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# The Evolution of CERN EDMS

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**Abstract.** Large-scale long-term projects such as the LHC require the ability to store, manage, organize and distribute large amounts of engineering information, covering a wide spectrum of fields. This information is a living material, evolving in time, following specific lifecycles. It has to reach the next generations of engineers so they understand how their predecessors designed, crafted, operated and maintained the most complex machines ever built.

This is the role of CERN EDMS. The Engineering and Equipment Data Management Service has served the High Energy Physics Community for over 15 years. It is CERN's official PLM (Product Lifecycle Management), supporting engineering communities in their collaborations inside and outside the laboratory. EDMS is integrated with the CAD (Computer-aided Design) and CMMS (Computerized Maintenance Management) systems used at CERN providing tools for engineers who work in different domains and who are not PLM specialists.

Over the years, human collaborations and machines grew in size and complexity. So did EDMS: it is currently home to more than 2 million files and documents, and has over 6 thousand active users. In April 2014 we released a new major version of EDMS, featuring a complete makeover of the web interface, improved responsiveness and enhanced functionality. Following the results of user surveys and building upon feedback received from key users group, we brought what we think is a system that is more attractive and makes it easy to perform complex tasks.

In this paper we will describe the main functions and the architecture of EDMS. We will discuss the available integration options, which enable further evolution and automation of engineering data management. We will also present our plans for the future development of EDMS.

## 1. What does EDMS bring to Physics?

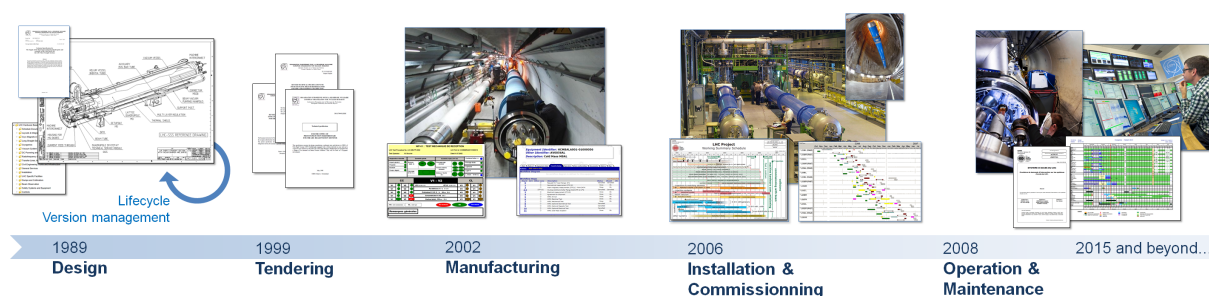
The beginning of EDMS dates back to 1995, when CERN recognized for the first time the necessity of an Electronic Data Management System in the scope of the Large Hadron Collider project. The experiments and detectors used at CERN have a lifetime of 25 to 40 years and are prone to a large turnover of personnel. It often happens that one generation of engineers designs and builds the installations, which are then operated and maintained by another generation. Throughout this time the information related to the design, construction and maintenance of the different components must be available and accessible, not only to the engineers and technicians, but also to the manufacturers providing the equipment, located in different parts of the world. This is what EDMS is there for: supporting the full lifecycle of the collider, from its conception, through design, manufacturing and installation, up to maintenance and decommissioning.

With every new large scale project, the complexity of the machinery grows, and so do the quality requirements. In addition CERN is obliged to follow strict regulations. The introduction



of EDMS back in '95 helped to organize the tremendous amount of engineering data, fulfill the quality requirements and establish the approval and test procedures. EDMS became CERN's PLM solution, becoming more and more mature over the years. Today EDMS stores more than a million documents and two million files and is used regularly by around 2 thousand users.

We intend to remain CERN's and HEP's community major partner for the next decades of challenging projects, such as the Hi Luminosity LHC and beyond.



**Figure 1.** The life of a LHC Dipole followed by EDMS from the beginning until now: Collaborative work – Traceability – Quality control – Lifecycle management – Long term data preservation

## 2. EDMS Functionality

The functionality of EDMS which we consider specifically relevant for the HEP community is focused on support for engineering and quality assurance processes, collaborative aspects of work and long term data preservation.

### 2.1. Structured data

The first strength of EDMS is the structured approach to data management. It allows the creation of documents and their classification, offering a wide range of document types, such as Specification, Technical Drawing, Schematics, Report, Non-conformity, Safety inspection, Meeting minutes, just to name a few. The documents can have associated properties and keywords, allowing for further fine grained document typology. Typically the documents are stored in project structures, where each document can be linked to more than one project node. This approach gives great flexibility of organization of information without the danger of data duplication. We support also item entities - they are used to define the metadata of equipment to be manufactured, serving as their technical template. The items can as well have technical documentation linked to them.

### 2.2. Lifecycles

Lifecycles are the implementation of formal processes and procedures followed by the engineers, and provide a framework for performing quality assurance. Any document must have a lifecycle associated to it at creation time. A lifecycle consists of statuses which mark the various stages of the work reflecting the evolution of documentation. Thanks to the document status it is easy to understand if a given design is already finished, approved and may go to tender, or if the work is still in progress. For example a lifecycle called "Approval with Engineering Check" offers statuses in which the comments are collected and formal approval is conducted. The final status of a document (such as Released) indicates that it is the official version with up to date information.

### *2.3. Version control*

EDMS enforces version control of documentation. Once a document reaches a final status, it can no longer be modified. A change requires creation of a new version of that document, which will keep previous version's metadata and associated files if the user wishes so. This new version will then follow the predefined lifecycle. Documentation versioning is another means of structured approach to data management. It provides traceability of changes by keeping the history of the versions, the time stamp of each modification and the data of the user who performed them.

### *2.4. Collaborative work*

In HEP collaboration, the work is never performed only at a single location. Therefore EDMS takes great care about the accessibility of data by any involved party, independently of their physical location, adequately to the type of the data and the authorization of the interested party. The documentation stored in the system can be marked as public, internal to CERN, restricted or sensitive. These visibility options are inline with CERN's Data Protection Policy (as recommended by the CERN IT department in 2013). In addition any documentation may change its visibility level as it becomes official – various configuration options exist today in EDMS to ease the access management. For example one can configure a project to enforce all related documents to become public when they reach a certain status.

The collaborative work is also eased by promoting the organization of documentation in a hierarchy of project nodes – the EDMS tree can then be used to easily navigate and filter large structures.

### *2.5. Fine tuned access rights*

Access control in EDMS is based on user authentication and authorization. The former is integrated with the CERN Single Sign On service, the latter is achieved via the internal setup of EDMS contexts, which provide a very flexible access model.

A context defines which group of users has access to a part of the system, as well as available document types and lifecycles. The users in the group might have read, write or delete access. Such granularity is useful when write access must be restricted to a small number of users. Depending on the project needs the contexts may implement complex rules, such as enforcing the sensitivity of documentation following a certain lifecycle and ensuring that it remains hidden for non authorized users. Besides the context and group access mechanisms, each document can be individually shared with any user of the system.

### *2.6. Personalization*

Many features introduced recently aim at user experience improvement. The system proposes to the users the pages / objects most recently viewed by them and offers the possibility of permanently bookmarking the objects. EDMS provides also the "Inbox" area, where users can see documents which require an action from them, such as e.g. giving comments.

## **3. Architecture**

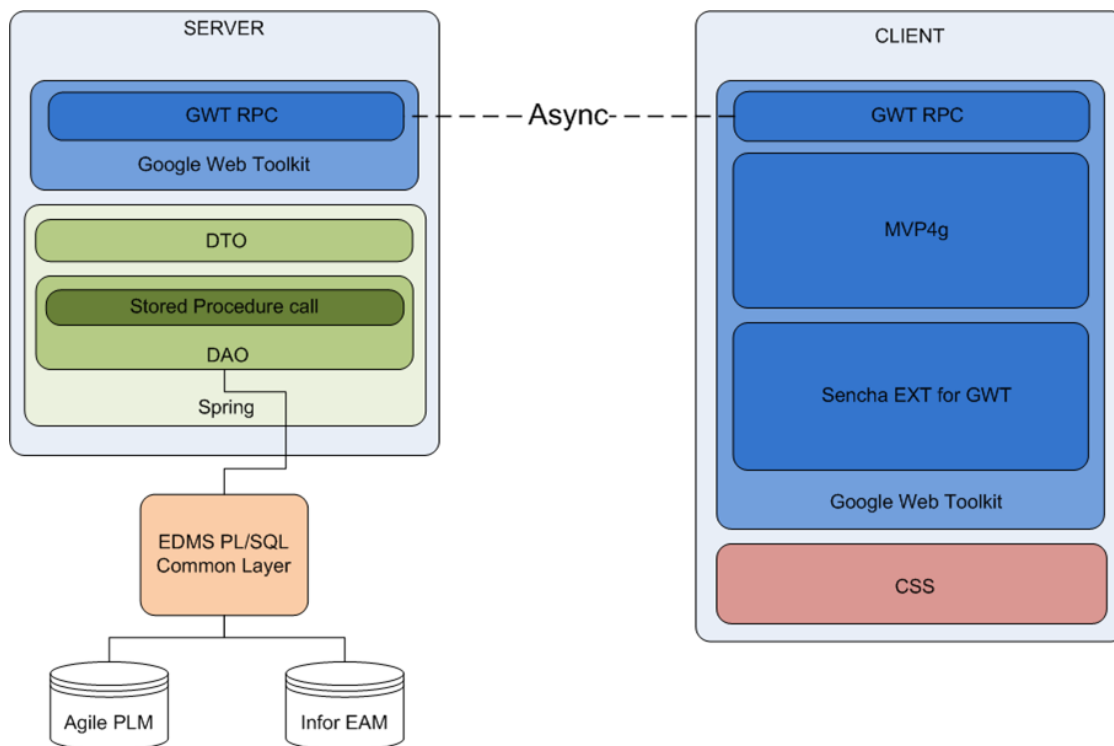
EDMS is based on Oracle Agile e6 PLM, which is a commercial PLM solution with an integrated file server. Over the years the product was heavily customized in order to meet the requirements of various user groups from inside and outside CERN. One of the first decisions made back in 1997 was the development of a web interface, to encourage a wider adoption of the system. The core of EDMS is the Oracle database, with the business logic implemented in PL/SQL. In order to interface with the native Agile functionality, an EDMS Action Broker was developed – a Java application which handles data modification actions.

The web interface was recently completely redesigned and rewritten in order to improve the user experience. On the client side we use a library based on GWT – GXT. The client – server

communication is done with asynchronous calls (GWT-RPC) allowing for partial page refresh and more fluid navigation. The Java server side is very thin, the services provide essentially gateways to the PL/SQL modules which contain the actual logic. In order to speed up and standardize the development of the Java code for calling the PL/SQL stored procedures, we developed a maven plugin, which generates the DTO (Data Transfer Object) and DAO (Data Access Object) classes basing on a mapping provided in an XML dialect. The server also deals with standard aspects of a web application such as authentication, session validation, cross-service exception handling and logging.

Apart from the web interface, there are other entry points to the system. EDMS provides a SOAP web service API allowing for programmatic input and output of data. These are used mostly for integration with other systems.

There exists also a semi-automatic way of importing large amounts of data in the batch mode via MICADO system (written in Java). The data can be defined in a simple excel sheet by a user with no programming knowledge. After running online and batch validations, the data is imported to the target system and the user is notified by email. It is worth noting that the batch imports are used not only for EDMS, but also for other systems, such as MTF, JMT (Job Management Toolkit used for contract management) and TIM (Technical Infrastructure Monitoring).



**Figure 2.** The architecture of EDMS 6 - simplified view

#### 4. Infrastructure

The business aspect of EDMS is completely separated from the infrastructure on which the service is run. The service is developed and maintained by the CERN GS-ASE group, whereas the infrastructure is managed by IT-DB group. This setup proved to be working well in the past years; we can be sure that EDMS runs on a standard infrastructure provided by CERN,

while being freed from the effort of updating and patching the hardware, the database and the application servers. The database is Oracle and is run on a cluster of two machines, the same applies to the application and HTTP servers, which dispatch the requests to appropriate Weblogic instances.

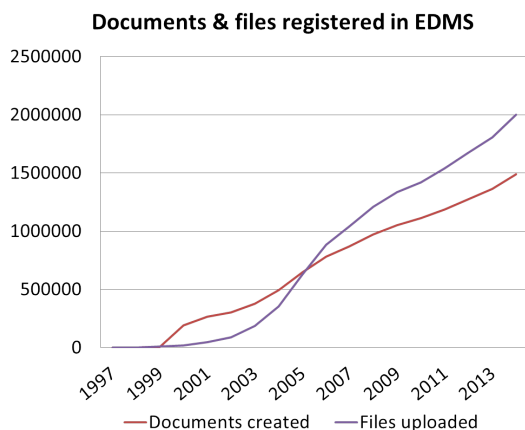
It is important to note that this architecture is mirrored twice: we have completely separate environments for development and test (pre-prod) purposes.

## 5. Usage evolution

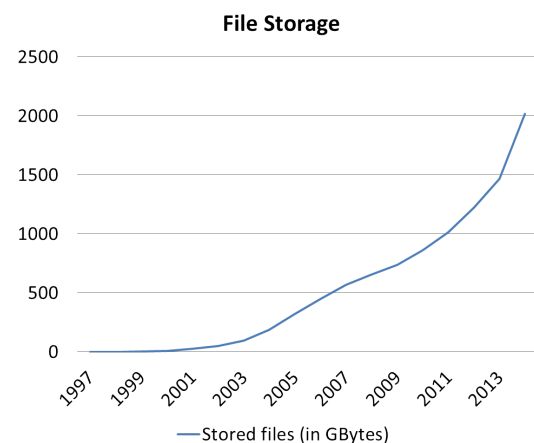
Ever since EDMS became operational, it has been growing substantially in various service areas: functionality, data volume, number of user groups, number of user requests and amount of training provided. We observed major usage peaks during the LHC design and installation, and further during the long shutdowns and maintenance. We expect another usage peak as the Hi Luminosity LHC Project gains momentum.

Significant amounts of older data are systematically imported to the system for the archivization and preservation purpose.

The majority of the user requests (more than 75%) is treated within the same day, with around 95% fulfilled within a week. Despite the small team behind EDMS, about 2700 requests are answered per year.



**Figure 3.** The growth of the number of documents and files.

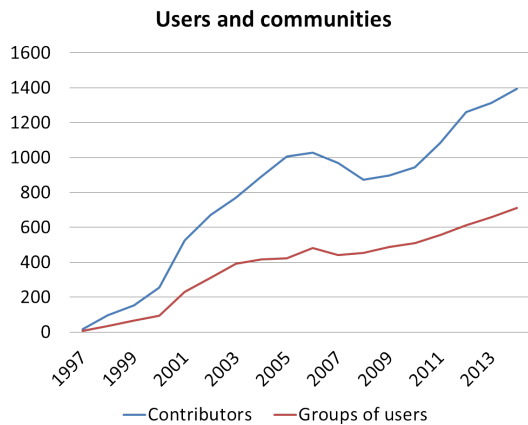


**Figure 4.** The growth of data volume.

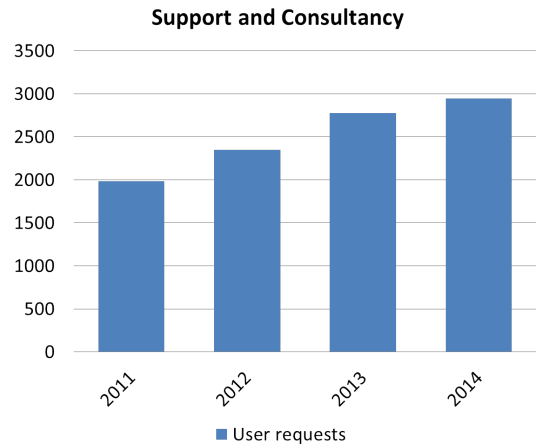
## 6. Integration evolution

From its early years EDMS was integrated with CDD (CERN Drawings Management System). This system, considered to be the predecessor of EDMS was already used by the design offices for drawing revisions and engineering control. A drawing prepared in a CAD system is registered in CDD, where it follows the engineering verification, automatic stamping and archiving procedures. It then becomes available for consultation in EDMS.

In the year 2000 EDMS was integrated with MTF (Manufacturing Follow-up System), which was a major milestone for both systems. The two together were at that point providing all functionality needed in the design, tendering, manufacturing and installation phases of the LHC and other CERN equipment. The integration was performed on a DB schema level, allowing for links between EDMS documents and MTF equipment and manufacturing steps. In the following years the objects hosted in MTF were made visible in the EDMS interface and vice versa, giving more context to displayed information. Although extremely beneficial to the users,



**Figure 5.** The evolution of number of communities using EDMS.



**Figure 6.** The amount of user requests fulfilled yearly since 2011.

the integration introduced tight coupling between the two systems, which causes maintenance issues on a regular basis. It is planned to loosen the dependencies and move towards more modular architecture.

In 2005 EDMS was chosen for the storage and follow up of safety inspections performed on the equipment and buildings. This decision resulted in providing of a whole set of dedicated functionality, accompanied by tools for automated data import. The aforementioned MICADO batch uploader was extended by a new plugin, dedicated to the safety inspections data processing.

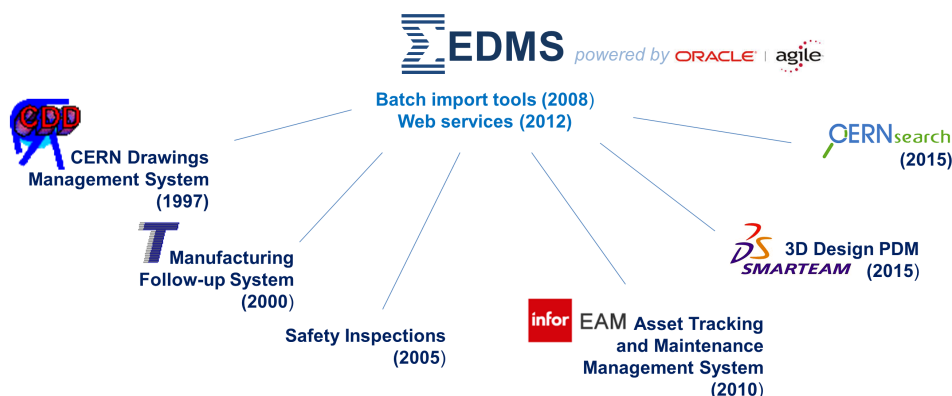
More recently EDMS tightened its links with the CMMS (Computerized Maintenance Management) system Infor EAM in order to better support the operation and maintenance phases of the LHC. New object types such as categories, maintenance management plans and spare parts became visible in EDMS and available for linking with the relevant EDMS structures and documents. We provided an interface view dedicated to maintenance management, which shows the documentation relevant for a chosen equipment, taking into account its associated work orders, installation location, its category, parent equipment, etc. The EDMS-CMMS tandem was heavily used during the LS1.

Since 2012 EDMS provides a standard SOAP API for system integration. It's currently used by several clients, such as EAM Light, (MMP) Maintenance Management Project, Sailor system, the Cern Control Centre operators and Smarteam (CAD design tool). The project of integration with the latter via this API is almost complete. It will allow publication of designs in EDMS directly from the CAD interface, enabling consistent information all along the line.

The latest big development in EDMS is the use of the central CERN Search engine. The project is scheduled to complete by the end of May 2015. It will bring enormous improvement for EDMS users, as in addition to the document metadata, file content will also be searchable, which was not possible with the previous solution. At the same time EDMS public data will gain more visibility among CERN users, as the EDMS collection will be available in the central search portal, next to the other data collections hosted at CERN.

## 7. User interface evolution

The web interface is the flagship part of EDMS, one which is most visible to the end users and the one which gets most requests for changes. It has evolved over time, following the functional and visual changes. Today's clean design has little in common with the version from early



**Figure 7.** The map of systems currently integrated with EDMS and the respective integration dates.

2000. After a complete rewrite of the interface which took place in the past three years, we have a product which is attractive in look & feel, user friendly, functional and robust. It is a result of a joint effort of the team and the key users who were involved early on, evaluating various interface components and giving ideas which were then driving the development. Major functional improvements include simplification of user actions, enhanced file upload thanks to introduction of drag&drop and removal of the limitation on the amount of files per request, provision of user favourite objects, the concept of a personal inbox containing requests from other users including the access requests, responsive navigation tree with contextual menu and filtering options.

## 8. Future plans

EDMS is rich in features, however we feel that some of them are available to a very restricted group of users. We would like to open them to a larger user community, so that the potential of the system can be better understood, realized and employed to the advantage of HEP users.

While focusing in recent years on the interface rewrite, we gathered a long list of interesting requirements, such as personal system settings, enhanced review processes with the possibility of file redlining, advanced email notification scheme allowing users to subscribe to change notifications on any document, more flexible write access sharing, automatic generation of pdf or thumbnail view of files. They will be ranked and systematically delivered in the near future. The main focus at the moment is the completion of integration with Smarteam and implementation of an administrator's configuration interface.

Apart from the web interface, the API will continue evolving in terms of functionality and technology. We plan to introduce RESTful APIs in order to further ease the access to raw data. Moreover this could be the first step towards providing a simplified mobile version of the system.

EDMS is changing for its users. We feel that we need to continuously simplify things, since very often the users have no prior PLM experience. With this goal in mind we are improving the system in all areas: interface, architecture, APIs, delivery delays, user training and communication. We readily host data and provide support to projects located outside CERN. We want to remain the key partner of the future engineering endeavours undertaken by CERN and the HEP community.

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