

ENGINEERING DOCUMENTATION AND ASSET MANAGEMENT FOR THE EUROPEAN XFEL ACCELERATOR

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Abstract

During the construction of the European XFEL, detailed technical as-built documentation has been generated for the accelerator. It is stored in an Engineering Data Management System, which provides an inventory of major accelerator components and contains documents such as specifications, 3D-CAD models and drawings, work instructions, inspection and repair records, certificates and more. Inventory and documents are of great importance for maintaining the accelerator throughout its life-time. The paper provides an overview of the available engineering documentation, describes methods of using and updating the documentation, and discusses its expected role and benefits in future maintenance processes.

INTRODUCTION

The European XFEL project team has created extensive technical documentation during the design and construction of the accelerator. It is based on a configuration database, the DESY EDMS, which has originally been introduced for the production of the superconducting cavities and the accelerator modules and has then been extended to cover the whole inventory of accelerator components [1] [2]. The configuration database registers components and their used materials, and it tracks the component design, fabrication and installation history. It contains engineering documents and drawings, and work and inspection records. In the construction project, technical documentation has been driving design, fabrication and quality management processes.

In the upcoming operation phase, the role of documentation is changing. The aim to provide reliable and highly available beams poses strong requirements on operation and maintenance. The technical documentation now has to support processes like asset management, condition and status monitoring, maintenance planning and change management.

The configuration database can be accessed through intuitive web interfaces, with dedicated support for mobile devices in the accelerator tunnel by component tags with QR codes. Numerous tools have been developed for automatically uploading and cross-linking documents, thus reducing documentation efforts for the project teams. The configuration database has performed well in the construction project and now serves as a foundation for operation and maintenance activities.

REQUIREMENTS

In the XFEL construction project, engineering documentation was set up as a central service, which was provided as part of the work package “information and process support”. The work package was created in response to increasing demand from project team and management for standardized tools and procedures to cope with technical documentation. Major requirements included enabling distributed and inter-disciplinary engineering collaboration, supporting quality management, complying with legal regulations, and laying foundation for later operation, maintenance and upgrades [3].

The resulting solution covers all requirements and has been successfully operated during the construction project. It now has to be transferred to the operation phase. While the major demand of the construction project was supporting collaborative engineering, the focus of attention now switches to availability and reliability requirements and the expected longevity of accelerator operation.

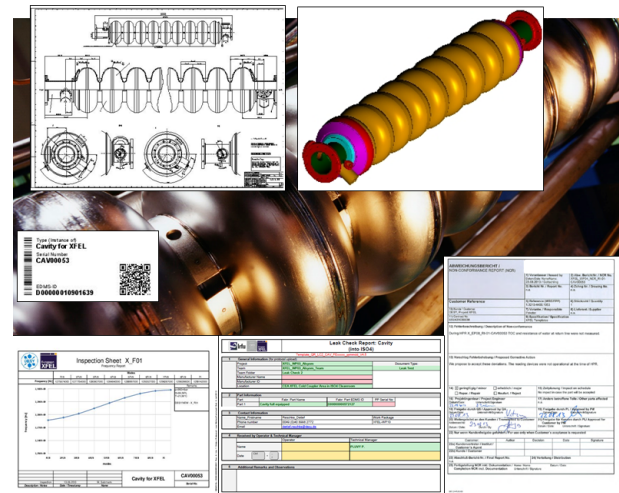


Figure 1: Example for accelerator component documentation, showing design documents (top) and various inspection records (bottom).

Figure 1 shows an example of a well-documented component. Quick and location-independent access to the full accelerator documentation is essential for service (“health”) checks, and maintenance and repair of accelerator components. This is true for both regular maintenance periods and, even more so, for emergency access in

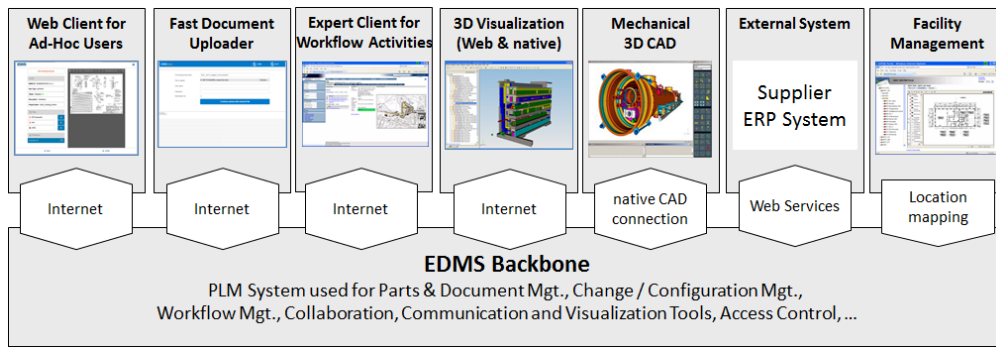


Figure 3: DESY EDMS solution architecture.

case of failure and unexpected downtime. Unavailability of the information in a central online repository may cause longer repair times and as a consequence fewer user hours. The aim is to evolve the technical documentation into a foundation for preventive and predictive maintenance.

Availability of the information over the life-time of the XFEL facility is crucial, including history and change logs. Operations will face staff fluctuations, and the technical documentation should provide enough details and context to enable efficient operation and maintenance work also after more than a decade of operation, which requires keeping the documentation continuously up to date.

SOLUTION OVERVIEW, STATUS AND PERSPECTIVE

A solution for technical documentation based on the DESY EDMS has been provided and successfully operated throughout the construction project. It consists of a configuration database, a number of web-based clients for different user groups, workflows and tools for automating document processing, integration with external databases at partner labs, and data structures and templates for standardizing documentation efforts [4]. Figure 3 highlights the current solution architecture.

The overall technical documentation coverage of the facility varies. While essential and mission-critical sections and components are usually well documented, the documentation of more conventional components (such as e.g. technical infrastructure) still needs to be post-processed and completed. Figure 2 shows a summary report for quickly accessing inventory and documents of an accelerator section.

The current solution can be directly carried over to the operation phase, but new requirements will need some extensions of the software. Some developments will be within the scope of the current system, such as e.g. additional metadata attributes for capturing component usage information, or for tracking and documenting changes from incidents. Others may require extending the system scope by addressing novel functionality, such as e.g. maintenance planning, but such extensions are already foreseen in the system architecture and will be straight forward to implement with the available concepts.

USING THE DOCUMENTATION

Accessing documentation is the most essential use case for providing required documents whenever and wherever needed. Document access ranges from desktop access by experts, planners or supervisors to fast-response and ad-hoc access by technicians while on the job anywhere in the facility.

SASE 3 - XTD 2 10.05.2017 12:18:54 (C4571)									
XFEL Cell Regular SASE 3	Cell03.SA3	Cell04.SA3	Cell05.SA3	Cell06.SA3	Cell07.SA3	Cell08.SA3	Cell09.SA3	Cell10.SA3	Cell11.SA3
Undulator U68	X042-2040	X028-2027	X048-2038	X033-2031	X020-2030	X022-2013	X020-2036		
RFEL UndulatorKammer	XFEL_UndulKammer-129	XFEL_UndulKammer-132	XFEL_UndulKammer-130	XFEL_UndulKammer-128	XFEL_UndulKammer-126	XFEL_UndulKammer-124	XFEL_UndulKammer-122		
Arccoil Big SASE 1+3	S144	S141	S142						
Arccoil Small	S043	S044							
RFEL Intersection Start SASE	I081	I082							
RFEL Intersection Regular SASE									
Phase Shifter	PS049-2019	PS029-2022							
RFEL Beam Loss Monitor	RFEL_BLM_0224	RFEL_BLM_0214	RFEL_BLM_0213	RFEL_BLM_0212	RFEL_BLM_0211	RFEL_BLM_0210	RFEL_BLM_0209		
RFEL Beam Loss Monitor	RFEL_BLM_0226	RFEL_BLM_0219	RFEL_BLM_0218	RFEL_BLM_0217	RFEL_BLM_0216	RFEL_BLM_0215	RFEL_BLM_0214		
RFEL Beam Loss Monitor	RFEL_BLM_0213	RFEL_BLM_0212	RFEL_BLM_0211	RFEL_BLM_0210	RFEL_BLM_0209	RFEL_BLM_0208	RFEL_BLM_0207		
RFEL Beam Loss Monitor	RFEL_BLM_0207	RFEL_BLM_0206	RFEL_BLM_0205	RFEL_BLM_0204	RFEL_BLM_0203	RFEL_BLM_0202	RFEL_BLM_0201		
RFEL Beam Loss Monitor	RFEL_BLM_0201	RFEL_BLM_0199	RFEL_BLM_0198	RFEL_BLM_0197	RFEL_BLM_0196	RFEL_BLM_0195	RFEL_BLM_0194		
RFEL Beam Loss Monitor	RFEL_BLM_0194	RFEL_BLM_0193	RFEL_BLM_0192	RFEL_BLM_0191	RFEL_BLM_0190	RFEL_BLM_0189	RFEL_BLM_0188		
RFEL Beam Loss Monitor	RFEL_BLM_0188	RFEL_BLM_0187	RFEL_BLM_0186	RFEL_BLM_0185	RFEL_BLM_0184	RFEL_BLM_0183	RFEL_BLM_0182		
RFEL Beam Loss Monitor	RFEL_BLM_0182	RFEL_BLM_0181	RFEL_BLM_0180	RFEL_BLM_0179	RFEL_BLM_0178	RFEL_BLM_0177	RFEL_BLM_0176		
RFEL Beam Loss Monitor	RFEL_BLM_0176	RFEL_BLM_0175	RFEL_BLM_0174	RFEL_BLM_0173	RFEL_BLM_0172	RFEL_BLM_0171	RFEL_BLM_0170		
RFEL Beam Loss Monitor	RFEL_BLM_0170	RFEL_BLM_0169	RFEL_BLM_0168	RFEL_BLM_0167	RFEL_BLM_0166	RFEL_BLM_0165	RFEL_BLM_0164		
RFEL Beam Loss Monitor	RFEL_BLM_0164	RFEL_BLM_0163	RFEL_BLM_0162	RFEL_BLM_0161	RFEL_BLM_0160	RFEL_BLM_0159	RFEL_BLM_0158		
RFEL Beam Loss Monitor	RFEL_BLM_0158	RFEL_BLM_0157	RFEL_BLM_0156	RFEL_BLM_0155	RFEL_BLM_0154	RFEL_BLM_0153	RFEL_BLM_0152		
RFEL Beam Loss Monitor	RFEL_BLM_0152	RFEL_BLM_0151	RFEL_BLM_0150	RFEL_BLM_0149	RFEL_BLM_0148	RFEL_BLM_0147	RFEL_BLM_0146		
RFEL Beam Loss Monitor	RFEL_BLM_0146	RFEL_BLM_0145	RFEL_BLM_0144	RFEL_BLM_0143	RFEL_BLM_0142	RFEL_BLM_0141	RFEL_BLM_0140		
RFEL Beam Loss Monitor	RFEL_BLM_0140	RFEL_BLM_0139	RFEL_BLM_0138	RFEL_BLM_0137	RFEL_BLM_0136	RFEL_BLM_0135	RFEL_BLM_0134		
RFEL Beam Loss Monitor	RFEL_BLM_0134	RFEL_BLM_0133	RFEL_BLM_0132	RFEL_BLM_0131	RFEL_BLM_0130	RFEL_BLM_0129	RFEL_BLM_0128		
RFEL Beam Loss Monitor	RFEL_BLM_0128	RFEL_BLM_0127	RFEL_BLM_0126	RFEL_BLM_0125	RFEL_BLM_0124	RFEL_BLM_0123	RFEL_BLM_0122		
RFEL Beam Loss Monitor	RFEL_BLM_0122	RFEL_BLM_0121	RFEL_BLM_0120	RFEL_BLM_0119	RFEL_BLM_0118	RFEL_BLM_0117	RFEL_BLM_0116		
RFEL Beam Loss Monitor	RFEL_BLM_0116	RFEL_BLM_0115	RFEL_BLM_0114	RFEL_BLM_0113	RFEL_BLM_0112	RFEL_BLM_0111	RFEL_BLM_0110		
RFEL Beam Loss Monitor	RFEL_BLM_0110	RFEL_BLM_0109	RFEL_BLM_0108	RFEL_BLM_0107	RFEL_BLM_0106	RFEL_BLM_0105	RFEL_BLM_0104		
RFEL Beam Loss Monitor	RFEL_BLM_0104	RFEL_BLM_0103	RFEL_BLM_0102	RFEL_BLM_0101	RFEL_BLM_0100	RFEL_BLM_0099	RFEL_BLM_0098		
RFEL Beam Loss Monitor	RFEL_BLM_0098	RFEL_BLM_0097	RFEL_BLM_0096	RFEL_BLM_0095	RFEL_BLM_0094	RFEL_BLM_0093	RFEL_BLM_0092		
RFEL Beam Loss Monitor	RFEL_BLM_0092	RFEL_BLM_0091	RFEL_BLM_0090	RFEL_BLM_0089	RFEL_BLM_0088	RFEL_BLM_0087	RFEL_BLM_0086		
RFEL Beam Loss Monitor	RFEL_BLM_0086	RFEL_BLM_0085	RFEL_BLM_0084	RFEL_BLM_0083	RFEL_BLM_0082	RFEL_BLM_0081	RFEL_BLM_0080		
RFEL Beam Loss Monitor	RFEL_BLM_0080	RFEL_BLM_0079	RFEL_BLM_0078	RFEL_BLM_0077	RFEL_BLM_0076	RFEL_BLM_0075	RFEL_BLM_0074		
RFEL Beam Loss Monitor	RFEL_BLM_0074	RFEL_BLM_0073	RFEL_BLM_0072	RFEL_BLM_0071	RFEL_BLM_0070	RFEL_BLM_0069	RFEL_BLM_0068		
RFEL Beam Loss Monitor	RFEL_BLM_0068	RFEL_BLM_0067	RFEL_BLM_0066	RFEL_BLM_0065	RFEL_BLM_0064	RFEL_BLM_0063	RFEL_BLM_0062		
RFEL Beam Loss Monitor	RFEL_BLM_0062	RFEL_BLM_0061	RFEL_BLM_0060	RFEL_BLM_0059	RFEL_BLM_0058	RFEL_BLM_0057	RFEL_BLM_0056		
RFEL Beam Loss Monitor	RFEL_BLM_0056	RFEL_BLM_0055	RFEL_BLM_0054	RFEL_BLM_0053	RFEL_BLM_0052	RFEL_BLM_0051	RFEL_BLM_0050		
RFEL Beam Loss Monitor	RFEL_BLM_0050	RFEL_BLM_0049	RFEL_BLM_0048	RFEL_BLM_0047	RFEL_BLM_0046	RFEL_BLM_0045	RFEL_BLM_0044		
RFEL Beam Loss Monitor	RFEL_BLM_0044	RFEL_BLM_0043	RFEL_BLM_0042	RFEL_BLM_0041	RFEL_BLM_0040	RFEL_BLM_0039	RFEL_BLM_0038		
RFEL Beam Loss Monitor	RFEL_BLM_0038	RFEL_BLM_0037	RFEL_BLM_0036	RFEL_BLM_0035	RFEL_BLM_0034	RFEL_BLM_0033	RFEL_BLM_0032		
RFEL Beam Loss Monitor	RFEL_BLM_0032	RFEL_BLM_0031	RFEL_BLM_0030	RFEL_BLM_0029	RFEL_BLM_0028	RFEL_BLM_0027	RFEL_BLM_0026		
RFEL Beam Loss Monitor	RFEL_BLM_0026	RFEL_BLM_0025	RFEL_BLM_0024	RFEL_BLM_0023	RFEL_BLM_0022	RFEL_BLM_0021	RFEL_BLM_0020		
RFEL Beam Loss Monitor	RFEL_BLM_0020	RFEL_BLM_0019	RFEL_BLM_0018	RFEL_BLM_0017	RFEL_BLM_0016	RFEL_BLM_0015	RFEL_BLM_0014		
RFEL Beam Loss Monitor	RFEL_BLM_0014	RFEL_BLM_0013	RFEL_BLM_0012	RFEL_BLM_0011	RFEL_BLM_0010	RFEL_BLM_0009	RFEL_BLM_0008		
RFEL Beam Loss Monitor	RFEL_BLM_0008	RFEL_BLM_0007	RFEL_BLM_0006	RFEL_BLM_0005	RFEL_BLM_0004	RFEL_BLM_0003	RFEL_BLM_0002		
RFEL Beam Loss Monitor	RFEL_BLM_0002	RFEL_BLM_0001	RFEL_BLM_0000	RFEL_BLM_0000	RFEL_BLM_0000	RFEL_BLM_0000	RFEL_BLM_0000		

Figure 2: Summary report of XFEL SASE section showing parts inventory with links to further part documentation.

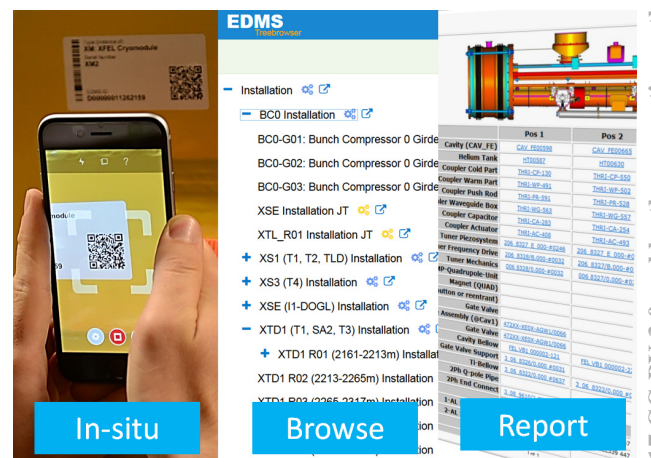


Figure 4: Different methods of accessing technical documentation of the European XFEL.

Users can access component documentation in-situ by scanning a dedicated QR-code attached to the component. The QR code contains a direct link to the component's EDMS record and its related documentation. Alternative access methods include tree browsers and summary reports of beamline (sub-) sections, and of course a search. All access methods are available for many kinds of mobile and desktop devices and may be used without any user training. Figure 4 illustrates some of the different ad-hoc access methods.

KEEPING THE DOCUMENTATION UP-TO-DATE

Being able to catch any document or information immediately when it occurs is a vital capability for keeping documentation up to date. For this reason, the EDMS offers a variety of easy-to-use input channels.

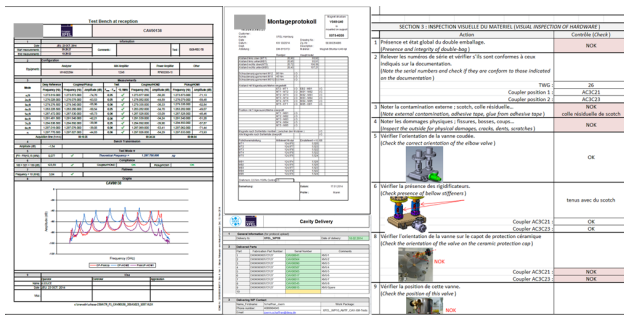


Figure 5: Examples for spreadsheet-based process documentation.

Process users can upload documents through a simple web-page which requires only a file name and user credentials. It works equally well for quality engineers filling spreadsheet-based checklists, or partners providing (scanned) manufacturer certificates, independent of whether they are located on site, at partner labs, or sub-contractors in industry. Figure 5 shows different kinds of forms, certificates and vendor documents which were provided during component fabrication.

For even higher throughput, quickly configurable web-services are available for integrating with external databases and information systems. They have been used for example in the series production of the superconducting rf cavities, capturing more than 100,000 documents, an

amount which could have no longer been handled without proper automation.

EXPERIENCE

The technical documentation and its supporting systems have evolved into an important ingredient to efficient and effective project work. The most essential applications were using documentation for quick in-process information, leading to better quality of the related work, and using documents to initiate and track workflows.

It is important to provide solutions with immediate practical value and low additional workload for the work packages. Value of documents was typically found in clarifying deliverables, interfaces and responsibilities by agreeing who will provide which information, and thus conduct which activity when; by passing information about incoming components ahead of their delivery; and of course by completeness, reliability and repeatability of document-driven procedures. Low additional workload was achieved by providing central documentation services, including delegating central systems engineers to work packages to help ramping up documentation tasks, and jumping in when additional capacities were needed.

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