FULL SCALE CFD SIMULATION OF AN ADVANCED EXHAUST AFTERTREATMENT

6TH TWO-DAY MEETING ON PROPULSION SIMULATIONS USING OPENFOAM TECHNOLOGY

Milan / Italy, 11.03.2024

Zaldua, N.; Pace, L. / Emitec Technologies GmbH

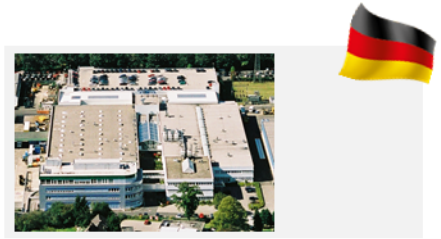
Public

EMITEC TECHNOLOGIES GmbH: PORTFOLIO OF METAL SUBSTRATES

FROM CHAINSAW TO LOCOMOTIVE

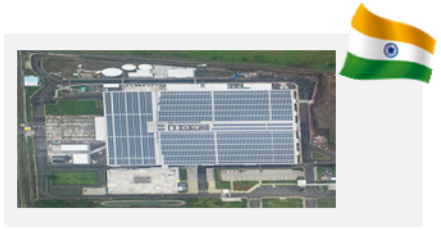
EMITEC TECHNOLOGIES

GLOBAL FOOTPRINT

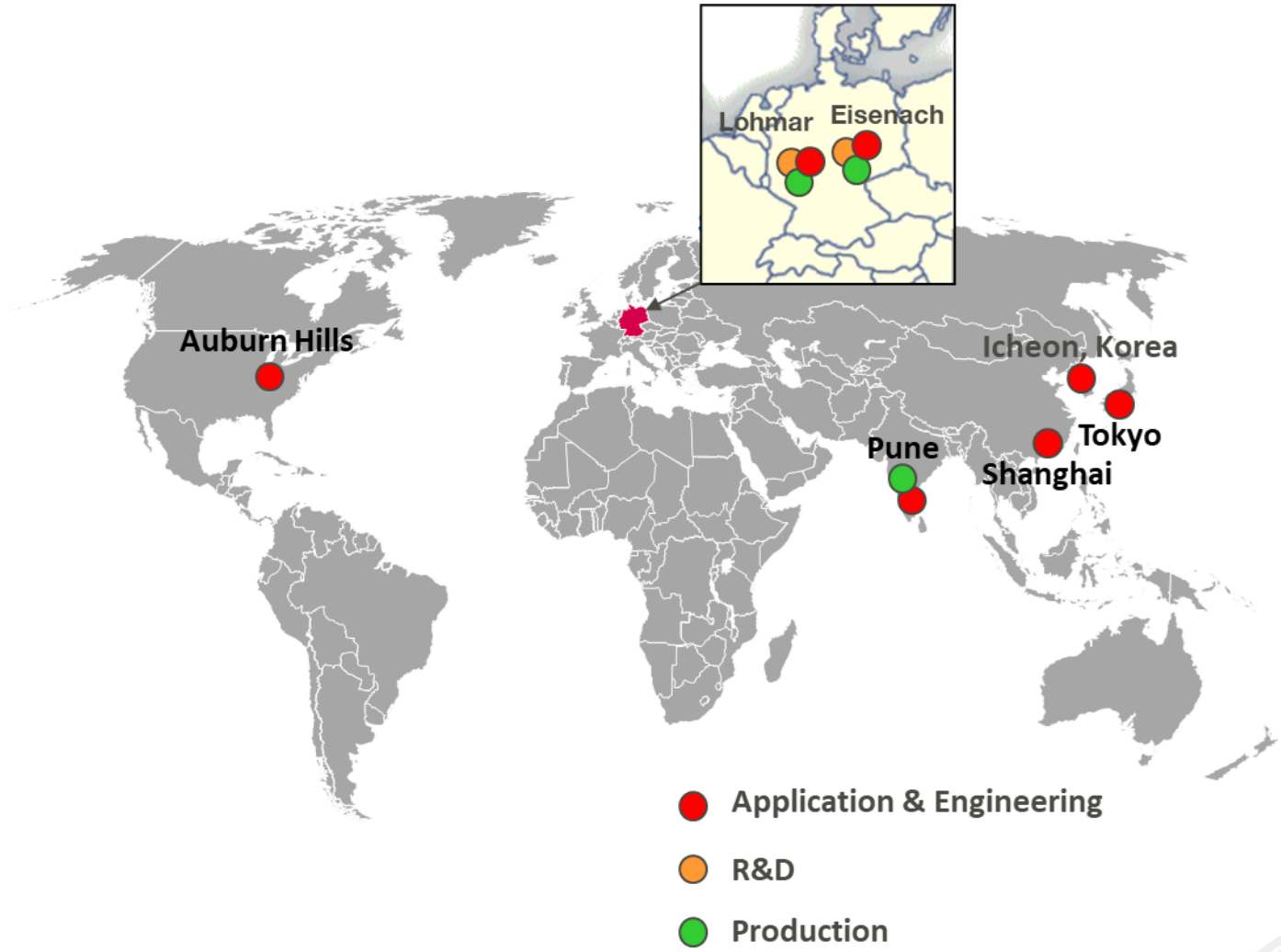


Lohmar, 1986 – HQ

Eisenach, 2001

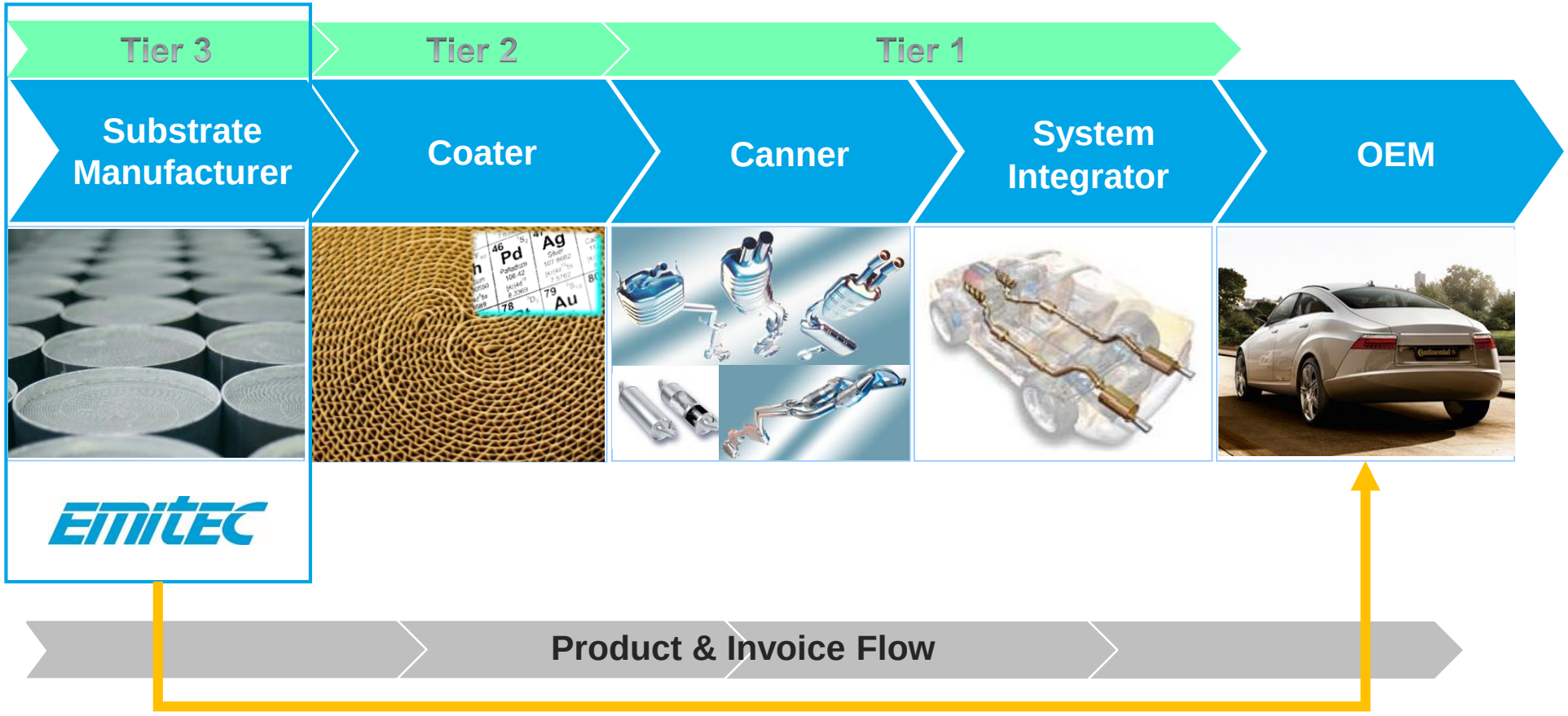


Pune, 2006



SUPPLY CHAIN

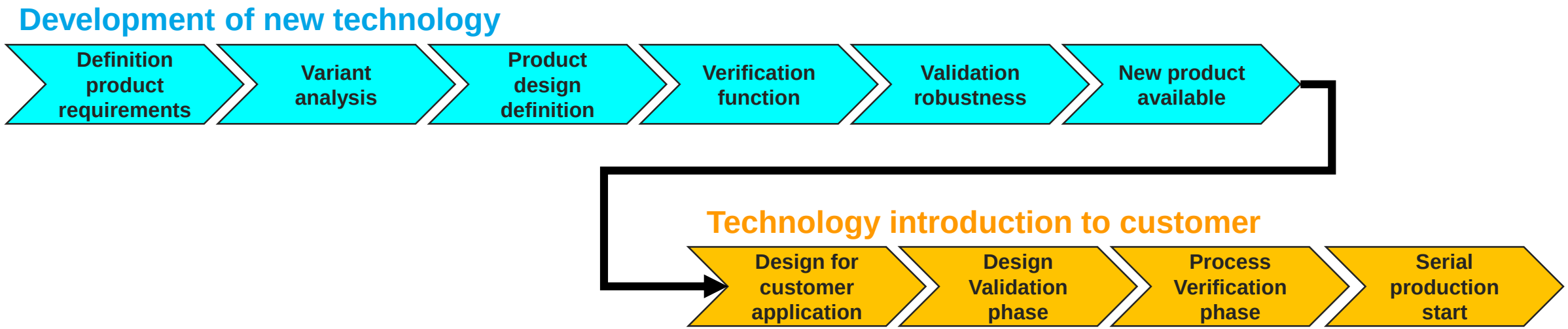
FROM EMITEC TO FINAL CUSTOMER (OEM)



Always in direct contact with OEM / final customer

COMPONENT DEVELOPMENT AND VALIDATION PROCESS

WORKING PROCESS FOR THE INTRODUCTION OF A CERTAIN TECHNOLOGY UP TO NOW



- **Development / introduction of new technology**: testing required (verification / validation)
- **Final customer**: strong involvement in component development process, continuous communication
- **Component supplier**: involvement in system development relatively low
- **Timing challenges** could be faced by:
  - Fusioning partially both main processes
  - Applying flexible project management in agreement with and supported by the final customer

REQUIREMENTS FOR THE FUTURE

LEGISLATION ON EMISSIONS

- **European legislation:**
  - Eu7 (PassCar): similar to Eu6
- **Chinese legislation:**
  - Ch7: still unknown, possible scenarios being studied
- **USA legislation:**
  - LEV IV: Aggressive Driving, Quick Drive Away, High Power Cold Start Standards for PHEV, cold cycles such as US06…

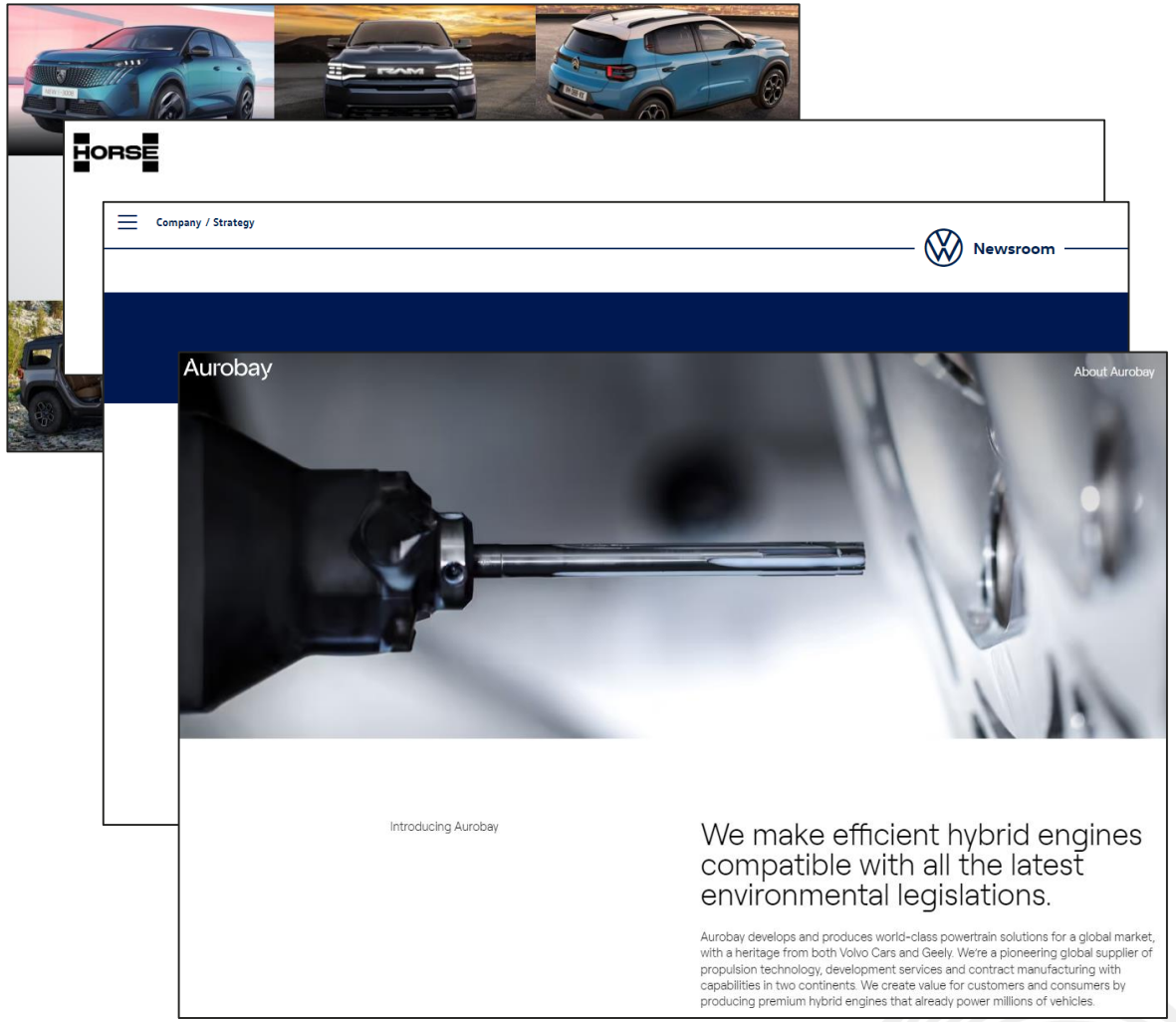
Limits Cars	Euro 7		China 6b		China 7 (Matching EU Limits)		China 7 (Matching EU CF)	
	Laboratory	RDE	Laboratory	RDE	Laboratory	RDE	Laboratory	RDE
NO_x gasoline	60 mg/km	66 mg/km	35 mg/km	74 mg/km	35 mg/km	63 mg/km	35 mg/km	39 mg/km
NO_x diesel	80 mg/km	88 mg/km	35 mg/km	74 mg/km	35 mg/km	63 mg/km	35 mg/km	39 mg/km
PM	5 mg/km	5 mg/km	3 mg/km	6 mg/km	3 mg/km	5 mg/km	3 mg/km	3 mg/km
PN	PN_{10} $6x10^{11}$#/km	PN_{10} $8x10^{11}$#/km	PN_{23} $6x10^{11}$#/km	PN_{23} $13x10^{11}$#/km	PN_{10} $6x10^{11}$#/km	PN_{10} $11x10^{11}$#/km	PN_{10} $6x10^{11}$#/km	PN_{10} $8x10^{11}$#/km
CO gasoline	1.000 mg/km	1.000 mg/km	500 mg/km	1.050 mg/km	500 mg/km	900 mg/km	500 mg/km	550 mg/km
CO diesel	500 mg/km	500 mg/km	500 mg/km	1.050 mg/km	500 mg/km	900 mg/km	500 mg/km	500 mg/km
THC	100 mg/km	100 mg/km	50 mg/km	105 mg/km	50 mg/km	90 mg/km	50 mg/km	50 mg/km
NMHC	68 mg/km	68 mg/km	35 mg/km	74 mg/km	35 mg/km	63 mg/km	35 mg/km	35 mg/km
CF RDE	CF NO_x = 1,1 CF PN = 1,34		CF = 2,1		CF = 1,8		CF NO_x = 1,1 CF PN = 1,34	

Source possible Eu7/Ch7 scenarios: „The Long Path of the EU7/VII Emission Legislation and its Consequences; Influence on Exhaust Gas Aftertreatment", Emitec Technologies; International Vienna Motor Symposium; 2024 (Vienna, Austria).
Source USA legislation: "Innovative and cost-effective Exhaust After Treatment for LEV Tier IV emission legislation", Aurobay, Emitec Technologies; 12. Internationaler Motorenkongress; 2024 (Baden-Baden, Germany)

REQUIREMENTS FOR THE FUTURE

FINAL CUSTOMER

- **Strategical reorientation**: electrification, BEV full development (especially in European market)
- **Redefinition of financial targets**: increased profitability dictated for ICE / existing systems
- **Internal restructuration:** re-allocation of available resources
- **Outsourcing**: development competences outsourced to engineering service providers / system developers

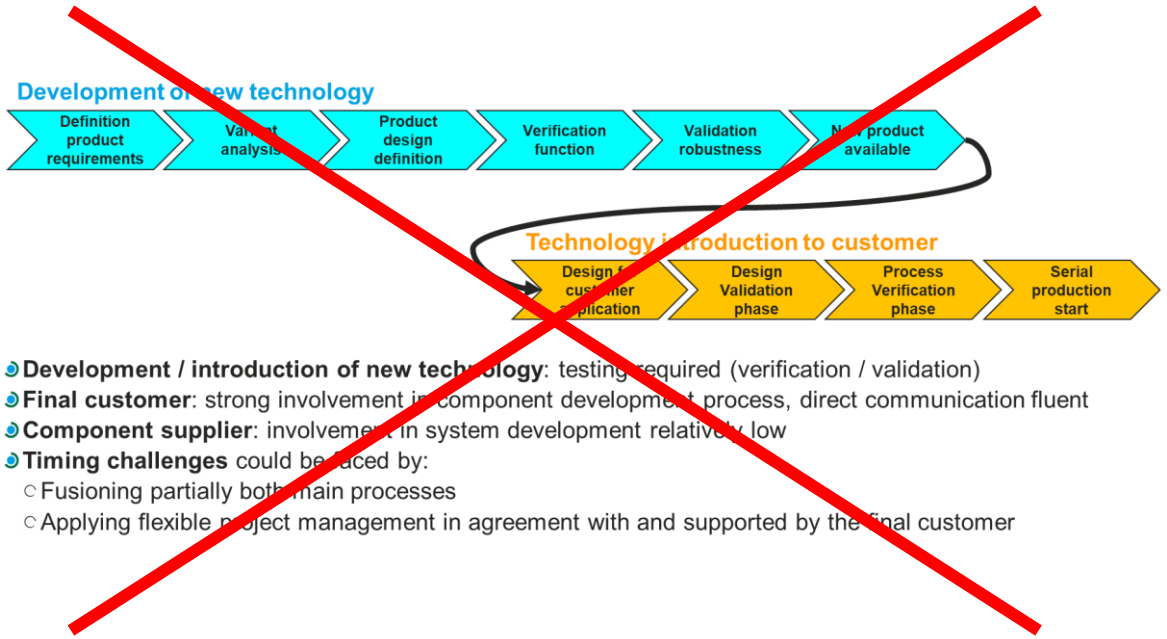


Source: https://www.stellantis.com/content/dam/stellantis-corporate/investors/events-and-presentations/presentations/Stellantis-FY2023-Results-Presentation.pdf; https://www.horse.cars/about-horse; https://www.volkswagen-newsroom.com/en/strategy-3912; https://www.aurobay.com/about/introducing-aurobay

REQUIREMENTS FOR THE FUTURE

COMPONENT SUPPLIER

- Past working boundary premises obsolete



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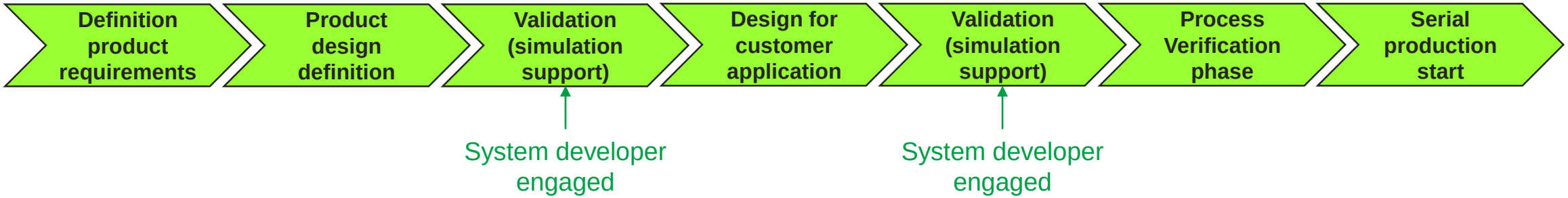
Future working premises:

- **Development / introduction of new technology**: reduced testing, reduced timing
- **Final customer**:
  - Low/no involvement in component development process, low/no direct communication
  - Reduced resources
- **System developer / service provider:** strong involvement in component development process, direct communication needed
- **Component supplier**: involvement in system development increased
- **Timing challenges** can be faced by:
  - Reshaping the working process
  - Increasing the usage of virtual tools (simulations)

COMPONENT DEVELOPMENT AND VALIDATION PROCESS

FUTURE WORKING PROCESS FOR THE INTRODUCTION OF A CERTAIN TECHNOLOGY

New technology development and introduction to customer



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APPLICATING SIMULATION SUPPORT TO NEW TECHNOLOGIES

METALIT® SUBSTRATE CS DESIGN (CROSSVERSAL STRUCTURE)

CS Design

- Material and cost savings (no flat foils between corrugated foils)
- Geometric Surface Area compensated by applying higher cell densities and improved mass transfer
- Improved coating distribution by reduced contact lines
- Lower pressure loss compared to standard substrates with same efficiency

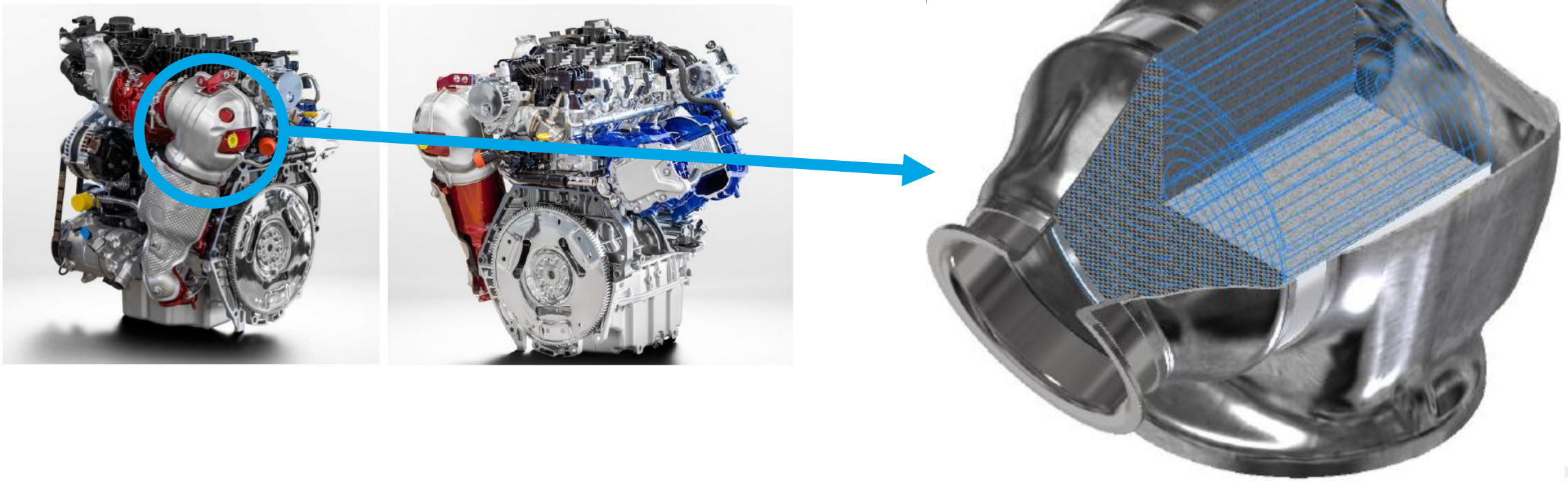
APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION

Source: Testcar courtesy from Stellantis; University Politecnico di Milano

APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

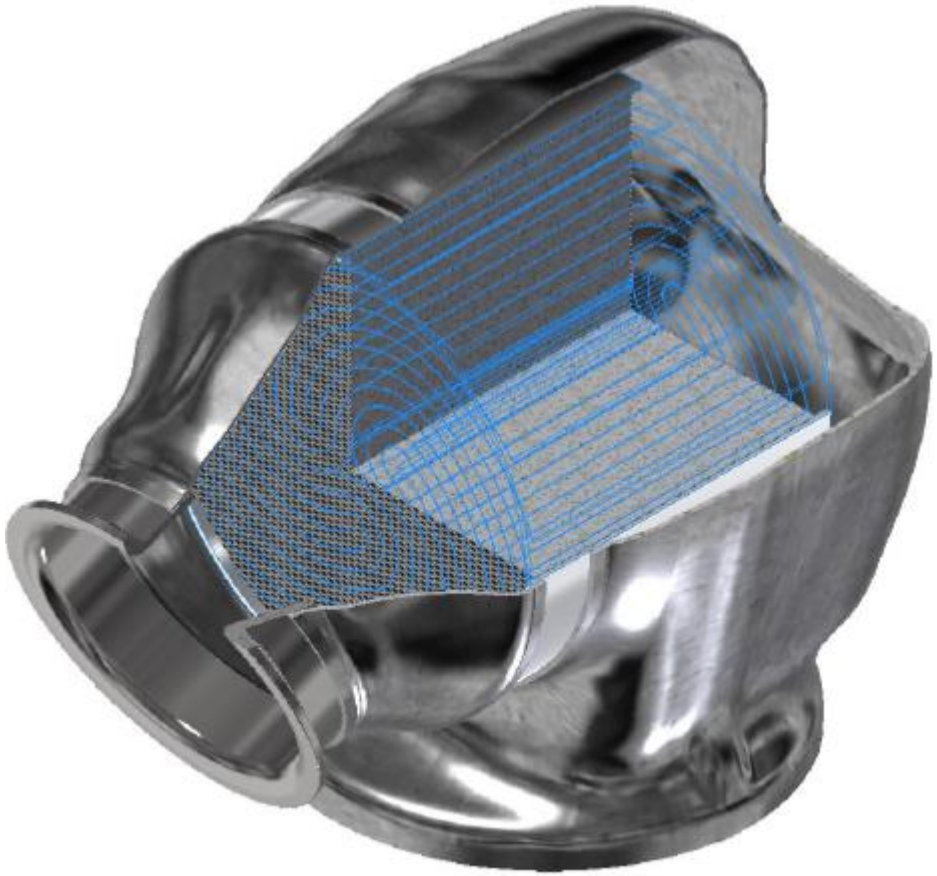
CUSTOMER APPLICATION

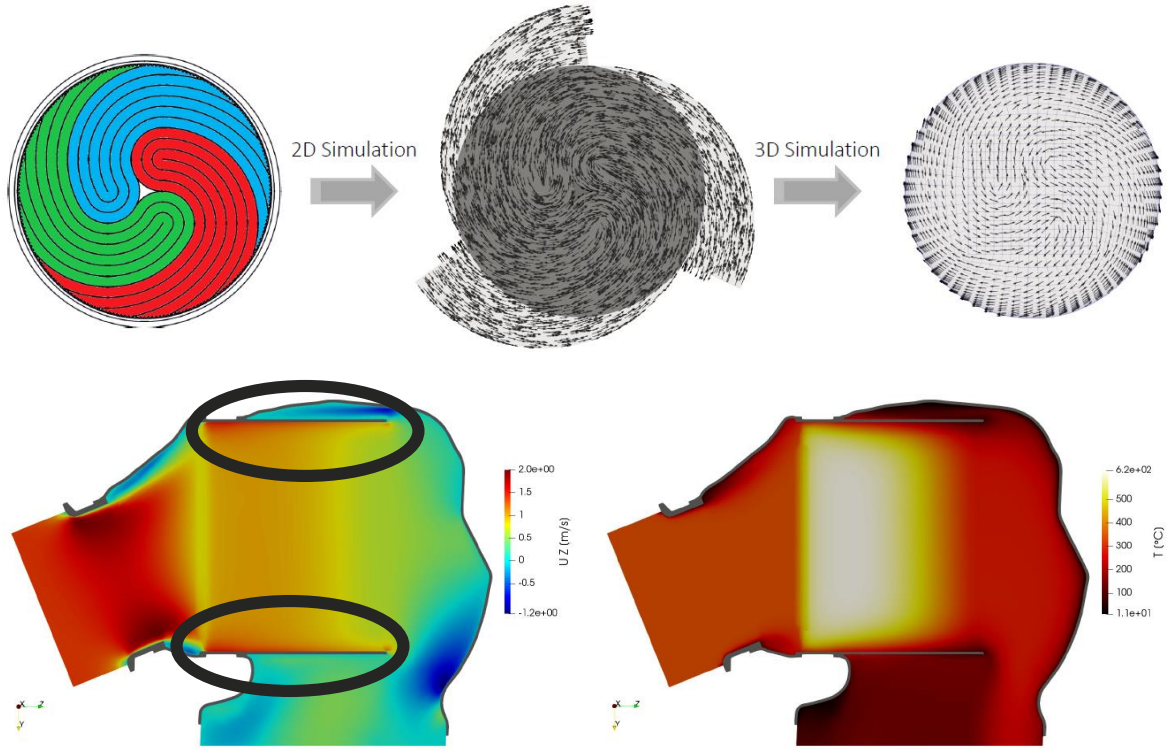


Source: University Politecnico di Milano

APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION. TEMPERATURE DISTRIBUTION IN SUBSTRATE



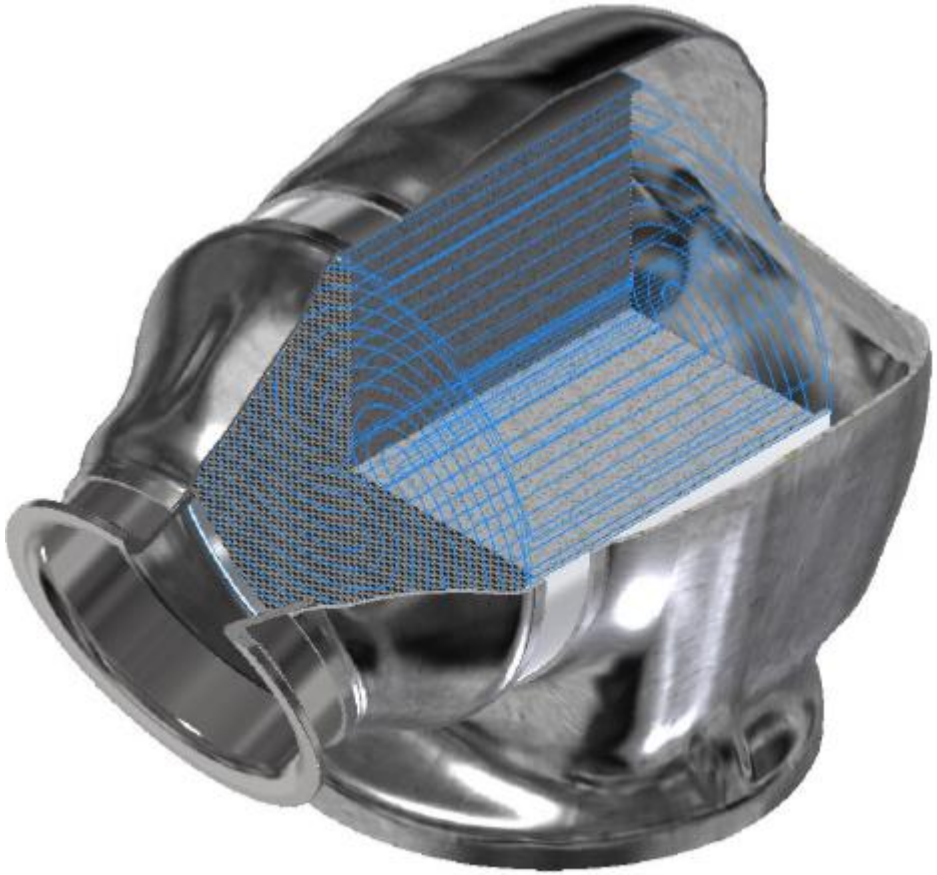


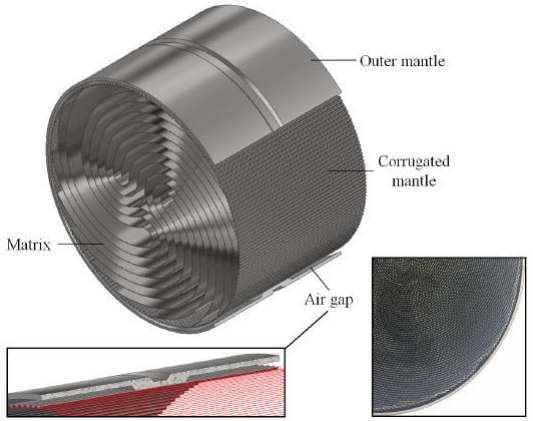
- Analysis of thermal distribution identifies spots to be improved

Source: University Politecnico di Milano

APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION. SUBSTRATE MANTLE DESIGN OPTIMISATION





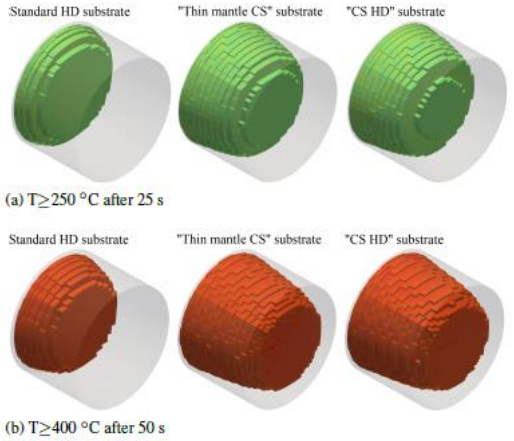


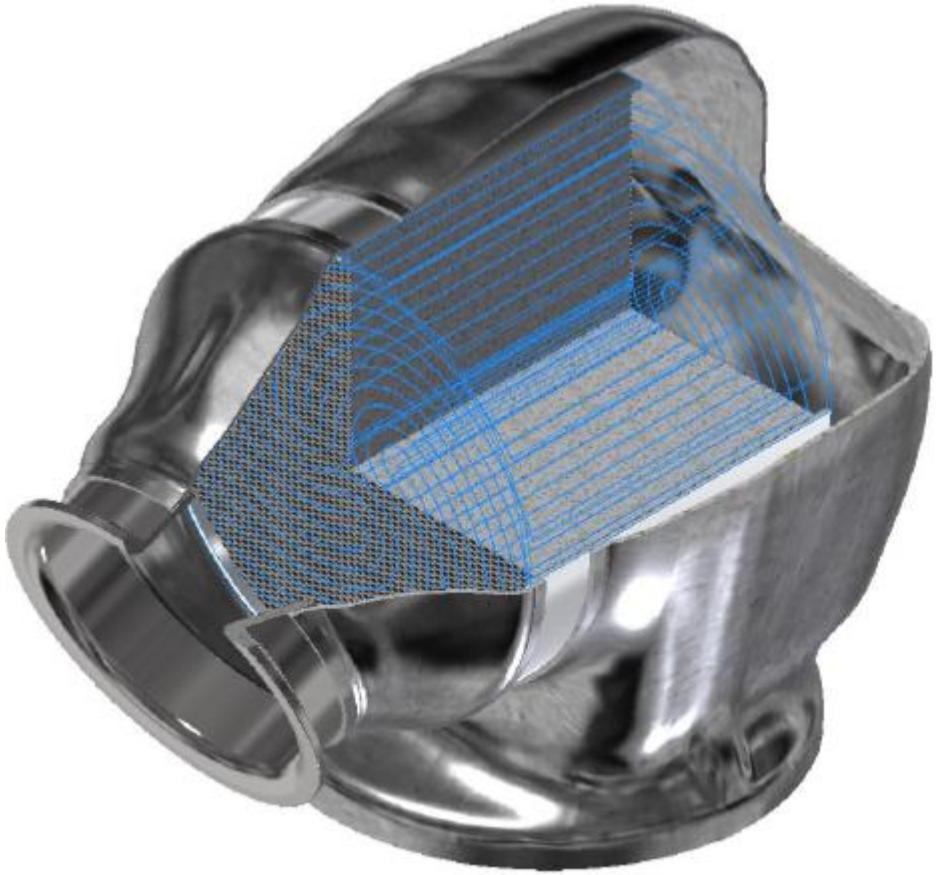
Figure 29: Matrix volume at a temperature greater than or equal to 250 and 400 °C, respectively after 25 and 50 s.

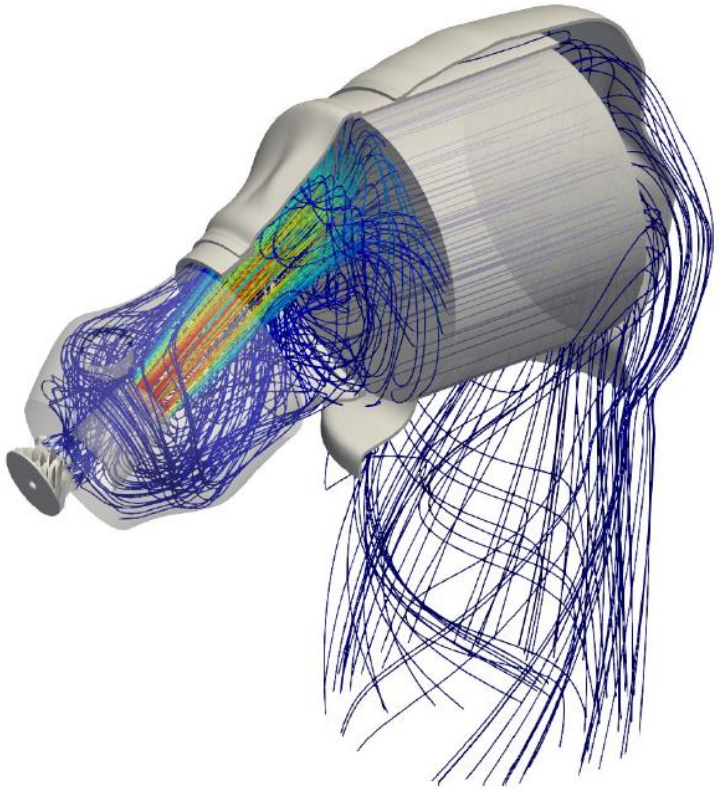
- Simulation allows design optimisation of the substrate mantle (reduction of thermal losses) without additional testing loops

Source: University Politecnico di Milano

APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION. FLOW DISTRIBUTION IN SUBSTRATE



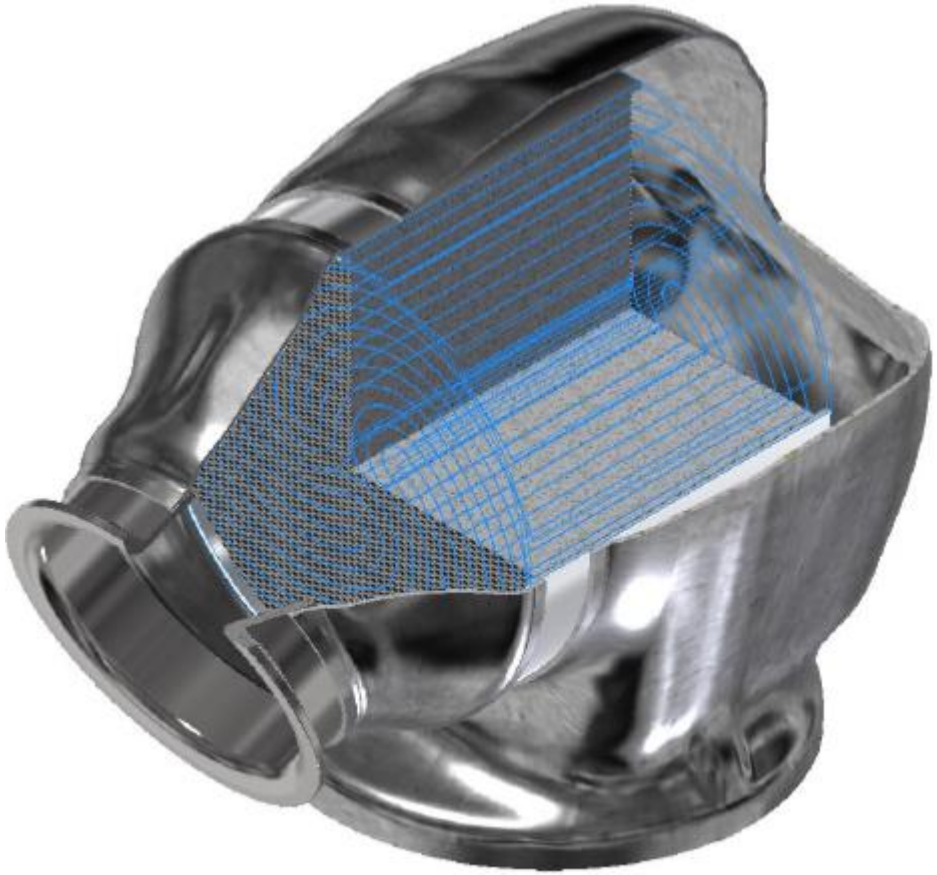


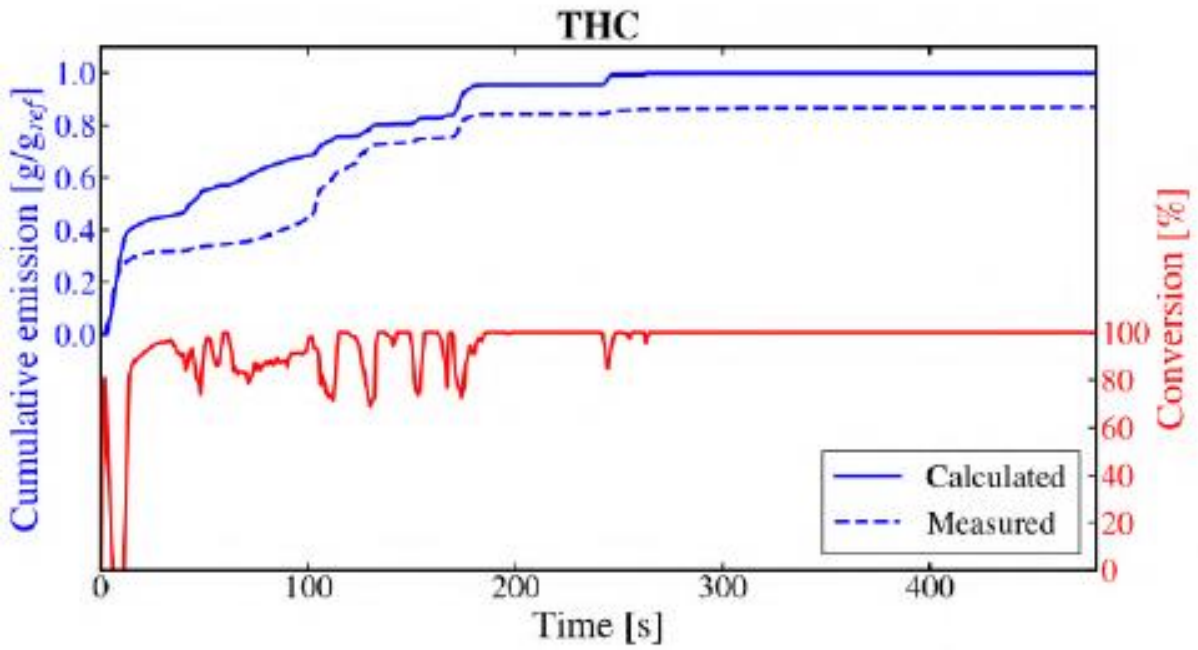
- Simulation allows to vary / adapt the flow distribution according to the specific application

Source: University Politecnico di Milano

APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION. FLOW DISTRIBUTION IN SUBSTRATE



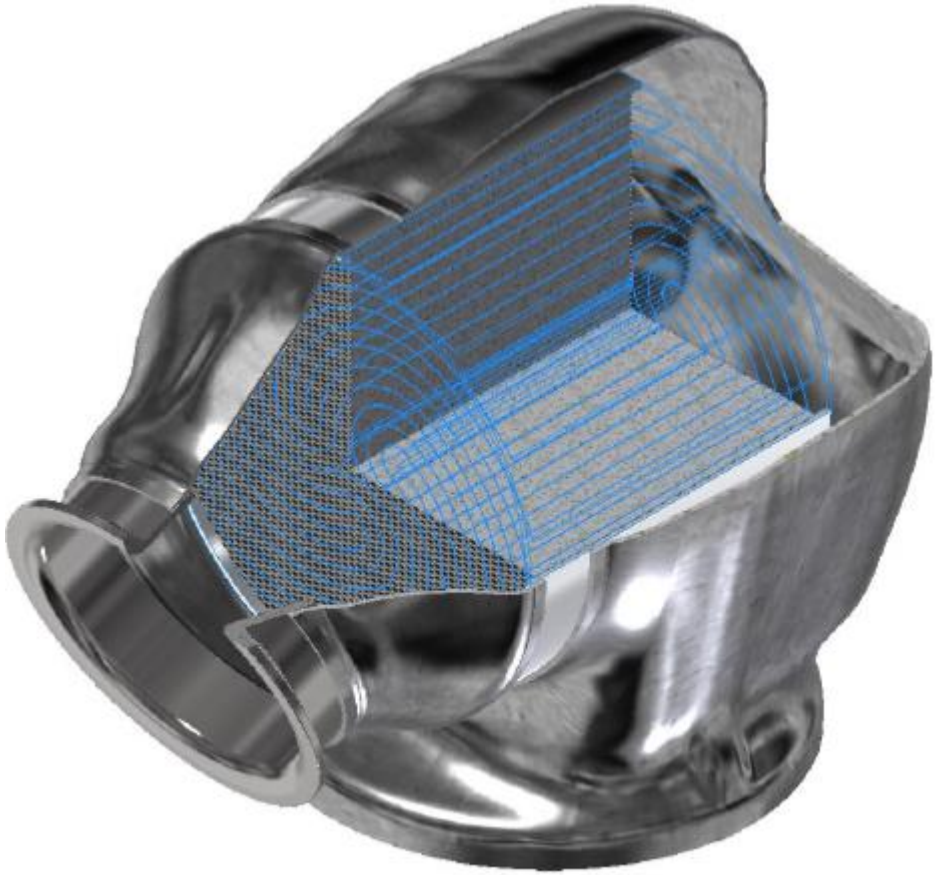


- Simulation of pollutants allows to verify the validity of the optimsed design with different driving cycles

Source: University Politecnico di Milano

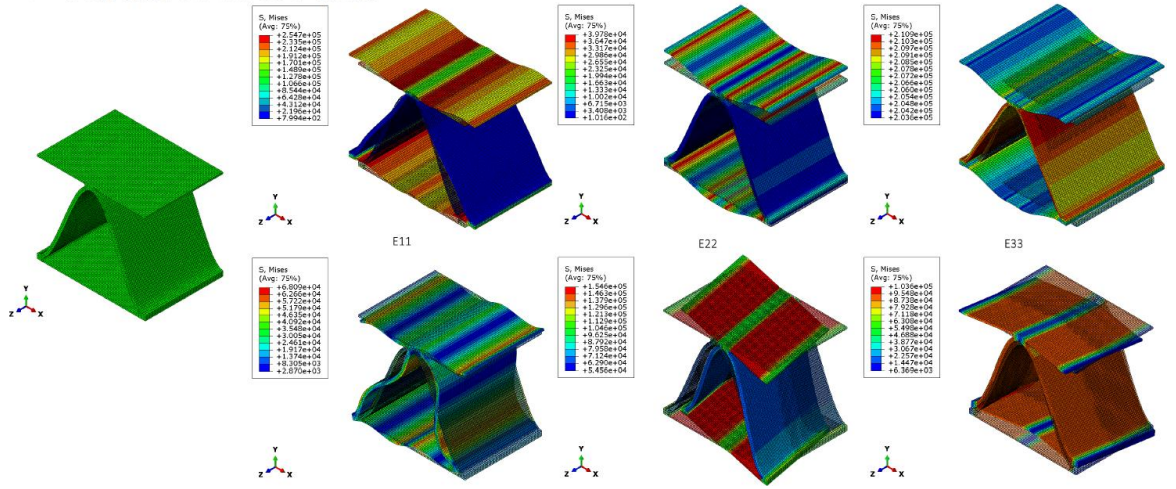
APPLICATING SIMULATION SUPPORT WITH NEW TECHNOLOGIES

CUSTOMER APPLICATION. FLOW DISTRIBUTION IN SUBSTRATE



Source: University Politecnico di Milano

➢ **Von Mises stress field**



- Stress simulation is desirable to prevent failures and optimise the design before final validation

CONCLUSION

- Changing legislation and customer requirements make it mandatory to adapt the component supplier working premises to the new situation:
  - The need for new technologies remains
  - Reduced resources on the customer side need to be considered
  - Development timing needs to be reduced
  - Testing needs to be reduced
  - Relationships with the final customer and system developers need to be redefined
  - A stronger integration of the component development within the system development process is needed

CONCLUSION

- Simulation tools will play increasingly a key role in the future in the component supplier world:
  - Increase of in-house simulation resources
  - Increase of usage of external simulation services
  - Stronger coupling of single simulation processes with the system development process
  - Comprehensive simulation tools requested for evaluating all significant development steps

THANK YOU!