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# **Commissioning, Maintenance and Operation of Experiments at the LHC**

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## **Overview**

### **Purpose of this document**

The LHC Resources Review Boards have the dual authority to allocate funds to the LHC experiments and to monitor the use of those funds. In existing Memoranda of Understanding (MoU) that define costs and funding commitments for constructing the LHC detectors, it is stated that MoUs will be drawn up to cover costs and funding for the Maintenance and Operation (M&O) of those detectors.

Given the scale of LHC detector projects, M&O costs are incurred not only when the detectors are running but also during construction and commissioning. Institutes and agencies committed to supplying 'deliverables' have implicit responsibility for M&O costs associated with the construction and commissioning of those items. The purpose of this document is to prepare the way for producing MoUs that clearly define responsibilities for M&O costs that are not already accounted for during the commissioning phase and for M&O costs when the experiments will be in full operation.

### **Contents of this document**

The information in this document is presented for consideration by the RRBs. M&O MoUs should then emerge from the joint deliberations of the Funding Agencies (FAs), the Collaborations and CERN Management.

The document contains preliminary estimates of the total cost of operating the LHC experiments and a draft list of items that incur M&O costs. Ultimately this list will define what is included and is not included in the M&O MoUs. It will cover material costs plus any personnel costs related to detector operation that are either 'billed' e.g. outsourced manpower or external, e.g. the use of non-collaboration personnel for tasks directly and exclusively to do with LHC detector M&O.

Possible algorithms for sharing M&O costs are outlined with some consequences of adopting different schemes. A uniform approach to all four experiments is highly desirable.

### **Timetable**

This document will be discussed at the RRBs in April 2001. It is hoped that those discussions, followed up by the written exchange of comments, will allow draft M&O MoUs to be prepared for examination by the RRBs in October 2001.

### **Period of validity**

This document is aimed at preparing for MoUs covering M&O costs during detector construction, commissioning and operation from 2002 onwards. Costs for 2001 will be handled 'informally' as has been the case hitherto. Costs and funds that evolve with time, for example during the transition from construction to running, will be presented in MoU Annexes that will be updated annually for approval by the RRBs.

## **Costs**

The RRBs must concur that all M&O costs are correctly itemised and that there is a reasonable framework for an equitable cost distribution among the participating countries, agencies and institutes. It will be the ongoing task of the RRBs to oversee the provision and spending of M&O monies and to take action if problems arise with cash flow, contributions, crises or the evolution of responsibilities. It seems likely that in some cases the RRBs will have to sanction in-kind rather than cash contributions to M&O costs.

Annexe A is a draft list of items incurring M&O costs with tentative categorisation that the RRBs should scrutinise for completeness and correctness. Annexe B contains *very* preliminary estimates of total M&O costs for the years 2002 to 2007. Estimates for individual experiments have been given to the corresponding RRBs. NOTE that all estimates were made on the basis of LHC machine start-up in 2005 and that for sub-detectors, only electronics maintenance is included.

### **Cost categories**

There are three categories of M&O costs according to the items involved. These categories define responsibilities for covering the costs.

- *Category A* concerns equipment built using Common Funds e.g. magnets, or services and operations common to the whole experiment e.g. software licences
- *Category B* concerns maintenance of equipment built by a sub-set of the collaboration, mainly sub-detectors
- *Category C* concerns items for which the host laboratory, CERN, would naturally assume responsibility e.g. access and some safety issues

The FAs and Collaborating Institutes (CIs) will be apportioned a share of Category A costs, and of Category B costs for any specific projects in which they participate.

CERN provides the basic laboratory infrastructure and must cover all costs of running the LHC machine. Concerning Category A and Category B costs, CERN will be treated as the other CIs and, as the host laboratory, will pay some specific Category C costs.

### **Cost sharing**

The goal is to reach an equitable sharing of M&O costs and to find effective methods of managing and monitoring the funds. Two algorithms are commonly used to cover M&O costs of HEP experiments, namely sharing by number of scientists (authors) and sharing by costbook (capital investment). Cost-sharing algorithms may be different for category A and B items.

#### ***Category A items***

Sharing by scientists rather than by costbook is popular as it is linked directly to the exploitation of the detectors and is perceived to be a fair measure of benefit. In this context, 'scientists' are taken to be fully-qualified PhDs, or the equivalent, appearing as named authors on publications of the collaboration. This implies that a reference publication is defined annually.

### ***Category B items***

Category B items can be handled in the same way as category A items, namely uniformly across the collaboration, though maybe with a different cost-sharing algorithm e.g. by costbook.

Alternatively, FAs and CIs can retain responsibility for their own category B costs and sharing can vary with experiment and with sub-system. Because many LHC sub-systems have multiple participants, the Institutional Boards of the collaborations will have to manage and monitor costs and funds, as the RRBs will do for category A items. It will be incumbent on the spokesperson to guarantee the integrity of all sub-systems to the Collaboration, the RRBs and CERN, and to demonstrate that there is sufficient provision for M&O, e.g. via a document presented annually to the RRBs. In addition, a recovery plan must be agreed in case of a disaster in any one sub-system, and the threshold at which intervention will occur must be defined.

### **Sharing between Member States and Non-Member States**

There are three groups of participants in LHC experiments, Member States, non-Member States that have contributed to building the LHC machine as part of the LHC project plan, and non-Member States that have not so contributed. As a Collaborating Institute, CERN is in the third group.

It is important that all participants are treated in a transparent way and that due recognition is given for contributions to the machine construction. Member States should benefit, as should non-Member States that have contributed to the machine, at a level proportional to their contribution.

### ***Rebates***

A possible way of recognising contributions to the machine is via 'rebates', whereby CERN pays part of the category A bill of contributors. The total rebate would be fixed, with individual rebates attributed according to the level of contribution of the group to which the FA or CI belongs i.e. Member State or contributing non-Member State.

<b>Detector related costs</b>		<b>Test beams and calibration facilities</b>	
Gas consumption	A	General operation	A
M&O of magnet	A	Upgrades	A/B
M&O of gas systems	A	Common electronics and DAQ	A
M&O of cooling systems (incl. consumption)	A	Electronics pool rentals	A/B
M&O of external cryogenics	A	Counting & control rooms	A
M&O of proximity cryogenics	A	<b>Laboratory operations</b>	
M&O of internal cryogenics	A	Laboratory instruments	A/B
M&O of moving/hydraulic systems	A	Electronics pool rentals	A/B
Detector safety systems	A	Assembly and active storage areas	A/B
Shutdown maintenance and operation	A	Workshops	A/B
Magnet power supply maintenance	A	<b>General services</b>	
UPS maintenance for common systems	A	Cooling, ventilation and pumps	A
Electronics pool rentals	A	Power	A
Sub-detector electronics maintenance	B	Radioprotection & safety	A/C
Beam pipe	A	Survey	A/B
Counting & control rooms	A	Access system (LHC machine)	C
<b>Collaboration Secretariats</b>		Gerant de site (LHC machine)	C
Economat	A	Heavy transport	A
Photocopying machines, fax, printers	A	Cranes	A
Printing and publication costs	A	Cars	A
Secretarial assistance	A	Elevators (LHC machine)	C
<b>Communications</b>		Sump pumps	C
GSM phones	A/B	Insurance (CERN standard)	C
Automatic call-back	A/B	Passive storage space	A/B
Videoconferencing	A/B	<b>Consultancy</b>	
<b>On-line computing</b>		PRR, MOB, ...	A
Data storage	A	Engineering	A
Data recording media	A	<b>Outreach</b>	A
Detector controls	A		
Computer/LAN maintenance/replacement	A		
System management	A		
Software license fees	A		
<b>Off-line computing</b>			
Common desktop infrastructure	A		
Data management	A		

## ANNEXE A

Items incurring M&O costs during the construction, commissioning and running of LHC experiments, with TENTATIVE categorisation

Item	ALICE+ATLAS+CMS+LHCb					
	2002	2003	2004	2005	2006	2007
<b>Detector related costs</b>						
Gas consumption	220	370	710	1500	1500	1500
M&O of magnet	370	480	550	875	875	875
M&O of gas systems	50	165	350	655	730	730
M&O of cooling systems (incl. consumption)	410	635	675	915	915	915
M&O of external cryogenics	300	300	300	1400	1400	1400
M&O of proximity cryogenics	50	120	180	300	300	300
M&O of internal cryogenics	50	120	170	230	230	230
M&O of moving /hydraulic systems	315	345	350	455	455	455
Detector safety systems	35	40	75	149	149	149
Shutdown maintenance and operation	1300	2250	3100	4360	4260	4260
Magnet power supply maintenance	130	155	155	345	355	355
UPS maintenance for common systems	145	170	210	285	315	315
Electronics pool rentals	210	290	360	465	465	465
* <i>Sub-detector electronics maintenance</i>	300	350	500	10800	12800	12800
Beam pipe	200	200	200	800	800	800
Counting & control rooms	50	50	200	323	333	343
<b>Secretariat costs</b>						
Economat	105	115	135	270	290	290
Photocopying machines, fax, printers	155	180	195	280	280	280
Printing and publication costs	120	130	150	250	330	330
Secretarial assistance	820	850	890	1310	1310	1310
<b>Communication costs</b>						
GSM phones	56	60	98	118	118	118
Automatic call-back	47	47	67	88	89	89
Videoconferencing	85	90	135	190	190	190
<b>On-line computing</b>						
Data storage	70	165	222	507	608	697
Data recording media	123	154	1650	2412	2451	5145
Detector controls	424	367	436	605	625	645
Computer/LAN maintenance/replacement	240	375	480	3882	7210	8115
System management	420	600	730	1330	1410	1410
Software license fees	120	140	210	465	465	465
<b>Off-line computing</b>						
Common desktop infrastructure	100	145	190	280	300	300
Data management	350	360	500	1050	1100	1100
<b>Test beams and calibration facilities</b>						
General operation	435	435	435	180	190	140
Upgrades	195	195	165	75	75	75
Common electronics and DAQ	210	210	190	140	180	110
Electronics pool rentals	520	560	600	395	285	265
Counting & control rooms	85	85	75	65	65	65
<b>Laboratory operations</b>						
Laboratory instruments	300	400	300	290	245	190
Electronics pool rentals	100	100	100	130	490	130
Assembly and active storage areas	240	270	270	180	180	180
Workshops	60	90	90	120	120	120
<b>General services</b>						
Cooling, ventilation and pumps	940	940	940	1500	1500	1500
Power	2600	2600	2600	10100	10100	10100
Radioprotection & safety	868	868	868	1440	1440	1440
Survey	160	160	160	240	240	240
Access system (LHC machine)	480	480	480	480	480	480
Gerant de site (LHC machine)	480	480	480	480	480	480
Heavy transport	900	920	940	400	380	380
Cranes	770	800	830	680	640	640
Cars	145	160	160	160	160	160
Elevators (LHC machine)	480	480	480	480	480	480
Sump pumps	480	480	480	480	480	480
Insurance (CERN standard)	0	255	340	510	510	510
Passive storage space						
<b>Consultancy</b>						
PRR, MOB, ...	10	60	60	60	60	60
Engineering	200	220	200	140	140	140
<b>Outreach</b>						
	80	80	80	98	98	98
<b>Grand Totals</b>	<b>18108</b>	<b>21146</b>	<b>25496</b>	<b>55717</b>	<b>61676</b>	<b>64839</b>

ANNEXE B  
 VERY preliminary estimates of combined M&O costs during 2002 – 2007  
 based on schedule for LHC start-up in 2005

\* *Note that only electronics maintenance is included for sub-detectors*