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Report of the LHC M&O Scrutiny Group for the November 2008 RRB

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1. **Composition of the Scrutiny Group**

Cristinel Diaconu (Marseille) and George Ginther (Rochester) joined the SG for the 2008 scrutiny round, replacing Marc Winter (IRES, Strasbourg) and Vera Luth (SLAC). In addition, two new members have recently been appointed to the group, although not in time for their participation in the full 2008 scrutiny process. Michal Turala (Crakow) joins as a delegate from a small member state, while Gabriele Cosmo (CERN) replaces Sascha Schmeling as an active CERN member. While the Group was slightly short of its full complement for this year's process, the Group believes that the scrutiny process remained rigorous and robust.

2. **Scrutiny process**

The RRB M&O Scrutiny Group (SG) met on 5 and 6 May 2008 for initial discussions of the submissions from the five experiments, ALICE, ATLAS, CMS, LHCb and TOTEM. At that meeting the SG met with each of the five Resource Coordinators (RCs), to review the figures for past spend and the proposed future budgets. Over subsequent months, subgroups of the SG had further meetings with the RCs and others, to continue reviewing and refining the figures. The SG met again on 29 and 30 September, when further discussions were conducted with the five RCs to finalise the figures for projected future M&O costs, for submission to the RRB. The Group had discussions with the CSO, Jos Engelen, at its May meeting, and the Chair and Secretary had further discussions with him on 25 September.

As usual, the work of the SG has been greatly helped by the quantity and quality of the documentation provided by the RCs and by their co-operation, patience and competence

in addressing the many issues raised by the Group. The SG believes, however, that the process could be made even more efficient by more timely delivery of material in advance of meetings, to allow more careful review of all documents before the discussions.

The SG continues to use the set of summary "Vera" spreadsheets that record total past income and total spend for Category A M&O, together with the future projections. These spreadsheets are complete and up-to-date for the four major experiments, and cover the period from 2002-2012. It is expected that a "Vera" spreadsheet for TOTEM will be started next year when the total spend for 2008 becomes available.

The Scrutiny Group recognizes that the task of projecting M&O costs for 2009 and beyond, into the operational phase of the experiments, necessarily involves significant uncertainties. Currently many M&O costs are rising steeply as the experiments move to the new regime of operation and exploitation. In what is a period of considerable uncertainty over the readiness of the LHC, the SG notes that all of the experiments are working hard to evolve their strategies in the light of changing expectations about machine switch-on and expected luminosities. The SG has scrutinized the projected M&O costs for 2009 and beyond, and believes them to be reasonable as best estimates at this time. However actual costs would clearly be affected by further changes in the machine schedule and by new circumstances that may arise during operation of the experiments.

Table 1 gives a summary of the requests for Category A M&O for CY2009.

Experiment	Total (excluding power costs)	Total (including non-member state share of power costs)
ALICE	4687	5350
ATLAS	13610	14710
CMS	10408	12208
LHCb	2508	2592
TOTEM	449	

Table 1. Year 2009 Category A estimates (in kCHF).

3. **Service Level Agreements**

A significant fraction of the experiments' M&O budgets are allocated to Service Level Agreements with several CERN departments. These cover items such as beam pipe and vacuum systems, cryogenics, magnet controls, power converters, cooling and ventilation, power distribution systems, safety monitoring and access controls, surveying, gas distribution, cranes and transport. A subgroup of the SG reviewed the Service Level Agreements with the RCs; Table 2 summarizes the situation up to 2010. These costs are

expected to remain substantial during the exploitation phase, and the figures will evolve in the light of operational experience. The resource coordinators believe that these agreements continue to represent good value for money. The SG expects to continue to monitor and scrutinize these figures in the future.

Expt \ *Year*	*2008*	*2009*	*2010*
ALICE	720	720	720
ATLAS	4268	3638	3643
CMS	1779	1779	1779
LHCb	448	446	371

Table 2. Current status of M&O Service Agreements: figures are in kCHF and show total amounts in M&O A that are covered by Service Level Agreements.

4. **ALICE**

ALICE submitted their closing report for the 2007 M&O Budget to the RRB on 16 April 2008. The actual costs (spent plus committed) amounted to 3,665 kCHF for Cat A, including power costs, to be compared with budgeted costs of 4,103 kCHF. At that time there was 315 kCHF in outstanding contributions. ALICE provided the SG with a level-two breakdown for 2007 accounting, which has been very useful to understand the 2007 expenditure and 2009 requests. For CY2009, the projected Cat A budget total is 7279 kCHF including 2592 kCHF for power (663 kCHF for the non-member state share), representing a modest increase of 1.3% over the CY2008 budget.

The SG has examined in detail the overall ALICE M&O costs. At the beginning of the summer, the scrutiny subgroup raised specific questions on 28 points in the level-2 budget requests. In meetings with the ALICE resource coordinator and via email exchanges, all issues were discussed and all major ones were resolved.

The projected overall costs for ALICE are currently expected to remain approximately constant for the years from 2008 to 2010, but replacement of PCs for the online systems in years 2011 and 2012 may produce an increase in costs. In the light of this, the SG should review PC replacement costs each year.

As requested by the SG in 2007, the additional M&O A resources required to cover hiring of external staff for the ALICE magnet control in 2008 is no longer required, with the CERN group again covering that task.

Gas consumption costs, required mainly due to imperfect recycling, were reviewed on the basis of a detailed breakdown provided by ALICE. Consumption is expected to decrease from 365 kCHF in 2008 to 332 kCHF in 2009, and to 320 kCHF from 2010 onwards. However, the increasing cost of Xenon may pose a problem in the future. The experience gained in 2009 with a reduced number of TRD modules will allow ALICE to present better estimates for 2010 and beyond.

A description of the manpower requirements for shutdown activities was provided. The SG endorses ALICE's request for 150 kCHF for consumables for the years 2009 and 2010 (new detectors will be installed) but requests a reduction to 100 kCHF for the years 2011 and 2012. It is recognized that these figures may be renegotiated according to experience.

ALICE asks for an additional 70 kCHF for 0.5FTE for database management. This is a new request arising apparently from insufficient support from IT department (discussed later also for the other experiments). After considerable discussion, and given that ALICE does need this database support and there seems to be no prospect of IT providing it, the SG endorsed the request. The SG would support the provision of the required FTE of manpower as in-kind, rather than as cash paid to IT department.

ALICE provided the SG with a detailed list of tasks in offline computing. About 25 people are working in this area at CERN, with about 4 FTE funded from M&O Cat A. ALICE requested to increase this total to 5 FTE from 2009 onwards. After discussion, the SG agreed to recommend 4.5 FTE on M&O Cat A in 2009, and 5 FTE from 2010, but requires ALICE to provide a breakdown for next year of the specific central tasks that are to be included in the 5 FTE of M&O A effort.

A description of outreach activities for ALICE, paid from M&O A, was provided by Catherine Decosse and endorsed by the SG.

No other significant issues were identified. The SG considers the requested ALICE M&O Cat A budget for 2009 to be reasonable.

5. **ATLAS**

M&O Category A

ATLAS submitted their closing report for 2007 to the RRB on 15 April 2008. The approved M&O Cat A budget for 2007 was 11,722 kCHF, including 1,470 kCHF for power (475 kCHF for the non-member state share). The final 2007 Cat A expenditure amounted to 10,522 kCHF (including 500 kCHF for non-member state power charges), with an additional commitment of 538 kCHF for technical services deferred to future years, representing a total actual plus committed expenditure of 11,060 kCHF (excluding the member state power costs). This is to be compared with a budget of 10,727 kCHF. The Cat A costs for supporting the Trigger DAQ system were about 1300 kCHF for

personnel and hardware. As budgeted, about 1500 kCHF was spent on core offline computing, predominantly for support of technical personnel. The expenditure for test beams, collaborative tools and administrative support account for the remainder of the costs in 2007. The general operations test beam line included 355K compared to 40K budgeted, the increase being due to the end-cap toriod magnet accident.

The M&O Category A budget for CY2008 is 14,109 kCHF, including 2,220 kCHF for power (of which 858 kCHF is the non-member state share). ATLAS anticipate incurring 340 kCHF of additional unbudgeted costs while starting up the magnets, to cover additional manpower for testing, brackets to block the end-cap toroids (ECT) on their tracks, modifications to the ECT and solenoid services, completion of electrical work, and acquisition of a redundant water pump. However it is expected that these additional costs can be accommodated within the existing 2008 budget because a reduced expenditure on liquid nitrogen is expected.

The ATLAS M&O Cat A budget request for CY2009 is for 16,430 kCHF including 2,820 kCHF for power (1,100 kCHF for the non-member state share), based on the assumption that the ATLAS detector will be in full operational mode (with beam from 1 April through 30 November). Among the various major categories, the largest increases relative to the 2008 budget are attributed to computer hardware, power costs, and infrastructure repairs and improvements.

As ATLAS prepares for routine operations, they have become aware of potential single points of failure in their infrastructure which could cause significant downtime, and they are attempting to address these infrastructure limitations, proposing to put the necessary expenditure into Category A M&O, an example being 280 kCHF requested for water pumps. The effort to consolidate detector cooling systems is expected to result in increased costs of 350 kCHF per year for personnel and equipment. The plans are to improve water circulation pumps for the racks and the magnets, as well as inner detector cooling systems and compressors. This cost is spread out over several years (included currently in budgets through 2012). The SG supports these efforts, but will look closely at the details of activities and costs in future years.

Because of the increasing price of xenon and uncertainties in recycling rates, there is the potential for a cost-overrun of up to 500 kCHF for TRT gas. ATLAS does not include any contingency for this in the 2009 budget. The proposed budget covers the current best estimated of the gas costs, but SG recognizes that this may need to be revisited as ATLAS gains operating experience.

For the Trigger/DAQ system, the procurement model calls for replacement of CPUs after three years; in fact the unit processor costs are 24% lower than previously budgeted. The cost of power supply maintenance has also increased by 50 kCHF as of 2009 to 115 kCHF per year. ATLAS also propose to move support for two online network administrators to Cat A M&O as of 2009, in addition to the ten FTE of system administration effort already included in the preliminary budget, resulting in an increase of 220 kCHF per year (which is available as an in-kind contribution). These network

administrators support the data network, the back-end network and the control network, and do represent common services for the entire experiment.

The ATLAS budget plan does not include any contingency, and the estimated risk is between 500 to 1,000 kCHF for 2009, or about 5% of the total. There is the possibility that the extended shutdown may result in increased costs, but expenditure is expected not to depend on the beam energy or machine intensity.

Several funding agencies made extraordinary contributions to finance the construction of the forward detectors (Alfa/Lucid/ZDC) for ATLAS for the common benefit of the experiment. ATLAS proposes to incorporate the M&O expenses (75 kCHF starting in 2010) associated with the forward detectors into Cat A, because the construction contributions were not part of the core, and there is no obvious means to support this as a Cat B expense. While the SG had some misgivings about this proposal, there seems to be no better alternative mechanism, and consequently the SG endorsed the proposal.

At this time, the Category A M&O budget projections for the years 2010 through 2012 are at about the same level as the 2009 request, modulated by the plans for trigger/DAQ hardware procurements, which produce a small dip in the 2010 budget. The expected costs total 16,000 kCHF in 2010, and a significant increase to 18,600 kCHF in 2011, falling to 17,200 kCHF in 2012 (with power costs assumed to be constant at the 2009 budget levels). In these figures, no allowance has been made for inflation.

M&O Category B

The M&O Category B budget for 2008 is 6,866 kCHF, including 2,072 kCHF for hired manpower at CERN (but excluding in-kind contributions). The Inner Detector subsystems anticipate a ~10% carryover at the end of 2008. The LAr group reported on substantial concerns about the low-voltage power supplies. The TileCal group requires a significant increase in manpower to refurbish all 256 drawers, spending 403 kCHF more than budgeted in 2007, and anticipating spending 189 kCHF more than budgeted in 2008. However, reductions are being made in other areas, and in-kind contributions have been available to offset the larger expenditure on manpower. The muon subsystem group reported on failures of 26 power supplies, which is a cause for concern.

ATLAS conducts its own internal scrutiny for the M&O Cat B budgets for each of the subsystems, and since 2007 has provided reports to the Scrutiny Group. The M&O Cat B budget request for 2009 is 6,976 kCHF, including 2,048 kCHF for hired manpower at CERN (but excluding in-kind contributions), several percent lower than anticipated in late 2007. The technical manpower required at CERN has increased by 3 FTE, to a total of 18, in 2009 compared to the projection made in late 2007, but this still represents a significant reduction relative to the 2008 levels.

In the scrutiny of M&O B the SG verified that there was no duplication of budget requests in Cats A and B for inner detector cooling. It is recognized that the dividing line

is unclear in such a complex system, but the SG would like to see more clearly the delineation for next year's scrutiny.

The costs of the pixel replacement are included in the M&O Cat B budget requests, starting with 800 kCHF in 2009. It is anticipated that the required smaller diameter beam pipe and the tooling for removal and insertion will be Cat A items, but this needs clarification. A detailed proposal with realistic costs and schedules is expected to be available in early 2009. The inner detector group also anticipates procuring additional high voltage units for the pixel system in 2009 through 2011, to facilitate high luminosity running. This effectively represents a cost-to completion that is being addressed via M&O Cat B.

Modifications to the 58 low-voltage power supplies for the LAr are expected to cost 300 kCHF during the winter shutdown. The group is also investing 1100 kCHF from the core funding in prototypes to replace these power supplies, with these prototypes expected to be ready for testing this autumn. The expectation is that the LAr group will replace the power supplies, at an estimated cost of 1,200 kCHF spread over the years 2009 through 2011.

The Cat B M&O budget projections for the years 2010 through 2012 show a slow decrease relative to the 2009 level, falling by 11% by the year 2012.

6. **CMS**

CMS submitted the closing report for the 2007 M&O Cat A budget to the RRB on April 14, 2008. The actual costs amounted to 9,548 kCHF for Category A (including power costs of 1455 kCHF paid by non-CERN member states). The total Category A costs are to be compared with budgeted costs of 9,698 kCHF. As in past years, Cat A expenses were driven by the various technical services invoiced by CERN, such as access and crane operations and spare parts, gases, cooling and ventilation plants, and magnet operation. The Category B support is provided directly by the collaboration.

The total CMS M&O A budget request for 2009 amounts to 12,208 kCHF (including power costs), some 750 kCHF less than the provisional request presented to the RRB in April 2008, and only 2% higher than the 2008 budget. A few significant changes occurred in the budget request for 2009 when compared to 2008, and are discussed in more detail below. These changes are mainly due to the gain of knowledge acquired during the terminal phase of the construction and to experience gained during the start of commissioning.

The SG has examined in detail the overall CMS M&O costs for 2009. At the beginning of the summer, the scrutiny subgroup raised specific questions on 22 points in the level-2 budget requests. Special emphasis was put on cooling and gas systems, computing, shutdown activities and technical support. In two meetings with the CMS resource coordinator and via several email exchanges, all issues were discussed and addressed.

The increase of the gas system operations costs, from 160 kCHF to 210 kCHF is due to the request for 0.5 FTE of manpower. This request is based on the realisation that more effort is needed properly to coordinate contract work (commercial and internal). This additional fraction of FTE would provide the focal point for this coordination effort, while also providing additional technical support. This requirement for more coordination is also appearing in other areas, which will be the subject of future budget requests.

CMS made substantial progress in 2008 in dealing with the issue of gas leaks, an area that must be given constant attention during the future running. The refresh rate is at present 10%. For nine months of running per year, the estimated costs for gas consumption amount to 496 kCHF per annum.

The recirculating cooling fluid losses are about 50 kg per day (at 65 CHF per kg), much higher than anticipated. The current plan is to reduce these fluid losses by a factor of four and efforts are ongoing to achieve this. For nine months of running per year, losses of some 12.5 kg per day still represent a permanent increase of cooling fluids expenses, reaching 220 kCHF per year as of 2009. In order to find a long term solution to this problem, a study is underway to design an upgrade to the cooling system. It is likely that such a project would imply a major investment, which would need to be discussed at the appropriate time. At present no request on M&O Cat A has been endorsed by the SG for the upgrade of the cooling system.

CMS has made a new request for a spare conical section of the beam pipe, in order to complete the kit of spare beam pipe sections. This will enable the experiment to recover rapidly from any damage that may occur during the start of LHC operations. The requested increase amounts to 150 kCHF for beam-pipe and vacuum consumables, resulting in a total of 270 kCHF for 2009 and decreasing to a baseline of 150 kCHF for the following years.

The CMS collaboration has an urgent need for additional engineering support estimated at the level of 75 person-months. The process of defining the tasks and the share within the collaboration is ongoing. To cover the most urgent needs, the item related to Reviewing and Engineering has been increased from 60 kCHF in 2008 to 150 kCHF for 2009. The SG endorsed this, but any additional future requests will need to be scrutinised.

Procurement of the TDAQ system is going well, costing 2450 CHF per machine which is significantly less than the forecast of 3000 CHF. The completion of the DAQ online farm, foreseen to reach a capacity of 50 kHz (about half of the planned full capacity) after the end of the first run and full capacity by 2010, will cost 1,000 kCHF less than envisaged. Currently an increase in the budget in is foreseen in 2010 for replacements, but this will be reviewed next year in the light of experience.

7. **LHCb**

LHCb submitted the closing report for the 2007 M&O Budget to the RRB on April 16, 2008. The actual costs amounted to 1,996 kCHF for Category A (excluding power costs), well in line with the budgeted costs of 2,222 kCHF. The main cost drivers for LHCb are general services, online computing and detector-related costs.

For CY2009, the proposed LHCb Category A M&O budget amounts to 2,508 kCHF (not including power costs), an increase of 7% relative to the CY2008 budget. The total is projected to rise by only a few percent, in line with inflation, over the next few years.

As mentioned above, LHCb remain concerned about costs for gas and coolants. A small amount for contingency has been included in the budget projections, but real costs will only become known after considerable operational experience.

Support for core computing will mainly be paid for as Project Associate costs for 2 FTEs, to cover central production and some support for grid work. This spend needs to be monitored to ensure the funds go where intended.

Currently LHCb has no model for PC replacements, but intends to purchase as required, estimating a total requirement of 300 kCHF per year. A full modernization of the system is planned for 2012.

As requested in the 2007 scrutiny round, LHCb has moved a large number of electronics pool rental items from M&O Cat A to Cat B.

The SG discussed with LHCb in detail most lines in their M&O Cat A request, and was satisfied that proposed costs were justified.

8. **TOTEM**

TOTEM submitted their first ever M&O Cat A budget request to the SG at the end of 2007. Following scrutiny of the request, the SG sent a memorandum to the CSO on 28 November 2007, and a budget of 463kCHF was approved for 2008 by email discussion between the CSO and the appropriate RRB delegates. At the start of 2008 significant spending had to await the payment of M&O A contributions and this tended to slow down the expenditure. At present, the income has reached about 300kCHF and the expenditure about 200kCHF, and no significant overspend is anticipated by the end of CY 2008.

The TOTEM M&O A request for 2009 is 449 kCHF, which is 14 kCHF less than for 2008. The main cost drivers are again core computing at 2.5FTE (93 kCHF), online and slow controls at 2 FTE (96 kCHF), detector-related costs (147 kCHF) and test beams (40 kCHF).

Computing costs have decreased by 38 kCHF from 2008 due to the completion of some software tasks. Detector-related costs, on the other hand, have increased by 58 kCHF, partly due to the inclusion in M&O A of an annual purchase of one volume change of C_3F_8 cooling fluid (16 kCHF) to cover losses either experienced or anticipated during the testing phase, and for expected losses during routine operation of the Roman Pots. At least a full year's running experience will be needed to evaluate whether this level of replacement will be required in the longer term. The cooling category for 2009 also contains a one-off purchase of a cooling-water heat-exchanger to prevent possible contamination of the general cooling-water network. Provision is also included for 19 kCHF/year for the anticipated radiation safety costs (movement and storage of equipment, plus purchase of additional radiation monitors), required because of the proximity of telescopes T1 and T2 to the CMS beam pipe and end cap, which necessitates dismounting and moving the systems to safe areas each time there are changes to the CMS configuration. Test-beam costs should peak at 74 kCHF in 2008, fall to 40 kCHF in 2009 and then continue at 30 kCHF for the following three years. This will provide for the completion of the tests on the Roman Pots and the T1 and T2 systems and then to make tests for higher luminosity running (Silicon detectors and GEM detectors (RD51)).

Currently, the overall M&O Category A budget is projected to reach a steady state of 428 kCHF/year in 2010.

For M&O Category B, the request for 2009 and each of the following years until 2011 is 247 kCHF per year, to be compared with 217 kCHF in 2008. In 2009, the costs are divided between detector-related costs (195 kCHF), on-line computing (50 kCHF) and general services (2 kCHF), with the sharing between operation and consumables in the ratio 1:2. The operations costs represent about one third of the total detector-related costs and mainly represent the subsistence costs for visiting technicians to install and remove the detectors.

9. **Other issues**

There is general concern among the resource coordinators that the experiments are increasingly being asked to pay for items and services which they believe to be host laboratory responsibilities (Category C M&O). In some cases, the experiments feel they have little option but to pay, due to expediency, in order to secure vital items or services. Some examples are fire alarms, access doors and elevators, cooling and ventilation installations, and toilets. There is also concern about provision of sufficient radiation dosimeters to facilitate smooth detector operations.

CERN IT has requested a total of 3 FTE of manpower from the experiments to supplement what they have available for database support (1 FTE from each of ATLAS and CMS and 0.5 FTE from each of ALICE and LHCb). The resource coordinators believe that this support should come from IT. However ALICE has included 70 kCHF in the budget to cover for this, while CMS has agreed to allocate a CERN Fellow from its

quota (charged at 100 kCHF per annum from M&O A), selected jointly with IT. LHCb intends to pay for 1 FTE, half of which is for the requested database support and half for other computing support. ATLAS are still in discussion with IT to try to settle the issue; if they have to provide for this support, they would propose to provide it from their in-kind M&O B effort.

There is also concern about the level of support for collaborative tools used for videoconferencing, which the experiments and the SG believe should be a host laboratory responsibility. Both ATLAS and CMS have been using EVO for this purpose. However additional funding is now required to allow continued use and development of EVO. CERN management has indicated that they intend to investigate this problem. The proposed M&O Category A budgets do not now include any amounts for this item, but if support is not provided, additional funding in M&O A will be sought next year.

The model adopted in many of the budget estimates is for a 5% failure rate per year for electronics. Such estimates, and other such assumptions, should be revisited by the experiments and the SG once routine operating experience has been established.

Prompt payment of invoices issued to funding agencies continues to be of importance. The overall picture is good, although a small number of outstanding unaddressed invoices remain. For all experiments, the accumulated differences between total contributions received and actual expenditures are within the 10% allowed range (CERN-RRB-2006-026).

10. **Composition of the Scrutiny Group in 2009**

For 2009, significant changes are required to the composition of the Scrutiny Group. The UK delegate and current chair, George Lafferty (Manchester), has completed his term and is to be replaced. The German delegate, Joachim Mnich (DESY), is stepping down due of pressure of other work, and a replacement needs to be found for him also. The Group has recently been strengthened by an additional new member from a small state, Michal Turala (Crakow), and by a new active CERN member, Gabriele Cosmo, allowing Sascha Schmeling to concentrate on his role as scientific secretary.

11. **Summary**

Table 1 gives a summary of the requested M&O Category A budgets for ALICE, ATLAS, CMS, LHCb and TOTEM. The SG has carefully scrutinized the budget requests of these five experiments, examining in detail many of the line items. The Scrutiny Group took note of Category B estimates where available, but looked in more detail at the Category B budget request for ATLAS.

The RRB Scrutiny Group recommends approval by the RRB of the 2009 estimates for the M&O budgets for ALICE, ATLAS, CMS, LHCb and TOTEM.

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