Network Code on Emergency and Restoration

DSO Technical Expert Group – Brussels

DT Emergency and Restoration

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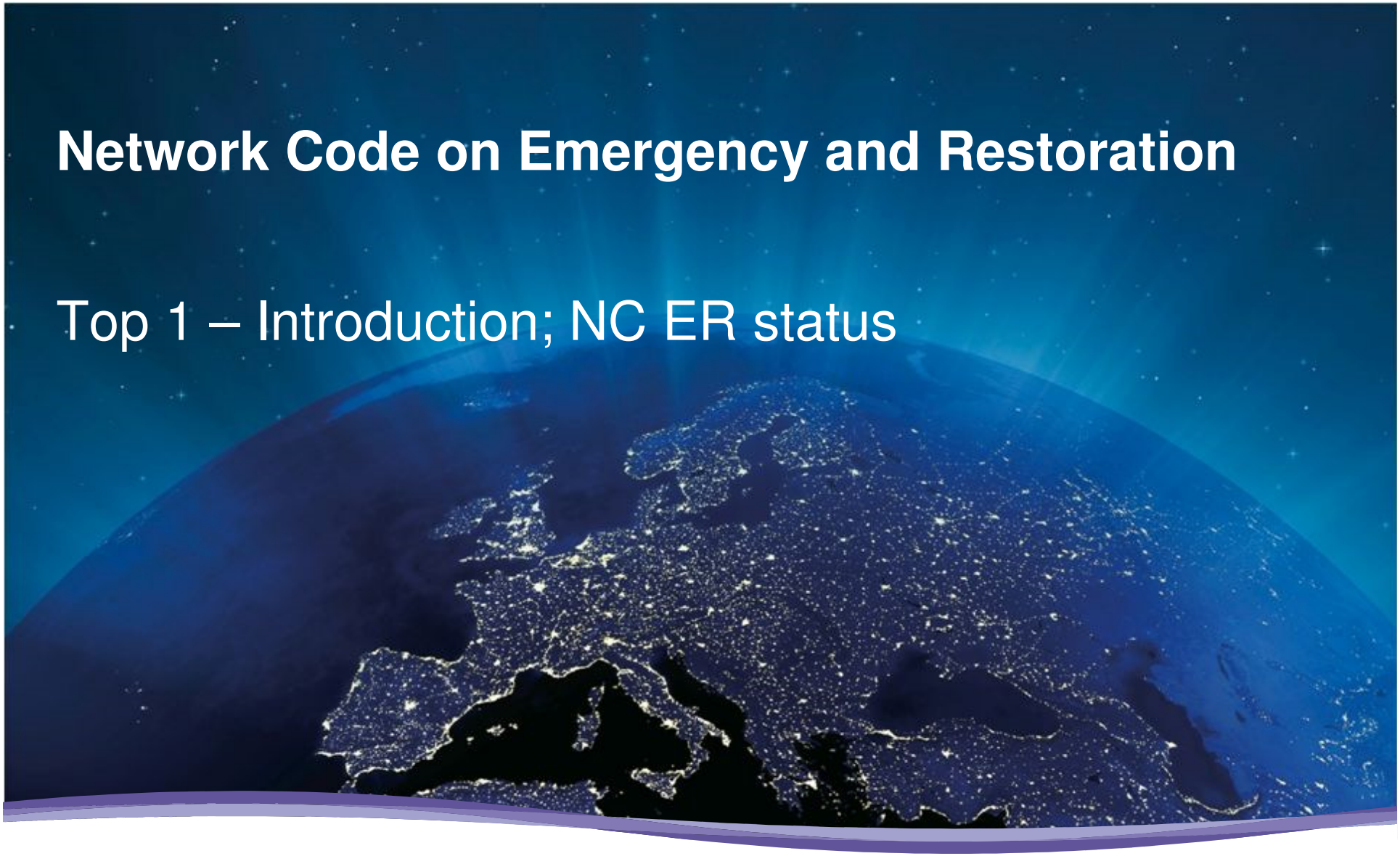
Agenda

Subject	Time	Lead
1. Welcome, NC ER status **DSO presentation**	9:30-9:55	Laurent Lamy *ENTSO-E Convenor of NC ER DT* DSO'representatives
2. Discussion on the topics from questionnaire sent by ENTSO-E	30 min	Laurent Lamy
3. System defence plan principles – initial thoughts Q & A	50 min.	Tudal Loxq, NC ER Drafting Team member DSOs representatives
Coffee break	10 min.	
4. System Restoration plan design principles - initial thoughts Q & A	30 min.	Fabian Heus, NC ER Drafting Team member DSOs representatives
5. Information exchange, communication tools and protocols Q & A	20 min.	Jens Jacobs, NC ER Drafting Team member DSOs representatives
6. Conclusion	15 min.	Laurent Lamy
End of Workshop and lunch	12:30	

Network Code on Emergency and Restoration

Top 1 – Introduction; NC ER status



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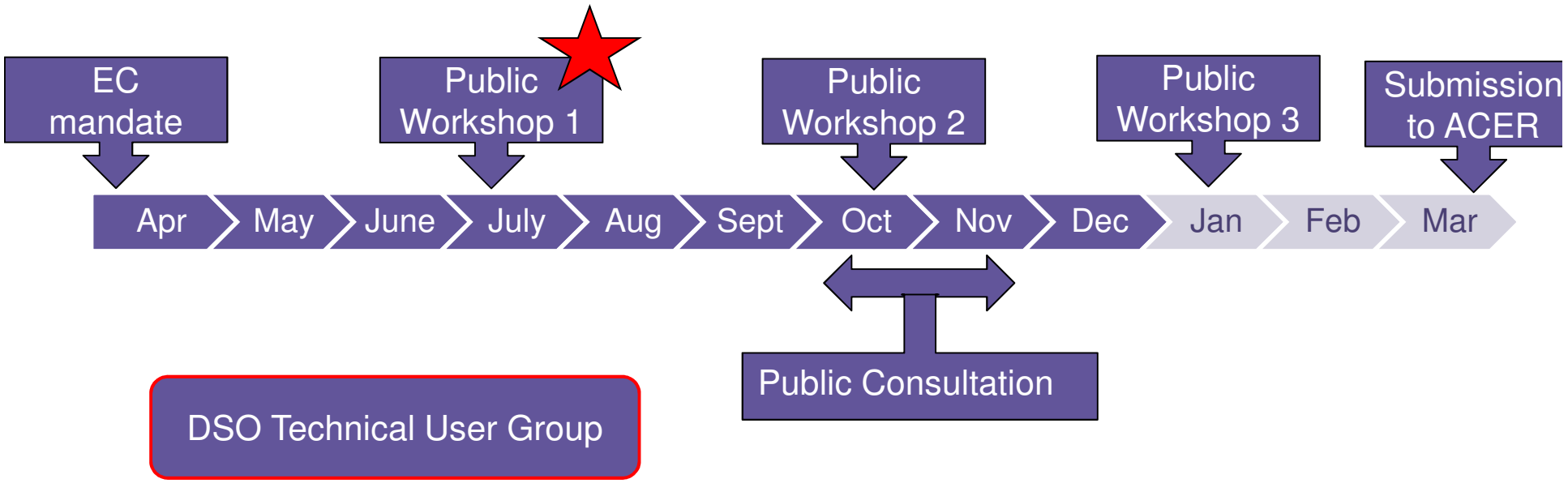
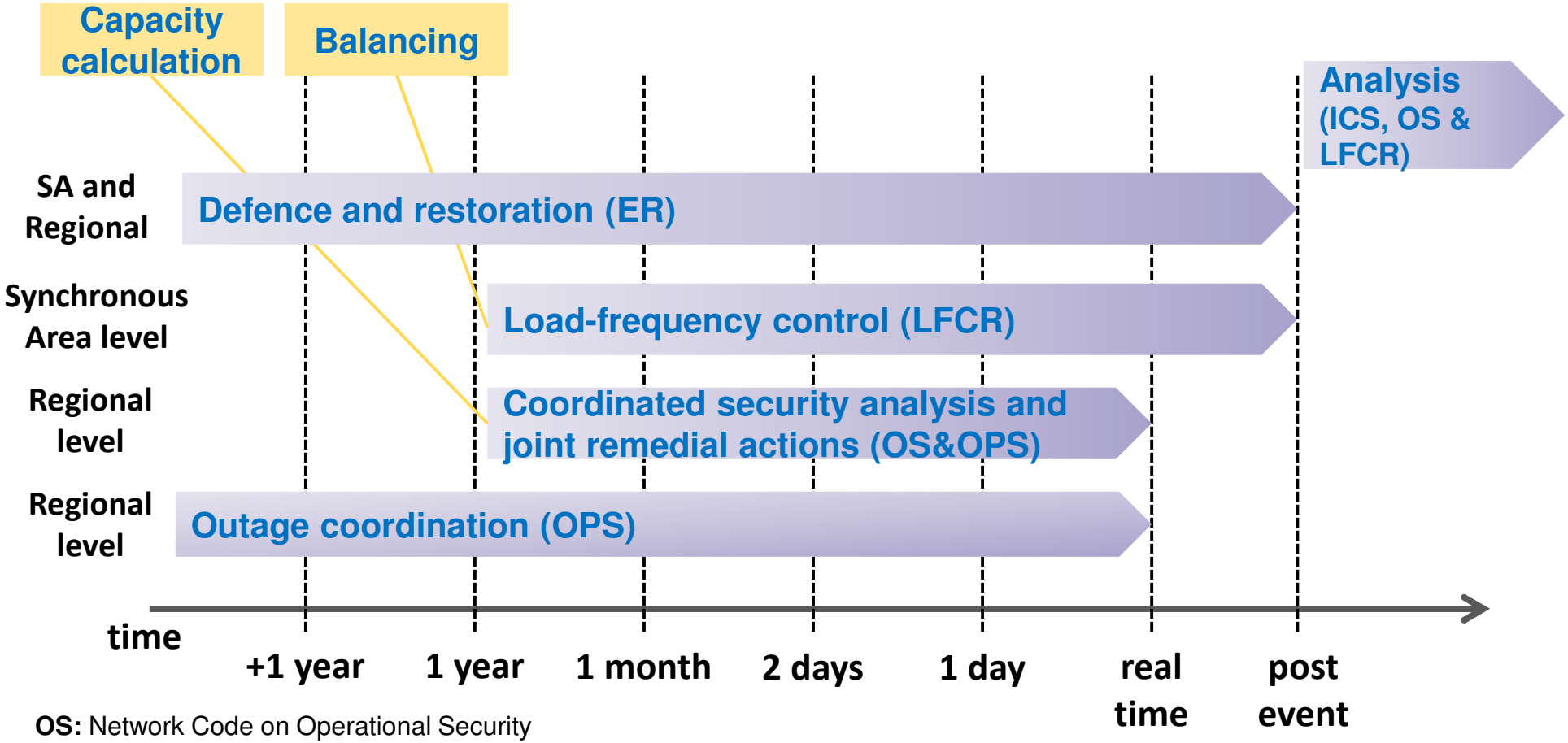
NC ER - Timetable



Emergency and Restoration: the fourth System Operation Network Code



OS: Network Code on Operational Security
OPS: Network code on Operational Planning and Scheduling
LFCR: Network code on Load-Frequency Control & Reserves
ER: Network Code on Emergency and Restoration (under development)
ICS: Incident Classification Scale

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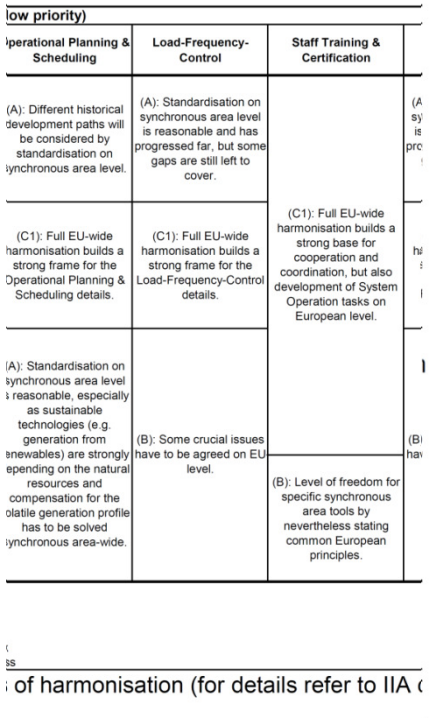
ACER Framework Guidelines on Electricity System Operation

ACER Framework Guidelines for Emergency and Restoration

Objectives	
1	To operate the electrical system in a safe, secure, effective and efficient manner
2	To apply same principles for different systems
3	To enable the integration of sustainable technologies
4	To make full use of information and communication technologies



Emergency & Restoration
(A): Standardisation on synchronous area level is reasonable and has progressed far, but some gaps are still left to cover.
(C1): Full EU-wide harmonisation builds a strong frame for the Emergency & Restoration details.
(B): Some crucial issues have to be agreed on EU level.

Synchronous area is the key area for harmonisation

Principles:

- Coordination to minimise impact
- Responsibility sharing
- Market options open

Data exchange important during emergency and restoration – starting point of the NC OS

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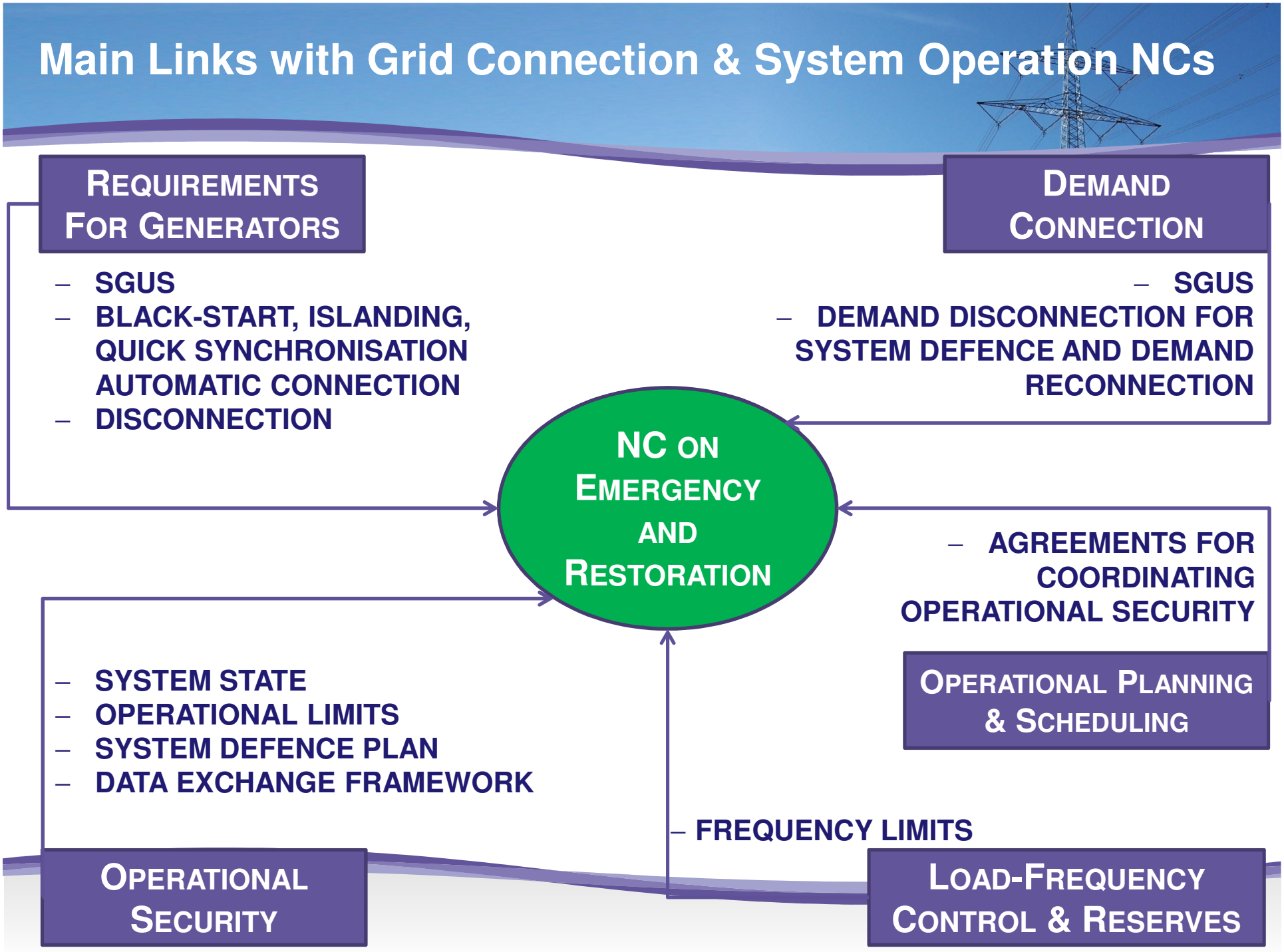
Main Links with Grid Connection & System Operation NCs



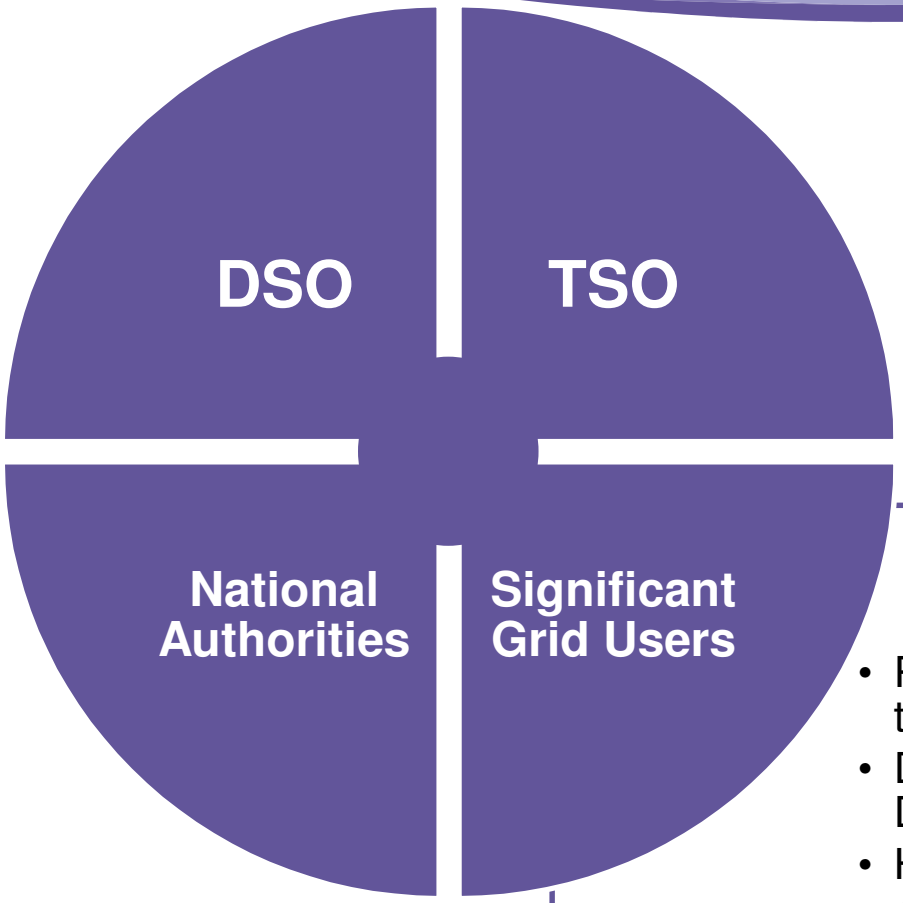
NC ER Objectives

To determine common requirements and principles to manage Emergency, Blackout and Restoration System States:

- to prevent the propagation or deterioration of an incident, in order to avoid a widespread disturbance and Blackout State
- to ensure efficient and rapid restoration from Emergency or Blackout System States

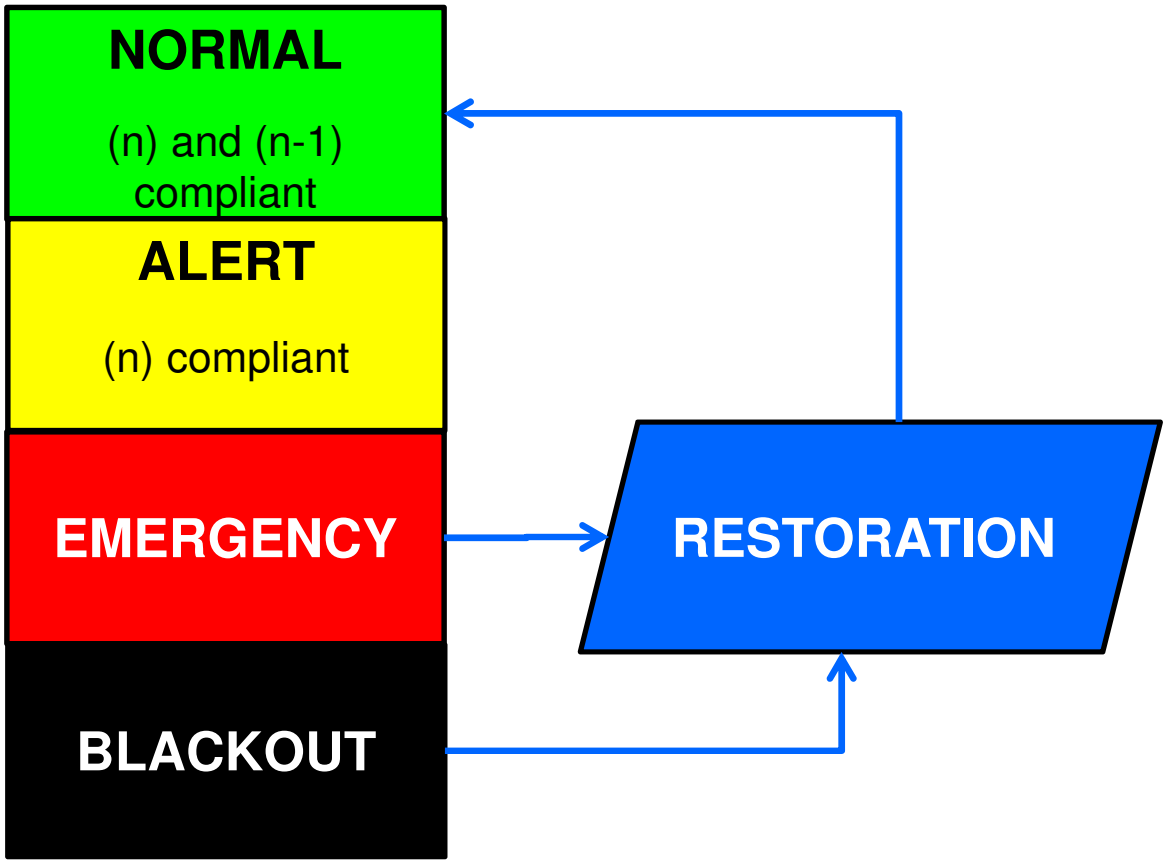
To coordinate system operation in Emergency, Blackout and Restoration System States in a common and coherent way throughout the EU and in 3rd countries where applicable

NC ER addressees



- Power Generating Modules types B, C, D
- Demand Facilities providing Demand Side Response
- HVDC Systems
- *PGM type A as in NC OS*

System States



System States (Article 8 NC OS)

Emergency State

- at least 1 deviation from Operational Security Limits and times
- frequency is outside the limits for Normal and Alert States
- at least one measure of the System Defence Plan is activated
- complete loss of all tools and facilities for more than 30 minutes

Blackout State

- loss of more than 50% of load in the TSO Responsibility Area
- total absence of voltage for at least 3 minutes in the TSO Responsibility Area and triggering Restoration plans

Restoration

- procedures are implemented to bring operational parameters within Operational Security Limits

NC ER Structure

System Defence Plan

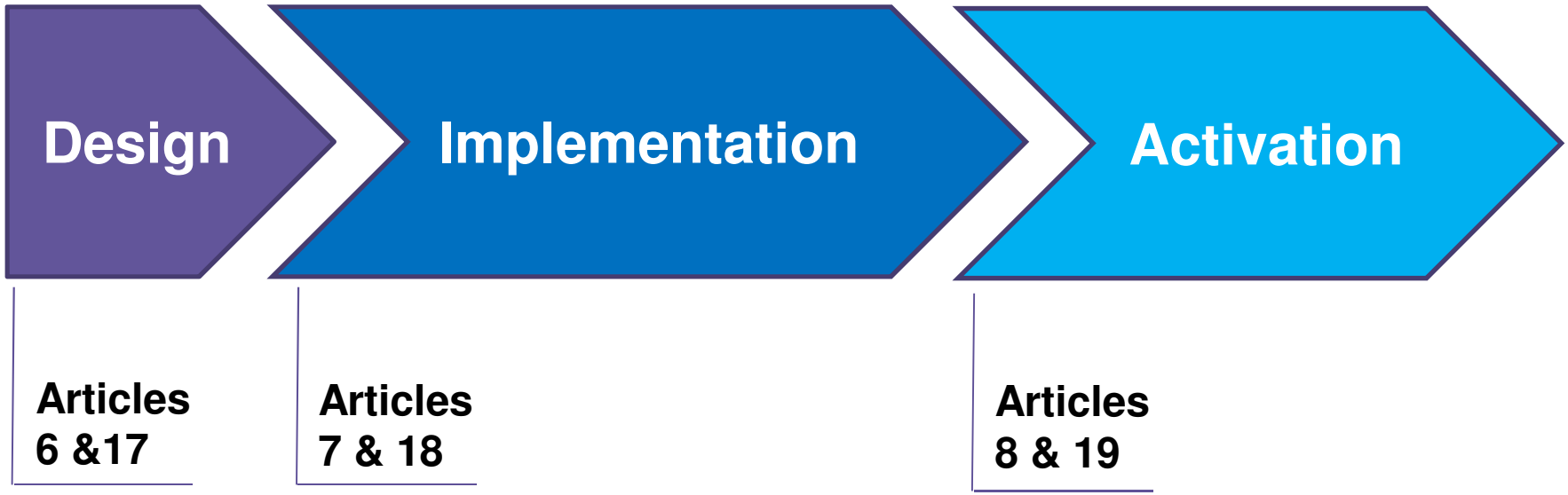
Restoration Plan

Information exchanges and communication

Compliance and review

Legal / general provisions

Defence and Restoration Plans Phases



Defence and Restoration Plans Structure

Plan Structure

Prerequisites	System Protection Schemes	Procedures
Means to be implemented before the Plans can be activated	Automatic schemes	• Activation conditions • Set of actions • Instructions issued by TSOs

Emergency & Market

- ✓ Emergency State (OS) => market will continue according to the rules
- ✓ Emergency situations (CACM) => TSO has the right to curtail Cross Zonal Allocated Capacities

Potential impact to the market according to the market rules

Potential curtailment of Cross Zonal Allocated Capacities (ex-post justification) according to CACM

- **FWGLs ask for NC to define** a procedure for restoration of regular market operations after technical restoration
- **Objective:** minimise effects to the market
- **Challenge:** harmonise rules at a pan-European level

Emergency & Restoration Plans - efficiency

ACER FWGLs

Emergency prevention and restoration plans shall – besides technical needs – consider cost-benefit issues on macroeconomic and market level

Current practice

Economic efficiency implicitly taken into account by TSOs

- Defence plan: **minimise the impact** to grid users with the minimum resources
- Restoration plan: minimise the time to restore **the whole system** with the minimum resources
  - ✓ while considering **existing constraints** (e.g. civil security issues)

➔ These constraints increase significantly the complexity of the problem; TSOs analyse different scenarios, to select **the most efficient option**

➔ Several market options for the procurement of relevant services

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Top 2 – Questionnaire to DSO

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How to cover the issue of smart grids in the NC ER?

- Current ENTSO-E approach is not to make specific provision regarding smart grids in the code, but we also do not intend to block smart grids with any provision in NC ER.
- What view of DSOs on this topic?
- Do you consider this should be covered in the NC ER on European level as regulation or should it be left to each member state to deal with this issue in their national grid code?

➔ Please provide us with your view and examples how and what should be tackled in the code regarding smart grids.

LFDD - Dispersed generation issue

LFDD scheme shall be designed according to principles set forth in NC ER, using capabilities required in NC DC.

Dispersed generation is a major issue when implementing the LFDD scheme, because it influences the real “Demand” that can be disconnected.

DT ER approach is to define a functional target in the code without limiting the technical means to reach this target (kind of relays, distribution of relays...).

In addition, the NC DC foresees a yearly DSO notification of LFDD settings.

➔ What process should be followed in case the yearly DSO notification on LFDD shows it is not compliant anymore with the target?

➔ From your point of view, what should be tackled in the code regarding the issue of dispersed generation in the LFDD scheme design and implementation?

Compliance testing

Testing of Significant Grid Users capabilities used by Defence and Restoration Plans required in NC RfG, NC DC and NC HVDC.

To ensure reliability of these capabilities, NC ER proposes to define a maximum periodicity to perform these tests.

Capacities to be tested:

- Black Start [every 3 years]
- Houseload operation [types C and D, after any modernisation or after two unsuccessful consecutive tripping in real operation
- LFSM- O [every 6 years for type B, every 5 years for type C, every 3 years for type D]
- LFSM- U [every 5 years for type C, every 3 years for type D]
- LFDD / LVDD relays behaviour (capability for operation from a nominal AC supply input) [every 5 years]
- Demand Side Response: demand modification [every year]

➔ Please provide us with your view on this topic, including on the proposed periodicity.

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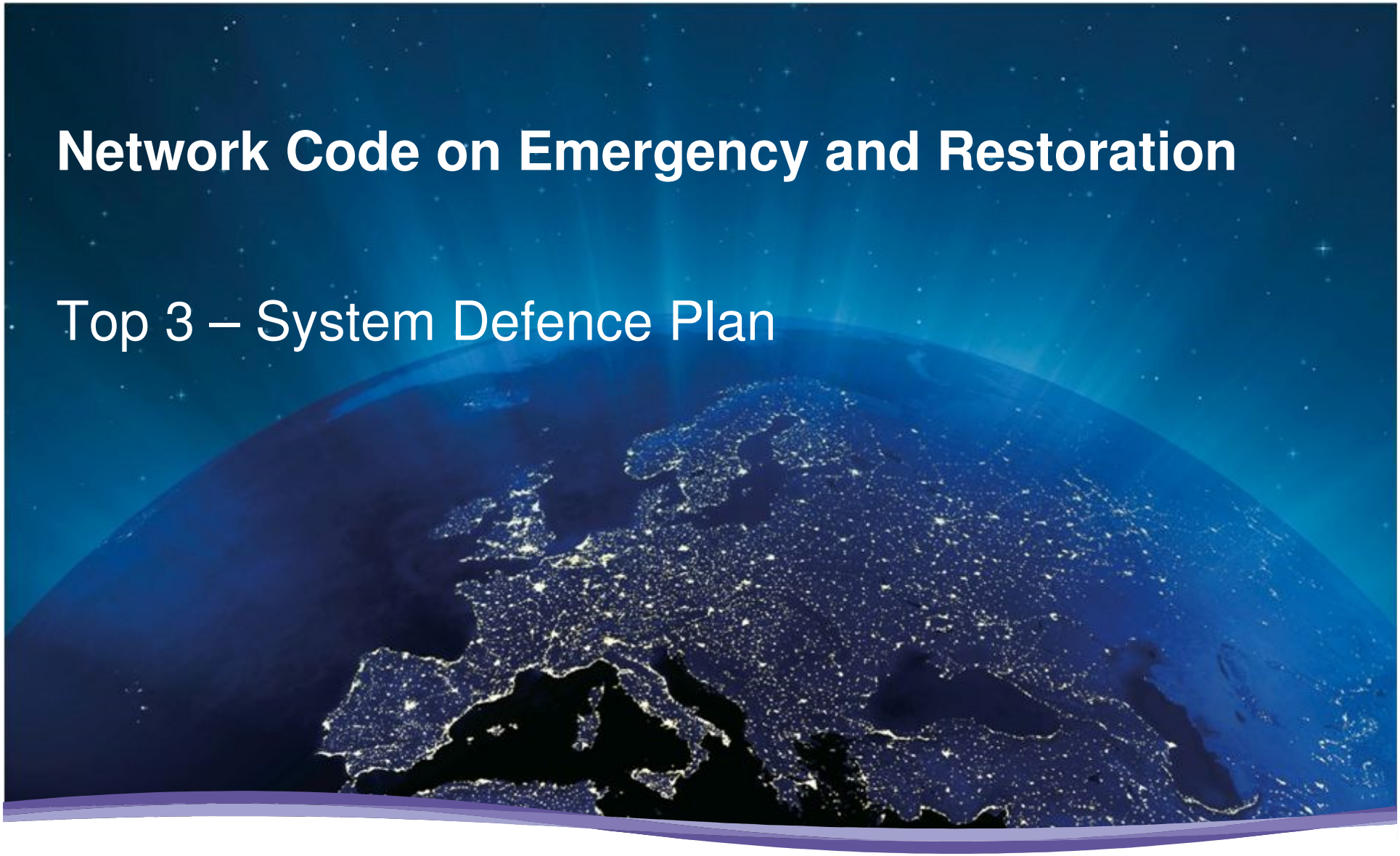
Top 3 – System Defence Plan



Tudal LOXQ

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System Defence Plan: Objective

System Defence Plan = summary of measures to be undertaken to prevent the propagation or deterioration of an incident in the Transmission System, in order to avoid a widespread disturbance and Blackout State

- Technical measures: System Protection Schemes such as Automatic Low Frequency Demand Disconnection Scheme
- Organisational measures: procedures to be followed in different situations

➔ System Defence Plan requires **coordination** between

- **TSOs**
- **TSO** and the **DSOs** and **SGUs** in its Responsibility Area

System Defence Plan Principles

Each TSO designs a System Defence Plan that meets the EU objective to avoid widespread disturbance

Covering at least

- System Frequency
- Transmission System steady-state Voltage
- Power flows exceeding Operational Security Limits
- Absence of Adequacy

Taking into account

- Consequences of Exceptional Contingencies
- Stability Limits
- Short-circuit current limits
- Technical behaviour of SGUs and type A PGM

Ensuring

- Minimal impact for grid users
- Specific grid users needs are fulfilled
- Economical efficiency
- Not to introduce additional risks

System Defence Plan Implementation

➔ **TSO** to ensure the implementation and availability of measures to be implemented directly on the **Transmission System**

➔ **DSOs** and **SGUs** to ensure the implementation and availability of measures to be implemented on **DSOs or SGUs installations**

- TSO to communicate these measures and the implementation deadline (national scrutiny)

System Defence Plan (SDP) Activation

NC ER foresees the activation of:

- **System Protection schemes** of the SDP: when relevant operational parameter exceeds a limit (as defined in the SDP)

- **Procedures** of the SDP:
  - When in Emergency State (and no Remedial Action efficient enough)
  - When proved necessary by a forecast study (e.g. Absence of Adequacy)
  - In application of a specific procedure subject to NRA approval

➔ DSOs and SGUs shall follow SDP instructions issued by the TSO.

➔ Coordination between TSOs needed if potential cross-border impact.

➔ Preparation phase can be needed before activation.

System Defence Plan (SDP): TSO Coordination

TSO coordination in Emergency situations refers mainly to:

- **Interconnectors opening rules**
- **HVDC Systems assistance**
- **Assistance for Active Power**

Need for a multi-party agreement for Emergency and Restoration:

- NC OS, article 8(10): Activation of SDP measures in coordination with TSOs having signed the same multi-party agreement (as in NC OPS).
- NC OPS, article 20: Description of the multi-party agreement but no reference to coordination in case of Emergency (and Restoration).

➔ Amendment of the multi-party agreement defined in NC OPS, needed.

Measures of the System Defence Plan

The System Defence Plan of each TSO shall consist at least of:

- System Protection Scheme: at least the **Automatic Low Frequency Demand Disconnection**

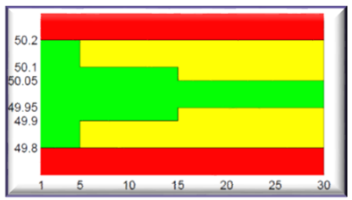
- Procedures:
  - **Frequency** deviation management
  - **Voltage** management
  - **Power flow** management
  - **Assistance for Active Power**
  - **Manual Demand Disconnection**

Measures of the SDP: Frequency Deviation Management

Frequency deviation management includes

- **Procedure**
  - ✓ Includes **manual** and **automatic** actions
  - ✓ For **under**- and **over**-frequency deviations
  - ✓ **"Before"** activation of Automatic LFDD Scheme (or for smaller deviations)

- **Automatic Low Frequency Demand Disconnection Scheme (LFDD)**
  - ✓ Automatic scheme
  - ✓ Only to **under-frequency** deviation



Measures of the SDP: Frequency Deviation Procedure

- **Load Frequency Control Structure shall not endanger the Transmission System**

  In CE: freezing of the secondary controller

- **Global behaviour and actions on the Generation/Demand shall support frequency**

  In case of disconnection of embedded generation before reaching 49Hz, compensation is required on Generation/Demand in the LFC area.

- **Demand Side Response & Limited Frequency Sensitive Mode to be used as much as possible before activation of the LFDD**

LFSM–O for severe over-frequency

Frequency between 50.2 and 50.5Hz, generation decrease down to Pmin

LFSM–U for severe under-frequency

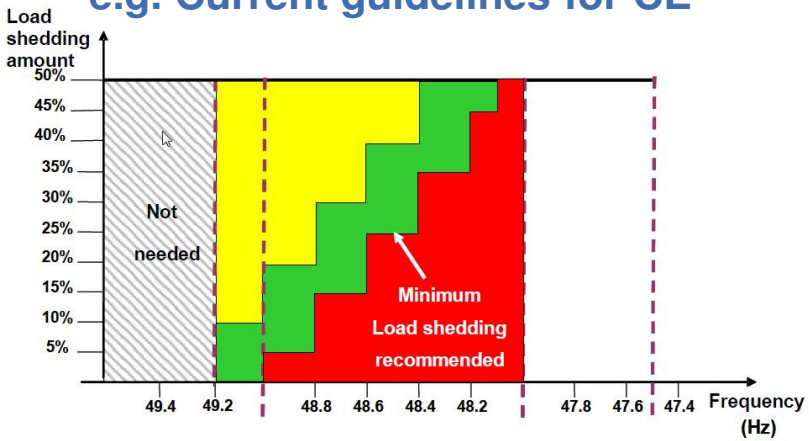
Frequency between 49.8 and 49.5Hz, generation increase up to Pmax

Measures of the SDP: Automatic LFDD Scheme

➔ The objective is to **harmonise the Automatic Low Frequency Demand Disconnection (LFDD) Scheme** per Synchronous Areas.

- Harmonised thresholds for Continental Europe not defined yet. Study on going for CE.
- Demand Disconnection to be geographically evenly spread
- PGM installed capacity disconnection to be minimised

e.g. Current guidelines for CE



➔ To be implemented by TSOs or DSOs in most cases.

➔ **The code defines a functional target and does not prescribe technical solutions.**

Measures of the SDP: Voltage Management

- **Activation:** when Operational Security Limits are violated and Remedial Actions are not sufficient

- NC OS article 10(18) defines some measures related to voltage management to be included in the SDP

- More analysis to evaluate the level of harmonisation for:
  - Coordination with DSOs and Significant Grid Users for Reactive Power management
  - Automatic Low Voltage Demand Disconnection Scheme
  - On-Load Tap Changer Blocking Scheme
  - Special Protection Schemes

Measures of the SDP: Power flow management

- **Activation:** when Operational Security Limits are violated and Remedial Actions are not sufficient

- NC OS article 12(5) deals with Remedial Actions to be used in Normal State to manage power flows

- More analysis to evaluate the level of harmonization for:
  - Power Generating Modules disconnection
  - Demand Disconnection
  - Special Protection Schemes

Measures of the SDP: Assistance for Active Power

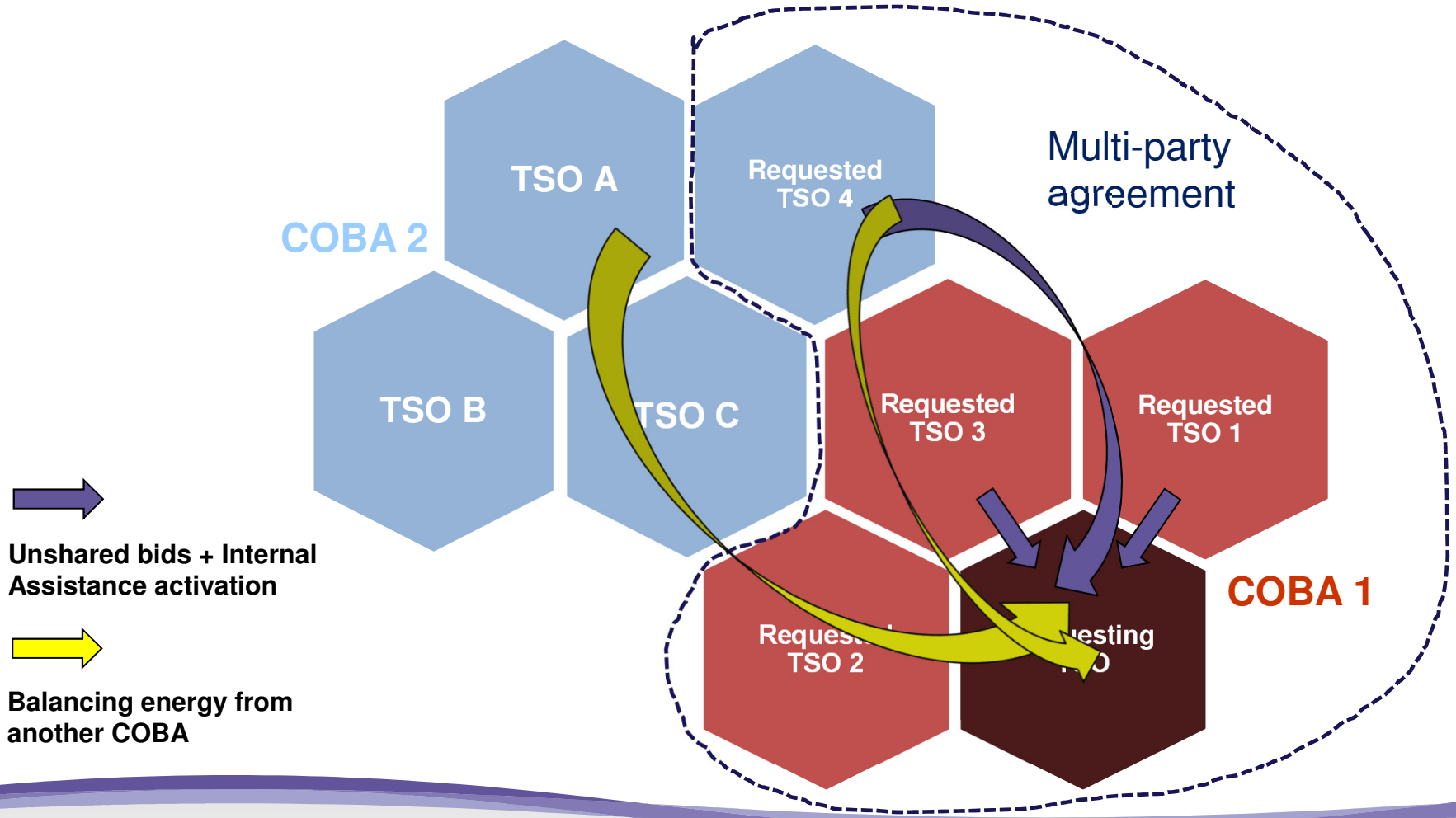
- ➔ **Activation:** absence of Adequacy as described in NC OPS, article 46(3)

- ➢ **Internal request:**
- ➔ Balancing Service Providers and
- ➔ Power Generating Modules (with no contract with BSP): Shall put all technically available power at disposal of the requesting TSO

- ➢ **Cross-border request:**
- ➔ To all TSOs having signed the multi-party agreement
- ➔ 3 possible actions for a requested TSO to help the requesting TSO:
  - ➢ Make available Unshared Bids
  - ➢ Activate Balancing Energy from other Coordinated Balancing Areas
  - ➢ Internal request of Assistance for Active Power “on behalf of” the requesting TSO

Measures of the SDP: Assistance for Active Power

Cross-border request of Assistance for Active Power



Measures of the SDP: Manual Demand Disconnection

- Activation:
  - to solve overloads or under voltage situations
  - in case the Assistance for Active Power has been requested but is not sufficient to ensure Adequacy on its Responsibility Area in D-1 and intraday, leading to a risk of frequency deterioration

- TSO shall determine the amount of Demand to be disconnected

- The required amount of Demand shall be disconnected:
  - directly by the TSO; or
  - By the DSOs: without undue delay, respecting the amount and area specified by the TSO while minimising impact on grid users

Review of the System Defence Plan (SDP)

➔ **Every year: written notification on LFDD** provided by DSOs and Demand Facility owners according to NC DC

➔ **Every 5 years: complete review of the SDP** by each TSO

- Network developments
- Capabilities of new equipment
- New SGUs and existing and new type A Power Generating Modules
- Analyses of system incidents
- Operational data collected during normal operation and after incident

➔ Can lead to modification of System Protection Schemes and Procedures

What process to consider in a situation of e.g. non-compliance of Automatic Low Frequency Demand Disconnection Scheme due to embedded generation?

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Top 4 – Restoration Plan

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Restoration Plan: Objective & Definition

Objective*:* bring back the system from Emergency or Blackout State to Normal State, as soon and as efficient as possible

NC OS (article 8(1)(e): Restoration:

i. Procedures are implemented to bring frequency, voltage and other operational parameters within the Operational Security Limits defined according to Articles 9, 10 and 12 in accordance with Article 8(5); and

ii. Demand Facilities are connected at a pace decided by the TSOs in charge of Restoration, depending on the technical capability and feasibility of the Transmission System resources and Significant Grid Users which are Power Generating Facilities.

Actions of restoration are launched once the system is stabilised

Restoration Plan: What is Happening on the Grid?

Starting point:

A stabilised system after the event(s).

Restoration from Emergency or Black-out State

What the situation could be in an area (could be an entire synchronous area):

- Blackout (no Voltage) (Italy 2003)
- Frequency Deviation > 200 mHz longer than 1 minute
- Grid splitting (Emergency): Frequency Deviation (4 November 2006)
- **...**

Restoration Plan: How? (1)

Re-energising? Two principles:

1. Bottom-up: individual control area re-energises its own area to be ready for resynchronisation with another area
2. Top-down: individual control area uses external voltage sources from tie-lines

Restoration plan contains all the measures to reenergise the system:

Restarting and synchronisation of

1. generator units
2. load units
3. other areas
4. market processes

Tools:

1. Black-start units
2. Manual/automatic activation of reserves
3. Help from TSO (including via HVDC-links)
4. Help from DSO and Significant Grid Users

Restoration Plan: How? (2)

The Restoration Plan needs **coordination**:

- Between **TSOs**
- Between a TSO and the **DSOs** and **SGUs** in its Responsibility Area

Framework for Restoration Plan to be established:

- at least at Synchronous Area level
- taking into account specificity and complexity of each SA

Framework Restoration Process: One Example

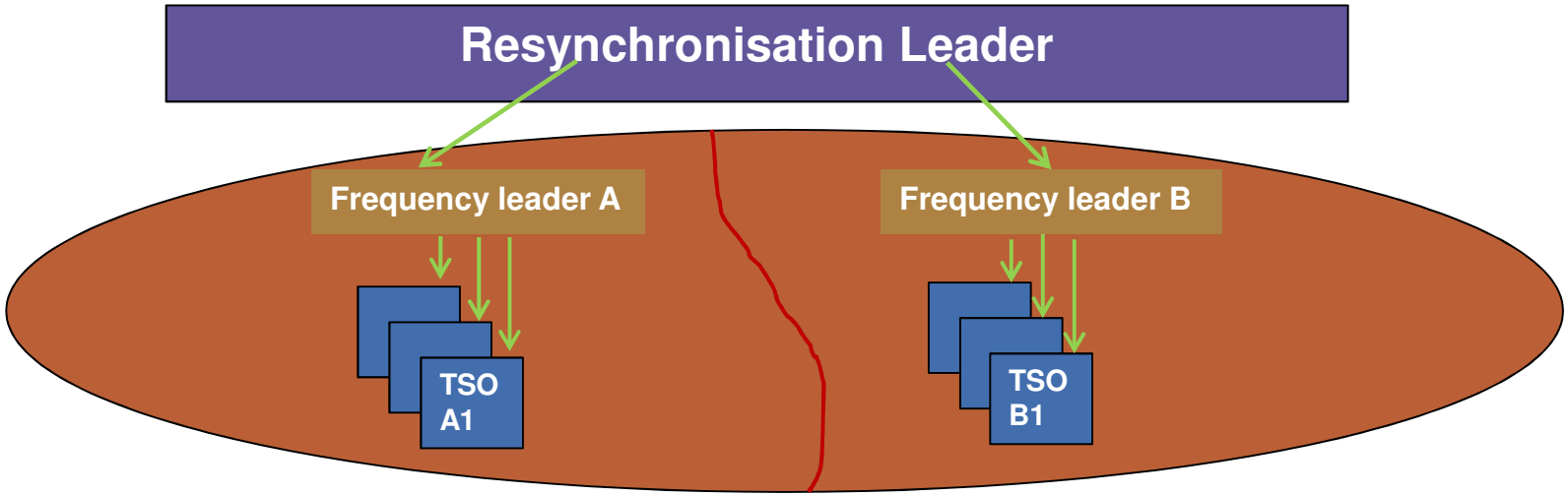
Situation of the areas	RESTORATION STEPS		LEADERSHIP
Black-out	Bottom up	Building from black start one or more island(s) One or more big units regulating the frequency	No leader needed
Frequency deviation >200mHz With or without system split	Top-down	Step by step extension of the on-voltage area. Reconnection of load/generation under one frequency leader	Frequency leader
	Frequency management	In splitted system, or in top-down areas, all TSOs but one have their LFC in frozen mode: frequency leader in LFC mode and coordinates replacement reserves	
Stable splitted areas f near 50 Hz	Resynchron -isation	A frequency value have to be agreed upon Once reconnected, only one frequency leader must remain in frequency mode.	Resynchronisation leader
	Final supplying	All TSOs put their LFC in normal mode Supply remaining lost load	No leader needed

Restoration Plan: Resynchronisation

Continental Europe: at least 2 TSOs in trouble?

Two kinds of leadership will be recognised:

1. **Frequency leader**. Coordinates the frequency management by means of activation of generation reserves within area in trouble.
2. **Resynchronisation leader**. Is in charge of coordinating frequency leaders and of executing the resynchronisation of the affected areas.



Market Restoration – Relatively New Topic

Framework Guidelines:

Procedure for restoration of regular market operations after technical restoration

Procedure, Yes:

- How to communicate?
- When to communicate?
- Who communicates?

…

Roles and Responsibilities – Clarity is Critical

It is critical that during the restoration process:

- all actors understand their role and responsibilities
- all actors understand their rights

Framework Guidelines (page 27):

Restoration related organization and procurement of black-start and islanding capabilities, as well as ancillary services shall be assigned exclusively to the TSOs, which shall have the duty and power to decide on any subsequent applicability at the DSO level..

The DSOs shall support the system restoration according to the plan.

In a critical operating state the significant grid users shall comply with instructions from TSOs and participate in emergency planning, restoration procedures and exercises planned and carried out by TSO.

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Top 5 – Information Exchange and Communication, Tools and Facilities

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Links with NC OS

Chapter 3 **Data Exchange** of **NC OS** builds the basis for the Chapter "Information Exchange and Communication, Tools and Facilities" of the NC ER.

➔ The NC ER will not define type of data, communication means, format and standards since the provisions of NC OS apply for NC ER

➔ Timing and responsibilities will be defined in common TSO proposal that will be subject to regulatory approval.

➔ Cooperation with DSOs on the data exchange processes is foreseen

Information Exchange and Communication, Tools and Facilites: Objectives

- Specify the relevant information needed to guarantee a sufficient and fast restoration
- Establish a common understanding between TSOs, DSOs and SGUs on the information to be exchanged and the communication channels used
- Set the minimum requirements for TSOs, DSOs and SGUs to guarantee the availability of communication at any time
- Set the minimum requirements for TSOs to guarantee the functionality and availability of control rooms in any system state at any time

Information Exchange

Information Exchange: TSO ↔ DSO, SGUs

– DSOs to provide information about the abilities/means, e.g. related to **islands or frequency regulation**

– SGUs involved in Restoration Procedures to provide information, e.g. about their technical conditions (e.g. ability of a Power Generating Module to stay in its current status)

Information Exchange: TSO ↔ TSO

– between neighbouring TSOs, especially information about successful islanding or preferred communication channels

– information needed by the Frequency Leader of a SA, e.g. successful islanding or the ability of frequency regulation

Communication

- Communication channels to be used between the relevant TSOs, DSOs, SGUs and Substations including at least two independent communication channels with specific requirements

  - Channel A:
    - direct/no public communication channel
    - prioritised
    - blackout proofed and with backup power supply
  - Channel B:
    - blackout proofed and with backup power supply

- **Already common practice for the majority of the TSOs**

Facilities

- Secure power supply for the main auxiliaries of main & backup control rooms including e.g.:
  - Communication channels
  - SCADA / EMS system
  - Load Frequency Control equipment

- Evacuation procedure for moving from the main to the backup control room:
  - each TSO to prepare the procedure
  - ensure operation when moving to backup control room

- Backup power supply for the most important substations of each TSO
  - TSO to decide about the relevant substations to be equipped

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Top 6 – Conclusion

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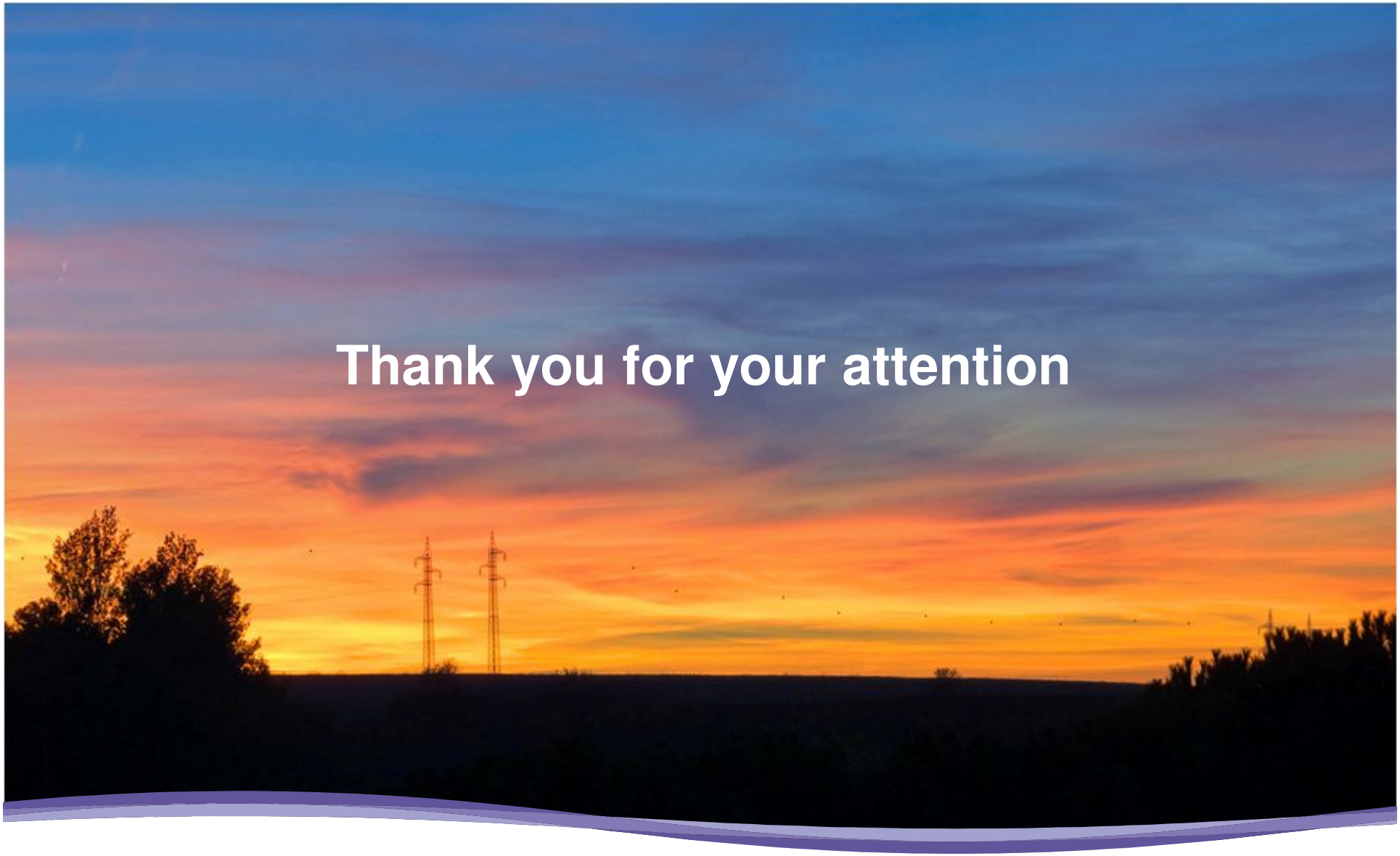

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Annex

System Defence Plan Activation

Emergency conditions (NC OS)

- Expected behaviour

at least 1 deviation from Operational Security Limits and times

- the TSO to activate a measure of its Defence Plan (NC ER) if Remedial Actions are not sufficient

frequency is outside the limits for Normal and Alert States

- the TSO to activate a measure of its Defence Plan (NC ER)

at least one measure of the System Defence Plan is activated

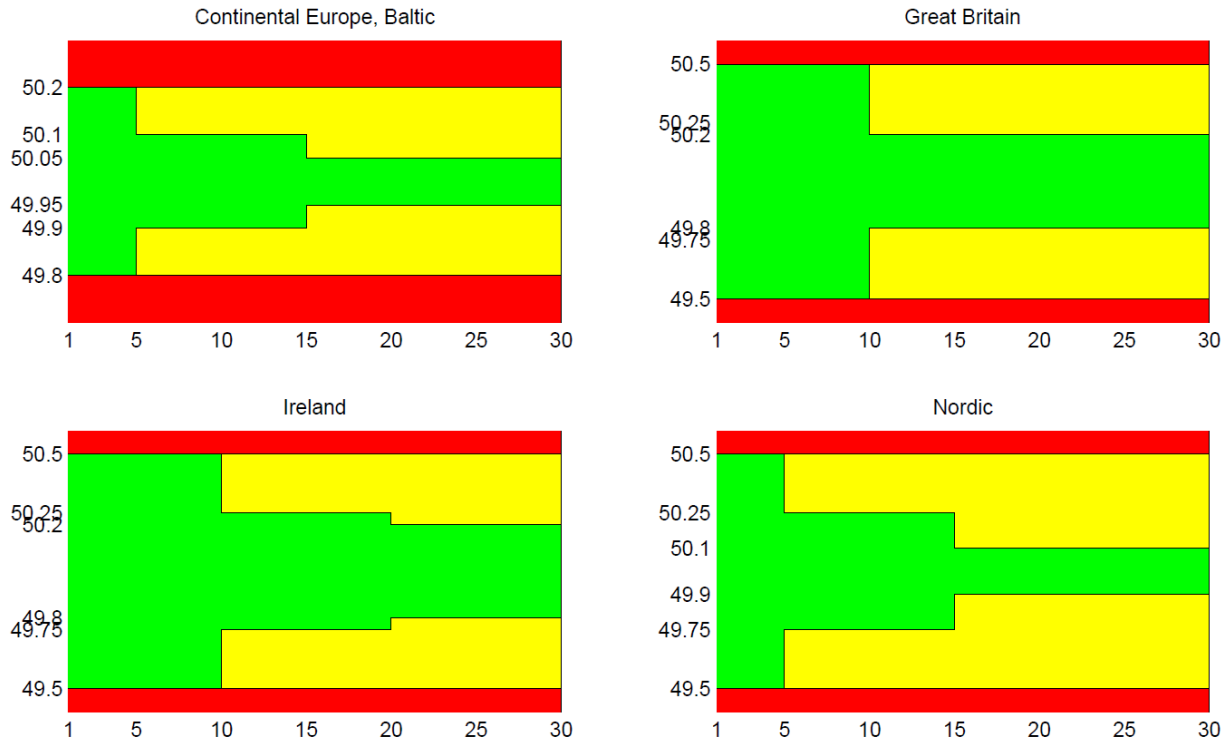
- Remedial Actions are not sufficient to master a risk to deviate outside your Operational Limits: the TSO to anticipate and take measures to avoid the deterioration of the situation (NC ER)

complete loss of all tools and facilities for more than 30 minutes

- the TSO to activate its business continuity Plan (NC OS)

Measures of the SDP: Frequency Deviation Management

NC LFCR defines the frequency criteria to enter into Emergency State:



Annex: LFDD & Embedded Generation