WAMS Applications for The Control Room of The Future using the Next Generation Grid Operations Framework

DNV Energy Systems

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12 April 2022

Agenda

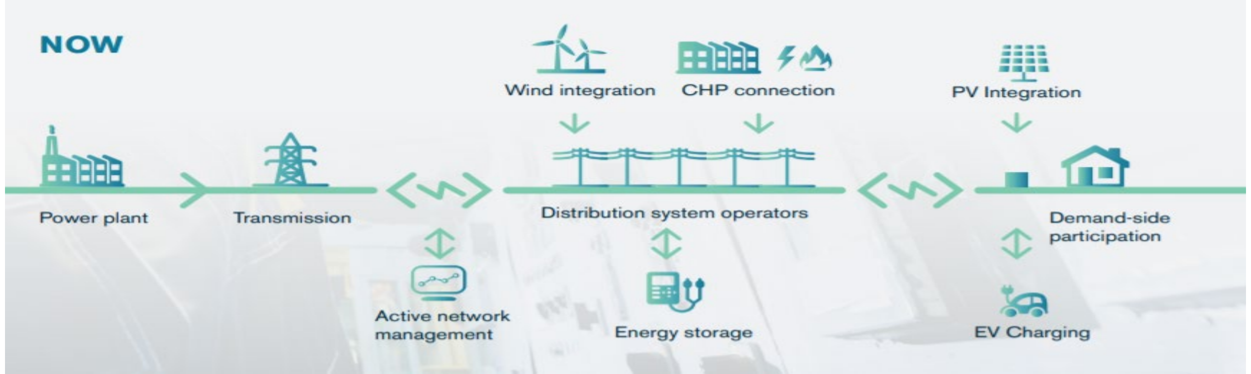
- Next Generation Grid Operations (NextGen GridOps) Framework Introduction
  - Future system operations
  - Building a machine
  - Modular architecture
- WAMS and NextGen GridOps Framework
  - Knowledge Preservation
  - Applications
- Q&A

Next Generation Grid Operations (NextGen GridOps Framework) Introduction

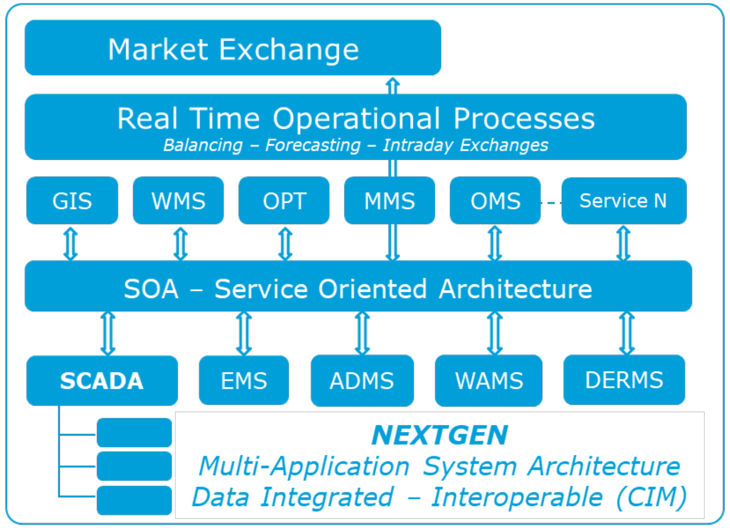
System Operations are becoming more COMPLEX and DEMANDING

Smart cost-efficient strategy in dealing with increasing grid ops complexities

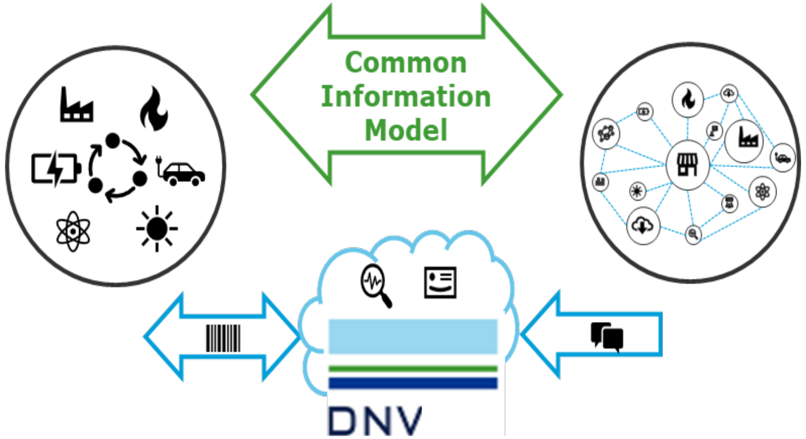
- **New market** & system requirements
- Integrate to existing + new applications
- **Real time** performance + response
- RT data **integration** + exchange (data model)
- Data quality + compatible data sets
- **Project realization** time + budget



Building the Next Generation Grid Operations Machine



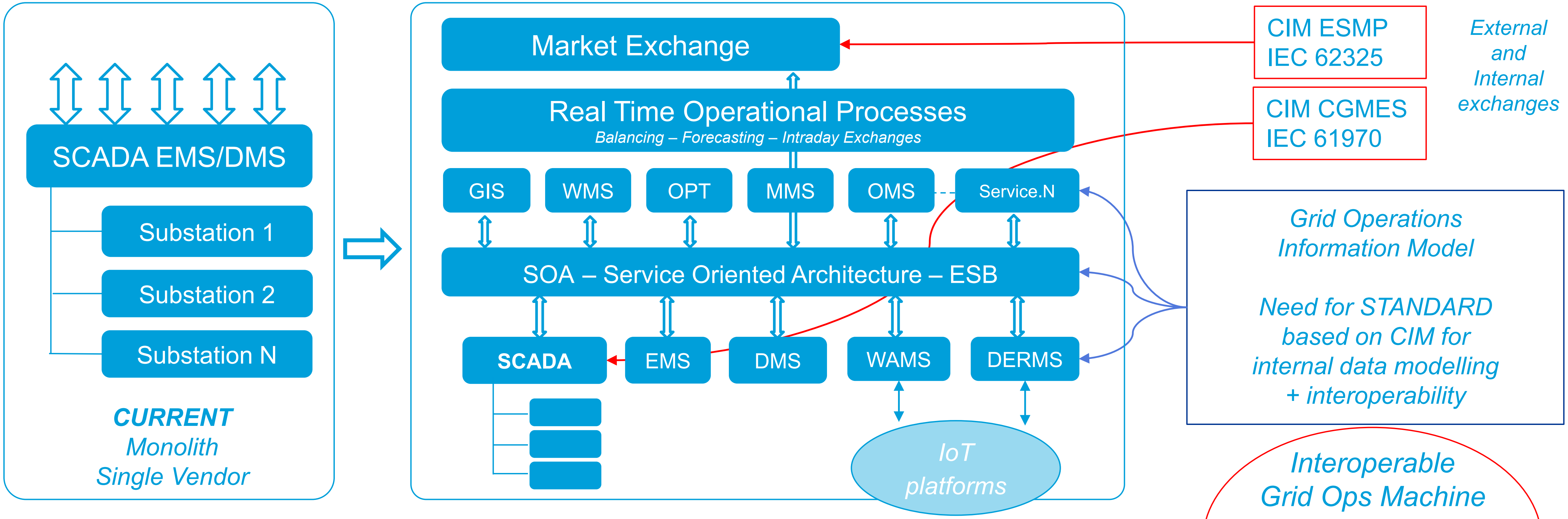
CIMbion Automated Data Testing



BUILDING the MACHINE

Migrate to the NEW DIGITAL GRID OPERATIONS MODEL

How to MIGRATE to – steps to define



Interoperable
Grid Ops Machine
*(**CIM** IEC 61968)*

CIM Definitions
CIM Testing

More: Data – Complexity – Real Time

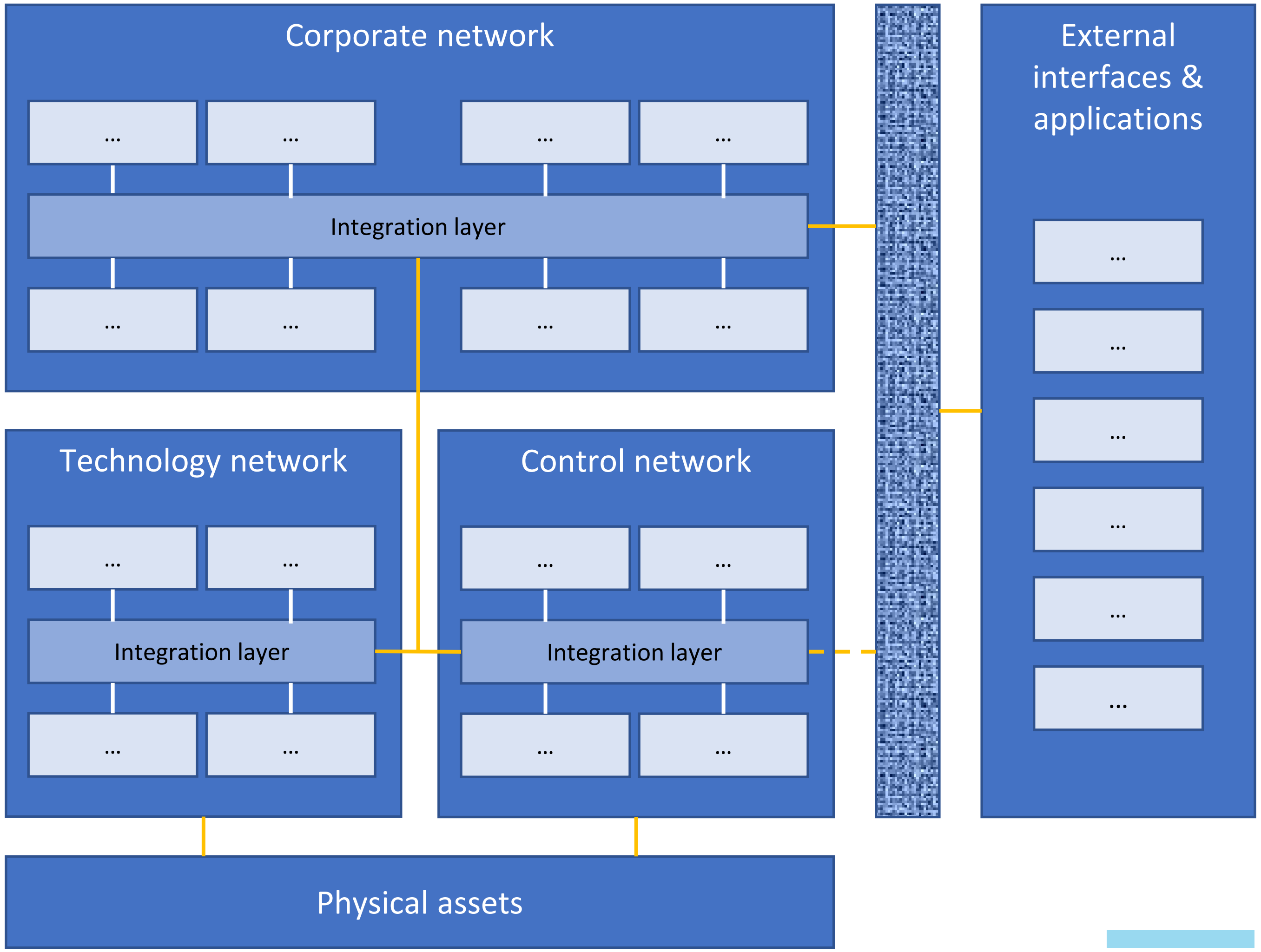
Multi-vendor → Multi-contract → Distributed Risk

NEXTGEN Grid Operations
Multi-vendor Application Data
Integrated System Architecture
Modular and Service Oriented

Data & information Security – Secure Architecture + Applications

A modular, flexible and secure architecture allows high interoperability enabling interaction between different applications & departments

- High interoperability allows **data to be shared** and new business functions to be introduced
- **Clear segregation** between corporate network (which contains most users & applications) and technology & control networks
- Applications in the control network should be **able to operate** when other networks fail
- Applications in the corporate network aren't able to directly influence applications in the control network (only information provisioning)
- Applications communicate with each other via an integration layer, unless very specifically approved. In principle there are **no point-to-point connections** between applications
- Any data shared between networks flows via **integration layers, incl. security principles**



Our understanding – creating more value with data in increasing grid complexity with many stakeholders and renewable energy integration

Core KPI

- **Security of Supply**
- **Quality of Supply**
- **Safety**
- **TCO**
- **Regulation & compliancy**
- **Public image**
- **Sustainability**

Existing challenges & opportunities

Data & process standardisation required to reduce complexity with many stakeholders

Improved interoperability required between the different solutions and new renewables to improve existing monitoring & control functions and to allow (real-time) calculations & simulations

Improved data quality to allow better (automated) decision-making

New digital technology to be infused in the core processes of the company

Improved **grid development and resiliency** improvement

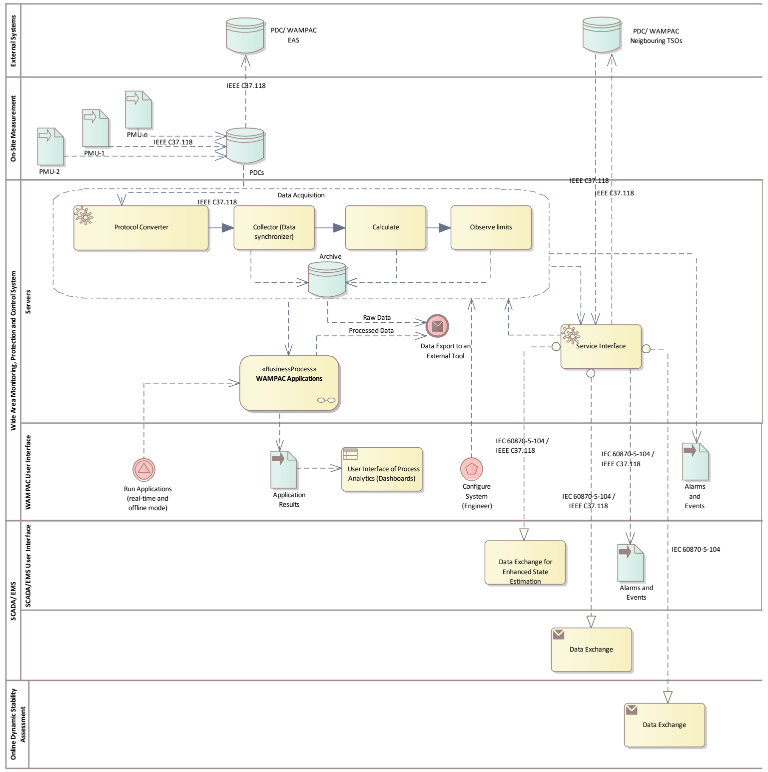
Strategic priorities

- Creating value with WAMPAC

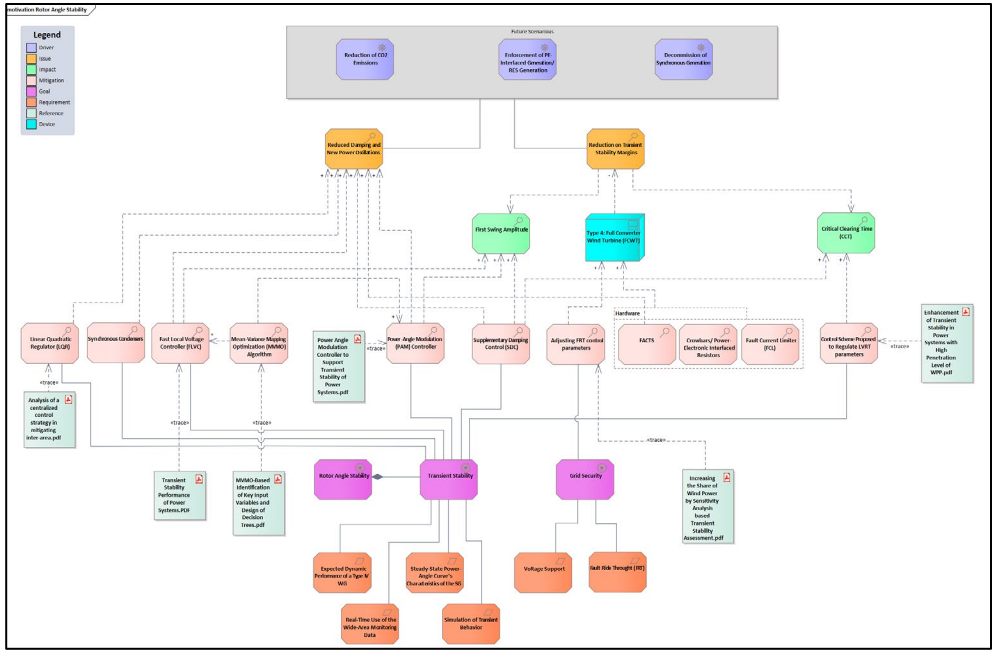
WAMS and NextGen GridOps Framework

DNV

WAMS Practical Examples



Modelling of Business Processes by Using BPMN 2.0 in Enterprise Architect

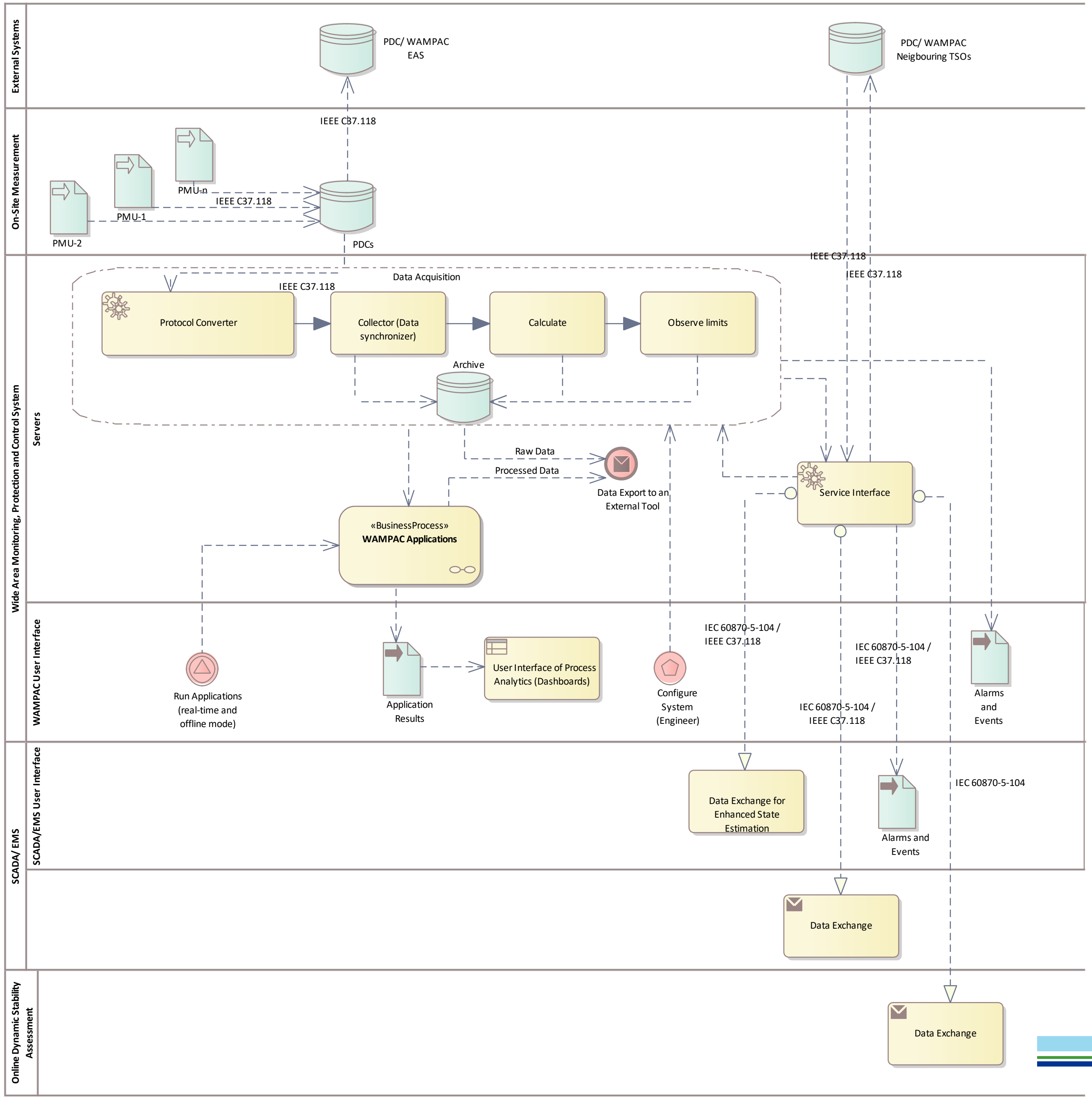


Definition of information implementation process by using ArchiMate 3.0 in Enterprise Architect

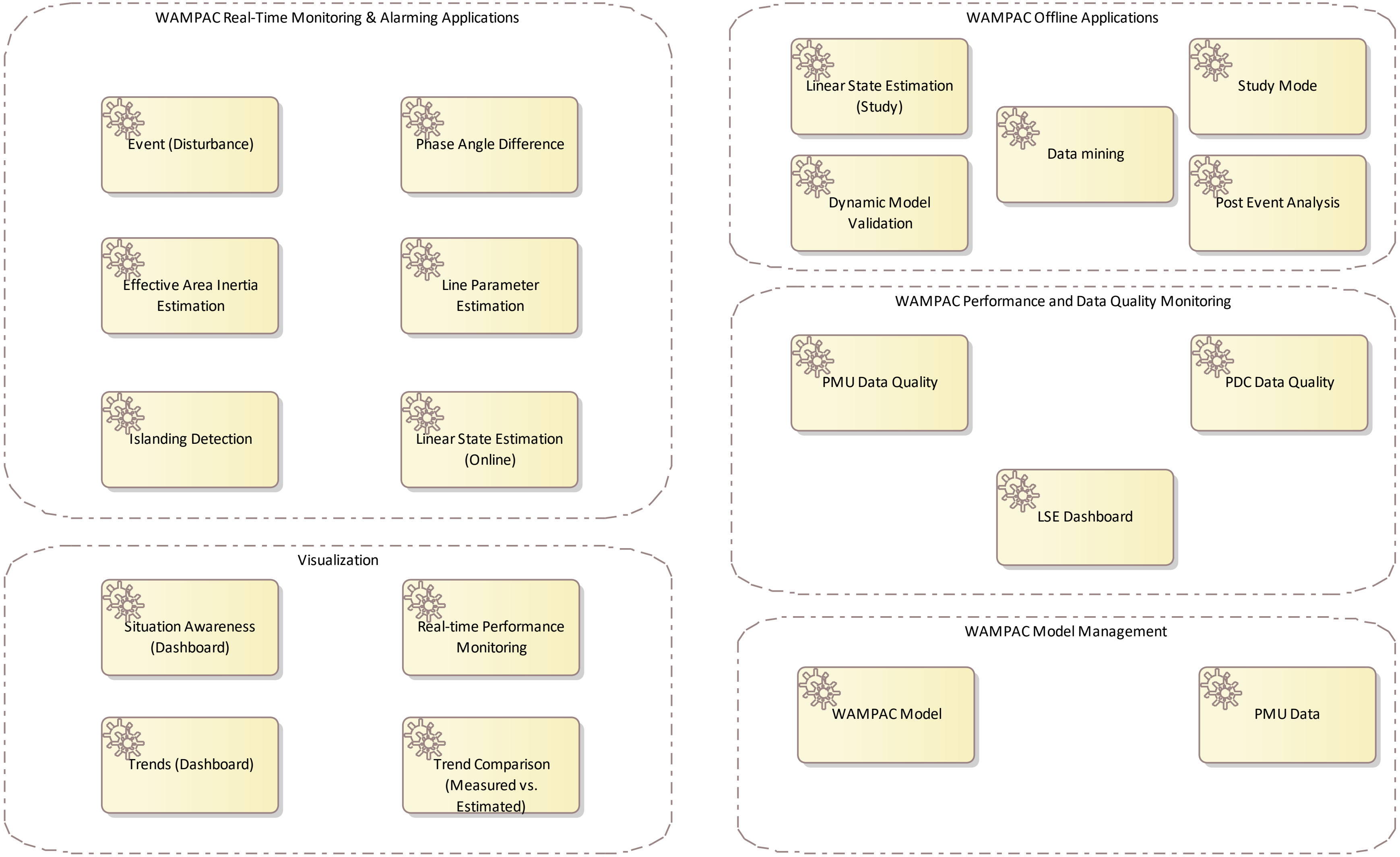
- Definition of Roadmaps
- Using information for practical examples

Example process flow:

- Clear business processes for WAMPAC,
- including its integration with peripheral systems.



WAMPAC Applications diagram



Process of Information Implementation

DRIVER

Motivators behind the project:

- Carbon neutrality
- Distributed generation
- High share of energy from RES

ISSUE

Obstacles introduced due to new technologies:

- Reduced damping
- New power oscillations
- Decrease of inertia

IMPACT

Highly affected areas by newly occurred issues:

- Highly dynamic behaviour
- High RoCoF
- Reduction of maximum power flow

MITIGATION

Enhancement or a solution of issues and impacts:

- Wide Area Monitoring System (WAMS)
- Supplementary damping control
- Synchrophasor technology

GOAL

Objective when implementing mitigations:

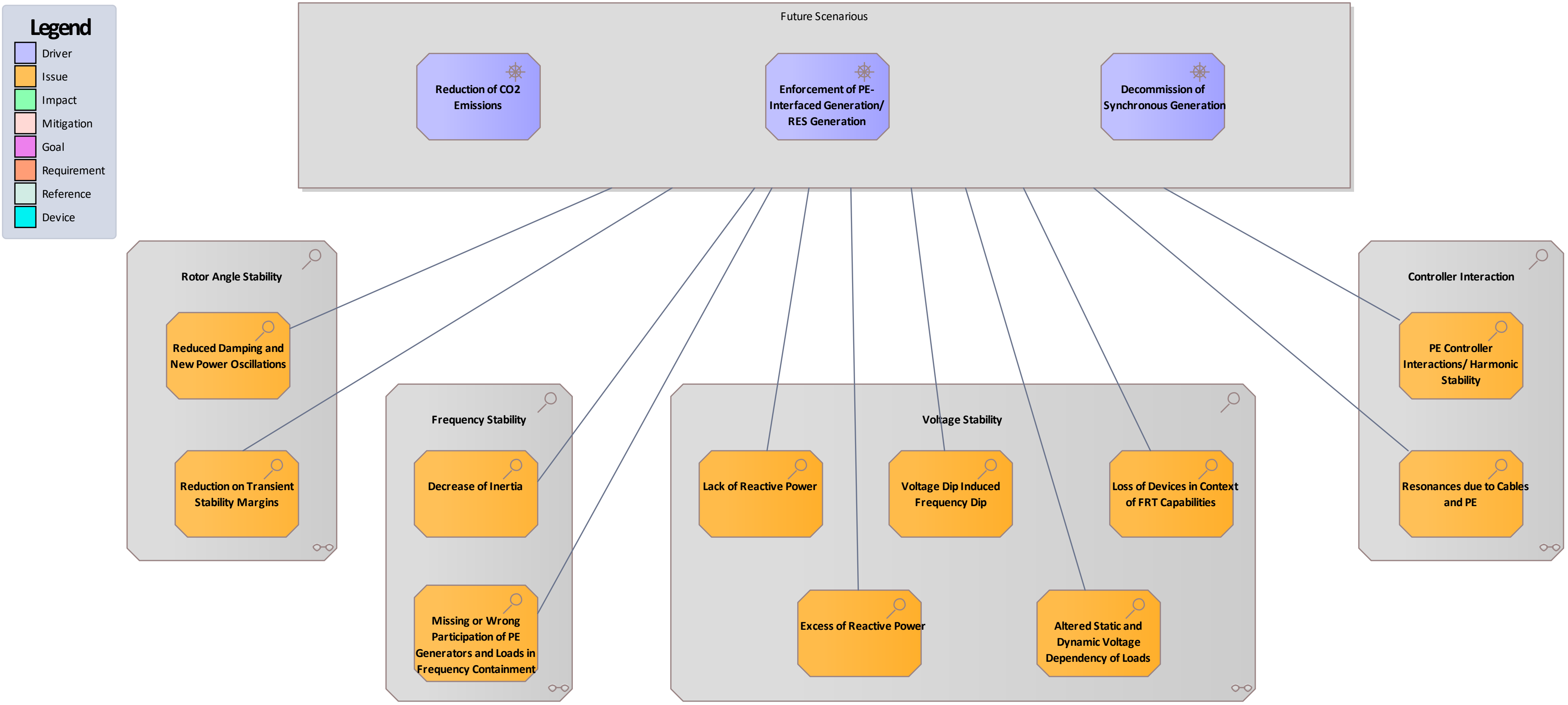
- System stability → rotor angle stability → transient stability
- Security of supply
- Grid reliability

REQUIREMENT

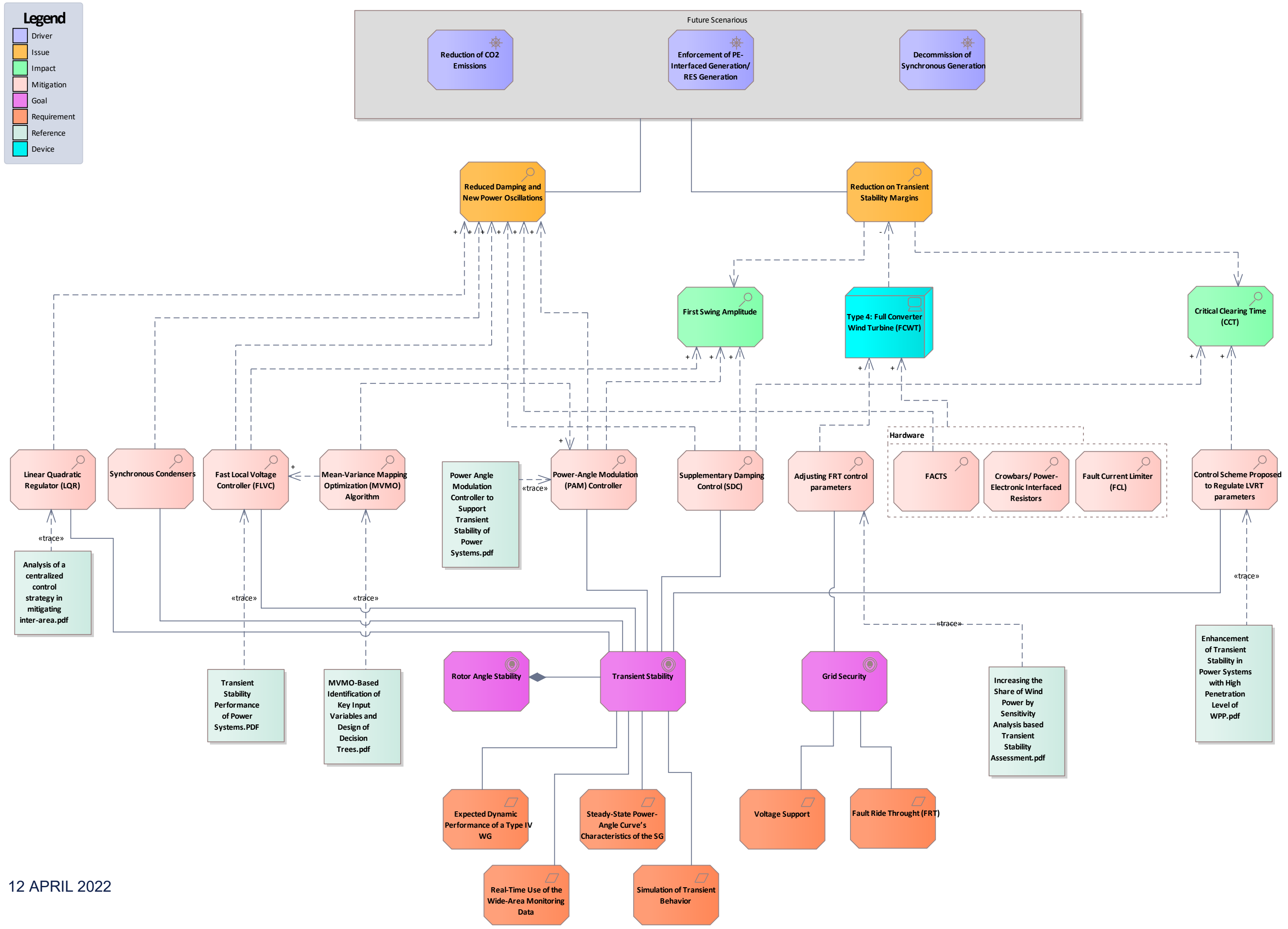
Requirements for mitigation implementation:

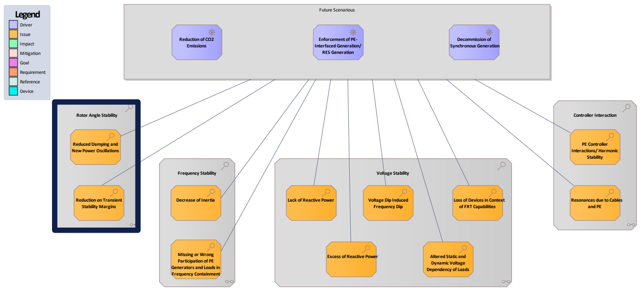
- Dynamic performance of a Type IV wind turbine
- Real-time use of wide-area monitoring data
- Simulation of transient behaviour

Rotor Angle Stability – Framework Implementation



Rotor Angle Stability – Framework Implementation

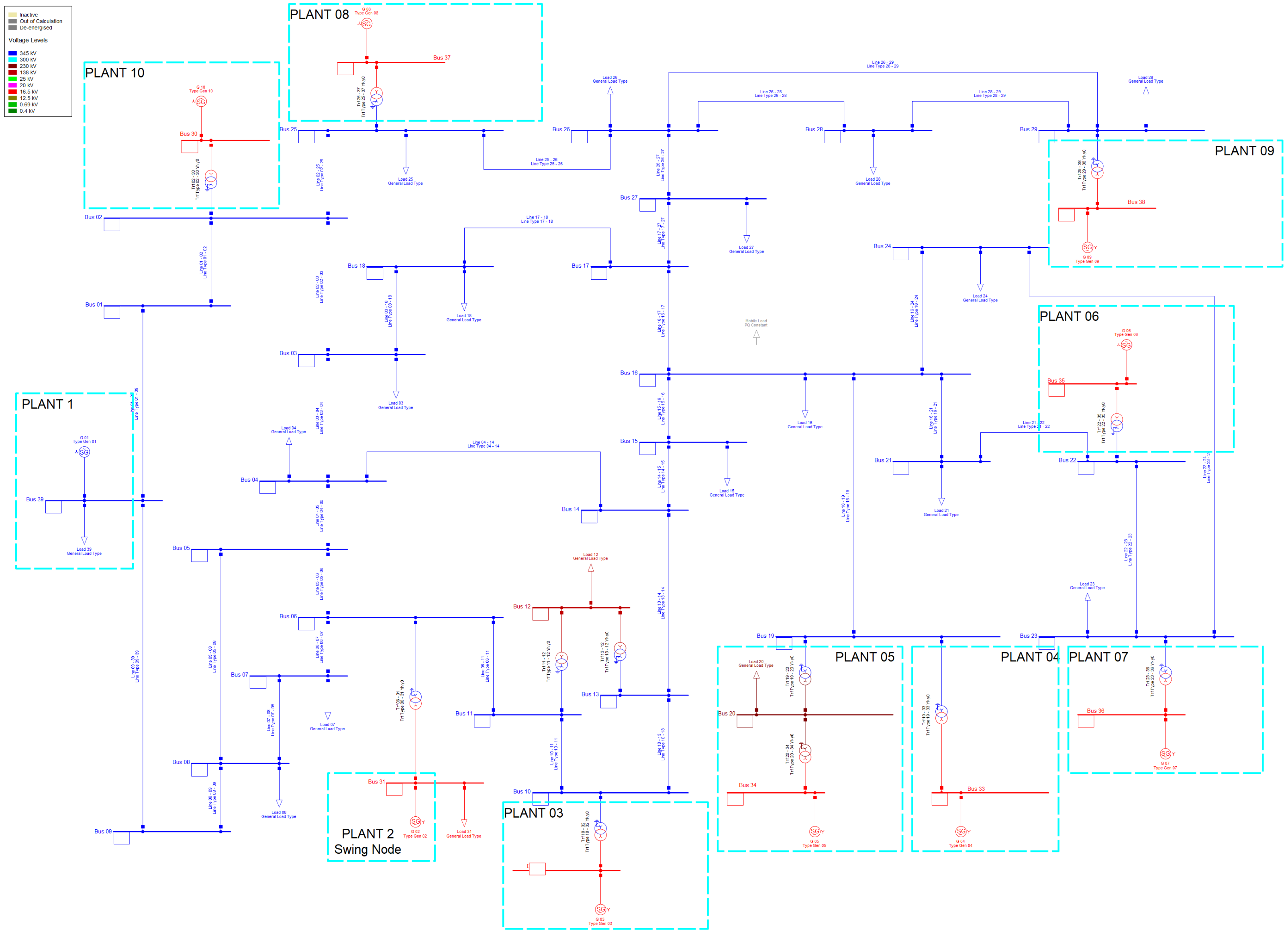




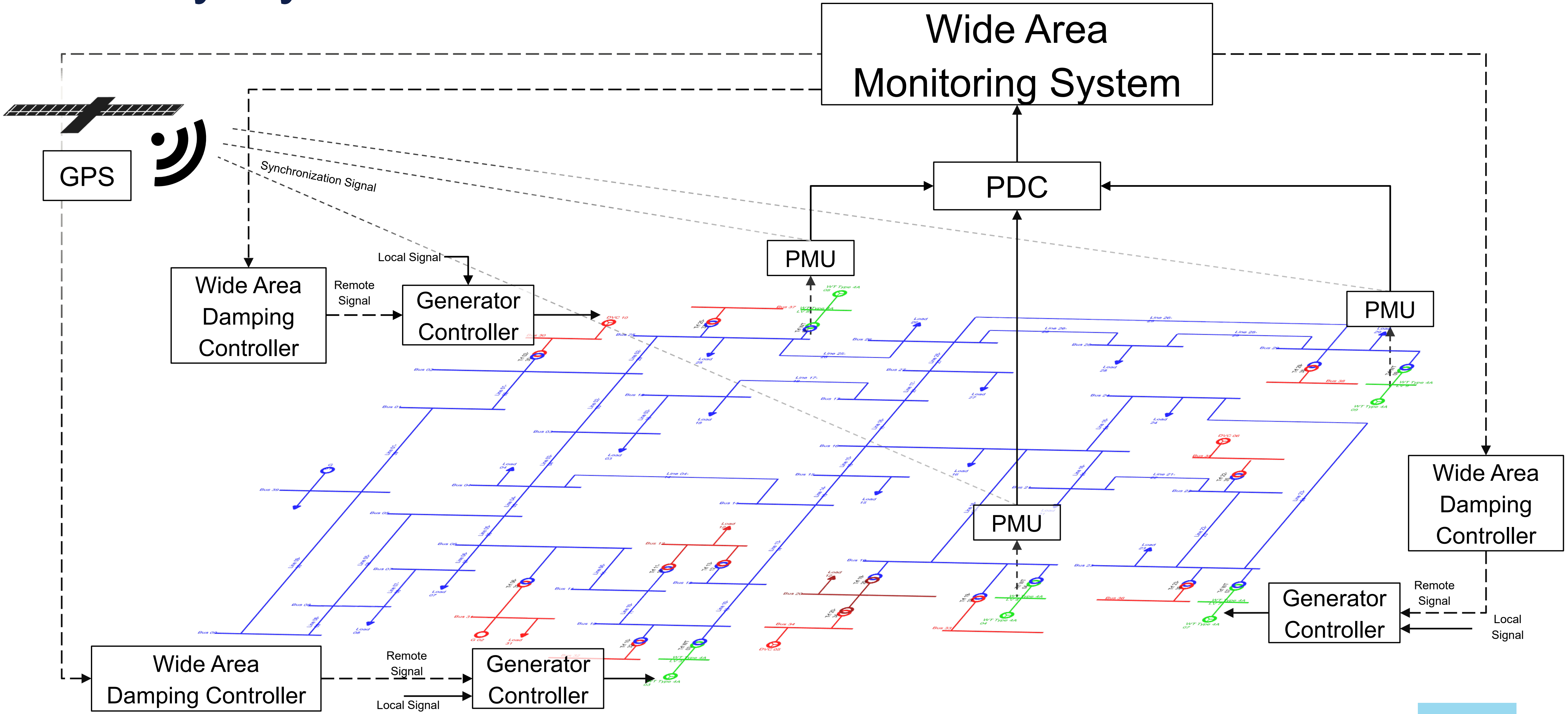
Application of WAMS Information from NextGen GridOps Framework

- Context:
  - Case Study IEEE 39 Bus New England Test System
  - Direct Voltage Control receives a remote signal
  - The remote signal fed to the controller is voltage magnitude (due to the previously developed structure of DVC)
  - The controllability was evaluated by studying damping of critical modes of oscillation
  - Deployment of 3 PMUs and 3 WADs was considered in this project
    - Evaluation of observability and controllability of the system
    - Input / output signal selection method

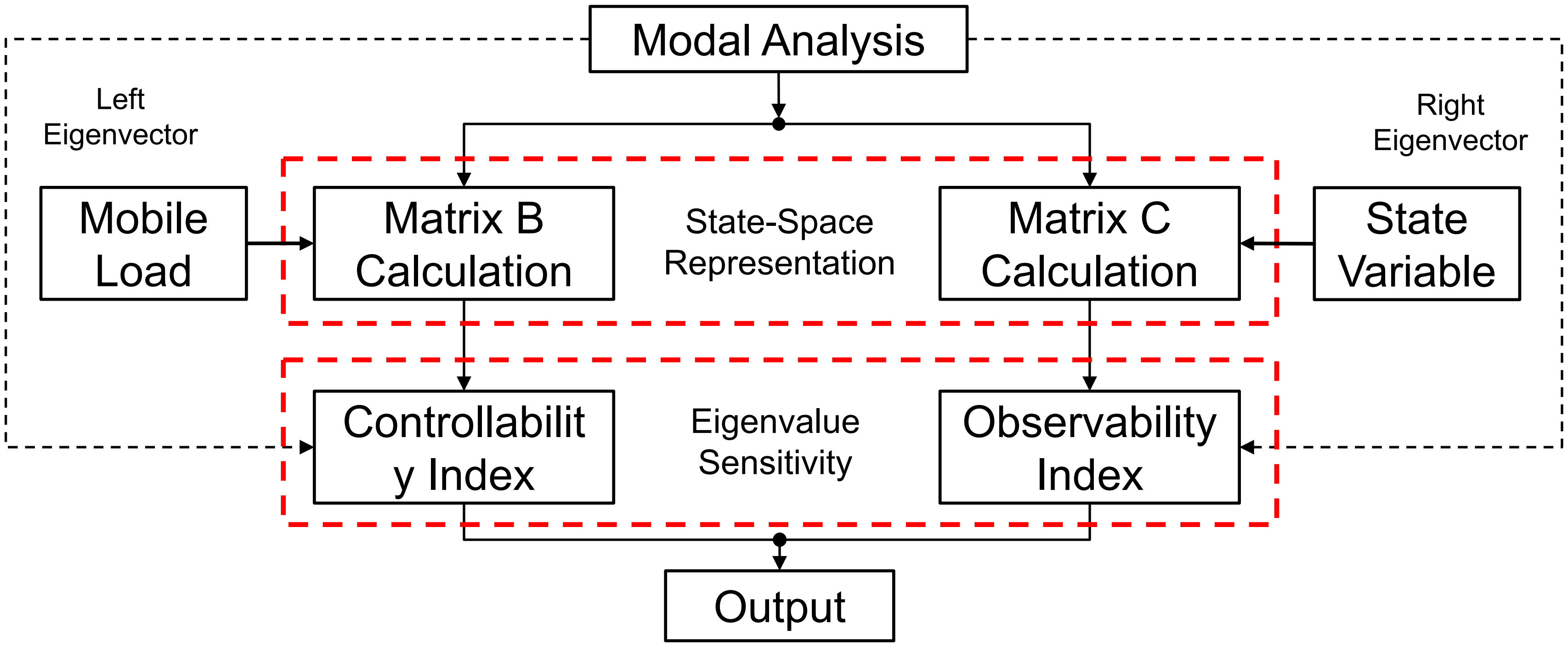
Study System and WAMS Structure



Study System and WAMS Structure



Input / Output Signal Selection Method



ABLE:

- Identify buses with highest controllability and highest observability
  → PMUs
  → WADC

NOT ABLE:

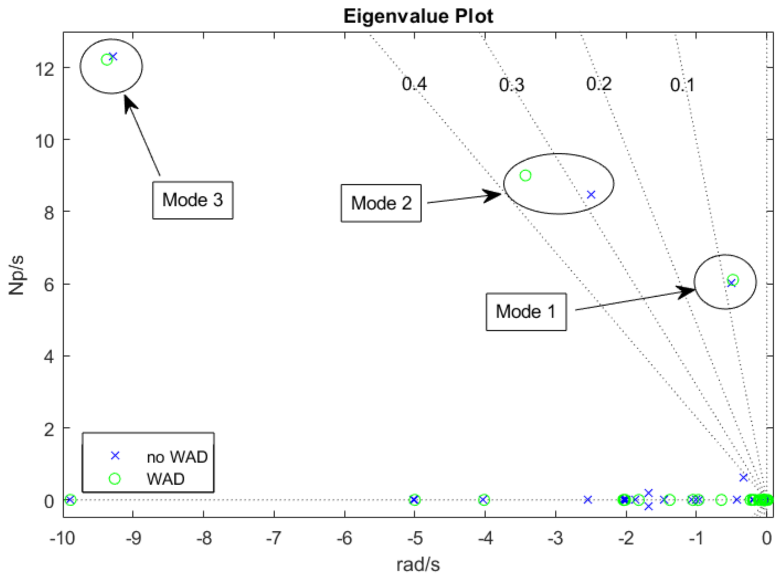
- Determine number of required PMUs & WADC
- Determine best inputs for WADC
- Determine best PE-interfaced device (DVC, VSM, grid-following control) for a specific bus

Case Study IEEE 39 Bus New England Test System

WAMS with 2 Synchronous Generators and 8 DVC

SETUP

- 2 synchronous generators
- 8 Direct Voltage Controllers
  - 3 Damping Controllers → WAD
- 3 Voltage measurements → PMU



Power Plant	Bus	OI	Power Plant	Bus	CI
Power Plant 5	Bus 34	1	Power Plant 7	Bus 36	1
Power Plant 7	Bus 36	0.988	Power Plant 6	Bus 35	0.950
Power Plant 4	Bus 33	0.982	Power Plant 4	Bus 33	0.906

Modes	Eigenvalue	Damped Frequency		Damping Ratio	
Mode 1	-0.509 ± j 6.021 -0.481 ± j 6.107	0.958	0.972	8.40 %	7.90 %
Mode 2	-2.491 ± j 8.488 -3.428 ± j 9.006	1.351	1.433	28.2 %	35.6 %
Mode 3	-9.292 ± j 12.30 -9.372 ± j 12.22	1.958	1.957	60.3 %	60.9 %

With WADC

WADC

Concluding Words

- Next Generation Grid Operations (NextGen GridOps) Framework was developed to support defining and designing the Grid Operations Machine with real-time data exchange between different applications and by different vendors.
- The Grid Operations Machine is based on an integrated system architecture without point-to-point connections between applications, deploying a service-oriented architecture instead.
- The NextGen GridOps Framework is structured in Enterprise Architect according to latest standards and its modular structure allows speedy redeployment of previously implemented solutions.
- Deploying the framework will help strengthen the confidence of grid operators in the future to come through better; being able to manage the ever-increasing complexity of the power grids and renewable generation and better enhancing their situational awareness operating the energy system.

Questions?

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