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CONFIGURATION MANAGEMENT IN THE SERIES PRODUCTION OF THE XFEL ACCELERATOR MODULES

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Abstract

The series production of the superconducting accelerator modules for the European XFEL requires a production rate of one module per week. To reach this goal, assembly procedures have to be well-defined and repeatable, and the punctual supply of parts from the contributing institutes has to be assured. Configuration management has been introduced for clarification of responsibilities and for establishing procedures.

The paper gives an overview of the configuration management solution which is in place for the assembly of the XFEL accelerator modules, and reports experience and lessons learned from production of the first modules.

INTRODUCTION

The objective of the series production of the XFEL accelerator modules is to assemble 103 accelerator modules at a throughput of one module per week. The modules are integrated using an industrial subcontractor who is working at the research lab with the lab infrastructure and under supervision of lab staff. Challenges include getting the infrastructure and procedures ready, setting up the supply chains, training the teams, and ensuring the modules are produced according to specification [1].

This paper describes how configuration management helps to clarify and establish procedures and responsibilities, and how it helps to ensure production quality in the collaborative engineering setup. After a brief introduction of some key configuration management concepts, the paper describes how configuration management is implemented and has evolved into an essential practice in the series production of the XFEL accelerator modules. The paper concludes with benefits and lessons learned.

CONFIGURATION MANAGEMENT

Configuration management (CM) is a business process which enables organizations to manage their configurations (i.e. products) as supposed to be, and which ensures that configurations (i.e. products) conform to their documented requirements.

A configuration denotes a set of parts, also often referred to as components, which are assembled into a product. Such parts can include e. g. mechanical and electronic hardware, software, accessories, documentation, or services. “Configuration” emphasizes that complex products are built from numerous parts which all have to be matched, and which have to behave according to their individual specifications in order to enable the product to function as a whole.

Major CM activities include baseline definition, item identification, change control, status accounting and auditing [2] [3]:

- **Baselines** are consistent sets of documents which describe a configuration at a specific point in time in the product lifecycle. They comprise e.g. the applicable specifications, design drawings, fabrication instructions and quality control templates.
- **Identification** ensures that any element in a baseline or in a physical product may be recognized and tracked. It provides the ability to create an inventory, and to keep track of the entire history of each part and document.
- **Change control** aims at managing inevitable changes to requirements as a project progresses. It provides mechanisms for releasing documents, and for controlling the impact of changes.
- **Status accounting** is the basis for recording and reporting information to management. It addresses current item properties and whereabouts, as well as statistics on requested changes or observed problems.
- **Audits** are intended to validate that product development has completed to a certain stage, and that it has achieved its performance and functional characteristics as specified. They are the key method for ensuring product compliance with specifications, policies and contractual agreements, and they are often conducted as formal reviews at decision gates.

CM scales well and may be implemented in small and medium-sized projects as well as in large-scale, globally distributed enterprises.

CRYOMODULE PRODUCTION SETUP FOR THE EUROPEAN XFEL

The XFEL cryomodules are produced in a collaborative effort of numerous partnering research labs, who are acting as in-kind contributors to the project. The labs have sub-contracted the production of many components to industrial suppliers.

The core activity is the assembly and integration of the modules, which is performed by CEA in Saclay. CEA assembles and delivers 103 cryomodules for the European XFEL. CEA has constructed a dedicated assembly plant which optimizes the assembly workflow. The modules are assembled by an industrial sub-contractor, who is using the infrastructure at CEA and who is working under the

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supervision of CEA staff. Completed modules are delivered to DESY for RF acceptance tests at a target rate of one module per week [1] [4].

The cryomodule parts are supplied to CEA by different XFEL work packages. Most are produced in industry. Some parts are delivered to CEA directly by their vendors, while others are received from the responsible partner labs after performing acceptance tests and additional pre-processing. Figure 1 illustrates parts originating from different work packages [5].

As a central collaboration platform, the DESY Engineering Data Management System, DESY EDMS, connects the contributing partners. It stores the entire configuration information and coordinates the essential workflows [6] [7].

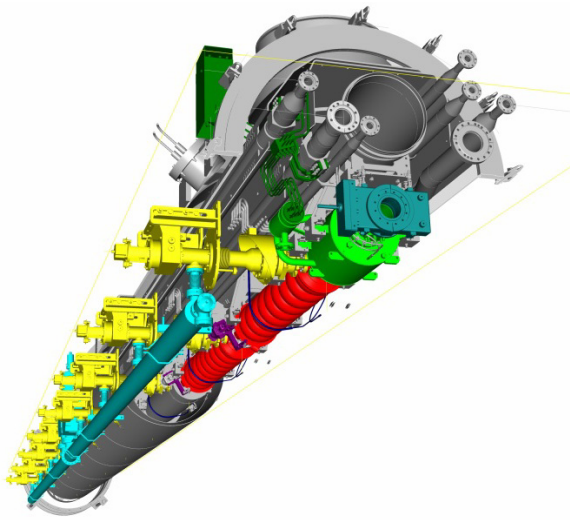

Figure 1: Design model of an XFEL accelerator module. Different colors illustrate parts originating from different supplying work packages.

BASELINE DEFINITION: HOW TO BUILD AN ACCELERATOR MODULE

The entire information which is necessary for producing a cryomodule is contained in the cryomodule baseline. The baseline is centered on the "manufacturing bill of material" (MBOM), a hierarchical breakdown of cryomodule components in accordance with the module assembly procedure. Figure 2 shows a high-level excerpt of the cryomodule MBOM. The indentation level L corresponds to the assembly stations in the plant and lists all the parts needed at that station. For example, level 6 corresponds to the string assembly area in the cleanroom, where all the level 6 parts are assembled into a cavity string.

The MBOM also lists the responsible work package and coordinator for each part and is the major tool for clarifying responsibilities. Furthermore, for each MBOM element, a set of describing documents is stored in the DESY EDMS. Those documents include CAD model and drawings, assembly instructions, and instructions and

L	Name	Quantity
1	XM: XFEL Cryomodule	
2	VCMS: Vessel + Cold Mass + String	1
3	CMAS: Cold Mass + Aligned String	1
4	CMS: Cold Mass + String	1
5	STR: Cavity String	1
6	CCC: Cavity + Cold Coupler	8
7	Cavity full equipped	1
7	CCP: Coupler Cold Part Assembly	1
7	Aluminium Seal NW40	1
7	Coupler Cold Part Assembly Set	1
6	BQU: BPM-Quadrupole-Unit	1
6	CBL: Cavity Bellows	8

Figure 2: High-level excerpt from cryomodule MBOM.

templates for inspections and acceptance tests. The MBOM together with all its describing documents is the output of fabrication planning, it provides the complete instruction and forms the fabrication baseline for producing a cryomodule.

The full cryomodule MBOM contains around 500 lines.

ITEM IDENTIFICATION: BUILDING THE INVENTORY

For managing the configuration of the individual cryomodules, every physical part that is produced, and all the documents and inspection records that are created are registered in the configuration database. The DESY EDMS assigns unique identifiers to all these items, ensuring they can be unambiguously recognized and tracked.

For every physical part, the EDMS stores all its inspection and test records, including material and vendor certificates. It relates the physical part with its corresponding MBOM element and links it with the particular document versions that have been used in the production of that part. The EDMS also records the part locations and the part usage. All the information is captured during audits, which are described further below.

As a result, a physical bill of material (BOM) is created bottom up for each individual cryomodule. The BOM together with all production and inspection records forms the product baseline.

CHANGES AND NON-CONFORMITIES: COPING WITH REALITY

Once the fabrication baseline is established and production has started, changes will occur. Changes are a reality, and they have to be addressed properly in order to keep their impact under control and ensure that also under changing conditions, modules will remain compliant with their specifications.

Minor changes to the fabrication baseline, such as adding notes to drawings or instructions, or extending inspection templates, are introduced by revising the according

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documents. The EDMS version control system ensures that cross-references from product baselines point to the correct document versions. Major changes, e.g. in the module design, would be handled by formal change requests prior to revising the baseline.

Changes to the product baseline arise during production whenever discrepancies are detected between specifications and inspection results. They are documented in non-conformity reports, which are then evaluated in a formal decision making process, as to whether the affected parts shall be used-as-is, reworked or replaced.

The procedures for revising documents, processing change requests and handling non-conformity reports are well-defined. They assign responsibilities to roles, e.g. revisions may be introduced only by quality managers, decisions on non-conformity handling have to be taken by the responsible work package leader, etc. The procedures are supported by electronic workflows in the EDMS [7].

STATUS ACCOUNTING: RECORDING AND REPORTING INFORMATION

A wide range of reports on the current production status can be created from configuration management information. They address a variety of purposes, e.g. enabling fabrication managers to follow-up on individual parts, or helping quality managers to analyze the systematics of non-conformities. Examples for reports include:

- Ad-hoc access to physical part production status, including latest inspection records, current location, and release date and usage history.
- Reconciliation of BOM and MBOM, i.e. comparison whether an individual module contains all the parts it is supposed to contain.
- Summary of all non-conformities which occurred during production of a particular module.
- Location distribution of all parts of a specific type, e.g. distribution of all cavities.
- List of all open non-conformity reports in module production.

All the reports can be obtained interactively from the DESY EDMS.

AUDITING: ENSURING QUALITY AND COMPLIANCE

Audits are the major information catch points during cryomodule production. They include incoming inspections for every received physical part, quality inspections whenever modules are transferred from one assembly station to the next, and inspections by external authorizing bodies. All these audits are well-defined and documented by templates which contain work instructions for performing the audit, forms for recording the results, and conditional formatting for quickly highlighting whether results are in the expected limits.

All the inspection records are uploaded to the EDMS. It is essential that inspection records are received completely and timely to ensure up-to-date results in status accounting.

BENEFITS AND LESSONS LEARNED

The configuration management solution provides the central collaboration platform for all contributing laboratories and industrial suppliers, and it is the foundation for quality management. It helps achieving compliance with legal regulations (e.g. pressurized equipment directive), a precondition for the operating permission for the XFEL.

CM is well-known in major industries, but not so much in research labs, and introducing CM was a cultural change for all involved parties. The CM solution has been mostly developed during the fabrication of the pre-series modules, which has been a challenge and hard effort, as there were not many references from which to start working. But the CM activities also soon started to become rewarding, especially creating the MBOM and the fabrication baseline was an essential ingredient in organizing module production.

CM relies extensively on documentation. Documents are often perceived as archival records, which can be provided after an activity is completed. In series production, documents need to be received in-time, as they are essential for process control, e.g. in decision making or non-conformity handling. The use of templates and the use of automation procedures for uploading and post-processing documents in the EDMS help to ease the documentation efforts and to timely receive the documents.

CONCLUSION

A configuration management solution is readily in use in the series production of the XFEL accelerator modules. While bringing the CM solution into operation was a complex and tedious task, it has now become an essential practice in managing the complexity of the module production.

REFERENCES

[1] C. Madec et al., “The Challenges to Assemble 100 Cryomodules for E-XFEL”, SRF2013, Paris, Sept. 2013, p. 810 (2013); http://ipnweb.in2p3.fr/srf2013/

[2] V. C. Guess, “CMII Standard for Enterprise-Wide Configuration Management and Integrated Process Excellence (Rev. H)”, CMII Research Institute, Phoenix, AZ, March 2014.

[3] C. Haskins (Ed.), “INCOSE Systems Engineering Handbook”, ver. 3, INCOSE, Seattle, WA, June 2006.

[4] S. Berry et al., “Clean Room Integration of the European XFEL Cavity Strings”, IPAC14, these proceedings.

[5] H. Weise, “How To Produce 100 Superconducting Modules for the European XFEL in Collaboration and with Industry”, IPAC14, these proceedings.

ISBN: 978-3-95450-132-8 doi:10.18429/JACoW-IPAC2014-THPRO006

[6] L. Hagge et al., "Making Engineering Data Available at the European XFEL", IPAC2011,San Sebastián, Sept. 2011, p. 3077 (2011); http://www.jacow.org
[7] L. Hagge et al, "Experience and Benefits from PLM-Based Parts Management at European XFEL", IPAC2013, Shanghai, May 2013, p. 3306 (2013); http://www.jacow.org