



Real-Time Simulation at RTE international: HVDC C&P Replica Applications

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MADRID, SPAIN



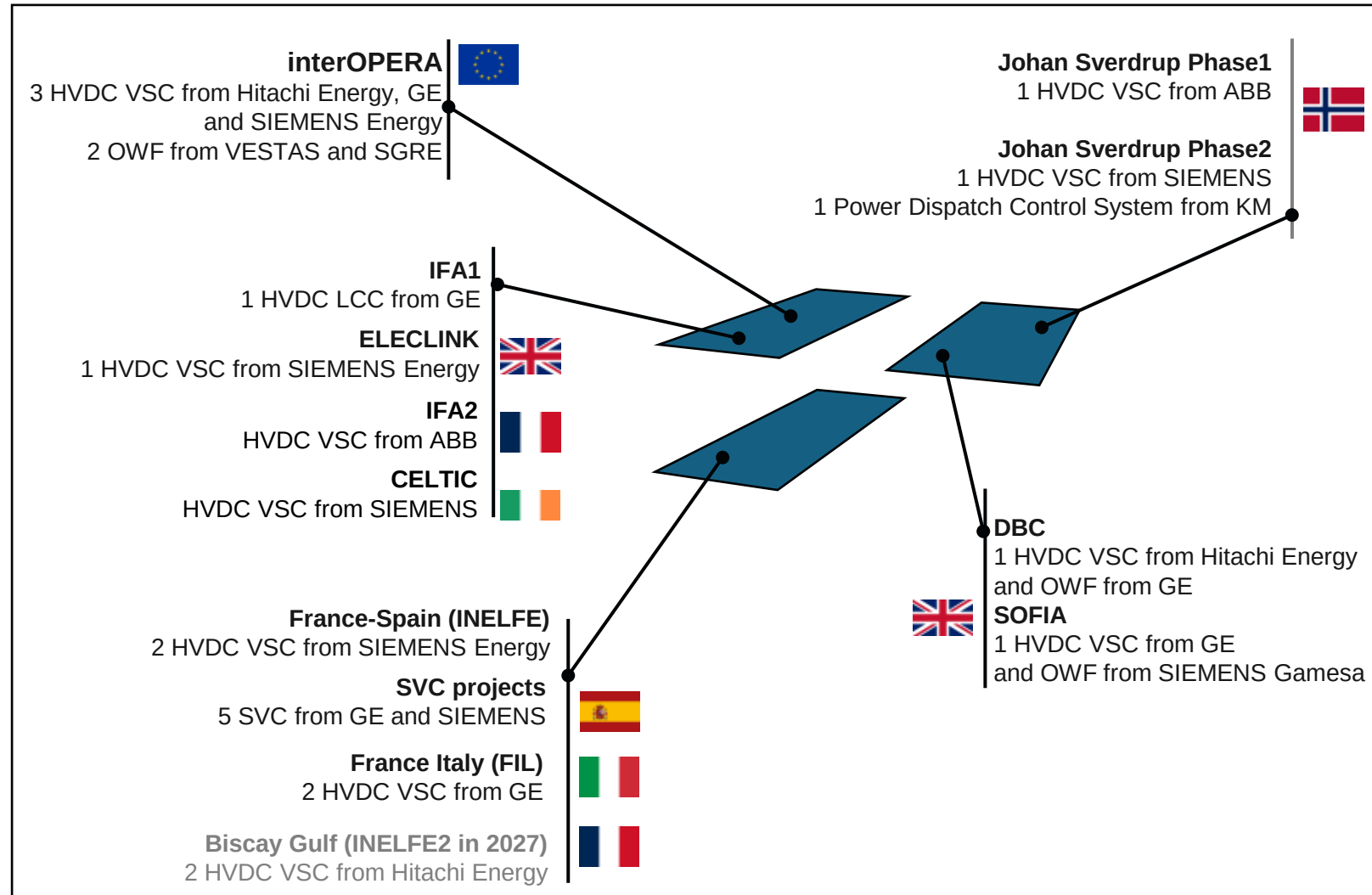
HVDC C&P Replicas at RTE Transfo Campus



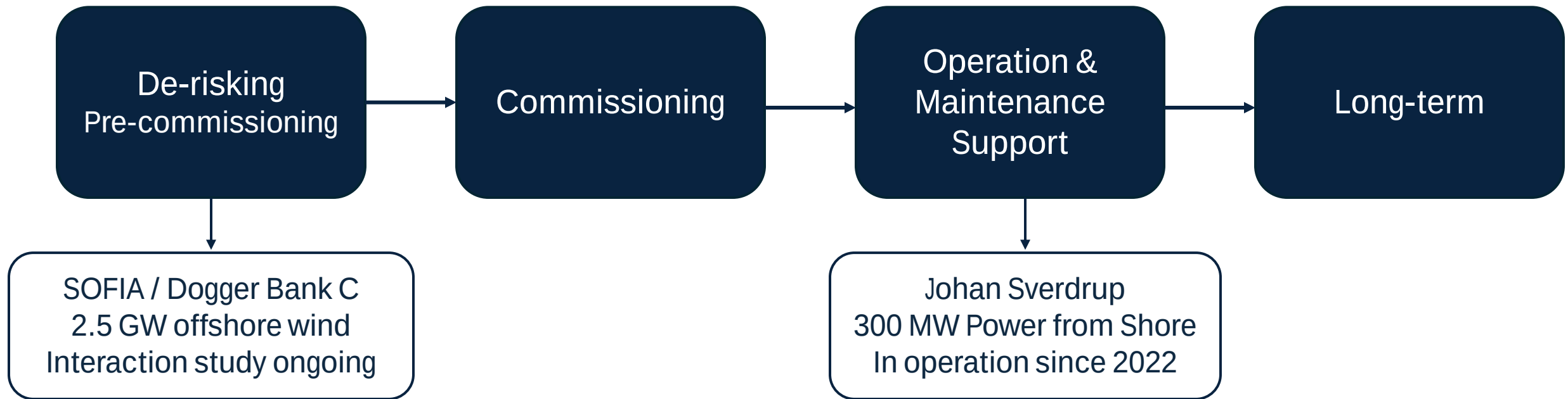
Real-time lab facility

RTE Campus Transfo hosts:

- 20 replicas of HVDC & FACTS projects
- 20+ real-time simulators
- ~250 physical C&P cubicles



The Life of a Replica



- Two multi-vendor HVDC interaction studies, at two different stages

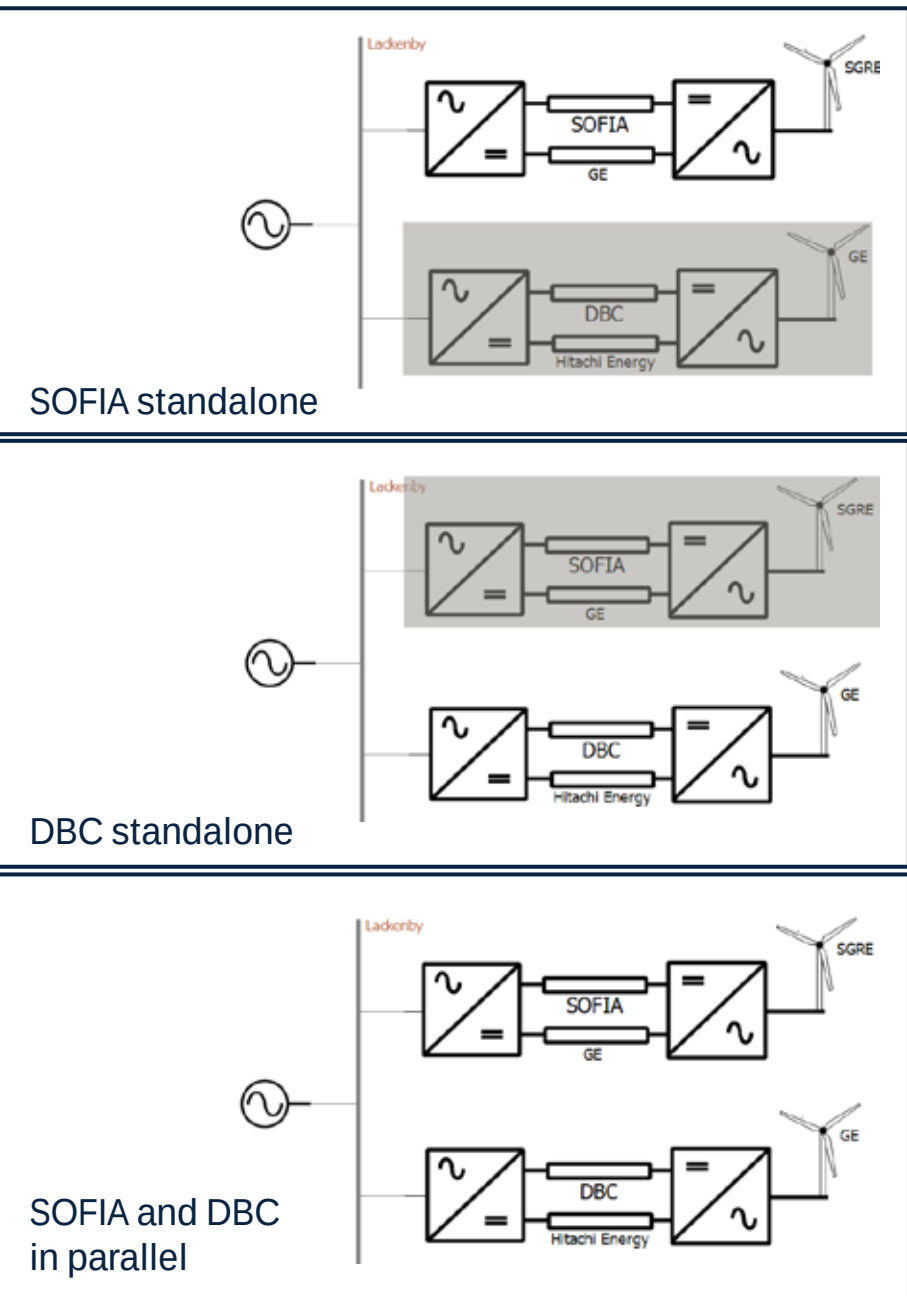
SOFIA and Dogger Bank C

- SOFIA: 1320 MW, GE Vernova HVDC, ± 320 kV, 220 km, 100 x 14 MW Siemens Gamesa turbines
- Dogger Bank C: 1200 MW, Hitachi Energy HVDC; ± 320 kV, 272 km, 87 x 14 MW GE Vernova Haliade X

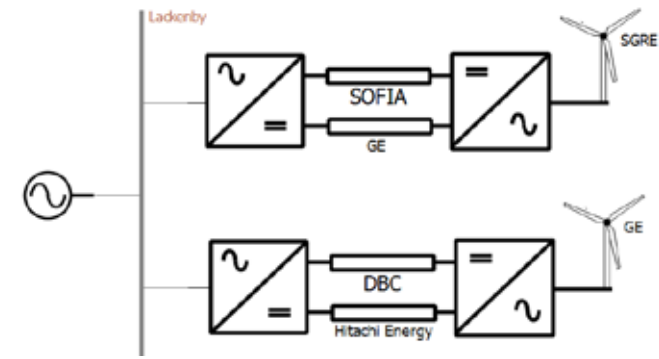


Interaction Study

- **Objective** of the study: assessment of possible adverse interactions between SOFIA and DBC.
- **Tools:** Offline and real-time EMT simulations.
- **RTEi's role:**
 - Independent 3rd party
 - Assuring IP protection
 - Definition of tests
 - Performing simulations
 - Sharing results with stakeholders
 - Contribute to mitigation solutions.



Offline and Real-Time Studies



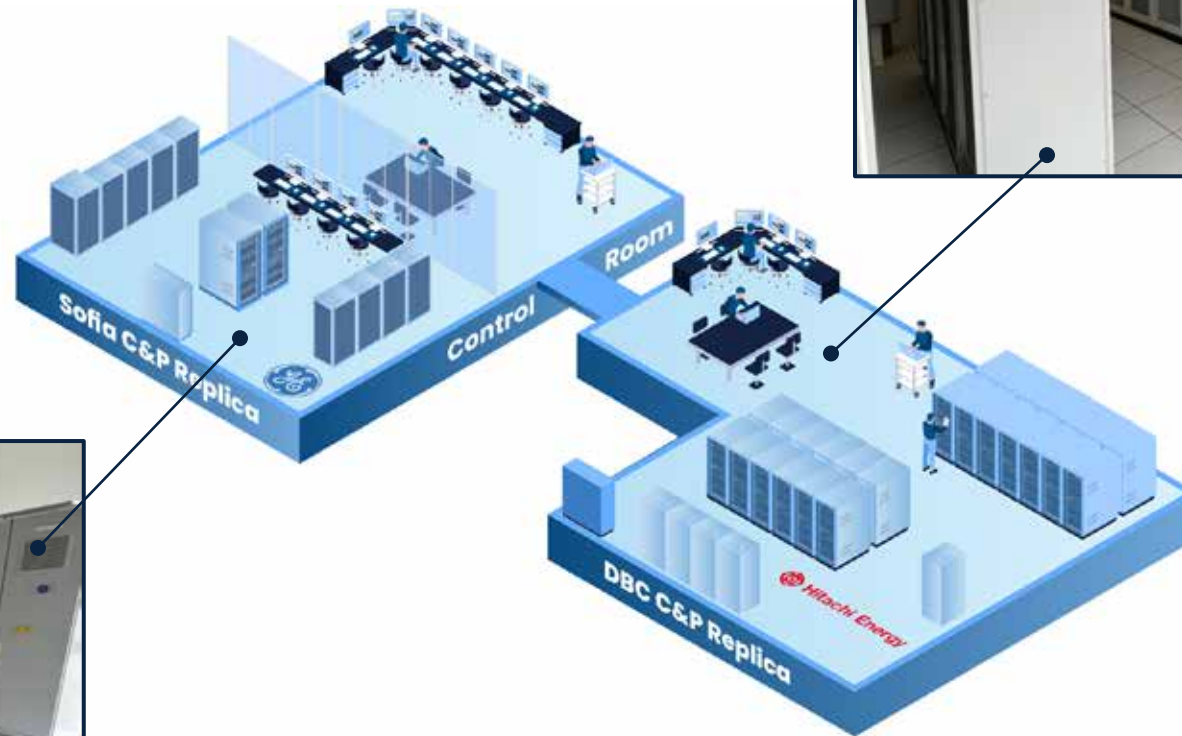
WP1: Offline EMT interaction studies

- EMT model specifications
- Test individual models
- Merging models and automation
- Running simulations (500+ cases)
- Analysis and discussion

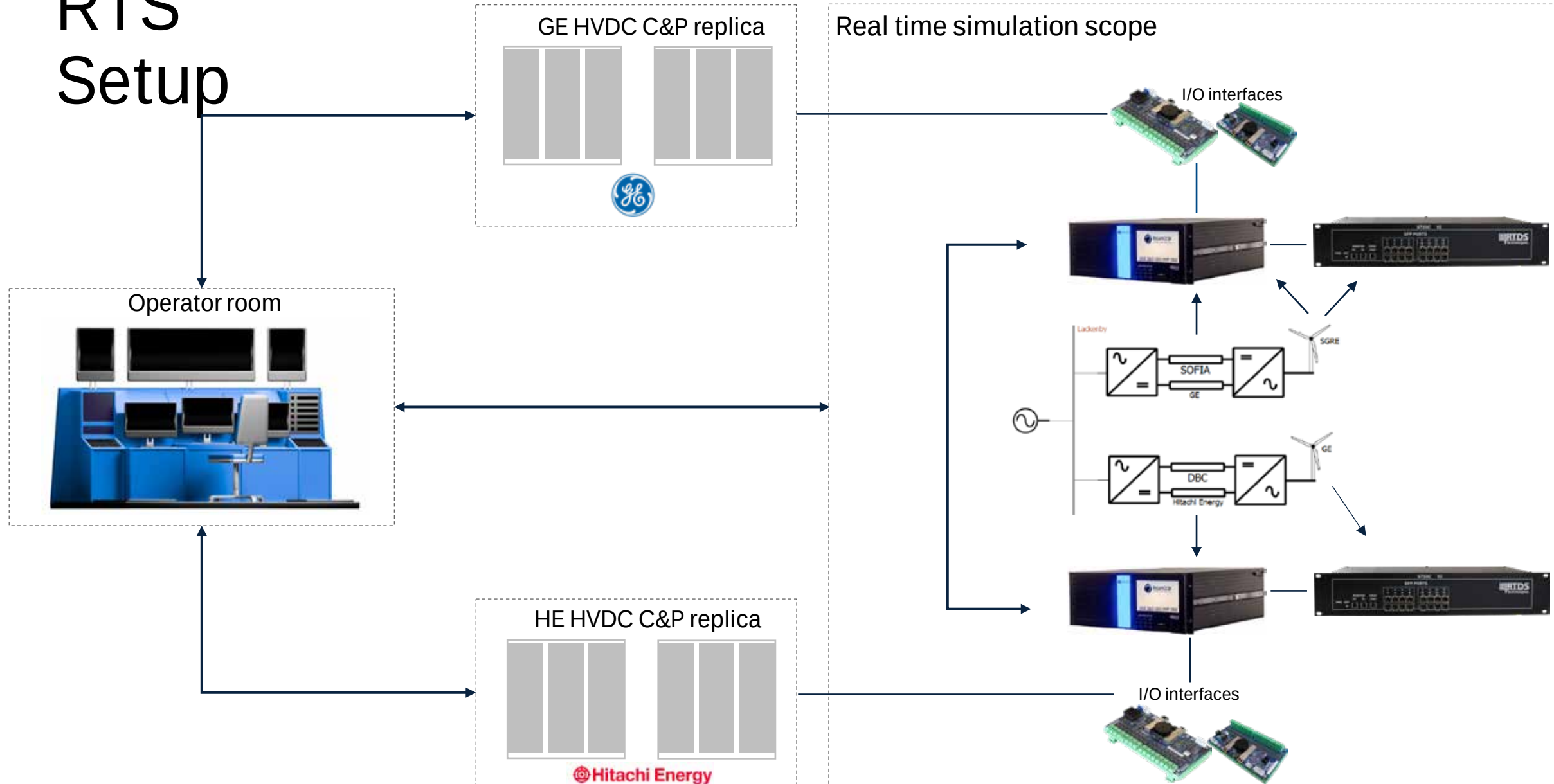
WP2: Real-time EMT interaction studies

- Replica specifications
- Procurement of the RTS
- FAT participation
- Preparation of the real-time lab facility
- Testing individual replicas (PSCAD benchmarking)
- Model adaptation (HVDC+OWF merging)
- Running simulations
- Analysis and discussion

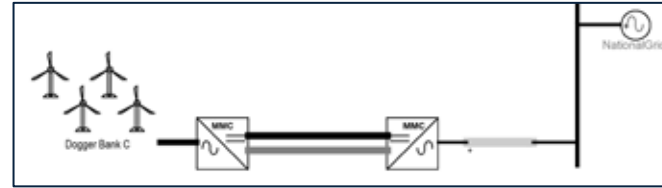
SOFIA and DBC Replicas



RTS Setup



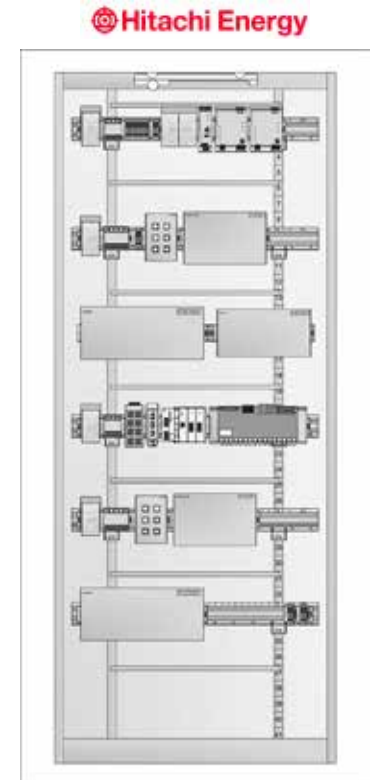
WTG and OWF Representation: DBC



Loading of the firmware on a GTSOC board
(C&P of the WTG: converter control, wind turbine control and wind farm control)

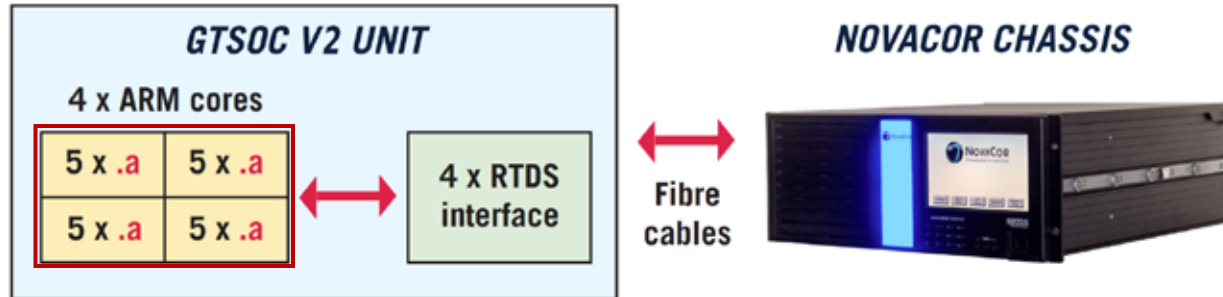


Loading of the WTG model
(electrical network) on a NovaCor



DBC HVDC C&P replica

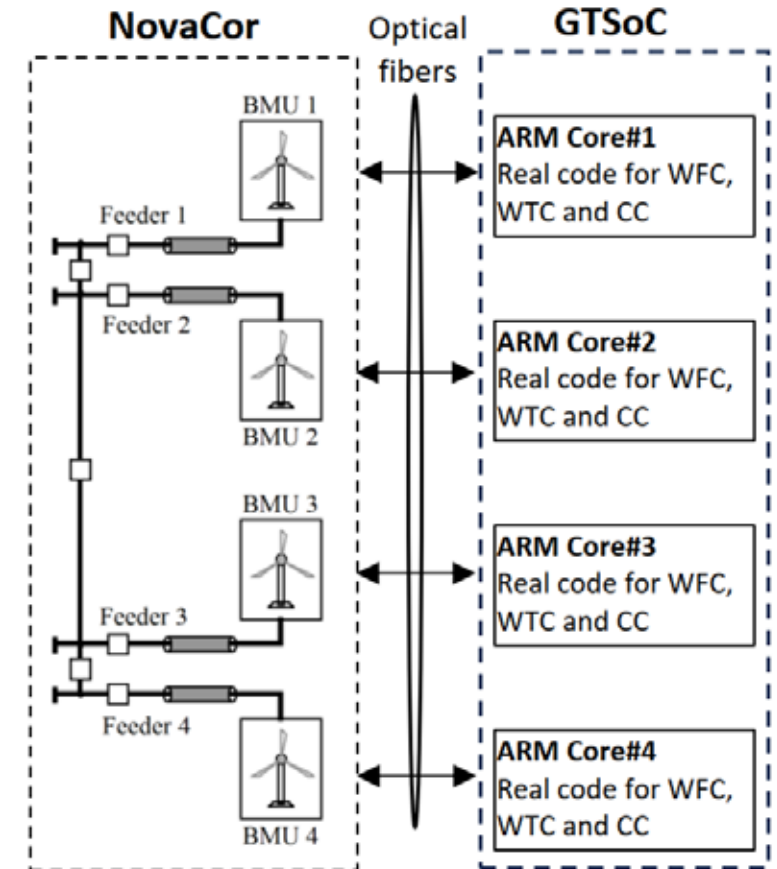
WTG and OWF Representation: DBC



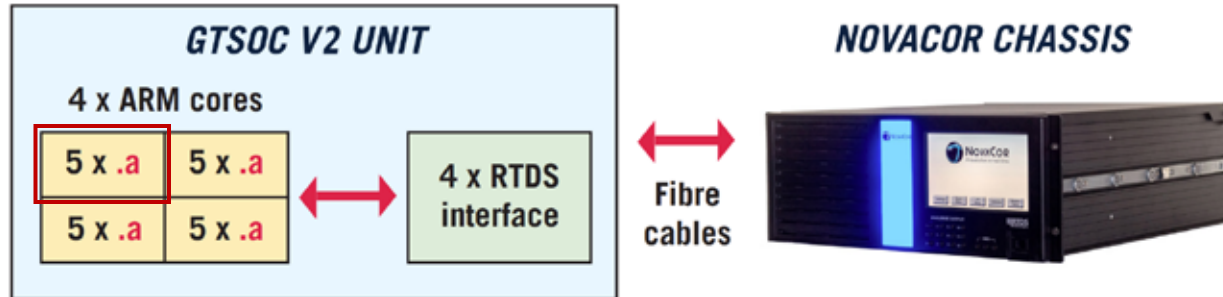
- 1 GTSOC board
- 4 ARM core licensed
- 1 NovaCor Core licensed

Step by step implementation

1. Standalone test: 1 BMU connected to an AC grid
2. Standalone test: 4 BMUs connected to AC grids
3. Test 4 BMUs connected to the DBC HVDC link model



WTG and OWF Representation: SOFIA



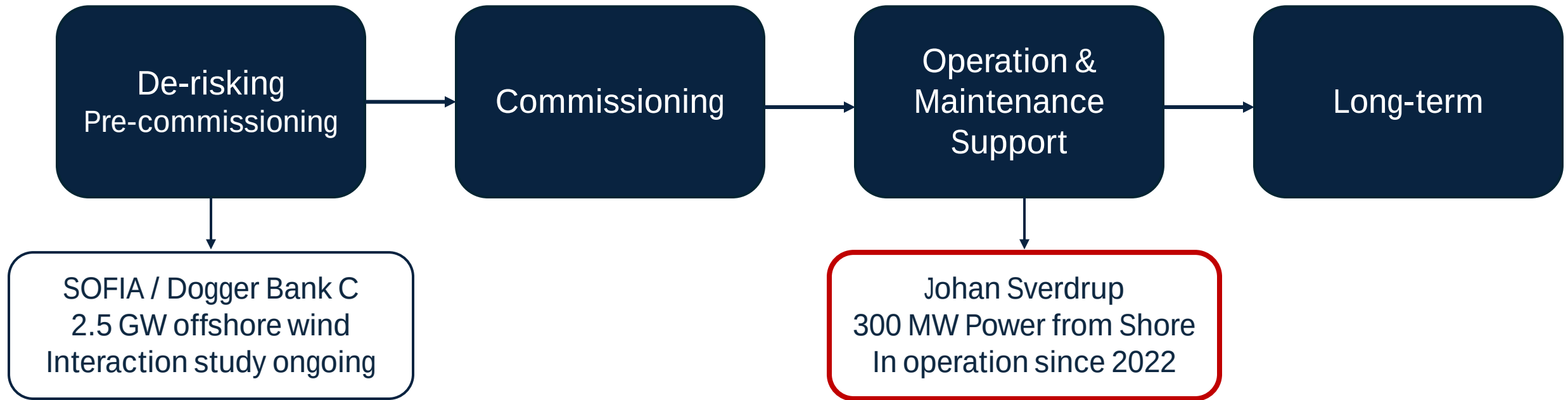
- 1 GTSOC board
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- The firmware of the PPC (SGRE) is loaded on a GTSOC board.
- For SOFIA, only one PPC runs on GTSOC (18 μ s execution time).



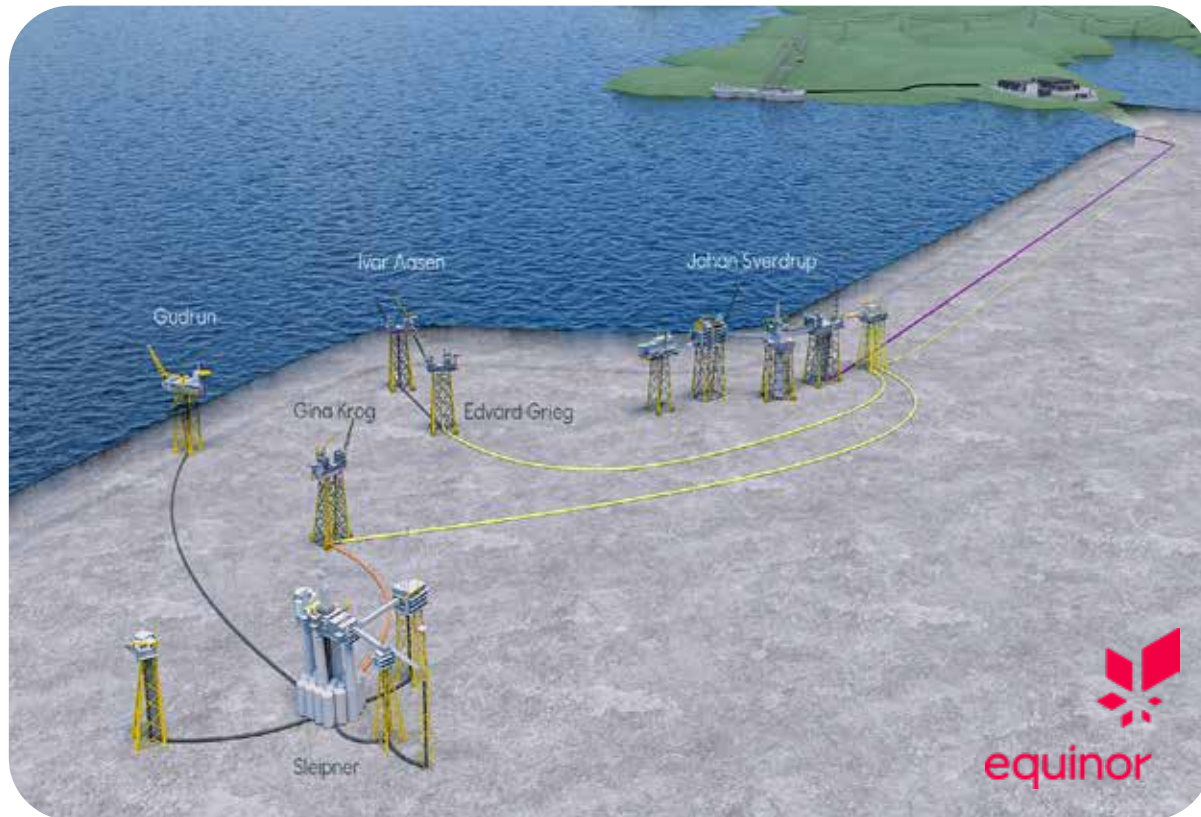
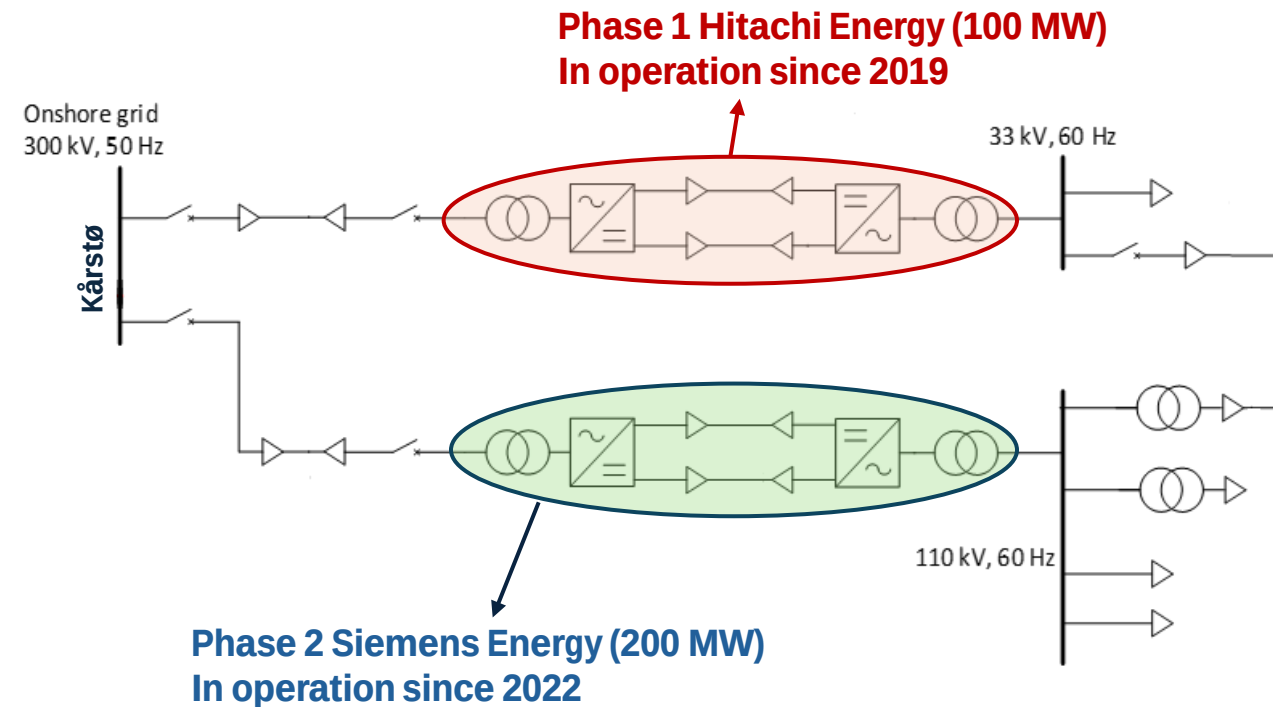
Final setup with the integration of the new GTSOC V2 in the SOFIA RTDS setup

The Life of a Replica



Johan Sverdrup: Power from Shore

- Two HVDC vendors in parallel, coordinated by a third vendor (PMS).
- Grid forming offshore.

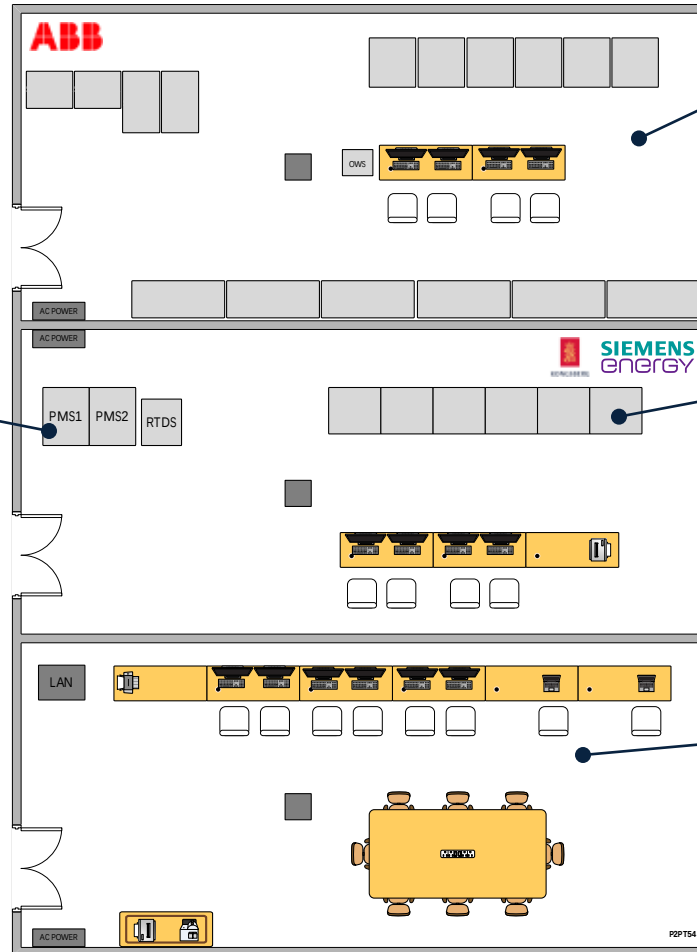


Johan Sverdrup: Replicas



PMS

RTDS rack 1
+ SyncRelay



HVDC1 C&P replica



HVDC2
C&P replica



Hitachi Energy
remote control

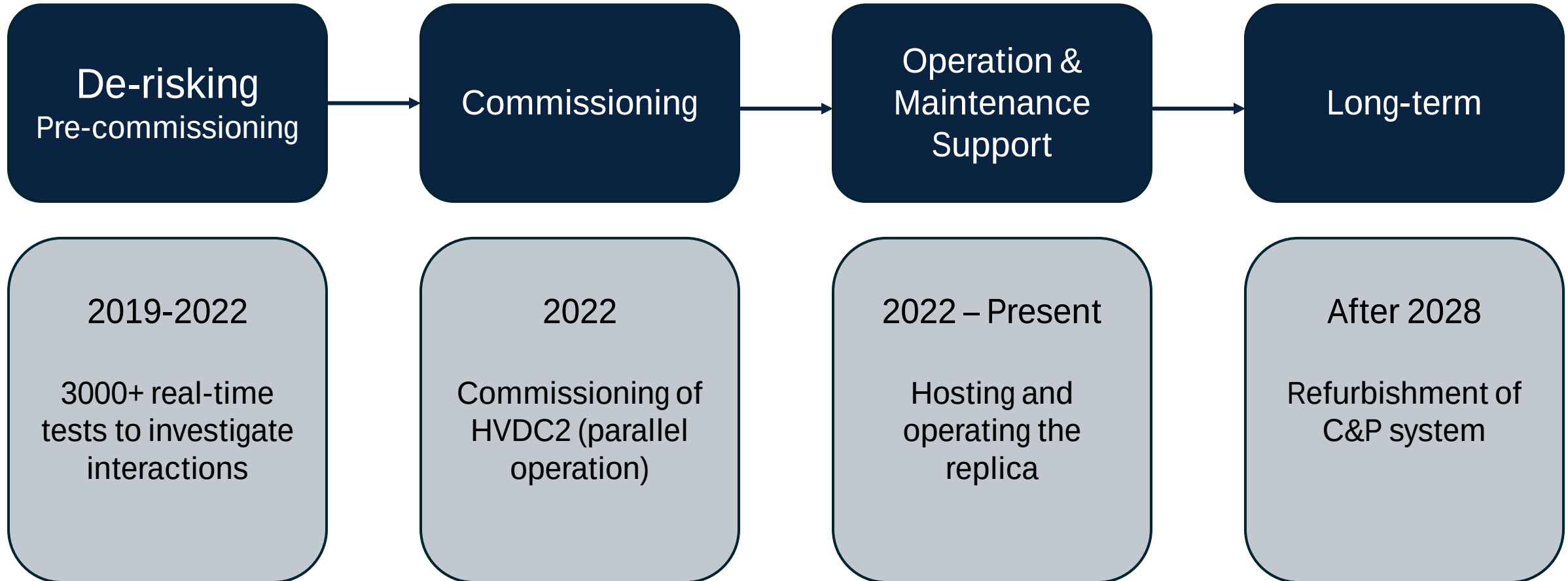
Kongsberg
remote control

Siemens Energy
remote control

Synch Relay

RTDS
interface

Johan Sverdrup: The Life of a Replica

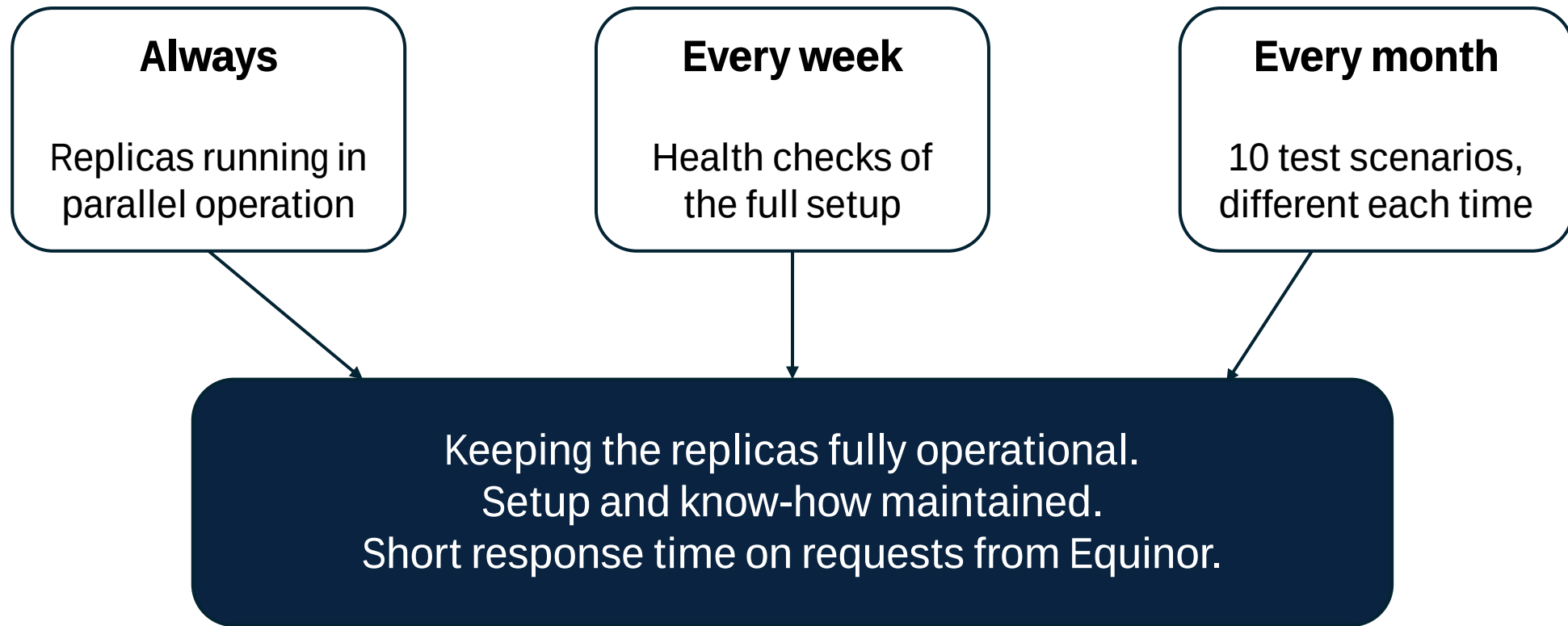


Operation & Maintenance Support using Replicas

- Since the commissioning in 2022, the Johan Sverdrup HVDC real-time lab has been hosted and operated by RTEi.
 1. Maintaining the replicas and expertise
 2. Software update testing
 3. Post-event analysis
 4. Testing new operating conditions
 5. Operator trainings

Operation & Maintenance Support using Replicas

1. Maintaining the replicas and expertise



Operation & Maintenance Support using Replicas

2. Software updates:

- Vendor updates for HVDC1, HVDC2, or the PMS are tested before implementation onsite, with both links and the PMS together, which no single vendor can do because of IP.
- Non-regression tests to check the update does not degrade parallel operation.

3. Post-event analysis:

- Site fault recordings and event lists analyzed with the same TFR reader as onsite.
- The analysis can be performed using real-time and offline simulations.

4. Testing new operating conditions: New procedures, synchronization schemes, operating ranges, etc. are tested on the replica before use offshore.

Operation & Maintenance Support using Replicas

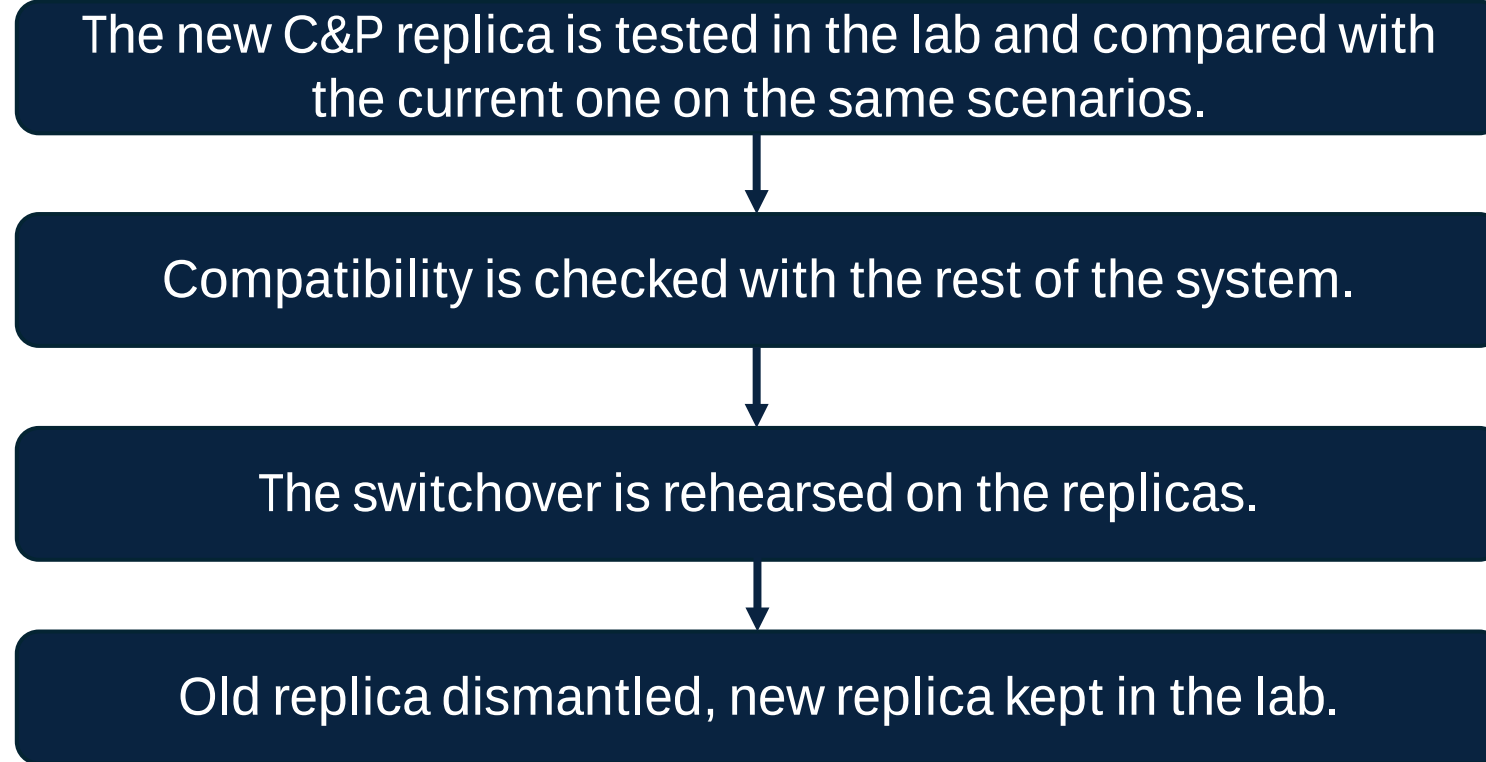
5. Operators training

- Same HMI and operator stations as on site.
- Operators can practise start-up/shutdown sequences, various operation conditions, fault scenarios, loss of communication etc.
- 5-day trainings in groups of 4-5 operators, organized once a year.



Long-Term Life of the Replicas

C&P replica refurbishment: Replicas make it possible to check the new one works with the rest of the existing system.



Conclusions

- Replicas are lifetime assets: from pre-commissioning de-risking to commissioning, operation, maintenance, training and refurbishment.
- Real-time HIL complements offline EMT studies: real C&P code, real sequences and quality control of the models.
- GTSOC brings real wind turbine and wind farm control code into multi-vendor HIL setups.