INTEGRATION OF DIGITAL TECHNOLOGIES TO GIS

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IEEE/PES Substation Committee - GIS Subcommittee

GIS Users' Group January 12, 2012 Meeting Agenda

Agenda

- Introduction to digital GIS
- SF6 monitoring
- Circuit-breaker condition monitoring
- Partial discharges monitoring
- NCIT advanced technology
- Integration of digital applications
- Conclusion

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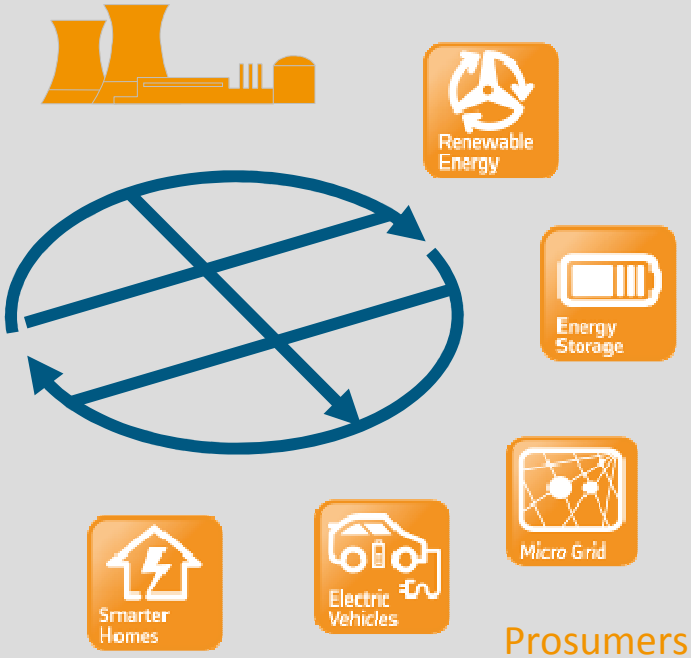
21st century Grid: towards a two-way flow of energy and information

From a traditional top-down network…

… to a meshed network with two-way flow of energy and information



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Benefits of integrated digital technologies into GIS/GIL

Real-time and flexible solutions as a decision support tool for asset management

- Increase reliability & availability of equipment
- Optimize maintenance plans
- Check capacity for temporary overloads
- Prepare investments plans

The digital GIS Substation is one of the major components of the value chain of a Smart Grid

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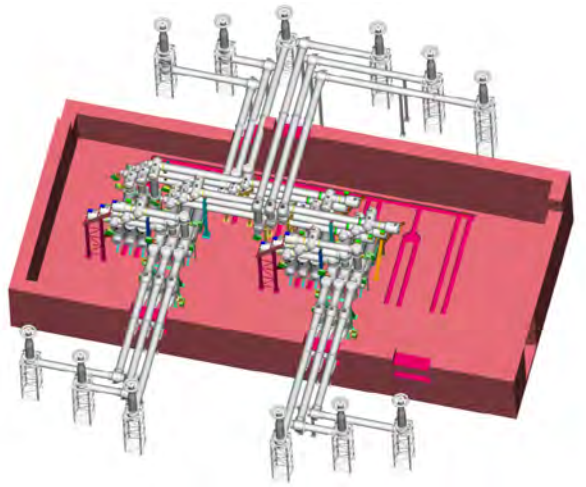
Digital GIS Substation : what is it ?

Digital GIS includes:

- **Advanced local functions**
  - SF6 control & monitoring
  - CB control & monitoring
  - Partial discharges monitoring
  - NCIT sensors for measurement
  - Bay controller

- **Integrated monitoring applications**
  - Data management at GIS level
  - Communications to substation level



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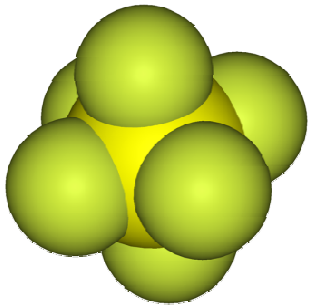
Operation & Maintenance help tool: SF6 monitoring



Modern online SF6 Monitoring helpful for

- Catastrophic type leaks detection
- Medium-term trends for maintenance plan
- Long term trends for SF6 environmental impact

Main challenge: set-up SF6 on-line indicators

- Rationalize SF6 policy
- Fulfill international regulations
  - Kyoto protocol
  - GIS standards (IEC 62271-203 & IEEE C37.122)

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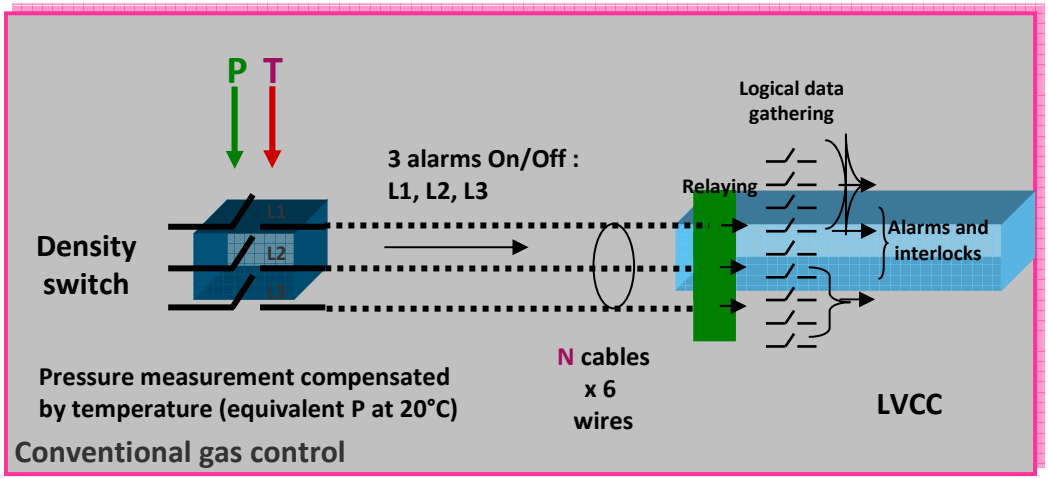
Evolution of the monitoring in GIS

Usually the monitoring in GIS consisted in :

- Conventional SF6 gas control using density switches
- Gas alarms only carried over the LVCC mimic



Main drawbacks :

- No indication in case of any sensor problem
- SF6 leakage in the atmosphere without indication before the threshold 1

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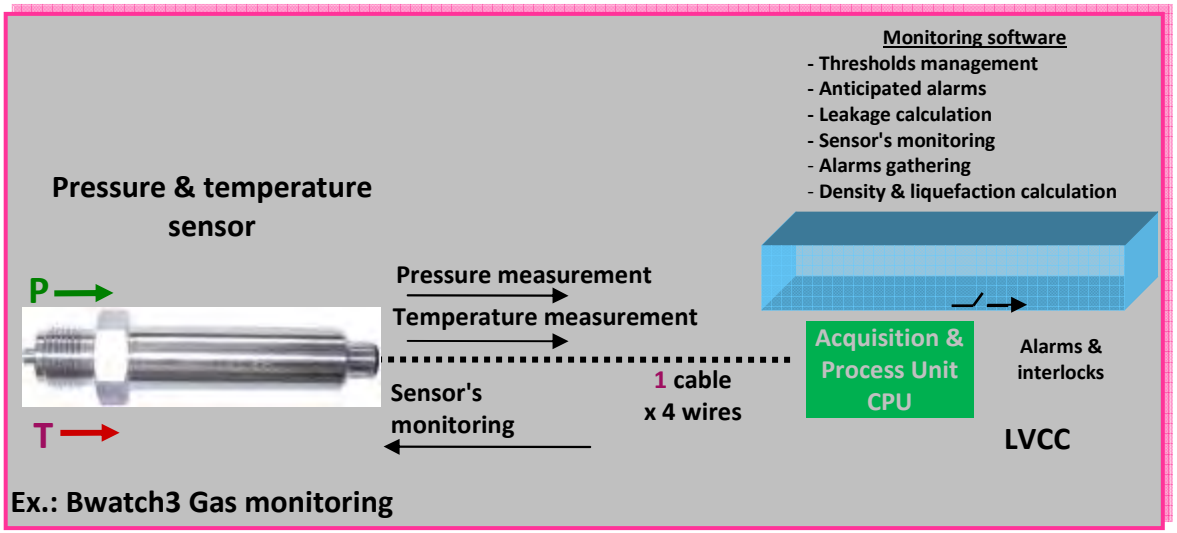
Evolution of the monitoring in GIS

In the 2000's, the GIS monitoring integrated the last technologies

– Digital sensors and PLC



Concept based on a modular system enable to evolve

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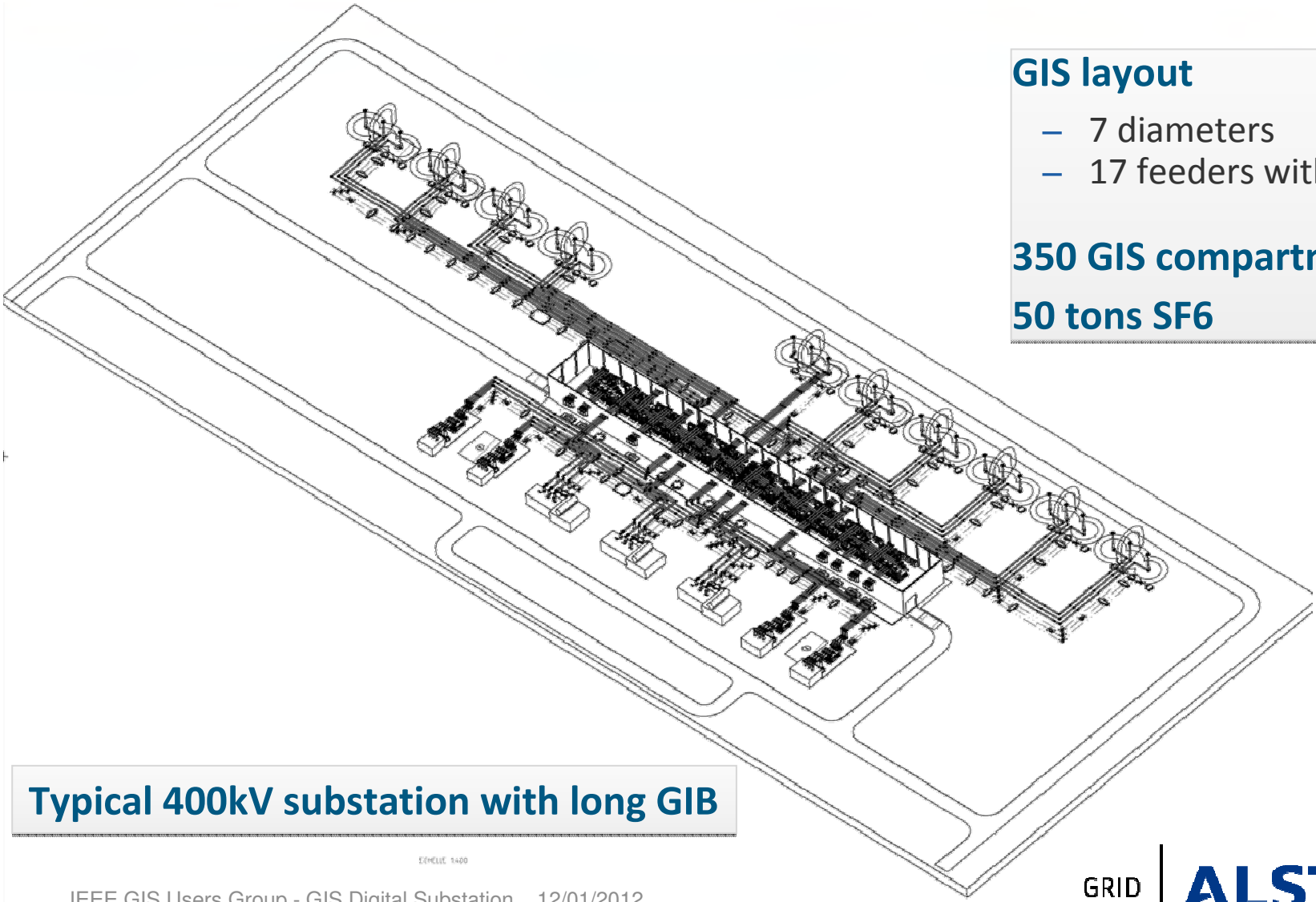
SF6 monitoring study case – cabling impact



GIS layout

- 7 diameters
- 17 feeders with GIL

350 GIS compartments

50 tons SF6

Typical 400kV substation with long GIB

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SF6 monitoring study case – cabling impact

Conventional gas control solution

Need of 1 control cable for each single density switch

Type of cable:

- Copper tape screen cable
- 6 x 2.5mm² conductors
- Linear weight = 560 kg/km

Total length = 64 km

Total weight = 36 tons

Digital gas control solution

Need of 1 process bus for each single bay & 1 prolongator for each sensor

Type of cable 1 (Bus)

- DeviceNet process bus (thick)
- Linear weight = 88.4 kg/km

Type of cable 2 (Transmitter)

- DeviceNet process bus (thin)
- Linear weight = 33.4 kg/km

Total length = 5.7 km

Total weight = less than 1 ton

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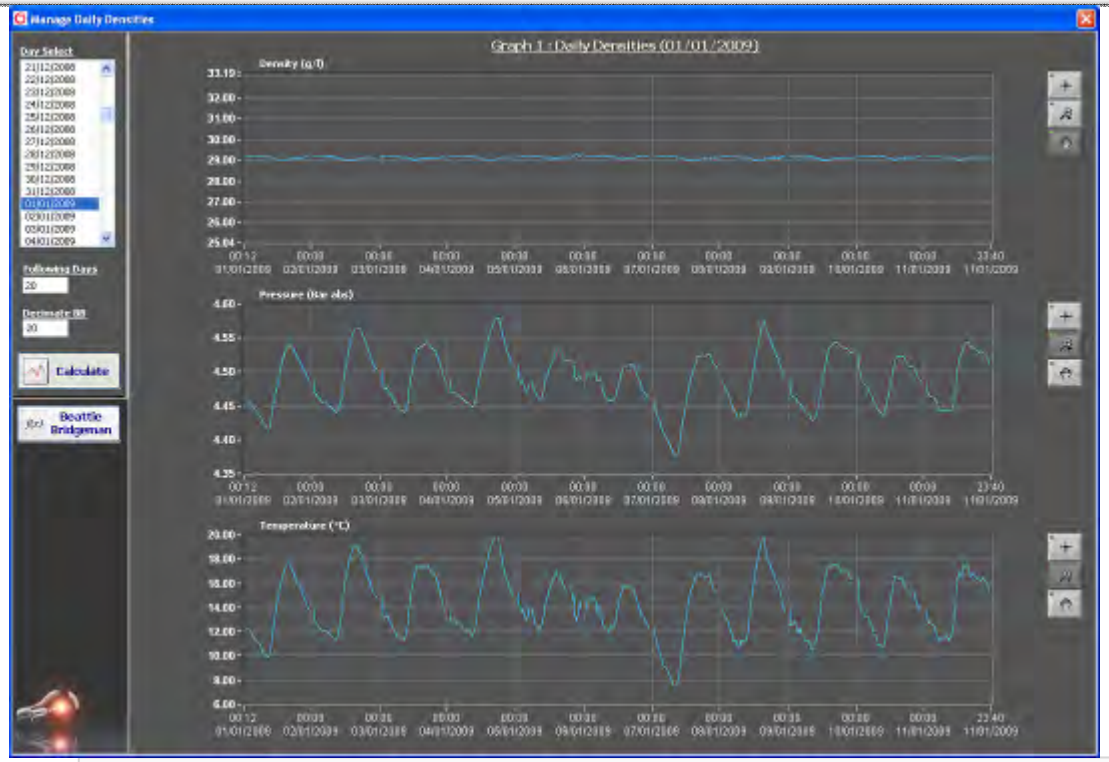
SF6 monitoring – Medium & long term trends

Long GILs subject to atmospheric constraints

- Use of modern technology for data acquisition
- Expert software to determine long term trends with right accuracy



Daily variation of density/pressure/temperature

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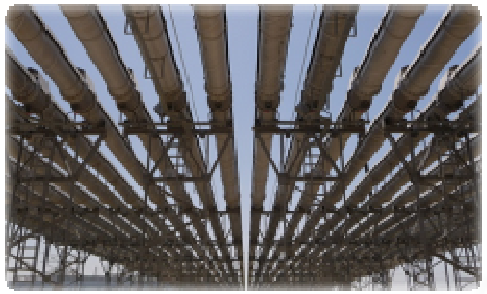
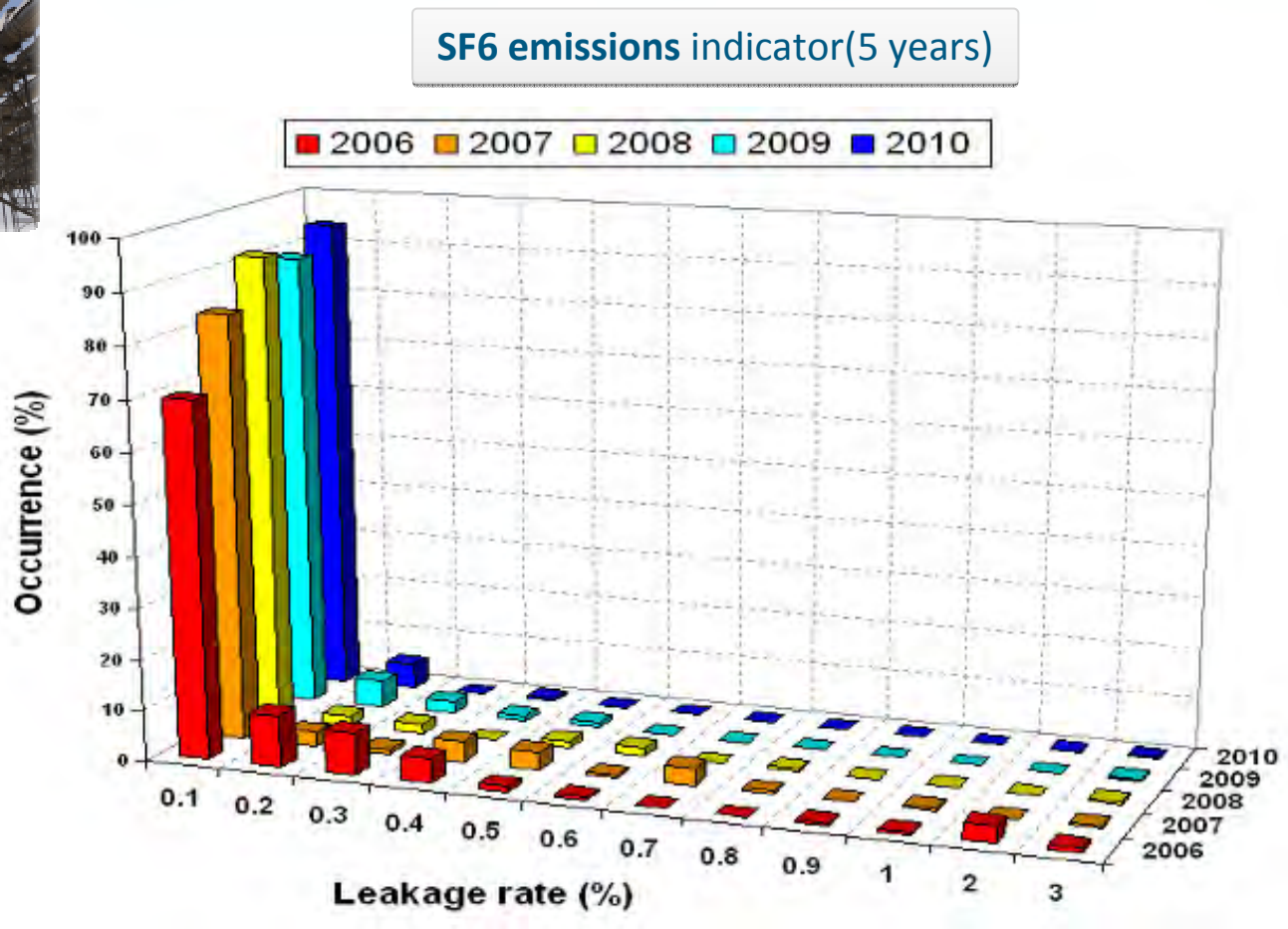
SF6 monitoring – data collection and analysis



400 kV GIS
10 bays
186 compartments
(indoor & outdoor)
16.3 tonnes SF6



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- **Circuit-breaker condition monitoring**
- Partial discharges monitoring
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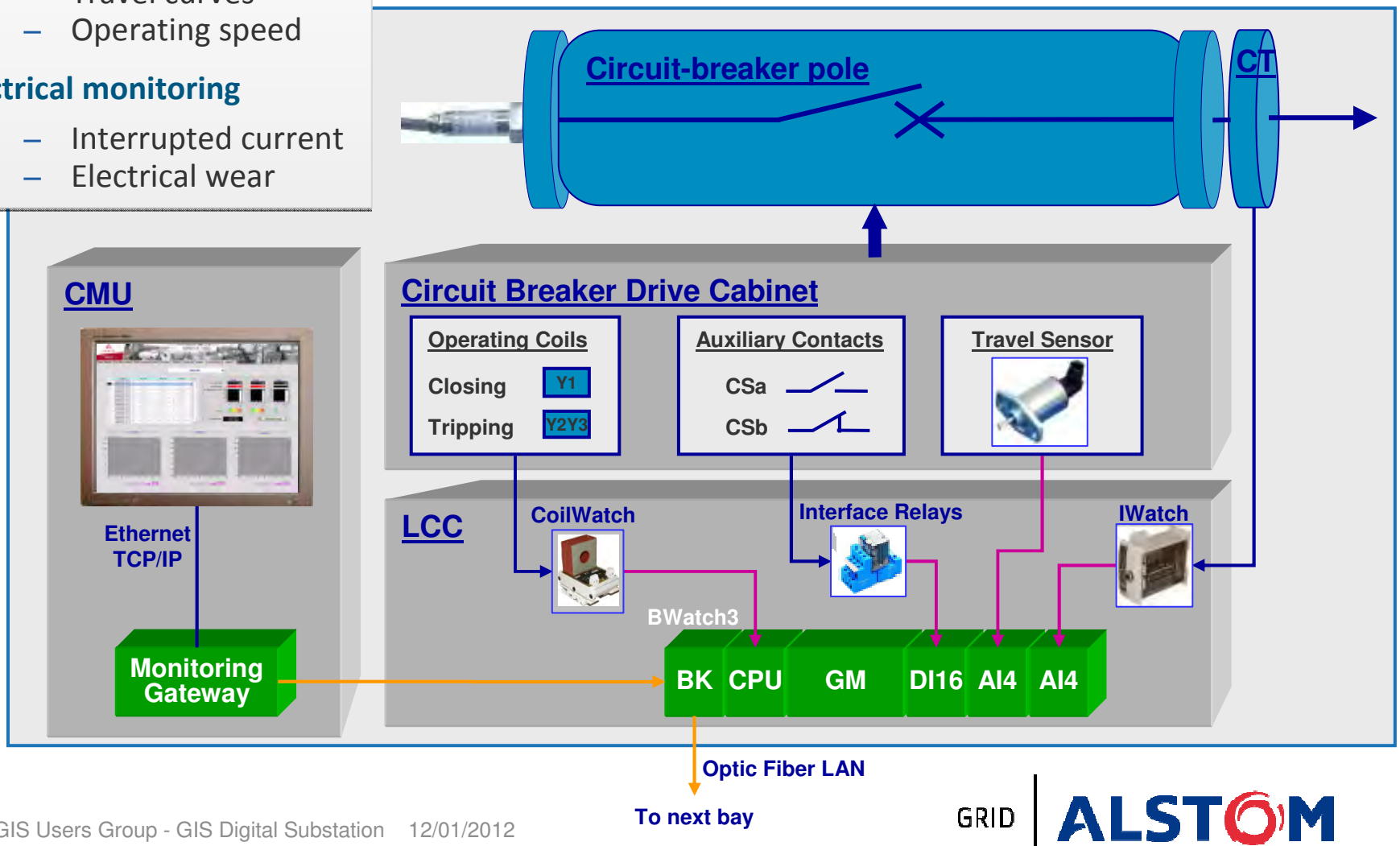
Circuit-breaker monitoring layout

Mechanical monitoring

- Travel curves
- Operating speed

Electrical monitoring

- Interrupted current
- Electrical wear



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CB Condition monitoring as support of control applications: PoW switching

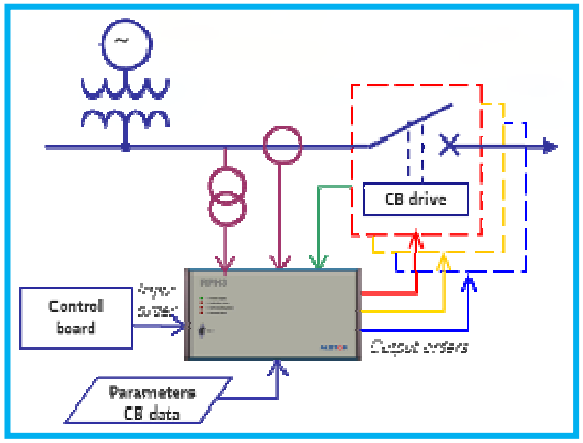
Fundamental principles for success of controlled switching

- Identification of a target moment
- Operating time reliable estimation

Main challenge

- **Perfect matching between the synchronous operating relay and the device being controlled**
  - Circuit-breaker's condition & parameters integration
  - Sophisticated algorithm including
    - Instantaneous compensation routines
    - Self-learning routines

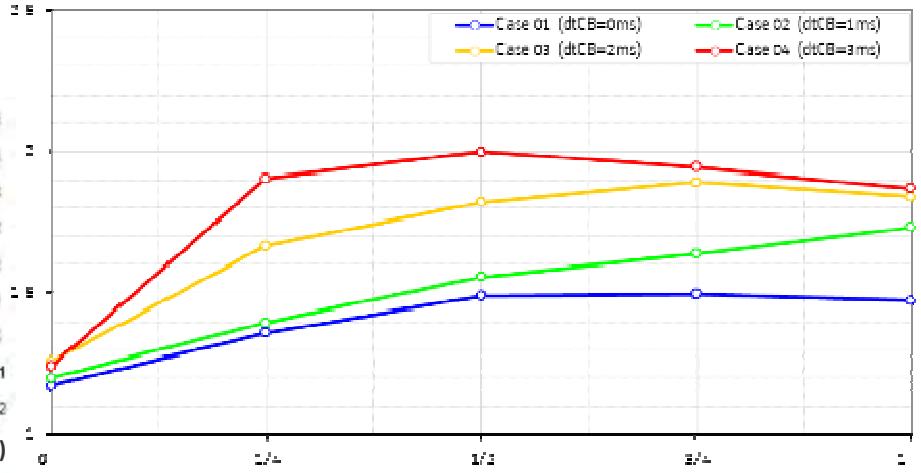
CB Condition monitoring as support of control applications: PoW switching



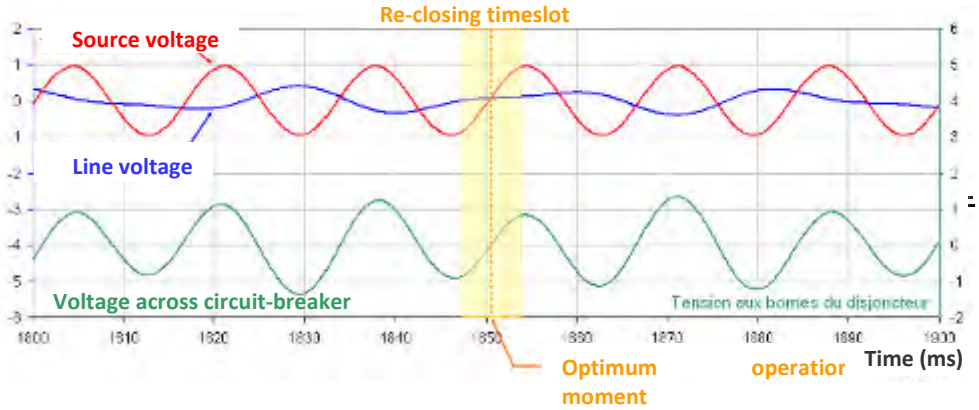
Transmission line switching application

- Single line to ground fault
- Single pole fast reclosing operation

Overvoltage profile along the transmission circuit



Reclosing time slot



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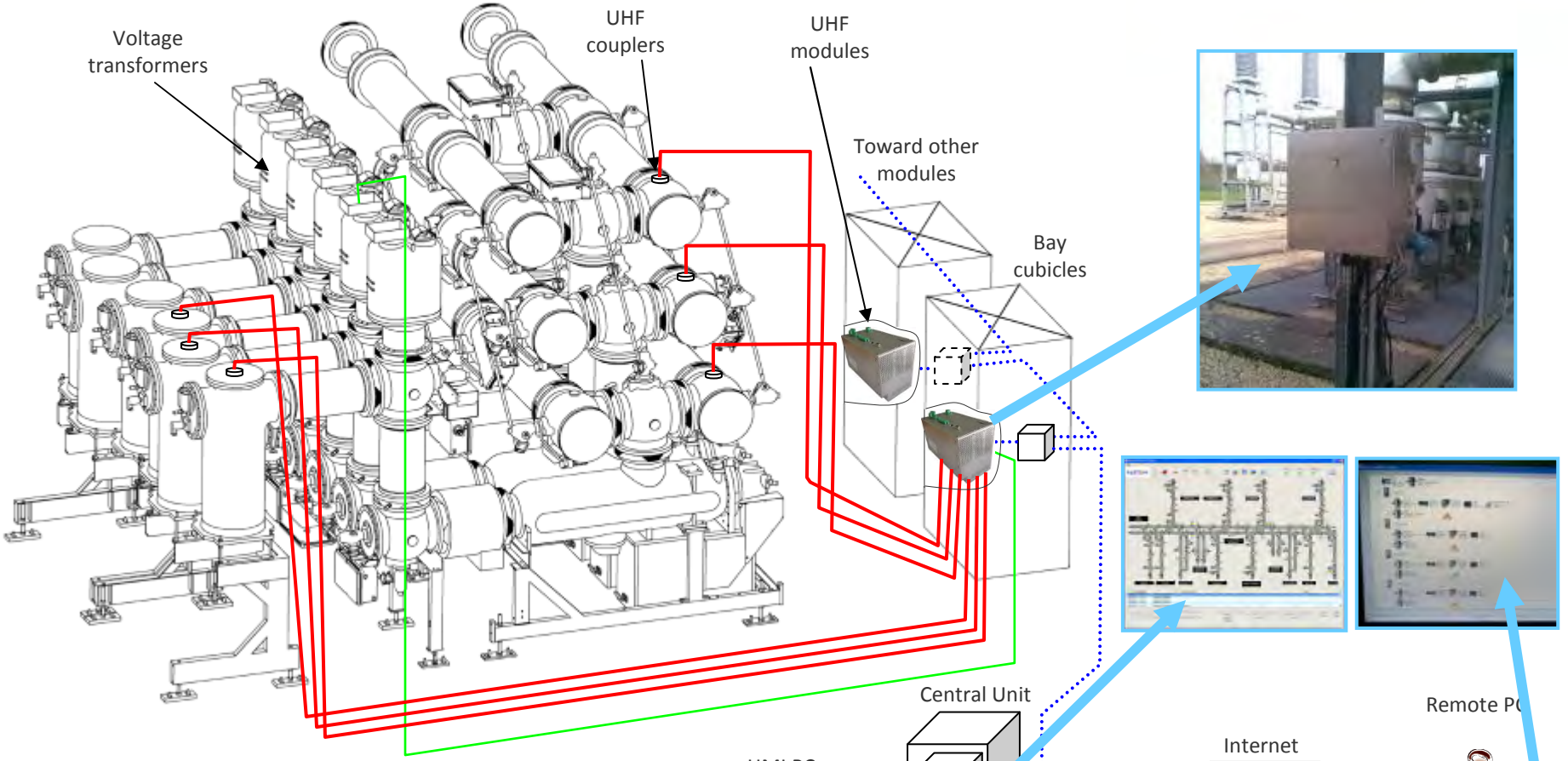
Typical layout on a GIS bay



Expert supprt group in GIS PL

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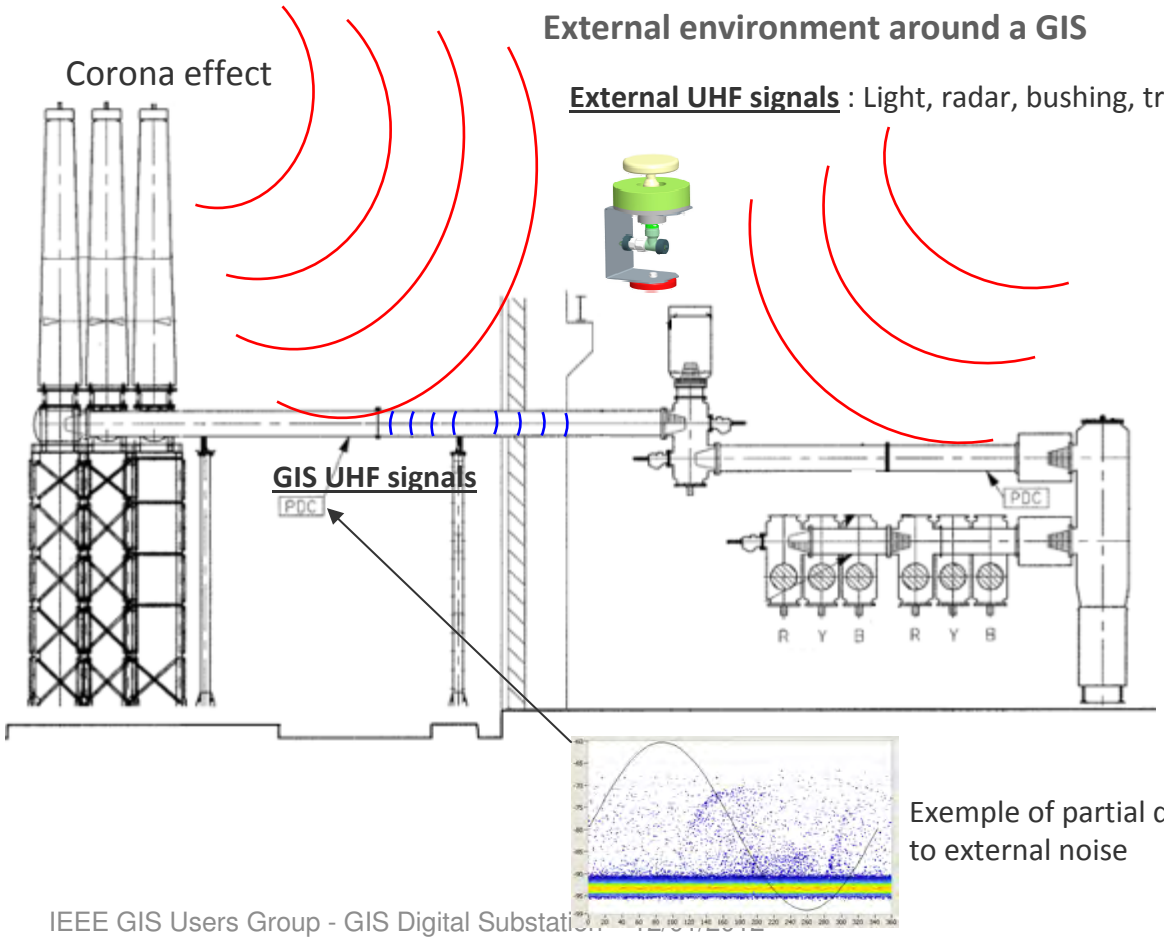
Operation & Maintenance help tool: PD monitoring

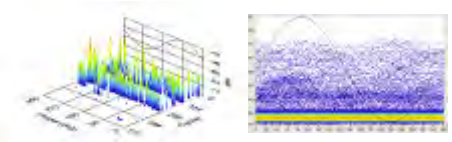
Main challenge

- **Generate alarms only in case of confirmed Partial Discharge**

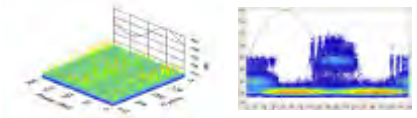


Exemple of partial discharge coupled to external noise

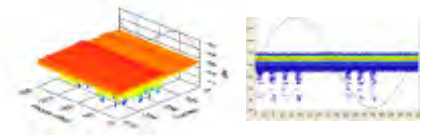
Light noise



Corona noise



Cell phone noise



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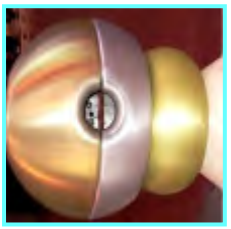
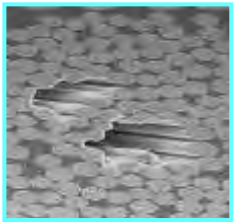
Partial discharge signal classification

Expertise: classification in 4 main types

- Protrusion electrode
  - LV protrusion (enclosure)
  - HV protrusion (conductor)
- Floating electrode
- Defective insulator
- Free moving particle





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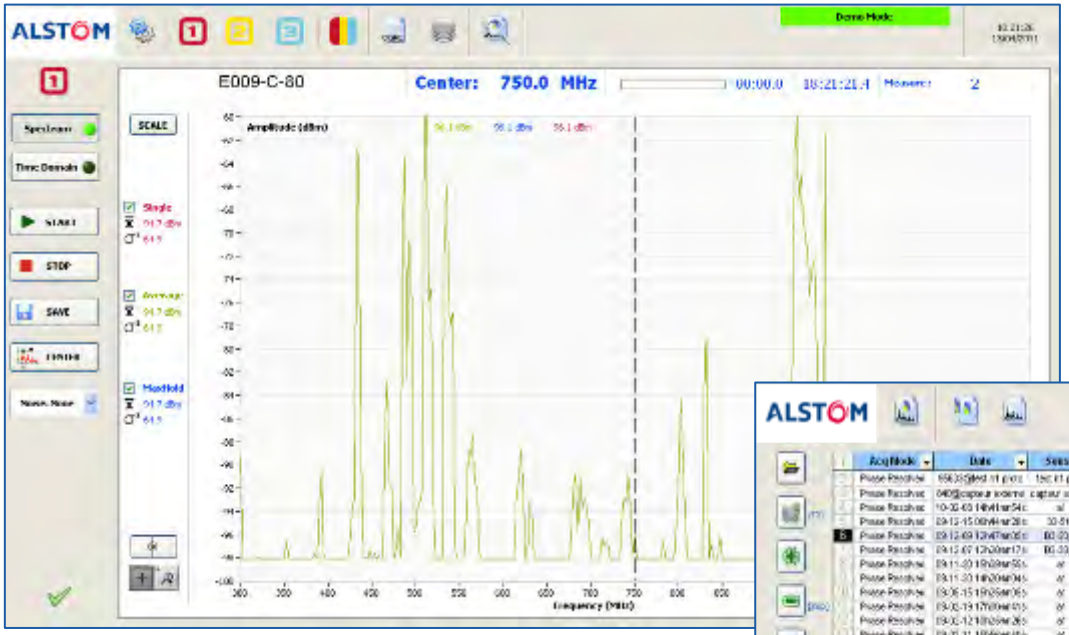
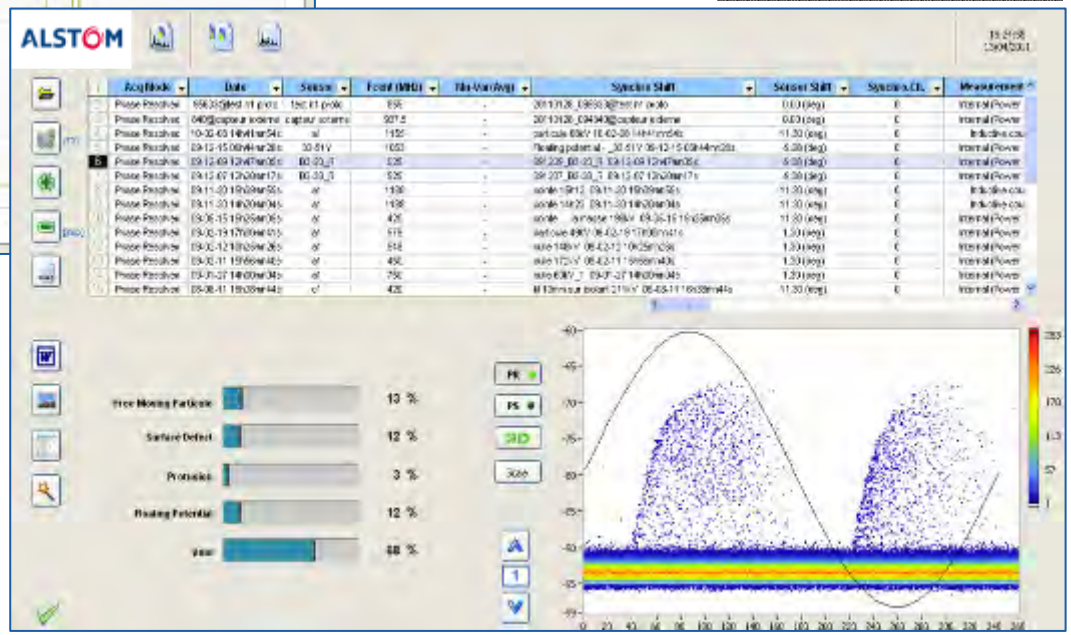
Partial discharge analysis methodology



1 - PD ACQUISITION

2 - PD EXPERTISE



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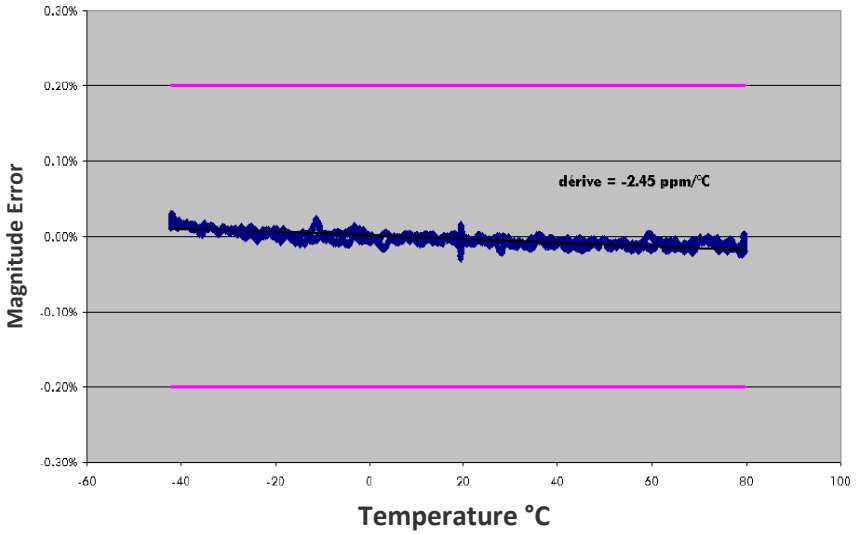
NCIT : Technology Choice
Advanced Measuring Systems for I &U

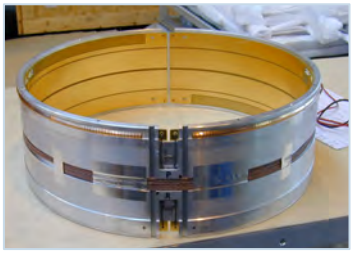
Optics - Electronics → Digital communication

AIS 69 to 1100 kV & GIS 145 to 800KV applications

Faraday Technology
Capacitor divider Technology
Rogowski Technology

Measurements are elaborated with new sensors, using modern technologies





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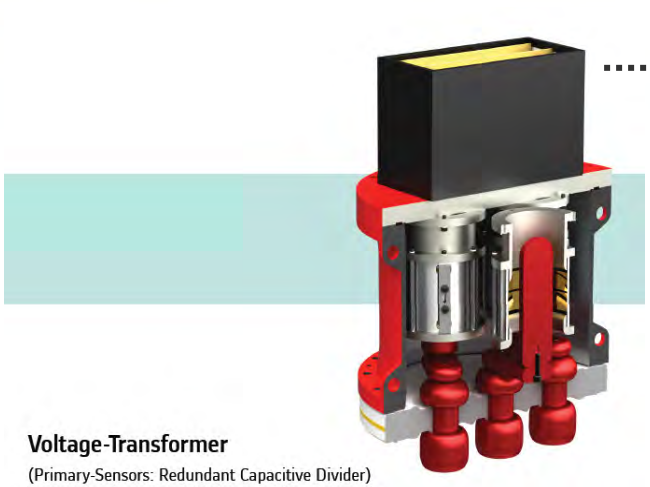
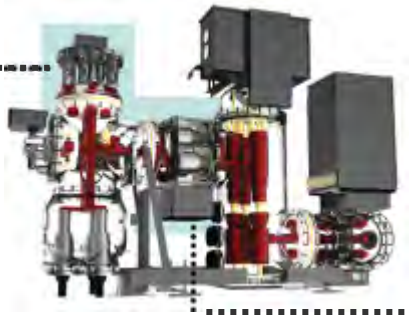
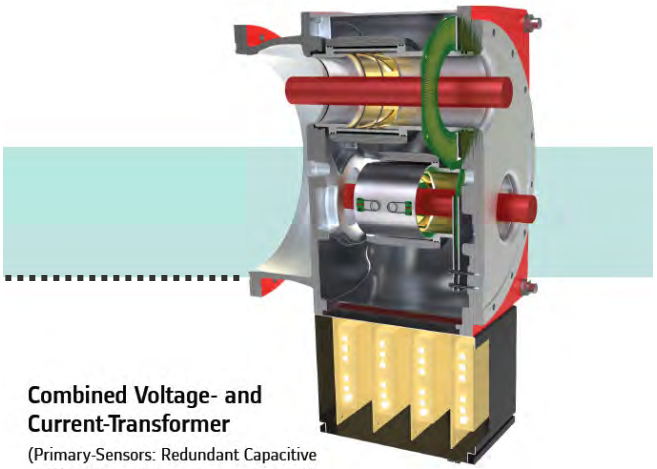
Sensor integration in GIS Example: F35 – Integration of CT & VT



Voltage-Transformer
(Primary-Sensors: Redundant Capacitive Divider)





Combined Voltage- and Current-Transformer
(Primary-Sensors: Redundant Capacitive Divider and Redundant Rogowsky Coils)

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OPTI-Control NCIT Integration in GIS

F35 – Integration digital LCC

Merging Unit

Distance Protection Relay

Digital Bay Controller

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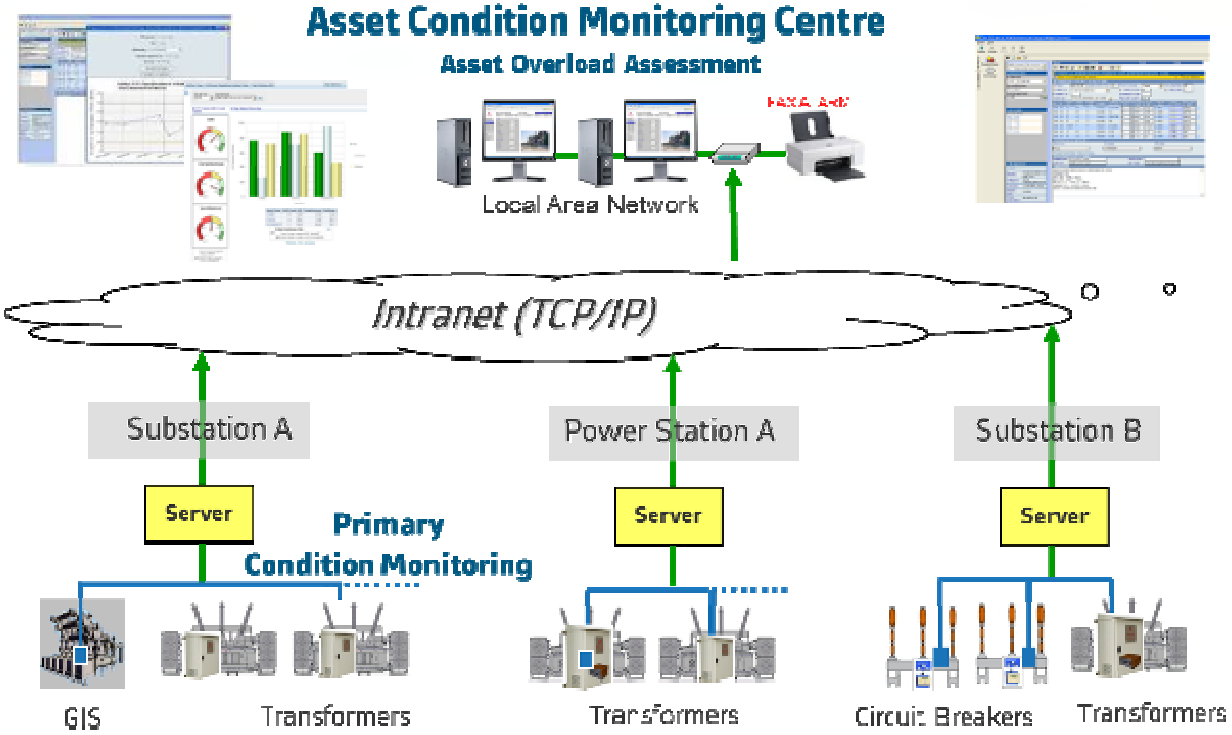
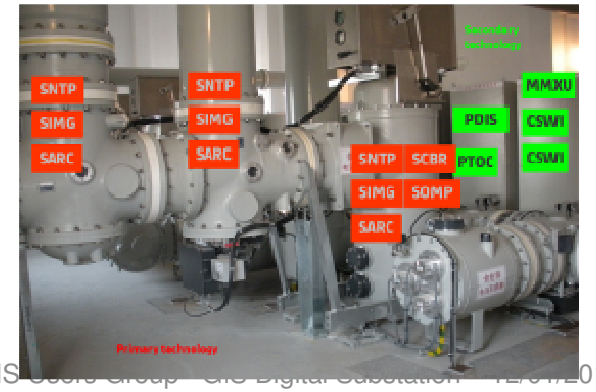
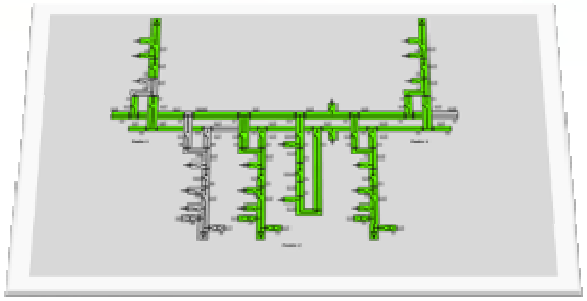
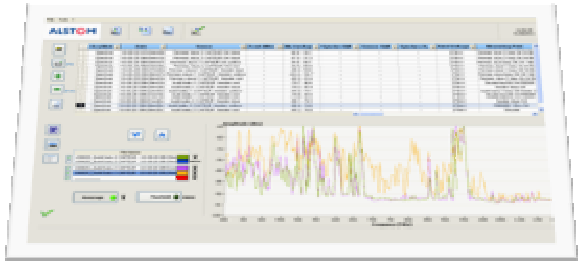
Condition: integration of monitoring applications thanks to expertise tools and IEC61850 models

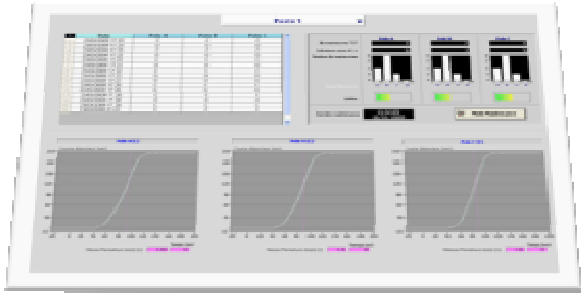




Firewall







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GIS monitoring - References

More than 120 GIS Substations commissioned with Digital Monitoring, 1100 IED'S and 18000 compartments monitored

All types of GIS voltage levels

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Digital substation in China during NCIT commissionning phase.

NCIT EVT

NCIT ECT

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Conclusion: establishing links between field applications

Integration of digital applications enables:

- **Correlation of strategic data**
  - Via IEC61850 network architectures
  - By powerful "Manager" tools
- **Optimization of operating and maintenance modes**
- **Opening to “Network Management System"**

The digital technologies are an invaluable path for optimization process between End-User and GIS equipment Supplier

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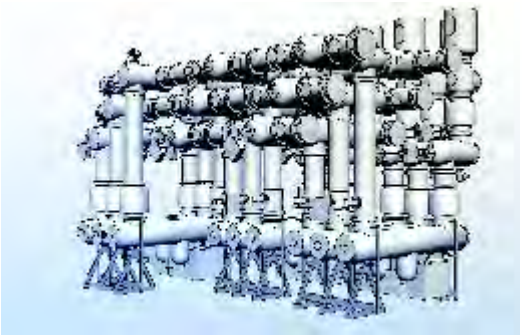
Thanks a lot
for your attention



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