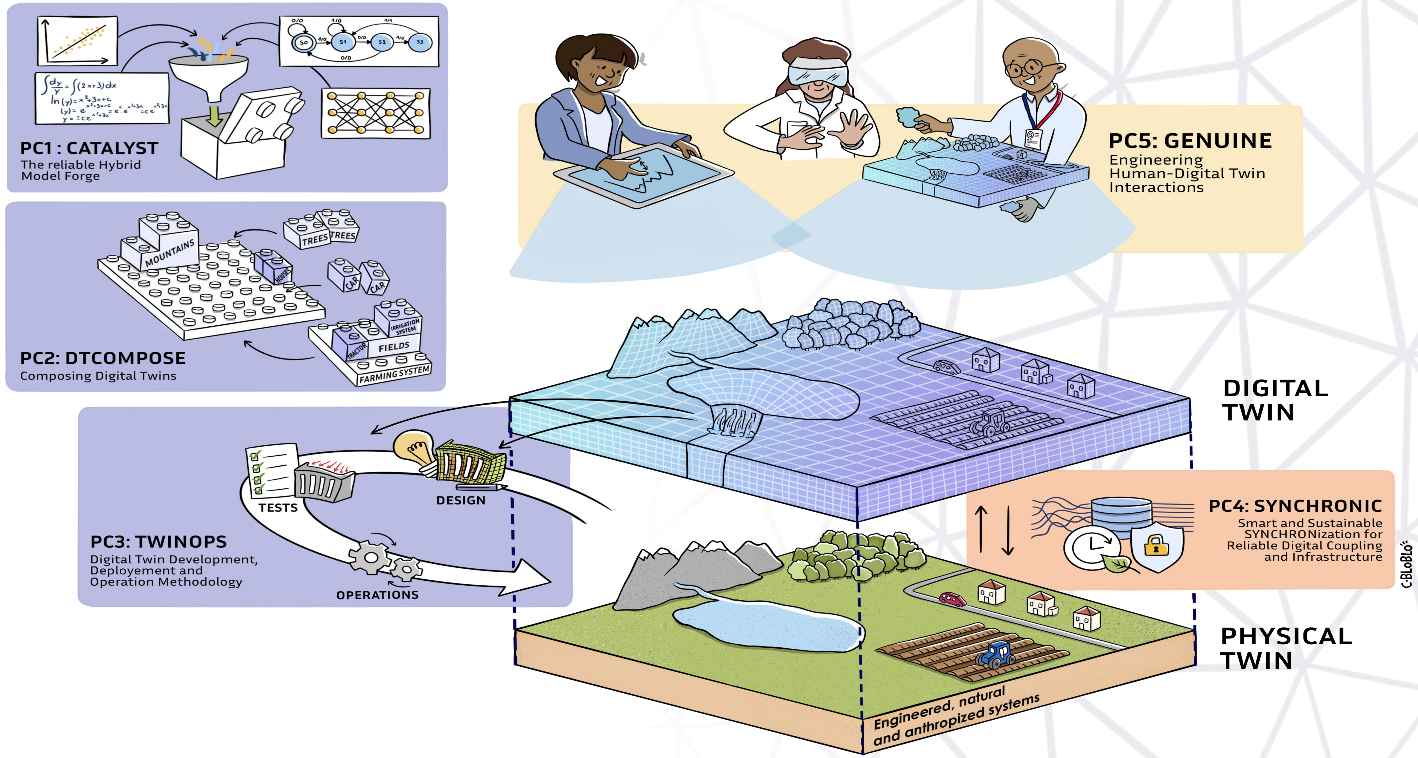
PC1: Catalyst

The Reliable Hybrid Model forge



Participating Partners:

Inria, Université Côte d'Azur, INRAE, Université de Pau et des Pays de l'Adour, Telecom Paris, CEA, Université de Toulouse, IMT Atlantique Bretagne-Pays de la Loire École Mines-Télécom, CNRS

External Partners:

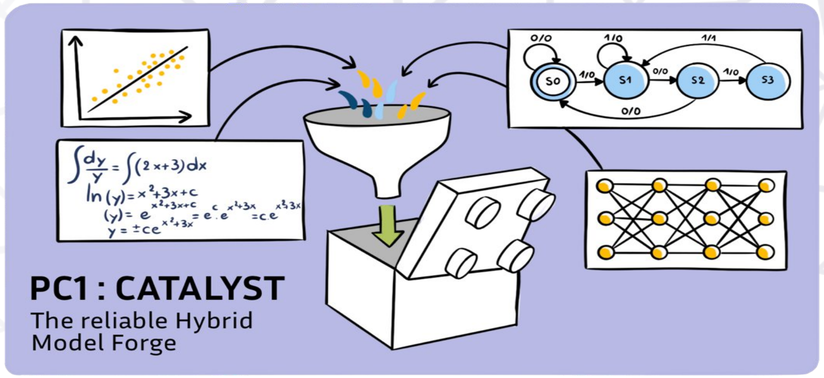
CETIM

→ 25 Participants Enrolled so far

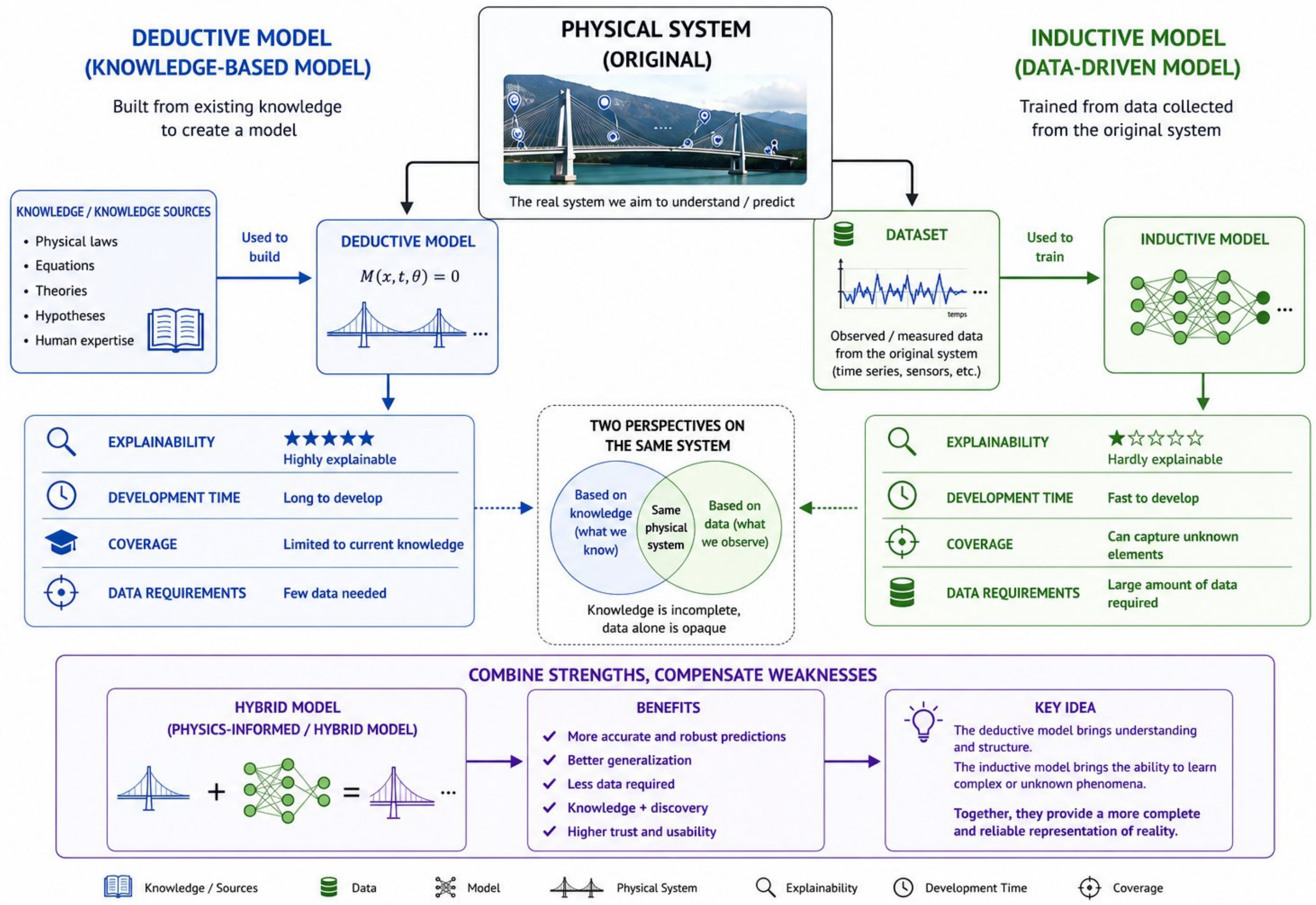
Models in DT

A Digital Twin is an organized and intricate set of digital models representing an intended or actual “original” object or system throughout its lifecycle.

- where a **model may serve as a substitute for the represented asset when addressing specific questions**.

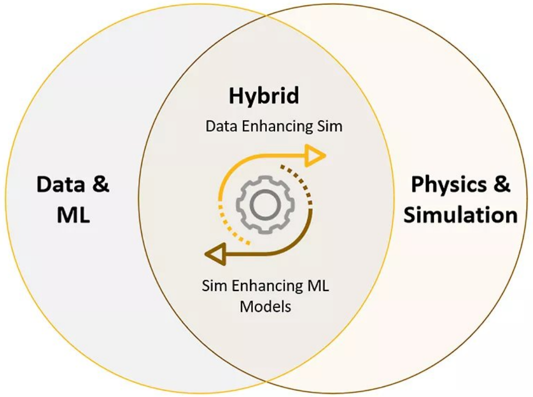


(hybrid) Models in DT

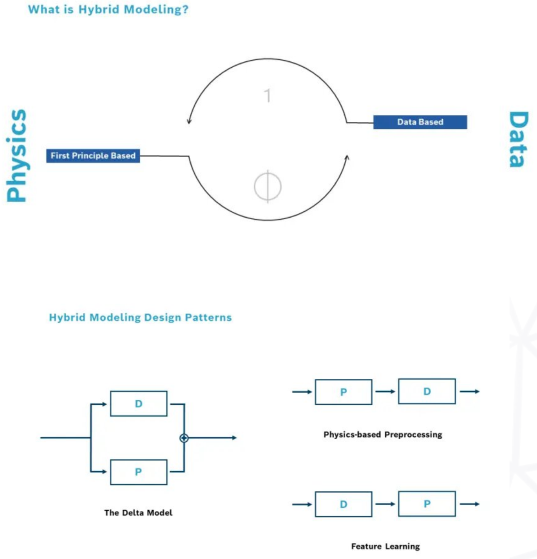


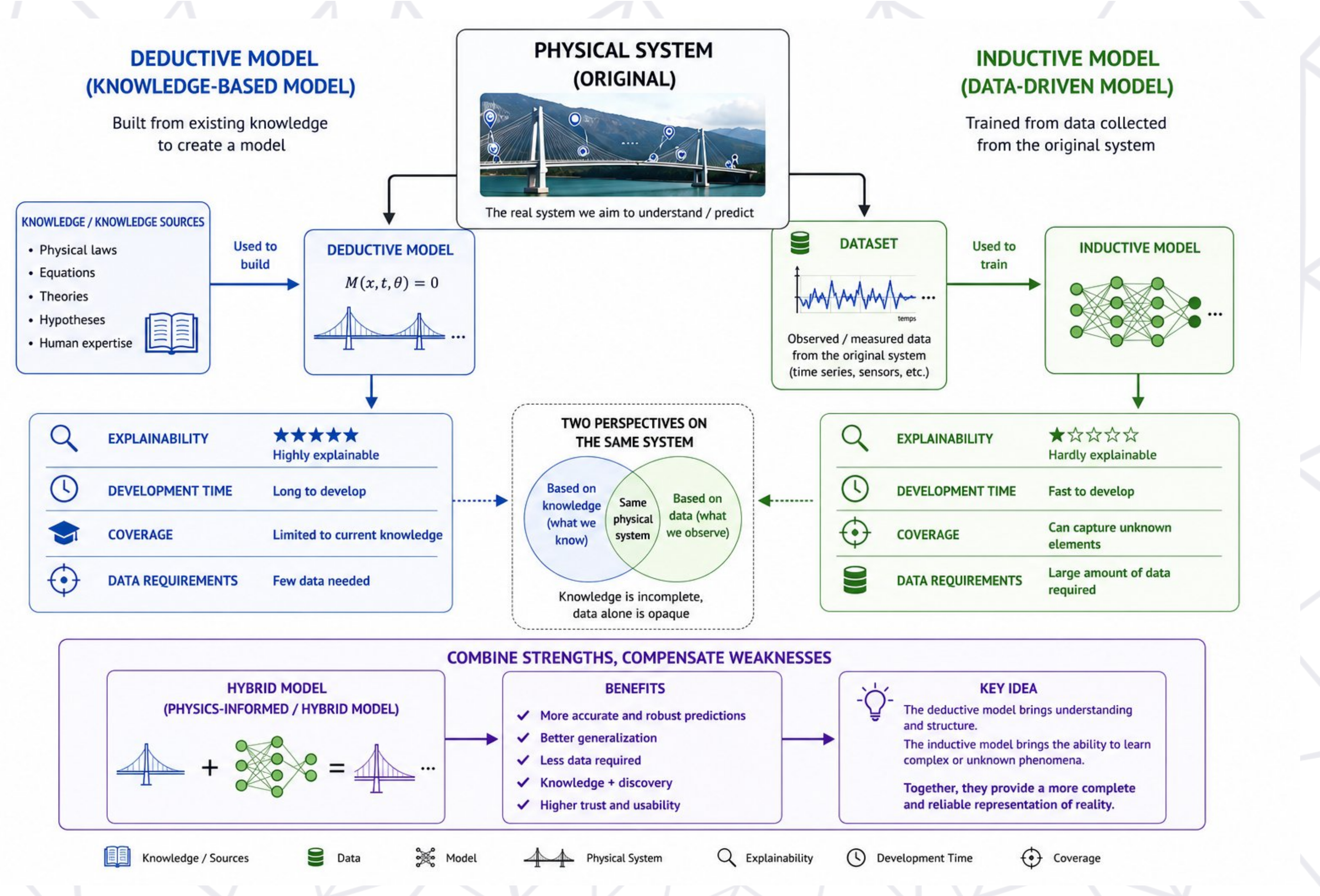
(hybrid) Models in DT

[Ansys](#)



[Bosch](#)





Reality of (hybrid) Models in DT

Behind the scenes, hybrid modeling suffers from

- [⚙] Technical heterogeneity across models
- [👥] Inconsistent modeling practices and skill sets
- [🔧] Manual, ad hoc hybridization approaches
  - [?] Limited transparency in the rationale
  - [◐] Hidden but critical design and dimensioning choices
  - [≈] Benefits that are difficult to characterize (at least a priori)
  - [#] Extensive technical hard-coding

Catalyst:TheReliableHybridModelF

Project Implementation, the one slide

Three Cohesive work packages, driven by **eight PhD thesis**, all **co-advised** amongst the **ten partners**, with at least three **common use cases**.

$\longrightarrow$ **multi-fidelity** and **uncertainty** addressed throughout.

- WP 1: Interface for Hybridization(s)
- WP 2: Hybridization and Federation Operators
- WP 3: Interface and Composition Analysis

Documents
Software

M18 — **D1.1 :** State of the Art

M24 — **D1.2 :** Conceptual Architecture

M36 — **D1.3.1:** Interface Enricher & Model Composer; **D1.3.2:** Prototypes

M48 — **D1.4.1:** Integration & Technical Architecture; **D1.4.2: 1st Catalyst Integration**

M54 — **D1.5.1:** Final Results; **D1.5.2:** Catalyst Demonstrator

Project Implementation

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→ **multi-fidelity** and **uncertainty** addressed throughout.

- WP 1: Interface for Hybridization(s)

  Leader: UPPA
  Partners: Inria (DiverSE, Hycomes, Kairos), UniCA, INRAE, Telecom Paris (ACES)

  Objectives:
    - Standardize the manipulation and characterization of heterogeneous models
    - Ensure homogeneous and automatic reasoning while preserving model specificity

  Key Tasks:
    - Create structured metadata for model management
    - Provide functional and extra-functional interfaces for hybridization
    - Enable model mutation and adaptation capabilities

- WP 2: Hybridization and Federation Operators
- WP 3: Interface and Composition Analysis

Project Implementation

Three Cohesive work packages, driven by **eight PhD thesis**, all **co-advised** amongst the **ten partners**, with at least three **common use cases**.

→ **multi-fidelity** and **uncertainty** addressed throughout.

- WP 1: Interface for Hybridization(s)
- WP 2: Hybridization and Federation Operators

  Leader: Kairos (Inria)
  Partners: DiverSE (Inria), INRAE, IRIT/ACADIE (CNRS), Telecom Paris (LabSoc)

  Objectives:
  - Identify and formalize structural and behavioral hybridization patterns
  - Replace ad-hoc processes with systematic hybridization operators

  Key Tasks:
  - Elicit and formalize operators for simulation workflows
  - Define operators for model hybridization
- WP 3: Interface and Composition Analysis

Project Implementation

Three Cohesive work packages, driven by **eight PhD thesis**, all **co-advised** amongst the **ten partners**, with at least three **common use cases**.

→ **multi-fidelity** and **uncertainty** addressed throughout.

- WP 1: Interface for Hybridization(s)
- WP 2: Hybridization and Federation Operators
- WP 3: Interface and Composition Analysis

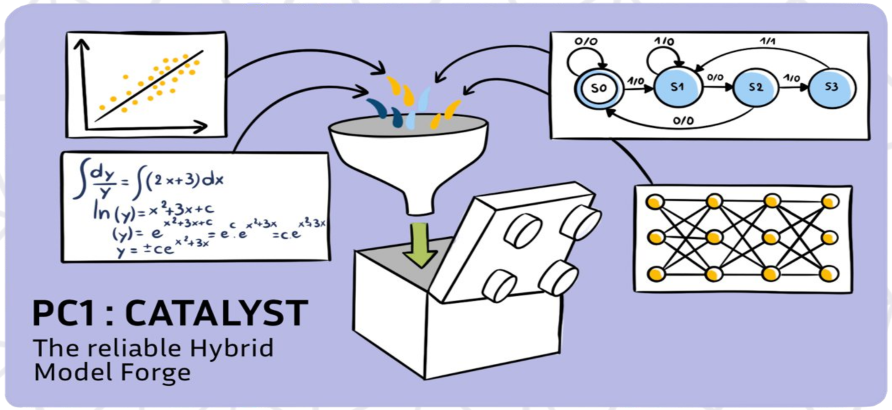
Leader: Telecom Paris (LabSoc)
Partners: Inria (DiverSE, Hycomes), CNRS IRIT (ACADIE), UPPA, CEA (LITEN), UniCA, Univ. Toulouse (Aniti), Univ. Toulouse Jean Jaurès (IRIT/SM@RT)

Objectives:
- Provide analysis of models, interfaces, and hybridization operators

Key Tasks:
- Analyze models to enrich their interfaces
- Identify synergies and hybridization opportunities across interfaces
- Analyze hybridization operators to improve resulting model interfaces

Current Status

- Virtual Kick-off held in May
- In-person Kick-off planned for late of summer
- PhD thesis:
  - 2 Active (started),
  - 3 Starting in October
  - 1 Pending (likely starting in October)
  - 2 Under active recruitment.



Catalyst extra Slides

- Thesis list and status
- Envisionned Common Use Cases

Catalyst research focuses (PhD subjects)

- Smart Scenario Exploration for Digital Twins through Validity Envelopes
- Explainable and Traceable Hybrid Model Management for Digital Twins
- Model Hybridization in Digital Twins for Mechanical Engineering *

  ** financée par un accord bi latéral avec le CETIM*
- Compositional Hybrid Digital Twins for Fermented Microbial Ecosystems
- Formal Engineering Methods for Digital Twin Development
- Interpretable and Robust Machine Learning for Physics-Based Numerical Simulations
- Structural Methods for Mixed Model/Data Digital Twin Engineering
- Distributed Abductive Reasoning for Self-Explaining Digital Twins

Thèse Commencée
Candidat·e trouvé·e
Candidats potentiels

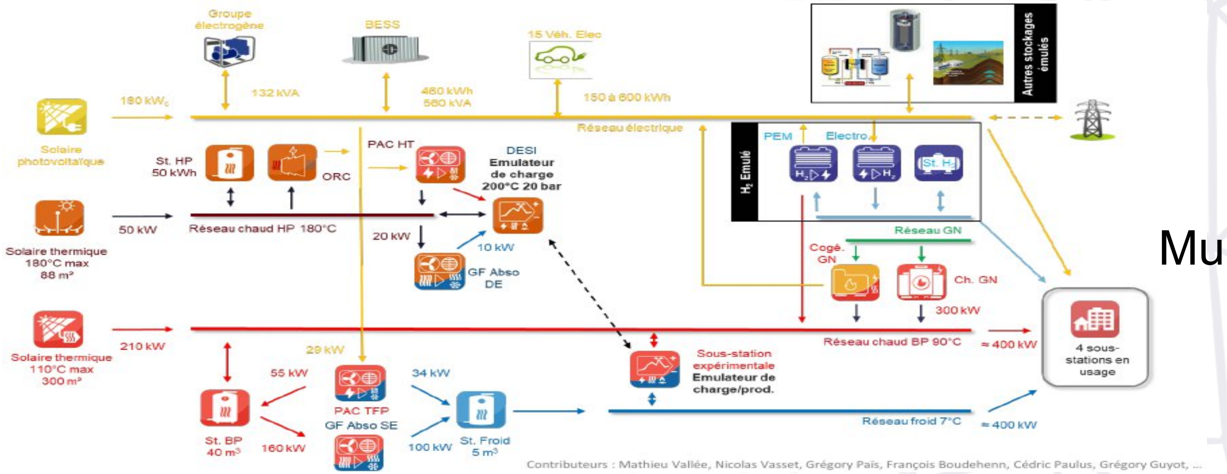
Engineering Digital Twins Catalyst

i3S sophia antipolis UNIVERSITÉ CÔTE D'AZUR

Uses cases

- Still open ; should federate all of us.

JNEM - thermal-hydraulic loop



Multi-Energy System

FermenTwin