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CONFIGURATION MANAGEMENT BEST PRACTICES

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Abstract

Configuration management (CM) is used for the configuration of complex systems in many fields, such as IT, aeronautics, shipbuilding, space systems, nuclear power plants, etc. and is indispensable for the long-term operation of any large facility. In the Engineering Department, configuration management consists of managing the technical description and layout of the accelerators and transfer lines (and their various components), as well as managing all the modifications made during their evolution over time. It is about all the processes that ensure the conformity of the accelerators with the requirements of their operation, throughout their life cycle. The aim is to provide a clear and coherent representation of the CERN main technical facilities at a given point in time. This paper will present, the best practices that constitute the configuration management of accelerators and transfer lines in the EN-ACE group.

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Configuration management (CM) is used for the configuration of complex systems in many fields, such as IT, aeronautics, shipbuilding, space systems, nuclear power plants, etc. and is indispensable for the long-term operation of any large facility. In the Engineering Department, configuration management consists of managing the technical description and layout of the accelerators and transfer lines (and their various components), as well as managing all the modifications made during their evolution over time. It is about all the processes that ensure the conformity of the accelerators with the requirements of their operation, throughout their life cycle. The aim is to provide a clear and coherent representation of the CERN main technical facilities at a given point in time. This paper will present, the best practices that constitute the configuration management of accelerators and transfer lines in the EN-ACE group.

INTRODUCTION TO CONFIGURATION MANAGEMENT [1]

Complex technical and industrial installations such as those in service at CERN require the study, design, procurement, manufacture and quality control of numerous equipment, throughout their entire lifecycle. However, Configuration management considers the global space of a facility covering the spaces for which an equipment fulfils the function, and the ones corresponding to immaterial space such as transport or reserved volumes. To have good synergies between all the stakeholders, it is necessary to define processes that will monitor the specifications attached to the functional position type identified in a top down approach. Configuration management gathers the functional and physical characteristics of hardware and space as described in the associated technical documentation. For hardware, it makes the link between the asset, a physical object, and the data that includes documents, drawings, 3D CAD models etc. The same applies to space but without the asset. Configuration management is a process ensuring that consistency is maintained among the parameters, the requirements, the physical and functional attributes and the documentation describing an object, including its interfaces. It is essential particularly when changes are made during the life-cycle of an installation or a project.

CONFIGURATION MANAGEMENT IN ACCELERATORS & TECHNOLOGY SECTOR (ATS)

History and scope

The injector chain of the LHC is made of a succession of beam lines, Linac3, Linac4, PS Booster, LEIR, PS Ring, SPS and LHC developed since the mid-50s. The increasing complexity of industrial accelerator equipment made necessary to resort to configuration management from the 1970s onwards. The databases and the naming of the various components having been set up and exploited from the birth of the machines, allows to manage all the related equipment over time. Today, the configuration management of the primary beam lines is under the responsibility of the Configuration and Layouts section (EN-ACE-CL) within the EN department. The experimental areas are managed by BE-EA and SY-STI groups, with procedures and tools based on the same principles as those inherited from the CL section [2]. This paper concerns the processes and practices managed by EN-ACE-CL.

The strategy

Configuration Management provides a clear and coherent representation of the CERN accelerators (LHC machine and its injectors) at a given point in time (past, present and future). At CERN the concept of ‘Layout’ is also considered within the scope of Configuration Management. The term ‘Layout’ is used to describe the sequence of functional positions within a facility at a given point in time. CM consists essentially in four practices conducted in parallel and covers the equipment throughout its life cycle.

1- Identification of the items in the configuration

This process consists in selecting the items of the accelerator systems hardware and/or software which need to have their configuration managed. The approved and released parameters and documents are recorded, respectively, in the individual accelerators configuration baselines, stored in the form of a Product Breakdown Structure (hierarchy of systems and sub-systems containing items) in EDMS (Engineering & Equipment Data Management Service) [3] and within the Layout database (LDB) [4].

2-Control of the configuration

As the CERN accelerators are complex machines, it is necessary to keep track of numerous technical changes throughout their life cycles. For installed beam lines, all change to the baseline configuration must be properly defined, documented, and approved by the dedicated executive committee, Injectors and Experimental Facilities Committee (IEFC) or LHC Machine Committee (LMC), before their implementation. The change process allows stakeholders and management to monitor all changes and to work in the respect of safety, quality and schedule while taking into account technical, economic, scheduling and space constraints.

A change to a project or facility is managed using Engineering Change Request (ECR) documentation [5]. The executive committees or project management teams, responsible for the concerned facility or project, provide the final validation of any ECR.

3-Recording of configuration states

All versions of the accelerators are archived, and it is therefore possible to obtain a complete picture of a given facility at a given point in time. Installed beamline versions are usually named with the program stop, e.g., RUN2022, while for the project it is usually the optics version that is the main driver of the label, e.g., HL-LHC optics 1.6. Moreover, since LS2, there is the possibility to manage parallel configurations (present and future). A tagging system in EDMS allows to obtain the correct content of a baseline over time. For example, the baseline node of the LHC triplets will indicate that the variants installed at points 1,2,5,8 are identical up to LS3 and will reflect the variant changes at 1 and 5 for HL-LHC. The same applies to the Layout DB via a cursor moved on a time that allows obtaining dynamic layout information.

4-Verification of the configuration

Change control is a collaborative effort between the equipment owners, integration, configuration and coordination teams, to ensure that the activities were performed as foreseen, and that documentation is up-to-date and correct. As part of the verification of changes, panoramic photographs are taken on site. This is the final stage of quality control.

The strategy to conduct the LHC configuration management is defined by the Quality Assurance Procedure LHC-PM-QA-304 [6] since the construction in 1998.

Configuration Management Process

In accordance with the strategy defined above, the CL section carries out the configuration management of the CERN accelerators based on the following processes:

1- Naming process

Configuration management links all data together by means of a unique code assigned to each piece of equipment.

Quality assurance documents define the general conventions for naming accelerator components. They also give the naming relationship with the drawing codes related to these components. The naming process is made of several phases. Group-coding officers (GCO) manage the equipment codes in their groups. The CL section ensures the final quality control and naming homogeneity throughout the accelerators and creates the equipment codes in a dedicated database called the Naming database [7]. On request of the equipment owner, the CL section generates the equipment codes in the CERN Drawing Directory (CDD [8]) and the items in EDMS. These items can be used by the equipment owners and the asset management team to ensure the link to assets in HEXAGON (INFOR EAM [9]).

All code requests are tracked via the Service NOW request management system [10].

2 -Hardware Baselines Management Process

The baseline documentation is stored in EDMS and contains more than 12000 documents such as Engineering Specifications (ES), Installation Procedures (IP), Hardware Commissioning Procedures (HCP), Machine Protection System commissioning procedure (MPS), Engineering Change Requests (ECR), Engineering / Technical Notes (EN) and Operational Procedures (OP)... The components of the accelerators are organized in a hierarchical structure in the form of a Product Breakdown Structure (PBS) that evolves over time. Based on the unique code created for each piece of equipment, the technical documentation and item associated to a functional position will be stored in EDMS throughout its entire life cycle. The design data produced by the design offices can be consulted with the help of 2D or 3D viewers when it passes a certain validation stage.

3- Layout Management Process

The Layout is the sequence of functional position all along the beamlines, covering equipment and reserved spaces. The Layout DataBase is a centralised system: a single interface and a single database, which allows multiple versions of the Layout of each accelerator and transfer line to be built in parallel. The LDB stores positioning data of the functional positions.

- Equipment is classified by type and precisely located in the machine in three dimensions using functional positions e.g., TCSPM.B4L7.B1 - Secondary Collimator with Pick-Up Metallic.

- Reserved spaces such as lines of sight, intervention volumes around jacks, provision for shielding also inherit a name and a type and are precisely located, e.g. GIMQA.13L3 Reserved volume around jack (700 upstream, 0 downstream).

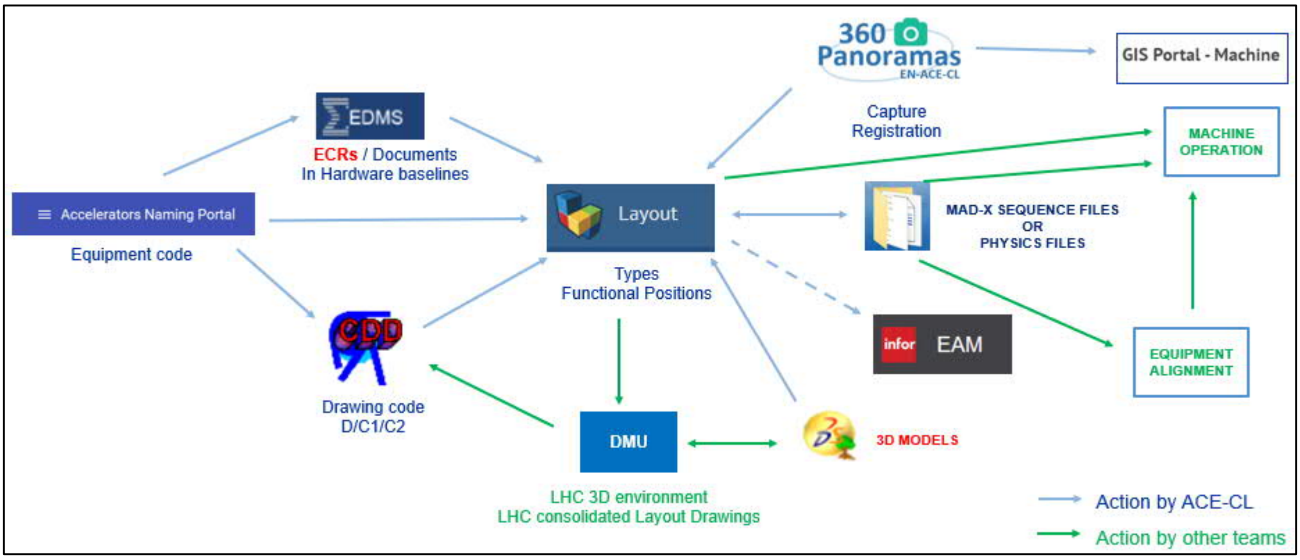

Figure 1: Tools involved in the configuration management

All the necessary data defining the types and the functional positions comes from different sources such as technical specifications, drawings, optics files, ECRs, etc... Layout data can be used by many collaborators: for example, by the survey team to position equipment in the machine, by the colleagues from operations for beam optics calculation or hardware commissioning of electrical circuits, etc. This data is also used to produce the LHC layout drawings directly from the Layout database, using the LHC DMU (Digital Mock Up) tool [11].

4- Panoramas: Photographic Recording Process

Fully immersive 360-degree panoramic photographs are captured of the machines, assemblies and installed equipment after every technical stop or long shutdown. They are linked together using automatically generated arrows, allowing users to easily navigate through a photographic representation of the machines and facilities.

Panoramas [12] are used for a variety of reasons, from recording installations to helping to plan modifications and upgrades when machine interventions are either not possible, or to comply with ALARA (As Low As Reasonably Achievable) principles by aiming to reduce incurred radiation doses.

Photographic records contribute to provide a clear and coherent status of a facility at a given point in time, covering the past and present.

5- Quality Control Process

The CL team works with the 'Organisation, Scheduling and Support (EN-ACE-OSS) and 'Integration' (EN-ACE-INT) teams to prepare and monitor the implementation of changes in the field in collaboration with the equipment owners. The monitoring of activities is done with the Track-it tool, implemented by the EN/IM group [13] for aggregating and centralising information regarding interventions from their announcement at a committee to the actions that follow them. Site visits are organized to check that the changes are in accordance with the specifications and ECRs. The documentation and the LDB are then updated. As part of the verification of changes, panoramic photos are also updated. This is the final stage of quality control.

CONCLUSION

At CERN, configuration management is an essential service to ensure over time the monitoring and compliance of installed beam lines and the coherence of configuration items of projects. The follow-up of modifications is a work that requires rigour and method to keep the documentation and databases up to date. The work of the section is organised in accordance with the LHC quality plan and requires the use of innovative and efficient engineering tools: EDMS, Naming Portal, LDB, Catia V5® CAD software, ENOVIA Smarteam® product data management, DMU and Panoramas. The collaboration with the equipment owners, the colleagues of the different professions involved is essential for the success of the EN-ACE-CL team's work.

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