HIL AND RTDS ASSISTED DE-RISKING OF THE JOHAN SVERDRUP PROJECT

MING CAI

RTE INTERNATIONAL

2023 EUROPEAN RTDS TECHNOLOGIES INC. USER'S GROUP MEETING 2023

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AGENDA

- Introduction – the Johan Sverdrup Project
- De-risking the Johan Sverdrup Project using HIL and RTDS

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JOHAN SVERDRUP PROJECT

- Johan Sverdrup O&G field – largest O&G field in the North Sea (~150 km west of Stavanger)

14-17 bn	1.9-3.0 bn	755,000
Investment estimate €	Resources bbl	Production capacity bpd

*Courtesy of Aker Solutions

*Courtesy of Equinor ASA

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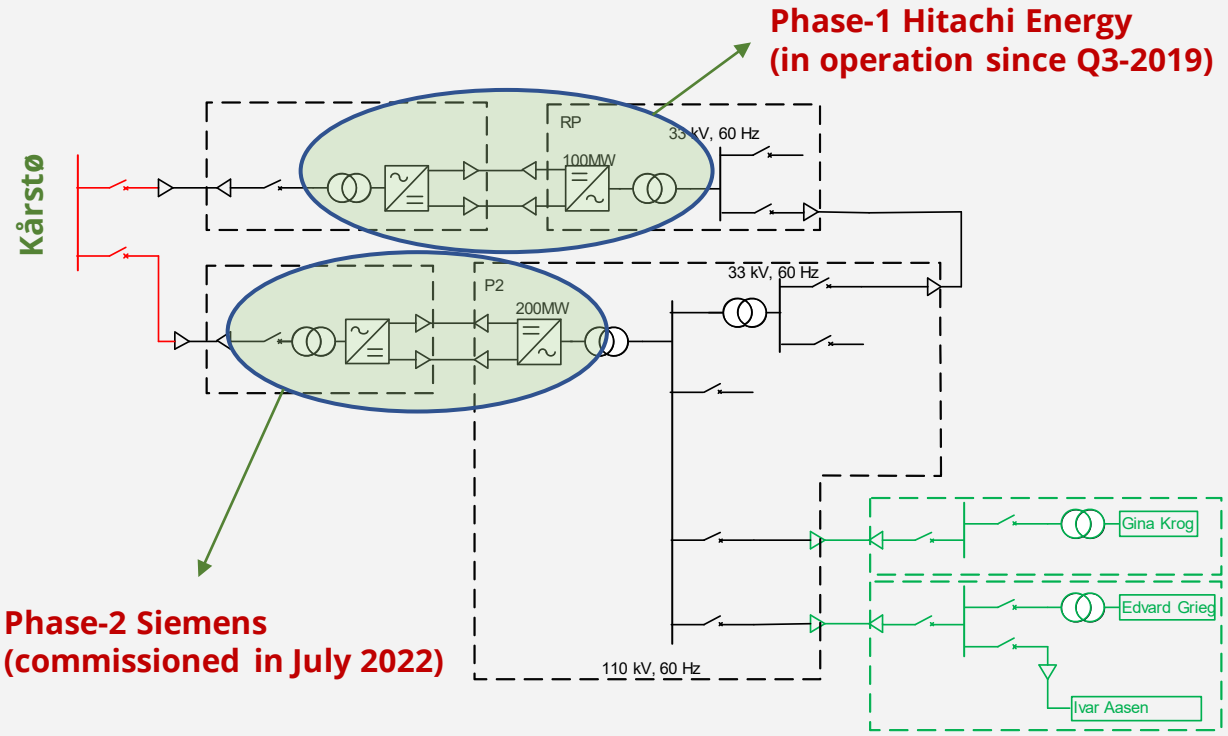
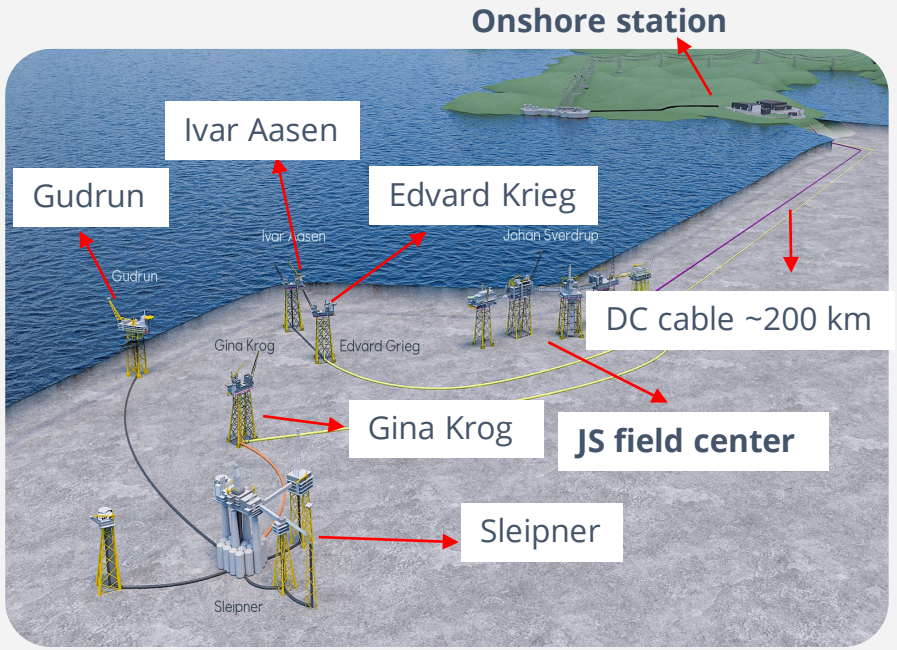
JOHAN SVERDRUP PROJECT

- JS O&G field powered by 2 multi-vendor parallel-connected HVDC links developed in 2 consecutive phases
- Europe's first multi-vendor parallel-connected HVDC systems in grid-forming operation





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- Introduction – the Johan Sverdrup Project
- **De-risking the Johan Sverdrup Project using HIL and RTDS**

PROJECT DE-RISKING USING HIL AND RTDS

- **Hardware-in-the-loop (HIL) simulation using the C&P replicas from both HVDC vendors and the RTDS simulator – an indispensable approach to de-risking the parallel operation of the Johan Sverdrup HVDC systems**

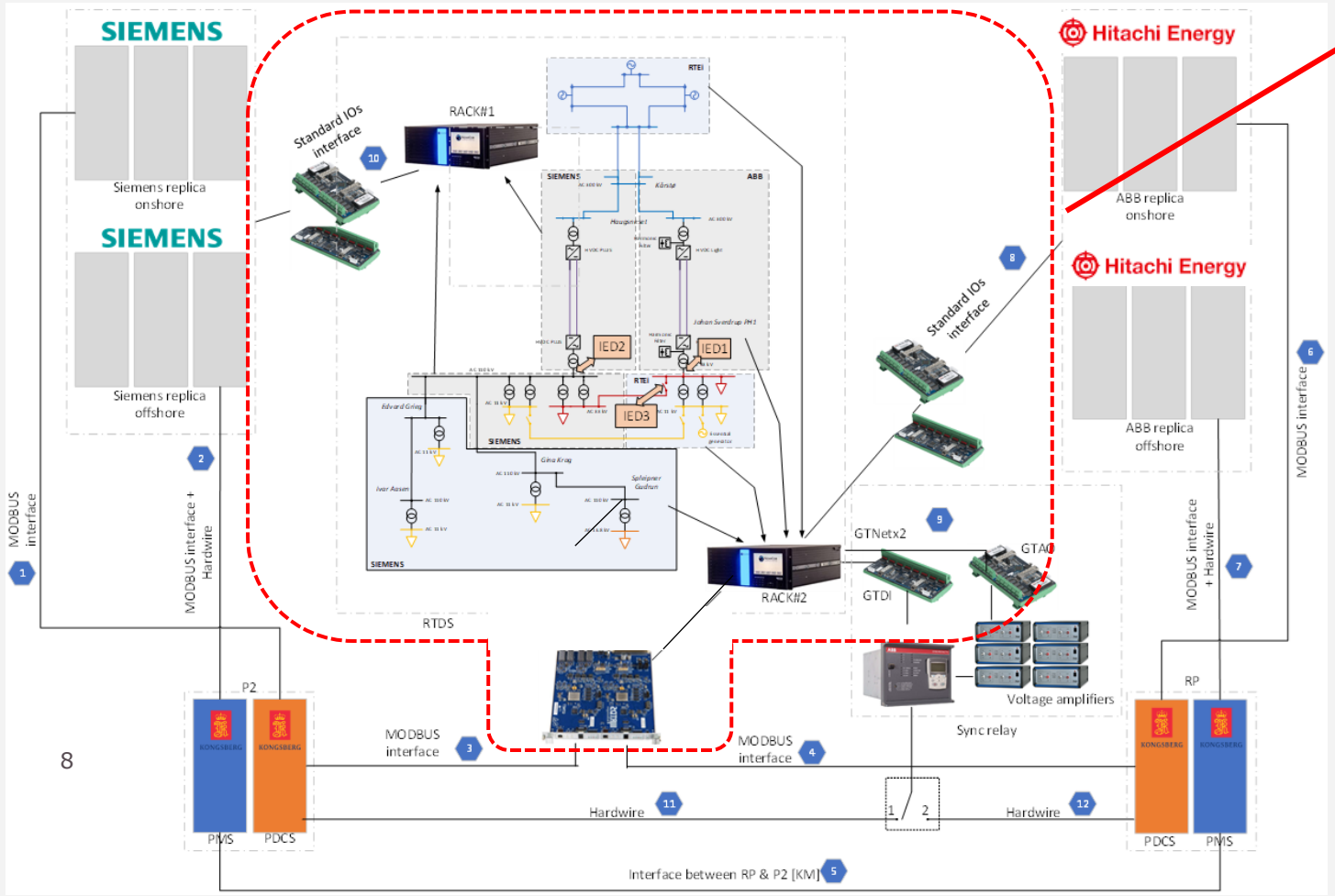
  - A master controller, namely the Power Management System (PMS), is used to coordinate power sharing between both HVDC links, provide secondary V/f control and supplementary functionalities. The PMS functionalities are not available in offline EMT model.

  - Issue of IP rights protection makes it impossible to use a detailed open offline C&P model of Phase-1 HVDC in the design phase of Phase-2 HVDC to anticipate any potential interaction phenomena.

  - Accurate representation of the C&P functions implemented by both vendors is compulsory to investigate potential interaction phenomena and to improve interoperability.

  - Extremely helpful in preparing for and performing on-site commissioning of parallel operation.

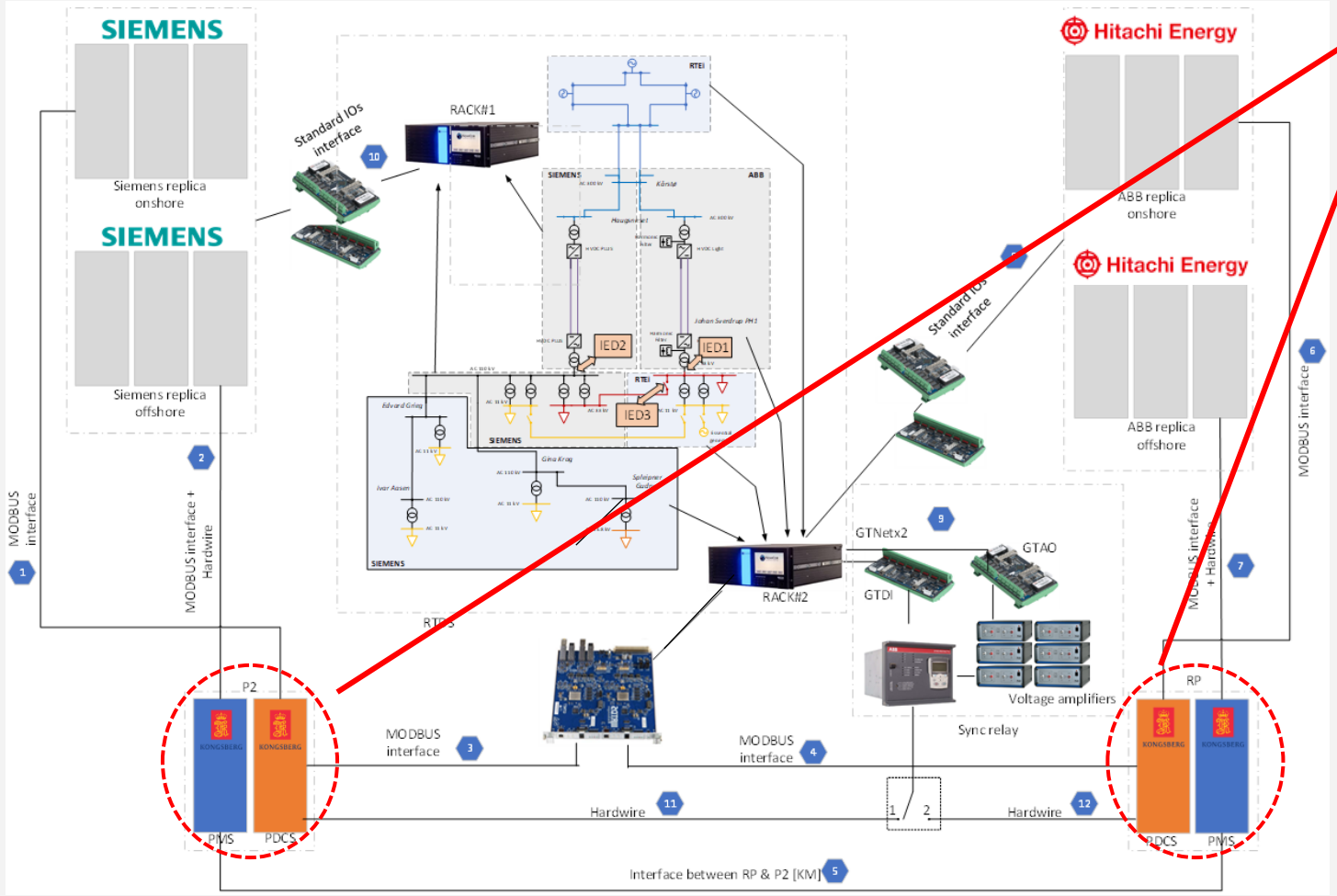
SYSTEM HARDWARE OVERVIEW



RTDS scope

- 2 Novacor chassis (15 cores)
- 1 GBH for cross-rack communication
- 1 GTNET×2 card for Modbus communication with PMS/PDCS

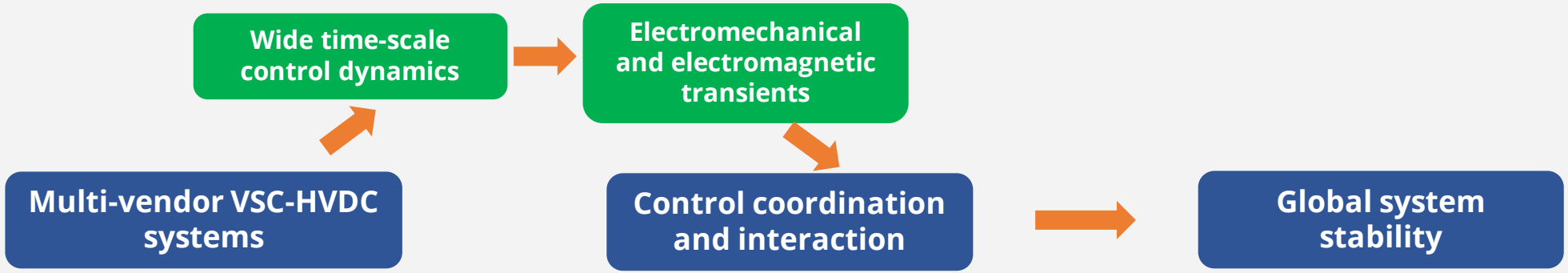
PMS/PDCS – MASTER CONTROLLER



- **PMS/PDCS (Power Dispatch Control System**
  - Power sharing
  - Secondary V/f control
  - Gradual load sharing
  - Coordination during coupling and decoupling of both links
- **Slow dynamics and operator intervention intensive**
- **Designed and manufactured by Kongsberg Maritime (Norway), not available in offline EMT models**

SYSTEM STUDIES WITH HIL AND RTDS

- **Control interactions**
  - ➢ Both HVDC systems were designed and implemented by their respective vendor, without information exchange/communication on any level



- System-level stability analysis

System-level stability analysis

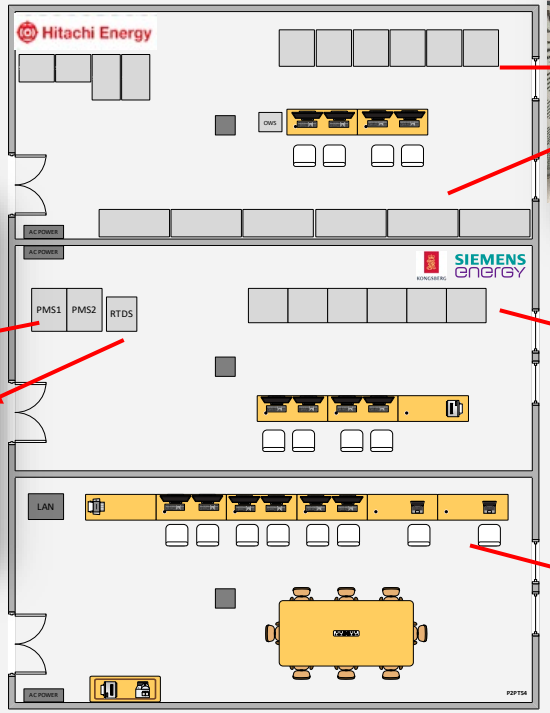
- ➢ Small-signal stability
- ➢ Large-disturbance stability

For the Johan Sverdrup project

- ➢ Impossible to analyze the overall control structure (black-boxed)
- ➢ HIL assisted EMT simulation used to analyze stability and system coordination

SYSTEM STUDIES WITH HIL AND RTDS

PMS/PDCS



RTDS + SyncRelay

- C&P replicas are housed separately with secure access.
- Remote access to C&P software has been established for each vendor.
- An iterative procedure for problem-solving has been set up for both offline and RT studies
- A test matrix with a dozen categories has been defined, covering dynamic performance and functional aspects of parallel operation.

Over 3000 tests were performed using HIL and RTDS in the course of 2.5 years before Phase-2 commissioning in July 2022

HIL AND RTDS ASSISTED ON-SITE COMMISSIONING

- **Commissioning tasks**

  - Testing of HVDC1 update for parallel operation
  - Testing of relevant HVDC2 functions for parallel operation
  - Testing of parallel operation both onshore and offshore

- **Stringent conditions for on-site commissioning**

  - High overall system complexity with multiple stakeholders (2 HVDC vendors, 1 master controller vendor, Equinor, RTEi, etc.)
  - Very short window of process shutdown allocated for annual platform maintenance

- **Therefore, it was decided to**

  - Test HVDC1 update during production
  - Test relevant HVDC2 parallel functions during HVDC2 commissioning
  - Test parallel operation of both links within only 2 days of process shutdown

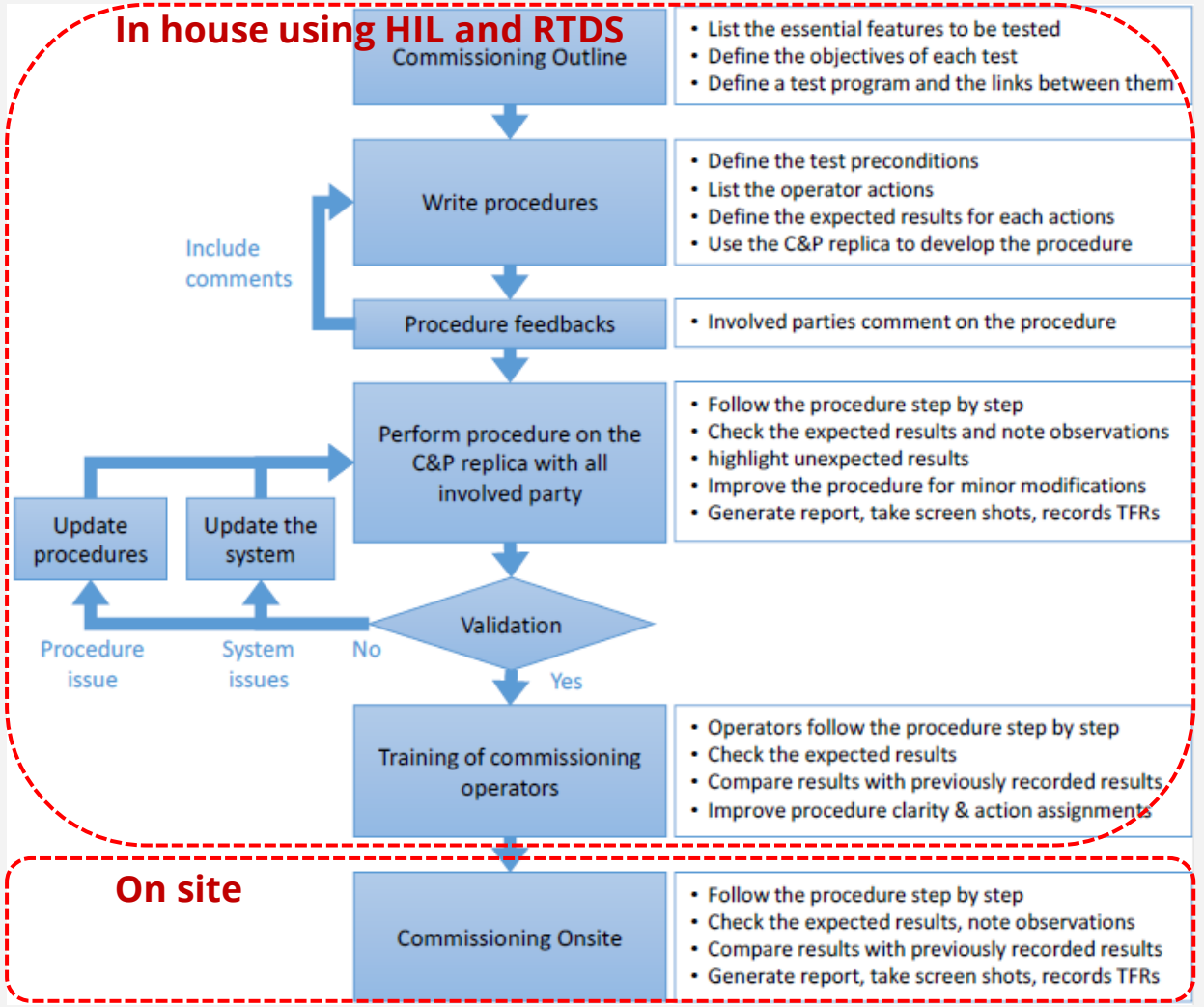
- **Any unexpected trip or malfunction would prolong the anticipated shutdown period, incurring considerable financial losses**

HIL setup with RTDS was used to prepare for on-site commissioning

HIL AND RTDS ASSISTED ON-SITE COMMISSIONING

- **Preparation of on-site commissioning using HIL and RTDS**
  - Remote participation of all parties to each HIL commissioning test after internal review
  - Observation and comments from all parties
  - Expected results confirmed and validated with proof of HMI screenshots and TFR
  - System debugging and update
  - Operator training prior to on-site commissioning

Commissioning went swimmingly with no hiccups while respecting allocated time window



TO SUM IT UP

- The HIL setup with RTDS simulator was used to de-risk the Johan Sverdrup project – Europe's first multi-vendor parallel-connected HVDC systems in grid-forming operation.

- Multiple interoperability issues were detected from over 3000 RT tests between 03/2020 and 07/2022.

- Several system updates have been tested, validated and implemented.

- On-site commissioning on an extremely tight schedule was successfully achieved thanks to ample preparation using HIL setup and RTDS.

RTDS support team – highly experienced, prompt response, valuable technical assistance in the Johan Sverdrup project

THANK YOU!
MERCI!

Markus Vor dem Berge, Director, Power Electronics and Studies at RTE international
Tel : +33622580838 Email : markus.vor-dem-berge@rte-international.com
www.rte-international.com
Ming CAI, Technical Expert, Power Electronics and Studies at RTE international
Tel : +33627864831 Email : ming.cai@rte-international.com
www.rte-international.com