LESSONS LEARNED FROM THE FIRST LONG SHUTDOWN OF THE LHC AND ITS INJECTOR CHAIN

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Abstract

The First Long Shutdown (LS1) of the LHC and its Injector chain, which started in February 2013, was completed by the first quarter 2015. A huge number of activities have been performed; this paper reviews the process of the coordination of LS1 from the preparatory phase to the testing phase. The preparatory phase is a very important process: an accurate view of what is to be done, and what can be done is essential. But reality is always different, the differences between what was planned and what was done will be described. The paper will recall the coordination, reporting and decisional processes, highlighting points of success and points to be improved in terms of general coordination, in-situ coordination, safety coordination, logistics and resource management.

INTRODUCTION

After a long shutdown lasting two years (LS1), the Large Hadron Collider (LHC) and the whole accelerator chain are now running, and the physics in LHC at an energy of 13TeV will start as early as June 2015. The restart of the LHC marked the completion of a very challenging, intense and enriching period, the LS1.

As defined by the directorate of CERN the LS1 aims to perform all activities needed for a safe and reliable operation of the accelerator complex at nominal energy, taking into account essential rules: safety first, quality second and schedule third.

ORGANISATION

The LS1 started in February 2013, and the preparatory phase last two years. Since the beginning, the project leader, F. Bordry, has been nominated, and the project structure has been built. The LS1 Committee has been created, as the steering committee, concerned with all technical and organisational aspects of the LS1 for the CERN accelerator complex. [1]

Several sub-projects structures have been created, with specific activities and scopes. In the LHC machine the major projects were the Superconducting Magnets and Circuits Consolidation (SMACC) and the Radiation to Electronics (R2E); these projects reported directly to the LS1 committee, and ad hoc project structures have been established. In the Injectors (PSBooster, PS, SPS) several projects have also been performed, and the project leaders reported directly to their Group leaders, who reported the overall progress to the LS1 committee; in these cases, no specific structures have been implemented. Concerning the maintenance activities, for the whole accelerator complex, they were under the responsibility of the Group leaders.

Follow Up

In the LHC machine, specific indicators have been implemented to follow up the major projects as SMACC (Figure 1) and R2E; the maintenance and other activities were followed by the LS1-LHC dashboard, which gave the overall overview of the progress of all the activities in the LHC machine [2]. In the Injectors, one progress curve per injector has been created, to follow up the progress of projects and maintenance activities.

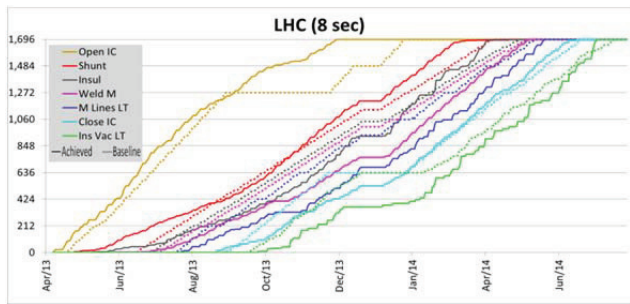

Figure 1: – LS1-SMACC Dashboard.

For each machine, LHC, SPS, PS and PSBooster a technical coordinator has been appointed. The technical coordination is part of the EN-MEF Group, and the main role is to manage activities in the short and medium term. The technical coordinators chair weekly coordination meetings following up the progress of activities and the main milestones, reviewing safety aspects and issues, and gathering all the stakeholders. The technical coordinators were following the Quality Assurance Process ensuring that 3D integration studies were kept up to date, Engineering Change Requests (ECR) are edited, and their follow-up is correctly implemented. Moreover from time to time, they provided ad hoc support to equipment groups in order to ensure a smooth progress.

Baseline Versus Reality

In the accelerator complex, the Long Shutdown 1 roadmap included (Figure 2):

- A preliminary test phase in order to detect existing faults,
- A preparatory phase including lock-out,
- The work phase,
- The recovery of operational conditions,
- The hardware tests.

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Thanks to a strong coordination, and committed teams, most of the activities were on schedule, and none of them altered Safety or Quality.

During the course of the LS1, additional activities were implemented. Prior to implement these new activities, the LS1 Committee examined each new request, scrutinizing the impact on other activities, resources and the global schedule. Resources across groups were re-organized to meet the objectives and respect the main milestones; the SMACC team was for instance re-organized when it appeared necessary to double the percentage of splices to be fully consolidated [3].

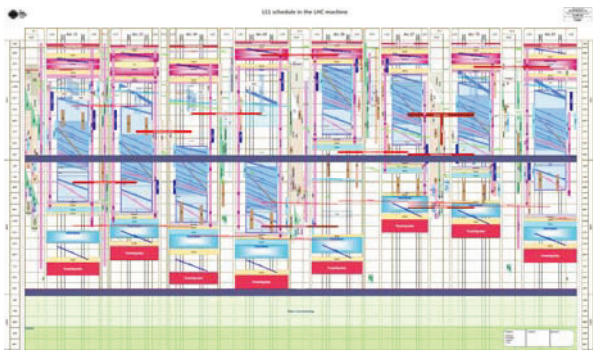

Figure 2: LS1-LHC Baseline (March, 2013).

Figure 3: LS1-LHC Updated Baseline (August, 2014).

The results of the type test for Copper Stabilizer Continuity Measurements (CSCM), performed during the preliminary test phase, proved their usefulness, to increase reliability [4]. The CSCM tests were, therefore, included in each sector, during the cool down phase (at 20K). In order to mitigate the impact on the end date of the LS1, ad-hoc resources were re-allocated.

To include these new tests, a new baseline of the LS1 schedule was edited (Figure 3). [5]

The PS complex and SPS were given back to operation in due time. The LS1 duration for LHC, initially defined to 22 months, encountered three months of delay mainly due to the additional tests performed, and the evolution of safety rules.

NEXT STEPS

The feedback on LS1, given by the key stakeholders during the "LS1 debriefing day", held in March 2015, is being analysed. It is, indeed, crucial to identify the points of success and points to be improved in terms of organization, coordination and resource management. This analysis will help to re-inforce the project structure which will be set up by the Long Shutdown 2 (LS2) project leader, J.M. Jimenez.

LS1 LESSONS LEARNED

Project Management

A strong organization was set up for the LS1, by the project leader, F. Bordry. The success of the LS1 proved its efficiency. The LS1 Committee, gathering each group and project leaders involved, met on a regularly basis, to follow and report on the progress of activities, to arbitrate on potential issues, to solve problems and set directions. The steering committee met at least on a weekly basis in order to manage urgent issues and decisions.

Safety

Safety as top priority paid: With respect to the 3.4 millions of working hours, only 64 minor accidents have been recorded in the underground areas. The safety aspects were deeply taken into account during the preparation phase: The Work Package analysis meetings, organized in collaboration with the technical and safety coordination, which analysed the risks generated by the activity or by the environment, prepared the land for the joint inspection and ALARA (As Low As Reasonably Achievable) committee. The ALARA principle has the objective to minimize the exposure of personnel to ionizing radiation; this requires a team approach between operation, experiments, equipment groups, contractors, radiation protection group, safety officers etc.

The authors would like to emphasize that:

- All the procedures and training related to safety have to be available at least 6 months before the start of a shut-down. This in order to take into account the mandatory steps during the preparation phase.
- Despite the involvement of workers concerning safety aspects, it is recommended to publicize basic safety rules, on a regular basis.

Scoping Phase

The Plan tool, developed for the LS1, recorded in a unique repository, all activities requested. The support needed from other groups was detailed for each request. The LS1 project leader and the CERN Management prioritized the activities and postponed some with respect to the unavailability of the resources. This tool was paramount to manage widely the project, but should be in the future available two years prior to the start of a Long Shutdown, in order to have a clear roadmap as soon as possible.

Resource Management

One of the main challenges of the LS1 was the allocation of experts across the different sub-projects; a detailed and resources loaded schedule was set up by the stakeholders, with the support of the technical coordination, taking into account the requests coming from the different machines. Potential conflicts on resource allocation are inherent to such a big project but

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these conflicts have been solved during the weekly coordination meetings. As highlighted by the Group leaders, the coordination meetings of machines using the same resources should be merged to increase their effectiveness. The flexibility spirit, shown during the LS1, should be maintained and the resource sharing shall be organized as soon as possible.

Coordination & Reporting

The coordination tools and coordination structure used to manage such a long shutdown were effective and should be used in the future shutdowns. The detailed schedules were maintained with the MS-Project package: while in the Injectors one schedule officer per machine was designated, in the LHC machine three schedule officers were responsible for the different types of area (service areas, Long Straight Section and arcs) and the different main projects. The linear schedules, showing a synthetized view in each facility, are the automated results of the different schedules (through Excel Visual Basic). Key Performance Indicators were implemented, allowing visualising easily any deviations and delay, and implementing strategies for recovery. Graphs and figures presented in the dashboards were essential to detect and correct deviations.

The sub-projects implemented during the LS1 needed a special organisation and sufficient autonomy. They had to be effective and reactive in order to face to unexpected issues. During the LS1, the management of surface logistics and quality have been done at the sub-project level, and this gave successful results.

In the future, during the preparation and follow-up of a long shutdown, all the activities around infrastructures, should be managed centrally, to avoid fragmentation; in particular the activities inducing access restrictions such as the cabling campaigns, the electrical maintenances, the cooling and ventilation works and the safety systems interventions.

CONCLUSION

The first Long Shutdown requested two years of solid preparation and the results are rewarding. The project structure, the deep involvement of CERN staff, the anticipation and the excellent team spirit were the main ingredients of this success. New challenges are now in front of us, as the preparation of the Long Shutdown 2, with the implementation of major projects (LHC Injector Upgrade and High Luminosity LHC), Consolidation and Maintenance activities. The LS1 and the experience acquired during this challenging period are a solid background for a fruitful LS2.

ACKNOWLEDGMENTS

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