

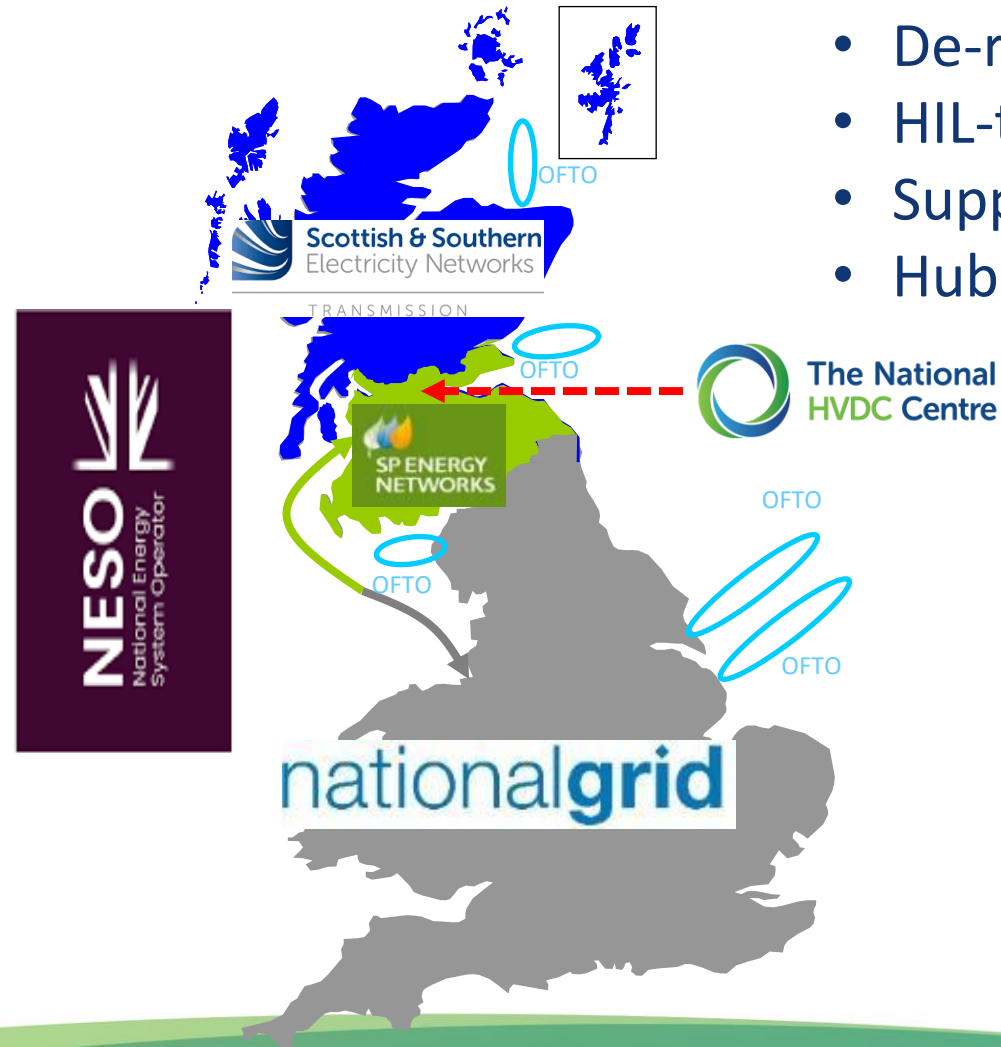
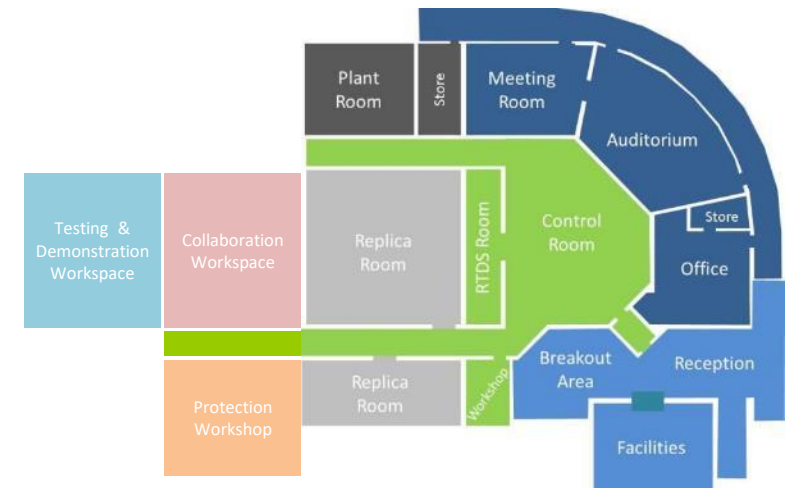
RTDS UG 2026

De-Risking Multi-Terminal, Multi-Vendor HVDC Interoperability: The Aquila Experience

October 2026

Who Are we? - the National HVDC Centre

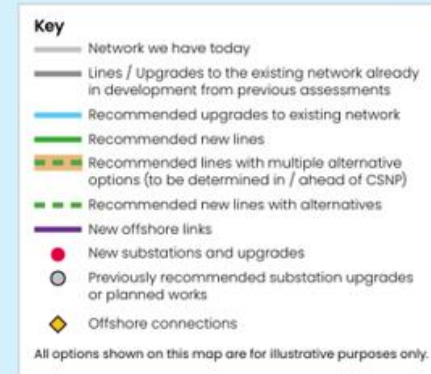
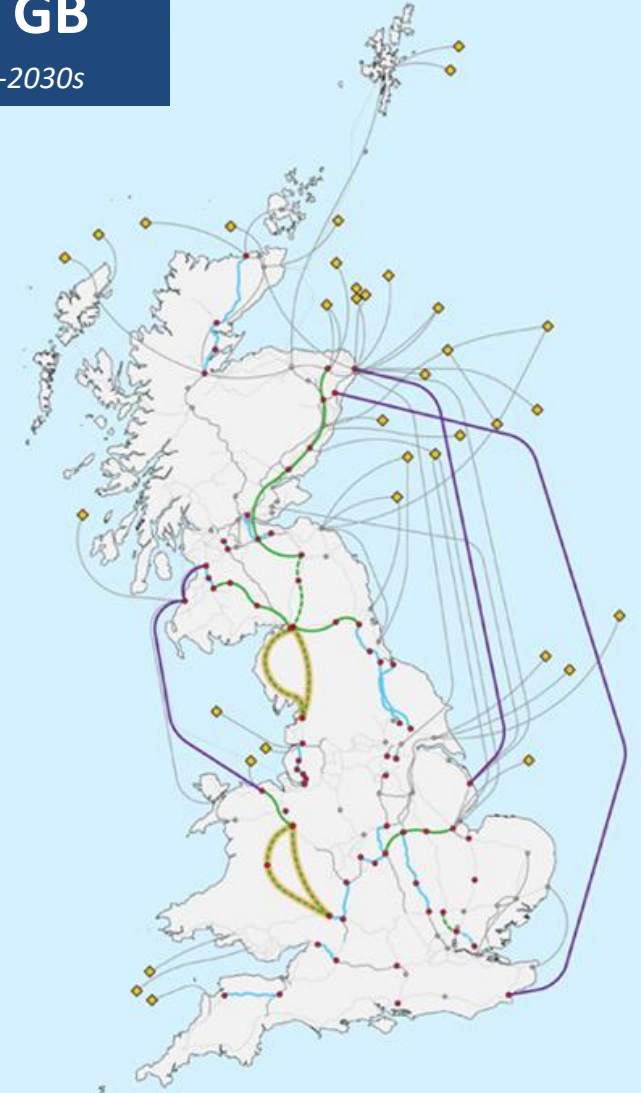
- Part of SSEN-T, partner of SPEN, NGET, and NESO
- De-risking the adoption and evolution of HVDC networks
- HIL-testing, simulation and training for HVDC
- Supporting commissioning and operation
- Hub for HVDC knowledge exchange, expertise and innovation.



- Context:
 - The **Pathway to 2030 Holistic Network Design (2022)**:
 - Integrated network design to unlock Clean Power 2030
 - Enabling the large-scale delivery of offshore wind – Target of **23 GW offshore wind**
 - **Beyond 2030 (2024)**
 - **Further 21 GW of offshore wind** from Scotland
- **Current Status (NESO update June 2026)**:
 - Simplified project configurations
 - High capacity offshore HVDC links off the **eastern and western coasts** => **large volumes of RES** from **North Eastern Scotland** into **Northern England, the English Midlands** and further south.
 - Strategic **onshore reinforcements** across **northern England, North Wales, the Midlands** and **Southern England** => more interconnected and flexible transmission system

Future HVDC in GB

44 GW of offshore wind by mid-2030s



Aquila Background in 2022

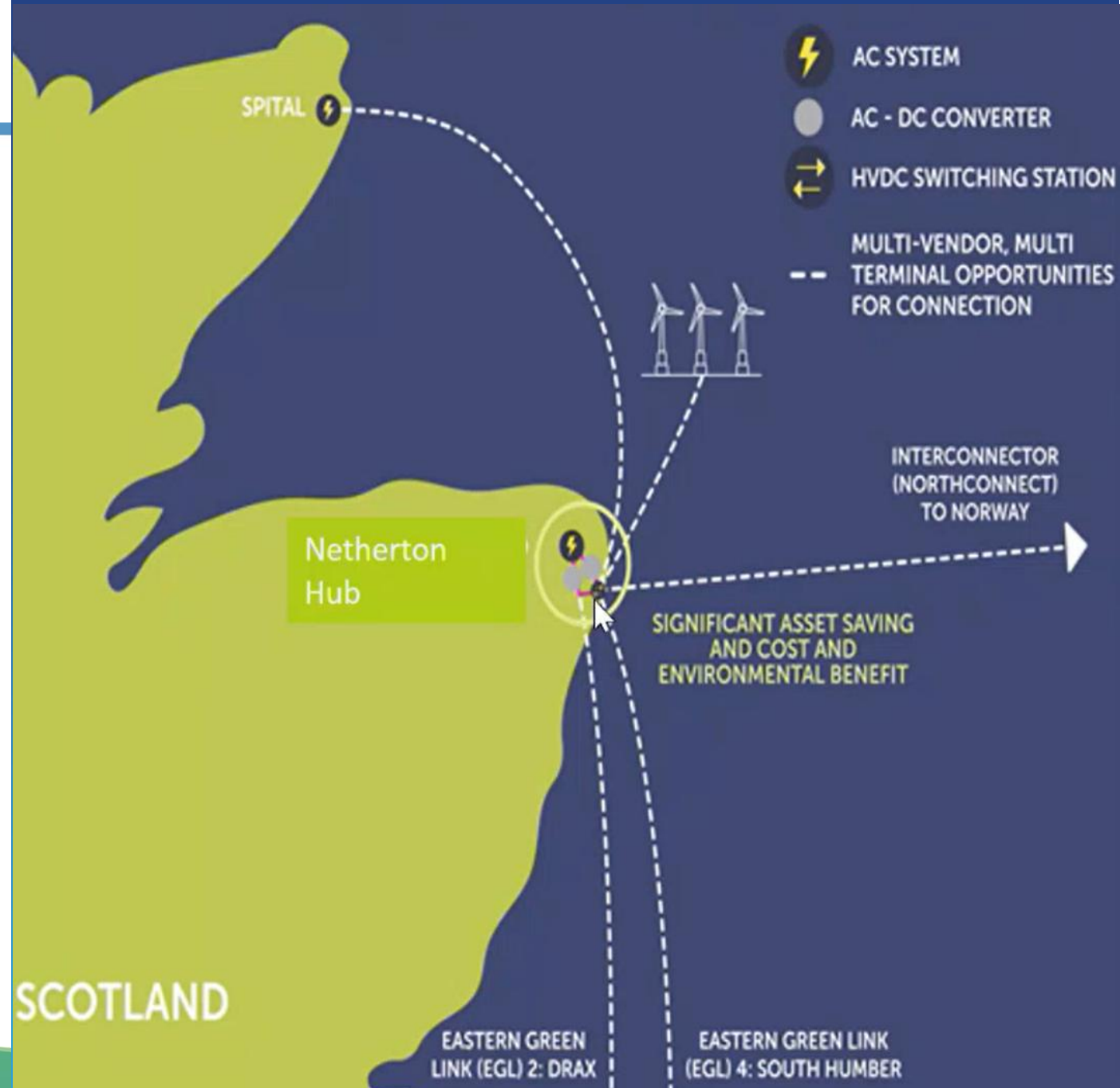
- Context:

- Enabler of target towards “net-zero”
- Offshore HVDC transmission network to utilize massive wind power
- Multi-Terminal-Multi-Vendor Offshore network as a business case

- Context:

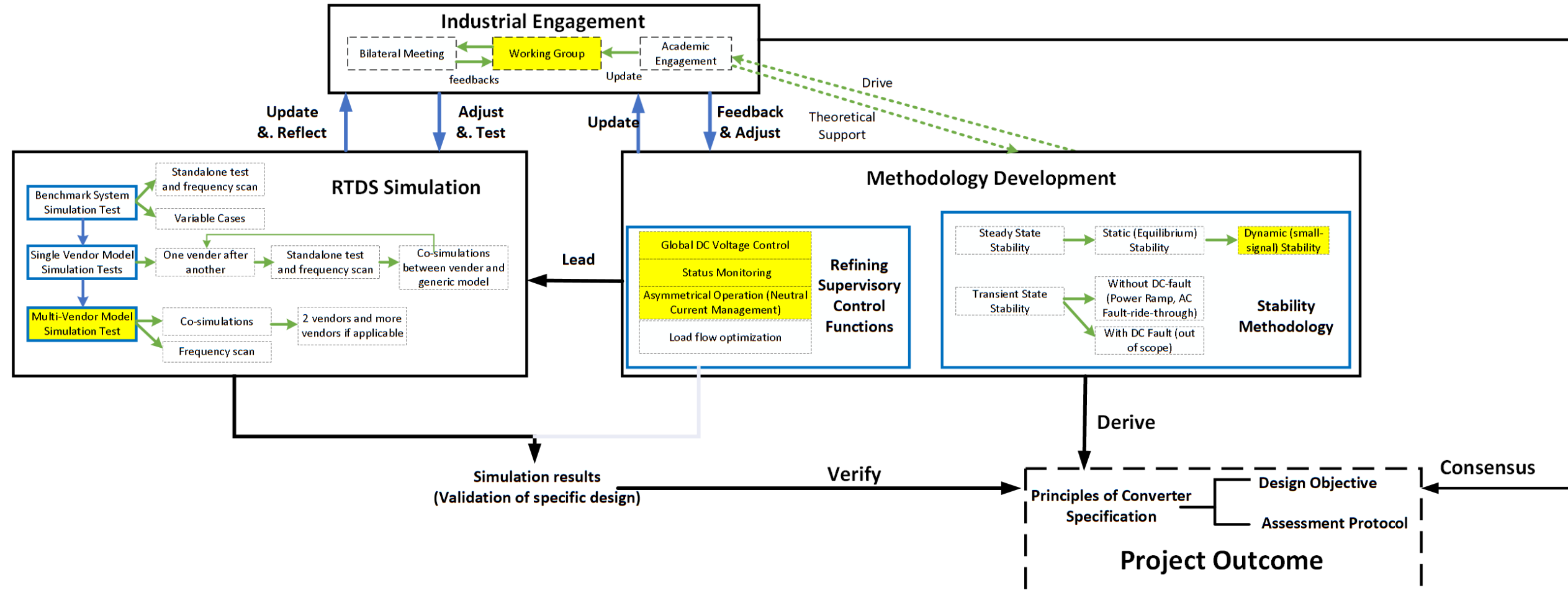
- De-risk future procurement, development and operation
- Interoperability with control interactions
- Simulation benchmark for MTMV using RTS
- Tender spec and grid code

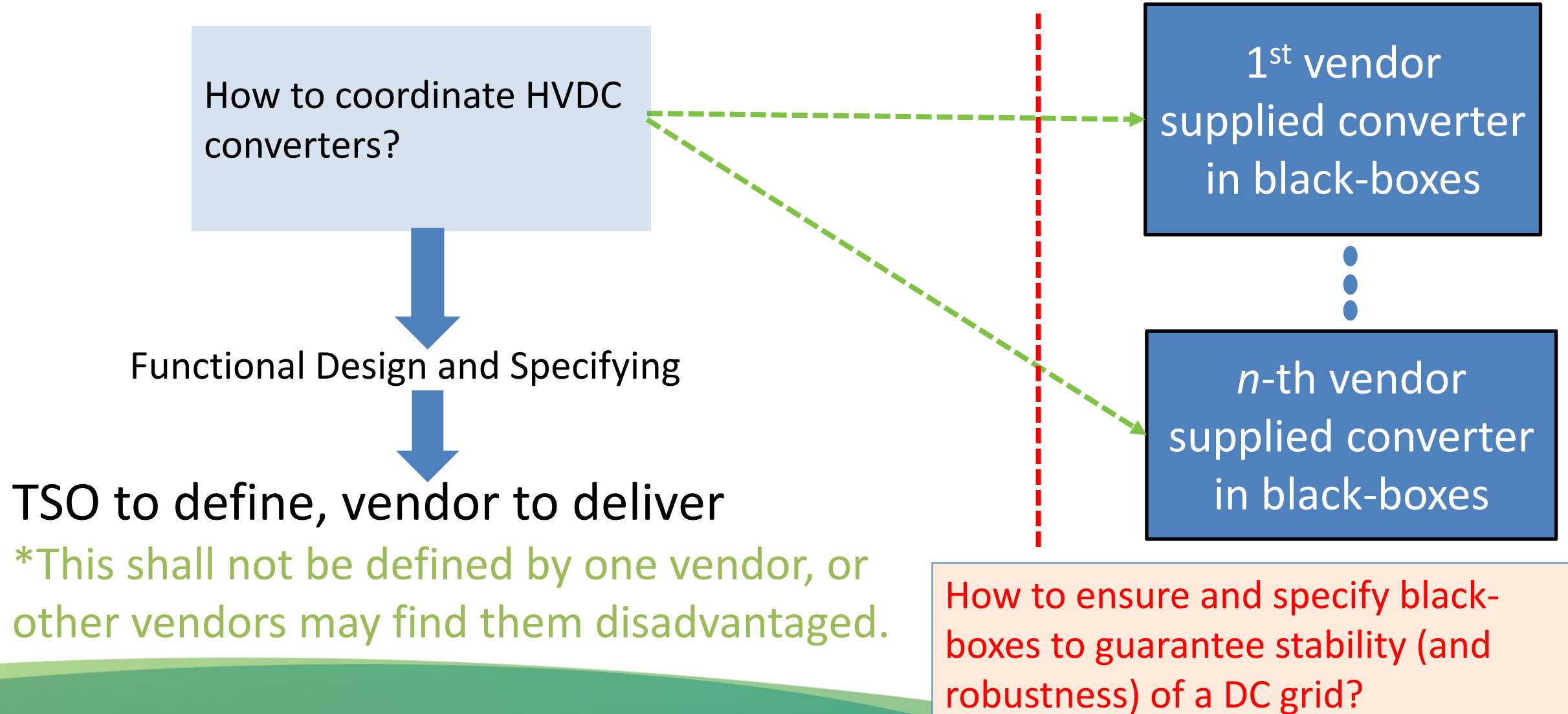
[Project Aquila](#)



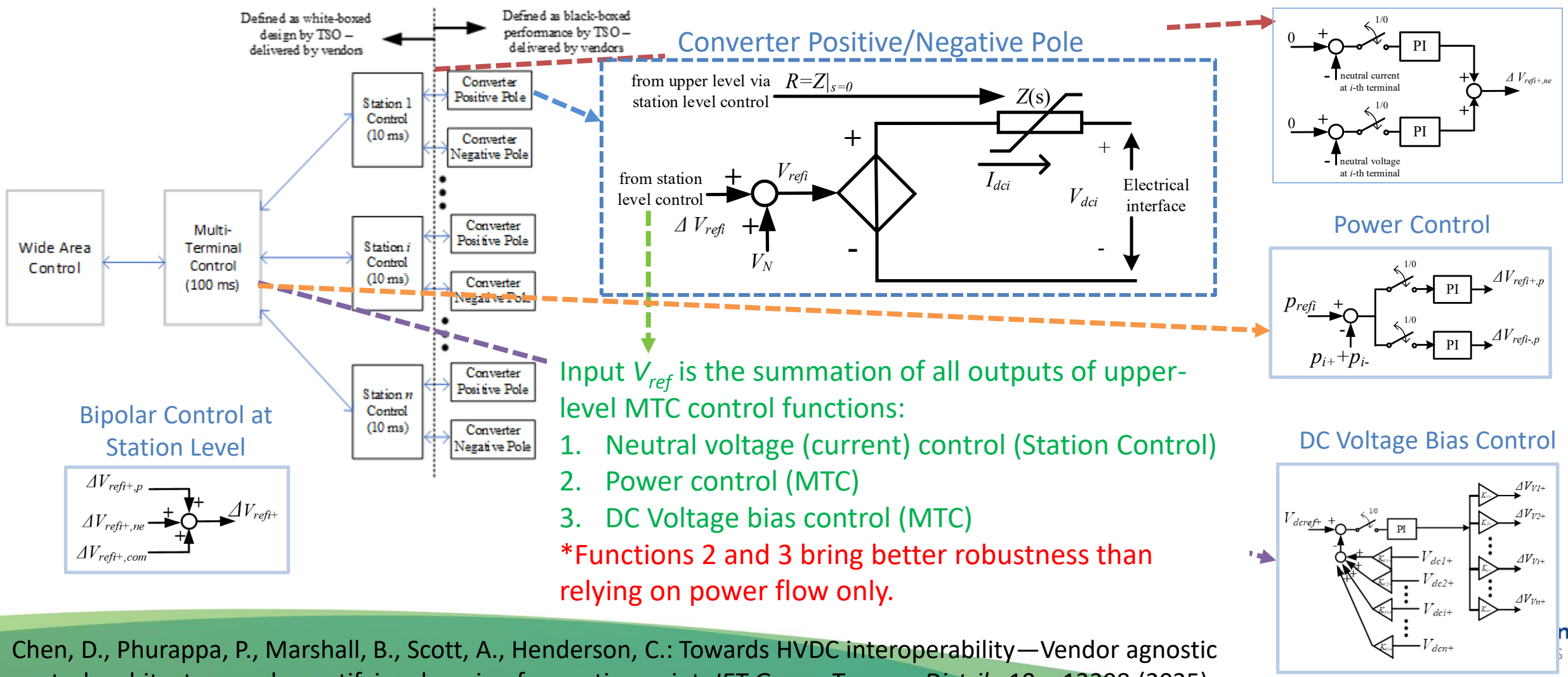
- **Project Aquila** brings together major HVDC vendors and GB TOs/SOs
 - Develop a practical **control architecture** and **testing framework** for **multi-terminal, multi-vendor HVDC interoperability**
- The **GB HVDC Interoperability Expert Working Group**: GE Vernova, Mitsubishi Electric, Hitachi Energy, Siemens Energy, and TOs
 - Review control strategies, testing methodologies, specifications, and vendor progress.
- The **National HVDC Centre** leads the *Aquila Interoperability* workstream. HVDC OEMs provide the HVDC Centre with **IP-protected, real-time “black-box” converter station models**
 - Stability assessments and real-time interoperability testing to demonstrating of reliable operation of MTMV
 - Preserving vendor confidentiality.

Project Scope

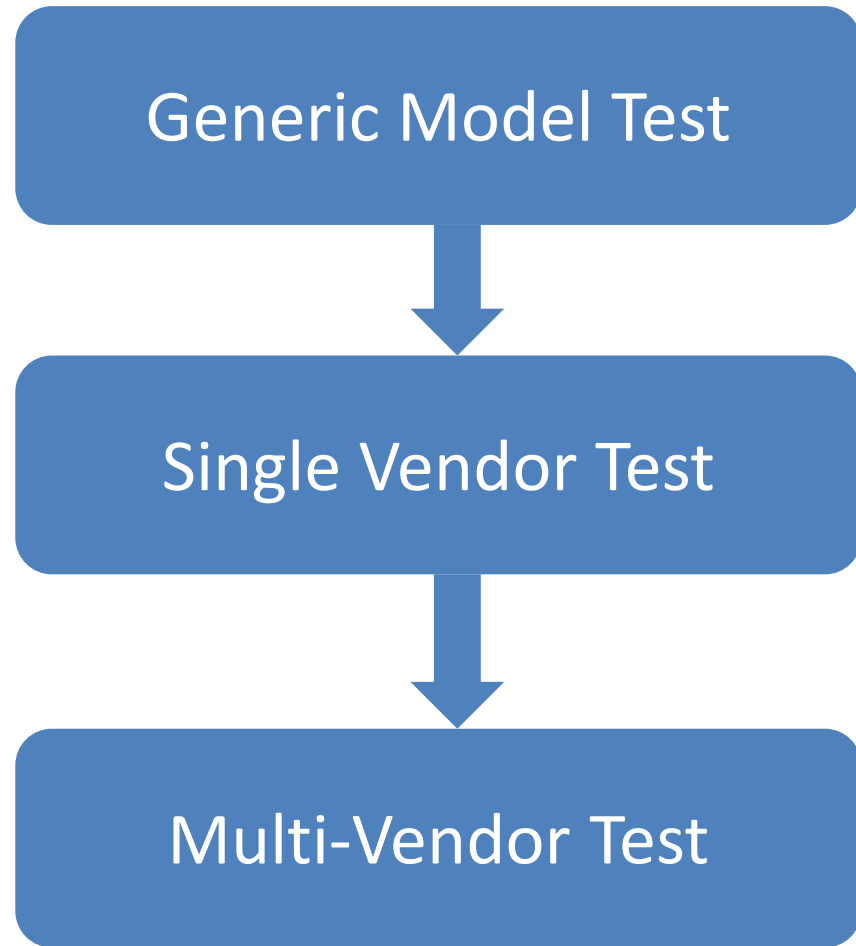
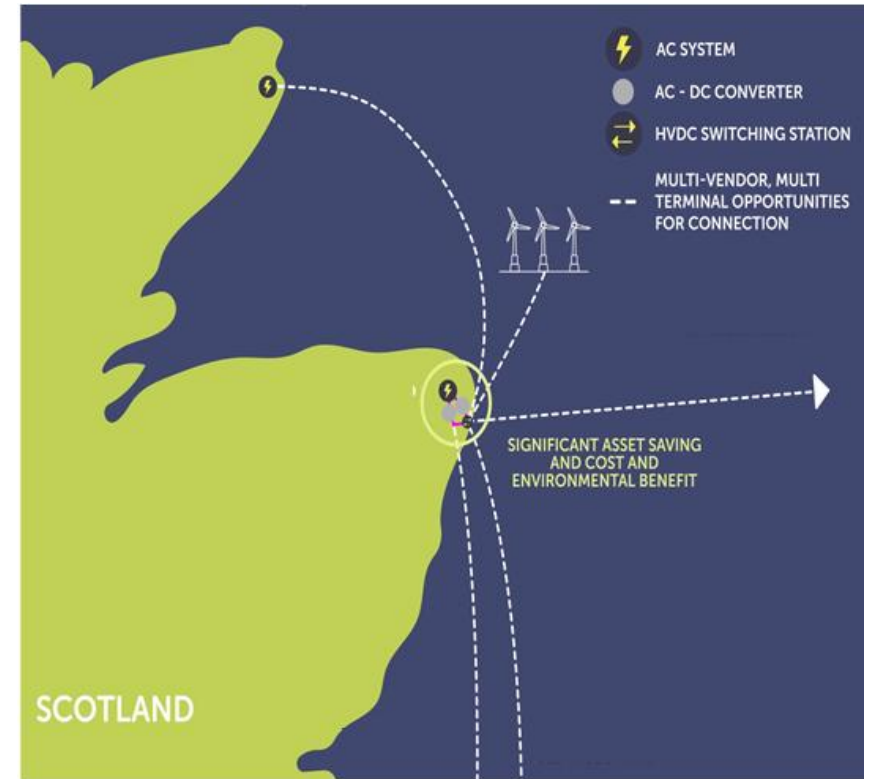




Control Architecture

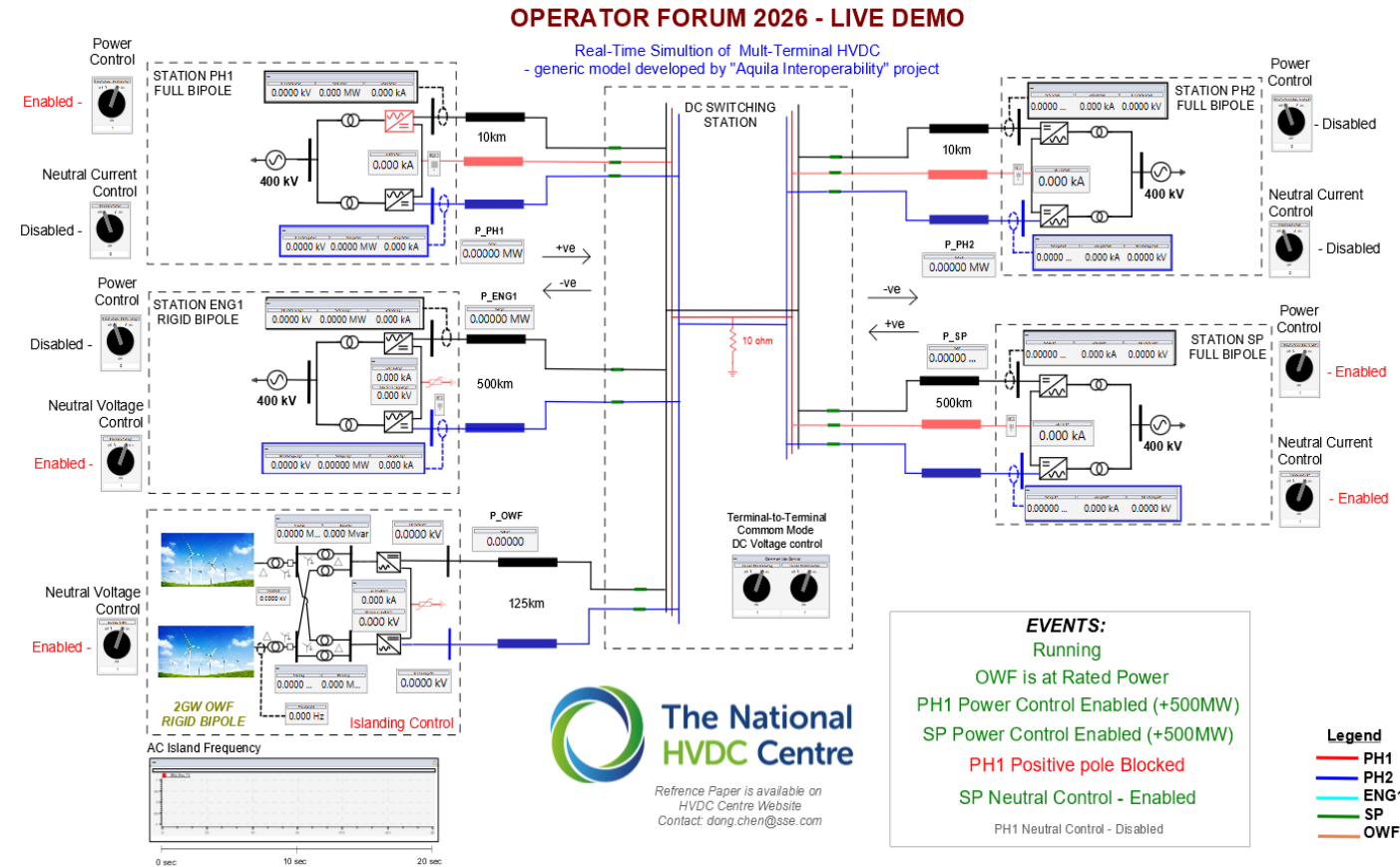


Three Stages in Multi Vendor Multi-Terminal Test

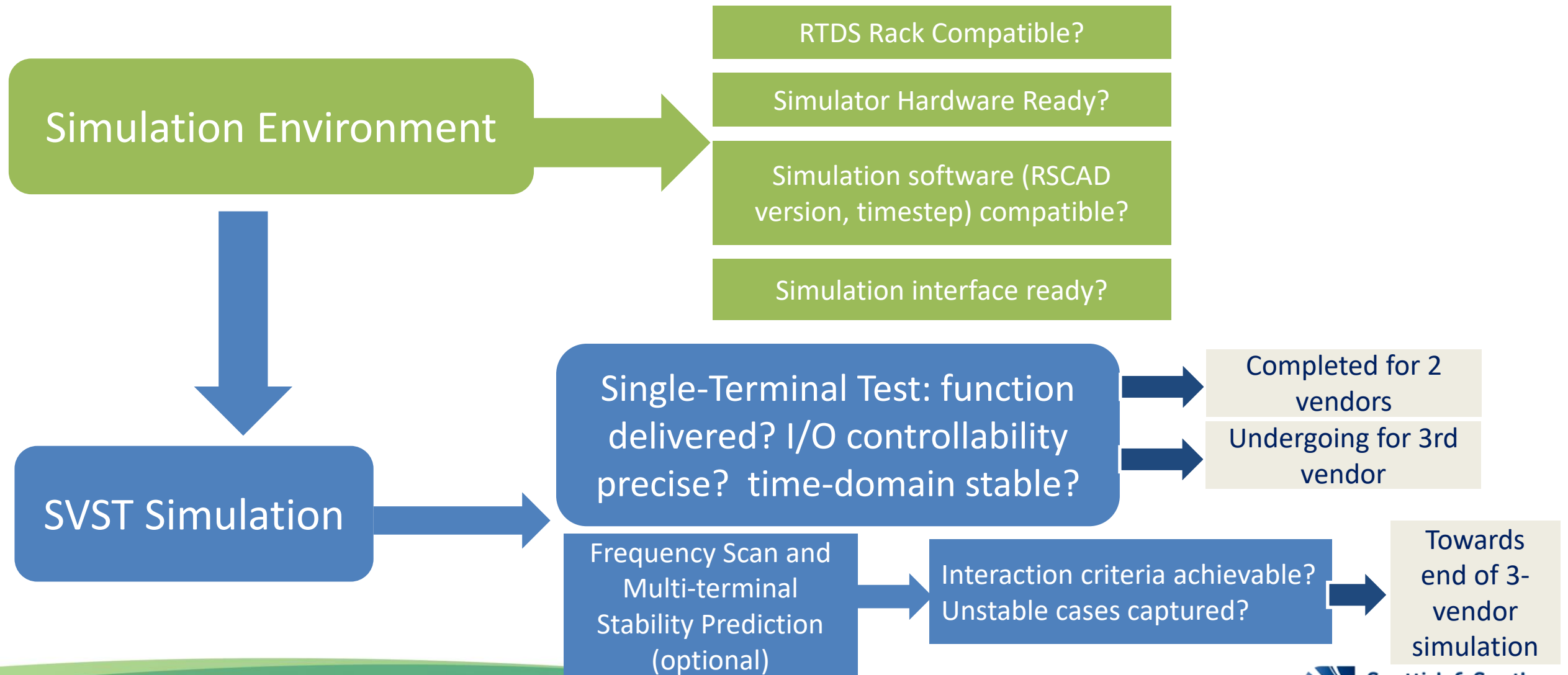


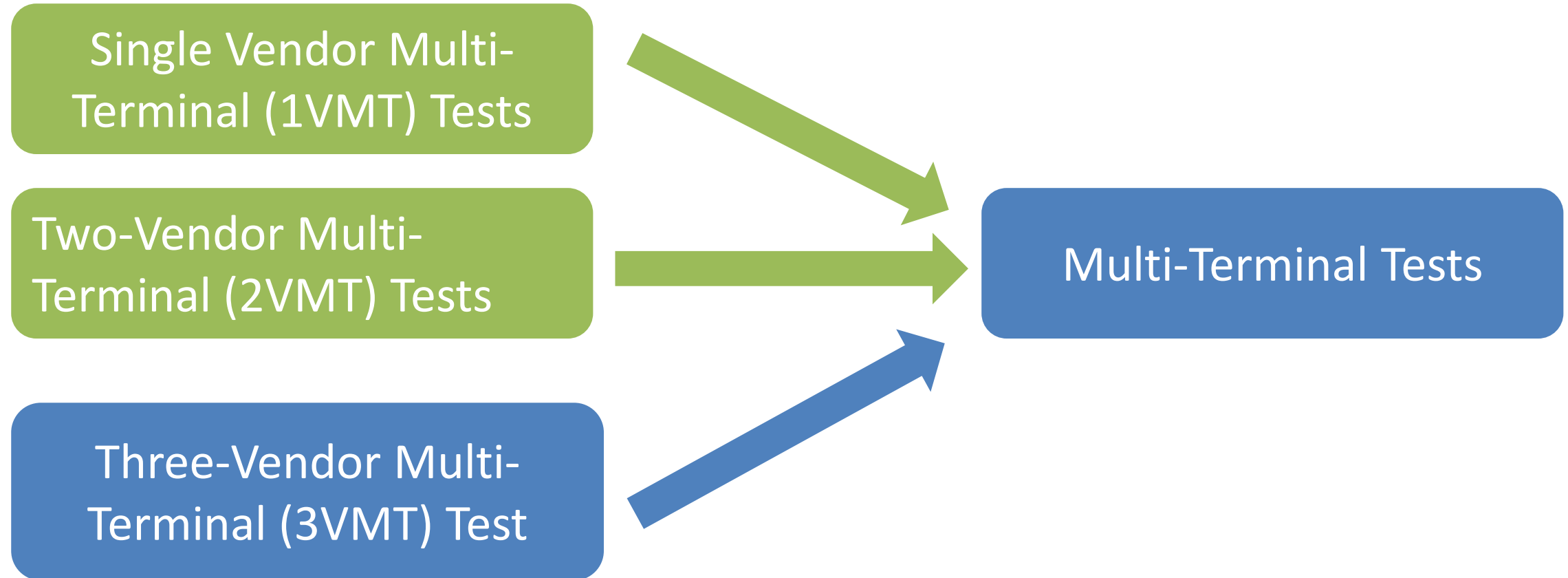
Generic Model Configuration

- 4(5)- terminal bipolar HVDC system
 - 4 onshore bipolar terminals
 - 1 bipolar offshore terminal as an option
- Topology: Star Connection
 - Partial DMR
 - 3 bipolar sections with DMR
 - 1 bipolar section without DMR
 - 1 offshore terminal (optional) without DMR
- Objectives:
 - Control architecture functioning?
 - Steady state Stability framework reliable?
 - Framework of control specification viable?
- Modular design and converter ready to be replaced by vendor's model
- Automation available for traversing a range operational scenarios



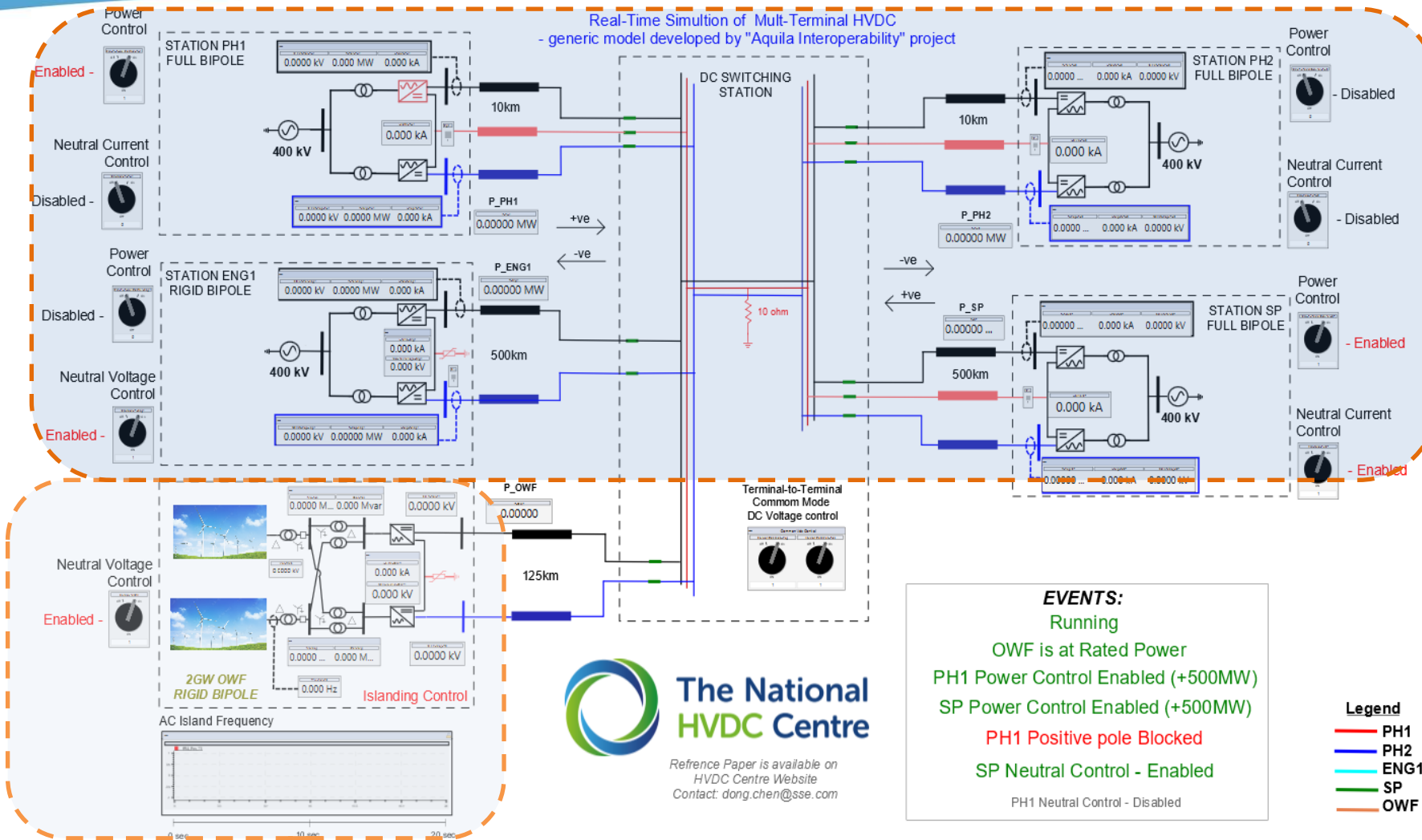
Single Vendor Single Terminal (SVST) Test





- To accelerate the process, we may skip single- and two- vendor tests in next steps
- 1VMT and 2VMT may serve as an optional diagnostic procedure for three-vendor tests
- Offshore HVDC remains generic and optional

RT Black-Box Testing: 3-Vendor-4-Terminal Model



- 2 Terminals to be supplied by Vendor A;
- 1 Terminal by Vendor B
- 1 Terminal by Vendor C

- GTSOC-based black-box models (SIL):
 - GTSOC v1
 - GTSOC v2
- Cbuilder embedded

Optional Generic Model by HVDC Centre

Multi-terminal Multi-vendor VSC HVDC demonstration.

- What we have done-

World first demonstrations



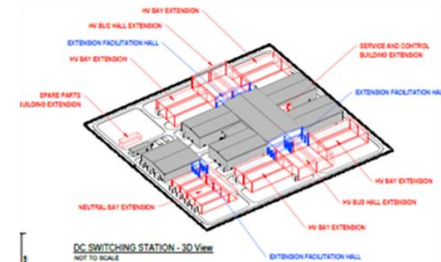
- More to come!

- More Vendors



- More projects (offshore hubs & onshore hubs- GB and continental Europe & beyond)

Specifications- layouts interfaces, data, design (Q2, 2024/5)



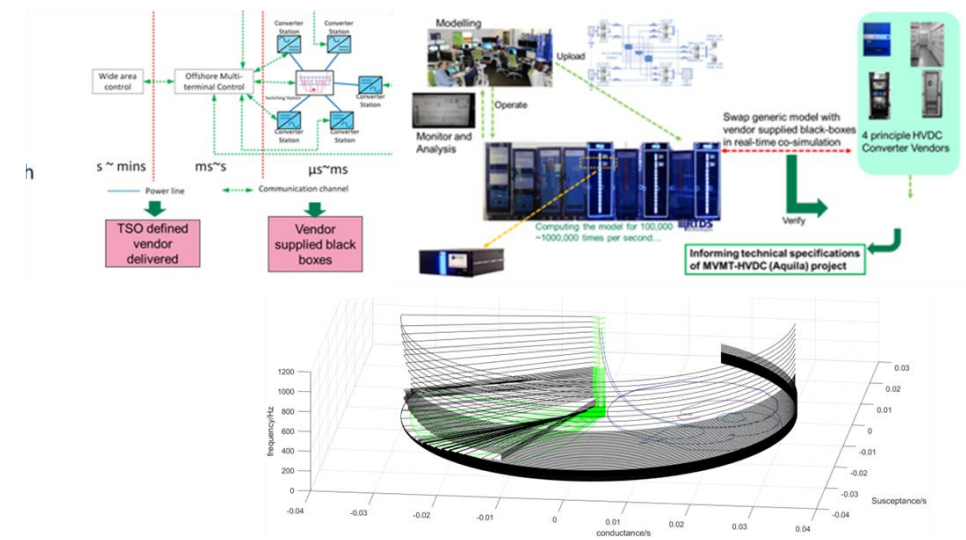
Enables contracting, consenting, delivery

Patent protection, legal commercial review (Q4 2024/5)

Multi-Vendor Multi-Terminal Control	This Patent covers an advanced control system for coordinating HVDC converters supplied by different vendors in a multi-terminal configuration. This enables smooth power flow orchestration between all terminals- prioritising stable operation intact and post-fault.
Multi-Vendor Multi-Terminal Operability	This Patent allows operation across unbalanced conditions across a range of configurations and outages to maximise the availability of an integrated HVDC grid.
Multi-Vendor Multi-Terminal Stability	This patent provides a mathematical proof of network stability that can then be monitored in real time- and provides a basis for clear specification of an vendors' converter interface to a DC network

Enables legal & commercial space for interoperability

MTMV Control specification and testing (Q3 2024/5)



Enables clear roles& responsibilities, & assured performance

	Aquila Interoperability Package	DCSS hub and associated design and specification	Aquila Commercial and Legal package.
Who?	Lead by HVDC Centre (September 2021- April 2024)	Lead by SSEN-T HVDC engineering team (September 2021- April 2024)	Lead by SSEN-T Innovation, Commercial, legal and procurement teams in association with University of Groningen (April 24- April 25)
What?	Vendor Agnostic multi-terminal control, control interface specification, design input. Associated test & demonstration approach	Tender pre-engineering, specifications, layouts, design at vendor agnostic level.	Requirements at tender & contracting phase, liabilities and responsibilities allocations, how to manage "switch on" and lifecycle support thereafter.
Why?	Patented approach protecting vendor agnostic delivery. Respects vendor IP as in real industrial project. Tested demonstration across vendor replicas	Planning, tender and contractual engineering documents enabling interoperability	Independent review and assessment of readiness to contract and manage multi-vendor solutions.

Thanks for listening.
Any questions, please?

❑ For further information, please visit www.hvdccentre.com ; OR email: [info@hvdccentre.com/](mailto:info@hvdccentre.com)



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