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NEW COORDINATION TOOLS TO PREPARE THE PROGRAMMED STOPS IN THE LHC AND ITS INJECTORS

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Abstract

The LHC and its Injectors are submitted to an overall lifecycle of three to four years of physics delivery to Experiments with a two-year long stop, also known as Long Shutdown (LS). The years of physics delivery are ended by a programmed stop for the immediate preventive and corrective maintenance, also known as (Extended) Year-End Technical Stop – (E)YETS. This regular cycle is to be addressed in parallel with other projects: the upgrade projects to the accelerator complex of the LHC (High-Luminosity project) and to its Injectors (LHC Injectors Upgrade), and the "standard" consolidation tasks. This paper describes the way the programmed stops coordination group prepares the activities to take place during the stop with a set of new tools and processes that ease the communication between the stakeholders of the coordination.

INTRODUCTION

The preparation of the coordination of activities resides on three pillars: the description of the change along with its impact analysis, a scheduling simulation in order to verify the feasibility of the change implementation as well as assessing the risks on co-activities during the implementation; a simulation of the space analysis to assess the space needed for the installation process. Obviously, the information from the field when the change occurs is needed to check the correct proceeding of the installation. The process explaining the interactions between the stakeholders of the coordination group is described in [1]. The tools recently developed reinforce this process.

THE INTERNAL COORDINATION WORK

PLAN, the strategic tool for the Accelerators and Technology Sector in order to collect consistent information well upstream of their implementation, is described in [2]. For what concerns the implementation in itself, the strategic tool to get access into the facilities to execute the work is controlled by the IMPACT tool [2, 3]. Between these two ends – from the early request to the time of installation – the coordination of the programmed stop must be organised.

The to-do list of a programmed stop is made of activities issued from the usual maintenance items, the consolidation of existing equipment, and the new items issued from upgrade projects. All these items have been validated in PLAN, which ensures that all groups participating in an activity can allocate the resources for the requested work.

Introducing Parallel Configurations

In order to keep coherent:

- the set of documents making the new baseline,
- the schedule of the activities to implement it during the programmed stop,
- and the layout of the beamlines with its 3D rendering,

tools should include a proper time-dependency feature. Hence, the coordination work is organised on a programmed stop basis.

Validation of a Configuration

The long-term documentation produced for the hardware baseline [4] and the events validated in PLAN get to the coordination team in a non-programmed – random – timeframe. It is then important to trace when an activity is to be performed and to submit all the changes – baseline and scheduling – for a programmed stop to the appropriate committee for final approval, as shown in Figure 1.

Whereas the schedule for a programmed stop is a single object, the documentation is individually attached to a single activity, making this approval being completed over several iterations.

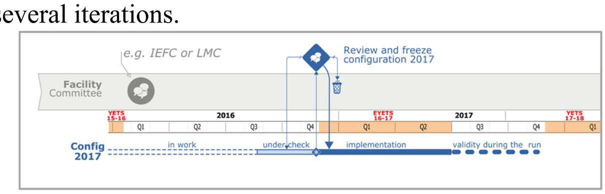

Figure 1: Definition, validation and implementation time of the configuration for the 2017 Run.

Multiple Configurations

The activities that have been validated through PLAN, that are scheduled for a programmed stop beyond the immediate next, need to be part of a future configuration.

The coherence check of a given configuration is to check whether, for instance, the same space has not been allocated twice, or whether two documents are not contradictory. This implies the handling and the management of several parallel baselines or configurations. Figure 2 represents the different configurations up-to the post-LS2 version.

Coordination Methodology

Amongst all documents of the baseline, [5] has shown that the coordination mainly works with one type of document – the Engineering Change Request, that looks more like an Installation Request – as a main support for describing the coming change and summarising all the main actions to be done by the various stakeholders to perform the installation. While this document is very efficient to synthesise the request for a change, it is clearly not able to trace all the actions carried out by the different coordination stakeholders to allow this change.

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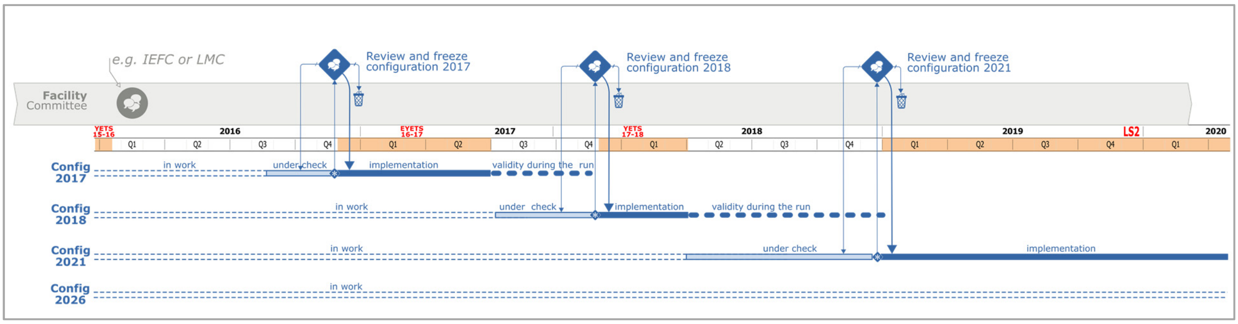

Figure 2: Parallel configurations of the beamlines. Each configuration – schedule of the works, documentation, layout and integration – requires validation before implementation.

The Need for Tracing Actions

The process inside the coordination team is collective and collaborative. Any of the internal stakeholders of the coordination has the possibility to fetch, get, update and share information on an activity. Also, he/she should be aware of any change occurred to an activity since his/her last visit. The process is a co-construction between the stakeholders, and a single database should be shared by all and a unique source of reliable information.

The Need for Simulations

The process (see Figure 3) of a study phase [6] shows the different simulations needed to assess the feasibility of an installation request. This process is recursive until all simulations converge towards an acceptable solution.

- For the planning and scheduling team, the simulation consists in verifying that the sequence of work is sufficiently accurate to give an estimate and can be inserted in the overall schedule.
- The request should satisfy the minimal requirement for safely implementing the change, especially when co-activities are detected.
- For the integration, the simulation consists in verifying that the space request also takes into account the dependencies (powering, racks, etc.), that the space is not already allocated, is sufficient for the volumes described with adequate clearance, etc.

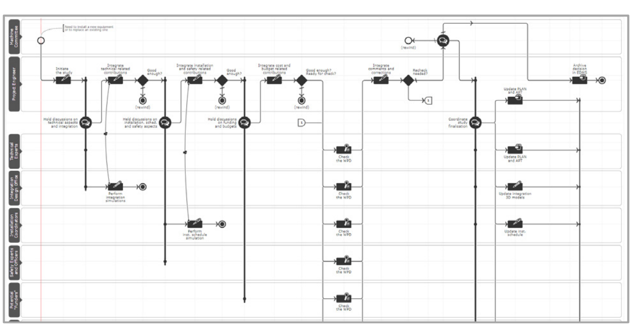

Figure 3: Illustration of the simulation processes extracted from the Study Phase [6] for a new equipment process.

The Need for Fast Simulations

Amongst all the possibilities of tools enhancement, these were retained:

- More robust, faster, and more flexible Visual Basic tool for the linear schedule and a faster identification of the critical path as described in [7].
- Faster and more flexible layout drawing generation to study the impact of a change or to get a layout drawing in a project context, e.g. HL-LHC project.
- Fast tagging (e.g. tagging with “Run 2018”, “Run 2021”, “Run 2026”) of the documentation over the different baselines to indicate their affiliation to a given baseline.

TOOLS RECENTLY DEVELOPED

Track-It

To answer the request for a tracing and collaborative tool for programming the activities, the development teams within the coordination group have created a new tool named Track-It [8] based on the case management module in Infor EAM, which is CERN’s central asset and maintenance platform [9]. This tool aggregates all kinds of information and knowledge that are required for the implementation of activities validated in PLAN. It enables the tracking of the implementation, from its preparation to its follow-up, in terms of needs, tasks, documentation, integration studies and comments.

Figure 4 and Figure 5 show a sample of such a track with its different tiles on the screen.

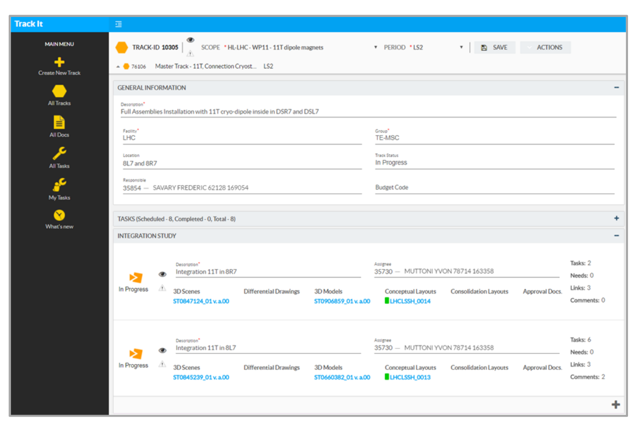

Figure 4: Main tiles for the LHC 11T cryo-dipole installation track.

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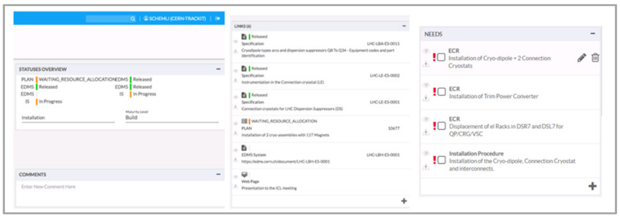

Figure 5: Tiles for overview, comments, needs and links for the same track as above.

Schedule Simulations

In order to allow a friendlier visualisation of the schedule (linear schedule), to optimize activities and to evaluate potential schedule bottlenecks, a tool has been developed. Thanks to its flexibility, it allows to be adapted to different beam lines (LHC and its Injectors), and to take into account the different specificities (access rules, topology,…). Based on the essential rule – safety first, quality second, schedule third – the simulations and optimization works are mainly focused on the constraint management induced by the activities performed in the machine. Accordingly, tool functionalities such as constraint highlighting on a specific area and/or period have been developed to allow the quick identification of conflicts between activities leading to the violation of the rule mentioned before. In such a case, the overall vision provided by the tool is intensively used to initiate iterative work/discussions with the concerned stakeholders in order to optimize the main works sequences and ensure the safe and reliable completion of all declared activities [7].

Layout Drawings in Excel

The formal [10, 11] – and heavy – path for generating a consolidated layout of a slice of a beam line is to go through the sequence "1. Change request, 2. Update of the layout, 3. Sending the new positions to the digital mock-up tool, 4. Storing the 3D scenes and 2D drawings within the CAD repository". A new and faster path was developed around the Excel® tool [12] to answer the need for quick simulations. Figure 6 illustrates the two paths.

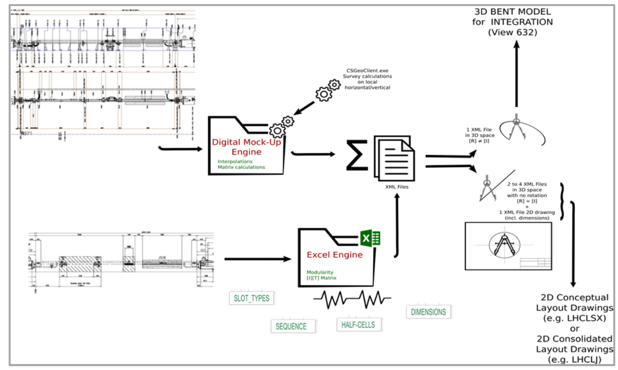

Figure 6: Excel engine and Digital Mock-Up paths to generate 3D scenes and 2D layout drawings.

The new path allows the alteration of the sequence of elements making up the beamline, the association to new CAD shapes to analyse the impact of a change of equipment types, and the immediate generation of XML files to display in Catia V5® CAD software.

Documentation Tagging for Parallel Baselines

Out of the many possibilities for parallelising hardware baselines, the fast tagging of entire branches of the tree allows to easily show a precise and complete configuration option at a given period. Understanding when a particular change and its associated documentation has been implemented is now quite easy, see Figure 7

CONCLUSION

A new set of tools was developed for the Coordination Unit of the programmed stops to actively and collaboratively prepare the future works of Long Shutdown 2. As a rehearsal phase, these tools were successfully used for handling the 2017-2018 Year-End Technical Stop. Co-constructing is sometimes a challenge in large teams, mainly when information gets to the coordination members in an unstructured and partial way. Particular attention should be given to keep the flow of information to and inside the coordination entity as fluid as possible and to consolidate the knowledge on each of the activities over the preparation phase.

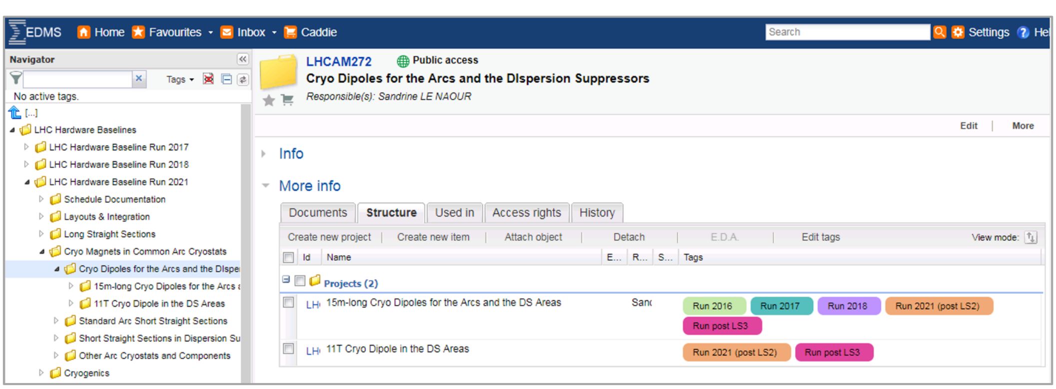

Figure 7: Extraction of the LHC hardware baseline for the Run 2021 (post-LS2) showing the validity periods associated to the installation of the 11 T cryo-dipoles.

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