Contribution of DSO to voltage regulation

Based on IEC 62559-2 edition 1
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1. Description of the use case

1.1. Name of use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
	Distribution Management, Users, Distribution System, Real-Time Operation, Transmission System, Operational planning, Long-term planning, Energy Markets	Contribution of DSO to voltage regulation

1.2. Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2018-06-27	Hugo Morais Belen Goncer Jérôme Cantenot		Approved Version

1.3. Scope and objectives of use case

Scope and objectives of use case	
Scope	Coordination mechanism for scheduling and deploying optimal reactive power exchanges in primary substations for improved voltage control in the TSO and DSO networks.
Objective(s)	Improve the quality of electricity supply Control the reactive power flow at the TSO/DSO interface areas Improve the system security
Related business case(s)	

1.4. Narrative of Use Case

Narrative of use case
Short description
This use case defines the information exchanges between TSO and DSO to optimize reactive power management actions for voltage control purpose. This includes taking into consideration existing resources at the DSO level to support TSO operations, thus supporting the whole network. Coordination between DSO and TSO should take place to avoid impacting the DSO voltage level when the TSO performs reactive power management actions. The TSO and DSO should coordinate the reactive power at each primary substation (i.e. at the TSO-DSO interface) at different timeframe's (several hours or days ahead) in operational planning. At real time, the DSO should try to meet the set point using its flexibility assets (e.g. capacitors banks, inductances, storage...) available for the DSO usage and the reactive power that can be injected/absorbed by the SGU connected in MV network. When the network operation system of DSO receives (i.e. from the interface exchange platform) a request for a setpoint of reactive power (Q, tan_phi, or P/Q diagram), it activates levers with respect to a merit order list. This SUC describes 2 levers: using capacitors bank in the DSO substation and/or sending control signals to the SGU.
Complete description

This Use Case handles the coordination mechanism between TSO and DSO regarding the voltage control and reactive power management within the DSO and TSO networks based on:
· The reactive power flexibility assessment in the DSO and TSO networks;
· The coordination between the DSO and TSO regarding the constraints management for the reactive power and voltage control;
· Optimal control of voltage and reactive power sources in power systems with presence of DER;
· The exact required information and operational requirement that are exchanged between the stockholders in timely manner in order to manage optimally the reactive power and voltage control at different parts of the grid.

The energy resources in the DSO can contribute to optimising the reactive power in the TSO network, which requires to represent the different SGUs in the DSO network within the operational planning strategy.

In the present SUC, the voltage control assets at the DSO network could be controlled by the DSO upon inquiry by the TSOs (real time and operational planning). This service can be voluntary or mandatory depending of the rules in each country. For mandatory participation of DSO, a remuneration scheme should be considered.

The output reactive power from the Significant Grid Users (SGU) could be used to contribute in supporting the TSOs' voltage as in the following process:
· The DSOs can contribute in supporting the voltage in the TSOs' network by managing the flow of the reactive power in the distribution network.
· The TSO performs the reactive power flow calculations and issue the voltage setpoint at the interface point.
· The DSOs estimate the reactive power capabilities of SGU, and perform the power flow calculations to reach the agreed and issued setpoints of reactive power flow at TSO-DSO interface.
· Both of the TSO and DSO agree on a certain level of reactive power flow at the interface point in which doesn't violates the distribution voltage and loading limits.

Scenario description:
1a. Agreement in the DSO participation in voltage control: If the participation of DSO in the voltage regulation was mandatory, the TSO and DSO should agree in the amount of contribution for each period of time and for each primary substation. This agreement should be inquired by the TSO and the DSO should perform an analysis in operational planning to inform the TSO concerning the maximum participation (reactive power maximum and minimum limits). After the agreement, the participation of the DSO in the service is mandatory.
1b. If the service was voluntary, the TSO can send the service request in operational planning or in real-time. The DSO should validate if it is possible to participate in the service and inform the TSO.

2. TSO notifies the DSO concerning a reactive power setpoint in real-time: The TSO sends to the DSO the required reactive power value and its duration at each primary substation. The reactive power information can be done in three formats: value of Q; value of tg phi; P/Q operation region. In the present SUC is only considered a reactive power setpoint Q.

3. Activation of DSO flexibilities to meet the set point not violating quality of supply standards in distribution network.

When the moment of activation arrives, the DSO should try to achieve the setpoint requested by the TSO using the existing reactive power flexibility at the distribution network:
· The reactive power that can absorb or supply the SGU connected in MV networks;
· The reactive power that can injected/absorbed by the capacitors banks and by the reactors. The DSO can also adjust the OLTC of the transformers to avoid constraints in the distribution network;
· Even if the DSO can't achieve the setpoint, they will try their best to be as close as possible from the target.

1.5. Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
1	Deviation between the reactive power flow and the value required		Improve the quality of electricity supply Control the reactive power flow at the TSO/DSO interface areas Improve the system security
2	Reduction of voltage deviation		Improve the quality of electricity supply Improve the system security

1.6. Use case conditions

Use case conditions	
Assumptions	
1	Legal Rules: Legal issues should be taken into considerations which allow and incentive the DSOs to interact for supporting the voltage in the TSOs, and vice versa.
Prerequisites	
1	Contract power information: If the TSO sends a P/Q diagram to the DSO, the TSO should know the contracted power with the DSO
2	SGU Remote Terminal Unit: SGUs must be equipped with remote terminal units to send their measurements to the DSO and to receive the Q set points.
3	Capacitor banks operation point: If the DSO disposes with capacitors banks, he should know the state of the capacitors banks
4	SGU characteristic P/Q: DSO should know characteristic P/Q of SGU

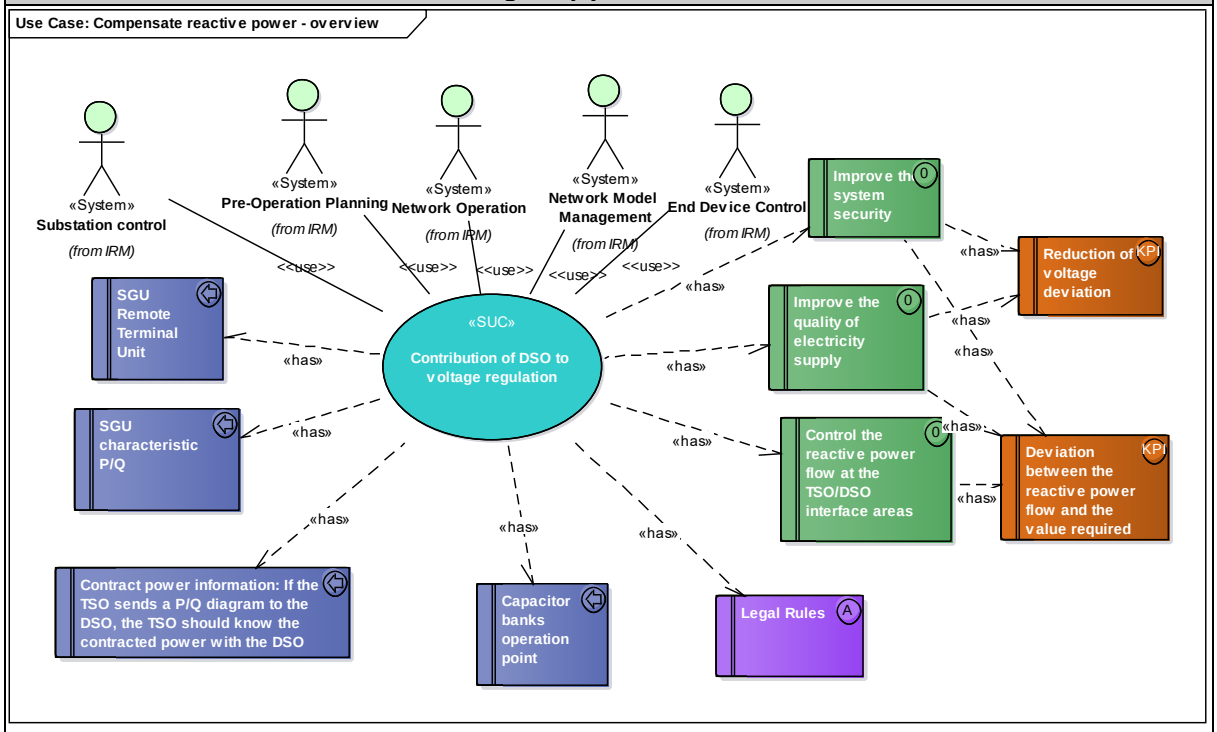
1.7. Further information to the use case for classification/mapping

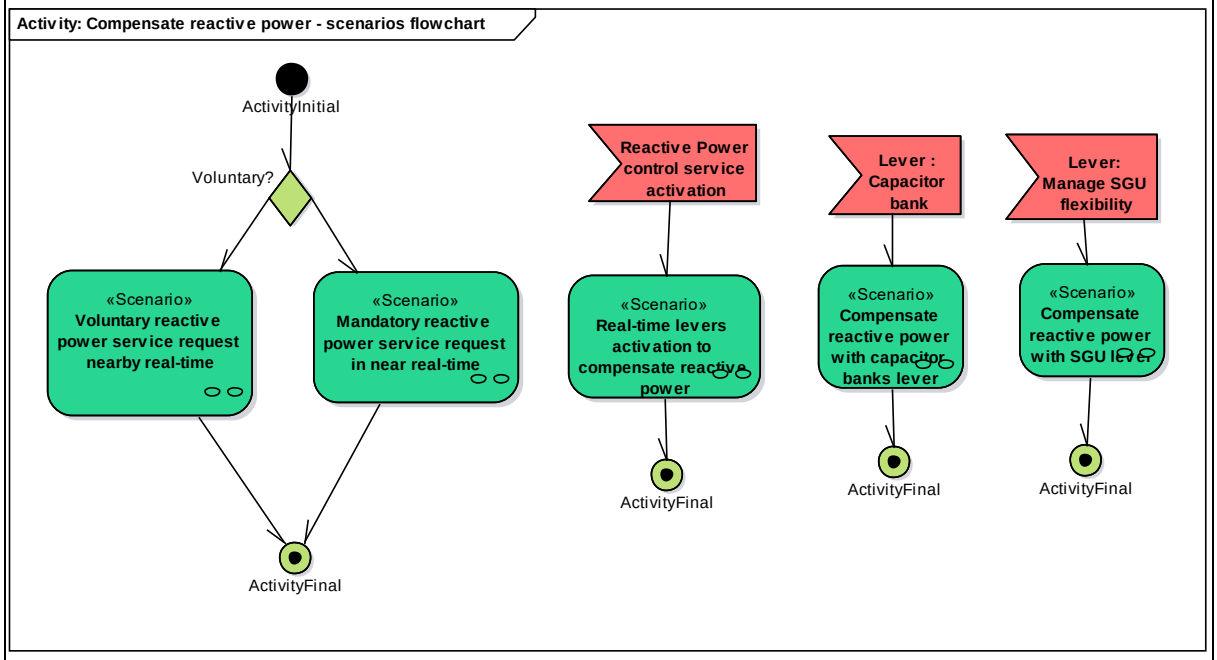
Classification information
Relation to other use cases
<<BUC>> TSO and DSO coordination of reactive power management to voltage control proposes <<BUC>> Coordination of operational planning activities between TSO and DSO <<SUC>> Information exchange using a collaborative platform
Level of depth
Prioritisation
High
Generic, regional or national relation
Generic
Nature of the use case
SUC
Further keywords for classification
Reactive Power Control, Volt-Var Regulation

1.8. General remarks

2. Diagrams of use case

Diagram(s) of use case





3. Technical details

3.1. Actors

Actors			
Grouping (e.g. domains, zones)		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
Substation control	System	The End Device Control (EDC) business function include the ability to control the end device in regards to meet new configuration setting, operation (e.g. enabling demand response) or other system services control by network operation. This role is a specialization of the EDC for a substation.	
Network Model Management	System	The Network Model Management (NMM) manages information for establishing and maintenance of the functional description of the network grid that is provided by current installed asset (as-built model), planned installed asset (future model) or potential installation (what-if/ hypothetical model). The focus is to provide a mathematical model of the network grid that can be used in different analysis of the grid, including but not limited to steady state power flow, state estimation, contingency analysis as part of security assessment and stability analysis. It maintains master representations of the power system for network analysis functions, so that all analysis shares the same source information. Network Model Management (NMM) handles both internal enterprise element and cross entity both in the horizontal and vertical domain, e.g. TSOs-TSOs and TSOs-DSOs coordination.	
Network Operation	System	The Network Operation function includes business activity directly involved with monitoring and operating the power grid as a whole system. • The phrase ‘directly involved’ indicates that the covered activities are limited to a hands-on focus on keeping the power grid running successfully, and more indirect influences on grid operation, such as energy markets, will be covered by other business functions. • The phrase ‘as a whole system’ indicates that local activity, such as operating a generating plant or substation, is excluded, and here the concern is a system perspective, such as is typical in transmission or distribution control centres.	
End Device Control	System	The End Device Control (EDC) business function include the ability to control the end device in regards to meet new configuration setting, operation (e.g. enabling demand response) or other system services control by network operation.	

Pre-Operation Planning	System	The Predictive Operation Planning (POP) business function involved in forecasting future operation situation with an acceptable level of reliability, the inclusion of what-if scenarios and risk assessment. This include the management of adequate that requires system operators and planners to take into account scheduled and reasonably expected unscheduled availability of equipment, while maintaining a constant balance between supply and demand.	

3.2. References

4. Step by step analysis of use case

4.1. Overview of scenarios

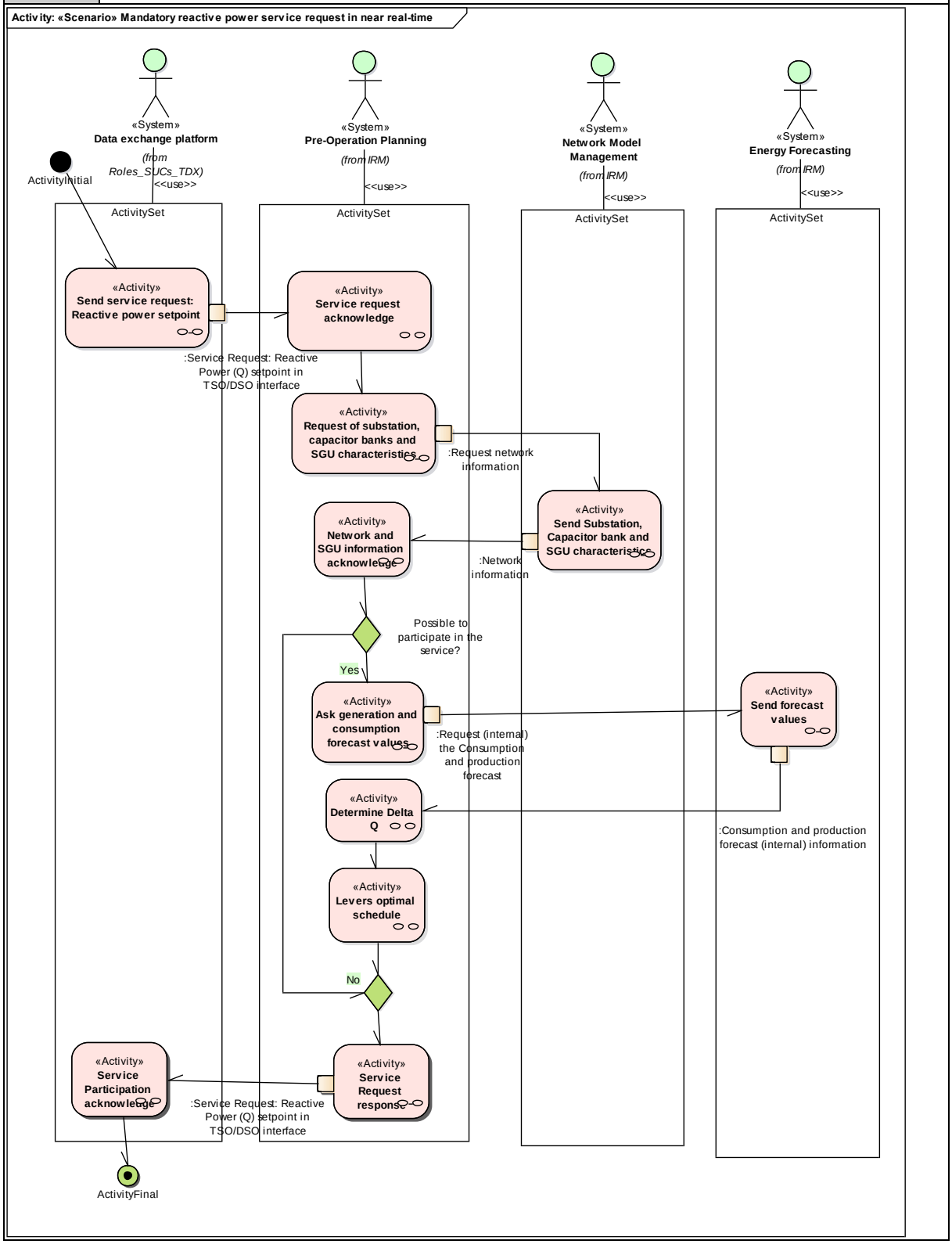
Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
1	Mandatory reactive power service request in near real-time	In the presented scenario is illustrated the process to lead with a mandatory service request concerning the reactive power setpoint in the TSO/DSO interface. This service should be requested in operational planning. As the process is mandatory, the DSO needs to determine if it is technically possible (Capacitors bank operated in manual mode) and if the DSO can guarantee the requested value of reactive power. If not possible, the DSO should inform the value that he can guarantee. Normally, a small variation around the Q requested is possible. In the present edscenario is considered that this variation is a fixed value agreed previously between TSO and DSO.				
2	Voluntary reactive power service request nearby real-time	In the presented scenario is illustrated the process to lead with a voluntary service request concerning the reactive power setpoint in the TSO/DSO interface. This service can be requested in operational planning or in near real-time. As the process is voluntary, the DSO only needs to validate if he can participate in the service or not. Technically, the capacitors banks in the concerned substations should allow the operation in "Manual" mode. This means that the operator or an algorithm can activate or deactivate the capacitors groups.				
3	Real-time levers activation to compensate reactive power	In the presented scenario is illustrated the process to activate, in real-time, the service request concerning the reactive power setpoint in the TSO/DSO interface.		Reactive Power control service activation		
4	Compensate reactive power with capacitor banks lever	In the presented scenario is illustrated the process to activate the capacitor bank lever for reactive power compensation.		Lever : Capacitor bank		
5	Compensate reactive power with SGU lever	In the presented scenario is illustrated the process to activate the reactive power compensation lever of SGUs.		Lever: Manage SGU flexibility		

4.2. Steps - Scenarios

4.2.1. Mandatory reactive power service request in near real-time

Scenario step by step analysis

Scenario	
Scenario name	Mandatory reactive power service request in near real-time



Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
1.1		Send service request: Reactive power setpoint	The platform should identify the concerned DSO and transmit the request. The setpoint can be a value of reactive power (Q), a tan_phi (Q/P), or a P/Q diagram. In the presented SUC is considered that the setpoint is the reactive power Q in the TSO/DSO interface.			Pre-Operation Planning	Info1-Service Request: Reactive Power (Q) setpoint in TSO/DSO interface	
1.2		Service request acknowledge			Pre-Operation Planning			
1.3		Request of substation, capacitor banks and SGU characteristics	The system should identify the measurement units in the TSO/DSO interface, the capacitor banks (in the substations) and the SGU with impact in the initial request. The technical characteristics of capacitor banks and the characteristics and contracts of producers are also necessary.		Pre-Operation Planning	Network Model Management	Info2-Request network information	
1.4		Send Substation, Capacitor bank and SGU characteristics	Based in the patrimonial information, the Network model management system should send the required information.		Network Model Management	Pre-Operation Planning	Info3-Network information	
1.5		Network and SGU information acknowledge			Pre-Operation Planning			
1.6		Ask generation and consumption forecast values	To determine the participation in the service, the system needs the forecast values of active and reactive power in the TSO/DSO interface, the forecast of the		Pre-Operation Planning		Info4-Request (internal) the Consumption and production forecast	

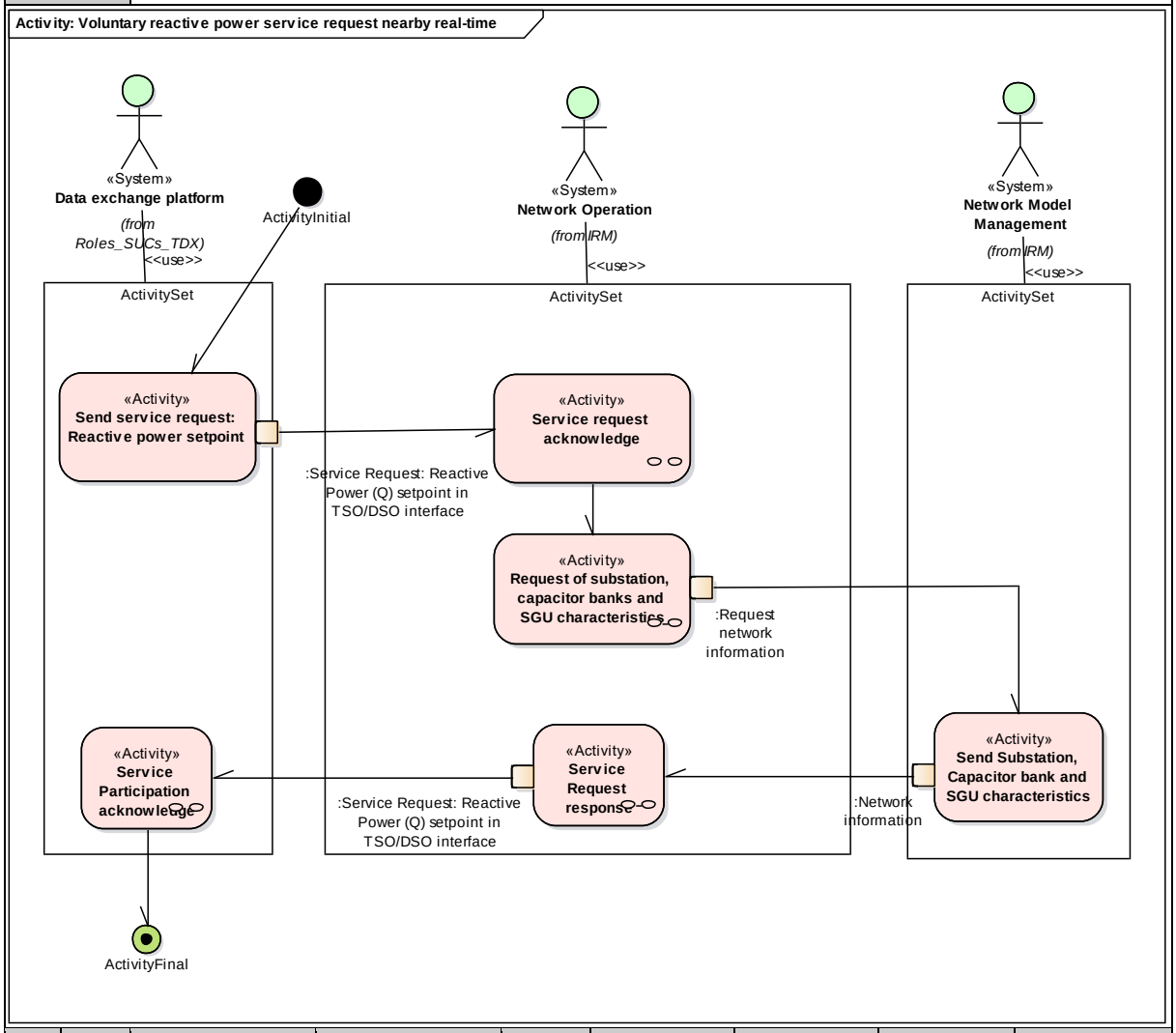
			capacitor bank operation status and the forecast of active and reactive power for each SGU able to participate in the service.					
1.7		Send forecast values	The forecast system should provide both the active and reactive powers. Depending of the systems, the forecast values of reactive power are not available. The system can assume some rules to determine the reactive power in function of the forecasted active power. To lead with uncertainties, several quantiles should be provided for each forecast value. The process to compute the forecast is not the focus of this SUC. It is assumed that the forecast values are available.			Pre-Operation Planning	Info5-Consumption and production forecast (internal) information	
1.8		Determine Delta Q	Determine the expected Delta Q based in the service request and in the expected generation/consumption forecast in the TSO/DSO interface.		Pre-Operation Planning			
1.9		Levers optimal schedule	Based in the delta Q and in the levers characteristics and costs the system should determine the optimal solution. The consumption and generation uncertainties should be considered in the method.		Pre-Operation Planning			

1.10		Service Request response	Based in the technical characteristics and in the contracts, the Network Operation system should send the information concerning the possibility to participate in requested service. The reactive power control is not possible if the capacitors bank don't have the possibility to switch to Manual Mode. In this case the network operator should inform the platform that is not possible to participate in the service. As the service is mandatory, the system should also inform the platform the value of reactive power Q that the DSO can guarantee. The price of the service is assumed that was previously defined between the TSO and the DSO.		Pre-Operation Planning		Info1-Service Request: Reactive Power (Q) setpoint in TSO/DSO interface	
1.11		Service Participation acknowledge						

4.2.2. Voluntary reactive power service request nearby real-time

Scenario step by step analysis

Scenario	
Scenario name	Voluntary reactive power service request nearby real-time



Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
2.1		Send service request: Reactive power setpoint	The platform should identify the concerned DSO and transmit the request. The setpoint can be a value of reactive power (Q), a tan_phi (Q/P), or a P/Q			Network Operation	Info1-Service Request: Reactive Power (Q) setpoint in TSO/DSO interface	

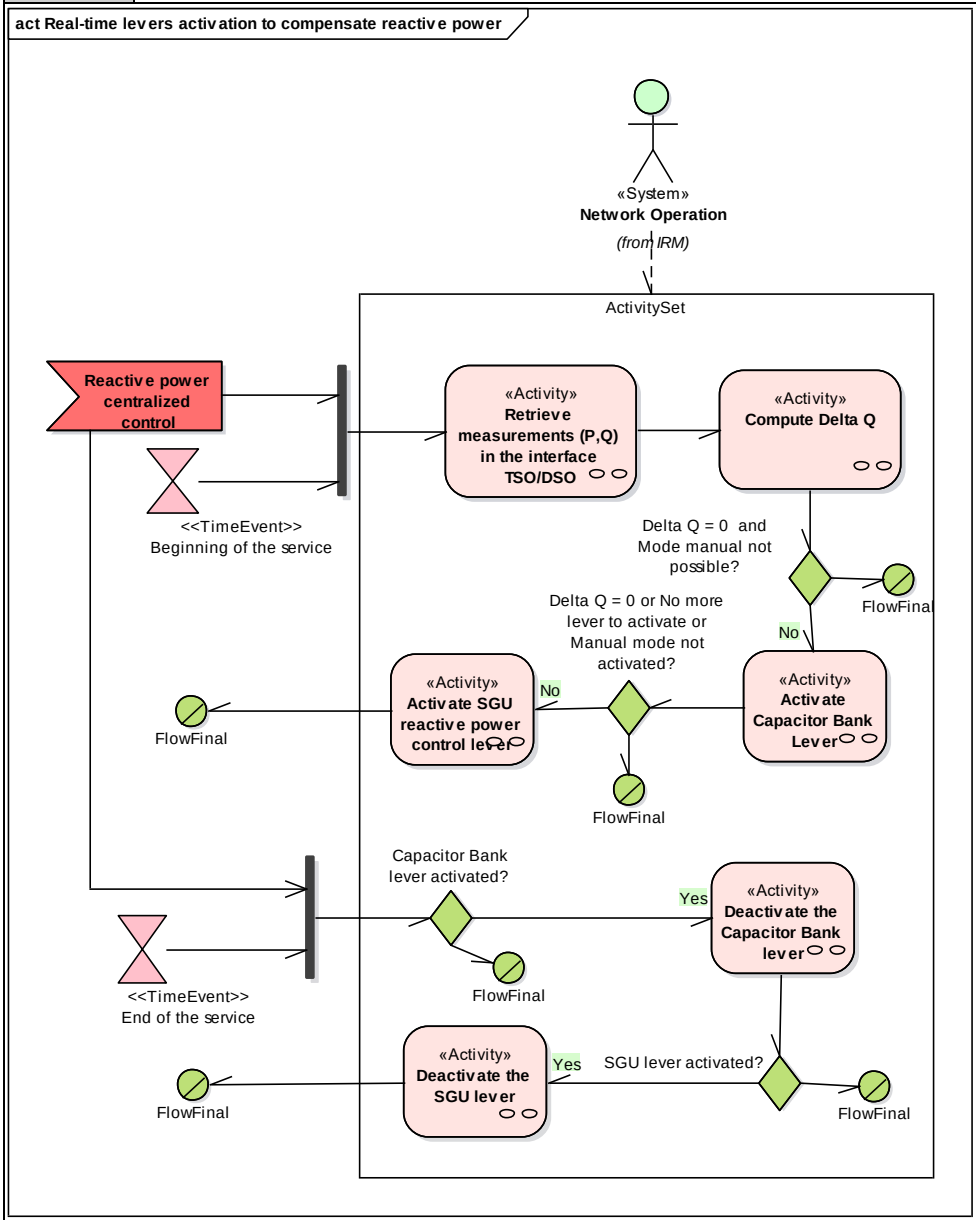
			diagram. In the presented SUC is considered that the setpoint is the reactive power Q in the TSO/DSO interface.					
2.2		Service request acknowledge			Network Operation			
2.3		Request of substation, capacitor banks and SGU characteristics	The system should identify the measurement units in the TSO/DSO interface, the capacitor banks (in the substations) and the SGU with impact in the initial request. The technical characteristics of capacitor banks and the characteristics and contracts of producers are also necessary.		Network Operation	Substation control, Network Model Management	Info2-Request network information	
2.4		Send Substation, Capacitor bank and SGU characteristics	Based in the patrimonial information, the Network model management system should send the required information.		Substation control, Network Model Management	Network Operation	Info3-Network information	
2.5		Service Request response	Based in the technical characteristics and in the contracts, the Network Operation system should send the information concerning the possibility to participate in requested service. The reactive power		Network Operation		Info1-Service Request: Reactive Power (Q) setpoint in TSO/DSO interface	

			control is not possible if the capacitors bank don't have the possibility to switch to Manual Mode. In this case the network operator should inform the platform.					
2.6		Service Participation acknowledge						

4.2.3. Real-time levers activation to compensate reactive power

Scenario step by step analysis

Scenario	
Scenario name	Real-time levers activation to compensate reactive power



Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
3.1		Retrieve measurements (P,Q) in the interface TSO/DSO	The measurements of active and reactive power are sent periodically to the network operation system. In the					

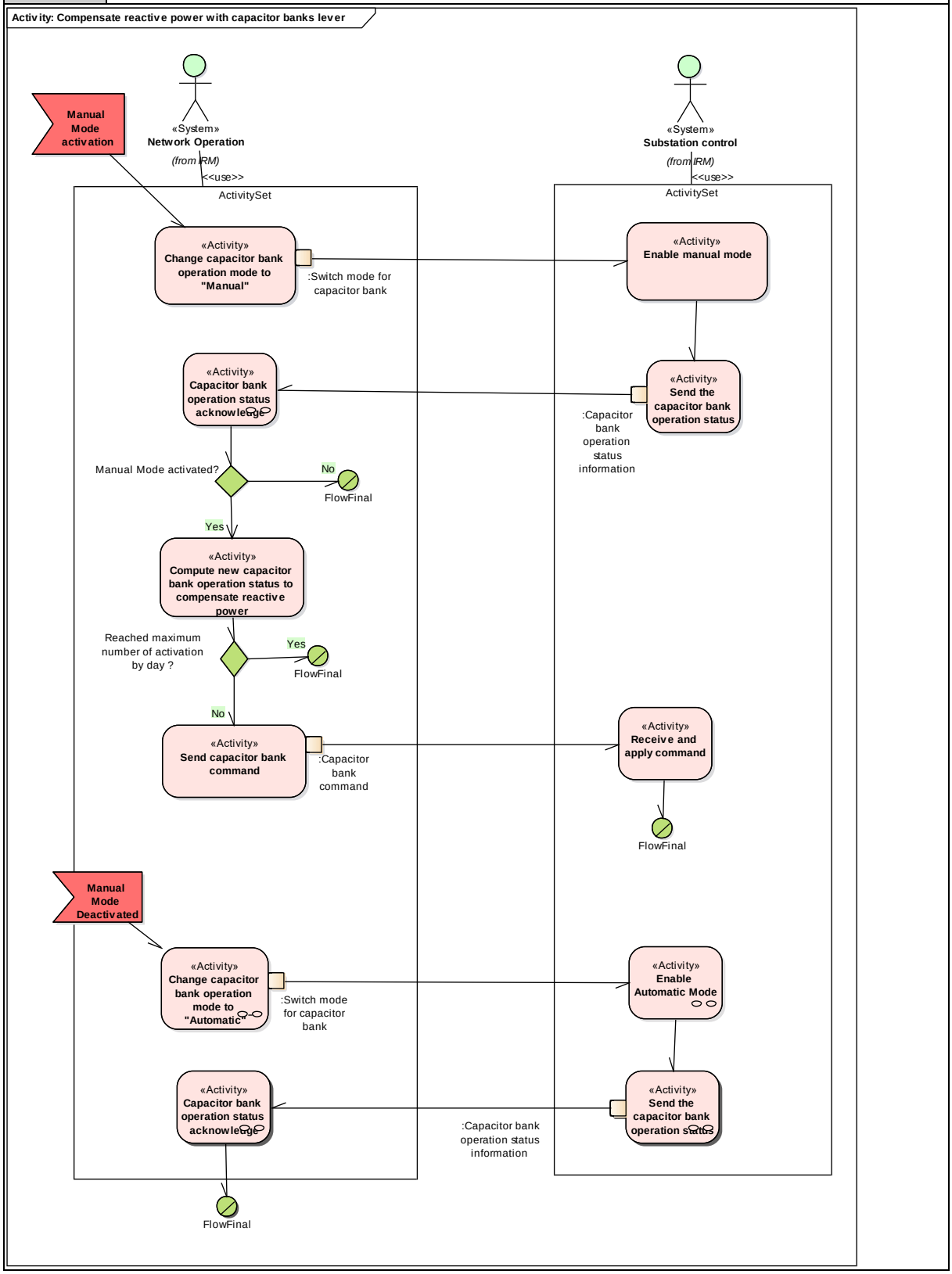
			specific case of France, the interface is on HV side of the transformer HV/MV. The measurements are sent every 10 minutes (average of P and Q by phase). This means that all the process should be executed every 10 minutes.					
3.2		Compute Delta Q	Compute delta Q (amount of reactive power to compensate) based in the service request and in the measured values in the TSO/DSO interface.					
3.3		Activate Capacitor Bank Lever	If a reactive power compensation was required, the system should firstly activate the capacitor bank lever. The activation process is described in the scenario "Compensate reactive power with capacitor banks lever" presented in this SUC. If the service was mandatory, the information concerning the scheduling should be considered as reference in the activation.					
3.4		Activate SGU reactive power control lever	If the compensation made by the capacitor banks was not enough the method should, when possible technically and by					

			contract, manage the reactive power of SGU. When the order to change the capacitors bank to mode "Manual" is not confirmed, the activation of other levers, like the reactive control of SGU, are not allowed. The activation process is described in the scenario "Compensate reactive power with SGU lever" presented in this SUC. If the service was mandatory, the information concerning the scheduling should be considered as reference in the activation.					
3.5		Deactivate the Capacitor Bank lever	Deactivate the Capacitor Bank lever. The deactivation process is described in the scenario "Compensate reactive power with capacitor banks lever" of the presented SUC.					
3.6		Deactivate the SGU lever	Deactivate the SGU lever. The deactivation process is described in the scenario "Compensate reactive power with SGU lever" of the presented SUC.					

4.2.4. Compensate reactive power with capacitor banks lever

Scenario step by step analysis

Scenario	
Scenario name	Compensate reactive power with capacitor banks lever



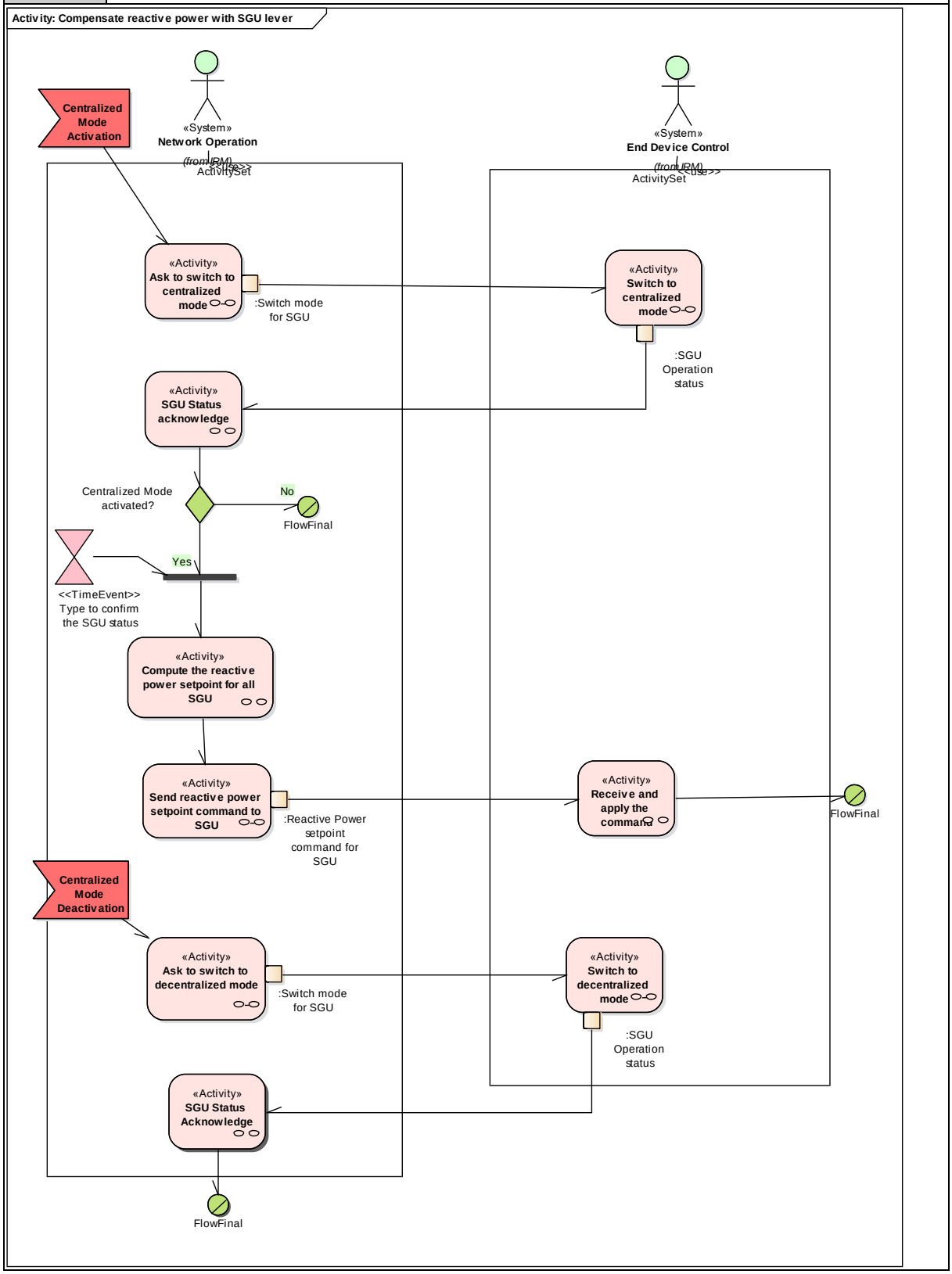
Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
4.1		Change capacitor bank operation mode to "Manual"	To activate the capacitor bank lever, the first step is to commute the automatic operation mode to manual operation mode. The manual operation mode means that the operator or the algorithms can define manually the activated capacitor groups.		Network Operation	Substation control	Info6-Switch mode for capacitor bank	
4.2		Enable manual mode	Enable the Manual mode operation status and deactivate the Automatic mode.		Substation control			
4.3		Send the capacitor bank operation status	The substation control should confirm the capacitor bank operation status (Manual / Automatic), the capacitor bank groups status (Open / Close) and the measured reactive power.		Substation control	Network Operation	Info7-Capacitor bank operation status information	
4.4		Capacitor bank operation status acknowledge			Network Operation			
4.5		Compute new capacitor bank operation status to compensate reactive power	Based in the actual activated groups, in the reactive power measured and in the one required by the TSO, the system should determine the capacitors groups to be activated. If the service		Network Operation			

			was mandatory, the information concerning the scheduling should be considered as reference in the activation. It is strictly forbidden to overcompensat e. For example, to compensate for 2 KVAr, if a lever offers 1 or 3 KVAr, the 3KVAr option is forbidden.					
4.6		Send capacitor bank command	Send the orders to open or close the capacitor bank groups		Network Operation	Substation control	Info8-Capacitor bank command	
4.7		Receive and apply command	Enable the Automatic mode operation status and deactivate the Manual mode.		Substation control			
4.8		Change capacitor bank operation mode to "Automatic"			Network Operation	Substation control	Info6-Switch mode for capacitor bank	
4.9		Enable Automatic Mode			Substation control			
4.10		Send the capacitor bank operation status	The substation control should confirm the capacitor bank operation status (Manual / Automatic), the capacitor bank groups status (Open / Close) and the measured reactive power.		Substation control	Network Operation	Info7-Capacitor bank operation status information	
4.11		Capacitor bank operation status acknowledge			Network Operation			

4.2.5. Compensate reactive power with SGU lever

Scenario step by step analysis

Scenario	
Scenario name	Compensate reactive power with SGU lever



Step No	Event	Name of process/activity	Description of process/activity	Service	Information producer (actor)	Information receiver (actor)	Information exchanged (IDs)	Requirement, R-IDs
5.1		Ask to switch to centralized mode	The SO should ask the SGU to give the control mode of reactive power to the SO. Other option is the SGU not give the control to SO but follows the SO reactive power setpoints. This order can be sent to several SGUs.		Network Operation	Producer Control, End Device Control	Info9-Switch mode for SGU	
5.2		Switch to centralized mode	The SGU will give the control to SO or follow the orders disabling the normal functioning rules. The SGU should inform the SO confirming the operation mode status and the actual measurements.		Producer Control, End Device Control	Network Operation	Info10-SGU Operation status	
5.3		SGU Status acknowledge	The SO should wait for the confirmation of all SGUs during a period of time. At the end of this period, the SO should consider in the service only the SGUs that have sent the status confirmation.		Network Operation			
5.4		Compute the reactive power setpoint for all SGU	Based on the SGU status and in the reactive power control needs, the network operation system should determine the		Network Operation			

			reactive power setpoint for each SGU. If the service was mandatory, the information concerning the scheduling should be considered as reference in the activation.					
5.5		Send reactive power setpoint command to SGU	Send the orders following the determined setpoints		Network Operation	Producer Control, End Device Control	Info11-Reactive Power setpoint command for SGU	
5.6		Receive and apply the command			Producer Control, End Device Control			
5.7		Ask to switch to decentralized mode			Network Operation	Producer Control, End Device Control	Info9-Switch mode for SGU	
5.8		Switch to decentralized mode			Producer Control, End Device Control	Network Operation	Info10-SGU Operation status	
5.9		SGU Status Acknowledge			Network Operation			

5. Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Info1	Service Request: Reactive Power (Q) setpoint in TSO/DSO interface	Request of HV/MV substation use limit (S_Max) - Request ID - User ID (the user that request the service) - Start Time (day,hour,minute) - Stop Time (day,hour,minute) - Substation ID - Q requested / engaged - Service participation (yes / no) If the service was voluntary, the TSO can request a participation sending the value Q requested and the DSO can respond with the value Service participation (yes/no). If the service was mandatory, the DSO should also send the value that will engage in the service (Q engaged). In operation, the value should be inside a defined interval around the Q_engaged.	

Info2	Request network information	Service Type Substation ID	
Info3	Network information	Service Type Substation ID Transformer ID Capacitor bank ID Capacitor bank groups ID Capacitor Manual Mode [Possible / Not Possible] Each Substation can have several transformers, each transformer can have several capacitor bank and each capacitor bank can have several groups. SGU ID Type of contract Characteristic P/Q Remote reactive power control [Possible / Not Possible]	
Info4	Request (internal) the Consumption and production forecast	The consumption and generation forecast (scheduled information) are needed by several SUCs. This BO request intends to be general for all the SUCs Int. Request ID Type of Request Substation Transformer Feeder Start Time (day; hour; minute) End Time (day; hour; minute) The time should be done in intervals of 15 minutes.	
Info5	Consumption and production forecast (internal) information	The consumption and generation forecast (scheduled information) should be provided by several SUCs. Int. Request ID Type of Request Substation Quantile Pconso_Substation Pprod_Substation Qconso_Substation Qprod_Substation Transformer Quantile Pconso_Transformer Pprod_Transformer Qconso_Transformer Qprod_Transformer Feeder Quantile	

		Pconso_Feeder Pprod_Feeder Qconso_Feeder Qprod_Feeder Start Time (day; hour; minute) End Time (day; hour; minute) The time should be done in intervals of 15 minutes. If necessary, several quantiles can be included in the forecast. With this information, more advanced algorithms leading with uncertainties can be adopted.	
Info6	Switch mode for capacitor bank	Capacitor bank ID Select mode (automatic or manual)	
Info7	Capacitor bank operation status information	Capacitor bank ID Status of functioning mode (Automatic / Manual) Status for each capacitor group (Activated / Deactivated)	
Info8	Capacitor bank command	Capacitor bank ID Status (open or close) for each capacitor group	
Info9	Switch mode for SGU	SGU ID Mode (Centralized / Decentralized)	
Info10	SGU Operation status	SGU ID Operation Mode (Centralized / Decentralized) P (kW) Q (kW) U (kV)	
Info11	Reactive Power setpoint command for SGU	SGU ID Q setpoint [MVAr]	

6. Requirements (optional)

7. Common terms and definitions

8. Custom information (optional)