

ENGINEERING DESIGN MANAGEMENT AND TOOLS FOR THE CERN EDMS

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Abstract

At CERN as well as in the collaborating physics institutes and companies all around the world contributing to the design and construction of the LHC, many different CAD systems are used. A number of applications have been developed at CERN to integrate the design data from these systems into the general engineering framework managed by the CERN EDMS. On one hand, this requires creating virtual models with physical constraints in the designs to test in advance how it all fits together, i.e., building a digital mock-up of a large assembly from the smaller components. On the other hand, designs in 2D and 3D received from all the different sources need to be managed in a coherent and persistent manner. A Web-based system, CartWeb, assists users in filling in title blocks and enforces the standard CERN QA-rules on title block data. Official drawings are archived in the EDMS in the universally used plotter language HP-GL/2. Automatic utilities exist for adding approval stamps and signatures to drawings in this format. These drawings can be visualised on many different platforms by using the HP-GL viewer developed at CERN. Finally, a Web-based conversion facility, Consult, has been developed for easy exchange of designs between different CAD systems. Consult allows archived designs from the EDMS to be retrieved in several different CAD formats.

1 CERN CAD CONTEXT AND EDMS

CERN uses two main CAD systems for mechanical design work and for creating site, accelerator, and detector layouts. CERN's current principal CAD system, Euclid from EADS Matra Datavision, is used both for 2D and 3D work, while AutoCAD from AutoDesk is used essentially for 2D work. Before the introduction of the general purpose Engineering Data Management System (EDMS), drawings were managed by an Oracle-based application developed in-house. This application, which has been in use for many years, has provided us with extensive experience in distributing, reviewing, and approving drawings in electronic form rather than as paper copies. Furthermore, insight gained in this process has formed a solid background for the implementation of the EDMS for managing all types of documents at CERN. For a complete description of the CERN EDMS see [1].

2 DRAWING MANAGEMENT

With the replacement of drawing boards by CAD systems in the early nineties, it became possible to abandon paper and microfilm archives in favour of computer databases containing CAD model and drawing files. In the CERN context, where a large share of design

work is done in outside HEP-institutes and industrial companies using many different CAD systems, it was decided to use the de-facto standard HP-GL/2 plotter language as a platform-neutral storage format in addition to the native CAD files.

2.1 Drawings and Models Produced at CERN

After a designer has finished a design, the corresponding drawing files have to be verified, approved and archived. Applications have been developed in-house to help designers and engineers perform this process and to automate it as much as possible.

The first of these applications is CartWeb. It is available to designers working with Euclid, and is being adapted to work with AutoCAD. CartWeb is designed to interactively help designers complete the drawing title block (*cartouche* in French) and bill of materials with the appropriate data.

Other applications are used to archive drawing plot files and to edit them to add verification and approval data. Plot files can be displayed on a computer screen using the CERN HP-GL viewer. Some of the 3D models stored in the EDMS can also be directly visualised using the WorkView3D viewer from DeltaConcept [2]. These applications are used both with drawings created at CERN and those supplied by outside institutes and companies working on CERN projects.

2.2 CartWeb

Before a drawing can be archived, it must contain the official CERN title block. The drawing title block contains a unique drawing number, a title, optionally a longer description, names and dates of modification, bill of materials, etc. When creating drawings in the CAD system, the designer starts by using a template containing placeholders for all these data. Title block items can be filled in as the drawing is being created, but before the drawing can be archived, a drawing number must be requested and all the title block data registered in the EDMS. This is done with the CartWeb application. CartWeb is a Web-based title block editor to help the designer edit drawing title blocks in a consistent manner and following CERN's quality-assurance rules. A CartWeb session can be launched interactively from the active CAD system. A Web browser window is opened where EDMS authentication is first requested unless the user is already authenticated. Then all already existing title block data are transferred from the CAD system to the CartWeb server. If the drawing is new, a simple editing session is started in the Web browser. If the drawing already exists in the EDMS, existing title block data are retrieved and the two data sets are compared. Any

changes and discrepancies are resolved by asking the user which data to use before starting the editing session. After all editing has been done and the designer exits CartWeb, the modified data are transferred both to the EDMS and the CAD system to be integrated into the current drawing. A screenshot of a CartWeb session is shown in Figure 1.

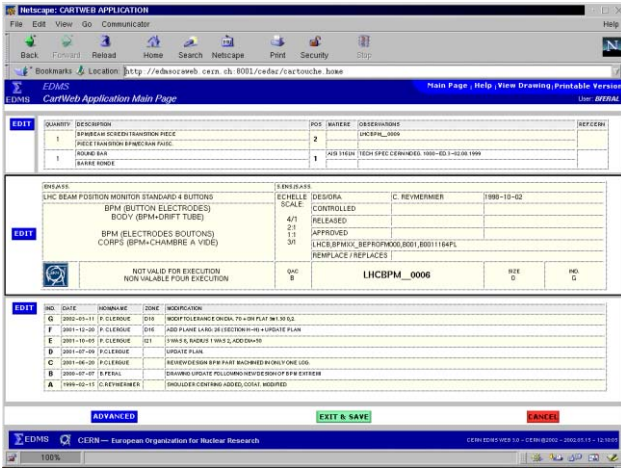


Figure 1: CartWeb session in a browser window. The bill of materials, title block data and modification log are displayed and edited in the same format as they will appear in the drawing.

2.3 Drawings Produced by Outside Institutes and Companies

In the case of a global project such as LHC it is highly desirable to use common solutions and a central repository to manage drawings and documents. The collaborating institutes and commercial companies are requested to provide HP-GL/2 plot files of the engineering drawings they create. These drawings are prepared at the institutes and companies with their local CAD systems using their own standards and quality assurance procedures. Each drawing is required to reserve a blank area at a predetermined location, where the CERN drawing number and approval data are automatically inserted when the drawing is archived in the CERN database.

Two schemes are used for transmitting plot files to CERN:

- The EDMS Web interface can be used both to register the drawings and to upload the corresponding plot files.
- The drawing metadata, in the form of a spreadsheet, and the corresponding plot files can be sent to CERN on a CD to be copied into the database.

Adherence to these procedures guarantees that drawings produced anywhere can be retrieved, displayed and printed in a unified fashion.

2.4 Archiving and Viewing HP-GL Files

After the drawing has been duly registered in the EDMS, the next step is to physically archive the drawing. The archival process can either be launched manually or triggered automatically when the drawing has passed its

formal approval process. In the case of drawings prepared at CERN, the archiving process begins with the automatic creation of an HP-GL/2 plot file of the drawing using the appropriate CAD system in batch mode. As CERN cannot have available a version of every possible CAD system, drawings from outside institutes should be in the correct plot file format before the archiving process starts. The plot file is then edited by another application to insert the appropriate approval information into the title block depending on the approval status of the drawing. The modified plot file is uploaded to the EDMS, from where it can be accessed and viewed using the CERN HP-GL viewer. Only a properly archived and approved drawing can become official and may be used in manufacturing.

The CERN HP-GL viewer is an application for visualising HP-GL and HP-GL/2 plot files. It is available for all major operating systems including Microsoft Windows, Apple Macintosh, Linux, and most commercial Unix-variants. The viewer allows the user to display plot files on screen with functions to zoom and rotate the view. It is also possible to make simple mark-ups and annotations to the plot file and to create composite plot files by including other plot files as blocks. The viewed file can be saved as an HP-GL or HP-GL/2 file or converted into PostScript, Encapsulated PostScript, DXF, or CGM. The drawing can also be printed directly from the viewer using the native printer interface of the operating system. The CERN HP-GL viewer is available free of charge to all High-Energy Physics institutes in the world and sold to commercial companies. There is a Web site for the viewer, where information and demonstration versions of the viewer for all supported architectures can be found [3]. A screenshot of the viewer is shown in Figure 2.

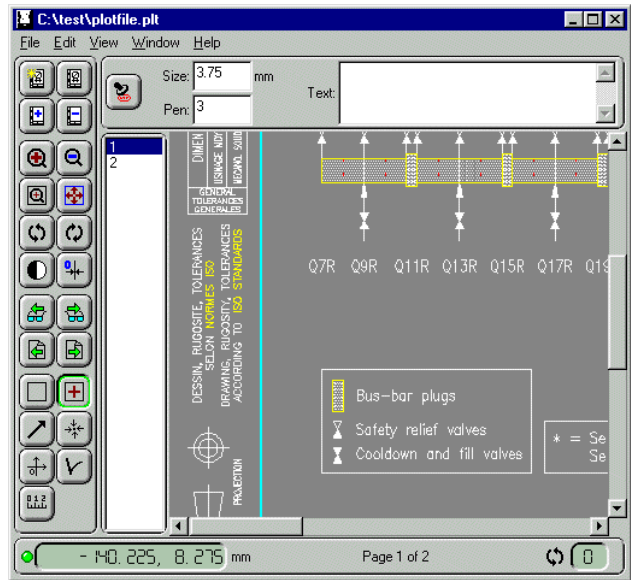


Figure 2: Main window of the CERN HP-GL viewer. A button toolbar on the left gives easy access to the most common viewer functions. An optional mark-up toolbar and a multi-page navigation toolbar are also visible.

3 CAD EXCHANGE

CERN designers and engineers must regularly access unfinished 2D and 3D CAD designs that were originally created on-site or received from external sources. CERN collaborators contributing to the projects must also be able to follow the work being done at CERN in order to carry out their part of the project.

In the past it was impossible to access Euclid data at CERN without the Euclid system since the data are kept in a central database instead of in separate independent files. The CAD exchange facility Consult was created to address this specific problem and it quickly proved itself as an extremely useful tool for a large number of users who have to extract data from the CERN Euclid database.

Consult is a software wizard hidden behind a set of Web pages and CGI scripts. Given a CAD model and the format to convert to, it tries to use the best available tool for the conversion. In the past this was done manually by the support team. Consult supports downloading data from and uploading data to CERN in several formats, among others STEP, VRML2, DXF, Euclid3, HP-GL, IGES, and Catia V4. The future goal is to extend Consult support to native AutoCAD formats as well.

The conversion success rate with Consult is of the order of 85%, which is the percentage of conversions resulting in a useful end result. This is mainly due to the large variation in internal representations of the different CAD formats, which makes automated one-to-one conversions very complicated. For the same reason some loss of information is inevitable in conversions between certain formats. Nevertheless users are very satisfied with the service, which is demonstrated by over 10,000 conversions done annually using Consult. A Web site is available for Consult support [4].

4 DIGITAL MOCK-UP

Integrating the LHC machine into the tunnel is a major challenge. Any conflicts between already installed equipment and new items in transport must be solved in advance in order to avoid delays and extra costs during installation. Experience gained with LEP has already shown how CAE tools can help in the integration process. A useful Digital Mock-Up (DMU) system must be able to do collision detection between complicated 3D-objects and to visualise their movements by producing animations to be viewed later.

The CERN DMU software is based on solid database architecture combined with accurate 3D-calculations. A key requirement has been to keep the system flexible and easy to interface to different software packages such as Excel, Oracle, Euclid, or Robcad from Tecnomatix. Considerable effort has been made to keep the system portable between Unix and Microsoft Windows. The first prototype of the software is already in production [5].

A virtual model of the entire LHC is currently being prepared. The actual tunnel has been modelled, and all the elements of the machine constructed as 3D CAD objects have been positioned accurately based on data from the theoretical design. An illustration of a DMU model is shown in Figure 3.

It turns out that the challenge in creating a successful DMU is not the software development and computing. The data required for creation of the model originate from many sources and various services at CERN. These include civil engineering (the tunnel and ground obstacles), steelwork, machine elements and survey zones, cryogenic lines, transport infrastructure, reserved zones, fluid tubes, cable trays, and other equipment like racks, boxes, safety systems, etc. Constant co-ordination and communication between all the different groups involved is required to keep the DMU databases and 3D models up to date. This is the real challenge of the DMU and it cannot be automated on a computer.

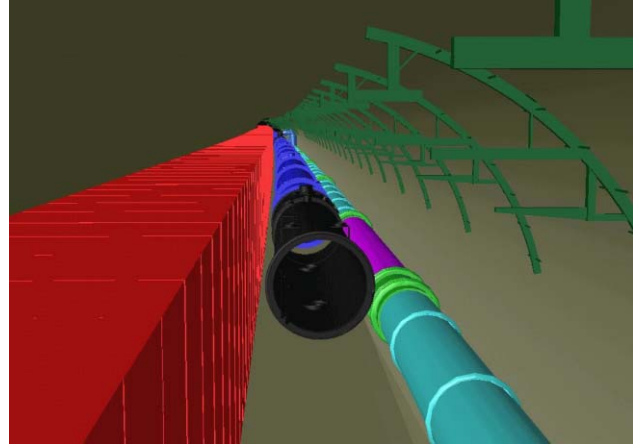


Figure 3: A DMU rendering of a transport envelope in the LHC tunnel. The LHC cryostat structures as well as the cable tray supports above the beam line are visible.

5 REFERENCES

- [1] C. Boyer et al., "The CERN EDMS - Engineering and Equipment Data Management System," EPAC'02, Paris, June 2000.
- [2] <http://www.deltaconcept.ch/>
- [3] <http://cern.ch/hpplview/hpplviewer.html>
- [4] http://wwwconsult.cern.ch:8001/HTML/consult_home_page_fr.htm
- [5] S. Chemli et al., "A virtual CAD Model of the LHC," EPAC'00, Vienna, June 2000.