

THE COMMISSIONING OF THE CONTROL SYSTEM OF THE ACCELERATORS AND BEAMLINES AT THE ALBA SYNCHROTRON

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Abstract

Alba [1] is a third generation synchrotron located near Barcelona in Spain. The installation of the Control System for the Accelerators (Booster, Storage Ring, Transfer lines and Front-Ends) finished at the end of 2010. The final functional tests took place during the first weeks of 2011, right before the commissioning of the Storage Ring, which started the 8th of March. Currently we are carrying out the final stages of the installation and commissioning of the seven experimental stations of the phase 1 (known as Beamlines at Alba). The control system is based on the middle layer provided by TANGO combined with open source SCADA, Sardana [2][3][4]. It is highly distributed relying extensively on Ethernet as a Field Bus. It combines diskless machines running Tango on Linux and Windows, with distributed PLCs connected to remote peripheries. In several cases, application specific hardware has been produced in house. This paper describes the design, requirements, challenges and the lessons learnt during the installation and commissioning of the control system.

THE CONTROL SYSTEM

The infrastructure implicated in controls includes more than 350 racks, 6300 equipments and 17000 cables. The controls architecture is highly distributed, comprising about 2500 network devices. The central Tango Installation for the Control and data acquisition of the accelerators has today 5680 devices and 1480 processes running.

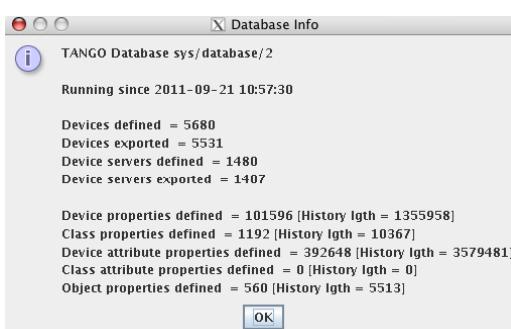


Figure 1: Summary of the Tango database for the control system of the Accelerators.

Besides the controls for the Accelerators, there is one control system per Beamline, implementing the same architecture, running on industrial PCs installed in the Beamline and virtual machines in the computing room.

Each Beamline has an independent Tango installation, controls hardware and disk space in the central storage. The networks between machine controls and Beamline controls are separated, having a firewall in between. Thus the interfaces between Machine and Beamlines are implemented via virtual machines acting as gateways, and PLC direct connections.

In this first deploy of the control system for the accelerators comprises about 84 cPCI, and 22 industrial PCs distributed in the service area, all diskless running Linux openSUSE11.1 with a kernel 2.6.27 (known as Input/Output controllers or IOCs in our naming convention). The central services run in multicore servers or virtual machines in the computing room. We extensively use Nagios for monitoring controls IOCs, workstations, services and servers. Nagios combined with the Alarm system [5] has been of a great utility during the commissioning and operation.

INSTALLATION

The installation of the control system started with a prototype for the control system of the Linac-to-Booster transfer line (LTB), which was installed at the end of 2007. That installation served to test our management tools, external contractors, and to tune the project planning and execution. The year 2008 was mainly focused on the mechanical installation of the equipments of the Accelerator. In 2009 the booster was carried out and in 2010 the Storage Ring. The installation of the controls for the Beamlines was more spread in time. It has mostly occurred between 2010 and 2011.

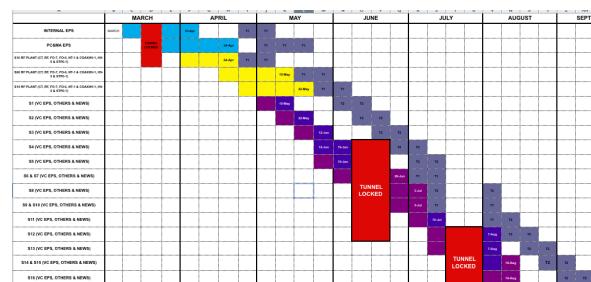


Figure 2: Cabling installation and verification, sequenced over the 16 sectors.

One of the biggest challenges was the coordination of the cabling in the different sectors combined with the check of the different subsystems, in particular EPS. The installation of the cabling for the Accelerators has been accomplished roughly in thirteen months, four months for

installing about 1200 cables of the booster and nine months for installing the 9000 of the storage ring.

MANAGEMENT TOOLS

During the installation and commissioning, a detailed plan, the commitment of many people including external contractors, and the assistance of a number software applications have been determinant for success. The most important are the cabling database [6], the request tracker (RT), the timeDB and the project management tool.

Cabling Database

A central database manages all the definitions, names and plug information related to equipments and cables. This is the central repository where types of equipments, cables and connectors are declared allowing later managing instances of every item. The types of equipment, connectors, cables and “cable configurations” are defined and inventoried as the first step. Next, instances of equipments, cables and connections between equipments are defined. Once this was completed, the cable lengths have been calculated and the manufacturing order has been determined. After the cables have been received they were installed in the final position, labelled and verified. The cable database plays a key role in all phases. Reports for manufacturing, labels, and diagnosis of the tests are generated from the database. In order to do this, the information must be consistent at any time. This has been a great challenge and an important key for the success.

Having a consistent and up-to-date central repository of the equipments and cables for the control system opens many new possibilities from the installation and operation point of view. During the pre-installation phase, the equipments were assembled, mounted and tested in the warehouse, and the record of those tests was kept in the database. Also valuable information like MAC addresses, IP addresses, boot servers, etc. was added during this phase. This made possible to create from the cabling database, configuration files for several network services, such as DNS, DHCP, Radius.

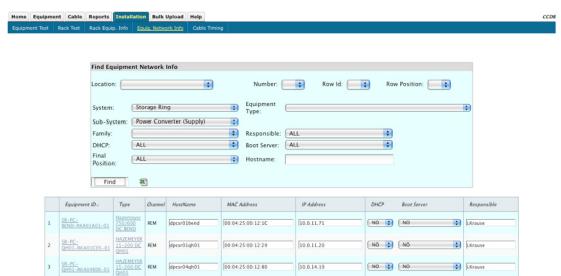


Figure 3: Snapshot of the web interface of the Equipment and Cabling database.

Many components of programs running in the PLCs of the Equipment Protection System are generated automatically from the database. The huge effort done for keeping the database up-to-date and consistent pays back

here, when software components are generated automatically, reducing errors and increasing the efficiency. A Visual Basic Script running in excel creates files containing the declaration of variables, data structures, software tasks, Modbus mapping and documentation. The Logic is still programmed manually due to the difficulty managing the large number of exceptions to the standard interlock rules. In addition, Tango attribute names and the expert GUIs are also generated from the controls equipment and cabling database.

RT

RT (Best Practical Solutions LCC), has been intensively used in the computing division. It is a great tool for implementing ITIL [7] practices. Tickets are distinguished between Incidents, problems, User Requests and Request for changes. After their creation they are assigned to Unit services and to a responsible.

TimeDB and the Project Management Tool

The time spent in projects, services, problems or any other task is logged and managed by another web application, the timeDB.

Projects are managed following the PRINCE2 methodology [8], and assisted by the Computing Project Management tool, another application developed by the Management Information System group (MIS), and extensively used by the entire Computing division. It handles Business Cases, Plans, Risks, Communication management, etc. up to Project Initiation, Highlight and Exception Reports.



Figure 4: Trend chart of the time allocated in the computing division in the years 2010 and 2011. Green corresponds to Services, Blue to Projects and Red to RT.

COMMISSIONING

The commissioning of the control system started at the beginning of 2008. A prototype of served to both test the concept and do commissioning of the LINAC and the transfer line. Later, at the end of 2009 the commissioning of the Booster started. It took place during few days in

2009 and the first weeks of 2010. At that time, RT was setup and tuned, adding the concept of services (as described in ITIL best practices), combined with incidences, problems and different type of requests. We also improved the project management tool and the timeDB.

In November 2010, the control system for the machine was ready for operation, but unfortunately, due to a delay in the authorization permit issued by the local authorities, we started only few weeks later, the eight of March 2011. In the meanwhile, we changed the schedule and we installed 3 (out of 6) insertion devices. The 16th March 2011 we had the first accumulated beam and the 18th we opened the first Front-End (BL09: a Beamline on a Bending magnet). In June the Front-Ends corresponding to the two helicoidal undulators and the conventional wiggler were open. The Machine was shutdown the tenth of June, to allow the installation of the remaining insertion devices.

During the summer we installed two in-vacuum undulators and one superconducting wiggler. We setup the cabling, electronics and the control system and we restarted the machine at the end of August.

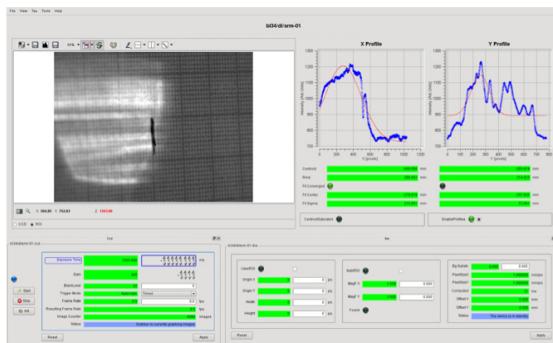


Figure 5: Snapshot of the first beam seen as visible light from a bending magnet taken the diagnostics Beamline.

During the commissioning, the management tools and the on-call service were fully operational. The computing division had a total of four persons on-call simultaneously, two controls engineers, one Electronics engineer and one system administrator. In the RT's controls queue, there were 192 standard requests and 49 tickets directed to the on-call service. These tickets were about half incidents half request for changes.

There were few losses of the beam due to the control system. Most of these unjustified interruptions of the service, have been due to Interlocks, either provoked by the Personnel Safety System (false intrusions or errors in the logic activating the beam killer) or by the Equipment Protection system (Interlock boards, water cooling, Ethernet Powerlink communications). Both are particular sensitive to any issue because they operate in many cases directly stopping the accelerators. After the first days where the issues were identified and fixed in the case of the EPS and avoided in the case of the PSS, the number unexpected interlocks was remarkably reduced. The PSS

was fixed on the 23rd of June, and is already accepted and certified by TÜV.

CONCLUSION

The commissioning of the control system is an important and time-consuming task, which shall be planned, and considered accordingly in the time schedule. It is particularly tricky, because it is the last one before the commissioning of the accelerators, and it has dependencies with all the predecessors, hardware installation, equipments, fluids, sensors, cables, etc. It is necessary to break it down in parts, typically divided in subsystems, and always regarding the progress of the installation of the equipments. The equipment protection system is a particularly complex example, because it is spread all over the place, counting more than eight thousand signals installed at different times in different places. It always required three phases; checking of the cables, functional tests of the subsystem or sector and finally the general functional test.

Having a pre-installation campaign was crucial for speeding up the final installation. Most racks were preinstalled in 2007 and 2008, including equipments and internal cables, which resulted in a significant workload advanced in time.

The management tools, in particular the cabling database was crucial for maintaining the consistency and reducing the tests and early maintenance costs.

Although for a new installation like Alba, apparently operation and installation do not interfere, it was not the case. During the installation, there were quite a few "routine" operations, like Factory and Site acceptance tests of equipments, Bake-outs of vacuum chambers and equipments, etc. which implicated the different support groups in Computing, having an important impact in the final workforce for development and commissioning.

CONTRIBUTIONS

Many people have worked in this project. This is a work achieved with the effort of the whole computing division. The whole controls, electronics, network system administration groups actively participated in the design, installation and tests of the control system. Among them, the persons in charge of the network, M. Díaz, R. Escriba, had an important role. Furthermore, the help of the Management Information System group, in particular, O. Sánchez, I. Costa, A. Nardella, A. Klora, D. Salvat and V. Prat, who developed and maintained the cabling database, the TimeDB and the Project Management system has been crucial.

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