CERN-C-RRB-2005-01/Rev.
16 November 2005

Memorandum of Understanding

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

between

The EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH ("CERN"), an intergovernmental Organization having its seat at Geneva, Switzerland, as the Host Laboratory of the Worldwide LHC Computing Grid, 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 Worldwide 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 Worldwide 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 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-intensive 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 Worldwide LHC Computing Grid is made through the conclusion of this Memorandum of Understanding ("MoU"), which defines the Worldwide 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 Worldwide 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 reports regularly 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 Worldwide LHC Computing Grid (hereinafter "WLCG") 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 Worldwide LHC Computing Grid Collaboration (hereinafter "WLCG 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 WLCG Collaboration. For each Member, Annex 1 and Annex 2 show the duly authorised representative to the WLCG Collaboration. WLCG 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 WLCG or expose resources to it, without themselves being WLCG 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 WLCG Collaboration shall give access to the necessary software and to the WLCG itself, for purposes related to the execution of the LHC Experiments. In order to ensure the smooth functioning of the WLCG for its users, such access will be subject to written acceptance of such conditions as the WLCG 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 WLCG.

Article 2 : Purpose of this MoU

2.1 This MoU governs deployment and exploitation of the WLCG. 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 WLCG Collaboration and defines the status of staff working for a Member of the WLCG 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 WLCG 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 WLCG Collaboration shall secure the necessary funding and shall accept this MoU and any related agreement that is in place between the Members of the WLCG Collaboration and is disclosed to it. Such joining shall be negotiated by the management of the WLCG Collaboration and shall be subject to approval by the C-RRB. In order to (continue to) qualify for membership of the WLCG 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 WLCG Collaboration they are indistinguishable in all respects from single sites.

3.4 Any Funding Agency may withdraw its support from the WLCG Collaboration by giving not less than eighteen months notice in writing to the management of the WLCG 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 WLCG Collaboration shall be negotiated through CERN and approved by the C-RRB.

3.5 The Institutions are expected to remain Members of the WLCG 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 WLCG Collaboration in accordance with the procedures agreed by the WLCG 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 WLCG and LHC Experiment data of which it has the unique copy (or unique permanent backup copy), make alternative storage arrangements with other WLCG Collaboration Members and shall move the data to them. Such moving of data shall be negotiated with the managements of the WLCG 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 WLCG Collaboration shall, before closing access to any Grid Operations services that it has been providing, cooperate actively with the management of the WLCG Collaboration (which has final responsibility for ensuring continuity for these services) to make alternative arrangements.

Article 4: The Aims and Organisation of the WLCG Collaboration

4.1 The organizational structure of the WLCG 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 WLCG 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 WLCG, 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 availability[1].
- 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 WLCG 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 WLCG 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 WLCG. 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 WLCG 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 WLCG Collaboration. At any given time there will be several alternative environments on offer but the WLCG 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 WLCG 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 WLCG 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 LHC Experiments it supports and/or to the WLCG Collaboration management for sharing amongst the LHC Experiments as it sees fit.

[1] (time running)/(scheduled up-time)

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 WLCG 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 WLCG Collaboration.

4.7 In addition, Annex 6.6 shows the resources that Funding Agencies have volunteered to pledge in order to help with LCG deployment at CERN.

4.8 It is a fundamental principle of the WLCG 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.

4.9 Institutions may clearly have computing resources that are earmarked for purposes unrelated to the WLCG and are not pledged to LHC Experiments as Computing Resource Levels. These resources are neither monitored centrally by the management of the WLCG 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 WLCG and Sharing of Responsibilities for its Execution

5.1 Annex 7 gives an overview of the planned WLCG deployment schedule leading to first physics data taking.

5.2 The programme of work for the WLCG deployment, together with the sharing of the workload amongst the Members of the WLCG 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 WLCG Collaboration and the LCG Project, 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 this 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 WLCG 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 WLCG 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 WLCG 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 WLCG 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 WLCG 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 WLCG 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 WLCG 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 WLCG Collaboration contributing (the "Contributors") pre-existing software or having created software in the execution of the WLCG (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 WLCG 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 this 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 WLCG 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 WLCG 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 WLCG 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 to reduce, retain or set-off any obligation under this MoU by invoking 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 WLCG and related computing resources, including their participation in the WLCG Collaboration, 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 and Members of the LHC Experiments) that it has entered into with third parties.

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 WLCG. 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 WLCG 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 Worldwide LHC Computing Grid.

Done in Geneva

on _____

For CERN

_____

Jos Engelen
Chief Scientific Officer

Done in _____

on _____

For

_____

Annex 1. WLCG Tier0 and Tier1 Centres, and the CERN Analysis Facility

Tier0 and the CERN Analysis Facility

Experiments served with priority				*Representative to WLCG Collaboration*
ALICE	*ATLAS*	*CMS*	*LHCb*	
X	X	X	X	W. von Rüden

Tier1

Centre	*Experiments served with priority*				*Representative to WLCG Collaboration*	*Funding Agencies*
	ALICE	*ATLAS*	*CMS*	*LHCb*		
Canada, TRIUMF		X			M. Vetterli	TRIUMF
France, CC-IN2P3	X	X	X	X	F. Malek, (Deputy: F. Hernandez)	IN2P3/DAPNIA
Germany, GridKA	X	X	X	X	K.-P. Mickel	BMBF/FZK
Italy, CNAF	X	X	X	X	M. Mazzucato (Deputy: L. Dell'Agnello)	INFN
Netherlands, NIKHEF/SARA	X	X		X	K. Bos	NIKHEF
Nordic Data Grid Facility (NDGF)	X	X	X		B. Vinter	NDGF
Spain, PIC		X	X	X	M. Delfino (Deputy: G. Merino)	MEC
Taipei, ASGC		X	X		S. Lin	Academia Sinica
UK, RAL	X	X	X	X	J. Gordon	PPARC
USA, BNL		X			US ATLAS (Contact: J. Shank)	DOE/NSF
USA, FNAL			X		US CMS (Contact: L. Bauerdick)	DOE/NSF

Annex 2. WLCG Tier2 Centres and Federations of Centres that together constitute a Tier2 Centre

Institution	*Experiments served with priority*				*Representative to WLCG Collaboration*	*Funding Agencies*
	ALICE	*ATLAS*	*CMS*	*LHCb*		
Australia, University of Melbourne		X			n.n.	AusHEP
China, IHEP, Beijing		X	X		Gang Chen	MoST NSFC
Czech Rep., FZU AS, Prague	X	X			M. Lokajicek	MSMT CR
France, CC-IN2P3 AF	X	X	X	X	F. Malek, (Deputy: F. Hernandez)	IN2P3/DAPNIA
France, French Tier-2 Federation - LAL, Orsay - LPNHE, Paris - DAPNIA, Saclay - Subatech, Nantes - Uni B. Pascal, Clermont-Ferrand - LLR, Plaiseau - IPN, Orsay	X	X	X	X	F. Malek, (Deputy: F. Hernandez)	IN2P3/DAPNIA
Germany, DESY, Hamburg		X			V. Gülzow	BMBF/DESY
Germany, GSI, Darmstadt	X				P. Malzacher	BMBF/GSI
Germany, ATLAS Federation, Munich - MPI für Physik - Ludwig Maximilian Universität - Leibniz Rechenzentrum - Rechenzentrum Garching der MPG		X			S. Bethke	MPG
Germany, CMS Federation - DESY, Hamburg - RWTH, Aachen			X		V. Gülzow	BMBF/DESY
India, TIFR, Mumbai			X		A. Gurtu	DAE
India, VECC/SINP, Kolkata	X				Y.P. Viyogi	DAE
Italy, INFN Tier-2 Federation	X	X	X	X	P. Capiluppi	INFN
Japan, ICEPP, Tokyo		X			H. Sakamoto	University of Tokyo
Pakistan, Pakistan Tier-2 Federation - NCP - PAEC			X		H. Hoorani	PAEC/NCP
Poland, Polish Tier-2 Federation - Krakow - Warszawa	X	X	X	X	R. Gokieli, Warszawa	Ministry of Science & Information

Institution	*Experiments served with priority*				*Representative to WLCG Collaboration*	*Funding Agencies*
	ALICE	*ATLAS*	*CMS*	*LHCb*		
Romania, Romanian Tier-2 Federation - NIPNE - PUB - ISS - ICI - ITIM	X	X			M. Dulea, NIPNE	National Authority for Scientific Research
Russian Fed., Russian Data-Intensive GRID (RDIG)[1]	X	X	X	X	V. Ilyin	Agency for Science and Innovation/JINR
Spain, ATLAS Federation - IFAE, Barcelona - IFIC, Valencia - UAM, Madrid		X			J. Salt (alt: A. Pacheco Pages, J. del Peso)	MEC
Spain, CMS Federation - CIEMAT, Madrid - IFCA, Santander			X		F. Matorras (alt: N. Colino)	MEC
Spain, LHCb Federation - UB, Barcelona - USC, Santiago				X	R. Graziani Diaz (alt: J.J. Saborido Silva)	MEC
Switzerland, CSCS		X	X	X	M-C. Sawley (alt.: C. Grab)	CHIPP
Taipei, Taiwan Analysis Facility Federation - Academia Sinica - National Taiwan University - National Central University		X	X		S. Lin	Academia Sinica
UK, Grid London [2] - Brunel - ICL - QMUL - RHUL - UCL	X	X	X	X	D. Colling, ICL	PPARC

[1] The Russian (distributed/advanced) Tier2 Cluster

[2] Within the UK there is an agreement for each Tier2 to support the four main WLCG Virtual Organisations (VO's). In the above table this shows as an "X" against each experiment. In practice not all sites within a UK Tier2 will support all VO's and the impact of scheduling at those sites that do support all LHC experiments will need to be considered in estimating available resources.

Institution	*Experiments served with priority*				*Representative to WLCG Collaboration*	*Funding Agencies*
	ALICE	*ATLAS*	*CMS*	*LHCb*		
UK, NorthGrid [2] - Daresbury Lab. - Lancaster - Liverpool - Manchester - Sheffield	X	X	X	X	R. Jones, Lancaster	PPARC
UK, ScotGrid [2] - Durham - Edinburgh - Glasgow	X	X	X	X	N. Glover, Durham	PPARC
UK, SouthGrid [2] - Birmingham - Bristol - Cambridge - Oxford - RAL - Sussex - Swansea - Warwick	X	X	X	X	J. Tseng, Oxford	PPARC
USA, Boston/Harvard ATLAS T2 - Boston Univ. - Harvard Univ.		X			J. Shank	DOE/NSF
USA, US CMS T2 Federation - Univ. of California, San Diego - Caltech - Univ. of Florida - MIT - Univ. of Nebraska, Lincoln - Purdue Univ. - Univ. of Wisconsin, Madison			X		L. Bauerdick	DOE/NSF
USA, Midwest ATLAS T2 - Univ. of Chicago - Indiana Univ.		X			J. Shank	DOE/NSF
USA, Southwest ATLAS T2 - Langston University - Univ. of New Mexico - Oklahoma Univ. - Univ. of Texas, Arlington		X			J. Shank	DOE/NSF

Annex 3. Minimal Computing Resource and Service Levels to qualify for membership of the WLCG 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 WLCG Collaboration. All centres shall provide & support the Grid services, and associated software, as requested by the experiments and agreed by the WLCG 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 standard[1] 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. They will be reviewed by the operational boards of the WLCG Collaboration.

Service	***Maximum delay in responding to operational problems***			***Average availability[2] measured on an annual basis***	
	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[3] – prime service hours[4]	1 hour	1 hour	4 hours	98%	98%
All other services – outwith prime service hours	12 hours	24 hours	48 hours	97%	97%

[1] The standard supported desktop systems are agreed periodically between CERN and its user community.

[2] (time running)/(scheduled up-time)

[3] Services essential to the running of the Centre and to those who are using it.

[4] 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 Centre[5] 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 WLCG;
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 WLCG 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.

[5] 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. They will be reviewed by the operational boards of the WLCG Collaboration.

Service	*Maximum delay in responding to operational problems*			*Average availability measured on an annual basis*	
	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 – prime service hours[6]	2 hour	2 hour	4 hours	98%	98%
All other services – outwith prime service hours	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 WLCG and by named AF's as defined in paragraph 1.4 of this MoU;
iii. operation of an end-user analysis facility;

[6] 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.

iv. provision of other services, e.g. simulation, according to agreed Experiment requirements;

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. They will be reviewed by the operational boards of the WLCG Collaboration.

Service	*Maximum delay in responding to operational problems*		*Average availability[2] measured on an annual basis*
	Prime time	*Other periods*	
End-user analysis facility	2 hours	72 hours	95%
Other services	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 (September 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 WLCG 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 WLCG 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
Czech Rep.	MSMT CR	P. Krenek, M. Lokajicek
Denmark	National Science Research Council	J.D. Hansen
Finland	HIP	D.O. Riska
France	CEA/DAPNIA	J. Zinn Justin, J. Ernwein
France	IN2P3	F. Le Diberder, F. Étienne
Germany	BMBF	J. Richter
Germany	FZK	K.P. Mickel
Germany	DESY	V. Gülzow
Germany	GSI	P. Malzacher
Germany	MPG	S. Bethke
Italy	INFN	U. Dosselli
The Netherlands	NIKHEF	F. Linde, A.J. Van Rijn
Norway	NRC	B. Jacobsen
Poland	Ministry of Science & Information	J. Królikowski, M. Turala
Spain	MEC	D. Espriu, N. Colino
Sweden	Research Council	A.C. Lagerkvist
Switzerland	CHIPP	A. Clark
United Kingdom	PPARC	R. Wade, J. Seed

Non-Member States

Country	Funding Agency	Represented by
Australia	AusHEP	n.n.
Canada	TRIUMF	R. Orr
China	MoST NSFC	Hesheng Chen
India	DAE	C.V. Ananda Bose, P.S. Dhekne
Japan	Univ. Tokyo	H. Uchiyama, S. Terakado, T. Kawamoto (alternate)
JINR, Dubna	JINR	A.N. Sissakian
Pakistan	PAEC/NCP	M. Ahmad, H. Hoorani
Romania	Natl. Authority for Scientific Research	A. Anton, N.V. Zamfir
Russia	Agency for Science & Innovation	Yu.F. Kozlov, V.I. Savrin
Taipei	Academia Sinica	O. Tzeng, S.C. Lin
USA	DOE	J. O'Fallon, S. Gonzalez (alternate)
USA	NSF	J. Lightbody, J. Whitmore (alternate)

Annex 5. The WLCG Collaboration

Annex 5.1. The Organizational Structure of the WLCG Collaboration

1. High-level Committees:

   1.1. Concerning its main technical directions, the WLCG Collaboration shall be governed by the **WLCG Collaboration Board** (CB). The CB shall be composed of a representative of each Institution or federation of Institutions that is a Member of the WLCG 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 without voting rights. 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 WLCG Collaboration and of this MoU in particular. It also acts as a clearing-house for conflicts that may arise within the WLCG 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 WLCG Collaboration operates or on specialist aspects within their areas of expertise.

2. The **WLCG Management Board** (MB) supervises the work of the WLCG Collaboration. It is chaired by the LCG Project Leader and reports to the OB. The MB organises the work of the WLCG 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 WLCG 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-0 and 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 WLCG 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 WLCG. 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 WLCG 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 WLCG 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 WLCG 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 WLCG Management and CERN Management, without voting rights.

6. The **LCG Project Leader** represents the WLCG 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.

7. The CB shall ensure, through the establishment of appropriate sub-committees, that **publications, presentations and press releases** made in the name of the WLCG Collaboration conform to such standards, in particular standards regarding fair representation of the technical contributions of the Members of the Collaboration, as it may determine or that may be prescribed by Protocols in force between Members of the Collaboration.

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 WLCG Institutions. The required quality of these Services is defined in Annex 3. In cases where an Institution has not yet defined planning numbers for some later years, it is understood that the offered Computing Resource and Service Levels in these years will in any event not be less than in the last year for which planning numbers are given.

Annex 6.1. Tier0 Computing Capacities

CERN Tier0	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	2400	4800	12500	15900	26200	
Disk (Tbytes)	230	450	1300	1300	1800	
Tape (Tbytes)	1500	3400	13600	23600	33900	
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)	2600	5100	10000	14600	15000	
Disk (Tbytes)	850	1700	4200	5200	5300	
Tape (Tbytes)		1500	3400	5700	5900	

Annex 6.3. Tier1 Computing Capacities

TRIUMF, Canada	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	600	316	1060	1900		
Disk (Tbytes)	110	220	620	920		
Tape (Tbytes)	120	120	400	740		
Nominal WAN (Mbits/sec)			10000	10000	10000	

CC-IN2P3, France	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1170	2670	6770	10500	17300	
Disk (Tbytes)	520	1600	3800	5400	8400	
Tape (Tbytes)	535	1450	3460	6380	9900	
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

GridKA, Germany	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1030	2010	7140	11500	17400	
Disk (Tbytes)	280	910	3300	5200	8100	
Tape (Tbytes)	393	1050	3470	7510	11800	
Nominal WAN (Mbits/sec)	10000	10000	20000	20000	20000	

CNAF, Italy	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1800	2400	5500	8000	11500	
Disk (Tbytes)	850	1200	2500	4000	5800	
Tape (Tbytes)	850	1000	2100	4100	6000	
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)	306	1680	4380	7540	12300	
Disk (Tbytes)	170	1100	2500	3800	6100	
Tape (Tbytes)	143	719	1810	3550	5740	
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

Nordic Data Grid Facility	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	567	1940	3960	5570	7730	
Disk (Tbytes)	170	590	1400	2100	3200	Includes pledges of CPU and Disk for TOTEM.
Tape (Tbytes)	240	435	1070	1500	2260	
Nominal WAN (Mbits/sec)	2000	5000	10000	20000	20000	

PIC, Spain	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	250	749	2250	3370	5050	
Disk (Tbytes)	140	410	1200	1800	2800	
Tape (Tbytes)	158	474	1420	2130	3200	
Nominal WAN (Mbits/sec)	1000	2500	10000	10000	10000	

ASGC, Taipei	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	950	1770	3400	3600		
Disk (Tbytes)	400	900	1500	2400		
Tape (Tbytes)	500	800	1300	2000		
Nominal WAN (Mbits/sec)	4800	10000	10000	10000		

RAL, UK	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	980	1490	2710	4210	5860	
Disk (Tbytes)	450	840	1500	2100	3000	
Tape (Tbytes)	664	1080	2070	3930	5710	
Nominal WAN (Mbits/sec)	2500	10000	10000	10000	10000	

BNL, US	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1120	2560	5300	9520	16300	
Disk (Tbytes)	520	1100	3100	4600	8400	
Tape (Tbytes)	300	603	2020	3710	6180	
Nominal WAN (Mbits/sec)	2490	9950	19900	29900	39800	

FNAL, US	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	728	1790	4260			
Disk (Tbytes)	100	700	2000			
Tape (Tbytes)	250	300	3220			
Nominal WAN (Mbits/sec)						

Annex 6.4. Tier2 Computing Capacities

Australia, University of Melbourne	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	60	150	300	500	700	
Disk (Tbytes)	10	200	300	400	500	
Nominal WAN (Mbits/sec)						

China, IHEP, Beijing	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	100	500	1400	1400	2000	
Disk (Tbytes)	20	50	400	400	600	
Nominal WAN (Mbits/sec)						

Czech Rep., FZU AS, Prague	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	300	400	1900	2900		
Disk (Tbytes)	70	200	900	1400		
Nominal WAN (Mbits/sec)						

France, CC-IN2P3, AF	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	44	1380	3600	5620	9860	
Disk (Tbytes)	7	210	460	730	1100	
Nominal WAN (Mbits/sec)						
Tape (Tbytes)		170	450	660	1000	

France, French Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	340	1470	1620	1620	1620	
Disk (Tbytes)	61	330	340	340	340	
Nominal WAN (Mbits/sec)						

Germany, DESY, Hamburg	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	300	900	900	1200		
Disk (Tbytes)	110	340	340	570		
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

Germany, GSI, Darmstadt	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	100	260	660	860	1100	
Disk (Tbytes)	30	80	200	260	340	
Nominal WAN (Mbits/sec)	100	100	1000	1000	1000	

Germany, ATLAS Federation, Munich	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	60	60	330	530	880	
Disk (Tbytes)	20	27	150	260	430	Only MPI and RZG part of Federation!
Nominal WAN (Mbits/sec)	660	660	1000	1000	1000	

Germany, CMS Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	300	900	900	1400		Only DESY part of Federation!
Disk (Tbytes)	67	200	200	400		
Nominal WAN (Mbits/sec)	10000	10000	10000	10000	10000	

India, TIFR, Mumbai	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	150	300	450	600	800	
Disk (Tbytes)	100	200	300	450	600	
Nominal WAN (Mbits/sec)	34	160	620			

India, VECC/SINP, Kolkata	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	150	300	450	600	600	
Disk (Tbytes)	20	40	60	80	80	
Nominal WAN (Mbits/sec)	20	80	100	160	160	

Italy, INFN Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1500	2500	5000	8000	11000	
Disk (Tbytes)	300	600	1500	2500	3500	
Nominal WAN (Mbits/sec)						

Japan, ICEPP, Tokyo	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	200	1000	1000	1000	1000	
Disk (Tbytes)	40	200	200	200	200	
Nominal WAN (Mbits/sec)	1000	2000	2000	2000	2000	

Pakistan, Pakistan Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	160	410	800	820	870	
Disk (Tbytes)	50	80	200	200	200	
Nominal WAN (Mbits/sec)	5	10	42	42	42	

Poland, Polish Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	600	650	750			
Disk (Tbytes)	32	32	36			
Nominal WAN (Mbits/sec)	1000	1000	2000	2000	2000	

Romania, Romanian Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	300	600	900	1200	1500	
Disk (Tbytes)	20	40	80	120	160	
Nominal WAN (Mbits/sec)	1000	1000	10000	10000	10000	

Russian Federation, RDIG(3)	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	2230	4060	5890	7870	10900	The Russian Capacities are available at the end of the year.
Disk (Tbytes)	780	1500	2400	4100	6200	
Nominal WAN (Mbits/sec)	1000	2500	2500	5000	10000	
Tape (Tbytes)	400	780	1500	2200	3500	

Spain, ATLAS Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	130	240	720	1100	1600	
Disk (Tbytes)	21	91	270	400	610	
Nominal WAN (Mbits/sec)						

Spain, CMS Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	100	410	1000	1800	3300	
Disk (Tbytes)	28	110	280	470	890	
Nominal WAN (Mbits/sec)						

Spain, LHCb Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	33	100	300	500	750	
Disk (Tbytes)	0	0	1	1	2	
Nominal WAN (Mbits/sec)						

Switzerland, CSCS, Manno	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	240	730	2400			
Disk (Tbytes)	90	260	870			
Nominal WAN (Mbits/sec)	1000	1000	10000	10000	10000	

Taipei, Taiwan Analysis Facility Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	200	300	400			
Disk (Tbytes)	15	30	75			
Nominal WAN (Mbits/sec)	2	10	10			

UK, Sum of all Federations	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	3800	3800	4800	5400	6000	
Disk (Tbytes)	530	540	600	660	720	
Nominal WAN (Mbits/sec)						

USA, Boston/Harvard ATLAS T2	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	350	730	1100	1600		
Disk (Tbytes)	170	370	480	630		
Nominal WAN (Mbits/sec)						

USA, CMS Tier-2 Federation	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	1500	3300	7000			
Disk (Tbytes)	250	550	1400			
Nominal WAN (Mbits/sec)	5000	5000	10000			

USA, Midwest ATLAS T2	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	510	900	1100	1300		
Disk (Tbytes)	130	260	460	790		
Nominal WAN (Mbits/sec)						

USA, Southwest ATLAS T2	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
CPU (kSI2K)	900	1500	1700	2100		
Disk (Tbytes)	200	380	540	700		
Nominal WAN (Mbits/sec)						

Annex 6.5. Grid Operations Services

See Annex 3.4 for a description of the services provided.

ASGC, CC-IN2P3, CERN, CNAF, Russian Data-Intensive Grid (RDIG), RAL	
Scope of the service	Grid Operations Centre for sites in the EGEE grid
Period during which the centre operates as the primary management centre	Responsibility cycled around sites on a weekly basis.

Indiana University iGOC (*anticipated, pending development of funding model*)	
Scope of the service	Open Science Grid Operations Centre
Period during which the centre operates as the primary monitoring centre	24 × 7 × 52

BNL, Fermilab	
Scope of the service	US-ATLAS and US-CMS Virtual Organisation Support Centre respectively
Period during which the centre operates as the primary monitoring centre	24 × 7 × 52

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

Annex 6.6. Pledges by Funding Agencies for Common WLCG Resources at CERN

Voluntary additional contributions to LCG deployment at CERN are listed in the following tables. In the case of personnel, the Project management will, in consultation with the Funding Agency concerned, assign clear responsibilities to each individual.

BMBF, Germany	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	3.8	1.7	0.4			
Materials (kCHF)						

DAE, India	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	0.7	1	1			
Materials (kCHF)						

INFN, Italy	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	16.3	16	11.2	8.9	6	
Materials (kCHF)	130	130				

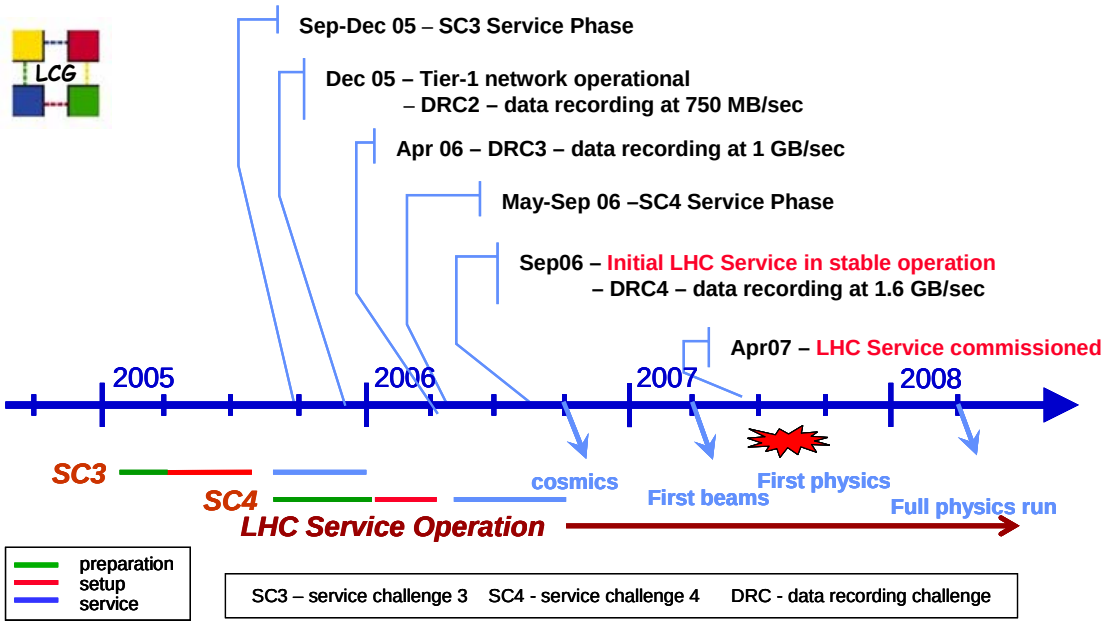
ADI. Portugal	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	3.5	3.5				
Materials (kCHF)						

FASI/JINR	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	3	3	3			
Materials (kCHF)						

ASGC, Taipei	Pledged	Planned to be pledged				Comment
	2006	2007	2008	2009	2010	
Personnel (FTE)	4	4				
Materials (kCHF)						

The actual contributions that are made, as well as any additional contributions that emerge, will be reported *post facto* by the Project management to the C-RRB.

Annex 7. WLCG Deployment Schedule from 2006 to 2008



Annex 8. Programme of Work for the Deployment of the WLCG 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-proton run and 1.85 GBytes/sec during the heavy-ion 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.

The LCG Service Challenges

The LCG Service Challenges are a mechanism by which the readiness of the overall LHC Computing Service to meet the requirements of the experiments is measured and if necessary corrected.

Service Challenges 1 and 2 focussed on building up the necessary data management infrastructure to perform reliable transfers between the Tier-0 and Tier-1 sites as permanent production services with the appropriate throughput. Service challenge 1 involved a core set of Tier-1 sites and proved an important learning experience for providing these services. Service challenge 2 met its throughput goals of 100MBytes/sec per site with a total of 500MBytes/sec sustained out of CERN, but did not yet include experiment-specific software or offline Use Cases.

Service Challenge 3

Service Challenge 3 commenced in July 2005 involving all Tier-1 sites, together with a small number of Tier-2s. It has two phases – a setup phase, during which an initial throughput test was made, followed by a four-month service phase of stable operation during which experiments are committed to carry out tests of their software chains and computing models. A further throughput test is scheduled for late October, following debugging and optimisation of the components involved, as a result of the initial tests in July.

The throughput targets for each Tier-1 are 150 MBytes/sec network-disk, and 60 MBytes/sec network-tape, with CERN capable of supporting 1 GByte/sec for the transfers to disk and 400Mbytes/sec for those to tape at the Tier-1s. Most of the Tier-1 centres are supporting Tier-2 sites for upload of simulated data – some are also performing transfers in the opposite direction, corresponding to download of analysis data.

The service phase of Service Challenge 3 started on 1st September 2005 and includes additional software components, including a grid workload management system, grid catalog, mass storage management services and a reliable file transfer service. The service phase is scheduled to operate for four months from September to December 2005.

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 Tier-1 sites will be involved, together with the majority of the Tier-2s. 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.

As for Service Challenge 3, it consists of both a setup and service phase. 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.

Centre	*ALICE*	*ATLAS*	*CMS*	*LHCb*	*Target Data Rate MBytes/sec*
Canada, TRIUMF		X			50
France, CC-IN2P3	X	X	X	X	200
Germany, GridKA	X	X	X	X	200
Italy, CNAF	X	X	X	X	200
Netherlands, NIKHEF/SARA	X	X		X	150
Nordic Data Grid Facility	X	X	X		50
Spain, PIC Barcelona		X	X	X	100
Taipei, ASGC		X	X		100
UK, RAL	X	X	X	X	150
USA, BNL		X			200
USA, FNAL			X		200
Target data rate at CERN					1,600

Table 1 – 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 1). 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 WLCG 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 WLCG 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. Collaboration Agreement between the European Organization for Nuclear Research and the University of Tokyo. No. K937/IT November 2002. (Including one Addendum)
5. 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
6. Memorandum on the Swiss Contribution to the LHC Computing Grid Project. October 2003
7. Collaboration Agreement between the European Organization for Nuclear Research and the Computing Centre, Academia Sinica, Taipei. No. K941/IT March 2003
8. 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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