For the RRB to take note

Revised agreement for the Maintenance & Operation budget of the online systems of the LHC experiments ALICE, ATLAS, and CMS

1. Introduction

The Maintenance & Operation budget (M&O) of the online systems of the LHC experiments ALICE, ATLAS, and CMS is based, since 2004, on a model agreed between the RRB Scrutiny Group (SG) and the experiments [1]. An interim agreement was used for the 2012 budget request [2] on the understanding that a task force would be set up in 2012 [3] to propose an updated agreement.

This document prepared by the task force is the resulting updated agreement on the policy of hardware replacement for the online systems, the system administration needs and the procedure to establish the M&O budget. Its scope includes:

- The replacement profile of the hardware used in the online systems.
- The management of the special CERN account used for the purchase of this hardware.
- The software licenses used for the online systems.
- The manpower used for the system administration of the online systems.

The revised policy will start to be applied for the 2013 budget request and will remain applicable for at least one full replacement cycle i.e. 2018.

In the case that this revised replacement model proves to be not sustainable, the experiment's TDAQ teams will do what is necessary to ensure the required operational performance of the experiment's online system.

2. Replacement of Computing, Data Storage, and Networking Equipment

2.1 Regular equipment

The regular computing equipment (PCs, edge switches, storage equipment and servers) used for dataflow and software online triggering will be used for 5 years if technically possible and then replaced. The motivation for the replacement include: reliability of equipment as it ages, maintainability, suitability of old equipment to follow the evolution

of operating systems and suitability of old equipment to work with new equipment (including that purchased to replace faulty items, further staging, etc.).

The conditions for using a piece of equipment for 5 years:

- Continuation by suppliers to provide 5 years of warranty (See Appendix A).

- Compatibility with operating system evolution (Scientific Linux CERN for the DAQ systems and Windows for the DCS systems)

- Compatibility with the experiments policy of supporting a single version of the operating system.

- The replacement of the equipment will be performed at a time compatible with the experiment operation.

The budget request for replacing the equipment will use the investment cost.

2.2 Large chassis network equipment

The large chassis network routers used by the experiments constitute a particular type of equipment. Their replacement implies a significant downtime of the online systems, thus can only be envisaged during long LHC shutdowns.

The change of network chassis could have knock-on effects on other type of equipment, i.e. at least the change of uplink to edge switches.

This category of equipment will be used for at least 5 years if technically possible and then replaced most probably during long LHC shutdowns. The conditions for using large chassis network routers for 5 years is the continuation by suppliers to provide the corresponding period of warranty (See Appendix A).

This category of equipment is also the object of a yearly maintenance cost which will be included in the M&O budget request. This maintenance is mandatory to keep a valid warranty.

The budget request for replacing the equipment will use the investment cost.

2.3 Racks, crates, commercial interfaces and single board computers

The electronics crates used by the experiments are based on the VMEbus standard for the time being, possibly another standard in the future, and are combined with commercial interfaces to PCs or single board computers (SBC). The SBCs are PC-like processor boards for modular electronics.

The SBCs are purchased through a single purchasing contract, covering all experiments, and is used by ALICE and ATLAS. The current contract includes a repair service of seven years beyond the three-year initial guarantee period. The same conditions relative to the operating system for using a piece of equipment for 5 years as stated in 2.1 are applicable to SBCs as well.

The water-cooling systems of the computing racks housing the online computers are rear mounted coolers. The turbines of these systems require annual repairs and periodic preventative maintenance.

The budget request will include 5% of the investment to cover annual repairs and periodic maintenance.

The budget for their complete replacement will be included in the M&O budget when needed.

2.4 Custom hardware

The custom hardware (mostly optical links and computer adapters for those links) needs to be maintained or replaced whenever technology changes make them obsolete.

The custom hardware will therefore be the subject of a separate annual M&O budget line corresponding to 5% of the construction cost. This budget will be used for purchasing spares, repairing or replacing broken hardware.

The budget for the replacement of obsolete custom hardware will be included in the M&O budget as needed.

3. Addition and Revision of the Requirements of the Online Systems

The design requirements on the online systems of the experiments have led to their present design and sizing. However, the performance requirements demanded of the online systems have evolved considerably with operations and are expected to evolve further. Subsequently the performance and size of the online systems is required to evolve to meet these new requirements. This evolution may for example consist of incorporating additional or new detector elements or in an increase of the nominal performances before or at design luminosity. Addressing new or updated requirements sometimes requires addition of hardware. The budget for this additional hardware will be included in the M&O when needed.

4. Special Account for the Purchase of Hardware with the M&O Budget

The LHC schedule has been frequently modified and could further evolve. Planned M&O budgets are determined by the original installation scenarios of the online systems. However, in some cases, e.g. large chassis switches, the physical replacement of the

equipment is determined by the shutdown periods of the LHC machine. The revised policy must be flexible enough to accommodate such changes

A special account has been created for each experiment to manage the related cash flow and to use this account to smoothen the overall experiment M&O-A profile [4]. This account is credited by the hardware related part of the yearly online computing budget and its use is strictly limited to the hardware purchases. This budget gives the possibility of deferring purchases, when necessary, for carrying over part of the budget from one year to the next or permitting advanced purchases within the agreed budget framework for future years. This special account is not part of the procedure for refunding surplus M&O-A contributions [5].

5. Software Licenses

The M&O budget will include the license fees of the commercial software used by the online systems.

6. System Administration

Dedicated teams with the appropriate technical skills, experience of the system and continuity will provide the best maintenance of the online systems and the necessary rapid resolution of problems. The number of FTEs required in the team for each experiment will depend on various factors, including the size of the system, the reliability of the hardware and software used, the complexity and heterogeneity of the system, and the availability of tools.

Although the LHC collaborations are very large, attempts to find suitably qualified effort for system management inside the collaborations have failed. Most people employed by the institutes (physicists, physicist-programmers and engineers) do not have the required profile. The few institutes who do have some people with the proper qualifications are not prepared to locate them at CERN for adequate periods.

The tasks of the system administration team as documented in [1] are continuing and are not projected to decrease over the period 2013–2018. The size of the teams will remain at its present value during and after the LS1 and might be revised after LS2 if the size of the systems to be administered would substantially change. Therefore we will continue with the current model for the M&O budget request [6].

7. References

[1] Response from the LHC experiments to the RRB Scrutiny Group concerning the Maintenance and Operation of online systems (Trigger, Data Acquisition, Event Filter Farms, and Control Systems), 6 September 2004.

http://committees.web.cern.ch/Committees/LHCRRB/SG/SG_General/online_all_4_reply_sept04.pdf
http://committees.web.cern.ch/Committees/LHCRRB/SG/SG_General/online_sept04.ppt

[2] Online Computing Hardware Replacement Policies for the LHC Experiments, CERN RRB-2011-059.

[3] Online Computing Replacement Meeting, 7 June 2012
https://indico.cern.ch/getFile.py/access?resId=1&materialId=slides&confId=190890

[4] Report of the LHC M&O Scrutiny Group for the October 2011 RRB, CERN-RRB-2011-076.

[5] Refund of Surplus M&O Category A Contributions, RRB-2006-026.

[6] The M&O Scrutiny Group Report for the October 2005 Resources Review Boards, CERN-RRB-2005-083.

Appendix A

The computing equipment used in online systems has an instrumental role on the experiment performance. It cannot be directly compared to the same equipment used in a computing center for processing recorded data. Its good functioning must be guaranteed during the period of operation of the experiment in order to avoid any loss of luminosity.

The computing equipment used in online systems has in particular to be covered by a warranty during its period of operation for several reasons. We summarize hereafter these reasons for each category of equipment:

- The network equipment is currently purchased under the CERN IT frame contract. The maintenance of this equipment, being the upgrade of firmware or the replacement of broken equipment is only possible if the equipment is under maintenance.

- The same condition applies to the maintenance of all types of data storage equipment (such as NetApp file servers or storage arrays).

- Most of the dataflow PCs have all a distinct role because they are reading out a different part of the detector. They have therefore to be repaired or replaced in case of malfunction. The homogeneity is also needed for dataflow PCs due to the custom I/O cards and the logistics aspects of the corresponding device drivers.

- All the HLT PCs perform a similar function and the HLT of all experiments are designed to gracefully degrade their performance if a few nodes break. However the overall experiment performance depends upon the global processing power

available in the HLT which has to be maintained even in the case of failure of a large number of nodes.

The warranty includes the upgrade of firmware for the networking and data storage equipment and the repair or replacement within one or two working days of low-level random failures (< 10%/year) of all types of equipment. This is why a pool of spares is available at the experimental area for an immediate intervention by the system administration team. The warranty is also used to cover the risk of failure of a large fraction (> 10%/year) of a batch of equipment after a few years of operations.

The warranty is currently purchased for 3 years at the purchase time and extensions for the 4th and 5th years are envisaged to be purchased in the corresponding years. The yearly cost of the warranty is between 5 and 10% of the purchase cost for the two additional years. The annual failure rate is also observed to be around 10% during the useful-life period of operation but can reach higher values when the equipment reaches the wear-out period. We believe it to be more cost effective to purchase the warranty than purchasing 10% of spares and it gives a coverage in case of large failure rates such as the ones recently experienced by the experiments for some equipment batches.

The warranty can also be compared to other ways to repair or replace equipment. For some failures (such as one passive component broken) the repair is very simple for the manufacturer and almost impossible for the end user. In case of a large failure rate, the replacement of equipment could of course be done by purchasing new equipment. One has however to take note that large purchases involve a heavy administration (announcement in the CERN Finance Committee, market survey, call for tender) which takes months. The resulting delay would immediately imply a loss of integrated luminosity which does not appear as a reasonable and cost effective option.