U.S. CMS Software and Computing Management Plan

August 2001, V 1.01
Revised February 2004, V2.07

Revision History

V1.01 Original version of August 2001, submitted to JOG with concurrence of CMS and the PMG

V2.07 Modified version of February 2004, outlines the roles of the U.S. CMS Research Program Manager

TABLE OF CONTENTS

U.S. CMS SOFTWARE AND COMPUTING MANAGEMENT PLAN 1

1. GOALS OF U.S. CMS SOFTWARE AND COMPUTING 5

1.1 Objectives of U.S. CMS Software and Computing 5

1.2 Schedule Objectives 7

1.3 Cost Objectives 8

2. SCOPE AND ORGANIZATION 8

2.1 The Core Applications Software Subproject 8

2.2 The User Facilities Subproject 9

3. UPPER LEVEL MANAGEMENT 10

3.1 The Level 1 Manager 10

3.2 The Level 2 Managers 12
3.2.1 The Core Applications Software Subproject 12
3.2.2 The User Facilities Subproject 13

3.3 The U.S. CMS Advisory Software and Computing Board (U.S.ASCB) 14
3.3.1 Mandate of the U.S. ASCB 14

3.4 Fermilab Oversight and the Project Management Group 14
3.4.1 The U.S. CMS Research Program Manager 14
3.4.2 Project Management Group (PMG) 15
3.4.3 External Review Committee SCOP 15
3.4.4 Change Control 15

3.5 Development of the Work Plan 16

3.6 Allocation of Funds 16

3.7 Management and Control Systems 17
3.7.1 Reviews 17
3.7.2 Cost estimates and Contingency 17
3.7.2 Development of the Work Plan 17

4. INTERRELATIONSHIP WITH OTHER ENTITIES 18

4.1 Relation to CMS 18

4.2 Relation to U.S. CMS and to the U.S. CMS Research Program 19

4.3 Relation to Fermilab **20**

4.4 Relationship to the U.S. Funding Agencies **21**

5. EVOLUTION OF U.S. CMS SOFTWARE AND COMPUTING **21**

5.1 Review and Modification of this Management Plan **21**

APPENDIX A. TECHNICAL BASELINE DOCUMENT **21**

APPENDIX B. SCHEDULE, MILESTONES AND DELIVERABLES DOCUMENT **22**

APPENDIX C. COST DOCUMENT **22**

APPENDIX D. CHANGE CONTROL THRESHOLDS **23**

APPENDIX E. LETTER FROM FUNDING AGENCIES TO FERMILAB **24**

REFERENCES **27**

SUBMISSION AND APPROVALS **28**

1. Goals of U.S. CMS Software and Computing

The Compact Muon Solenoid (CMS) collaboration is bringing together some 2000 physicists and engineers from around the world to build, operate and do research with one of the two major experiments at the Large Hadron Collider (LHC) at CERN. The LHC allows to explore the physics frontier up to and beyond the TeV energy scale, and CMS will exploit the full range of physics made accessible for the first time by the LHC's combination of high luminosity of $10^{34}cm^{-2}s^{-1}$ and 14 TeV center of mass energy. It will use its high resolution crystal calorimeter, muon tracker and hadron calorimeter systems to study the mechanism of electro-weak symmetry breaking via the detection of Higgs bosons, search for supersymmetry and detect other signs of new physics including the onset of effects from extra dimensions of space-time.

The CMS detector is capable of precisely measuring events containing electrons, muons, photons, jets and missing energy. The multi-level trigger systems will filter in real time the data from 10^9 interactions per sec produced by the LHC to select interesting events at a rate of approximately 100 Hz, recording 100 MB/sec of raw data. This corresponds to several Petabytes of stored raw and processed data in the first year of operation, starting in 2007. The data volume is expected to increase rapidly, so that the accumulated data volume will reach many hundred Petabytes by around 2015.

To fully realize the potential of the CMS research program, this data is to be accessed, analyzed and processed using a computing fabric that extends over a worldwide grid of national, regional and local facilities. The necessary software and computing effort for CMS thus exceeds in scale and complexity anything that has so far been achieved in High Energy Physics (HEP). Even the new generation of experiments that started to take data between 1999 and 2001 do not approach this scale. Because of the large number of participants and their wide geographical distribution CMS will need to employ what is essentially a new model of distributed computing and data analysis, which is without precedent in HEP. It will do so during a period of rapid change in software practices and hardware technologies. To respond to these challenges, in 1999 U.S. physicists in CMS started the U.S. CMS Software and Computing effort (U.S. CMS S&C). U.S. CMS Software and Computing has become part of the U.S. CMS Research Program, managed like a project, as described in this Management Plan.

1.1 Objectives of U.S. CMS Software and Computing

The goal of the U.S. CMS Software and Computing effort is to provide the software and computing resources needed to enable U.S. physicists to fully participate in the physics program of CMS. Additionally it should allow U.S. physicists to play key roles and exert an appropriate level of leadership in all stages of the computing-related activities, from development of the reconstruction programs and software infrastructure to the extraction of physics results. This capability should extend to physicists working at their home institutions.

A key element in achieving this goal is to develop the software and to construct the facilities to provide an integrated environment for remote collaboration that would make possible central U.S. roles in the data analysis. This includes:

- providing the resources to support participation in the development of software associated with the design, calibration, commissioning, and analysis of the detectors in which U.S. CMS members are involved;
- providing the resources to support the participation in the development of reconstruction, simulation, and analysis frameworks and other physics applications infrastructure at a level appropriate to the number, capabilities, and experience of U.S. CMS physicists; and
- providing the resources and facilities for participation by U.S. CMS physicists, especially those who wish to remain based in the U.S., in all analysis efforts and activities of interest to them.

The word 'resources' is meant to include personnel — for development, operations, and support, as well as the hardware, commercial software purchases, and contracts for other services required.

A Software and Computing effort in U.S. CMS was initiated in FY 1999. It has a baseline plan for a period until the end of FY 2008. To build the required software and computing systems, the U.S. CMS Software and Computing effort has a planned scope, set of deliverables and milestones, a schedule and a funding profile. To achieve its goals U.S. CMS Software and Computing is organized as a project, as part of the U.S. CMS Research Program and overseen by Fermilab as the U.S. CMS host lab.

U.S. CMS functions within the context of the full CMS experiment, which in turn functions as an experiment of CERN. It is essential that the U.S. CMS Software and Computing effort stay well aligned with both the scientific goals of the U.S. CMS Research Program, and with the policies and approaches of CMS and CERN.

U.S. CMS S&C provides services and facilities to U.S. CMS and the whole of CMS, through a Tier-1 regional computing center at Fermilab, and a set of Tier-2 centers at U.S. universities. Efforts are provided by the computing organization of the U.S. CMS host lab, by U.S. universities and by other organizations. Services and facilities provided to U.S. CMS at Tier-1 and Tier-2 centers need to integrate well with the local organizations providing them, making optimal use of and exploiting synergies and economies of scale with other local, national and global computing activities, like computing for other experiments, U.S. and international Grid projects etc.

As importantly, these facilities and services must couple smoothly to CERN central computing and other Tier-1 and Tier-2 regional computing centers. CMS and LHC computing facilities worldwide will form a global LHC computing Grid, so that U.S. physicists can work productively whether at their home institutions or at CERN.

The U.S. CMS Software and Computing effort is closely coordinated with the international CMS Computing and Core Software Project (CCS) [1] that covers

(1) the computing aspects of the design, construction, evaluation and calibration of the CMS detector
(2) the storage, access and processing of event data
(3) event reconstruction and analysis, and
(4) the computing and remote collaborative infrastructure for the above.

U.S. CMS Software and Computing supports U.S. CMS' efforts to do its appropriate share of the CMS work and also to solve special problems related to the geographical separation of U.S. physicists from the site of the experiment.

CERN expects that significant data analysis will take place external to CERN. The U.S. goals are consistent with that policy by marshaling U.S. national resources to support the analysis activities of U.S. physicists on CMS. The U.S. expects to do this in a cost effective way by leveraging the knowledge, talent, and experience with HEP computing that exists within U.S. universities and Fermilab, which is the U.S. CMS host institution. It is expected that the U.S. national computing infrastructure for CMS will federate with the world-wide LHC computing grid.

The U.S. also has particular issues to deal with as a result of being separated from the source of experimental data and the repository of knowledge and expertise at CERN, by an ocean and by six to nine time zones. The U.S. CMS Collaboration is itself widely spread out, as a result of the geographical expanse of the United States. U.S. physicists are thus particularly dependent on a well-coordinated distributed data analysis system, able to deliver data and/or analysis results reliably and with acceptably short delays across transoceanic as well as national networks. These issues coupled to the unique position of the U.S. in computing and networking technologies make it unavoidable that the U.S. takes a lead role in these efforts, and bears the brunt of much of the R&D work and associated costs.

The long distance to the experiment means that U.S. physicists are particularly reliant on videoconferencing for meetings and participation in the daily activities of the experiment. A high quality remote collaborative environment is required for collaborative work on the software and data analysis, and will be an important part of this effort.

No remote collaborative technology can fully compensate for the out-of-phase work cycles resulting from the time difference between the U.S. and Europe. The U.S. is thus obligated to focus some of its activities

nationally and sometimes regionally within the U.S., in order to allow the physicists of U.S. CMS to work efficiently.

This problem will be partly solved by the presence of a Tier-1 Regional Center and a Physics Analysis Facility (which itself is not a U.S. CMS Software and Computing deliverable) at Fermilab in the U.S. Central time zone, use of remote collaborative technologies within the U.S., and the use of an hierarchical and federated Grid of networked computing and data resources, that places a Tier-2 Regional Center in each of several U.S. regions.

1.2 Schedule Objectives

The schedule for CMS Software and Computing foresees an initial R&D phase, leading to a Technical Design Report (TDR), and an implementation and deployment phase. After FY2008 regular operations and continuous upgrades will commence. The R&D phase runs from FY2000 to FY2005. Significant R&D in computing is needed to reach the objectives to develop the technologies and to establish the engineering foundations of the distributed computing system for the U.S. CMS Software and Computing User Facilities. This will include providing computing and networking test-beds, performing prototyping of Tier-1 and Tier-2 computing facilities and supporting CMS "Data Challenges". The three-year implementation phase follows from FY2006 to FY2008.

The schedule for software development and deployment is defined taking into account a number of constraints: the ongoing software needs to support detector and trigger design optimization and construction, the software R&D required in particular for the large and world-wide distributed data systems and the availability of manpower resources. The schedule reflects an iterative development strategy, aiming to provide continuously working software while simultaneously evolving into software systems with the functionality and performance ultimately required.

The CMS software project has defined major milestones that reflect the iterative software development process in four phases. The first phase, completed at the end of 1998, is the proof of concept for the key elements of the software architecture proposed in the CMS Computing Technical Proposal. The second phase, which was completed at the end of FY2000, covers the development of functional prototypes of the various software modules, which were then being exercised using large samples of simulated events and test beam data, to be used for High Level Trigger studies and the Trigger TDR. The third phase involves the development of the prototypes into fully functional software. This software is being used in Data Challenges, in preparation of writing the Computing TDR, and later for detailed studies of the detector and its sensitivity to various physics processes, which will be documented in the Physics Technical Design Report. The fourth phase is the preparation of the software for production and the exercising of a complete software system with pre-production computing systems. The software efforts in the U.S. follow this schedule.

A brief list of the major CMS software, data production and analysis milestones is given below.

- Dec 2002 Trigger and Data Acquisition System Technical Design Report (TDR)
- Apr 2004 5% Data Challenge (DC04)
- Oct 2004 Software and Computing TDR
- Apr 2005 10% Data Challenge (DC05)
- Dec 2005 Physics TDR: support interactive analysis
- Apr 2006 20% Data Challenge (DC06); about full complexity
- Oct 2006 Delivery of production-grade Core Software systems
- Apr 2007 Fully operational central systems (20%capacity)
- Apr 2007 Start of LHC machine operations
- Apr 2008 Fully operational central systems (50% capacity)
- Apr 2009 Fully operational computing systems (100% capacity)

After FY2008 the R&D and implementation phases will have ended, but U.S. CMS will require continuing funding for software and computing. Computing equipment will need to be replaced in a rolling fashion, and the necessary performance upgrades to cope with increasing data samples are expected from continuous advances in computing technologies (Moore's law) when replacing equipment. Running the Tier-1 and Tier-2 facilities and supporting core software will need continuous resources. This will be subject of the operations phase of the U.S. CMS Research Program.

1.3 Cost Objectives

U.S. CMS Software and Computing is jointly funded by the Department of Energy and the National Science Foundation through the U.S. LHC Research Program. Its scope and funding profile have been determined through a "baselining review" in November 2001. In 2002 revised funding guidance from the DOE was received, and the U.S. CMS Software and Computing base line was reviewed again, after scraping to a "bare-bones" scope and funding profile, in the joint DOE/NSF review in January 2003.

The U.S. CMS Research Program has been given guidance from DOE and NSF as to a best effort funding profile.

The U.S. CMS Software and Computing cost objective is $70M, integrated from FY2002 to the end of the deployment phase in FY2008 (including the NSF "leadership" component). The details of the cost estimates have been established during the reviews of the U.S. CMS Software and Computing efforts.

2. Scope and Organization

The U.S. Software and Computing effort has two major subprojects:

- The Core Applications Software subproject (CAS)[2]
- The User Facilities subproject (UF)[2]
- U.S. CMS Software and Computing will provide the core framework and infrastructure software, and the hardware to support the reconstruction, simulation and physics analysis. This does not include the development of the actual reconstruction software, nor the software for specific physics analyses, much of which will be written by physicists. While the funding of the efforts described here is separate from that required for the reconstruction and physics analysis software, all these efforts are obviously closely related and must be coordinated. This is discussed below. The remainder of this section provides a brief characterization of the two major subprojects.

2.1 The Core Applications Software Subproject

The Core Applications Software Subproject will develop software

- to support the design, development, modeling, optimization, and commissioning of software related to detectors being constructed by U.S. CMS;
- to provide its share of the framework and infrastructure software required to support data analysis and simulation for CMS;
- for remote collaborative tools and services for the distributed model of computing that will enable members of U.S. CMS to carry out data analysis while they are at home in the U.S. or resident at CERN; and
- to satisfy any specialized needs required to carry out data analysis activities of interest to members of U.S. CMS.

U.S. CMS' core software efforts have focused on three main areas:

- the ORCA and OSCAR frameworks for the object-oriented event simulations and reconstruction
- The User Analysis Environment
- Distributed System Development

The U.S. will also, by virtue of its interests and its expertise, participate through the Core Applications Software subproject in various R&D and common projects.

In addition to developing software, this subproject will also provide expert programming personnel to assist the physicists in developing reconstruction and physics analysis programs by serving as mentors, reviewers, advisers and, where appropriate, as software tool-writers. This will ensure that the software produced will be easy to integrate into the whole system, will be efficient in its use of hardware resources, and will be maintainable and adaptable for the full life of the CMS data analysis.

Figure 1 below shows the organization chart of the U.S. CMS Software and Computing effort.

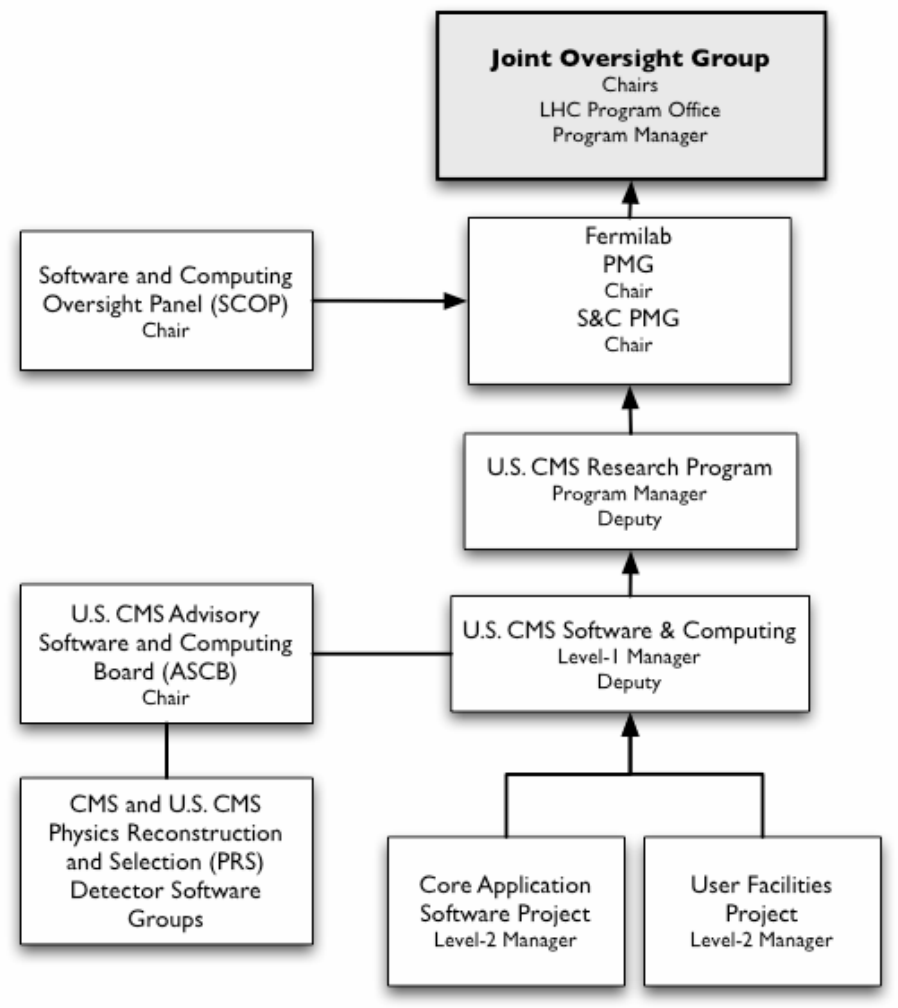

Figure 1 *Abbreviated version of organization of U.S. CMS Software and Computing showing the main subprojects and the key links to U.S. CMS, Fermilab, and the U.S. funding agencies.*

2.2 The User Facilities Subproject

The mission of the "User Facilities" subproject is to provide the enabling infrastructure to permit U.S. CMS collaborators to fully participate in the physics program of CMS, and to do so from their home sites if they choose**.** This enabling infrastructure will consist of the software and hardware needed to access, analyze and understand data as well as to support software development efforts by U.S. CMS physicists and computing professionals. The major cost and personnel-requirements driver for the subproject is a regional

computing center at Fermilab to support U.S. physicists working on CMS. It is appropriately sized to support this community that comprises almost 25% of the full CMS collaboration.

The Fermilab regional center will include substantial CPU, data storage and data access facilities. It will be able to deliver portions of the data as required to other U.S. CMS institutions through high-speed networks and will have a high bandwidth network connection to CERN. It will also include user support personnel, personnel to manage licenses and license acquisition, and personnel to contract for needed services. It will have the responsibility and personnel to develop or acquire any software that is required to carry out its production and operation activities. It will provide a variety of training and consulting services to help university physicists carry out their computing activities at their home institutions and at Fermilab. It will also provide support for many development activities during the detector construction period before data taking begins.

In addition to developing software required to carry out its mission, this subproject will also provide expert programming personnel to serve as liaisons to programmers developing software by serving as reviewers and advisers. This will ensure that the software produced elsewhere in U.S. CMS will be easy to integrate into the whole system, will be efficient in its use of hardware resources, and will be maintainable and adaptable for the full life of the CMS data analysis.

An important and integral part of the User Facilities are Tier-2 regional centers, as defined by the joint ATLAS-CMS MONARC project. They are regional computing facilities located at U.S. institutes and sized at about 2-5% of the main CMS CERN facility (and therefore 10-20% of the capacity of the Tier-1 center). Current plans call for five Tier-2 centers in the U.S. The Tier-1 at Fermilab plans to support data import/export, documentation and software distribution to these centers

The R&D and prototyping phase from 2001 to 2004 involves installation of prototype Tier-2 centers. The deployment of permanent Tier-2 computing facilities will start after that. The sites for the Tier-2 regional centers are not yet identified. The U.S. CMS Advisory Software and Computing Board will decide the selection criteria for the permanent Tier-2 facilities. Proposals will be solicited from institutions that wish to be considered as permanent Tier-2 facilities. The selection procedure will involve a review committee reviewing the proposals to evaluate which Tier-2 sites will provide the greatest benefits to U.S. CMS. The review committee will produce a report with recommendations to the Level 1 Manager, who will make the final decision where to locate the permanent Tier-2 centers.

3. Upper Level Management

The roles and responsibilities of the upper level management are described in this document. These entities are:

- the Level 1 Manager (L1M) and the deputy of the L1M;
- the Level 2 Manager (L2M) for the Core Applications Software subproject;
- the Level 2 Manager (L2M) for the User Facilities subproject;
- the Fermilab Computing Division (CD) and its Division Head;
- the U.S. CMS Research Program Manager;
- the U.S. CMS Advisory Software and Computing Board (U.S.ASCB); and
- the Fermilab Director or designee, being advised by the U.S. CMS Project Management Group (PMG).

3.1 The Level 1 Manager

The Level 1 Manager (L1M) represents U.S. CMS Software and Computing in interactions with the U.S. CMS Research Program Manager, CMS management, CERN, DOE, NSF, Fermilab, the collaborating universities, and related external R&D projects. He or she reports to the U.S. CMS Research Program Manager and the director of Fermilab or his designee and through them to DOE and NSF. The L1M has authority to negotiate on behalf of the U.S. CMS Software and Computing Project with collaborating

institutions and with Fermilab for collaboration or laboratory resources and for their optimal utilization and management. The L1M is responsible for completing the work plan by achieving the approved scope within budget and on schedule. He/she must also ensure that the deliverables of U.S. CMS Software and Computing conform to the technical specifications that are set for them. Finally, he/she is responsible for doing all this in manner consistent with CMS scientific policy. The L1M will be appointed by Fermilab in consultation with the U.S. CMS Research Program Manager and the U.S.ASCB and will receive the concurrence of the DOE and the NSF. During his/her tenure, the L1M will be a member of Fermilab's staff. Administratively, the L1M will be a member of the Fermilab Computing Division and his/her staff organization will reside in the CD. It is expected that the L1M will have experience and background in HEP experiment, software development, management, and operations issues and skills that would predict success as a project manager in this role. The L1M will serve as long as there is continuing confidence of the Fermilab Director, the U.S. CMS Research Program Manager, the Collaboration, and the funding agencies. Any change of the L1M will require the same level of concurrence as specified.

The specific responsibilities of the L1M include

1. developing the baseline work plan especially with respect to budget, personnel requirements, schedule, Level 1 (L1) milestones, and L1 deliverables;
2. executing the approved work plan in a manner consistent with the technical and scientific policies of U.S. CMS;
3. developing an integrated Cost and Schedule Plan;
4. establishing and maintaining the organization of U.S. CMS Software and Computing, within the Fermilab Computing Division, required to manage procurements, maintain schedules, submit reports, develop budgets, carry out quality assurance, maintain the work plan and the record of all revisions to it, and maintain safety standards and records;
5. developing the annual budget request to the DOE and NSF. This request is reviewed by the U.S.ASCB and requires concurrence by the U.S. CMS Research Program manager and approval by the PMG;
6. providing liaison between the U.S. CMS Software and Computing and the CMS Software and Computing Technical Board (CCS-TB) and Steering Committee (CCS-SC);
7. at his/her discretion, in consultation with the U.S.ASCB and with the concurrence of the PMG, appointing a deputy or other supporting staff to assure management continuity during periods when he/she is absent or unavailable;
8. appointing the two Level 2 (L2) managers in consultation with the U.S.ASCB and with the concurrence of the PMG. Consulting on and concurring with the appointment of Level 3 (L3) managers by the L2 managers;
9. developing or adopting general technical and quality assurance standards to which deliverables must conform. This includes making sure that U.S. CMS software and facilities conform to applicable CMS and CERN standards and practices, and can operate with them without unnecessary additional integration effort;
10. providing coordination and oversight to the Level 1 and Level 2 projects. Oversight may be accomplished by requiring appropriate regular reports, following and tracking the results of technical reviews, and conducting reviews using both internal and external committees or experts. Coordination may involve making sure that the User Facilities Subproject can supply test beds to the Core Applications Subproject for major development activities;
11. making adjustments to Memoranda of Understanding, MOUs, and Statements of Work, SOWs, with collaborating universities and laboratories. These MOUs and SOWs are initially formulated as part of the work plan but adjustments may be necessary in the course of the effort;
12. allocating resources within U.S. CMS Software and Computing. These allocations are largely set by the work plan and the annual budget request. However, adjustments are often necessary. The work plan includes a management reserve that will be allocated subject to the formal change control procedure;
13. reporting variances from the scope, schedule, or cost estimates to the PMG and developing action plans for dealing with them. The L1M informs the U.S.ASCB of such variances;

14. exercising change control authority as described in this plan and bringing change issues that exceed his/her authority to the attention of the PMG;
15. establishing technical advisory committees where appropriate;
16. providing reports and organizing reviews in conjunction with the funding agencies; responding to requests for information from U.S. CMS, Fermilab, and the funding agencies; and
17. developing a technology-tracking plan, in conjunction with the Level 2 managers and with similar efforts at CERN, with the advice of the U.S.ASCB. The tracking plan should allow U.S. CMS Software and Computing to take advantage of new, more cost-effective technologies that may arise during the period of its execution.

3.2 The Level 2 Managers

The Level 2 Managers are appointed by the Level 1 Manager in consultation with the U.S.ASCB and with the concurrence of the PMG. The main responsibility of the L2Ms is to manage their subproject so that they successfully produce the deliverables on schedule, within budget, and within their technical specifications.

3.2.1 The Core Applications Software Subproject

The L2M of the Core Applications Software Subproject is appointed by the L1M in consultation with the U.S.ASCB and with the concurrence of the PMG. This position will normally be held by a physicist who is a member of U.S. CMS and is expert in software development and HEP data analysis. The subproject will be responsible for developing software components, carrying out evaluations and feasibility studies, and performing various tests.

Responsibilities of the L2 Manager for Core Applications Software include:

1. defining, in consultation with and subject to the concurrence of the L1M, the milestones and deliverables of the subproject;
2. developing the technical specifications of each component and deliverable of the subproject;
3. defining, in consultation with and subject to the concurrence of the L1M, the organizational substructure of the subproject. This includes defining the L3 projects and proposing, subject to the approval of the L1M, the L3 project leaders;
4. developing, under the guidelines provided by the L1M, the annual budget proposal for the subproject;
5. allocating resources and identifying resource imbalances or deficiencies within their subprojects. Allocations are largely set by the work plan and the annual budget request. Making adjustments within prescribed limits of resources within their subprojects. Proposing adjustments to SOWs with collaborating universities and laboratories to the L1M. Changes are subject to the change control procedures outlined in this document;
6. delivering the scope of the subproject on schedule, within budget, and in conformance with the technical specifications and quality assurance guidelines;
7. organizing (and documenting) internal reviews to make sure that deliverables will meet the technical specifications and the quality assurance standards;
8. being accountable for all funds allocated to the subproject;
9. maintaining the Cost and Schedule Plan for this subproject;
10. providing reports as required to the L1M; and
11. carrying out any other duties assigned by the L1M.

3.2.2 The User Facilities Subproject

The Level 2 manager of the User Facilities Subproject is appointed by the L1M in consultation with the U.S.ASCB and with the concurrence of the PMG. He/she will be experienced in and knowledgeable about HEP physics analysis production issues, hardware acquisition, operations issues, and the development of software components as relates to operations and production.

The Level 2 manager will have significant responsibilities connected with the U.S. CMS Regional Computing Center at Fermilab and will normally be a member of Fermilab's staff.

Responsibilities of the L2 Manager for the User Facilities Subproject include:

1. developing the definition of the milestones and deliverables of the subproject;
2. developing, subject to review by the L1M and with the input from the U.S.ASCB, the technical specifications of each component and deliverable of the subproject which will include the acquisition of hardware components, contracting for services (such as network connectivity), acquiring software for operations or monitoring, and developing software to integrate components and to manage production or operations activities where required;
3. defining the organizational structure of the subproject. This includes defining the L3 projects and proposing, subject to the approval of the L1M, the L3 project leaders. Each Tier-2 center will be a Level 3 project and have its own Level 3 manager, who will report to this L2 manager. For Tier-2 and special purpose centers, each center will appoint, with the concurrence of the Level 2 manager for User Facilities, a manager who will be responsible for CMS activities at the Tier-2 or special purpose center and this manager will be the Level 3 project leader for the center for U.S. CMS Software and Computing;
4. developing, under the guidelines provided by the L1M, the annual budget proposal;
5. negotiating adjustments to the MOU with Fermilab, in particular with the Computing Division, for support of the U.S. CMS Tier-1 Regional Center;
6. negotiating annual SOWs with Tier-2 or special purpose centers, and with their managing organizations as appropriate, should they become part of U.S. CMS computing. The purpose of the SOW is to define what specific deliverables the center will provide and what resources and services are needed from the Tier-1 center;
7. delivering the scope of the subproject on schedule, within budget, and in conformance with the technical specifications and quality assurance guidelines. This will include developing Requests for Information (RFIs), Requests for Proposals (RFPs), acquisition plans, implementation plans, technical specifications, acceptance tests and criteria, etc;
8. organizing (and documenting) internal reviews to make sure that deliverables will meet the technical specifications and the quality assurance standards;
9. being accountable for all funds allocated to the subproject;
10. maintaining the Cost and Schedule Plan for this subproject;
11. providing reports to the L1M;
12. working with potential candidates for Tier-2 and special purpose centers to prepare their proposals. The parts of proposals for such centers , which relate to CMS, must be approved by the management chain described in this document; and
13. carrying out any other duties assigned by the L1M.

3.3 The U.S. CMS Advisory Software and Computing Board (U.S.ASCB)

The U.S. CMS Advisory Software and Computing Board provides input and feedback for U.S. CMS Software and Computing. The composition of the board and its relationship to U.S. CMS and CMS are partially described in this document[3]. It is composed of:

- six at large members elected from the U.S. CMS collaboration;
- the U.S. CMS Physics Coordinator (also elected);
- the Chair of the U.S. CMS Collaboration Board (ex-officio);
- the Head of the Fermilab Computing Division (ex-officio);
- the CMS Project Manager of Computing and Core Software (ex-officio);
- the U.S. CMS Research Program Manager (ex-officio);
- the Level 1 Manager for U.S. CMS Software and Computing and his or her deputy, if appointed (ex-officio); and
- the Level 2 Managers for the User Facilities and for the Core Applications Subproject (ex-officio).

The seven elected members of the ASCB will select a chair, who shall be one of the 6 at large members.

3.3.1 Mandate of the U.S. ASCB

The U.S.ASCB advises the Level 1 Manger on scientific and technical policy for U.S. Software and Computing, consistent with the scientific direction and goals of U.S. CMS and CMS. Technical, scientific, operations, and resource allocation issues are to be discussed frequently by the board with the goal of providing continuous input and feedback as required for effective execution of the work plan for U.S. CMS Software and Computing.

The U.S.ASCB is involved in defining the work plan by providing the interface to U.S. CMS in setting the requirements for this plan and for helping to develop any overall policies associated with it. It provides scientific and technical input and feedback to assure that U.S. CMS Software and Computing is indeed carrying out the policies of U.S. CMS and international CMS, which will certainly evolve over time, and is faithfully executing the work plan.

Recommendations are made to the Level 1 Manager. Scientific issues with a major potential impact on the physics results to be obtained by U.S. CMS will be brought before the U.S. CMS Advisory Board, and to the U.S. CMS Collaboration Board, if needed, and resolved in a manner consistent with international CMS.

3.4 Fermilab Oversight and the Project Management Group

In letters signed in August 1999 and in November 2000, the Department of Energy and the National Science Foundation have requested that Fermilab, as U.S. CMS Host Institution, exercise management oversight for U.S. CMS Software and Computing. Oversight responsibility is vested in the Fermilab Director or designee, who is advised by the U.S. CMS Project Management Group. The Fermilab Director or designee reports to the Joint Oversight Group.

3.4.1 The U.S. CMS Research Program Manager

Fermilab appoints the U.S. CMS Research Program Manager for overall line management responsibility for the U. S. CMS Construction Project and the U. S. CMS Research Program, which includes U. S. CMS Software and Computing, Maintenance and Operations, and Research and Development for possible future detector improvements.

The U.S. CMS Research Program Manager is a member of U.S. CMS. He/she interacts with the host laboratory, international CMS and the US funding agencies to identify and represent the needs for the entire U.S. CMS Research Program and provides the input required to optimize the program within the available funding, once it is known.

The U.S. CMS Research Program Manager will act to optimize the full U.S. CMS Research Program, taking into account the line organization and baseline plans for U.S. CMS Software and Computing and Detector Maintenance and Operations.

3.4.2 Project Management Group (PMG)

To provide oversight of the U.S. CMS Software and Computing Project, the mandate of the Project Management Group for the U.S. CMS Construction Project is extended.

Specific members are added to the PMG for their expertise in software, computing, and data analysis issues. These include

- the U.S. CMS Software and Computing Level 1 and Level 2 Managers; and
- the chair of the U.S. ASCB.

Also the U.S. CMS Research Program Manager, the U.S. CMS Collaboration Board Chair and the Head of the Fermilab Computing Division are members of this PMG. Other members or observers with specific expertise or interest in this area and who represent U.S. CMS, Fermilab, or the funding agencies may be added.

These members comprise the PMG sub-group for Software and Computing. The chair of the PMG has appointed the Fermilab Associate Director for Research to chair the U.S. CMS Software and Computing Project Management (sub-) Group, to oversee U.S. CMS Software and Computing.

The sub-group chair, in consultation with the L1M and with input from the U.S. CMS Research Program Manager and the chair of the U.S.ASCB, prepares the agenda for these meetings. The chair of the U.S. CMS PMG may also choose to hold meetings with this sub-group or to have joint meetings of the group associated with the Construction Project, the group associated with the Maintenance and Operations program, and this sub-group based on the issues to be addressed. The chair of the PMG prepares the agenda for these meetings. The PMG receives the reports of the L1M for U.S. CMS Software and Computing.

Oversight of U.S. CMS Software and Computing is implemented in part through reviews. Along with providing frequent interactions with U.S. CMS Software and Computing management, the PMG will identify actions and initiatives to be undertaken to achieve the goals including the allocation of both financial and human resources. The PMG also functions as the Baseline Change Control Board.

3.4.3 External Review Committee SCOP

The chair of the Software and Computing sub-group of the PMG establishes a standing external review committee that periodically examines and evaluates all aspects of U.S. CMS Software and Computing, the Software and Computing Oversight Panel (SCOP). A recognized expert in HEP computing chairs the committee. Its membership includes international HEP computing experts and participation from CMS software management.

The SCOP reports to the Fermilab Associate Director for Research in his oversight role, and it should provide advice to the U.S.CMS Software and Computing Manager. The chair of the SCOP will be invited periodically to meetings of the Fermilab Physics Advisory Committee to present the status and plans for U.S. CMS Software and Computing. The Panel will meet regularly and produce a written report.

3.4.4 Change Control

The U.S. CMS Software and Computing Level 1 Manager will control changes in requirements, costs and schedule, in consultation and agreement, as appropriate, with the PMG, the U.S. CMS Research Program Manager and the U.S. ASCB.

Detailed change control thresholds are established in three areas: technical changes, schedule changes, and cost changes and are given in Appendix D. Formal change requests will be submitted and the Fermilab U.S. CMS Project Management Group and the U.S. CMS Research Program Manager will consider and approve or disapprove all change requests that trigger the threshold set in Appendix D.

The Project Office will maintain a log of such approved change requests at any level. This log will be available for review by all management. All cost changes to the baseline costs shall be traceable. The L1M must approve in advance all procurements requiring the use of management reserve.

3.5 Development of the Work Plan

Working with the U.S.ASCB and following the funding guidance, the Level 1 Manager, in consultation with the U.S. CMS Research Program Manager, creates and updates the plan for U.S. CMS Software and Computing.

The U.S. CMS Software and Computing work plan defines the scope of the effort and the technical, cost and schedule baseline. It is expressed in form of a Work Breakdown Structure and a resource loaded schedule, which defines milestones and deliverables. It specifies the initial funding profiles, resource loaded schedules, budgets, Memoranda of Understanding (MOUs), and Statements of Work (SOWs) for the estimated effort. The work plan also outlines policies relevant to U.S. CMS Software and Computing, e.g. for local computing hardware support, for software and hardware systems at Tier-1 and Tier-2 centers, for long-term maintainability, licensing and support for software products, physicist support, overlap with construction project subsystem needs, etc.

The U.S. CMS Software and Computing work plan is technically realized as a set of documents, maintained by the management office, that are to be considered appendices of this Management Plan. This set of documents include the resource loaded WBS and schedule, the budget sheets, the MOUs and annual SOWs, and documents outlining policies relevant to U.S. CMS Software and Computing. These documents together make up the work plan. Changes to these documents follow change control as outlined above.

The L1M, with advice from the U.S.ASCB, will develop these items and will present them to the PMG for approval, and eventually to the Joint Oversight Group. The technical baseline is presented in Appendix A and schedule and milestones are presented in Appendix B. Estimations of costs and development of the baseline budget are detailed in Appendix C.

Use of facilities, services and infrastructure, including those at Fermilab, shall be agreed upon via Memoranda of Understanding. Within the framework of the MOUs, specific items shall be negotiated annually by Fermilab (as host laboratory), by the L1M and by the collaborating U.S. CMS institutions. These specific items are incorporated in the annual Statements of Work. The U.S. CMS Research Program Manager is signatory of the MOUs and SOWs.

It is expected that U.S. CMS Software and Computing will incorporate contributions towards its deliverables from efforts outside its scope. Examples are Grid-related R&D and deployment of Grid middleware into CMS software and computing systems through separately funded projects, like PPDG[4] and GriPhyN[5], or deployment of prototype Tier-2 installations through iVDGL[6]. U.S. CMS Software and Computing will seek to place MOUs with these projects to agree on deliverables and schedules.

3.6 Allocation of Funds

DOE and NSF will make funds available for support of U.S. CMS Software and Computing on an annual basis. The Level 1 Manager determines the allocation of funds to U.S. CMS institutions (including Fermilab as the host lab and the Tier-1 center). To this end, each year the L1M will review, negotiate and approve the SOW with institutions that are part of the U.S. CMS collaboration. The SOWs will include a description of the work to be performed, the requested funds and the manpower to be assigned to that year's activities. Also, through reviews, the projected costs will be known at WBS level 3. Subsequently, purchase orders are issued to those institutions. Explicit arrangements are defined in the U.S. CMS Software and Computing MOUs and annual SOWs. A management reserve will be held by the Level 1 Manager and will be applied during the fiscal year on the basis of performance and needs.

The U.S. CMS Research Deputy Program Manager will be the Principal Investigator if an NSF co-operative agreement. The Principal Investigator will administer disbursement and utilization of funds

provided by the NSF for U.S. CMS Software and Computing, subject to this management plan and the configuration, change control and reporting procedures herein defined.

The Administrator of NSF Funds is responsible for administration, disbursement and reporting of the use of NSF funds. The annual Statement of Work describes a work plan for each institution that is consistent with the scope of U.S. CMS Software and Computing approved by the funding agencies. Expenditures will be authorized at the lowest level of the WBS in a manner consistent with the approved Statement of Work for each institution. The NSF funded institutions invoice by WBS activity. The Level 1 Manager's approval is required before invoices are paid.

3.7 Management and Control Systems

Relevant formal management systems and requirements are implemented to aid in achieving the goals and deliverables, and to account properly for the use of funds. Instruments for U.S. CMS Software and Computing tracking and reporting include the SOW and cost reporting.

The requested resources for U.S. CMS Software and Computing are estimated using the resource loaded WBS. The cost baseline is established and approved and is equal to the sum of the budgeted costs for each element of the WBS. Escalation is done assuming an annual escalation rate as given as guidance from DOE. In addition, an overall management reserve will be held each fiscal year and released during that year.

Reporting will be done to the PMG, the U.S. CMS Research Program Manager, and to the U.S. LHC Program Office. U.S. CMS Software and Computing will issue quarterly reports on project status, technical achievements, financial and schedule performance. Software and computing is different from detector construction projects, in that software and computing schedule performance cannot easily be measured by "earned value" as an adequate metric for that has not been developed. Also, experience on labor costs for production of software cannot readily be extrapolated. Instead, U.S. CMS Software and Computing will use detailed effort and milestone tracking.

Schedule performance is assessed by milestone completion. Spent effort is assessed on the basis of regular effort reports from engineers and managers, using a bottom-up approach, where for each WBS item expenditure of labor is accumulated. The need for extensive and well-defined milestones and deliverables is recognized to allow measuring schedule performance. The WBS will therefore be refined as the effort evolves to provide well-defined milestones and deliverables at an appropriate level of detail.

3.7.1 Reviews

To assess performance Fermilab runs the regular SCOP reviews, as mentioned above. In addition, DOE and NSF will conduct periodic comprehensive reviews, normally one every year. Management will also give a verbal status report in a yearly one-day meeting between reviews.

3.7.2 Cost estimates and Contingency

Cost estimates do not contain a contingency. Management will annually retain a fraction of the budgeted funds as a management reserve to mitigate problems, as described above. The cost estimations that are the basis of the planned scope and funding profile rely on extrapolation factors, which in some cases are more than an order of magnitude. To assess the risk of cost overrun, cost estimations will be continuously updated by tracking technology evolution. The computing facilities will be built to cost. Staging of procurements will mitigate cost overruns due to eventual unfavorable technology and cost developments.

3.7.2 Development of the Work Plan

The work plan is outlined in Appendices A, B and C of this document. These Appendices define the schedule, milestones, deliverables, costs and budget. Appendix A refers to the document that defines the Work Breakdown Structure, Appendix B refers to the document that shows the schedule and milestones

and Appendix C refers to the document with detailed cost estimates. This set of notes defines the work plan and is part of this Management Plan. The work plan gets reviewed regularly, as described above, and revisions to the documents, the WBS, schedule and cost, with respect to the approved plan, are subject to change control.

4. Interrelationship with Other Entities

4.1 Relation to CMS

U.S. CMS Software and Computing operates within the context of the US CMS Research Program, headed by the Research Program Manager, and within the internationally funded CMS experiment located at CERN.

The U.S. CMS Software and Computing Management implements decisions taken by the CMS Collaboration, the CMS Resource Review Board (RRB) and the Computing Resource Review Board (C-RRB), and works within the directions given by the U.S. CMS Research Program Manager. The RRB comprises representatives from all funding agencies involved in CMS and LHC computing, respectively, and the managements of CERN and the CMS collaboration. The U.S. has DOE and NSF representatives. Deliverables of U.S. CMS S&C and the U.S. CMS research program to CMS and the LHC computing system will be subject of a Memorandum of Understanding with CERN.

The CMS collaboration organizational structure consists of two parts[10]. There is a federal element, responsible for overseeing the CMS project as a whole, which consists of the Collaboration Board (CB), the Management Board, the Finance Board and the Technical Coordination Group. This central structure is complemented by a set of quasi-independent bodies responsible for subprojects. The CMS collaboration has organized the CMS software and computing efforts as a subproject, together with the Physics preparations and DAQ and trigger. The “Computing and Core Software” (CCS), the “Physics Reconstruction and Selection” (PRS) and the “Trigger and Data Acquisition” (TriDAS) projects are united in the “CPT” project[9]. In CMS, each subproject is governed by a separate Institutional Board, except for CPT, which has the CB as its institutional board.

The CB is the entity within CMS that must ratify all policy and technical decisions. The CB elects its chair for a three-year term. The U.S. CMS managers have no official role in the CB. Currently, the U.S. CMS Research Program Manager is also the Fermilab Institution Representative, and thus is member of the CMS CB.

The CMS Management Board (MB) is responsible for directing the CMS project and for drawing up policy. It is chaired by the CMS Spokesperson, who is elected by the CB for a three-year term. The MB interacts with the CERN management and its scientific committees. Membership includes technical coordinators and the subsystem project managers. There are also regional representatives, and the U.S. CMS Collaboration Chair is currently a member of the MB.

The CMS Steering Committee (SC) is a subcommittee of the MB and assists the MB in its task of directing and overseeing the CMS project. The SC is responsible for the execution of the CMS project in line with overall policy laid down by the MB. Subsystem project managers are members of the SC.

The U.S. CMS managers are not members of the MB and the SC. Currently, the U.S. CMS Research Manager is also the CMS HCAL subproject manager, and thus is member of the CMS MB and SC.

The CPT project has a common technical board between the three subprojects, the Joint Technical Board. The CCS Project Manager, his or her deputy, the PRS and the TriDAS project managers represent the CPT subsystem on the CMS Steering Committee. CCS has a Technical Coordinator and a Resource Manager. The CCS project manager has overall responsibility for the direction of the CCS Project including all tasks carried out for that project by U.S. CMS Software and Computing. The CCS Technical Board is a forum for preparing CMS technical policies on Computing and Core Software issues, in an advisory capacity to

the CCS Project Manager. It includes so called “Tier1/Tier2 technical experts”, appointed by the CCS Project Manager in consultations with the regional centers. The U.S. CMS Software and Computing L1M attends these meetings.

The CCS Finance Board is responsible for the funding and expenditure issues of CCS, including “Software Agreements”. Membership includes representatives of funding agencies, nominated by the funding agency contacts. The U.S. CMS Software and Computing L1M is the representative of the U.S. funding agencies.

The CCS Steering Committee advises the CCS Project Manager on all aspects of the project. Meetings are held frequently. The CCS Project Manager nominates experts to be members of the CCS SC. It is expected that the U.S. CMS Software and Computing managers would be nominated to be members of the CCS SC.

The collaborative aspects of CCS are handled by the CPT Institutional Board, which is identical to the CMS Collaboration Board, with separate meetings on CPT issues. For their meetings, the U.S. CMS Software and Computing L1M will attend the CMS CB as alternate for the Fermilab institutional representative.

To create a strong reciprocal linkage between U.S. CMS Software and Computing and the overall CMS project, the CCS project manager is an ex officio member of the U.S.ASCB. The U.S.ASCB has the responsibility for providing liaison between U.S. CMS Software and Computing and the CCS Institutional Board, and the U.S. CMS Software and Computing Level 1 Manager will act as liaison to the CCS Technical Board.

As far as execution of the U.S. CMS work plan is concerned, decisions by the CMS Steering Committee or the CCS Project Management should also be adapted directly or, if not compatible with U.S. operating procedures, adapted so as to match the decisions as closely as possible. In the latter case CMS management should be consulted and informed about the detailed U.S. implementation.

The U.S. CMS collaboration will be contributing to CMS computing in a variety of ways, each of which will have an appropriate formal mechanism for establishing milestones, deliverables, and specifications. Levels of support for production activities, including those required to support the design, testing, simulation, and commissioning of the detector should be supported by MOUs negotiated with CMS by the L1M with input from the U.S.ASCB and with the approval of the PMG and funding agencies. The software development that directly relates to the international CMS effort should be developed as part of the CMS software and computing plan and approved, presumably as part of the work plan for U.S. CMS Software and Computing, by the PMG and the funding agencies. Software efforts specifically in support of U.S. physicists or intended to solve particular problems specific to the U.S., should be developed as part of the work plan with substantial input from U.S.ASCB and approved by the PMG and, if required, by the funding agencies.

4.2 Relation to U.S. CMS and to the U.S. CMS Research Program

U.S. CMS Software and Computing provides suitable computing hardware and framework and infrastructure software to facilitate a broad range of offline software tasks by the U.S. CMS Collaboration. At present, major U.S. CMS activities are R&D on the network-distributed LHC computing models, building the reconstruction, detector and analysis software, study and verification of the CMS detector design, high level trigger and data acquisition system performance, and study of CMS’ physics capabilities using fully simulated and reconstructed events.

The work by U.S. physicists on these tasks is fully integrated with the work of the CMS collaboration as a whole. U.S. CMS has several areas of leadership, including the computing model R&D, reconstruction and detector software, the user analysis environment, and high level triggers. In the LHC running phase a more unified U.S. CMS structure managing the software and data analysis will be formed as appropriate (see section 5).

The U.S. CMS Construction Project is responsible for the construction of specified elements of the CMS detector as designed by U.S. physicists. The scope of the project extends from the detector elements to transducers to front end electronics, through L1 pipelined triggers, L2 and L3 triggers and data acquisition

including the L3 computing farm and data logger. U.S. Software and Computing concerns the steps needed to facilitate these tasks all the way to physics analysis by providing suitable hardware, framework and infrastructure software.

The U.S. CMS Maintenance and Operations effort consists of the operation of the U.S. built detector, R&D for possible upgrades, the M&O Program Office, and Physics Analysis Center/Virtual Control Room.

The CMS experiment is a unified enterprise, in which the Construction Project, the U.S. CMS Maintenance and Operation Program and U.S. CMS Software and Computing will be well coordinated to meet the needs of U.S. CMS physicists seamlessly as they work on tasks from the building and commissioning of detector elements, to building the software and production systems, to the physics analysis. The U.S. CMS Research Program Manager facilitates this coordination.

This link is formally made in that the U.S. CMS Research Program Manager is ex-officio member of the U.S. ASCB, and the Level 1 Manager of the Software and Computing is a member of the U.S. CMS Advisory Board. The U.S. CMS Research Program Manager is signatory of the MOUs and of the annual SOWs with each institution.

For each Fiscal Year the U.S. CMS Research Program Manager makes an initial allocation of the funding provided to the U.S. CMS Research Program. Within the funding guidance of each year, and considering the funding baselines of U.S. CMS Software and Computing and the Maintenance and Operations Program, the U.S. CMS Research Program Manager advises the DOE and the NSF about how the Research program funding gets divided. Scope changes must be approved by the PMG with concurrence of the U.S. CMS Research Program Manager. Such scope changes will be based on proposals made by the L1M and the Maintenance and Operations program manager, with the U.S. CMS Research Program Manager receiving those proposals and considering them for approval by the PMG.

During the Fiscal Year, the U.S. CMS Research Program Manager concurs on change requests, which assign management reserve, as described above. This procedure assigns management reserve to the tasks, but allows the PMG and the U.S. CMS Research Program Manager to approve and track the use of that reserve for the entire research program.

4.3 Relation to Fermilab

The Fermilab Computing Division is home to U.S. CMS Software and Computing within Fermilab, is providing the efforts for running the U.S. CMS Tier-1 regional center and is supporting U.S. CMS in many ways. CMS Computing is a major part of the computing work at Fermilab and it is important to ensure that the strategic plans for computing at the lab are well aligned with Fermilab's role as host lab for U.S. CMS, well aligned with Fermilab's role in the Grid world and well aligned with what needs to be done to support other scientific programs of the lab. This strategic alignment will produce significant cost savings for the project as it is able to exploit the synergy with other major Fermilab computing efforts.

It is therefore important for the Fermilab Computing Division Head to play a formal role in the project planning for the US CMS Software and Computing Project. The division head is ex-officio member of the U.S. ASCB and of the PMG, as described above. The CD Head should be involved in project planning with the L1M to abet this strategic alignment.

The L1M and the L2M for the User Facilities subproject are members of CD. The ‘project office’, which provides administrative resources to U.S. CMS Software and Computing management, resides within the Fermilab Computing Division. The staff for the Tier-1 Regional Center and much of the staff for the User Facilities Project are members of Computing Division.

As the U.S. CMS host lab, Fermilab is involved in major U.S. CMS activities besides U.S. CMS Software and Computing. As part of the U.S. CMS Research Program, but with funding separate from U.S. CMS Software and Computing, Fermilab is providing a “Physics Analysis Center” for U.S. CMS. Fermilab is also a collaborating institution of CMS and U.S. CMS, with a Fermilab CMS group that consists of scientists, engineers and technical personnel from all Fermilab divisions. All these CMS activities at Fermilab should be synergistic and well coordinated.

4.4 Relationship to the U.S. Funding Agencies

The Department of Energy (DOE) and the National Science Foundation (NSF) are the funding agencies for U.S. CMS Software and Computing. As such they monitor technical, schedule and cost progress for the program. The organizational structure is shown in Appendix E.

The DOE has delegated responsibility for the U.S. CMS activities to the Office of Science, Division of High Energy Physics. The NSF has delegated responsibility for the U.S. CMS project to the Division of Physics, Elementary Particle Physics Programs.

U.S. CMS Software and Computing receives substantial support from both DOE and NSF and there is close collaboration between DOE and NSF supported groups. It is therefore essential that DOE and NSF oversight be closely coordinated. The DOE and NSF have established a Joint Oversight Group (JOG) as the highest level of joint U.S. LHC Program management oversight. The JOG has responsibility to see that the U.S. LHC Program is effectively managed and executed so as to meet the commitments made to CERN. The JOG provides programmatic guidance and direction for the U.S. LHC Research Program and coordinates DOE and NSF policy and procedures with respect to both.

5. Evolution of U.S. CMS Software and Computing

This plan applies to the 'initial development and deployment phase' for the software and facilities. Once that phase is complete, the software and the facilities go into the 'operation, support, and further development phase'. This should occur after CMS starts taking data. At that point, there should be a new 'operations plan' which would replace this plan.

It is very important to recognize that software development and hardware evolution will continue throughout the life of CMS. The resources required for the ongoing operation of the facilities and evolution of the software and hardware are quite significant. The operation of the Regional Center is at least a 15-20 year commitment. For at least 2/3 of its lifetime, it will be in an 'operations' rather than 'construction' phase. Continual investment in software development, technology tracking, and R&D throughout this period will be essential if the facilities are to continue to serve the interests of U.S. CMS as physics and computing technology move forward. Similarly, the scientific software will be in a state of continual development and evolution throughout the operations period. This will be driven both by changes in physics goals and analysis techniques and by changes in underlying software and hardware technologies.

The U.S. Software and Computing effort will finish in FY2008. The ongoing CMS Research Program after that is not the subject of this plan and operations and management of that phase will be delineated in a later operations plan.

5.1 Review and Modification of this Management Plan

After its adoption, this Management Plan is periodically reviewed by the Level-1 and Level-2 Managers as part of the preparation for reviews by the Project Management Group or Software and Computing Oversight Panel. Proposals for its modification may be initiated by the L1M, the U.S. CMS Research Program Manager, the U.S. CMS Advisory Software and Computing Board, the Fermilab Deputy Laboratory Director, and the funding agencies. Modifications of the Management Plan will require approval of the L1M, the U.S. CMS Research Program Manager, the Fermilab Associate Director for Research, the DOE/NSF Project Manager, and the Joint Oversight Group.

Appendix A. Technical Baseline Document

This appendix describes the technical baseline and the Work Breakdown Structure.

It is provided as a separate document and can be obtained at the following URL:
http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/v0.99/uscms_pmp_appendix_a_v0.99.pdf

Appendix B. Schedule, Milestones and Deliverables Document

This appendix describes the schedule for U.S. CMS Software and Computing. It outlines the baseline schedule, milestones and deliverables for the User Facilities and the Core Application Software subprojects.

It is provided as a separate document and can be obtained at the following URL:
http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/v0.99/uscms_pmp_appendix_b_v0.99.pdf

Appendix C. Cost Document

This appendix outlines the baseline costs and funding profile for U.S. CMS Software and Computing.

It is provided as a separate document and can be obtained at the following URL:
http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/v0.99/uscms_pmp_appendix_c_v0.99.pdf

Appendix D. Change Control Thresholds

	Oversight Level	Management Level
	U.S. CMS Research Program Manager Fermilab Associate Director for Research	US CMS Software and Computing Manager
Technical	Any change in scope that has a significant impact on the CMS physics performance or the ability of U.S. CMS to participate in the CMS research, and selection of institutions for Tier-2 centers and other significant work. Significant changes in scope or detailed design of the UF system.	Any change in scope, physics performance of a subsystem or the ability of U.S. CMS to participate in CMS research. Selection of institutions for Tier-2 centers and other significant work. Selection of changes in scope or detailed design of subsystems.
Schedule	Greater than three month change in a Level 2 milestone.	Greater than a one month change in a Level 2 milestone. Greater than one month change to milestones defined by the L1M.
Cost	Cumulative changes greater than $100 thousand to the US CMS Software and Computing cost baseline at WBS Level 2, or changes of one FTE year in level of effort agreements.	Cumulative changes in the cost baseline of $100 thousand at WBS Level 2 or changes in the FTE count in level of effort agreements.

Appendix E. Letter from Funding Agencies to Fermilab

U.S. Department of Energy
and the
National Science Foundation

JOINT OVERSIGHT GROUP

August 18, 1999

Dr. Michael Witherell
Director
Fermi National Accelerator Laboratory
P.O. Box 500
Batavia, Illinois 60510-0500

Dear Dr. Witherell:

The U.S. Large Hadron Collider (LHC) Construction Project is well underway. The International Agreement between the United States and the European Organization for Nuclear Research (CERN) provides that beyond the LHC Construction Project U.S. scientists participate as full partners in the LHC Research Program. The Department of Energy (DOE) and the National Science Foundation (NSF) are now considering the elements necessary for successful U.S. participation in the Research Program following the completion of the U.S. LHC Construction Project and commissioning of the facility.

The International Agreement provides that the U.S. funding agencies represent the U.S. interests with the governing bodies of CERN. This representation will be carried out primarily through the DOE/NSF Joint Oversight Group (JOG). The JOG, in turn, interacts with the U.S. collaborations to provide the funding, oversight, and infrastructure needed for the U.S. involvement. The scientific collaborations, which are responsible for the specification, design, and fabrication of the two detectors, ATLAS and CMS, will also be responsible for operation of the detectors and analysis of the physics data. The U.S. groups, U.S. ATLAS, and U.S. CMS, are expected to share in these responsibilities. Due to the long lead times involved in preparing for the research program, we must act now to formalize the management arrangements for the research phase. In particular, there must be a formal management structure with clear lines of fiscal authority to support the current efforts to design and implement the software, computing, and networking that will enable U.S. physicists to be competitive in data analysis.

The conclusion of a series of agency reviews of directions for LHC computing is that the computing should be managed as a project with a clear management structure. The Host Laboratory model has proven to be a successful vehicle for the U.S. LHC Construction Project. Consequently, the JOG wants to use this model for the U.S. LHC Research Program, which comprises the activities necessary for participation in the operation of the CMS and ATLAS detectors and in the related physics programs. With regard to the CMS detector, we are asking the Fermi National Accelerator Laboratory (Fermilab), in addition to hosting the U.S. CMS Construction Project, to assume the role of Host Laboratory for the U.S. CMS Research Program, consistent with the International Agreement and its Detector Protocol.

Host laboratory responsibilities for the U.S. CMS Research Program include management oversight for U.S. CMS computing. It is understood that, along with management oversight for the computing project, Fermilab will function as the Regional Center (Tier 1) for U.S. CMS computing. We request that, as Host Laboratory, in concert with the U.S. CMS Collaboration, Fermilab direct the preparation of a Project Management Plan (PMP) for U.S. CMS software, computing, and networking. This plan should recognize the software and computing initiatives already underway. Since these activities are intimately involved with the extraction of physics results, the full CMS Collaboration must be involved in the evolution of the PMP. The draft PMP should be submitted to the JOG for review and approval prior to implementation.

Just as the detector collaborations are embarking on a new paradigm for data analysis, the funding agencies are embarking with the U.S. LHC Research Program on a new paradigm of international cooperation. To ensure that the U.S. program is well managed and productive, we ask that you accept the Host Laboratory role outlined above for Fermilab, indicating your willingness by signing on the concurrence line below.

Thank you in advance for your help in continuing our successful partnership in management oversight of the U.S. LHC Program.

Sincerely,

John R. O'Fallon
Co-chair
Joint Oversight Group
Department of Energy

John W. Lightbody, Jr.
Co-chair
Joint Oversight Group
National Science Foundation

cc:
Rodger Cashmore, CERN
Michel Della Negra, CERN
Robert Eisenstein, NSF
Daniel Green, FNAL
Martha A. Krebs, SC-1
Luciano Maiani, CERN
Harvey Newman, CalTech
S. Peter Rosen, SC-20
Ken Stanfield, FNAL
Robert Wunderlich, CH/Fermi

****

On behalf of the Fermi National Accelerator Laboratory, I accept the role of Host Laboratory for the U.S. CMS Research Program.

Dr. Michael Witherell
Director
Fermi National Accelerator Laboratory

REFERENCES

1 The CMS Collaboration, Computing Technical Proposal. CERN/LHCC 96-45, December 1996. The full CTP text is available at http://cmsdoc.cern.ch/cms/CMG/CTP/index.html

2 U.S. CMS Applications Software Sub-project, L. Taylor (on behalf of U.S. CMS), 23 April 1999. http://cmsdoc.canr.ch/~cmscan/uscmssw/review_may_99/papers/app_sw.pdf

U.S. CMS User Facilities Sub-project, J. Womersley (on behalf of U.S. CMS), 23 April 1999. http://cmsdoc.canr.ch/~cmscan/uscmssw/review_may_99/papers/RegionalCenter.pdf

3 The membership of the U.S.ASCB required an amendment to the CMS constitution, which was revised accordingly.

4 PPDG proposal http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/docs/scidac01_ppdg_public.pdf

5 GriPhyN proposal to NSF ITR http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/docs/griphyn_proposal_final.pdf

6 IVDGL proposal to NSF ITR http://computing.fnal.gov/cms/bauerdic/uscmssc/pmp/docs/iVDGL_proposal_all.pdf

7 Project management plan of the CMS CPT project, CMS internal note CMS IN-2002/068, http://cmsdoc.cern.ch/documents/02/in02_068.pdf

8 CMS Constitution, revised June 2003, http://cmsdoc.cern.ch/doc/gen/docs/constitution_030619.pdf

Submission and Approvals

_____
Lothar A.T. Bauerdick
U.S. CMS Software & Computing Manager
Fermilab

_____
Dan Green
U.S. CMS Research Program Manager
Fermilab

_____
Hugh Montgomery
Associate Director
Fermilab

_____
Ken Stanfield
Deputy Director
Fermilab