HARDWARE COMMISSIONING OF THE LHC: QUALITY ASSURANCE, FOLLOW-UP AND STORING OF THE TEST RESULTS

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ABSTRACT

During the commissioning of the LHC technical systems (the so-called Hardware Commissioning [1]), a large number of test sequences and procedures will be applied to the different systems and components of the accelerator. All the information related to the coordination of the Hardware Commissioning will be structured and managed towards the final objective of integrating all the data produced in the Manufacturing and Test Folders (MTF) [2] at both equipment level (i.e. individual system tests) and commissioning level (i.e. Hardware Commissioning). The MTF for Hardware Commissioning will be mainly used to archive the results of the tests (i.e. statuses, parameters and waveforms) which will be used later as reference during the operation with beam. MTF is an indispensable tool for monitoring the progress of the different tests and ensuring the proper follow-up of the procedures described in the engineering specifications; in this way, the Quality Assurance process will be completed. This paper describes the specifications for the development of the MTF, their general structure, as well as the methodology used for their implementation in an optimal and reliable way.

INTRODUCTION

The LHC is subdivided into eight sectors. Each of these sectors will be commissioned as a single unit. Prior to the commissioning phase (HC), every equipment will undergo the so-called individual system tests (IST) which validate its proper functioning. For both cases, IST and HC, an information system has to be available in order to:

- Organize and make available the logical distribution of machine components (e.g. by equipment, by equipment group, etc) together with their geographical distribution (e.g. the Quench Protection System for the superconducting magnets has components connected to the same electrical circuit which are located in both the tunnel and other adjacent service areas)
- Archive the technical documents, prepared by either the equipment groups or the HC team in collaboration with them, which will be used during the commissioning (e.g. schedules, procedures, sequences, access conditions safety rules, etc)
- Provide process tracking capabilities, identify deviations, create proper reporting lines and update, if necessary, schedules and other documents
- Perform quality assurance surveillance with well defined references.

The document structure allows evaluating precisely the timing of the different commissioning phases and the situation with respect to the general planning; it also acts as a repository of information for the future activities. This information system has the adequate flexibility to cope with unexpected changes. It is designed to become a key tool for tracking progress and decision making during the LHC technical systems start up.

MTF FOR THE HARDWARE COMMISSIONING

The Requirements

The structure of the information system must be accessible from different entry points. Access should be possible using any system, equipment, geographical distribution, etc as entry points. For example, if the entry is a power converter of a circuit, information can be obtained about the system and equipment it belongs to, where it is located, when it is going to be commissioned, which tests and documents are going to be applied, or have been applied, etc.

The structure representing equipment being commissioned will be self-consistent and static: all the parts of the architecture are fixed and defined. The only data which may change are schedule dates.

The architecture

The architecture is implemented within the Engineering Data Management Service (EDMS) [3]. The EDMS is a tool developed at CERN. It uses CADIM, a commercial engineering data management system from Eiger & Partner, and provides management services on engineering and equipment data. Figure 1 shows a diagram of the structure implemented. Each sector is made of different regions and each region contains different equipment groups. An equipment group is the collection of different equipment which are commissioned together. As identification attributes, the systems have their type and a unique ID. The equipment groups contain a list of equipment with their ID and type as well. This equipment can, in some cases, belong to several equipment groups. An example is cryogenics, that it is an equipment group by itself but is also an equipment forming part of the *superconducting circuits equipment group*. The result of all this exercise is the full machine divided and structured in a tree that is implemented and supported by EDMS.

Hanging from each node of the EDMS tree there is an MTF that contains all the HC data, including test results, workflow, schedule, documents, etc. The MTF application is an integral part of EDMS at CERN, and was developed to capture manufacturing and test data for the LHC project to provide traceability of large quantities of complex parts manufactured in a geographically distributed environment. It uses MP5, a commercial asset tracking and maintenance management system from Datastream Inc.

A great part of the development has been done by the EDMS and MTF team in order to adapt the tool to the commissioning needs. The design of the structure and information that MTF should contain for the commissioning and individual system tests has been decided taking into account the needs of each of the equipment groups and equipment.

The factors considered for the design include the requirements during the preparation of the tests and during their execution, as well as the future needs as a reference tool during the operation of the accelerator.

According to the previous, there are two main MTF designs: one for the individual systems tests and one for the hardware commissioning activities. They contain mainly: parameters that come from the reference database and from measurements, tests (e.g. status, dates and results) and documents.

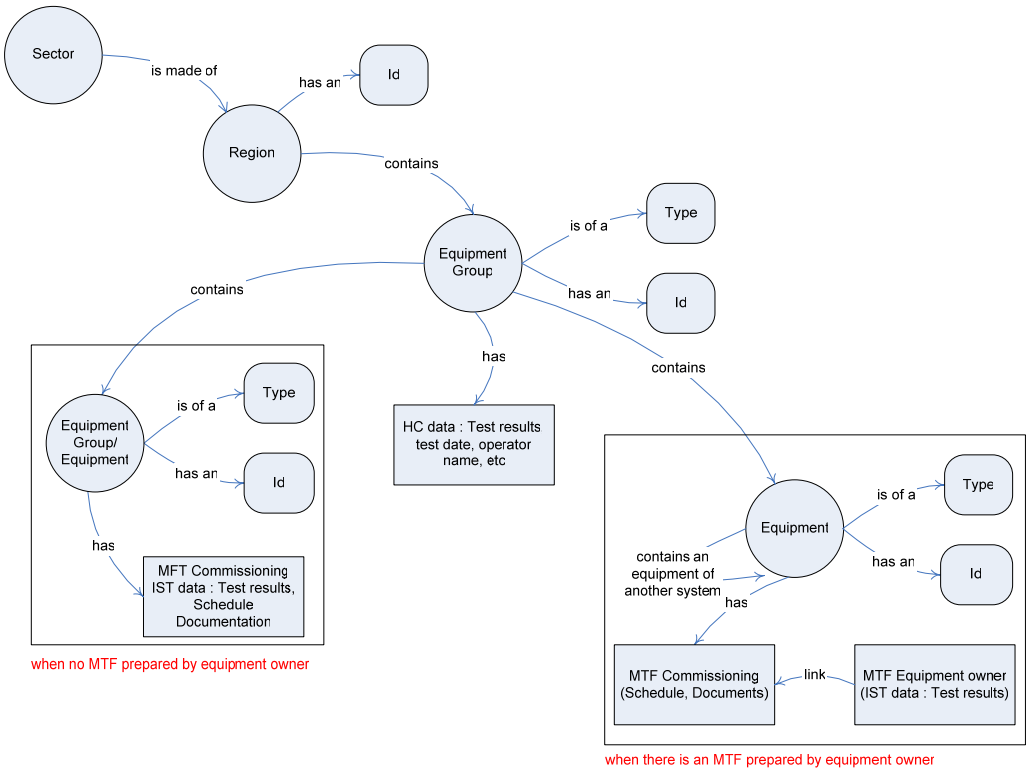

Figure 1. Breakdown of the machine into equipment and equipment groups, and associated documentation.

Inside these two main groups, each equipment and each equipment group have different requirements and therefore different data stored.

MTF ENTITIES

The criterion that has been followed is based onto two main aspects: identification of the geographic distribution and the hardware functionality.

Geographical

Sectors and regions are based on the geographical distribution of the hardware. In each sector, the machine is subdivided in cold (cryogenic) stretches and room temperature stretches that are separated by vacuum sector valves; the latter are always the physical limits of the regions.

Hardware

The hardware comes as a second level in the form of Equipment Groups, which contain all the equipment that are involved during the commissioning in each region. As an example, consider the superconducting circuits of one region or all the electrical quality assurance activity to be carried-out in that region.

The third level is the different Equipment, which are part of the Equipment Groups.

MTF ENTRIES

For each *MTF entity*, there are three types of information stored in MTF. All this information is defined in appropriate documentation [4].

The Main Parameters

These consist in the data pertaining to configuration, calibrations, limit values, nominal values, etc. For instance, in a superconducting circuit, these data will show the list of magnets belonging to each circuit, the current leads for the circuit, the power converters and the cryogenic feed box where the current leads are connected.

These data come from the “as-design” reference database of the LHC, and from test results that will be stored in the MTF database. In the future this data will be integrated in the “as-built” reference data base.

Hardware commissioning steps

This is the list of steps which will be carried out during the commissioning and which are described in the approved procedures [5]. The data collected during the steps will be part of this type of information. Every step in MTF must have a correspondent step in the applied technical procedure.

Documents

This area covers the documents describing the equipment, the system, the individual system tests, the hardware commissioning steps and the results. As a request from the users, in some cases, a view from the MTF data base is provided in order to open directly the documents from the web interface independently from the document format.

TYPES OF MTF

The MTF has been adapted to the level of the structure to which it is linked.

MTF for a region

It contains a link to the approved schedule for the commissioning of the region, showing the times allocated for each equipment group. It includes the status for each entry in the schedule, including the percentage completed, the person responsible, etc.

MTF for an equipment group

The MTF concerning an equipment group contains the information about the hardware commissioning activities. It includes reference parameters, the tests to be applied and their status with the date of execution and the person responsible, results, as well as the applicable documents.

MTF for an equipment

At the level of equipment we will find two different situations:

- In the first case, there are MTF data concerning the individual system tests introduced by the equipment owners. The data will be automatically linked from the existing equipment MTF to the commissioning MTF. The latter will contain all the IST details (components, test parameters and test results).
- For the second case, there is no MTF defined by the equipment owners. The information about the IST will be the status (i.e. ok, not ok, done, not done, who did it, when and related non conformities), introduced directly in the commissioning MTF.

MTF INTERFACES

In order to increase the performance of the MTF from the user's point of view, use cases have been done identifying the different ways of interaction. Three different interfaces have been designed for the time being.

1. Navigator (editable). The navigator consists in a clickable EDMS structure from which it is possible to access the MTF web page directly.
2. Parameters Report (non editable). In order to have a view of the needed parameters defined by the users, an interface has been designed that will report on the chosen elements.
3. Step report (non editable). To fulfil the process tracking necessities, the step report shows the status of the tests and the non-conformities of the chosen elements.

As the commissioning advances and new necessities appear, other interfaces may be created.

FILLING UP THE MTF

Online storing. There is the possibility of introducing all the information generated by the tests through a web page interface. This method has been implemented to have the information required for validation in order to continue the tests readily available on the same day.

Quasi on-line storing. In order to be able to upload big amounts of data coming from steps or parameters which are not needed immediately, a procedure has been created. A script has been added at the end of the software application used to run the equipment under test. Depending on the test results, the script produces an XML file including the following contents: the result of the test (i.e. done, ok, not ok), the name of the operator performing the test, the date and the resulting files (i.e. diary file and an analysis file). This report is automatically sent by the software application via e-mail to the EDMS server and uploaded every night.

CONCLUSIONS

The HC MTF tool has been used during the first hardware commissioning campaign for the short circuit tests of a set of about thirty power converters. The test results were introduced manually for some tests and automatically for other tests: with this evolution, the test activity could be followed up at the pace the tests were carried-out. Moreover, both the data collected during the tests and the sequence which has been followed are traceable.

The considerable amount of data produced during this relatively short test campaign (3 weeks) is now available for analysis and also constitutes a guarantee of the quality assurance of the tests performed.

Due to the large amount of data, documents and test results, the centralization of information in a well defined repository (i.e. the Hardware Commissioning MTF) was necessary in order to efficiently find back any information at anytime and from any entry point (i.e. any user knowing one entry can access all data following a global logic).

This tool has been designed keeping the collider operation in mind. In order to ensure this, an operations crew will work on the improvement of the MTF during the coming tests.

The MTF for Hardware Commissioning has proven so far to be a valuable tool that eventually satisfies all the specified requirements.

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