LHC Computing Grid Project

Status of Resources and Financial Plan

Computing Resources Review Board – October 2006

1. Introduction

This report contains a few "firsts". The first announcement of a balanced budget for LCG Phase 2 at CERN, the first accounting figures for the WLCG Grid and the first presentation of revised requirements of computing capacity for the LHC experiments. The report will cover these three points plus a summary of the progress towards signing the WLCG MoU.

2. Progress in Signing the WLCG Memorandum of Understanding

The total number of member state Funding Agency having announced to sign the WLCG MoU amounts to 20 for 7 Tier-1 and 22 Tier-2 centres/federations distributed over ~80 sites. Six of these signatures are still lacking including signatures for two of the Tier-1s.

Thirteen non-member state Funding Agencies have announced to sign the WLCG MoU, covering. 4 Tier-1 and 19 Tier-2 centres/federations distributed over ~45 sites. Three of these signatures are still missing.
Table 1 lists the received and lacking signatures.

Table 1: Signature Status of WLCG MoU

Member States

Country	**Funding Agency/Signatory**	**Already Signed (Y/N)**
Belgium	FNRS	Y
Belgium	FWO	Y
Czech Rep.	MSMT CR	N
Denmark	National Science Research Council	Y
Finland	HIP	N
France	CEA/DSM/DAPNIA	Y
France	CNRS/IN2P3	Y
Germany	FZK	Y
Germany	DESY	Y
Germany	GSI	Y
Germany	MPG	Y
Italy	INFN	Y
The Netherlands	NIKHEF	Y
Norway	NRC	N
Poland	Ministry of Science & Education	Y
Portugal	GRICES/LIP	Y
Spain	MEC	N
Sweden	Research Council	N
Switzerland	SER/SNF/ETH/CSCS	N
United Kingdom	PPARC	Y

Non-Member States

Country	Funding Agency/Signatory	Already Signed (Y/N)
Australia	AusHEP	N
Canada	CFI	Y
China	MoST/NSFC	Y
India	DAE	Y
Japan	Univ. Tokyo	Y
JINR, Dubna	JINR	N
Pakistan	PAEC/NCP	Y
Romania	Natl. Authority for Scientific Research	Y
Russia	Federal Agency for Sc. & Innovation	N
Taipei	Academia Sinica	Y
Ukraine	National Academy of Sciences	Y
USA	US-ATLAS	Y
USA	US-CMS	Y

Table 2 lists additional Tier-2s which are not yet included in the current WLCG MoU tables, but plan to join later. Of these I expect signatures from two Brazilian Funding Agencies and from Estonia before the end of the year. Discussions are going on with a number of additional Tier-2 candidates. The number of WLCG sites will continue to grow.

Table 2: Planned Additional Tier2 Centres or Federations

Institution	*Experiments served with priority*			
	ALICE	*ATLAS*	*CMS*	*LHCb*
Austria, UIBK, Innsbruck		X		
Brazil, Brazilian Tier-2 Federation - CBPF - UERJ - UFRJ - UNESP		X	X	X
Canada, Canada East Tier-2 Federation		X		
Canada, Canada West Tier-2 Federation		X		
Estonia, NICPB, Tallinn			X	
Hungary, Hungarian Tier-2 Federation - KFKI, Budapest - SZTAKI, Budapest - Eotvos Univ., Budapest - Debrecen Univ.	X		X	
Israel, HEP-IL Federation - Technion, Haifa - Weizmann, Rehovot - Tel Aviv Univ.		X		
Slovenia, SiGNET Tier-2		X		

3. Funding and Expenditure for LCG Phase 2 at CERN

Table 3 shows the cost and funding estimates for LCG Phase 2 at CERN.

Table 3: LHC Computing Budget Estimates in MCHF

	2005	2006	2007	2008	TOTAL
Funding					
From CERN Budget					
- Personnel	***1.510***	***16.985***	***17.730***	***17.015***	***53.240***
-Physics	***0.000***	***11.925***	***12.195***	***13.970***	***38.090***
- IT		8.410	8.625	10.805	**27.840**
- PH		3.515	3.570	3.165	**10.250**
-Additional	***1.510***	***5.060***	***5.535***	***3.045***	***15.150***
- IT	1.160	3.825	4.260	2.135	**11.380**
- PH	0.350	1.235	1.275	0.910	**3.770**
- Materials	***1.410***	***23.350***	***16.630***	***25.310***	***66.700***
- Physics Operations		***4.950***	***4.860***	***4.860***	***14.670***
- IT		4.540	4.430	4.450	**13.420**
- PH		0.410	0.430	0.410	**1.250**
- Tier 0 and CERN Analysis Facility	1.410	18.400	11.770	20.450	**52.030**
Contributions via Team Accounts*					
- Personnel		1.950	1.860	1.180	**4.990**
- Material		0.845	0.260		**1.105**
In-kind Contributions*					
- Personnel		0.910	0.950	0.120	**1.980**
Total					
- Personnel	**1.510**	**19.845**	**20.540**	**18.315**	**60.210**
- Materials	**1.410**	**24.195**	**16.890**	**25.310**	**67.805**
Total Funding	**2.920**	**44.040**	**37.430**	**43.625**	**128.015**
Planned Expenditure					
- Personnel **	1.510	19.845	20.660	17.660	**59.675**
- Materials	1.410	23.350	17.060	29.060	**70.880**
- Physics Operations		4.950	4.860	4.860	**14.670**
- Tier 0 and CERN Analysis Facility	1.410	18.400	12.200	24.200	**56.210**
Total Planned Expenditure	**2.920**	**43.195**	**37.720**	**46.720**	**130.555**
Balance Personnel	**0.000**	**0.000**	**-0.120**	**0.655**	**0.535**
Balance Materials	**0.000**	**0.845**	**-0.170**	**-3.750**	**-3.075**
Balance	**0.000**	**0.845**	**-0.290**	**-3.095**	**-2.540**

* As pledged and planned to be pledged in the WLCG MoU (Annex 6.6)

** - Personnel from EGEE and EGEE-II at a cost of 2.9 MCHF will participate in LCG at CERN during the years 2006 - 2008
- Operators Support from Computer Centre at a cost of 1.4 MCHF will participate in LCG at CERN during the years 2006 - 2008
These resources are not included in this Table.

The positive personnel balance will be reduced to zero, as this amount will be needed to balance requirements in the years 2008 and 2010. It should also be noted that the personnel planning for LCG Phase 2 at CERN relies on a successor EU project to EGEE II to deliver ~14 FTE to the Grid Deployment activities.. The really positive aspect of this table compared to the figures given to the C-RRB of April 2006 is the massive improvement of the materials balance from a figure of -13.992 MCHF in April to only -3.075 MCHF now. This amount is judged to be small enough to be manageable. The improvement is largely due to the revised requirement figures from the experiments based on the latest information on the LHC ramp-up schedule.

Table 4 shows the materials requirements for Phase 2 at CERN with more detail, showing mainly the costs of the basic infrastructure in comparison to the cost of the computing capacity required by the experiments for the Tier0 and CAF.

Table 4: Costs and Funding for Physics Computing Materials at CERN in MCHF

Funding	**2005**	**2006**	**2007**	**2008**	**TOTAL**
From CERN Budget					
- *Materials*		*23.35*	*16.63*	*25.31*	***66.69***
- Physics Operations		4.95	4.86	4.86	**14.67**
- Tier0 and CERN Analysis Facility	1.41	18.40	11.77	20.45	**52.02**
Contributions via Team Accounts					
- *Materials*		*0.85*	*0.26*		***1.11***
Total Materials Funding	**1.41**	**24.20**	**16.89**	**25.31**	**67.80**

Planned Expenditure	**2005**	**2006**	**2007**	**2008**	**TOTAL**
- *Physics Operations*		*4.95*	*4.86*	*4.86*	***14.67***
- *Tier0 and CERN Analysis Facility*	*1.41*	*18.40*	*12.20*	*24.20*	***56.21***
- Basic Infrastructure		7.46	6.08	5.70	**19.24**
- Tier0	1.41	9.56	4.25	8.80	**24.02**
- CERN Analysis Facility		1.38	1.87	9.70	**12.95**
Total Materials Expenditure	**1.41**	**23.35**	**17.06**	**29.06**	**70.88**

Balance	**0.00**	**0.85**	**-0.17**	**-3.76**	**-3.08**

4. Resource Usage Accounting for External Tier-1s and CERN

Figure 1 shows CPU time delivered and disk and tape storage used at the external Tier-1s and CERN. Data for the months January to March are not complete. From April onwards the graphs also show the installed capacities and the corresponding WLCG MoU pledges.

Figure 1: Accounting for External Tier-1s and CERN

It is interesting to note that for tape storage centres have more or less purchased and installed the pledged capacities. This is the obvious result of the fact that for CPU and disk prices are still falling regularly whilst not much money can be saved by delaying tape purchases.

To get the full picture of the resources used WLCG jobs submitted via the Grid and submitted locally are both included. Automatic CPU time accounting exists for the EGEE sites and automatic storage accounting for the EGEE sites is at the proposal stage. For now each Tier-1 and CERN submits a monthly accounting summary based on their internal accounting system.

Although the usage of the resources looks low, higher peaks are buried under the monthly mean values. High continuous usage cannot be expected now when the Tier-1s are used primarily for data challenges, testing and commissioning, all of which require sufficient capacity for short times. This situation will continue until the arrival of a steady stream of data from the LHC. In the mean time there is still a need to increase the installed capacity to learn handling the amount of computing equipment required for the years 2008 and onwards.

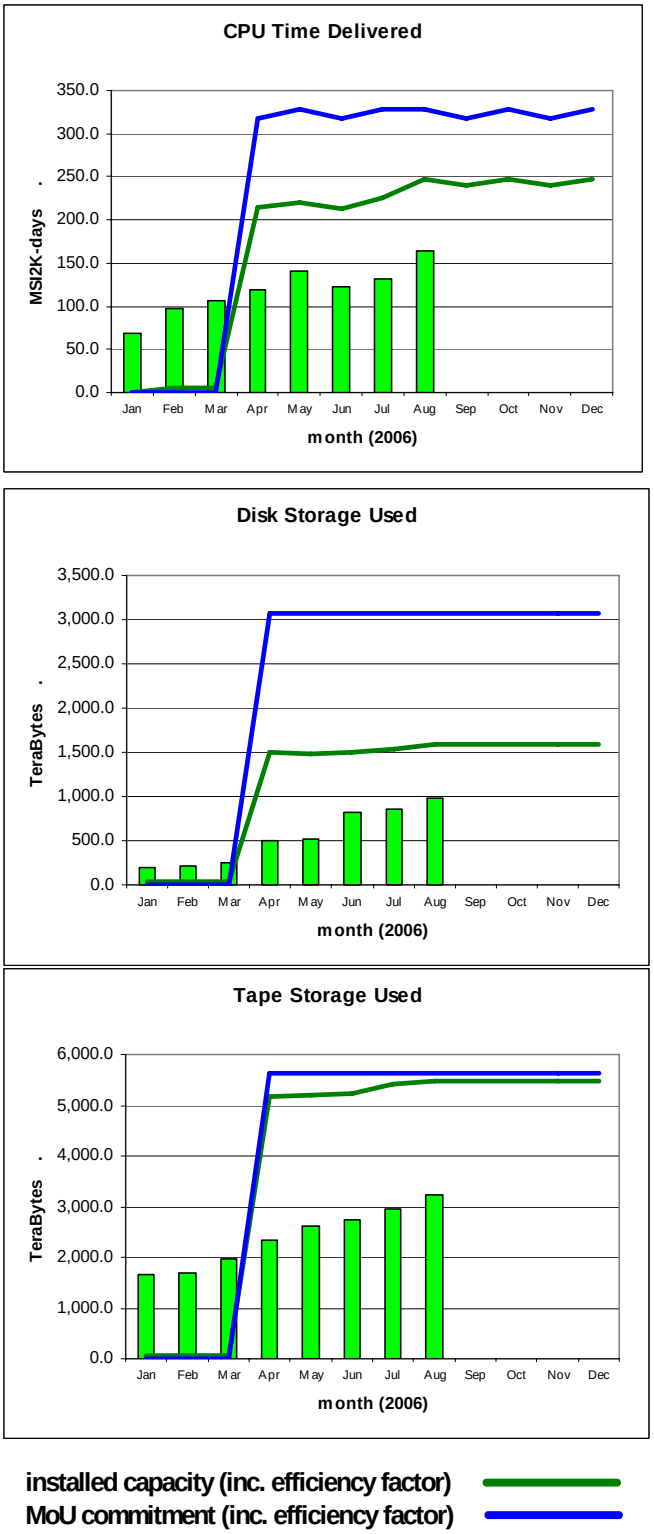

Figure 2 shows the distribution of usage over the external Tier-1s and CERN.

Figure 2: Usage by Site

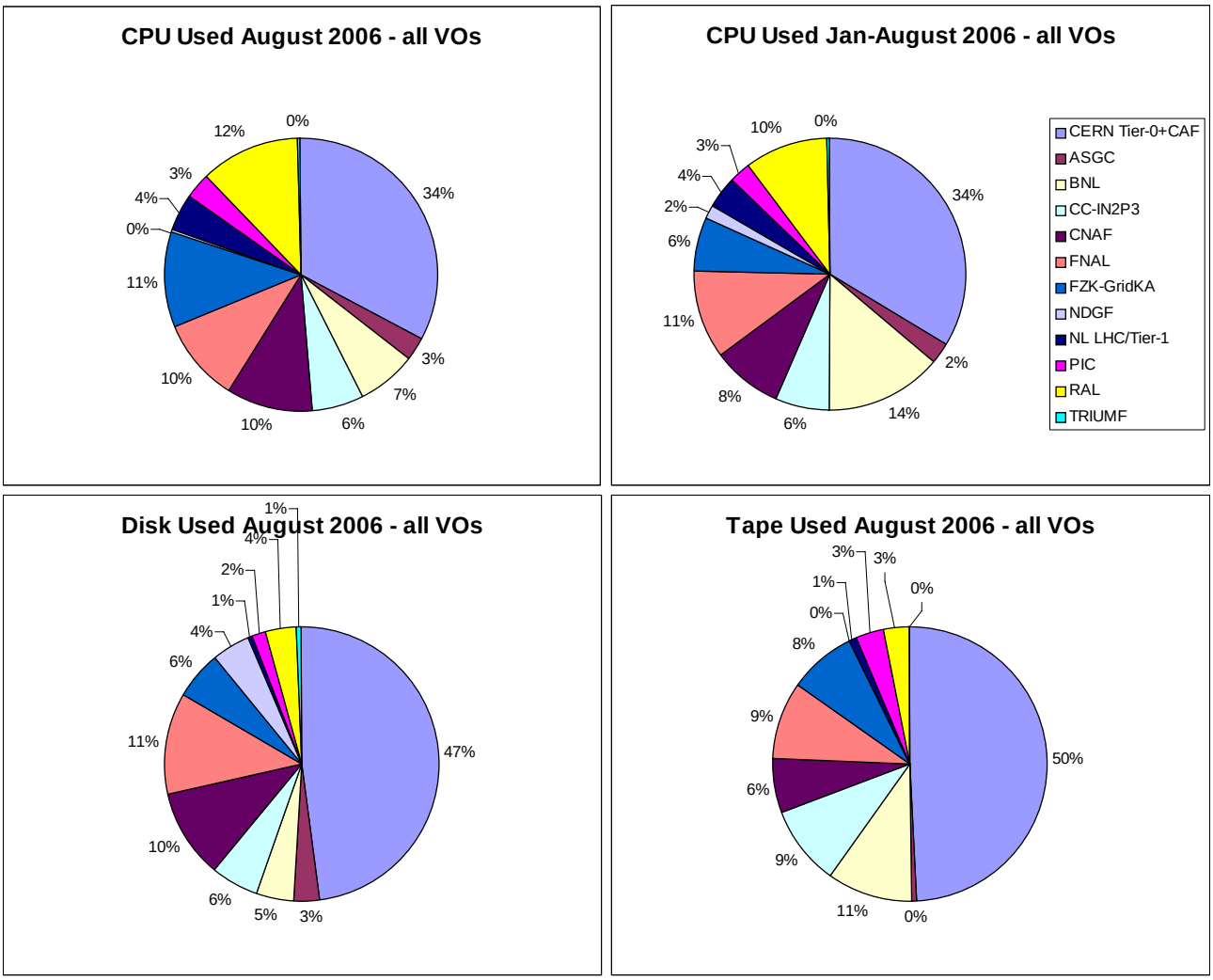

Table 5 gives the detailed usage by site in tabular format.

Table 5: Usage Details by Site

		cpu		*disk occupancy*			*tape occupancy*		
Site Summary	***KSI2K-days***	***% of installed***	***% of pledge***	***TBytes at end of period***	***% of installed***	***% of pledge***	***TBytes at end of period***	***% of installed***	***% of pledge***
CERN Tier-0+CAF	221,631	75%	50%	470	67%	87%	1,586	63%	106%
ASGC	20,791	37%	17%	30	89%	11%	13	4%	3%
BNL	79,897	88%	55%	46	37%	13%	328	78%	109%
CC-IN2P3	41,734	47%	27%	55	89%	15%	298	68%	56%
CNAF	60,821	30%	26%	102	32%	17%	207	41%	24%
FNAL	72,055	62%	76%	120	171%	171%	300	100%	120%
FZK-GridKA	39,714	48%	30%	55	28%	28%	260	66%	66%
NDGF	17,274	33%	23%	44	60%	37%	0	0%	0%
NL LHC/Tier-1	25,545	80%	64%	7	63%	6%	22	44%	15%
PIC	15,702	80%	48%	15	102%	15%	106	92%	67%
RAL	79,521	104%	62%	36	86%	11%	102	40%	15%
TRIUMF	1,768	80%	8%	6	71%	32%	0	0%	0%
Total	**513,114**	**59%**	**40%**	**856**	**56%**	**28%**	**2,952**	**55%**	**52%**

5. The Revised Computing Capacity Requirements

Using the latest planning information for the start-up of the LHC accelerator a new estimate has been made of the time during which the experiments will be taking data during 2007 and 2008. Using this estimate each of the experiments has revised its requirements for computing capacity in 2007-2010. The revised requirements also take account of other new information available to the experiments, including new estimates of event sizes, trigger rates and program performance.

During the early running period significant use can be made of background data to study individual sub-detector characteristics and performance even with low luminosity. The revised requirements are therefore not directly related to the integrated luminosity.

Tables 6 to 8 compare the revised resources required at CERN and the aggregate requirements for Tier-1s and Tier-2s with the current pledges from 2007 to 2010. The pledges used are the current pledge figures from the latest MoU tables except for the CERN Tier0 and CAF, where new pledge figures are used. The new CERN pledges show that we plan to be able to fulfil the requirements of the experiments until 2009, but foresee a 30% shortfall in 2010.

For the Tier1s and Tier2s the tables show surplus capacity in 2007, more or less a balance in 2008 and a lack of resources in 2009 and 2010, which is probably made worse by the fact that a number of centres have not yet given pledge figures for these years and the 2008 figures for these centres are used also in 2009 and 2010.

Table 6: Requirements and Pledges at CERN

CERN Tier0 + CAF	2007	2008	2009	2010
CPU (kSI2K) required	7570	21080	28440	42790
CPU (kSI2K) pledged	7570	21080	28440	29700
Balance	0%	0%	0%	-31%
Disk (Tbytes) required	1290	4150	6930	12590
Disk (Tbytes) pledged	1290	4150	6930	8700
Balance	0%	0%	0%	-31%
Tape (Tbytes) required	2280	10690	23410	41080
Tape (Tbytes) pledged	2280	10690	23410	28000
Balance	0%	0%	0%	-32%

Table 7: Requirements and Pledges at External Tier-1s

Tier1s	2007	2008	2009	2010
CPU (kSI2K) required	13113	42523	68623	116143
CPU (kSI2K) pledged	18424	47735	70568	104944
Balance	40%	12%	3%	-10%
Disk (Tbytes) required	6277	21784	38885	66308
Disk (Tbytes) pledged	9069	24037	35312	53615
Balance	44%	10%	-9%	-19%
Tape (Tbytes) required	6857	28684	55500	92092
Tape (Tbytes) pledged	7997	23621	40267	58880
Balance	17%	-18%	-27%	-36%

Table 8: Requirements and Pledges at External Tier-2s

Tier2s	2007	2008	2009	2010
CPU (kSI2K) required	15926	46874	79923	128885
CPU (kSI2K) pledged	28295	48152	64316	82074
Balance	78%	3%	-20%	-36%
Disk (Tbytes) required	3543	14413	25315	40365
Disk (Tbytes) pledged	6847	12836	19261	25080
Balance	93%	-11%	-24%	-38%

The summary requirements in the tables cover only computational (CPU) and storage capacity, which are a function of the integrated physics beam time. Additional requirements have also been defined in the Memorandum of Understanding, the Computing Technical Design Reports and other documents, including: service level (availability, reliability, response time in the event of a problem), data access within a site, magnetic tape performance, relational database services, data transfer performance between sites, grid operations services. Most of these factors have not changed, and in particular the full data performance will have to be handled whenever the accelerator is running. The total cost at each site is therefore not linearly related to the CPU and storage requirements, with each site making a substantial investment in their basic infrastructure (see Table 4 for CERN).

At the time of the last C-RRB the capacity planned to be available at computing centres did not fulfil the requirements of the experiments. The reductions in the revised requirements have largely eliminated this shortfall and ensure that the computing systems will be ready to enable the physicists to take advantage of the full potential of the LHC machine and detectors.