

System-Level Testing Approach

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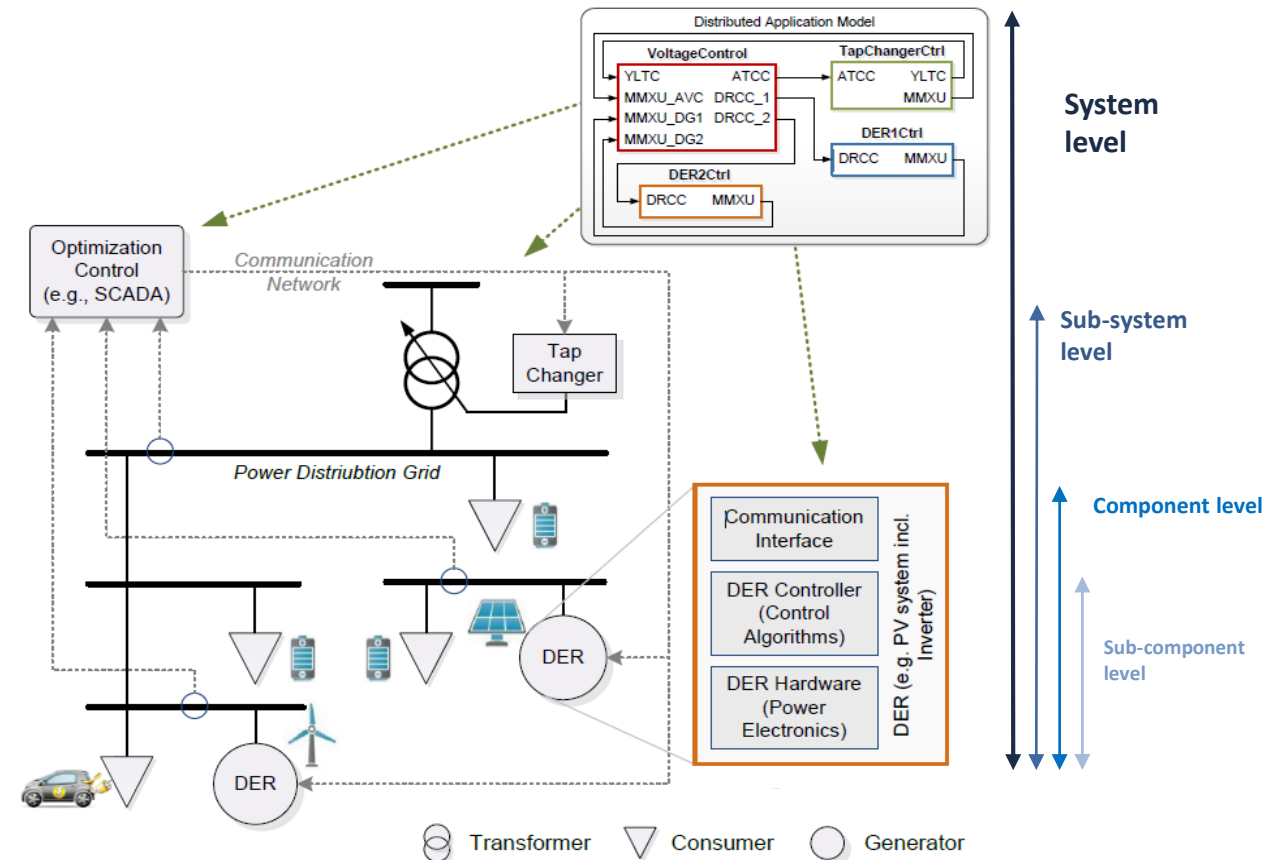
Virtual ERIGrid Final Conference

April 1, 2020

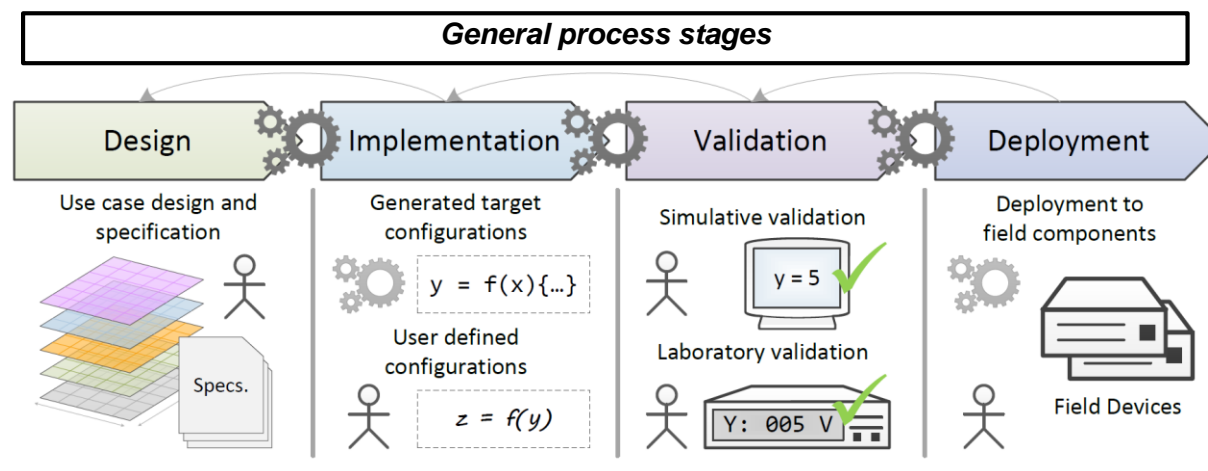


Complexity in Cyber-Physical Energy Systems

- Integration of
 - Innovative information and communication technologies
 - Power electronic-based grid components
- Advanced system functionalities (e.g. ancillary service provision)
 - Intelligence on different levels of CPES



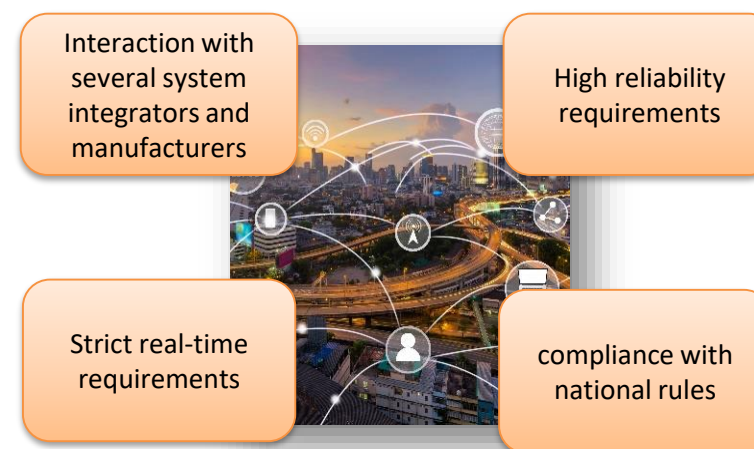
Design and validation of CPES



Validation of multi-domain cyber-physical system of systems are known from other domains (e.g. aviation, automotive)



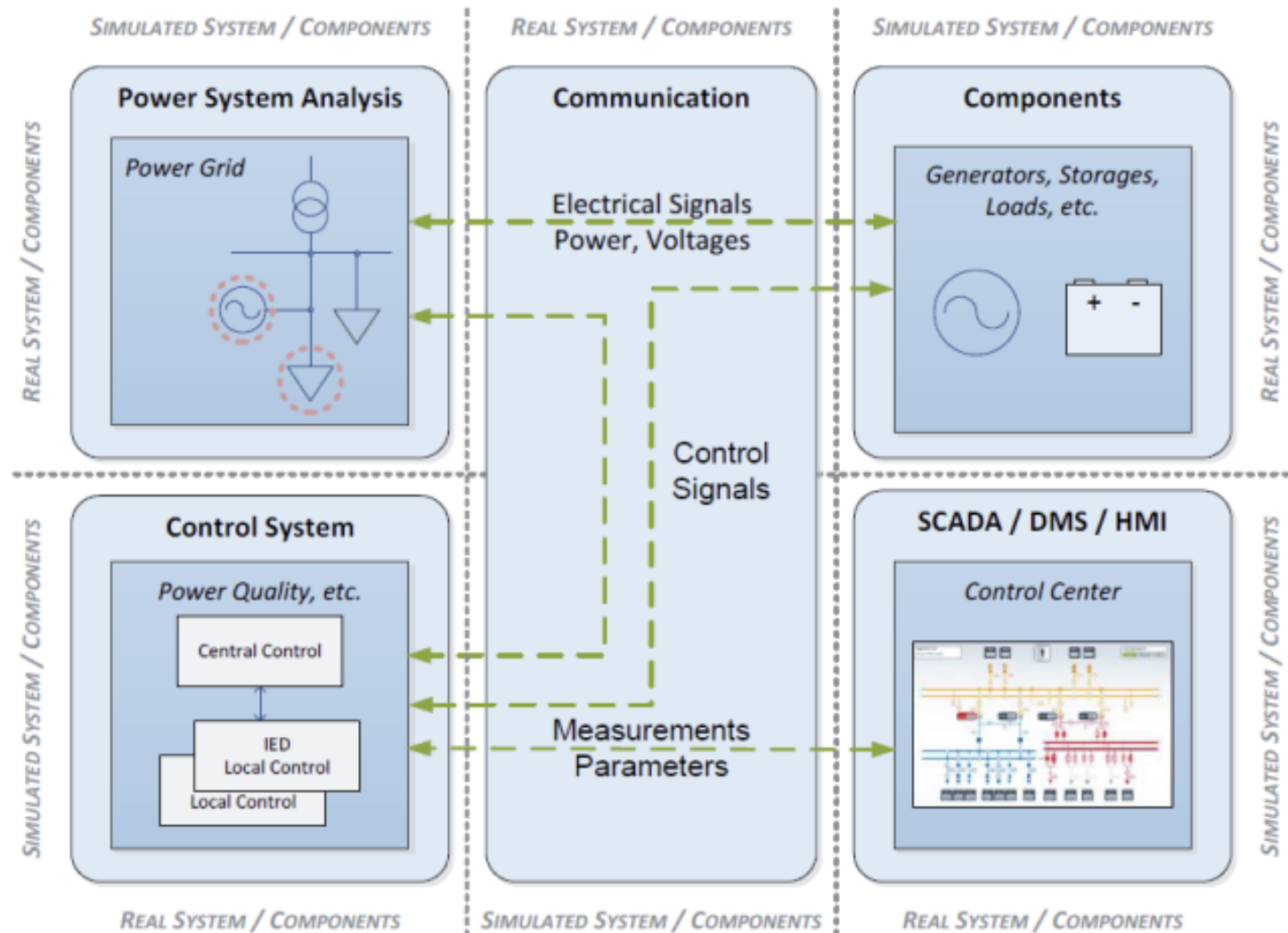
So, challenges in CPES?



Even more to think about!

CPES validation over advanced testbeds

- CPES validation and related test experiments need to be carried out over improved tools that combine virtual and real components.

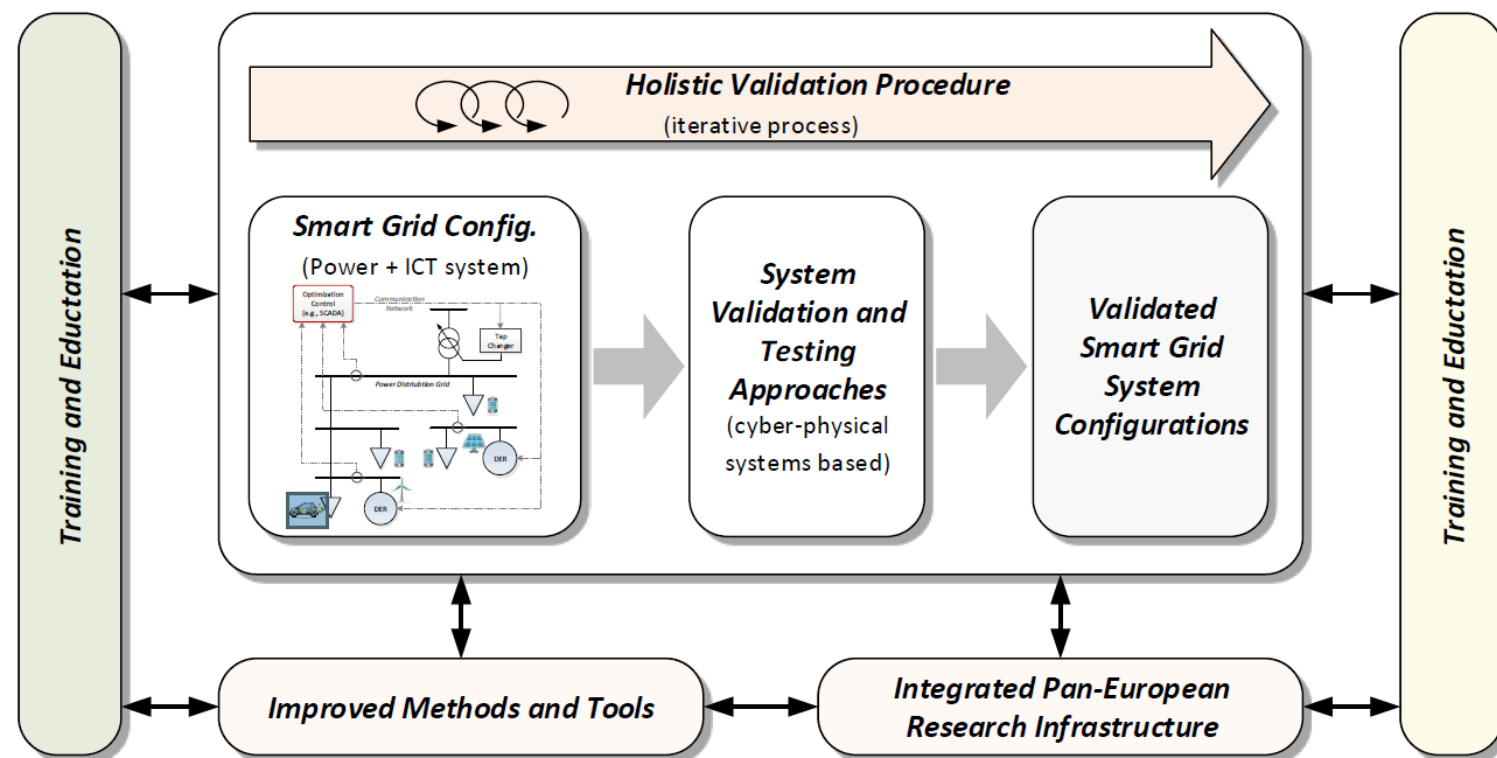


So what do we need?

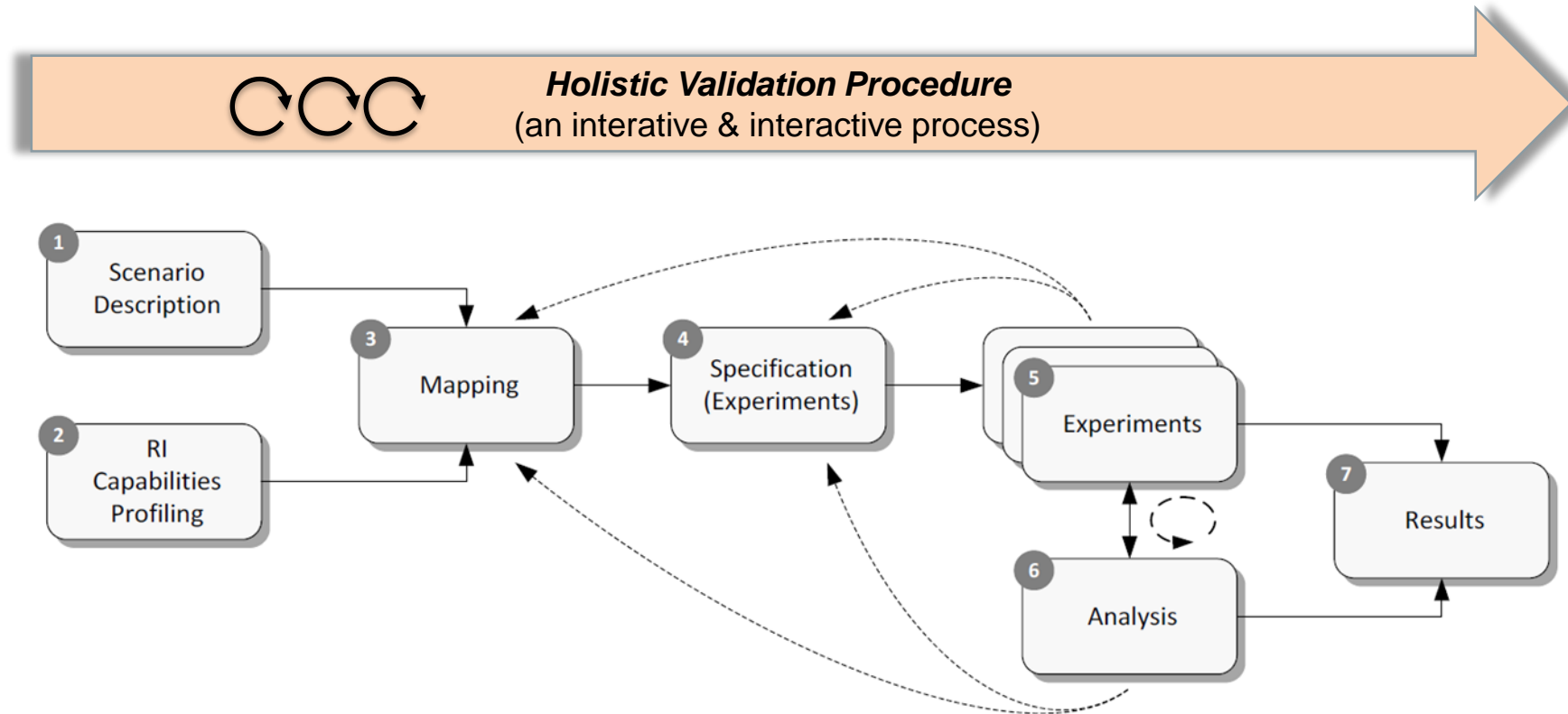
- **Reproducible system validation**
toward reproducible smart energy system testing; validate “systems” not components.
- **Integrated hardware & software testing on advanced testbeds**
facilitate the use of advanced testbeds in relevant technical and commercial settings
- **Tests systems that combine multiple domains**
e.g. Power, Comm. and Automation
- **Systematically design tests & integrate results from various experiments for a holistic assessment**
i.e. combine simulation, co-simulation,
HiL, PHiL, CHiL, different Labs, ...

ERIGrid Validation Approach (recall)

- Development of a formalized, holistic validation procedure for testing smart grid systems
- Improvement of simulation and lab-based testing methods supporting the validation activities
- The provision of a corresponding and integrated pan-European RI based on the partner's laboratories.



ERIGrid Holistic Testing & Validation

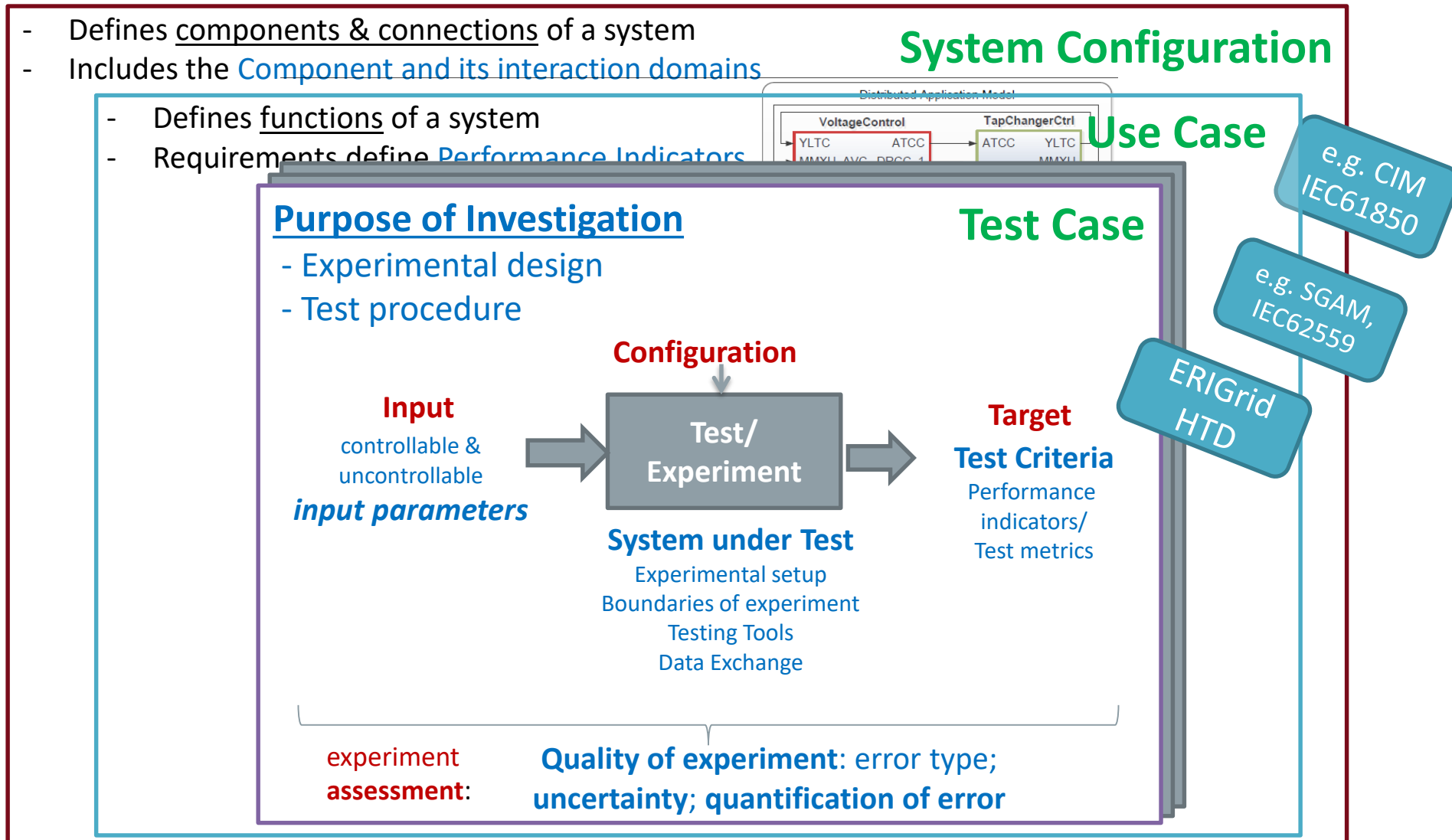


"Holistic testing is the process and methodology for the evaluation of a concrete function, system or component (object under investigation) within its relevant operational context (system under test), corresponding to the purpose of investigation."

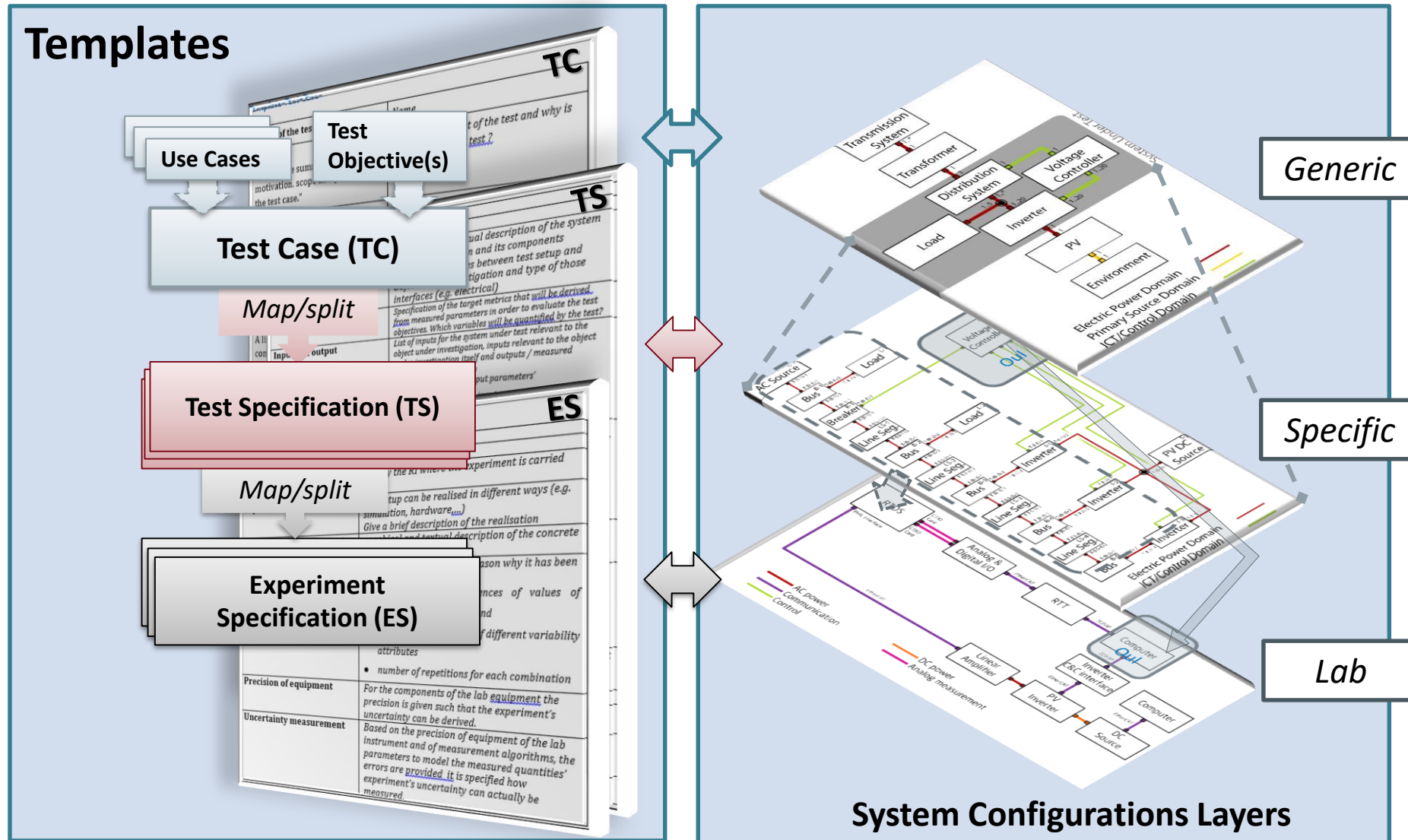
The Basics

HOLISTIC TEST DESCRIPTION (HTD)

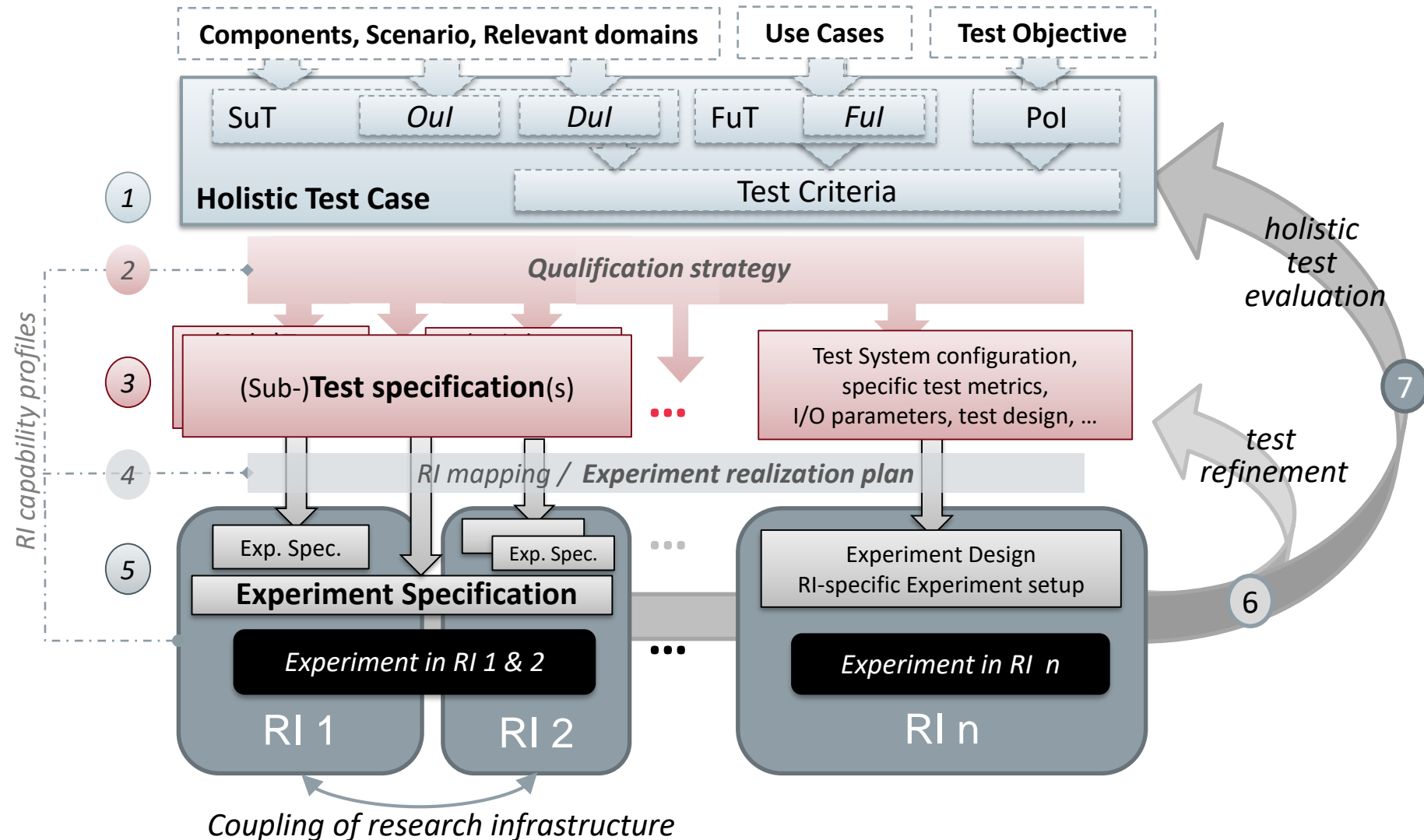
An additional layer of specification



Holistic Test **Description** layers

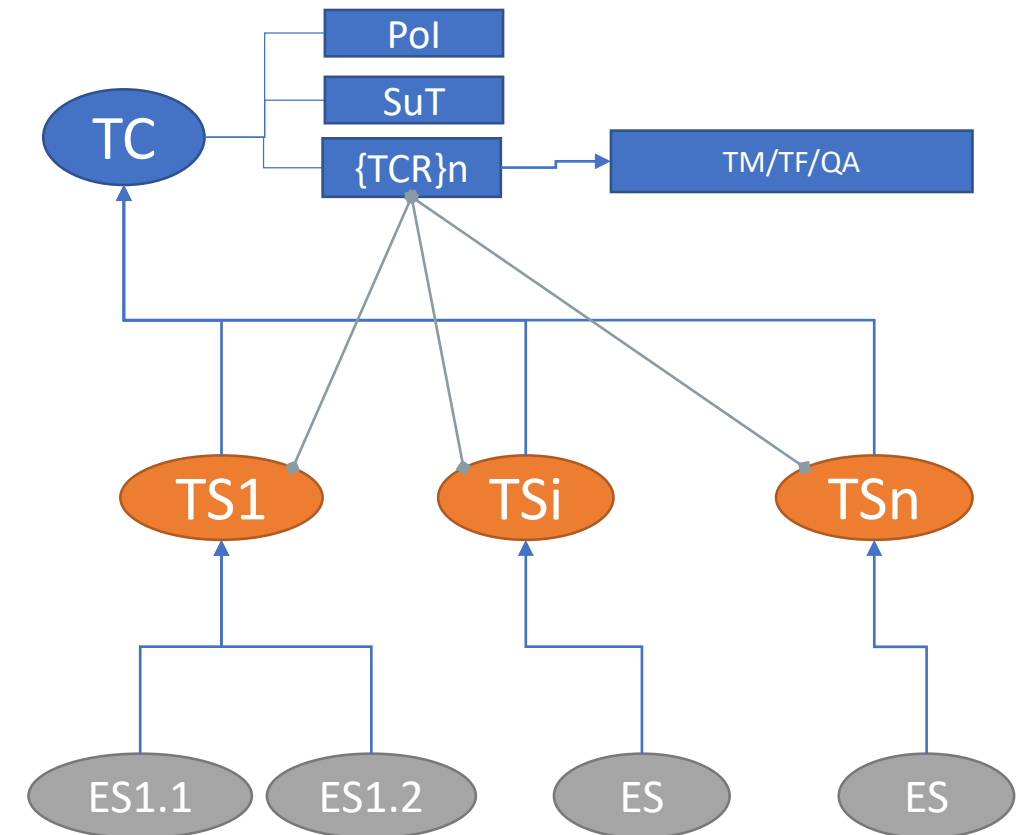


Process view with main concepts



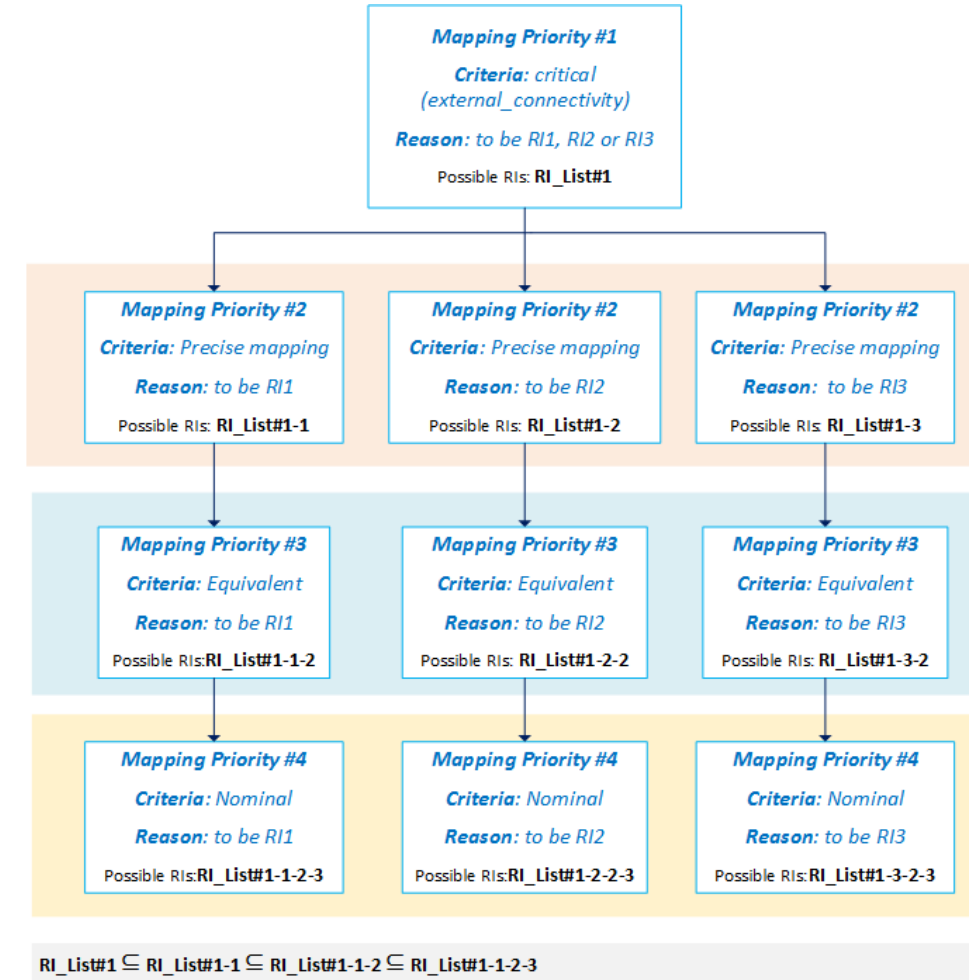
Qualification Strategy

- Logical breakdown of Test Case
- Plan several sub-tests, meeting different test requirements of case
- Consider test-bed qualification as part of validation strategy
- Formulate strategies, e.g.
 - Testing chain
 - Incremental testbed validation



Experiment Realization Plan

- Uses ERIGrid Research Infrastructure Database
- Strategies for deriving a set of suitable experiment setup from
 - Test Specification and
 - RI Database queries
- Three Strategies proposed:
 - Table method
 - Hierarchical method
 - Relaxation method
- Adapts Test Specification where needed



Hierarchical mapping - one of the RI mapping strategies

The realisation

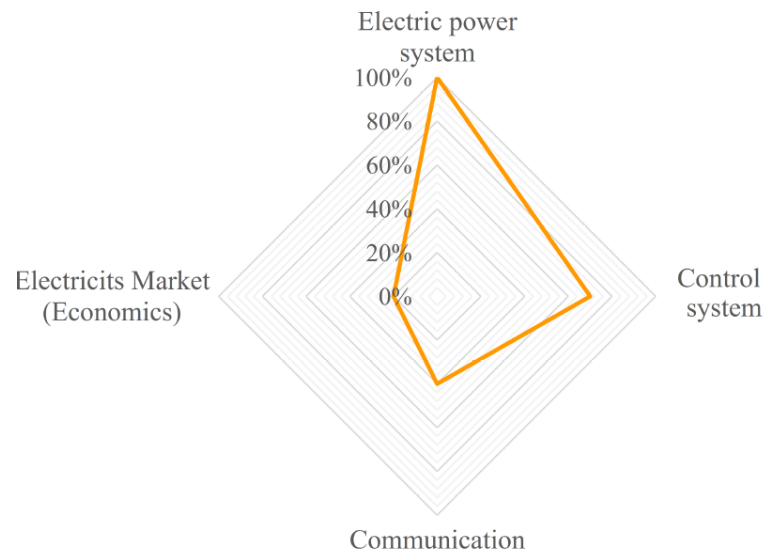
APPLICATION EXPERIENCE

Application Experience

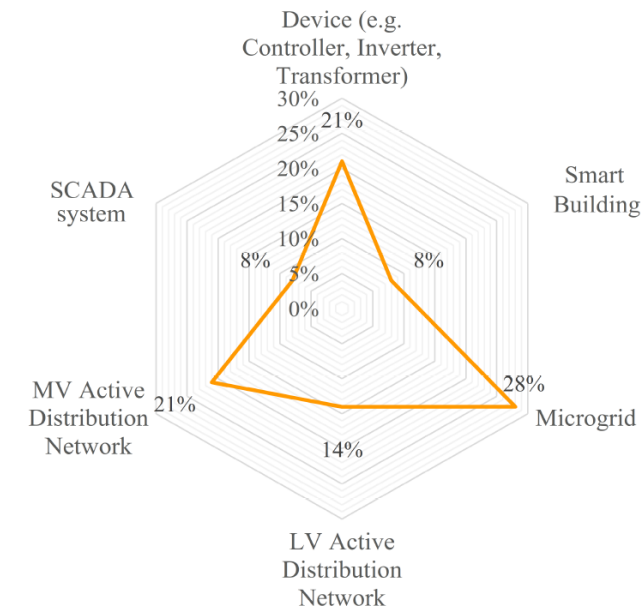
- ERIGrid Transnational Access projects
- ERIGrid Joint Research Activities (JRAs)
- Other European and national projects



Domains under investigation



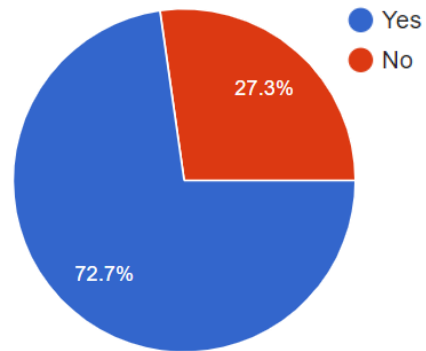
Systems under Test



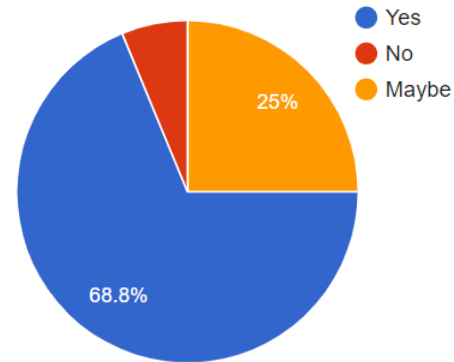
TA Users' experience

via surveys

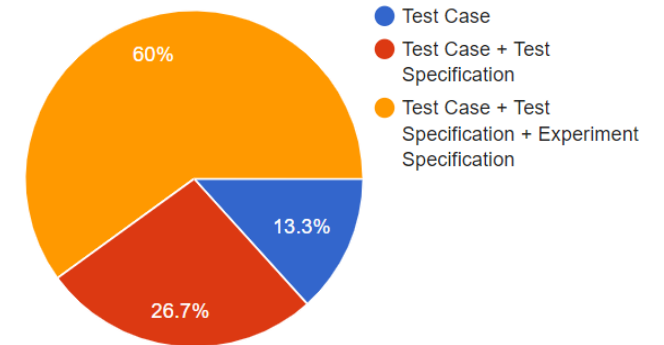
Use of HTD methodology for documentation of projects



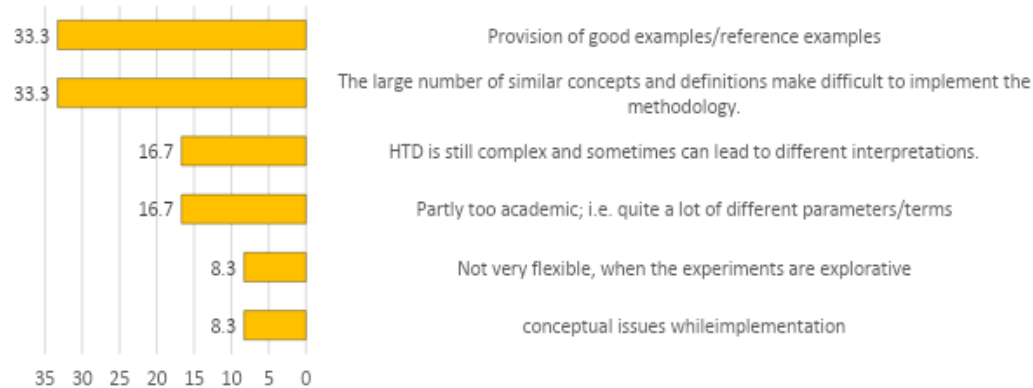
Reuse of HTD methodology in future projects



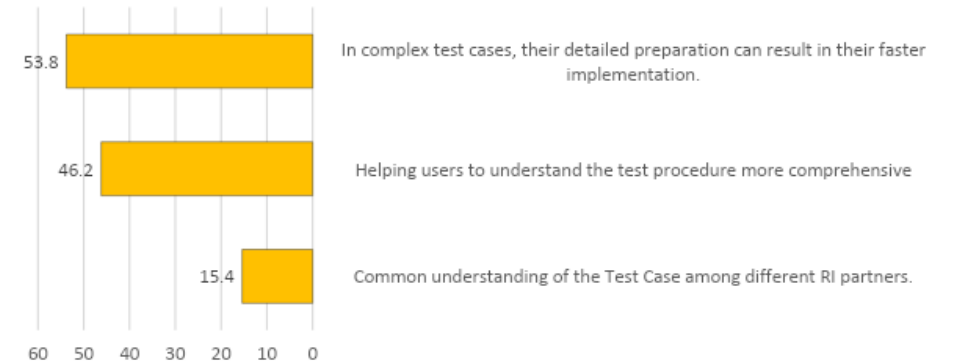
To what extend the HTD methodology is used



Potential improvement



Positive points



Improvement for exploitation of methodology

A. Detailed Method Description

B. Guidelines

C. Templates

D. Examples

Article
ERIGrid Holistic Test Description for Validating Cyber-Physical Energy Systems
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energies
Test Case
Test Specification
Experiment Specification

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Templates and guidelines relating to the ERIGrid Holistic Test Description.

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Holistic Test Description (HTD)

Templates and guidelines relating to the ERIGrid Holistic Test Description (HTD).

Recommended use

For introductory use, read the guidelines. You find concept definitions, explanations of the template fields, step-by-step instructions and a few examples. Better even, read the paper [1].

Conclusion

- Smart Energy Systems validation requires a more comprehensive view on testing and testbed suitability.
- **Holistic Test Description provides a qualitative framework for testing**
 - Domain independent; aligned with smart grid standards & methods
 - Facilitates design of complex validation efforts
 - Abstraction supports test systems design independent of testbed
 - Complements quantitative design of experiments approaches
- **Guidelines, Templates and Examples available**
 - Active community committed to further development
 - Embedded in international smart grid testing networks
- **Method applied and proven in several smart energy research projects**

Thank you for your attention!