LHC REFERENCE DATABASE: TOWARDS A MECHANICAL, OPTICAL AND ELECTRICAL LAYOUT DATABASE

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Abstract

The LHC project has entered a phase of integration and installation of thousands of diverse components. The Hardware Commissioning work has also started. Collecting and distributing reliable and coherent information on the equipments and their layout becomes a crucial requirement in the lifecycle of the project. Existing database tools had to evolve to a more generic model to cover not only optical layout, but also the mechanical and the electrical aspects. This paper explains the requirements, the implementation and the benefits of this new database model.

INTRODUCTION

The layout database in its initial state was a set of optical objects regrouped in classes and instances. The database model was structured around a finite number of systems covering: Magnets, Cryo-assemblies and their cold masses, Beam Instrumentation, Radio Frequency, and Collimation. The main usage of the database was to provide a MAD input sequence file, used to check the consistency of the collider by achieving a valid optic.

THE NEEDS

The integration work bases itself on the complete knowledge of all the equipments that will be installed in a given area of the tunnel. Important systems and their intrinsic organisation (sectors and sub-sectors) like the Vacuum chambers and instruments, the cryogenic line (QRL), the general services and the electrical circuit definition needed to be incorporated in the database to obtain a description of the machine as realistic as possible. This Integration work requires a coherent up-to-date view, at any time, over different systems. The database will also serve as a reference for many equipment providers to design the layout of their systems. Indeed, on its own, the provider cannot know if the localization of his equipment is not in conflict with the equipments of others. Thus, the database aims to provide a "global picture" of the whole machine configuration.

In parallel, the database will feed the logistics and planning teams with the characteristics and the quantities of types of equipments to transport and install in the tunnel.

Additionally, for installation follow-up purposes, the LHC layout database will be the source of slots for the MTF [1] tool which will associate physical equipment and functional position*.

The initial scope of the database was limited to the main ring area. Extensions to complementary civil works like UAs, RRs, REs, and to Injection and Dump Lines are essential to get a complete set of data for the hardware commissioning and future operation of the collider.

THE CONSTRAINTS

Versioning

The configuration evolves from a version to another. Slots are added, suppressed, moved, shortened, and extended. Data is collected and changes must be recorded by versioning the layout in a global coherent state at a periodic time. To become official a change has to go through the process of an individual Engineering Change Request (ECR). The package of changes between two versions of the layout is summarized in an EDMS Technical Note which in turn is submitted to an EDMS approval process before becoming an official release. The version 6.5 of the configuration is currently under approval, while the layout version 6.402 is still being the officially approved version.

Impact of changes on the overall coherence

In most cases, a slot change has an impact on some surrounding slots, whether they belong to the same system or to another, since their positioning can be relative to this slot (a positioning constraint may link them). These changes can quickly turn the configuration into a global incoherence state. A single equipment provider cannot verify the overall coherence of his layout.

Naming conventions

A slot instance has an official name according to the LHC equipment naming conventions [2]. It can also have specialist names (cryogenic line, vacuum, survey, electrical, functional) using different naming algorithms. This is a constraint to take into account in the new model definition.

Data publication

The large amount of data collected and checked has to be published on the WEB [3] and distributed to a set of clients using programs such as MAD program [4], Digital

* A Functional position (slot) is a volume positioned in an LHC underground area which determinate a function to be fulfilled at this location. The function is fulfilled by any appropriate physical equipment (managed in MTF) hosted by the slot.

Mock-Up toolkits (DMU) [5] or MTF. The services provided have to remain unchanged and fully available to the client.

THE DATABASE MODEL

Database choice

The new model has been designed to handle frequent changes in the LHC Collider configuration. Versioning coherence and interference checking are important issues which could not be satisfied with standard CERN tools. Thus, it was decided to implement a new database schema (Oracle8i) including the data containers (tables, materialized views…) and the "business logic" (PL/SQL) surrounding it.

Database objects

The database model is structured in 3 layers giving different points of view on the machine: Mechanical, Optical and Electrical.

The tables correspond to the following set of basic objects to manipulate: slot types, slots, interfaces, regions, MAD parameters, MAD types and elements, hierarchy of slot types and MAD types classes, Electrical types and objects, segments, connections, circuits (Figure 2).

Triggers attached to each table call methods stored in dedicated PL/SQL packages. This applies the “business logic” to each object and keeps track of their main changes in a log table.

Slot identifiers

At each versioning process, the whole layout was imported in the database. Each time, the objects imported were assigned new identifiers in the database, making their traceability almost impossible. By providing a unique primary key to objects for their entire life cycle, the new model now handles incremental updates. It really eases the data maintenance and allows keeping the history of the changes applied to the data. As a result, the names of the objects which were used as unique identifiers have become common attributes like other additional names.

Interfaces and coherence checking

The model is now scalable to accept the introduction of new systems and to ensure the interfacing and coherence between them. Indeed, to partially detect inconsistencies, relationships ("Interfaces") between slots and their relative positioning, have been implemented into the data model and exploited to generate reports on the coherence state of the slots. These relationships not only apply to slots of the same system but also to those of different systems, e.g. standalone quadrupoles and vacuum adjacent components.

Another way to find out inconsistencies is to use the functional positions as a source, in association to 3D CAD models, to render 3D realistic graphical scenes. This is achieved using the DMU toolkit. The Integration team then disposes a powerful 3D collision detection system.

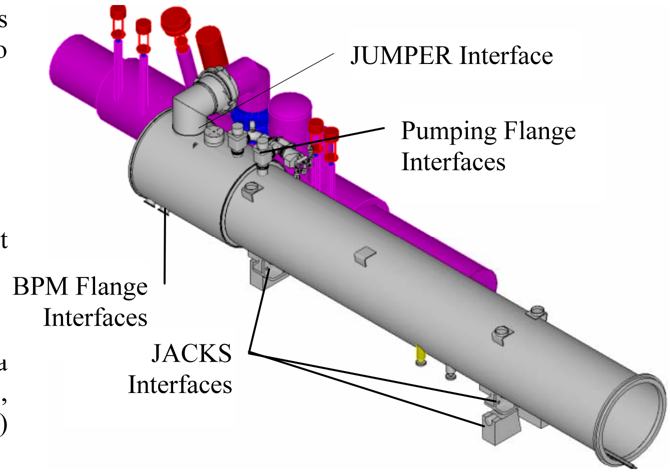

Figure 1: Short Straight Section Interfaces

Regions

Only machine regions (half-cells, sectors…) were described in the initial database model. Adding new systems such as vacuum, cryogenic line, powering… implies to detail the structures of the corresponding sectorisation. The new model is now able to handle almost any sectorisation scheme.

Electrical and mechanical data

The links between mechanical and electrical data have been improved. A detailed description of the electrical circuits and electric components allow the generation of MAD sequence files in a new format and the exploitation of circuit data by various clients for construction, protection and operation of the LHC magnet powering system. The stored data and the generated sequence files are now reflecting a realistic description of the physical installation in the tunnel. The MAD program is still a reference to check the optics of the machine.

NEW SERVICES

With the start-up of this new database model and the amount of data already available on many systems, new needs have raised.

The database provides input data to the MTF so as to link equipments and their hosting slots. This association is then collected back to the database. Thus, it becomes possible to provide the data to the Superconducting Magnet Analysis tools [6] to compute statistics on the magnetic field distribution based on the position of the magnets in the ring.

The vacuum layout (chambers, modules…) and the beam screens layout combined with some additional apertures data will soon make feasible the description of a complete aperture model of the ring for the MAD program.

After a few improvements of the database model, the hardware commissioning data already collected should soon be available on the WEB.

Both the main vacuum layout and the vacuum instrumentation layout are redistributed to the vacuum control team to feed their control system (PVSS).

CONCLUSION

The new database model proposes three points of view on the collider layout: mechanical, optical and electrical regrouped in a single database.

We now have the possibility to extend the scope to all the elements of the main ring; we are no longer limited to optical elements. The database allows combining data of different systems to describe dependencies (interfaces) between them in order to ease the inconsistencies detection work.

This new database is in a validation phase and should be in production during summer 2004. But the database is already solicited by new clients interested by the data collected and checked so far.

REFERENCES

[1] "The CERN Engineering Data Management System - A status report", T. Pettersson et Al., EPAC'00, Vienna, June 2000

[2] LHC Equipment Naming Convention: https://edms.cern.ch/doc/103369, R. Saban

[3] http://cern.ch/lhclayout/

[4] http://mad.home.cern.ch/mad/

[5] "A Virtual CAD Model for the LHC", S. Chemli et Al., EPAC'00, Vienna, June 2000.

[6] http://sma.cern.ch

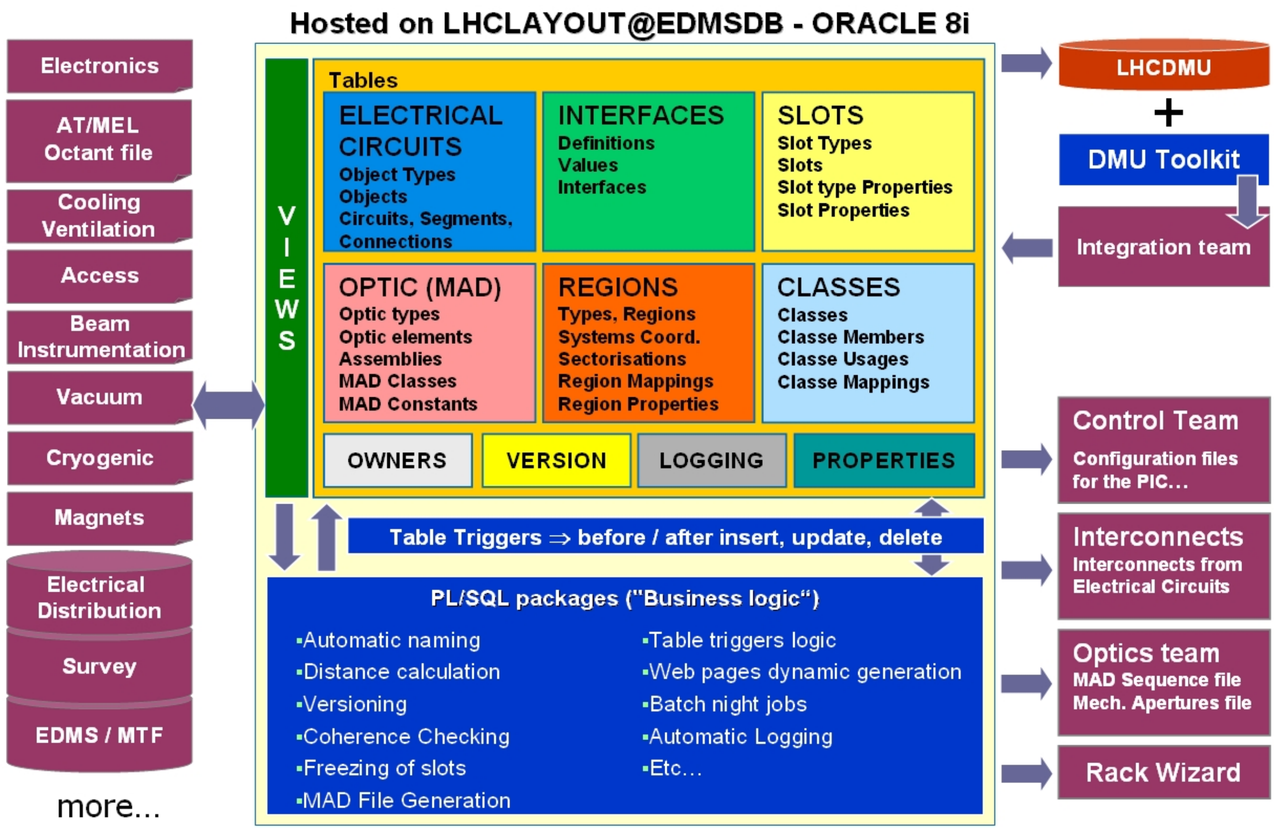

Figure 2: LHC Functional Layout Database Overview