ENGINEERING COLLABORATION EXPERIENCE AT THE EUROPEAN XFEL

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Abstract

Efficient engineering is among the critical success factors for any accelerator project. It requires an effective project organization, fast and efficient engineering processes, a culture of open-mindedness and intensive communication, and practical tools to be in place and well aligned. The paper describes ingredients and examples for efficient engineering collaboration at the European XFEL.

INTRODUCTION

The construction of the European XFEL involved a huge internationally distributed and inter-disciplinary engineering effort. This paper discusses examples for good engineering practices which have been successfully developed and applied in the construction of the European XFEL, including the appropriate combination of de-/central activities in design collaboration and integration; the use of manufacturing bills of materials for coordinating and tracking contributions, as well as for clarifying responsibilities; the right amount of reviews for keeping activities in synch; some specific needs of and measures for in-kind collaboration; and general methods, tools, practices and spirit for efficient communication and collaboration.

PROJECT ORGANIZATION

The European XFEL construction project had to obey two project organizations: A work package organization for managing the project, and a contract organization for managing in-kind contributions.

In-kind contributions were agreed with partner laboratories, while work packages were organizing the project into teams according to a mostly functional breakdown of tasks and responsibilities. Partner labs could contribute to several work packages, and each work package could receive contributions from several partners. Figure 1 illustrates the project organization.

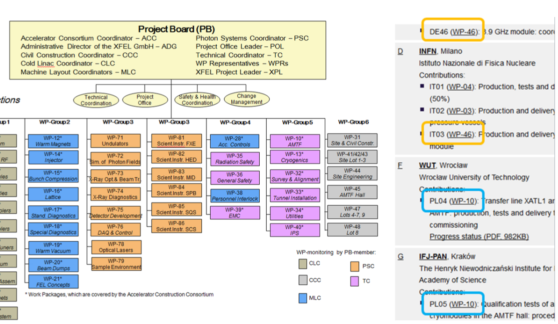

Figure 1: XFEL work package organization (left) and contract organization (right, excerpt), illustrating laboratories which contribute in-kind to more than one WP.

The in-kind contracts implement the formal project organization, while the project was practically managed following the work package organization. The co-existence and difference of the two organizations implied that all decisions and activities had to be reached on the basis of consensus, which was the guiding principle and one of the major strengths of the project.

(DE-) CENTRALIZATION

In huge international projects with in-kind contributions, one of the major challenges for engineering collaboration is finding the right balance of central and de-central activities. In-kind contributors are part of the project because of their excellence, which suggests they should be able to use their established local infrastructure and standards in their de-central locations. The accelerator facility, on the other hand, requires all contributions to seamlessly fit, which implies a strong need for central standardization of components, tools and procedures to ensure processes are not interrupted when parts are transferred between partners.

The general strategy at the European XFEL was to accept and decouple de-central activities at component level from central integration. Design integration models and a central configuration database were frequently updated and iterated to detect potential conflicts as early as possible. The approach worked very well and is illustrated by several examples in the next sections.

EXAMPLE: DESIGN INTEGRATION

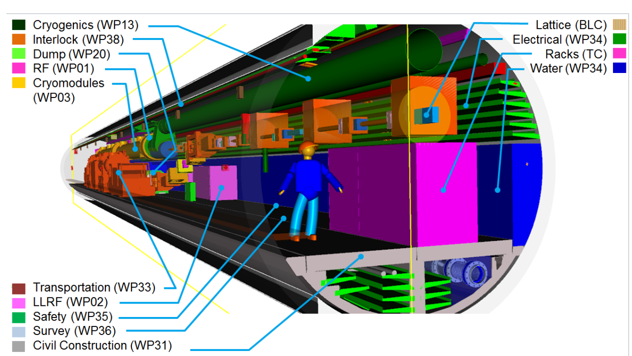

Figure 2: Example for XFEL CAD integration model, listing the contributions and their owning groups.

The major objective of design integration at the European XFEL was to provide a complete and consistent design description of entire facility. A central design integration office received and integrated contributions from all partners and performed clash checks [1]. The design data was owned and solely modified de-centrally by the responsible partners. The central design integration team maintained more than 150 CAD models of the various sections of the facility, which were iterated with and updated by the de-central partners on a bi-weekly basis. Figure 2 shows an example for an integrated model of a small tunnel section.

The central clash checks helped detecting collisions before fabrication started and thus saved cost. The ubiquitous availability of integrated visualization models enhanced vision sharing and communication among teams, easing collaboration and decision making.

EXAMPLE: PARTS MANAGEMENT AND QUALITY CONTROL

The major objectives of parts management included clarifying responsibility and (fabrication) procedures for in-kind contributions, monitoring the supply chains to ensure the timely availability of sufficient material, and providing a scalable and rapidly adaptable scheme for issuing and receiving work instructions and quality inspection records.

Extended manufacturing bills of material, MBOM, were created for components, which listed the required parts, their responsible providers and further administrative and procedural information. An inventory database registered manufactured parts according to their MBOM definitions and enabled contributors, to upload and attach documents to the part records as production progressed [2] [3]. Figure 3 shows an excerpt of the MBOM for the accelerator modules (top) and how module fabrication and test progress was tracked by incoming inspection records (bottom).

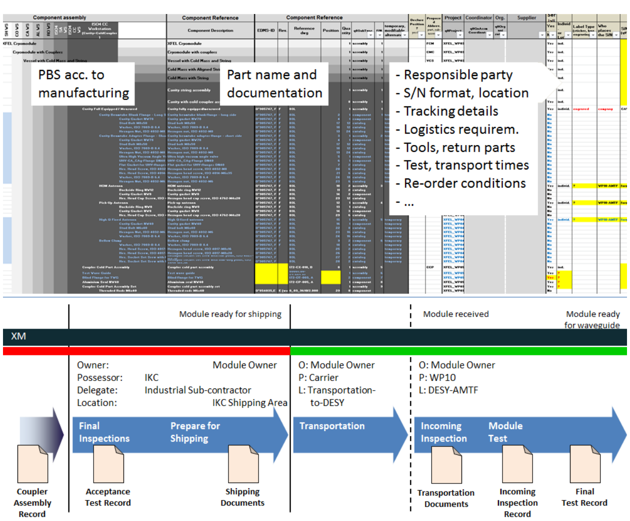

Figure 3: Sample MBOM (top) and excerpt from fabrication and test process (bottom).

MBOMs and the configuration database became the central tool for coordinating and monitoring the de-central fabrication by partners, sub-contractors and in-kind contributors. Forms and inspection records were based on spreadsheets, which could be uploaded and automatically post-processed. They could also be easily modified and extended, e. g. with notes and instructions, by the work package teams without breaking the automatic processing. The mechanism collected extensive technical documentation on-the-fly and provided good coverage of ongoing activities.

EXAMPLE: PROJECT MANAGEMENT

One essential task of the project office was to maintain complete, consistent and up-to-date project schedules. Similar to the previous examples, the approach was to decouple project-wide scheduling from WP-specific task planning. An enterprise project management system was introduced which kept detailed project plans in the de-central work packages, and a central integrated project plan containing only milestones to manage their dependencies [4]. Figure 4 illustrates the general approach.

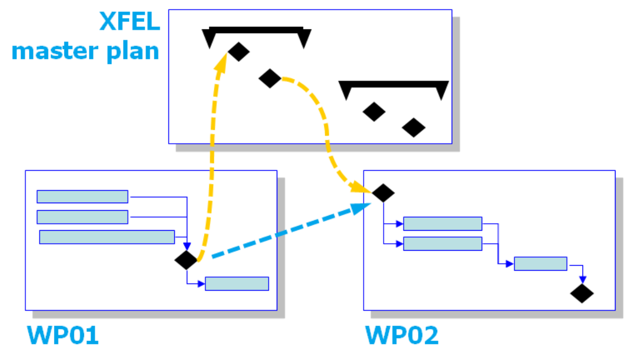

Figure 4: De-/central project planning: Detailed schedules are kept in the work packages (bottom) and integrated in a central milestone plan (top).

The XFEL project management database contained more than 50 project plans from different work packages, which have been integrated and managed in a central milestone plan. Benefits included early detection and resolution of conflicts, and very intuitive visualization for efficiently communicating and tracking dependencies and budget controlling. Standard reports where used in regular project progress meetings to control the project progress, to identify delays, and to track the money flow.

REVIEWS

Complementing the continuous central integration efforts, an independent scheme of project reviews was set up to double-check on the completeness, correctness, consistency and compatibility of evolving designs, schedules and other engineering deliverables. Reviews were organized by sub-system and accelerator section, and for the overall project progress.

Engineering reviews were held when sub-systems approached one of their major milestones to assess the readiness for the next phase. Conceptual design and production readiness reviews checked the interfaces with other sub-systems and examined the fitness for the specified tasks, as well as the impact on project risks and safety. Project reviews were held three times for overall schedule consolidation. All reviews have been standardized with

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templates. Figure 5 shows a sketch of the project lifecycle and the major engineering reviews with some of their content, highlighting the content evolves as the project progresses.

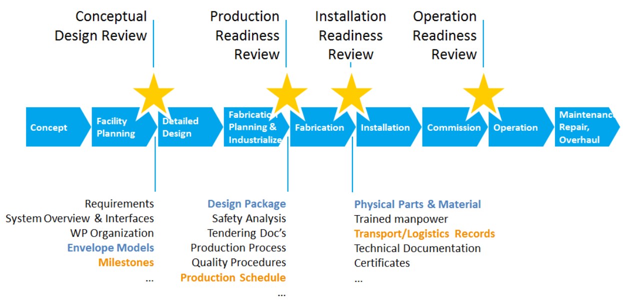

Figure 5: Project lifecycle with engineering reviews and examples for their content. Colors indicate the evolution of engineering design and schedule.

Engineering reviews were essential, as during the final stages of design and the ramp-up of production, updates of engineering designs and work package schedules occurred very frequently, bearing the risk that some of them are missed and not properly checked for their impact by other work packages. The engineering reviews ensured that all schedule and design changes were properly accounted for. In addition, the reviews were an important mechanism for collecting engineering documentation.

EXPERIENCE

The previous examples have demonstrated that the same de-/central process scheme has been successfully applied to various collaborative engineering activities. The strategy was in all cases to decouple detailed local activities from central integration efforts, and to implement a central repository with provided up-to-date information to the entire process.

The processes profited from intensive and timely collaboration, where collaboration implies commitment to delivering contributions in time; open-mindedness for feedback; readiness to help when needed; and willingness to compromise when resolving conflict. The guiding principle has always been to keep the engineering processes running, which has always been achieved by a collaborative spirit.

All processes were driven by documents, which conveyed work instructions, captured inspection records, and at the same time by their presence were able to indicate the actual process status. Documentation was based on spreadsheet forms, which could be automatically processed, and web-based tools for uploading, which were non-invasive to the partners' IT environments.

In-kind contributors were seamlessly fit into the de-/central process schemes. It was important to define expected deliverables, including their documentation, in advance and include them into the IKC agreements. To avoid returning parts to partner sites in case rework is needed, it was beneficial to be prepared for receiving engineers from the IKCs and provide them with adequate infrastructure and thus not loose time in case fixes are needed during installation and commissioning.

It was essential to initially support de-central teams when establishing collaboration processes. Learning new tools and complying with novel procedures tend to first put additional workload on the work packages, which they are hardly able to cope with. Central services can help setting up tools and provide trainings on the job until a certain level of routine is reached, this way also enhancing smooth operation of the overall process.

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