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PROCESS CONTROL MIGRATION TOWARD LHC VENTILATION FUNCTIONALITY

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Abstract

The adaptation of the ventilation systems as well as the integration of equipment to fit with the new LHC ventilation requirements lead us to consider a global re-engineering of the existing control system. This, decade old process control structure is composed of elements which are mixed between industrial and home made devices. The proposed modifications are made in order to upgrade the present control system and to provide efficient and well adapted control architecture to integrate the LHC ventilation equipment of the injection tunnels. Moreover, we need a plan for the next fifteen years of the LHC life cycle. The document is to present the situation of the present control system of the LEP ventilation process and to propose a plan for the migration of the control architecture. This is done considering the fact that elements of the present control infrastructure could no longer be supported from 2003 and major components must be removed from the CERN communication infrastructure.

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INTRODUCTION

The adaptation of the present ventilation systems as well as the integration of new equipment to fit the LHC ventilation requirements lead us to consider a global re-engineering of the existing control system including the re organization of the control architecture. This is done in order to adapt a decade old process control structure. This structure is composed of elements which are a mixed between industrial and home made devices. These modifications are to be made in order to upgrade the present industrial control system and to provide a complete, efficient and well adapted control architecture to integrate the LHC ventilation (which will be removed from the LEP) equipment of the injection tunnel and to face with the next fifteen years of the LHC life cycle and without becoming obsolete.

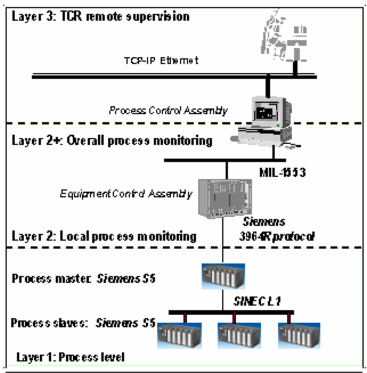

Figure 1. Present control system architecture for the LEP ventilation installations

1 GENERAL DESCRIPTION OF THE PRESENT SITUATION

1.1 The Process level

The process level *"slave structure"* is composed of multiple Siemens PLCs S115U. Each PLC is in charge of one or several air handling units and their associated dampers. Its role is to ensure the proper running and monitoring of these units. The process level *"master structure"* is composed of a Siemens PLC S115U. The master PLC is in permanent communication through the Sinec-L1 bus, with the process PLC slaves. The master monitors all the exchange of the ventilation process data bases between the slave PLCs sharing the same communication bus and located at the same point. It monitors also the exchange of the ventilation process database with the other master PLCs located at different shafts.

1.2 The Local Process Monitoring

The local Process Monitoring is a combination with of three different components:

- The ECA (Equipment Control Assembly), which is considered as a gateway from the process PLCs to the upper level.
- The PCA (Process Control Assembly), which drives the different ECAs and provides an overall monitoring and status through the transmission of information and process commands along the accelerator.
- The MIL-1553, which is the bus interface between the PCA level and the different ECAs.

2 ON NECESSITY OF A CONTROL ARCHITECTURE MIGRATION

2.1 Introduction

The motivation for the upgrade of the present structure is the replacement of old technology elements that are no longer supported –or that will not be supported in a short term and the need to adapt the control system to follow further requirements.

2.2 The Helix Project

The existing control infrastructure, which is presently supported by the SL-CO Group is going to be reengineered during the oncoming two years (approximately up to end 2004). The SL HELIX Project refers to the HP-10.20 Eradication & Linux Integration of the SPS/LEP controls infrastructure. The main goal of this project is in a near future to replace the PCA, ECA and the associated MIL 1553 bus in the CERN technical infrastructure. The consequence for the process control of the LHC ventilation is that layer 2 and consequently the process communication, will disappear and must be replaced with an industrial communication infrastructure.

2.3 The Sinec L1 bus

Siemens has confirmed that the Sinec L1 bus is not longer supported. The production, support of the different bus components, as well as the communication card, has been stopped by Siemens. In a short term the problems put forward by the lack of spare parts will have a direct effect on the PLCs communication stability.

2.4 LHC new requirements

The new installations for the ventilation process of TI2, TI8 will be fitted with a new generation of PLCs. These new equipments should be integrated in the present control architecture and the ventilation process should be controlled and monitored. The possible different operating mode and consequently the different air flow working point required for the LHC might involve some functional modifications in the PLC application software of the air handling units involved for the ventilation of the tunnel.

3 DESCRIPTION OF THE PROCESS CONTROL MIGRATION

3.1 Introduction

The project of the process control migration concerns the modifications of the present control architecture and its environment. It includes the PLCs for the ventilation of the LHC main tunnel, the different alveoles and PLCs for the ventilation of the injection tunnels TI2, TI8. The development of the TCR-SCADA applications to assure the TCR remote monitoring of the ventilation process is also to be considered as part of this project.

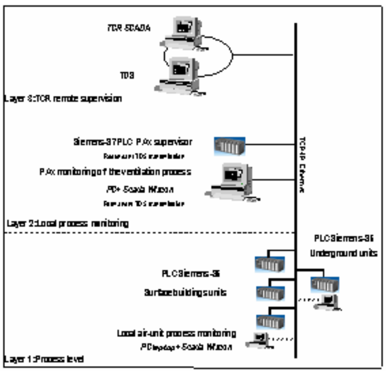

Figure 2. Process Control system architecture for the PAx-LHC ventilation

At the process level (layer 1), the objective is the substitution of the local Sinec-L1. The retained solution is to consider the TCP-IP Ethernet network as a fieldbus. This solution is well adapted to the geographic configuration of the different air handling units. It facilitates the integration of the present and future PLCs and permit to avoid any long distance fieldbus cables between the considered surface buildings and the underground area. This well known solution is technically the most appropriate to reduce the cost of software development for the PLCs communication and give a good level of flexibility over the coming years. Laptop PC which contains the local SCADA applications permits through Ethernet a local connection to the PLCs running the air handling units. It also provides status information of the different units involved in the PAx shaft

At the local process monitoring level (Layer 2) a Siemens S7- PLC supervisor of the area replaces the master S5-PLC. Its role is to handle the operating mode. It receives orders from the upper level and dialogues with the others PLC supervisors on each adjacent shaft. It issues commands to the appropriate PLCs at the lower level and contains an exact copy of the entire alarms and events data base situated in each PLC. Additionally, it manages the communication and dialogues with the TCR Technical data Server in order to assure a redundant transmission to the SCADA station of the information of the TCR applications.

The SCADA-Station provides an overall monitoring of the PAx installations through local standard synoptics. It manages the communication and dialogues with the TCR Technical Data Server in order to assure the permanent transmission of the information with the TCR applications.

At the TCR level (Layer 3) the TDS is either in permanent communication with the PAx SCADA Station or the PAX supervisor PLC to assure the transmission of the ventilation process information. The PVSS2 SCADA contains the MMI applications for the remote monitoring of the ventilation units.

3.2 Potential constraints

A number of factors must be considered at the beginning of the project and will have a consequent influence on the work load and the financial evaluation in parallel.

- Lack of documentation on PLCs air-units application software
- ECAs is more than a basic gateway: certain commands has been programmed directly in the ECA.
- Siemens Siclimat-software used is not *standard software,* available any more. The programs need therefore to be migrated to another software platform.

3.2.1 Lack of update documents

Some important modifications have been realised in the early stage of the LEP project. These modifications have not been commented in the application software and reported to the existing documentation. Moreover, not any flow chart or functional algorithm on the process has been produced. The existing documentation cannot serve as a base document. This complete lack of update documents requires a pre-analysis of the current application programs running the air handling units.

3.2.2 ECA is more than a gateway

In the present control architecture the ECA device is normally considered as a basic gateway. Its main role at the lower level is to handle the communication port in relation with the master PLCs and collect the complete database of the ventilation process. However, the ECAs of the ventilation process have not only been considered as a basic gateway but a complementary device to the PLC. The ECA contains some part of application program which now should be introduced in the master PLC. The preliminary work shall be to clearly analyse and identify the functionality of these programs and re-introduce them in the future master PLC application software.

3.2.3 Siemens Siclimat-software is not a standard software

The Siclimat software is a specific application-layer developed software from the Siemens S5 PLCs development software. It is based on particular functional blocs specially designed to perform automated task in relation with the ventilation applications. The Siclimat-software has never been upgraded over the last years. We must therefore refer to the initial version developed and provided by Siemens during the construction of the LEP accelerator.

4 VOLUME OF THE WORKS

4.1 Preliminary re-engineering

The re-engineering of the process is a preliminary stage to any functional analysis. It allows the realisation of an inventory of the present application programs on the different PLCs running the ventilation units. It constitutes a fundamental stage for a complete verification of the operating modes currently in used. Its main goal is to prepare a complete updated documentation. The quality of the successive functional and dysfunctional analyses will depend on the good achievement of the preliminary re-engineering stage. The preliminary re-engineering stage comprises the following steps and must be considered for every PAx:

4.2 Scope of the work at the Layer 1

The work at the layer 1 represents about 60% of the global works foreseen per PAx including the integration of the underground and TI2, TI8 units. It comprises the following steps per PLC:

- Installation of Ethernet Network
- Modification of the PLCs hardware structure
- Adaptation and or modification of the application programs
- PLCs Ethernet Software integration and data transmission
- Functionality tests

4.3 Scope of the Work at the Layer 2

The work at the layer 1 represents about 20% of the global works foreseen per PAx. It comprises the following steps per SCADA-Station and supervisor PLC:

- Integration of the PLC supervisor
- Integration of the SCADA-Station
- Local Process PLCs data transmission
- PLC supervisor to PLC supervisor for (PAx to PAx-1, PAx+1) data transmission
- SCADA-PLC data transmission
- SCADA to TDS integration and data transmission
- PLC to TDS redundant integration and data transmission
- Preparation and validation of the TDS database
- Functionality test

4.4 Scope of the Work at the Layer 3

The work at the layer 3 represents about 20% of the global works foreseen per PAx

Development of the TCR remote synoptic on PVSS2-SCADA

MMI Test and alarms validation.

5 CONCLUSION

This document explains the present situation and gives a solution to cover the further LHC area. This is done considering the fact that major components of the present architecture (Siemens-PLC) are preserved in their original structures. Only the necessary works to integrate the Ethernet communication are to be considered as the most consequent modification. This project seems to be feasible and shall normally be completed for the LHC start-up in 2006. This assumes an organisational project structure adapted and a financial issue in relation with the proposed estimation.