IMPLEMENTATION OF A STANDARD INTEGRATED PROTECTIVE RELAYS LIFE TIME MANAGEMENT STRUCTURE IN A NEWLY ESTABLISHED POWER UTILITY

Dipl. Ing. Andreas Fräbel
RWE WWE Netzservice GmbH– Germany
andreas.fraebel@rwe.com

Dr. Zeljko Schreiner
IPS GmbH – Germany
zeljko.schreiner@ips-energy.com

ABSTRACT

In the specific case of larger power system corporations, protection relays and settings management are typically influenced by several functions, groups or divisions within that organization. These include Network Planning, Engineering, System Analysis, Asset Management, Operations and Site Services. During organization restructuring processes, newly established companies are often faced with problems caused by the new structure, new data, new assets, new personnel, etc. This paper will describe the practical implementation of and key learning points from the entire process of protection relays life cycle management, including relay data, settings and testing management. The paper will also describe the integration of several IT systems involved in the support of Protective Relays Life Cycle Management. The process of data structuring, digitalization and migration from legacy sources, including paper, excel and relay settings files, into a structured central database will be described. The authors will present optimized solutions around the relay life cycle and settings management process that will allow more efficient data management in respect of data controlling and cyber security. Further, the paper will present an optimized setting workflow management with integration of data and information, starting from a trigger for settings changes over setting calculation, setting implementation and testing until the point of confirmation of settings in service. The interaction of several softwares for setting calculation, setting management and setting testing will be described. Finally, the paper will present a current case study around optimized protection and automation settings management processes, realized as a joint project between RWE WWE, IPS, and Electrocon.

INTRODUCTION

During deregulation, RWE separated transmission and distribution to three independent companies. This paper presents the case of the implementation of an efficient protective relays life cycle management regime within RWE WWE.

INITIAL CHALLENGES

Next figure 1 presents in summary the key challenges faced during establishment of the new power utility organization within the context of implementation of a new protection life cycle management system:

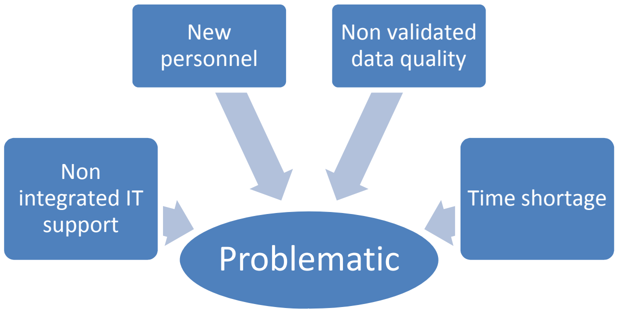

Figure 1: Initial Challenges

During restructuring of the company, new organizational responsibilities and new personnel responsibilities were established. Time shortages were caused by the fact that the entire implementation needed to be done in parallel with daily work. As previously described, the integration of several IT systems used within protection life cycle management was not finished. RWE WWE was forced to implement an entire new process whilst attempting to reuse some of inherited data. Further, all of these existing data sources were non up-to-date, non-validated and not confirmed. Several IT systems were planned to be used including the legacy Asset Inventory Database that RWE had developed, (in following RWE DB) and to implement new commercial IT systems. Integral 7 for load flow and short circuit calculations, CAPE for protection setting calculations and IPS-EPIS™ Enterprise Protection Information System for the management of the Protective Relay data suite.

PREVIOUS ORGANISATION OF RELAYS AND SETTING LIFE CYCLE MANAGEMENT

Setting life cycle management was managed in the new organization structure in the following way. The trigger for setting editing/creation was done by e-mail. Variable setting parameters were calculated by using some internal software, Excel macros or manually. A variable parameters setting sheet was produced by using Excel templates or by MS Visio, Word or some other software capable to design graphs for grading diagrams. As part of this approach, default non-variable settings files were defined and stored separately within a central network location. The settings sheet managed only selected variable parameters. After the setting sheet was created, it was converted into a pdf file and e-mailed to local operations for further use. Thus the management of the setting sheets was completely separated from the relay inventory and, in addition, separate from network topology, hierarchy and from management of the default relay files and actual relay files. Local operations implemented setting within relays on site by using paper (pdf) setting sheets as reference for variable settings and using default template files for non-variable settings. Actual setting files were saved only within local operations and were not managed or stored centrally. No feedback on the setting calculations existed. The majority of the historical settings data was still saved predominantly as scanned paper documents. Overall, it can be seen that that there was no management of the setting history. Further, there was no formal structural relationship between the protection setting and testing management.

AN OPTIMISED SOLUTION

The newly established RWE company had established the target of optimizing the existing lack of protection setting management and to implement more robust, reliable and transparent settings life cycle management by using several commercial IT systems. The following project targets were defined:

- Integrated interdivision IT supported Setting Workflow Management to be implemented.
- Implementation of a controlled and transparent 3 key stage setting workflow process, defined by:
    1. System Change Notification (trigger for setting request)
    2. Processing of Setting Request (Simulation, calculation etc.)
    3. Implementation and testing on site inclusive of feedback to central data management
- Efficient integration of all required IT systems in order to optimize data flow and allow control of the setting by tracking the origin of the setting value for each parameter
- Integration of relevant E-mail communication within same setting management database system
- Integration of the central reference setting database application which will interface all other systems required to work in this process.
- Implementation of the entire setting data set inclusive of the variable setting parameters, non variable (base, default) setting parameters, relay setting files (binary) and all other auxiliary setting information, such as grading diagrams, which were needed to be managed.
- Integration of the protection testing management in the same system in order to ensure that testing of the relay is a confirmation of the relay setting.

INTERFACING

In order to optimize dataflow and ensure data consistency, the following interfaces are required:

- Commercial interface IPS-CAPE Bridge™
- Topology exchange in PSS/E format
- Newly developed interface for location hierarchy with RWE DB
- XRIO and OCC automation interface

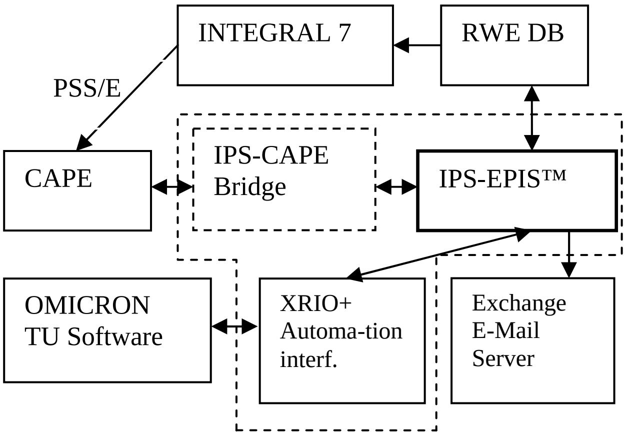

Figure 2: IT Integration - Interfaces

MAIN INTEGRATION STEPS

STEP 1 - Digitalisation of the protection settings

The pre-request for digitalization of the relay settings within a structured database was to have data models within database which replicated manufacturer protection data models. Data models must incorporate all relay setting parameters in order to keep control of all setting parameters. Further data models must be mapped (synchronized) between the IT systems implemented for setting calculation and setting management (CAPE and IPS-RELEX™ part of EPIS™ suite). Implementation of step 1 required classification and analysis of each individual existing setting sheet.

Problems related to Step 1

The following problems have been faced within step 1:

- Existing scanning of the paper setting sheets has been the only data source for the setting parameter import
- Setting sheets has been not structured. Over 600 different classes (lay-outs) existed
- Over 1500 Setting sheets have been manually written (manual manuscripts)
- Only pdfs of the original document were saved (I.e. a pdf from the original excel document was saved in state of original excel)
- Setting data on the setting sheets has been never checked with all settings on site.
- Within setting sheets, different parameter names are often used, such as manufacturers (especially

old electromechanical relays)

STEP 2 - Implementation of Location Hierarchy

In order to implement relay setting management, it was necessary to implement a location hierarchy with location for each individual relay. This location hierarchy had to be mapped (synchronized) between the IT systems implemented, being RWE DB, CAPE and IPS-RELEX™. For this purpose, the interface between RWE DB and IPS-RELEX™ was developed. Further, the standard interface IPS-CAPE Bridge™ was used.

Problems related to Step 2

- Location names were not the same within the setting sheets and asset management database
- CAPE required substation and feeder names without German special characters

STEP 3 - Implementation of the relay objects

In the third step, it was necessary to implement at each location protection relay objects that would be the "owner" of the future setting. This data must be mapped with the relay type database within IPS-RELEX™ and within CAPE.

Problems related to Step 3

- The only source that was used for population of the relay instances was the information within the pdf setting sheet.
- The Relay Type reference on the setting sheet was often not compatible with manufacturer type name.
- Firmware information which may influence the data model was not available at all

STEP 4 - Implementation of the settings

Many problems were solved during the previous steps in classification of the setting sheets, implementation of the data models, implementation of the location hierarchy and population of all relay instances. Further implementation of the protection settings was undertaken. Specifically two different methodologies have been used. Firstly, manual entry of the data from all setting sheets which cannot be digitalized. Secondly, data import by using specially developed software for conversion from pdf into CSV files. After a very difficult implementation, this task was done. An entire setting was created between variable settings within setting sheets and selected base (fixed) settings labeled on the setting sheet. For this, base setting management was implemented in complement.

STEP 5 - Data control and validation

This project step was very important in order to start the use of the entire IT system. Several steps needed to be taken but the precondition for all steps was data control and confirmation. Data control and confirmation was achieved by using information in the office and by using confirmation of the information on the respective site. The following information was required to be controlled:

- Validation of Substation and Feeder names (ID's) between different IT systems
- Validation of relay types and corresponding data models between site information, CAPE™ and IPS-RELEX™ systems.
- Validation of imported (entered) settings with on-site information by using setting comparison with reference database setting as standard functionality of IPS-RELEX™.

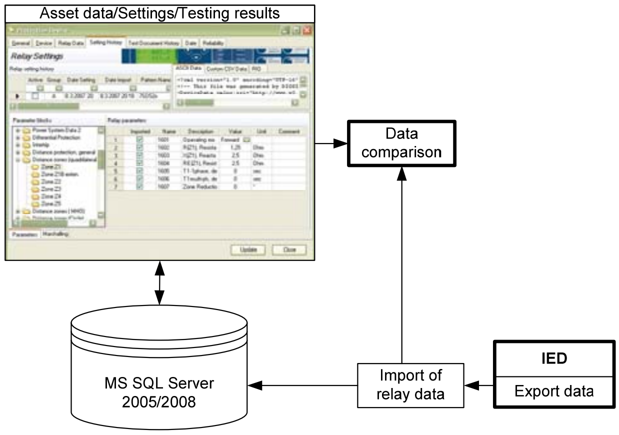

Figure 3: Setting Data Comparison

STEP 6 - Definition of the setting life cycle process

In order to allow efficient protection life cycle management, computer supported Setting Workflow Management was introduced. For integration of the setting workflow management, the standard module SWM™ within IPS-EPIS™ suite was implemented. The following process objects have been introduced:

- **SCN** - System Change notification
  - **GSR**- Global Setting Request
    - **RSR** - Relay Setting Request

SCN - System Change Notification

This is the trigger for setting creation/change. SCN has 4 process parts: Open, in process, resolved and closed.

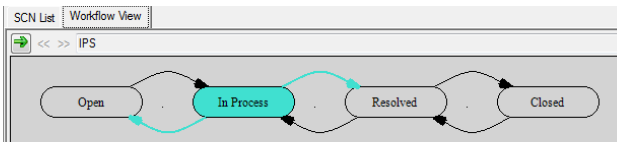

Figure 4: SCN - Process

One SCN can have one or more GSR - Global setting requests.

GSR - Global Setting Request

GSR represents the customer specific process of development/maintenance of the relay settings. The entire e-mail regarding definition of the appropriate relay setting process is managed within GSR. One GSR incorporates one or many RSR - Relay Setting Requests. Each setting within GSR is labeled with a unique Setting Request Identifier - SRI. The system is able to handle several different customer specific workflows for different requirements (E.g. Workflow for new 110 kV line, Transformer bay, installation of specific new protection, recalculation of existing settings, etc). The system handles all necessary document templates required for each Setting Request. Further, the system incorporates user administration rights management where it is possible to adjust user rights related to protective relay setting management.

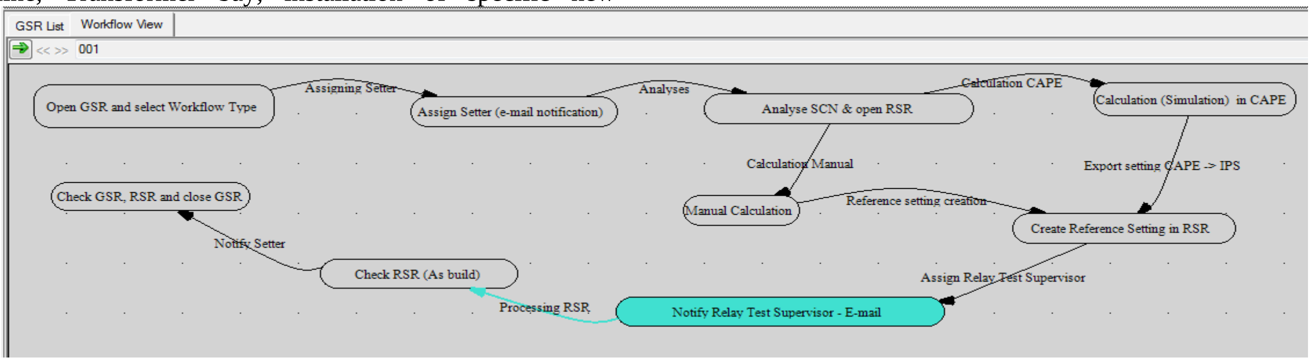

Figure 5: GSR - Example of customer Specific Setting Request Process

RSR - Relay Setting Request

RSR is the relay setting request and this represents the relay setting for each individual protective relay. The workflow presented in figure 6 below is linked with the reference relay setting in the same database. Changes to each stage are followed with e-mail notification to the designated responsible users.

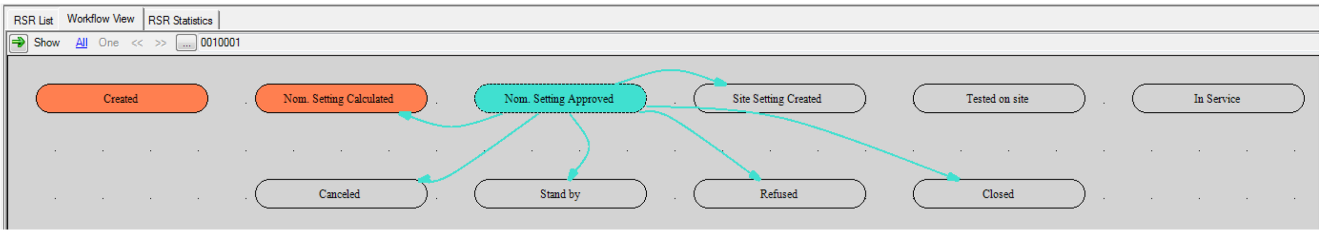

Figure 6: RSR-Relay Setting Workflow

Setting Life Cycle Workflow

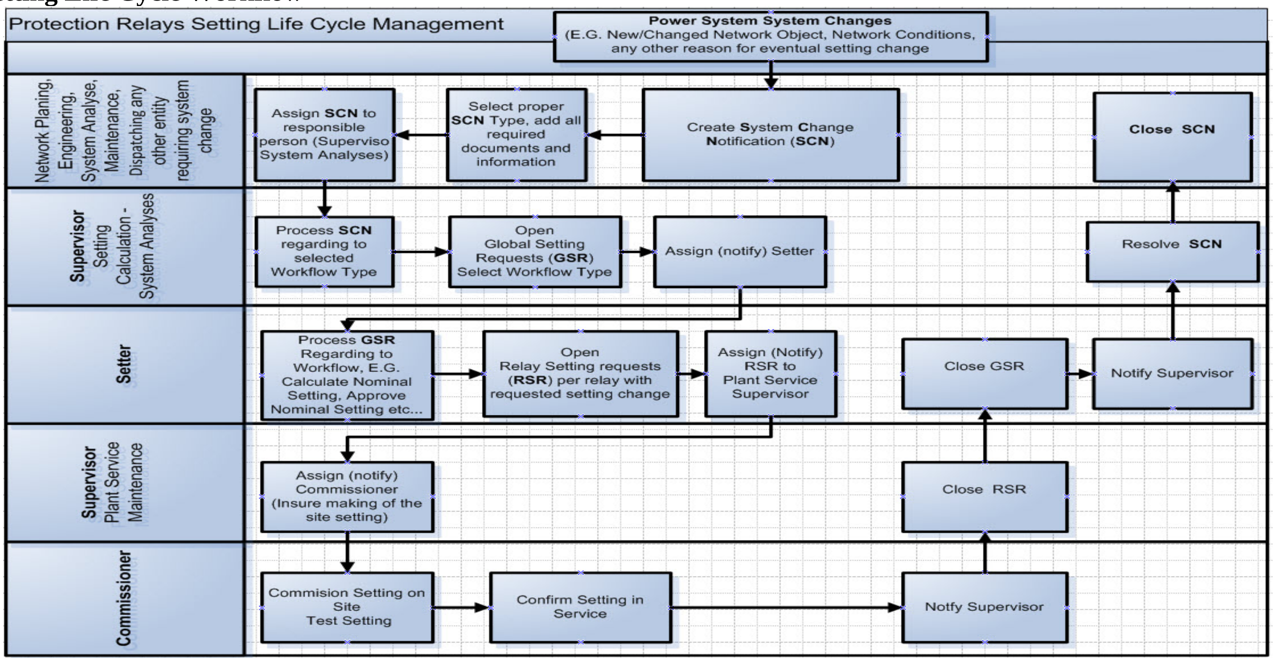

Figure 7: Example of Setting Workflow Process with using SCN-GSR-RSR structure

STEP 7 - Integration of Relay Testing as part of the relay life cycle process

Relay testing introduced the following data structure:
Location Hierarchy (E.G. Substation / Feeder / Cubicle)
*Protection Device (Relay)
*Setting History
*Setting 1
*Parameter Set 1
*Testing History
*Test 1
*Test Results (Test result tables)
*Test Document 1
*Test Document 2
...
*Test Document n
*Test 2
*Parameter Set n
*Setting 2
*Setting n

For relay testing, OMICRON control center technology was used. Testing automation and management was undertaken with XRIO technology implemented within the IPS-RELEX™ system. For each relay model, a list of predefined omicron control center templates was defined. Each template was defined with XRIO technology and relative dependency of the test parameter to the respective relay setting parameter. Further automation interfaces between the OMICRON control center and IPS-RELEX™ were used. The Automation interface was importing relay settings from the setting database of IPS-RELEX™ into the appropriate test document and, after testing, was exporting the test results to be stored within IPS-RELEX™. In this way, a standard test document can be generated which is controlled by the relay setting. Changes of the relay setting will hence cause changes of the test document. Import of the relay setting is possible from any digital relay independent of support for the relay in XRIO. This can be achieved since the system implemented incorporates its own XRIO generator.

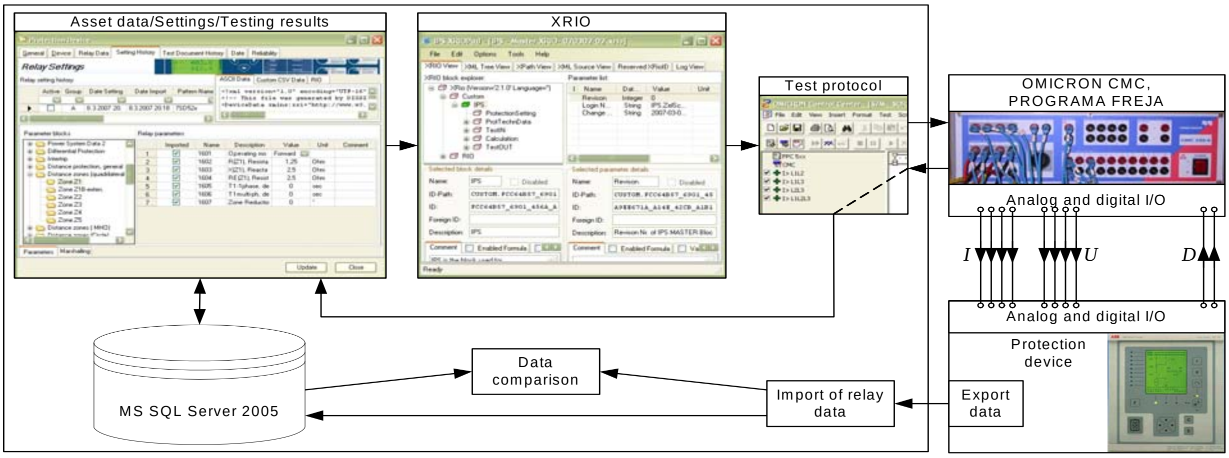

Figure 8: Functional Circle of the protection testing

CONCLUSION

This paper describes the practical integration of an enterprise wide protective relays information system. Within the scope of the paper, has not been possible to explain the entire complexity of the project implementation and lessons learned. However, the authors have presented how mastering modern IED time data management has become a very complex subject. Further requirements related to cyber security provide additional significant challenges to an already complex domain. This paper has shown the additional complexity associated with the issues faced by a newly established power utility organization. Further, the paper has presented practical case material on the optimization of protection life cycle management by enterprise wide integrated standard software solutions.

REFERENCES

[1] Adam Middleton, Joze Bizjak, Dr. Zeljko Schreiner, 2010, " Intelligent Power System Data Management Systems (DBMS)", *Proceedings PAC Word Conference*

[2] H.Borland ESB Networks, D.Coleman Electrocon, Z. Schreiner IPS, A.Middleton GE, " Challenges of Modern Settings Management facing Relay Manufacturers, Power Utilities, Settings Management Specialists and Power System Calculation Software Vendors ", *Proceedings PAC Word Conference 2010*

[3] IPS-EPIS™ Enterprise Protection Information Systems (EPIS) System Description, IPS GmbH 2010