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LARGE HADRON COLLIDER COMMITTEE

Review of Computing Technical Design Reports CMS

November 2005

Executive Summary

The LHC experiments and the LCG are assembling the computing infrastructure required to process the large amount of data expected in the years 2007-2010 and beyond. Each experiment has prepared a Computing Technical Design Report (TDR) for review by the LHCC. These Computing TDRs outline the requirements for the basic infrastructure that will be needed for LHC computing during the first few years of data taking. These computing models will most likely evolve over time as the detectors are commissioned and data analysis begins.

The review committee felt that the TDR documents from the experiments contained the conceptual designs of the computing systems. Technology is evolving rapidly, and while the overall goals are clearly defined, in many instances, choices of specific technology remain. In part, this is due to the pressure to delay decisions to be able to take advantage of technical advances and falling prices. In addition, the distributed computing model using the GRID is still undergoing intensive testing and commissioning.

The committee stresses that these computing models remain essentially untested. Some components were exercised during the data challenges and the recent service challenges. Other critical elements will be tested in the coming year. The lack of testing under battle conditions is particularly true for the distributed analysis portion of the models. The Tier-0 planning is the most advanced and the planned Tier-0 resource seemed well matched to the needs of the experiments.

The ongoing program of Service Challenges (SCs) forms the core of the conditioning tests for the Worldwide LHC Computing Grid (WLCG). SC-3 was underway at the time of the review. A list of the required WLCG baseline services and associated milestones has been established. Much work remains to be done to build and commission this global system of computers and have them operating 24 x 7. The committee applauds all the work that has been accomplished through the data challenges and the service challenges, but cautions that there are still very significant milestones to be met during the coming year.

The experiments have not yet fully determined their plans for alignment and calibration. The committee recommends that the experiments develop their calibration and alignment strategies as soon as possible - including the use of the CAF at CERN and the Tier-1 and Tier-2 centres. These plans should be developed in collaboration with the (W)LCG.

Large-scale data analysis tests are scheduled for the coming year that will use the WLCG baseline grid services. By September 2006, the major components of the computing systems will have been tested and the production system should be in operation. This is approximately the same timescale for initiating the large computing purchase required for the start of the LHC. The committee urges the computing management to proceed with caution in purchasing computing and to re-evaluate the resource planning regularly so that the computing resources are purchased only when needed. At the same time, we recognize the need to proceed with planned purchases for 2006 so that infrastructure is put in place and the large-scale system tests can advance.

A large quantity of common infrastructure software has been developed for the LHC. Much of this software development was done through external (non-CERN) funding. A plan is needed to support the computing and software infrastructure after the funding for EGEE and other GRID project funding comes to an end. This support plan should be included in the MoU process.

The computing resources at the Tier-1 and Tier-2 centres are identified through the MoU process. This process has already identified a large fraction of the required resources. It is important to keep in mind that there could still be large uncertainties in the resource requirement estimates. Moreover, the overall balance of resources amongst the experiments for resources outside of CERN seems difficult to achieve. There is an estimate of the pledged resources pledged for each experiment. At the time of the October review, ALICE had only identified about 50% of their required computing resources (CPU, disks, tapes). CMS was also lacking the required pledges to meet their resource needs. ATLAS and CMS have differing computing requirements for their Tier-1 sites. The committee finds that these differences are not fundamental but depend primarily on the details of their computing models.

The resource balance amongst the experiments is a major concern and must be resolved to ensure the physics output of all experiments. The current balancing scheme outlined in the MOU that involves descoping recommendation from the LHCC seems unworkable without some means for enforcement.

The review committee supports the first steps of the transition of the LCG organization towards management of the operation of a global LHC "computing centre". The committee feels that the management of this global computing project still needs to be strengthened. Issues of balance of resources and global operations will require a strong organization and management team. We encourage a stronger connection between the computing planning process and the physics goals of the experiments. Therefore, we recommend that a "Computing Coordinator" be appointed to work together with CERN management, the LCG project and the four experiments.

The committee congratulates the collaborations and the LCG for their work presented in the Computing TDRs and recommends approval. More detailed comments and specific recommendations are outlined in the full document.

Introduction

Starting in 2007 the LHC is expected to produce proton-proton collisions at a center of mass energy of 14,000 GeV with an initial luminosity of approximately 2 x $10^{32}cm^{-2}s^{-1}$. The luminosity is expected to rise steadily until it reaches the design luminosity of $10^{34}cm^{-2}s^{-1}$ by 2010. It is expected that the trigger rates will not vary much with luminosity, which implies that the expected amount of data output rate will remain roughly constant.

Table 1 provides a comparison of the event size and trigger rate for the four experiments during p-p collisions. The event size, trigger rate and speed of the reconstruction and simulation codes are the fundamental parameters that are used to calculate the required production capacity. The capacity needed for analysis is more difficult to calculate and depends on the number of users, the number of analysis groups, and access patterns that are strongly analysis dependent. The AOD data will generally be available for analysis, but during commissioning access to the ESD and perhaps even the RAW data is anticipated.

p-p (HI)	**SIMU**	**Sim ESD**	**RAW**	**Trigger Rate**	**RAW Rate**	**RECO**	**AOD**	**TAG**
	MB	**MB**	**MB**	**Hz**	**MB/s**	**kB**	**kB**	**kB**
ALICE (HI)	300	2.1	12.5	100	1250	2500	250	10
ALICE (pp)	0.4	0.040	1.0	100	100	200	50	10
ATLAS (pp)	2	0.5	1.6	200	320	500	100	1
CMS (pp)	2	0.4	1.5	150	225	250	50	10
LHCb (pp)	--	0.4	0.025	2000	50	75	25	1

Table 1: The anticipated event size and raw data rates for the four experiments during proton-proton (pp) collisions at the LHC are presented in the Table. Also included are the estimates for Heavy Ion (HI) collisions at the ALICE experiment. SIMU: Simulated RAW data, RAW: data from the experiment to be recorded in mass storage, RECO (or ESD): output from the reconstruction code, AOD: reduced data format for analysis, TAG: summary for event selection.

There are large uncertainties on the estimates of processing times and how they scale with luminosity. These numbers will only be known when LHC data is available. Reprocessing of datasets primarily occurs at the Tier-1 centres. The experiments have estimated that this reprocessing could happen several times per year. It is anticipated that the number of passes be limited by the manpower available for validation and preparation of production software releases as well as by the overall compute capacity.

Planning for detector calibration and alignment is beginning for each of the experiments. In general, these schemes have not yet been worked out in detail and the impact on processing and reprocessing has not yet been fully evaluated.

The estimates for computing (cpu and disk) resources requirements for the LHC Computing system from 2007 to 2010 are presented in Figure 1 and Figure 2. These estimates include the requirements at CERN (Tier-0 and CAFs), the Tier-1 centres and the Tier-2 centres (or federations). The CPU resources are expected to grow from about 53 MSI2K in 2007 to over 330 MSI2k by 2010. At the moment 11 Tier-1 centres have been identified. The expected disk requirement for the beginning of LHC operations 2007 is about 17 PB. This expands to about 135 PB in 2010. Mass storage (tape) requirements grow from about 14 PB in 2007 to almost 140 PB in 2010.

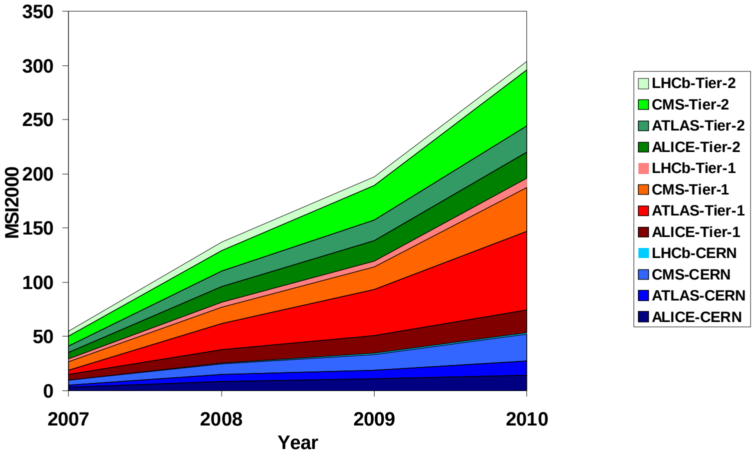

Figure 1 CPU requirements at the Tier-0, Tier-1 and Tier-2 centres for each of the four experiments. The time period is from 2007 to 2010.

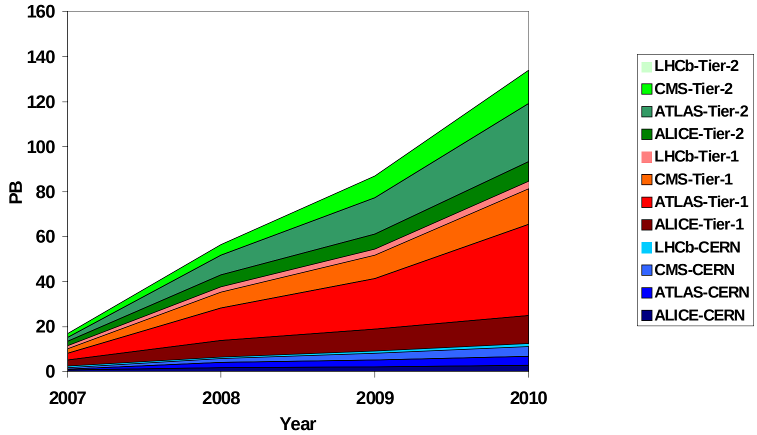

Figure 2 Disk requirements at the Tier-0, Tier-1 and Tier-2 centres for each of the four experiments. The time period is from 2007 to 2010. Note that LHCb plans to use the Tier-2 centres for MC production. Their analysis will primarily done at the Tier-1 centres.

For 2008 the total CPU requirements are 83 MSI2K and the disk requirements call for a total of 31 PB of disk at all centres. The exact amounts, of course, depend on the details of the LHC commissioning and run plan. More information on 2007- 2008 physics and calibration plans will be available during the coming year.

The Computing-Resource Review Board (C-RRB) has begun reviewing detailed MoUs regarding level of service and capacity at the Tier-1 and Tier-2 centres. The pledges collected at the time of the October meeting are presented in Table 2. While the overall level of the pledged resources for cpu, disk and tape at the centres was within about 20-30% at the time of this report, some experiments appear to have significant deficits in their identified resources at the Tier-1 and Tier-2 centres.

Tier-1 Planning for 2008		ALICE	ATLAS	CMS	LHCb	SUM 2008
CPU - MSI2K	**Offered**	6.7	22.7	12.5	4.4	46.3
	TDR Requirements	12.3	24.0	15.2	4.4	55.9
	Balance	**-46%**	**-5%**	**-18%**	**-0%**	**-17%**
Disk - PBytes	**Offered**	2.8	12.5	5.7	2.2	23.2
	TDR Requirements	7.4	14.4	7.0	2.4	31.2
	Balance	**-62%**	**-13%**	**-18%**	**-10%**	**-25%**
Tape - PBytes	**Offered**	3.2	9.1	8.1	1.9	22.3
	TDR Requirements	6.9	9.0	16.7	2.1	34.7
	Balance	**-54%**	**1%**	**-51%**	**-9%**	**-36%**

Includes current planning for all Tier-1 centres

Tier-2 Planning for 2008		ALICE	ATLAS	CMS	LHCb	SUM 2008
CPU - MSI2K	**Offered**	5.0	19.5	17.4	4.4	46.3
	TDR Requirements	14.4	19.9	19.3	7.7	61.3
	Balance	**-65%**	**-2%**	**-10%**	**-42%**	**-24%**
Disk - PBytes	**Offered**	1.4	5.9	4.5	0.8	12.6
	TDR Requirements	5.1	8.7	4.9	0.023	18.723
	Balance	**-72%**	**-33%**	**-8%**	**n/a**	**-33%**
# Tier-2 federations - included(expected)		12 (13)	20 (28)	17 (19)	11 (12)	28 (37)

Table 2 contains the Computing Resource Planning for 2008 from October 2005. This table was complied at the time of the October 2005 review and includes 28 Tier-2 centres or federations and all Tier-1 centres.

The Computing TDR Review Process

In early 2005 the LHCC reviewed the Computing Models of the four LHC experiments and released a report[i] containing an evaluation of the plans for data management and computing at the LHC. At that time, each of the four LHC experiments had produced estimates of their anticipated computing capacity requirements in terms of disks, tapes, CPUs and networks for the Tier-0, Tier-1 and Tier-2 centers. These numbers were documented in their Computing Model documents (ALICE[ii], ATLAS[iii], CMS[iv], LHCb[v]) that were submitted to the LHCC in mid-December 2004 and reviewed in January 2005.

The review committee found that "*aside from issues of peak capacity, … the computing models presented are robust enough to handle the demands of LHC production computing during early running (through 2010.) There remains a concern about the validity of the data analysis components of the models.*" The committee did not consider costs in their evaluation, so there was not a comprehensive analysis of the scope of the computing requirements, except to say they should be sufficient to address the production requirements.

The four experiments and the LCG Collaboration submitted Technical Design Reports documents for the Computing Projects in June 2005 - ALICE[vi], ATLAS[vii], CMS[viii], LHCb[ix], LCG[x]. The LHCC received these materials and listened to a series of presentations from each of the four experiments and the LCG at the June 2005 LHCC meeting. The committee invited four external referees, one per experiment, to review the documents along with the LHCC members. In addition to the external referee, LHCC members helped to evaluate the Computing TDR of their "home" experiment. The LHCC LCG referees read and made comments on the TDR for the LCG.

The referees produced a set of questions concerning the individual TDRs. On October 7-8, 2005 the referees met together at CERN. During this two-day meeting, the leaders of the computing projects in the experiments and the LCG project were asked to supply answers to these sets of questions for the reviewers. All external referees and many LHCC members attended these sessions, which covered all five TDRs. The committee met in closed session on October 8 for discussions. This document contains a summary of these discussions and from the follow-up discussions at the October LHCC meeting. In addition to these general comments, specific comments and recommendations for each of the five TDRs are also given in this report.

The committee was impressed by the outline towards building global computing models that was outlined in the TDRs, but found that the documents contained conceptual designs or status reports rather than technical designs as in the case of the detector TDRs.

General Comments

The committee felt that the TDR documents from the experiments contained the conceptual designs of the computing systems. Technology is evolving rapidly, and while the overall goals are clear, in many instances, the technology choices have not yet been made. In part, this is due to the pressure to delay decisions to be able to take advantage of technical advances and falling prices. In addition, the distributed computing models using the GRID are still undergoing intensive testing and commissioning.

The committee stresses that the computing models remain essentially untested. Some of the components have been exercised during the experiments' data challenges and the recent service challenges. The agreement on the grid baseline service has been a good step toward global interoperability and much of this infrastructure will be tested within the upcoming year.

Testing under battle conditions – many users, chaotic access patterns - is a particular challenge before data taking begins. The distributed analysis portion of the computing models remains the least well tested. The outcome of these exercises could have an impact on Tier-1 and Tier-2 resources requirements.

Tier-0 planning is the most advanced and the resource requirements seemed well matched to the needs of the experiments.

The ongoing program of Service Challenges (SCs) forms the core of the conditioning and testing for the WLCG baseline services. SC-3 was underway though one month behind schedule at the time of the review. A list of required WLCG baseline services and associated milestones has been established and will be reviewed before SC-4. Much work remains to be done to build and commission this global system of computers and have them operating 24 x 7.

The committee applauds the work that has been done on the service challenges, but cautions that there are still significant milestones to be met in the coming year.

A CERN Analysis Facilities (CAF) is now foreseen for all experiments. The committee believes that these facilities are critical for commissioning and early calibration/alignment studies. In general, their usage should be defined better by the collaborations. The committee fears that the user community will migrate their analysis to these facilities rather than distribute their analysis to the Tier-1 or Tier-2 sites. This could create difficulties since the CERN and the CERN computing centre will not be able to house the computing power needed to accommodate this large user community.

The experiments still need to address their calibration and alignment schemes and the impact on computing resources and processing scenarios. The committee has several concerns: the CAF may be heavily loaded with analysis jobs from many users if not properly managed, and the Tier-2 centres may not be prepared to offer 24x7 coverage that may be required for these time critical tasks.

The committee recommends that the experiments develop their calibration and alignment strategies as soon as possible - including the use of the CAF at CERN and the Tier-1 and Tier-2 centres. These plans should be developed with close communication with the (W)LCG.

Large-scale data analysis tests are also scheduled for the coming year that will use the WLCG baseline grid services. By September 2006, the major components of the computing systems will have been tested and the production system should be in operation. It should be the right time to initiate large computing purchases that will put the required resources in place for the start of the LHC.

The committee urges the computing management to proceed with caution and to re-evaluate the resource planning regularly so that most computing resources are purchased only when needed. At the same time, we recognize the need to proceed with planned purchases for 2006 so that infrastructure is put in place and the large-scale system tests can advance.

A large body of software has been developed for the LHC by the LCG and by EGEE, OSG and other software collaborations and GRID projects. This software comes in many flavors. It could be middleware, an application, or an analysis tools. Many of these software products have become critical components of the infrastructure for the LHC computing systems.

A plan is needed to support the computing and software infrastructure after the funding for EGEE and other GRID project funding comes to an end. This support plan should be included in the MoU process.

Funding agencies and institutes from many parts of the globe are contributing to the LHC computing effort. There are 11 Tier-1 sites and more than 28 Tier-2 identified and many of these sites will provide services for more than one experiment. Overall, the promised resources seem reasonable.

The WLCG is a collaboration of institutes that are committed to providing LHC computing based on grid technologies. The true spirit of grid is “experiment blind”, and if this were indeed true, there would be little concern regarding balance of resources amongst the experiments. Institutions and funding agencies, however, often prefer to support local interests when assigning resources and it seems doubtful that this will change. According to the Computing MOU, it is proposed that the C-RRB and the Resource Scrutiny Group (RSG) determine the availability of global computing resources. If these available resources are not sufficient, the LHCC will then be consulted to recommend the proper balance.

Overall balance of resources amongst the experiments for resources outside of CERN will be difficult to achieve. An estimate of the missing resources for each experiment was been made. At the time of the October review, ALICE could not identify approximately 50% of their required computing resources (CPU, disks, tapes) in the Tier-1 centres.

ATLAS and CMS have similar resource requirements at the Tier-0, however they have significantly different computing needs at their Tier-1 sites. The committee finds that this imbalance is not fundamental – meaning it does not originate from detector or physics effects, but that the differences depend mainly on the details of the computing model. One should note that there could still be large uncertainties in these resource numbers.

The resource balance issues are a major concern and must be resolved to ensure the physics output of all experiments. The current balancing scheme outlined in the MOU that involves descoping recommendation from the LHCC seems unworkable without some means for enforcement.

The role and mission of the LCG must refocus as LHC operations approaches. LHC computing depends on the success of the GRID and funding agencies (and other scientists) from all over the world are monitoring the HEP commitment to GRID computing. The LCG must have a strong commitment to operating large scale distributed computing on the grid.

The LCG can no longer be seen as a development or a deployment project. The LCG needs to become an organization focused on the operation of a global service. The review committee supports the first steps of the transition of the LCG towards a global LHC “computing centre”. Daily management of WLCG service and operations remains a concern. It is not clear to us how conflicts will be managed and priorities will be established.

The committee feels that the management of this global computing project needs to be strengthened. Issues of balance of resources and global operations will require a strong organization and management team and this team has to operate on a global scale as well as be responsive to the physics goals of the experiments.

We encourage a stronger connection between the computing plans and to the physics goals of the experiments in the management. Therefore, we recommend that a "Computing Coordinator" be appointed to work together with CERN management, the LCG project and the four experiments

General Conclusions

The committee expresses its congratulations to the collaborations and the LCG for their Computing Technical Design reports. These documents form the foundation for the data production and physics analysis facilities and infrastructure at the LHC. While many of the concepts have been tested and validated, much remains to be done put achieve a distributed analysis structure based on GRID tools that can be used by a large number of LHC physicists. We advise a follow-up review of LHC Computing in Fall 2006. This could be done at the time of the LCG Comprehensive Review.

The committee finds that the Computing TDRs provide the necessary foundation for planning for data production and analysis. At this time, however, these models remain essentially untested. There remains a particular concern about the validity of the data analysis components of the models and recommends a follow-up review in Fall 2006.

Comments and Recommendations for CMS

The computing system of the CMS experiment at the LHC is based on a distributed model, which foresees the use of Grid resources, services and toolkits. CMS prepared a TDR which provides a top-level description of the organization of the CMS Offline Computing System. This document presents in detail the motivations behind the baseline Computing Model, describes the use of tiered computing centres and services required, shows the formal management plan and the required resources.

The goals of the CMS Computing TDR are: to summarize and refine the CMS Computing Model and elaborate on the data analysis and the role of Tier-n centres; to present the architecture of the CMS computing system; to detail the project organization and technical planning; to form the basis for further internal discussion.

Baseline targets and development strategies are presented. CMS will use Grid resources, services and toolkit as basic building blocks. Prompt reconstruction and data archiving will be performed on the CERN Tier-0, considerable (re-)processing as well as data custody, selection and distribution will be done at remote Tier-1 centres. Analysis and Monte Carlo production will be done at Tier-2 centres. The CMS-CAF (CERN Analysis Facility) will be used for high-priority, short-latency data processing and analysis support.

Data are structured in streamed primary datasets according to their trigger masks, which allows for priority-driven distribution and processing, and data tiers (RAW, RECO, AOD, TAG) in order to optimize sequential data access.

The use of distributed resources and services implies the use of dedicated data management services that locate, store and transfer data in a safe, efficient and accountable manner. Management of large computational tasks, such as re-processing a large set, is performed by using data management services and additional (Grid and CMS) services. The computing TDR gives a high-level description of workload management for tasks specific for the experiment (such as basic data distribution, prompt reconstruction and calibration, data re-processing, offline calibration, Monte Carlo production), as well as Grid tasks (such as job prioritization, monitoring and Grid interoperability).

The details of many of the above services and workflows will be given in the Physics TDR, to be released in spring 2006, together with the detailed description of software components and releases, conditions database, analysis. The Computing TDR presents the guidelines that were followed in putting together the architecture of the baseline computing system. These include: optimization for the most common use case for read access and bulk processing; decoupling parts of the system in order to minimize dependencies; provenance tracking; simplicity.

The Computing TDR presents finally a comprehensive project management plan, which allows tracking the various project deliverables and detecting and eliminating potential bottlenecks. The computing organization is based on projects and programs, in order to keep the overall project well-scoped and institutional responsibilities well defined. There are 4 programs defined (technical, integration, operations, facilities), and a management team is in place, with the purpose of making a paradigm shift towards a working system from end to end. This implies close contact with a number of other computing projects and committees such as

WLCG, EGEE, OSG, CERN-IT, Tier-1 and Tier-2 management teams. Securing the necessary manpower (computing professionals) is a management issue to be addressed.

A computing schedule has been defined, in which the main project phases are outlined and major computing milestones are specified. They include: computing support for the Physics TDR, a data challenge with cosmic rays, a number of service challenges in conjunction with WLCG, joint computing/software/analysis system challenges, and commissioning of the computing system for real data taking.

Computing capacity requirements, general computing service requirements and CMS-specific computing service requirements have been identified. The associated pledges will be negotiated through MoUs.

General comments for CMS

The committee finds the design and architecture of the CMS Computing Model adequate and flexible enough to be adapted to any unforeseen circumstance that might arise in the actual implementation process. Design principles and justifications build on previous experience and the general approach is on the conservative side. The resource requirements are based on well-founded estimates.

The committee is a bit puzzled on the structure of the TDR itself, since it was expected to find detailed technical implementations of the various services, tasks, workflows, whereas the actual document is something closer to a conceptual design report, sometimes even to a status report. For this reason, it was not possible to comment in detail on technical choices on a number of subjects, due to the lack of details and to CMS still working to finalize the technical implementation.

CMS explicitly recognized this in the Computing TDR, and developed a number of milestones (see Table 3) in conjunction with LCG milestones, to be met in the next two years, which keeps them confident of building a computing system that is capable of processing and analyzing data in a timely and efficient way when the LHC will provide them.

The committee finds the set of milestones adequate to implement successfully the CMS computing system. However, there are concerns that the schedule is too aggressive and that there is no time to recover in case of design flaws, failures, bottlenecks, or simply from delays in delivering computing components. As an example, the committee finds that the periods allowed to re-visit the computing systems based on “lessons-learned” of previously completed milestones are too short and suggests adding more contingency, if possible.

As a general comment, the committee is concerned that the computing infrastructure has been designed without a clear view of some of the applications and software frameworks which will use it – e.g., prompt and offline calibration, detector alignment, conditions databases, which are still not implemented yet.

Specific comments and recommendations for CMS

The committee is pleased to see that a CERN Analysis Facility (CAF) has been introduced, which supersedes a combination of Tier1+Tier2 previously proposed. This CMS CAF is currently part of the CERN planning, but the resources to construct it have not been fully identified yet. The CMS CAF plays a critical role in processing data at a small turn-around time, especially for commissioning and prompt calibration/alignment studies. However it is also open to all CMS members for analysis-related tasks. The committee is concerned that the potential use of the CAF by any CMS member to perform analysis might jeopardize detector calibration and monitoring, and recommends CMS to implement engineering and policy tools which ensure that regional Tier-2 resources be used for analysis activities. In addition, we recommend that CMS develops a detailed workflow for prompt calibration/alignment at the CAF, by taking into account the implications on the conditions databases and the impact on the Tier-0.

Calibration and alignment procedures are also not implemented yet in the computing system. These are typically resource-consuming tasks, whose performance has significant impact on the allocation of computing resources. For instance, the alignment of the CMS tracker, consisting of O (1000s) silicon detector modules, represents a completely new challenge. Great care must be taken in its actual implementation in order to keep the needed computing resources as small as practical. The committee recommends that calibration and alignment procedures be carefully evaluated and the impact on CAF resources be assessed accordingly.

The implementation and deployment of a system of distributed conditions databases is still missing in CMS. The experiment is following common developments by LCG, based on distributed caching. The proposed database technology is Oracle. The committee notices that the requirements on the architecture of the conditions database in terms of e.g. access performance for a single executable and as a function of the number of processing nodes, and in general the conditions database workflow, have not been evaluated yet, and recommends CMS to give high priority to this critical item of the computing system.

The committee finds the streaming of data from the Event Filter farm very attractive for subsequent data selection, distribution and prioritization. However, the 10% overlap between the O (50) datasets mentioned in the TDR seems to be a goal. The committee urges CMS to proof that this figure is achievable, since it may have a significant impact on resource requirements.

The committee is pleased to see that the analysis workflows are being exercised successfully by real physicists within the CRAB system, but notices that the scale of the tests performed so far is below the operational usage foreseen for a running experiment. The committee is looking forward to upcoming service challenge tests, which will exercise the system at larger scales, both on the number of submitted jobs and on the accessed sites, and prove that the data analysis model, inherently more chaotic than production tasks, is indeed achievable. The committee looks forward to seeing the results of these tests.

The CMS software framework is being redesigned, and not mentioned at all in the TDR. The committee finds that the software framework is a critical item, which drives many implementation details in the computing system, and strongly recommends that CMS give a high priority to developing, deploying and testing on a short timescale this re-engineered software framework.

The management of the CMS computing project is well defined, and a structure is in place in order to track the various project deliverables and detect and deal with potential bottlenecks. The computing management team consists of four main programs (technical, integration, operations, and facilities), each of which has one or more coordinators. The committee notices that some program coordinators are not named yet, and that the biggest problem in staffing the project is securing the required level of effort for user support and operations. CMS expects that introducing an additional 15FTE Category-A effort in the CMS M&O they should be able to staff the most important support and operation functions. There are also ~15 missing FTEs in Category-B of the CMS M&O. A major concern remains that CMS has not yet been able to identify the intellectual leadership to define the analysis support area, and also progress on defining the facilities area is slow. The committee notices that lack of manpower would result in a reduction of scope, which will have significant implications for the physics program of CMS.

Level 1 Parent Milestone	Date (version 34.2)	Milestone Title	Level	ID
CPT-1	Aug-04	DC04 (5%) Data Challenge Complete	2	CPT-101/C
	Jan-05	Computing Model paper complete (1st draft Computing TDR)	2	CPT-102/C
	Jun-05	**Submission of Computing TDR**	**1**	**CPT-1**
CPT-2	Jul-05	Initial integration of baseline computing components	2	CPT-202/C
	Sep-05	Computing systems ready for Service Challenge SC3	2	CPT-204/C
	Dec-05	Computing systems ready for Cosmic Challenge	2	CPT-212/C
	Dec-05	**Baseline Computing/Software Systems & Physics Procedures for Cosmic Challenge and Physics TDR**	**1**	**CPT-2**
CPT-3	**Apr-06**	**Submission of Physics TDR (Vols 1 and II)**	**1**	**CPT-3**
CPT-4	Mar-06	Computing Systems ready for Service Challenge SC4	2	CPT-402/C
	Jun-06	Computing systems at Tier-0, 1, 2 centres ready for CSA-2005	2	CPT-404/C
	Sep-06	**Computing, Software and Analysis Challenge (CSA-2006) complete**	**1**	**CPT-4**
CPT-9	**Dec-06**	**Submission of addenda to Physics TDR**	**1**	**CPT-9**
CPT-5	Oct-06	Computing systems re-visited based on CSA-2006 lessons learned	2	CPT-502/C
	Dec-06	Integration of Computing Systems at Tier-0, 1 and 2 centres	2	CPT-504/C
	Feb-07	**Computing and Software Systems and Physics Procedures ready for data-taking**	**1**	**CPT-5**
CPT-6	Feb-07	Tier-0 centre and CERN Analysis Facility ready for pilot run	2	CPT-601/C
	Apr-07	Tier-1 and 2 centres ready for pilot run	2	CPT-602/C
	Jun-07	**Tier 0, 1 and 2 Computing Systems Operational (pilot run capacity)**	**1**	**CPT-6**
CPT-7	**Apr-08**	**Tier 0, 1 and 2 Computing Systems Operational (low luminosity capacity)**	**1**	**CPT-7**
CPT-8	**Apr-09**	**Tier 0, 1 and 2 Computing Systems Operational (high luminosity capacity)**	**1**	**CPT-8**

Table 3 CMS Computing Milestones from the TDR

The committee is impressed by the work accomplished by CMS in producing its Computing TDR. Even though the document resembles a conceptual design report rather than a TDR, it shows a step forward towards the implementation and deployment of physics analysis within the CMS experiment. Nevertheless, a lot of work remains to be done in order to be ready for data taking. Achieving the goals of the upcoming Level-1 milestones is very important.

Appendix A

Committee Representation for October 7-8 review

Chair: P. McBride
Representatives from the LHCC: K. Borras, F. Forti, S. de Jong, M.Martinez-Perez, V. Kekelidze, B. Peyaud
External:
D. Boutigny (CC-IN2P3-Lyon; for ALICE C-TDR),
T. Haas (DESY; for ATLAS C-TDR),
C. Bozzi (INFN Ferrara; for CMS C-TDR),
Alan Campbell (DESY; for LHCb C-TDR)
LHCC Chairman and Secretary: S. Bertolucci, E. Tsesmelis

Also present at the review
PH Department: J.-J. Blaising, D. Schlatter
IT Department: J. Knobloch

[i] Review of Computing Resources for the LHC Experiments CERN/LHCC/2005-006 http://committees.web.cern.ch/Committees/LHCC/lhcc-2005-006.pdf
[i] ALICE Computing Model CERN-LHCC-2004-038/G-086, draft: 05-Jan-05, updated 04-Feb-05
[i] The ATLAS Computing Model CERN-LHCC-2004-037/G-085
[i] The CMS Computing Model CERN-LHCC-2004-035/G-083
[i] LHCb Computing Model CERN-LHCC-2004-036/G-084 (CERN-LHCb-2004-119)
[ii] ALICE Technical Design Report of the Computing CERN-LHCC-2005-018, ALICE-TDR-012
[iii] The ATLAS Computing Technical Design Report CERN-LHCC-2005-022, ATLAS-TDR-017
[iv] CMS The Computing Project Technical Design Report CERN-LHCC-2005-023, CMS-TDR-007
[v] LHCb Computing Model CERN-LHCC-2004-036/G-084 (CERN-LHCb-2004-119)
[vi] ALICE Technical Design Report of the Computing CERN-LHCC-2005-018, ALICE-TDR-012
[vii] The ATLAS Computing Technical Design Report CERN-LHCC-2005-022, ATLAS-TDR-017
[viii] CMS The Computing Project Technical Design Report CERN-LHCC-2005-023, CMS-TDR-007
[ix] LHCb Computing Model CERN-LHCC-2004-036/G-084 (CERN-LHCb-2004-119)
[x] LHCb Computing Model CERN-LHCC-2004-036/G-084 (CERN-LHCb-2004-119)