# DERIVED SCADA FUNCTIONS FOR HYBRID CONTROL CENTERS OF NUCLEAR POWER PLANTS – AN APLICATION FOR CERNAVODA NPP

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*Cernavoda NPP is a CANDU 600 power reactor, PHWR type, exported by AECL Canadian designer in ROMANIA. CANDU 600 has plant computers used for direct reactor and main nuclear systems control and also for supervisory control of BOP and HMI functions. This concept leads to hierarchical centralized connection of around 1400 analog loops and 500 digital signals from various plant systems to control computers. Due to reduced computing capabilities of the old equipments the modern data processing was not available. Starting from year 2001 a process Ethernet LAN was built in connection with plant computers allowing data acquisition of historical plant variables and any on-line processing. Also two PXI type data acquisition computers were connected in LAN to have instrumented data from the two special safety shutdown systems. Many Gigabytes of historical data are stored now in LAN servers. Recent projects are focused on the use of SCADA technologies.*

*Romanian National Grid has recently interconnected with UCTE. The "Union for the Co-ordination of Transmission of Electricity" (UCTE) is the association of transmission system operators in continental Europe, providing a reliable market base by efficient and secure electric "power highways". Inside this union National Grid has requirements for every plant for quality of electricity and everyone is necessary to participate at grid frequency primary control. Plant droop respond very well at frequency variations but the challenge for the plant control equipment is to accommodate long term reactor variable power control to support variable turbine power. This control mode called 'reactor follow turbine', is very demanding for operation personnel: they are not comfortable with reactor power self modification, even it is limited control band. These concerns lead to the need of extra measures for instrumentation verification of calibration status: during frequency control all power measurement instruments has to work accurate and provide continuous on-line confirmation of any drift start. Accuracy of power measurements is also requested to guarantee power license limit of national regulatory board is not trespassed.*

*Cernavoda NPP is now in progress with implementation of SCADA technologies and is looking for available commercial packages which best fit into plant process LAN.*

**Keywords**: hybrid control center, SCADA, architecture, communication

## 1. Introduction

This paper is an overview of the implementations and development intents based on local experience and available data acquisition systems. There are also exposed expectations of plant personnel from these systems promises.

It is our opinion that the plant operation organization reluctance in front of new technologies may be defeated only by well organized and coordinated efforts of the technology groups inside organization to reveal the benefits and gain confidence by pilot projects. In Cernavoda NPP one of these technology groups is Control

Computers Group, a technical group responsible for software based automation systems from plant.

The plant is in commercial operation from December 1997 after a long construction period which made many types of equipment obsolete. This fact generated actual efforts for modernization.

Day by day engineering effort for safe and efficient plant operation needs implementation of new methods, as soon as these are matured. In this very beginning stage control computers group has taken the role of promoting these methods based on previous achievements related with data acquisition and the success of introducing IT based data analysis methods in all plant departments.

## 2. Hybrid Control Center

Control centers were traditionally equipped with control panels allowing centralized commands. From this places were decision makers supervise industrial processes there are commands sent through control loops in response of instrumentation signals grabbed here. Traditional analog controllers some times are powered by digital controls and the trend is in replacing analog with digital. It is the place where modern electronic data processing plays a major role in making operators action more effective in behalf of nuclear safety for public and production gains.

Power plant control centers comprise a number of specific workspaces that provide the facilities and tools to support operating staff in centralized supervision, control, and management of station safety and power production. These workspaces range from very specialized facilities (e.g., Emergency Response Centre for coordination of station response in large accidents) to conventional office and staff support facilities (e.g., office areas for shift work and outage planning, documentation and equipment storage, break and eating areas, and washrooms). The conventional practice has been to cluster the control centre workspaces adjacent to the plant control room. Operational experience worldwide has demonstrated that the accuracy, completeness and efficiency with which work is performed in the plant control centre is a key enabling factor in attaining effective plant operation. To achieve top regulatory and peer performance ratings, utilities require control centers whose workspace layouts, functions, support tools, and resources effectively support shift staff in working together to meet station operating objectives.

## 3. Data acquisition developments

During last years Control Computers Group developed a Plant Information System. This program was started with the Gateway system, a customized PC based system which allowed data transfers to and from the plant computers for various needs. Initial process variables trending facilities became available for Responsible Systems Engineers, the qualified personnel in charge with various plant systems surveillance. Using from the beginning WEB based technologies and process LAN, the system became very popular. After high quality reactor scram analysis using the electronic data were conducted and after these reports expedited the national regulatory board approval for plant restart, the plant management has planned the

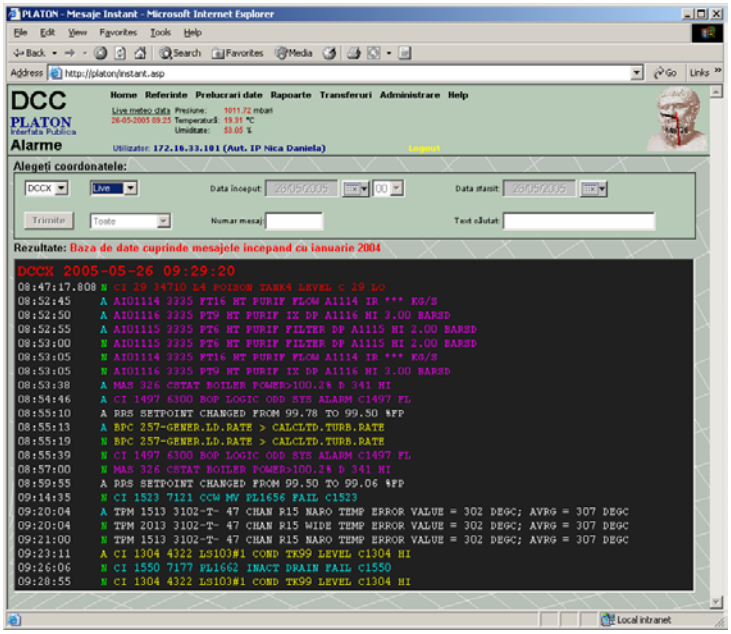


Figure 1 Expandable on-line systems help operators

development of some on-line systems and technologies.

At that moment became evident that Historical Data needs be preserved for any post-event and long term systems behaviors analyses. The response of Computer Group was to set up data servers for long term data storage and develop trending tools for current work needs, available in any PC of the corporate LAN. The result was an increased number of personnel became familiar with the system. For the time been there are almost 400 registered users of the system and every day the system is used by 50 to 100 people.

The on-line system has a number of other applications. It is accepted that an on-line system can handle multiple functionalities on the same hardware support. It is only necessary to be careful with system redundancy. An example from Cernavoda NPP local experience is how data can be processed in behalf of Main Control Room operation needs: The system was able to handle on-line plant alarms generated by control computers. The process LAN system which also handles the printing of alarms in control room was prepared to create data bases of alarms. An idea at that time was to make real time access to all plant personnel at these alarms. As could be seen in the picture a replica of the control room annunciation was made available in every business PC connected to corporate LAN together with selection tools for alarm filtering. We found useful to have these alarms in process network due to the very good synthesis of plant events it provide. The next step was natural and evolved the system to the plant operation dimensions. This step was to make alarms mouse sensitive and connected to the Alarm Response Manual (ARM). A click of the mouse open on the PC display the appropriate page of ARM to fully explain the alarm and automatic/operator actions associated with the selected alarm. In this way the system added important operator training dimensions but most important was the ability to fast support the Main Control Room Operator with actions he must take. The benefits of having such a fast system available in Main Control Room generated a new project consisting in qualification of the system as a Main Control Room system. This helped to provide enough reliability and redundancy to the system, useful characteristic for new applications (like OLM) which will be inserted in the system.

Daily plant activities are supervised by technical departments as part of Plant Systems Surveillance Program. The figure bellow illustrates how a feedwater valve changeover appears on trending screen, allowing on-line mode supervision. The trending system was prepared to record so called 'data sets' which every user can set.

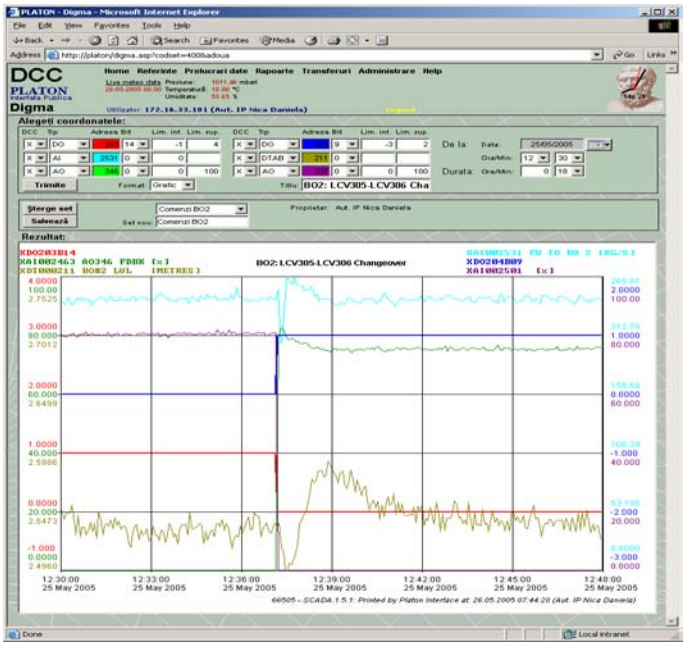


**Figure 2 – A trending data set create process patterns**

These are groups of parameters and attributes associated with individual specific activities in plant which have the best representation in the data trending screen. Every data set is recorded with a proper title which allows easy retrievals. In the picture you can see an example for "**BO2:LCV305-306 Changeover"** data set used by the plant engineers to monitor correct operation of BO#2 LCV's. Moving this data set to other time stamps allow simple verification by easy graphically comparing a standard template with the data set after the valves were operated. At these point became clear that automating of such template verification will be the beginning of *equipment condition monitoring* at Cernavoda NPP and also that the big amount of data we store will be more efficiently exploited. We followed patterns verification approach in several practical cases. Such a case was when behavior of reactivity mechanisms was subject of lack of confidence. Comparing the pattern of the rods insertion sequence with previous normal patterns regained confidence in reactivity mechanisms capability. This was reported to National Regulatory Board which accepted and permitted plant start-up.

Special cases were plant templates are relatively well known are graphical displays of control computers. It is operator's action to produce hard copy of computers displays when unusual activities are observed. The Plant Information System has capability to record all hardcopies produced in control room. This will allow much easy case identification for model training when OLM methods will be implemented.

## 4. Available IT technologies for SCADA implementation

At Cernavoda NPP intention is to attach the SCADA functions to the Plant Information system on a permanent basis. Here we discuss several facts that motivate this solution. The plant information system proved to be available for indirect process variables calculations and signal processing like filtering which allow on-line supervision of important plant parameters. Such a development which encourages insertion of SCADA functions is the PHYDIS software. This is a program which on-line calculates the exact inventory of large heavy water mass in various plant recipients and determines presence of leaks. In the picture bellow could be observed an example of daily fluctuations of heavy water in main tanks and in the next picture the associated variations of the rate. The success of integration of such program gives

direction for the future developments. New SCADA functions can be attach to Plant Information in the two possible methods: *in batch-mode* new software will use SQL interrogation strings on real-time data base and *in on-line mode* using real time connections at OPC server. The OPC server allows access to any process variable which is connected to the system from any PC node in process LAN. Having these two connection techniques at plant data, equivalent from OLM point of view, we can now imagine any integration versions.

Historical plant data system need continuously be improved by including other data islands relevant for process descriptions. Various *daq* systems should be interconnected. Because every system has at least triplicate instrument channels for a process variable this is a good way to increase the number of instruments contributing to parameter estimate. In the phase of calibration reduction this will reduce the number of planned calibrations. To provide uniform interface for applications a LAN server must concentrate all plant variables. These variables could be connected in real time through the above mentioned OPC server or from the aggregated data base by unified naming conventions and data path. In the figure bellow could be observed the way signals from control computers (DCCX&DCCY) are aggregated with signals from Special Safety Systems 1 & 2. Because all field instruments are connected to both control computers then this is useful for validation of digital segment of instrument loops. For the safety systems additional data acquisition equipment was installed. High speed PXI type PCs and appropriate signal conditioning is able to perform even noise diagnostic tasks.

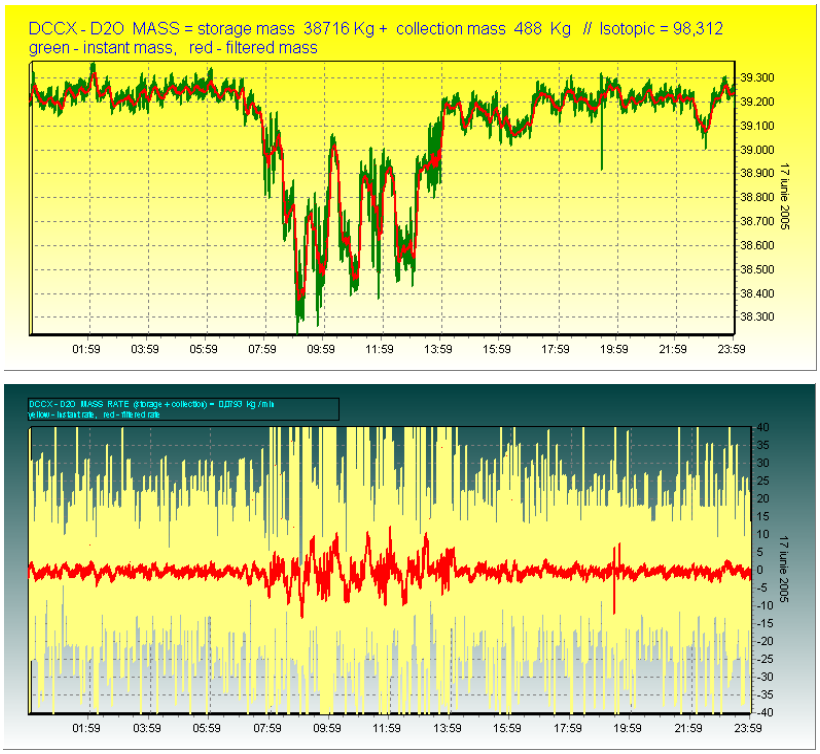


Figure 3 - Example of attached calculated data at Plant Information System

## 5. Other identified use of SCADA functions

As could be seen in the bellow picture the information from Plant Information system is used also in the Emergency Control Center (ECC) for coordination of station response in large accidents. The safety concept used at Cernavoda NPP requires 2 such centers, main and alternate ECC. Special application in ECC is Critical Safety Parameters Monitor. This is a symptom based system expected to be

used during harsh conditions of site accident.

The design of this system raised concerns about the sensor accuracy validation. That's why sensors connected at this system are associated with Plant Post-Accident Monitor system in Main Control Room, a bulk of earthquake and environmental qualified sensors. In ECC there are no means to verify accuracy of sensors as in Main Control Room where there are methods of validation which could be performed using alternative panel indications and Secondary Control Room sensors. For the time being on-line calibration methods seems to be a candidate for sensors validation in ECC pre and post accident.

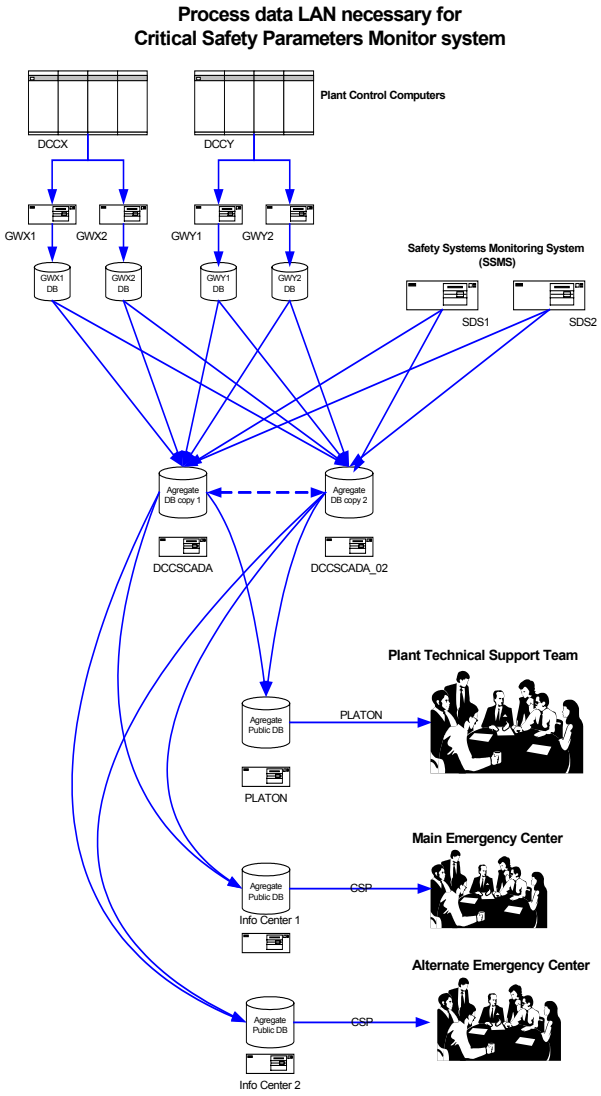


Fig.4

A very accurate functionality of Critical Safety System is essential due to the fact that this is the main automated system which shows the plant status and safety conditions of nuclear fuel during a site accident. Considerable investment in LAN infrastructure is needed due to long distances between ECC and the Main Control Room of the plant. Modern cheap fiber optic cables allow best implementation.

## 6. Conclusions

Various forms of SCADA technologies exist in the recent history of Plant Information system and these facts prepared the plant personnel for impact of new automated methods.

The Plant Information system at Cernavoda NPP is a strategic investment and several developments are in progress. As soon as this system became qualified for operation use it will contribute to the evolving plant control center needs and will constitute the baseline for the development of new automated facilities.

In today developments it is common and natural the integration of On Line Monitoring methods for evolved plant needs. This approach will combine real-time data acquisition and real-time processing with off line asynchronous activities such calibration databases from maintenance department or neutron flux and fuel assessment of reactor physics group.

This goal has to be achieved by selecting appropriate software package compatible with IT technologies already available in Plant Information system.

After the system became operational it will serve other automated facilities of the plant and not only calibration reduction initiatives or on-line signal accuracy validation.

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