Look Ahead Security Assessments: Operations radar to navigate high IBR waters in the journey to Net Zero

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Background to the Ireland & Northern Ireland Power System

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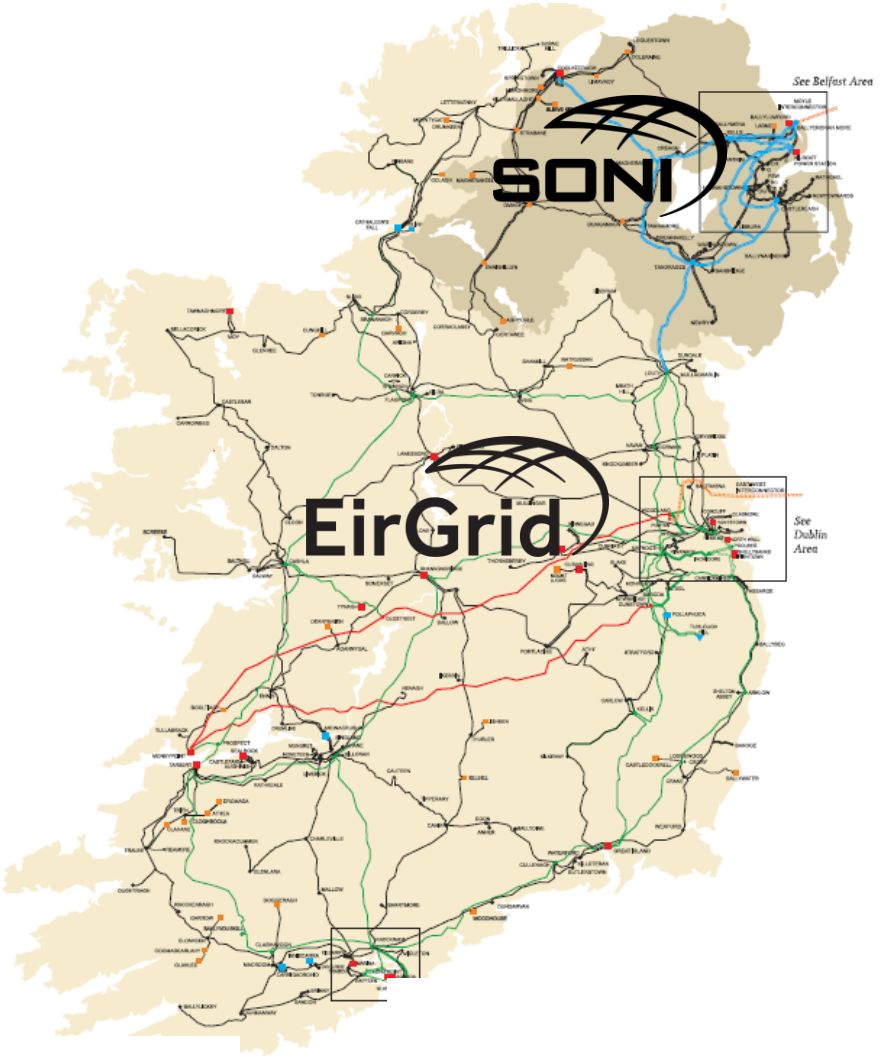
The TSOs of Ireland and Northern Ireland



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Background: All-Island Power System Overview

System

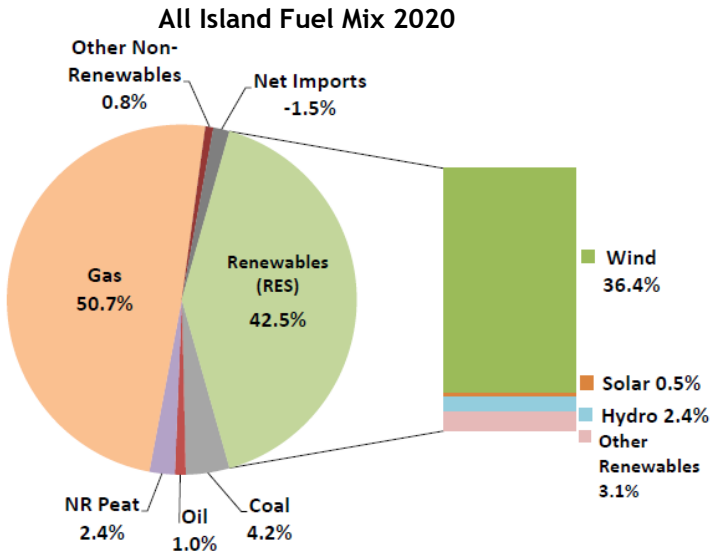
- Transmission: 110/220/275/400kV
- Single Synchronous Area & Market
- Two Jurisdictions / TSOs
- Jurisdictional Transmission Control
- All-Island Scheduling and Dispatch

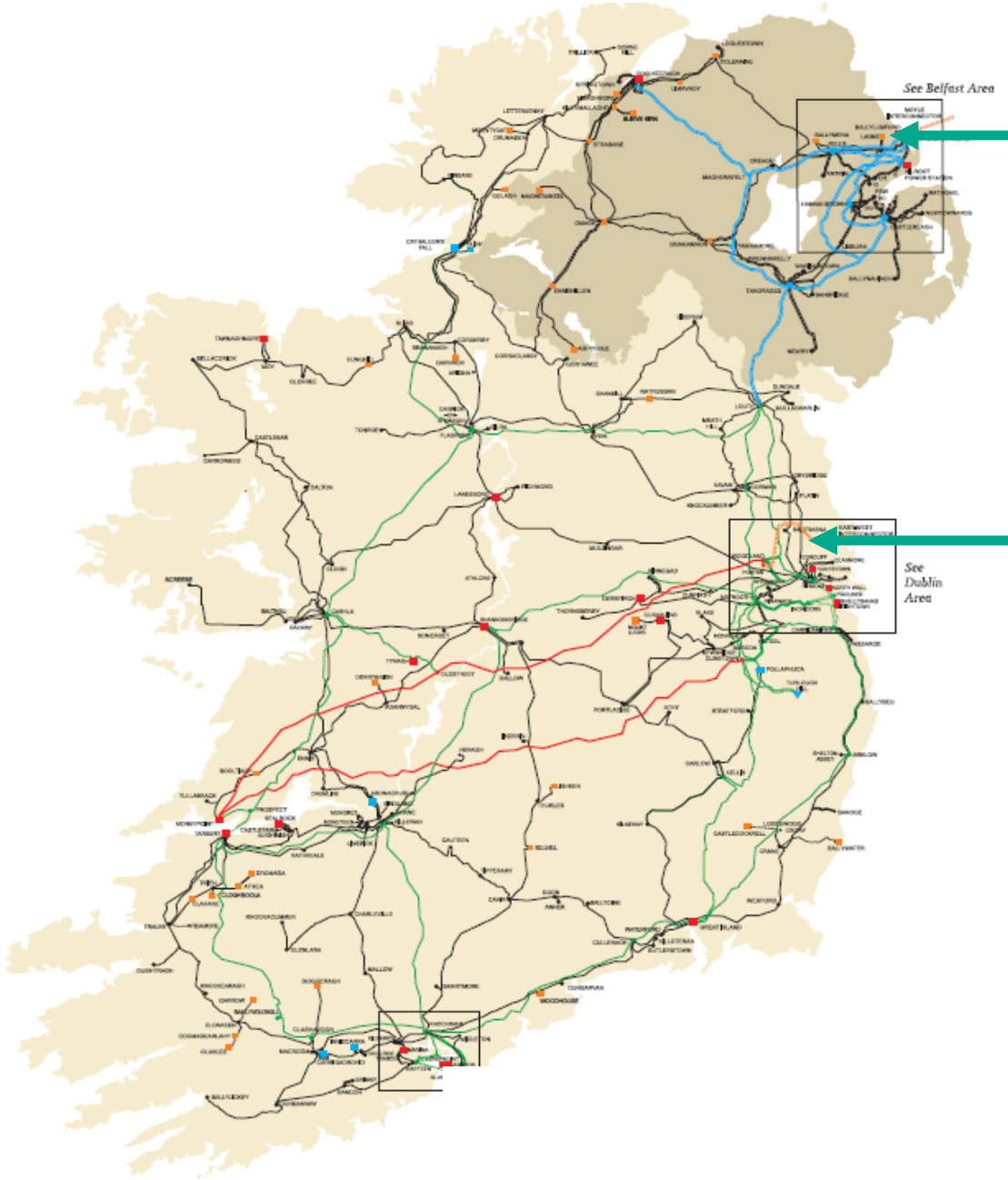
Demand

- Peak Demand: 7.0 GW
- Valley Demand: <2.5 GW

Generation

- Installed Wind: 5.9 GW
- Peak Wind: 4.6 GW (Feb 2022)

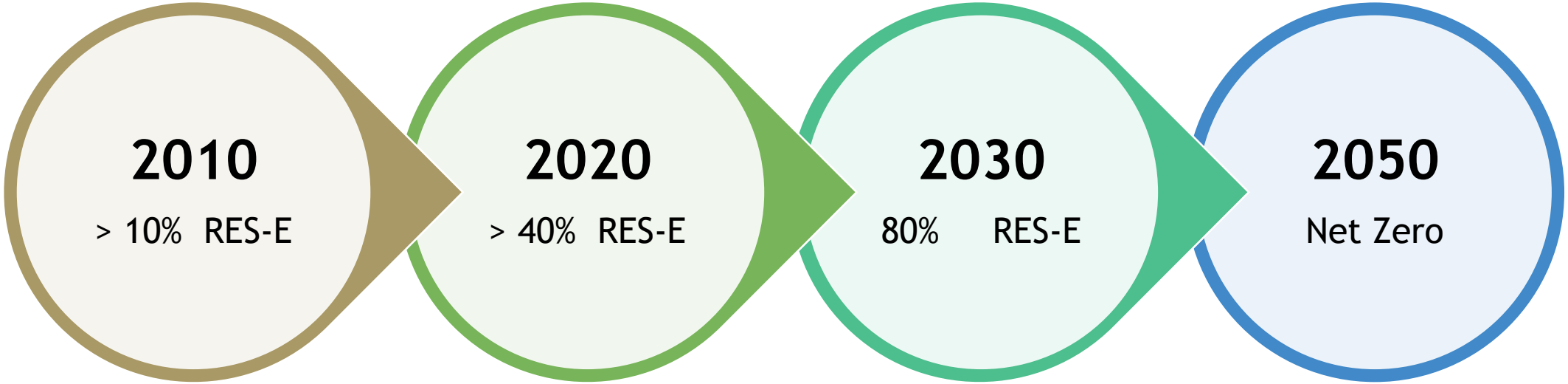




Moyle
+/- 500 MW
HVDC (LCC)
to Great Britain

EWIC
+/- 500 MW
HVDC (VSC)
to Great Britain

RENEWABLES REVOLUTION



Clear decarbonisation agenda backed up by legislation

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RES-E : Renewable Energy Sources producing Electricity

ON-LINE DYNAMIC SECURITY ASSESSMENT: REAL TIME AND LOOK AHEAD

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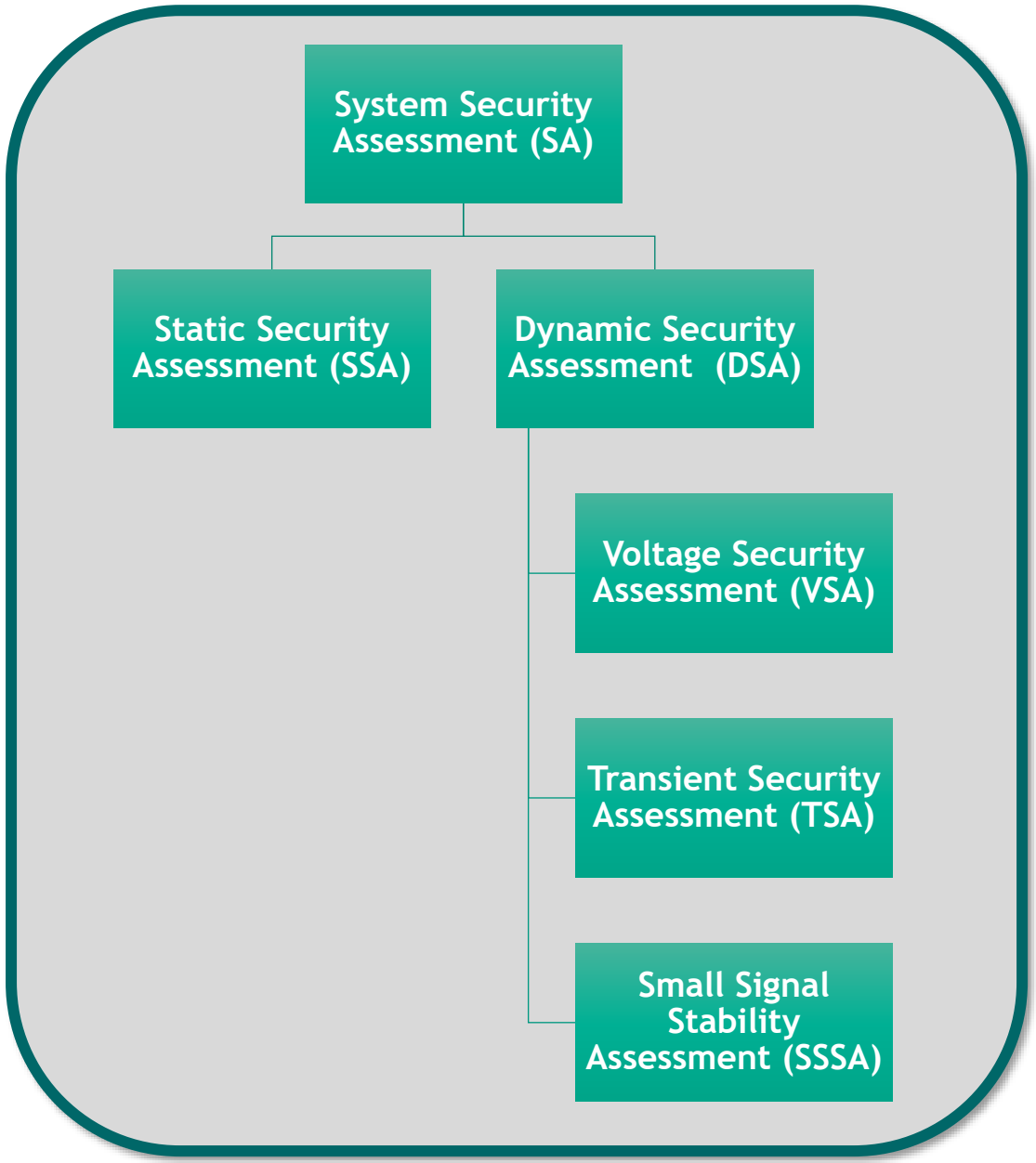
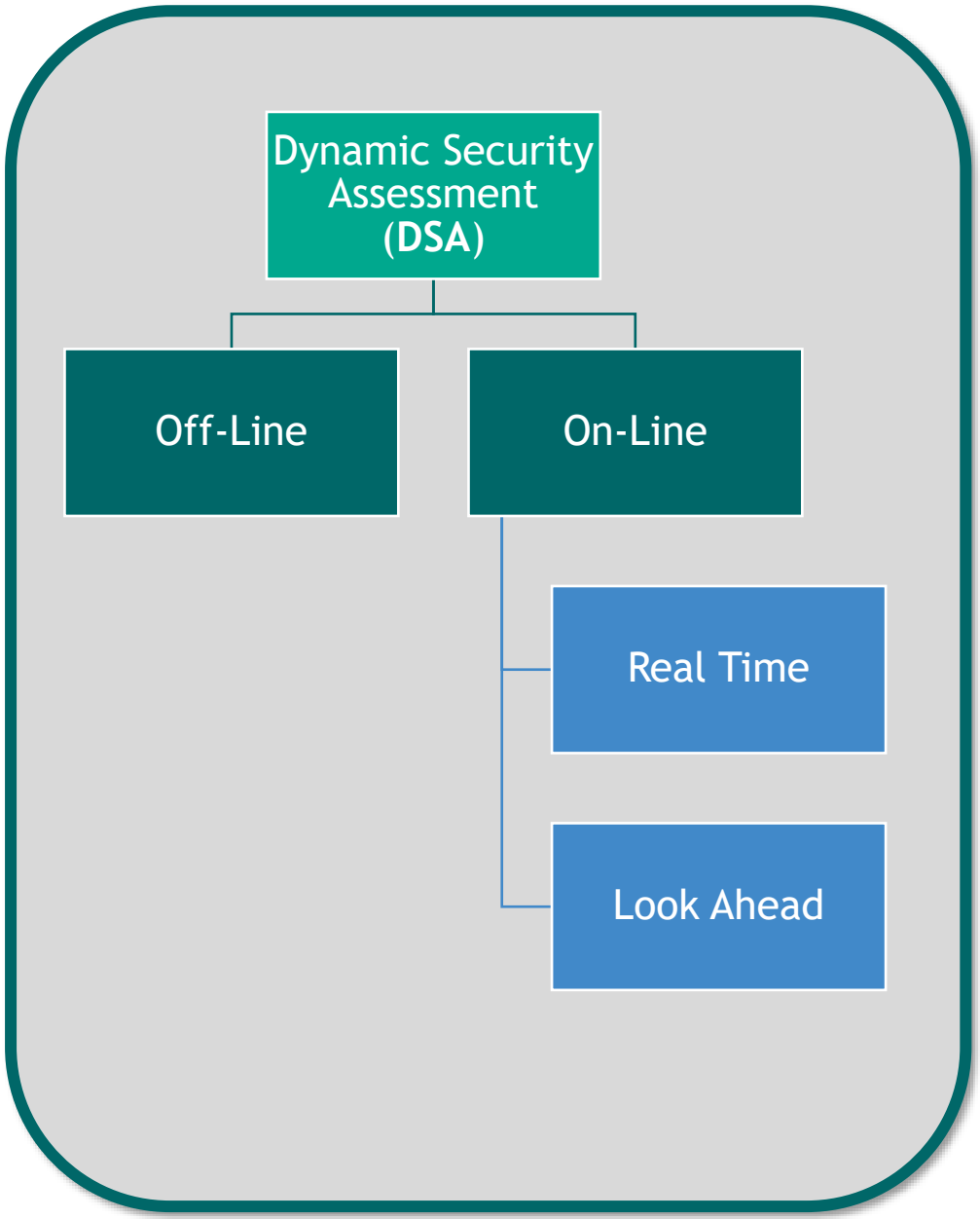
Terminology





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Our DSA journey

- **May 2009**
  - Pilot proof of concept
- **Sep. 2010**
  - On-line **WSAT** (RT) go live in Dublin
- **Nov. 2012**
  - Extended **All Island WSAT** go live in Dublin and Belfast
- **Nov. 2016**
  - **Hardware upgrade** for solution time improvement (15 to 5 minutes)
- **Dec. 2020**
  - **LSAT (RT + LA)** go live in Dublin and Belfast
- **2023**
  - **Retirement** of WSAT

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Why Look-Ahead DSA?

- Real Time DSA capabilities have supported integration of high levels of wind generation, up to 65% SNSP
- Operational complexity increases with level of non-synchronous renewables
- Forward looking DSA capabilities were identified as a requirement to increase SNSP above 65%
- Currently, we are operating at 75% SNSP
- Look Ahead provides adequate advance visibility of insecurities and allows implementation of effective correction actions in a timely manner

System Non-Synchronous Penetration

$$SNSP = \frac{\text{Wind + Solar + HVDC Imports}}{\text{Demand + HVDC Exports}}$$

LSAT in a nutshell

Look-ahead Security Assessment Tool (**LSAT**) is an on-line application to monitor **voltage security** and **transient security** of the transmission system in both **Real-Time** and **Look-Ahead** time frames

Key features:

- Full integration of EMS (GE E-terra) and DSA (Powertech DSATools) applications
- Interfaces with other applications:
  - Market Management System (MMS)
  - Outage Management System (OMS)

Critical requirements:

- **Availability** ➔ redundancy in DSA servers and data transfers
- **Speed** ➔ high performance servers and distributed processing
- **Accuracy** ➔ regular monitoring and validation against system incidents
- **Visualization** ➔ clear presentation of results in dashboard
- **Archiving** ➔ results are archived and available for off-line analysis and auditing at any time

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LSAT Functionality

On-Line Real-Time

- Automatic process
- 5 minutes cycle
- Start from EMS State Estimator Solution

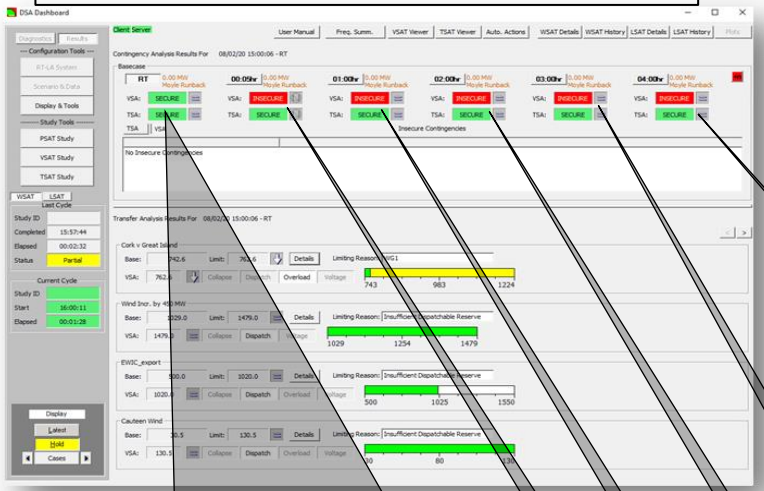
On-Line Look-Ahead

- Automatic process
- User selectable frequency and period of analysis
- Look-ahead time-points
- Based on Market Schedules and Outage Plans

Off-Line Study

- Manually triggered
- User selectable period of analysis
- Look-ahead time-points
- User defined generation schedule and planned outage input data

ON-LINE LSAT



RT

LA

Immediate Past

Future

-5 mins

Now

Market Trade periods

Day+1

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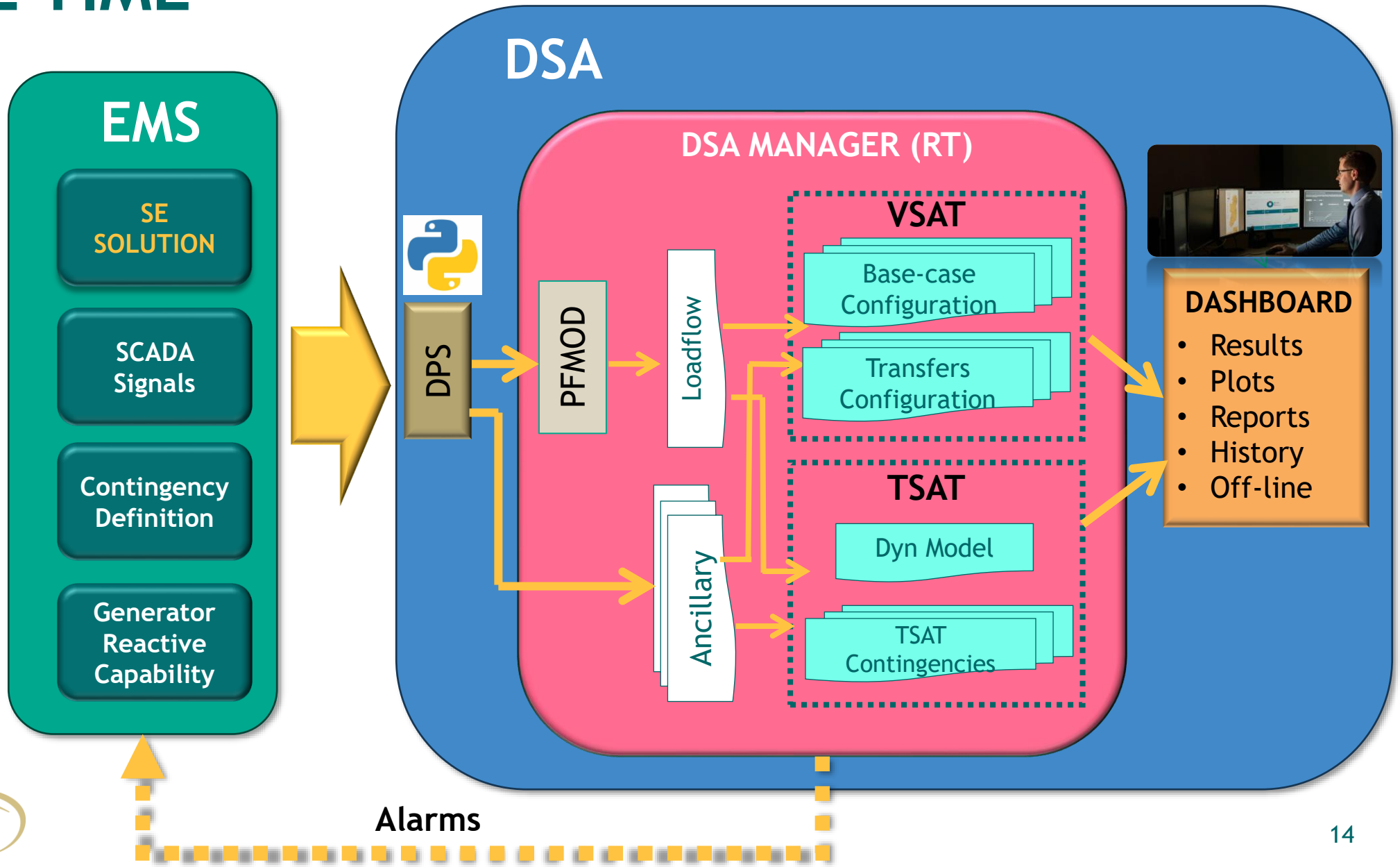
Performance

Model size

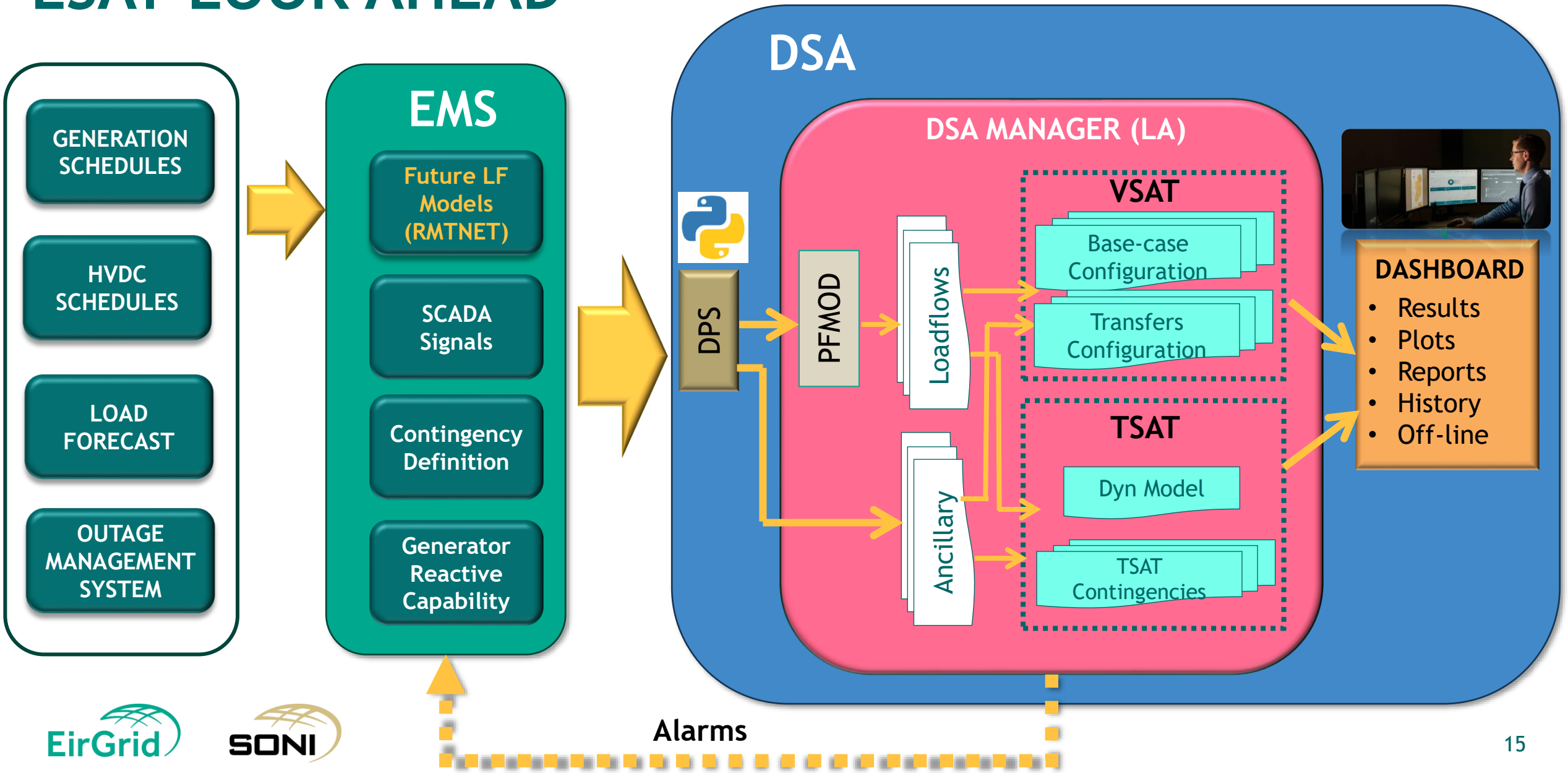
Component	number
Bus	1500
Generator	420
Line	850
Transformer	900
Load	650
HVDC LCC	1
HVDC VSC	1

- **Real-Time**
  - 5 minutes per cycle
- **Look-Ahead**
  - 3 minutes per cycle

LSAT REAL TIME

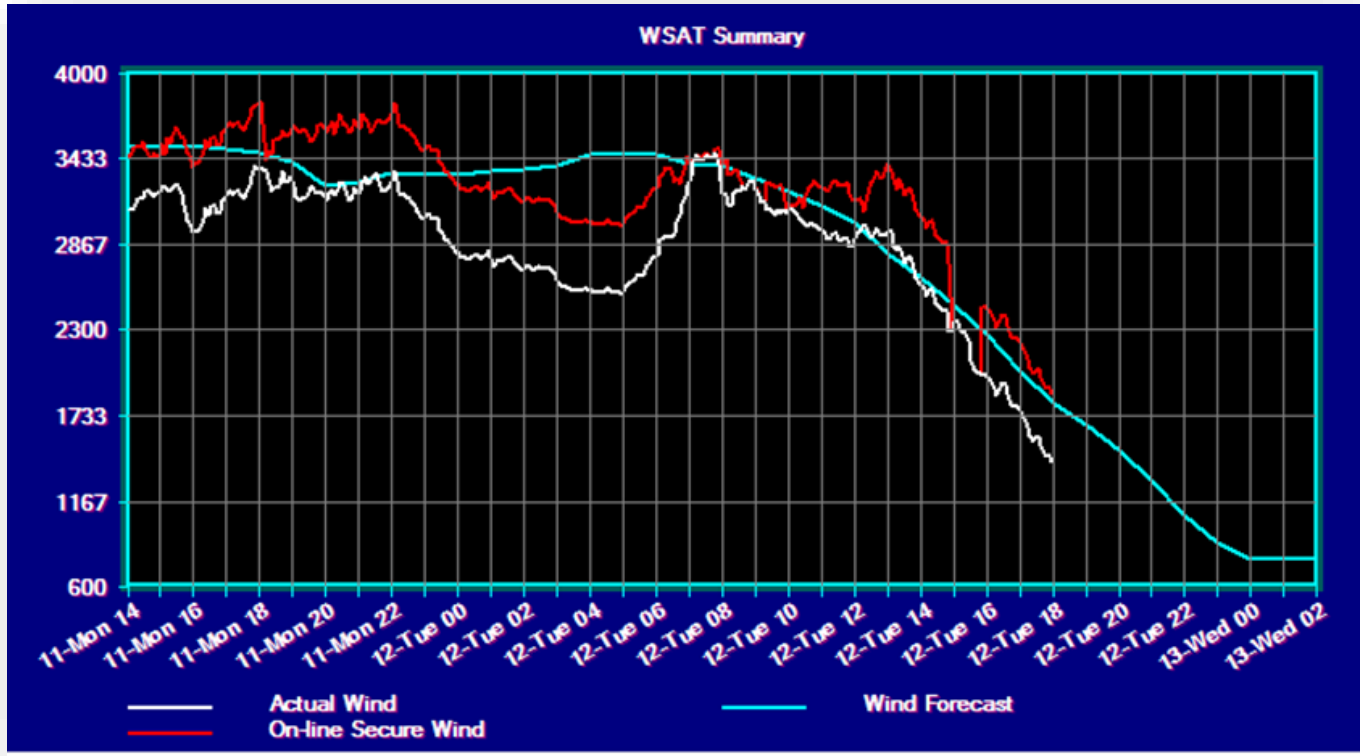


LSAT LOOK AHEAD



Voltage Security Assessments (VSAT)

- Load-flow simulations
- Base case and Transfer analysis
- Contingency list imported from EMS at each cycle (~ 900 ctg)
- Generator reactive capability limits adjusted during transfers
- Special Protection Schemes are represented
- We want to know:
  - Is base-case secure?
  - Distance to insecurity?
  - Secure level of wind?



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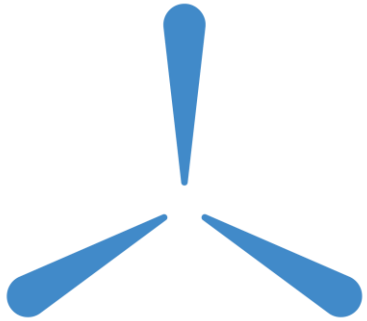
Transient Security Assessments (TSAT)

- Phasor-Domain simulations
- Combination of generic and UDM models
- Over **800** pre-defined contingencies running to 15 seconds
- Early termination feature for secure contingencies
- Post contingency we want to know:
    - Are all synchronous machines still synchronized?
    - Does system frequency stay within limits?
- In Rotor-Angle insecure scenarios, Preventative Control Measures (PCM) are suggested



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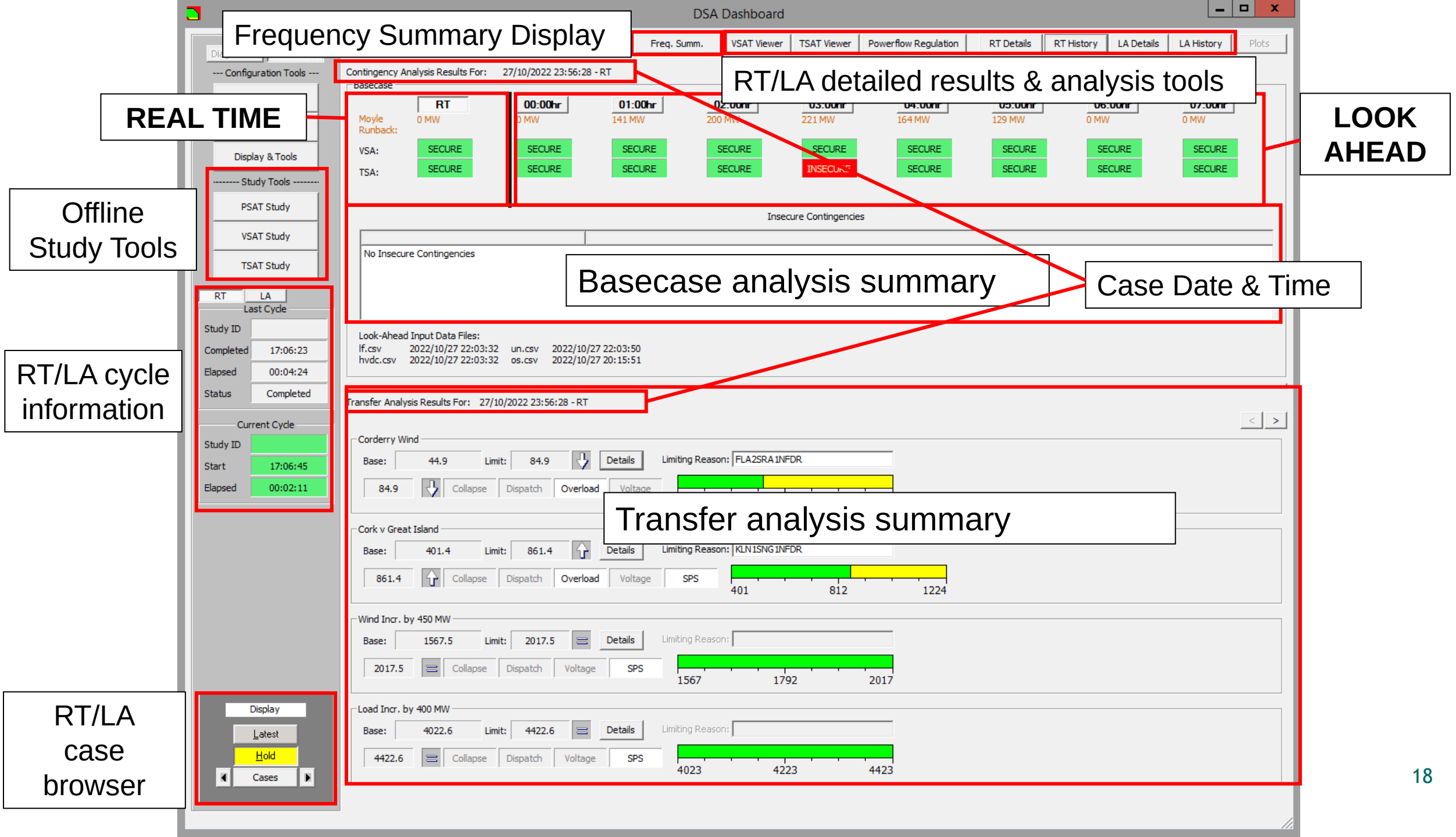

Frequency Summary Display
DSA Dashboard
Freq. Summ.
VSAT Viewer
TSAT Viewer
Powerflow Regulation
RT Details
RT History
LA Details
LA History
Plots
RT/LA detailed results & analysis tools
REAL TIME
LOOK AHEAD
Contingency Analysis Results For: 27/10/2022 23:56:28 - RT
Basecase
RT
00:00hr
01:00hr
Moyle Runback:
0 MW
141 MW
200 MW
221 MW
164 MW
129 MW
0 MW
0 MW
VSA:
TSA:
SECURE
INSECURE
Insecure Contingencies
No Insecure Contingencies
Basecase analysis summary
Case Date & Time
Look-Ahead Input Data Files:
lf.csv 2022/10/27 22:03:32 un.csv 2022/10/27 22:03:50
hvdc.csv 2022/10/27 22:03:32 os.csv 2022/10/27 20:15:51
Offline Study Tools
--- Configuration Tools ---
Display & Tools
-------- Study Tools --------
PSAT Study
VSAT Study
TSAT Study
RT/LA cycle information
RT
LA
Last Cycle
Study ID
Completed 17:06:23
Elapsed 00:04:24
Status Completed
Current Cycle
Study ID
Start 17:06:45
Elapsed 00:02:11
Transfer Analysis Results For: 27/10/2022 23:56:28 - RT
Transfer analysis summary
Corderry Wind
Base: 44.9
Limit: 84.9
Details
Limiting Reason: FLA2SRA 1NFDR
84.9
Collapse
Dispatch
Overload
Voltage
Cork v Great Island
Base: 401.4
Limit: 861.4
Details
Limiting Reason: KLN1SNG 1NFDR
861.4
Collapse
Dispatch
Overload
Voltage
SPS
401
812
1224
Wind Incr. by 450 MW
Base: 1567.5
Limit: 2017.5
Details
Limiting Reason:
2017.5
Collapse
Dispatch
Voltage
SPS
1567
1792
2017
Load Incr. by 400 MW
Base: 4022.6
Limit: 4422.6
Details
Limiting Reason:
4422.6
Collapse
Dispatch
Voltage
SPS
4023
4223
4423
RT/LA case browser
Display
Latest
Hold
Cases

RT

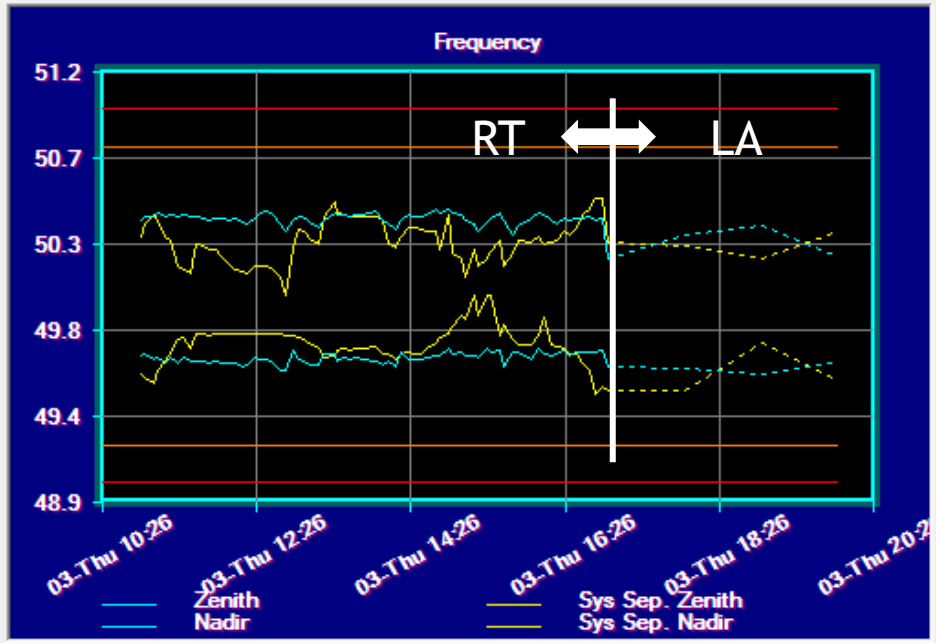
LA

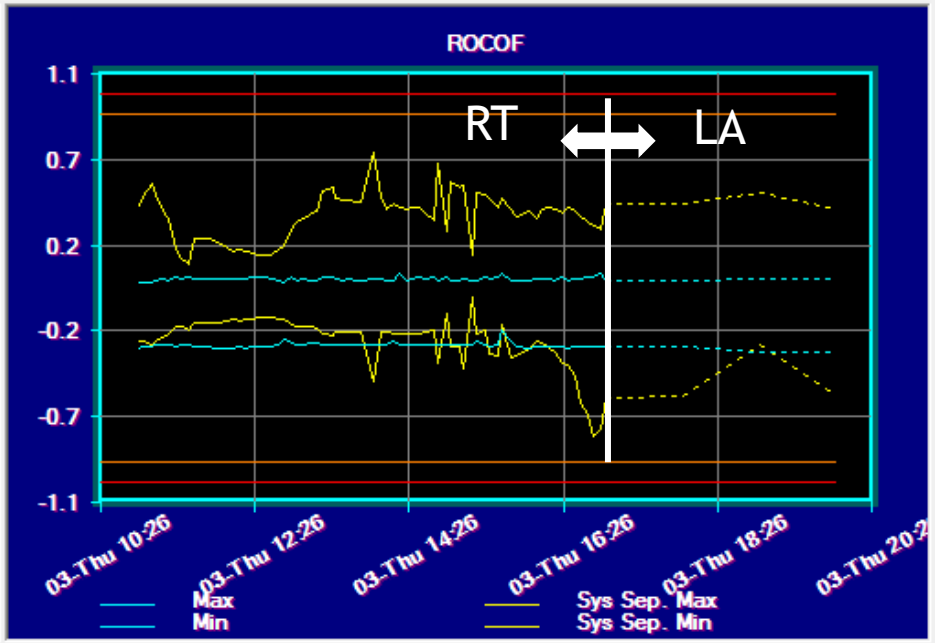
Frequency Summary

File

System Separation

Time	Nadir (Hz)	Nadir Contingency	Zenith (Hz)	Zenith Contingency	Negative ROCOF (Hz/s)	Negative Contingency	Positive ROCOF (Hz/s)	Positive Contingency	Sys. Sep Nadir (Hz)	Sys. Sep Zenith (Hz)	Sys. Sep ROCOF (Hz/s)	Sys. Sep ROCOF (Hz/s)
03/11/202...	49.65	GTISLAND GI	50.21	BPS 30-KEL	-0.334	GTISLAND GI	0.056	GLANAGOW	49.54	50.35	-0.557	0.411
03/11/202...	49.58	GTISLAND GI	50.38	LOUTH-WOC	-0.329	GTISLAND GI	0.049	GLANAGOW	49.75	50.20	-0.295	0.488
03/11/202...	49.61	GTISLAND GI	50.33	BALTRS10-C(	-0.307	AGHADA AD_	0.043	AGHADA AD_	49.49	50.26	-0.556	0.434
03/11/202...	49.62	GTISLAND GI	50.20	BPS 30-KEL	-0.306	AGHADA AD_	0.044	AGHADA AD_	49.49	50.29	-0.564	0.440
03/11/202...	49.71	GTISLAND GI	50.42	BLAKET90-M.	-0.307	AGHADA AD_	0.076	POOLBEG PB	49.51	50.53	-0.726	0.306
03/11/202...	49.70	GTISLAND GI	50.41	BLAKET90-M.	-0.305	GTISLAND GI	0.061	POOLBEG PB	49.47	50.52	-0.766	0.325
03/11/202...	49.70	GTISLAND GI	50.42	BLAKET90-M.	-0.307	GTISLAND GI	0.059	POOLBEG PB	49.60	50.46	-0.650	0.344
03/11/202...	49.70	GTISLAND GI	50.42	BLAKET90-M.	-0.307	GTISLAND GI	0.055	POOLBEG PB	49.64	50.44	-0.597	0.366
03/11/202...	49.70	GTISLAND GI	50.42	BLAKET90-M.	-0.307	GTISLAND GI	0.054	POOLBEG PB	49.69	50.37	-0.451	0.395
03/11/202...	49.68	GTISLAND GI	50.41	BLAKET90-M.	-0.312	GTISLAND GI	0.044	GTISLAND GI	49.70	50.33	-0.399	0.417





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Dynamic Model Validation

Data Gathering
- Event selection: Generator trips and system fault
- PMU data gathering and screening
- LSAT cases gathering

Case Set-up
- Data preparation scripts + manual adjustments
- Matching Power Flow data, Monitor and contingency data
- Dynamic models

Simulation
- Dynamic Simulation
- Playback Simulation

Analysis
- Quantitative
- Qualitative

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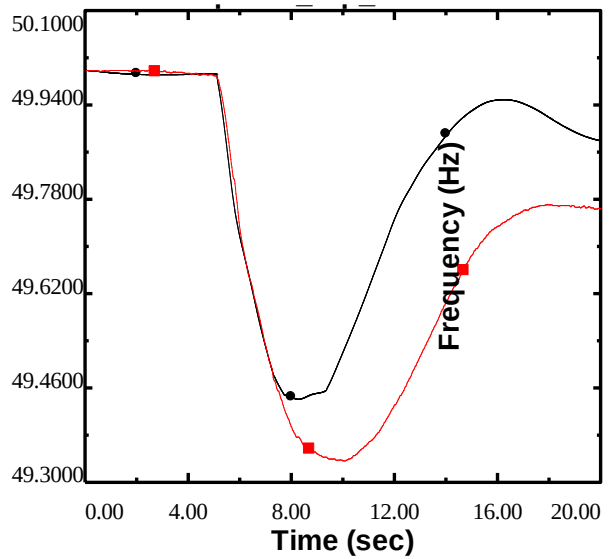
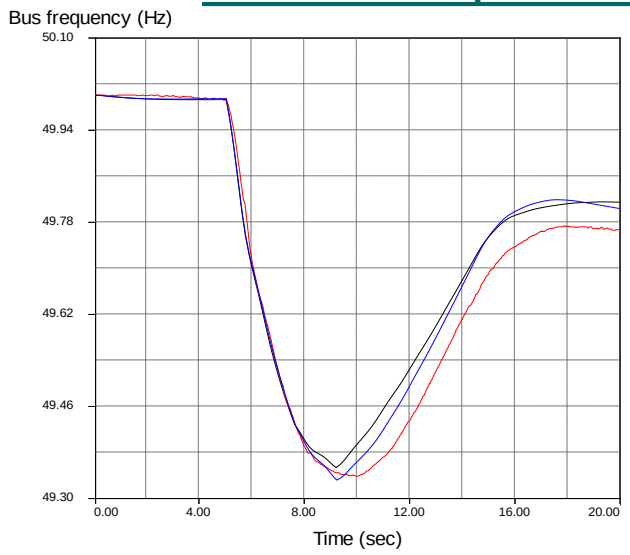
Original model



Simulation results
PMU data

Tuned model parameters



Simulation results (1)
Simulation results (2)
PMU data

Sharing our experience (i)

- DSA assessments are as good as the starting loadflow case
  - RT: SE solution. Generally good.
  - LA: RMTNET solution can be challenging. Highly dependent on the voltage regulation settings and the outage definition. Continuous improvements.
- Arming SPS and other model parameters
  - RT: use SCADA signals
  - LA: logic implemented in python dynamically updating model parameters
- Model upkeeping
  - Consistency in bus/equipment naming between EMS and DSA files
  - Adding dynamic models for new equipment in synch with EMS
  - Regular review and update of SPSs and TSAT contingencies
  - Pre-production testing environment with live data feeds
  - Continuous monitoring and updating by dedicated team ➔ do not underestimate the effort required!!

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Sharing our experience (ii)

- Over 12 years of DSA operation 24/7. Improvements introduced over the years.
- LSAT Project delivered during covid-19 lockdown
  - Fully remote
  - Multi-disciplinary skills and cross-functional project team
  - Project team geographically dispersed across multiple time zones
  - Complex new interfaces required
  - Step-change in computing power requirements
  - Excellent vendors support
- Operator experience
  - Training: before roll out and periodic refreshers
  - Continuous feedback
  - Confidence built over time
  - Actions taken in Control Rooms based on LSAT outcomes

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Proven Benefits

LSAT provides **radar-like** guidance on how to operate the power system in a safe and secure manner while minimizing wind curtailment.

It helps maintain power system security **under all conditions**, including abnormal scenarios that may not have been captured in off-line studies supporting operational constraints.

It has become a critical decision support tool that allows **pushing the operational boundaries** to integrate more renewables in Real Time operations with confidence. Currently, operating at **75% SNSP, 1 Hz/sec and running a trial with reduced number of synchronous units online.**

Key contributor for **meeting government renewable targets.**

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Thanks for your attention
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