FEEDBACK ON CONTROLS FROM 2015 OPERATION

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Abstract

The talk will first look back at the Long Shutdown 1 (LS1) from hardware and software consolidation perspectives. The review of the operation of the controls system during 2015 (what worked well and not so well) will be presented as well as the preliminary conclusions of the LS1 controls review held with Operation and Equipment groups early December 2015. Finally an outlook for the coming years and next EYETS and LS1 will be provided.

LOOKING BACK AT LS1

LS1 was a unique opportunity for CO & EQ GPs to perform a massive consolidation from both hardware and software viewpoints. From the hardware viewpoint, BE-CO together with the equipment groups launched in 2019 a major hardware renovation plan with 420 LHC Front-End Computers upgraded and 200 new machines for WorldFIP Gateways, new CPUs, the doubling of Quench Detection System segments.

On the software side, the control system was upgraded to the latest controls framework versions (FESA, CMW/RDA, LSA). This implied some non-backward compatible changes on some major frameworks and had important impact on equipment and operation developers, mainly for LHC injectors. These drawbacks will be analysed in details in the second part of this paper (Preliminary summary from LS1 review).

LHC COMMISSIONING AND CONTROLS OPERATION 2015

The impact of the numerous and invasive changes in the controls systems done during LS1 on the re-commissioning of the LHC injectors in 2014 was high. To minimize the perturbations on the beam operation, an extensive programme driven by BE-CO was put in place (60 dry-runs over 5 months) to allow an early debugging and resolution of the problems.

Starting one year later than injectors, LHC experienced in 2015 a much smoother start-up than the injectors in 2014, for the obvious reason that many issues had already been identified and fixed by end of 2014. After the LHC re-commissioning phase, the operation of the controls system was flawless throughout 2015 with a remarkable reliability and stability. The contribution of controls to the beam downtime in 2015 was one of the lowest over all CERN systems involved in the LHC operation.

Technical highlights from controls operation in 2015

While the average performance of the controls was high on average, two systems experienced a couple of failures in 2015, which required a special care.

The first system was the Java Messaging Service (JMS) extensively used as a communication protocol between Java applications. The JMS failures generated a total of 11 hours of downtime, impacting critical services as LSA, SIS. After several improvements, the system became stable since November 2015,

The second system was the legacy timing distribution system (DTM) to applications, which caused 3 hours of downtime. The replacement of this software is foreseen for the machine start-up in 2016.

The migration of front-end software classes (FESA) from the RDA2 protocol to the new RDA3 version generated an unforeseen impact in a few cases. If the client application was not restarted after the migration, the active subscription to the accelerator devices got lost, provoking, as the most serious issue, the interruption in the data logging. An improvement based upon the automatic detection of the protocol change and the notification to client applications will be in place for the machine start-up in 2016.

Finally, we experienced, on very rare occasions. a freezing of the WorldFIP gateways on Kontron machines. The insourced development of a new WorldFIP master has been decided as a mid-term solution while launching the progressive installation of new in-house bus arbiters cards and associated high-level libraries to replace the WorldFIP Bus Arbiters (WorldFIP master) for all LHC systems (Power converters, QPS, Cryogenics, ..). The installation will start during the YETS 2015-16 and will be completed by LS2. This initiative will complete the insourcing of the WorldFIP technology inside BE-CO.

Organization during operation 2015

In terms of support, by migrating from the previous 'Piquet' support to 'Best Effort' in the PS Complex, BE-CO has succeeded in standardising its support model across all machines. Since 2014, the support is unique and based on the best-effort SPS-LHC model.

We have observed a remarkable reliability of all the new hardware systems installed during LS1 installations. It is worth mentioning that the few interventions by BE-CO experts were performed on the non-renovated systems only.

An efficient issue management system has been put in place for the monitoring of operational issues and requests. The roles of the Exploitation Manager and of the Smooth Upgrades Working Group (SUWG) (for the coordination of upgrades during technical stops) have been extremely valuable to ensure a quick resolution of the problems.

OUTLOOK FOR 2016 OPERATION

A meeting to collect the feedback on controls operation in 2015 and new requests for 2016 is foreseen for early February 2016 on the same model as the meeting held in 2015. This meeting, open to the equipment groups, will give them the benefit to record the OP feedback on their own systems. This meeting has proven to be important to tune the priorities of the CO developments to fit the OP needs.

The close collaboration between BE-CO and BE-OP for the development of applications is a key component to ensure that the controls system meets the operation requirements in terms of friendliness, functionality, and performance. The two groups will discuss the wish from BE-OP to reinforce their collaboration by establishing joint developments, software coaching and an increased participation from BE_OP in the core BE-CO components.

OUTCOME FROM THE LS1 CONTROLS REVIEW (HIGHLIGHTS)

The LS1 controls review was held on December 1, 2015 with one representative per equipment group, two representatives of BE-OP and one representative per BE-CO activity. A preliminary summary only is provided in this paper while the final report by the reviewer is expected to be produced by mid 2016.

The principal aim of the LS1 review was to improve the services, processes and tools of BE-CO for the future long shutdowns, based on the external and internal feedback of our users on the way BE-CO had handled the work during LS1.

The review provided a high level and non exhaustive view of the strong and weak points of the work organization and achievements during LS1.

What worked well

The hardware installation worked very well, while the context was challenging: this was a major renovation task with the upgrade of 460 FECs in the LHC injectors, to be dismantled with no technical documentation and no way to roll back. The installation planning was respected and the new installations experienced no error and no hardware failure.

Another successful achievement was the specification by the MCCs (Machine Controls Coordinator) of each individual upgrade (50 EDMS specifications). All upgrades were described in a formal EDMS document, approved by group leaders of the concerned groups. It was considered as a reference for the technical solution and for its deployment and installation planning between BE-OP, the equipment groups and BE-CO. Work plans and work packages of activities to be performed during LS1 in the framework of the ACCOR project were well defined and organized within BE-CO and agreed with equipment groups before the start of LS1. Reviewers stressed the importance of the MCCs and underlined the need of a closer collaboration between them and equipment groups. Reviewers also asked that major modifications in the control architecture to be reviewed by BE-CO and equipment groups before being proposed to CO3 for approval by IEFC/LMC.

A positive outcome of the LS1 organization was the BE-CO-driven dry-runs for the whole injector chain to recommission the new controls. Dry-runs covered not only developed by BE-CO but also those developed by all the equipment groups. 30 dry-runs were organized by the MCCs. These were recognized by BE-OP as essential for an early debugging and for setting milestones on the deployments by BE-CO and the equipment groups. They helped creating a remarkable synergy in BE-CO and a solid friendly collaboration with equipment groups and BE-OP. Finally the support from BE-CO towards operational and development issues and the on-site help to EQ GPs to help them migrate classes was highly appreciated.

What could be improved?

Planning; a global planning at the BE-CO group level, regrouping all activities to be performed during LS1, was missing. Without such a planning, it was difficult for the BE-CO management to identify dependencies between agreed activities, to pinpoint activities on the critical path and to set delivery dates for critical activities.

FESA framework and tools: tt was outlined that the FESA3 framework and related tools were not sufficiently mature for pain-free development and operational deployment before late into LS1. This forced several equipment groups to take the decision to maintain and further extend the use of FESA2 tools in order to reach commissioning deadlines. The development tools, used for class design and delivery, relied on resource-intensive computing. Several API changes were made between FESA2 and FESA3 that were only seen at run-time. It was observed that despite the variety of the official BE-CO wiki pages, the information was rather often difficult to find due to obsolete information, poor structure, and difficulty to search;

FESA API: a lack of preliminary discussion of the FESA class APIs between BE-OP, the equipment groups and BE-CO sometimes led to the late discovery that a new class did not fit InCA or the generic applications. This problem stemmed from the incorrect common assumption that compliance with FESA design rules guaranteed the compatibility with InCA. FESA and InCA (with JAPC) have incompatible sets of features (handling of unsigned values, filters, rolling-buffer, non-partial-set). Features possible in the FESA3 interface are not supported by higher-level software, but these conflicts are not visible at the initial FESA3 design phase.

InCA/LSA and tools: after 10 years of development, LS1 was an opportunity for the LSA team to implement new features and an improvement of performance; those turned to be non-backward compatible changes . The LSA APIs underwent a major refactoring, as did the InCA

Acquisition server, client API and WorkingSets and Knobs. The impact of this was that external developers had to adapt to the new APIs. In general the API changes were well documented and code snippets were provided. It was also felt by the BE-OP developers that there was a certain lack of documentation and training on how to use BE-CO tools and software.

Configuration tools: some important tools for migration and deployment were missing during LS1 and the existing tools were still not user-friendly when making many changes. In some cases existing tools were removed before a new version was available. The reviewers recommend that the necessary supporting tools be developed in parallel with the new version of a service and in close collaboration with the users.

Integration and testing: before delivering the different services for use by equipment groups, no full integration tests of the different layers of the control architecture (FESA, CCDB, InCA) were done by BE-CO. A clear strategy on how to restart the complete control infrastructure at the end of LS1 was missing within BE-CO before the start of LS1. A specific issue for some equipment groups was the impossibility to test INCA integration on development devices outside the technical network, which meant issues with incompatibility were in some cases only discovered during dry runs close to the machine start-up with beam. In addition, many controls equipment lack a simulation mode, which means that the development and commissioning of the higher layers of the system depend upon the ability for the equipment to function in a real environment, perhaps even with beam. This can delay the testing of a full vertical slice until late in the recommissioning period.

OUTLOOK FOR COMING YEARS

In the light of the LS1 experience and the outcome of the LS1 review conducted end 2015, strategic improvements have been identified and are listed below:

- Put in place and publish a global planning with all upgrades. The EYETS 2016/17 will be used as pilot to fine tune for LS2. The planning should ensure synchronization points for the various service releases and a smoother integrated environment for the downstream developments to be performed by the equipment groups.
- Improve internal synchronization of key framework releases (CMW, FESA,..) and announce in advance non-compatible changes & measure impact with EQ/OP developers
- Provide a CO stable environment to equipment and operation developers well before the start of LS. This is not evident how to put this in place but discussions are on-going.
- Formal agreement via ECRs for new development and major modifications Ex: specification of the API for each new FESA class
- Use the Controls Coordination Committee (CO3) committee to coordinate upgrades for the LS recommissioning. Injector Re-commissioning Working Group (IRWG). Machine Controls Coordinators should be the BE-CO links with OP/ABP Machine recommissioners.
- The need for flexible scripting tools especially for the Machine Developments (MD) should not be underestimated by BE-CO, as, for instance, the importance of Python for the equipment groups. It is a widely used and vital tool to diagnose equipment, even in the operational environment. The reviewers recommend that BE-CO consider fully supporting Python and giving direction regarding which version to use and good practices on how to use it.

CONCLUSION

The BE-CO group had a large upgrade program for LS1 which generated many changes on the controls hardware and software infrastructure. Controls were ready for LHC start-up but the group acknowledges the high impact on equipment and operation developers. The Controls for LHC 2015 operation worked well with no outstanding technical issues and very little downtime. From the lessons learnt during LS1 and the outcome of the LS1 controls review, BE-CO will take actions to put in place a more efficient coordination with our users.