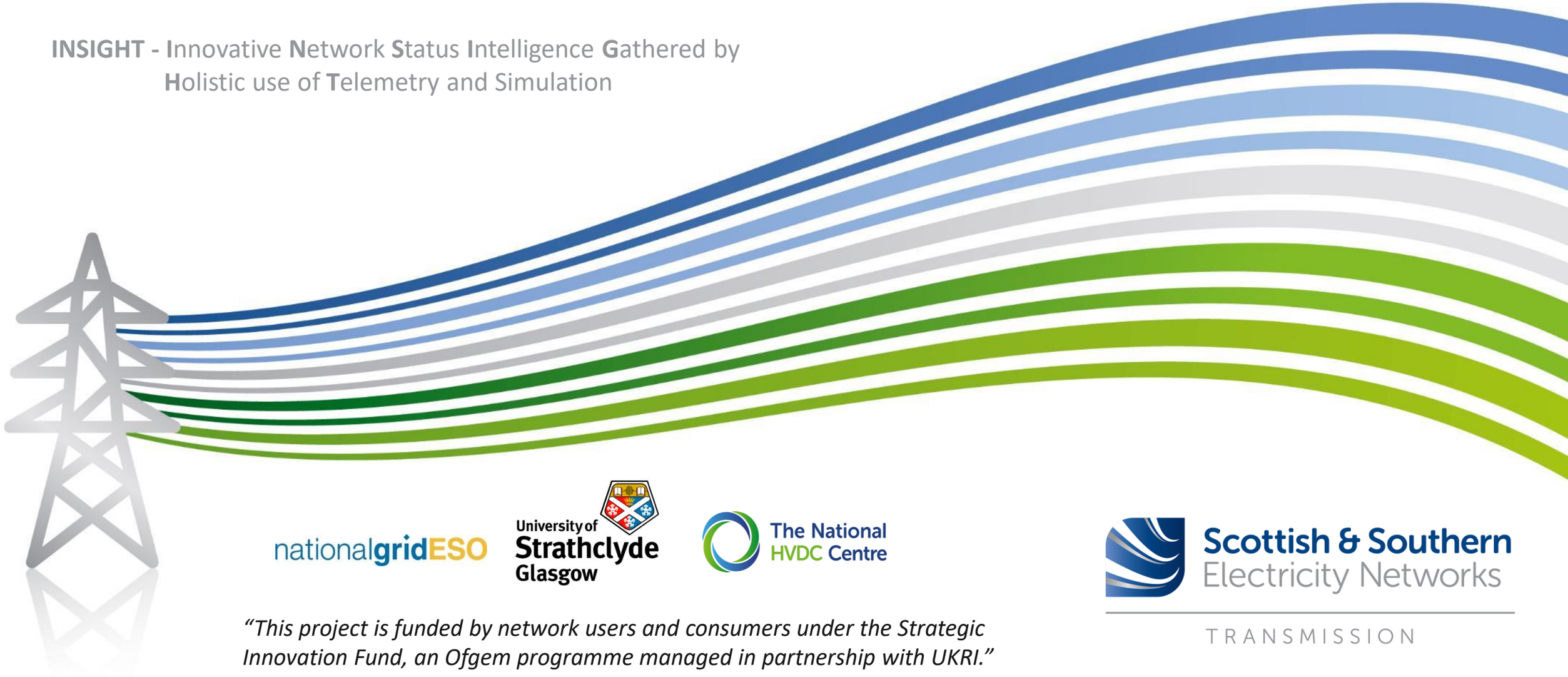
INSIGHT: ‘Show and Tell’

14th June 2023

INSIGHT - Innovative **N**etwork **S**tatus **I**ntelligence **G**athered by **H**olistic use of **T**elemetry and Simulation



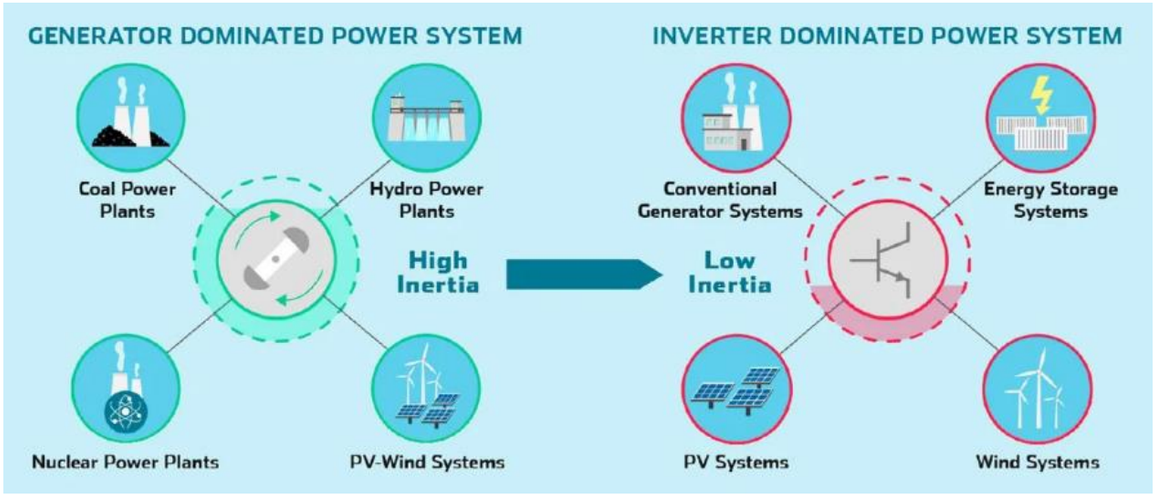
“This project is funded by network users and consumers under the Strategic Innovation Fund, an Ofgem programme managed in partnership with UKRI.”

The Problem

The **Net Zero** energy system transition is causing new types of oscillations on the electricity transmission network

Why?

- A move from synchronous power generation to asynchronous power sources on an unprecedented scale.
- Renewable energy sources such as wind and solar are intermittent unlike traditional coal and gas-fired power stations.
- The UK grid operates at 50Hz and must be dynamically kept within very specific limits for continuous safe operation.
- Historically, high-inertia generator turbines could manage any transient instabilities, but new technologies are needed for low-inertia renewable energy sources.



Wind turbine inertia - supporting the grid with active power (skeletontech.com)

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Project Overview

Objectives:
Deliver a virtual, real-time alert and control system that can monitor and mitigate different types of oscillation events experienced on the network.

Benefits:
- Improve the network strength, stability and reliability.
- Reduced likelihood of network disruptions.
- Potentially a low-cost solution that does not require expensive stability resources.

Discovery Phase:
- Develop an understanding of the problem and best practice - Globally.
- Investigate models & tools that may be used to; simulate network oscillation patterns, assess their suitability and develop a list of the key datasets for a new model.

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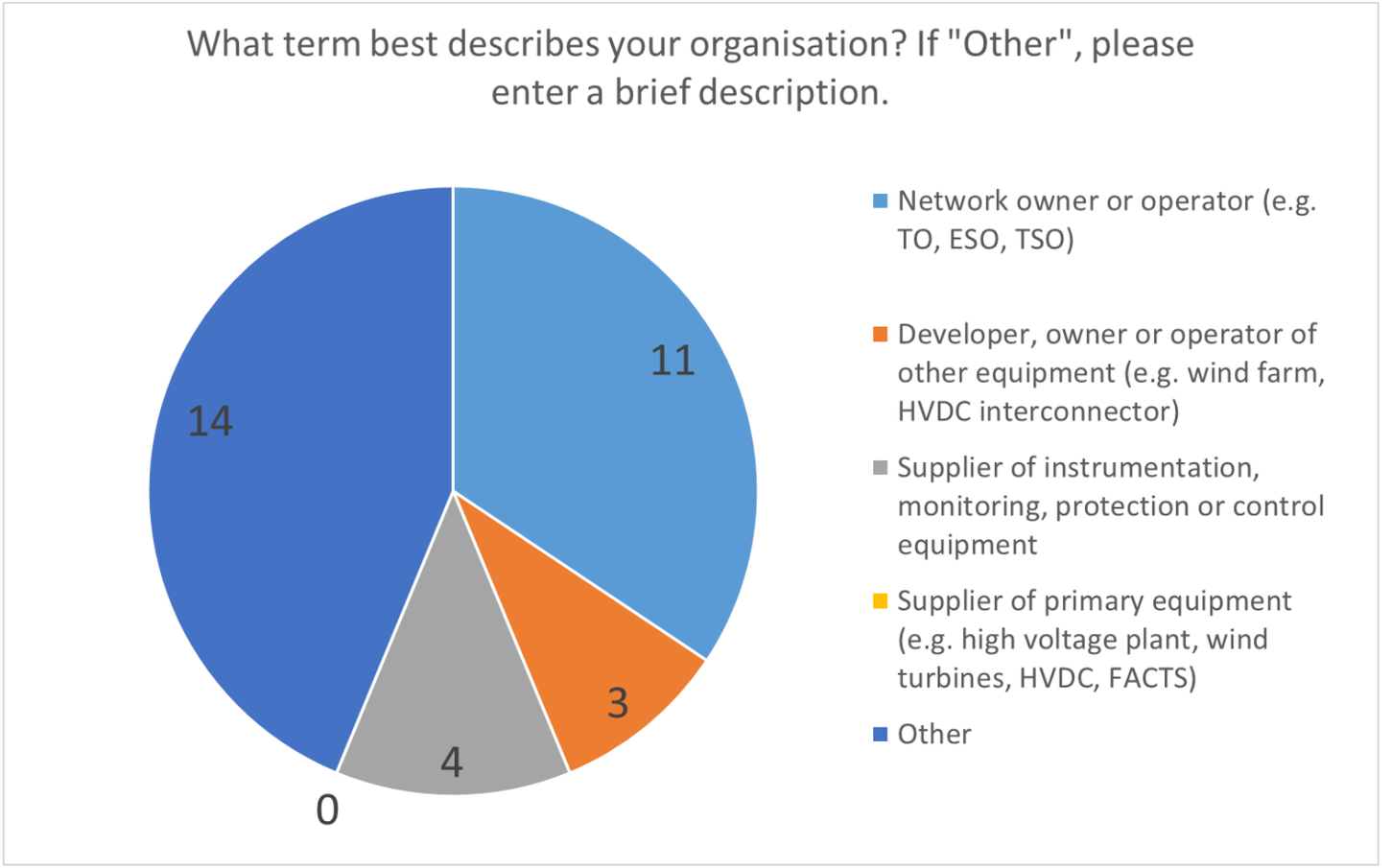
User Needs (1)

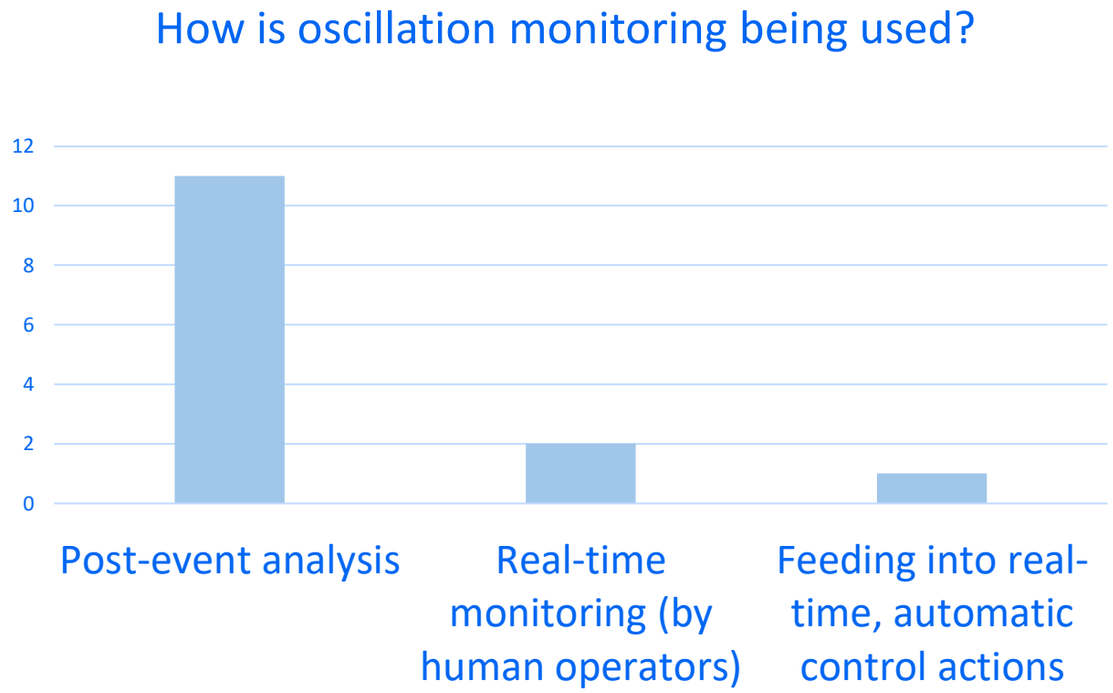
- Industry survey
- Invitations to 55 organisations from across the industry worldwide
- 32 responses
- Including 11 from electricity system owners and operators



User Needs (2)

- Although most system operators/owners had some capability to detect and analyse oscillation events

- Almost all were concerned that this capability was not sufficient for future:
  - Increased risk of oscillation events in future (due to IBR events)
  - Existing monitoring systems are reliant on manual analysis of data offline after the event



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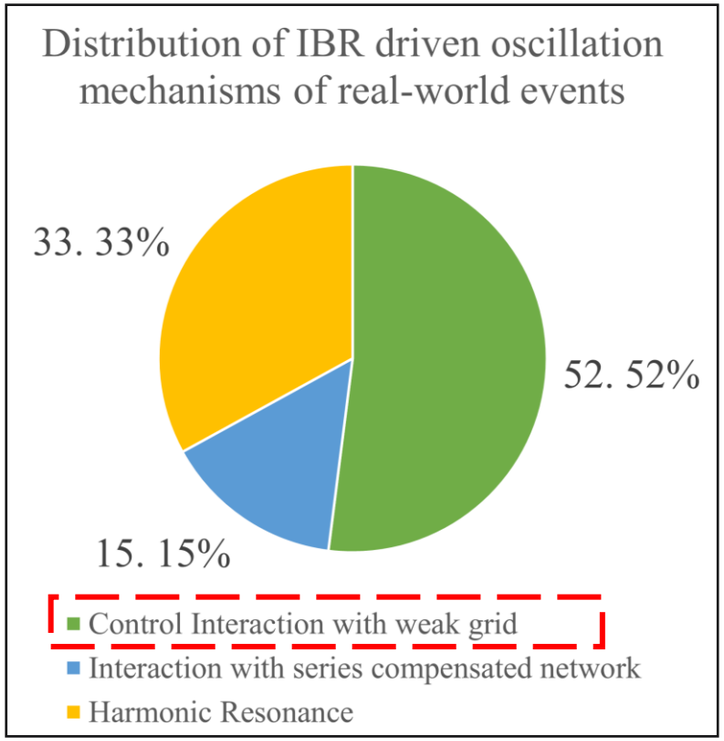
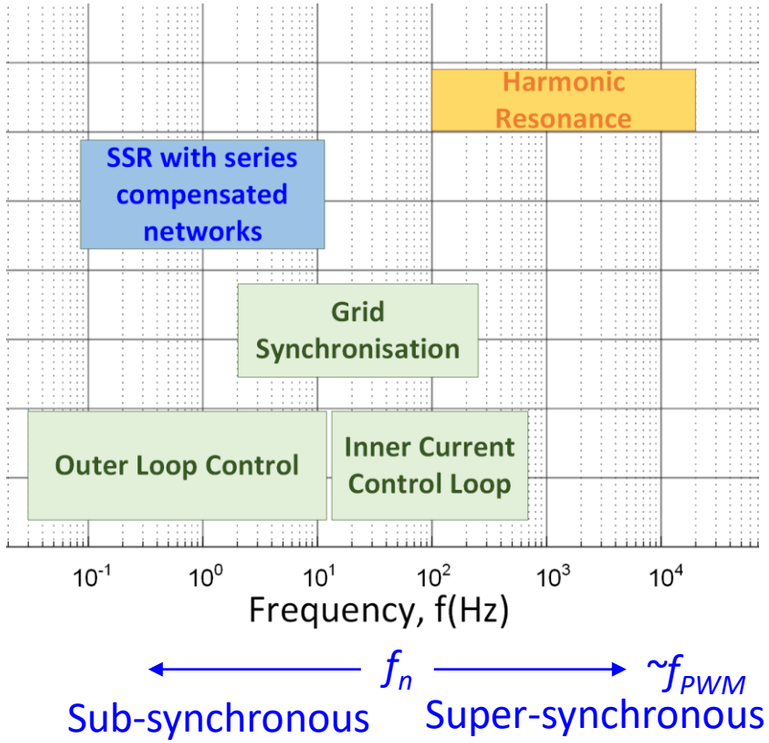
Opportunities for addressing the Problem

- Learnings from previous innovation projects, and system events in GB and around the world and the increasing deployment/development of PMU style technology
  - Visor
  - PMU deployment as Part of STCP 27-01 in RIIO-T2
- IBR resources have useful technical capabilities
  - Inverter based resources can provide configurable voltage and oscillation damping support to the system.
    - Have large MVAR ranges
    - Can be designed to have power oscillation damping
    - Control modes can be designed to be adapted based on system conditions

IBR driven oscillations: state of the art

- ✓ **Survey of real-world oscillation events**
- ✓ **Underlying mechanisms of emerging system oscillations**
  - Influenced by **proprietary controllers** and **system operating conditions**
  - Manifest in **a wide frequency range**
- ✓ **Suitability of existing measurement techniques**
  - PMUs: subject to aliasing
  - Waveform measurement units (WMUs): better suited, but limited deployment
- ✓ **Review of existing/emerging system oscillations solutions**
  - Existing solutions: focus on electromechanical oscillations
  - Emerging solutions: attempt to address IBR oscillation but in R&D stages





Control interactions with weak grid conditions: prominent causes for IBR driven oscillations

Wide frequency range poses challenges to existing oscillation monitoring / mitigation tools (e.g. PMUs)

Key Findings

- ❑ Existing measurement tools have limited capability to monitor wide range of IBR driven oscillations
- ❑ Manual operator actions, e.g. curtailing IBR output, may not be optimal or sufficient.

IBR driven oscillations: modelling requirements

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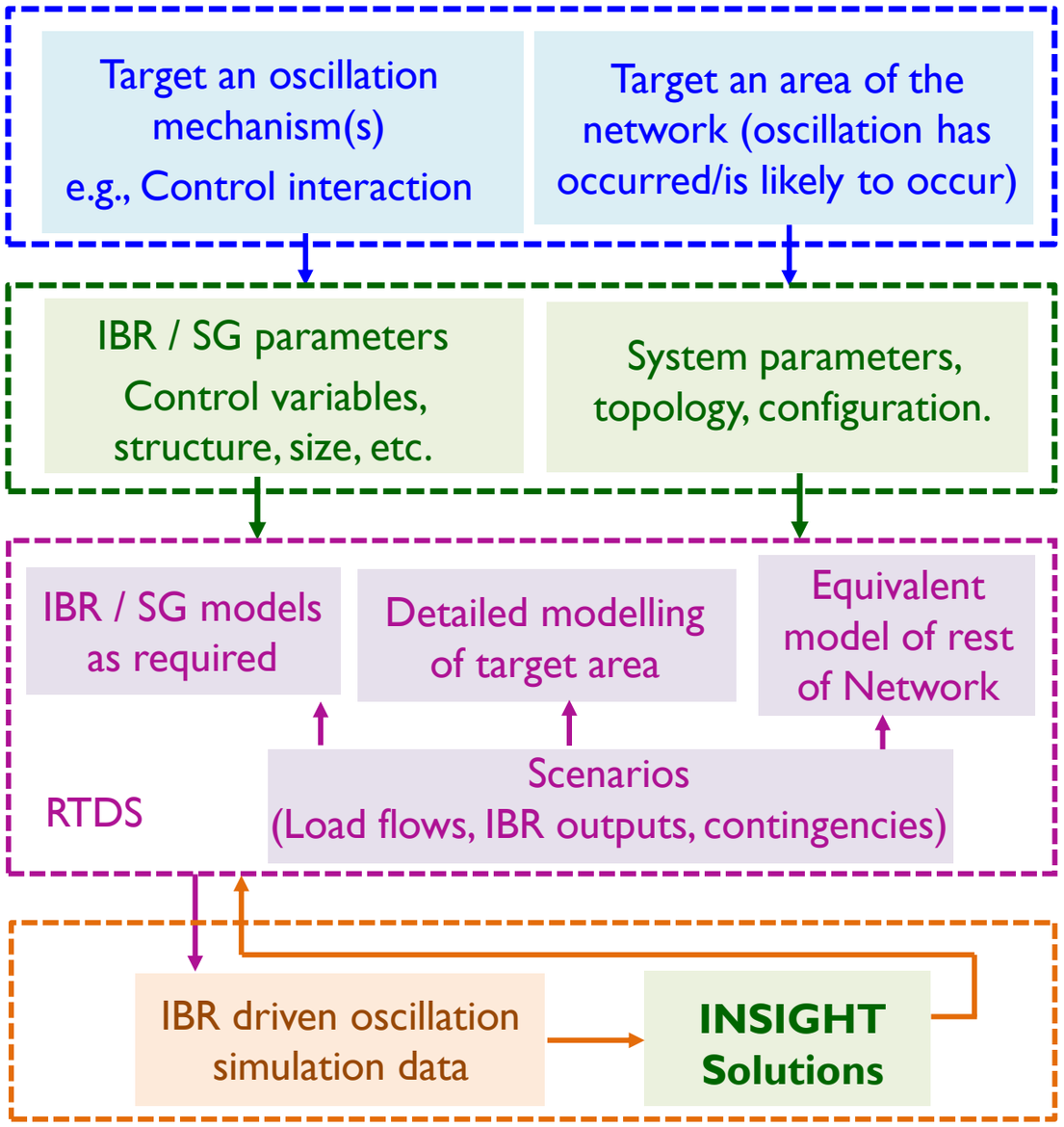
- ✓ **Electromagnetic Transient (EMT) vs Phasor Domain (PD) modelling**
  - EMT representation of IBR controllers needed to model IBR oscillations
  - Representation of IBR controller dynamic performance important

- ✓ **Review of EMT modelling of IBR oscillations**
  - Real-world event investigations utilise site specific, OEM, EMT IBR models
  - Benchmark test systems using generic IBR models and equivalent networks have been proposed to approximate real world events

- ✓ **Modelling/simulation requirements of IBR driven oscillations:**
  - Detailed, site-specific OEM models of IBR controllers most accurate but complex
  - "Blackbox" OEM models can be used if available
  - If mechanism understood a simplified model can be utilised
  - Simulation of a wide array of credible scenarios

Alpha Phase Modelling Plan



Potential Benefits Assessment

- Generation of Insight and understanding of the mechanisms of oscillation emergence and propagation
  - By ensuring that the right data is monitored, and the right mitigations are evaluated the system can be better planned to avoid these events.
- Increases real time system visibility - and therefore resilience and reliability
  - Ensures tools to monitor network in real time keep pace with changing technology.
  - Provides a platform for action and investigation to respond to oscillation events that were not predicted at planning timescales.
  - Reduces the risk of large-scale events by providing the ability to react to events in real time.
  - Allows the ability to reduce system constraints and actions required to remove instability risk, potentially saving on system operational costs.
- Utilise the inherent capabilities of IBR resources to provide support to the network
  - This allows for increasing of the system stability by utilising already planned for construction and currently installed technologies and plant.

How ESO thinking of the project has evolved

- Project ambition is to allow real-time control of TO devices to damp oscillations
- Is there potential scope to assess the User asset's ability to dampen these types of oscillations?
  - Could we determine who is the most effective at damping an oscillatory mode? (i.e., tailor the response to the event)
  - Would that be the right approach?
  - These types of instability should be designed out: the GC places the onus on Users to assess and address oscillatory behaviour and mitigate before connecting

Key outcomes and future activities

Gaps with business-as-usual approaches

- Improved monitoring tools needed to supplement PMUs & Post Event analysis
- System planning approach (via modelling) difficult to achieve due to complexity of IBR control interaction and modelling
- Real-time monitoring/control solutions available not readily suitable for IBR driven oscillations
  - **Post-event analysis** typically done for understanding real–world IBR driven oscillations
  - **Offline EMT modelling** used to investigate past events/assess risk of future events
  - Optimal (real-time) monitoring and control capability are not commonly available

How can INSIGHT address the gap

- Enhanced monitoring of IBR oscillation across a wide frequency range:
  - Investigate wider utilisation of **high-resolution measurements**.
  - Better utilisation of existing measurements (PMUs, DFRs etc), e.g., **data driven algorithms**
- Enabling real time control/mitigating actions.
- Comprehensive validation of solution before deployment
  - Develop representative, **real-time models** that approximate real-world events
  - Provides a common framework to **engage and assess potential solution providers**
  - Progress to **trial demonstration** of identified solutions

Project Contact Details:

Jonathan.Powell@sse.com

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