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N-level digital architecture for development of electrified vehicles

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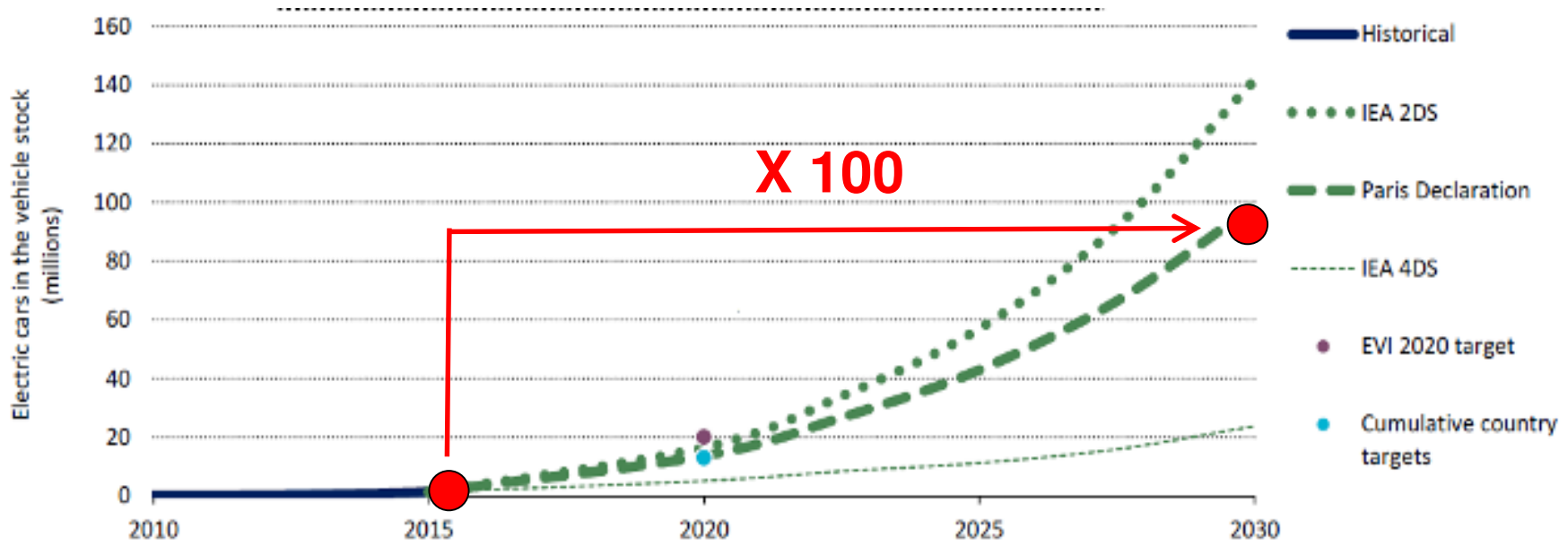
Context

Development of electrified vehicles

Challenge of the e-Mobility



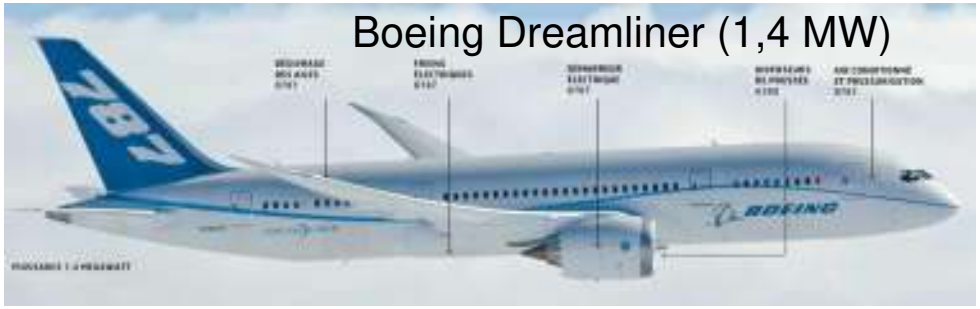
Note: 2DS = 2°C Scenario; 4DS = 4°C Scenario.

From 1 M to 100 M of EVs in 15 years to limit global warming to +2°C

+ innovative EVs: longer range, shorter charging time, reduced cost, etc.
+ industry 4.0: more adapted vehicles [2]

1 "Global EV outlook 2016, beyond one million electric cars", International Energy Agency, 2016
2 "Digitalisation, research & innovation: transforming European industry and service", European Commission, August 2017

Different kinds of vehicles



V-model of vehicle development

time

system requirements

prototype testing

subsystem requirements

subsystem testing

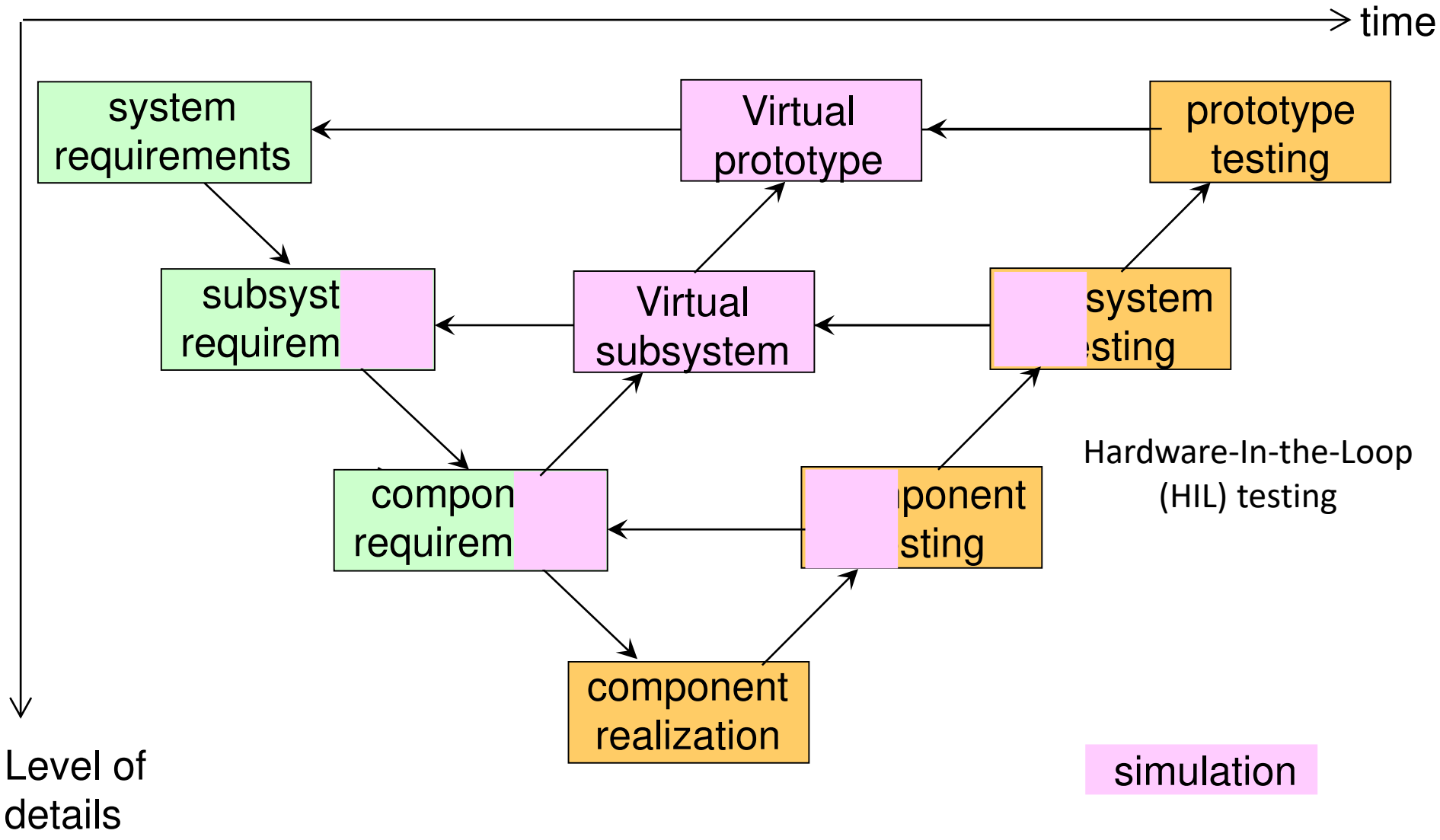
component requirements

component testing

component realization

Level of details

Digitalization and W-model



Challenges in flexible simulation

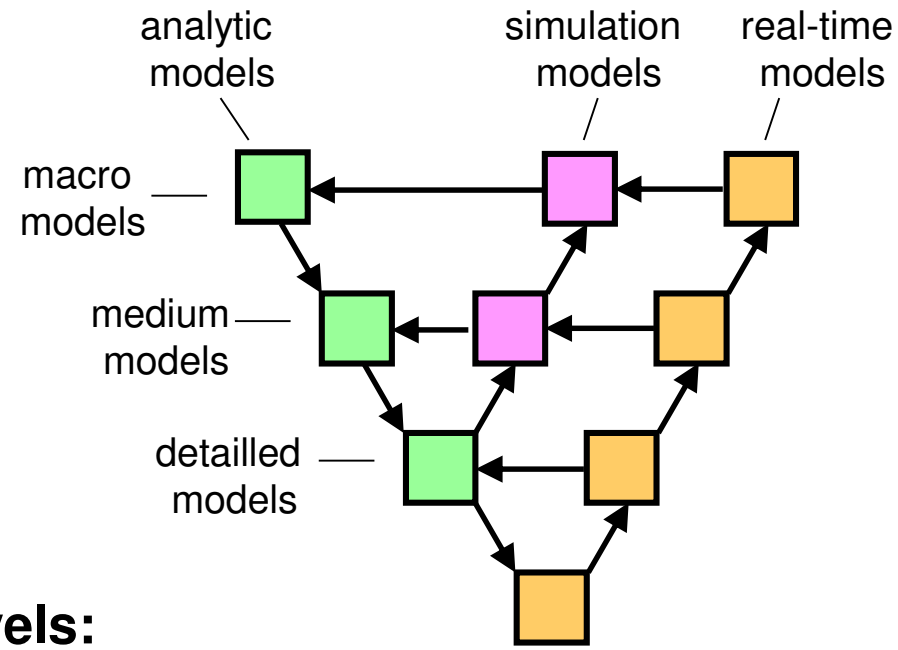
Many different models for:

- the different axes

  (design, simulation, validation)

- the different levels

  (system, sub-system, component)



Low interaction between axes and levels:

(low adaptability requires re-development of models)

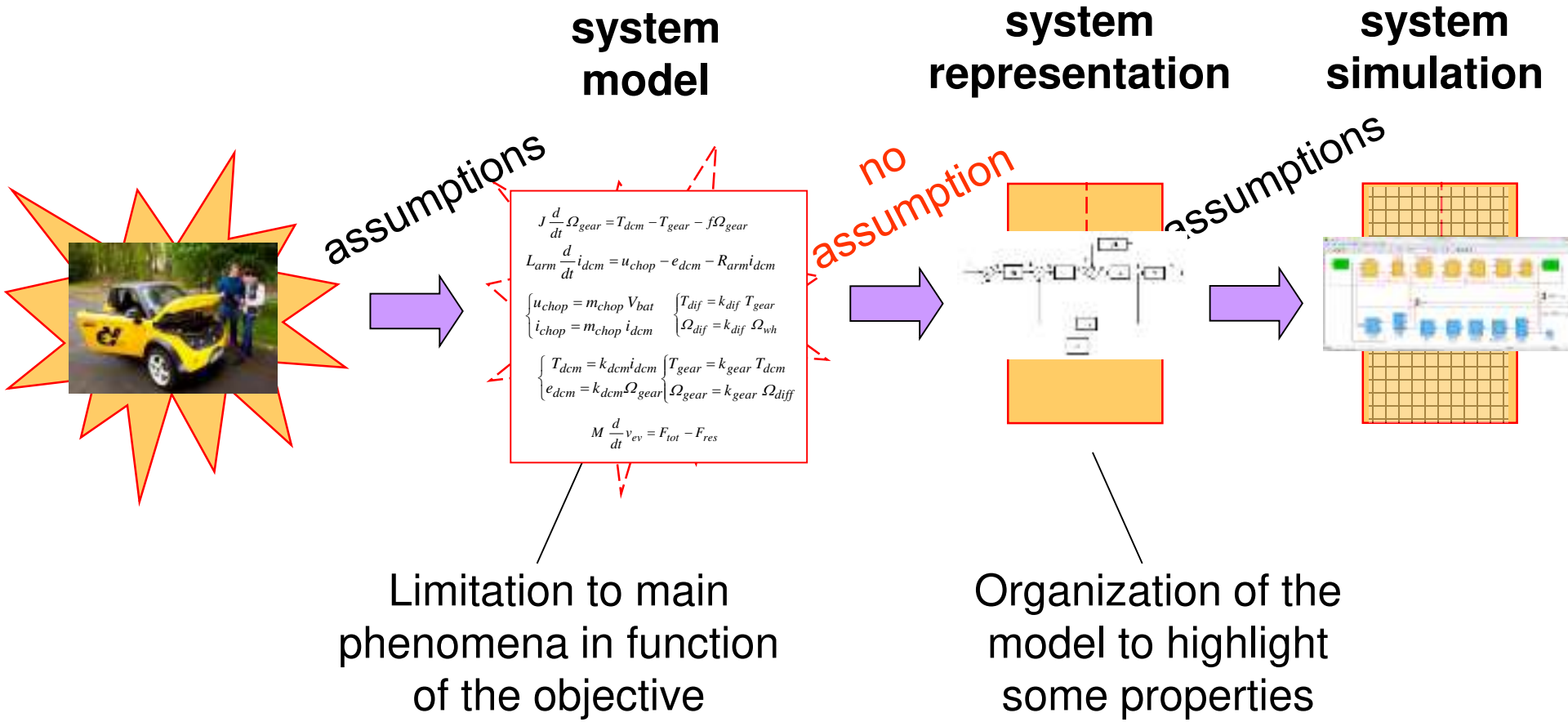
- reduction of the efficiency of the V-model process
- reduction of the efficiency/performance of the vehicle
- increase of the development time

How to improve?

Concepts

Models, Representation, Simulation

From the system to simulation



Limitation to main phenomena in function of the objective

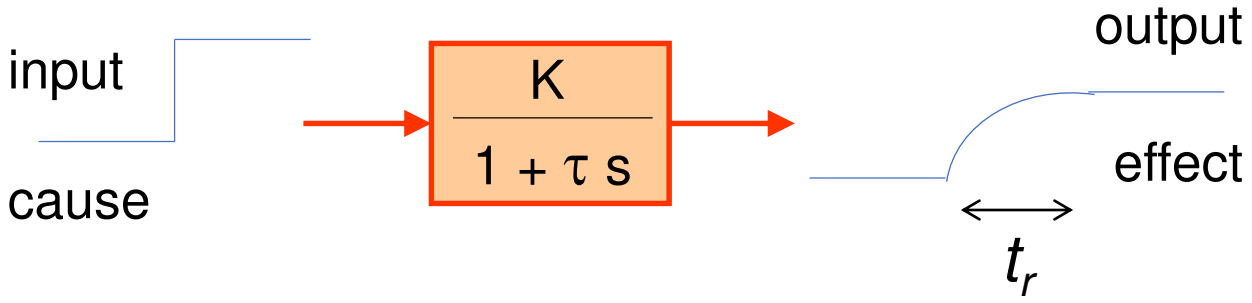
Organization of the model to highlight some properties

Different possibilities at each step in function of the objective

First: respect of causality principle

the cause leads to the effect
i.e. the output is delayed from the input
i.e. the output is an integral function of the input
i.e. the model describes an energy storage

e.g. first order system



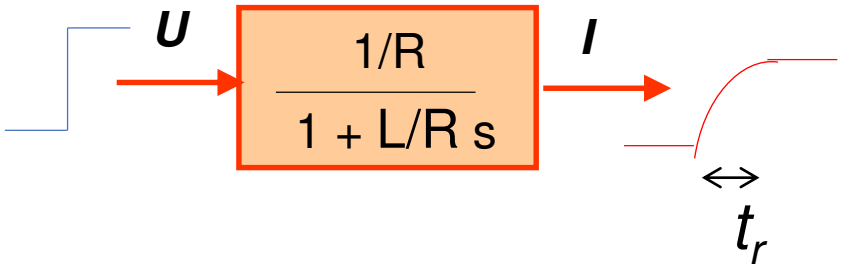
an input change leads to
an output change **with a delay**

Only integral relationships are causal
(physical behaviour, better understanding, safer management)

Dynamical vs. static models

Dynamical model:
considers transient states
(accurate results)

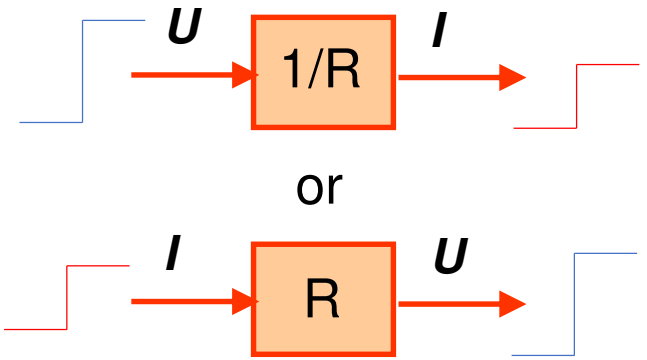
$$U(t) = L\frac{d}{dt}i(t) + Ri(t)$$



Fixed I/Os for causality

Static model:
only considers steady states
(fast computation)

$$U(t) = Ri(t)$$



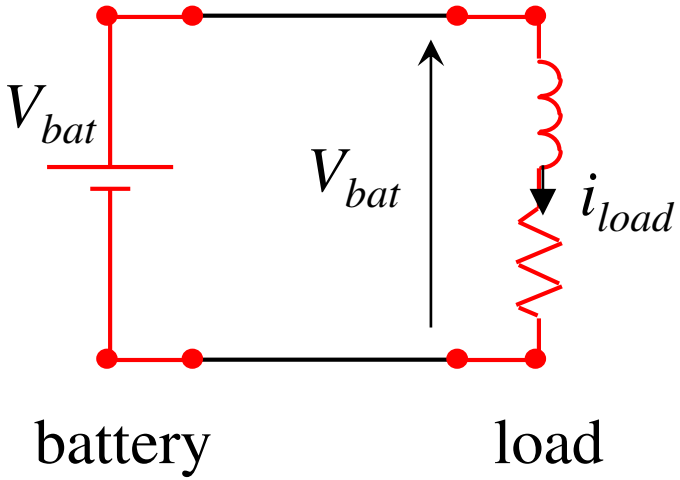
Floating I/Os (acausal)

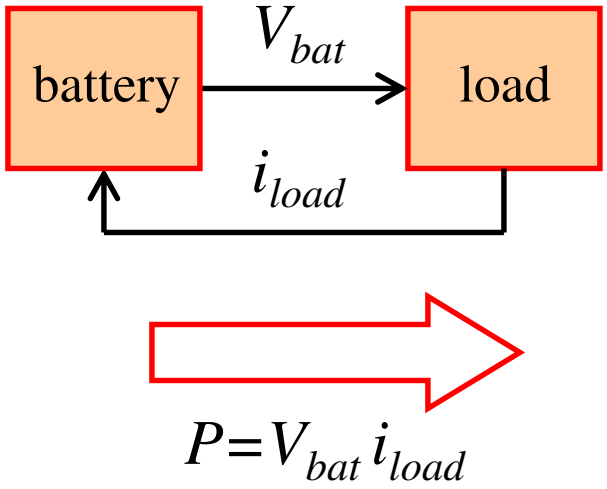
Static models don't conserve the physical initial causality

Structural vs. functional representation

Structural representation:
component interconnected
by physical links
(for design and implementation)

Functional representation:
functions interconnected
by virtual links (variables)
(for analysis and control)

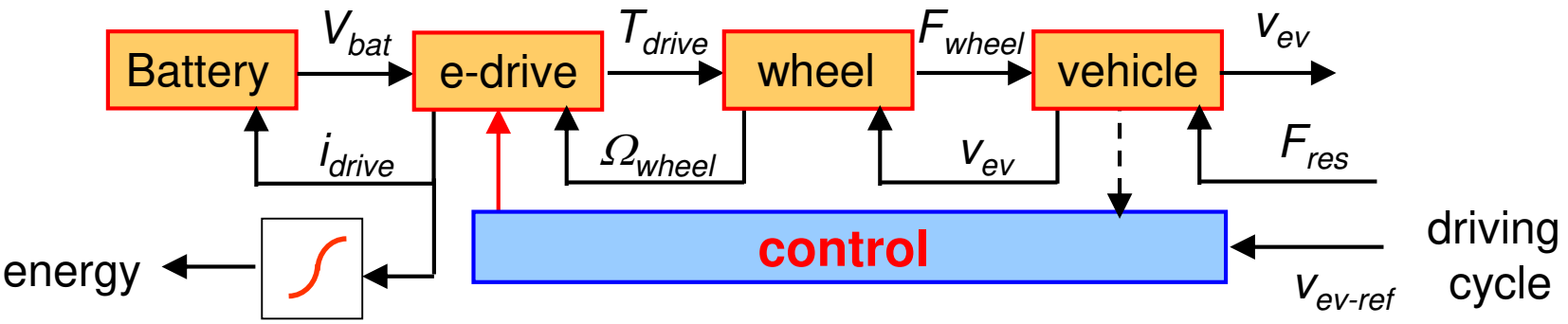




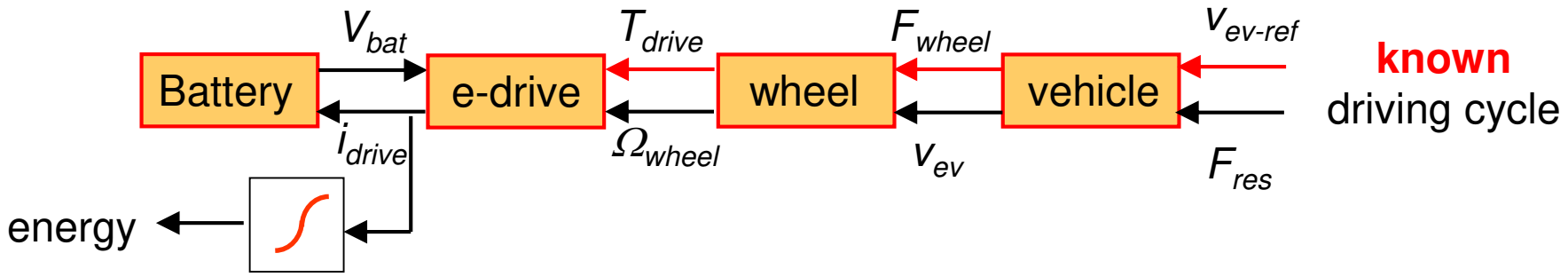
Structural representation: easy interconnection of subsystem (acausal)
Functional representation: better system understanding (causal)

Forward vs. backward simulation

Forward simulation: respect of the time flow (direct computation)

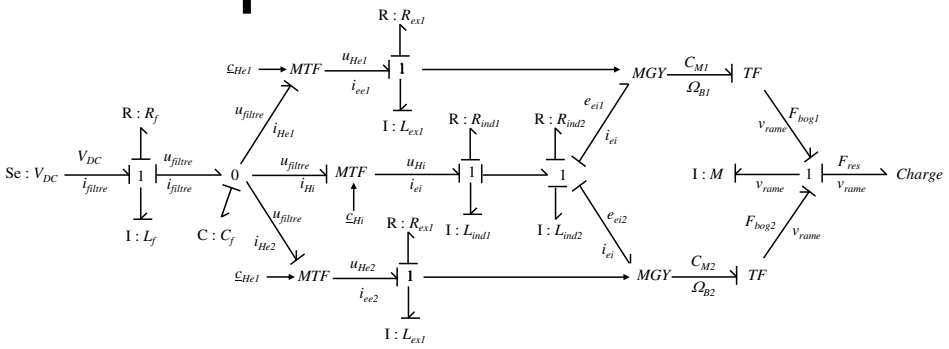


Backward simulation: from the results to the origin (inverse computation)



Backward requires non-causal organisation and/or model reduction
Forward requires control development

Graphical formalisms



Bond Graph

- modelling / representation tool
- acausal description
- structural description

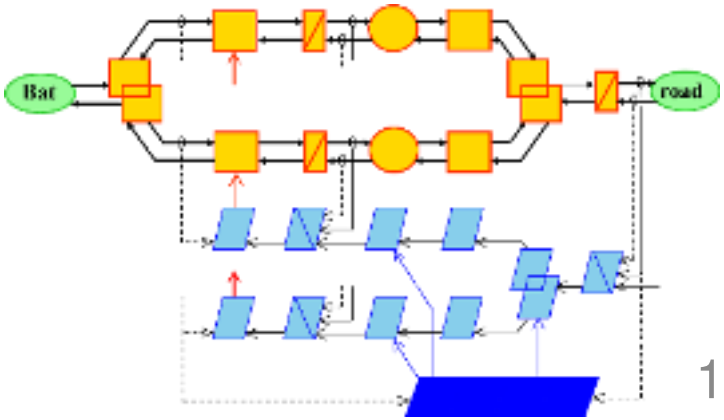
- ➢ easy interconnections
- ➢ highlights conflict of association
- ➢ for design and analysis

A lot of simulation package are Based on Bond-Graph (e.g. AMESIM)

Energetic
Macroscopic
Representation

- model organization
- causal description
- functional description

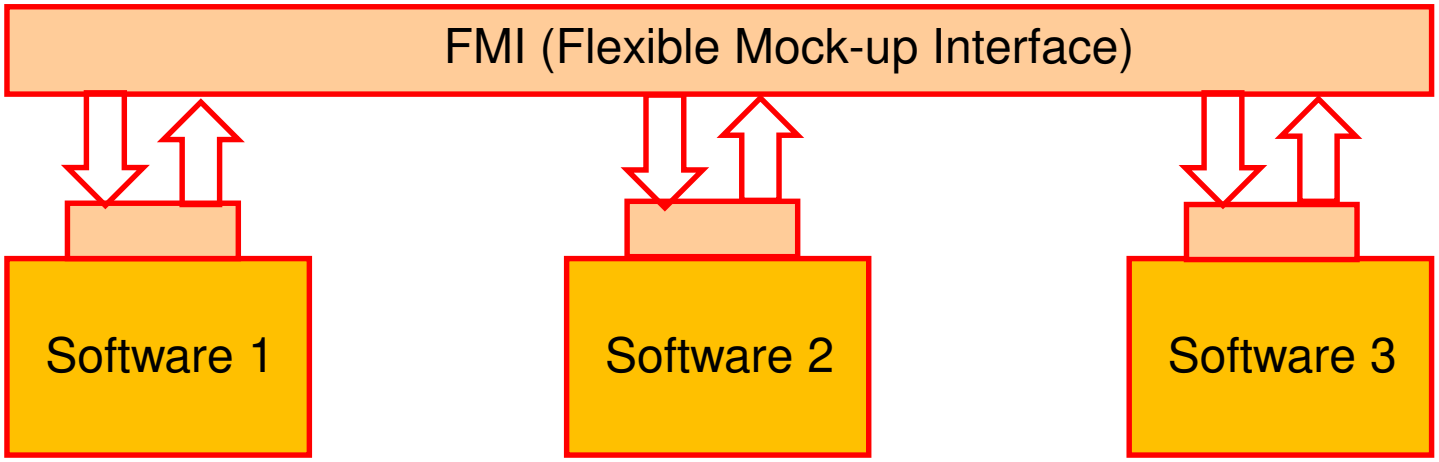
- ➢ fixed I/Os (causality)
- ➢ for control organization
- ➢ fast computation time



Global / Partial Simulation

Advanced simulation package

Co-simulation of software packages

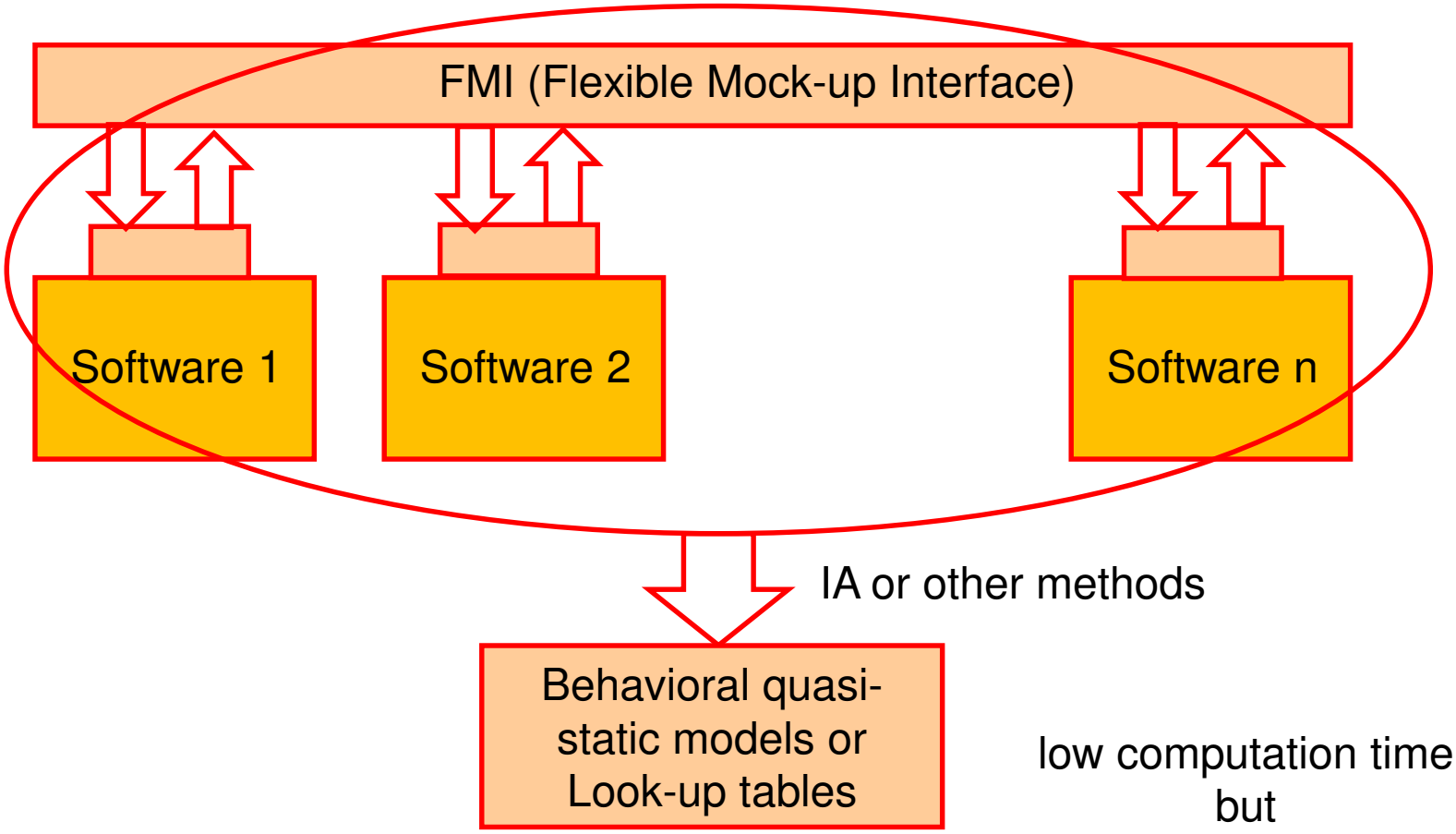


Pros:
Each part can use its own software
Multi-level models available in each software

Cons:
Development of FMI (synchronization, interface, etc.)
Increase of the computation time (no real-time application)

On-going H2020 projects on green vehicle :
OBELICS / HIFI-Elements / UPSCALE / VISION-xEV / XILforEV

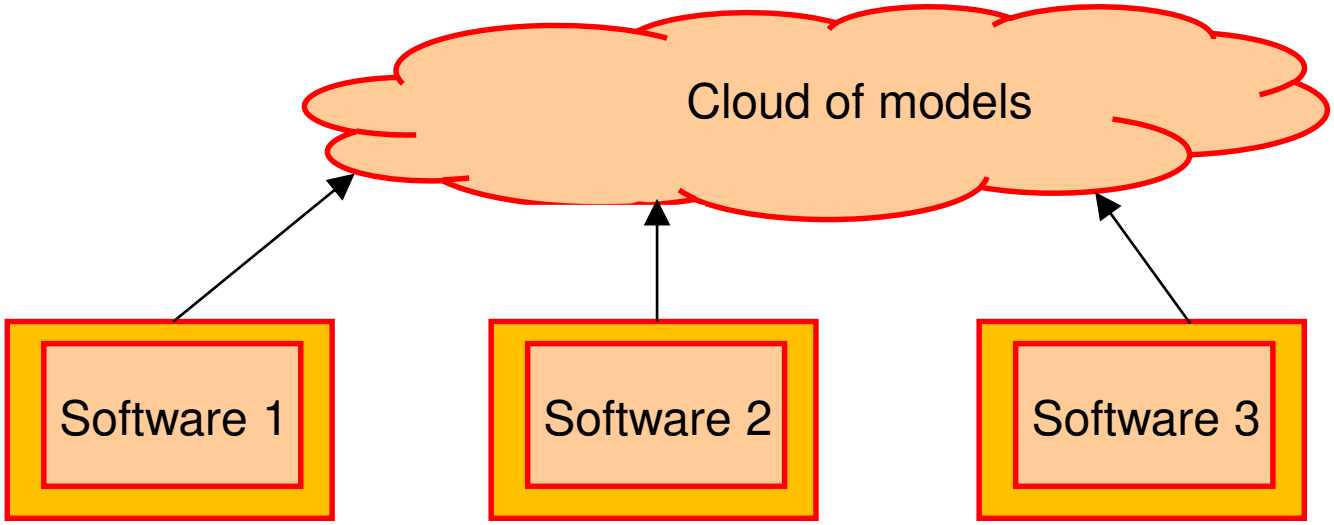
Co-simulation & HIL testing



low computation time
but
lower accuracy

On-going H2020 projects on green vehicle :
OBELICS / HIFI-Elements, etc.

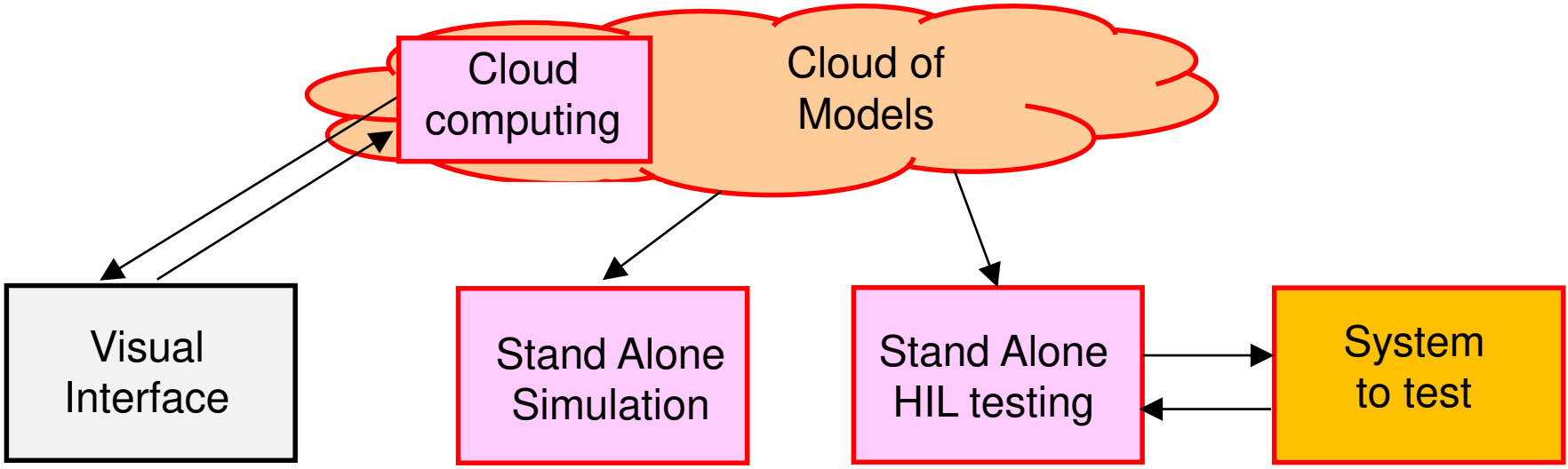
Unified functional organisation



Pros:
Direct connection between models
Fast computation time (possible real-time application)

Cons:
Development of unified functional libraries in different software
Pre-solving of conflict of association

Unified functional organisation (2)

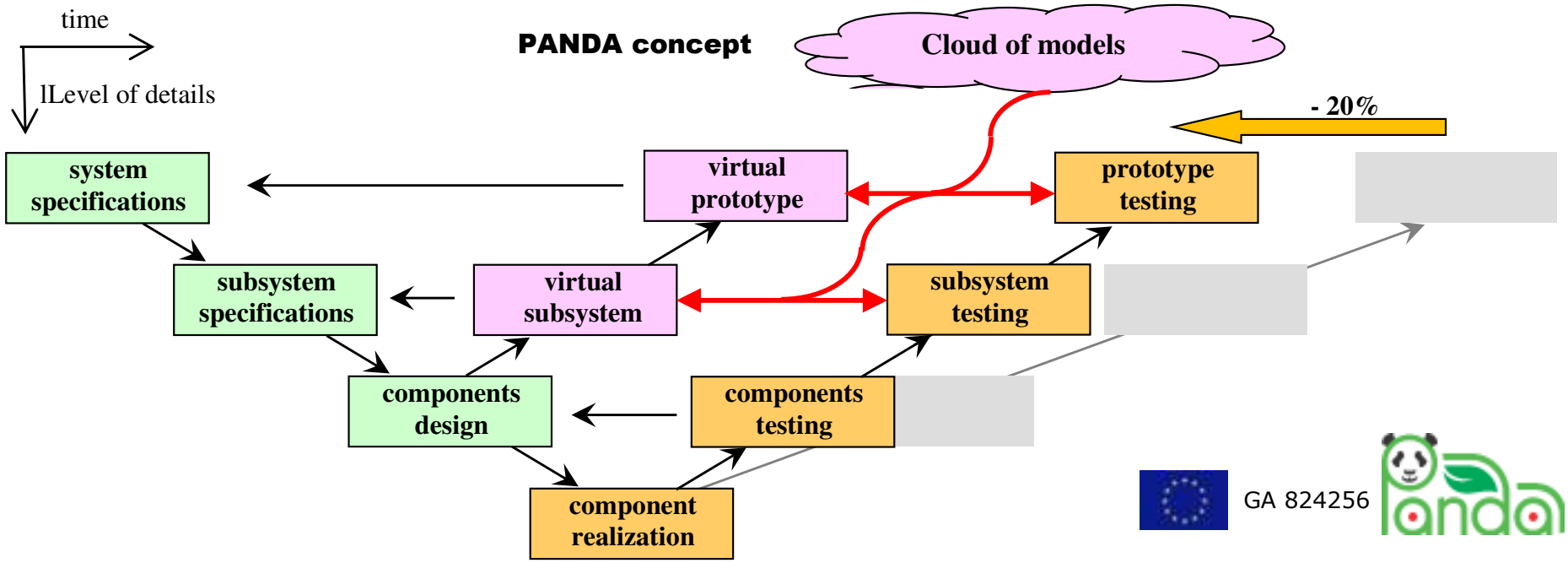


Cloud computing:
No need of powerful computer

Stand Alone computing:
Upload of the models from the cloud
For virtual testing (pure simulation) or real testing (HIL)

Example of PANDA

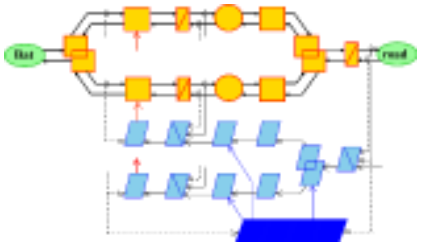
Powerful **A**dvanced **N**-level **D**igital **A**rchitecture for models of EVs and components



Unified model organization for virtual and real testing of electrified vehicles

PANDA developments

EMR formalism



L2EP Laboratoire d'Electrotechnique et d'Electronique de puissance de Lille

Université de Lille

Application to an industrial software

Simcenter AMESIM

SIEMENS Ingenuity for life

study cases

Electric Vehicle

Renault ZOE

RENAULT Passion for life

Fuel Cell Vehicle

MobyPost

UBFC UNIVERSITÉ BOURGOGNE FRANCHE-COMTÉ

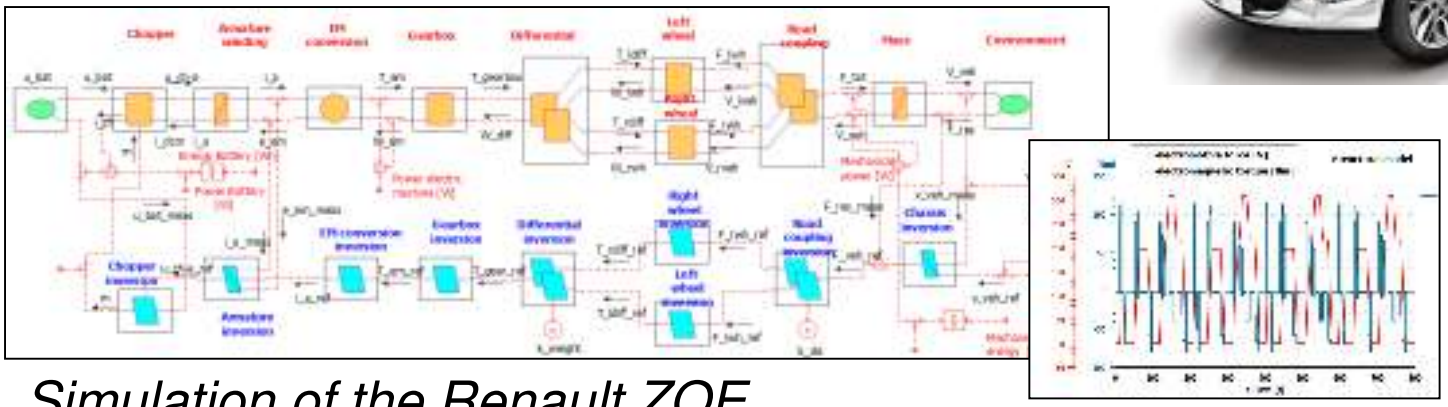
Hybrid Vehicle

48V-based HEV

Valeo

First results

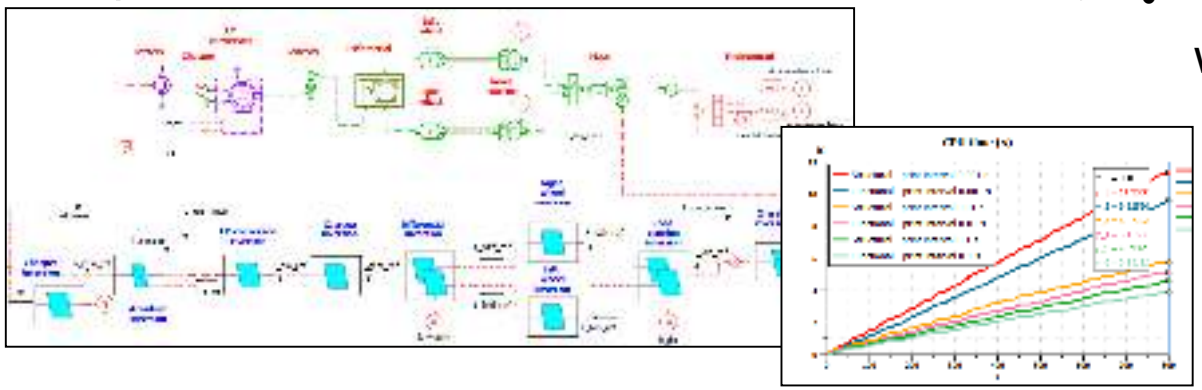
EMR-based (functional) library
In Simcenter AMESIM (structural software)



Simulation of the Renault ZOE

- same model / control
- same accuracy
- -15% of computation time with the functional library

Comparison with the AMESIM structural library:



[Husar VPPC'19]

Conclusion

It’s finished!

Conclusion

From the classical V-model to a W-model for

- Virtual testing of subsystems / vehicles
- Real testing of components / subsystems (HIL testing)

The digitalization of the process requires simulation models of different levels of accuracy for the same component

Two different approaches:

- Co-simulation of structural software packages using FMI
  (easy to use, long computation time, not adapted for HIL testing)
- Unified functional organisation
  (less intuitive, low computation time, adapted for HIL testing)

Our PANDA
Thanks you for your attention !

H2020 PANDA project

https://project-panda.eu/

EMR formalism

http://www.emrwebsite.org/