DESIGN AND FIRST IMPLEMENTATION OF A VACUUM DATABASE FOR LHC MAIN RING AND TRANSFER LINES

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Abstract

During the construction of LHC, much information about vacuum equipment is scattered at different levels and activities have to be shared and not duplicated. To gather this data, a completely new database is designed, in relation with other existing databases and personal data storage. An inventory and analysis of the data required by the users has been done. Disparate types like history of existing equipment, coming from an existing Oracle Database, test results, drawings and studies need to be stored. Different groups of people are involved and a user interface will provide access to an overview of LHC activities for the vacuum group. This paper presents the results of the analysis of the user requirements and some ideas how to implement them.

1 INTRODUCTION

At present time, most of the design data for LHC used by the vacuum group is available on paper or in private computer files. However, all specifications and drawings are inserted in a project wide engineering data management system (EDMS) called CEDAR [1] using in house designed tools like the CERN Drawing Directory (CDD) [2] and the future Traveller, or a commercial product CADIM. As our data has to be shared with other groups, it was necessary to make an inventory of the required data and to propose some solutions to store them, trying to avoid as much as possible duplication or unnecessary development.

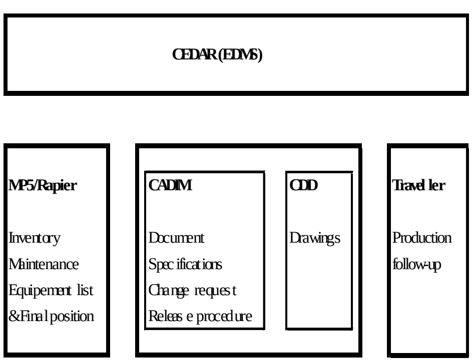

Figure 1: Overview of CERN EDMS.

2 IDENTIFICATION OF THE REQUIRED DATA

A number of interviews have been performed with engineers and physicists in order to assess the requirements in the field of databases for the vacuum system [3], leading to the following inventory.

2.1 Accelerator design data

When a project like LHC is launched, a set of fundamental parameters is produced by machine physicists and equipment specialists. These parameters, often referred to as the base line design, are published in a report, which has received the name of Yellow Book for the LHC project [6].
Conceptual layouts will produce the required data to count and localise the equipment from the various systems. Functional specifications will describe the required functionality of the various components of the accelerator and will become the initial input for the equipment design process. Finally, interface specifications will insure that the boundaries between the various systems are properly described.

2.2 Vacuum equipment design data

In the design phase, the project engineer makes use of a variety of disparate data.
Because of the large number of existing accelerators, it is very important to base the design of the LHC vacuum system on the gathered experience. This is achieved by grabbing out concepts and figures from previous design, running in and performance reports. The reports are available on paper in most cases and the compilation of this data is in general saved on local files using desktop applications, like text processors or work sheets.
For systems like the vacuum system, another important source of design information comes from experiments performed in the laboratories or on existing accelerators, either at CERN or in other institutes. The data collected from these experiments is primarily stored in spreadsheet like tables and is being made public through contributions to conferences or workshops.
A further input for the project engineer at the design phase comes from manufacturers catalogues and data sheets.
The result of the design phase is finalised in documents like engineering specifications or drawings and schematics. In most cases, prototypes of whole or part of an equipment are being manufactured and tested. Here again, the test data, which will be used to qualify the series production, is mostly stored in the desktop computers of the engineers.

2.3 Vacuum equipment manufacturing data

Once the design has been validated, technical specifications will provide the basis for market surveys and calls for tenders aiming at having the equipment manufactured by the European industry. Unlike the documents used in the design phase, which come in a vast variety of format, templates exist for the technical documents required for market surveys and calls for tenders, compatible with most commonly used text processors. They are general enough to be used for vacuum equipment.

During the manufacturing process, all data required to insure the traceability according to the LHC Quality Assurance Plan [5] will have to be stored, taking into account the variety of data format which will be provided by the manufacturers. In the case of components of the vacuum systems, this concerns mechanical tolerances, leak rates and ultimate pressures, pumping speeds, etc.

2.4 Vacuum equipment installation data

In order to install the equipment from the various systems, installation layouts will have to be produced. They will provide the exact localisation of every individual vacuum component. Some of them, like the cold bore of the cryomagnet, are in fact part of the magnet, whereas others, like pumps or gauges, have their independent life cycle. The data required to produce these layouts will be associated to the data of individual instances of every component and form the basic inventory of the vacuum system. The spare parts must complete this inventory, in order to allow for the traceability of the maintenance and repairs activities.

In addition, it is required to define how the vacuum system (beam vacuum and insulation vacuum) is divided into manageable sectors.

2.5 Vacuum equipment operational and maintenance data

It is important to define at an early stage which data will be required to operate the vacuum system.

The first requirement comes from the fact that most of the active vacuum equipment, like pumps, valves and gauges, will be remotely controlled. Definition of the behaviour of the equipment, of the physical values the equipment can control, of the actuation it accepts, as well as the physical way of how to access the equipment must be kept in a database.

Making use of the basic inventory of the vacuum system, the data required for maintaining or keeping track of the maintenance of the equipment is also to be stored.

Finally, the physical values that can be gathered by the instrumentation of the vacuum system, mainly pressures, will have to be stored using logging programs. This data has to be stored in such a way that it remains possible to correlate the vacuum parameters with other fundamental parameters like beam current or energy.

The operation phase will require most of the vacuum data to initialise all the front-end computers and acquisition devices, and to set up all equipment. Device history and inventory could be of a great help when a problem has to be solved.

3 INTEGRATING THE VACUUM DATA IN EXISTING DATA BASES

The available data for the design and manufacturing of the vacuum system is often stored on paper or on local desktop computers, in a variety of different formats. This is a serious drawback in view of sharing data among users, as well as it makes the availability of a reliable long term storage doubtful. This problem has been identified at the project level in 1994 when an Engineering Data Management System (EDMS) has been put into place. A previously existing CERN Drawing Directory application is storing the drawings and will eventually become part of the EDMS. Finally, the follow up of maintenance of equipment from several major systems, like LEP cryogenics and electricity distribution, makes use of a commercial product, MP5/Rapier.

3.1 Experimental data

There are several possibilities to preserve the data gathered from experimental set-ups. The initial documents can be saved, either in their original format or in a portable format (e.g. Adobe's pdf) on the EDMS server, with a link from one of the access interfaces. Documents available on paper can be scanned and also converted into a portable format. Alternatively, the data can be imported into a relational database like ORACLE. The advantage of this second approach is that it becomes much easier to correlate this data with data from other sources. However, it requires a careful analysis of the data before creating the data tables.

3.2 Reports

As most of the reports are produced using common text processors, it makes sense to store these documents on the EDMS server, either in native format or in a portable format.

3.3 Drawings and specifications

There is no reason not to use the existing facilities for the drawings and specifications of the components of the vacuum system. This insures that the major design issues are following the recommended approval path. As there is little data to be correlated with other systems, there does not seem to be a need for a relational model.

3.4 Manufacturing data

An electronic traveller has been defined in the framework of the LHC Quality Assurance Plan, along with remedies in the case the manufacturer can not adhere to the proposed solution. The manufacturing of components of the vacuum system produces a lot of information on which it would be desirable to compute statistics. It is therefore envisaged to import into a relational database all the manufacturing data, trying to find ways to minimise the need to retype data.

3.5 Installation data

The LEP vacuum system is described in a database allowing to follow its evolution. Vacuum components, identified by their type, are assigned dates when they are installed or dismounted from the accelerator. Although the cold arcs of LHC are likely to remain unchanged over the life cycle of the accelerator, there still is a length of some 2 km which will be built in a more classical way. Furthermore, some 6 km of transfer lines between SPS and LHC, as well as two times 700m of beam ejection lines, will have to be described. It is therefore our aim to use a database with features similar to the one for LEP to describe the LHC vacuum system.

3.6 Vacuum equipment maintenance data

Although the existing LEP database allows to keep track of changes of the description of the vacuum system, there is no record of which instance of any type is installed in the accelerator, hence no possibility to keep a history of maintenance and repairs.

A significant effort has been made to have an up to date inventory of the vacuum components in all accelerators which are maintained by our group. The outcome of this should be available by the end of the year and it is planned to use the MP5 product, which is based on ORACLE, to deal with the maintenance data.

4 DATA INTERFACE

LHC data are created everywhere at CERN. Most of the divisions are working on this project and have their own data.

4.1 Data entry and maintenance

The aim of the vacuum database is to take benefit from CERN available wide tools and to incorporate our data inside the existing systems. We will have to design and build the structure we need to accept all the present and future data types. This includes also what will come from external companies, which will take part in the LHC project. This last point is very important to allow CERN to keep all conception and design data, as well as test results, in a way to insure proper actions and controls while the LHC will run.

Most of the vacuum data, like specifications, drawings, tests will be entered inside the Oracle database using CADIM/TUOVI [7].

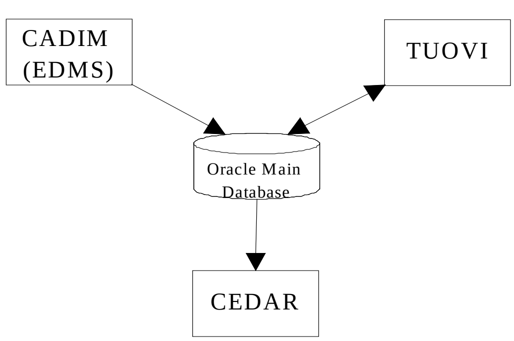

Figure 2: Tools to access CERN databases

Operational data, like measurement logging, will be inserted into the database using specific data acquisition programs.

4.2 Data extraction

Two main tools have been created at CERN to visualise data extracted from Oracle Database: TUOVI and CEDAR. These programs are used throughout CERN and the LHC experiments. A specific application is needed to create a report, a selection of existing documents. A graphical user interface, like JavaGuils, will be used to display operational data. This program allows the operators to access archived and current values of measurement.

Information from the vacuum system will be extracted from the database to create machine layouts.

4.3 Archiving of data

Archiving of data must allow usage of data in the future. One of the main problems, for the moment is to insure compatibility with different versions of software used to create a document.

One solution will be to save the documents using two different formats: the native format used by the software which created the document and a text format, when applicable, to retrieve the documents in the future independently from the software.

5 CONCLUSION.

After a careful analysis of the data requirement for the LHC vacuum system, it seems that in most cases the tools which have been made available at the project level, in particular the EDMS system, can be used both to store and access our data. Today, this system does not yet provide versioning, therefore implementation of our own data structures will be required to follow changes in the description of the vacuum system. We will also implement our own tables to keep data on which it is desirable to perform statistics, like manufacturing data.

REFERENCES

[1] The CEDAR project by T. Pettersson at al., EPAC 98, Stockholm, 1998. http://www.cern.ch/CEDAR/project.html

[2] CERN-EST-96-004; CDD CERN Drawings Directory User’s manual by C. Delamare, S. Petit, 1996. http://wwwlhc01.cern.ch/cdd/

[3] Interviews of vacuum engineers and physicists, private communication, I. Laugier 1999.

[4] Private communication, S. Mallon Amerigo 1999.

[5] LHC Quality Assurance Plan http://wwwlhc01.cern.ch:8050/lhc_proj/owa/lhcp.page?p_number=600

[6] LHC Yellow Book http://www.cern.ch/CERN/LHC/YellowBook95/yellow.shtml

[7] TuoviWDM – Web Access to Engineering Documents http://hutinfo.cern.ch/