

## **Proposal for a Working Procedure to accurately exchange existing and new calculated Protection Settings between a TSO and Consulting companies**

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### **1. ABSTRACT**

When a TSO or DSO needs to work together with consulting companies in order to define protection settings, the exchange of data and results can be inaccurate and could lead to errors. DIgSILENT GmbH has provided consulting services regarding protection and system stability studies to the main TSO in Bolivia (ENDE Transmisión) for more than ten years. During this time, protection settings for more than 240 protection devices in the 69 kV, 115 kV and 230 kV transmission networks have been calculated. The effort required to keep control of the actual status of the settings of protection devices and generator controllers (AVR, PSS, GOV) and to compare the newly calculated settings with the existing ones is very high. A protection settings database has been implemented in the Asset Management System StationWare based on the native setting files of the protection devices. The database contains all parameters of the protection devices, irrespective of the device manufacturer and the access rights to the settings of the users can be individually defined.

This paper describes the process for the implementation of the database. The proposed working procedure which facilitates the TSO to share selected information with consulting companies is described, as well the corresponding procedure allowing consulting companies to submit the calculated settings such that the TSO can compare them with the existing settings in a faster and more accurate way.

### **2. MOTIVATION**

All settings of protection devices and controllers, as well as all equipment data, independent of manufacturer, should ideally be maintained on one centralized asset management system [1]. In this way any user with corresponding read/write access can have quick and accurate access to currently and historically applied settings on the protection devices or on the generator controllers. Based on this approach, a user with limited read/write access could be assigned to a consulting company. Its access would be limited to the data that its project focuses on.

In addition to this, the system should also contain a process that represents the ongoing project, which is being executed by this external consulting company. Having a well-defined process with different tasks, each referring to the different steps or studies included in the project, offers full transparency of the project progress. For example a project P1 can contain 2 tasks: T1 protection and T2 stability study. Both tasks could be performed by one consulting company or by different companies. In this way the TSO has a complete overview of ongoing projects.

In order to fulfil the requirements specified above, a protection database has been implemented in the asset management software. The implementation of the database includes an interface to the calculation software that can be used by the supplier of consulting services to calculate new protection settings. This implementation is similar to the solution proposed in [2]. The implementation of the database is illustrated in Figure 1

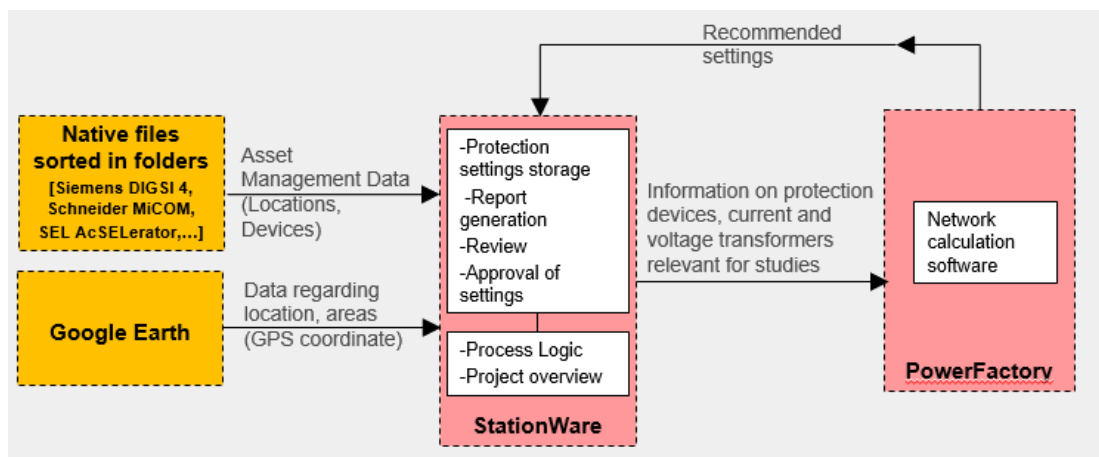


Figure 1 Overview of the protection database implementation

### 3. IMPLEMENTING THE DATABASE

Protection settings files provided by the TSO (around 630 native setting files) were sorted according to their topological location in corresponding subfolders. Using a Python script, the created folder structure, which corresponds to the network topology, was read and summarized in a .csv file. In this way an overview of the network substations and their branches was created. A .csv file is necessary to automatically create the network model or structure in the asset management tool. This step is shown in Figure 2

	A	B	C
85	Guaracachi	Trafo T-31 (6TZ-2)	PP2 SEL387E
86	Guaracachi	Trafo T-31 (6TZ-2)	Ter SPAJ140C
87	Guaracachi	Trafo T-32 (6TZ-1)	PP1 RET521
88	Guaracachi	Trafo T-32 (6TZ-1)	PP2 SEL387E
89	Guaracachi	Trafo T-32 (6TZ-1)	Ter SPAJ140C
90	Karachipampa	L. Aranjuez	PP1 REL531
91	Karachipampa	L. Aranjuez	PP2 EPAC
92	Karachipampa	L. La Plata	7SL87 PP1
93	Karachipampa	L. La Plata	7SL87 PP2
94	Karachipampa	L. Potosí	PP1 RED670
95	Karachipampa	L. Potosí	PP2 SEL421
96	Kenko	Banco 3CA-1	REC670
97	Kenko	Banco 3CB-2	PP1 Micom
98	Kenko	Banco 3CB-2	PP2 UP PLUS
99	Kenko	L. Cota Cota	PP1 EPAC

Figure 2 Data storage and newly created csv file

From Google Earth a .kmz file with the GPS coordinates of the substations was created. A second Python script was used to extract the geographical location data from .kmz file and transfer it into a csv file. To have a better overview of the network data, the whole network was split into 6 network groups according to their GPS coordinates. The two csv files were then combined using a third Python script, which was executed directly from the asset management tool in order to create the network model automatically. The creation of the network model is illustrated in the Figure 3.



can be generated in order to inform the responsible person about the status of the settings definition. In Figure 5 the implemented lifecycle for protection devices in this project is represented.

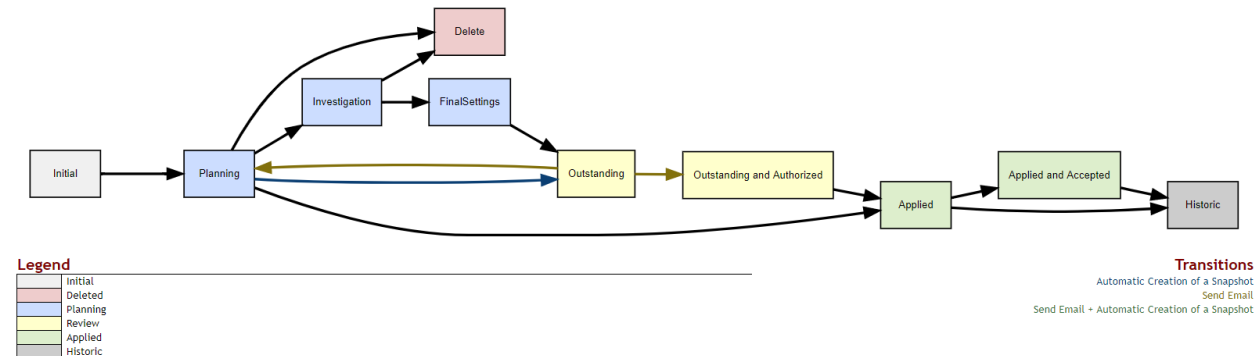


Figure 5: Lifecycle of a settings file

The fact that for each transition between two phases of the settings lifecycle, individual access rights can be defined for each user, is the essence of this proposal. In this way a TSO that assigned a protection or stability study to consulting company could create a user with limited access to locations, devices, phases and transitions in the lifecycle in order to share sensitive information regarding currently applied settings or to evaluate or review the new proposed settings which should be the result of the study. Furthermore, the existing settings could be imported in the network model directly from the asset management tool, if an interface is available.

### 3.2. Process definition

The management of running projects could also be performed from the asset management software. Here, all phases that a study should go through while it is being executed are defined. The proposed lifecycle for the execution of a project is shown in Figure 6. In this case the first stage would be the “Initial” phase which means defining a study task, assigning devices of interest to the process and preparing data. The step “StudyRegistration” would consider gathering offers from different consulting companies and selecting a consulting company that has provided the best offer. After this is done, the “StudyExecution” step begins, at which point, the selected consulting company would be informed, and given a link to the asset management software, so that they can access the required data.

The consulting engineer should have access to the “StudyExecution” phase and to the phase “CalculatedSettingsToStationWare”. In this last phase, the calculated results will be exported from the calculation software back to the asset management software, after which the consulting engineer can move the study to phase “StudyResultReview”. This action triggers an email, informing responsible TSO engineers that the study has been completed by the consultant and that the review of results can be done. If the results are approved, the study goes in phase “ResultsApproved” where TSO engineers can generate native files containing new, changed settings and export them to the actual relay. If the results are not approved, the study is sent back to one of the two phases, where the consultant will be informed about the issues so that he can implement the required modifications.

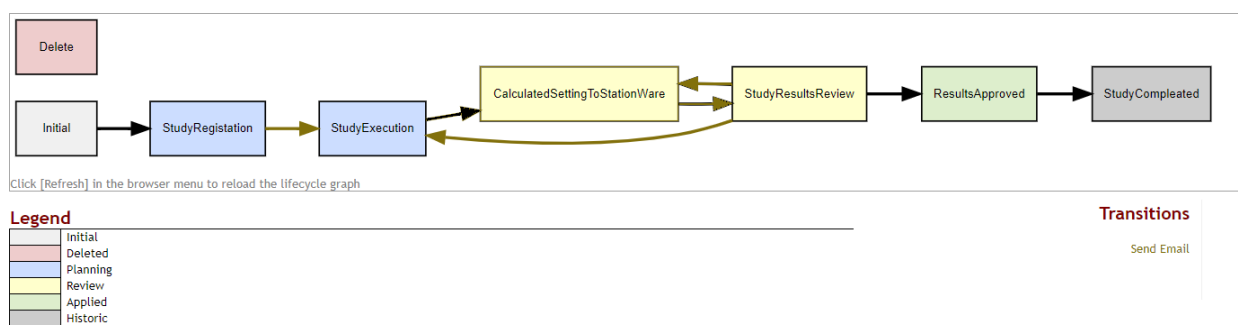


Figure 6: Schema of a Task Lifecycle

This way of dealing with a study allows the project manager to always have an overview of the current study status. An additional benefit is the possibility to track changes and generate reports directly from the asset management software.

### 3.3. User Management

Each person involved in the execution of the project should have a named user with corresponding access rights depending of the assigned role in the execution of the project.

The different users should be allocated to defined groups that represent the company structure or the project area where they have access. The proposed user groups structure is shown in Figure 7.

#### Users and User Groups

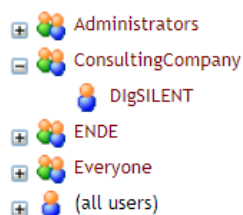


Figure 7: Proposed User Groups Definition

The consulting group has the most limited access rights, focused only on the study that is being executed. After the study has been successfully completed, the access rights of external users or user groups should be removed. The number of consulting users depends on the number of parallel studies being executed.

## 4. EXAMPLE OF A STUDY

The TSO is dealing with the construction of a new transmission line connecting two existing substations. This project not only includes the calculation and definition of the settings for the new installed protection devices, but also the new proposed settings must be coordinated with existing relays. Different protection functions are considered in the new relays, e.g. 21/21N, 68, 67N and 87L.

### 4.1. Preparation tasks for TSO

TSO engineers should prepare the access to the database of the asset management software for the consulting company, i.e. new locations, protection devices, CTs and VTs have to be defined. Once the database is updated, a process should be created on the corresponding locations. All protection devices of interest should be assigned to the newly created process. The different tasks to be considered in the process (protection study, stability study, etc...) should be defined. Figure 8 shows the protection devices to be considered for the construction of the new transmission line.

**StationWare 2016** Navigator Help Change Password Logout

My StationWare Hierarchy Reports Scripts History Library Administration Search Object by ID

ENDE > Empresa: ENDE > Area: NORTE > Project: P1883 Mazocruze-Pallina 230kV

**Process [Project]**

ID	19313
Name	P1883 Mazocruze-Pallina 230kV
Description	
Foreign Key	
Process Type	ProjectProcess
Created	3/15/2018 1:12:34 PM [sljijjak]
Last Change	3/15/2018 2:49:06 PM [sljijjak]

Actions

Edit...	Create Task...
Assign Devices...	Create Task from Template...
Copy...	[Report] Audit Trail...
Move...	[Report] ProjectReport_21...
Detach...	
Delete...	

Attributes Tasks Assigned Devices Additional Documents Notes Links Audit Trail

Name	Path	Manufacturer	Usage	Type	Category	Description
75L87 PP1	ENDE > NORTE > Mazocruz > 230 > Mazocruz-La Palca	Siemens	75L87	Relay	75L87 PP1	
75L87 PP2	ENDE > NORTE > Pallina > 230 > Pallina-Mazocruz > Contorno Bajo-Mazocruz II	Siemens	75L87	Relay		
75L87 PP1	ENDE > NORTE > Pallina > 230 > Pallina-Mazocruz > Contorno Bajo-Mazocruz II	Siemens	75L87	Relay		
75L87 PP2	ENDE > NORTE > Pallina > 230 > Pallina-Mazocruz > Contorno Bajo-Mazocruz I	Siemens	75L87	Relay		
75L87 PP1	ENDE > NORTE > Pallina > 230 > Pallina-Mazocruz > Contorno Bajo-Mazocruz I	Siemens	75L87	Relay		
75L87 PP2	ENDE > NORTE > La Palca > 230 > La Palca-Mazocruz	Siemens	75L87	Relay	75L87 PP2	
75L87 PP1	ENDE > NORTE > La Palca > 230 > La Palca-Mazocruz	Siemens	75L87	Relay	75L87 PP1	
PP2 SEL421	ENDE > NORTE > Kenko > 115 > Kenko-Mazocruz	SEL	SEL421_generic	Relay	PP2 SEL421	
PP1 REL531	ENDE > NORTE > Kenko > 115 > Kenko-Mazocruz	ABB	REL531_generic	Relay	PP1 REL531	
PP2 SEL421	ENDE > NORTE > Mazocruz > 115 > Mazocruz-Kenko	SEL	SEL421_generic	Relay	PP2 SEL421	
PP1 REL531	ENDE > NORTE > Mazocruz > 115 > Mazocruz-Kenko	ABB	REL531_generic	Relay	PP1 REL531	
PP2 SEL421	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Vinto	SEL	SEL421_generic	Relay	PP2 SEL421	
PP1 REL531	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Vinto	ABB	REL531_generic	Relay	PP1 REL531	
75L87 PP2	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Pallina > Mazocruz-Contorno Bajo II	Siemens	75L87	Relay		
75L87 PP1	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Pallina > Mazocruz-Contorno Bajo II	Siemens	75L87	Relay		
75L87 PP2	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Pallina > Mazocruz-Contorno Bajo I	Siemens	75L87	Relay		
75L87 PP1	ENDE > NORTE > Mazocruz > 230 > Mazocruz-Pallina > Mazocruz-Contorno Bajo I	Siemens	75L87	Relay		
75L87 PP2	ENDE > NORTE > Mazocruz > 230 > Mazocruz-La Palca	Siemens	75L87	Relay	75L87 PP2	
PP1 REL531	ENDE > CENTRAL > Vinto > 230 > Vinto-Mazocruz	ABB	REL531_generic	Relay	PP1 REL531	
PP2 SEL421	ENDE > CENTRAL > Vinto > 230 > Vinto-Mazocruz	SEL	SEL421_generic	Relay	PP2 SEL421	

Figure 8 Devices assigned to a process "project" in Asset Management Software

New users should be created with corresponding read/write access rights for the engineers involved in the execution of the project. After this task is completed, the TSO should change the status of the task to "StudyExecution". This change of status informs the consultant and provides him with all necessary data to start with the study. Figure 9 shows this transition.

**StationWare 2016** Help

Change Status from [StudyRegistration] To ...

StudyExecution  
Status Change Date 3/26/2018 10:06:35 AM

Owner

Send Email

Available Users

Test

Recipients

To Recipients

Include Remove DigSILENT, DigSILENT [DigSILENT]

Cc Recipients

Include Remove

Available Relevant Users Only

Notes/Reason

Change Status

Figure 9 Changing status of the task from "StudyRegistration" to "StudyExecution"

#### 4.2. Study execution by the consultant

The asset management software offers an API (application programming interface) that allows a user to access the data stored in the asset management software via scripting. In this way, data exchange between the asset management software and the network analysis software can be done automatically and is completely user definable.

In this example data stored in the StationWare asset management software is imported directly to the PowerFactory network analysis software via a script written in Python.

The Python script accesses devices that are assigned to the process. For each assigned device, one relay object is created in the network model. By having access to a relay, the script also has access to all information regarding the relay (location, selected current transformer and voltage transformer, etc). Using this source, corresponding current and voltage transformers are created and assigned to the protection device. Also the relay type is assigned to the relay object. The script structure for the information exchange is represented in Figure 10.

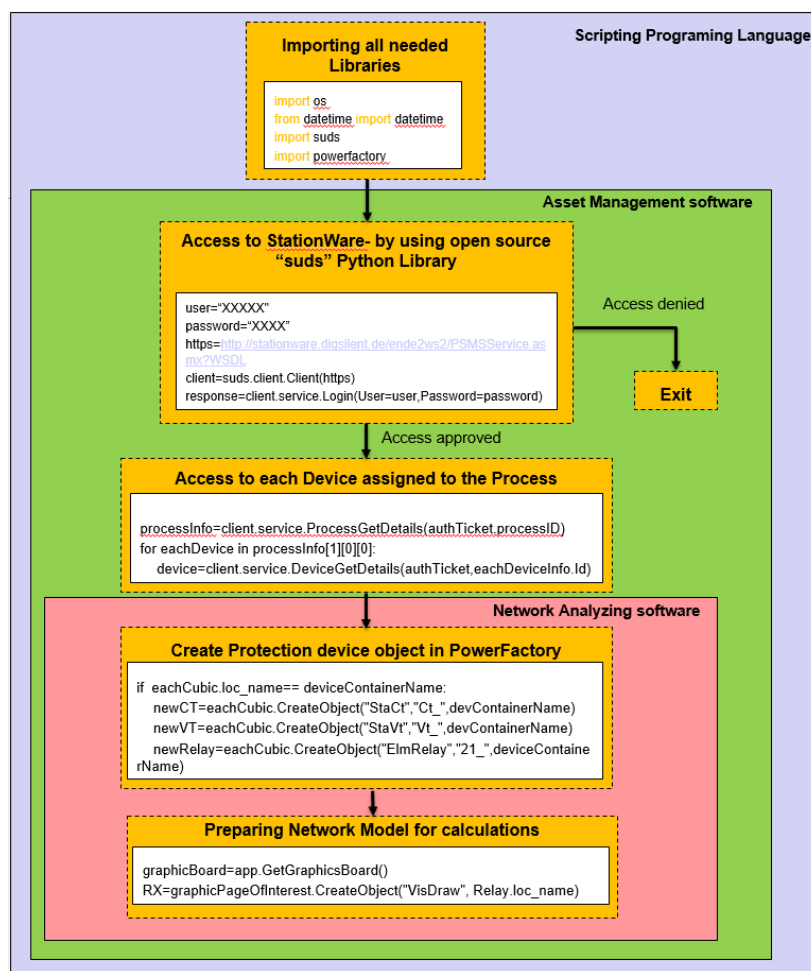


Figure 10. Script for exchanging data from Asset Management software and Network Analyzing software

Once the network model has been adjusted and all elements of interest implemented in the network analysis software, the protection settings in the lifecycle phase "Applied" (i.e. those that are currently on the relays, and available in the asset management software) can be imported. Those settings will be used as a starting point for the investigation.

The complete study is executed while the process task in the asset management software is in the status "StudyExecution". Once the new settings are calculated the consulting engineer should move the process task to the status "CalculatedSettingsToStationWare". In this way the TSO engineer is informed

automatically that the study is moving to a finishing phase and that the settings are in the process of being exported from the network analysis software to the asset management tool in order to be reviewed. Once the export of the protection settings is finished, the consulting engineer should change the status of the project to "StudyResultReview". Now the TSO can start with the review of the new proposed settings using available comparison functions in the asset management software. If there are comments or protection settings needs to be recalculated, the process task can be moved back to one of the two phases that the consulting engineer has access to. The consulting engineer will be automatically informed of the new project status.

#### **4.3. Finishing study work**

Once the consulting engineer has finished the new calculation, the settings are back in the asset management software and there are no more comments from the TSO engineer, the study is finished. Consulting engineer user expires and from that moment on no access on the TSO data by external users is allowed.

The TSO engineer can then proceed with his work. The new settings can be exported into the format that the real relay can read and it can be applied to the relay. If a report is needed, it can be automatically created and sent to the responsible person. API is available offering complete used-defined report generation.

### **5. CONCLUSIONS**

An innovative, transparent and safe working process has been proposed in order to manage the flow of sensitive information between a TSO and consulting companies in both directions regarding the scope of work, existing and new calculated protection settings.

This working process helps to reduce the information loses or errors during the transcription of a large number of parameter settings from a database to a network analysis tool and vice versa. In the same way this process improves the review task by using existing comparison tools.

The application of asset management software which tracks not only the data changes but the person responsible for each calculation, revision and approval of protection settings, ensure full transparency through the process.

### **6. REFERENCES**

- [1] D. Bangert and U.Hoffmann, "Implementation of a Protection Database to Manage Protection Settings at 50Hertz Transmission GmbH," in *9.FNN-ETG Tutorial Schutz- und Leittechnik*, Berlin, 2016.
- [2] A. Ludwig and H. Grünert, "Einbindung eines Schutzeinstelltools in eine vorhandene Systemarchitektur," in *10. FNN-ETG Tutorial Schutz- und Leittechnik*, Berlin, 2018.
- [3] DIgSILENT GmbH, "StationWare User Manual Version 2016," Gomaringen, 2017.
- [4] DIgSILENT GmbH, "StationWare Service Methods 2016 R4," Gomaringen, 2017.
- [5] Google, "<https://developers.google.com/maps/documentation/javascript/>".

### **7. BIOGRAPHIES**

**Strahinja Ljiljak** received his BS degree from the University of Novi Sad in Serbia in 2011, and Master from University Magdeburg in Germany in 2013. Currently he is working as application and consulting engineer at DIgSILENT GmbH. Before joining his current company he was working as study engineer in GridLab GmbH and on Brandenburg University of Technology.

**Manuel Castillo** is head of the department Industrial Systems & Protection within DIgSILENT GmbH. He obtained the Master of Science degree in electrical power engineering from the Rheinisch-Westfälische



Technische Hochschule (RWTH) of Aachen, Germany, in 2000. Before joining DIgSILENT as an application and consulting engineer in 2004 he worked as project engineer for several companies in the energy sector such as ALSTOM and AREVA.

He gained extensive experiences in the sector of modelling and simulation of power systems as well as integrated power system analysis within numerous international projects. His work for DIgSILENT especially includes the execution of protection studies for transmission, distribution and industrial clients. He also contributed to several On- and Offshore projects by evaluating the grid code compliance of the wind farm connection to the public network. This work included among others the execution of steady state calculations in order to verify the dimensioning of the equipment and the wind farm influence to power quality issues in the grid as well as the execution of dynamical simulations in order to analyse the wind farm behaviour during faults. Since 2005 Manuel Castillo presented more than 100 trainings and seminars about the use of the power system analysis software DIgSILENT PowerFactory for network planning, network operation and network design in German, English and Spanish language.