THE INFORMATION SYSTEM FOR LHC PARAMETERS AND LAYOUTS

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Abstract

The construction of the Large Hadron Collider, LHC, at CERN implies both the handling of a huge amount of information and the control of the coherence of this information. The LHC machine parameters have to be maintained coherent as the design evolves from the conceptual stage to the actual, installed, machine and have to be made available to all concerned. Design data is provided in many different formats from the machine builders, drawings, technical documents, meeting notes, lattice simulation input files, etc. The World Wide Web is being used to make the information accessible both at CERN and at the external collaborating laboratories. In this paper we describe the implementation of an Oracle database as the central common repository for machine parameters and of information for the automatic generation of CAD layout drawings and WWW pages. This system is integrated in a larger context, the EDMS system for the LHC project, which encompasses both the accelerator and the experiments.

1 AIM

The Information system for the LHC Parameters and Layouts has been created with the aim to always have an up to date set of the LHC baseline information accessible to the community of people working with the LHC project. The baseline information is the set of approved and released documents that represent the definition of a product at a specific point in time. Configuration baselines are established whenever it is necessary to define a reference configuration during the product's life cycle. This baseline is then used as a starting point for further activities. To keep the baseline information up to date implies considerations about the coherence of the parameter set, the uniqueness of the source of the information, updates and the necessity of keeping track of updates, information retrieval, the way of presenting the information and access rights. Important are also the integration into the general Engineering Data Management System for the LHC Project ([1]) and the links to other parts in the EDMS system.

2 SCOPE

All elements and concepts for the LHC should be stored in the system. Automatic generation of beam optics input files and layouts of the machine from the machine description, also stored in the system, can be done by using the entities in the database describing the different magnets and other accelerator systems. CERN Drawing directory can also be visualised.

The system should also guarantee the correctness and coherence of data that might be of interest for several groups of people. Links are made available to more detailed information that interests only a limited number of people. A history of modifications with date and references are kept. A simple search mechanism permits to find pages containing a specified string. Statistics of the access to the pages is accessible.

3 STRUCTURE FOR STORING THE PARAMETERS

Magnets and cavities are examples of physical objects, they have parts and they have a physical structure. They also have properties (i.e. field) related to parameter settings (i.e. current). One can also say that the accelerator is a physical object, with a structure, with parameter settings, and properties, however, a strict view of the objects is really beneficial only when we have many objects of the same kind. Then we can reuse the same templates for several objects. We confound "parameters" and "properties" in what follows; for example field and current for a magnet are both parameters.

Above a certain level of detail an object may have a parameter that influences the beam. At the highest level, the accelerator, the beam parameters (the specification of the performance of the machine) are defined. Each beam parameter has associated to it a definition. It is possible to define relations to other beam parameters and to calculate automatically derived parameters.

The data has been structured to correspond to the product breakdown structure defined for managing the project data (drawings, specifications etc.), the PBS. In this way parameter tables can be easily accessed, not only from the special interface for parameters and layouts, but also from the corresponding nodes in the PBS.

The parameter pages have links to reference papers, minutes of meetings, layouts and to the CERN drawing directory.

4 IMPLEMENTATION

2.1 The implementation of the parameter database

The entity-relationship model is used to implement the idea of objects and parameters related through a set of parameter values. The "is_a / can_be" rules implements the inheritance. There are objects of type "model" from which other object may inherit its set of parameters, with or without its set of values. The "pbs_child / pbs_parent" is a reflexive relationship that indicates the fact that an object may be made up of other objects. With this relationship the parts breakdown structure can be modelled. The "has / for" relationship describes the fact that an object may have one or more parameters; a parameter may be applied to one or more objects. Each pair object-parameter has a single value. In this way we try to have unique definitions of parameters that can be reused for several objects.

The choice of ORACLE tools for the implementation was based on the fact that this is the only system that is maintained at CERN. Prototyping in other systems (object oriented) was carried out, but these systems did not have enough maturity for our needs. During the design phase the Oracle CASE tool Designer/2000 was used to help in the modelling and to generate the code.

2.2 Layouts and drawings

Different types of layout drawings are required throughout the project's life cycle. In the development phase conceptual layouts are used to allocate space to the machine components along the beam line. This process does not lend itself to easy automation, as proposed solutions have to be negotiated between groups and individuals responsible for the design of the components. Once a suitable conceptual layout is achieved, its data, essentially the location and size of each machine component, can be entered into the database. After verification of the coherence of the layout with the Methodological Accelerator Design (MAD) program, the data can be used to automatically produce schematic and installation layout drawings which are essential for a successful and timely installation of the machine.

Schematic linear layouts, in which components are represented by simple boxes, are produced with AutoCAD whereas more detailed representations are produced with the 3D CAD system Euclid, using a library of 3D models of the machine components.

Approved changes (following an Engineering Change Request, ECR) are implemented by modifying the locations of components in the database and by modifying the 3D models in the library. This is followed by the production of a new set of layouts with the CAD application.

2.3 The implementation of the optics file generation

A complete description of the future "LHC installed in its tunnel" is stored in the machine database tables (presently about twelve thousand elements). For the moment local tables are used but in the future the information will be obtained through links to the LHC machine database, so as to have a unique source for all parameters.

The LEP Database ([2]), used for current machine operation, was taken as a starting point. As the LHC has two rings the tables had to be extended to handle the ring information. The tools generating data to be used in beam optics calculations and to produce layout drawings were equally modified to handle the two rings, and were shown to work well.

Complete MAD input data files are created for both rings, using unique names.

Unfortunately each modification of the machine layout still requires a large amount of manual intervention to the database tables. New methods are presently explored to accelerate this process in such a way that after layout changes new drawings and beam optics input data can be rapidly made available.

The input file for optics calculations with MAD is generated entirely from the database by a program written in Pro*C

5 THE PRESENTATION OF THE BASELINE PARAMETERS

The presentation of the parameters is also automated to ease the maintenance of the information and the creation of new pages. All the World Wide Web pages are created automatically and have the same layout, see figure 1. This means that all pages benefit from updates and new utilities, and that the general layout of the pages can be easily modified. The pages are kept simple and with limited possibilities to escape the page structure via hyperlinks. They are kept in a tree structure, with chapters and subchapters.

The database is keeping the contents of the pages and also information about the title of the page, its set of navigation buttons and the type of contents. The type of contents can be for example a static text or a list of parameters for a table. General procedures are written to build the tables.

This WWW Interface is programmed in PL/SQL, using the Oracle Web Server.

The layout drawings are managed with the CERN Drawing Directory (CDD) application [3] like all other LHC project drawings. Associated to the CERN developed HPGL viewer this gives access to the drawings via the WWW for display on computer screens, for reviewing and for printing.

Another presentation on the WWW uses the Computer Graphics Metafile (CGM) format. This offers interesting

possibilities to link the graphic elements of a drawing to other drawings, documents or database records. This approach makes it possible to navigate graphically through the whole set of layout drawings and associated parameters.

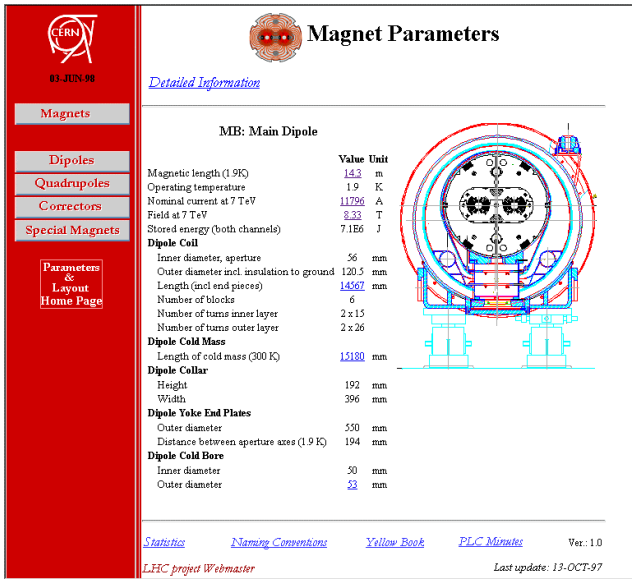

Figure 1: Example of automatically generated page.

6 OUTLOOK

The system is dynamic; extensions and refinements are continuously put into the system and more complete reference lists set up.

For the parameters describing the beam, definitions and relations will be put into the system.

The information stored in the system is the basis for the LHC Design Report and it will be possible to generate tables and other data directly from the database.

More work on the database is needed to ensure the maintenance over the project lifetime.

7 REFERENCES

[1] C.Delamare, F.Dittus, R.Evensen, M.Ferran, C.Hauviller, B.Faugeras N.Hoimyr, M. Mottier, J.Nikkola , T.Pettersson , B.Rousseau, H.van der Welde, G.Faber, "The CEDAR Project", this conference.

[2] A. Albrecht et al., "CERN's Accelerator Description Using Databases", Proceedings of the 1992 European Oracle Users Group Meeting, March 1992.

[3] C.Delamare, I.Fernandez, F.Jeannin, S.Petit, "CDD CERN Drawings Directory User's manual: Version 1.1", CERN-EST-96-004.