OPAL-RT TECHNOLOGIES

HIL real-time simulators
Applications and benefits for ECU controllers validation

OPAL·RT
TECHNOLOGIES

- CORPORATE PRESENTATION

- REAL-TIME SIMULATORS: METHODOLOGY & BENEFITS

- HARDWARE AND SOFTWARE ARCHITECTURE

NICE TO MEET YOU!

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OPAL-RT Europe

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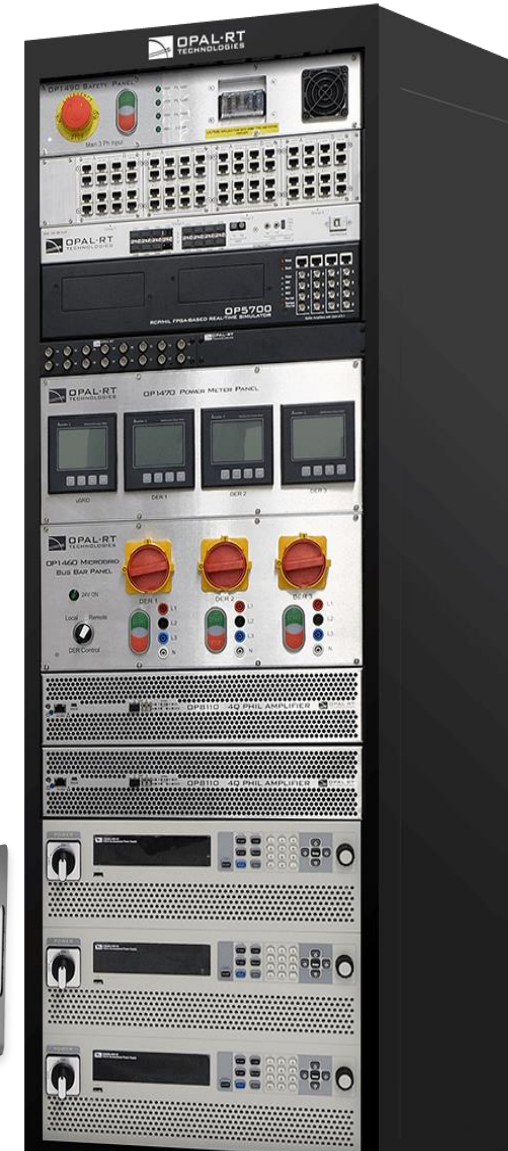OPAL-RT Europe
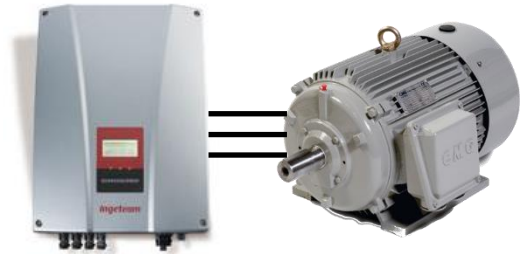
yoann.mougenot@opal-rt.com

WHAT WE DO

REAL-TIME DIGITAL SIMULATORS
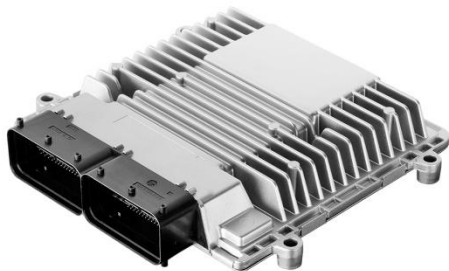
OPAL-RT
TECHNOLOGIES

OBJECTIVES FOR OUR CUSTOMERS

DESIGN, TEST & VALIDATE COMPLEX CONTROL SYSTEMS BEFORE PHYSICAL TESTING
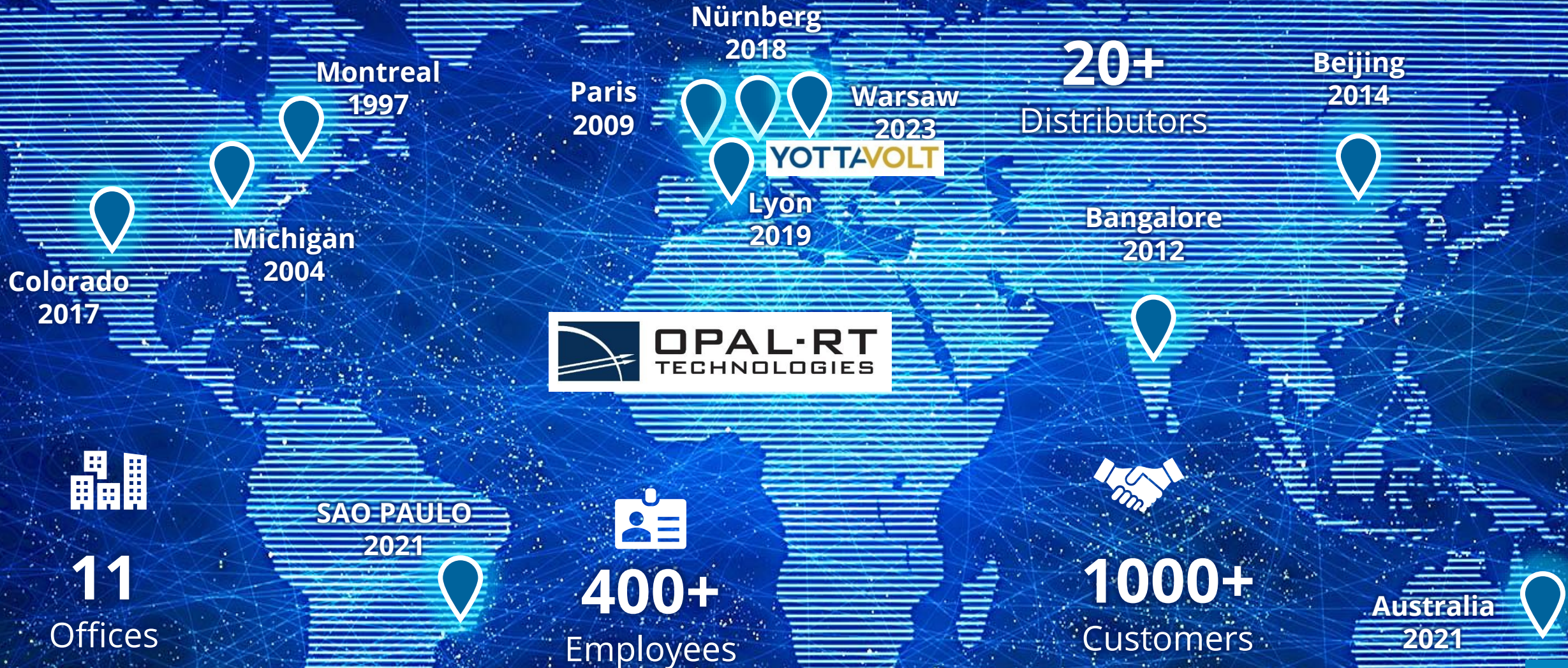
CONTROL ALGORITHMS

ECU

PROTECTION RELAYS

BMS

MICROGRID CONTROL

OPAL·RT TECHNOLOGIES

Nürnberg
2018

Montreal
1997

Paris
2009

Warsaw
2023

20+
Distributors

Beijing
2014

YOTTAVOLT

Michigan
2004

Lyon
2019

Bangalore
2012

Colorado
2017

OPAL·RT
TECHNOLOGIES

SAO PAULO
2021

11
Offices

400+
Employees

1000+
Customers

Australia
2021

6

OUR SERVICES

Trainings

- Trainings which allow our customer to use real-time simulators autonomously
- On-site trainings / e-learning platofrm

Technical support

- Local field application engineers teams
- Bring support to our customers

Real-time simulation expertise

- Models development
- Consulting
- Specific trainings

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

REAL CAR

REAL CONTROL SYSTEM

Measurements

Commands

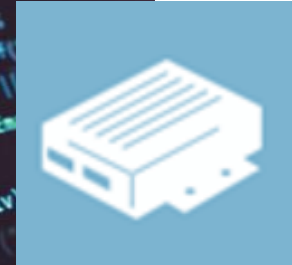# REAL-TIME SIMULATION METHODOLOGY & BENEFITS

SIMULATED CAR

REAL CONTROL SYSTEM

Measurements

Commands

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

REAL GRID

REAL CONTROL SYSTEM

Measurements

Commands

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

SIMULATED GRID

REAL CONTROL SYSTEM

Measurements

Commands

BENEFITS FOR OUR CUSTOMERS

SAVE TIME, RISK & COST BY TESTING EARLIER NEW CONTROL DEVICES

DESIGN

VALIDATION

DELIVERY

MAINTENANCE

ENERGY

TRAINS & SHIPS

TRANSPORT
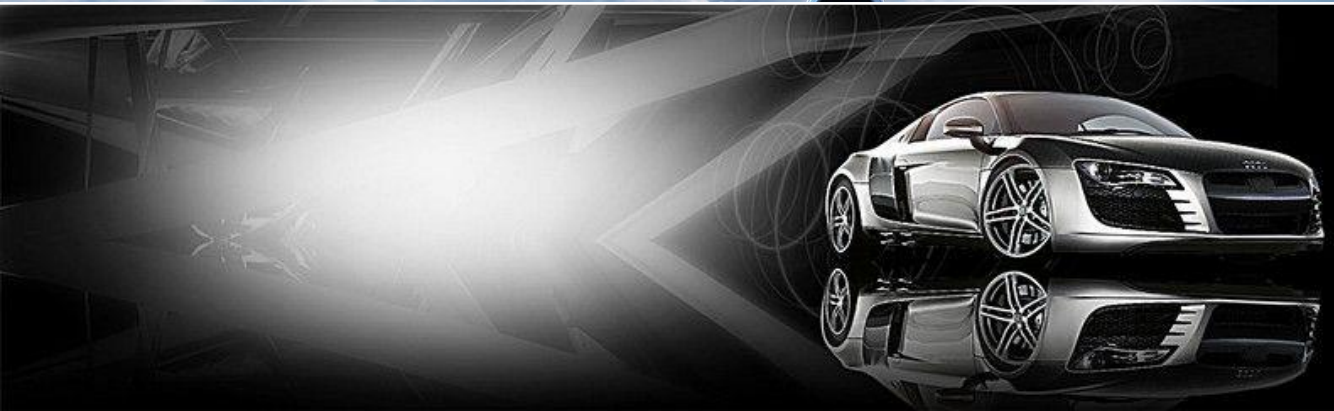
AUTOMOTIVE

INDUSTRIAL

ACADEMIC

13

OUR CUSTOMERS (SAMPLE)

OPAL-RT TECHNOLOGIES

ENERGY

Hydro Québec · GE Energy · Rte Réseau de transport d'électricité · HOPS · eDF · Enel · MŰEGYETEM 1782 · engie · ABB · Schneider Electric · EAT·N · TE TotalEnergies · DNV·GL · KONČAR · Vestas · Ingeteam · iter china eu india japan korea russia usa · PROTECTA HUNGARY · CERN

AEROSPACE

DASSAULT AVIATION · CSA ASC · BOMBARDIER · ThalesAlenia Space a Thales / Leonardo company · SAFRAN AEROSPACE · DEFENCE · SECURITY · Pratt & Whitney A United Technologies Company · ROLLS ROYCE · WOODWARD · Avio · LIEBHERR · EMBRAER

AUTOMOTIVE

TATA · GM · TOYOTA · TESLA · VOLVO · RENAULT · John Deere · RIMAC · JAGUAR · LAND ROVER · Valeo · Ford · DELPHI

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

Real-time simulation software + **Real-time simulator** + **To test control devices**

RT-LAB / HYPERSIM / VeriStand

Customer can import his/her model to be simulated or create it from scratch

Graphical user interface to perform test

Processor cores & FPGA to simulate model in real-time

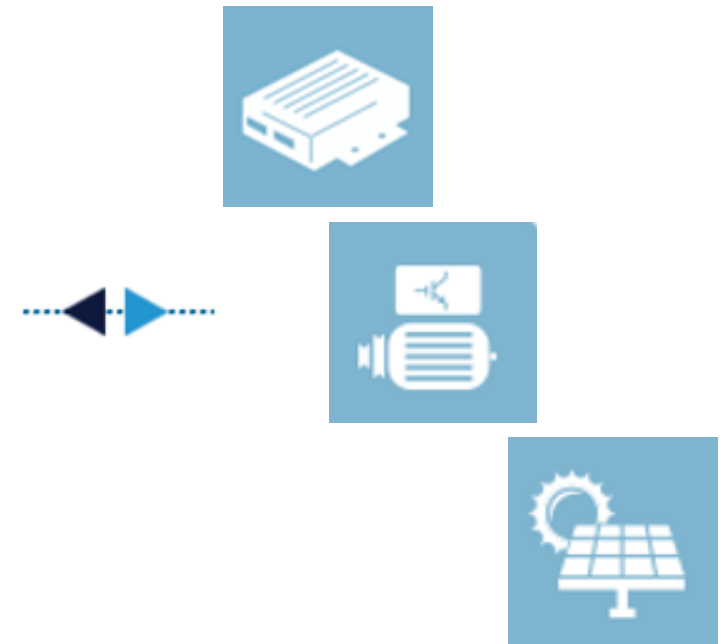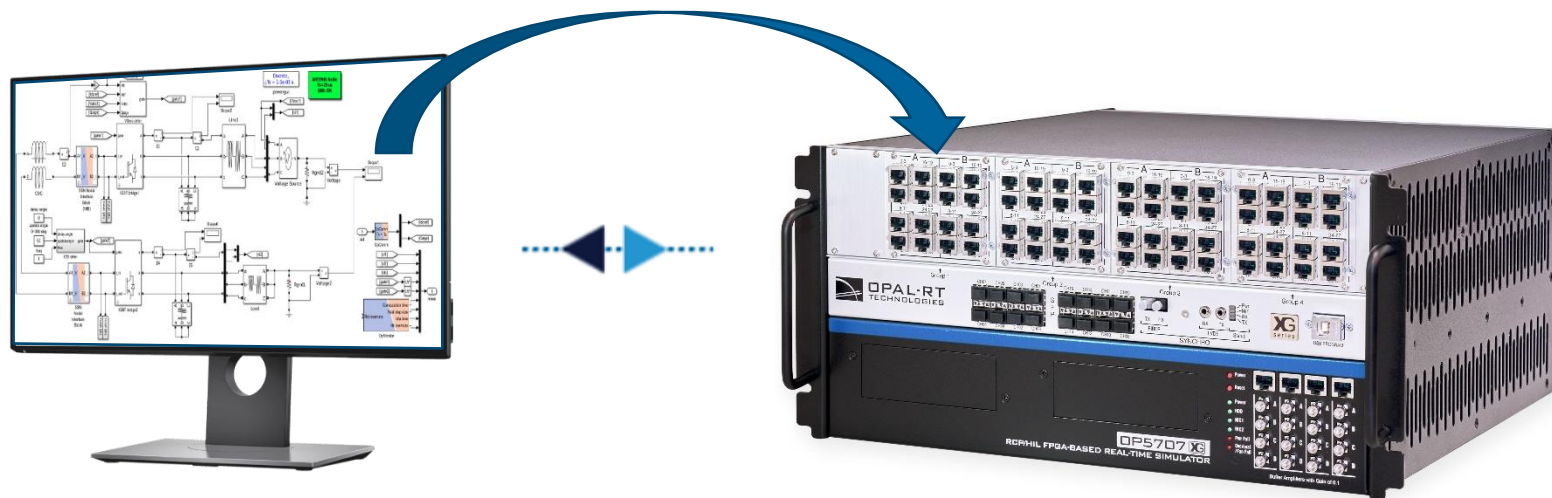Inputs/outputs interfaces and sensors to connect devices under test

Device is lured thanks to RTS

Controllers (ECU, protections, SCADA)

Electrical machines

Real power devices

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

REAL-TIME SIMULATION METHODOLOGY & BENEFITS

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MODEL/SOFTWARE-IN-THE-LOOP

RT-LAB

WORKSTATION

REAL-TIME SIMULATOR
(Simulated Controller)
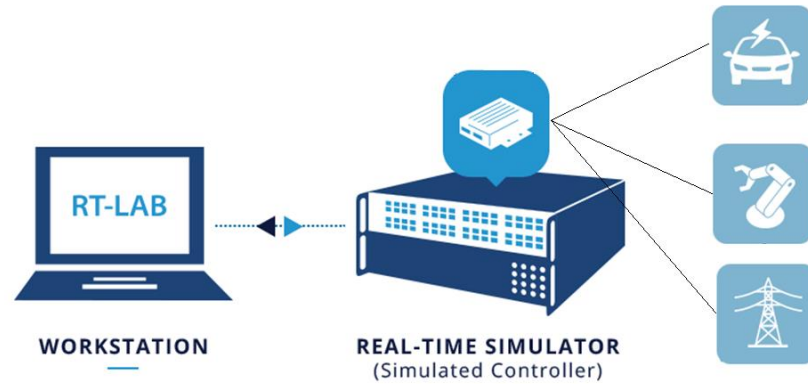
RAPID CONTROL PROTOTYPING

RT-LAB

WORKSTATION

REAL-TIME SIMULATOR
(Simulated Controller)

**ACTUAL DRIVE &
MECHATRONIC SYSTEMS**

HARDWARE-IN-THE-LOOP

WORKSTATION

REAL-TIME SIMULATOR

ACTUAL SYSTEM
Controllers

POWER HIL

RT-LAB

WORKSTATION

REAL-TIME SIMULATOR

POWER AMPLIFIER

ACTUAL SYSTEM

PV, Wind Farms, Motors, Loads,
Controllers, Protective relays

SENSORS
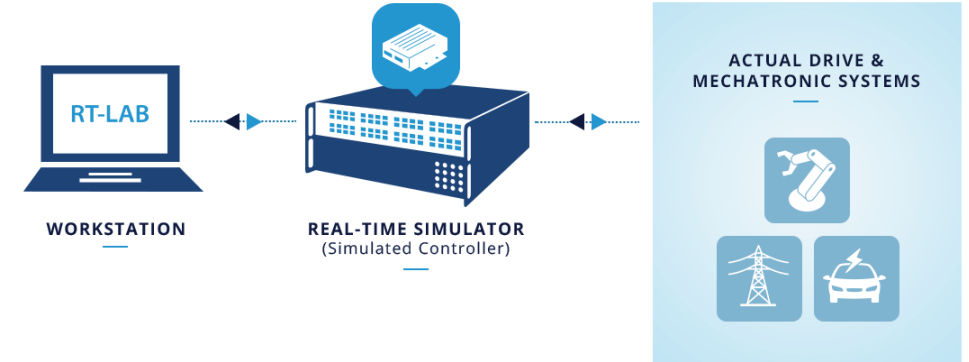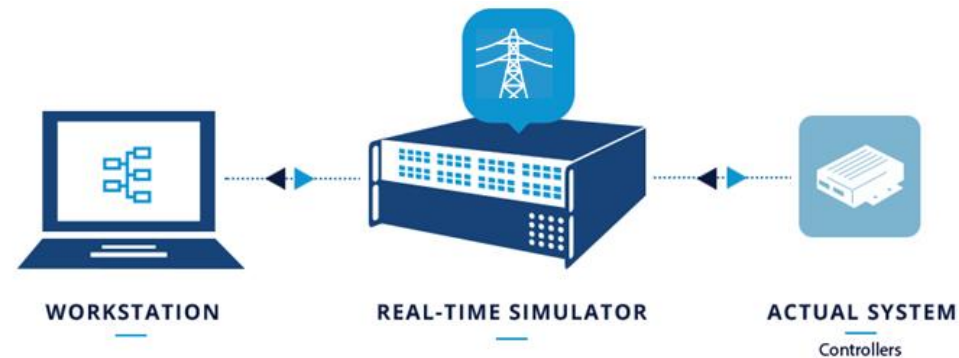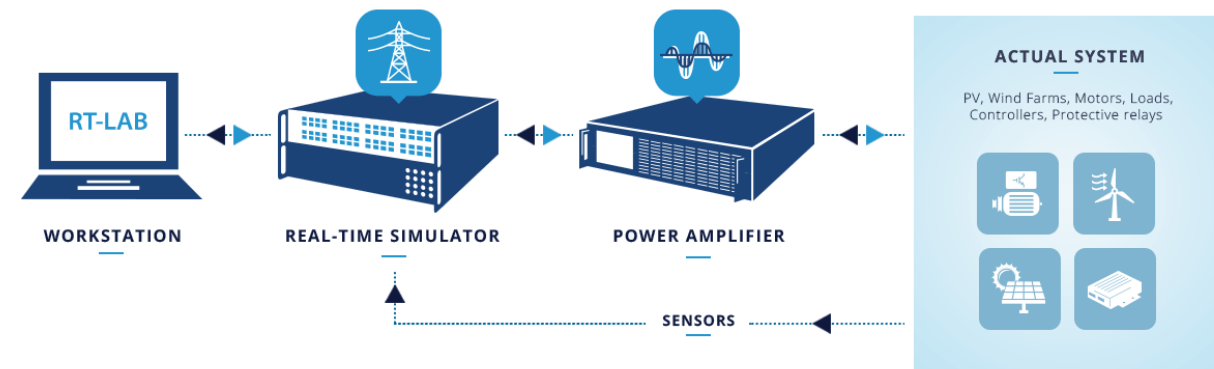
HARDWARE & SOFTWARE ARCHITECTURE

OP5707XG

- From 4 to 32 INTEL® CPU cores (XG)
- XILINX® FPGA board Virtex 7
- Up to 8 I/O boards
- Up to 4 3rd part boards (Sync, Ethernet)
- SFP Modules for optical fiber
- More information

OP4610XG

- 6 CPU cores (XG)
- XILINX® FPGA board Kintex 7
- Up to 4 I/O boards
- Up to 2 3rd part boards (Sync, Ethernet)
- SFP Modules for optical fiber
- More information

OP4512

- 4 INTEL® CPU cores
- XILINX® FPGA board Kintex 7
- Up to 4 I/O boards
- 1 3rd part boards (Sync, Ethernet)
- SFP Modules for optical fiber
- More information

HARDWARE & SOFTWARE ARCHITECTURE

Analog outputs
16 channels
[-16V; +16V]
DAC: 16-bits, 1 or 2 Msps

Analog inputs
16 channels
[-20V; +20V]
ADC: 16-bits, 0.4 Msps

Digital outputs
32 channels
PWM or Static digital
« ON »: 5 to 30 V

Digital Inputs
32 channels
PWM or Static digital
« ON »: 4.5 to 50 V

DB37 + Screw terminals
Ethernet ports / Specif. Connect.
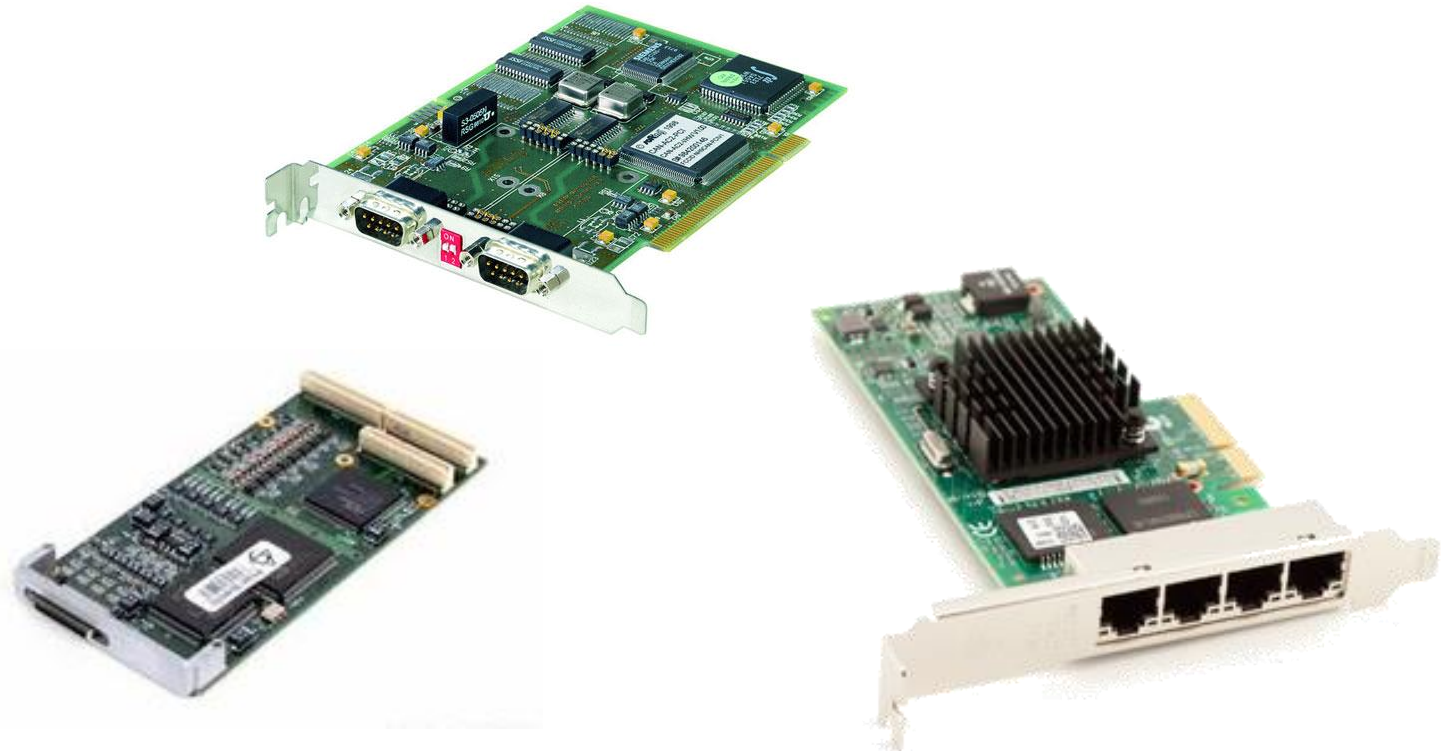*(Real-time simulator rear part)*

Digital inputs/outputs
32 I/O reconfigurable channels
PWM or Static digital
« ON »: ± 50V

Easy access to I/O
(Access on real-time simulator top part)

[icon] More information
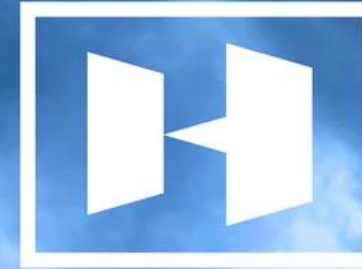
Supported communication protocols (partial list)

- IEC61850 GOOSE, SV & MMS

- C37.118

- DNP3

- IEC 60870-5-104

- TCP/IP, UDP/IP

- Modbus

- RS485, RS232

- CAN bus

- Aurora

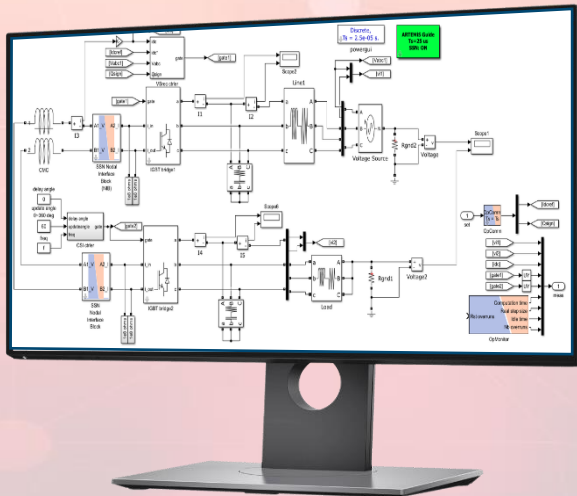**MULTI-DOMAIN, FLEXIBLE, SCALABLE SIMULATION PLATFORM**

POWERFUL POWER SYSTEMS SIMULATION PLATFORM

RT-LAB

MATLAB® & SIMULINK®

RT-LAB enhances the capabilities of **Simulink** models to enable their execution in **real-time** and interface them with **real external hardware**. Supports virtually any kind of application.

SPECIALIZED ADD-ONS

ARTEMiS — *detailed simulation of electrical systems*

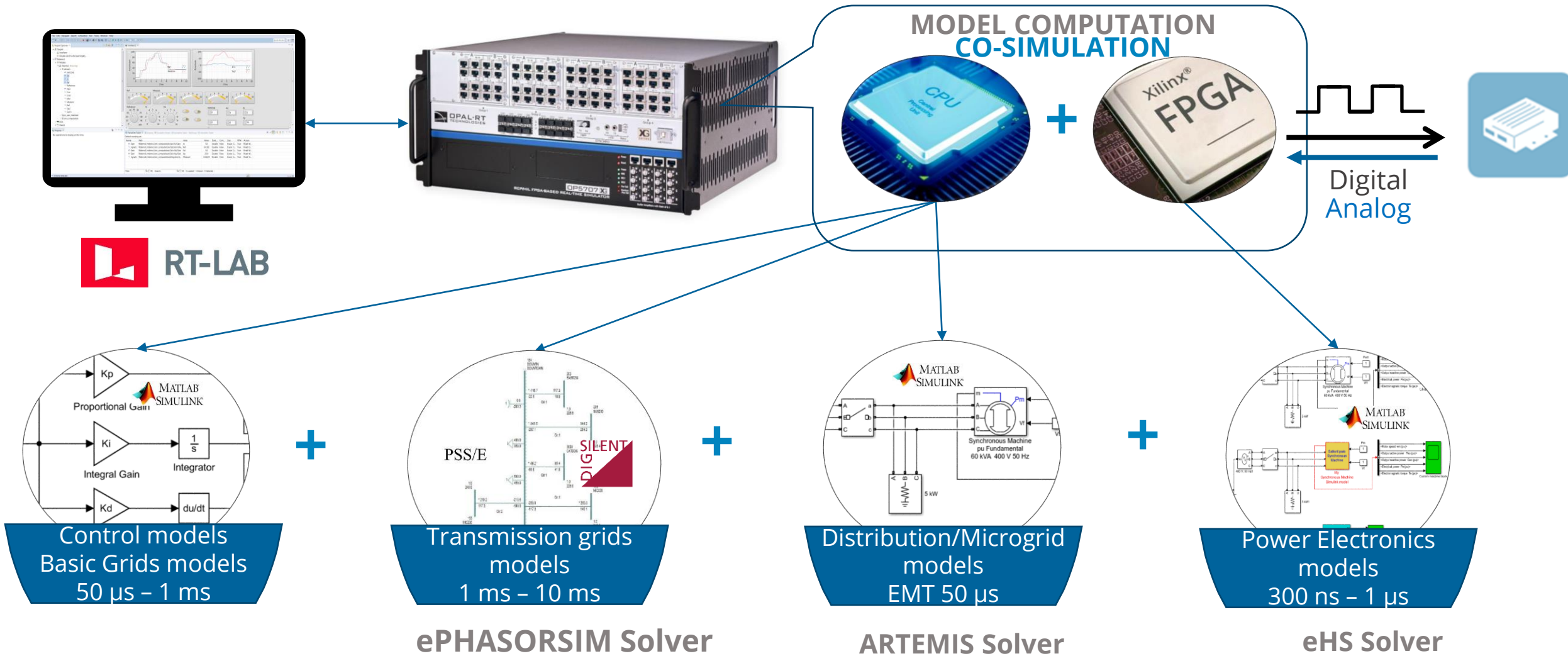**ePHASORSIM** — *average simulation of large electrical grids*

eFPGASIM — *detailed simulation of very fast electrical systems*
Compatbile with NI Veristand & PXI chassis
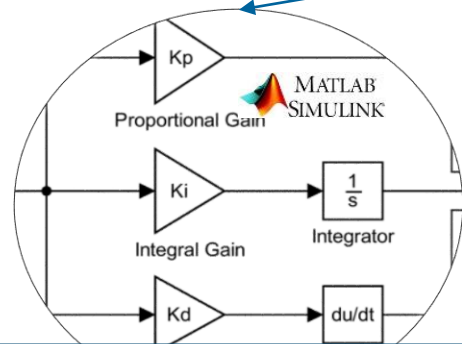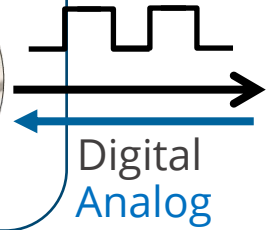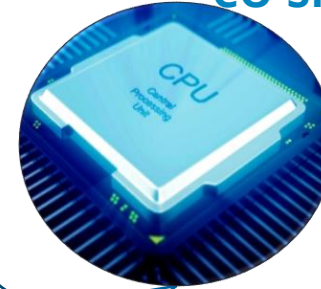
HARDWARE & SOFTWARE ARCHITECTURE

MODEL COMPUTATION
CO-SIMULATION

RT-LAB

Digital
Analog

Control models
Basic Grids models
50 µs – 1 ms

+

Transmission grids
models
1 ms – 10 ms

ePHASORSIM Solver

+

Distribution/Microgrid
models
EMT 50 µs

ARTEMIS Solver

+

Power Electronics
models
300 ns – 1 µs

eHS Solver

HARDWARE & SOFTWARE ARCHITECTURE

MODEL COMPUTATION
CO-SIMULATION

VeriStand

Digital
Analog

Control models
50 µs – 1 ms
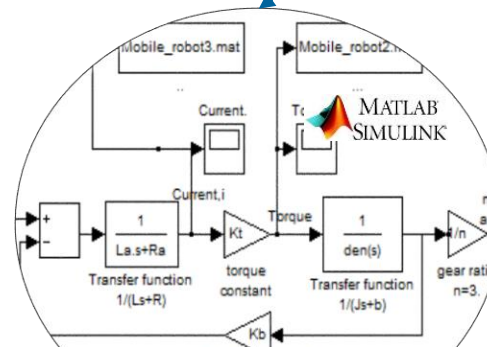
Mechatronics models
1 ms – 10 ms
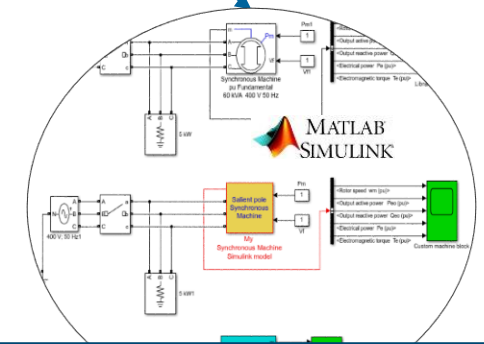
Power Electronics
300 ns – 1 µs

eHS Solver   VeriStand
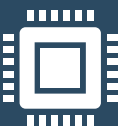
eHS | Power Electronics Add-On

MAIN APPLICATIONS
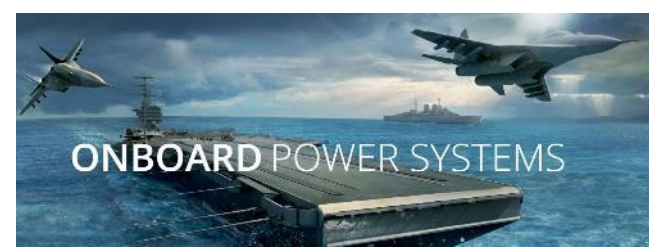
CONCLUSION

Complex industrial electrical and electromechanical systems
Complex systems studied through virtual models

Uniqueness of some projects
Models can be adapted to any unique project

Fast evolution of technologies
Flexibility of models which can be upgraded

Belated validations can compromise the project
Validation can be progressive, from design phase

More complex and sophisticated control strategies
Control can also be simulated, as well as its interactions with the plant system

Shorter development time
More lab tests starting early reduce need for rework or waiting for parts

Huge validation effort required
Validation can be progressive, from design phase and highly automated

Dangerous test cases
Dangerous scenarios are simulated and studied thouroughly

On-field tests hard to conduct
Many tests can be carried out in the lab with a virtual environment

Cost optimisation
Less prototypes, less destructive tests, more virtual configurations, less risk

THANK YOU!

MORE INFORMATION

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