QUALITY MANAGEMENT OF CERN VACUUM CONTROLS

F. Antoniotti , J.P. Boivin, E. Fortescue-Beck, J. Gama, P. Gomes, P. Le Roux, H. Pereira, G. Pigny
CERN, Geneva, Switzerland

Abstract

The vacuum controls Section (TE-VSC-ICM) is in charge of the monitoring, maintenance and consolidation of the control systems of all accelerators and detectors in CERN; this represents 6 000 instruments distributed along 128 km of vacuum chambers, often of heterogeneous architectures and of diverse technical generations. In order to improve the efficiency of the services provided by ICM, to vacuum experts and to accelerator operators, a Quality Management Plan is being put into place.

The first step was the standardization of the naming convention across different accelerators. The traceability of problems, requests, repairs, and other actions, has also been put into place (VTL). This was combined with the effort to identify each individual device by a coded label, and register it in a central database (MTF). Occurring in parallel, was the gathering of old documents and the centralization of information concerning architectures, procedures, equipment and settings (EDMS). To describe the topology of controls components, the data structure is being defined, for later implementation (Layout-DB).

Once complete, the quality and efficiency of ICM services can only improve, and appropriate performance indicators will be in place to display them.

INTRODUCTION

For the Section's activities, it is critical to centralize the information, and to homogenize the methods and tools; ICM must also ensure the preservation and evolution of knowledge, while minimizing the effort to keep information up-to-date.

During 2010, a Quality Management (QM) Plan was introduced in ICM. It defines the means to ensure that any product/intervention/service is consistent with the expectations. The provided mechanisms will allow the achievements to be monitored, and so improve the quality of the services offered to vacuum experts and to accelerator operators.

STRATEGY: TARGETS & TOOLS

The preliminary step of the ICM QM-Plan was to define the requirements for vacuum controls. Which information needs to be tracked? How much time should be dedicated to the daily exploitation of the quality tools? What is the opinion of the service providers and their clients?

Firstly the actions have to be tracked; the requests from users together with the reports of interventions have to be followed-up; knowing these, the planning of activities and the level of priority are easier to define. Furthermore statistics can be automatically produced, such as the distribution of problems, actions or resources by machine or type of equipment.

Secondly, the devices/components of the vacuum control system (called assets) have to be traced; starting with identifying every one by a unique serial number. The purpose is to know the history of the assets: manufacturing, installation, calibration, tests measurements, repairs, etc.

Thirdly, the documentation is also a major issue. The main objective is the preservation and sharing of knowledge; it should also allow the formalization of the repair and intervention methodology, such as the procedures to calibrate controllers.

Fourthly, the evolution of the vacuum system layout and associated instrumentation also needs to be followed. In each accelerator a functional position is defined, representing a place reserved for a given function: a type of device to control a gauge, specific parameters inherent to that functional position, etc.

For each of these 4 targets, ICM selected a particular tool:

- VTL (Vacuum controls Tracking Log), to track issues and actions;
- MTF (Manufacturing and Test Folder [1]), to manage assets;
- EDMS (Engineering & Equipment Data Management Service [2]), to manage documentation;
- Layout-DB (Layout DataBase [3]), to describe the systems layout and their interconnections;

STANDARDIZATION: NAMING

The vacuum controls architecture and equipment have a rich history spanning several decades; they have been evolving, with the construction of every new accelerator machine and with the availability of new technologies: several versions of the same equipment, from different generations, may coexist in the same machine [4].

As a result of different naming conventions per machine, the very same equipment may have different names across accelerators, although being absolutely interchangeable.

Before starting to use the QM selected tools (VTL, MTF, EDMS, Layout-DB), it was essential to standardize the naming conventions across all of the machines. The first step was launched in 2010, when ICM started to identify and list all types of equipment used in vacuum controls.

Naming

In 2012, an inventory was created with 275 codes (equipment type names); initially inspired from the naming usage in the LHC, this list defines the rules for coding the types of vacuum controls equipment,

ISBN 978-3-95450-139-7

independently of the machine. It conforms to the "LHC Quality Assurance Definition" (called HC-coding), which defines the equipment serial number with 19 characters, extensively used in MTF. A part of this string represents the equipment type, directly exploitable as the functional position type in Layout-DB.

This new ICM naming convention has been integrated in the Accelerators Naming Portal, the CERN official naming repository for accelerators. It will certainly evolve according to the needs in hardware development.

The creation of a common codification for controls equipment across different accelerators has been the second step in the ICM QM-Plan, essential for the harmonized use of VTL, MTF, EDMS, Layout-DB and VAC-DB (chap. TOPOLOGY: LAYOUT-DB).

Moreover, ICM is actively collaborating with other vacuum Sections, to ensure the coherence of vacuum device naming in old and new projects.

The deployment of the new names while preserving the correspondence with the old names is in progress inside the machines and VAC-DB.

TRACKING ISSUES & ACTIONS: VTL

The Vacuum-controls Tracking Log (VTL) is in production since Jan-2013.

The project of a tracking tool started in 2011, in order to avoid random and unstructured office-visits, phone-calls and emails. The first phase was to collect the requirements from users and experts, in order to evaluate current and future tracking procedures; it was also the occasion to clarify the roles of link-persons and their substitutes, organized by machines and projects; the tracking practices in other Groups and Departments have also been investigated.

The ICM tracking tool was initially intended for implementation with APEX (Application Express, by Oracle); however, a lack of human resources meant that the tool was actually developed using the REDMINE application. This is a Web interface for a MYSQL Database, based on the programming language RUBY. Robust and completely modifiable/customizable by plugins, the REDMINE application is widely used by Universities around the world, is cost-free, and fully conforms to our requirements.

Among all the tracking tools compared, SharePoint and JIRA drew our attention. The first one has the advantage to be part of the Microsoft Office software pack, and is easy to implement and to use. But its compatibility with other operating systems is not certain; once developed, the application seems difficult to relocate to another WEB location; a significant part of the development may be lost.

Unlike SharePoint, JIRA is robust and optimized to interface databases. The most important drawback was its significant cost, directly indexed on the number of users. Only recently at the end of 2012, a CERN-wide license for JIRA is available and support is provided by the IT group. In the course of 2014, ICM will perform tests on JIRA to evaluate whether the functionalities of REDMINE are transferable.

Managed by tickets, VTL can organize all requests and reports by categories (Equipment Layout, Software, Hardware, Other) and by machines (LHC, SPS, CPS, AD, CLEX, ISL, LIN4, Labs, Other).

When creating a new issue in VTL, the requester does not need to know who the contact persons are: the link-person and their substitutes are automatically selected according to the subject and are notified. There is the possibility to attach files to the issue, to better clarify it; however, VTL is not primarily a document repository: EDMS must be used instead.

VTL provides a means to: follow the dates of request, execution and completion; assign a level of urgency; record the solutions implemented; highlight the response delay, the engaged resources and the volume of issues handled.

Using this information, the planning of activities, the management of the priorities, and the allocation of resources are greatly simplified. The extracted statistics will certainly contribute to improve the Section's efficiency.

By the end of Aug-2013, some 700 issues had been created; of those, 420 required industrial support (FSU). These VTL issues have been the primary source of information for a recent analysis of the FSU activities, concerning: requests, weekly planning, validation of weekly reports, definition of typical execution times, performance evaluation, and verification of invoices against the volume of work performed.

With the implementation of the tool being fully achieved, current developments are mainly focused on improving the functionalities of statistics and user-friendliness.

ASSET MANAGEMENT: MTF

The PART-ID

Each individual ICM device can now be referenced by a unique "part-identifier", conforming to the LHC Quality Assurance Definition (HC-coding). This 19-character identifier comprises an 8-character "equipment-code" (name of equipment-type), defined in the ICM naming convention; and a unique 8-character "serial-number". This was the first requisite to use MTF [1].

Labeling

Each individual device must carry a label with the coded "part-identifier". For this purpose, ICM uses halogen-free technical labels from BradyTM; these had been certified by several organizations, like UL (Underwriters Laboratories® Inc.) and CSA (Canadian Standards Association), and are also in use by other Groups at CERN.

These labels are made of white polyester, resistant to a temperature of 120 degree Celsius, for up to 30 days; they adhere to any type of material, without risk of damaging

ISBN 978-3-95450-139-7

the surface of electronic cards, as often happens with certain label glues.

ICM has chosen only two label formats:

- 1D-barcode Code 128 (38.1 x 12.7 mm), for front-panels and electronic cards;
- 2D-code Datamatrix (9 x 9 mm), for small surfaces like back-panel of modules.

By Dec-2012, some 10 000 labels had been applied to equipment in the LHC, as well as in labs and storages areas; by Aug-2013, this number has increased to nearly 13 000, which corresponds to more than 50% of the total labels (23 000) to be applied to all ICM equipment.

The labeling campaign is also the occasion to inspect the corresponding measurement chain: in 2012, more than 500 channels were examined from the instrument connector up to the HMI (Human-Machine Interface), concerning the vacuum gauges of the LHC beam. With particular respect to the TPG300 controllers, 1 500 items were tested and identified, and 2 700 labels were applied.

Information Storage & Retrieval

During 2012, starting with the most critical equipment types (controllers for gauges and ion pumps), about 1/3 of the 15 000 ICM devices were defined in MTF. Device information is uploaded to MTF using templates defined in EDMS; all uploads are recorded and traceable.

Before starting to enter any information in MTF, the manufacturing steps and the proprieties for each device type had to be defined. Without this time-consuming phase, the historical information about the assets would not be directly exploitable in the MTF database.

Stored in MTF, the full history of every registered asset allows us to:

- optimize future repairs (minimize MTTR – Mean Time To Repair);
- organize preventive maintenance actions (maximize MTBF - Mean Time Between Failures);
- know its location at any moment (machine, lab, storage) via Layout-DB, essential for spares management; each asset installed in the machines has to be linked to a Functional Position in the Layout-DB;

DOCUMENTS MANAGEMENT: EDMS

EDMS (Engineering & Equipment Data Management Service [2]) is a Product Lifecycle Management platform, based on two commercial products: Agile PLM, (by Oracle) and Infor EAM (by Infor).

Since 2011, the ICM Section has made a large effort to gather old documents and centralize all information on hardware & software architectures, and on procedures for equipment tuning or repair. This implied locating, retrieving and examining a large number of scattered electronic folders and personal paper documents, in the cases where they even existed.

To standardize the repository folder, the EDMS context TE-DEP-VSC-ICM was created. By Aug-2013, more than 210 documents have been created (76% use the ICM context).

TOPOLOGY: LAYOUT-DB

Functional Positions

The Layout-DB [3] is an Oracle database, managed by BE-CO-DA, which models the topographical structure of all CERN accelerators (their "Layouts"). Each accelerator component is assigned a "Functional Position", upon which are specified all its relationships (Optical, Mechanical, Electrical, Logical).

The Functional Position symbolizes a place reserved for a given function, within a system (magnetics, powering, cryogenics, vacuum, etc.) of the accelerator; it is defined by a function, a location and an occurrence number.

In the Layout-DB, the relationships, connections and hierarchies between those Functional Positions may be described to any level of detail, providing all of the information needed to follow the topology of the entire chain of acquisition, control and interlocks.

The decision regarding the level of details required is part of the preliminary definition of the data architecture in Layout-DB, for each accelerator system.

VAC-DB

For ICM, the generic attributes of every type of controller or instrument, together with any individual features, are currently stored in a set of Oracle databases (VAC-DB).

A custom Java application (DB_editor) is used to upload and retrieve VAC-DB data. Another one (DB_export_tool) combines information within VAC-DB, to produce the configuration files for both PLC (DataBlocks) & PVSS [5] (DataPoints, CMW / DIP servers, LHC-Logging, LASER, etc.).

The information about the geographical distribution of all vacuum sectors and equipment lies either in the Layout or Survey databases. In the case of the LHC machine, the position of vacuum instruments can be automatically retrieved from Layout-DB by VAC-DB, using a synchronization script; in 2012, a more robust version was put into place.

For the accelerators whose position information is available only in the Survey-DB, there is no automatic synchronization: the data must be manually imported into the VAC-DB. Hopefully, all accelerators are progressively migrating to Layout-DB.

In the future, all VAC-DB data will also be stored in Layout-DB; which will then become the primary repository of information on vacuum controls. VAC-DB might be kept as an on-line buffer interface to Layout-DB, allowing the manual change of data in case of necessity.

The tools to upload/retrieve data, and to produce the configuration files, will have to be adapted in collaboration with the Layout-DB team.

Meanwhile, ICM will be working on the convergence of the controls architecture towards the UNICOS framework (CERN Unified Control Systems). In collaboration with EN-ICE, the generators of the

ISBN 978-3-95450-139-7

configuration files will have to be adapted to this framework too.

Racks Layout

Currently, the management of the ICM typology information is difficult, given that this is available in several different drawing or text formats: it is impossible to automatically exploit those documents to produce lists or tables. Furthermore, this format consumes time to maintain. Once in Layout-DB, the information will be extracted online and formatted as needed, as table or drawing, which is not possible with the current formats.

Timeline

A new version of Layout-DB (web interface and data structures) is under development in BE-CO-DA section, improving performances and access rights management.

Currently, the only vacuum controls information available in Layout-DB is the position of the instruments of certain accelerators (started with LHC).

During the following years, a substantial effort is still needed to fully benefit from the Layout-DB:

- finalize the definition of the data architecture and level of detail; implement the data architecture;
- collect, update & organize information about the components and topology of all machines; a large part is completed for the LHC.
- upload all that information, including racks layout, to Layout-DB; migrate VAC-DB contents to Layout-DB; define & implement the links between electrical drawings, Layout-DB, MTF, VTL and SCADA.
- adapt the generators of PLC & PVSS configuration files to both Layout-DB and UNICOS;

SCHEDULE & RESOURCES

Phases

2010 – 11: Preparation of the QM-Plan: definition of the requirements; collection and centralization of the information; improvements on the ergonomics, the productivity of VAC-DB and PVSS [5].

2012 – 14: Implementation: naming convention; development and commissioning of tracking and information treatment tools; benefit from LS1 opportunity to easily access the field, in order to collect and update detailed information on architectures, cable and interlocks layout, rack configuration, equipment parameterization and calibration; updating all documentation on architecture and on equipment inventory; extensive labeling of assets; execution of modifications and consolidations; development of new tools for automatic data analysis and reporting. Altogether, these activities require a peak in the human resources.

2015 – 17: ICM QM will be in production: finalize the structure and data upload to MTF and Layout-DB; conclude all interconnections between electrical drawings, Layout-DB, MTF, VTL, SCADA, and Logging-DB; continue/finish development of tools for automatic data analysis and reporting; migrate VAC-DB to Layout-DB; implement and commission the first version the VAC-UNICOS framework and associated tools (target: Linac4).

2018: LS2 (second LHC Long Shutdown): various QM actions triggered by the upgrades and modification on all CERN accelerators; deploy and commission VAC-UNICOS framework on LHC and its injectors. These activities will again imply a temporary increase in manpower.

Manpower

The total estimation for the entire project is 230 man-months, corresponding to 2.7 FTE per year, in average over 8 years.

The ICM QM-Plan reflects only the technical aspects of the Project; the human factors are not easy to estimate and put in a schedule. Quality Management touches all the activities in the Section and demands an underlying attitude and philosophy of work; a lack of guidance, motivation or understanding may inevitably delay or compromise part of the Plan.

Essential activities, like information retrieval & recording, equipment labeling or tracking of actions, may be perceived as time-consuming and tedious; people must be aware that their contribution is vital to the improvement of quality and availability of the systems.

Once complete, the quality and efficiency of ICM services can only improve, and appropriate performance indicators should be in place to measure them.

CONCLUSION

This document describes the main aspects of the Quality Management Plan, being put into place within the vacuum controls Section (TE-VSC-ICM). Several methods & tools have been defined, and are progressively being implemented & used. The ICM QM-Plan relies on standard applications, widely used and supported at CERN.

REFERENCES

[1] D. Widegren, "Pushing Asset Management & Traceability to the Limit at CERN", IAM09, London, UK, Feb-2009

[2] S. Petit, T. Pettersson, D. Widegren, "CERN EDMS - The PLM Platform for the LHC, the largest scientific machine ever built by man", PDT Europe 2006, Toulouse, Oct-2006

[3] P. Le Roux et al "The LHC Functional Layout Database as Foundation of the Control System", ICALEPCS07, Knoxville, Oct-2007

[4] P. Gomes et al., "The Control System of CERN Accelerators Vacuum [Current Status & Recent Improvements]", ICALPECS11, Grenoble, Oct-2011

[5] F. Antoniotti et al., "Developments on the SCADA of CERN Accelerators Vacuum", ICALEPCS13, S. Francisco, Oct-2013.

ISBN 978-3-95450-139-7