Powerful Advanced N-level Digital Architecture for electrified vehicles and components

www.project-panda.eu

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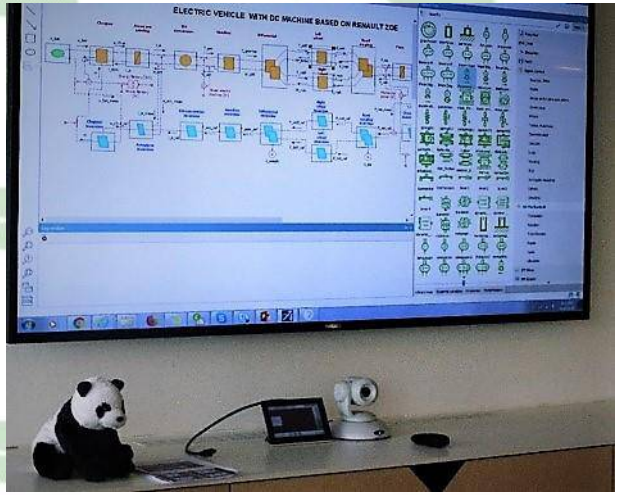
Outline

1. PANDA concept
2. PANDA virtual testing (BEV, HEV, P-HEV)
3. PANDA real testing (HIL testing of battery)
4. PANDA perspectives

1. PANDA concept



V-model of vehicle development

time

system requirements

subsystem requirements

component requirements

component realization

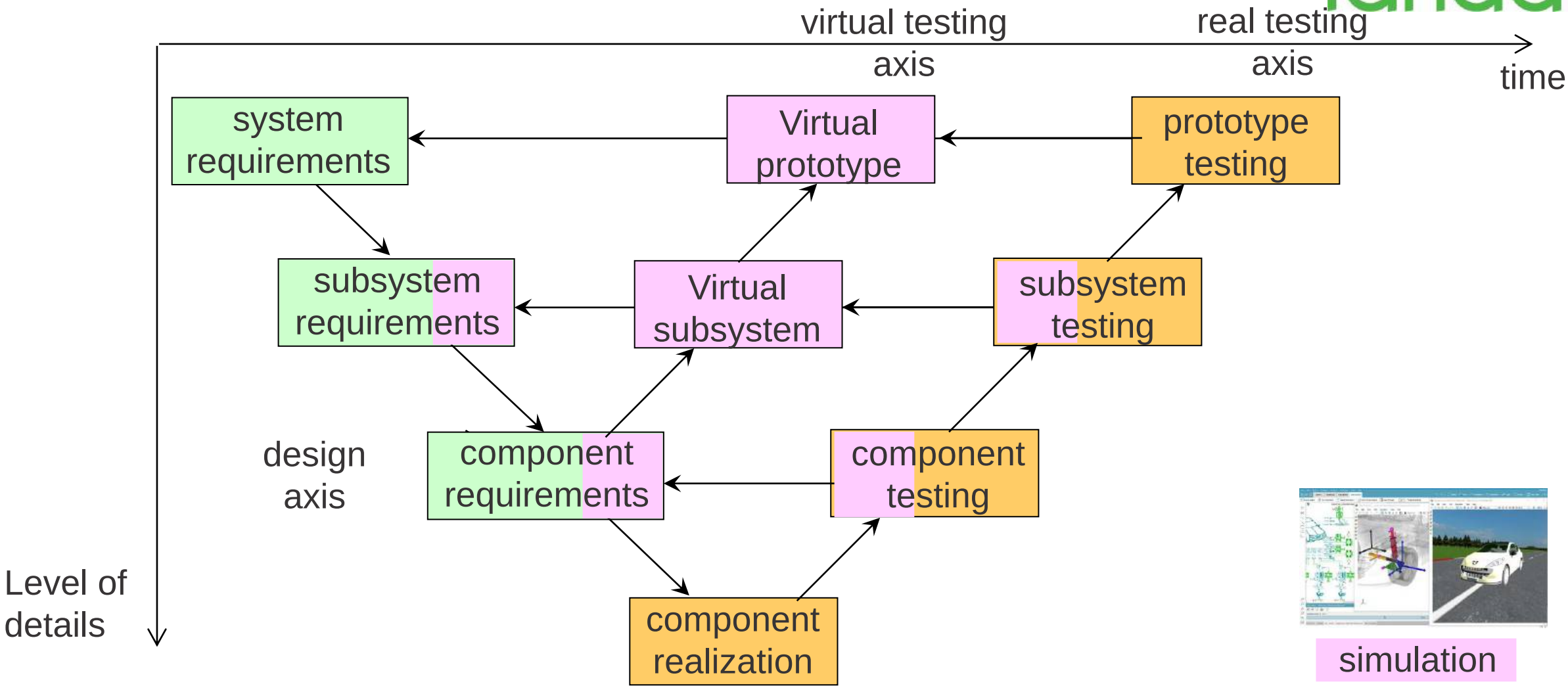
component testing

subsystem testing

prototype testing

Level of details

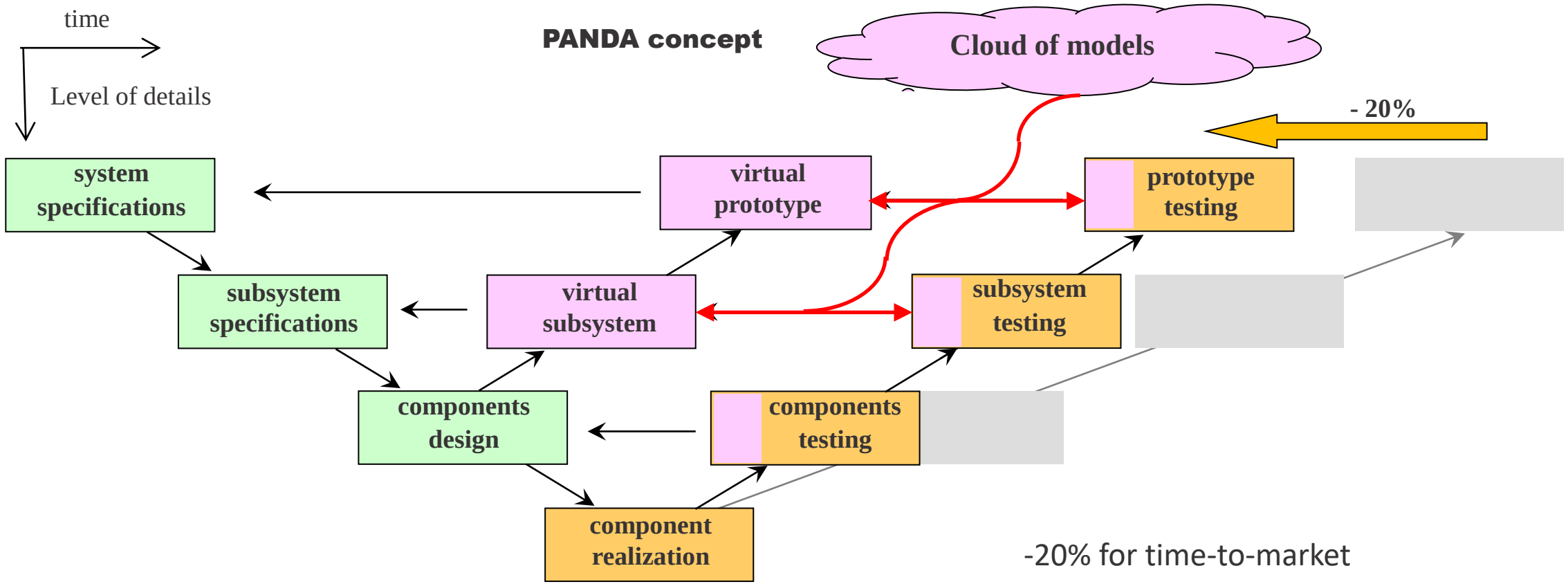
Digitalization & W-model proposed in PANDA



simulation

PANDA objective

Disruptive and **open access model organization** in the development process for fast and efficient development of innovative EVs



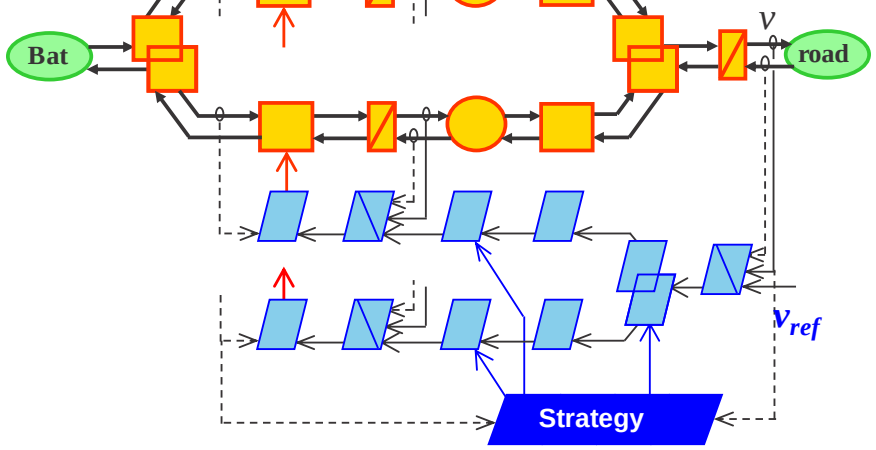
PANDA disruptive simulation method

- **Functional simulation:**

  Based on Energetic Macroscopic Representation formalism

  EMR is a **causal functional** formalism for model and control organization

  - Exclusive integral causality
  - Interaction principle



- **Cloud of model:**

  for sharing models with all partners

  Multi-level model of the same component

  - For virtual testing
  - For real testing

Unified organization using EMR formalism

Tazzari Zero of Université de Lille

1

$$J\frac{d}{dt}\Omega_{gear} = T_{dcm} - T_{gear} - f\Omega_{gear}$$

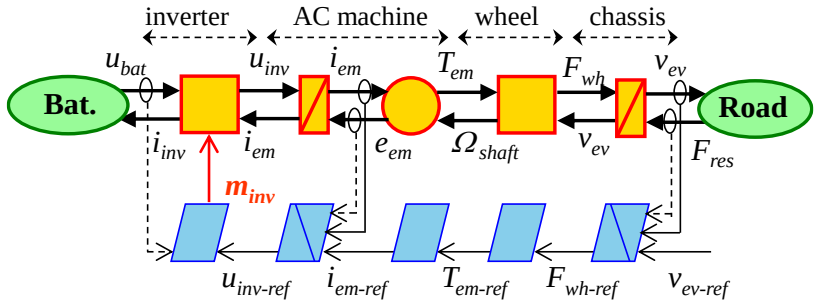
$$L_{arm}\frac{d}{dt}i_{dcm} = u_{chop} - e_{dcm} - R_{arm}i_{dcm}$$

$$\begin{cases} u_{chop} = m_{chop}\, V_{bat} \\ i_{chop} = m_{chop}\, i_{dcm} \end{cases} \quad \begin{cases} T_{dif} = k_{dif}\, T_{gear} \\ \Omega_{dif} = k_{dif}\, \Omega_{wh} \end{cases}$$

$$\begin{cases} T_{dcm} = k_{dcm} i_{dcm} \\ e_{dcm} = k_{dcm}\Omega_{gear} \end{cases} \quad \begin{cases} T_{gear} = k_{gear}\, T_{dcm} \\ \Omega_{gear} = k_{gear}\, \Omega_{diff} \end{cases}$$

modelling equations

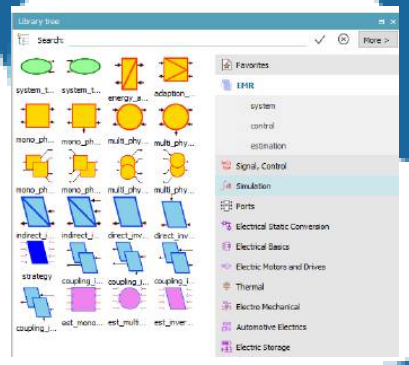
2

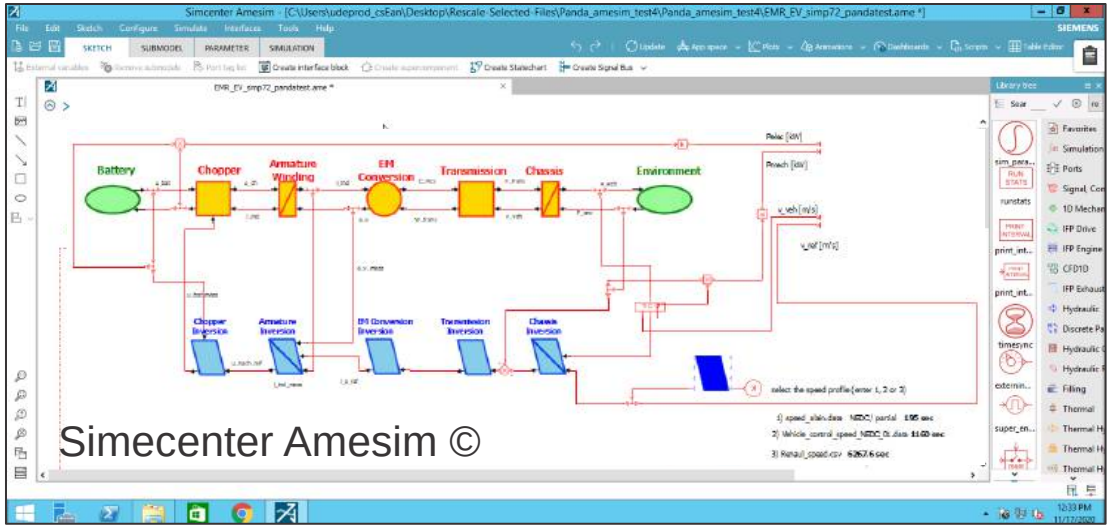


model & control organization using EMR

3

New EMR library In Simcenter Amesim ©

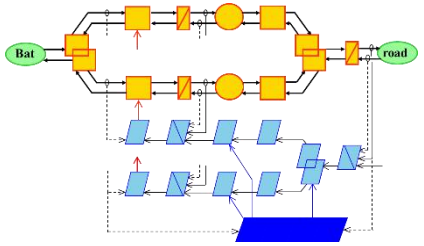




Simecenter Amesim ©

PANDA supports

EMR formalism



L2EP Laboratoire d'électrotechnique et d'électronique de puissance de Lille

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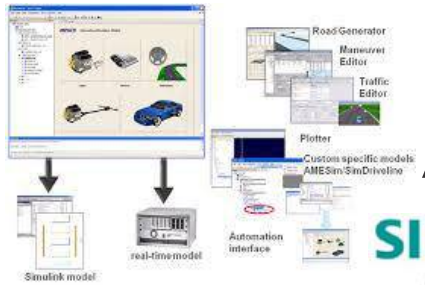
Application to an industrial software



Simcenter Amesim ©

SIEMENS Ingenuity for life

study cases

Electric Vehicle

Renault ZOE

Renault Group

Fuel Cell Vehicle

MobyPost

UBFC UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ

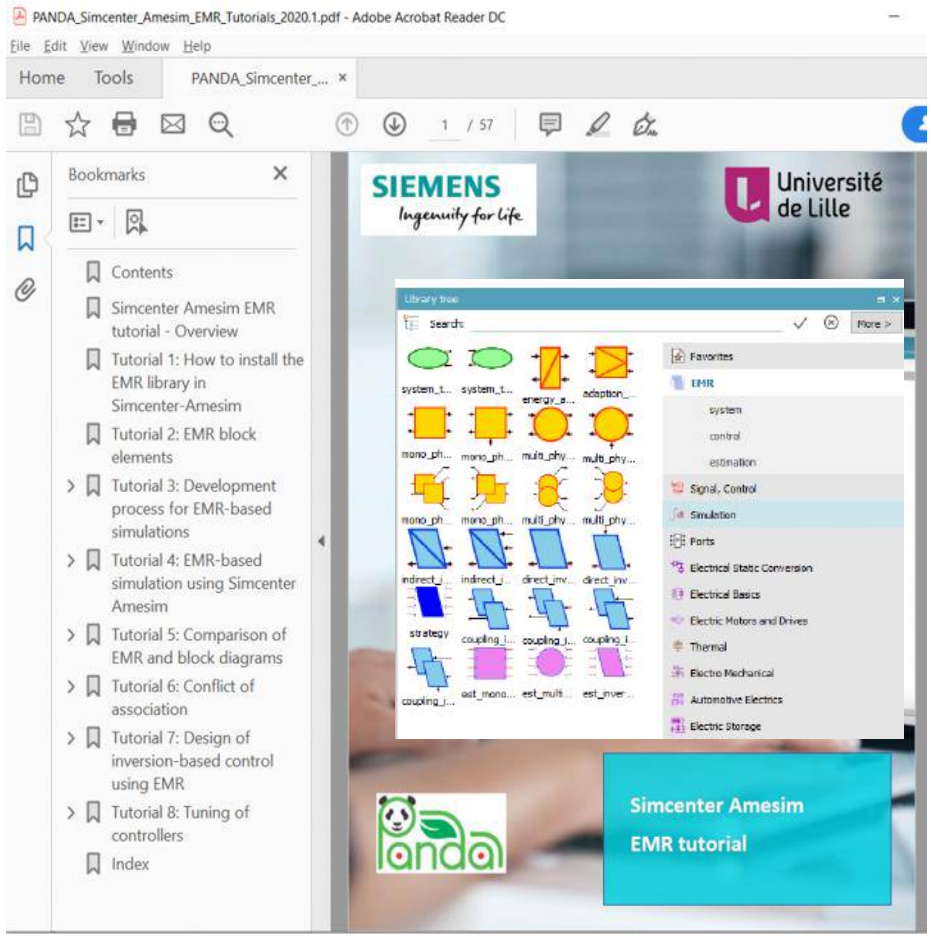
Hybrid Vehicle

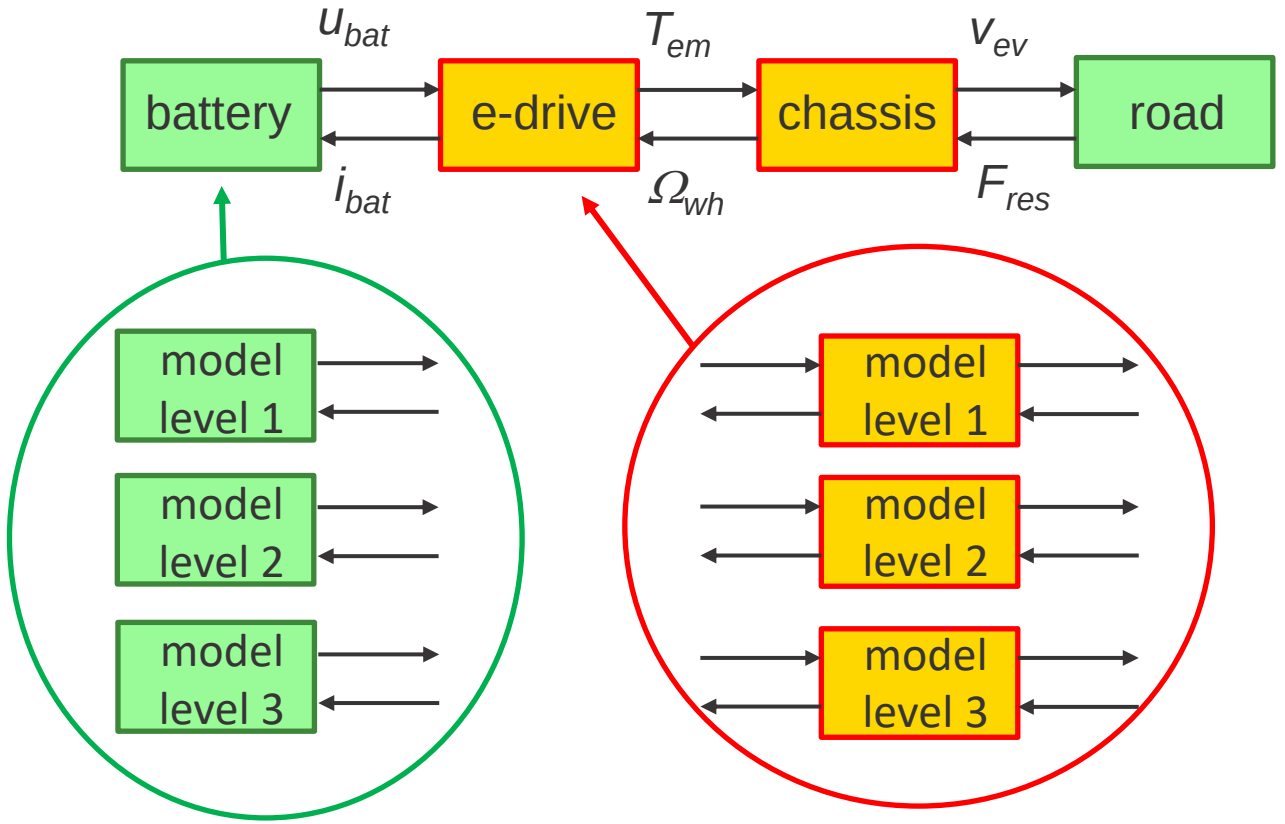
48V-based HEV

Valeo

2. PANDA virtual testing

New EMR library in Simcenter-Amesim © for multi-level simulation



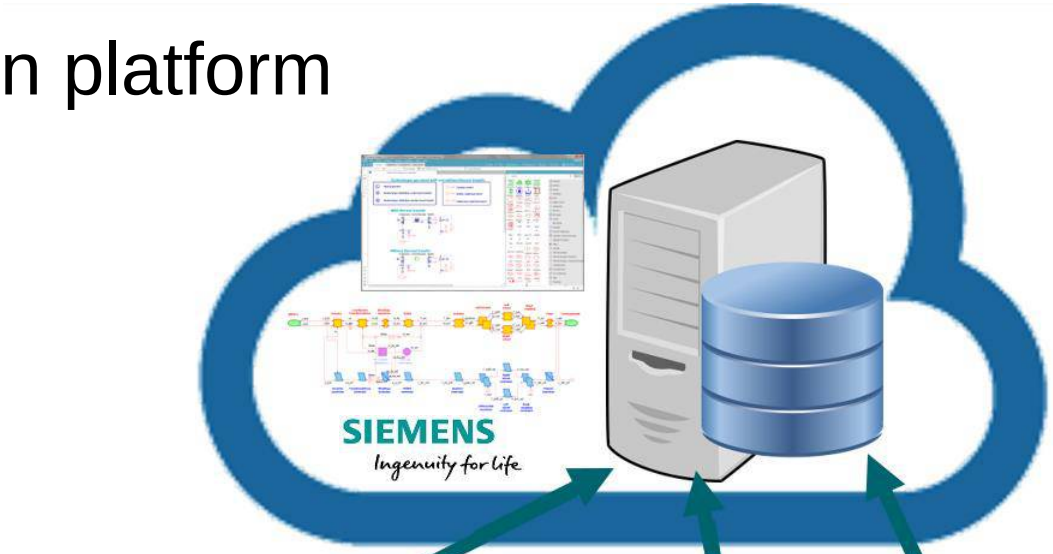


- Different models can be **interchanged by "plug & play"**

Cloud simulation platform

- with cloud EMR library and computing facility

- **fast sharing models and knowledge between partners**, for seamless integration of a complete vehicle model



- Development of models
- EMR organisation of models

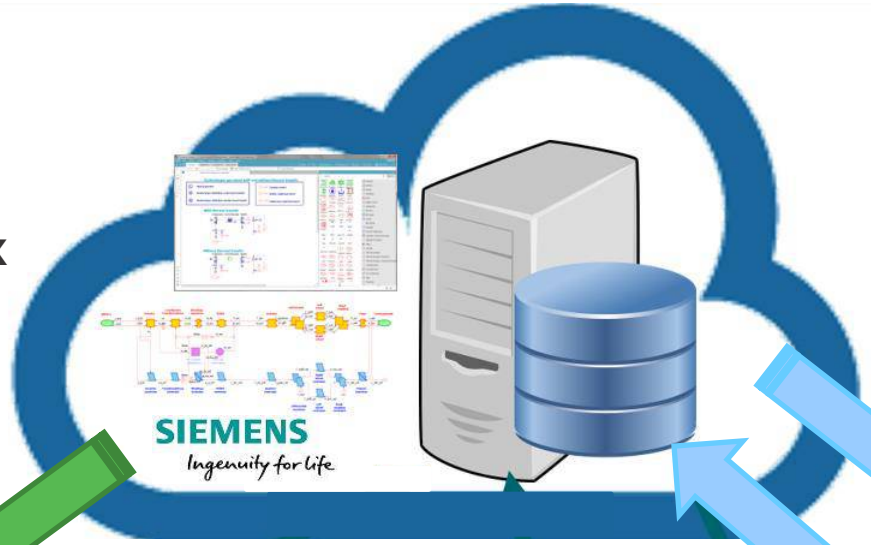
Simulation of BEV

Simulation of FCV

Simulation of P-HEV

Stand alone or cloud simulation

possibility of **black-box** models for IP



Upload Simulation results

upload simulation files

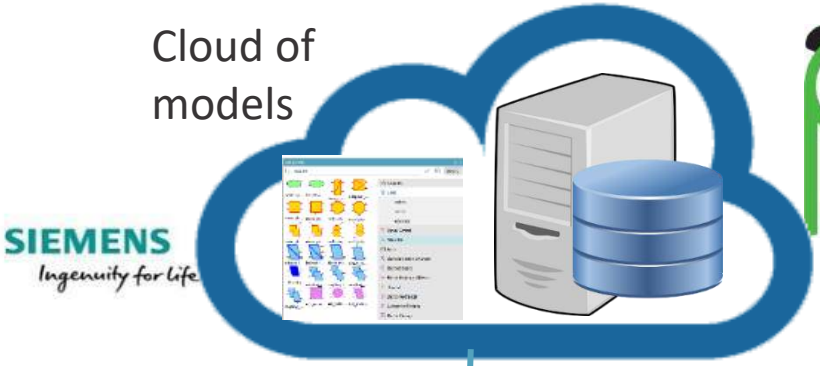
download component model

stand-alone simulation on local computer

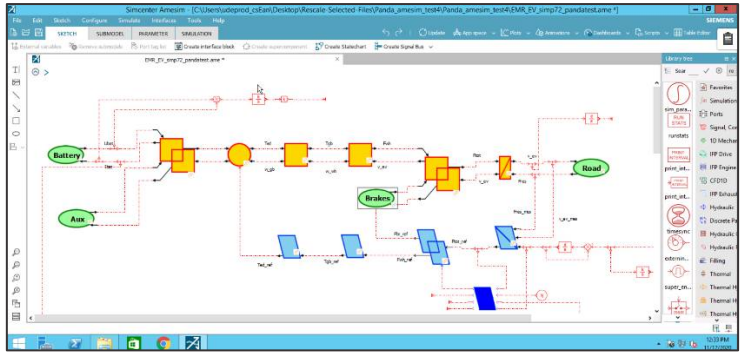
Cloud-computing simulation in the cloud

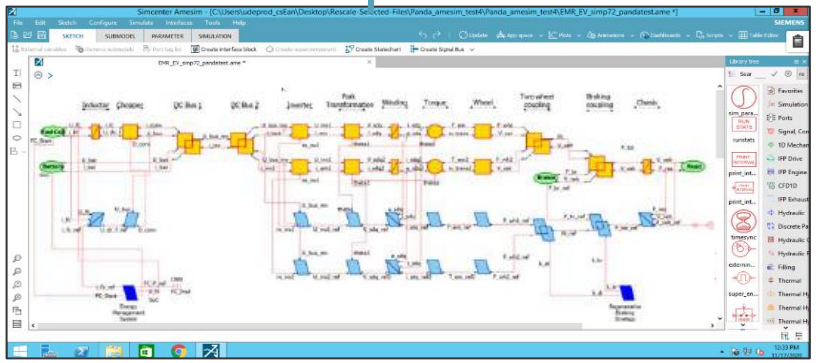
Virtual testing of the reference vehicles

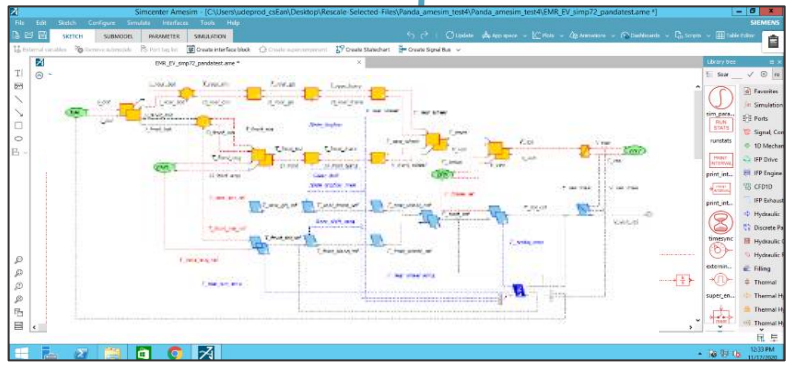
Cloud of models



SIEMENS
Ingenuity for life







Renault Group

BEV (Renault Zoe)
Accuracy 97%

UBFC
UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ

FCV (Mobipost)
Accuracy 95%

Valeo

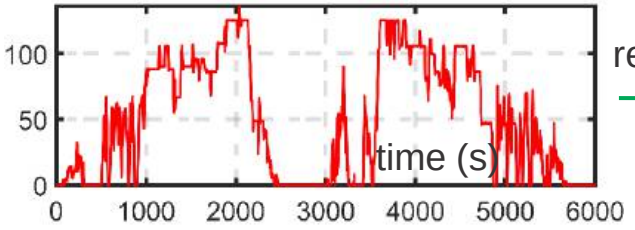
P-HEV (Valeo Demo Car)
Accuracy 97%

Model validation

measurements

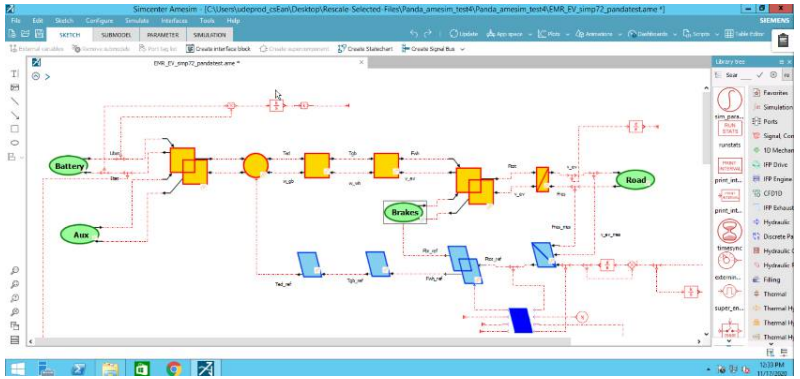
Renault Group

Velocity (km/h)



Extra-urban real driving cycle

reference



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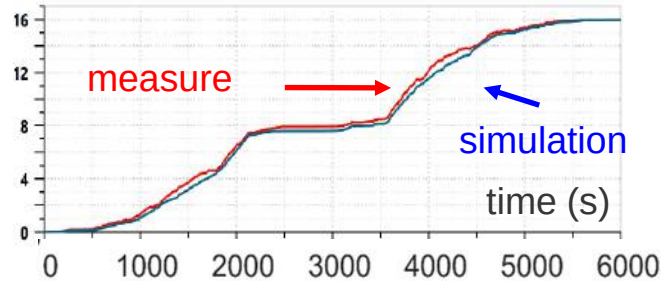
SIEMENS
Ingenuity for life

measurements

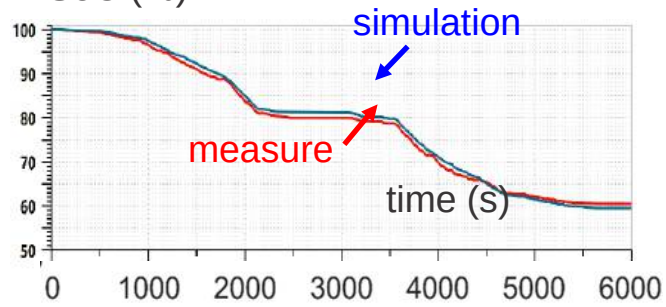
different real driving cycles
from RTR track

results

Energy (kWh)

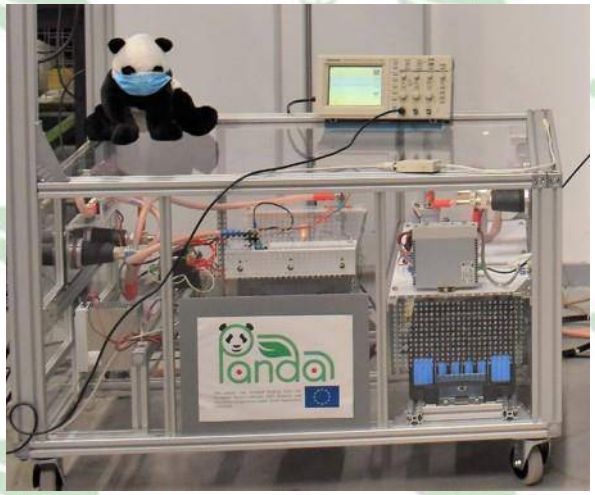


SoC (%)



Error on energy < 2%
for different driving cycles

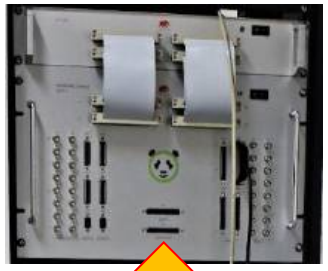
3. PANDA HIL testing



Real testing of the P-HEV subsystems (Hardware-In-the-Loop testing)

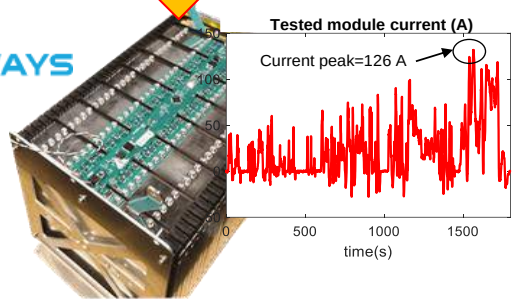
Cloud of models

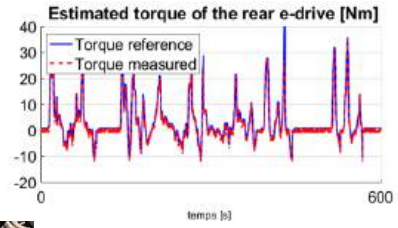
Real-time simulator

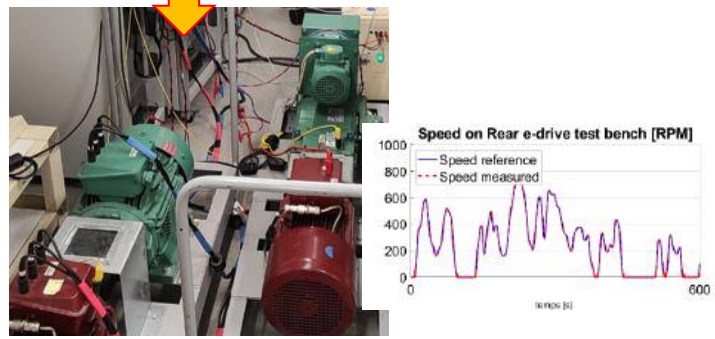


Typhoon HIL

BLUWAYS







HIL testing the battery

VUB VRIJE UNIVERSITEIT BRUSSEL

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HIL testing the e-drive

UNIVERSITATEA TEHNICĂ

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HIL testing the e-subsystem

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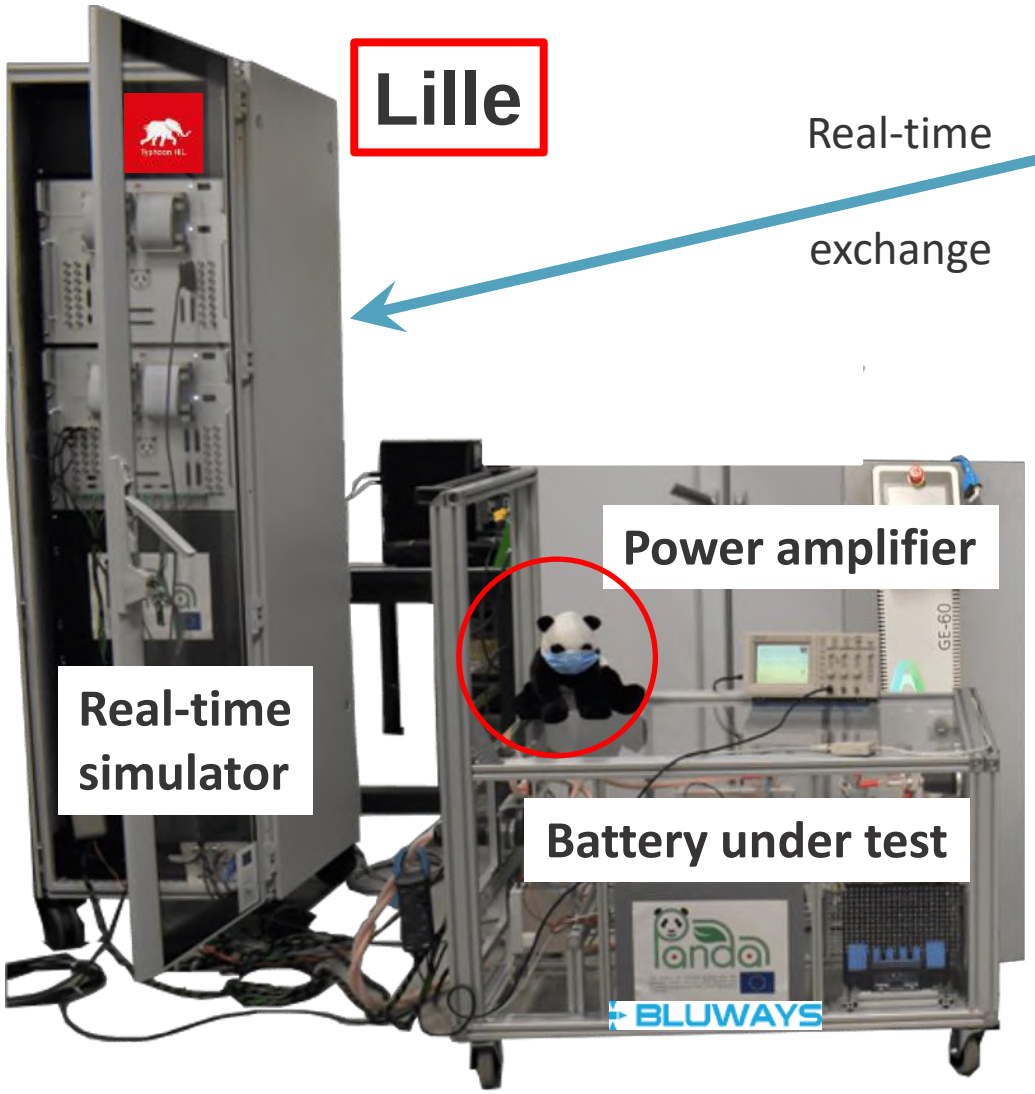
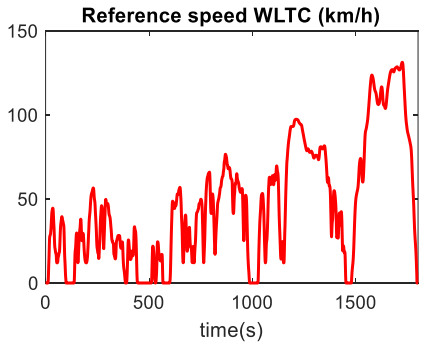
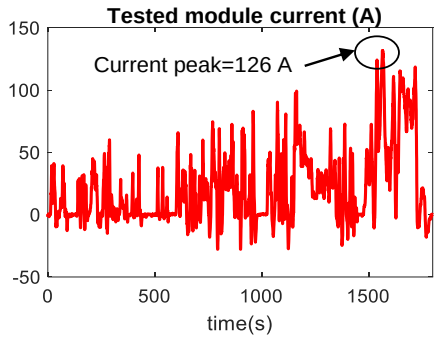
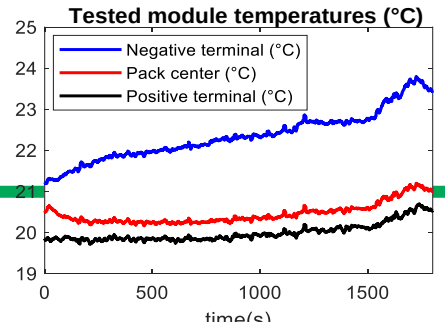
Valeo

Example of Cloud-based HIL testing





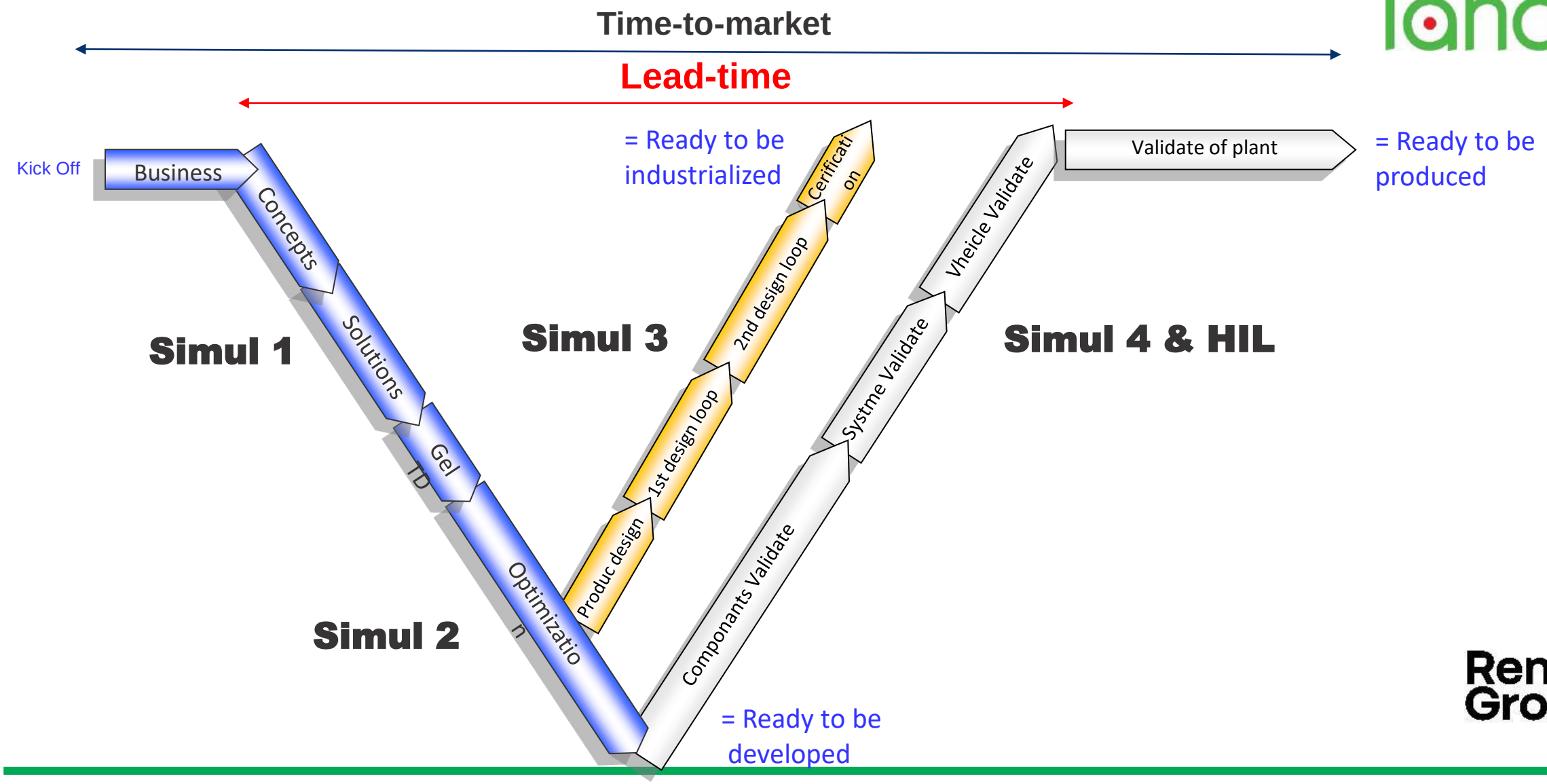




Stand-alone HIL & cloud-based HIL

4. PANDA perspectives

Vehicle development using the W-model



Potential gain in lead time

Representative scenario for developing a completely new vehicle (based on a real development schedule)

	Reference weeks	PANDA Gain	New scheme weeks
Training	0		**10**
Vehicle comparisons	50	**40%**	30
Tested solution	20	**50%**	10
Components Optimization	50	**50%**	25
Certification & testing	60	0%	60
Total	180		135

method training / cloud development (evaluated by SISW with no prior knowledge on EMR)

Potential gain of 25% in lead-time (if cumulative gains)

Short-term: evaluation Group

(using the cloud of models)

signed agreements

SHERPA ENGINEERING

EV charging station

SEGULA TECHNOLOGIES

retrofit gas-electric ship

MEL MÉTROPOLE EUROPÉENNE DE LILLE

new automatic subway

SNCF

Hydrogen train

Chemins de fer du Jura

new electric locomotive

Hes·so VALAIS WALLIS

Perspectives

- **Business model for the EMR library in Simcenter AMESIM © and other softwares**
  - education version and industrial version ?

- **Spin-off for helping companies to adopt the PANDA method**
  - from PhD students involved in PANDA
- **New applications for the PANDA methodology**
  - other transport sectors, renewable energy conversion systems, positive energy building, etc.
  - contribution to some submissions to Horizon Europe calls (interest in the method / cloud)
- **Extension to training of future European high-level scientists**
  - proposal to HE MSCA Doctoral Network
- **Towards standardization of model organization of xEVs**

Conclusion

- **A unified method for model organization based on the EMR formalism**
  - Fixed I/Os of the different subsystems (causality)
  - Applications in 3 different software packages (portability)
  - Validation with 3 real vehicles (BEV, FCV, HEV) (reliability)

- **A cloud of models for virtual and real testing**
  - multi-level models (flexibility)
  - Seamless interconnections of different environments (interoperability)
  - Different power HIL testing (flexibility)

Our PANDA
Thanks you for your attention !

H2020 PANDA project

https://project-panda.eu/

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