

CERN-C-RRB-2005-01

31 March 2005

Memorandum of Understanding

for Collaboration in the Deployment and Exploitation of the LHC Computing Grid

between

The EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH (“CERN”), an intergovernmental Organization having its seat at Geneva, Switzerland, as the Host Laboratory, the provider of the Tier0 Centre and the CERN Analysis Facility, and as the coordinator of the LCG project,

on the one hand,

and

all the Institutions participating in the provision of the LHC Computing Grid with a Tier1 and/or Tier2 Computing Centre (including federations of such Institutions with computer centres that together form a Tier1 or Tier2 Centre), as the case may be, represented by their Funding Agencies for the purposes of signature of this Memorandum of Understanding,

on the other hand,

(hereafter collectively referred to as “the Parties”).

Preamble

- (a) Early in the year 2000, CERN launched a wide-ranging review, chaired by S. Bethke (MPI Munich), of the status and plans for the computing for the Experiments at CERN's Large Hadron Collider (LHC). This included a survey of the anticipated needs of the Experiments. The Steering Group of the review submitted its final report to the Research Board via the LHC Committee (CERN/LHCC/2001-004) on 22 February 2001. In the knowledge of this, CERN Council, at its session of 20 September 2001, approved the LHC Computing Grid ("LCG") project and in particular its Phase 1 of technology development and tests leading to a production prototype (CERN/2379/Rev.). Council also took note of the plans at that time for the deployment and exploitation phase of the project (Phase 2).
- (b) Before proceeding to Phase 2, the LCG project will undergo a technical, financial, and manpower review (CERN/DG/RB 95-234) by the LHCC based on a Technical Design Report. This process will be completed during 2005.
- (c) The purpose of the LHC Computing Grid is to provide the computing resources needed to process and analyse the data gathered by the LHC Experiments. The LCG project, aided by the Experiments themselves, is addressing this by assembling at multiple inter-networked computer centres the main offline data storage and computing resources needed by the Experiments and operating these resources in a shared grid-like manner. One of the project's most important goals is to provide common software for this task and to implement a uniform means of accessing resources. It has been found useful to classify the computer centres functionally in Tiers. Tier0 is at CERN. It receives the raw and other data from the Experiments' online computing farms and records them on permanent mass storage. It also performs a first-pass reconstruction of the data. The raw and reconstructed data are distributed to the Tier1 Centres. Tier1 Centres provide a distributed permanent back-up of the raw data, permanent storage and management of data needed during the analysis process, and offer a grid-enabled data service. They also perform data-heavy analysis and re-processing, and may undertake national or regional support tasks, as well as contribute to Grid Operations Services. Tier2 Centres provide well-managed, grid-enabled disk storage and concentrate on tasks such as simulation, end-user analysis and high-performance parallel analysis. In addition CERN provides an Analysis Facility that has the functionality of a combined Tier1 and Tier2 Centre, except that it does not offer permanent storage of back-up copies of raw data.
- (d) Agreement to collaborate on the deployment and exploitation of the LHC Computing Grid is made through the conclusion of this Memorandum of Understanding ("MoU"), which defines the LHC Computing Grid Collaboration and its objectives, and the rights and obligations of the Collaboration Members. The needs of the Experiments, on which the pledged Computing Resource Levels (Annex 6) are based, have been reviewed in January/February 2005 by an expert committee appointed by the LHCC and chaired by P. McBride (FNAL) (CERN/LHCC-2005-006).
- (e) A Computing Resources Review Board ("C-RRB") has been constituted. It comprises the representatives of all LHC Computing Grid Funding Agencies, and of the managements of CERN, the LHC Experiments and the LCG project. It is chaired by CERN's Chief Scientific Officer and meets normally twice per year, in spring and

autumn. The LCG project management regularly reports to the C-RRB on technical, managerial, financial and administrative matters.

- (f) This MoU replaces the Interim Memoranda of Understanding (IMoU's) and Collaboration Agreements listed in Annex 10.

Article 1 : Parties to this MoU

- 1.1 The Parties shall be CERN as the Host Laboratory, the provider of the Tier0 Centre and the CERN Analysis Facility, and as the coordinator of the LCG project, on the one hand, and all the Institutions participating in the provision of the LHC Computing Grid with a Tier1 (listed in Annex 1) and/or Tier2 (listed in Annex 2) Computing Centre (including federations of such Institutions with computer centres that together form a Tier1 or Tier2 Centre), as the case may be, represented by their Funding Agencies for the purposes of signature of this MoU, on the other hand.
- 1.2 The Parties together constitute the LHC Computing Grid Collaboration (hereinafter "Collaboration"), of which they are termed Members. Each federation of Institutions constituted in accordance with paragraph 1.1 above shall count as a single Member of the Collaboration. For each Member, Annex 1 and Annex 2 show the duly authorised representative to the Collaboration. Collaboration Members will receive appropriate credit in the scientific papers of the LHC Experiments that they serve.
- 1.3 An Institution may have one or several Funding Agencies, which are established bodies controlling all or part of the Institution's funding. In the execution of this MoU, an Institution, depending on its situation, may be represented in funding matters by its Funding Agency or Agencies, or it may have the authority to represent itself in some or all matters. Annex 4 lists the Funding Agencies and their duly authorized representatives to the C-RRB.
- 1.4 The LHC Experiments will have available to them Additional Facilities (hereinafter "AF's") that access the services of the LHC Computing Grid or expose resources to it, without themselves being Collaboration Members. These AF's are thus not Parties to this MoU. To such AF's as are named by the LHC Experiments, the Members of the Collaboration shall give access to the necessary software and to the LHC Computing Grid itself, for purposes related to the execution of the LHC Experiments. In order to ensure the smooth functioning of the LHC Computing Grid for its users, such access will be subject to written acceptance of such conditions as the Collaboration shall from time to time decide but which shall in any event include the conditions set out in Article 10 and paragraph 13.1 of this MoU. It shall be the duty of the LHC Experiments to ensure that these AF's receive and install the necessary software and are competent in its use, and that they comply with the conditions for access to the LHC Computing Grid.

Article 2 : Purpose of this MoU

- 2.1 This MoU governs deployment and exploitation of the LHC Computing Grid. It defines the programme of work to be carried out and the distribution of duties and responsibilities of the Parties as well as the Computing Resource Levels they will offer to the LHC Experiments. It sets out organisational, managerial and financial guidelines to be followed by the Collaboration and defines the status of staff working for a Member of the Collaboration at CERN, the legal framework applicable to the contribution and creation of intellectual property, and the mechanism for resolution of disputes. It also sets out the mechanism by which the motivated requests of the LHC Experiments are reviewed annually on the advice of an independent, impartial and expert body (see paragraph 7.2 below), and by which any mismatches with the pledged Computing Resource Levels are identified for action.
- 2.2 The LCG project Phase 2 is executed in the framework of the CERN scientific programme, as approved by the CERN Council. The provisions of this MoU are complemented by the bilateral Agreements (including Protocols) concluded between CERN and Member State and/or non-Member State Institutes, which shall be without prejudice to the performance of this MoU.

Article 3 : Duration of this MoU and its Extension

- 3.1 The initial period of validity of this MoU governs the expected deployment phase of the LHC Computing Grid and the expected first five full years of LHC physics running, i.e. from the date of its signature until 31 December 2012.
- 3.2 The validity of this MoU shall be extended automatically, each time for a successive period of five years beyond the initial period or, as the case may be, the previous five-year period, except as the C-RRB may determine otherwise. This provision notwithstanding, this MoU shall terminate if and when the LHC programme is declared closed by the CERN Council.
- 3.3 Any Institution that wishes to join the Collaboration shall secure the necessary funding and shall accept this MoU and any related agreement that is in place between Members of the Collaboration and is disclosed to it. Such joining shall be negotiated by the management of the Collaboration and shall be subject to approval by the C-RRB. In order to (continue to) qualify for membership of the Collaboration, each Institution shall comply with the minimal levels-of-service criteria ("Computing Resource and Service Levels") specified for Tier1 and/or Tier2, as the case may be, in Annex 3. In particular:
 - 3.3.1 A Tier1 Centre may (exceptionally) comprise a federation of computer centres.
 - 3.3.2 Centres wishing to offer Tier2 services may also form federations with other such centres in order to comply jointly with the minimal levels-of-service criteria.

- 3.3.3 In both cases it is essential that such federations establish unified technical and operational management, so that in their dealings with the rest of the Collaboration they are indistinguishable in all respects from single sites.
- 3.4 Any Funding Agency may withdraw its support from the Collaboration by giving not less than eighteen months notice in writing to the management of the Collaboration and the Director General of CERN. In such an event, it shall ensure that all of the affected Institutions are in compliance with paragraphs 3.5 and 3.6 below. Reasonable compensation to the Collaboration shall be negotiated through CERN and approved by the C-RRB.
- 3.5 The Institutions are expected to remain Members of the Collaboration for the duration of the LHC programme, the computing needs of which are foreseen to grow with time, and the long-term commitment of Tier1 Centres is especially important. Nevertheless, any Institution may withdraw from the Collaboration in accordance with the procedures agreed by the Collaboration, which procedures shall be subject to the General Conditions for Experiments Performed at CERN, and by giving not less than twelve months notice in writing to its Funding Agency or Agencies. Loss of data due to such withdrawal cannot be tolerated and the Institution wishing to withdraw shall, before closing access to those LHC Computing Grid and LHC Experiment data of which it has the unique copy (or unique permanent backup copy), make alternative storage arrangements with other Collaboration Members and shall move the data to them. Such moving of data shall be negotiated with the managements of the Collaboration and of the Experiments concerned and approved by the C-RRB.
- 3.6 The integrity of Grid Operations services must be preserved and so an Institution wishing to withdraw from the Collaboration shall, before closing access to any Grid Operations services that it has been providing, cooperate actively with the management of the Collaboration (which has final responsibility for ensuring continuity for these services) to make alternative arrangements.

Article 4: The Aims and Organisation of the Collaboration

- 4.1 The organizational structure of the Collaboration as of the date of entry into force of this MoU is described in Annex 5.
- 4.2 The technical participation of the Institutions is defined in terms of Computing Resource Levels that they pledge to provide to one or more of the LHC Experiments and Service Levels that they pledge to the Collaboration, having in both cases secured the necessary funding. Institutions may clearly have other resources that they do not pledge in this way. The Institutions shall pledge "Resources" and "Services" separately, specifying all of the parameters relevant to each element (e.g. size, speed, number, effort, as the case may be). As far as possible they shall associate with each element key qualitative measures such as reliability, availability and responsiveness to problems. Tier1 Centres shall also pledge (separately) the

consolidated Computing Resource and Service Levels of other Tier Centres (if any), for which the Tier1 has responsibility:

4.2.1 Resources. These shall be pledged separately (as applicable) for Tier1 services and Tier 2 services (defined in Annex 3)

- Processing capacity (expressed in commonly agreed units).
- Networking. Due to the distributed nature of the LHC Computing Grid, it is particularly important that each Institution provides appropriate network capacity with which to exchange data with the others. The associated Computing Resource Levels shall include I/O throughput and average availability¹.
- Access to data (capacity and access performance parameters of the various kinds of storage, making clear which figures refer to archival storage).

4.2.2 Services

- Grid software and common applications provision and maintenance. The Collaboration Board (see Annex 5) shall agree the list of common software to be installed and maintained, updating the list from time to time as may be necessary to match the needs of the Experiments. The LHC Experiments are expected to use as far as possible a common set of software, especially infrastructure software. The Collaboration shall ensure its Grid compatibility, packaging, distribution and installation as required, as well as the necessary technical feedback.
- Grid Operations Services spanning all or part of the LHC Computing Grid. These services are described in Annex 3.4. For considerations of efficiency, it is vital that they be pledged on a long-term basis and not just from year to year.

4.3 The broad decisions on the operating system environments that may be used in connection with the LHC Computing Grid shall be taken by consensus of the Overview Board described in Annex 5.1. The precise versions and distributions are an operational matter for the management of the Collaboration. At any given time there will be several alternative environments on offer but the Collaboration is not obliged to make its software available for arbitrary environments. It is thus important for authors of applications software in the LHC Experiments and in the Collaboration to avoid narrow dependencies on operating systems or environments.

4.4 If, for whatever reason, the Computing Resource Levels pledged by an Institution to a particular LHC Experiment are not being fully used, the Institution concerned shall consult with the managements of the LHC Experiments it supports and with that of the Collaboration. In such situations it is encouraged to make available some part or all of the Computing Resource Levels in question to one or more of the other

¹ (time running)/(scheduled up-time)

LHC Experiments it supports and/or to the Collaboration management for sharing amongst the LHC Experiments as it sees fit.

- 4.5 Annex 6 shows, for each Institution, the Computing Resource and Service Levels pledged in the next year and planned to be pledged in each of the four subsequent years.
- 4.6 The Institutions, supported by their Funding Agencies, shall make their best efforts to provide the Computing Resource and Service Levels listed in Annex 6.1 to Annex 6.5. In particular, in order to protect the accumulated data and the Grid Operations services, any Institution planning to reduce its pledged storage and/or Grid Operations services shall take the measures necessary to move to other Institutions the affected data (belonging to the LHC Computing Grid and/or LHC Experiments) of which it has the unique copy (or unique permanent backup copy) and/or Grid Operations services that it has been providing, before closing access to the data and/or provision of the Grid Operations services. Such moving of data and/or Grid Operations services shall be negotiated with the managements of the LHC Experiment(s) concerned and of the Collaboration.
- 4.7 It is a fundamental principle of the Collaboration that each Institution shall be responsible for ensuring the funding required to provide its pledged Computing Resource and Service Levels, including storage, manpower and other resources. The funding thus provided will naturally be recognised as a contribution of the Funding Agency or Agencies concerned to the operation of the LHC Experiments.
- 4.8 Institutions may clearly have computing resources that are earmarked for purposes unrelated to the LHC Computing Grid and are not pledged to LHC Experiments as Computing Resource Levels. These resources are neither monitored centrally by the management of the Collaboration nor accounted as contributions to LHC computing. Any such resources that are nevertheless subsequently made available to the LHC Experiments (and used by them) will be accounted in the normal way as contributions to LHC computing.

Article 5 : Programme of Work for the Deployment of the LHC Computing Grid and Sharing of Responsibilities for its Execution

- 5.1 Annex 7 gives an overview of the planned LHC Computing Grid deployment schedule leading to first physics data taking.
- 5.2 The programme of work for the LHC Computing Grid deployment, together with the sharing of the workload amongst the Members of the Collaboration, is given in Annex 8. Some of this work has been executed under the terms of the interim agreements listed in Annex 10. In addition, some aspects are covered by the bilateral Agreements referred to in paragraph 2.2 above.

Article 6 : Approval and Oversight

- 6.1 The C-RRB has the following approval and oversight roles with respect to the Collaboration, in the exercise of which it shall operate by consensus except as it shall itself decide otherwise :
- 6.1.1 Approval of Phase 2 of the LCG project.
 - 6.1.2 Approval of the present MoU and thereafter monitoring its execution.
 - 6.1.3 Approval of Amendments and Addenda to the present MoU.
 - 6.1.4 Participation in the resolution of disputes, as described in Article 12 below.
 - 6.1.5 Approval of new Members of the Collaboration on the proposal of the Collaboration Board.
 - 6.1.6 Annual approval at its autumn meeting of the Computing Resource Levels pledged to the LHC Experiments by the Institutions for the following year. To this end, the management of the Collaboration shall report to the C-RRB at its spring meeting the Computing Resource Levels pledged by the Institutions for the next year and planned to be pledged in each of the four subsequent years (update of Annex 6) revising the information, if necessary, for the C-RRB's autumn meeting.
 - 6.1.7 Annual approval of the overall sharing of the pledged Computing Resource Levels amongst the LHC Experiments, following the procedure for review of requirements set out in Article 7 below.
 - 6.1.8 For each Institution, the Computing Resource Levels i) actually made available by the Institution and ii) actually used by each of the LHC Experiments are monitored centrally by the management of the Collaboration, which reports the figures for the previous year to the C-RRB at its spring meeting, along with the equivalent cost of providing these Computing Resource Levels at CERN. The C-RRB shall take note of the participation of the Institutions concerned, in terms of the Computing Resource Levels that were actually made available, and shall act accordingly.

Article 7 : Sharing of LHC Computing Grid Resources amongst the LHC Experiments

- 7.1 The users of the pledged Computing Resource Levels are the LHC Experiments, represented in their relations with the Collaboration by their managements.
- 7.2 The C-RRB shall approve annually, at its autumn meeting, on the advice of an independent, impartial and expert review body - the Resources Scrutiny Group ("RSG"), which shall operate according to the procedures set out in Annex 9, the overall refereed resource requests of each LHC Experiment for the following year. At the same meeting it shall take note of the Computing Resource Levels pledged

for the same year to each Experiment by the Institutions. If it emerges that the pledged Computing Resource Levels are inadequate to satisfy the refereed requests of one or more Experiment, the C-RRB shall seek further contributions of Computing Resource Levels. Should a shortfall persist, the C-RRB shall refer the matter to the LHCC, which may require a scaling down and/or prioritisation of requests in order to fit the available Computing Resource Levels.

Article 8 : Responsibilities of CERN as the Host Laboratory, and of the Institutions

- 8.1 The specific responsibilities of CERN as the Host Laboratory for the LHC Computing Grid are detailed in Annex 3.1.
- 8.2 The general responsibilities of CERN as the Host Laboratory and of the Institutions are set out in the General Conditions for Experiments Performed at CERN (“the General Conditions”). The General Conditions form an integral part of this MoU, it being understood however that in case of contradiction or ambiguity between the terms of this MoU (including the Annexes) and the General Conditions, the former shall prevail.
- 8.3 All equipment brought to the CERN site must comply with CERN's safety regulations. The design, test criteria and testing of equipment shall be discussed well in advance with CERN's safety officials. All equipment brought to CERN shall remain accessible for inspection by the Group Leader in Matters of Safety, which post is defined in paragraph 4.2 of the General Conditions.

Article 9 : Status of Staff

- 9.1 If and in so far as they are required to perform work on the CERN site in the execution of this MoU, the staff of the Members of the Collaboration (other than CERN) shall be granted the status of Associated Member of the Personnel of CERN.
- 9.2 The staff shall at all times during their association with CERN remain employed by, and receive a salary from, the employing Member, who shall ensure that, through itself or directly by its staff, they shall have adequate social security cover, including health and accident insurance at levels prevailing in the region around CERN. The employing Member shall hold CERN free and harmless from liability in this respect.

Article 10 : Intellectual Property

- 10.1 The Members of the Collaboration contributing (the “Contributors”) pre-existing software or having created software in the execution of the LCG project (jointly the “Software”) shall warrant and ensure that they have or have procured the rights to

contribute such Software for use (which term in this article shall include any integration, redistribution, modification and enhancement) by the Members of the Collaboration, the Members of the LHC Experiments, and the AF's referred to in paragraph 1.4 above (jointly the "Community"), subject to the conditions of the present article.

- 10.2 The Contributors herewith grant a free, irrevocable and non-exclusive right to the Community to use the Software, always in conformity with applicable license conditions, for the exclusive purposes of executing this MoU and the LHC Experiments.
- 10.3 The Contributors shall, in so far as permitted by applicable license conditions, endeavour to make the Software generally available under Open Source license conditions (see Annex 11 for template license conditions).
- 10.4 Except as expressly provided in this article, the Members of the Collaboration provide no warranties or representations of any kind to the Community and shall have no liability to it with respect to the Software, it being understood that each member of the Community shall bear the consequences of its use of the Software.

Article 11 : Amendments

- 11.1 The Collaboration shall make every effort to ensure that the information contained in the Annexes to this MoU is kept up-to-date. To this end it shall review the information at least annually in time for the spring meeting of the C-RRB.
- 11.2 This MoU may be amended at any time, subject to the prior written agreement of the C-RRB, with the agreement of the Parties.

Article 12 : Disputes

- 12.1 The primary mechanism for the resolution of disputes shall be negotiation within the Collaboration in the first instance and then if necessary in the C-RRB. Should these fail to conclude, the dispute shall be finally settled by arbitration through the President of the CERN Council, who may adopt any form of arbitration process.
- 12.2 It is understood that any issues that have arisen during the lifetime of the prior Collaboration Agreements and Interim MoU's listed in Annex 10 shall be without prejudice to the rights and obligations laid down in this MoU. No party shall be entitled under this MoU to reduce, retain or set-off any obligation due under these prior Collaboration Agreements and Interim MoU's.

Article 13 : Liability

- 13.1 Except as provided for in paragraph 9.2 of this MoU, the Parties shall have no liability towards each other for any loss or damage resulting from their use of the LHC Computing Grid and related computing resources, including their participation in the LCG project, nor shall they be liable towards the AF's defined in paragraph 1.4 of this MoU, it being understood that each Party shall hold the other Parties free and harmless from claims relating to transactions (other than its licensing of the AF's) that it has entered into with third parties in this connection..
- 13.2 For the avoidance of doubt, it is understood that CERN is under no obligation to provide insurance cover for any of the Parties, including in particular third party liability cover.

Article 14 : Annexes

- 14.1 All the Annexes are an integral part of this MoU. They are understood to be the planning basis for the deployment and exploitation of the LHC Computing Grid. All of the Annexes are subject to update as provided for in paragraph 11.1 and, in particular, Annex 6 will be updated annually as described in paragraph 6.1.6.

Article 15 : Final Provisions

- 15.1 This MoU is not binding on the Parties, it being understood however that the Parties recognize that the success of the Collaboration depends on all Members adhering to its provisions.

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The European Organization for Nuclear Research (CERN)

and



declare that they agree on this Memorandum of Understanding for collaboration in the deployment and exploitation of the LHC Computing Grid.

Done in Geneva

Done in _____

on _____

on _____

For CERN

For



Jos Engelen
Chief Scientific Officer

**Annex 1. LHC Computing Grid Tier0 and Tier1 Centres, and the CERN Analysis Facility
Tier0 and the CERN Analysis Facility**

<i>Experiments served with priority</i>			<i>Representative to LHC Computing Grid Collaboration</i>		
<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>	<i>LHCb</i>		
X	X	X	X	W. von Rüden	

Tier1

<i>Centre</i>	<i>Experiments served with priority</i>			<i>Representative to LHC Computing Grid Collaboration</i>	<i>Funding Agencies</i>
	<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>		
TRIUMF, Canada		X			NSERC
GridKA, Germany	X	X	X	X	BMBF
CC-IN2P3, France	X	X	X	X	IN2P3
CNAF, Italy	X	X	X	X	INFN
NIKHEF/SARA, NL	X	X		X	NIKHEF
Nordic Data Grid Facility	X	X			
ASCC, Taipei		X	X		NSC/Academia Sinica
RAL, UK	X	X	X	X	PPARC
BNL, US		X			DOE
FNAL, US			X		DOE
PIC, Spain		X	X	X	MEC

Notes

- 1) Entries in *italics* have still to be confirmed

Annex 2. List of Tier2 Centres

Institution	Experiments served with priority				LHC Computing Grid Collaboration	Funding Agencies
	ALICE	ATLAS	CMS	LHCb		
CSCS, Switzerland		X	X	X	M-C. Sawley (alt.: C. Grab)	CHIPP
FZU AS, Prague, Czech Rep.	X	X			M. Lokajicek	
Hungarian Tier-2 Federation, Hungary	X		X		G. Vesztergombi, KFKI	NKTH
- KFKI, Budapest - SZTAKI, Budapest - Eotvos Univ., Budapest - Debrecen Univ.						
Helsinki Institute of Physics, Finland			X			
Polish Tier-2 Federation, Poland	X	X	X	X	R. Gokieli, Warszawa	Ministry for Scientific Research and Information Technology
- Krakow - Warszawa						Ministry of Science and Education
Russian Tier-2 cluster ² , Russian Fed.	X	X	X	X		
HEP-IL Federation, Israel		X			L. Levinson, Weizmann	
- Technion, Haifa - Weizmann, Rehovot - Tel Aviv Univ.						
Pakistan Tier-2 Federation, Pakistan			X			PAEC
- PAEC - NCP - NUST - COMSATS						
Brazilian Tier-2 Federation, Brazil		X	X	X		CNPq
- UFRJ - UERJ - CBPF						
TIFR, Mumbai, India			X			DAE
VECC/SINP, Kolkata, India	X					DAE
Uni B. Pascal, Clermont-Ferrand, France	X	X		X		IN2P3

² The Russian Tier2 cluster consists of over 10 institutes in Moscow, Protvino, Dubna, Troitsk, St.Petersburg and Novosibirsk

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<i>Institution</i>	<i>Experiments served with priority</i>				<i>Representative to LHC Computing Grid Collaboration</i>		<i>Funding Agencies</i>
	<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>	<i>LHCb</i>			
Fédération Ile de France, France - LAL, Orsay - LPNHE-Paris - DAPNIA-Saclay	X	X	X	X			IN2P3
CC-IN2P3, Lyon, France		X	X				IN2P3
INFN Tier-2 Federation, Italy - INFN-Bari - INFN-Bologna-CMS - INFN-Cagliari - INFN-Catania - INF-Frascati - LNL-Legnaro - INFN-Milano - INFN-Napoli - INFN-Padova - INFN-Pisa - INFN-Roma1 - INFN-Torino	X	X	X				INFN
RWTH, Aachen, Germany					X		
GSI, Darmstadt, Germany	X						BMBF
Freiburg Univ., Germany		X					
DESY, Hamburg, Germany		X	X		X		BMBF
Mainz Univ., Germany		X					
MPI/LMU, Munich, Germany		X					
Univ. Wuppertal, Germany		X					
UIBK, Innsbruck, Austria		X					BBWK
ATLAS Federation, Spain - IFIC, Valencia - IFAE, Barcelona - UAM, Madrid		X					MEC
LHCb Federation, Spain - UB, Barcelona - USC, Santiago				X			MEC

Draft 4.5 LHC COMPUTING GRID COLLABORATION

<i>Institution</i>	<i>Experiments served with priority</i>				<i>Representative to LHC Computing Grid Collaboration</i>	<i>Funding Agencies</i>
	<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>	<i>LHCb</i>		
CMS Federation, Spain - CIEMAT, Madrid - IFCA, Santander			X			MEC
Grid London ³ , UK - UCL - ICL - Brunel - RHUL - QMUL	X	X	X	X	David Colling, ICL	PPARC
NorthGrid ³ , UK - Manchester - Liverpool - Sheffield - Lancaster - <i>Daresbury Lab.</i>	X	X	X	X	Roger Jones, Lancaster	PPARC
ScotGrid ³ , UK - Edinburgh - Glasgow - Durham	X	X	X	X	Nigel Glover, Durham	PPARC
SouthGrid ³ , UK - Birmingham - Cambridge - Warwick - Swansea - Bristol - RAL - Oxford - Sussex	X	X	X	X	Jeffrey Tseng, Oxford	PPARC
Southwest ATLAS T2, USA - Arlington Univ. - Oklahoma Univ - Univ. of New Mexico - Univ. Texas (LU)		X				DOE/NSF

³ Within the UK there is an agreement for each Tier2 to support the four main LCG VOs. In the above table this shows as an "X" against each experiment. In practice not all sites within a UK Tier2 will support all VOs and the impact of scheduling at those sites that do support all LCG experiments will need to be considered in estimating available resources.

Draft 4.5 LHC COMPUTING GRID COLLABORATION

<i>Institution</i>	<i>Experiments served with priority</i>				<i>Representative to LHC Computing Grid Collaboration</i>	<i>Funding Agencies</i>
	<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>	<i>LHCb</i>		
Midwest ATLAS T2, USA - Univ. of Chicago - Indiana Univ.		X				DOE/NSF
Boston/Harvard ATLAS T2, USA - Boston Univ. - Harvard Univ.		X				DOE/NSF
CMS T2, USA - MIT - Univ. of Florida - Univ. of Nebraska - Univ. of Wisconsin - Caltech - Purdue Univ. - Univ. of California			X			DOE/NSF
Canada East Tier-2 Federation, Canada		X				
Canada West Tier-2 Federation, Canada		X				
IHEP, Beijing, China		X				IHEP
Univ. of Melbourne, Australia		X				
ICEPP, Tokyo, Japan		X				ICEPP

Notes

- 1) Entries in *italics* have still to be confirmed

Annex 3. Minimal Computing Resource and Service Levels to qualify for membership of the LHC Computing Grid Collaboration

This Annex describes the qualitative aspects of the Computing Resource and Service Levels to be provided by the Host Laboratory (CERN), Tier1 Centres and Tier2 Centres in order to fulfil their obligations as Parties to this MoU. Also described are the qualitative aspects of Grid Operations Services. The quantitative aspects of all of these services are described for each Party in Annex 6. Only the fundamental aspects of Computing Resource and Service Levels are defined here. Detailed service definitions with key metrics will be elaborated and maintained by the operational boards of the Collaboration. All centres shall provide & support the Grid services, and associated software, as requested by the experiments and agreed by the LHC Computing Grid Collaboration. A centre may also support additional Grid services as requested by an experiment but is not obliged to do so.

Annex 3.1. Host Laboratory Services

The Host Laboratory shall supply the following services in support of the offline computing systems of all of the LHC Experiments according to their computing models.

- i. Operation of the Tier0 facility providing:
 1. high bandwidth network connectivity from the experimental area to the offline computing facility (the networking within the experimental area shall be the responsibility of each Experiment);
 2. recording and permanent storage in a mass storage system of one copy of the raw data maintained throughout the lifetime of the Experiment;
 3. distribution of an agreed share of the raw data to each Tier1 Centre, in-line with data acquisition;
 4. first pass calibration and alignment processing, including sufficient buffer storage of the associated calibration samples for up to 24 hours;
 5. event reconstruction according to policies agreed with the Experiments and approved by the C-RRB (in the case of pp data, in-line with the data acquisition);
 6. storage of the reconstructed data on disk and in a mass storage system;
 7. distribution of an agreed share of the reconstructed data to each Tier1 Centre;
 8. services for the storage and distribution of current versions of data that are central to the offline operation of the Experiments, according to policies to be agreed with the Experiments.
- ii. Operation of a high performance, data-intensive analysis facility with the functionality of a combined Tier1 and Tier2 Centre, except that it does not offer permanent storage of back-up copies of raw data. In particular, its services include:
 1. data-intensive analysis, including high performance access to the current versions of the Experiments' real and simulated datasets;
 2. end-user analysis.
- iii. Support of the termination of high speed network connections by all Tier1 and Tier2 Centres as requested.
- iv. Coordination of the overall design of the network between the Host Laboratory, Tier1 and Tier2 Centres, in collaboration with national research networks and international research networking organisations.

- v. Tools, libraries and infrastructure in support of application program development and maintenance.
- vi. Basic services for the support of standard⁴ physics “desktop” systems used by members of the LHC Collaborations resident at CERN (e.g. mail services, home directory servers, web servers, help desk).
- vii. Administration of databases used to store physics data and associated meta-data.
- viii. Infrastructure for the administration of the Virtual Organisation (VO) associated with each Experiment.
- ix. Provision of the following services for Grid Coordination and Operation:
 1. Overall management and coordination of the LHC grid - ensuring an effective management structure for grid coordination and operation (e.g. policy and strategy coordination, security, resource planning, daily operation,...);
 2. The fundamental mechanism for integration, certification and distribution of software required for grid operation;
 3. Organisation of adequate support for this software, generally by negotiating agreements with other organisations;
 4. Participation in the grid operations management by providing an engineer in charge of daily operation one week in four (this service is shared with three or more other institutes providing amongst them 52-week coverage).

The following parameters define the minimum levels of service:

<i>Service</i>	<i>Maximum delay in responding to operational problems</i>			<i>Average availability⁵ measured on an annual basis</i>	
	Service interruption	Degradation of the capacity of the service by more than 50%	Degradation of the capacity of the service by more than 20%	During accelerator operation	At all other times
Raw data recording	4 hours	6 hours	6 hours	99%	n/a
Event reconstruction or distribution of data to Tier-1 Centres during accelerator operation	6 hours	6 hours	12 hours	99%	n/a
Networking service to Tier-1 Centres during accelerator operation	6 hours	6 hours	12 hours	99%	n/a
All other Tier-0 services	12 hours	24 hours	48 hours	98%	98%
All other services ⁶ - prime service hours ⁷	1 hour	1 hour	4 hours	98%	98%
All other services ⁶ - outwith prime service hours ⁷	12 hours	24 hours	48 hours	97%	97%

⁴ The standard supported desktop systems are agreed periodically between CERN and its user community.

⁵ (time running)/(scheduled up-time)

⁶ Services essential to the running of the Centre and to those who are using it.

⁷ Prime service hours for the Host Laboratory: 08:00-18:00 in the time zone of the Host Laboratory, Monday-Friday, except public holidays and scheduled laboratory closures.

Annex 3.2. Tier-1 Services

Each Tier1 Centre⁸ forms an integral part of the central data handling service of the LHC Experiments. It is thus essential that each such centre undertakes to provide its services on a long-term basis (initially at least 5 years) and to make its best efforts to upgrade its installations steadily in order to keep pace with the expected growth of LHC data volumes and analysis activities.

Tier1 services must be provided with excellent reliability, a high level of availability and rapid responsiveness to problems, since the LHC Experiments depend on them in these respects.

The following services shall be provided by each of the Tier1 Centres in respect of the LHC Experiments that they serve, according to policies agreed with these Experiments. With the exception of items i, ii, iv and x, these services also apply to the CERN analysis facility:

- i. acceptance of an agreed share of raw data from the Tier0 Centre, keeping up with data acquisition;
- ii. acceptance of an agreed share of first-pass reconstructed data from the Tier0 Centre;
- iii. acceptance of processed and simulated data from other centres of the LHC Computing Grid;
- iv. recording and archival storage of the accepted share of raw data (distributed back-up);
- v. recording and maintenance of processed and simulated data on permanent mass storage;
- vi. provision of managed disk storage providing permanent and temporary data storage for files and databases;
- vii. provision of access to the stored data by other centres of the LHC Computing Grid and by named AF's as defined in paragraph 1.4 of this MoU;
- viii. operation of a data-intensive analysis facility;
- ix. provision of other services according to agreed Experiment requirements;
- x. ensure high-capacity network bandwidth and services for data exchange with the Tier0 Centre, as part of an overall plan agreed amongst the Experiments, Tier1 and Tier0 Centres;
- xi. ensure network bandwidth and services for data exchange with Tier1 and Tier2 Centres, as part of an overall plan agreed amongst the Experiments, Tier1 and Tier2 Centres;
- xii. administration of databases required by Experiments at Tier1 Centres.

All storage and computational services shall be "grid enabled" according to standards agreed between the LHC Experiments and the regional centres.

⁸ The term "Tier1 Centre" includes a distributed Tier1 Centre according to the provisions of this MoU. In terms of services and levels of service a distributed Tier1 Centre shall be indistinguishable from a single-location Tier1 Centre.

The following parameters define the minimum levels of service:

<i>Service</i>	<i>Maximum delay in responding to operational problems</i>			<i>Average availability⁵ measured on an annual basis</i>	
	Service interruption	Degradation of the capacity of the service by more than 50%	Degradation of the capacity of the service by more than 20%	During accelerator operation	At all other times
Acceptance of data from the Tier-0 Centre during accelerator operation	12 hours	12 hours	24 hours	99%	n/a
Networking service to the Tier-0 Centre during accelerator operation	12 hours	24 hours	48 hours	98%	n/a
Data-intensive analysis services, including networking to Tier-0, Tier-1 Centres outwith accelerator operation	24 hours	48 hours	48 hours	n/a	98%
All other services ⁶ - prime service hours ⁹	2 hour	2 hour	4 hours	98%	98%
All other services ⁶ - outwith prime service hours ⁹	24 hours	48 hours	48 hours	97%	97%

The response times in the above table refer only to the maximum delay before action is taken to repair the problem. The mean time to repair is also a very important factor that is only covered in this table indirectly through the availability targets. All of these parameters will require an adequate level of staffing of the services, including on-call coverage outside of prime shift.

Annex 3.3. Tier-2 Services

Tier2 services shall be provided by centres or federations of centres as provided for in this MoU. In this Annex the term Tier2 Centre refers to a single centre or to the federation of centres forming the distributed Tier2 facility. As a guideline, individual Tier2 Centres or federations are each expected to be capable of fulfilling at least a few percent of the resource requirements of the LHC Experiments that they serve.

The following services shall be provided by each of the Tier2 Centres in respect of the LHC Experiments that they serve, according to policies agreed with these Experiments. These services also apply to the CERN analysis facility:

- i. provision of managed disk storage providing permanent and/or temporary data storage for files and databases;
- ii. provision of access to the stored data by other centres of the LHC Computing Grid and by named AF's as defined in paragraph 1.4 of this MoU;
- iii. operation of an end-user analysis facility;
- iv. provision of other services, e.g. simulation, according to agreed Experiment requirements;

⁹ Prime service hours for Tier1 Centres: 08:00-18:00 in the time zone of the Tier1 Centre, during the working week of the centre, except public holidays and other scheduled centre closures.

- v. ensure network bandwidth and services for data exchange with Tier1 Centres, as part of an overall plan agreed between the Experiments and the Tier1 Centres concerned.

All storage and computational services shall be “grid enabled” according to standards agreed between the LHC Experiments and the regional centres.

The following parameters define the minimum levels of service:

<i>Service</i>	<i>Maximum delay in responding to operational problems</i>		<i>Average availability⁵ measured on an annual basis</i>
	<i>Prime time</i>	<i>Other periods</i>	
End-user analysis facility	2 hours	72 hours	95%
Other services ⁶	12 hours	72 hours	95%

Annex 3.4. Grid Operations Services

This section lists services required for the operation and management of the grid for LHC computing.

This section reflects the current (3/2005) state of experience with operating grids for high energy physics. It will be refined as experience is gained.

- **Grid Operations Centres** – Responsible for maintaining configuration databases, operating the monitoring infrastructure, pro-active fault and performance monitoring, provision of accounting information, and other services that may be agreed. Each Grid Operations Centre shall be responsible for providing a defined sub-set of services, agreed by the Collaboration. Some of these services may be limited to a specific region or period (e.g. prime shift support in the country where the centre is located). Centres may share responsibility for operations as agreed from time to time by the Collaboration.
- **User Support** for grid and computing service operations:
 - First level (end-user) helpdesks are assumed to be provided by LHC Experiments and/or national or regional centres, and are not covered by this MoU.
 - **Grid Call Centres** – Provide second level support for grid-related problems, including pro-active problem management. These centres would normally support only service staff from other centres and expert users. Each call centre shall be responsible for the support of a defined set of users and regional centres and shall provide coverage during specific hours.

Annex 4. List of Funding Agencies and their Representatives to the Computing Resources Review Board

Member States

Country	Funding Agency	Represented by
Austria		
Belgium	NFWO	J. Lemonne
Belgium	FNRS	J. Sacton
Bulgaria		
Czech Rep.		M. Lokajicek, P. Krenek, M. Sumbra, V. Vrba
Denmark		J.D. Hansen
Finland		D.O. Riska
France	CEA	J. Zinn-Justin, J. Ernwein
France	IN2P3	F. Étienne, F. Le Diberder
Germany	BMBF	J. Richter
Germany	GSI	D. Muller
Germany	FZK	K.P. Mickel
Greece		
Hungary		M. Boda, G. Vesztergombi
Italy		U. Dosselli
The Netherlands		F. Linde, A.J. Van Rijn
Norway		S. Irgens-Jensen
Poland		M. Turala
Portugal		F. Bello
Slovak Republic		
Spain		D. Espriu, M. Delfino
Sweden		L. Gidefeldt, A.C. Lagerkvist
Switzerland		A. Clark
United Kingdom		R. Wade, J. Seed

Non-Member States

Country	Funding Agency	Represented by
Australia		S. Tovey
Canada		K. Wilson, R. Orr
China		G. Tong
India		S. Bhave
Japan	Univ. Tokyo	T. Kawamoto
JINR, Dubna		A.N. Sissakian
Pakistan		M. Ahmad, H. Hoorani
Romania		N.V. Zamfir
Russia		Yu.S. Kozlov, V.I. Savrin
Taipei		S.C. Lin
USA	Univ. Boston	J. Shank
USA	DOE	J. O'Fallon, R. Cousins, T. Ferbel
USA	FNAL	L. Bauerdick, D. Green
USA	NSF	J. Whitmore, H. Gordon, P. McNamara, M. Tuts

(These are the countries that have provided planning information so far)

Annex 5. The LHC Computing Grid Collaboration

Annex 5.1. The Organizational Structure of the Collaboration

1. High-level Committees:

- 1.1. Concerning its main technical directions, the Collaboration shall be governed by the **LHC Computing Grid Collaboration Board (CB)**. The CB shall be composed of a representative of each Institution or federation of Institutions that is a Member of the Collaboration, the LCG Project Leader and the Spokespersons of each LHC Experiment, with voting rights; and the CERN Chief Scientific Officer (CSO), and CERN/IT and CERN/PH Department Heads, as ex-officio members without voting rights, as well as a Scientific Secretary. The CB elects the **Chairperson of the CB** from among its Members. The CB meets annually and at other times as required.
- 1.2. A standing committee of the CB, the **Overview Board (OB)**, has the role of overseeing the functioning of the Collaboration and of this MoU in particular. It also acts as a clearing-house for conflicts that may arise within the Collaboration. The OB shall be chaired by the CERN CSO. Its other members comprise one person appointed by the agency/agencies that funds/fund each of the Tier-1 Centres, the Spokespersons of the LHC Experiments, the LCG Project Leader, the CERN/IT and CERN/PH Department Heads, and a Scientific Secretary. It meets about four times per year.

Both the CB and the OB may co-opt additional non-voting members as they deem necessary. The non-voting members complement the regular members by advising on (e.g.) matters concerning the environment in which the Collaboration operates or on specialist aspects within their areas of expertise.

2. The **LHC Computing Grid Management Board (MB)** supervises the work of the Collaboration. It is chaired by the LCG Project Leader and reports to the OB. The MB organises the work of the Collaboration as a set of formal activities and projects. It maintains the overall programme of work and all other planning data necessary to ensure the smooth execution of the work of the Collaboration. It provides quarterly progress and status reports to the OB. The MB endeavours to work by consensus but, if this is not achieved, the LCG Project Leader shall make decisions taking account of the advice of the Board. The MB membership includes the LCG Project Leader, the Technical Heads of the Tier-1 Centres, the leaders of the major activities and projects managed by the Board, the Computing Coordinator of each LHC Experiment, the Chair of the Grid Deployment Board (GDB), a Scientific Secretary and other members as decided from time to time by the Board.
3. The **Grid Deployment Board (GDB)** is the forum within the Collaboration where the computing managements of the experiments and the regional computing centres discuss and take, or prepare, the decisions necessary for planning, deploying and operating the LHC Computing Grid. Its membership includes: as voting members -

one person from each country with a regional computing centre providing resources to an LHC experiment (usually a senior manager from the largest such centre in the country), a representative of each of the experiments; as non-voting members - the Computing Coordinators of the experiments, the LCG Project Leader, and leaders of formal activities and projects of the Collaboration. The Chair of the GDB is elected by the voting members of the board from amongst their number for a two year term. The GDB may co-opt additional non-voting members as it deems necessary.

4. Concerning all technical matters, the Collaboration shall be subject to review by the **Large Hadron Collider experiments Committee** (LHCC), which makes recommendations to the **Research Board** (RB).
5. Concerning all resource and legal matters, the Collaboration shall be subject to the **Computing Resource Review Board** (C-RRB). The C-RRB is chaired by CERN's Chief Scientific Officer. The C-RRB membership comprises a representative of each Funding Agency, with voting rights, and (ex-officio) members of the LHC Computing Grid Management and CERN Management, without voting rights.
6. The **LCG Project Leader** represents the Collaboration to the outside and leads it in all day-to-day matters. He/she shall be appointed by the CERN Director General in consultation with the CB.

Annex 6. Pledged Computing Resource and Service Levels of the Institutions

The following tables give the size of pledged and planned Computing Resource and Service Levels of the LHC Computing Grid Institutions. The required quality of these Services is defined in Annex 3.

Annex 6.1. Tier0 Computing Capacities

CERN Tier0	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	2500	5940	12270	14600	24210	
Disk (Tbytes)	400	548	1066	1126	1468	
Tape (Tbytes)	2420	4660	11390	21670	33360	
Tape (Mbytes/sec)	1723	1723	1723	2348	2348	
Nominal WAN (Mbits/sec)	80000	100000	120000	140000	160000	

Annex 6.2. CERN Analysis Facility Computing Capacities

CERN Analysis Facility	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)		3560	7840	17030	27390	For 2006, any capacity necessary for this function will be drawn from that pledged for the Tier0
Disk (Tbytes)		2220	4147	6748	9493	
Tape (Tbytes)		1130	2190	5300	9770	
Tape (Mbytes/sec)		600	600	600	600	

Annex 6.3. Tier1 Computing Capacities

TRIUMF, Canada	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	600	1200	1800	2400		
Disk (Tbytes)	113	226	340	453		
Tape (Tbytes)	400	800	1200	1600		
Tape (Mbytes/sec)						
Nominal WAN (Mbits/sec)			10000	10000	10000	

GridKA, Germany	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1300	3020	8820	11580	14340	
Disk (Tbytes)	192	490	980	1430	1880	
Tape (Tbytes)	450	1400	3000	5800	8600	
Tape (Mbytes/sec)						
Nominal WAN (Mbits/sec)	10000	10000	20000	20000	20000	

CC_IN2P3, France	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1540	4312	12100	15730	20450	
Disk (Tbytes)	242	677	1970	2561	3330	
Tape (Tbytes)	1000	3000	4500	5850	7600	
Tape (Mbytes/sec)	350	400	500	600	700	
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

CNAF, Italy	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1800	2400	6300	10500	18000	
Disk (Tbytes)	850	1500	3500	5600	9000	
Tape (Tbytes)	850	1500	4000	6000	9500	
Tape (Mbytes/sec)	500	1000	2000	2400	2700	
Nominal WAN (Mbits/sec)	5000	10000	20000	30000	40000	

NIKHEF/SARA, NL	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1160	2720	4720	7530	13510	
Disk (Tbytes)	700	1450	2900	5800		
Tape (Tbytes)	600	1200	2300	4600		
Tape (Mbytes/sec)						
Nominal WAN (Mbits/sec)	10000	100000	100000	100000	100000	

Nordic Centre	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	600	1400	2800	3600	4600	
Disk (Tbytes)	140	400	1400	2600	4000	
Tape (Tbytes)	140	400	1400	2600	4000	
Tape (Mbytes/sec)						
Nominal WAN (Mbits/sec)	2000	5000	10000	20000	20000	

ASCC, Taipei	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	850	1770	3320			
Disk (Tbytes)	200	350	500			
Tape (Tbytes)	500	1000	2000			
Tape (Mbytes/sec)	80	160	200			
Nominal WAN (Mbits/sec)	4800	10000	10000			

RAL, UK	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1150	2843	5156	7903	7110	
Disk (Tbytes)	434	858	1639	2794	2518	
Tape (Tbytes)	1150	1640	1570	1570	1570	
Tape (Mbytes/sec)	310	360	360	700	700	
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

BNL, US	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1125	2558	5300	9520	16266	
Disk (Tbytes)	525	1108	3093	4619	8374	
Tape (Tbytes)	300	603	2023	3707	6175	
Tape (Mbytes/sec)	180	360	600	1080	1920	
Nominal WAN (Mbits/sec)	2488	9952	19904	29856	39808	

FNAL, US	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	728	1792	4256			
Disk (Tbytes)	100	700	1986			
Tape (Tbytes)	250	300	3224			
Tape (Mbytes/sec)	240	240	900			
Nominal WAN (Mbits/sec)						

PIC, Barcelona	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)			2000			
Disk (Tbytes)			1160			
Tape (Tbytes)			2320			
Tape (Mbytes/sec)						
Nominal WAN (Mbits/sec)						

Annex 6.4. Tier2 Computing Capacities

Centre "A"	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)						
Disk (Tbytes)						
Nominal WAN (Mbits/sec)						

Centre "B"	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)						
Disk (Tbytes)						
Nominal WAN (Mbits/sec)						

Etc.....

Annex 6.5. Grid Operations Services

See Annex 3.4 for a description of the services provided.

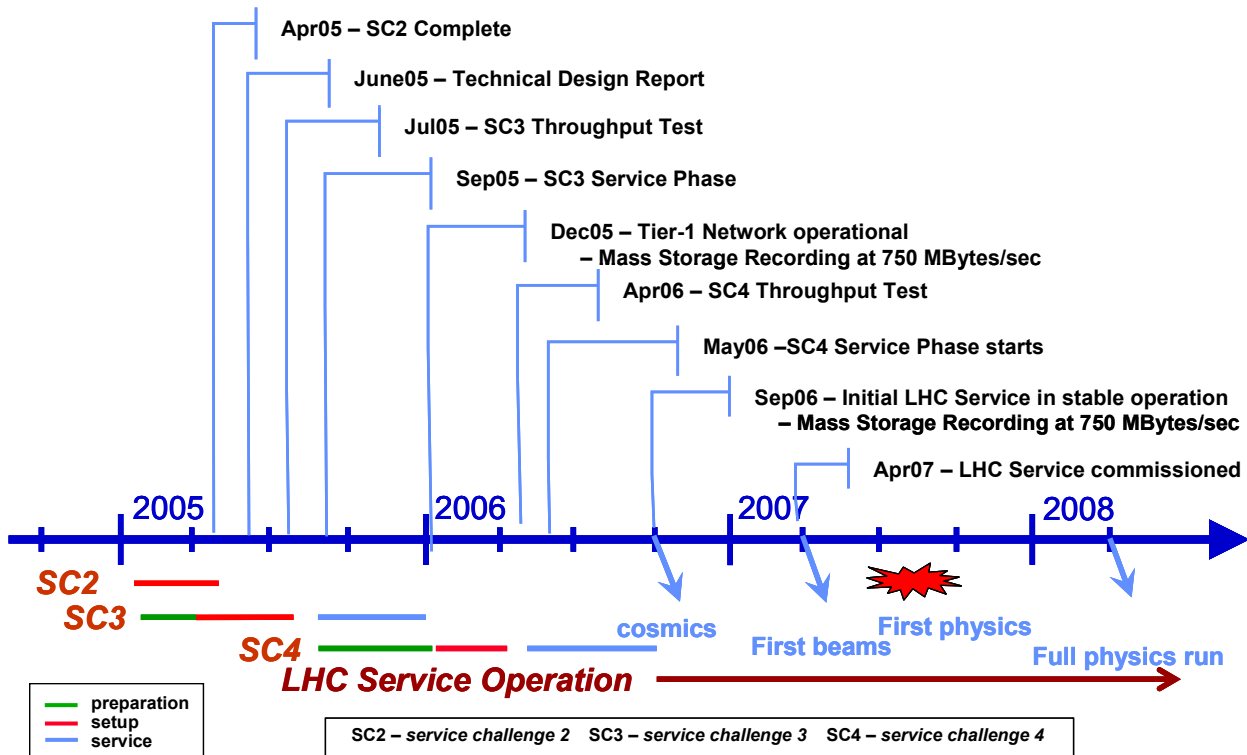
ASCC, CC_IN2P3, CERN, CNAF, MSU-RDIG (Russian Data-Intensive Grid), RAL	
<i>Scope of the service</i>	Grid Operations Centre for sites in the EGEE grid
<i>Period during which the centre operates as the primary management centre</i>	Responsibility cycled around sites on a weekly basis.

Indiana University iGOC (anticipated, pending development of funding model)	
<i>Scope of the service</i>	Open Science Grid Operations Centre
<i>Period during which the centre operates as the primary monitoring centre</i>	24 × 7 × 365

BNL, Fermilab (anticipated)	
<i>Scope of the service</i>	US-ATLAS VO Support Centre and US-CMS Support Centre respectively
<i>Period during which the centre operates as the primary monitoring centre</i>	24 × 7 × 365

ASCC, GridKA	
<i>Scope of the service</i>	Grid Call Centre for sites in the EGEE grid
<i>Period during which the centre operates as the primary call centre</i>	The centres take primary responsibility during working hours in their respective time zones.

Annex 7. LHC Computing Grid Deployment Schedule from 2006 to 2008



Annex 8. Programme of Work for the Deployment of the LHC Computing Grid and Sharing of Responsibilities for its Execution

Data Recording

CERN must be capable of accepting data from the experiment data acquisition (DAQ) systems and recording it on magnetic tape at a long-term sustained average rate of 1.6 GBytes/sec during the proton run and 1.85 GBytes/sec during the ions run. During 2004 the disk-tape writing rate was demonstrated at 1 GByte/sec. In March 2005 the recording rate for simulated DAQ through mass storage system to tape was demonstrated at 450 MBytes/sec. The target DAQ-mass-storage-tape rate achievable at the end of December 2005 is 750 MBytes/sec, rising to the full nominal data rate of 1.6 GBytes/sec by August 2006. These demonstrations must be performed in parallel with the *Service Challenge* activities described below.

Service Challenge 2

The goal of *Service Challenge 2* is to demonstrate reliable file transfer, disk to disk, between CERN and at least five Tier-1 centres, sustaining for one week an aggregate throughput of 500 MBytes/sec at CERN. The minimum capability at each Tier-1 is 100 MBytes/sec. The Tier-1 sites taking part are BNL, CNAF, FNAL, GridKA, IN2P3, NIKHEF/SARA and RAL.

The service should use the initial version of the reliable file transfer service, provided by CERN.

The target is to complete this challenge by end April 2005.

Service Challenge 3

Service Challenge 3 operates a reliable base service including most of the Tier-1 centres and some Tier-2s. It has two phases – a setup phase terminating with a throughput test, followed by a three-month period of stable operation during which experiments may carry out tests of their software chains and computing models.

The throughput goals at each Tier-1 are 150 MBytes/sec network-disk, and 60 MBytes/sec network-tape, with CERN capable of supporting 1 GByte/sec disk-network.

The goal of the throughput test is to maintain for one week an average throughput of 400 MBytes/sec from disk at CERN to tape at the Tier-1 sites. The Tier-1 sites taking part are ASCC, BNL, CNAF, FNAL, GridKA, IN2P3, NIKHEF/SARA, RAL and TRIUMF. The target date for completing the throughput test is end-July 2005.

The service phase of Service Challenge 3 will include additional software components, including a grid workload management system, grid catalog, mass storage management services and Virtual Organisation (VO) management services. A small number of Tier-2

sites will also be involved, each supported by a Tier-1 centre. The initial list of participating Tier-2 centres and their supporting Tier-1s is given in the table below. The service phase is scheduled to operate for three months from September to December 2005.

<i>Tier-2/Federation</i>	<i>Tier1</i>	<i>Experiment</i>
Bari, Italy	CNAF, Italy	CMS
Turin, Italy	CNAF, Italy	Alice
DESY, Germany	GridKA, Germany	ATLAS, CMS
Lancaster, UK	RAL, UK	ATLAS
London, UK	RAL, UK	CMS
ScotGrid, UK	RAL, UK	LHCb
US Tier2s	BNL / FNAL	ATLAS / CMS

Table 1: Core Set of Tier-2 Centres in Service Challenge 3

Service Challenge 4

Service Challenge 4 aims to demonstrate that all of the offline data processing requirements expressed in the experiments' Computing Models, from raw data taking through to analysis, can be handled by the Grid at the full nominal data rate of the LHC. All Tier1 sites will be involved, together with the majority of the Tier2s. The challenge must complete at least 6 months prior to first data taking, when it will become the production service for LHC and is made available to the experiments for final testing, commissioning and processing of cosmic ray data.

The setup phase ends with a throughput demonstration sustaining for three weeks the target data rates at each site as defined in the following table. The throughput is measured network-tape at each Tier-1, and disk-network at CERN. The target date for completing the throughput test is end April 2006.

<i>Centre</i>	<i>ALICE</i>	<i>ATLAS</i>	<i>CMS</i>	<i>LHCb</i>	<i>Target Data Rate MBytes/sec</i>
ASCC		X	X		110
CNAF	X	X	X	X	220
PIC		X	X	X	200
CC-IN2P3	X	X	X	X	220
GridKA	X	X	X	X	220
RAL	X	X	X	X	220
BNL		X			65
FNAL			X		50
TRIUMF		X			65
NIKHEF/SARA	X	X		X	175
NORDIC DATA GRID FACILITY	X	X			90
<i>Target data rate at CERN</i>					1,600

Table 2 - Nominal Network/Tape Data Rates by Site

The service phase of Service Challenge 4 will include the basic software components required for the initial LHC data processing service, as defined in the LCG Technical Design Report. The service must be able to support the full computing model of each experiment, including simulation and end-user batch analysis at Tier-2 centres. The service phase is scheduled to operate for four months from May to September 2006.

Initial LHC Service

The initial LHC service is scheduled to enter operation by end-September 2006, capable of handling the full nominal data rate (see Table 2). The service will be used for extended testing of the computing systems of the four experiments, for simulation and for processing of cosmic data. During the following six months each site will build up to the full throughput needed for LHC operation, twice the nominal data rate.

Annex 9. Rules of Procedure for the Resources Scrutiny Group (RSG)

1. The Computing Resources Review Board (C-RRB) shall appoint a Resources Scrutiny Group ("RSG") to assist it in exercising its duty with respect to the oversight of the provision of computing for the LHC Experiments and in particular the independent scrutiny of the resource requests from the Experiments for the coming year. The RSG has a technical role and shall be composed of ten persons chosen appropriately by the C-RRB. The RSG shall perform its duties for all of the LHC Experiments. The members chosen by the C-RRB shall normally include at least one person from each of CERN, a large Member State, a small Member State, a large non-Member State and a small non-Member State.
2. The members of the RSG are appointed with renewable mandates of 3 years provided that, in the interest of continuity, half of the first members shall be appointed for a 2-year period.
3. The CERN Chief Scientific Officer shall select the Chair of the RSG from amongst the members chosen by the C-RRB.
4. At his or her discretion, the Chair of the RSG shall accept that, in exceptional circumstances, a member is replaced at an individual meeting by a named proxy.
5. Annually (year n), at the spring meeting of the C-RRB, three pieces of information are presented:
 - i. the LHC Computing Grid management reports the resource accounting figures for the preceding year ($n-1$);
 - ii. the LHC Experiments explain the use they made of these resources;
 - iii. the LHC Experiments submit justified overall requests for resources in the following year ($n+1$) and forecasts of needs for the subsequent two years ($n+2$, $n+3$). Although the justification will necessarily require an explanation of the proposed usage to sufficient level of detail, the RSG will only advise on the overall level of requested resources. It shall be for the managements of each LHC Experiment then to control the sharing within their Experiment.

The C-RRB passes this information to the RSG for scrutiny.

6. Over the summer, the RSG shall examine all the requests made by the Experiments in the light of the previous year's usage and of any guidance received from the C-RRB. In doing so it shall interact as necessary with the Experiments and in particular with representatives who are knowledgeable about their Experiment's computing models/needs. It shall also examine the match between the refereed requests and the pledges of Computing Resource Levels from the Institutions, and shall make recommendations concerning any apparent under-funding for the coming years. It is not the task of the RSG to negotiate Computing Resource Levels with the Institutions.
7. The RSG shall present the results of its deliberations to the autumn meeting of the C-RRB. In particular it shall present, for approval, the refereed sharing of resources for the next year ($n+1$) and shall make any comments thought relevant on the previous year's ($n-1$) usage. It shall also draw attention, for action, to any mismatch

(including mismatch due to lack of manpower) with the planned pledges of Computing Resource Levels for the next year (n+1) and the subsequent year (n+2).

8. In order to ensure efficient use of the pledged Computing Resource Levels, adapt to changing needs and respond to emergency situations, the RSG may convene at other times throughout the year, on the request of the LHC Computing Grid or LHC Experiment managements, to advise on any resource sharing adjustments that seem to be desirable. Such adjustments would then be applied by common consent of those concerned.

Annex 10. Interim MoUs and Collaboration Agreements pertaining to the earlier work on the LHC Computing Grid and replaced by this MoU

1. Collaboration Agreement between the European Organization for Nuclear Research and the Institute of Physics, Academy of Sciences of the Czech Republic jointly with the Committee for Collaboration of the Czech Republic with CERN. No. K981/IT July 2003
2. Memorandum of Understanding for Collaboration between the Helsinki Institute of Physics and the LHC Computing Grid Project - Phase 1 at CERN. December 2002
3. Memorandum of Understanding for Collaboration in the Phase 1 of the LHC Computing Grid Project between the European Organization for Nuclear Research and the Hungarian Ministry of Education, R&D Division. November 2001
4. Memorandum of Understanding for Collaboration in the Phase 1 of the LHC Computing Grid Project between the European Organization for Nuclear Research and the Istituto Nazionale di Fisica Nucleare. January 2002
5. Collaboration Agreement between the European Organization for Nuclear Research and the University of Tokyo. No. K937/IT November 2002. (Including one Addendum)
6. Protocol to the 1993 Co-Operation Agreement between the Government of the Russian Federation and the European Organization for Nuclear Research (CERN) concerning the Further Development of Scientific and Technical Co-Operation in High-Energy Physics and the 1992 Co-Operation Agreement between the Joint Institute of Nuclear Research (JINR) and the European Organization for Nuclear Research (CERN) concerning the Further Development of Scientific and Technical Co-Operation in the Research Projects of CERN and JINR concerning Participation in Phase 1 of the LHC Computing Grid Project. No. P064/LHC July 2003
7. Memorandum on the Swiss Contribution to the LHC Computing Grid Project. October 2003
8. Collaboration Agreement between the European Organization for Nuclear Research and the Computing Centre, Academia Sinica, Taipei. No. K941/IT March 2003
9. Memorandum of Understanding for the UK contribution towards funding for the LHC Computing Grid Phase 1. January 2003

Annex 11. Template Software License

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