Test Case 24

Author: Dimitrios Thomas (JRC), Petra Raussi (VTT), Vetrivel S Rajkumar (TUD), Jawad Kazmi (AIT)

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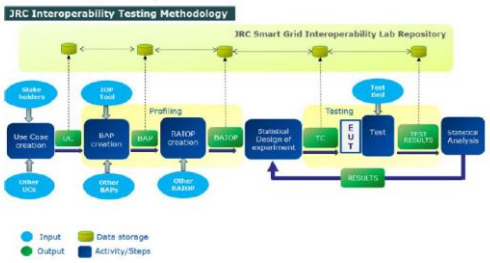
Name of the Test Case	Interoperability testing and validation in the activation chain of flexibility-related events in a local distribution network
Narrative Inc. use case and test objectives.	Smart grid interoperability is a main enabling facet of electricity technology developments. It comprises all parts of the smart grid, from generation to transmission and from distribution to consumption. Testing interoperability requires producing detailed test cases describing how smart grid components are intended to interact with each other. A systematic approach for developing smart grid interoperability tests may facilitate the dissemination of innovative solutions, the stability and resilience of the smart grid. The proposed Test Case is conducted following the JRC Smart Grid Interoperability ~~validation~~ testing methodology. The methodology is used mainly as a common framework for interoperability testing and consist of five stages; Use Case creation (UC), Basic Application Profile (BAP) creation, Basic Application Interoperability profile (BAIOP) creation, Design of Experiments (DoE), Testing and Analysis of Experiments (AE). Each stage allows the developer to select certain features then used in the subsequent stage. During the completion of all stages, the developer can select relevant standards, their options, test beds with all qualified and test equipment as well their attributes or functions used during the testing. The proposed methodology summarizes a set of best practices the developer could follow to complete in a smooth way a smart grid interoperability test.  Fig.1 A schematic overview of the JRC Interoperability testing methodology In this test case, we will investigate through the interoperability validation tests, the interaction and information exchange between the involved actors for a flexibility activation event. This event will be triggered by a local node voltage disturbance and followed by a consequent flexibility request. To this end, we will analyze voltage restoration level, time and con-

	trol.
Function(s) under Investigation (*FuI*) "the referenced specification of a function realized (operationalized) by the object under investigation"	Voltage restore, activation and restoration time for interoperability profiles (BAIOP), validate the interfaces between the actors involved in the flexibility activation chain, impact to the grid. In this use case, we will analyze the performance of the "voltage restoration" function, after a voltage disturbance occurs in the power grid when different system variables (input factors) are considered and changed. The performance of this function is assessed ~~under~~ from an interoperability point of view, where different system variables (input factors) potentially affecting the system performance are considered and their effect on the system response is analysed. A reference grid model will be used (JRA1.1?).
Object under Investigation (*OuI*) "the component(s) (1..n) that are to be qualified by the test"	~~Voltage restore, activation and restoration time for interoperability profiles (BAIOP), validate the interfaces between the actors involved in the flexibility activation chain, impact to the grid.~~The actual components and equipment under testing, e.g. communication infrastructure categorized by its technology (cable, Fiber, local Etherent, xDSL, etc.), controllers (e.g., RTU and Flexibility run in single-boards computers like Raspberry Pi), etc.
Domain under Investigation (*DuI*): "the relevant domains or sub-domains of test parameters and connectivity."	• Communication/ICT/Control • Electrical Power System
Purpose of Investigation *(PoI)* The test purpose in terms of Characterization, Verification, or Validation	PoI#1: Evaluate the interoperability between the involved actors and the different components in the system (flexibility provider, requester, other intermediates). Validate the interfaces along with specific communication technologies. PoI#2: Assess the restoration time and the level of the restored voltage among the different interface profiles
System under Test (*SuT*): Systems, subsystems, components included in the test case or test setup.	• Lower bound communication architecture: from the DSO to the Device through a Remote Terminal Unit (RTU) → two communication links: DSO ↔ RTU and RTU ↔ Device • Distribution system (lines, transformers, etc.): power distribution network (MV/LV) / LV distribution feeder
Functions under Test (*FuT*) Functions relevant to the operation of the system under test, including FuI and relevant interactions btw. OuI and SuT.	**In-focus functions**: Voltage restore (including restoration time), interoperability testing validation of the selected interfaces, real time simulator for the LV distribution benchmark network **Emulated functions**: ICT network emulator- communication network emulation, Controlling functions of the systems (e.g., DSO ↔ RTU and RTU ↔ Device)

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	Actuation functions: Flexibility signal (demand response) to manage voltage disturbance event in a system node **Observer functions**: SCADA monitoring system to detect voltage deviations and instruct the RTU for the activation of the selected flexibility source available in the system
Test criteria *(TCR)* Formulation of criteria for each PoI based on properties of SuT; encompasses properties of test signals and output measures.	• Safe and robust voltage for all nodes • Restore (in real time) of voltage to acceptable levels (0.95 pu < voltage < 1.05 pu) for the node the disturbance takes place • Restoration time for voltage testing the communication interfaces • Effectiveness of flexibility service activation patterns • Communication functionality, configuration and interoperability validation for all the tested interfaces
Target Metrics *(TM)* Measures required to quantify each identified test criteria	• The value of the voltage measured at node i after the flexibility (located at the same node) is activated in the attempt of restoring the voltage within the allowed DSO-specific voltage range • The time the system took in order to restore the voltage at node i
Variability Attributes *(VA)* controllable or uncontrollable factors and the required variability; ref. to PoI.	The admitted voltage deviation, which is the maximum allowed value from which the node voltage, in percentage, can deviate with respect to the reference voltage. This parameter is meant to be a DSO-oriented factor, and the influence of its variability on the system outputs (together with that of the other considered input factors) is studied.
Quality Attributes *(QA)* threshold levels for test result quality as well as pass/fail criteria.	• Power quality standard EN50160 • All node voltages within the specified limit (+ or -10%) • System restoration time

Qualification Strategy

Both PoI#1 and PoI#2 are met with Test Specification 24.01. The overall interoperability evaluation for the test will be in the form of a final “pass/fail” form. For PoI#2, the time that the system needs to activate the voltage support mechanism and successfully restore the voltage to acceptable levels will be evaluated. It should be also mentioned that although both PoI can be met by TS 24.01, multiple interfaces (each one corresponding to a different BAIOP) depending on the selected telecommunication technology will be tested for the two communication links under consideration (DSO ↔ RTU and RTU ↔ Device). These will result in multiple experiment specifications.

Test Specification 24.01

Reference to Test Case	Interoperability testing and validation in the activation chain of flexibility-related events in a local distribution network

Title of Test	***Interoperability validation and evaluation of the activation chain to satisfy a DSO flexibility request as a response to a voltage disturbance event at a specific grid node.***
Test Rationale	The aim is to investigate through the interoperability validation tests, the interaction and information exchange between the involved actors for a flexibility activation event. This event will be triggered by a local node voltage disturbance (functional disruption) and followed by a consequent flexibility request.
Specific Test System (graphical)	
Target measures	In the system under test, the interoperability test will be in the simple "pass/fail" form. The time the system requires to restore the voltage back to the desirable deviation levels is evaluated, i.e., the time that the system takes to respond to the voltage support mechanism after a disturbance in the power grid. If this time = ∞ --> fail, else --> pass
Input and output parameters	• Internal RTU time delay • Reference Voltage • Admitted Voltage Deviation • Time required for Flex to activate • Available flexibility capacity • Maximum activation time for flexibility
Test Design	A simulation period of X minutes long, during which a functional disruption is introduced in the system. This disruption causes a voltage disturbance and results in a flexibility activation request to restore the system back to acceptable conditions. The connection and communication between all the involved actors in the activation chain is evaluated under an interoperability point of view.
Initial system state	Initially the system service is operating "as usual". The grid loads are at their nominal values and the grid is functioning without disruptions. As far as the communication is concerned, we assume that the communication links between the various actors are 100% reliable.
Evolution of system state and test signals	The networked is continuously monitored by the SCADA. A voltage disruption (disturbance) is introduced at a specific node. The system (through the DSO) asks for flexibility so as to restore the voltage in a reasonable time period. The interconnection between the whole activation chain and all necessary actors is studied and assessed under an interoperability point of view.
Other parameters	
Temporal resolution	To be determined
Source of uncertainty	Only a deterministic type of disruption event is introduced.
Suspension criteria / Stopping criteria	30 minutes or permanent loss of communication and/or grid connection