

Model Based Software Developer

- CNH Industrial

Software Integration Responsible

- Arbos - Goldoni

Software Development Manager and Project Manager

- Lamborghini

Project Responsible

- BCS Tractor

Software Development Manager and Project Manager

- Maserati

Verification and Validation Responsible

- **Pure Power Control** (2019 –)

Software Development Manager

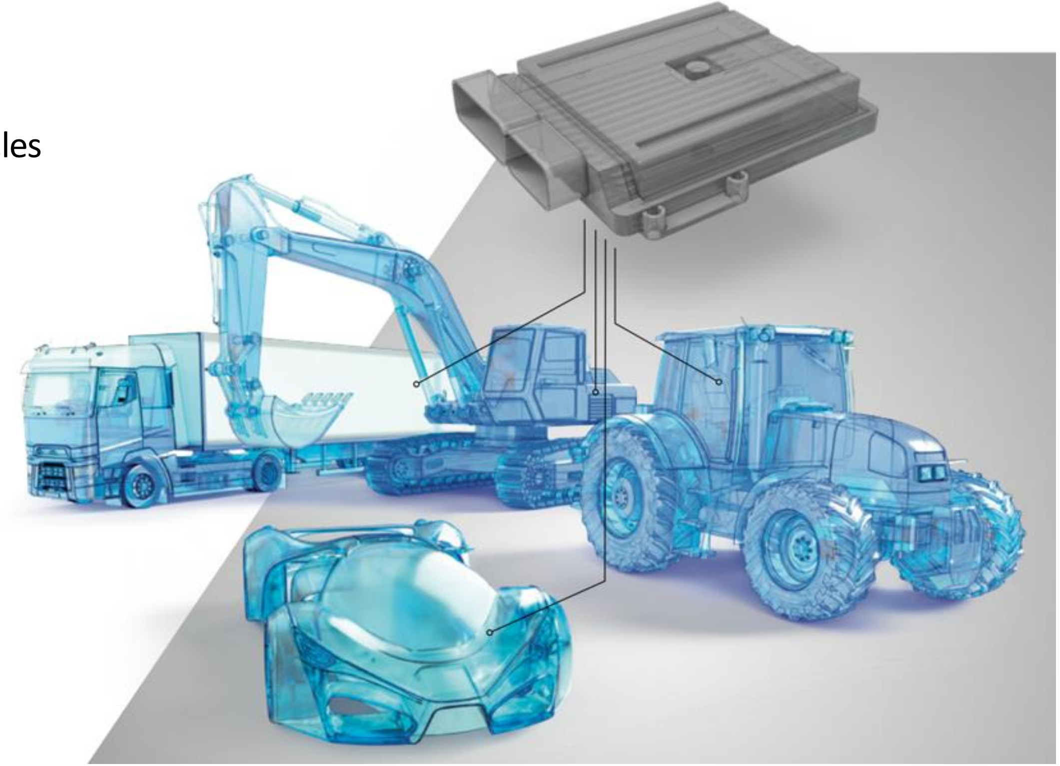
Technical Director (2023 -)

Our business

Advanced electronic control systems for innovative environmentally-friendly vehicles

- High efficiency
- Effective control
- Cut down emissions

Designed for electric, hybrid electric and fuel-cell vehicles



Company trend

Our team

35 FTE

7 PhDs in control, vehicles, physics, mathematics

24 Engineers in: control, vehicle, electric traction, electronics, computer science, mathematicians

1 Technician

3 Admin, **quality** and **marketing**

Our locations

Pisa (Cascina) Headquarter
- Administration, R&D
- Prototyping and testing

Modena Projects
- R&D, customer-support

Terni (MICH) Projects
- R&D

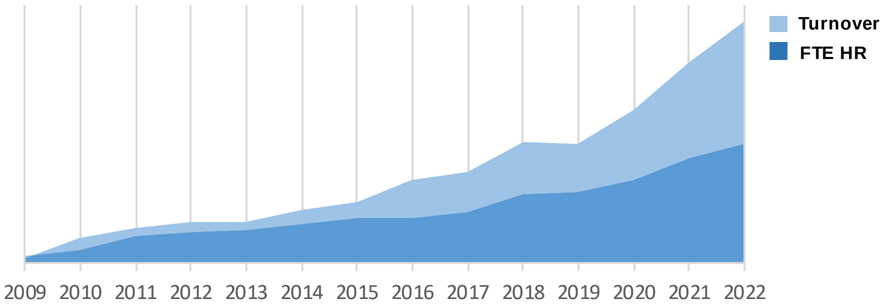
Our projects

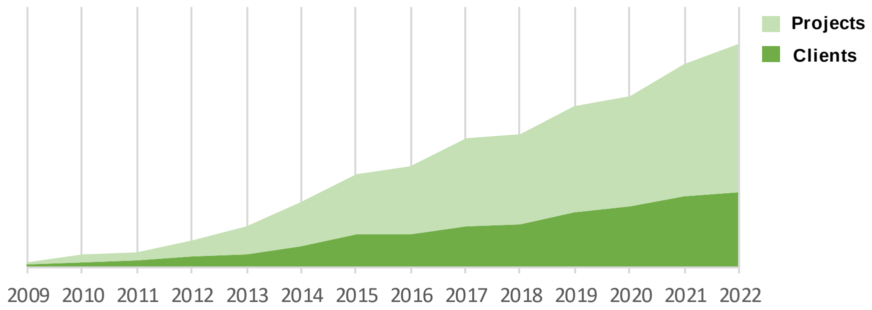
40 Clients

80 Projects

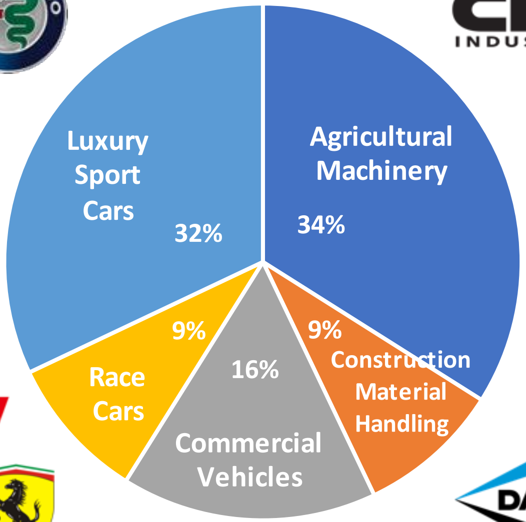
5 Business lines: luxury sport cars, race cars, agricultural tractors, truck and bus, construction and material handling

35% year-over-year turnover growth





Business lines and customers

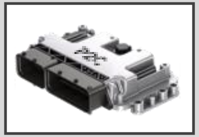


Products

Electronic Control Units

Vehicle Control Module (VCM) for BEV/HEV/FCEVs

Transmission Control Unit (TCU) for power shuttle/powershift/hydrostatic



Simulators

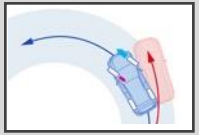
Hardware-in-the-Loop (**HIL**) Simulators

Driver-in-the-Loop (**DIL**) Simulators

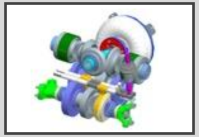
Software IPs

BEV/HEV/FCEV Powertrain Control

Vehicle Dynamics Control



Vehicle and Powertrain Control



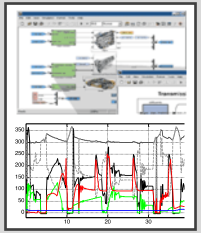
Transmission Control

Internal Combustion Engine Control

Engineering services

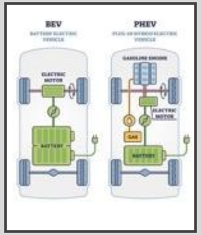
Simulation and Optimization

- Modeling, analysis and simulation
- Optimization and data processing



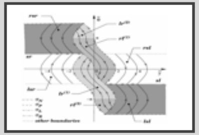
Design

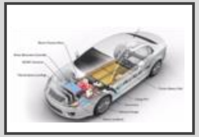
- Model-based System Engineering (MBSE) of **BEV/HEV/FCEVs**
- Design of electronic control systems



Development

- Advanced MBD control strategies
- Software architecture and MBD embedded software
- Software verification and validation
- Prototyping and testing
- Vehicle integration and qualification

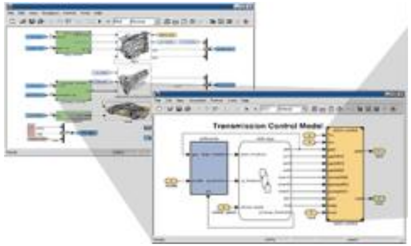


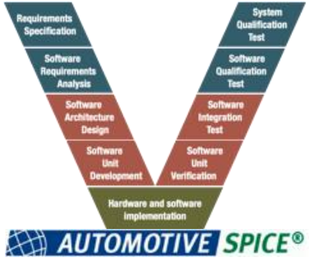


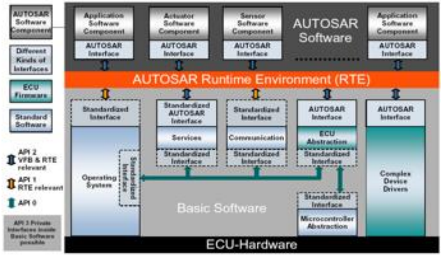
Competences in automotive controls

- Model-Based System Engineering (**MBSE**)
- Model-Based Design (**MBD**)
- Modelling, analysis and simulation
- Software quality: **MAB**, **MISRA**, **ASPICE** level 2
- Functional Safety: **ISO 26262**, **ISO 25119**, **IEC 61508**
- Design and implementation of **ASIL functions**
- Development of **AUTOSAR** Software Components
- Networking: CAN, CAN FD, CANOpen, LIN, Flexray, Ethernet
- Diagnostic protocols: UDS, J1939, KWP2000
- Calibration protocols: (XCP,CCP,XETK)

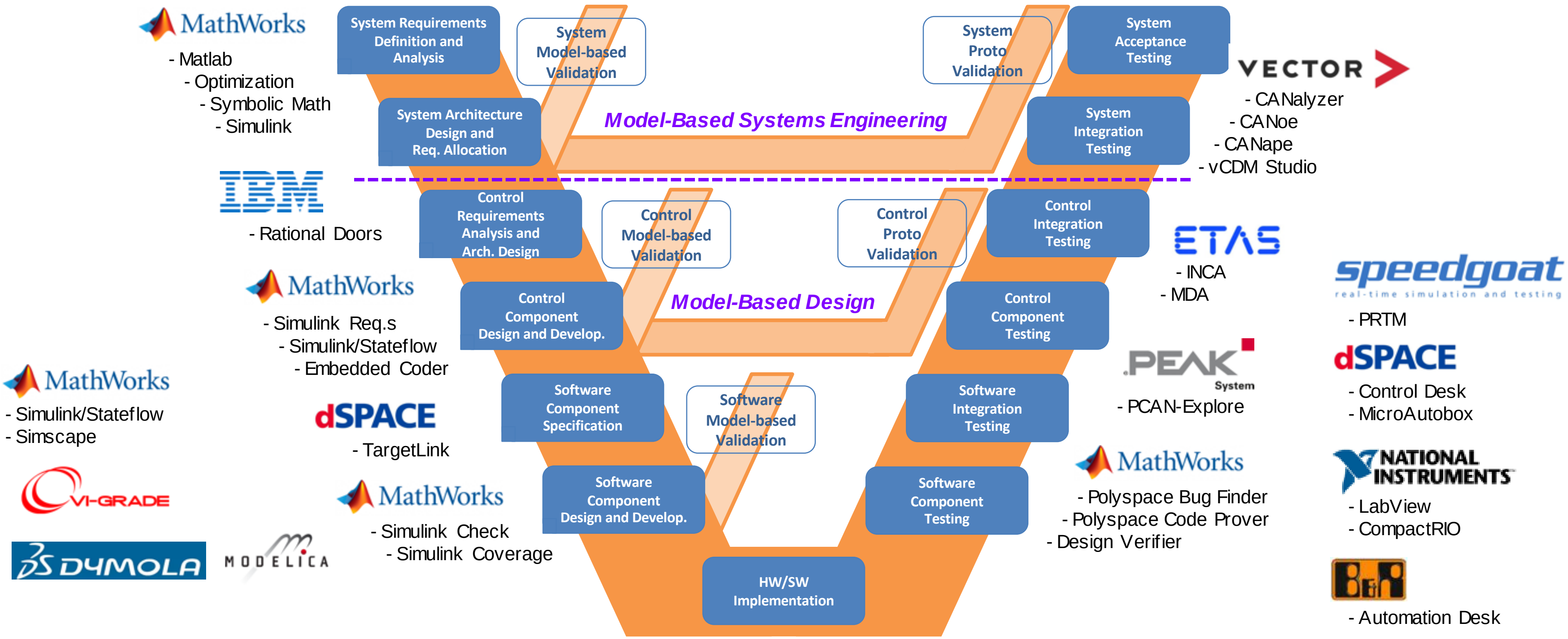
- **Design and development**
  - Requirements management, traceability, impact analysis
  - Software architecture design
  - Advanced control design, MIL validation
  - Firmware and coding: C embedded, C++
  - Automatic Code Generation from Model
- **Integration and testing**
  - SIL, HIL, lab and field experiments
  - Unit Test, Static and Dynamic Code Analysis
  - Software and Hardware Integration Test, ECU Qualification
  - Vehicle Integration and Qualification Test
  - Calibration on bench and vehicle, Dataset Management





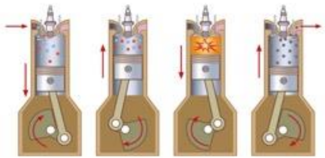


MBSE and MBD toolchain



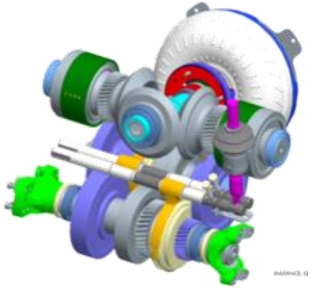
Internal Combustion Engine Control

- **Modeling and simulation of spark/compression ignition engines**
- Engine torque and crankshaft speed control
- Air charge estimation and control
- Turbo-charging and EGR control
- Direct and indirect fuel injection control, A/F control
- After-treatment systems and tail-pipe emission control
- Axle shaft oscillation detection and optimal damping
- Actual engaged gear identification
- **Internal combustion engine control calibration and testing**
- Engine diagnosis and recovery
- **OBDII diagnosis**
- RDE (Real Driving Emission) data processing and analysis
- Tailpipe active noise cancellation and sound profiling
- Tools for engine calibration and testing data analysis



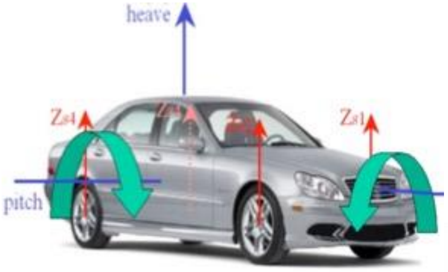
Transmission and Powertrain Control

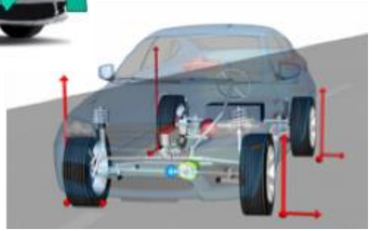
- Modeling and simulation of
  - Automotive manual and AMT transmissions
  - Off-highway vehicle transmissions, working hydraulics and powertrains
  - Battery packs, supercaps, fuel-cells, power converters, inverters, electric motors
  - Automotive driving cycles and off-highway vehicle duty cycles
- Single-clutch and dual clutch automotive gearbox control
- Power-shuttle transmission control
- Power-shift transmission control
- Hydrostatic CVT and power-split control
- Parallel and series hybrid hydrostatic powertrain control
- Battery electric powertrain control
- Parallel and series hybrid electric powertrain control
- Power-split hybrid electric powertrain control
- Electric/hybrid electric powertrain thermal management

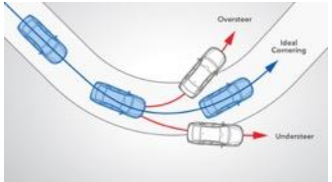


Vehicle Dynamics Control

- Modeling and simulation of
  - Chassis dynamics
  - Vehicle steering
    - Front-axle, rear-axle steering, 4-wheel and articulated steering
  - Wheel and brakes
  - On-road and off-road tire dynamics
- **Longitudinal dynamics control**
  - Drivability, cruise control, speed limiter
  - Traction and drag control
- **Vertical dynamics control**
  - Chassis and cabin suspension control
- **Lateral dynamics control**
  - All-wheel drive (AWD)
  - Torque vectoring (TV)
  - Skid steering







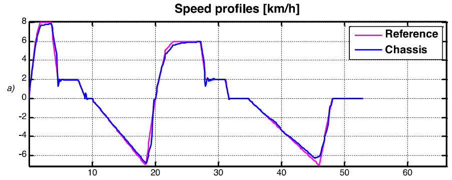
System Engineering of BEV/HEV/FCEVs

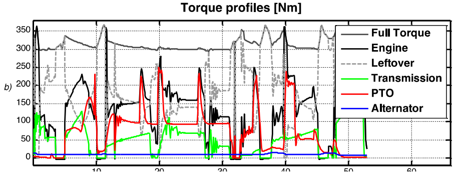
Analysis, benchmarking and **optimization** of advanced powertrains for BEV/HEV/FCEVs

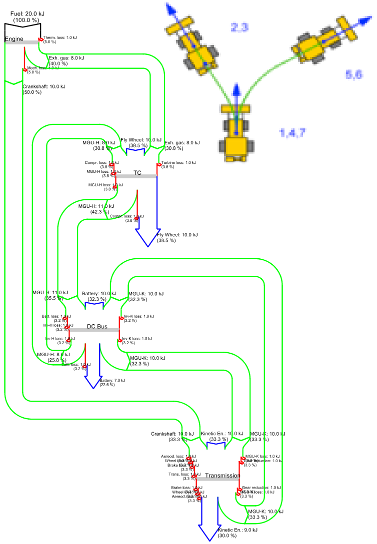
Requirement **formal specification**
- Vehicle performance, driving/duty cycles
- Vehicle economy, fuel saving, range

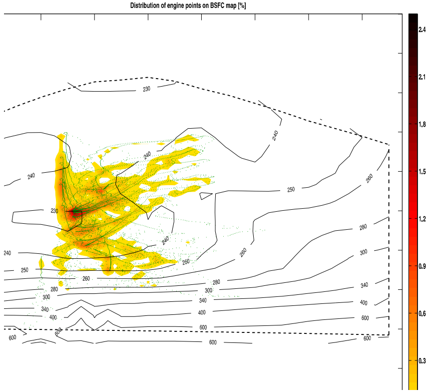
Modeling, **analysis** and **simulation**
- Vehicle dynamics and BEV/HEV/FCEV powertrains
- Working hydraulics, ancillary systems
- Power flow, operating modes and efficiency analysis

Extended **design space exploration** and **optimization**
- Identification of best powertrain architecture
- Optimization of component sizing
- Energy management strategies









Vehicle Control Module (VCM) for BEV/HEV/FCEVs

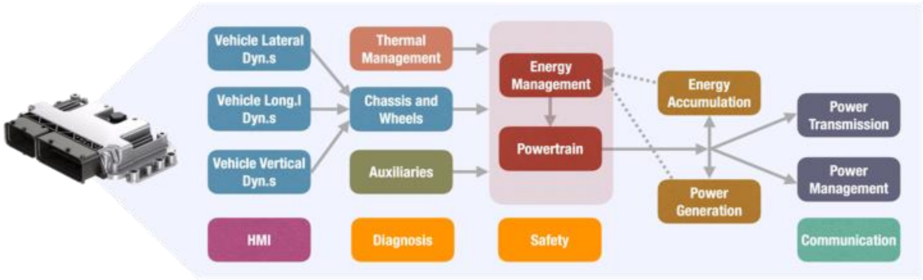
Configurable for **a variety of powertrain architectures** for
- Automotive and commercial vehicles
- Off-highway vehicles

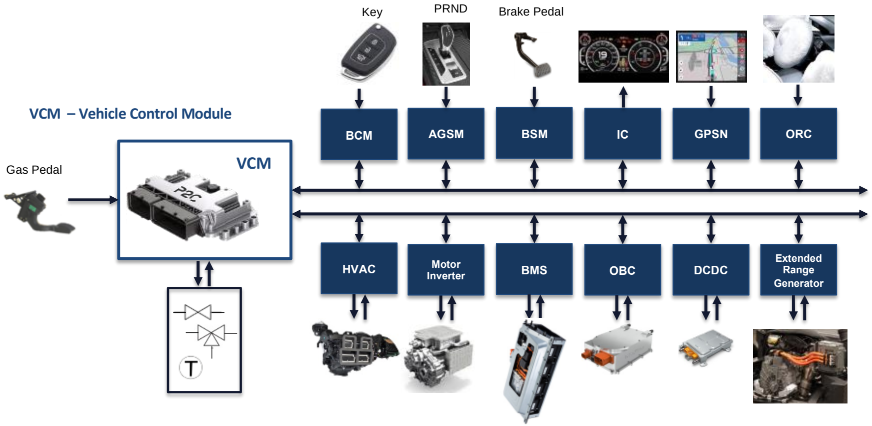
including tightly integrated **vehicle dynamics control**

Optimized for different on-board
- **Energy storage** technologies
- **Power generation** technologies

Developed according to state-of-the-art
- **ASPICE model-based design** with auto-coding
- Compliant to **MISRA**, **ISO 26262/25119**, **IEC 61508**

Available as
- Dedicated electronic control unit (**VCM**)
- **Software IPs** to be included in on-board ECU
- **Rapid prototyping** hardware for POC vehicle





Fuel Cell Electric Vehicle Simulator

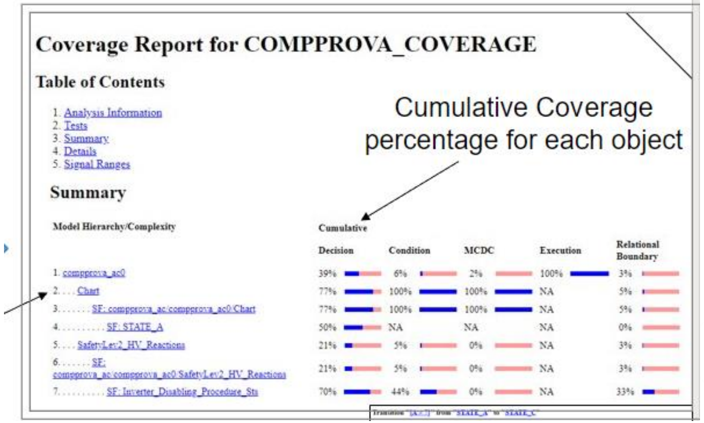
Model-based System Validation of **fuel-cell electric powertrains** for
- Heavy duty tractors and material handling vehicles
- Heavy duty trucks and busses

DIL-HIL co-simulation for requirement validation
- Vehicle performance and vehicle dynamics
- Vehicle economy, energy management, range
- Execution of driving/duty cycles/critical maneuvers

Fuel-cell electric vehicle virtual validation by real-time co-simulation:
- **FCEV Driver-in-the-Loop** (DIL) simulator
- **FCEV Hardware-in-the-Loop** (HIL) simulator
  a. Vehicle Control Module (VCM)
  b. Fuel-cell electric powertrain with VCM

Unit Test for Software Quality and Functional Safety

MIL Coverage : DC, CC, MCdC
Sil Coverage :MCdC, Statmentes



Coverage Report for COMPPROVA_COVERAGE

Table of Contents

1. Analysis Information
2. Tests
3. Summary
4. Details
5. Signal Ranges

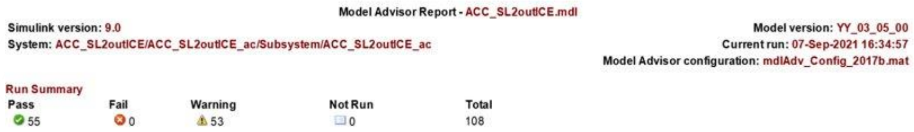
Summary

Model Hierarchy/Complexity	Cumulative Decision	Condition	MCDC	Execution	Relational Boundary
1. compprova_ac0	39%	6%	2%	100%	3%
2. . . . Chart	77%	100%	100%	NA	5%
3. . . . . . . SF: compprova_ac/compprova_ac0/Chart	77%	100%	100%	NA	5%
4. . . . . SF: STATE_A	50%	NA	NA	NA	0%
5. . . . SafetyLev2_HV_Reactions	21%	5%	0%	NA	3%
6. . . . . . . SF: compprova_ac/compprova_ac0/SafetyLev2_HV_Reactions	21%	5%	0%	NA	3%
7. . . . . SF: Inverter_Disabling_Procedure_Sts	70%	44%	0%	NA	33%

Automotive Sw Guidelines :
Misra, MAAB, ISO2622

Simulink model analysis in order to verify compliance of the model with defined modelling rules:

- Standard modelling quality rules (MAAB)
- Safety modelling rules (ISO26262)
- MISRA C:2012
- Custom Maserati modelling rules (not done)



Model Advisor Report - ACC_SL2outICE.mdl

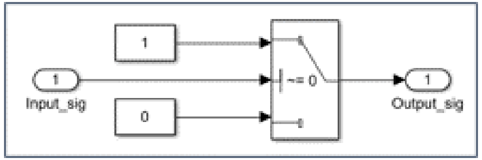
Simulink version: 9.0
System: ACC_SL2outICE/ACC_SL2outICE_ac/Subsystem/ACC_SL2outICE_ac
Model version: YY_03_05_00
Current run: 07-Sep-2021 16:34:57
Model Advisor configuration: mdlAdv_Config_2017b.mat

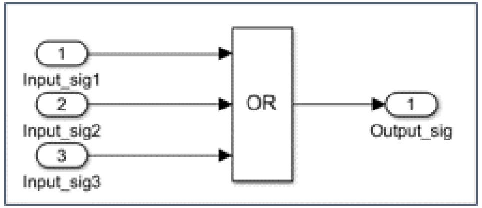
Run Summary

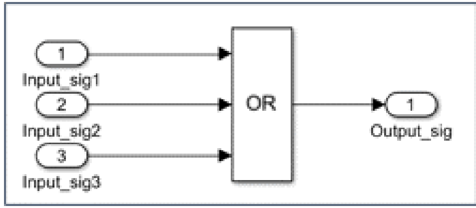
Pass	Fail	Warning	Not Run	Total
55	0	53	0	108

MIL Coverage Legend

Coverage Type	Description	Examples
Decision	It analyzes elements that represent decision points in a model, such as a Switch block or Stateflow states. A test case achieves full coverage if all the path of the model are taken at least once during the simulation.	Decision coverage objectives of the switch block: ❑ Output is from 1° input ❑ Output is from 3° input Decision coverage of the switch is 100% (2/2) if: • Input_sig ~=0 at least once • Input_sig ==0 at least once
Condition	It analyzes blocks that output the logical combination of their inputs (for example, the Logical Operator block) and Stateflow transitions. A test case achieves full coverage when it causes each input to each instance of a logic block in the model and each condition on a transition to be true at least once during the simulation, and false at least once during the simulation.	Condition coverage objectives of the OR block: ❑ Input port 1 is TRUE ❑ Input port 1 is FALSE ❑ Input port 2 is TRUE ❑ Input port 2 is FALSE ❑ Input port 3 is TRUE ❑ Input port 3 is FALSE Condition coverage of the OR is 100% (6/6) if: • Input_sig1 = T at least once • Input_sig1 = F at least once • Input_sig2 = T at least once • Input_sig2 = F at least once • Input_sig3 = T at least once • Input_sig3 = F at least once
MC/DC (Modified Condition/Decision coverage)	It analyzes blocks that output the logical combination of their inputs and Stateflow transitions to determine the extent to which the test case tests the independence of logical block inputs and transition conditions. A test case achieves full coverage for a block when a change in one input, independent of any other inputs, causes a change in the block output. A test case achieves full coverage for a Stateflow transition when there is at least one time when a change in the condition triggers the transition for each condition.	MCDC coverage objectives of the OR block: ❑ Input port 1 value determines the value of output ❑ Input port 2 value determines the value of output ❑ Input port 3 value determines the value of output MCDC coverage of the OR is 100% (3/3) if: • Input_sig1 varies between T and F at least once, while Input_sig2 = F, Input_sig3 = F • Input_sig2 varies between T and F at least once, while Input_sig1 = F, Input_sig3 = F • Input_sig3 varies between T and F at least once, while Input_sig1 = F, Input_sig2 = F







Unit Test for Software Quality and Functional Safety

P2C CONTROL SYSTEMS

Static Code Analisys

Run Time Check

Unreachable code
Invalid C++ specific operations
Correctness condition
Division by zero (DB0)
Uncaught exception
Function not returning value
Illegally dereferenced pointer
Return value not initialized
Non-initialized local variable
Non-initialized pointer
Non-initialized variable
Null this-pointer calling method
Incorrect object oriented programming
Out of bounds array index (OOB)
Overflow (OF)
Invalid shift operations
User assertion

Code Metrics

Check	Metric type	SQO1	SQ O2	SQ O3	SQ O4	SQ O5	SQ O6
Code Metrics	Comment density of a file	20 (lower limit)	20 (lower limit)	20 (lower limit)	20 (lower limit)	20 (lower limit)	20 (lower limit)
	Number of paths through a function	80	80	80	80	80	80
	Number of goto statements	0	0	0	0	0	0
	Cyclomatic complexity	**10**	**10**	**10**	**10**	**10**	**10**
	Number of calling functions	5	5	5	5	5	5
	Number of calls	7	7	7	7	7	7
	Number of parameters per function	5	5	5	5	5	5
	Number of instructions per function	50	50	50	50	50	50
	Number of call levels in a function	4	4	4	4	4	4
	Number of return statements in a function	1	1	1	1	1	1
	Language scope An indicator of the cost of maintaining or changing functions. Calculated as follows: (*N1*+*N2*) / (*n1*+*n2*) • *n1* — Number of different operators • *N1* — Total number of operators • *n2* — Number of different operands • *N2* — Total number of operands	4	4	4	4	4	4
	Number of recursions	0	0	0	0	0	0
	Number of direct recursions	0	0	0	0	0	0

Applied Mathematics for Automotive
Energy Management Strategies

P2C CONTROL SYSTEMS

Pontryagin's Maximum Principle

Fuel Consumption Minimization of PHEV

Function Optimization

Energy Comprehensive Optimization of BEV

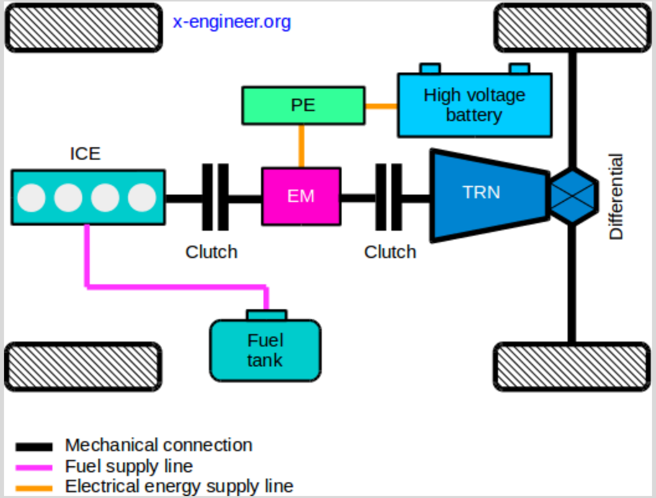
HPEGROUP

Energy Management Strategies

Fuel Consumption Minimization of PHEV

In **conventional no-hybrid powertrains**, engine power profile must meet the requested tractive power to perform a mission.

In **hybrid electric powertrains**, energy accumulation and electric motor provide an extra degree of freedom that can be exploited for fuel consumption minimization.



ICE: internal combustion engine
EM: electric machine
TRN: transmission
PE: power electronics

Energy Management Strategies

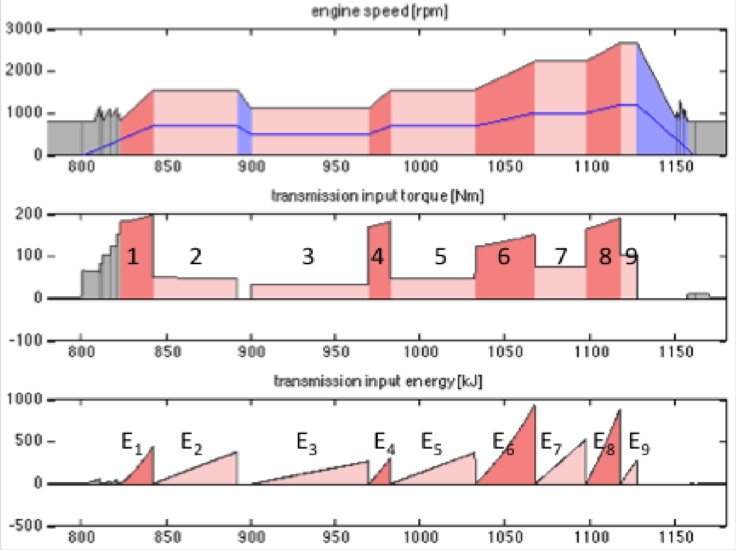
Fuel Consumption Minimization of PHEV

Mission time horizon is partitioned into slots, based on vehicle speed monotonicity.
Problem: Let E_i denote the energy delivered by engine in slot i:

Problem 1
Find optimal engine energy distribution E_i.

Problem 2
Find minimum fuel consumption engine torque profile for each slot i

- For constant engine speed (**Prob 2.a**)
- For constant engine acceleration (**Prob 2.b**)



Patented:
EP3138751 / US 20170088118 A1
EP3138714 / US 20170088120 A1

Energy Management Strategies

Fuel Consumption Minimization of PHEV

Problem 2

Find minimum fuel consumption engine torque profile for each slot i

- For constant engine speed (**Prob 2.a**)
- For constant engine acceleration (**Prob 2.b**)

Minimum fuel consumption engine torque profiles are explicitly determined by convex arguments or through Pontryagin's Maximum Principle necessary conditions and are expressed in terms of:

- engine speed ω
- mean-power demand $\frac{E}{\Delta T} = \bar{P}$

$$(\omega(t), \bar{P}) \longrightarrow \tau^{opt}(t)$$

Formalization of Prob. 2 as **optimal control** problem:

$$\begin{cases} \dot{x}(t) = \omega(t)\tau(t), t \in [t_i, t_{i+1}] \\ \tau(t) \in [\tau_{min}(\omega(t)), \tau_{max}(\omega(t))] \\ x(t_{i+1}) - x(t_i) = E_i \\ \min_{\tau} \frac{N}{4\pi} \int_{t_i}^{t_{i+1}} \omega q_E(\omega, \tau) ds \end{cases}$$

- $\dot{x}$ engine power $[W]$
- ω engine speed $[rad/s]$
- τ engine torque $[Nm]$
- E_i engine energy in slot i $[J]$
- $q_E(\omega, \tau)$ engine cycle fuel mass per cylinder $[g]$
- $G(\omega, \tau) = \frac{N}{4\pi} \omega q_E(\omega, \tau)$ fuel consumption rate $[g/s]$

Energy Management Strategies

Fuel Consumption Minimization of PHEV

Problem 1

Find optimal engine energy distribution E_i on each slot.

Solution to Problem 2 (a/b) provides the minimum fuel consumption value at the optimal torque profile for each i-th time slot:

$$(t_i, t_{i+1}, \omega_i(t), E_i) \longrightarrow FC_i^{opt}$$

The Problem 1 can be explicated and solved in the form:

$$\begin{cases} \min\limits_{E_i} \sum\limits_{i=1}^{N} FC_i^{opt}(E_i) \\ g(E_1, E_2, \dots, E_N) < 0 \\ h(E_1, E_2, \dots, E_N) = 0 \end{cases}$$

Constraints include:

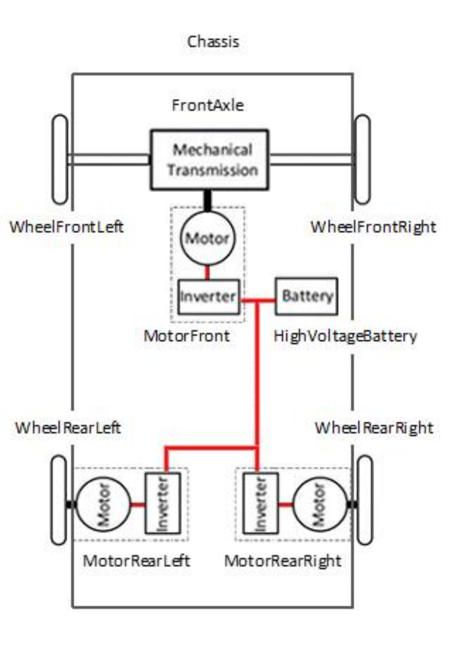
- Charge sustaining requirement for battery management (Constant SOC level)
- Engine, motor and battery physical constraints.

Energy Management Strategies

Energy Comprehensive Optimization of BEV

BEV architecture:

- The motion is provided by **three motors** (one front, two rear)
- Each motor is connected to battery via an **inverter**
- **Battery** is used to accumulate and supply electric energy to motors and other auxiliary loads
- A **differential** links the front motor with the front axle, composed of two half shafts connected to the **front wheels**
- Each **rear wheel** is connected, via a gear box, to one of the propeller shafts driven by the rear motors

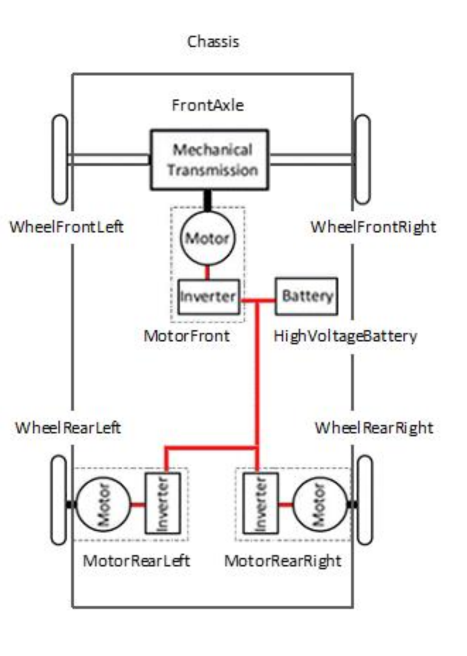


Energy Management Strategies

Energy Comprehensive Optimization of BEV

BEV architecture:

- The motion is provided by **three motors** (one front, two rear)
- Each motor is connected to battery via an **inverter**
- **Battery** is used to accumulate and supply electric energy to motors and other auxiliary loads
- A **differential** links the front motor with the front axle, composed of two half shafts connected to the **front wheels**
- Each **rear wheel** is connected, via a gear box, to one of the propeller shafts driven by the rear motors



Energy Management Strategies

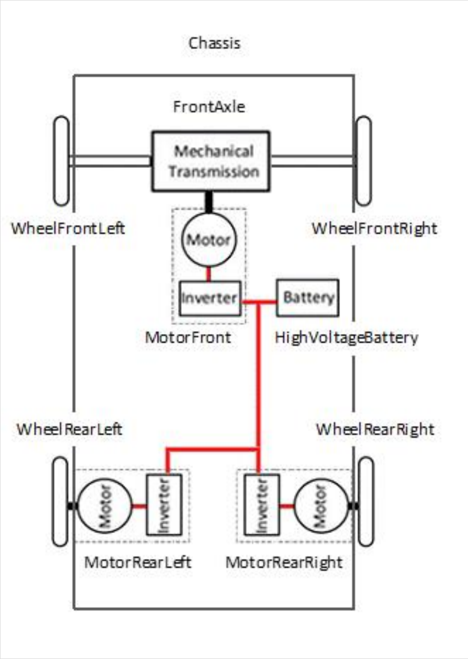
Energy Comprehensive Optimization of BEV

Simplified vehicle model through dynamical system in (t, d, E) domain:

$$\dot{E}(t) = -\frac{1}{\eta_B(t,v)}\left(\frac{1}{\eta_P(v)} v F_x(v) + P_{Aux}\right)$$
$$\dot{d}(t) = v(t)$$

$$E(0) = E_0$$
$$d(0) = 0$$
$$E(t) \in [E_{min}, E_0]$$
$$v(t) \in [v_{min}, v_{max}]$$

- d: travelled distance
- E: avilable energy in battery
- v: vehicle speed
- η_B: battery efficiency
- η_P: powertrain efficiency
- $f(v)$: resistance forces
- P_0: auxiliary load power



Energy Management Strategies

Energy Comprehensive Optimization of BEV

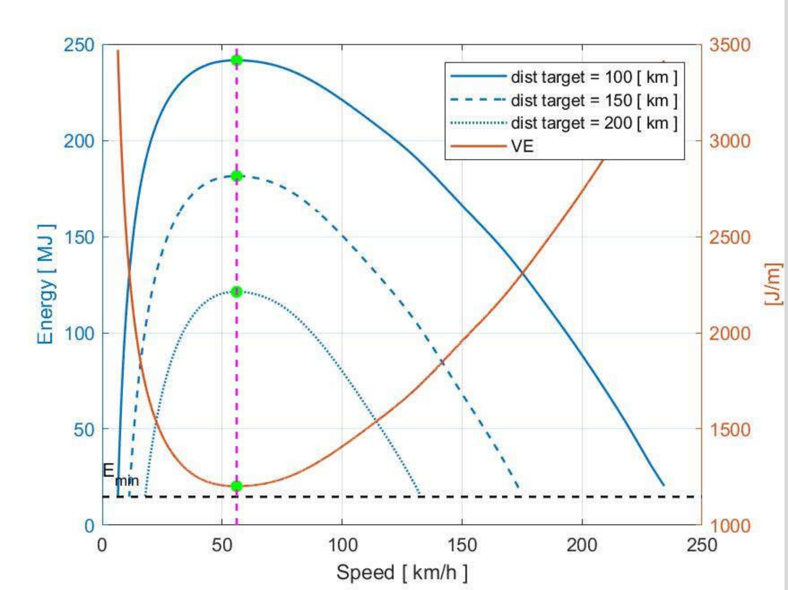
Maximum Range Speed Problem:

$$\max_{v \in [v_{min}, v_{max}]} \int_0^{T_f} v(t)\, dt$$

$$\begin{aligned} \dot{E}(t) &= -\frac{1}{\eta_B(t,v)}\left(\frac{1}{\eta_P(v)} v F_x(v) + P_{Aux}\right) \\ E(0) &= E_0 \\ E(T_f) &= E_{min} \end{aligned}$$

For the **Pontryagin's Maximum Principle** the optimal vehicle speed profile is *constant* and the problem can be rewritten in terms of vehicle energy:

$$\min_{v \in [v_{min}, v_{max}]} VE(v) := \frac{1}{\eta_B(t,v)}\left(\frac{1}{\eta_P(v)} F_x(v) + \frac{P_{Aux}}{v}\right)$$



Federico Mattioli – Product Manager

P2C CONTROL SYSTEMS

- **Alma Mater Studiorum – Università di Bologna**
  Bachelor degree in Mathematics, 2013 – 2016

- **Alma Mater Studiorum – Università di Bologna**
  Master’s degree in Mathematics (curriculum “generale e applicativo”), 2016 – 2019
  - Marelli S.p.A.
    Traineeship and Thesis

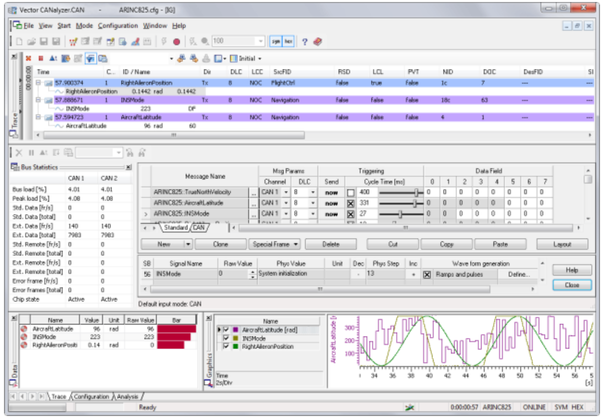
- **Pure Power Control s.r.l.**
  - Applied Mathematician and Software Engineer, 2019 – 2022
    - Maserati S.p.A
      V&V Specialist for BEV, ICE and MHEV vehicles, 2019 - 2022
      Dataset Manager, 2022 – 2022
  - Product Manager, 2023 – today
    - Maserati S.p.A
      Vehicle Dynamics Controls Product Manager, 2023 - today

HPE GROUP

Validation & Verification

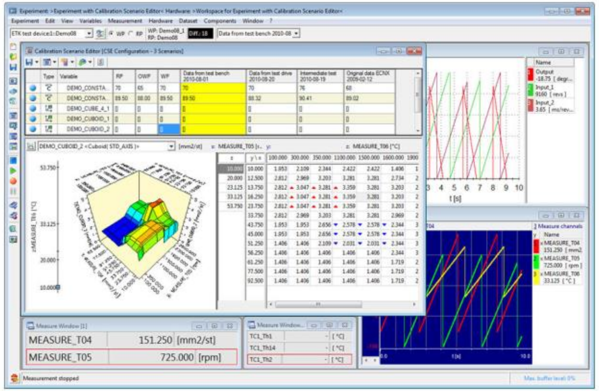
Benchtop Validation

CAN/LIN analysis and simulation



In-Vehicle Validation

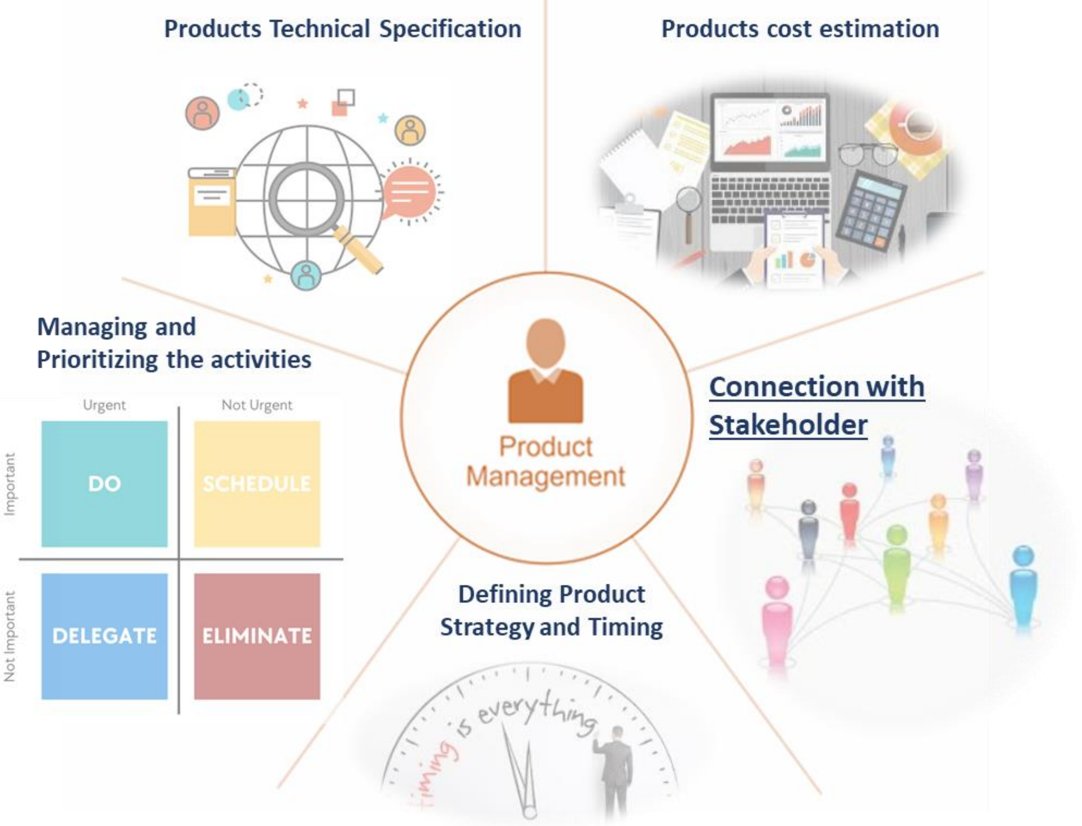
Internal variables monitoring and parameters calibration



Product Management

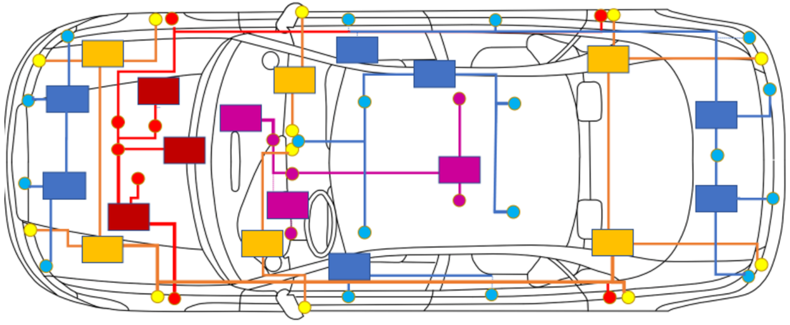
- **Main goals:**
  - Ensure project milestones are respected
  - Reduce workload of the team
  - Ensure project budget is not exceeded

- **How:**
  - Produce correct requirements
  - Estimate cost of new activities
  - Coordinate with external stakeholders
  - Coordinate internal team by defining correct timing, strategy and priorities

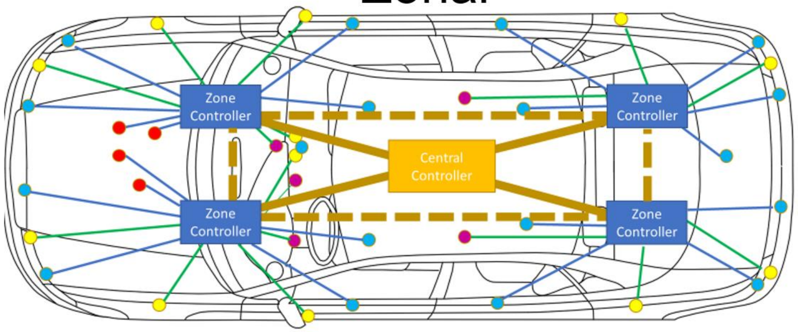


Vehicle Structure – ECU* Topology

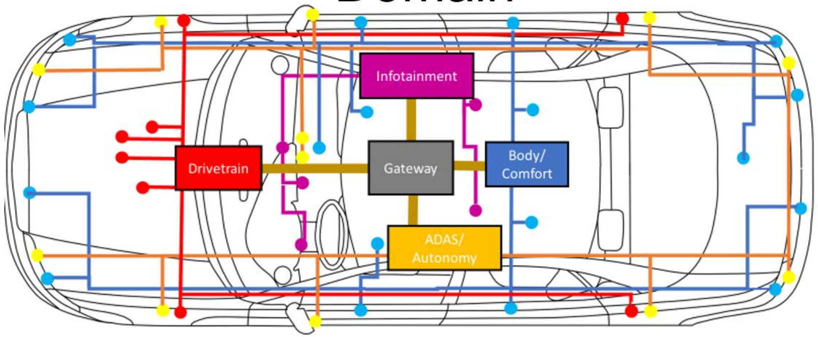
Classic



Zonal



Domain



Types of connections:

- Ethernet (40Gbit/s)
- FlexRay (10Mbit/s)
- CAN FD (8 Mbit/s)
- CAN (1 Mbit/s)
- LIN (19 Kbit/s)

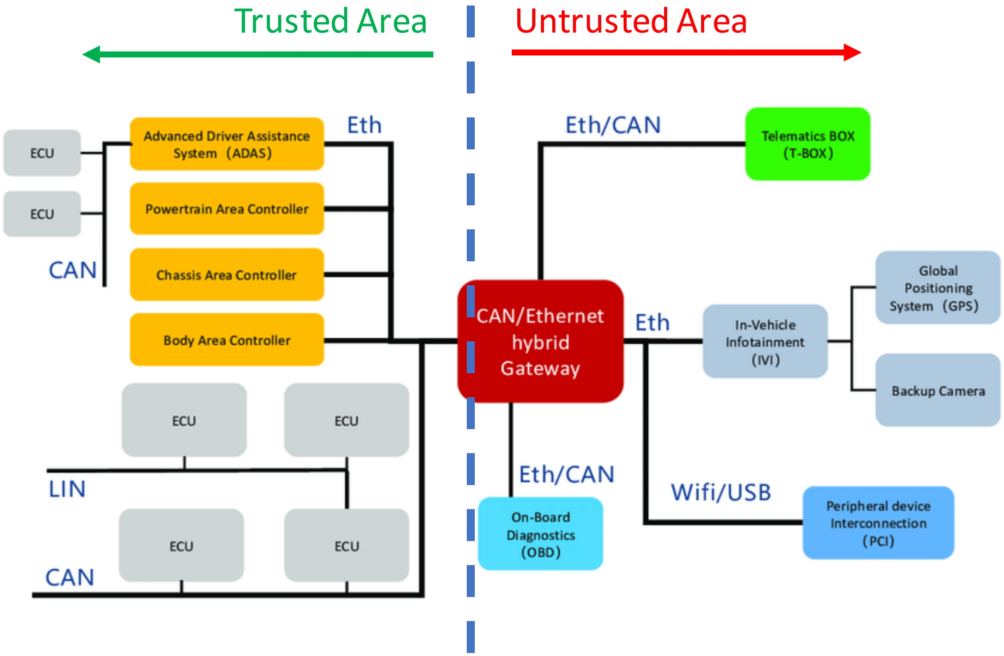
Optimization of:

- Costs and materials
- Weight of the vehicle
- Performance
- Security

*Electronic Control Unit

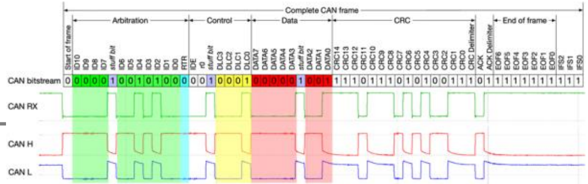
Cryptography and Cyber Security in Automotive

P2C CONTROL SYSTEMS



- **Why:**
  - Protect against crack of vehicle immobilizer
  - Protect ECUs from tampering
  - Secure company confidential data
  - Avoid usage of counterfeit parts
- **How:**
  - Physical secure of ECUs and wiring
  - SW/HW partition of protected data
  - Usage of algorithms to guarantee in-vehicle messages integrity
  - Usage of cryptography algorithms to protect the vehicle from external threats

In-vehicle message protection



- **Message Counter (MC) and Alive Counter (AC)**
  - non crypto
  Guarantee the integrity of the sender

```
int MC_Calc(int MC_old){
  int MC_new;

  if (MC_old == 15)
  {
    MC_new = 0;
  }
  else
  {
    MC_new = MC_old + 1;
  }

  return MC_new;
}
```

✓ *Message bits*

$$m(x)=m_{k-1}X^{k-1} + m_{k-2}X^{k-2} + \ldots + m_1X + m_0$$

✓ *CRC bits*

$$r(x)=r_{R-1}X^{R-1} + r_{R-2}X^{R-2} + \ldots + r_1X + r_0$$

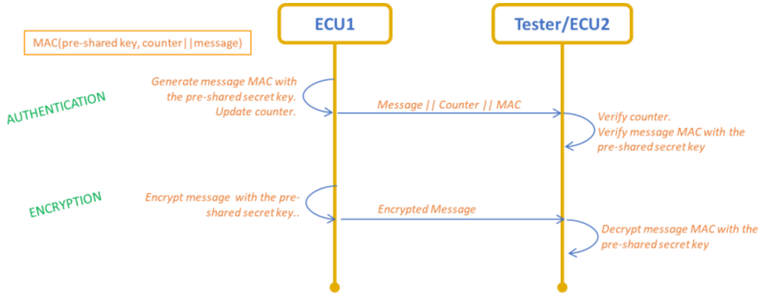
✓ *Generator polynomial*

$$G(x)=g_RX^R + g_{R-1}X^{R-1} + \ldots + g_1X + g_0$$

Modulo-2 division

$$X^Rm(x)+r(x)=p(x)g(x)$$

- **Cyclic Redundancy Check (CRC)**
  - non crypto
  Guarantees the integrity of the message

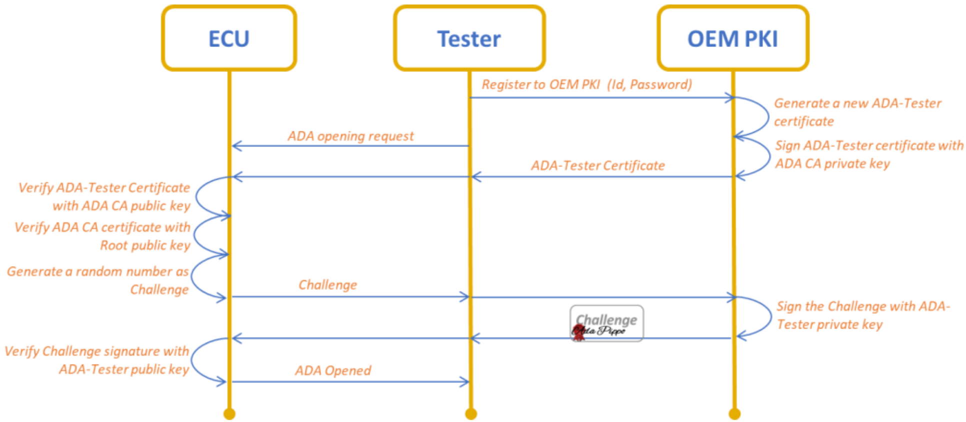


- **Cipher based Message Authentication Code (CMAC)**
  – based on AES
  Guarantees integrity of sender and message
  Guarantees authenticity of the sender

ADA – Authenticated Diagnostic Access

P2C CONTROL SYSTEMS

- **Based on RSA**
- **Usage:**
  - Critical diagnosis can be accessed by authorized users only (ex. engineers, dealers etc.)
- **Protection for:**
  - Programming of the ECU (and FOTA/AOTA*)
  - Hard Reset of the ECU
  - Calibration changes
  - Parameters tampering (ex. total odometer)
  - Confidential engineering data
  - Hiding of malfunctioning



*Firmware Over the Air
Application Over the Air

Different algorithm for different usage

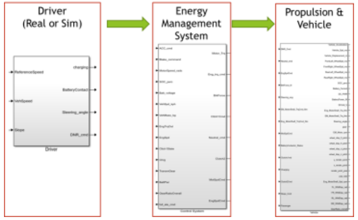
Algorithm	Automotive Typical Usage	NIST* Validity	Algorithm Class
AES-128	Immobilizer	> 2030	Symmetric Block Cipher
SHA256	Code Integrity, Digital Signature	> 2030	Hash function
CMAC (AES-128)	Message Authentication Authenticated Boot	> 2030	Message Authentication Code
HMAC (SHA256)	Message Authentication Authenticated Boot	> 2030	Message Authentication Code
RSA 2048	Authenticated Diagnostic Access	2030	Asymmetric Cipher Digital Signature
RSA 3072 RSA 4096	Authenticated Diagnostic Access	> 2030	Asymmetric Cipher Digital Signature
ECC 256	V2X applications: encryption and authentication	> 2030	Elliptic Curve Encryption Digital Signature
DRBG_CTR (AES-128)	Authenticated Diagnostic Access, Security Access, Key generation	> 2030	Pseudo Random Number

*National Institute of Standard and Technology

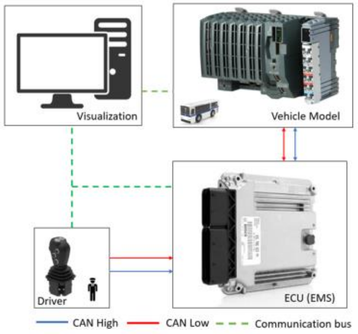
- **Each use case needs a dedicated algorithms/method**
- **Actual strategies may not be safe enough in the next future**

Optimization of HEV consumption

- **Scope:**
  - Finding optimal parameters for a real driving cycle
- **Activities:**
  - Finding optimum for homologation driving cycles
  - Finding optimum for real driving cycles
  - Finding optimum for Vehicle to City applications



Development and validation of the model



Embedding of developed model in the ECU and simulation of the rest of the vehicle

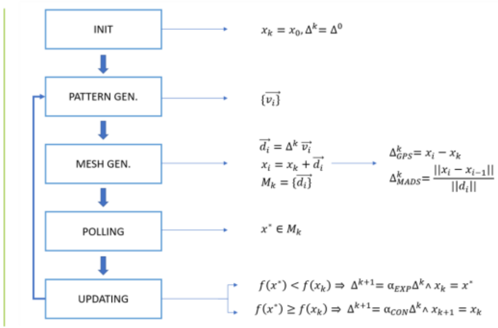
$$objfunc = maximize(Qc, Avg_{cons})$$

$$m_{efuel} = \int \frac{Pwr_{Batt} \cdot K_{\frac{gal}{m^3}} \cdot \rho_{Diesel\frac{kg}{m^3}}}{1000 \cdot 3600 \cdot 33.7}$$

$$m_{ICEfuel} = \int \frac{\omega_e \cdot T_e}{H_i \cdot \eta_e}$$

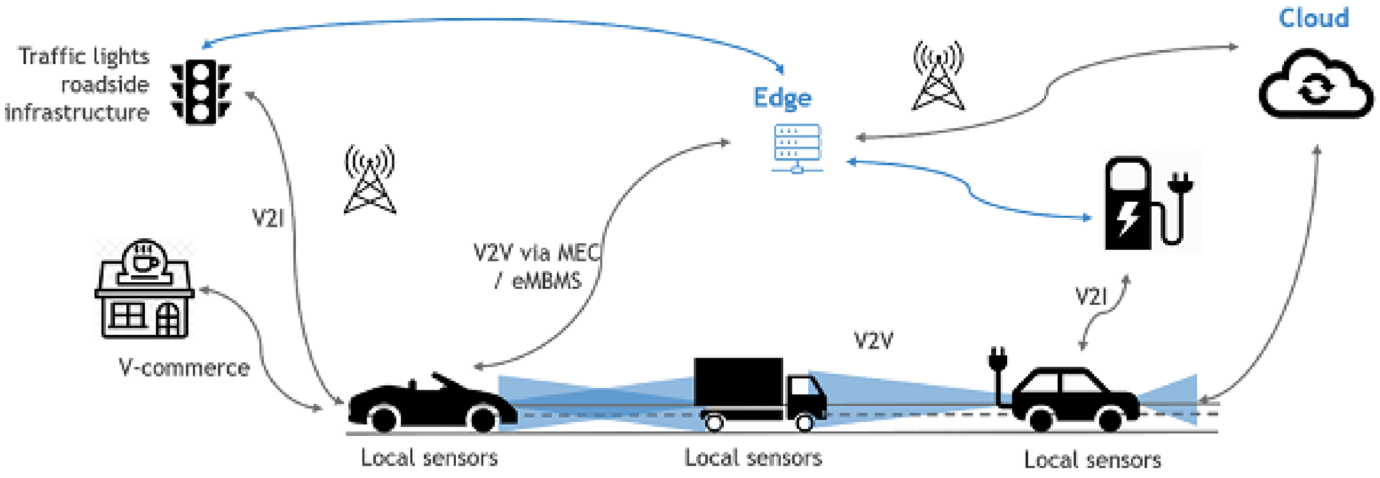
$$m_{ref} = m_{ICE} + m_{efuel}$$

$$Avg_{cons} = \frac{m_{ref}}{d \cdot \rho * Diesel_{\frac{kg}{l}}}$$



Data Collection on vehicle usage (V2C*)

- **Scope:**
  - Collect information about how the vehicle is used
  - Collect data of sold fleet
  - Foresee potential malfunctions
- **How:**
  - Store data in ECU's non-volatile memory
  - Send data to Company cloud
  - Produce statistics and metrics
  - Define a strategy to highlight relevant data



*Vehicle to Cloud

Contacts

Locations

- **Pisa (Cascina)** Headquarter

Via Carbonia 8, 56023 Visignano – Cascina (PI), Italy
Email: andrea@purepowercontrol.com
Tel: +39 050 749012

- **Modena**

Via C. Zucchi 21, int. 13A, 41123 Modena (MO), Italy.
Email: luigi.dimarco@purepowercontrol.com, federico.mattioli@purepowercontrol.com
Tel: +39 059 2153755, +39 338 8747234

- **Terni (MICH)**

Via L. Casale 7, 05100 Terni (TR), Italy.

Company Information

Registered Office: Via Carbonia 8, 56023 Visignano – Cascina (PI), Italy

Tax Code and VAT N. 02137760464

REA PI – 165427, MO-418086

www.purepowercontrol.com

info@purepowercontrol.com

info@pec.purepowercontrol.com