MATPOST 2019 20 TO 22 NOVEMBER LYON ESPACE TÊTE D'OR

Megger.

Event driven maintenance for IEC 61850 Substations

Periodic comparison of GOOSE data flow and of automatic post-fault analysis results

Andrea Bonetti

Megger - Sweden

Andrea Bonetti
Product Management and Application Department
Megger Sweden AB
Stockholm, Sweden
andrea.bonetti@megger.com

Miroslav Urosevic
KTH Royal Institute of Technology
Stockholm, Sweden
urosevic@kth.se

Sidney Fernandez
Relay Testing Application Department
Megger Limited
Manila, Philippines
sidney.fernandez@megger.com

Riad Yalda
KTH Royal Institute of Technology
Stockholm, Sweden
ryalda@kth.se

Nikolay Ignatovski
Telemechanics and telecommunications Department
Electricity System Operator EAD
Sofia, Bulgaria
NIgnatovski@ndc.bg

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ELECTRICITY SYSTEM OPERATOR

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Andrea Bonetti – Megger Sweden AB – andrea.bonetti@megger.com

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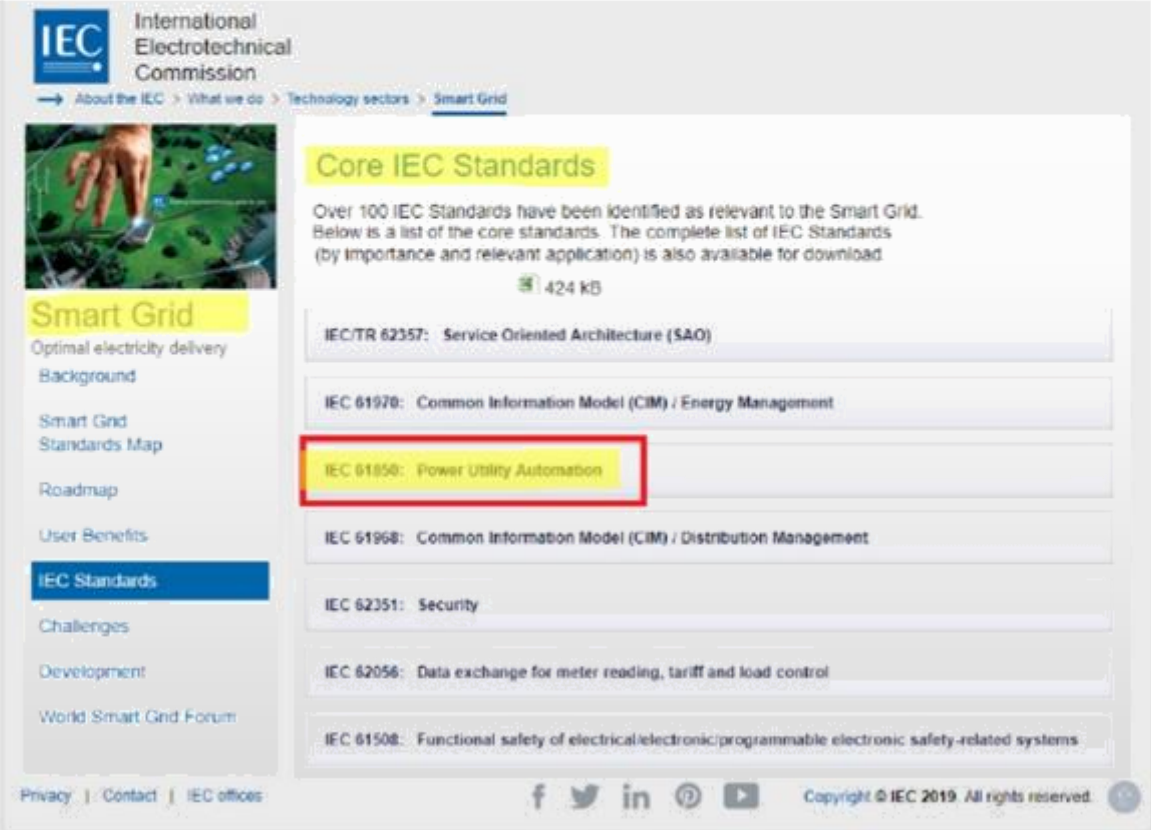
IEC 61850 – Standardized Digital Power System Technology – Smart Grid

IEC 61850 has to do with the standardized digitalisation of the electrotechnical technology → Smart Grid



IEC 61850 is one of the **core standards** for Smart Grid, according to IEC

How to address a new technology ?

When using a new technology …

… the methods and procedures used in the past **cannot always be directly extrapolated** from the new technique…

… The new methods will allow to achieve the same goals of the previous methods (routines)…

… it is necessary to **understand the purpose of the previous** procedures…

… and **see how the new technique can be used** to get the same purpose.

How to address a new technology ?

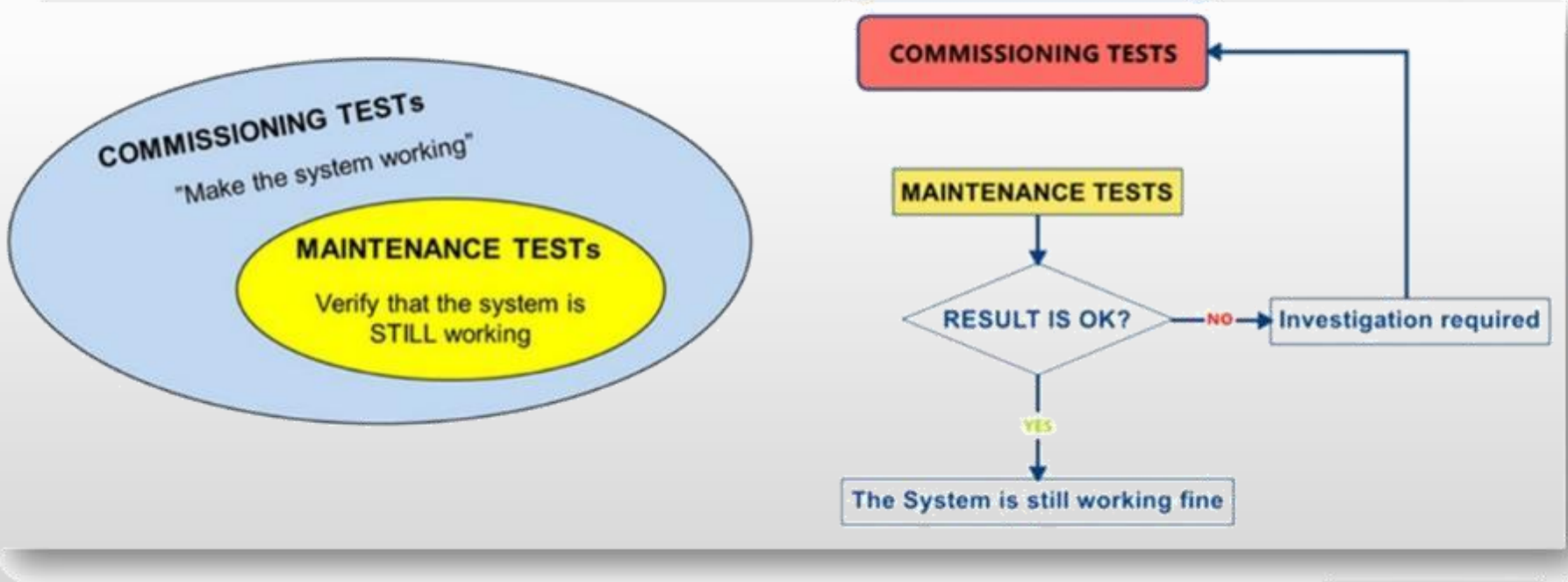
If you always do what you always did, you will always get what you always got.

– *Albert Einstein*

Purpose of Commissioning / Maintenance Tests

Commissioning tests are performed to set-up the system until its functionality is confirmed.

Maintenance tests are to verify that the system is still running correctly and are therefore a more restrictive subset of the commissioning tests.



How can we verify that the system is "still running well"?

The IEC 61850 system is a **(standardized) numerical system…**

…it makes sense to **use the numerical technology** to get information about the status of the system and to get solution to assess the status.

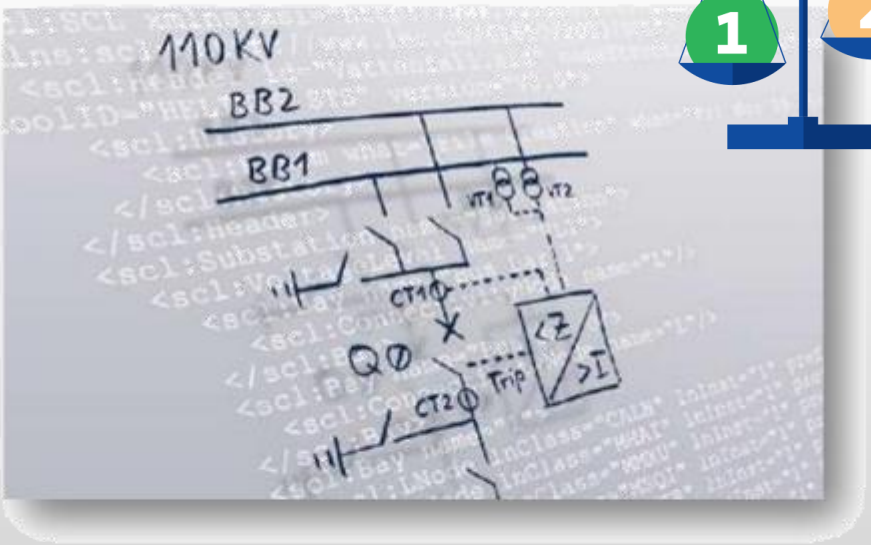
Non-Invasive comparison actions

Compare the previous proven correct status of the system with the current "unknown" status

the key is to SELECT the parts of the system that are able to give a reasonable representation of its status.

Compare GOOSE traffic with its SCD description

Compare the GOOSE traffic ….



with its description on the substation master SCD file.

Multimeter yesterday
GOOSE sniffer tomorrow

Conventional Multimeter

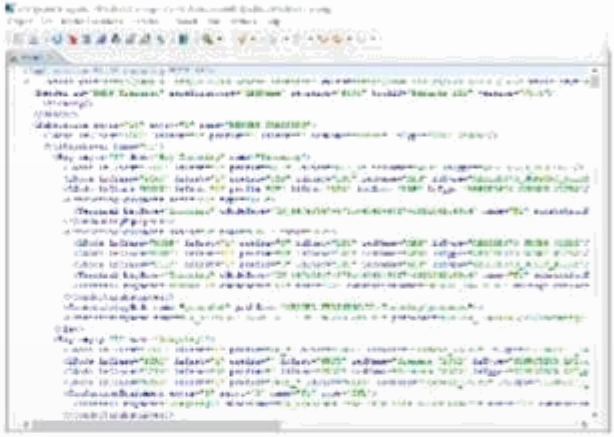
IEC 61850 GOOSE sniffer

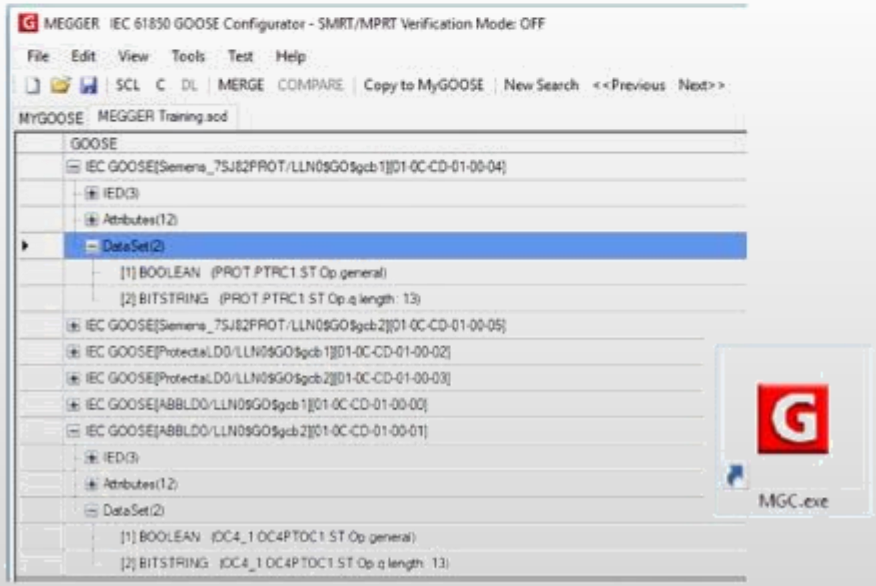
"as built drawing" yesterday SCD file tomorrow

Reading the "as built" drawing

Reading the "as built" SCD file

Substation SCD FILE.scd





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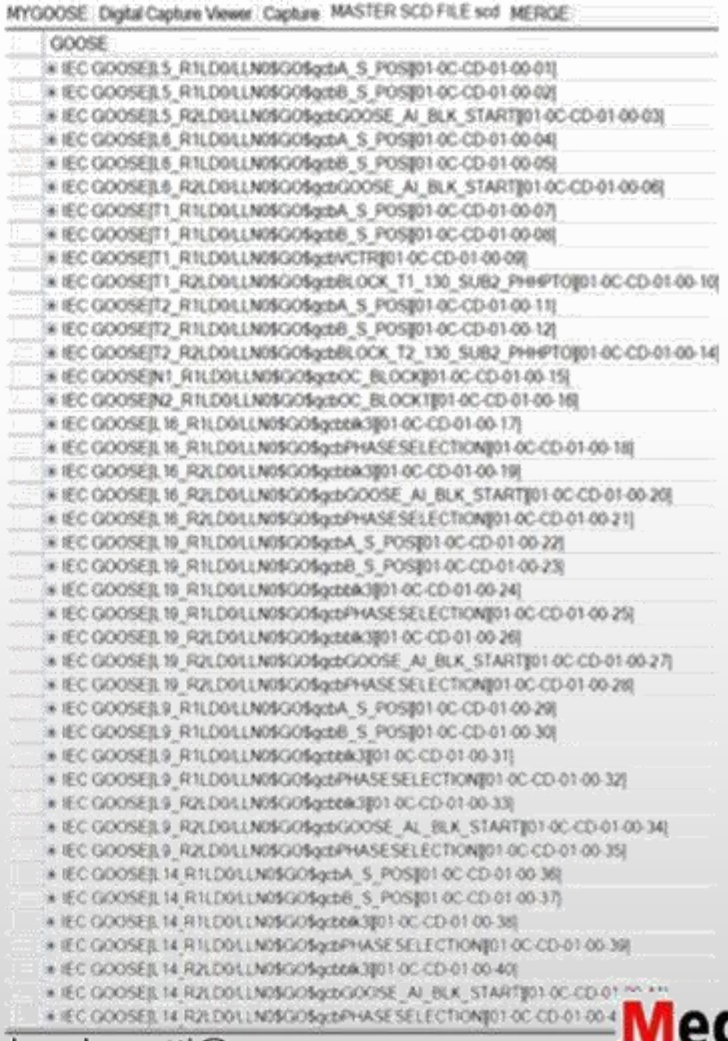
How it works in practice: TODAY!

"Reading the network"

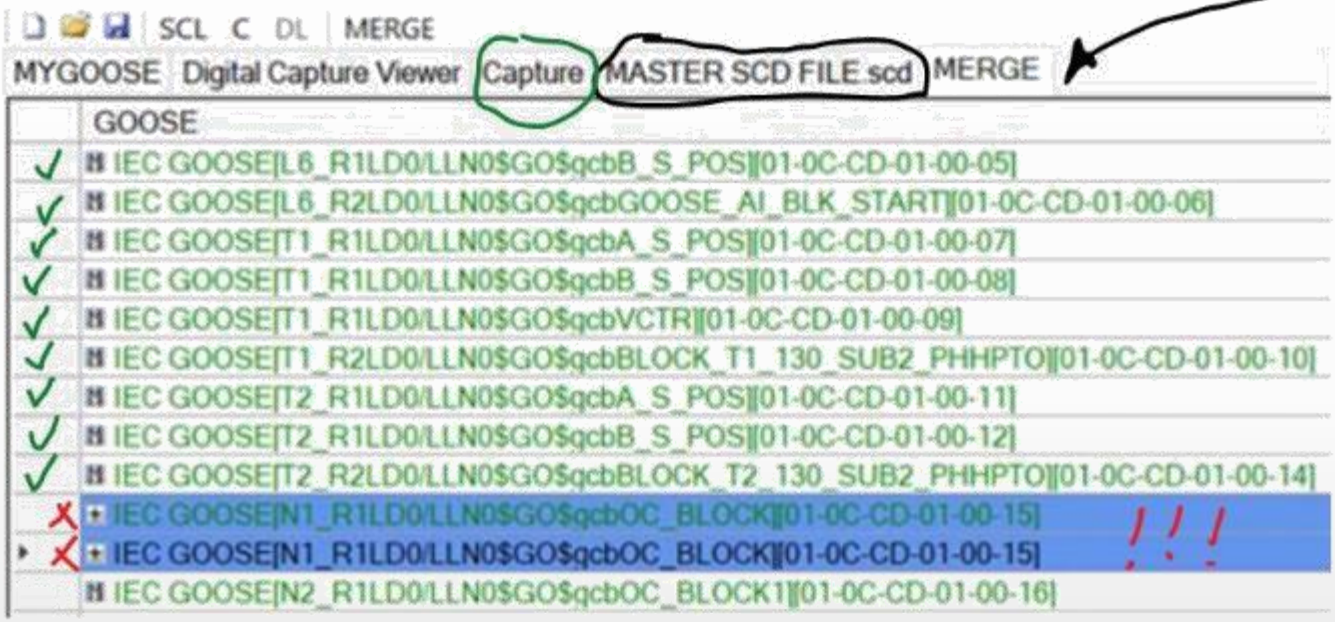
IEC 61850 GOOSE sniffer

Reading the as built IEC 61850 SCD file



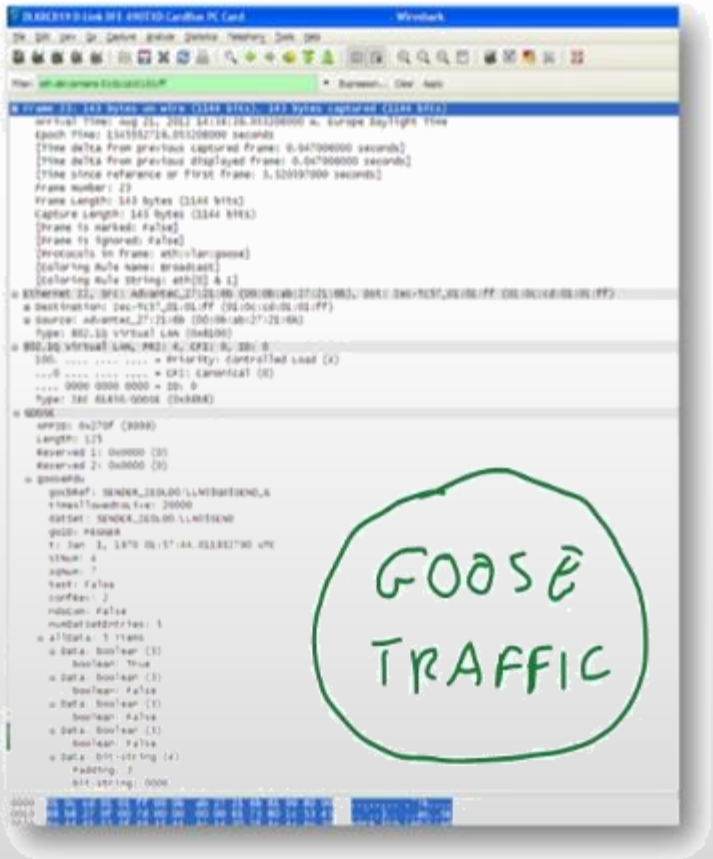
How it works in practice: TODAY!

Comparing (MERGING) "SCD GOOSE" with "Sniffed/scanned" GOOSE

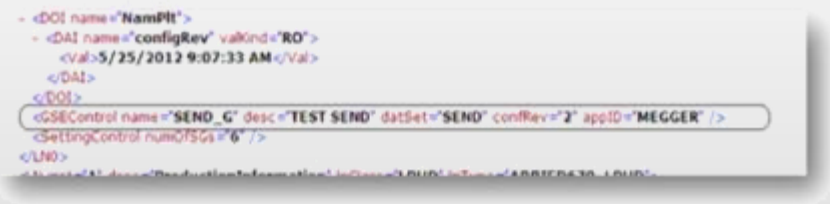


How it works in practice: TODAY!

Manual comparison of traffic (Wireshark/Ethereal) with XML (SCL) is too difficult and requires too much competence



SCL
(XML)



First comparison at FAT / SAT

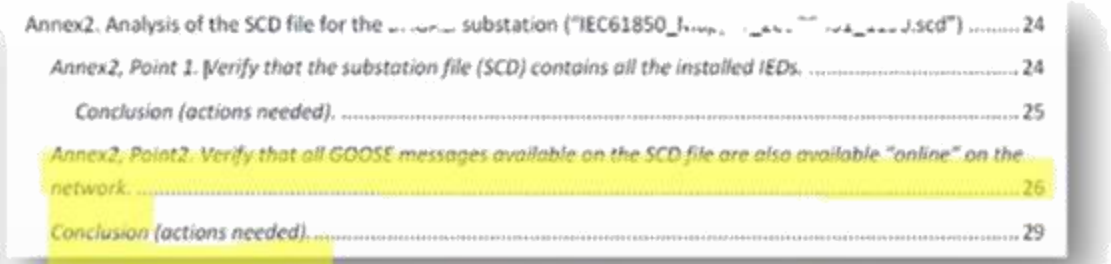

Test report FAT

Report – … FAT

STRI

Performed IEC 61850 related tests on …

to evaluate … agreement suppliers


Annex2. Analysis of the SCD file for the … substation ("IEC61850_… .scd") 24

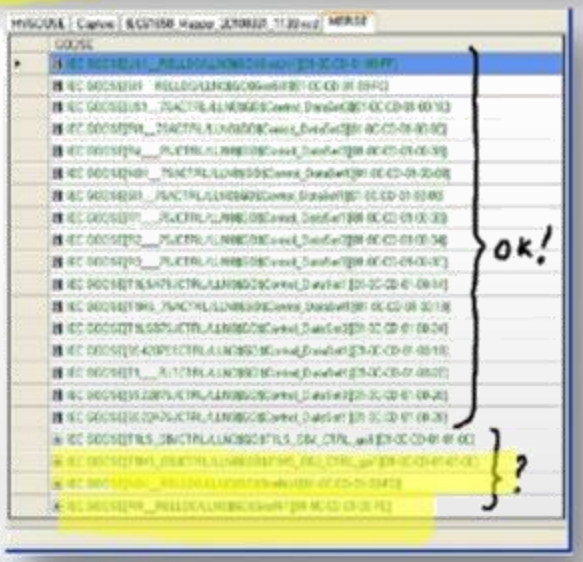
Annex2, Point 1. Verify that the substation file (SCD) contains all the installed IEDs. 24

Conclusion (actions needed). 25

Annex2, Point2. Verify that all GOOSE messages available on the SCD file are also available "online" on the network. 26

Conclusion (actions needed). 29

Example of IEC 61850 FAT where the MERGE algorithm has been used



Conclusion (actions needed).

The GOOSE engineering for the … IEDs "N01_…" and "RI1_…" is missing in the SCD file and it should be added.

For the … IEDs nothing can be said as their description is corrupted in the xml file itself.

Anyway there are two … IEDs that are sending GOOSE messages in the network.

Maintenance tests: Identification of differences in the GOOSE traffic

Identified issues so far with the (manual) merge/compare algorithm:

- **ETH Switch replaced with wrong settings.**
  Wrong VLAN settings. Some GOOSE disappeared (more **black** than **green**) and some GOOSE dropped (lost) their VLAN tag.
- **IED reconfigured and differently engineered**
  Some **green** GOOSE didn't get merge because of different CONFIG REVISION
- **IED out of service or disconnected**
  Some **green** GOOSE disappeared
- **New IED inserted**
  Some new **green** GOOSE appeared, SCD file has not been updated

Disturbance recording and data collection

Disturbance recorder files from protection devices and/or dedicated devices are becoming more and more important in power system operation and maintenance.
A systematic post-fault or post-event analysis allows to:

- Detect incorrect relay settings and give facts supporting their improvement
- Verify relay coordination
- Verify relay performances

- Determine the position of the fault (fault location)
- **Perform asset condition monitoring**

Retrieving the disturbance files has been a complex task in the past: proprietary vendor software was necessary to retrieve the information, proprietary communication protocol, lack of fast and reliable communication structure to transmit the disturbance files to a central location…

IEC 61850 provides Easier access to data for Post-Fault Analysis!

Thanks to the IEC 61850 standard today:

We **know the communication protocol for file transfer**
(FTP or MMS)

We **know how to communicate**
(Ethernet, 100 Mbit/s or 1 Gbit/s)

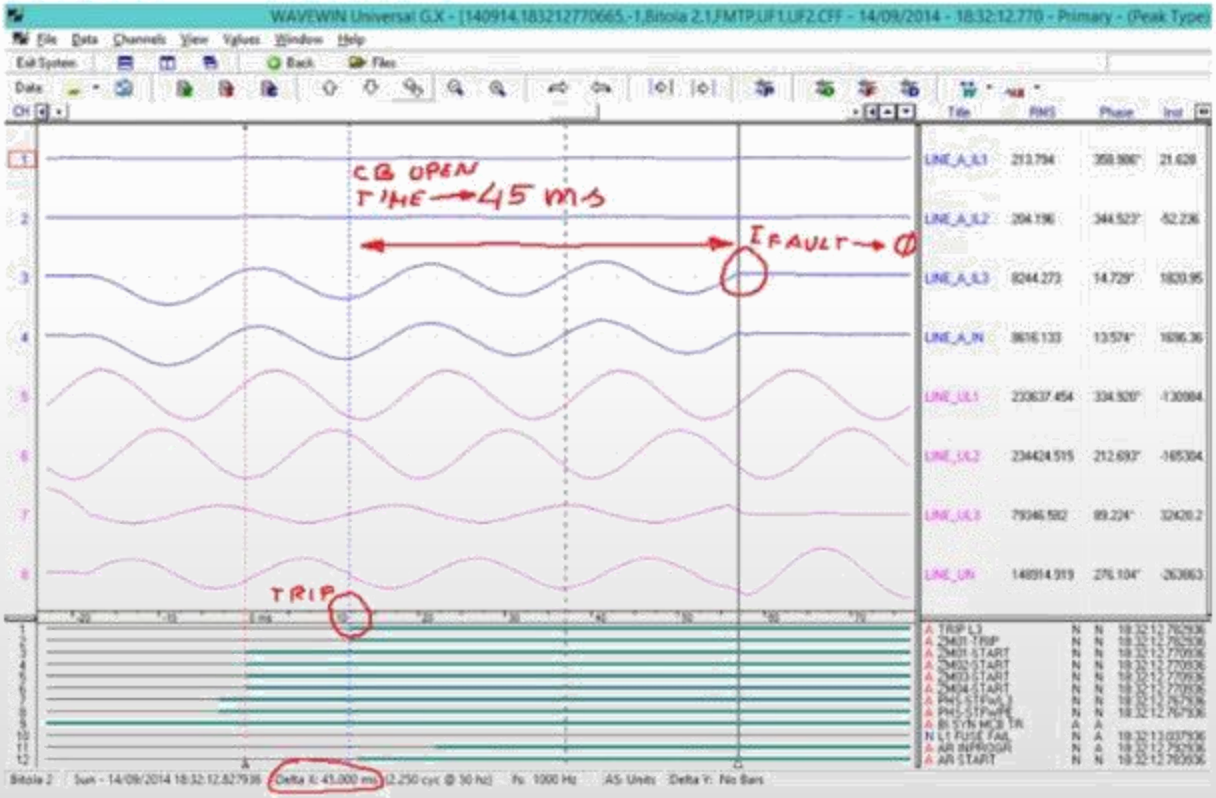
We **know how the files look like**
(COMTRADE)

We **know where the file are stored** in the IEDs
(folder /COMTRADE)

COMTRADE:
COMmon format for TRansient Data Exchange for power systems

Asset condition monitoring
CB Operating time

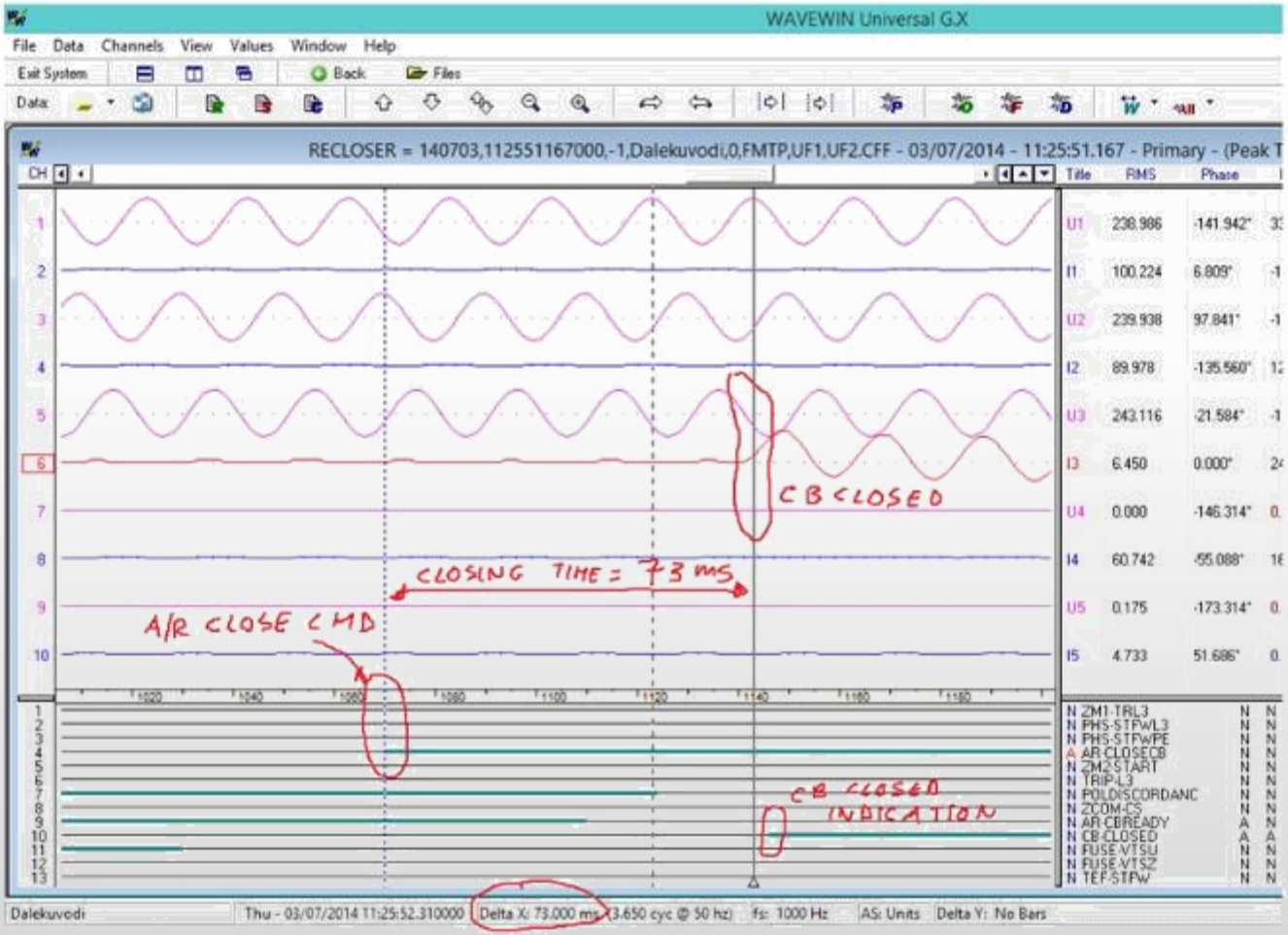
Considering some 3…4 ms for the TRIP binary output to close, we can reasonably state a circuit breaker opening time of approx. 40 … 41 ms (at least <= 45 ms).



DFR Courtesy of MEPSO

Asset condition monitoring
CB Closing Time

Let's measure the time from when the autorecloser CLOSE command is issued to when the circuit breaker has closed…



DFR Courtesy of MEPSO

Asset condition monitoring
CB Operating time

Automatic post-fault analysis is one important contribution to maintenance routines.

EXAMENSARBETE INOM ELEKTROTEKNIK, GRUNDNIVÅ, 15 HP
STOCKHOLM, SVERIGE 2019

Automatic post-fault analysis based on disturbance data stored in substation devices
Automatisk analys av felhändelser baserad på störningsdata lagrad i ställverksenheter

Approach towards the preventive maintenance
Tillvägagångssätt för förebyggande underhåll

MIROSLAV UROSEVIC

RIAD YALDA

We have the data, let's put resources on analyzing it!

Automated reading of COMTRADE files

- Multiple files for the same disturbance (configuration and data)
- Several versions of COMTRADE standard
- Data files in both ASCII and binary format

Configuration file

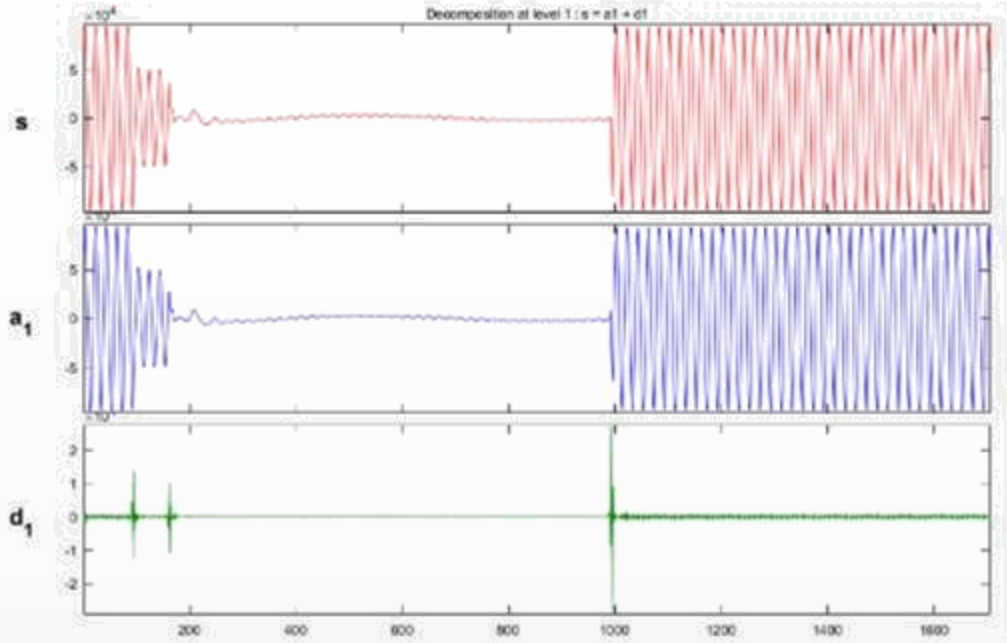
```
Station 1,1,2013
10,7A,3D
1,LINE_A_IL1,,, A,0.230458300000,0.0,0.0,-99998,99998,2.000000e+003,1.000000e+000,P
2,LINE_A_IL2,,, A,0.022458250000,0.0,0.0,-99998,99998,2.000000e+003,1.000000e+000,P
3,LINE_A_IL3,,, A,0.021235850000,0.0,0.0,-99998,99998,2.000000e+003,1.000000e+000,P
4,LINE_A_IN,,, A,0.218090100000,0.0,0.0,-99998,99998,2.000000e+003,1.000000e+000,P
5,LINE_UL1,,, V,3.244896000000,0.0,0.0,-99998,99998,4.000000e+005,1.100000e+002,P
6,LINE_UL2,,, V,3.389756000000,0.0,0.0,-99998,99998,4.000000e+005,1.100000e+002,P
7,LINE_UL3,,, V,3.212939000000,0.0,0.0,-99998,99998,4.000000e+005,1.100000e+002,P
1,PHS-STFWL1,,,0
2,PHS-STFWL2,,,0
3,PHS-STFWPE,,,0
50
1
1000,1300
21/07/2014,17:18:43.163033
21/07/2014,17:18:43.443032
ASCII
1
```

Data file

```
1,0,8965,-62316,-31781,-36,93572,-73193,-17368,0,0,0
2,1000,9112,-37506,-59397,-14,99558,-50577,-47178,0,0,0
3,2000,8340,-8860,-81030,12,95795,-23074,-72432,0,0,0
4,3000,6749,20605,-94751,28,82603,6888,-90591,0,0,0
5,4000,4482,48183,-99544,6,61234,36040,-99857,0,0,0
6,5000,1777,71171,-94494,6,33862,61757,-99350,0,0,0
7,6000,-1082,87244,-80043,43,3173,81428,-89112,0,0,0
8,7000,-3857,94661,-57667,52,-27906,93146,-70068,0,0,0
9,8000,-6271,92648,-29603,28,-56180,95787,-44200,0,0,0
10,9000,-8077,81589,1254,-8,-79021,89084,-14035,0,0,0
11,10000,-9083,62798,32006,-17,-94267,73625,17529,0,0,0
12,11000,-9209,38079,59878,16,-100297,51090,47400,0,0,0
13,12000,-8429,9363,81794,19,-96505,23457,72664,0,0,0
14,13000,-6825,-20155,95680,25,-83251,-6405,90773,0,0,0
15,14000,-4570,-47604,100283,31,-61959,-35619,100031,0,0,0
16,15000,-1862,-70574,94960,6,-34606,-61271,99533,0,0,0
```

Automated analysis of COMTRADE files

Wavelet transform analysis:

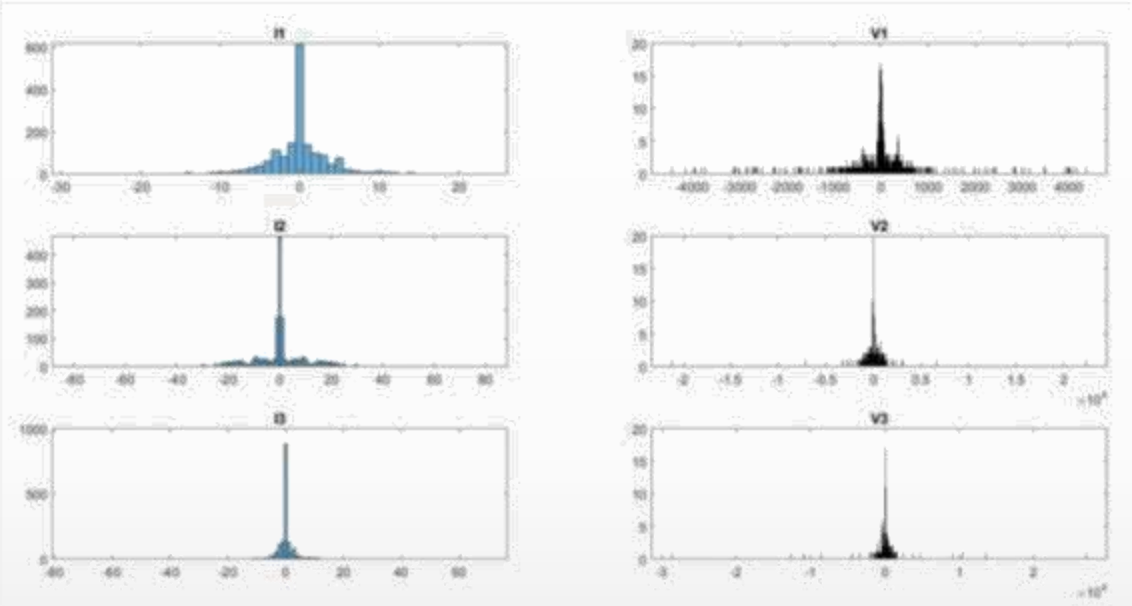


Other algorithms implemented to identify analog ”changes”: RMS, delta values, zero sequence components etc

1. RMS variations
2. Phase angle variations
3. Sequence components variations

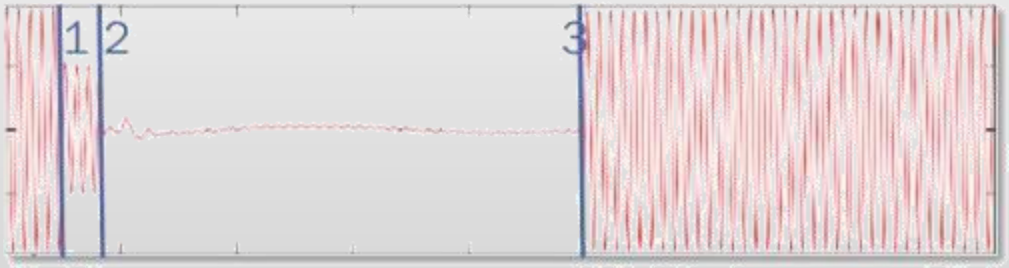
Automated analysis of COMTRADE files

Final fault event points chosen by a probabilistic decision on many coefficients:



Fault events identified from analog channels:

1. Fault start
2. Circuit breaker opening
3. Circuit breaker closing



Automated analysis of COMTRADE files

Software tested using COMTRADE files from the same substation containing shunt faults on 110 kV transmission lines

Fault date	Relay operate time [s]	Protection chain total operate time [s]	Circuit breaker operating time [s]	Circuit breaker closing time [s]
Bay Q1 Main protection				
[2018-03-25	0.018	0.068	0.05	0.068
[2018-8-06	0.018	0.068	0.05	0.078
[2018-08-07	0.016	0.068	0.052	0.078
[2018-08-13	0.017	0.068	0.051	0.074
Bay Q1 Backup protection				
[2018-03-25	0.018	0.078	0.06	0.077
[2018-08-06	0.018	0.068	0.05	0.078
[2018-08-07	0.016	0.068	0.052	0.064
[2018-08-13	0.015	0.068	0.053	0.083
Bay Q2 Main protection				
[2018-08-12	0.017	0.076	0.059	0.077
[2018-08-12	0.015	0.076	0.061	0.079
[2018-08-12	0.017	0.068	0.051	0.073
[2018-08-16	0.014	0.068	0.054	0.075

Warnings are generated if calculated operate times are above a threshold

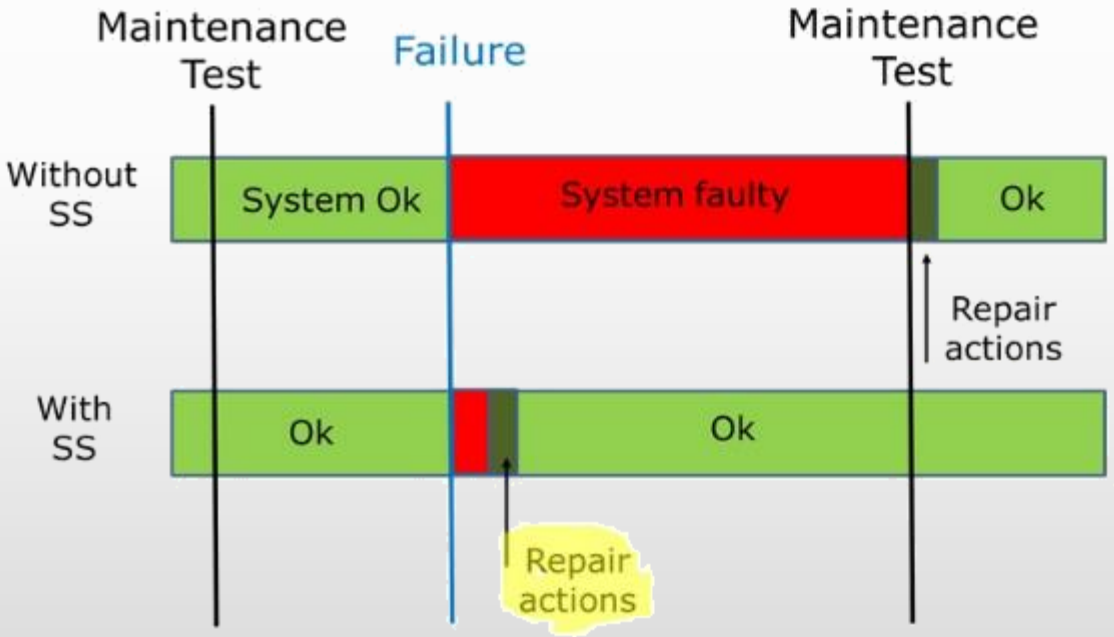
Future goal is to **compare the calculated operate times with previously calculated times and generate warnings if there is a substantial difference**

Automatic Maintenance tests. Approaching the substation self supervision

The tools need today manual efforts but the concept can be improved and performed automatically, for example once every day…

Reduced MTTR: information about failures in the communication between two particular IED available as soon as the problem occurs

→ **event oriented maintenance**



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Thank you to all of you!

Andrea Bonetti – Megger Sweden AB – andrea.bonetti@megger.com

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