DALLARA HOLISTIC VISION FOR ENHANCED VEHICLES PERFORMANCE

Gamma Technologies European Roadshow

Bologna 18.06.2024

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OUTLINE

- **Dallara Overview**
  - Core competences
  - Our approach
  - Ongoing projects

- **Design cycle**
  - Testing & Virtual analysis
  - Digital twin & Virtual testing

- **Vehicle Systems sizing**
  - Goals
  - Workflow

- **Why GT-SUITE**
  - Race and road cars cooling system sizing
  - Powertrain analysis
  - GT-SUITE vs Real data
  - Virtual cooling test bench
  - Conclusions

- **Next steps**
  - AI applications for vehicle systems

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DALLARA OVERVIEW

OUR VISION

We are a community that invests every day in a sustainable way for a better future and gives support, security and solidarity to its people, its families and its territory with appreciation and gratitude.
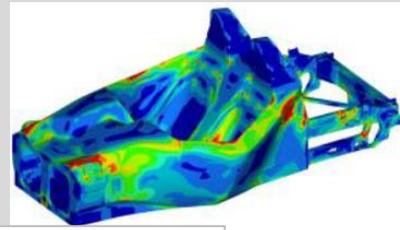
OUR MISSION

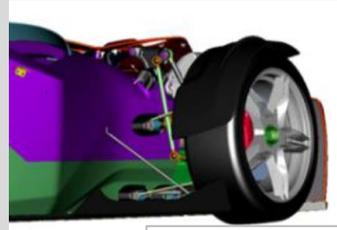"Our aim is to Design and Produce the fastest and safest cars in the World"

DALLARA OVERVIEW
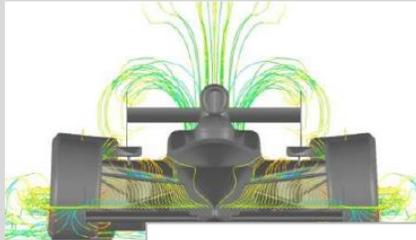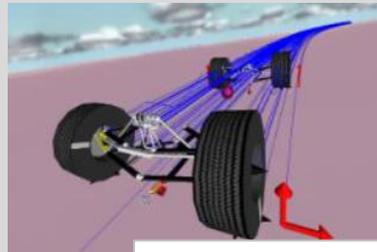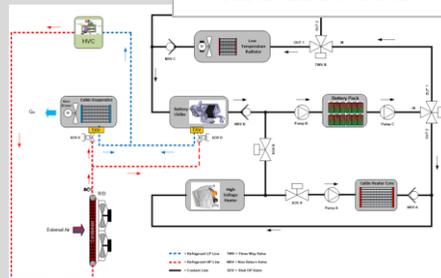## CORE COMPETENCES

STYLE
(CONCEPT/REGULATIONS)

1. ADVANCED COMPOSITE MATERIALS

2. AERODYNAMICS

3. VEHICLE DYNAMICS AND SYSTEMS

4. PRODUCTION
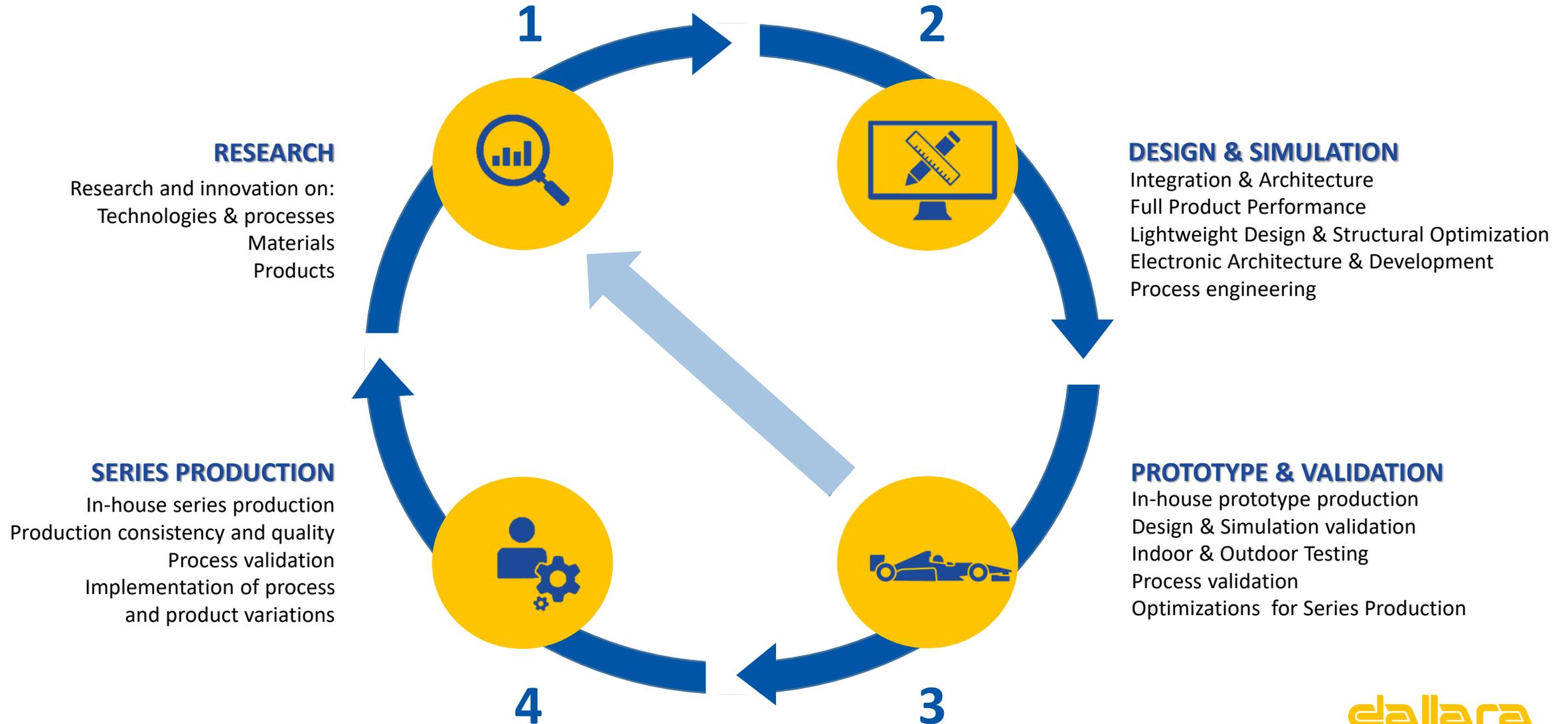
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DALLARA OVERVIEW

OUR APPROACH

1

2

RESEARCH

Research and innovation on:
Technologies & processes
Materials
Products

DESIGN & SIMULATION
Integration & Architecture
Full Product Performance
Lightweight Design & Structural Optimization
Electronic Architecture & Development
Process engineering

SERIES PRODUCTION
In-house series production
Production consistency and quality
Process validation
Implementation of process
and product variations

PROTOTYPE & VALIDATION
In-house prototype production
Design & Simulation validation
Indoor & Outdoor Testing
Process validation
Optimizations for Series Production

4

3

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DALLARA OVERVIEW
ONGOING PROJECTS

Recent projects relating to vehicle systems:

3 Hybrid Lmdh/Lmh vehicles (TC and NA)

1 Endothermal hypercar vehicle (Power > 1500 Hp)

1 Electric road vehicle

3 Endothermal single seater (TC and NA)

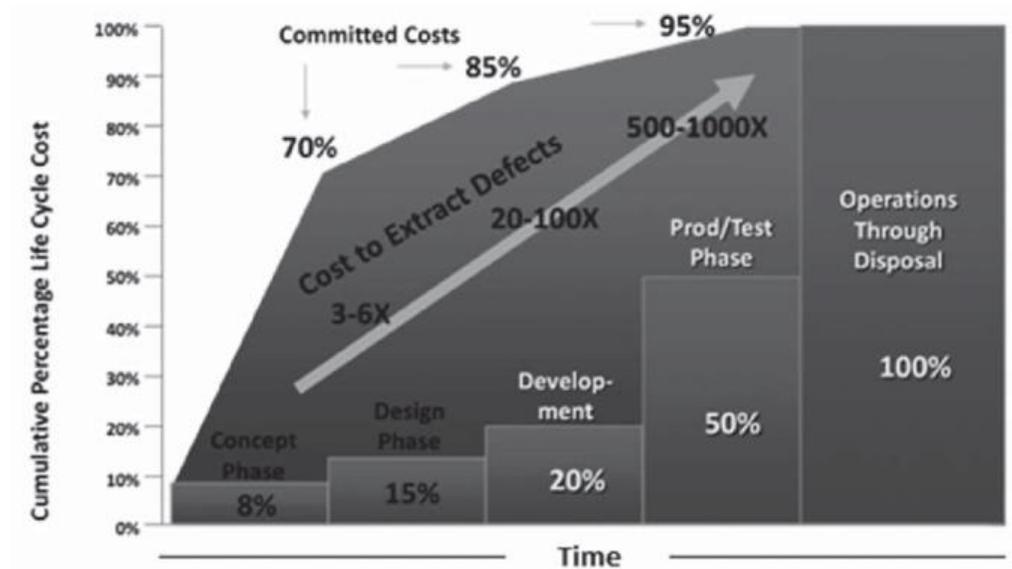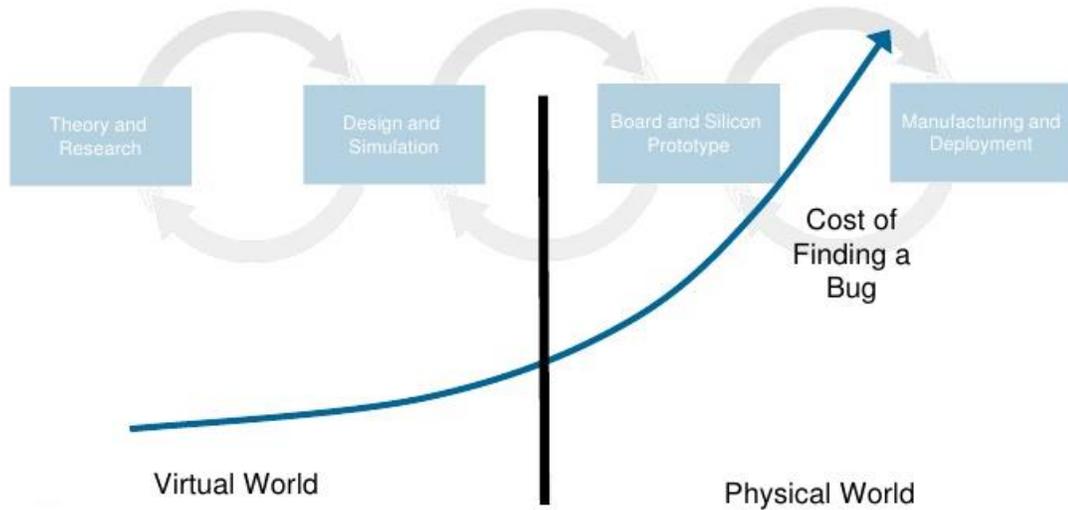1 Hybrid single seater vehicle (wip)

1 Hydrogen vehicle (Prestudy wip)

Development of several projects with different propulsion topology and targets

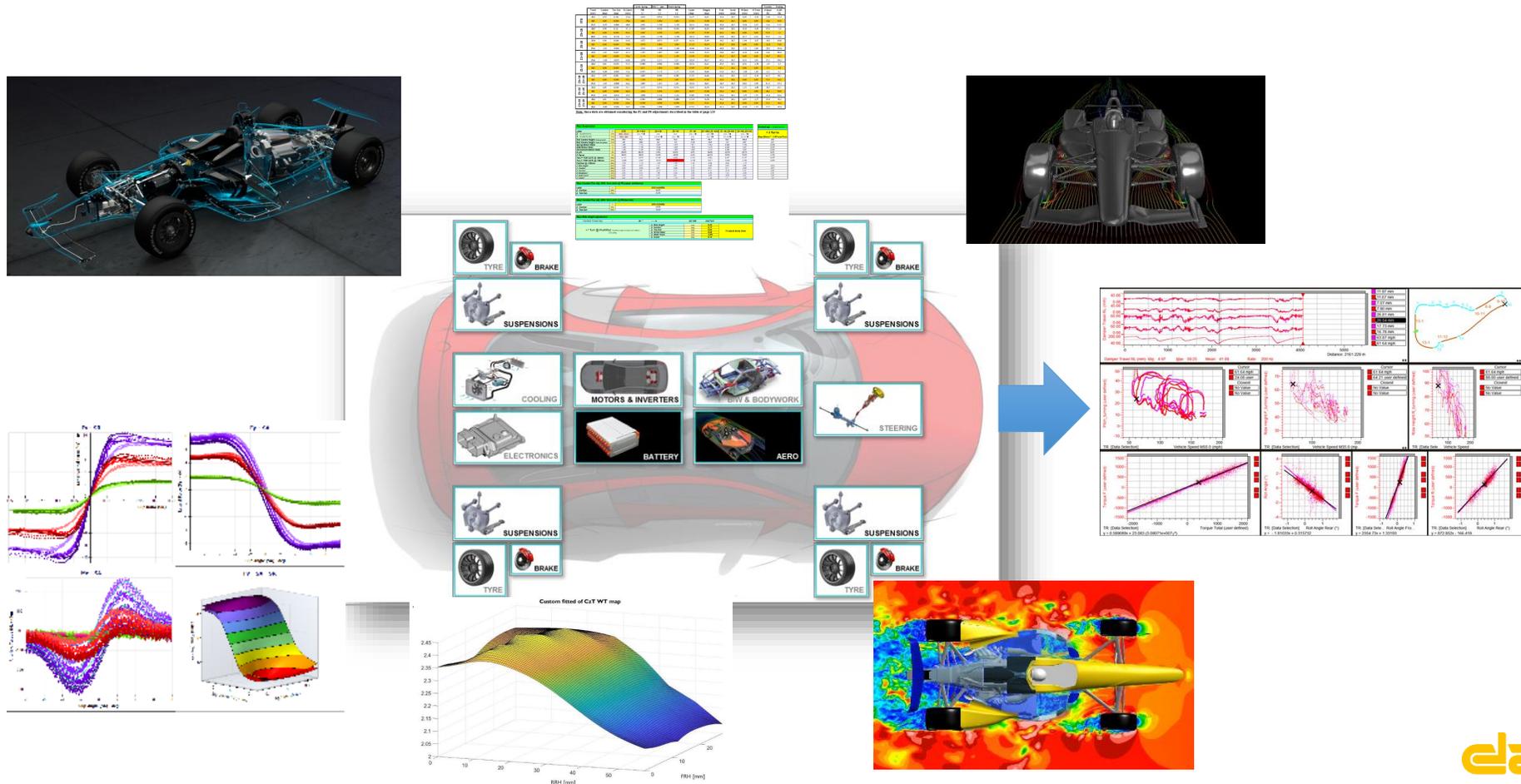# DESIGN CYCLE
## TESTING & VIRTUAL ANALYSIS

DESIGN CYCLE

DIGITAL TWIN & VIRTUAL TESTING

Increasing Complexity

Highly Detailed Design

Huge Adjustability & Complex Characterization

Very Large Amount of Data

DESIGN CYCLE

DIGITAL TWIN & VIRTUAL TESTING

The DIGITAL TWIN is able to capture in a virtual environment all the relevant physical aspects of your vehicle, allowing to maximize the virtual efforts in all the stages of the projects.
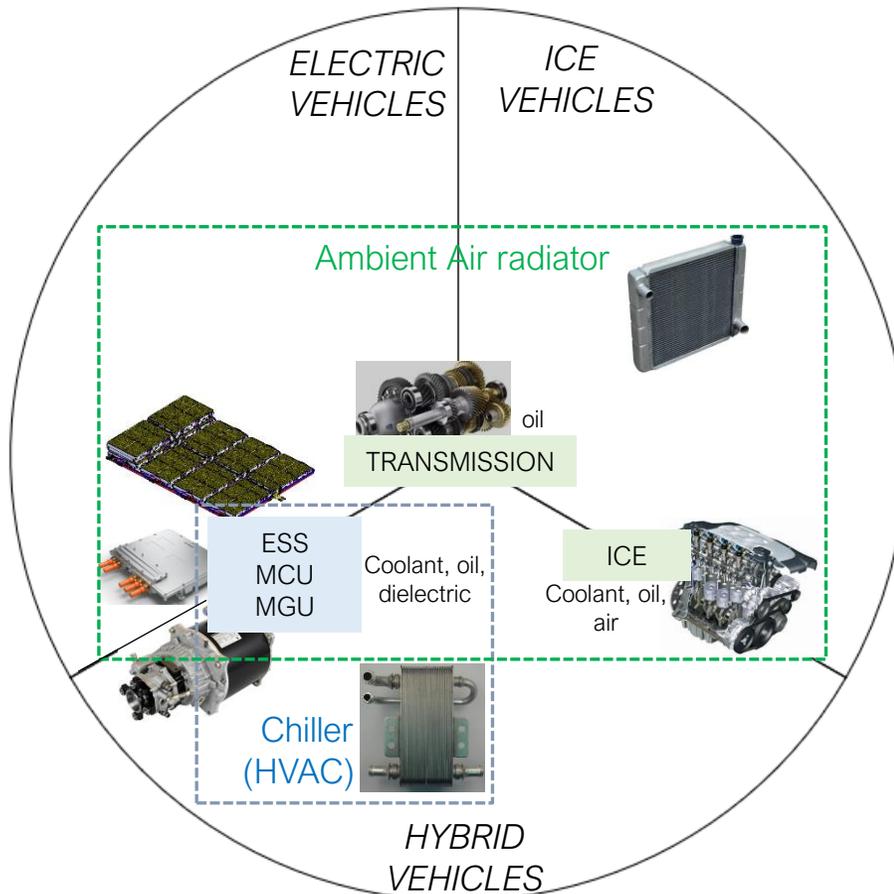
DESIGN CYCLE

DIGITAL TWIN & VIRTUAL TESTING

On completion of this process, the simulation models are representative and theoretically any physical test can be successfully replaced by a virtual one.
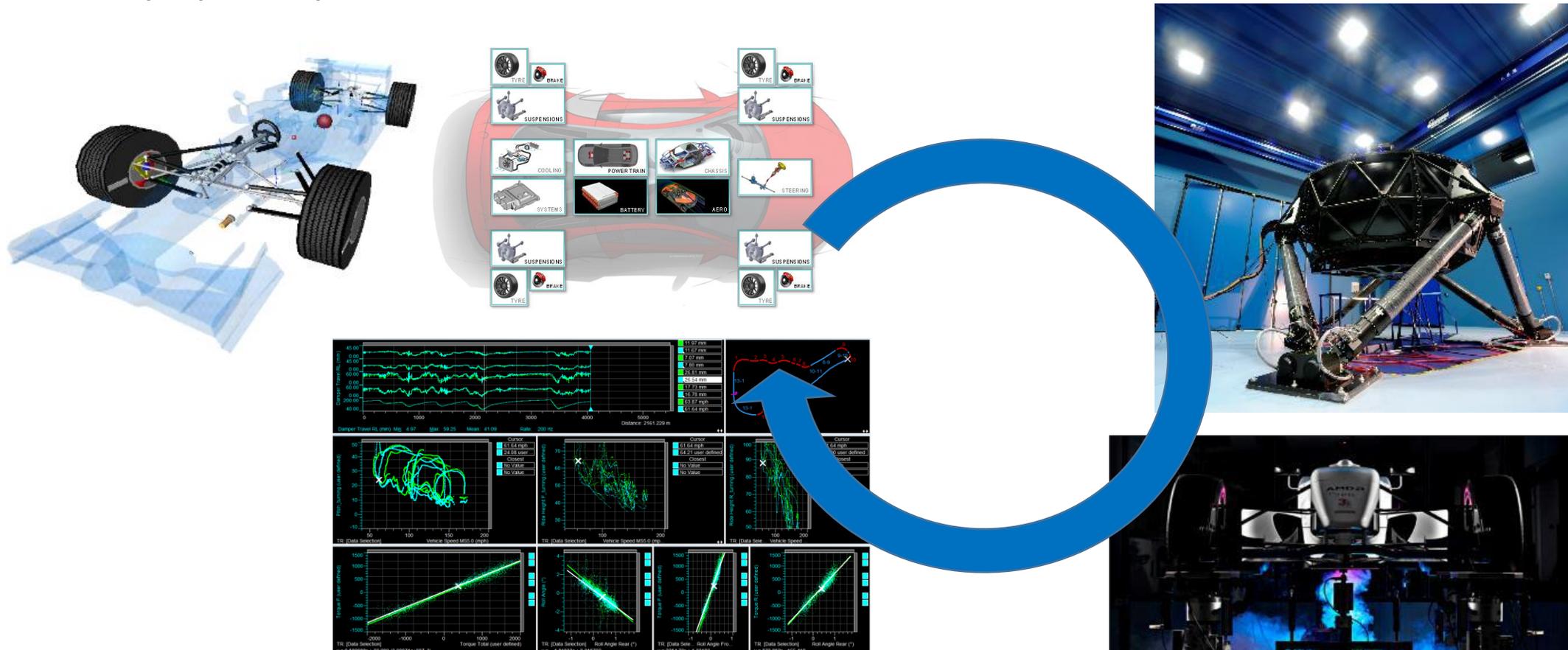
VEHICLE SYSTEMS SIZING

GOALS

- Support the Design and Aero departments for the system packaging definition (Heat Exchangers, layout and configuration)
- Refine thermal performance analysis of fluids (air, coolant, oil, dielectric, ...)
- Reduce Physical test by enhancing virtual simulation

ELECTRIC VEHICLES

ICE VEHICLES

Ambient Air radiator

oil
TRANSMISSION

ESS
MCU
MGU

Coolant, oil, dielectric

ICE
Coolant, oil, air

Chiller (HVAC)

HYBRID VEHICLES

HIGH TEMPERATURE
Fluid limit 95 /140 °C

LOW-MED TEMPERATURE
Fluid limit 40 / 80 °C

Vehicles today have many complex subsystems with challenging and different targets!

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VEHICLE SYSTEMS SIZING

WORK FLOW

Hand calculation

Excel calculation
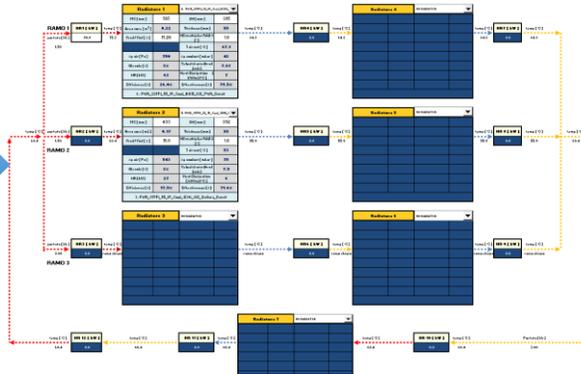
GT

1D systems simulation
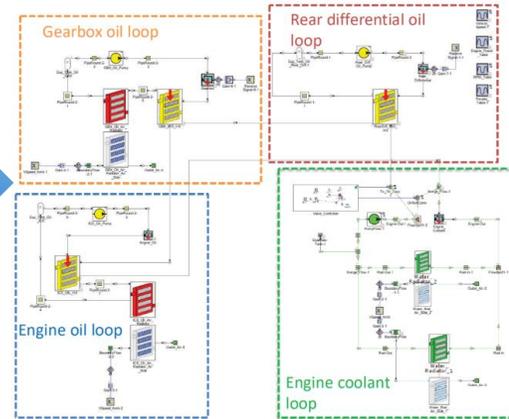
Indoor testing

Vehicle track test

Key factors:

- Correlation of steps
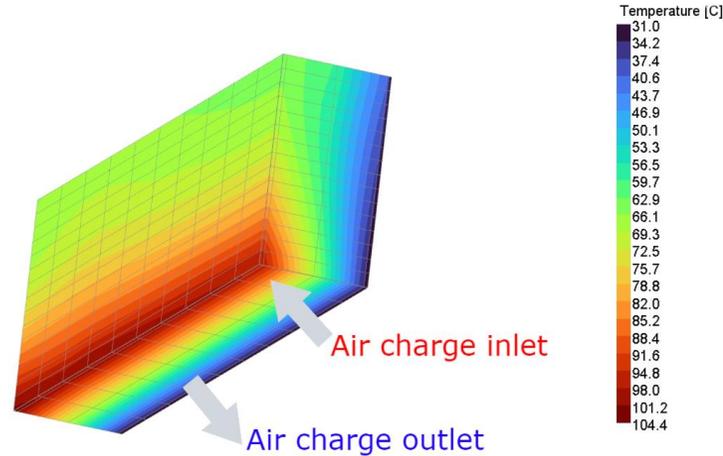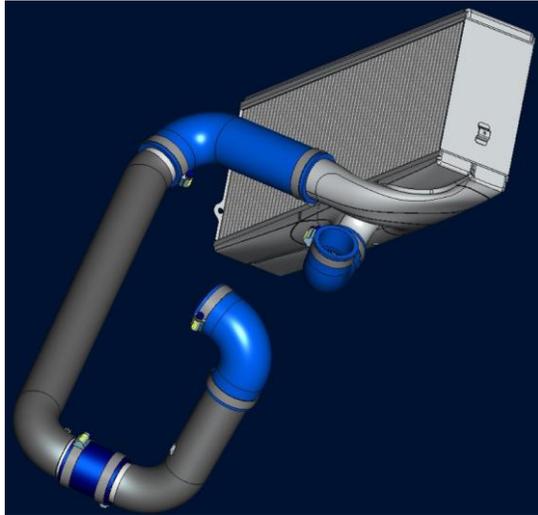- Essential data prediction in the first step

VEHICLE SYSTEMS SIZING

WORK FLOW
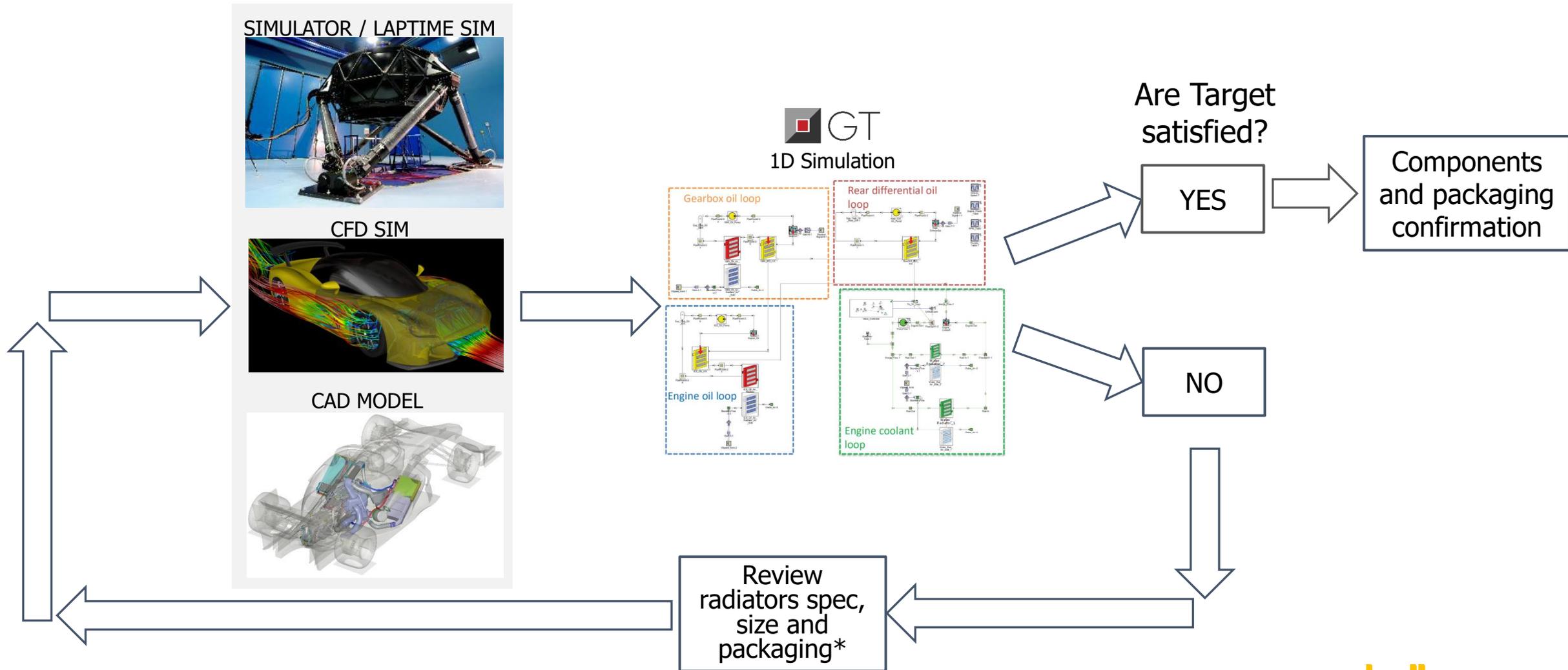
*Weight, aero efficiency and packaging implications on overall vehicle performance are evaluated for every cooling system configuration

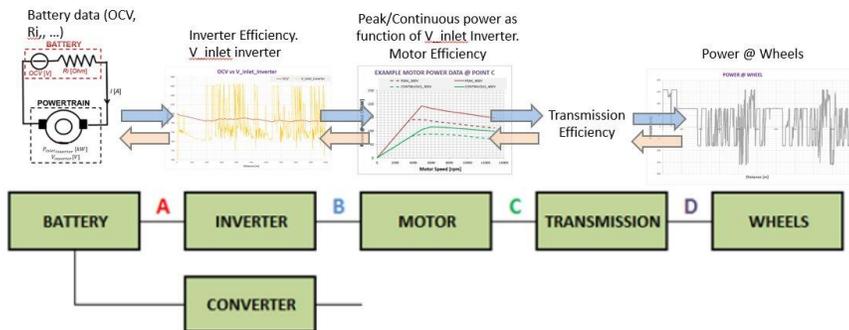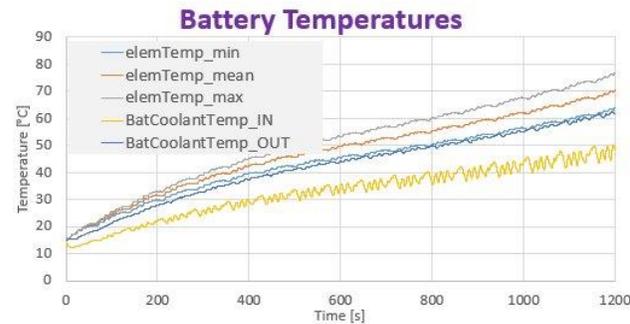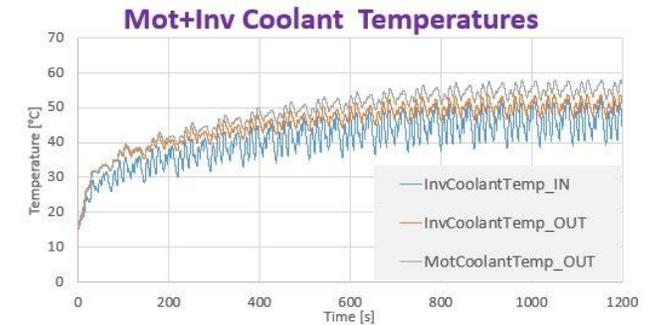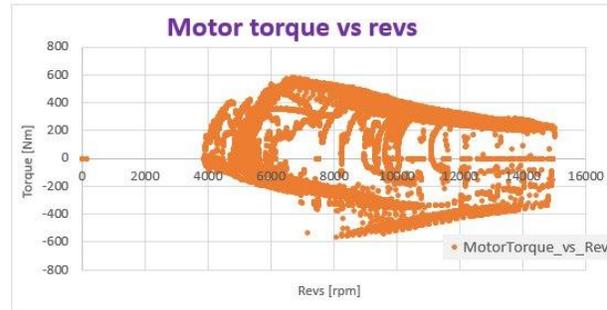# WHY GT-SUITE

RACE AND ROAD CARS COOLING SYSTEMS SIZING

Air charge inlet

Air charge outlet

Temperature [C]
31.0
34.2
37.4
40.6
43.7
46.9
50.1
53.3
56.5
59.7
62.9
66.1
69.3
72.5
75.7
78.8
82.0
85.2
88.4
91.6
94.8
98.0
101.2
104.4

T AIR CHARGE INTERCOOLER OUT

- - - Vehicle speed
— Track data
— GT Sim Validated

Temperature [C]

Speed [km/h]

1°C

20 km/h

Time [s]
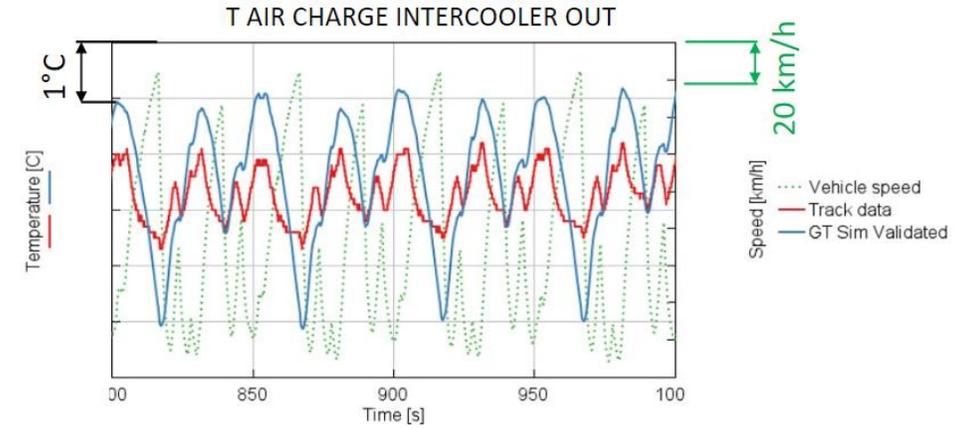
GT-SUITE ADDED VALUES

- Pipes Geometry imported directly from CAD allow a better pressure loss prediction and lower implementation timing

- Radiator discretization (air flow, air temperature and heat rejections maps) allow a better integration with CFD software

- Radiator calibrated model based on a perfomance target allow a better temperatures prediction

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WHY GT-SUITE

POWERTRAIN ANALYSIS
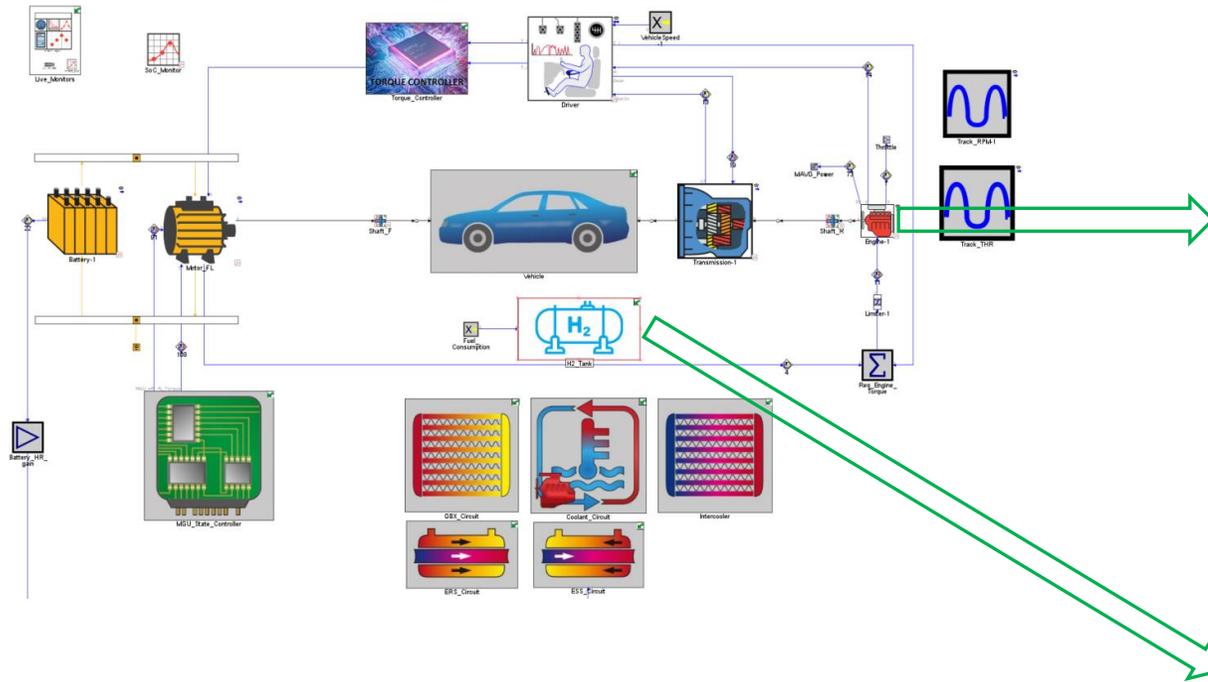
Electric and hybrid propulsions
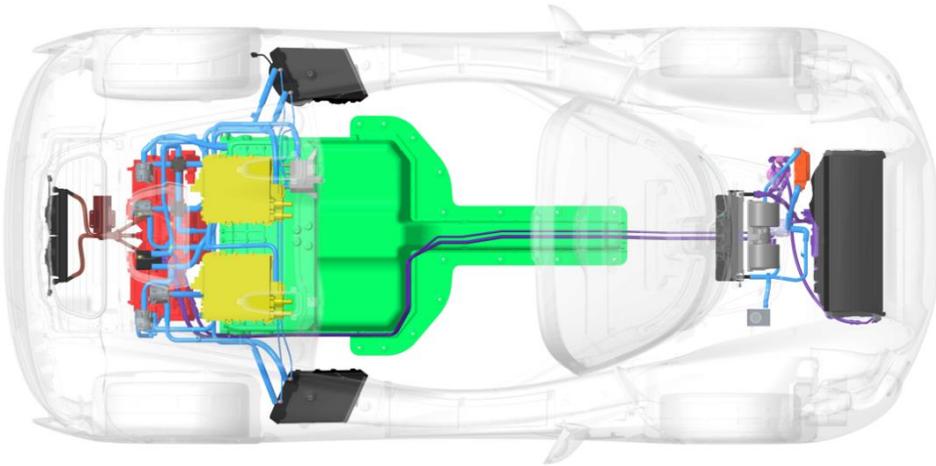
Longitudinal vehicle dynamics simulation together with the cooling performance: speed profile, fluids temperatures and range evaluation in the same simulation.
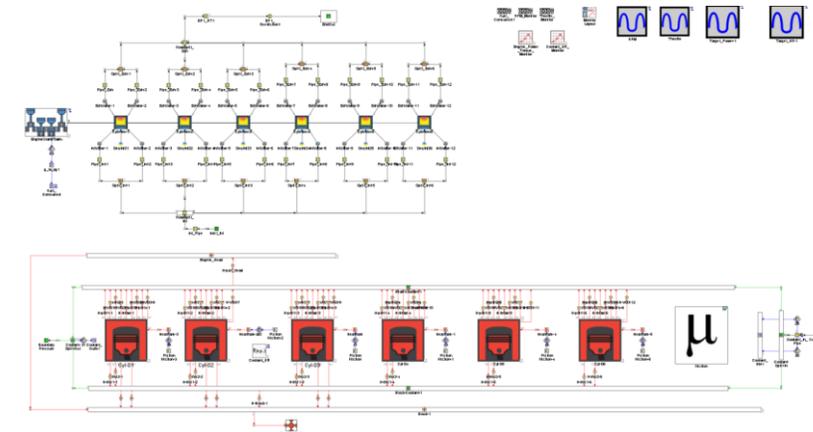
WHY GT-SUITE
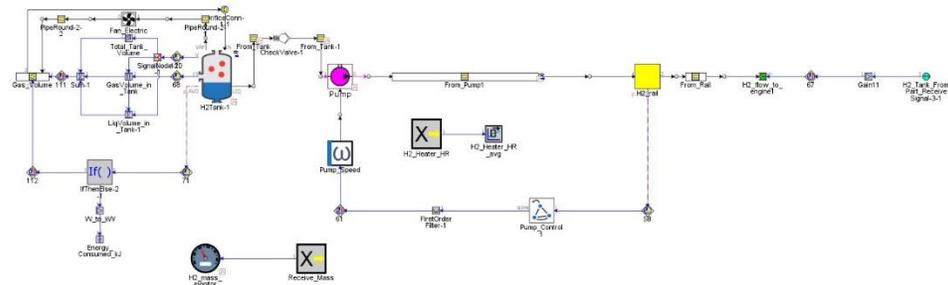
POWERTRAIN ANALYSIS
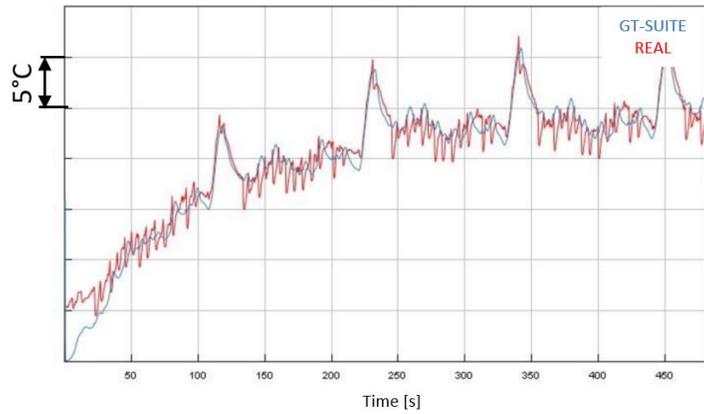
Hydrogen propulsions (WIP)

ICE MODEL

H2 FROM TANK TO RAIL

A single model (from tank to wheels) to analyse ICE power, heat rejections, temperatures, pressures, flow rates, hydrogen consumption and longitudinal vehicle performance in the same simulation.

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WHY GT-SUITE

GT-SUITE vs REAL DATA

ENDOTHERMAL HYPER CAR
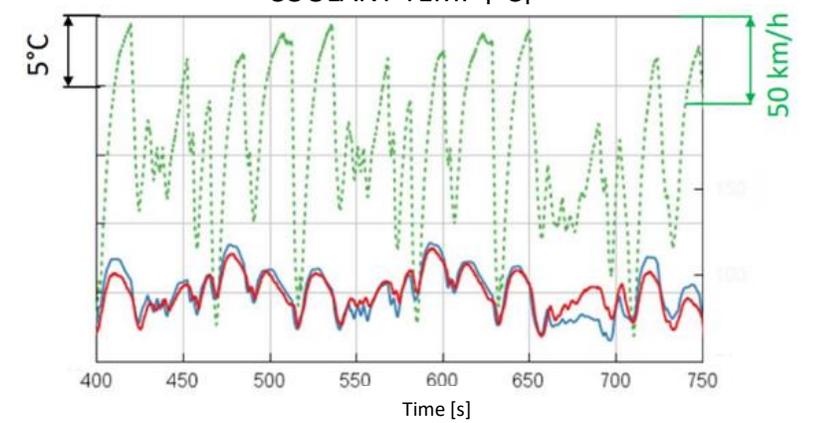
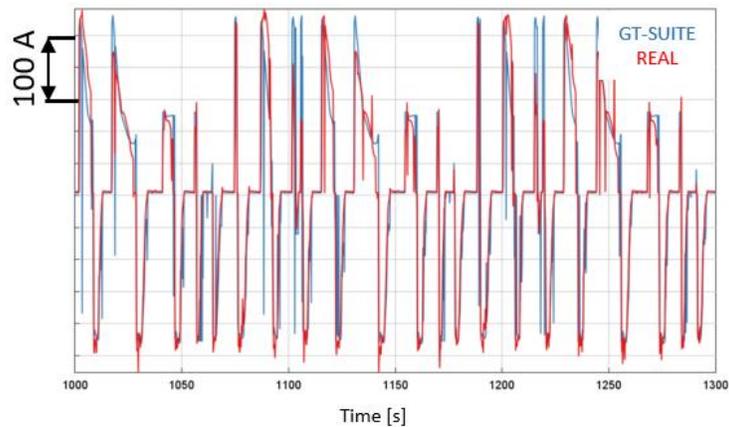

WCAC OUT AIR CHARGE TEMPERATURE [°C]

GBX OIL TEMP [°C]
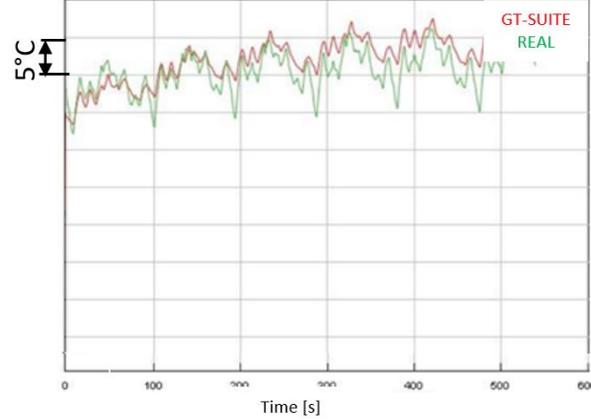
ENDOTHERMAL SINGLE SEATER
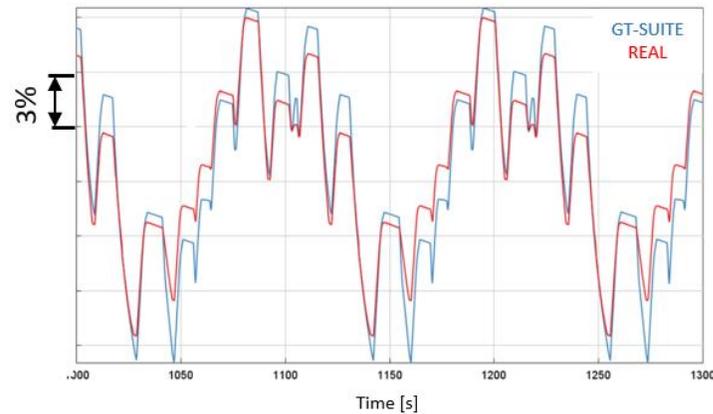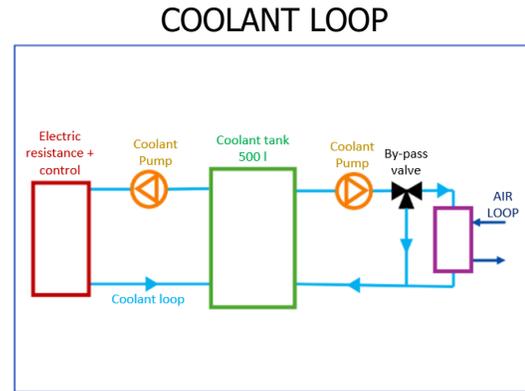

COOLANT TEMP [°C]

HYBRID RACECAR

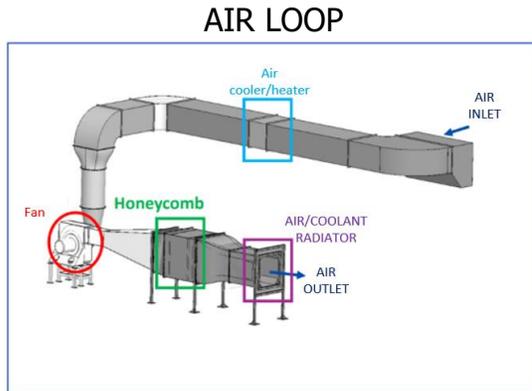BATTERY TERMINAL CURRENT [A]
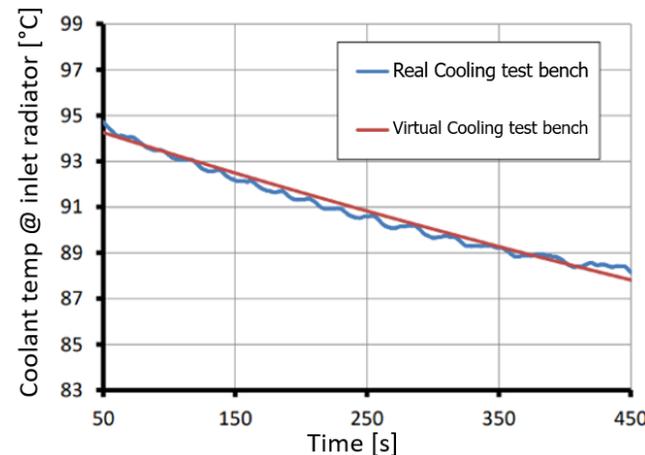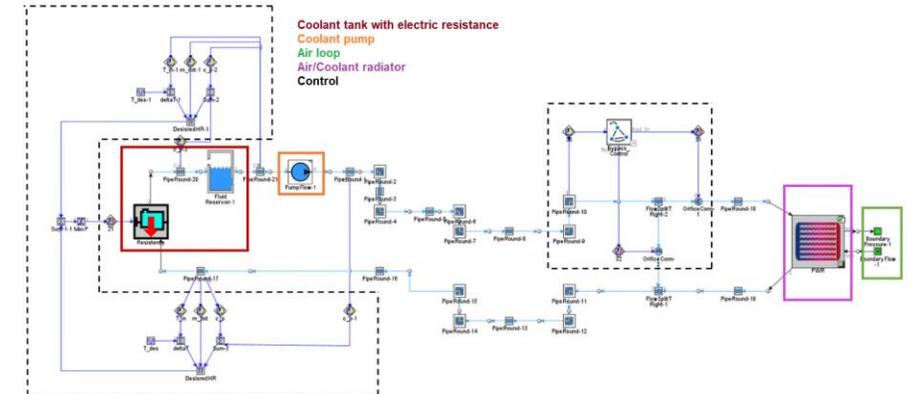

ESS SOC [%]

WHY GT-SUITE

VIRTUAL COOLING TEST BENCH

- GT-SUITE has supported the upgrade of the real cooling test bench

- The cooling test bench simulation model is used as pre-test and post-pro to support the testing activity

Real cooling test bench

Cooling test bench simulation model in GT-SUITE
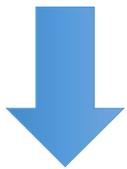

AIR LOOP

COOLANT LOOP

WHY GT-SUITE

CONCLUSIONS

GT

- High simulation results accuracy

- Low simulation models implementation timing

- Integration with CAD and CFD softwares

- Vehicle systems sizing and optimization of new powertrain technology: ICE, Hybrid, Electric, Hydrogen
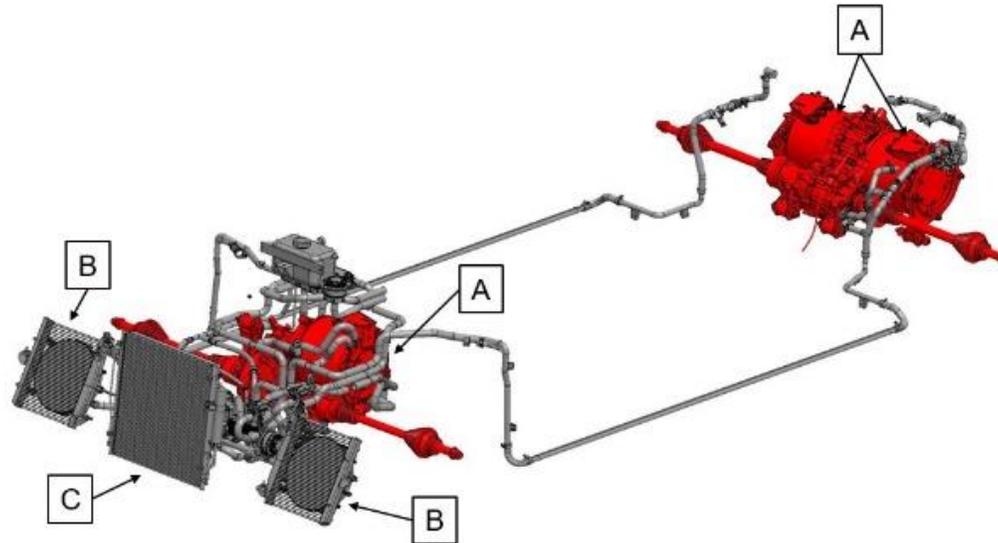
- Overall cost and timing reduction in both design and testing phases

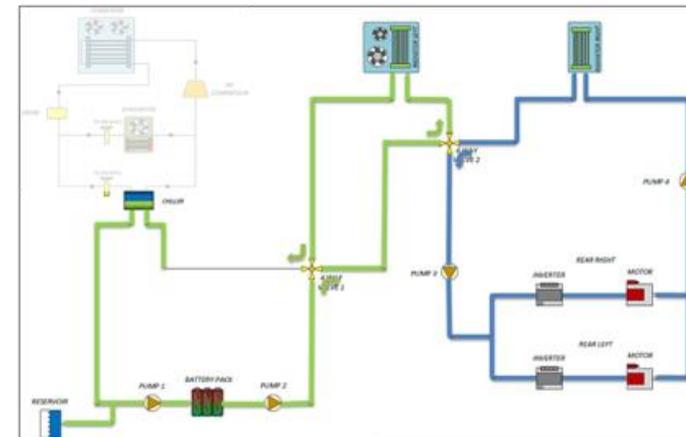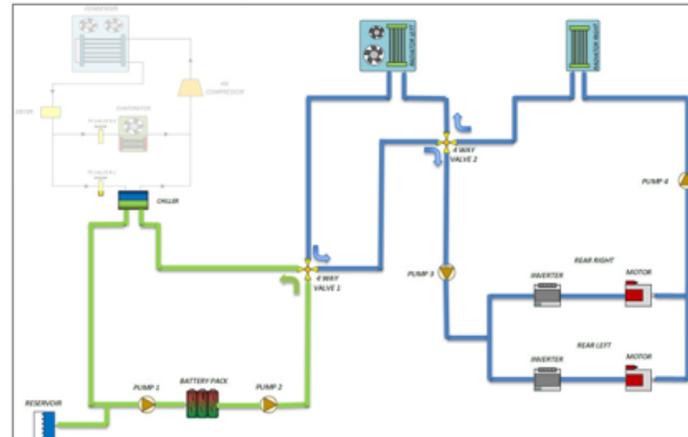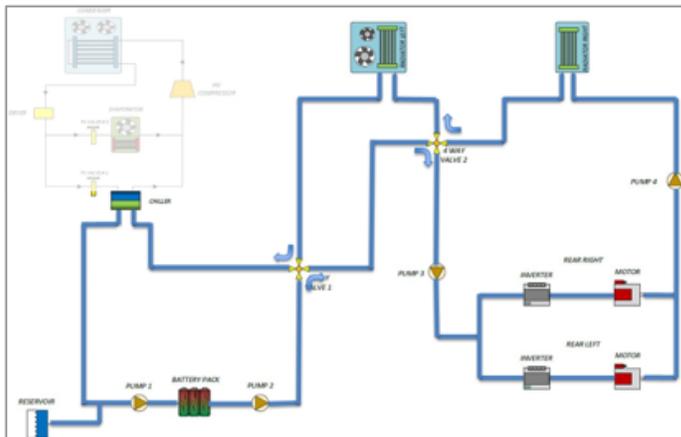- Vehicle performance improvements

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NEXT STEPS

AI APPLICATIONS FOR VEHICLE SYSTEMS

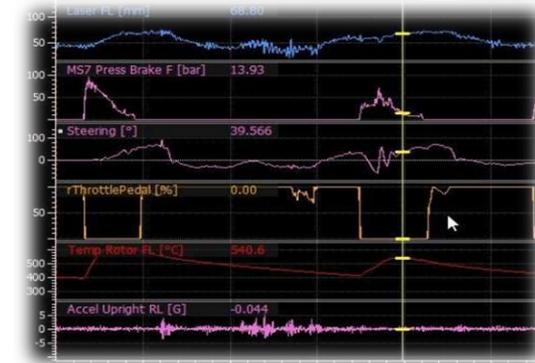- **Active cooling system** → control logic definition (virtually) and optimization (on track)

A. Electric motors

B. Air/coolant radiators

C. Condenser

NEXT STEPS

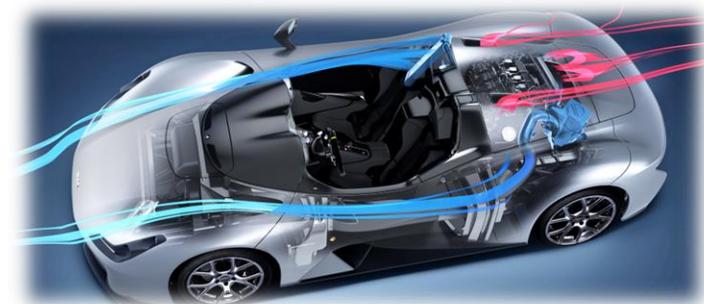## AI APPLICATIONS FOR VEHICLE SYSTEMS

- **Data Analysis** → allowing for a deeper understanding of correlations and interrelationships, anomalies and complex phenomena

- **System Modelling** → generating the maths around what is not easy to be physically described by equations. AI can generate the proper relation I/O not necessarily driven physics but just on correlation
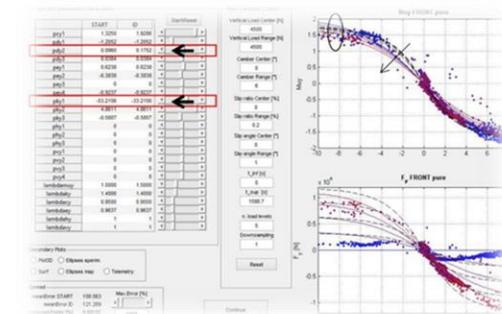
- **Systems Design** → In summary a progressive introduction can be considered in the whole car design process, discovering potential advantages in any area

Thank you for your attention