

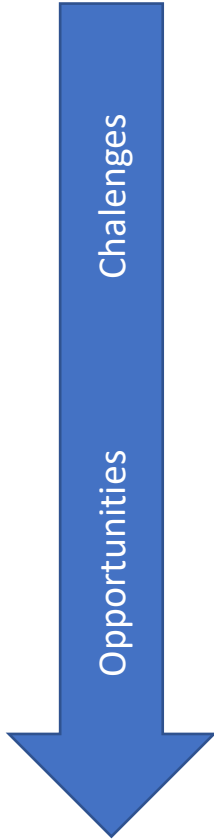


# NEW STAKES FOR NUMERICAL MODELING AND SIMULATION OF CYBER-PHYSICAL SYSTEMS

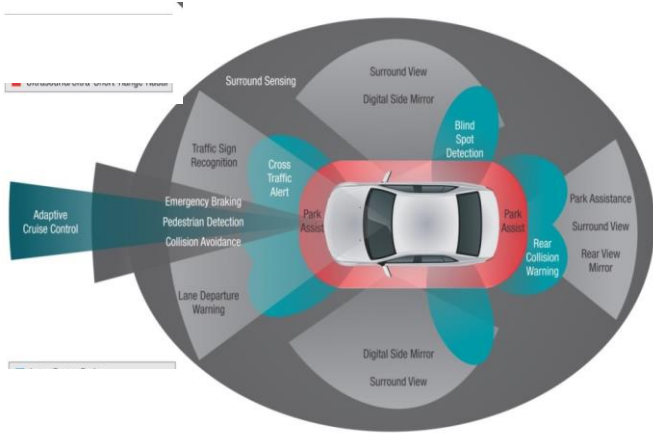


# Agenda

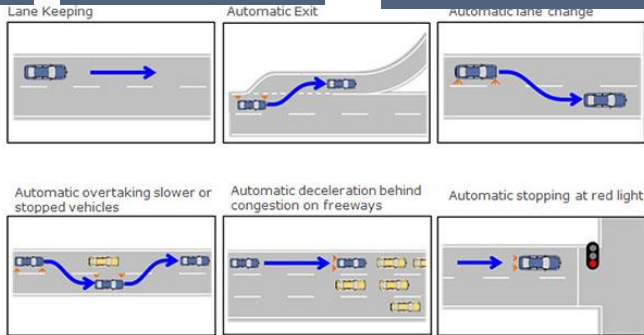
- From mechanical products to Cyberphysical systems
- Increase of complexity : systems, organization
- Evolution of validation/certification context
- New needs for Hi Fidelity modelling
- Bridge to fill the gap between MBSE and numerical modeling
  - New actors
  - New process
  - New tools
  - New communication : MIC



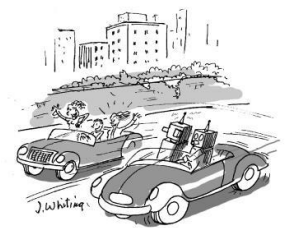
# Automotive industry : autonomous driving



## 1- Sensing      2- Cognition      3 - Decision      4- Actuation



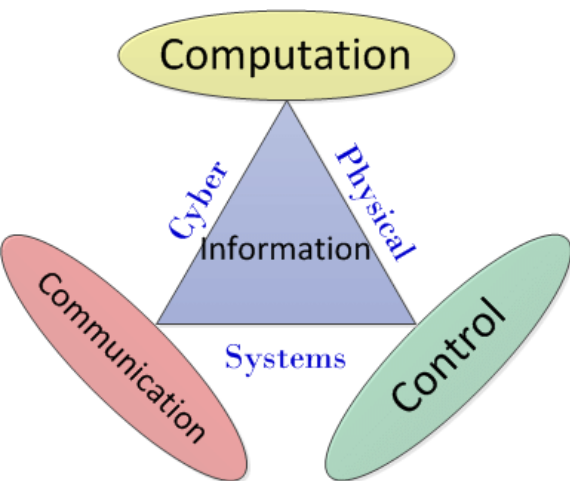
## Validation



"They shouldn't allow humans to drive!"

# Cyberphysical systems

A **Cyberphysical system (CPS)** is a Computer system in which a mechanism is controlled or monitored by computer-based algorithms.



**Cyber** : Computation, communication, and control that are discrete, logical, and switched.

**Physical** : Natural and human-made systems governed by the laws of physics and operating in continuous time.

**Cyber-Physical Systems (CPS)** : Systems in which the cyber and physical systems are tightly integrated at all scales and levels

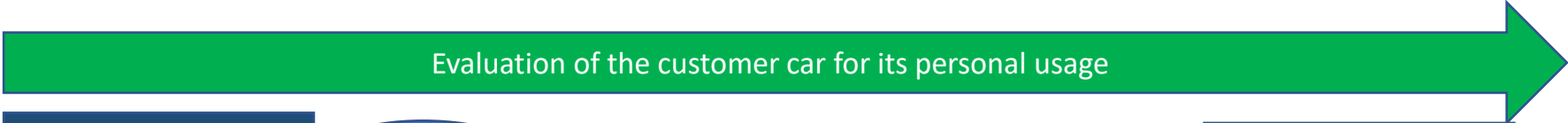
**Connections between parts increase :**

- Physical phenomena
- Control (sensor/ECU/actuators)
- Communication (between control units)

**Complexity !**

# Certification (ex : Automotive industry )

- Robustness of critical performances as safety, fuel consumption,...
- Validation and certification of vehicle tend to be extended to numerous situations



Normative physical test  
=>reproducible



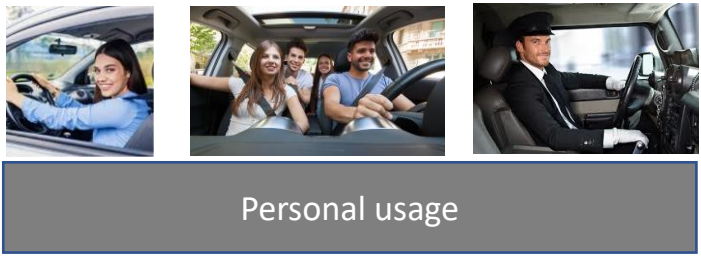
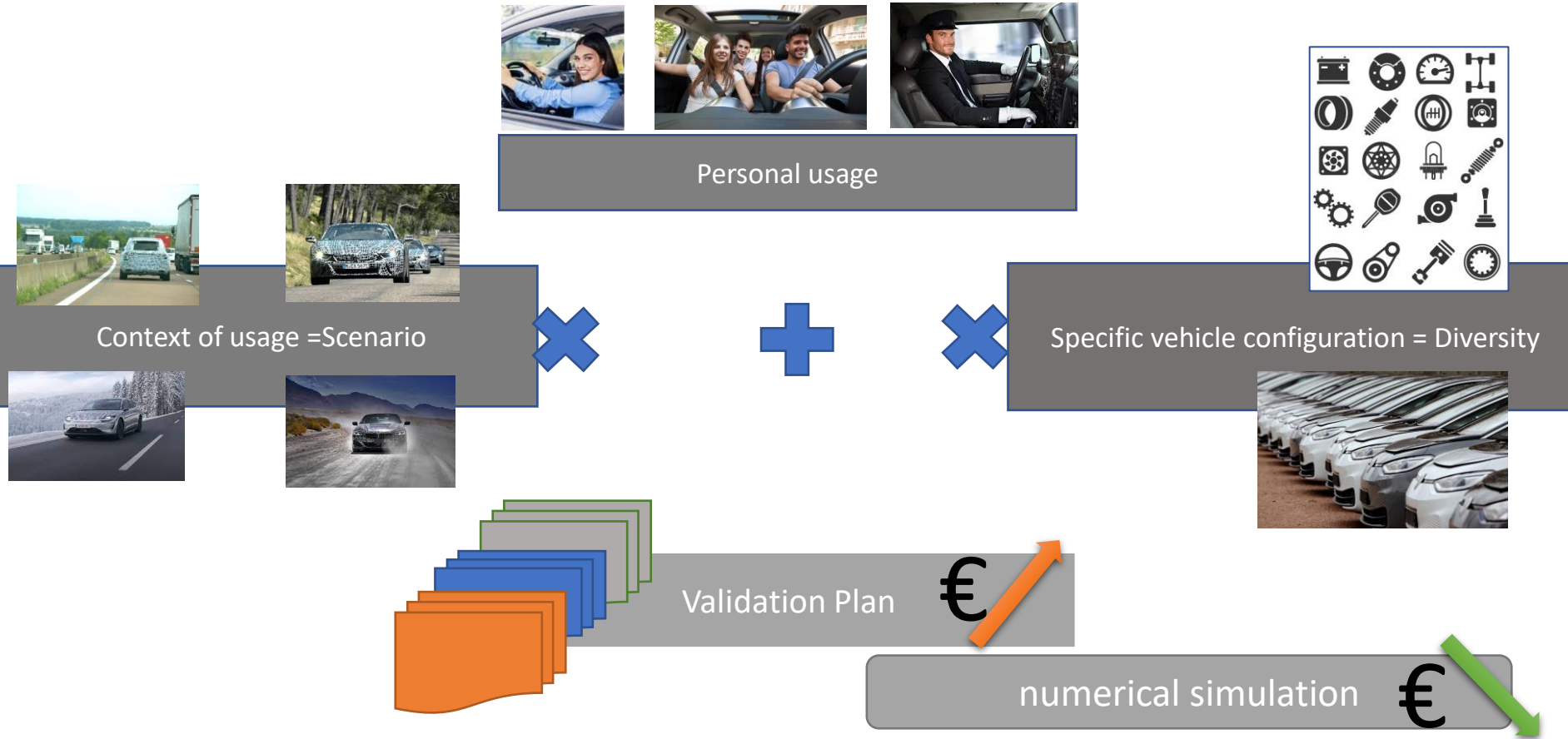
In laboratory

Random evaluation  
=>direct rating

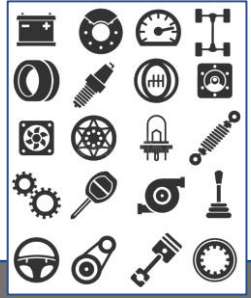


On open road

# Automotive industry : personal usage



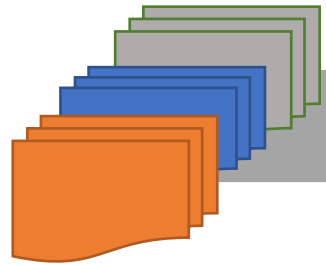
Personal usage



Context of usage = Scenario



Specific vehicle configuration = Diversity



Validation Plan



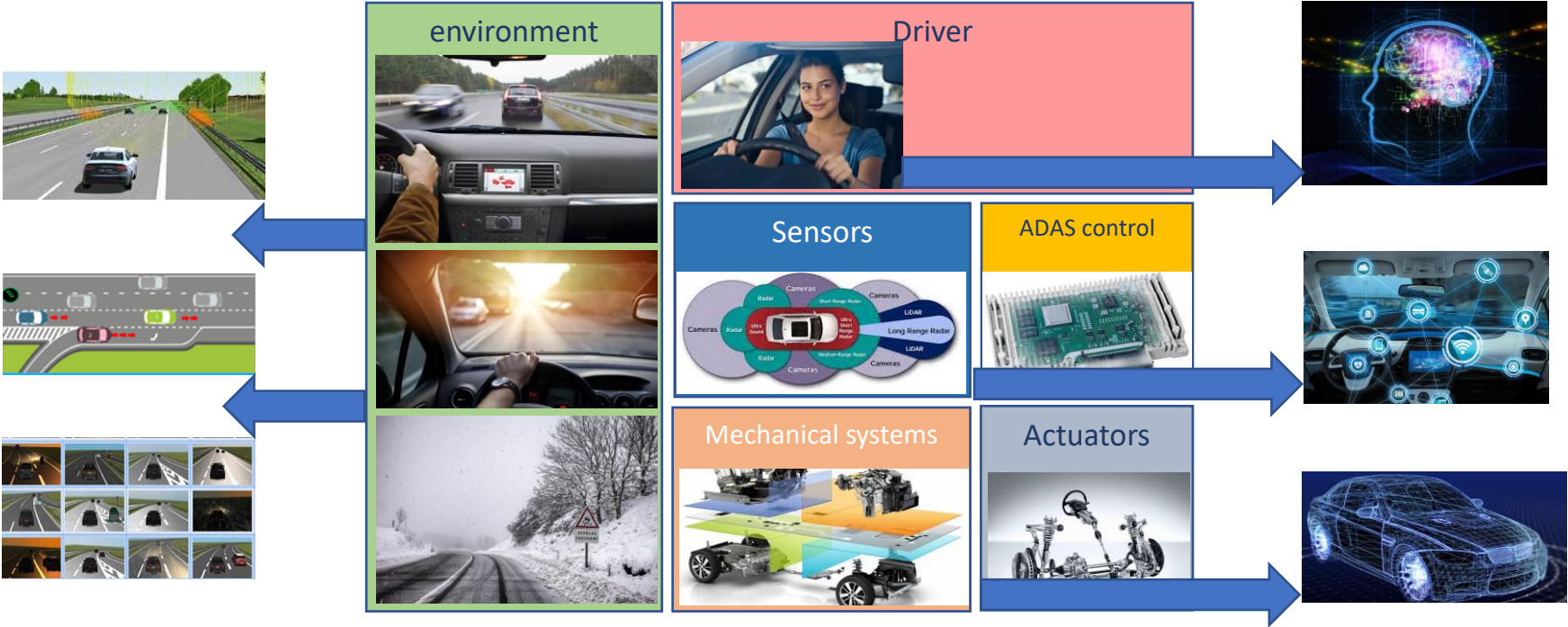
numerical simulation



# Simulation platform for Autonomous vehicle



# A complex assembly of models



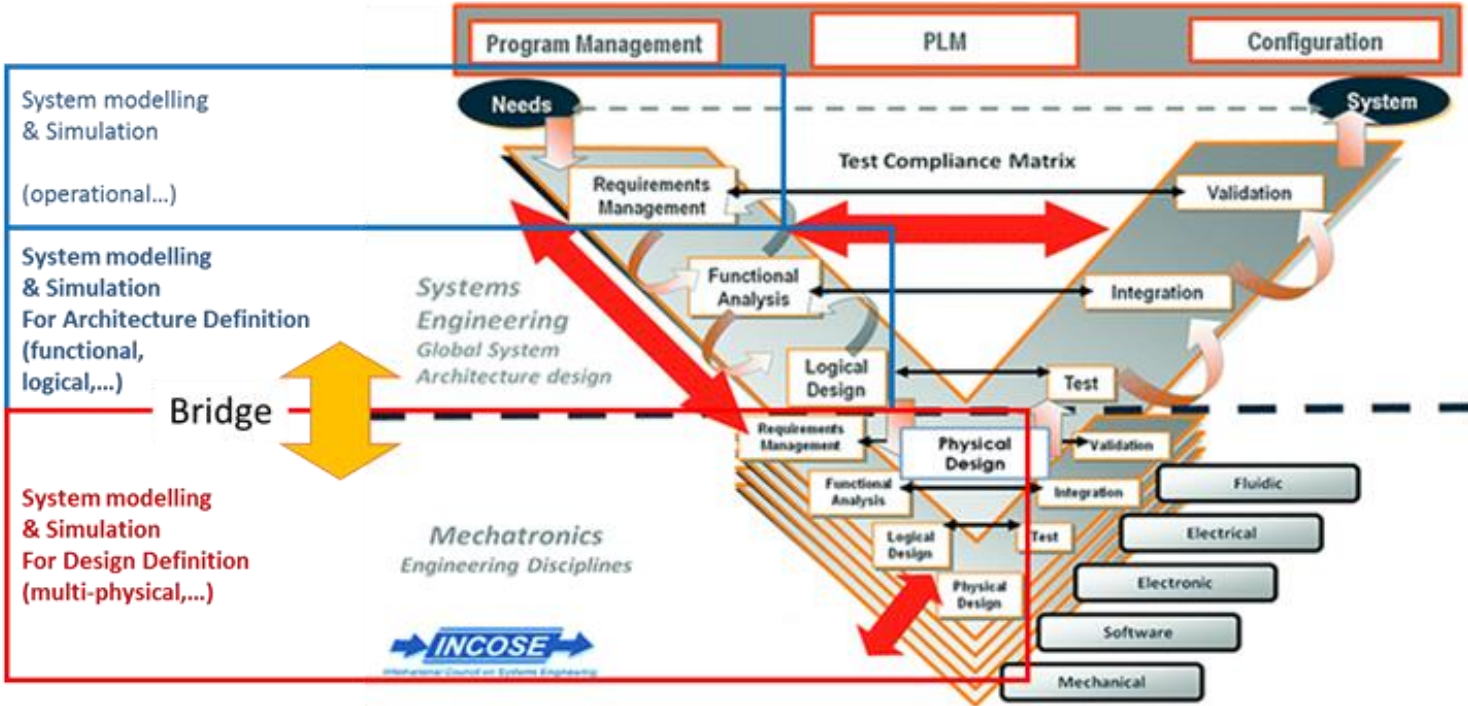
- ⇒ Need to assemble high fidelity model
- ⇒ Accuracy must be equal to physical tests



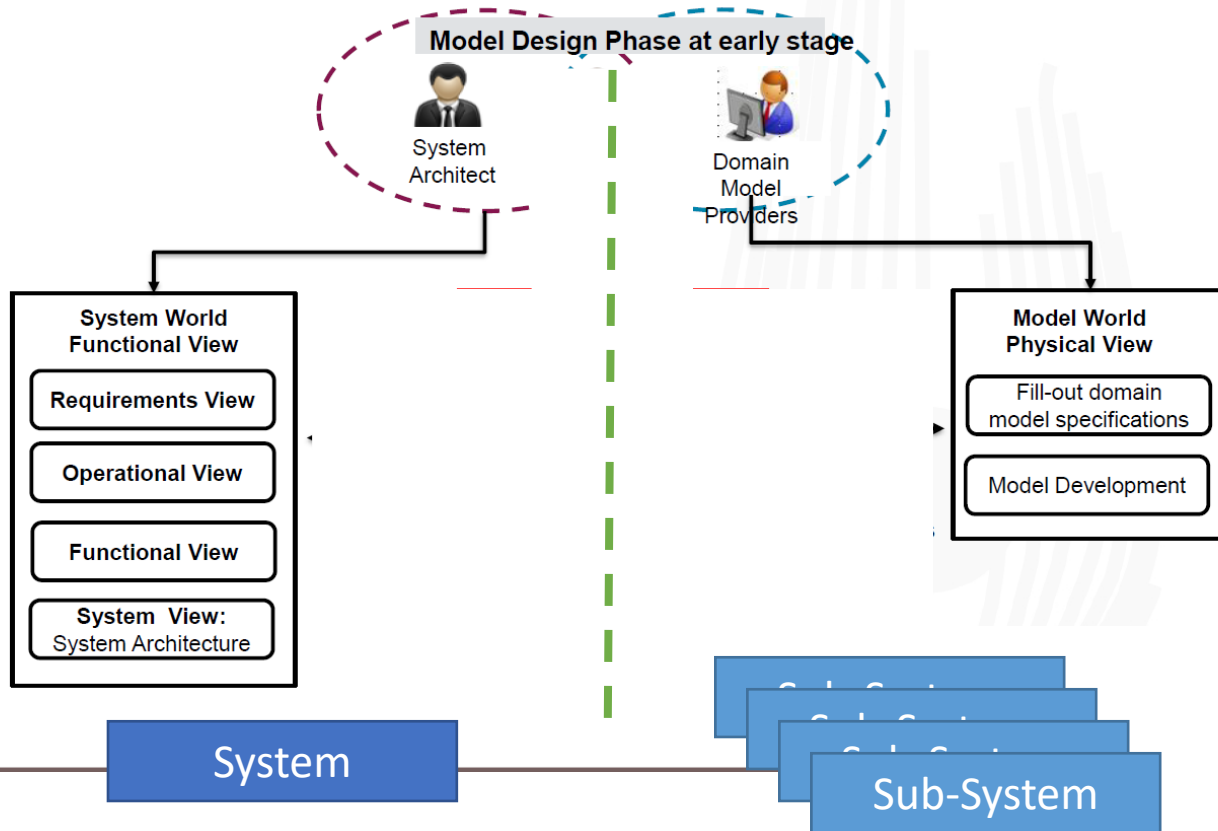
# General view of process and simulation activities

ISO 15288-2015  
 Technical process

- Business or Mission Analysis process
- Stakeholder needs and requirements definition process
- System requirements definition process
- Architecture Definition process
- Design Definition process
- Implementation process



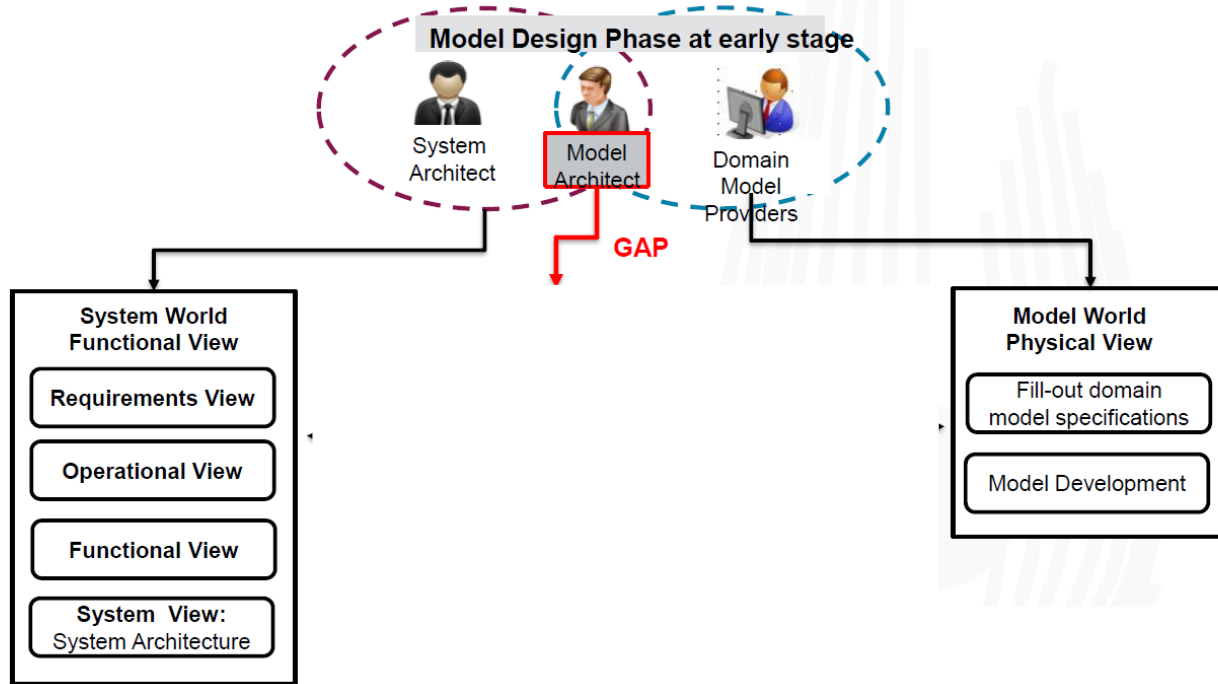
# Relationship between actors



## Actors are:

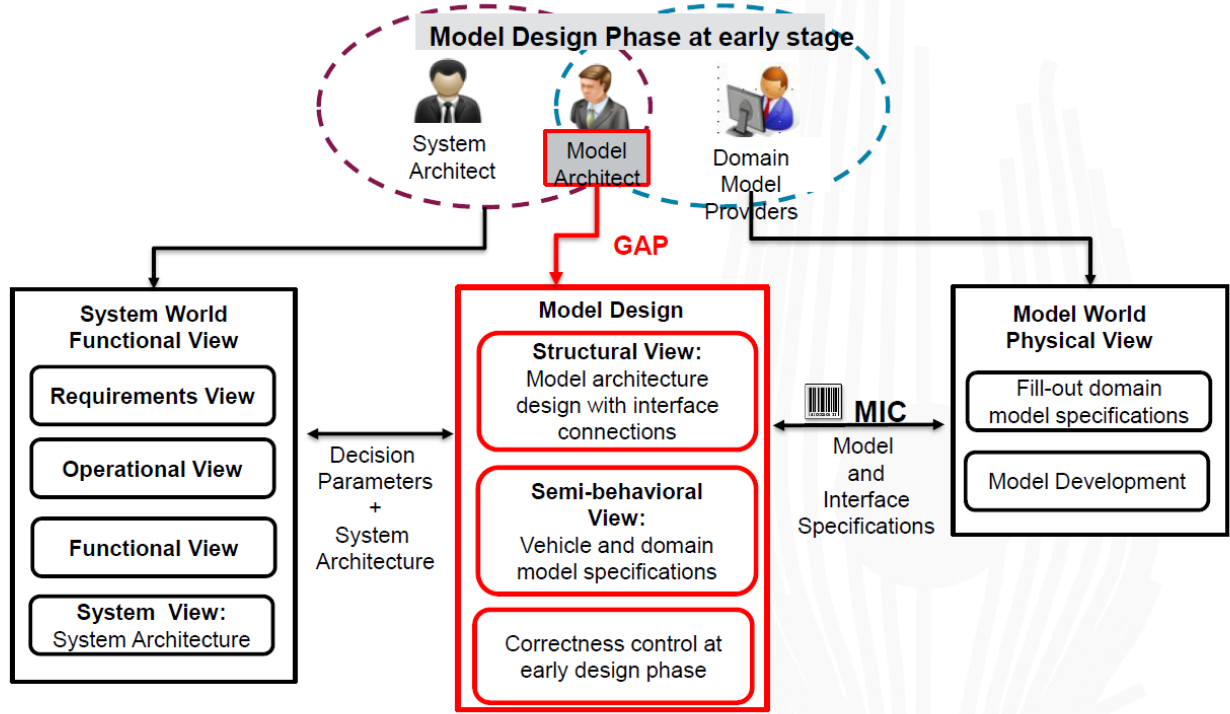
- Belonging to different teams or organization
- Developing models of different kinds
- Working with different process
- Using different methods and tools
- Using different references

# Relationship between actors



New role : model architect for managing the model of the vehicle and the assembly of models

# Relationship between actors



New role : model architect for managing the model of the vehicle and the assembly of models

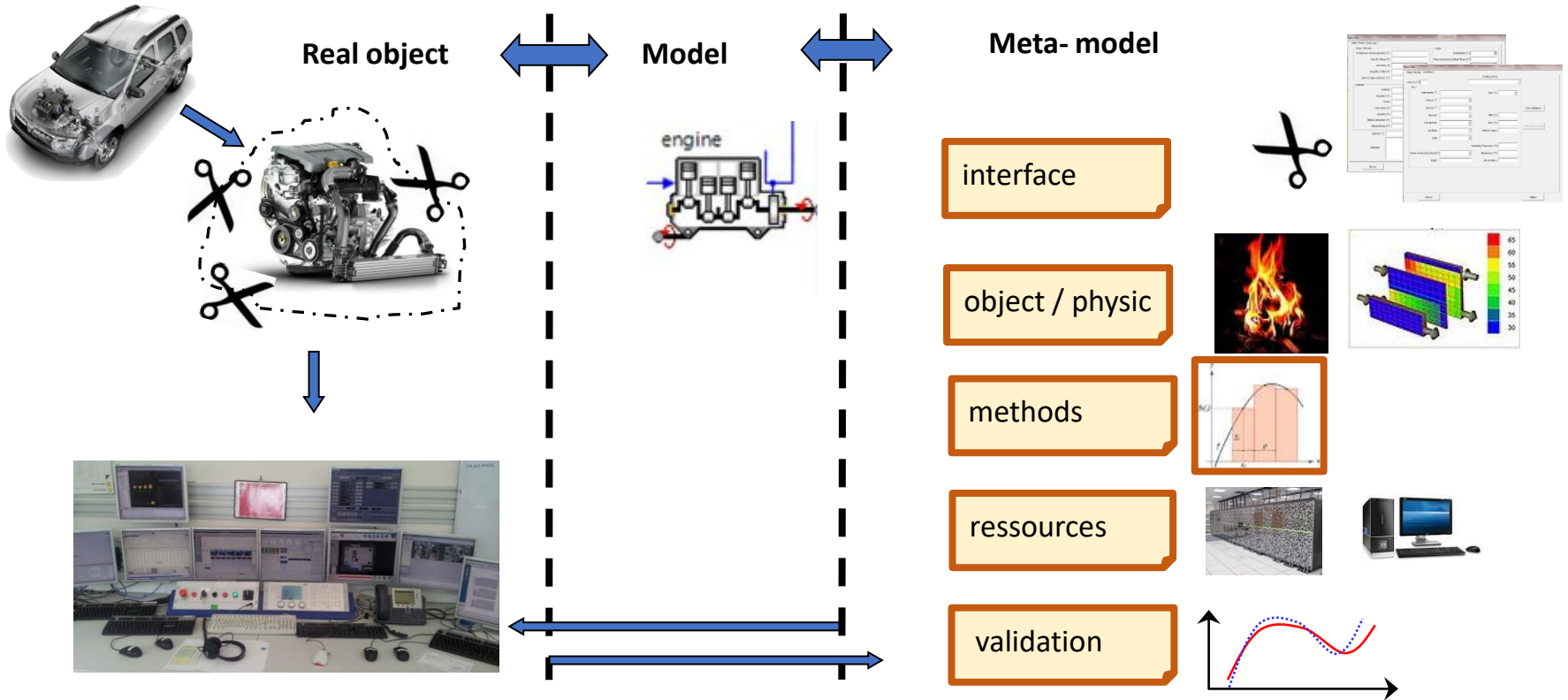
New processes for organizing the cooperation between actors

New methods and tools for transferring, exchanging and transforming models

Metamodel (Model Identify card) for facilitating the communication between actors without ambiguities

MIC: Model Identity Card

# MIC = Model Identity Card : 5 sets of items

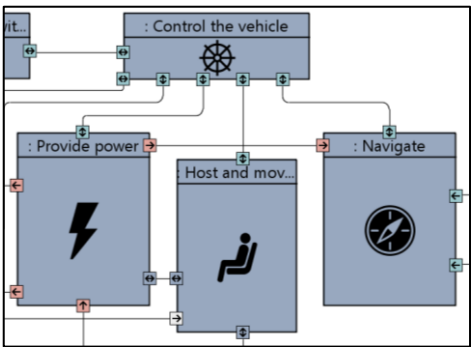


# Agility in simulation based desing :Numerical continuity

**SYSTEM ARCHITECT**



**System architecture**



Part of the system to simulate ?

Environment scenarios?

Observables, parameters ?

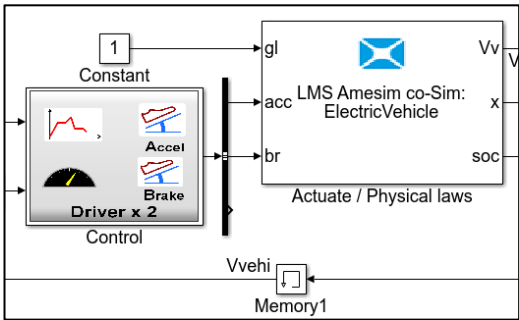
Correct representation of the system?

How to choose simulation models, re-use ?

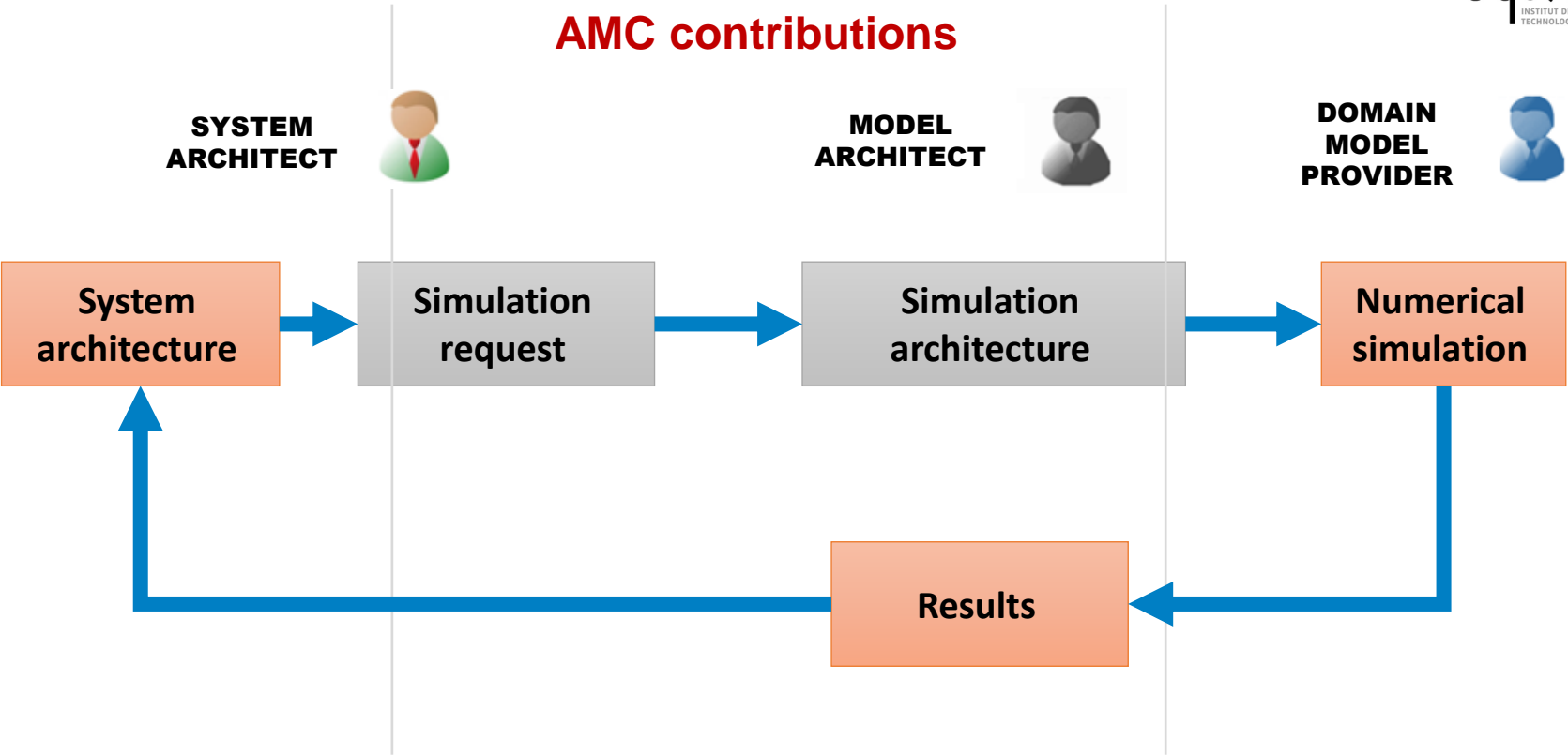
**DOMAIN MODEL PROVIDER**



**Numerical simulation**

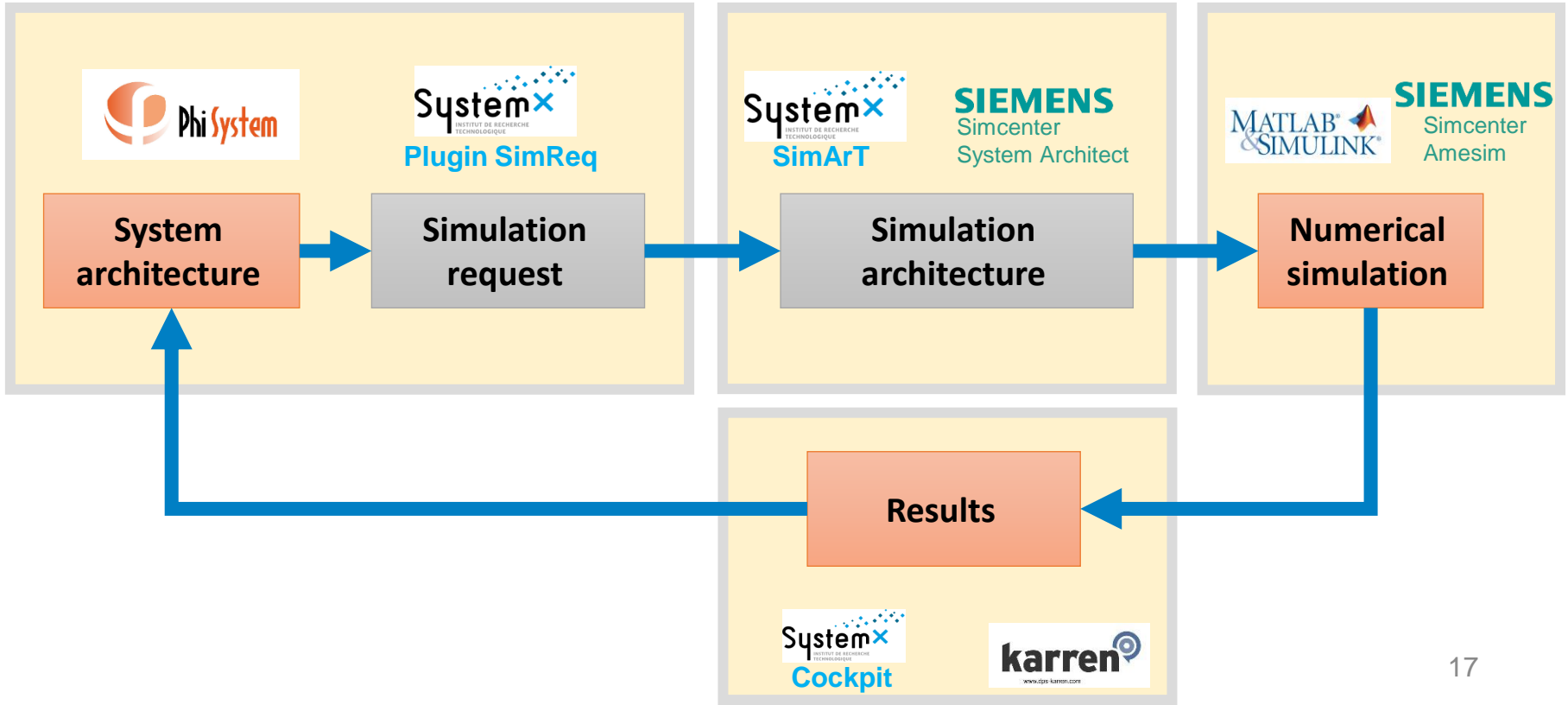


# Agility in simulation based desing :Numerical continuity



# Agility in simulation based desing :Numerical continuity

## Tooled methodology (illustrated on automotive use case)





# Publication of a white paper

- MIC specification document available at :
  - <https://mic.irt-systemx.fr/#/mic>

**MIC: Model Identity Card**  
Toward a standard to characterize simulation models

MIC Model Identity Card Partners Contact

### For a better characterization of simulation models

Simulation became a key enabler for the development of various systems, from their early development to their validation. Simulation needs are particularly important for complex systems. They include a large number of interesting components, and their behavior is difficult to predict without extensive computations.

The increasing use of simulation requires a better management of the simulation models. Simulation models need to be characterized with a variety of key information covering, for example, the represented system, the modeling choices, the hardware and software integration or the format concerning their use. This characterization can have different purposes depending on the strategic goals of the simulation model.

In the past, most systems were validated with a limited number of physical tests representing several cases scenarios. Indeed, physical tests were relatively expensive. Simulation can offer predictions at a lower cost and permit to cover a greater variety of cases. For all performances associated to safety, a risk of physical tests and simulation became mandatory to ensure a robust validation.

The Model Identity Card (MIC) offers a reference list of key information to characterize simulation models, both for specification and description. The MIC is made of tests organized in groups.

### A standard common denominator of simulation characteristics

The MIC is defined as the set of core information which appears to be useful to characterize most simulation models in most contexts. It does not intend to comprehensively cover every aspect of any simulation model. The MIC can be considered as a standard common denominator of simulation characteristics.

Please send all the comments and feedbacks you may have about the MIC through the contact page. They will be analyzed by the different partners working on the MIC (see the partners pages) to improve its definition. Please feel also free to use the contact page if you would like to become a partner and join us in the work.

Created in collaboration with:

SystemX Renault PSA  
Valeo Siemens  
SETIlevel

To download the associated documents please use the buttons below:

Specifications (pdf) ↓  
Introductory document (pdf) ↓

① General information  
Integration  
Content and computation  
(x, y) Ports, internal variables, and parameters  
Verification and validation

# Summary

1. Cyberphysical systems are more and more complex due (especially) to communication between sub-systems
2. Validation and certification of Cyberphysical systems request extended testing plan to cover scenario and diversity

**=> Hi-fidelity numerical modeling is needed to ensure the extended validation plan in support of the physical testing**

1. Numerical model must be initiated from the model-based design system by using a bridge (which is under development).
2. New role of actors are defined and their relationship must be supported by new methods : Metamodel (Model Identity Card for example)

# MELISSA



MICRO-ECOLOGICAL  
LIFE SUPPORT SYSTEM  
ALTERNATIVE

**THANK YOU.**

**Landel Eric**

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