WHAT HAS BEEN LEARNED FROM LS1

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Summary

The Long Shutdown 1, which started in February 2013, is almost finished. A huge number of activities have been performed, and the machine is now being cooled-down and power tested. As part of the preparation for Long Shutdown 2, the talk will review 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 presented.

Daily coordination is essential for the good progress of the works. The talk will recall the coordination and reporting processes, highlighting points of success and points to be improved in terms of general coordination, in-situ coordination, safety coordination (including safety rules), logistics…

INTRODUCTION

After 18 months of intense activities, the first long shutdown of the LHC and its injectors is ending. Beam is circulating in the LHC injector complex, while LHC is being cooled-down and power tested. Following interviews of group leaders involved the author will highlight the points of success and points to be improved in terms of general organization.

PREPARATION PHASE

The Long Shutdown 1 was, first, triggered by the need to consolidate the magnet interconnections to allow the LHC to operate at 14TeV in the centre-of- mass, in 2009. It became a major shutdown which in addition includes repairs, consolidation, upgrades across the whole accelerator complex, as well as maintenance.

Main Activities

After more than three years of operation, the accelerator complex needed a full maintenance of all the systems. Major consolidation and upgrade activities were added [1]:

PS & PS Booster: new access system, new ventilation system in PS, RF upgrades, radiation shielding around PS, vacuum control system, dump renovation…

SPS: vacuum coating of 16 dipoles to test e-cloud mitigation, kicker systems upgrade (impedance), RF system upgrade, cooling and ventilation upgrade, 18kV transformers replacement, replacement of irradiated cables, new optic fibre systems…

LHC: Superconducting Magnets and Circuits Consolidation, Radiation to Electronics, upgrade and consolidation of beam instrumentation, pumping stations…

Prioritization

The preparation phase started just after the decision to resume the LHC operation at 7TeV centre-of-mass. The detailed program was defined according to the following priorities:

- P0 -All activities needed for a safe operation
- P1 -All activities needed to operate at 14TeV
- P2 -All activities needed to ensure a reliable operation
- P3 -CERN approved projects
- P4 -CERN non approved projects

In order to avoid conflicts or overloads, the project leader team set up a tool "Plan" to gather and approve the activities. Groups were requested to declare the activities they intend to perform, and to detail the support they needed from other groups. This unique repository, with a simple approval process, eased the communication, helped the support groups to have a clearer picture of the support to be given. The resources availability declared by all the stakeholders facilitated the prioritization and acceptance process for the LS1 team, focusing only on discordance points. As reported by the different group leaders, "Plan" is an essential tool to prepare major shutdowns, but it should have been put in place earlier during the preparation phase. In addition, as reported by the support groups, not all the activities were declared in "Plan", which caused punctual overloads. In the future they recommend using "Plan", and reviewing the program regularly. Moreover the tool will be adapted to better fit our needs (redundancy with APT, granularity of items...)

LS1 Day

In June 2012, the LS1 project leader organized the LS1 day with the aim to announce the results of the survey and analysis of which activities will be performed during the first long shutdown (LS1), which activities might be performed subject to the availability of resources (call for extra manpower), and which activities will be postponed. The LS1 day provided, also, the latest update on LHC & injector planning. The support groups presented their activities and organization during LS1. According to the main stakeholders, this meeting was essential to crosscheck the requests from other groups and experiments, and to avoid omissions and misunderstandings.

Preparation Methods

During four years, prior to the start of LS1, a massive and solid preparation has taken place:

- The project's objectives were detailed into tasks. Stakeholders were identified. Furthermore, the resources (human, surface areas, materials), the project required, were identified. Coordination and management arrangements as well as monitoring and evaluation methods were defined.
- Coordination teams organized work package analysis meetings to review, for each activity, conditions prior to start, schedule, perimeter of worksites, storage areas, logistics aspects, risks and compensatory measures, and ALARA plans. During these meetings, gathering the different stakeholders, a lot of points were clarified.
- In parallel, groups and project leaders, established contracts and collaboration with external institutes, in order to fit their activities within the agreed time window.
- The good quality of documentation edited during the 4 years of groundwork indicates the good level of preparation: procedures, Engineering Change Requests needed for intervention.
- Fruitful external reviews were organized for the SMACC project.

This high level of preparation contributed largely to the success of LS1.

When to Start?

It took 4 years of intense preparation from the definition of global objectives to the start: to subdivide objectives to activities, activities to tasks, to ensure that the appropriate human resources were allocated and trained, to review the technical issues and mitigated actions, to prepare the interventions in supervised areas…

Group leaders underlined the importance of defining technical details in due time, in order to get contracts in due time. Moreover they highlighted the fact that additional staff, needed for a major shutdown, have to be employed around 2 years prior to start; this, considering the training of personnel to the accelerator complex specificities and the preparation time of the different projects.

IMPLEMENTATION PHASE

Coordination

Coordination meetings were important events through LS1, as they guided operational partners and other stakeholders through a process, which stimulated cooperation between them.

During these regular meetings, held by technical coordination teams and project leaders, progress of activities and readiness of equipment were reviewed, technical aspects were presented and discussed, as well as logistics, and safety matters. As mentioned by Group leaders, these forums were very useful as it facilitated the information flow and enhanced team spirit.

The need of seven coordination meetings in the injectors complex was challenged, as this was time consuming for the groups.

Schedules

Once the time windows of the shutdown of each machine were defined and the compliance between them was checked (especially in terms of resources), a baseline schedule was approved by the groups.

The schedules were reviewed on a weekly basis, thanks to the feedback given from the field and during coordination meetings. Ad-hoc meetings were held with groups/projects discovering unexpected issues or delays, in order to find technical solutions and to adapt the global plan, and additional activities were added, in the shadow of the others. The readiness of beam instrumentation and some of vacuum equipment, produced or tested on surface on CERN premises was one of the issues which was reported during LS1. The coordination team reacted promptly organizing the surface schedule from one service to another, up to the transport of the equipment in the machines. This schedule was weekly updated, synchronizing the surface and underground plans. In the future, this process shall be defined prior to the start of a shutdown.

Moreover, planners from coordination team were part of the SMACC and R2E projects. This eased the whole coordination process, and the information flow (crosscheck of information).

With respect to ALARA (As Low As Reasonably Achievable) principles, the activities in supervised areas were scheduled as late as possible in order to decrease as much as possible the level of radiation. These activities were thus on the critical path. This generated a lot of stress to the team involved, especially when unexpected events occurred. In the future, one will have to compromise between cooling period and reasonable margins.

Documentation

The configuration management is maintaining consistency of the machines functional and physical attributes through their life cycle:

- The hardware baseline is kept up to date thanks to Engineering Specifications, Hardware procedures, Tests procedures… and Engineer Change Requests. So far, around one hundred ECRs were treated for the LHC machine, and around sixty for the injectors complex. As shown in figure 1 below, around 20% of ECRs were released at the start of LS1, and around 10% have just been edited are being processed.

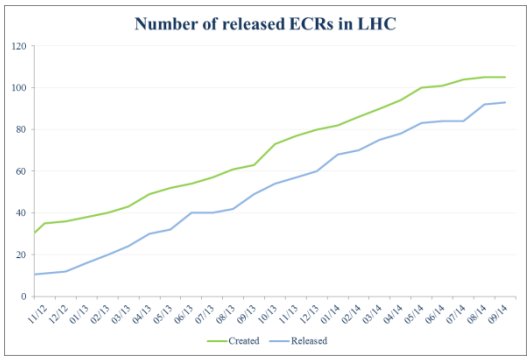

Figure 1 – Number of ECRs realised with respect to time

- Once Engineering Change requests and Engineering specifications are released, the layout database and the MAD/Y files are updated.
- The machine drawings with release notes are then edited.

The Group Leaders acknowledged the regular presentations of the ECRs progress in the different committees (LMC, IEFC, LSC) as it was most important to maintain the database of the machines up to date.

Daily Management

The LS1 involved around 1600 persons [1]. The preparation of logistics, induced by a massive arrival of personnel, has been well treated as no major issues appeared. The access in the machines were filtered thanks to the IMPACT system [2]. Moreover, the DIMR (Demande d'Intervention en Milieu Radioactif) was inserted in the IMPACT tool, and connected to the RAISIN database.

It is important, at this stage, to mention that most of the main stakeholders were the same as during the installation of LHC. This eased considerably the coordination processes, as each one knew the others and the procedures to follow.

The daily personnel access was fluid. Lift breakdown occurred, but solutions were put in place from the coordination side to reduce the effect of such inconveniences. The plan for the lift exchange (aging from LEP installation) is in the pipeline.

The material logistics was well organized. The material exiting the machines and experiments were processed through the TREC systems (Traceability of Radioactive Equipment at CERN) [2] installed at the exit of the machines. The lack of TREC buffer zones next to production and tests premises was reported by the stakeholders.

Information Exchange

Effective communication is a key determinant of any project success, and certainly for LS1. As already mentioned it is important to keep a good ratio between experts and new personnel in order to capitalize the experience of a shutdown. The communication channels were well defined, for the configuration management, but also for reporting progress of works (machine coordinators and project leaders reported regularly to the main committees); the dashboard of LS1 was weekly updated and available for public.

Some points of improvement have been mentioned during the interviews of Group and Project Leaders:

Coordination teams notice that information has sometimes difficulties to go down to the worksites. Fortunately, it was mitigated thanks to the very good follow-up on field.

Stakeholders encountered sometimes difficulties to find information on a specific project as each project uses different storage systems (edms, Sharepoint, indico).

"Notes de coupure" were prepared in due time and distributed largely. But one has to pay attention to give clear messages for non-experts. Moreover, it would be interesting to draw a repository of services unavailability and their impacts on the other systems.

Safety

Safety, top priority of LS1, has been carefully studied, and respected through the duration of LS1. The statistics, up to September 2014 show low rate for Frequency (7.3) and Severity (0.7), despite the enormous number of working hours (1.5 millions). This is largely due to the efforts of work supervisors and safety coordinators. Coordination teams mentioned the need to train the new work supervisors with respect to safety organization and specificities of CERN environment.

As underlined by Group Leaders, the safety courses for LS1 arrived very lately, and did not facilitate the arrival and training of the newcomers. Moreover, the implementation of new safety rules and procedures during the course of LS1 perturbed the activities leading to a lot of discussions.

Resources

As already mentioned, around 1600 persons intervened in the different machines of the accelerator complex. It is important to recruit our staff in due time. The specific case of work supervisors was already mentioned: 2 years prior to the start are needed to prepare both projects and personnel training. The non-LHC facilities suffered from the lack of resources, as part of the existing teams were redeployed from SMACC project. The major efforts made to redirect internal resources to LS1 activities paid, but it is important to involve them during the preparation phase, and to avoid partial detachment to increase effectiveness.

Group Leaders also reported the difficulties of maintenance contractors to find the adequate personnel needed to keep the tight schedule. The framework contracts were overloaded during the whole period of LS1 and additional works led to difficult negotiation both on financial and deadlines aspects.

Discrepancies between Baseline and Reality

This part will be detailed during the LS1 post-mortem day. All baseline activities were performed. Additional activities were included in the plan. For instance, the

consolidation of unexpected defaults (QRL compensator, 15%->30% of splices), as well as the non-announced ones. These last ones were disorganizing the support group activities, inducing more work for already overloaded groups. This specific point should be followed systematically during the future shutdowns.

CONCLUSIONS

Despite the points of improvement mentioned in this paper, and as reported by the CMAC (CERN Machines Advice Committee), "the tremendous work scope of LS1 is being successfully completed with only minor delays", thanks to the management process set up for LS1 and the strong commitment of our staff.

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