ORGANIZING THE ILC TECHNICAL DESIGN DOCUMENTATION

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Abstract

The Technical Design Report for the International Linear Collider, due at the end of 2012, will be accompanied by a detailed Technical Design Documentation (TDD), which will make all relevant technical design documents such as calculations, 3D CAD models and detailed descriptions available in a uniform fashion. The TDD will be stored in an Engineering Data Management System (EDMS) operated by DESY. We describe how the TDD will be organized, the process that is being introduced to collect and produce the TDD, and how the EDMS supports this process.

INTRODUCTION

The Global Design Effort for the International Linear Collider (ILC) has the goal to produce a Technical Design Report (TDR) for the ILC by the end of 2012, which will include an updated cost estimate, and which will be the basis for a decision about the future of this project. The TDR will be a written report similar to the Reference Design Report (RDR) [1] from 2007, which it will replace as main design document of the ILC. The TDR will be accompanied by and based on the Technical Design Documentation, which reflects the full level of detail to which the design of the ILC has been performed, and which will serve as basis for the final design after the project has been approved.

The Technical Design Documentation (TDD) must thus entail the full body of working documents such as design notes, parameter lists and calculations, lattice files, component lists and specifications. These documents need to be stored in a way that makes it possible to trace to the input on which calculations or designs are based, so that it can be checked and verified that the desired level of correctness, completeness and consistency has been achieved. The goal is to finally have a completely traceable documentation that allows drilling down from the final cost estimate to the fundamental parameter lists and lattice design files.

The TDD has to remain accessible at least until the end of operation of the ILC, which means for several decades.

CREATING THE TDD WITH AN ENGINEERING DATA MGT. SYSTEM

Creating and maintaining the full body of technical documentation for large, complex and long-lived systems is a mission-critical task for many industrial companies e.g. in the automotive and aerospace industry, and has lead to the development of industrial information system solutions called Engineering Data Management Systems (EDMS) or Product Lifecycle Management (PLM) systems. EDM systems are in operation in a growing number of accelerator laboratories around the world, and the GDE has decided to use the DESY EDMS, which DESY has introduced for the European XFEL, as supporting tool for the creation and long-term storage of the TDD [2] [3].

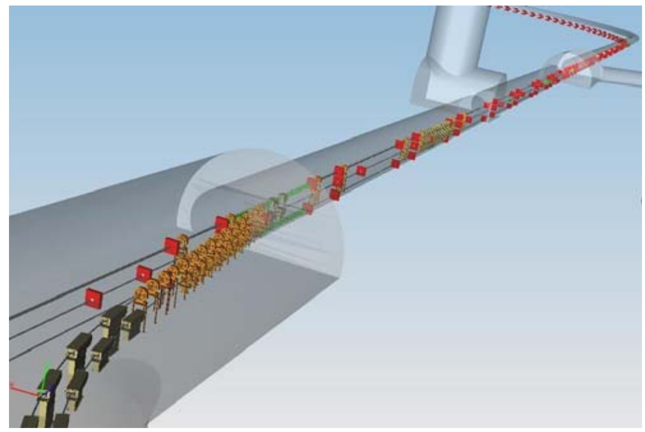

Figure 1: 3D visualization of the area of positron injection into the damping ring complex of the ILC. Several models have been combined for this figure: 3D CAD models of the positron source accelerator components and of the tunnel facilities, and a schematic illustration of the damping ring lattice.

The EDMS stores electronic data of any form such as text documents, spreadsheets, drawings and complete 3D CAD models (Figure 1) in a persistent and tamper-proof way. Documents are accessible by a unique alphanumeric identification string (e.g. "D00000000925325,E,1,2") and, once released, are protected against changes or deletion. Revisions of documents are possible and are clearly documented in a way that fulfils even the strict legal requirements for the documentation pertaining to potentially hazardous technical installations such as pressure bearing devices. The system has powerful full-text search capabilities and offers various ways to structure and categorize documents. A customizable access control protects confidential documents, and legally binding signoff procedures for planning documents are available. Relations between documents can be drawn to capture interrelations such as "A depends on B", "A refers to B" or "A is a design document for B". These relations can be centrally configured to react differently to updates of documents, so that e.g. always the latest version of a document can be referenced, or the precise revision that was valid at the time the relation was created.

Relations are also used to represent the structure of CAD models, where components and assemblies are

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linked by "A uses B" relationships. Thereby, the part structure of a complex system such as an accelerator can be explored within the EDMS, and documents such as calculations can be attached to the appropriate design elements.

With these capabilities, an EDMS is much more than simply a long-time storage for documents, it is an elaborate tool to support a *process* during the respective lifecycle phases of planning, construction and operation of a system (here the design of an accelerator). The purpose of this *process* is not to merely produce a paper trail whose production costs scarce resources, but to create a complete, consistent and correct design of the accelerator, which is the prerequisite for a reliable cost estimate. The efficient exchange of information that is complete and reliable, as testified by electronic approval and signoff procedures, is an important prerequisite for such a process.

Thus, it is important that creating the TDD is governed by a suitable process, which includes procedures to capture, review, iterate and evaluate documents and guidelines for the content of mandatory documents that shall be provided in similar form by all subsystems. Thus, the TDD is not an a posteriori collection of ad hoc documents, but the result of well-defined process, which focuses not on the creation of documentation, but is aimed at supporting the design process itself by providing reliable, up-to-date information as the design evolves in an orderly way.

To this end, a series of Baseline Technical Review (BTR) workshops are presently conducted. During each BTR workshop, a detailed review of a subsystem such as the Positron Source is conducted, and new design choices or changes to the existing RDR design are discussed and approved by the GDE management and the physics community. The aim is to have a first draft version of the mandatory documents ready for the BTRs, and finalize them within a few months after the BTR, so that in essence the BTRs serve as kick-off workshop for the finalization of the TDD for the respective subsystem.

CURRENT ACTIVITIES AND EXAMPLES

Two BTR workshops have been conducted so far, for the positron source [4] and the damping rings [5]. As these workshops continue, a standard set of documents has emerged. The Technical Area Groups (TAGs) are asked to provide a Work Breakdown Structure (WBS) of their system, along with a written System Overview, a Beamline Summary (which establishes official, short-hand nomenclature for all beamline sections, branch points, dumps, and treaty points between subsystems), and a Parameter List that summarizes the operating parameters of the system. These documents are required to be produced in advance of the BTR as the minimum set of design documentation..

Next, Lattice files are required in XSIF format [6], suitable as input to accelerator development programs such as MAD, MADX or BMAD. Component lists, which are consistent with the lattice and structured according to the beamline sections, and component specification sheets constitute the basis for further documents detailing calculations of heat loads, electricity consumption, water and cryogenic fluid requirements etc. These calculations then provide the foundation for capturing the requirements of the Conventional Facilities and Siting (CFS) group. All this information is finally collected to produce the Cost Estimate.

While the sequence of these mandatory documents suggests a certain work flow, the reality in a project that has been active for many years and has already produced an RDR with a complete cost estimate is somewhat different. The documents listed above exist already in some fashion for most of the systems, albeit in different formats and at differing levels of detail and accuracy. Therefore, available documents are first collected and entered into the EDMS with the help of the staff at DESY. In a second stage, they are evaluated by the Project Management and the TAG leaders for completeness and accuracy, before it is decided which documents need to be revised or created newly.

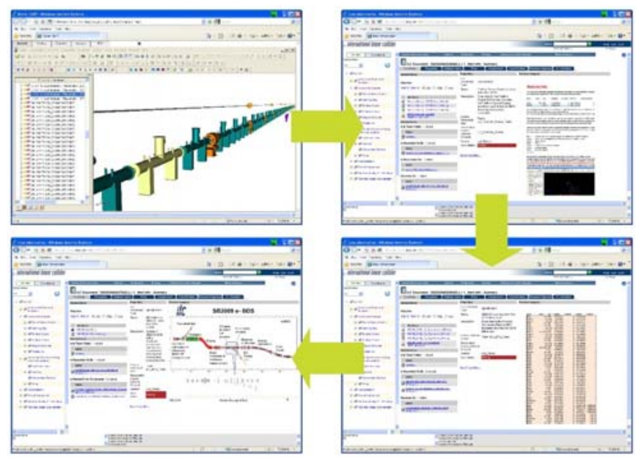

Figure 2: A single undulator cryomodule can be traced from its position within a 3D CAD model of the accelerator to the original lattice file stored in EDMS.

The process is monitored in a “Design Register” document, which is a table that summarizes the state of the documentation for all beamline sections.

Figure 2 illustrates how the EDMS system supports traceability between design documents: A 3D CAD model of an accelerator section (in this case, the helical undulator section of the ILC positron source) is stored in the system. The model has been generated on the basis of position data stored in an Excel spreadsheet, which depends on another spreadsheet that has been generated from the lattice data. All these items (CAD model, spreadsheet, and the lattice files) are stored in the EDMS, and linked with "depends on" relations. If the lattice file is updated, it is clearly visible which documents are still based on an outdated lattice version and need to be revised.

The lattice file is also used for creating an overview 3D model of the entire accelerator (Fig. 1 and Fig. 2, top left). This model uses so-called placeholder models of the accelerator components, which represent the components shape, but not its details. These placeholders are used to verify that the components fit into their foreseen spaces in the accelerator. The EDMS offers the capability to compare these placeholders with the detailed designs which are created in the TAGs to ensure that the reserved space is compatible with the space that is really needed (Figure 3).

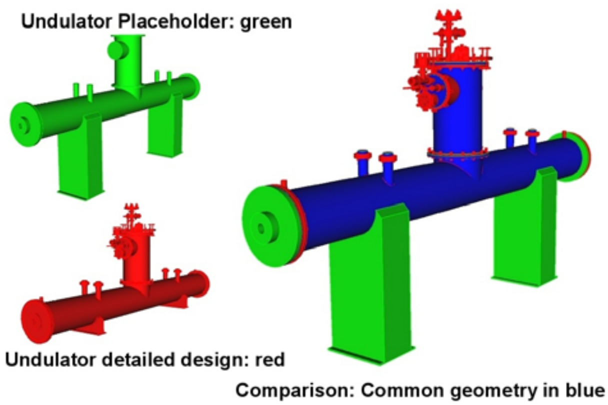

Figure 3: Comparison of placeholder and detailed design models

The system parameter lists, which exist for the accelerator as a whole and for all subsystems, are managed in a similar fashion. All subsystem parameter lists are related through a "depends on" link to the top level machine parameter list [7].

CONCLUSION

The aim of the Technical Design Documentation of the ILC project is to capture and make available all relevant technical information that has been and is being generated as part of the Technical Design Phase II. Central to the success of the TDD is the development of standards for mandatory documents that shall be provided for all subsystems, and the definition of a process how to generate, review and iterate these documents. A series of dedicated Baseline Technical Review workshops has been established in order to foster this process. Information exchange between the groups participating in the Global Design Effort, which are truly scattered around the world, benefits particularly from a system that provides a single point of information for everyone. So, instead of being a static "post mortem" archive of documents with varying content and structure, the TDD provides up-to-date and accurate information in a structured manner and in a predictable location during the design phase. Thus, the design process is supported and also shaped by the creation of the TDD.

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REFERENCES

[1] International Linear Collider Reference Design Report, vol. 1-4, ILC-Report-2007-001 (2007), http://www.linearcollider.org/about/Publications/Reference-Design-Report.
[2] L. Hagge et al., "Making Engineering Data Available at the European XFEL", IPAC2011, San Sebastián, THPC080; http://www.JACoW.org.
[3] J. Bürger et al., "DESY EDMS: Information Management for World-Wide Collaborations", PAC'09, Vancouver, May 2009.
[4] Positron Source Technical Review; http://ilcagenda.-linearcollider.org/event/5036.
[5] ILC GDE Meeting "Damping Ring Technical Baseline Review"; http://agenda.infn.it/-conferenceDisplay.py?confId=3793.
[6] P. Tenenbaum, "Guide to LIBXSIF, a library for parsing the Extended Standard Input Format of accelerator beamlines", LCC-Note-0060.
[7] N. Walker, "ILC Parameters"; http://ilc-edmsdirect.desy.de/ilc-edmsdirect/document.jsp?-edmsid=D00000000925325.