InterOPERA – WP1

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ABOUT INTEROPERA

The InterOPERA project will define technical frameworks and standards for electricity transmission and accelerate the integration of renewable energy. Ensuring that HVDC systems, HVDC transmission systems or HVDC components from different suppliers can work together – making them "interoperable"- is a top priority to accelerate Europe's energy transition.

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DISCLAIMER:

PROJECT DETAILS:

Duration: 1 January 2023 – 30 April 2027
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Agenda

- Introduction / Context / Objectives of InterOPERA
- Deliverable D1.1 – Minimum requirements for offline models
- Deliverable D1.1 – Minimum requirements for replicas
- Deliverable D1.2 – Minimum requirements for simulation platforms

Introduction - Context

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Current state-of-the art and limitations in offline

- Models are adapted for vendor's need during design and tests phases
- But
  - They are not fully adapted for TSOs use. It's difficult to integrate them in a TSO grid model due to :
    - Tool and compiler dependency
    - Impractical structure of the vendor's model (hard to copy/paste; to understand how it is organized,…)
    - Time step requirements
  - Their use on the long term is uncertain
  - There are cumbersome discussions for signal accessibility

New challenges with Multi-vendor – Multi-terminal HVDC grids (offline models)

- There is a need to hold different models of different vendors at the same time on the same circuit for interaction studies

And there is the need to exchange models for those interaction studies

=> Format and interfaces of the models shall be improved to facilitate these actions

- Extensions or adjustments or replacement in the topology of the grid are expected

And there is a need to perform post-event analysis

=> It shall be possible to perform studies with the models on the long run, with evolving tools

Current state-of-the art and limitations for real-time simulations

- Replicas (Hardware In the Loop) are tailormade
- Limitations
  - Replicas are designed to operate with one brand of real-time simulator (usually RTDS or HYPERSIM)
  - There are a lot of practical constraints

New challenges with Multi-vendor – Multi-terminal HVDC grids (real-time)

- For multi-vendor and long-term use of replicas,
  - Replicas are to be used during the whole life of the real system (about 20 years). During this timelap, it might be necessary to replace the RTS. Hence, it shall be possible to use replicas with several brands of RTS to anticipate and to facilitate potential future RTS replacement.
  - It shall be possible to use replicas from different vendors on the same platform at the same time

- OWP replicas is a new topic, less mature than HVDC C&P replica

- It might be complex and expensive to gather all replicas, as hardware-in-the-loop, at the same place :
  - The added value of replicas for interaction studies, compared with offline simulation, shall be assessed
  - Other solutions such as SIL (software-in-the-loop) shall be developed / benchmarked

InterOPERA proposal to meet these objectives

- 2 deliverables define the minimum requirements
  - For the provision of models, of replicas : D1.1
  - For the preparation of simulation platform

  to host these models/replicas and to perform efficiently the interaction studies : D1.2

Objective of the 1st stakeholder committee

- InterOPERA will perform dry-run tests to demonstrate the relevance of those minimum requirements and improve them if necessary (*not scope of today's meeting -> to be performed by end of the year)*

- InterOPERA will perform a benchmark between models and replicas to give some inputs to decide whether replicas shall be provided for interaction studies for real projects *(not scope of today's meeting)*

D1.1 Minimum requirements for offline models

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D1.1 – Minimum requirements for the provision of models for interaction studies

- /!\ : minimum = TSOs can request additional items
- /!\ : for interaction studies = these requirements are not suitable for all use cases
- /!\ : work is on-going, there might still be some changes

- Strategy :
  - start from current minimum requirements for single vendor studies
    - Type of studies
    - Frequency range (from 0.2 Hz up to 2500 Hz)
    - Modelling recommendation, etc.
  - Then complete with additional requirements to meet the interoperability objectives

D1.1 – offline – Managing the balance between confidentiality and accessibility

- The model shall be provided as open-box, with few exceptions defined, which can be provided as a black-box DLL:
  - Control and protection
  - Wind turbine electrical and mechanical model (except the wind turbine transformer)
  - Valve model

(in InterOPERA, the main assumption is that it is the duty of the lab to re-create and validate the open-box circuit in a different tool when needed)

- Request for a minimum list of signals to be accessed (cf. slide 15)

- Request for access to all parameters and settings needed for the interaction studies

D1.1 – offline – Managing tool interoperability for multi-vendor context

- Need for tool, solver, compiler or linker independent solutions for the black-box DLL : reference is made to the future IEEE/CIGRE DLL
  - ⇒Strong links between the IEEE TASS Task Force / CIGRE B4.82 WG and InterOPERA to speed up the experience with this solution
  - ⇒This will be tested in InterOPERA using EMTP and PSCAD

Crucial topic ! But the technical brochure is not published yet

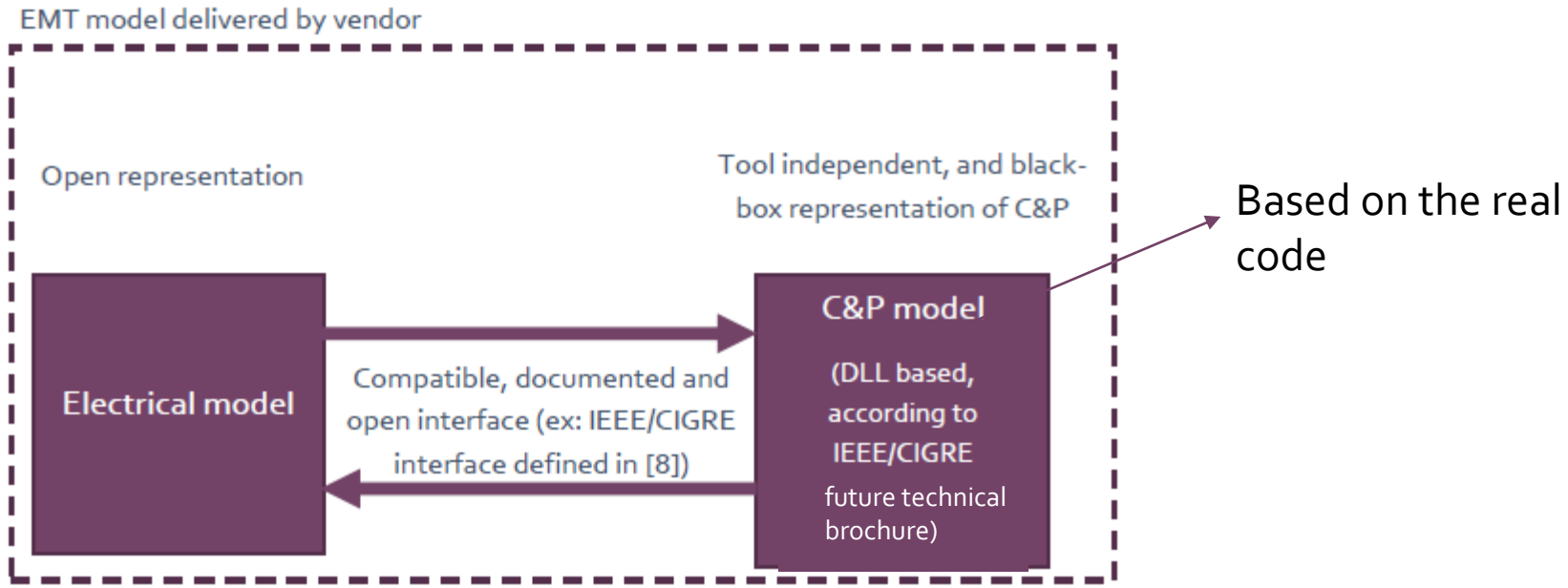

Figure 1 – Main principle of the separation between electrical component representation and C&P representation.

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D1.1 – offline – Managing multi-vendor context

- Definition of possible simulation time steps (1, 2, 4, 5, 10 and 20 µs)

- Each vendor shall consider multi-vendor context when developing the DLL:
  - no global variables shall be used;
  - it shall not rely on shared memory addresses that could be accessed or used by other DLLs

D1.1 – offline – Enabling practical use by system integrator

- Definition of a structure to be followed for easier copy/paste and for the sake of clarity:
  - 1st level of access = one block
  - 2nd level of access = at least 2 blocks :
    - power part
    - control and protection part (potentially split in 2 blocks)

- Definition of a minimum signal list for the detection of interactions *(but this list is not sufficient to solve interactions) (still under discussion)* :
  - Signals received as order (setpoints, mode,…)
  - Signals used as reference
  - Measurements, as measured by the control system
  - Protection information

- Importance of the documentation; list of minimum information to be provided for a good understanding and use of the model

D1.1 – offline – Ensuring minimum computing time

- DLLs shall be compatible with multi-instances, e.g. to support 2 different simulations running in parallel on the same computer, but with 2 different cores
- DLLs shall be compatible with the snapshot functionality
- Definition of a maximum allowed time for model initialization (= energizing + reaching the desired target)

D1.1 – offline – Ensuring long-term use of the models

- Open-box + tool and compiler independent DLL (as already mentioned) => to consider changes in tool
- Documentation (as already mentioned) => to transmit the knowledge
- Clear request for
  - Updates, every time it is necessary for the studies
  - Documentation : what are the differences, list of sanity tests to check the new model, version tracking document
  - Version management : use of unique identification number
  - Delivery of full package every time there is an update

Break

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D1.1 Minimum requirements for replicas

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D1.1 – Real-time – Main assumptions

- Requirements are written for HIL (hardware in the loop).
- SIL (software in the loop) is mentioned as a possible deviation -> vendors to make a proposal and to justify its relevance

- Same strategy as for offline :
  - start from current situation :
    - Power circuit modelling recommendation
    - What shall be included in the RTS model or not (to not overload the RTS)
    - Lab constraints and EHS requirement
    - Testing and commissioning process
    - Remote access
    - Lab training
    - Documentation
    - Maintainability and updates
  - and complete with new aspects

D1.1 – Real-time – Test setup

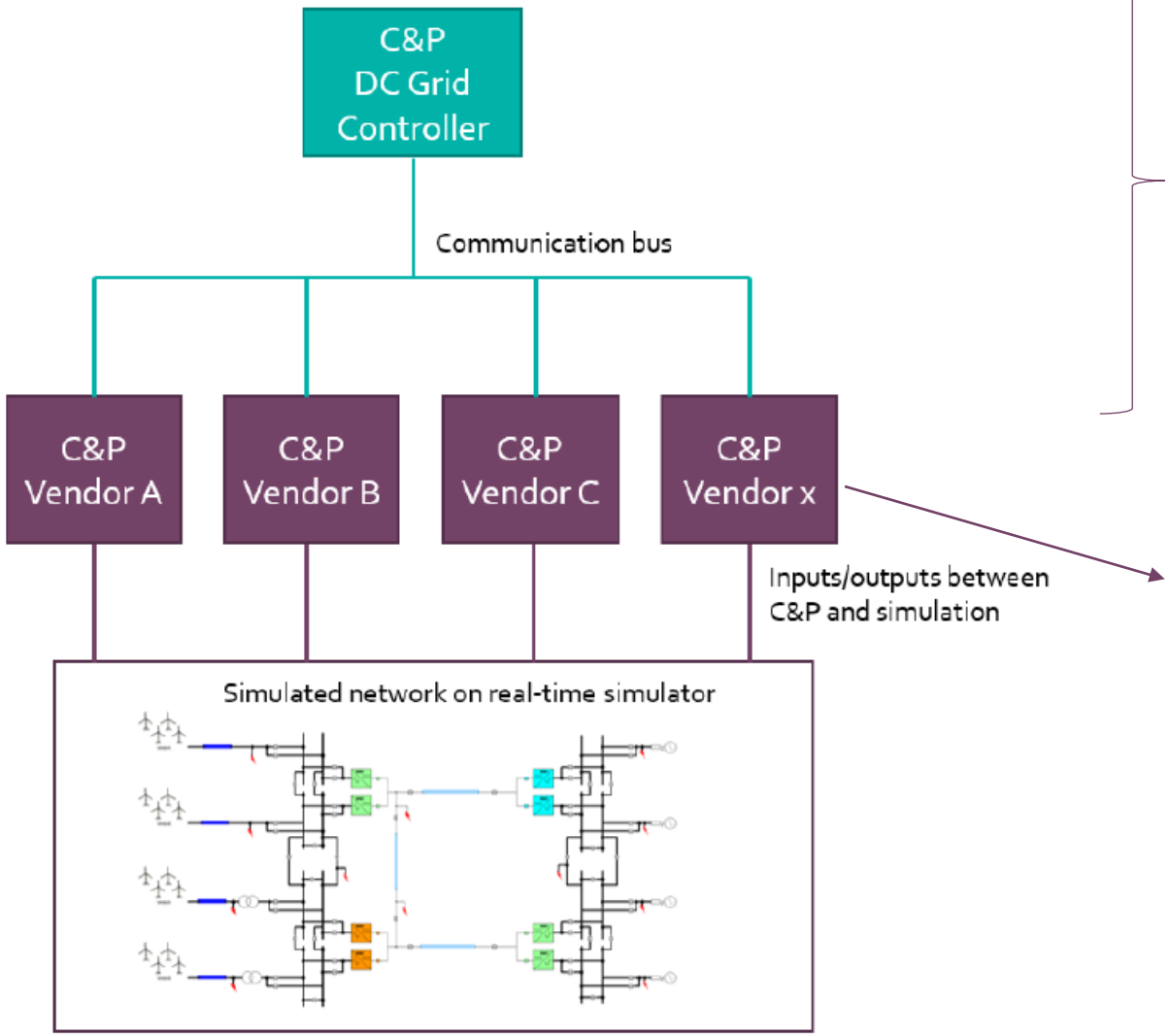

Figure 10 – Principle of the real-time simulation test setup

New in InterOPERA : This upper layer, even though not connected to the RTS, shall be provided, as its control influences the behavior of the grid

New in InterOPERA for WT and power plant controller
Link with IEC WG 61400 – 21 -5

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D1.1 – Real-time – Test setup

- 1 replica consists of
  - One model for the power part to be run on the RTS (if any)
  - The control and protection system
  - The communication system with 3rd party-system such as the DC Grid Controller (ex : gateway, router,…)
  - A Transient Fault Recorder, with external trigger interface
  - The relevant HMI to use the replica
  - The synchronization system
  - An external simulation platform, if necessary

D1.1 – Real-time – Managing confidentiality while ensuring minimum accessibility

Lab shall have access to :

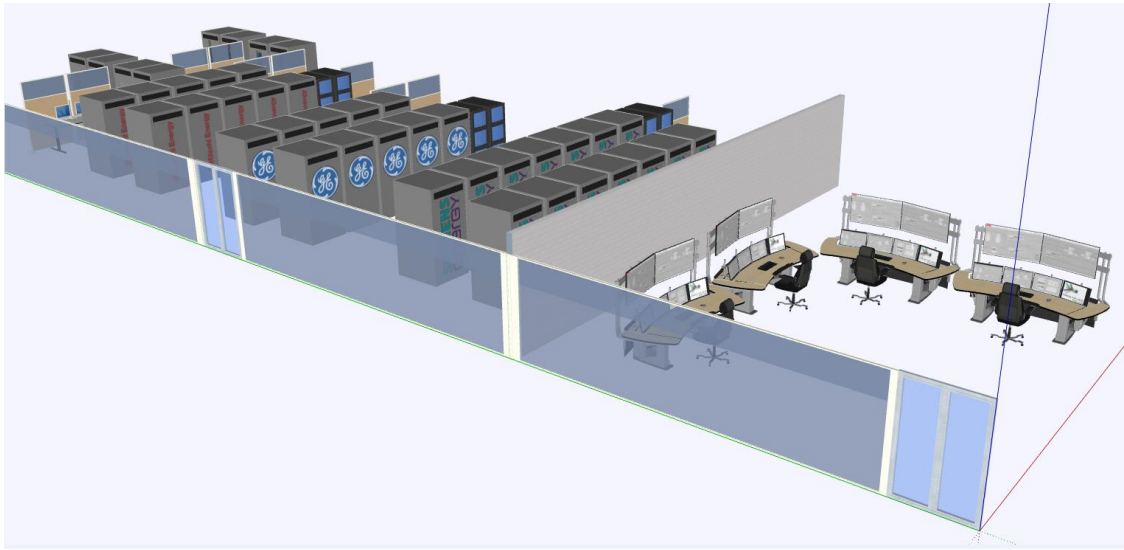
- A minimum list of signals (like offline)
- the HMI to operate the system
- specific settings / variables for interaction tests purposes

The vendor can have a supplementary TFR and log files for deeper analyses and troubleshooting.

D1.1 – Real-time – Managing confidentiality in a multi-vendor context

- *Multi-vendor context means that several vendors can come in the lab*

- 2 types of requirement :
  - Self-protection :
    - Software aspects : Vendor shall consider cybersecurity rules
    - Hardware aspects : Vendor shall define the appropriate type of cubicles (open chassis / closed cubicle / …)
  - Self-limitation : *Code of conduct for vendor's employee or subcontractor in the lab (link with other WP)*



D1.1 – Real-time – Managing confidentiality while ensuring minimum RTS interoperability

- Request to provide the power model, running on the RTS, as open-box (except the MMC converter valve model)

(in InterOPERA, it is the duty of the lab to prepare the power model for the 2nd RTS based on the power model prepared for the 1st RTS)

- For the wind turbines, there is the possibility to simulate the main circuit on an external platform, as black-box

/!\ : specific care about the coupling point, coupling method, documentation

D1.1 – Real-time – Managing real-time-simulator interoperability - HIL

- Request for well documented interfaces

- Request to **support** the lab for the use of the replica with different time steps (between 2 and 40 µs)
  - ⇒Rational for different time steps :
    - ⇒Different RTS = different solvers = different optimum time steps
    - ⇒Different vendors = different time steps used at their respective facilities
  - ⇒Rational for « support »: vendors don't (currently) have different RTS to test all possible time steps (this is different from offline)
  - ⇒How to consider adaptation of the control system to the RTS time steps ?

D1.1 – Real-time – Managing real-time-simulator interoperability – SIL uncertainties

- 2 types of SIL :
  - Running on an external system, that is not the real system => same requirements as HIL would apply (ensure interfaces interoperability)
  - Running on the RTS
    - Issue : there is no common format for RTS-independent-SIL => standard to be initiated in the future, outside InterOPERA ?
    - 2 solutions :
      - Provide 2 SIL solutions, one per RTS
      - Provide 1 SIL solution, for one RTS and consider this RTS as an external system to be interfaced with the main RTS if different

⇒ Different solutions can be tested in InterOPERA. Requirements to be written at a later stage with the return of experience.

⇒ Experience in preparing a tool-independent code for the tool-independent DLL can be re-used for the development of SIL solutions (but it is not sufficient)

D1.1 – Real-time – DC Grid Controller specific requirements in InterOPERA

- Possibility to perform automatic scenarios
- Possibility to emulate delays on the communication system between the DC Grid Controller and other controllers
- Support of the vendor in charge of the DC Grid Controller to test the communication with the other replicas => 3-parties coordination

- SIL requested as a nice-to-have on top of HIL (must-have) => for the DC GC, SIL is a promising solution for the future, e.g. for testing activity at vendor's facility.

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D1.2 Simulation platform requirements

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D1.2 – Simulation platform requirements

- 3 types of requirements :
  - Offline and real-time EMT simulation tools requirements
  - Complementary tools requirements for higher efficiency
  - Lab organization requirements

D1.2 – EMT offline simulation tools requirements

- On top of basic requirements:
  - Request for IEEE/CIGRE DLL import toolbox
  - Request for easy copy/paste of multiple modules at the same time
  - Recommendation for CIM (Common Information Model) – CGMES (Common Grid Model Exchange Standards) compatibility : possibility to import/export model

  Target : ensure higher interoperability between tools, facilitate model sharing between stakeholders; etc.

  /!\ ongoing work outside InterOPERA to complete these standards for EMT model, and more specifically for HVDC converter stations, WT EMT models
  - Recommendation for parallelization of one circuit in several subcircuits
  - Request for testing parallelization capability (embedded in the EMT tool or via another piece of software or via scripts, etc.)

D1.2 – EMT real-time simulation tools requirements

- On top of basic requirements:
  - Coordinated trigger of the TFRs of all the vendors

D1.2 – Complementary tools requirements for higher efficiency

- Request for automatic testing possibility

/!\ : in real-time, one can face limitations due to the replicas (ex : a manual action is expected on the C&P system of a vendor after a trip)

- Request for automatic performance check to detect for example :
  - Unexpected trip
  - Unexpected trigger of a specific mode of operation
  - Oscillations
  - Excessive reaction time or settling time
  - Overshoot outside the tolerance
  - Steady-state outside the tolerance
  - Reverse power flow

D1.2 – Lab organization requirements

- Platform facility requirements for real-time : place, room environment (temperature,…), power supply, access for cubicle delivery and installation, remote access,…

- Traceability requirements to ensure repeatability of the tests; track the results; save a copy of all the versions of models, scripts used during the project

- Confidentiality requirements to manage
  - access to the lab for real-time
  - access to the models
  - access to the results

  (this is linked with other WP in InterOPERA)

Any question ?

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