Development of Large-area AC Network Model for HIL Testing of a Wide-area Protection Scheme

- Hiranya Suriyaarachchi and Akbo Rupasinghe
- TransGrid Solutions Inc., Canada

ATC RTDS APPLICATIONS & TECHNOLOGY CONFERENCE

APPLICATIONS & TECHNOLOGY CONFERENCE 2025
CHICAGO, ILLINOIS, U.S.A.

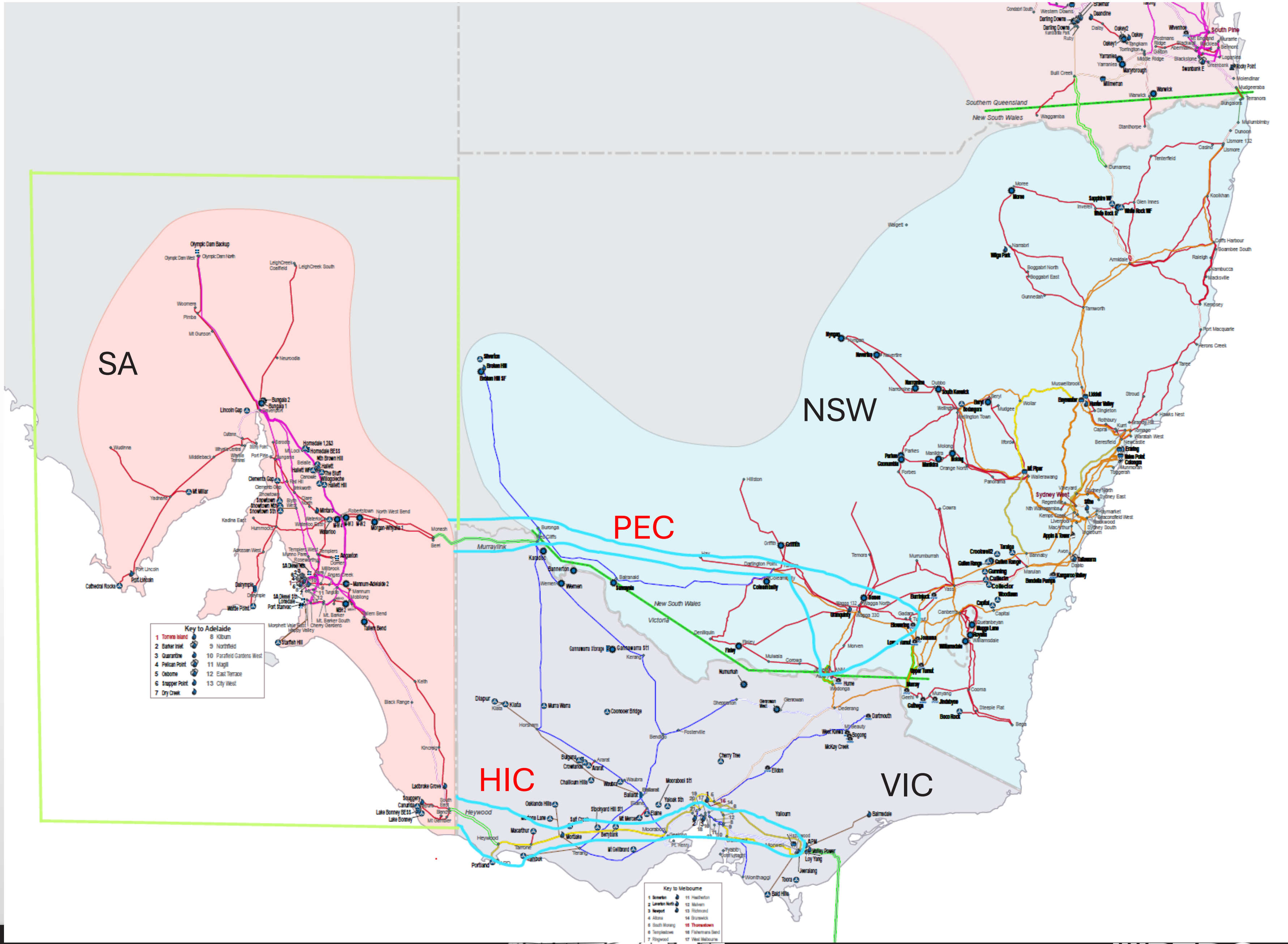
RTDS Technologies AMETEK

Introduction

- The South Australian AC System is heavily dominated by Generation from IBRs
- Maintaining the stability of such a system is always challenging
- To enhance the reliability and the security of the electricity supply, ElectraNet (SA) and TransGrid (VIC and NSW) is developing Project EnergyConnect (PEC)

Introduction

- Heywood Interconnector (HIC) – 750 MW
- Power EnergyConnect (PEC) – 800 MW, 900 km
- Robertstown (SA) – Buronga (NSW) – Waga Waga (NSW)
- Connection to VIC (Red Cliffs)



Need for the SPS

- Two parallel AC Interconnectors transferring almost 1500 MW
  - Each interconnector is a double circuit
- For a double circuit outage of each interconnector during high transfer
  - Overload of the other interconnector
  - Instability and system split
  - Separation of SA from NEM and potential loss of widespread system failure
- Vulnerability is due to a low probability event: non-credible contingency
- Due to the high impact – need for corrective measures – SPS

SAIT-RAS

- South Australian Interconnector Trip – Remedial Action Scheme
- A wide area scheme
- Both response and event-based scheme
  - Measurements from various points in the network
  - Status of the breakers
  - Adjust generation, load
- Due to the criticality of the scheme, HIL testing of the RAS hardware is planned

Reduced PSSE Network

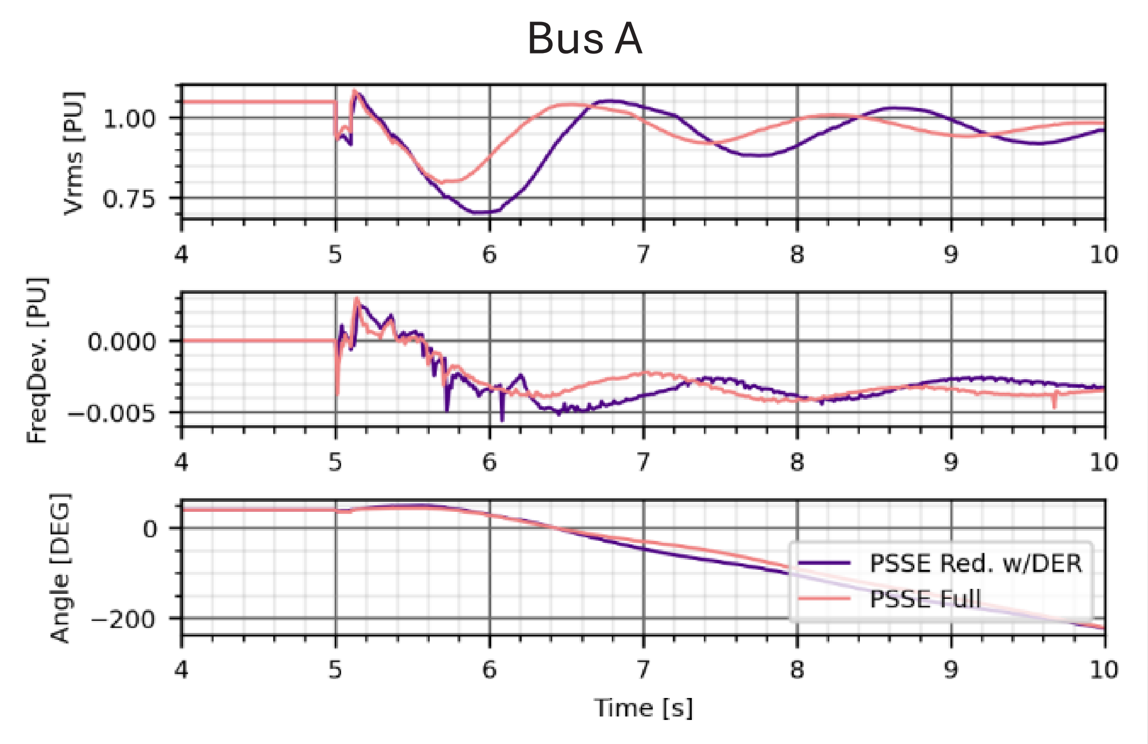
- Dynamic Equivalent contains all of SA and part of VIC and NSW.
- Murray link, PEC and HIC buses and major generation along PEC and HIC are retained.
- 13 boundary buses are identified in NSW and VIC and short circuit equivalents were developed at boundaries.
- Equivalent generator models and controls were attached at critical boundary buses and tuned to get a close match of the responses between the full case and dynamic equivalent.

Reduced PSSE Network

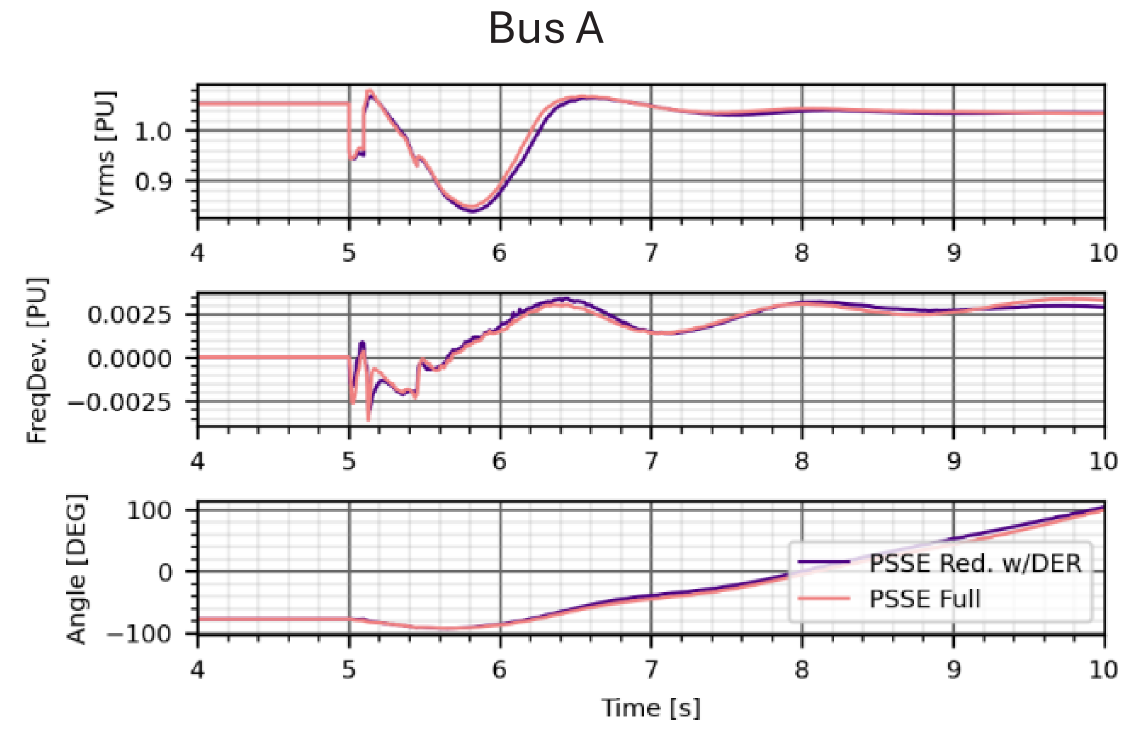
- Upon validation of the dynamic equivalent, the transmission network of SA was reduced (electrical equivalencing) while retaining important buses such as,
  - Buses from which synchro-phasor measurements are being taken
  - Load buses, generator buses and BESS buses accessed by PEC 2 SPS
  - Non-credible contingency buses
  - Buses corresponding to contingencies that require additional SA cross-tripping
  - Buses corresponding to contingencies that require SPS action in VIC
  - Interconnector buses
- DER and Complex load models were retained where necessary

Example Comparison

- Voltage, Frequency deviation and angle of South-East bus – Peak exports - CE1 PEC2 SPS enabled - Contingency 15



- Voltage, Frequency deviation and angle of South-East bus – Peak Imports - CI1 PEC2 SPS enabled- Contingency 15



PSSE to RSCAD Conversion

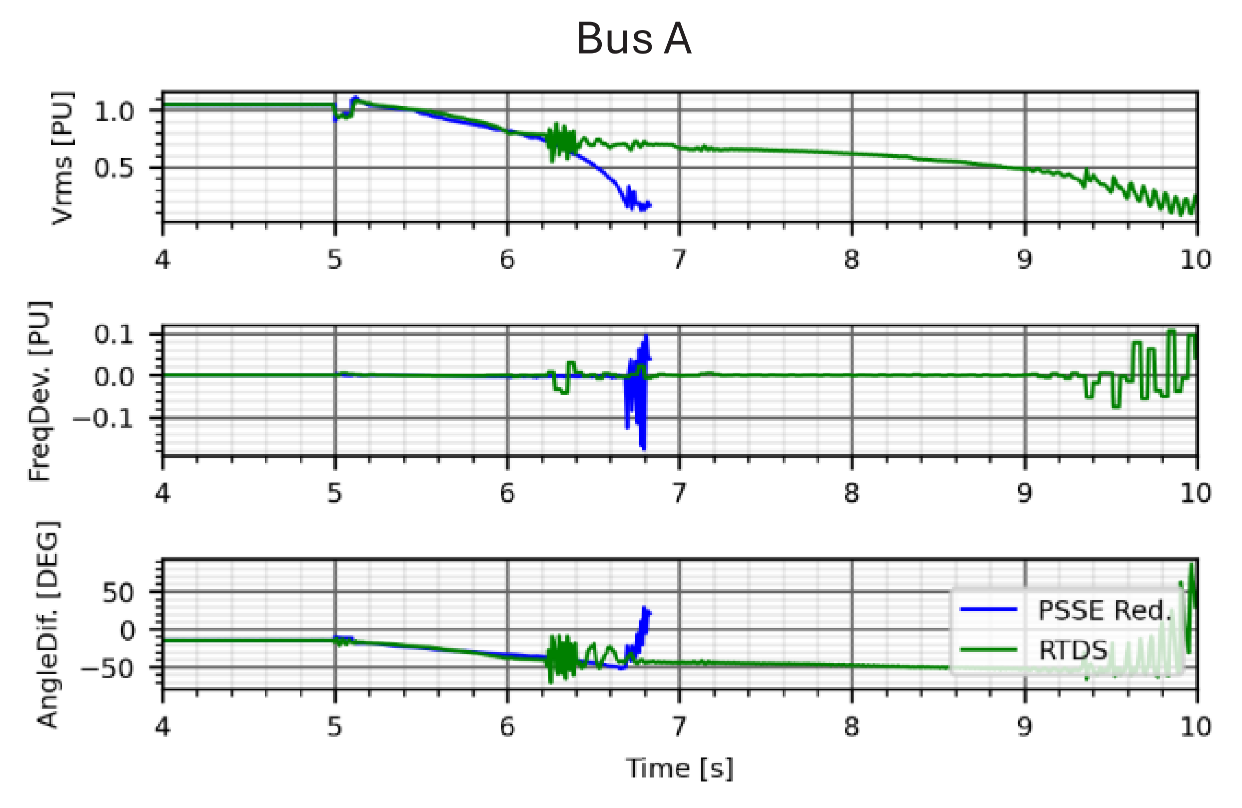
- Initial conversion from PSSE to RSCAD was done using the conversion tool available in RSCAD.
- The dynamic models were added later:
  - 5 - PV Plants
  - 10 – Type 4 Wind Plants
  - 7 - Type 3 Wind Plants
  - 6 – Type 2 Wind Plants
  - 3 - SVCs
  - 4 - STATCOMs
  - 4 - BESS
  - 41 - DER Models
  - 11 - Synchronous machines
- No RSCAD Models available. – Modelled with Generic models. Challenging to use the generic models and get a accurate response from the system

RTDS Resources

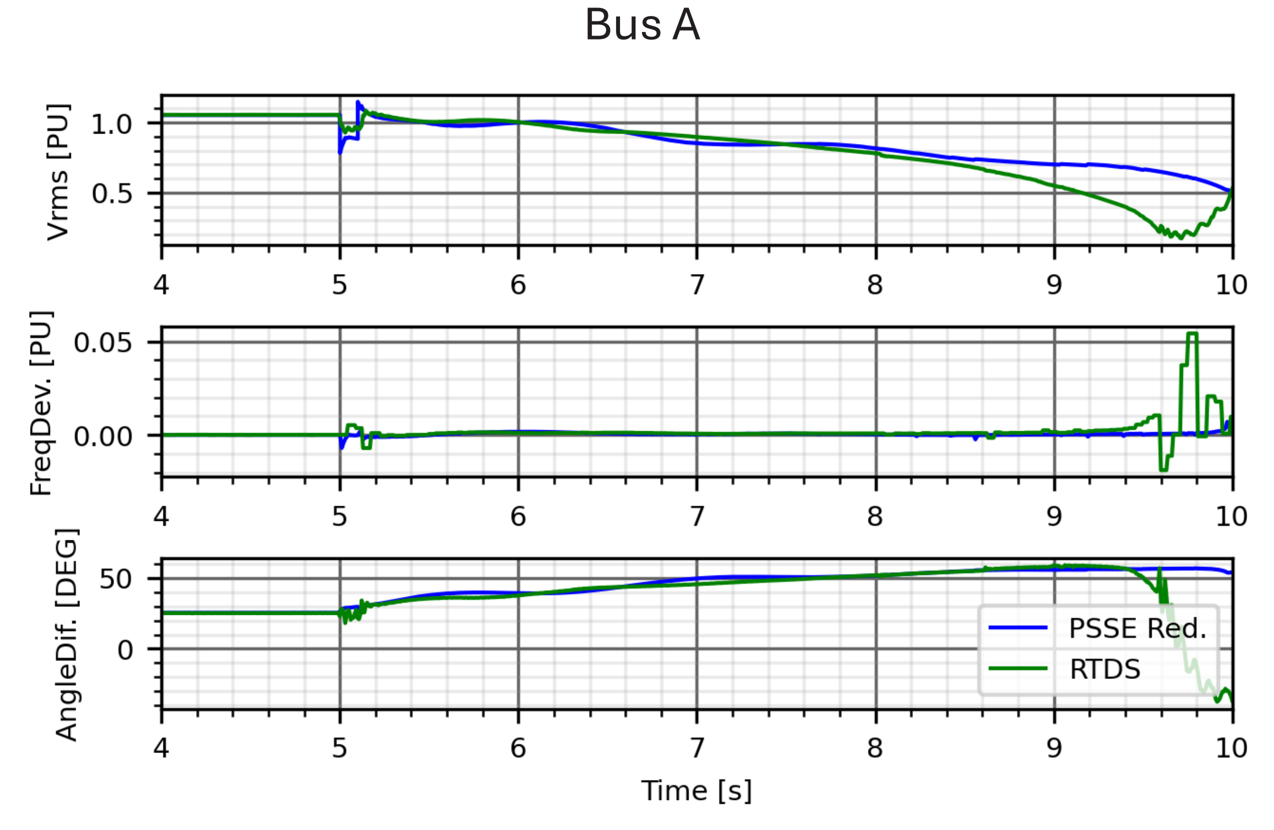
- 40xNovacore 2.0
- 6 x GTNET Cards
- GTDO/GTAO/GTDI Cards
- 82 PMU Signals
- 200 DNP Signals
- 48 Digital outputs
- 84 Digital inputs

Example Comparison

- Voltage, Frequency deviation and Angle difference of South-East bus – Peak Exports **without SPS** - Contingency 15

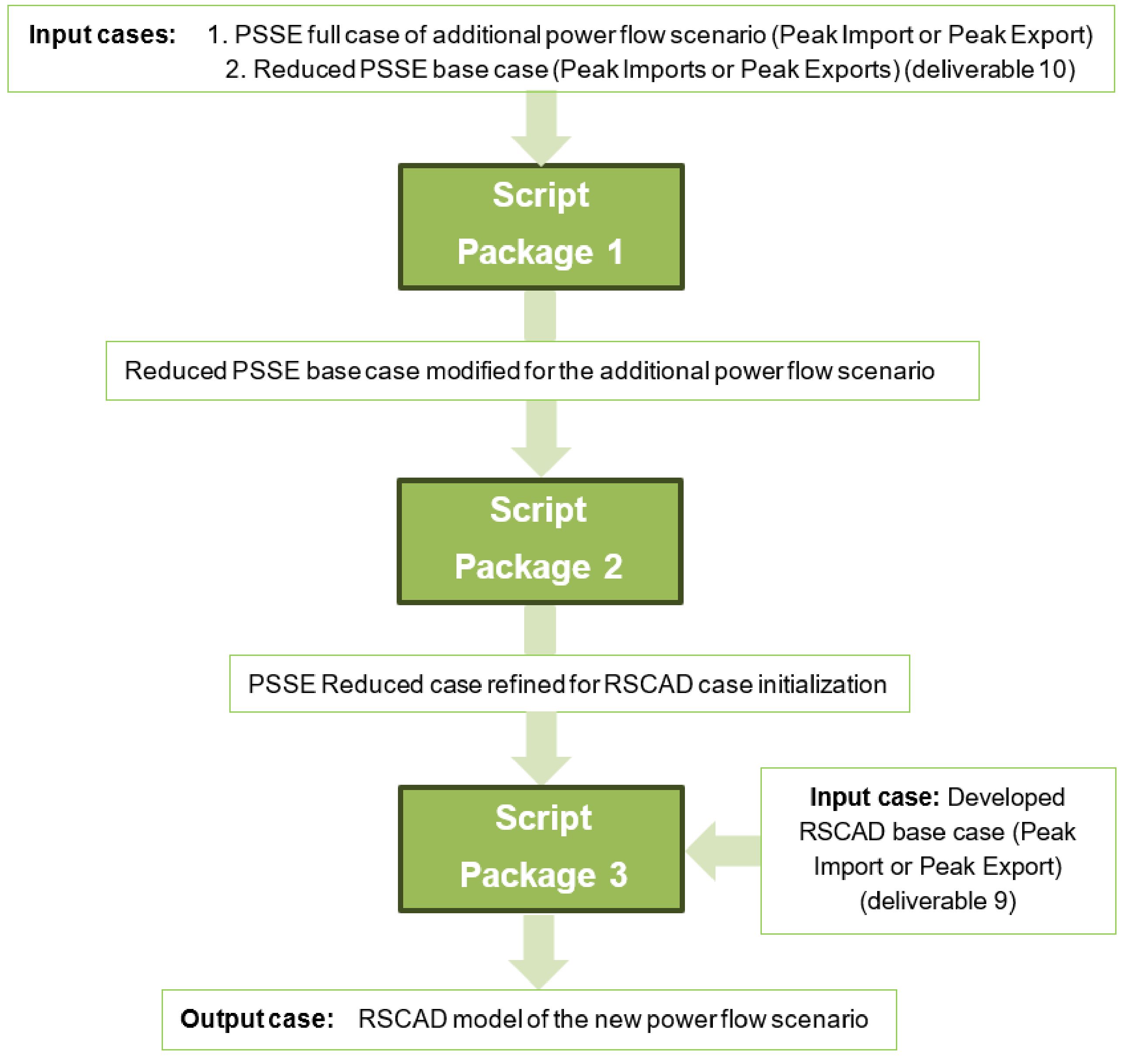


- Voltage, Frequency deviation and Angle difference of South-East bus – Peak Imports **without SPS** - Contingencv 15



Additional Power flows

- To adopt the developed RSCAD models for additional power flow scenarios
- Three script Packages provided
    1. Script to modify the reduced PSSE base cases to match the power flow variations in the full PSSE case
    2. Script to refine the modified reduced PSSE base cases to assist RSCAD model initialization
    3. Script to transfer modified, reduced PSSE cases to RSCAD case
- Separate scripts for Peak Imports and Peak Exports



Testing of the SAIT-RAS

- Done using a combination of RMS, EMT simulations and HIL Testing
  - EMT simulations are used for the accuracy of the models
- Due to the large number of signals used, slow signals (obtained using SCADA) is modelled as constants (Not updated during RTDS testing)
- Some other signals are read from COMTRADE files obtained from PSCAD simulations
- Testing to be commenced Q3 of 2025

Key Takeaways

- AC network equivalencing for RTDS modelling is a crucial step in HIL testing of wide area protection schemes
- Preserving accuracy within hardware limitations is a key challenge
- Utilities increasingly require flexible AC network models that they can utilize for multiple operating scenarios