



# Meistern Sie den Innovationsdruck mit modellbasierter Systementwicklung

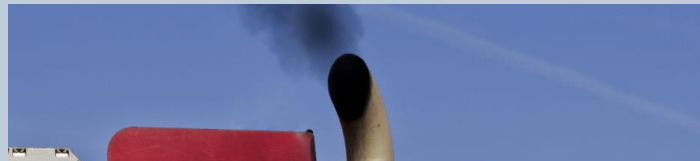
# Trends driving innovation in today's heavy equipment market...



## Regulations



More stringent noise regulation



Increased emissions standards



Higher safety requirements

## Market globalization



Competition



Globalization vs local requirements



Decentralized engineering

## Customer-centric vision



Increased variant numbers



Reduced cost of ownership



Increased productivity

# The Electrification has begun

**SIEMENS**  
*Ingenuity for life*

**GREEN CAR REPORTS** NEWS FIRST DRIVES ELECTRIC CARS HYBRIDS GUIDES GREEN LIFE [NEWSLETTER](#)

## World's largest EV never has to be recharged

ERIC C. EVARTS AUGUST 18, 2019 240 COMMENTS [View Gallery](#)



**CONSTRUCTION europe** THE MAGAZINE FOR EUROPE'S CONSTRUCTION INDUSTRY

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## First Volvo electric excavator delivered to customer

By Joe Sargent | 22 August 2019



**international construction**

**First look: World's first electric drilling rig on site**

By Joe Sargent | 29 October 2019

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# Warum Simulation und Test mit Siemens Digital Industries Software

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*Ingenuity for life*

#1

Industrial Software  
in Digital Enterprises

“The integration of product development, simulation and validation is now at the top of our agenda”

Tony Hemmelgarn, CEO Siemens PLM Software

30 - 95%

Zeitersparnis im  
Simulationsprozess

Simulate  
Test  
Explore

>40  
Jahre  
Simulation  
und Test  
Know How

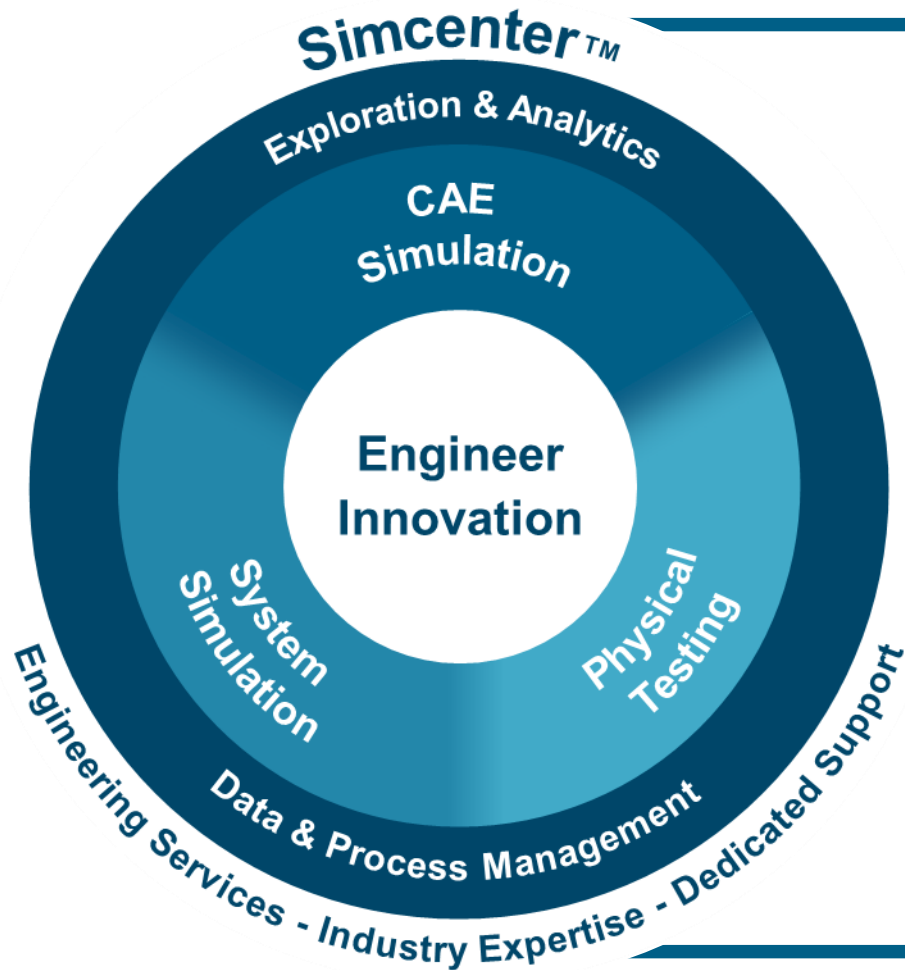
\$1.9B Investment  
In Simulation (in 7 Jahren)

Top 3

CAE Software  
Unternehmen  
in der Welt







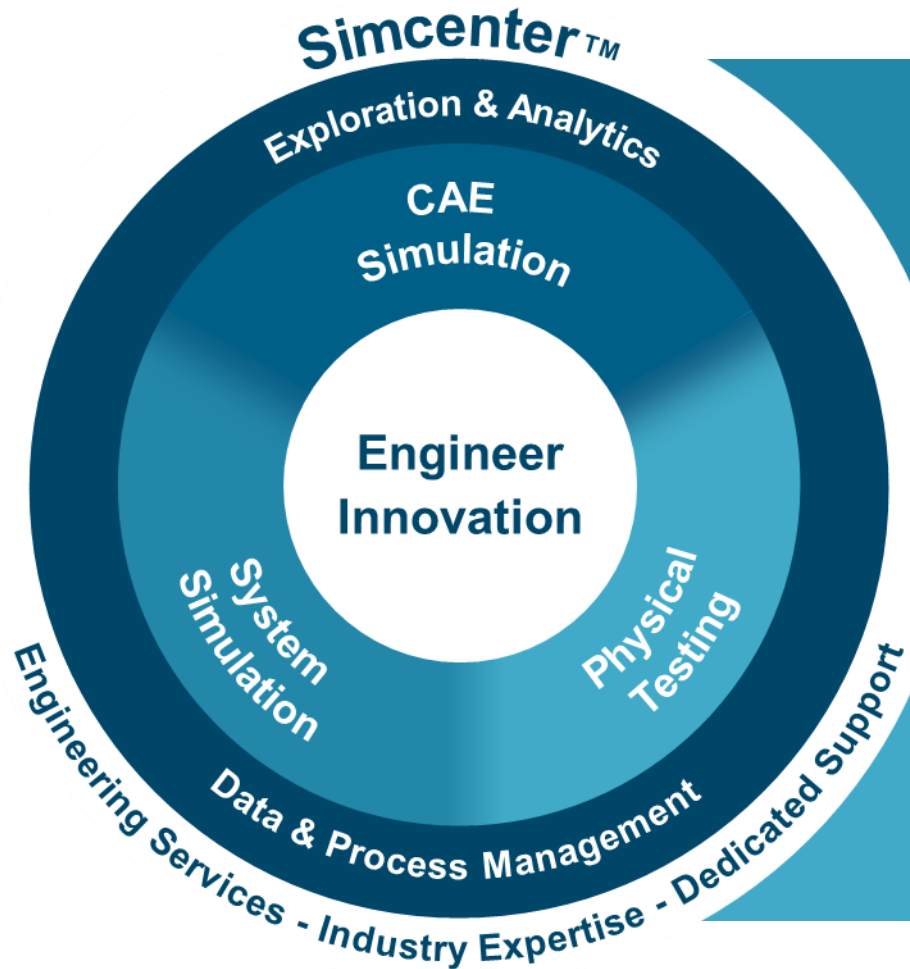
# Simcenter™

Engineer innovation

Simulate. Explore. Test.

# Simcenter overview

## Engineer innovation



### System Simulation

Simcenter Amesim, Simcenter Flomaster  
 Simcenter System Architect, Simcenter System Analyst  
 Simcenter Embedded Software Designer,  
 Simcenter Prescan 360, ...

### CAE Simulation

Simcenter 3D, Simcenter STAR-CCM+,  
 Simcenter Nastran, Simcenter Femap, Simcenter FLOEFD,  
 Simcenter MAGNET, Simcenter Madymo, Simcenter Tire,  
 Simcenter Motorsolve, Simcenter Speed, ...

### Physical Testing

Simcenter Testlab, Simcenter Testxpress  
 Simcenter Tecware, Simcenter T3STER,  
 Simcenter TERALED, Simcenter POWERTESTER,  
 ...

Exploration & Analytics - **HEEDS**

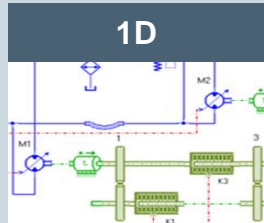
Data & Process Management - Teamcenter

Simcenter Engineering and Consulting

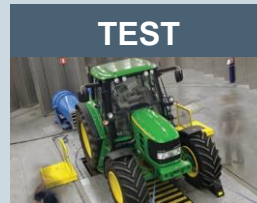
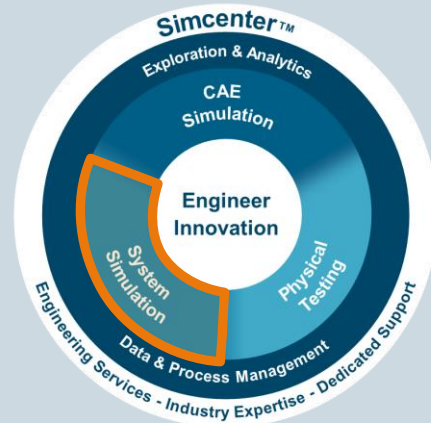
# Simcenter Strategy

## Deploying the digital twin ...

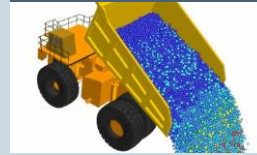
### Digital Twin



3D



CFD



### System



### Simcenter

- Deliver multi-fidelity digital twins for optimal systems performance
- Address all critical system characteristics for balancing attributes
- Evolve models over time
- Discover better designs, faster



# Simcenter Amesim for machine electrification

## Innovation areas



**Requirements  
Identification**

**Electric Motor  
& Battery  
Pre Sizing**

**Validate Sizing  
vs. Requirements**

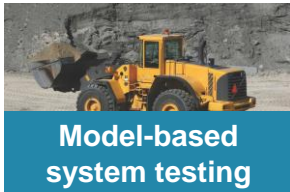
**Thermal  
management**

**Equipment  
integration**

**Control system**

# Simcenter™ Portfolio for Predictive Engineering Analytics

## Simcenter Amesim



**Model-based system testing**

### Industry specific

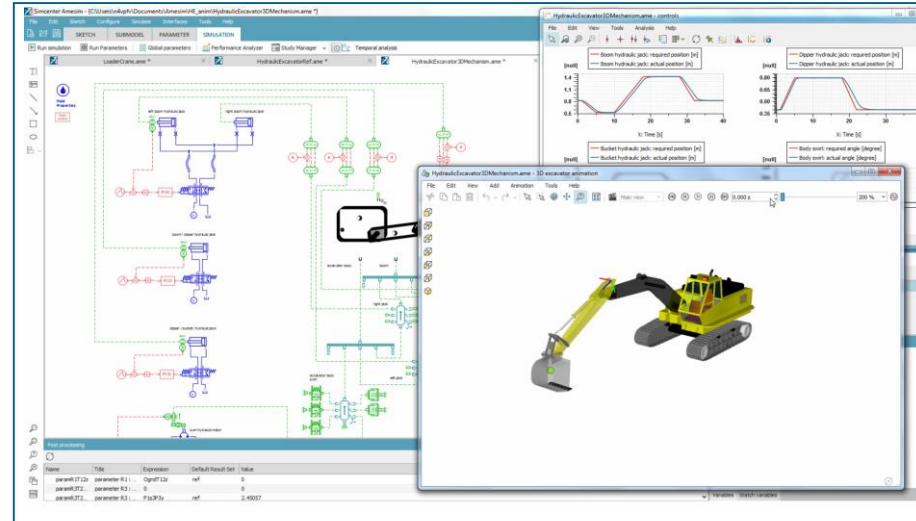
- Internal combustion
- After treatment
- Transmission
- Thermal systems
- Vehicle dynamics
- Electrical systems
- Pumps and compressors
- Electrohydraulic valves
- Fluid actuation systems
- Heat exchangers
- Heat pumps / refrigerators

**Pre-design**

**Systems sizing and integration**

**Performance balancing**

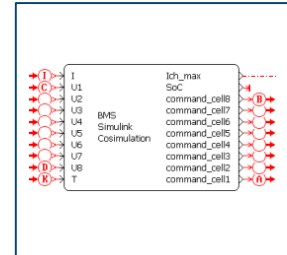
**Controls validation**



**Scalable simulation**

**Connecting “mechanical” – “controls”**

**Model reduction for real-time**

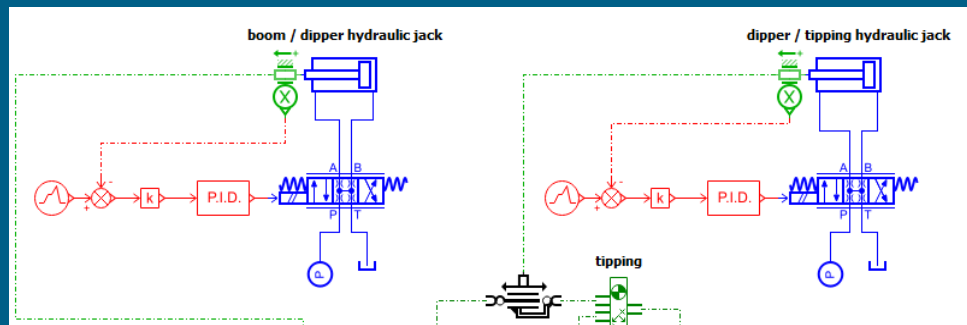


**Co-simulation**

**Open and customizable**

**>48 libraries**

**>6,500 multi-physics models**



**Hydraulics**

**Pneumatics**

**Thermal**

**Electrical**

**Mechanical**

**Signals**

Item	Component Type	Simulation Type	Simulation Status	Simulation Date
1	Hydraulic	Hydraulic	Completed	2020-01-15
2	Electrical	Electrical	Completed	2020-01-15
3	Thermal	Thermal	Completed	2020-01-15
4	Mechanical	Mechanical	Completed	2020-01-15
5	Control	Control	Completed	2020-01-15
6	Signal	Signal	Completed	2020-01-15
7	Hydraulic	Hydraulic	Completed	2020-01-15
8	Electrical	Electrical	Completed	2020-01-15
9	Thermal	Thermal	Completed	2020-01-15
10	Mechanical	Mechanical	Completed	2020-01-15
11	Control	Control	Completed	2020-01-15
12	Signal	Signal	Completed	2020-01-15

**System architecture management**

# Challenges – Compact excavator electrification

**Requirements  
Identification**

**Electric Motor  
& Battery  
Pre Sizing**

**Validate Sizing  
vs. Requirements**

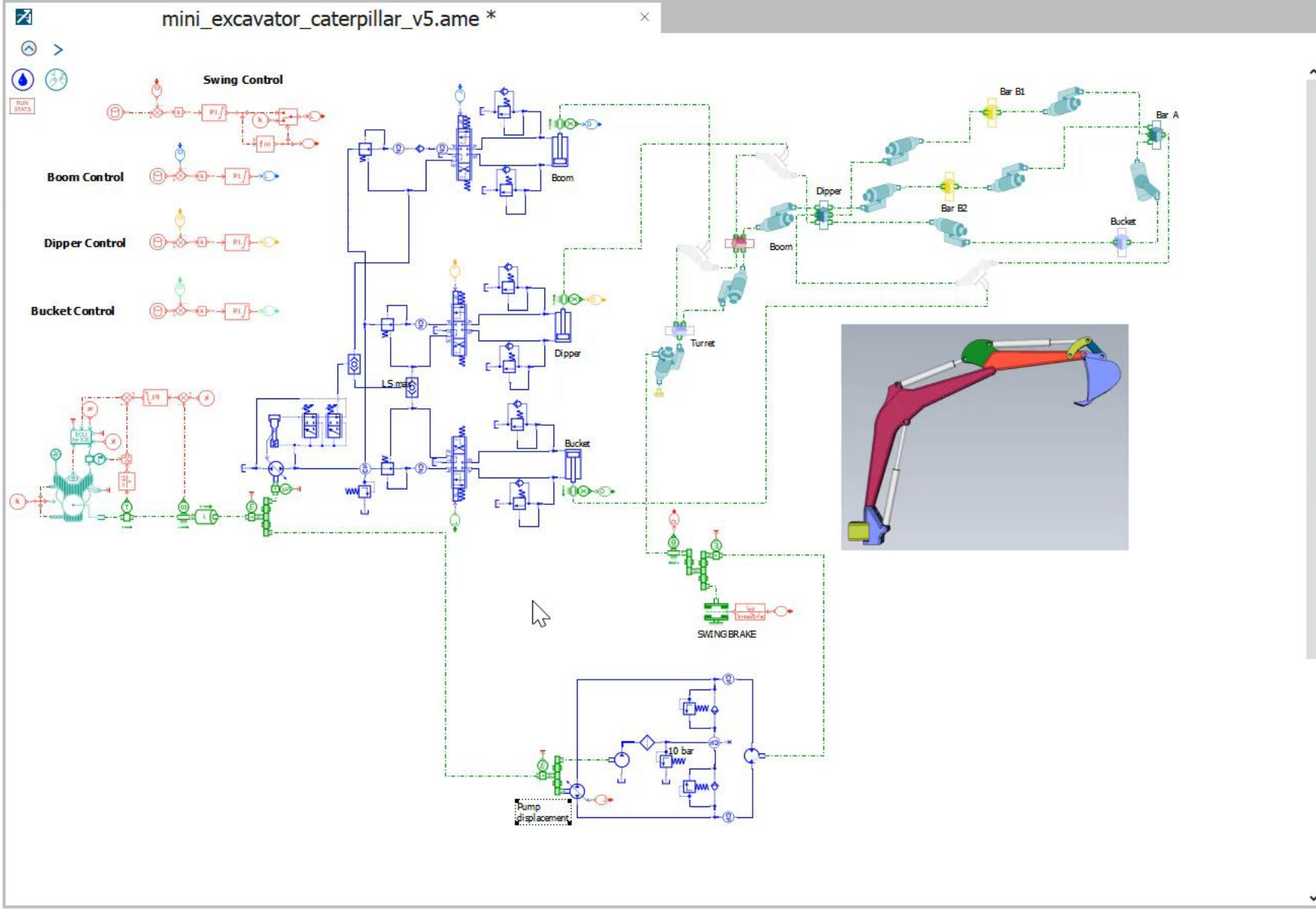
## Requirements Identification

### Starting from a diesel engine powered mini-excavator reference model

- Assess performance attributes like cycle time, fuel consumption
- Validate behavior and controllability of the machine
- Identify the maximum power and energy required for a day of operation

## Electric Motor & Battery Pre Sizing

## Validate sizing vs. Requirements



Parameters

Run monitor - mini\_excavator\_caterpillar\_v5.ame

Simulation time: 23 / 23 s

100%

Variables



**Requirements  
Identification**

**Fast E-powertrain pre-sizing (power/energy) to accelerate  
development during the concept phase**

**Electric Motor  
& Battery  
Pre Sizing**

**Validate Sizing  
vs. Requirements**

# Challenges – Compact excavator electrification

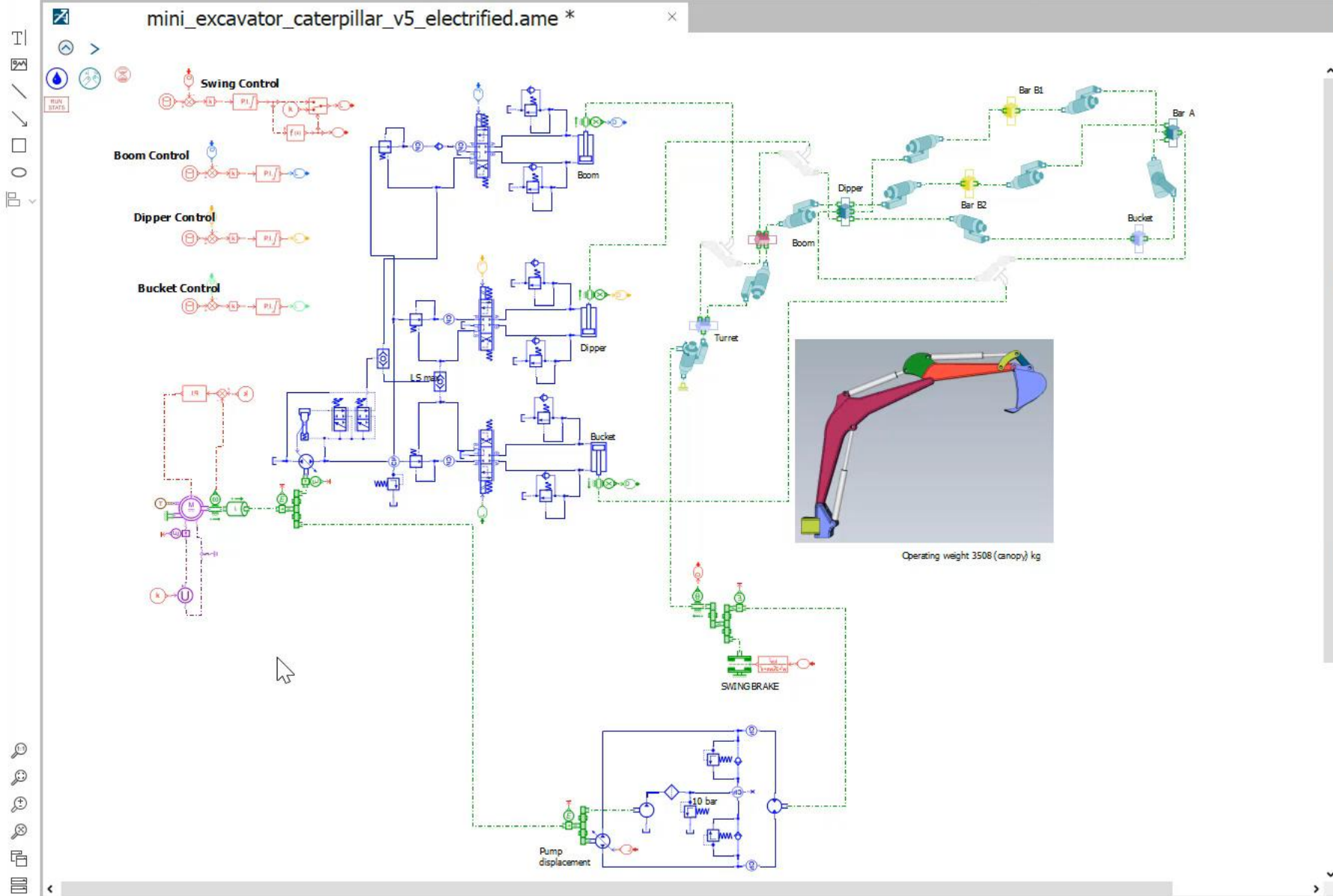
## Requirements Identification

## Electric Motor & Battery Pre Sizing

### Electric components must be carefully chosen to meet requirements:

- Identify required voltage level
- Select electric motor performances based on power requirements
- Select battery chemistry and capacity among an existing database

## Validate Sizing vs. Requirements



### Parameters

Run monitor - mini\_excavator\_caterpillar\_v5\_electrified...

Global simulation progress:

0%

Run 1: --- / 23 s

0%

Run 2: --- / 23 s

0%

### Variables



## Requirements Identification

Fast E-powertrain pre-sizing (power/energy) to accelerate development during the concept phase

## Electric Motor & Battery Pre Sizing

Define battery and electric motor specifications with no need for test data to reduce development costs

# Challenges – Compact excavator electrification

Requirements  
Identification

Electric Motor  
& Battery  
Pre Sizing

Validate Sizing  
vs. Requirements

**Simulation results must enable taking efficient engineering decisions:**

- Integrate results coming from detailed design solutions
- Assess electric motor dynamic behavior
- Assess battery ageing impact on autonomy requirement



## Requirements Identification

Fast E-powertrain pre-sizing (power/energy) to accelerate development during the concept phase

## Electric Motor & Battery Pre Sizing

Define battery and electric motor specifications with no need for test data to reduce development costs

## Validate Sizing vs. Requirements

Consider dynamic behaviors in electric components' integration to reduce effort for physical testing

## Requirements Identification

Fast E-powertrain pre-sizing (power/energy) to accelerate development during the concept phase

## Electric Motor & Battery Pre Sizing

Define battery and electric motor specifications with no need for test data to reduce development costs

## Validate Sizing vs. Requirements

Consider dynamic behaviors in electric components' integration to reduce effort for physical testing

## Why Simcenter Amesim?

**SIEMENS**  
*Ingenuity for Life*



Best-in-class **multi-physics** simulation tool

Extensive **battery modeling capabilities**

Simplified workflow through **Apps**

**Unique framework** for variant evaluation and multi-attribute balancing

# Simcenter Amesim

## Unique value proposition for machine electrification

### Reduce harmful emissions

"The modified coherent flame model accuracy combined with low computation times permit its application for cutting emissions of natural gas engines within Simcenter Amesim."

Olivier Marchand,  
CRMT



### Reduce machine development time

"This project is a quantum leap in engineering productivity in the construction equipment market. With process improvements in collaboration and co-simulation, Volvo CE has cut overall vehicle virtual prototyping time in early design phases in half."

Jonas Larsson,  
Volvo CE



### Validate mechatronic systems process

"Simcenter Amesim is a powerful tool for modeling and real-time simulations."

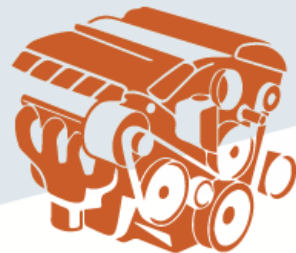
Dr. Truong Quang Dinh,  
Warwick University



### Improve machine NVH behavior

"The baseline Simcenter Amesim model provided insight into the problem's root cause and allowed engineers to perform parametric studies and evaluate possible countermeasures."

Rohit Saha,  
Cummins



### Innovate without risk

"Simcenter Amesim allows us to realize detailed models in the field of heat recovery, particularly in Rankine system components. Furthermore the controller design can be performed in combination with design software."

Dr. Bouzid Seba,  
Liebherr



### Reduce product cost

"We were not looking for a specific, tailor-made battery solution. Instead, we sought to combine off-the-shelf battery modules while optimizing the machine's overall range, cost and footprint."

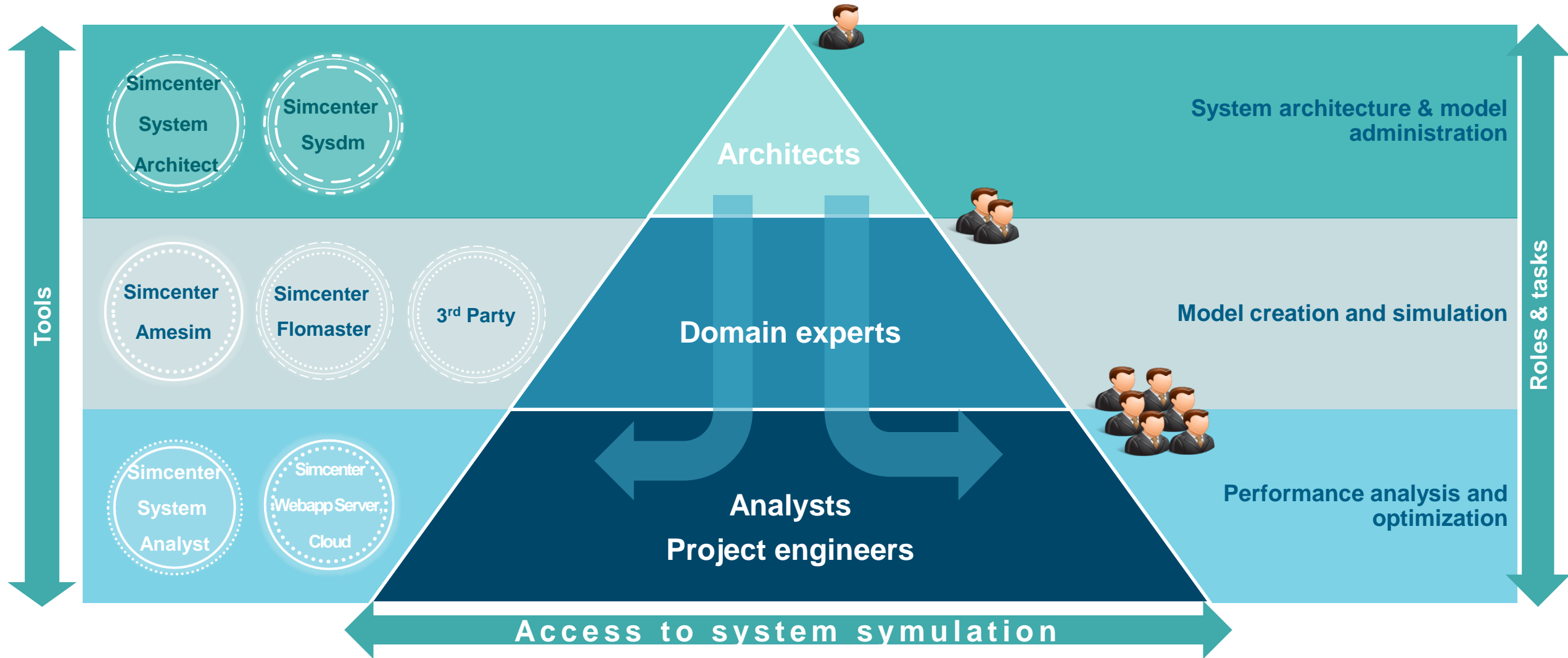
Max Boni,  
Mecalac



# System Simulation

## Roles and tools

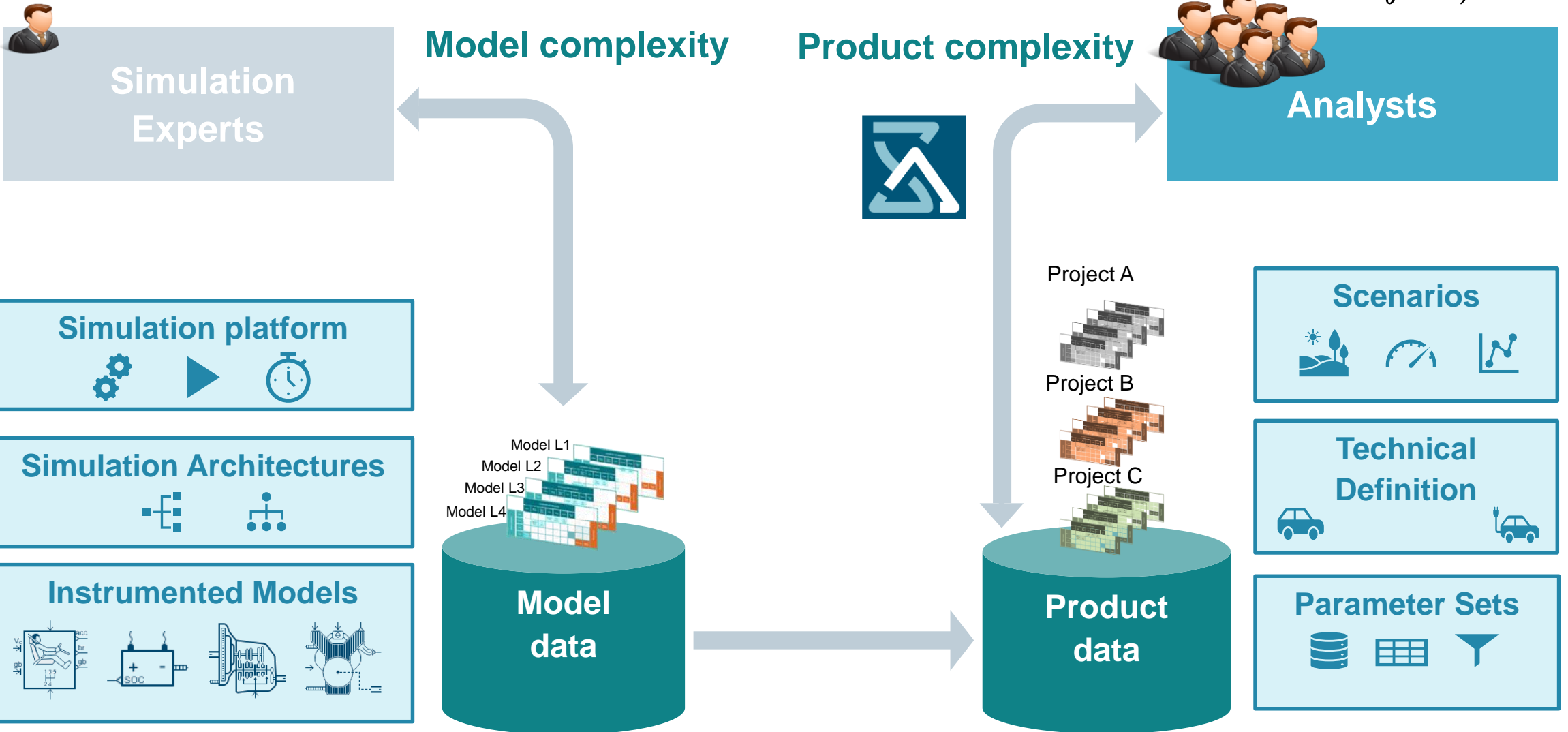
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# Collaborative Environment

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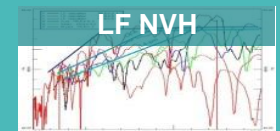
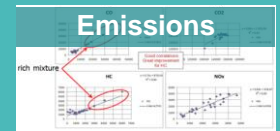
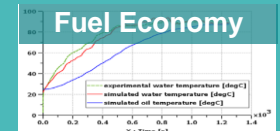
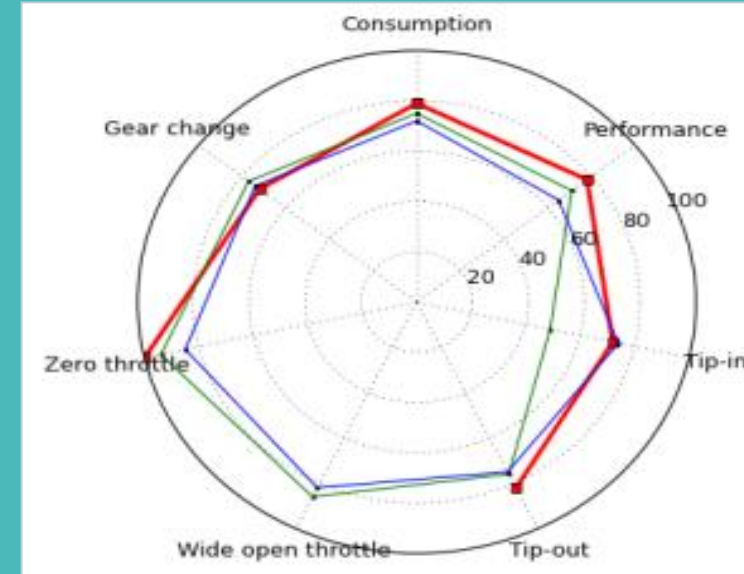
Our Enterprise Solution to give access to system simulation



Massive exploration of system variations

System simulation complexity mastered

Collaborative enterprise solution



Master

development under pressure

# Renault

## Reaching high energy savings in hybrid vehicles using Simcenter

# SIEMENS

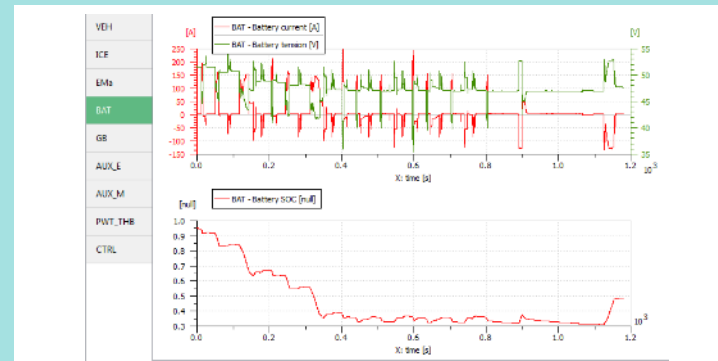
*Ingenuity for life*



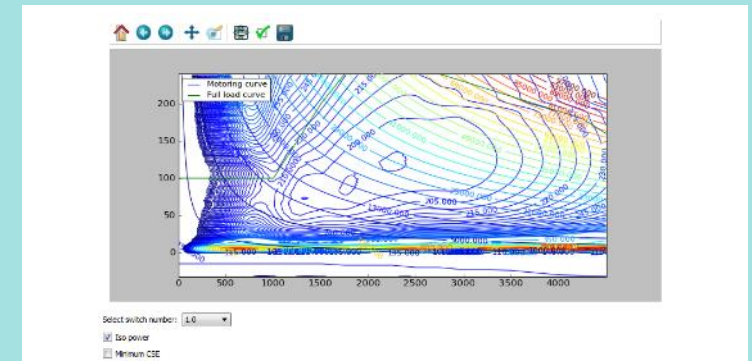
# RENAULT

Passion for life

### Performing complex multi-domain analyses for hybrid architectures



Battery behavior simulation



Internal combustion engine analysis

“Simcenter Amesim enables us to get a deep insight on energy performance of hybrid architectures and helps us select optimal architectures that fit our requirements early in the design process.”

Eric Chauvelier, Method and Simulation Manager

# Simcenter System Simulation

## Unique value proposition for machine electrification



**Reduce development cost  
with fewer prototypes**

**Analyze hybrid  
architectures early in the  
development cycle**

**Virtually assess systems'  
interactions**

**Study the influence of  
control strategies on  
energy consumption and  
performances**

**Balance critical attributes:  
Energy consumption,  
operability, productivity  
and reliability**

**Find the best comprise to  
fit both regulations and  
market requirements**

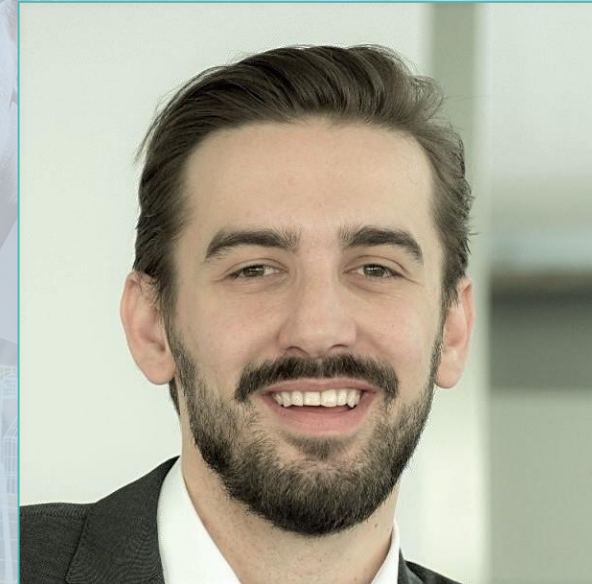
# Q&A



**Daniel Canchola, M.Sc.**

Portfolio Development  
System Simulation

Contact me: [daniel.canchola\\_lozada@siemens.com](mailto:daniel.canchola_lozada@siemens.com)



**Dipl.-Ing (FH) Sebastian Schmid**

Presales Solution Consultant  
System Simulation

Contact me: [schmid.sebastian@siemens.com](mailto:schmid.sebastian@siemens.com)