Nordic System Operation Agreement (SOA) – Annex Operational Security (OS)

Version	Approval date	Entry into force	Revision
1	11/12/2019	11/12/2019	SOA Annex Operational Security (OS) – Initial version
2	22/06/2022	22/06/2022	Minor text updates and inclusion of appendices for description of operation of individual interconnectors between TSOs

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1 Introduction

1.1 Interaction with other agreements

This Annex is part of the System Operation Agreement. This Annex makes references to the requirements set up in:

- Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter referred to as "SOGL"); — SOGL
- Commission Regulation (EU) (EC) 2015/1222 establishing a guideline on capacity allocation and congestion management (hereinafter referred to as "CACM"); — CACM
- Cooperation Agreement regarding Regional Security Coordination in the Nordic region, Nordic RSC (hereinafter referred to as "Nordic RSC Agreement");
- All TSOs' proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with article 40(6) of Commission Regulation (EU) 51 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter referred to as "KORRR"); — SOGL 40(6)
- All TSOs' proposal for a methodology for coordinating operational security analysis in accordance with Article 75 of Commission Regulation (EU) 51 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereafter referred to as "CSAM"); — SOGL 75
- Nordic TSOs' common methodology for regional operational security coordination in Nordic capacity calculation region in accordance with article 76 and article 77 of the Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter referred to as "Nordic ROSC Methodology" or "NROSC"); — SOGL 76/77
- Multilateral Agreement on Participation in Regional Security Coordination Initiatives" (hereinafter referred to as "MLA")

1.2 Background

The main principles of SOGL, Part II Operational Security (hereinafter referred to as "OS") are to achieve a harmonised and solid technical framework including the implementation of all necessary processes required for operational security, considering present and expected challenges, including rapid growth of renewable energy sources generation and their impact on system operation.

In this Annex the Nordic TSOs agree upon the main principles and requirements for ensuring operational security of the Nordic TSO's transmission systems.

1.3 This Annex

This Annex shall be considered in addition to the principles, requirements and conditions included in the SOGL. | SOGL, part II

In addition to the Annex, the methodologies that have been approved by the NRAs in accordance with articles 6(2) and 6(3) of the SOGL, apply. This Annex includes references to these methodologies. Where NRAs approved an implementation date in future, this Annex describes the existing situation. | SOGL 6(2) SOGL 6(3)

The Nordic TSOs anticipate regular updates in order to keep the agreements and methodologies in this Annex up-to-date. Consequently, this Annex includes mainly the agreements between the Nordic TSOs related to the existing situation. Changes shall be first approved by all Nordic TSOs, before the change will be implemented in the SOA at the latest when the change enters into force. The SOA maintenance group will follow the change agreed.

1.4 Geographic area

The geographical area to which this Annex applies is the Nordic synchronous area.

1.5 Structure of this Annex

This Annex is structured as following:

- Chapter 2: Operational Security Requirements
  - Chapter 2.1: Objective
  - Chapter 2.2: System states
  - Chapter 2.3: Remedial actions
  - Chapter 2.4: Operational security limits
  - Chapter 2.5: Voltage control and reactive power management
  - Chapter 2.6: Short-circuit current management
  - Chapter 2.7: Power flow management
  - Chapter 2.8: Contingency analysis and handling
  - Chapter 2.9: Protection
  - Chapter 2.10: Dynamic stability monitoring and assessment
  - Chapter 2.11: Availability of common means, tools and facilities
  - Chapter 2.12: Security plan for critical infrastructure protection
- Chapter 3: Data Exchange
- Chapter 4: Training

1.6 Definitions

For the purpose of this Annex, the terms used shall have the meaning of the definitions included in article 3 of SOGL, article 2 of CSAM and the other items of legislation referenced therein.

2 Operational Security Requirements

2.1 Objective

The increased system coordination achieved by monitoring the system state contributes to a coherent and coordinated behaviour of the interconnected transmission systems, both in each TSO's control area and between control areas.

2.2 System states

2.2.1 Rules & Methodologies

System state means the operational state of the transmission system in relation to the operational security limits. SOGL defines the following five system states:

- Normal state
- Alert state
- Emergency state
- Blackout state
- Restoration state

Normal state and alert state are both subject to SOGL whereas emergency state, blackout state and restoration state are subject to Network Code Emergency and Restoration (hereinafter referred to as "NC ER").

In the following the different system states are briefly described according to definition of the SOGL:

<u>Normal state</u>

Normal state means a situation in which the system is within operational security limits in the N-situation and after the occurrence of any contingency from the contingency list, taking into account the effect of the available remedial actions. SOGL 3(2)(5)

A transmission system shall be in the normal state when the conditions according to article 18(1) of SOGL are fulfilled. SOGL 18(1)

In case of an operational (N-1) disturbance, the power system must have been restored within 15 minutes to comply again with the operational security limits set forth in article 18(1)(a) and (d) of SOGL and the frequency set forth in article 18(1)(b) of SOGL. As long as TSOs only secures mFRR for disturbances, there is SOGL 18(1)(a) SOGL 18(1)(b) SOGL 18(1)(d)

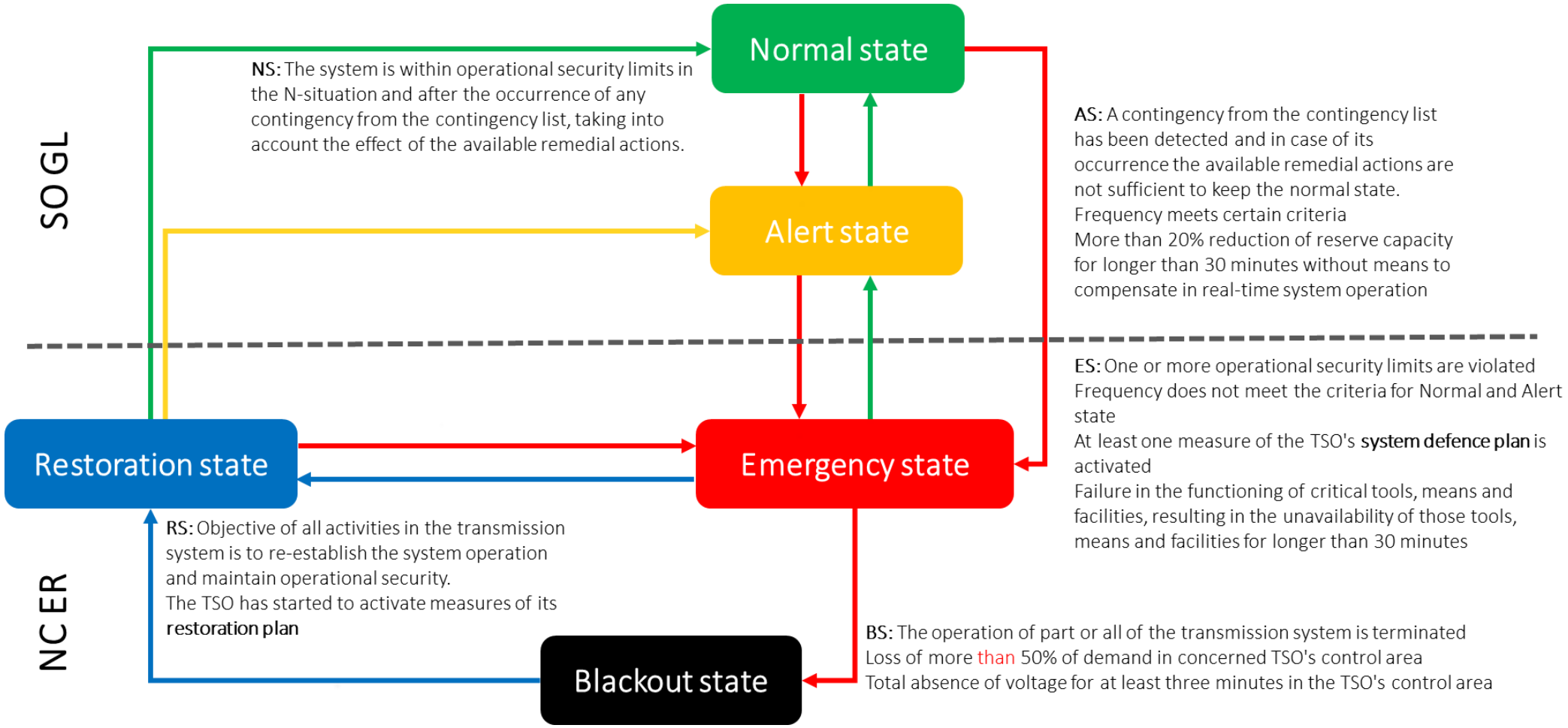
a risk that sufficient mFRR will not be available in relevant areas to handle a disturbance if parts of or all secured mFRR already have been used for normal balancing. This will imply that back-up measures will have to be available to be able to return to normal operation within 15 minutes. This may also be the case as a result of multiple operational disturbances within the same 15-minute period or in case of a new operational disturbance shortly after the first 15-minute period. In case of multiple operational disturbances within the same 15-minute period or a new operational disturbance shortly after the first 15-minute period, the system state may change to Alert state, Emergency state or Blackout state.	
<u>Alert state</u> Alert state means the system state in which the system is within operational security limits, but a contingency from the contingency list has been detected and in case of its occurrence, the available remedial actions are not sufficient to keep the normal state.	SOGL 3(2)(17)
A transmission system shall be in the alert state when the conditions according to article 18(2) of SOGL are fulfilled.	SOGL 18(2)
<u>Emergency state</u> Emergency state means the system state in which one or more operational security limits are violated.	SOGL 3(2)(22)
A transmission system shall be in the emergency state when the conditions according to article 18(3) of SOGL are fulfilled.	SOGL 18(3)
<u>Blackout state</u> Blackout state means the system state in which the operation of a part or all of the transmission system is terminated.	SOGL 3(2)(37)
A transmission system shall be in the blackout state when the conditions according to article 18(4) of SOGL are fulfilled.	SOGL 18(4)
<u>Restoration state</u> Restoration state means the system state in which the objective of all activities in the transmission system is to re-establish the system operation and maintain operational security after the blackout state or the emergency state.	SOGL 3(2)(38)
A transmission system shall be in the restoration state when a TSO, being in the emergency state or blackout state, has started to activate measures of its restoration plan.	SOGL 18(5)

2.2.2 Roles & Responsibilities

Each TSO shall monitor the transmission system parameters (e.g. active and reactive power flow, frequency, voltage) and determine in real-time the system state of its transmission system.	SOGL 19(1)(2)

Each TSO shall perform contingency analysis at least once every 15 minutes.	SOGL 19(3)
All TSO shall inform the other TSOs about the system state of its transmission system via the European Awareness System (hereinafter referred to as "EAS") for exchange of real-time data.	SOGL 19(4)

The following figure provides an illustrative overview of the different system states and their interdependencies:


SO GL
NC ER
Normal state
Alert state
Emergency state
Restoration state
Blackout state
NS: The system is within operational security limits in the N-situation and after the occurrence of any contingency from the contingency list, taking into account the effect of the available remedial actions.
AS: A contingency from the contingency list has been detected and in case of its occurrence the available remedial actions are not sufficient to keep the normal state.
Frequency meets certain criteria
More than 20% reduction of reserve capacity for longer than 30 minutes without means to compensate in real-time system operation
ES: One or more operational security limits are violated
Frequency does not meet the criteria for Normal and Alert state
At least one measure of the TSO's system defence plan is activated
Failure in the functioning of critical tools, means and facilities, resulting in the unavailability of those tools, means and facilities for longer than 30 minutes
RS: Objective of all activities in the transmission system is to re-establish the system operation and maintain operational security.
The TSO has started to activate measures of its restoration plan
BS: The operation of part or all of the transmission system is terminated
Loss of more than 50% of demand in concerned TSO's control area
Total absence of voltage for at least three minutes in the TSO's control area

2.3 Remedial actions

2.3.1 Roles & Responsibilities

Each TSO shall ensure that its transmission system remains in the Normal state and shall be responsible for managing operational security violations. Each TSO shall design, prepare and activate remedial actions considering their availability, the time and resources needed for their activation and any conditions which are relevant for each remedial action. — SOGL 20(1)

For violations of operational security limits, which need to be managed in a coordinated way, each TSO shall design, prepare and activate remedial actions in coordination with other concerned neighbouring TSOs and Nordic RSC. — SOGL 20(1)(b)

The design, preparation and activation of remedial actions shall follow the agreed principles of the regional operational security coordination procedure in accordance with Nordic ROSC Methodology. — NROSC

2.3.2 Rules & Methodologies

The remedial actions used by each TSO in system operation shall be consistent with the remedial actions considered in capacity calculation in accordance with article 25 of CACM and the Nordic methodology for coordinated redispatching and countertrading (herein after referred to as "Nordic CRC Methodology") in accordance with article 35 of CACM. — SOGL 20(2) CACM 25/35

2.4 Operational security limits

2.4.1 Roles & Responsibilities

Each TSO shall agree with its neighbouring TSO on common operational security limits for each interconnector considering at least the following physical characteristics: — SOGL 25(4)

a) voltage limits; — SOGL 25(1)
b) short-circuit current limits;
c) current limits in terms of thermal rating including the transitory admissible overloads;

Each TSO shall exchange the operational security limits for each interconnector with its neighbouring TSO. Each TSO shall update the operational security limits for each interconnector in coordination with its neighbouring TSO.

2.5 Voltage control and reactive power management

2.5.1 Objective

Voltage conditions in a transmission system are directly related to the reactive power situation at the system nodes. TSOs shall make sure that an excessive consumption of reactive power is compensated for. The goal is that the most efficient and effective producers shall be used to feed, respectively absorb,

enough reactive power in addition to the reactive power from other sources installed in the transmission system or at demand facilities. TSOs shall further ensure a continuous and locally sufficient reactive power balance to be able in turn to maintain adequate voltage levels.

2.5.2 Roles & Responsibilities

Each TSOs shall ensure that during Normal state the voltage remains in steady-state at the (inter)-connection points of the transmission system within the ranges specified by the operational security limits. SOGL 27(1)

Each TSO shall specify in coordination with its neighbouring TSO the adequate voltage control range for each interconnector in order to ensure that the common operational security limits are respected. SOGL 29(4)

2.5.3 Operational Procedures

If voltage at a (inter)-connection point of the transmission system is outside the ranges defined in the operational security limits all affected TSOs shall apply voltage control and reactive power management remedial actions in order to restore voltage at the (inter)-connection point. SOGL 29(1)

2.6 Short-circuit current management

2.6.1 Objective

Short-circuit current management is required to prevent all types of generating facilities, transmission system elements and related equipment from damage and to provide safety for persons, through the fast and selective disconnection of short-circuit faults. The objective of short-circuit current management is therefore to keep the impact of short-circuit currents at a level that provides secure functioning of the transmission system with system protection and its set-points.

2.6.2 Roles & Responsibilities

Each TSO shall determine: SOGL 30

- the maximum short-circuit current at which the rated capability of circuit breakers and other equipment is exceeded; and
- the minimum short-circuit current for the correct operation of protection equipment.

Each TSO shall perform short-circuit current calculations in order to evaluate the impact of neighbouring TSOs. SOGL 31(1)

Each TSO shall specify in coordination with its neighbouring TSO the maximum and minimum short-circuit current for each interconnector in order to ensure that the operational security limits are respected.

2.7 Power flow management

2.7.1 Objective

Each transmission system element has operational security limits in terms of power flow. These limits are relevant for protecting the equipment and the humans in the vicinity of a given transmission system element, considering the technical constraints of the used materials in order to avoid damage or premature ageing. The scope of power flow management provisions is therefore to establish the operational means to maintain power flows within operational security limits on every element of the transmission system.

2.7.2 Roles & Responsibilities

Each TSO shall maintain power flows within the operational security limits when the system is in Normal state and after the occurrence of a contingency from the contingency list. | SOGL 32(1)

In the (N-1)-situation, in the Normal state each TSO shall maintain power flows within the transitory admissible overloads having prepared remedial actions to be applied and executed within the timeframe allowed for transitory admissible overloads. | SOGL 32(2)

2.8 Contingency analysis and handling

2.8.1 Objective

The (N-1)-criterion has been a long established and proven operational practice which is common amongst TSOs. With the aim of maintaining the operational security of the transmission system, contingency analysis means simulating the tripping of transmission system elements. This analysis is conducted based on the observability areas of the TSOs, respecting operational security limits whilst preparing and activating remedial actions where required.

2.8.2 Roles & Responsibilities

Each TSO shall establish a contingency list, including the internal (i.e. inside TSO's control area) and external (i.e. outside of a TSO's control area but inside TSO's observability area) contingencies of its observability area by assessing, whether any of those contingencies endangers the operational security of the TSO's control area. The contingency list shall include both ordinary contingencies and exceptional contingencies identified by application of the methodology for coordinating operational security analysis. | SOGL 33(1)

In order to account for exceptional contingencies with high impact on its own or neighbouring transmission systems, each TSO shall include such exceptional contingencies in its contingency list. | SOGL 33(2)(c)

Each TSO shall ensure that potential violations of the operational security limits in its control area, which are identified by the contingency analysis, do not | SOGL 34(2)

endanger the operational security of its transmission system or of interconnected transmission systems.

2.8.3 Rules & Methodologies

The document "All TSOs' proposal for a methodology for coordinating operational security analysis in accordance with article 75 of Commission Regulation (EU) 51 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation" (CSAM) was approved by ACER according to Article 6(2)(c) of SOGL on 19 June 2019. SOGL 75

2.8.4 Operational Procedures

Each TSO shall coordinate its contingency analysis in terms of coherent contingency lists at least with the neighbouring TSOs from its observability area in accordance with the methodology for coordinating operational security analysis. SOGL 33(4)

Each TSO shall inform the TSOs in its observability area about the external contingencies included in its contingency list. SOGL 33(5)

Each TSO shall inform, sufficiently in advance, the TSOs concerned in its observability area of any intended topological changes on its transmission system elements which are included as external contingencies in the contingency lists of the TSOs concerned. SOGL 33(6)

2.9 Protection

2.9.1 Objective

Equipment protection is used to protect transmission system assets from faults. System protection schemes are used to detect abnormal system conditions and take predetermined, corrective actions to preserve system integrity and provide acceptable system performance, in a coordinated way.

2.9.2 Roles & Responsibilities

Before protection and backup protection equipment enter into service or following any modifications, each TSO shall agree with the neighbouring TSOs on the definition of protection set points for the interconnectors and shall coordinate with those TSOs before changing the settings. SOGL 36(5)

Where a TSO uses special protection scheme(s), it shall coordinate special protection scheme functions, activation principles and setpoints with neighbouring TSOs. SOGL 37(e)

2.9.3 Operational Procedures

After a protection operation, which had an impact outside a TSO's control area including interconnectors, this TSO shall assess whether the protection equipment in its control area worked as planned and shall undertake corrective actions, if necessary. | SOGL 36(3)

2.10 Dynamic stability monitoring and assessment

2.10.1 Objective

The goal of the dynamic stability monitoring and assessment is to ensure awareness regarding the current and future forecast system state of the transmission system with respect to stability, in the N-Situation and in the possible (N-1)-situation. In addition, dynamic stability assessment supports the decisions towards the most effective and efficient remedial actions, for preventing disturbances or correcting their consequences if disturbances occur.

2.10.2 Roles & Responsibilities

Each TSO shall monitor the dynamic stability of the transmission system by studies conducted offline. Each TSO shall exchange the relevant data for monitoring the dynamic stability of the transmission system with the other TSOs. | SOGL 38(1)

Each TSO shall perform a dynamic stability assessment at least once a year to identify the stability limits and possible stability problems in its transmission system. All TSOs shall coordinate the dynamic stability assessments, which shall cover all or parts of the synchronous area. | SOGL 38(2)

2.10.3 Rules & Methodologies

The TSOs agree that the document "Requirement for minimum inertia in the Nordic power system" that has been approved by RGN, is accepted by all TSOs. The document shall be revised every two years. | SOGL 39(3)(a)

2.11 Availability of common means, tools and facilities

2.11.1 Roles & Responsibilities

All TSOs shall adopt a business continuity plan regarding loss of common critical tools, means and facilities and shall define provisions for their maintenance, replacement and development. | SOGL 24(3)

2.11.2 Operational Procedures

All TSO shall review at least annually the business continuity plan and update it if necessary and in case of any significant change. | SOGL 24(3)

2.12 Security plan for critical infrastructure protection

2.12.1 Roles & Responsibilities

TSOs shall specify a security plan containing a risk assessment of common assets owned or operated by the TSOs, covering major physical or cyber threat scenarios. The security plan shall consider potential impacts to the interconnected transmission systems and shall include organizational and physical measures aiming at mitigating the identified risks. SOGL 26(1)(2)

2.12.2 Operational Procedures

All TSO shall review the security plan at least annually and update it if necessary or in case of any significant change.

3 Data exchange

3.1 Objective

The central purpose of the data exchange is to define the information required by the TSO to perform its tasks described in Part II Operational Security. Therefore, it has to consider all the possible data and information required to maintain the operational security in the transmission system. This includes real-time data, schedules, structural data and other data needed for analysis. Part of this data may also coincide with data required in other guidelines like the Guideline on Capacity Allocation and Capacity Management (CACM). This is because operational security is strongly inherent to the transmission system. For example, the capacity calculation is a specific kind of operational security analysis, considering different values of interchange between Responsibility Areas.

3.2 Rules & Methodologies

The document "All TSOs' proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with article 40(6) of Commission Regulation (EU) 51 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation" was approved by NRAs according to article 6(2)(a) of SOGL on 18 December 2018. SOGL 40(6)

4 Training

4.1 Objective

Operational training is required in order to guarantee that system operators and other operational staff are skilled, well-trained and that the system operator employees in real-time operation are certified to operate the transmission system in a secure way during all operational situations.

4.2 Roles & Responsibilities

Each TSO shall organise regular training sessions with its neighbouring TSOs to improve the knowledge of the characteristics of neighbouring transmission systems as well as the communication and coordination between employees of neighbouring TSOs in charge of real-time operation. The inter-TSO training shall include detailed knowledge of coordinated actions required under each System state.	SOGL 63(1)
Each TSO shall determine, in cooperation with at least the neighbouring TSO, the need and frequency for joint training sessions, including the minimum content and scope of those sessions, considering the level of mutual influence and operational cooperation needed. This inter-TSO training may include, but should not be limited to, joint training workshops and joint training simulator sessions.	SOGL 63(2)

4.3 Rules & Methodologies

Common contact language (orally and in writing) for communication between the system operator employees of the TSOs in charge of real time operation shall be English. Nordic languages may be used in oral communication when all system operator employees of the TSOs involved agree.	SOGL 62(1)

4.4 Operational Procedures

Each TSO shall participate with other TSOs, at least once a year, in training sessions on the management of inter-TSO issues in real-time operation. The frequency shall be defined considering the level of mutual influence of transmission systems and the type of interconnection - DC/AC links.	SOGL 63(3)
Each TSO shall exchange experiences from real-time operation, including visits and the exchange of experiences between system operator employees in charge of real-time operation, with their neighbouring TSOs, with any TSO with which there is or has been inter-TSO operational interaction and with the relevant regional security coordinators.	SOGL 63(4)

5 Appendix 1-8 Interconnectors between TSOs

Appendix no	Title	Involved countries
1	Joint operation between the Norwegian and Western Danish subsystems on the DC links Skagerrak poles 1, 2, 3 and 4	NO and DK1
2	Joint operation between the Finnish and Swedish subsystems on the AC links and Fenno-Skan	FI and SE
3	Joint operation between the Norwegian and Finnish subsystems	FI and NO
4	Joint operation between the Norwegian and Western Danish subsystems on the DC links Skagerrak poles 1, 2, 3 and 4	NO and DK1
5	Joint operation between the Western Danish and Swedish subsystems on the Konti-Skan 1 and 2 DC links	DK1 and SE
6	Joint operation between the Eastern Danish and Swedish subsystems on the AC links across Öresund and to Bornholm	DK2 and SE
7	Joint triangular operation between the Norwegian, Swedish and Western Danish subsystems	NO, SE and DK1
8	Joint operation between the Western and Eastern Danish subsystems on DC Link Great Belt	DK1 and DK2