European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS
USER PROJECT FACT SHEET

USER PROJECT	
Acronym	**IISLT**
Title	**Interoperability/Interchangeability via Simulation and Laboratory Testing**
ERIGrid Reference	**04.021-2018**
TA Call No.	**654113**

HOST RESEARCH INFRASTRUCTURE			
Name	**AIT SmartEST**		
Country	**Austria**		
Start date	**03.02.2019 & 05.05.2019**	**Nº of Access days**	**5 & 10**
End date	**08.02.2019 & 17.05.2019**	**Nº of Stay days**	**6 & 13**

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1. USER PROJECT SUMMARY (objectives, set-up, methodology, approach, motivation)

In the proposed project, based on the results obtained from the in-depth Smart Grid Architecture Model (SGAM)-based interoperability/interchangeability study of the European H2020 InterFLEX Project (under grant number 731289), an interoperability testing suite was worked out.

Within this context, IISLT works out technical solutions and recommendations to tackle the existing difficulties to ensure interoperability among different components/actors of Smart Grids (SGs). It is noteworthy that although IISLT is based on the results obtained from interoperability study of InterFLEX Project, however the same procedure can be applied to any set of demonstrations.

As the first step, the following common patterns have been identified as the core requirement for any flexibility usage in an EU power system context: voltage support, frequency support, congestion management, supportive services such as load forecasting, and patterns which are difficult to test for a laboratory validation such as customer engagement.

As the second step, two concepts have been identified for a flexibility activation. The upper bound test is for the evaluation of indirect interfaces typically through an aggregator while the lower bound tests are for the evaluation of the direct interfaces where a Distribution System Operator (DSO) is directly interacting with the flexibility sources. Fig. 1 shows these two concepts for the test case design of the interoperability validation in a laboratory.

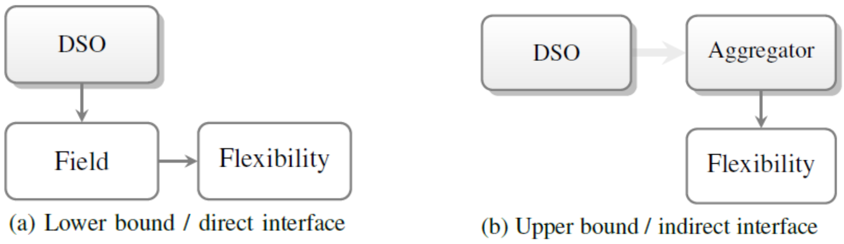

Fig. 1 : Proposed concepts of (a) lower and (b) upper bound test cases

From the above-mentioned categories, voltage support service has been chosen for the objective of this ERIGrid Project. Furthermore, the User Group (UG) focused on the lower bound setup, in which the DSO Supervisory Control and Data Acquisition (SCADA) is directly interfaced with the flexibility device through a Remote Terminal Unit (RTU). The power system voltage level is constantly monitored by the DSO-SCADA; when a voltage drop is detected (according a predefined tolerance threshold), the need of voltage support is translated into a flexibility request command directly sent to the flexibility source via an RTU. The RTU, in turn, activates the flexibility device, which offers its voltage support service in order to make the system stable again. The SCADA keeps on monitoring the system and reports back once the voltage is in the defined limits again. The validation scenario for the voltage support flexibility service is depicted in Fig. 2.

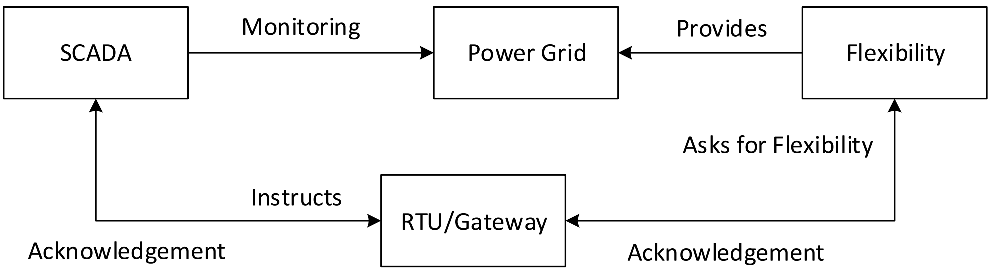

Fig. 1: Selected voltage support scenario for the interoperability testing

For the interoperability testing, AIT Lablink simulation and middle-ware framework has been utilized. For the test bed, three Devices Under Test (DUT) were modelled and were running on three Rasberry Pi single board computers. CIGRE European LV distribution network benchmark model was used as the reference grid and was simulated using the OPALRT real-time simulator. A network emulator (NRL CORE) running on a laptop with UBS-to-RJ45 connectors is used for communication network emulation. The schematic representation of the HIL test bed using Lablink and the Network Emulator could be observed in Fig. 3.

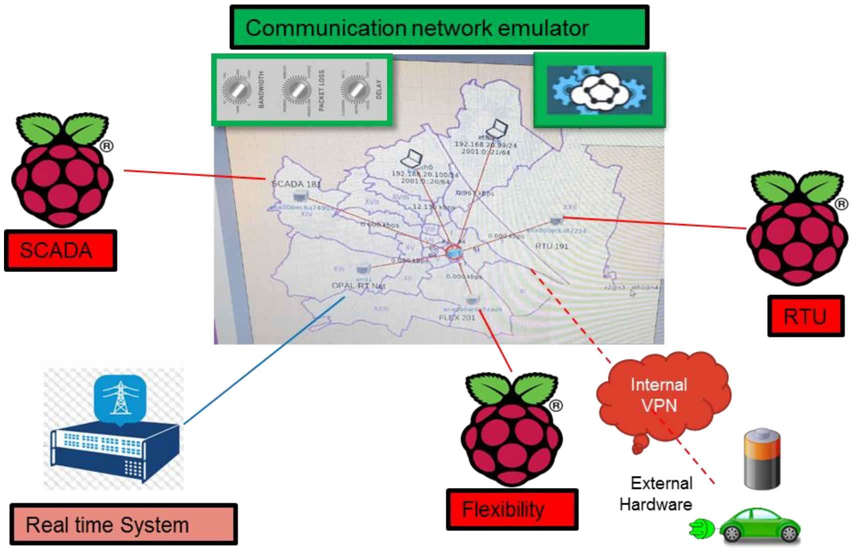

Fig 3: schematic representation of the HIL test bed using Lablink and the Network Emulator

Methodology and approach

Within the interoperability testing framework, the methodology followed by the UG is derived from the *"JRC Technical Report - Smart grid interoperability testing methodology"*, which proposes a systematic approach for helping the developer/experimenter in performing a smooth and comprehensive SG interoperability test, from the functional analysis and profiling phase all the way to the testing specification. The block diagram of the adopted methodology is depicted in Fig. 4, where the six-step work flow is summarized.

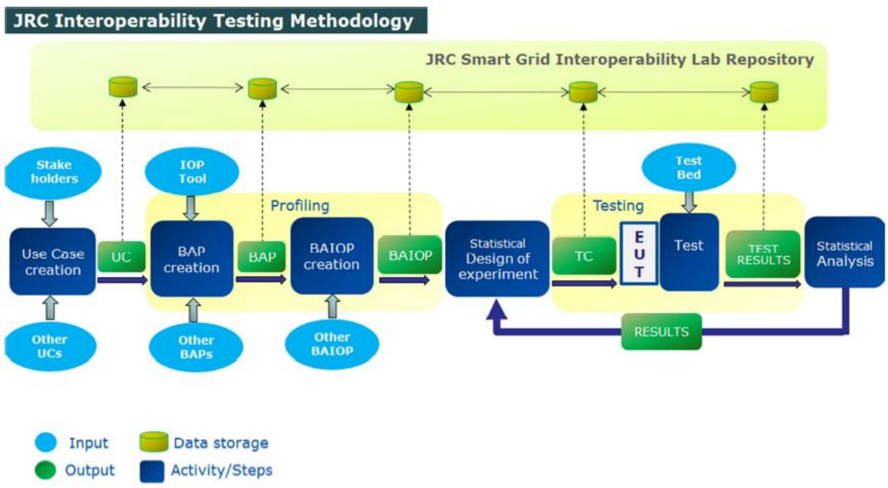

Fig. 4: JRC work flow for the methodological testing

After the preliminary stages of Use Case creation (1) and Basic Application Profile (BAP) – Basic

Application Interoperability Profile (BAIOP) (2-3) detailing, the focus was oriented to step 4, where the statistical Design of Experiments (DoE) was carried out. For the selected validation scenario, the DoE procedure has been accomplished by following the subsequent steps:

1. Definition of the goals of the experiments
2. Identification of the system response (or output) to measure
3. Identification of the process variables (or input factors) related to the power network interface, communication among different actors and the functional behavior of them which potentially may influence the system output
4. Statistical characterization of each input factor
5. Sampling of N values within the input factors' distribution functions

The consequent produced N test cases are then used as experimental points to be tested in the laboratory environment. After collecting the experimental results, a statistical analysis may follow, which can assist in evaluating the system performance, potentially under an interoperability point of view.

2. MAIN ACHIEVEMENTS (results, conclusions, lessons learned)

UG was able to identify categories which form the core requirement for any electrical flexibility usage in a European power system context. From these categories, three services, i.e., voltage, frequency, and congestion support are highlighted for the test in the laboratory. A device or resource offering electrical flexibility should be technically able to provide the flexibility at least for one, ideally for all three of these services. After identifying the common services, the following steps have been conducted to achieve a methodological interoperability testing:

- Exhaustive analysis of the Lablink tool.
- Design of experiment based on the JRC methodology.
- Setting up the selected set of actors and components in SmartEST Lab.
- Adoption/development of the components (SCADA, RTU, Flexibility) and the power grid.
- Implementation of the test suite including the communication platform
- Experimental analysis of the whole test set-up under different exemplary scenarios.

It is noteworthy that the proposed test bed can be extended to include external sources of flexibility, such as Distributed Energy Resources (DERs) at a remote location. As an example, via an internal VPN, a remote charging station of an external provided is accessible for an interoperability testing. This could be observed in Fig. 3.

Last but not least, the adopted DoE procedure included the statistical characterization of the selected input factors (step 4d), which consists in defining their probability distribution functions together with the corresponding intervals of variations. An effective and thorough definition of these elements is of paramount importance for the subsequent analyses which may be carried out after running the experiments, e.g., for Sensitivity and/or Reliability analysis. The preferred source of information for the input factors would the specifications required by the party who is willing to conduct the interoperability testing. In this work, a considerable amount of effort has been dedicated to extract such information from the demo implementations (InterFLex Use cases), which was of difficult access though due to confidentiality issues, time constraints of the Project, etc. Consequently, during the course of the UG work, the information for the input factors' statistical characterization has been derived mainly from device manuals, standards (if available) and previous practical hands-on, This issue should be taken into consideration for a better planning of the test environment.

3. PLANNED DISSEMINATION OF RESULTS (journals, conferences, others)

Based on the results and insights obtained from the laboratory experiments, a scientific paper was written and submitted to the conference call of IECON 2019. The idea was to demonstrate how the project results can integrate potential future interoperable standards for flexibility. A dedicated task was devoted to interchangeability and interoperability of the critical technology components for SG applications.

The UG expects to create a limited-scale but technologically advanced test facility to validate compliance of smart appliances and DERs with evolving smart grid standards. This will permit various elements to be either tested or simulated under controlled and repeatable environment.

As an expansion of the test bed and regarding the validation scenarios, the focus of this UG was oriented on the lower bound (direct) setup DSO ↔ RTU ↔ Flexibility source. However, other scenarios could also be validated, which include upper bound (indirect) set-ups, where DSO SCADA is interfaced with the Flexibility device via an aggregator. In addition to the voltage support, other flexibility services can also be validated, e.g. congestion management or dynamic frequency support.

4. PLANNED DISSEMINATION OF RESULTS THROUGH ERIGRID CHANNELS

Contact erigrid-ta@list.ait.ac.at to organise promotion of your results

Accepted publication:

- J. Kazmi, A. Ahmadifar, M. Ginocchi, F. Kupzog, M. Cupelli, O. Genest, M. Calin, M. Savic and A. Monti. "Identification of common services in European flexibility demonstrators for laboratory-based interoperability validation'', 8th International Conference on Renewable Energy Research and Applications (ICRERA), Brasov, 2019

Potential candidates:

- Open Access Journal by MDPI: Simulation-Based Validation and Design of Smart Grids
- Open Access Journal by MDPI: Smart Grid and Future Electrical Networks
- Open Access Journal by Energies: Monitoring and Control of Active Electrical Distribution Grids and Urban Energy Grids