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GEM Project Management Plan (DRAFT)

April 1, 1993

Abstract:

The GEM Technical Design Report defines the scientific, technical, schedule, and cost objectives for the GEM Project. This GEM Project Management Plan (GEM-PMP), together with associated documents establish and describe the guidance and controls that Project participants will follow to accomplish those objectives. This plan also defines the roles, responsibilities, and levels of authority for project participants and identifies key planning and management documents that will be utilized for control of the GEM Detector Project.

DRAFT
GEM PROJECT MANAGEMENT PLAN
APRIL 1, 1993

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1.0 INTRODUCTION

1.1 SCOPE

The GEM Technical Design Report[1] defines the scientific, technical, schedule, and cost objectives for the GEM Project. This GEM Project Management Plan (GEM-PMP), together with the associated documents listed in Appendix C, establish and describe the guidance and controls that Project participants will follow to accomplish those objectives. This plan also defines the roles, responsibilities, and levels of authority for project participants and identifies key planning and management documents that will be utilized for control of the GEM Detector Project.

A work plan description is provided together with the project Work Breakdown Structure (WBS) and associated costs and schedules. The management, planning, controls, reports and support tasks are identified. Plans for Environmental Safety and Health, Configuration Management, Systems Engineering and Quality Assurance are described. An Advance Acquisition or Assistance Plan addressing methods of procurement and types of subcontracts is attached.

The GEM Project is a diverse international enterprise organized to design, build, operate and analyze results from a large, experimental detector that will be operated in the SSC Collider. The GEM Collaboration understands the need to establish a clear management plan and structure to build the complex detector proposed. It also recognizes that the successful cooperation of groups from many areas of the world, supported under diverse funding arrangements, must be maintained for the GEM detector to be completed on schedule and to meet its technical and cost objectives.

1.2 PARTICIPANTS

The SSCL Project Management Plan (SSCL-PMP) defines the responsibilities of the Department of Energy (DOE) Office of the Superconducting Super Collider (OSSC), the DOE OSSC On-Site Project Office (SSCPO), the Texas National Research Laboratory Commission (TNRLC), and the Universities Research Association, Inc. (URA), the Department's Management and Operating (M&O) contractor for the SSC. The Superconducting Super Collider Laboratory (SSCL) is the institution organized by URA to carry out its responsibilities under the prime contract with DOE.

The Physics Research Division Project Management Plan for Detectors (PMPD) provides the framework within which the construction of all detectors will be carried out at the SSCL. It defines the responsibilities of the Physics Research Division and other SSCL divisions required to manage and support the detector programs. It is the higher level management plan from which this document, GEM-PMP, is developed.

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[1]GEM Technical Design Report, GEM-TN-93-262 (May 1, 1993).

GEM Collaboration was approved to proceed with the design of a major SSC detector. Subsequently, the GEM Technical Design Report (TDR) with supporting documents was delivered to the SSCL on April 30, 1993. Following review of this TDR by SSCL management in May-July, 1993, the GEM Collaboration is expected to proceed to construction, subject to validation reviews by the U. S. Department of Energy. This review is anticipated in October 1993.

This Project Management Plan is expected to go into effect at the time of the approval of the GEM Technical Design Report. Previous to that time there has been an evolution of several interim organizations. The first one, with two cospokesmen and a steering committee, prepared the GEM EOI (Expression of Interest). The second, adding the Collaboration Council, prepared the GEM LOI (Letter of Intent). The third interim organization is preparing the GEM Technical Design Report. It consists of two spokesmen, the Collaboration Council, the Executive Committee, an Acting Project Manager, and an initial set of subsystem groups. The intention is that the present interim organization will evolve smoothly into the final GEM organization described in this plan. The GEM organization is defined succinctly by Appendix B, which is the GEM Organization Plan.

Key members of the GEM Management are selected in consultation with the SSCL Director. The GEM Organization Plan defines requirements for membership in the Collaboration and for selection of key management.

The institutions that comprise the GEM Collaboration will design the GEM detector and will be responsible for its fabrication, installation and operation. The SSC Laboratory is one of the collaborating institutions within GEM and will have a central role in the management of the project.

The proposed detector is described in the GEM Technical Design Report. Following a review and approval process, a technical baseline will be established for the GEM detector that, together with this Project Management Plan, will form the basis for design administration of the GEM detector at SSC Laboratory.

1.5 REFERENCE DOCUMENTS

Appendix C contains a complete list of documents referenced in this PMP. The extent to which they apply is defined in individual sections of this plan.

GEM is one of two major detectors currently planned for the SSC. GEM consists of over 85 institutions and more than 700 scientists and engineers who will participate in the design and fabrication of the detector. A detailed listing of the current GEM membership is provided in Appendix A. A summary of academic institutions and laboratories by region is provided in Table 1-1.

1.3 APPLICABILITY

This plan provides guidance for the overall management of the GEM Project. The technical management aspects apply to all members of the Collaboration. Specific descriptions and conditions for tasks to be accomplished by GEM members will be identified in SSCL Memorandum Purchase Orders, Purchase Orders, Interlaboratory Agreements, Memoranda of Understanding, and/or Government to Government Agreements. Major procurements and activities funded by non-US institutions and other-than-DOE funds shall be governed by the rules, regulations, and procedures of those institutions.

Table 1-1. Collaboration Institutional Membership

Albania	2 institutions
Belarus	2 institutions
Brazil	2 institutions
China	9 institutions
Ecuador	1 institution
Georgia	1 institution
Germany	1 institution
India	3 institutions
Israel	1 institution
Japan	2 institutions
Korea	8 institutions
Mexico	2 institutions
Romania	2 institutions
Russia	12 institutions
Taiwan	1 institution
USA	49 institutions

1.4 BACKGROUND

The GEM Collaboration submitted an Expression of Interest[2] (EOI) in July, 1991 and was approved by the SSCL to develop a Letter Of Intent[3] (LOI). The LOI was submitted in November, 1991. After review by the SSCL Program Advisory Committee and the SSCL, the

[2]Expression of Interest to Construct a Major SSC Detector, B. Barish and W. Willis (Cospokesmen), July 8, 1991, GEM-TN-91-00001.

[3]GEM Letter of Intent; B. Barish and W. Willis (Cospokesmen), November 30, 1991, GEM-TN-92-00049.

2.3 TECHNICAL OBJECTIVES

A simplified representation of the GEM Detector is provided in Fig. 2-1. The detector consists of a large open magnetic volume occupied primarily by a precision muon spectrometer. Within the muon spectrometer the interaction point is surrounded by a central tracking system, and by particle calorimeters. This detector completely encloses the interaction point, except for small openings for the entering and exiting beams, and is designed to operate initially at the SSC luminosity of $10^{33}cm^{-2}s^{-1}$. The momenta of charged particles are measured with the tracking devices placed inside the solenoidal magnetic field, and the energies of hadrons, photons, and electrons are determined with the calorimeters. Muon momenta are measured precisely with the outermost set of tracking chambers. The calorimeter systems include an especially precise electromagnetic calorimeter based upon liquid krypton ionization calorimetry. The hadron calorimeter provides good hadron jet measurement and muon energy loss and tracking information. The central tracker plays an important role in reducing the influence of background processes on the search for new physics. This detector, with its emphasis on clean measurement of electromagnetic tracks and energies, is designed to carry out the frontier program of physics research embodied by the name of the detector, GEM, which is an acronym for Gammas, Electrons and Muons.

2.4 SCHEDULE OBJECTIVES

The major schedule objectives of the GEM program are given below. Additional details are provided in Section 9.0.

Description	Date
Begin Conceptual Design	January 92
Complete Technical Design Report	April 93
Start Detailed Design	July 93
Start Installation	January 96
Start Commissioning	March 99
Start Operations	September 99

2.5 COST OBJECTIVES

The cost of experimental systems established in the SSC Technical Baseline is $752M (FY90$). This budget is expected to partially support two large detectors and a number of smaller experiments. The remainder of the costs of the detectors are assumed to be supplied from funds outside of the SSC baseline estimate.

2.0 OBJECTIVES

2.1 PROGRAM OBJECTIVES

The overall program objectives of GEM are to design, construct, and operate a major experimental detector at the SSCL. The highest schedule objective is to achieve operational status of the GEM Detector when the SSC becomes operational. This detector will have the capability to explore the new physics domain opened-up by the operation of a proton-proton collider with a total energy of 40 TeV and a luminosity of $10^{33} cm^{-2} s^{-1}$ It is anticipated that important and fundamental discoveries concerning the ultimate nature of physical matter and forces will result from this program.

2.2 PHYSICS OBJECTIVES

While the principal objective of the GEM research program is the exploration and discovery of new physics, there are specific questions based on our present knowledge of high energy physics which have been used to guide the design of the GEM detector. These questions include:

a. What is the mechanism for electroweak symmetry breaking, the process by which particles obtain mass?

b. What are the properties of the *t* (top) quark?

c. Are there additional heavy bosons to indicate the presence of new, as yet undiscovered forces?

d. Are leptons and quarks elementary or are they composed of more fundamental particles?

e. Do particles exhibit a larger symmetry pattern such as supersymmetry?

The first two questions arise from the present direction of particle physics research and are of great current interest. Models of electroweak symmetry generally postulate the existence of one or more new particles such as the Higgs boson. If the Higgs boson exists it will be produced at the SSC, as will the top quark, and their detection is given high priority. Questions (c), (d), and (e) are more general but also more speculative. They illustrate the exploratory nature of experimentation in a new energy regime and serve to guide the detector design requirements.

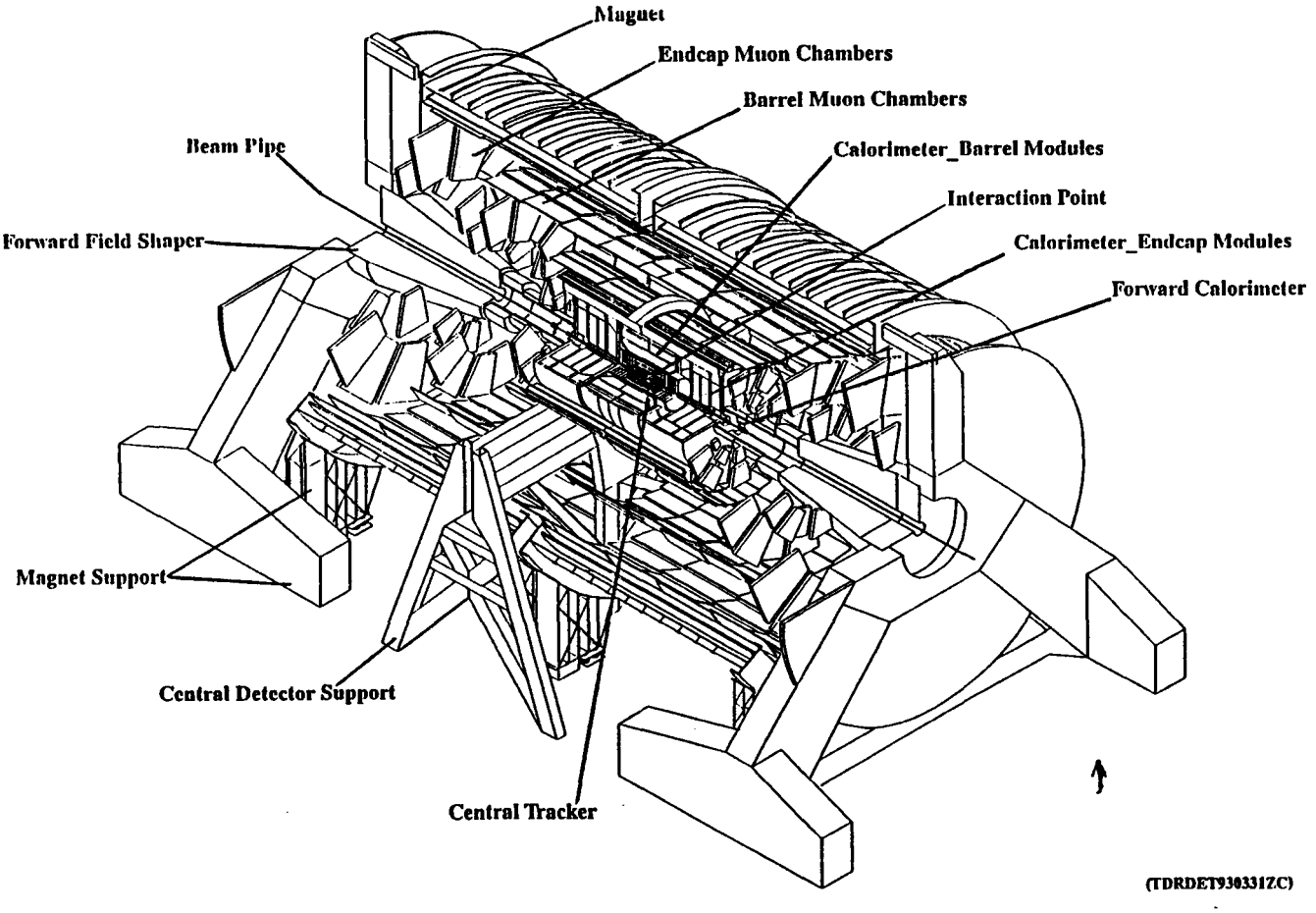

Figure 2-1. The GEM Detector

The GEM program total costs are estimated at about $500M (FY90$). The specific costs of GEM technical systems are provided in Section 8.0. Additional details are provided in Appendix F.

2. The Universities Research Association (URA), the management and operating (M&O) contractor for the SSC; and

3. The Texas National Research Laboratory Commission (TNRLC), the designated agent of the State of Texas.

The relationship of the above organizations are shown in Fig. 3.1. Brief summaries of their responsibilities are provided below. Specific details are given in the SSCL-PMP.

3.2.1 DOE Office of the Superconducting Super Collider Program (Program Office)

The DOE Program Office provides the policy and fiscal guidance for the construction of the SSC and oversees the development of the SSC-directed high-energy physics research program. Organizationally, this office reports to the Director of Energy Research, permitting a close coordination between the SSC effort and the high-energy physics program under the Office of High Energy and Nuclear Physics.

3.2.2 DOE On-Site Project Office Organization (SSCPO)

The DOE Project Office is responsible for administering the management and operating contract with URA, including approval authority for all actions within levels delegated to the Project Office. The Office provides guidance to the Laboratory management and monitors project execution by the URA staff. The Office reports to the DOE SSC Project Director.

Formal contact between DOE and GEM is via the PRD. The specific responsibilities include DOE review of plans and baselines, funding foreign travel, inter-governmental agreements, oversight and formal communication between DOE and SSCL. Detailed description of the DOE-SSCL interface is provided in the PMPD.

3.2.3 Universities Research Association (URA)

The Universities Research Association (URA) is the DOE M&O contractor responsible for the SSC design, construction, commissioning, maintenance and operations, including research programs. URA has responsibility for meeting the overall technical objectives within the SSC cost and schedule authorization provided by the Project Directives. The work of URA will be performed under the terms and conditions of DOE Contract No. DE-AC02-89ER40486.

3.2.4 Texas National Research Laboratory Commission

The State of Texas, acting through the Texas National Research Laboratory Commission (TNRLC) provides partial funding for the SSCL as well as assistance in the establishment of

3.0 MANAGEMENT ORGANIZATION AND RESPONSIBILITIES

3.1 OVERVIEW

Overall planning and execution of the SSC Laboratory's Experimental Program are the responsibility of the Physics Research Division (PRD) at the SSCL. Within the SSCL Experimental Program, one of the major detectors is the one proposed by the GEM Collaboration. The GEM Collaboration will be responsible to the Associate Director of the Physics Research Division (PRD) for financial and technical planning and for establishing performance goals. Establishment of the GEM Project, organized and managed under the provisions of this GEM Project Management Plan, is the principal means by which this responsibility is established and assured.

The PRD, and the GEM Project Department, will establish appropriate interfaces with the SSC General Manager's Office and the SSC Project Manager's Office and other SSCL divisions, particularly the Accelerator Systems Division (ASD), Magnet Systems Division (MSD), and Conventional Construction Division (CCD), to coordinate detector activities with SSC construction and operations. The SSCL organization is described in Section 3.3. The structure for management and oversight of the SSCL is outlined in Section 3.2.

The GEM management, specifically the Cospokesmen and the GEM Project Manager, will be responsible for organizing the Collaboration effort including the assignment of technical responsibilities together with the establishment of the baseline costs and schedules. Responsibilities include design, construction, and commissioning of the GEM detector as well as overall reporting and performance evaluation and associated environment, safety, and health related issues.

Construction of the detectors for the SSC will be undertaken by many organizations and institutions external to the SSC Laboratory. Likewise, significant portions of the detector funding will be provided by sources outside the SSC Project. For these reasons, part of the responsibility for construction of detector components will reside outside the SSCL. However, responsibility to the PRD Associate Director will be maintained by the GEM management through the GEM Project Manager resident at the SSCL. The GEM Project Manager will head the project organization of the collaboration.

3.2 SSC MANAGEMENT AND OVERSIGHT

There are three organizations with responsibilities for the establishment of the SSC Laboratory and construction of the facilities:

1. The DOE Office of the SSC, composed of the program office in Washington and the project office in Texas;

SSCL facilities. Detailed agreements (Memorandum of Understanding of November 9, 1990) have been reached regarding TNRLC activities in the following areas: Regional land use, supporting infrastructure (roads, power, etc.), state and local permits, financial assistance, land acquisition, and public relations.

3.3 SSCL ORGANIZATION

The SSCL organization is shown in Fig. 3-2. The Laboratory Director is responsible for all Laboratory research, operations, construction, policies and procedures. The Associate Director for Physics Research is responsible for the experimental program, including the definition of requirements for construction of the experimental facilities and the development of the initial complement of experiments. The General Manager, reporting to the Director, is responsible for overall program management and for assuring that Project activities and administrative and service functions are undertaken within the framework of overall Laboratory policies.

The SSCL Project Manager is responsible for overall planning, engineering, and construction of the Project within guidelines provided by Project Directives from SSCPO. This office is responsible for providing technical systems, constructing both special and conventional facilities and for providing liaison with R&D programs in support of the SSC Project. Reporting to the Project Manager are the Associate Directors for Accelerator Systems, Magnet Systems, and Conventional Construction. The Associate Director for Physics Research reports directly to the Laboratory Director. These Associate Directors have the responsibility to ensure that the design of the systems delegated to them meet SSC technical objectives within prescribed cost and schedule.

In general, formal coordination of GEM activities with the Accelerator and Conventional Construction Divisions is a responsibility of the PRD and is described in the PMPD. In order to maximize the flow of needed information among technical staff, informal working groups (both ad-hoc and standing) will also be appointed including members of GEM and other appropriate organizations. The working groups will be chaired by the Laboratory administrative unit with prime responsibility for the function and include members of all units with significant interests in that functional area. Members of working groups are appointed by the manager of the unit with principal responsibility for the functional area.

Superconducting Super Collider Management and Coordination

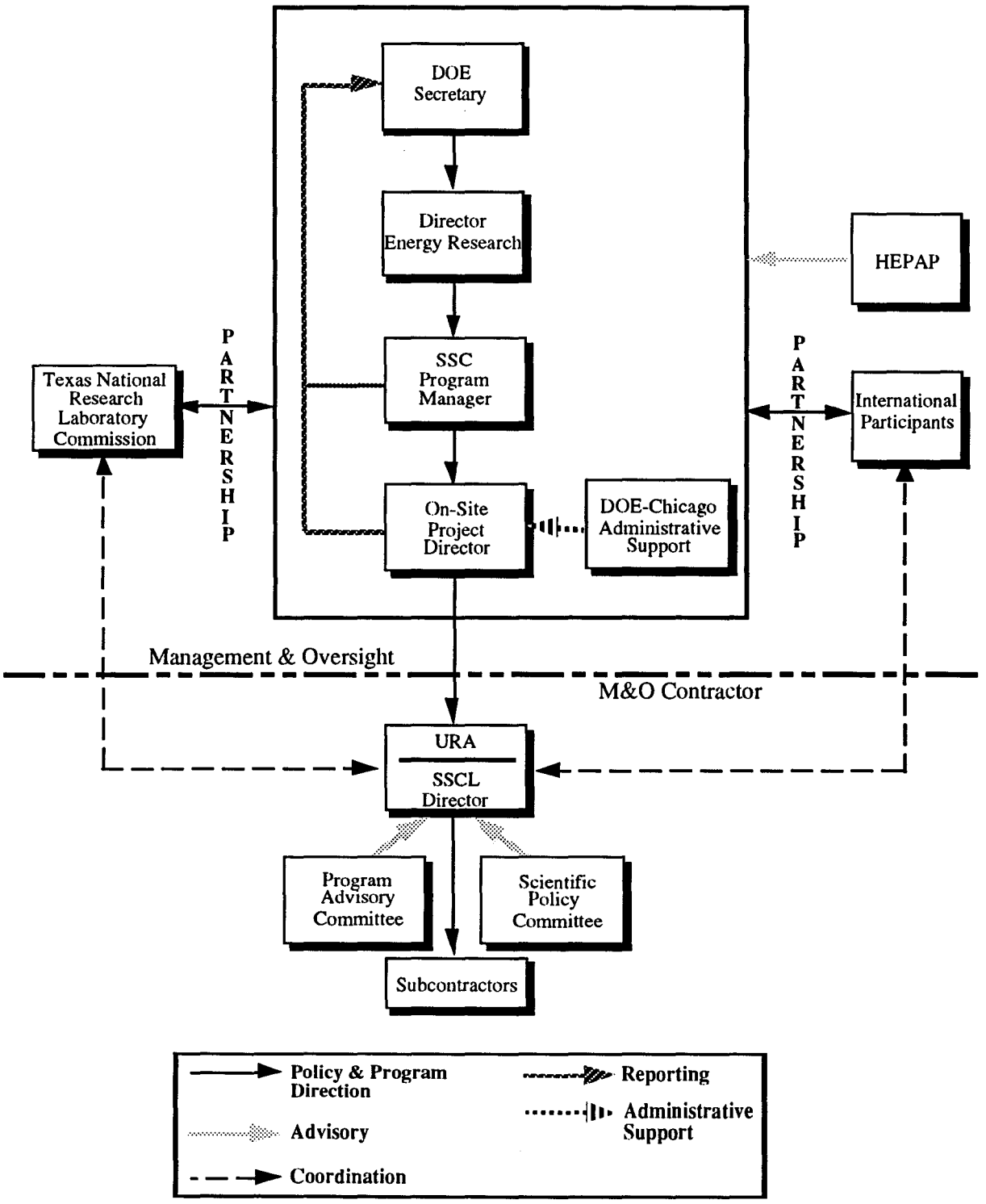

Figure 3-1. SSC Management and Oversight

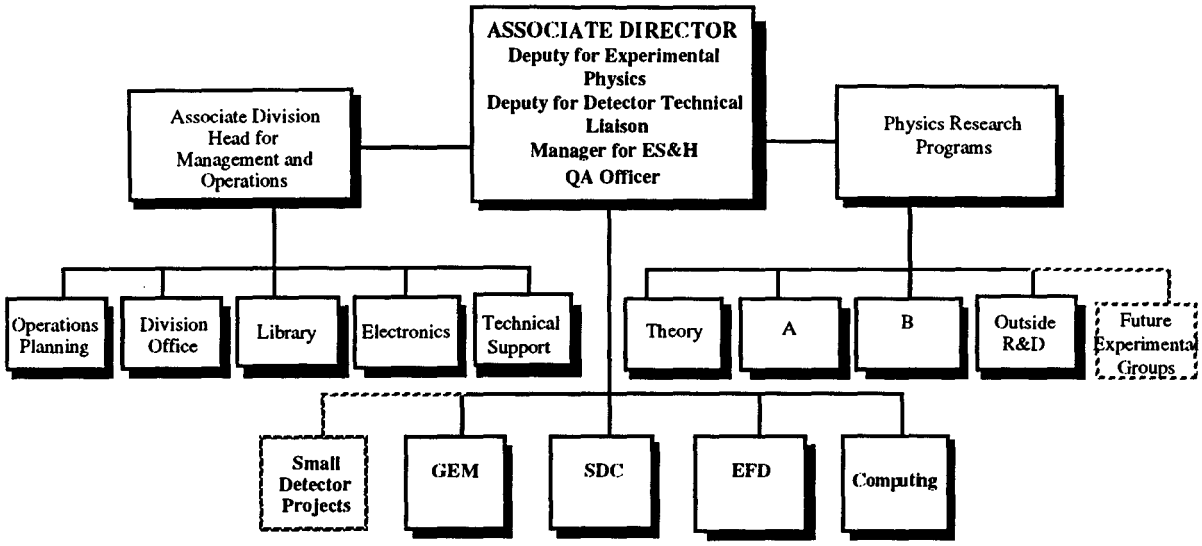

Figure 3-3. Physics Research Division Organization

3.4.2 GEM Project Department

Within the PRD, the GEM Project Department has the overall responsibility for managing the construction of the GEM Detector including controls, monitoring and review of cost, schedule and technical performance and of the QA and ES&H functions. This responsibility will also include assignment, coordination and tracking of all technical design and construction tasks for the detector itself as well as coordination of all interfaces between the detector and other SSCL technical systems. In particular, the Project Department will be the point of contact for management with regard to external institutional efforts contributing to the GEM Detector construction.

The GEM Project Manager heads the GEM Department as well as the project organization of GEM. This dual role integrates the line responsibility to the Physics Research Division with the overall GEM Management.

3.4.3 Other PRD Departments

Experimental Facilities Department

The Experimental Facilities Department (EFD) is responsible for developing requirements and technical specifications for GEM experimental facilities and for specialized and general engineering support to the GEM detector project as agreed upon between the GEM Project Manager and the EFD Department Head.

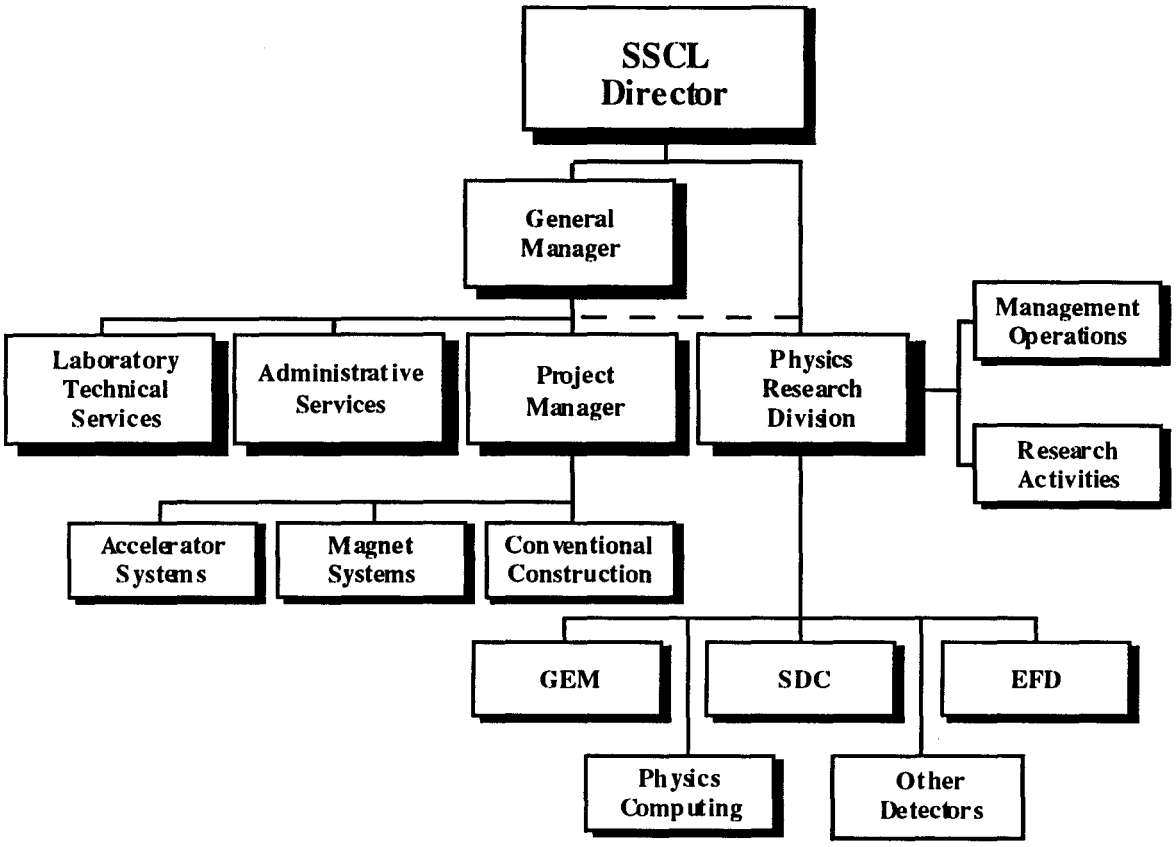

Figure 3-2. The SSCL Organization

3.4 PHYSICS RESEARCH DIVISION

3.4.1 General

The Physics Research Division (PRD) is responsible for managing and coordinating the detector construction effort for approved experiments. PRD responsibilities include specifying requirements for test beams and experimental facilities; establishing and monitoring safety and quality standards for the detectors; and providing support and specifications to promote commonalty, where applicable, among subsystem elements such as software and electronics.

The PRD will track approved detectors through design and fabrication and act as the project interface to ensure that required facilities (halls, utilities, infrastructure) are specified and constructed to meet commissioning schedules for the SSC.

The current organization of the PRD is shown in Fig. 3-3. Each major detector project reports directly to the Associate Director, PRD.

responsibilities of these officers are described in Appendix B (GEM Organization Plan). Three bodies provide management oversight for GEM: the Collaboration Council (CC), the Executive Committee (EC) and the International Committee (IC). The functions and modes of selection of these bodies are described in Appendix B. The present GEM management personnel are identified in Appendix D.

3.6 GEM SUBSYSTEM MANAGEMENT

The diagram of the organization proposed for the construction of the GEM detector is shown in Fig. 3-4. The box labeled GEM Management includes the cospokesmen, the PM, and the Chief Engineer.

The membership of the Collaboration is involved in the project on many levels. The collaborators are involved in all the subsystem construction projects (boxes at the bottom of the fig.), and in the installation and checkout of the detector. At the same time, they are also helping to prepare all the software and all the facilities at their home institutions that will make it possible for them to exploit effectively the data produced by the GEM detector.

The major subsystems which make up the detector are shown at the bottom of Fig. 3-4. Several important points need to be made concerning these subsystem organizations. Each of these subsystems is a major enterprise in itself and will be headed by a Subsystem Leader, Subsystem Project Manager, and Subsystem Chief Engineer (e.g., Muon Subsystem Project Manager). The Subsystem Project Manager and Chief Engineer report to the Subsystem Leader; a collaboration physicist who is the analog of the GEM spokesman for the particular subsystem. The Subsystem Project Manager (SPM) and Chief Engineer report to the PM as well, and are responsible for the design, fabrication, integration, and testing of all components of that particular subsystem. The Subsystem Project Managers are generally resident at the SSC Laboratory site.

The subsystem fabrication activities will generally be widely dispersed, not only within the U.S., but throughout collaborating foreign institutions. All coordination, tracking, and technical communications for the design and production of that subsystem will be the responsibility of the SPM. In some cases project funds to support the subsystem activities will originate with the SSCL and flow through the PM to the SPM. In most cases however, even though the SPM is

The EFD develops Experimental Facilities User Requirements documents for the GEM detector project and provides those requirements to CCD. The EFD will provide for the planning, design, procurement and installation of technical utilities for the GEM experimental facilities, including underground halls, surface buildings and infrastructure. The EFD supports communication between the GEM detector project and CCD, on issues related to experimental facilities.

Physics Computing

The Physics Computing Department will plan, design, procure, install, implement and operate off-line computing systems in support of detector design and experimental programs. Physics Computing works in close collaboration with the GEM computing group to define requirements for off-line systems, including simulation, event reconstruction and analysis, data base/calibration, data storage, networking, teleconferencing and coordination. The GEM computing group is also responsible for planning, developing and implementing on-line computing systems.

ES&H

The ES&H Coordinator for PRD is responsible for the coordination of ES&H planning and implementation on the detector projects, and for directing all other ES&H activities within PRD. The PRD ES&H Coordinator who is the Division Safety Lead, will ensure proper compliance with appropriate ES&H requirements, policies and laws, as defined by DOE, the SSCL and PRD. The PRD ES&H Coordinator will assist and support the Detector and Experimental Facility ES&H Coordinators and will provide assurance to the AD/PRD that the detector projects comply with all appropriate ES&H requirements.

Quality Assurance

The QA Officer for PRD will plan and coordinate QA programs, plans and implementation activities for the PRD. The QA Officer will assist and support detector project QA staff with implementation of QA programs on the detector projects, including QA for major procurements and in-kind contributions. The PRD QA Officer will prepare and maintain the overall QA Plan for PRD which will provide overall QA policies and guidelines for the detector projects, providing for communality and consistency. The PRD QA Officer will also be responsible for internal division QA audits and oversight, and will provide the primary PRD organizational interface to the SSCL QA organization and programs.

3.5 GEM

The GEM Organization Chart is provided in Fig. 3-4. The principal management officers of GEM are the cospokesmen, Project Manager (PM), and the Chief Engineer. The general

Although not explicitly shown in Fig. 3-4, there will have to be close interactions among the subsystem organizations at levels well below that of the GEM management. One example of this is in the intimate relationship between the Electronics Subsystem and the Central Tracker, Calorimeter, and Muon Subsystems. Electronics is an essential part of each of those three systems, and each will have within its own subsystem organization an electronics coordination function. The Electronics organization will provide explicit technical coordination to the tracker, calorimeter and muon sections; the coordinator will provide the required liaison.

Excellent communication will have to be maintained throughout the subsystem activities, through video-conferencing and relatively frequent meetings, to ensure that good coordination is achieved.

There will be a Subsystem Steering Committee (SSC), associated with each subsystem to advise the subsystem leader and project manager on technical directions and alternatives, and methods of performance. The members of the SSC will include scientists responsible for the design and fabrication of the subsystem or of major tasks within it, as well as other technical experts. These members of the SSC are to be chosen by the Subsystem Leader and SPM with approval from the PM and cospokesmen. These SSCs will act in an advisory capacity with decision authority in the hands of the Subsystem Leader and SPM. Their reports will be available to the cospokesmen, PM, and to the GEM EC.

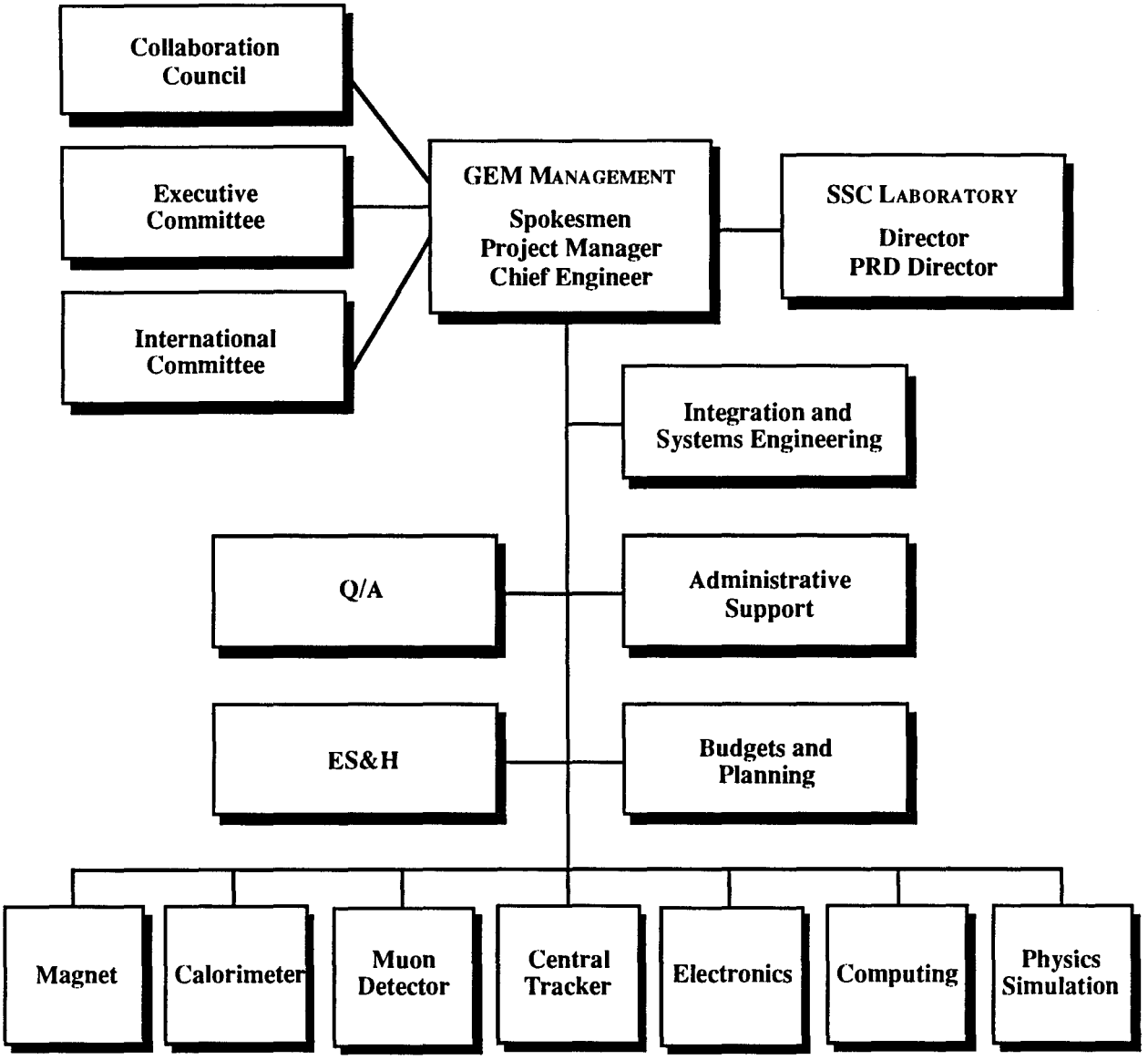

Figure 3-4. The GEM Organization

U.S. based, part of the support will come from non-U.S. funds. The SPM will interact closely with the non-U.S. leaders of activities relevant to the subsystem to ensure good coordination. The SPM will not have budget authority for the foreign funds, but will interact with the coordinators mentioned above to ensure that the distribution of resources, foreign and domestic, is well matched to the program objectives and schedule. The subsystems listed in Fig. 3-4 are all very complex, and there will be Task Leaders (TLs) and indeed a complex organizational tree. Some of the TLs will be dispersed in locations geographically separated from the SPMs.

At the Campus-Injector Complex on the west side and to a lesser extent at the Interaction Hall Cluster on the east side of the ring, there are groups of laboratory, shop, and office buildings with associated grounds, roads, parking lots, utility yards, etc. The utilities and services for the entire SSC as well as all of the operating staff, are largely concentrated in these two laboratory areas. During regular operation, the laboratory staff will consist of about 2700 people, of whom 2200 will be resident staff and workers and 500 will be visiting research scientists.

4.2 THE GEM DETECTOR

The GEM detector is described in detail in the GEM Technical Design Report. The following is a summary description and outlines the principal parts of the detector.

The GEM magnet encloses a cylindrical volume, concentric with the beam, energized by a solenoidal coil and filled with calorimetric and tracking detectors. This system is capable of measuring the momentum of charged tracks emitted from the interaction, within the detectors' very large angular acceptance. A hermetic calorimeter with fine-sampling electromagnetic sections and somewhat coarser hadronic sections provides precise energy measurement of electromagnetic species, and good measurement of hadronic tracks. One of the major GEM goals is to have excellent electron identification and precise measurement of the energies of isolated electrons, photons and muons. Outside the calorimeter is an extensive muon system including tracking and triggering chambers to provide muon identification, trigger capability and excellent momentum resolution.

An isometric drawing of the GEM detector is given in Fig. 2-1. It shows the principal components of the detector and serves as a reference for the following descriptions of detector subsystems. The detector subsystems are the basis for defining the high-level WBS of the detector.

1. Central Tracker Subsystem: The orbits of charged particles emerging from pp collisions in the GEM detector are measured by the central tracker subsystem. This system is divided into two subsystems: the Silicon Tracker (ST), and the Interpolating Pad Tracker (IPT). The ST surrounds the beam pipe in the innermost region of the detector. It consists of layers of Si strip detectors in a barrel configuration and disk layers to close the Si barrel ends.

   The Interpolating Pad Tracker occupies the volume from the ST outer radius to the inner wall of the electromagnetic calorimeter. It consists of 'superlayers' of interpolating pad chambers in concentric cylindrical layers.

2. Calorimeter Subsystem: The calorimeters measure the positions and energies of electrons, photons, and hadron jets. There are three defined subsystems in the calorimeter system; the Noble Liquid Ionization Calorimeter (IC), the Scintillating

4.0 WORK PLAN

4.1 SSC PROJECT OVERVIEW

The SSC consists of a superconducting storage ring system in which beams of protons travel in opposite directions around two rings of superconducting magnets. The protons are made to collide at certain interaction points, producing ultra-high-energy reactions for physics studies. Detectors for high-energy physics research are located at the interaction points. The project includes a series of injector accelerators which provide the input beam for acceleration and storage in the collider rings.

The stored protons are made to cross at locations where the collision reactions take place and where experimental detectors observe and measure the reaction products for physics study. The overall collider design can accommodate future beam bypass tunnels where additional interaction regions could be added to expand experimental capabilities.

The two collider rings confining the proton beams are housed one above the other in a common underground tunnel. The beams are guided around the desired path inside an evacuated beam tube by a system of superconducting magnets. This magnetic confinement system consists of a periodic array of bending and focusing magnets. The circumference of the rings is approximately 87 km (54 miles), a size governed by the maximum feasible magnetic field needed to reach the design energy of 20 TeV per ring.

The operating cycle of the SSC begins with the collider magnets maintained at low injection field while 2 TeV proton beams are loaded into both collider rings from the injector accelerator system. When injection is complete, the collider acceleration system is activated. The increase in the beam energy is accompanied by a corresponding increase in the magnet field strength thus keeping fixed the radial position of the beam orbit. This synchronous acceleration is completed in about twenty-five minutes when the beams reach their collision energy of 20 TeV.

At this point, the beams are steered into collision at the experimental interaction points. The resulting collisions can take place for about a day before the beams are depleted sufficiently that the refill and acceleration cycle must be repeated. The peak design luminosity, is 10^{33} Protons $cm^{-2}s^{-1}$.

The SSC experimental detectors are the means of carrying out the scientific experiments for which the SSC was constructed. Two large SSC experiments have so-far been identified, the Solenoidal Detector Collaboration (SDC) and the Gammas, Electrons and Muons (GEM) Collaboration. Each of these will have associated with it a large experimental detector (10,000-30,000 tons, 20-25 meters high, 40 meters long, typical dimensions). These detectors reside in large, underground caverns located at the beam interaction points.

Technical systems integration is the responsibility of the GEM Project Department including the overall integration of the detector with the SSCL experimental facilities.

4.3 METHOD OF PERFORMANCE

The GEM detector project will be funded through a combination of DOE, foreign and other non-federal funds. It will be scheduled and controlled under general DOE authority with management of non-DOE elements provided through Memoranda-of-Understanding (MOUs). Construction of the GEM detector is scheduled to begin in Fiscal Year 1993.

SSC management responsibility for the GEM detector construction, installation, and commissioning is vested in the GEM Project Manager who reports to the AD-PR. The PM will also be the designated manager and responsible person for GEM items supplied by non-DOE sources.

The GEM project management approach will utilize: (1) a baseline management approach, (2) in-process technical reviews of the design and development, and (3) approval of key specifications and program documents. The baseline management will include establishment of cost and schedule milestones for selected major deliverables at the beginning of each U.S. fiscal year. Projected fiscal-year costs for each contributing entity (DOE plus others), consistent with SSC budget obligation authority and other governing funding agreements, will be established and monitored.

Technical requirements are documented in GEM specifications which will become part of the design baseline as they are approved and placed under GEM project configuration control. Proposed changes to the technical, cost, and schedule baseline will be reviewed and approved by the GEM Change Control Panel, the GEM Change Control Board (the GEM Executive Committee), and, if necessary, the SSC Change Control Board prior to implementation in accordance with the configuration management and change control procedures discussed in Section 7.0 of this plan.

The conceptual design of the GEM detector outlined in the Technical Design Report and GEM Baseline book is the product of several years of analysis, design and tradeoffs. System and component designs have been reviewed against physics requirements and many alternative technologies evaluated. Descoping has been performed in many cases to lower the cost of the detector. Conceptual designs of detector subsystems within budgetary constraints are known as are the envelopes and general interfaces between subsystems.

The GEM Project Department is responsible for preparing a Level 3B specification that provides the design guidance for integration and interface design as well as the high-level requirements for the subsystems. The GEM Baseline book defines the detailed technical parameters of the subsystems. The Project Department also prepares Interface Control Documents

Calorimeters (SC), and the Forward Calorimeters (FC). The IC and SC subsystems are divided into separate Barrel Calorimeter (BC) and Endcap Calorimeter (EC) modules. The Forward Calorimeter is physically distinct from the EC. It covers the region in η from 3.0 down to 5.5. The technology decision has not yet been finalized, but it will have to be highly radiation hard.

3. Muon Subsystem: The Muon Subsystem consists of a system of cathode strip chambers supported by a stable, precision frame designed to provide precision measurement of muon trajectories. The cathode strip chambers provide the trigger capability as well.

4. Superconducting Magnet The entire detector volume is surrounded by a superconducting solenoid magnet of inner diameter 18m and length 32m. The magnet is wound in a single layer of aluminum stabilized niobium-titanium superconductor in a copper matrix. The central field is 0.8 Tesla.

5. Electronics Subsystems All electronic systems for collecting information from GEM detector systems, making decisions about event triggers and recording the information are included here. The electronics include the Front End electronics (FE), the Trigger System (TRIO) and the Data Acquisition (DAQ). The FE electronics, which are mounted in or near the detector, amplify and digitize the signals and store them for readout by the DAQ. The trigger system uses a reduced set of signals to rapidly form a signal that initiates the readout process. The DAQ collects digital data from the FE elements, formats them into events, and transfers these events to the on-line computer system. (Marlow added this)

6. Computing, Controls and Communications Subsystems In the GEM detector, only the computers used in the direct on-line signal processing are included in the cost. This subsystem also includes the slow controls and all communications systems for data, voice, and images.

7. Interface Systems: This area includes the various utility, safety, mechanical support and cryogenic systems that are not explicitly part of the detector subsystems. All design and simulation (structural, thermal, particle cascade and shielding) studies, other than physics and detector performance simulations, which cross subsystem interfaces are included. Major tooling and fixturing not associated with a single subsystem are included.

8. Project Management: This category includes the overall GEM Project Management including the functions of planning, tracking, reporting, and quality assurance.

detectors operated in the U.S., Europe, and Japan by international HEP collaborations. Recent examples include the CDF and D0 Detectors at Fermilab, the ZEUS and H1 Detectors at DESY, the AMY Detector at KEK, the L3 Detector at CERN, and the SLD Detector at SLAC. The size and dollar value of the GEM detector is larger by a considerable factor than any of these predecessors, but many of its technical features and characteristics are similar.

As noted above, each deliverable for the GEM detector is identified with a WBS element or group of elements. Likewise, each deliverable element has a provider uniquely identified in the RM. The GEM WBS is continued to a sufficiently low level to make each deliverable and its provider unique and trackable.

The method of management for the timely provision of deliverables as well as for their scheduling and tracking will be provided via the hierarchical organization of managers and responsible persons described in Section 3.0. The Subsystem Project Managers are responsible for monitoring sub-system and tracking progress on the elements under their jurisdiction. They will also report up the chain of responsibility to the Subsystem Leaders and to the GEM PM. The overall GEM Detector Project cost and schedule will be tracked by the Project Manager with a Performance Measurement System. Subsystem Project Managers are responsible for maintaining in detail their part of the overall cost and schedule tracking as directed by the GEM Project Department Program Planning and Controls Group. The subsystem project managers will be subject to general SSC change control protocols that are defined in this plan.

In practical terms, it will probably not be possible to implement the management scheme identified above at all institutions or in all participating countries. In such cases, the relevant manager or responsible person will establish and maintain appropriate alternate means of accomplishing the desired production ends as well as appropriate tracking and change control system procedures. The PM will approve, as part of the governing MOU, the specific method proposed for each deliverable utilizing a non-standard management method.

4.5 PLANS AND IMPLEMENTATION

4.5.1 Plans

Apart from the defined technical efforts of GEM, the following associated plans are described in subsequent chapters of this GEM-PMP:

- Environmental Safety & Health Implementation Plan
- Configuration Management Plan
- Systems Engineering & Integration Plan

(ICDs) that define the interfaces between the detector and external components such as the experimental hall and the collider, and will monitor the interfaces between detector subsystems.

Subsystem project managers will prepare lower-level specifications for their subsystems, components, and lower-level items. These managers are also responsible for the preparation of ICDs between their subsystems and those adjoining them, and between the components of their subsystems.

Subsystems and their components will be designed to meet the requirements outlined in the specifications, the GEM Baseline book and the ICDs. Designs will be documented in design reports and drawings that are checked by peers, senior engineers, and/or managers. Design reviews will be performed as outlined in Attachment 3. Research and development is being performed on detector components to ensure that unproven technology will meet the physics and engineering requirements of the detector.

Design reports, drawings and other documentation will be delivered to the SSCL to ensure that the item can be supported and maintained.

Prior to being put into operation at the SSCL, each component will be tested as described by the Acceptance Test Plan and receive an Operational Readiness Review.

The specifics of the disciplines and tools (e.g.: Environmental, Safety and Heath Protection; and Configuration Management) to be employed by GEM are found in this plan and its appendices and attachments.

4.4 RESPONSIBILITIES

The GEM detector project is a complex one in which a detector with a number of major subsystems (see Section 5.2) and many interrelated components is provided by a large number of organizations. Many of the providing groups and entities are funded through foreign and other non-DOE sources. For this reason, the appropriate responsibility description is in the form of a matrix in which the WBS is counterposed with the contributing organizations and entities. Many institutions are expected to play significant roles in the detector construction and their inter-relationships (as noted) will be complex.

The basic Responsibility Matrix (RM) is provided in Appendix H. The characteristic which makes the overall management feasible is the sparse occupation of the matrix elements in the RM. Each of the major subsystems has a subsystem project manager who reports to the GEM PM and who has the responsibility to coordinate production of items supplied under that subsystem.

This is not a new system of organization for the construction of HEP experimental detectors; it is, in fact, a well-proven and traditional method utilized for the construction of

locations outside the U.S. will be conducted in compliance with laws and regulations of the country in which the work is done.

Detector activity will be managed in accordance with SSCL policies and procedures, as applicable to the specific activity involved. If an exception is required, i.e., for work performed in a foreign country, the revised requirement or procedure will be addressed in institutional agreements (MOUs).

Compliance with DOE Orders and Regulations will be as defined in the SSCL PMP, as outlined in SSCL Policies and Procedures, or as described in other sections of this PMP.

4.7 RELATIONSHIP TO OTHER SSCL DIVISIONS

Responsibilities of other SSCL Divisions related to detectors and PRD relationships are outlined in section 3.4 of the PMPD.

- Quality Implementation Plan
- Advance Acquisition or Assistance Plan

Additional documents which involve the implementation of the above plans are described in Appendix J.

4.5.2 Baselines

The GEM project team is proceeding with detailed planning for the detector. The detailed planning, the technical, cost, and schedule baselines will be established. Those baselines will provide the basis for management control and reporting, and for configuration control. Baseline Management and Configuration Control are addressed in Section 7.0 of this GEM-PMP.

The baseline for the GEM Detector will include all elements of the project. Funding sources and potential in-kind contributions will be identified and summarized separately.

4.5.3 Annual Work Plans

The general processes associated with annual work plan development and annual DOE budget allocations are described in Section 4.4.2 of the SSCL PMP. The detector program within PRD will be subject to the same processes, as is all activity at the SSCL.

Annual work plans for the GEM program will be based on annual budget requests submitted by GEM. All annual work plans will be within the overall scope, schedule, and baseline budget.

4.5.4 Program Approval

While preliminary planning of SSC detectors has proceeded since 1984, actual detector development was officially initiated in FY 1990 with the call for Expressions of Interest (EOIs) for large SSC Detectors. GEM issued a formal Letter of Intent (LOI) in November 1991. The LOI approval signaled the start of the detailed planning and associated R&D required to prepare the Technical Design Report (TDR). The GEM TDR was completed and submitted to SSCL on April 30, 1993. Review of the TDR proceeds in two stages.

The first stage review is conducted by the SSC Laboratory, and the second is carried out by DOE.

4.6 PROJECT COMPLIANCE

All GEM Project activity will be accomplished in accordance with applicable local, state, and Federal laws, codes and regulations. In addition, any detector-related activity performed in

5.2 GOVERNMENT COORDINATION OF INTERNATIONAL PROGRAMS

Government-to-government agreements are expected for countries making large contributions to the SSC project. In this case, an institution-to-institution agreement signed as part of the GEM funding process may be attached to and form part of the government-to-government agreement. The GEM Management will be responsible for coordinating technical activities that form the basis of these agreements.

The DOE Program Manager has the responsibility for carrying out intergovernmental coordination and for negotiating with foreign governments to establish collaborative arrangements. The OSSC will be responsible for all contacts among representatives of the U.S. Government and foreign governments, and for overall policy and plans for the SSC program's formal international interactions.

For implementation of agreed-upon International Programs, the SSCL will be responsible for routine day-to-day activities such as action on duties, visas, tax considerations, and export licenses. Policy-sensitive actions will be forwarded to DOE for handling and resolution, as necessary. Official government-level communications with other countries will be handled by DOE.

5.3 GEM PLAN

5.3.1 General

GEM is comprised of approximately 85 institutions as indicated in Table 1-1. Within these institutions there are approximately 700 scientists and engineers presently identified as GEM members. (See Appendix A for current list of GEM participants.)

It has been recognized that GEM must obtain significant portions of its support outside of the SSC Total Project Costs. Within the Collaboration, plans are underway to identify non-DOE resources to support specific detector subsystems. The area of foreign participation has advanced slowly, and specific guarantees are likely to be finalized only after approval of the GEM Technical Design Report and this Project Management Plan by DOE.

The level of foreign participation in the detector itself is anticipated to be in the range of 150M$ (U.S. equivalent FY90 dollars). Most of the contributions to the GEM detector from foreign sources will be in the form of in-kind contributions of subsystems and components.

Participation in SSCL-based construction of GEM systems by foreign scientists, as well as subsequent HEP research work, will generally be supported by the host countries. These activities will be documented in Memoranda of Understanding (MOUs) between the SSCL and the participating institutions.

5.0 NATIONAL AND INTERNATIONAL PARTICIPATION

5.1 SSCL OBJECTIVES

Active participation of leading scientists from around the world will be required for the development of the full scientific potential of the SSC. International participation in high-energy physics experimental programs has become the norm at national and international laboratories. However, unlike the case for previous accelerators, the SSCL seeks, because of the SSC scale, participation of the world-wide scientific community in the design and implementation of the machine itself. The international policies and procedures for the SSC will not only build upon those already in place at existing DOE laboratories, but also will be extended to develop new partnership arrangements on a scale hitherto not attempted.

As a goal of the federal administration, the Department of Energy is seeking non-federal funding for one-third of the total SSC project cost and is seeking international partners for the construction and operation of the SSC. The State of Texas, as the host state, has agreed to provide $875 million toward the project. It is anticipated that the SSC will be supported by the international scientific community, and funding is actively being sought from foreign countries. The State of Texas has also given $100 million for Research and Development not included in the SSC Total Project Cost.

The Department of Energy has worked to develop an international plan that provides a framework in which international cooperation on the SSC can be implemented, and which forms a basis for negotiations with other countries. The primary-international objective for the SSC program is to share the benefits and the responsibility of the construction and operational phases of the SSC program with other nations, commensurate with their scientific and technological strengths and resources.

The following general objectives have been established for international participation in the SSC detector programs:

- To establish the best possible experimental systems (detectors) for the SSC which will ensure attainment of the SSC's physics objectives.
- To promote the participation of the most outstanding scientists and engineers in the world to plan, design, build and operate experimental systems for the SSC.
- To obtain sufficient resources, including both in-kind contributions and financial resources, to build the experimental systems selected for the SSC.

5.2 GOVERNMENT COORDINATION OF INTERNATIONAL PROGRAMS

Government-to-government agreements are expected for countries making large contributions to the SSC project. In this case, an institution-to-institution agreement signed as part of the GEM funding process may be attached to and form part of the government-to-government agreement. The GEM Management will be responsible for coordinating technical activities that form the basis of these agreements.

The DOE Program Manager has the responsibility for carrying out intergovernmental coordination and for negotiating with foreign governments to establish collaborative arrangements. The OSSC will be responsible for all contacts among representatives of the U.S. Government and foreign governments, and for overall policy and plans for the SSC program's formal international interactions.

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The level of foreign participation in the detector itself is anticipated to be in the range of 150M$ (U.S. equivalent FY90 dollars). Most of the contributions to the GEM detector from foreign sources will be in the form of in-kind contributions of subsystems and components.

Participation in SSCL-based construction of GEM systems by foreign scientists, as well as subsequent HEP research work, will generally be supported by the host countries. These activities will be documented in Memoranda of Understanding (MOUs) between the SSCL and the participating institutions.

effective performance by university groups, the PM will manage the distribution of funds for detector construction and be the recipient of all progress reports related to the work in progress.

Major industrial contracts provided through the SSCL for the purpose of constructing the GEM detector and its subsystems will be approved by the PM, who must also approve the method of performance and the means of contract supervision. Funds to support such contracts will be provided through the SSCL.

Foreign Contributions: Contributions of non-U.S. groups to the GEM detector construction project are likely to be provided in the form of contributions-in-kind. Typical contributions will comprise detector elements and subsystems. Installation and commissioning of these subsystems by technical personnel from the providing groups are likely to be part of the contribution.

The mechanism for specification of these contributions including scope and schedule will ordinarily be memoranda-of-understanding between the responsible parties in the supplying country and SSCL. The PM will be actively involved in the drafting of these MOUs and must approve their contents. The PM must also receive progress reports on construction and will accept the resulting deliverables when they are presented for incorporation in the detector.

In some cases, foreign contributions may be provided under official government-to-government auspices. In these cases, committees and government officials will be involved in the proposal, negotiation and approval process. The GEM management will also be involved in this process to insure that the agreed-upon components or subsystems to be supplied thereunder will meet the functional needs of the detector and are provided on schedule. The Funding Plan shown in Attachment 1 provides a matrix of potential non-U.S. contributions to the GEM project.

Non-Federal Contributions: Some components and subsystems for the GEM detector may be provided through non-federal domestic funding sources. It is expected that MOUs between the SSCL and the supplying entities will be the appropriate instruments for formalizing these contributions. These contributions will be handled in the manner described above for foreign contributions though they need not go through government-to-government channels.

5.4 FOREIGN TRAVEL

The nature of experimental research in high energy physics at the SSCL will necessitate special attention to foreign travel provisions. GEM will have strong international participation from the outset, with many countries contributing funds and manpower to construction, installation, and operation of the detectors. Many foreign nationals will be stationed at the SSCL for many years in order to manage their contributions. Others will make many trips back and forth over a period of years, with stays ranging from a few days to a few months.

5.3.2 Technical Responsibilities

The GEM Management (Project Manager and Cospokesmen) will be responsible for defining the work-scope and/or technical specifications and conditions for foreign contributions.

The GEM Subsystem Project Managers and Subsystem Leaders will direct the activities of their respective subsystems. This includes liaison with technical representatives of GEM from U.S. and foreign institutions. Subsystem project managers will provide technical direction, monitor program & schedules, and assure acceptance tests to verify system performance and compatibility.

5.3.3 Contractual Responsibilities

The SSC Project counts explicitly on non-DOE project involvement and cost-sharing. For the GEM Project a large fraction of the detector costs will be provided through "contributions-in-kind" from foreign collaborators or other non-federal contributions. The remainder of detector funding is expected to flow from DOE funds, primarily provided through the SSC Laboratory.

It will be necessary to adopt flexible contracting methods to utilize in an optimum way, the varied sources of support identified below. A number of procurement methods, already proven in other HEP projects at Fermilab and SLAC, will be utilized for accomplishing the detector program goals.

SSCL Provided Funds: The SSC Laboratory is expected to provide the single largest block of detector funds for construction of the GEM detector. These funds will be provided to the SSCL through DOE's Office of the SSC. Use of these funds within the SSC Laboratory or within the DOE Laboratory system can be accomplished by internal fund distribution and accounting means (cost accumulation codes and memorandum purchase orders). With these instruments, direct and existing mechanisms of supervision, reporting, and accounting are already in place and utilize well-defined laboratory labor rates and existing laboratory facilities to perform construction projects and tasks.

GEM University groups may have their funds provided directly through DOE's Office of the SSC. For universities with existing DOE contracts, the process is defined and rules for reporting and accounting are in place. This process has been utilized, in particular, for university efforts in the initial R&D activities for the GEM. In the design and fabrication phases of the detector, it is planned that MOUs will clearly define the work scope and associated schedule of accomplishment. SSCL Purchase Orders may be used to supplement specific University efforts.

In this process, the Project Manager will be involved in the funding decisions and reporting processes. This requirement derives from the PM's responsibility to integrate the work of university groups closely into the whole detector project. In order to insure timely and cost-

The SSCPO will be responsible for assuring that the provisions of DOE 1500.3, Foreign Travel, are followed. In some cases, in order to assure the success of international support to the GEM Program, special provisions for foreign travel may be required that involve exceptions to existing practices. The GEM Management will identify special needs and exceptions. To promote significant international involvement in the SSC Detectors and Experimental Program, DOE will review the need for new policies with regard to foreign travel, length of stay in the U.S., the provision of special Visas for work at the SSC and associated arrangements for the long-term visits by non-U.S. participants who are part of the GEM program.

6.0 ENVIRONMENTAL, SAFETY & HEALTH PROTECTION

This section describes the policies being established to ensure that Environmental, Safety and Health (ES&H) considerations are adequately addressed within the GEM project activities. Policies, procedures and descriptive information are contained in the GEM ES&H Implementation Plan. ES&H is a line management responsibility and will be implemented down through the sub-system organizations.

6.1 OVERVIEW

6.1.1 Introduction and Scope

The GEM program fully supports the SSCL ES&H policies and procedures, as described in the SSCL ES&H Manual. The ES&H program for the design, construction, installation, test and operation of GEM and supporting systems is intended to ensure a safe working environment at the SSCL. The GEM management will identify specific ES&H issues, will develop appropriate plans and detailed requirements, and will establish specific procedures as needed.

6.1.2 Objectives

The following general objectives have been established by GEM for the ES&H program for detectors:

- To establish and administer an ES&H program which promotes the accomplishment of SSCL ES&H objectives.
- To comply with federal, state and local laws, rules and regulations.
- To comply with the SSCL Supplemental Environmental Impact Statement and Mitigation Action Plan.
- To prevent personnel injury or loss of life during detector related work.
- To prevent damage to equipment caused by accidents during detector related work.
- To assure the GEM detector system is essentially hazard free and remaining hazards do not present a critical (serious) risk to the performance of the system.
- To prevent any environmental contamination during detector development, commissioning and operation.

6.1.3 Organization and Responsibilities

The SSCL has established two ES&H organizations which share responsibility for the SSCL ES&H program. The ES&H Oversight Office is responsible for the development of laboratory policies; the ES&H Operations Office is responsible for procedural development required to facilitate the implementation of policies. The PRD ES&H office has overall responsibility for ensuring compliance with appropriate ES&H requirements, policies and laws, as defined by the PRD ES&H Implementation Plan. PRD has established an ES&H office to provide oversight and support for GEM ES&H activities.

The GEM ES&H program for detectors is the responsibility of the GEM Project Manager. The GEM Project Manager has the responsibility for identifying specific ES&H issues and risks, and for establishing appropriate safeguards and procedures for addressing those risks. In order to accomplish the detailed ES&H planning, documentation, analysis and surveillance, a GEM ES&H Coordinator has been appointed. The ES&H coordinator shall be responsible for coordinating the implementation of the PRD ES&H program, for communication between the GEM project and PRD on matters of safety, and for maintenance of the GEM Safety documentation. Other ES&H coordinator responsibilities are outlined in the GEM ES&H Implementation Plan.

A Technical Safety Review Panel (TSRP), established by PRD shall be utilized to provide objective reviews of safety designs and documentation advising GEM, PRD and laboratory management.

6.1.4 System Safety Precedence

An order of precedence for resolving safety issues and identified hazards has been established by the GEM Project Management Office. Order of precedence shall be as follows:

Design for Minimum Risk: The primary means for mitigation of items shall be to eliminate the hazard through design. If an identified hazard cannot be eliminated then the design shall reduce the risk to an acceptable level as established in accordance with 6.1.3, herein.

Incorporate Safety Devices: Fixed, automatic or other protective devices shall be used in conjunction with design reduction to attain an acceptable level of risk or reduce the level. Provisions shall be made to for periodic functional checks as applicable.

Provide Warning Devices: When neither design nor safety devices can effectively eliminate or reduce hazards, devices shall be used to detect the condition, and to produce an adequate warning to alert personnel of the hazard. Devices may include audible, visual, permanent signs, movable placards or other customary warning, caution or advisory means.

Procedures and Training: Where it is impractical to substantially eliminate or reduce the hazard or where the condition of the hazard indicates additional emphasis, procedures and training shall be used. Procedures and training shall not be used as the only means to mitigate category I or II hazards (as defined by DOE 5481.1b and MIL-STD-882 and invoked by PRD ES&H procedure) without the concurrence of the Project Manager and ES&H Operations Office as a minimum.

6.1.5 Employee Training

GEM project employees and participants at the SSCL will be provided with procedures, training and information to ensure their safety. Briefings and presentations will be made to managers and supervisor to communicate ES&H policies, procedures and other information. Job specific training will be provided for topics including electrical, cryogenic, radiation, chemical, transportation, and handling safety. Related activities such as testing, and maintenance will have training requirements.

GEM visitors will be informed of SSCL ES&H rules and procedures applicable to their visit. In general, visitors will not be allowed in work areas without the advance coordination of the GEM Project Manager. Hosts will be responsible for the safety of visitors.

6.1.6 Documentation

GEM shall provide, as required, hazard assessments, safety analyses and evaluations. Formal analyses will be prepared as Safety Analysis Reports and submitted in compliance with DOE and SSCL requirements. Specific documents are defined in the ES&H Implementation Plan. Procedures and training documents will be prepared and released to comply with section 6.1.5 herein.

6.2 ENVIRONMENTAL PROTECTION

GEM shall follow standards and practices set by SSCL and PRD for environmental protection which fully support the DOE environmental protection policies and requirements. GEM will initiate activities necessary to ensure adherence to the SSCL Final Environmental Impact Statement (FEIS), Mitigation Action Plan (MAP) and the SSCL's ES&H Manual.

6.3 SAFETY AND HEALTH PROTECTION

The GEM management will implement health and safety program elements as outlined in the SSCL ES&H Manuals and will be implemented through the GEM ES&H Implementation Plan. This plan will address hazards and safety requirements related to installation, test, start-up, and operations of the GEM Detector by means of a set of Safety Analysis Reports followed by appropriate operating procedures.

6.4 EMERGENCY PREPAREDNESS

The GEM Project will adhere to the SSCL Emergency Preparedness Plan. Emergency preparedness involves the readiness to protect personnel, property and the general public from potential hazards arising from emergencies. A specific GEM emergency preparedness plan will be developed before GEM operation begins.

6.5 GOVERNMENTAL CODE COMPLIANCE

6.5.1 Activity on Site

GEM will comply with applicable U.S. Federal codes, laws and regulations, industrial codes and state rules, regulations and codes, as described in the SSCL ES&H Manual. In the event that certain codes or requirements are not applicable or are impractical, the proposed design solutions shall provide an equivalent level of safety, as intended in the original requirement. All safety commitments made to the public in DOE's SSCL SEIS will be met. The GEM ES&H Coordinator with the Project Manager will be responsible for clarifying compliance requirements and assisting in the resolution of complaints or deviations related to safety.

6.5.2 Activity at Other Institutions

Participants in GEM-related activities performed at institutions other than the SSCL (both domestic and foreign locations) will adhere to the local ES&H laws, rules and regulations in place at those locations.

The GEM Project Manager, and subsystem project managers will ensure that specific safety issues and safeguards are identified during the design process and communicated to fabrication, test and installation personnel (regardless of the institution involved).

6.6 SYSTEM SAFETY

System Safety is responsible for engineering support and safety risk management of technical systems. The GEM ES&H Coordinator communicates with the SSCL ES&H Office on technical safety matters and coordinates safety engineering tasks with safety coordinators assigned to each division. The mission of System Safety is to prevent, eliminate and control hazards and to minimize the probability of mishaps which could result in injury to personnel and damage to equipment. The goal is to accomplish this mission through design safety, which is a prelude to operational safety.

The SSCL PMP requires the development of a series of Safety Analysis Reports. The GEM ES&H Coordinator is responsible for systematic coordination of tasks required to develop these documents. Formal safety analysis reports and risk assessment reports will be prepared in

accordance with the intent of DOE 5481.1B Safety Analysis and Review System by SSCL ES&H policy/procedure. These reports thoroughly address the adequacy of the preventive or mitigative design features of all major systems and the administrative controls provided to limit the probability of adverse occurrence or the severity of hazards.

Human factors engineering considerations and human engineering design criteria and related safety requirements will be an integral part of the engineering process. Designs will reflect applicable system and personnel safety factors, including minimizing potential human error in the operation and maintenance of all facilities, technical systems, control rooms and workstations. Consideration of human factors will play a large role in the development of design, equipment usage, operator tasks, precautions, operational safety procedures, emergency procedures and safety training. The goal is to prevent human errors, injury and equipment damage.

7.0 CONFIGURATION MANAGEMENT, DOCUMENTATION AND CHANGE CONTROL

Configuration Management (CM) is a discipline for managing the functional and physical requirements documentation of a project. The GEM CM process is designed to ensure coordination of changes and to ensure that the technical, cost and schedule impacts of changes are considered. Formal CM involves configuration identification, configuration control, configuration status accounting, and configuration verification.

7.1 DOCUMENTATION

A technical, cost, and schedule baseline will be established for the GEM Project. The technical baseline consists of the approved documentation used to define the physical and functional requirements of the system and subsystems, including specifications, interface control documents and drawing packages. These specifications will be supported by cost and schedule documentation, As-Built drawings and specifications and these will be provided to and maintained by the SSCL.

The Technical Design Report (TDR) forms the initial GEM technical baseline. The requirements approved in the specifications take precedence over the more general requirements identified in the TDR. The Specification Tree (Fig. 7.1) identifies the specifications that will be developed within GEM and controlled by Configuration Management. Once approved, baseline documentation can be changed only through the change control process.

Lower-level specifications will be used to define the technical configuration of the detector subsystems to be developed and installed by individual subsystem managers. Changes to these configurations will be controlled by the GEM Project Manager and Cospokesmen and by Subsystem Project Managers and Subsystem Leaders.

7.2 DOCUMENT CONTROL

A GEM Document Control Center (GEMDCC) has been established at the SSCL to support GEM. The GEMDCC is a satellite facility of the SSCL DCC and uses the same procedures to ensure compatibility with the SSCL.

All documents concerning the GEM detector baseline will be controlled, distributed and stored in the GEMDCC. GEM Notes are also processed by the GEMDCC. The originals of all baseline documents as well as GEM Notes will be stored in the GEMDCC.

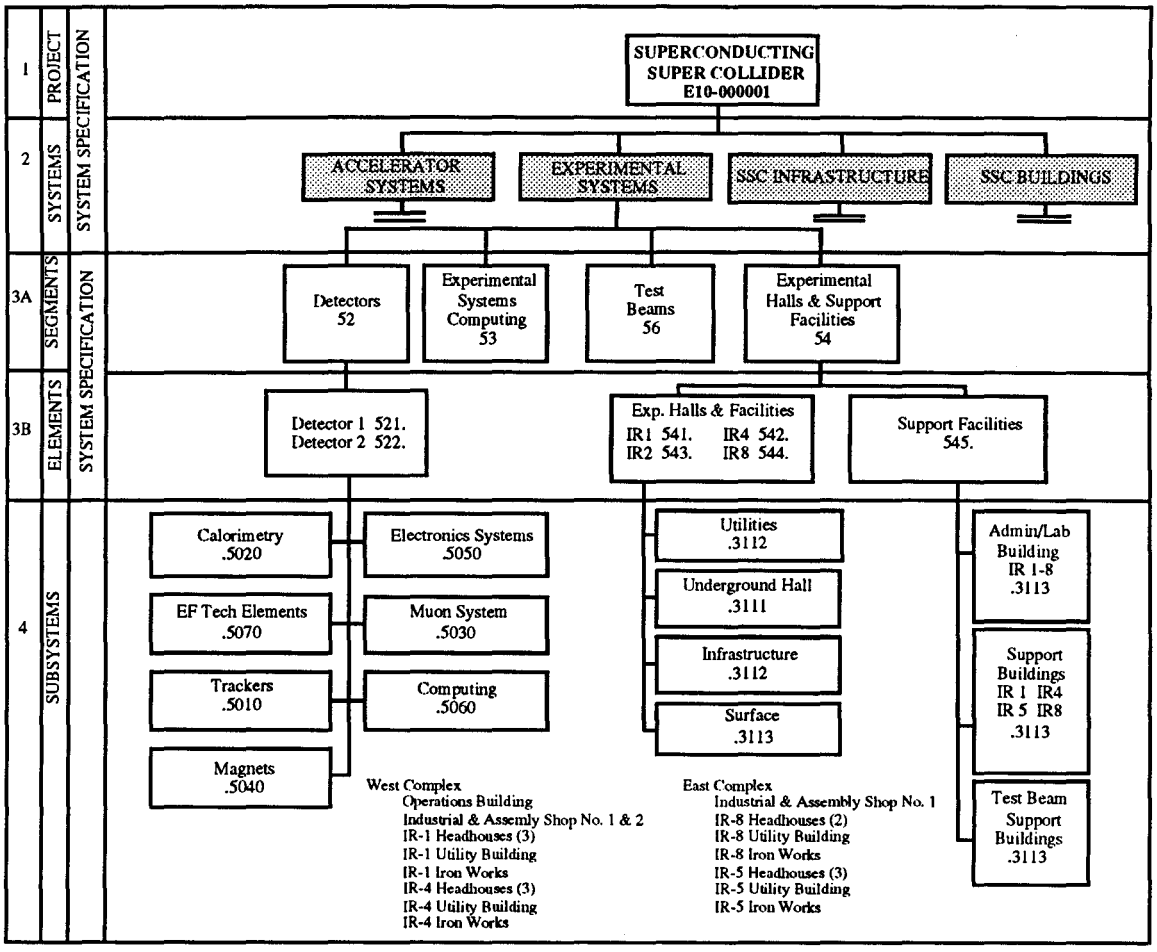

Figure 7-1. Experimental Systems Specification Tree

7.3 ORGANIZATIONAL RESPONSIBILITIES

The GEM Project organization and responsibilities are discussed in Section 3.0 of this document. The Configuration Management responsibilities are further defined below.

- GEM Spokesman: The GEM Spokesman is responsible for the GEM baseline, with final control of the changes. The Spokesman has final review authority/approval of decisions at the GEM CCB level (the GEM CCB is the Executive Committee).

- GEM Project Manager: The GEM Project Manager is responsible for the GEM baseline, including controlling its changes. The Project Manager has review authority/approval of decisions at the GEM CCP level. The decisions of the GEM CCP and PM are forwarded to the GEM Spokesmen and the CCB.

- Configuration Manager: The GEM Configuration Manager is responsible to the Project Manager for all matters pertaining to CM and will enforce applicable CM procedures and provide the necessary CM documentation.

- Systems Engineering: Systems Engineering monitors technical requirements and coordinates the impact of changes to hardware, software and facilities; ensures that specifications and interface control drawings are developed and updated to reflect changes; and ensures that all change actions are properly documented.

- Quality and Environmental, Safety, and Health: These groups ensure that all changes are consistent with the policies of the SSCL relevant to these disciplines.

- Document Control Center: The GEM Document Control Center issues the control numbers which are used to identify controlled documents and distributes and archives released documents.

- Cost and Schedule Control: This function, responsible to the Project Manager, monitors and records the impact of changes.

7.4 CHANGE CONTROL

Changes will be controlled through the Change Control Panel/Board process. Approval and change authority for the technical baseline is shown in Table 7-1. The change approval authority is dependent on the level of the change. The GEM Project Manager (PM) will chair a Change Control Panel (CCP) to approve, disapprove, or defer changes within his/her level of authority. Changes to GEM systems or interfaces above the approval level of the GEM PM must be approved by the GEM Spokesmen and Change Control Board (CCB), the PRD CCP or the SSCL/DOE CCBs. Change packages and the change process are described in Attachment 4.

Table 7-1. Detector Specification Approval Levels

	Prepare Spec.	Approve Spec.
Level 2, System Specification	SSCL Director	SSCPO
Level 3A, Segment Specifications	AD/PRD	SSCL Director
Level 3B, Element Specifications	GEM PM and Spokesmen	AD/PRD
Level 4, Component and Subsystem Specifications	GEM Subsystem PM and Subsystem Leader	GEM PM and Spokesmen

The Configuration Manager will serve as the point of contact on matters concerning configuration management and control. The GEM Project Manager will obtain cost and schedule coordination on Level 3B changes before presenting them to the PRD CCP for approval. The

change originator will obtain cost and schedule coordination on Level 4 changes before presenting them to the GEM CCP for approval.

The GEM CCP is established to accomplish the following:

- Determine the level of change (level 1, 2, 3A, 3B, 4, 5).
- Evaluate the change impact on cost, schedule, and technical performance.
- Approve Level 4 changes to the baselines and forward recommended change packages to the GEM CCB, the PRD CCP or the SSCL CCB, as required.

Members of the GEM CCP include:

- GEM Project Manager (or Deputy)- Chairperson
- GEM Cospokesmen
- GEM Chief Engineer
- GEM Subsystem Project Managers
- GEM Configuration Manager
- GEM Lead Systems Engineer
- PRD Experimental Facilities Manager (If applicable)
- CCD Task Leader for Experimental Facilities (If applicable)
- Cost/Schedule Coordinator
- Environmental, Safety & Health (ES&H) Manager
- Additional members as appointed by the GEM Project Manager

Decisions of the GEM CCP are forwarded by the GEM PM to the GEM CCB which is the GEM Executive Committee. These decisions will be forwarded as a complete written package well in advance of scheduled meetings of the GEM CCB. The GEM CCB is chaired by the spokesman who has final approval authority for GEM.

Minutes of the GEM CCP and CCB are concurred with by the Associate Director, Physics Research Division. Minutes of the CCP and CCB meetings are prepared by the GEM Project Manager, signed by the chairperson (or designee) and distributed to the other CCPs and the

CCB. Other distribution is determined by the CCP chairperson. Minutes of the Subsystem CCPs will be forwarded to the GEM PM and spokesman and to the members of the GEM CCP.

The GEM change control process will follow the guidelines contained in DOE Order 4700.4, the PMP for Detectors, and the PRD Configuration Management Policy for Detectors. All recommended changes to the technical, cost, or schedule baselines from within GEM or external to GEM are logged into the Configuration Management System via an Engineering Change Request (ECR) or a Change Cost/Schedule Request (CCSR), processed through the CCP/CCB and, if approved, are implemented and tracked.

Requests for Waivers and Deviations will be processed the same as for technical, cost or schedule changes. Exemptions, also processed through the CCP/CCB, will be used to request a temporary or permanent release from mandatory ES&H Standards as identified in DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards.

All changes to an officially released specification are prepared on a Specification Change Notice (see SSCL CMP) and submitted to the CCP. After the proposed change is approved, the notice will be used by Document Control to transmit the revised specification.

All changes to an officially released engineering drawing and/or parts list are prepared on an Engineering Change Notice (ECN). After the proposed change is approved, the notice will be used by Document Control to transmit the changes to the holders of the drawings. For specific instructions on completing an ECN form, refer to the SSCL Drafting Practices Handbook (P40-000140) - Section X, Drawing Revisions.

Procedures will be established to allow for processing engineering changes, deviations and waivers, cost/schedule changes, and exemptions on an emergency basis.

All formally controlled documents are released through the Document Control Center.

7.5 CONFIGURATION STATUS ACCOUNTING

Configuration status accounting provides the essential records and reporting of configuration data for all relevant GEM hardware and software. The primary objectives of configuration status accounting are:

- to maintain a current listing of all project baseline documentation
- to maintain current and accurate records of the status of changes, both completed and in process.
- to track specific hardware and software configurations.

Configuration Management will have an automated system for the recording and reporting of status accounting information. The GEM Project plans to use the SSCL automated system for the recording and reporting of configuration status accounting information. The GEM Project Manager is responsible for providing the configuration status on an as-needed basis. Access to this information will be made available to SSCL and GEM personnel through established computer networks.

Records on the status of changes enables an audit trail from acceptance of each change request to verification of change implementation. The records include:

- Change requests and change proposals.
- Baseline documentation status.
- Deviations, waivers and exemptions.
- Retrofit and modification (if applicable).

7.6 REVIEWS AND AUDITS

The technical baseline is managed throughout the GEM design and fabrication program to ensure that the system meets its specifications and that these specifications reflect the true configuration of the system. This is accomplished through sequencing of design reviews and audits. The technical reviews are described in Attachment 4 of this plan. Minutes of the technical reviews are recorded, processed and distributed by the Document Control Center. These review minutes, together with the documented test results, form the basis for the configuration audits.

A Physical Configuration Audit (PCA) will be performed on the detector and its subsystems to ensure that the technical documentation properly reflects the "as built" configuration.

8.0 PROJECT WBS AND COST ESTIMATE

8.1 GEM PROJECT WORK BREAKDOWN STRUCTURE

This section describes the Work Breakdown Structure (WBS) for the GEM Project. The GEM Project itself is at level four of the SSC Project WBS. The WBS for the GEM Project extends levels to facilitate detailed planning, scheduling and cost estimating.

8.1.1 Summary GEM WBS

Figure 8-1 displays the Level 2 WBS for the GEM Project.

Appendix E contains the GEM WBS, to Level 4. Each major element of the GEM WBS has been extended down to additional levels, as necessary to develop detailed cost estimates. The results are provided in the GEM Cost Estimate.

8.1.2 Usage of the GEM WBS

The WBS is a key project management technique used to organize and manage all SSC project work. It is utilized during the planning, status assessment, reporting and change control processes. It is also key to integrating information from various management systems at the SSCL. The following items highlight the WBS utilization for the GEM program.

Planning

The WBS allows the detector project to be broken down into manageable elements of work. For each element of the WBS there will be an associated scope of work, cost estimate and schedule. Each lower-level WBS element will be assigned to a responsible manager or organization.

Status Assessment

During periodic status assessment, each WBS account will be reviewed for progress and schedule status. Costs are collected and recorded against WBS account numbers. These assessments provide the mechanism for measurement of cost, schedule, and technical status of all work on the project.

Reporting

The WBS allows information to be summarized for reporting. It also allows managers to identify detailed problems that may be reflected in summary (reported) information. In addition, the WBS will support the technical management effort by providing clear visibility of all aspects of the project as it progresses from planning through execution.

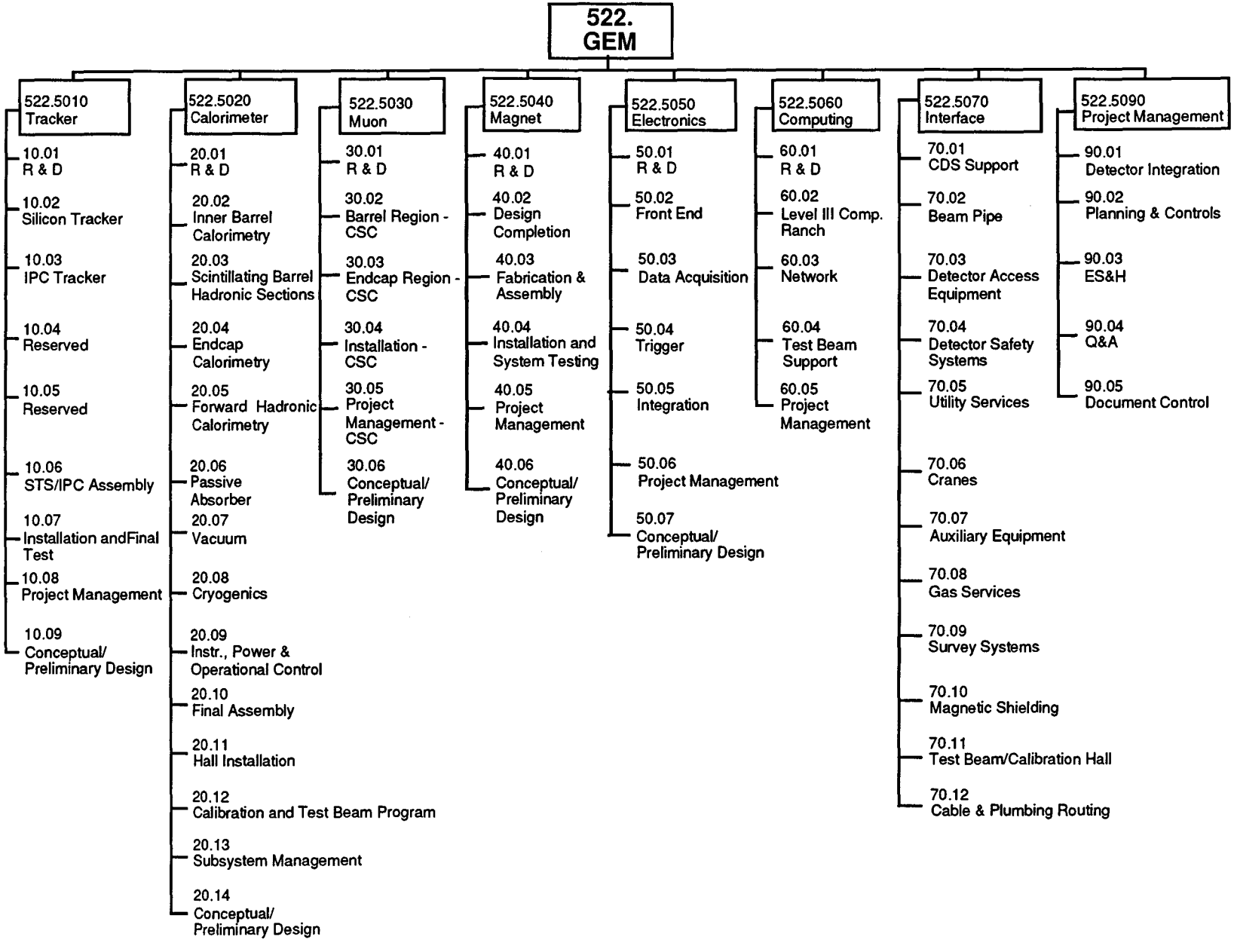

Figure 8-1. Summary WBS for the GEM Project

Integration and Change Control

The WBS also provides a key mechanism for integrating management systems used on the project. All work authorization systems, cost estimating and cost control systems, scheduling systems, technical and engineering management systems, quality management systems, and reporting systems will use WBS numbers to identify work. This allows information to be integrated as needed to manage the project, and to understand the impact when changes occur. In addition, the WBS provides a mechanism for tracking baselines and changes to the baseline.

8.2 COST ESTIMATES

8.2.1 Overview

A detailed cost estimate has been developed in conjunction with the Technical Design Report for GEM. The cost estimates include all components of the detector, (in US dollars). Determinations will be made as to which elements of the project will be funded by SSCL and which elements will be funded by outside sources or provided as in-kind contributions. These determinations will be based on technical capabilities and/or resources of specific GEM groups.

8.2.2 TDR Cost Estimate

The Cost Estimate for the GEM detector based on the Technical Design Report is summarized in Table 8-1. The cost to level 3 of the GEM WBS can be found in Appendix F.

Table 8-1. Summary GEM Cost Estimate

WBS No.	Title	Total $M (FY 1990)
1.	Central Tracker System	
2.	Calorimetry System	
3.	Muon System	
4.	Superconducting Magnet	
5.	Electronics System	
6.	Computing, Controls and Communications Systems	
7.	Interface Systems	
8.	Reserved	
9.	PM	
	Total	

8.2.3 Basis For Cost Estimates

The GEM cost estimates summarized in Table 8-1 ~~has~~ have been developed using a detailed set of cost procedures, which are described in detail in a separate report, GEM-TN-00017, Rev. G[4]. The cost estimate is based on the current detector design contained in the GEM Technical Design Report. The costs are determined from a "bottoms up" estimate for each element of the GEM WBS.

Estimates-at-Completion (EAC's) of the GEM Detector and various subsystems will be prepared as required by project management. Those estimates will normally be prepared at detailed levels, as work is completed, and summarized. Establishing and maintaining EAC's will be the responsibility of the GEM Project Manager.

8.3 GEM FUNDING

8.3.1 Overview

Funding for GEM will come from a variety of sources, including SSCL (DOE), foreign financial contributions, and in-kind contributions from participating collaboration institutions. Negotiations with GEM member institutions are in progress.

8.3.2 Funding Profiles

A funding profile represents the integration of cost estimate with schedule to provide a time-phased cost projection. Funding profiles for GEM will be prepared to assess different funding scenarios, and will be developed as required over the life of the project. Funding profiles may change, for instance, when cost estimates or schedules change, when annual funding allocations change or when additional funding (or in-kind contributions) are identified. A current funding profile will be developed for the GEM baseline reviews.

8.3.3 Annual SSCL Funding

Annual budget/funding needs are estimated each year as part the Field Task Proposal and Agreement (FTPA) process required by DOE. During the process the PRD submits projected funding requirements for the next two years to the SSC PMO, for submittal to DOE. These requests, supported by detailed planning and status information provide the basis for DOE's submittal to the President, who subsequently requests the funds from the U.S. Congress as part of the annual budget request.

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[4] "GEM Cost Estimating Plan", GEM-TN-00017, Rev. G

Actual annual budget/funding allocations, as approved by Congress and the U.S. Office of Management and Budget (OMB), are then transmitted to the SSCL by DOE. Based on actual funding, annual work plans may then need to be revised at the SSCL. PRD receives annual budget approvals from the SSCL PMO. PRD allocates funds/budgets to the GEM project, based on plans and requests submitted by the GEM Project Manager and the availability of funds.

8.3.4 Non-Project Funding

A preliminary estimate of non-project funding including foreign contributions is contained in Attachment 1. Final values will be based on detailed agreements (or MOUs) that will be established after approval of the GEM baseline.

8.4 COST MANAGEMENT

8.4.1 Cost Management Objectives

The following Cost Management Objectives have been established for the GEM Project:

- To estimate costs for all elements of GEM, in order to plan for the funding, financing, or in-kind contributions needed to cover those costs.
- To establish budgets for various elements of GEM in order to provide comparisons of actual costs to original cost estimates.
- To monitor and report cost performance in order to provide early warning of potential cost and schedule problems and to ensure funding will be available.

8.4.2 Cost Management Approach

On an annual basis, budgets will be established for each major element of the GEM Detector based on funding. Annual budgets will be based on the baseline cost estimates for approved work scope, and on the approved GEM schedule.

Actual costs and projected (estimated) costs will be routinely compared to budgets and the BCE, in order to identify potential cost or funding problems. All expenditures and commitments of U.S. government funds will be managed and accounted for in accordance with SSCL and DOE requirements.

8.4.3 Use of GEM Reserves

The GEM cost estimate is based on a low-level bottoms-up estimate. Appropriate reserves have been included for individual components. Use of these reserves will be the responsibility of the GEM Project Manager and GEM Spokesman (with concurrence from the

Associate Director of Physics Division) as long as the total project costs for GEM are not exceeded.

9.0 SCHEDULES

This section presents Summary milestones and schedule goals for the GEM Project. Detailed schedule information will be provided as part of the baseline (October 93). Schedule management for the GEM project is also addressed.

9.1 OVERVIEW

In order to support the overall SSCL schedule and startup of the collider in 1999, summary level milestones have been established for the GEM project. Lower level milestones and schedules however depend on a number of factors, including details of funding and contributions by collaboration participants.

A fully integrated GEM project schedule will be developed in conjunction with the GEM baseline costs. This overall plan will be developed by establishing logic and detailed schedules for each of the major elements of the GEM WBS. Interfaces with ASD and CCD schedules will allow for integration of GEM schedules with the integrated SSCL schedule. Subsystem managers are responsible for maintaining and reporting their subsystem schedules.

9.2 MAJOR GEM MILESTONES

The major milestones for the GEM Project are identified in Table 9-1. A partial list of lower level milestones can be found in Appendix I.

Table 9-1. Major GEM Milestones

Submit Letter of Intent	November	91
Submit Technical Design Report	April	93
PAC Approval Complete	August	93
DOE Approval Complete	December	93
GEM Construction Begins	January	94
Earliest Surface Building BOD	July	94
BOD of Underground Hall	April	96
Installation Complete	March	99
Commissioning Begins	March	99
Ready for Operations	October	99

9.3 SUMMARY SCHEDULE

Figure 9-1 displays the summary schedule for the GEM Project.

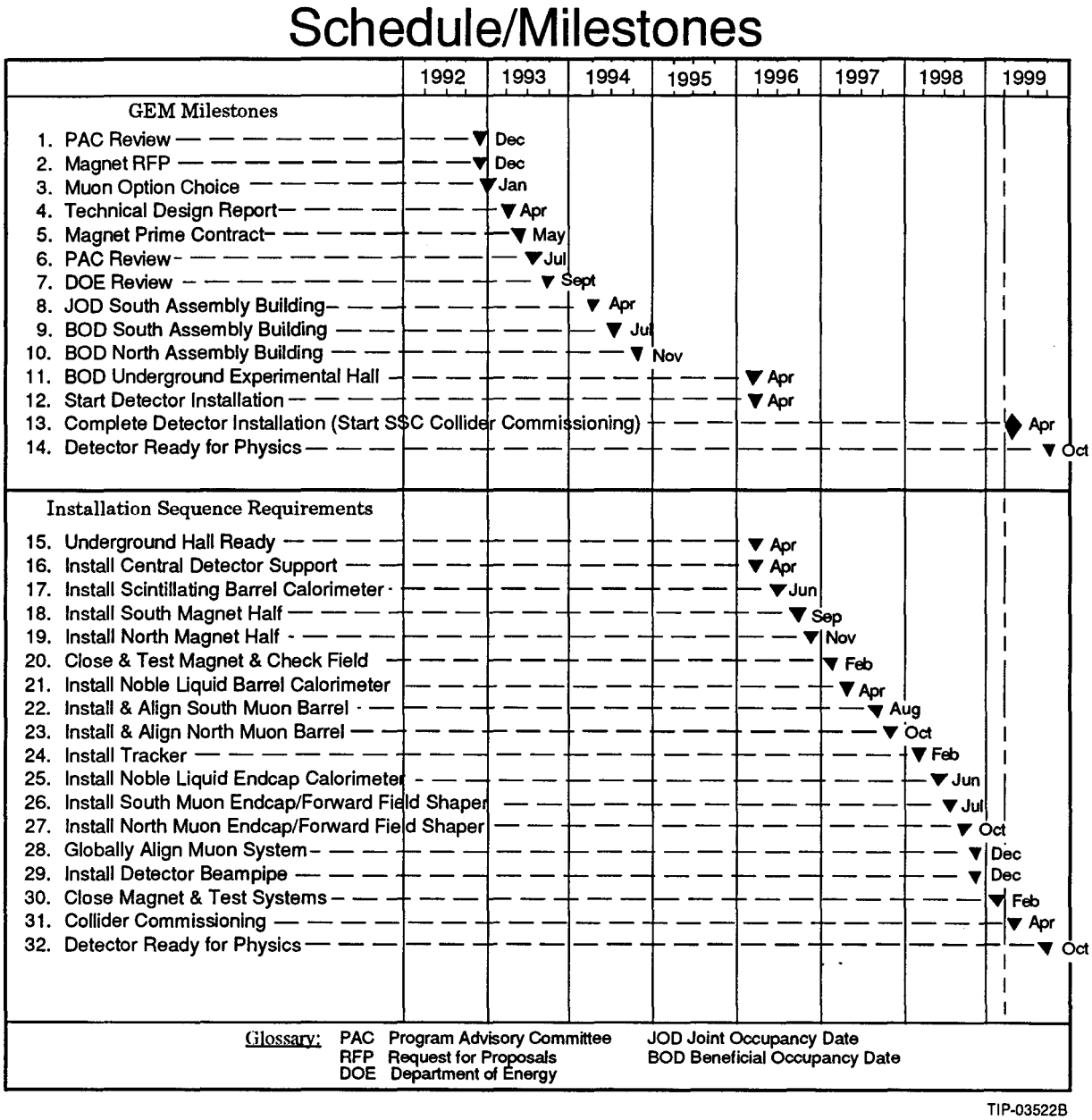

Figure 9-1. GEM Summary Schedule

9.4 LOGIC AND DETAILED SCHEDULES

9.4.1 Network Logic

Critical path network logic is being utilized to develop schedules for all major elements of the GEM Project. Networks are established at both intermediate and detail levels. Based on detailed planning and associated logic, intermediate network schedules are established and maintained, with interface ties among components and subsystems identified. These logic

networks provide the basis for summarized schedule information and for GEM schedule input into PRD and SSCL integrated schedules.

9.4.2 Detail Schedules

Detailed schedules for GEM components, subsystems, and tasks will be developed by responsible GEM subsystem project managers and subsystem leaders, with support from the GEM project scheduling staff. These detailed schedules are the basis for annual funding requests, as well as the logic and schedule information reported at more summary levels.

9.5 SCHEDULE BASELINE

The Summary milestones in Table 9.1 and the schedule provided in Fig. 9.1 are based on the cost and schedule estimates submitted with the GEM Technical Design Report. The GEM schedule baseline will be established together with the baseline costs (October 93) and maintained via the GEM change control process.

Each year the annual baseline schedule will be established based on available funding and collaboration input to provide a basis for GEM project performance measurement and reporting.

9.6 SCHEDULE MANAGEMENT

9.6.1 Schedule Management Objectives

The following Schedule Management objectives have been established for the GEM Project:

- To plan and schedule all activities required to meet milestone completion dates for the GEM detector.
- To integrate planning and schedule information from all collaboration participants to assure timely completion of each individual detector subsystem and component.
- To establish logical network plans in order to identify key interfaces, critical path activities and "hard" schedule dates, to minimize schedule problems and to assure timely completion of the GEM detector.
- To routinely monitor and report schedule status to GEM and PRD management.

9.6.2 Planning & Scheduling Approach

GEM Project plans and schedules will be based on both top-down and bottoms-up planning. Preliminary schedules have been developed based on overall need dates and preliminary

detector design information. Detailed plans and schedules will be finalized for all elements of the GEM project WBS after establishment of the project baseline.

9.6.3 Schedule Control

Both detailed and summary schedules will be monitored and updated on a routine basis. The usage of network logic will ensure ties to milestones so the impact of schedule status or changes will be visible.

Since the GEM detector project will include foreign contributions, schedules will be used to provide visibility of performance against commitments. Timely accomplishment of scheduled objectives can provide the verification of honored commitments.

The GEM project WBS will be used to assess the program schedule on a regular basis. The GEM project scheduling staff will obtain schedule status information from responsible GEM task leaders, will input and summarize schedule information and will provide schedule status and progress information to the GEM Project Manager and subsystem project managers.

9.6.4 Responsibilities

The GEM Project Manager has overall responsibility for directing and reviewing the GEM project planning, cost estimating and scheduling processes. He reviews summary cost and schedule information, evaluates tradeoff options and makes appropriate decisions.

The GEM Project Cost/Schedule (C/S) Coordinator is responsible for establishing cost estimating and scheduling methodologies and procedures. The GEM C/S Coordinator directs and coordinates the activities of subsystem C/S coordinators, provides for the integration of detailed and subsystem C/S information and summarizes formats and C/S information for GEM management. The GEM C/S coordinator is responsible for reviews and revisions to the GEM Cost Estimate and Schedule as well as C/S procedures and methodologies.

The GEM subsystem C/S coordinators will facilitate the development of detailed plans and schedules by working directly with GEM subsystem project managers. Based on input from the subsystem engineers and scientists, the subsystem C/S coordinators will develop appropriate logic network plans, cost estimates and detailed schedules. They will be responsible for supporting reviews of their subsystem costs and schedules.

Subsystem project managers will provide input to subsystem C/S coordinators, and will review and approve costs and schedules.

10.0 MEASUREMENT AND REPORTING

This section describes the performance measurement, reporting, review and communications processes which will be utilized in the management of the GEM Project.

10.1 PERFORMANCE MEASUREMENT

10.1.1 Overview

An integrated cost/schedule/technical Performance Measurement System (PMS) will be utilized on the GEM Project, in order to support GEM project management and reporting. Based on the GEM WBS and the approved GEM Baseline Technical Design, GEM will establish monthly performance measurement reporting. For GEM activity performed at non-US institutions, or involving in-kind contributions, special procedures will be implemented to track schedule and technical progress. In most cases special procedures will be approved by the GEM PM and spelled out in individual institutional agreements.

10.1.2 Cost/Schedule Performance Measurement

GEM Project cost and schedule performance measurement will involve the usage of a performance measurement baseline, monthly cost/schedule status measurement of GEM activity at US institutions, schedule status measurement for GEM work at non-US funded institutions and projections of at-completion status.

Performance Measurement Baseline

Upon approval of the GEM Technical Design and the associated scope, schedule and cost estimate, a Performance Measurement Baseline (PMB) will be established to provide a basis for comparing progress to plans, for identifying cost or schedule performance trends, and for projecting final costs and completion dates.

The PMB will be established at appropriate levels of the WBS, where responsibility for a subsystem, major component or set of activities is assigned to an institution or subsystems project manager. Specific WBS levels and accounts for performance measurement status and reporting will be established after the WBS and cost estimates are finalized.

Cost Schedule Status—Non-U.S. Funded Work

For GEM work performed outside the US, and at institutions not directly funded by the SSCL, detailed cost data may not be available, making cost status and assessments more difficult. For critical contributions, however, the GEM will request appropriate status information in order to assess potential cost problems which could jeopardize delivery of the technical products.

Schedule status will be reviewed on a regular basis on all GEM work, including activity at non-US institutions. Based on plans provided by those institutions, schedule status measurement will include identification of activities which have been started, completed or are in progress; milestones completed; and revisions to logic or dates for work remaining.

At Completion Projections

Estimates At Completion (EAC's) shall be established and maintained for major elements of the GEM WBS. Initially the EAC for the GEM Project will correspond to the baseline cost estimate. Based on actual performance, and as GEM work is completed, EAC's for individual WBS elements will be updated. EAC's may also change based on replanning associated with annual funding, technical breakthroughs, changes in contributions by non-US participations or revised logic.

For WBS elements associated with In-Kind Contributions, EAC's will not be changed unless formal agreements are revised or some other change occurs in responsibility for delivery of technical products.

For WBS elements funded by the SSCL, EAC's will be maintained and summarized for comparison to the baseline cost estimates and budgets.

10.1.3 Technical Performance Measurement

Technical performance will be assessed and reported monthly for all GEM activity. At summary levels of the GEM WBS, technical progress will be discussed in monthly progress reports, along with key technical issues, problems or breakthroughs.

At lower levels of the WBS, technical performance measurement will be a function of systems engineering, technical management and reporting. For individual components and subsystems, status of design and fabrication activities compared to plans, requirements and specifications will be carefully monitored.

For GEM work performed at institutions not funded by the SSCL, technical status reporting requirements will be defined in the institutional agreements. For all GEM work, detailed technical performance measurements will be the responsibility of the GEM subsystem project managers.

10.2 REPORTING

A GEM Project Monthly Progress Report (MPR) will be prepared and submitted to the AD/PRD at the SSCL by the GEM PM. The following sections will be included in the GEM MPR:

- Summary. The summary will contain a brief overview of the progress made during the period. Summary level cost and schedule status will be included. Any major problems or issues which surface during the month will also be identified.

- Technical Progress. This section, organized by subsystem (WBS level 2), will describe technical progress during the month on the various subsystems and components. All GEM activity in progress will be covered, including work at non-US institutions.

- Milestones/Schedule Status. A status report of major GEM Project milestones will be provided each month. This report will show planned, actual and projected completion dates for each milestone. In addition, this section will contain a brief schedule status for each major WBS element, to GEM WBS level 2.

- Cost Report. A summary cost report showing cumulative expenditures vs. budgets by WBS.

- Other Issues. Other issues may be included in the GEM MPR as determined by the GEM PM. Issues may include problem assessments, high level issues related to funding or in-kind contributions, requests for SSCL or DOE assistance or other issues which the GEM PM wants highlighted.

10.3 PROJECT REVIEW MEETINGS

10.3.1 Management Review Meetings

Review meetings will be conducted within GEM by the PM on a regular basis. On a monthly basis, the GEM Project Manager will meet with the AD/PRD to review the GEM Project MPR, overall project status and any special issues or problems. PRD and GEM subsystem project managers will be included in the meeting as determined by the GEM PM.

10.3.2 Technical Review Meetings

Technical review meetings will be conducted by the GEM Project Manager on a regular basis, as necessary to approve design requirements and specifications, to review technical status or issues, and to resolve technical problems. Scheduled technical review meetings associated with individual subsystems, components or integration/installation activities are defined in Attachment 3.

10.3.3 Collaboration Meetings

Periodic meetings of GEM Collaboration participants will continue over the length of the GEM Project. Collaboration meetings may include the GEM Executive Committee, GEM Collaboration Council, or GEM Subsystem Groups. These meetings will review project status, discuss key technical or scientific issues, establish or review GEM policies, approve new members or organizational changes. Collaboration meetings will be called and directed by the GEM Cospokesmen.

10.4 FORMAL COMMUNICATIONS

The GEM Cospokesmen and the Project Manager are responsible for all communications with GEM participants, including non-US institutions. Formal communications with DOE, the U.S. government, State of Texas, foreign governments and the general public, related to the GEM Project shall be through the AD/PRD via established SSCL procedures, and as outlined in the PMPD.

11.0 SYSTEMS ENGINEERING AND INTEGRATION MANAGEMENT PLAN

The systems engineering plan that will be utilized in the construction of the GEM detector and its supporting systems is described in this chapter. This plan is derived from the SSCL Engineering Management Plan and subsumes all aspects of that plan that apply to the production of the GEM Detector.

11.1 OVERVIEW

11.1.1 Introduction

The GEM Detector engineering process includes the development of conceptual designs, trade-off studies, establishment of a baseline design, detailed design, manufacturing, construction and verification of system performance. Integrated into the engineering process will be configuration management; quality assurance; specialty engineering; and environmental, safety, and health protection.

11.1.2 Systems Engineering Objectives

This chapter addresses the following objectives:

- Transform detector operational requirements into performance parameters, design details and a system configuration;
- Integrate related technical parameters and ensure compatibility of all physical and functional interfaces;
- Incorporate availability, reliability, maintainability, supportability, safety, environmental protection, and human factors into the engineering effort;
- Fabricate hardware, develop software and firmware, and progressively integrate functioning units into the detector which meet all design requirements and whose documentation correctly identifies the GEM detector;
- Verify the specified requirements;
- Commission the project components;
- Ensure the capability to operate and maintain the detector and supporting systems

11.2 DETECTOR ENGINEERING

11.2.1 Detector Design

Research and Development related to the detector design has been underway for several years. The Expression of Interest submitted to the SSCL in July 1991 provided an initial concept that was reviewed by the SSCL, DOE and the Program Advisory Committee. After additional studies and tradeoffs, a revised detector proposal was submitted with the Letter of Intent in November 1991. Since that time, a great amount of analysis and review has taken place. The result is the detector proposal contained in the Technical Design Report.

Reviews of the Technical Design Report are expected to establish a baseline design that will be documented in a Level 3B specification for the overall detector and Level 4 specifications that define the detector subsystems and components.

11.2.2 Interface Management

Interface Control Documents (ICDs) will be used to identify and define the interfaces between the detector and the collider and experimental facilities, and between the detector subsystems. They will be controlled through Configuration Management and reside in the GEM Document Control Center (GEMDCC). Changes to approved ICDs will be processed through the existing configuration management process the same as any change to the technical, cost, or schedule baselines.

The GEM Project Department is responsible for the definition of interfaces for the detector to the collider. A working group of PRD, GEM and Conventional Construction Division (CCD) personnel will determine the interfaces between the detector and the experimental facilities. The GEM Engineering and Integration Group will determine the interfaces between the detector subsystems.

GEM Systems Engineering personnel will provide the coordination required to implement the process and to document the results of the process. Resolution of interface issues should be achieved at the lowest level which is reasonable.

The ICDs will address the following topics:

- Physical interfaces (envelope, attachments, obscurations, alignment, mass properties)
- Electronic interfaces (format, rates, and identification of command signals, frequency characteristics, format and rate of data signals)

- Electrical interfaces (type, voltage, profile, and protection for electrical power; electromagnetic compatibility)
- Software (Data, message enabling, error detection)
- Fluid (Pressure, Flow rate, Temperature)
- Environmental (Vibration, temperature, humidity, radiation, magnetic field)
- Safety (Material restrictions, explosion proofing, radiation, operating limits)

11.2.3 Manufacturing

The manufacturing process will be capable of producing reliable hardware for GEM service. Because of the variety of system/equipment types, quantities, complexities, and criticality, no single set of decision criteria, guidance, or considerations can be provided to fit all programs. The following paragraphs provide general guidance for manufacturing and will be tailored to the application.

A Production Readiness Review (PRR) may be held for certain components such as those subject to mass production. The PRR results summarize achievement status and provide an assessment of production readiness and risk in each applicable area.

Manufacturing Planning Manufacturing planning will be accomplished as an integral part of development to ensure a smooth and timely transition into production. The principal focus of manufacturing planning will be producibility and the use of manufacturing processes where process control is emphasized.

Producibility Analysis. Producibility analysis is an element of manufacturing planning during early development stages. The design will be reviewed to identify those design characteristics that exceed industry practices thus creating an element of manufacturing risk. Examples of these characteristics include unusual configurations; applications of materials, tolerances, and finishes; and use of sensitive, hazardous, or other processes that suggest potential problems. Producibility criteria based on design characteristics will be developed and documented as the design is developed.

Process and Method Analysis. This analysis will consider material selection, production tooling, new or unique processes, test and inspection methods, tooling needs, and work methods to be used in production. This analysis may identify areas of manufacturing risk and a need to consider alternate approaches or parameters to enhance the capability to produce specified components.

Manufacturing Plan. A Manufacturing Plan will be prepared that identifies the approach and processes to be used in production of certain components. The plan is based on the results of planning and analysis activities that have been conducted to define the optimum approach. Accordingly, all actions required to produce, test, and deliver acceptable systems on schedule and at minimum cost will be defined. Where appropriate, the materials, manufacturing process flow (including test, inspection, and process control), time in process, tools, test equipment, facilities, and personnel skills will be described and integrated into a complete sequence of events.

Manufacturing Process Qualification and Controls. Where appropriate, manufacturing processes will be documented to the degree necessary to ensure repetitive stable production of products which conform to design requirements. These processes will be qualified during fabrication of development hardware. The procedures used in qualifying the manufacturing processes will ensure the adequacy of production planning, tool design, fabrication and assembly methods, and personnel training prior to the manufacturing decision.

11.3 CONVENTIONAL FACILITIES

11.3.1 Requirements

GEM conventional facilities are comprised of the experimental hall, surface facilities, utilities, and infrastructure. The technical requirements for the conventional facilities are described in the Level 3B specification, "GEM Experimental Facilities User Requirements (GEFUR)." CCD has expanded upon this specification with Design Requirements Documents (DRDs) that provide detailed guidance to the Architectural Engineer/Construction Manager (AE/CM).

11.3.2 Design

Design and construction of conventional facilities is performed by the AE/CM, under the technical direction of the SSCL-CCD. GEM is a customer for the conventional facilities and, through the Working Group System, is involved in the design and engineering to ensure that the completed facilities meet the established technical requirements within the Baseline Cost Estimate. The function of the Working Groups is to provide GEM input to the detailed design and to establish the coordination necessary to facilitate the process.

Interface control is facilitated through the working group system. Working Group members are chartered with the responsibility to keep GEM informed on requirements and interface issues and to obtain input from other GEM members as necessary.

11.4 DOCUMENTATION

11.4.1 Baseline Documents

The engineering process uses the baseline management concept consisting of a technical baseline plus cost and schedule baselines which support the technical baseline. The technical baseline consists of the approved documentation used to define the requirements, interfaces, and design drawing packages. The technical baseline progresses from conceptual, high level requirements, to more detailed requirements and design, to fabrication and manufacturing.

Specifications, interface control documents, and drawing packages are used for "design to" procurement or fabrication of items. Specifications will be in a hierarchy such that there is design traceability to the lowest level. Once approved, baseline documentation can be changed only through the Change Control Board and Change Control Panel. That is, the documents forming the baseline are under configuration control.

The Technical Design Report, the GEM Baseline book, specifications, interface control documents, and drawing packages are used to define the detector and its subsystems. The baseline will include cost estimates and schedules which support the technical baseline. Once approved, baseline documentation is changed through the change control process. (See Section 7.0)

11.4.2 Specifications

In order to implement the engineering process, GEM hardware, software, and facilities have been divided into manageable functional units each with its technical specifications and design criteria. This allocation to specifications is represented in a Specification Tree, Fig. 7.1. This specification tree also represents a requirements flow from top level requirements to increasingly detailed requirements for units that make up the GEM detector.

Five levels of specifications are in use at the SSCL:

1. Project, Level 1: The Level 1 specification sets the top level requirements for the SSC.

2. Systems, Level 2: The Level 2 specifications define the high-level requirements for Experimental Systems.

3. Segments, Level 3A: The Level 3A specifications contain the functional and physics requirements for Detectors, Experimental Halls & Facilities, Experimental Systems Computing, and Test Beams.

Elements, Level 3B: The Level 3B specifications define the requirements for the GEM Detector and the facilities for the GEM Detector. These specifications are the responsibility of the GEM Project Manager and GEM Spokesman and are approved by the Associate Director of PRD. Changes to the Level 3B specifications will be submitted to the PRD CCP for approval.

4. Subsystems, Level 4: The Level 4 specifications define the detector subsystems. The details of the Level 4 specification flow from the requirements found in the 3A and 3B specifications. These specifications, and the changes to them, are prepared by the subsystem project managers and subsystem leaders and are approved by the GEM Project Manager and GEM Spokesman.

5. Components, Level 5: The Level 5 specifications describe the detector components. They are approved and changed by the subsystem project managers and subsystem leaders.

There are four types of level 4 and 5 specifications that will be used to define the detector, its facilities and its systems.

1. Development and Performance Specification. Each hardware and software development specification will establish the performance, design, development, and test requirements for GEM project items under configuration management.

2. Product Specification. Development and preparation of a product specification will begin as the design stabilizes at each level of iteration. After approval of the corresponding development activities, a product specification, containing fabrication requirements, will be generated. The product specification will contain (a) a detailed description of the parts, parts selection criteria, and subassemblies of the product, usually by prescribing compliance with a set of drawings; and (b) those performance requirements and corresponding acceptance tests and inspections necessary to assure proper fabrication, adjustment, and assembly techniques.

3. Process Specifications. These define manufacturing processes which must be followed. They will identify manufacturing requirements, equipment, materials, procedures and operations, and any certifications required.

4. Material Specifications. These are provided as needed to identify the specific materials by requirement, character, quality, or formulation.

11.4.3 Specification Processing

During development, specifications undergo periodic progress reviews by GEM management. Final specifications will be subjected to appropriate reviews. Formal review and approval of each document will be recorded. Final versions of specifications will be provided to the GEM Document Control Center for reproduction and distribution. Changes approved by the Change Control Panel/Board will be implemented by a Specification Change Notice distributed by the Document Control Center to all persons holding a copy of the specification.

11.4.4 Documentation/Drawings

Engineering drawings are used to document the physical and functional design characteristics of GEM components. Configuration Management will verify that the documentation is properly reviewed prior to releasing the document(s) to Document Control. The verification includes but is not limited to:

- Checking each release package for proper release authority and functional department signatures.
- Reviewing the package for accuracy and completeness.
- Capturing data for the configuration status accounting database. (As a minimum, the listing of all released documents will be captured and stored in a data file.)

11.4.5 Documentation of Decisions

Design requirements are documented in specifications and interface control documents. Detailed design is documented in design drawings. These documents are part of the process to record design requirements of the system or component. When approved, these documents become the baseline. They can be changed only through the formal change control process.

11.4.6 Software Development

All GEM software development will follow software development plans (SDPs). Each SDP will be developed by the highest level individual in charge of software development for each subsystem. It will be approved by the Computing Subsystem Manager (CSM) and Project Manager. The contents of the SDP are shown in Appendix N. GEM will organize groups with Group Leaders to develop software. Each group will have projects with Project Leaders. The Project Leader will develop an SDP for the project, to be approved by the Group Leader, CSM, and PM.

11.5 CONFIGURATION MANAGEMENT

The approved Technical Design Report establishes the GEM baseline configuration. Engineering control will be provided through management of this configuration. GEM will implement configuration management (CM) as described in Chapter 7 of this document..

The GEM Document Control Center is responsible for assigning document numbers and for the reproduction, distribution, retention, and safekeeping of controlled engineering documents.

11.6 TECHNICAL REVIEWS

Technical reviews will be conducted to approve technical requirements or specifications and to review the technical design. Details are contained in the policy and procedures shown in Attachment 3.

11.7 TEST, EVALUATION, & COMMISSIONING

Tests and evaluation of the detectors and detector components will show that the technical objectives have been met. Testing may include developmental testing, qualification testing, acceptance testing, or some combination of these tests. In most cases, items (Level 4 and below) for which specifications have been developed under the GEM Project, will be subject to formal acceptance testing, performed by either the developer/builder or the GEM Engineering and Integration Group. Successful completion of acceptance testing indicates that the item under test has met all specified requirements.

11.7.1 Test Planning

For particular subsystems or components as well as for the detector as a whole, GEM will establish appropriate test programs. Review and approval authority will be defined to ensure that the test plans and procedures establish the proper test conditions to adequately measure the specific technical performance parameters. Test reports, problem analysis and corrective action plans will be generated for each defined test. This will ensure the results, analysis, and recommendations are fully integrated into the management and engineering decision process.

In planning for specific testing programs, the following factors will be considered.

- System level (e.g., subsystem, component, item,....)
- Types of tests and conditions related to critical performance parameters.
- Responsibilities for testing and relationships with other organizations.

- Numbers of test articles, hardware and software, and major resource requirements.
- Project schedule requirements.

For the detector as a whole, a GEM Detector Acceptance and Test Plan will be developed.

11.7.2 Verification Methods

Four methods will be used to verify requirements for both hardware and software during test and evaluation:

- Inspection. An observation or examination to determine conformity with requirements.
- Analysis. A review or study of data which may use mathematical formulas or models to show that requirements are met.
- Demonstration. A functional exercise wherein the qualitative requirements are verified by observation.
- Test. An exercise wherein quantitative performance is compared to requirements and is documented.

11.7.3 Reporting

Results will be reported after each significant test. Reports will be prepared by the cognizant group conducting the test and will include information necessary to document successes and failures. The GEM Project Manager and Subsystem Project Managers will receive copies of the test reports.

11.8 INSTALLATION AND INTEGRATION

The GEM Engineering and Integration Group will be responsible for ensuring integration of detector subsystems and the detector with the collider and experimental facilities.

During detector integration, the relevant specifications and interface control documents will be verified to ensure that the documentation will support the operations and maintenance of the detector, and that appropriate safety systems and procedures are in place.

The GEM Engineering and Integration Group will be responsible for installing the detector elements in the Collision Hall.

Prior to the start of installation, the required conventional facilities will be in-place and formally turned over to the SSCL. The GEM Project Manager will conduct a site inspection to insure that installation work may begin. Hardware installation will be performed according to approved installation drawings and procedures.

11.9 SPECIALTY ENGINEERING (RELIABILITY, MAINTAINABILITY, SUPPORTABILITY, HUMAN FACTORS ENGINEERING)

Application of the disciplines of reliability, maintainability, supportability, and human factors engineering starts early in the design process and continues throughout the life cycle of an item. The goal is to ensure that the item which meets its performance requirements will continue to do so over time, that it will do so in its operating environment, and that it can be logistically supported, operated, and maintained at the intended level of skill and training. Specialty engineering applications will be tailored based on criticality.

The objectives of this approach are (1) to affirm the inseparable relationship between material design and its specialty engineering characteristics, and (2) to direct the material acquisition emphasis toward engineering and manufacturing specifications, disciplines, and controls by which successful systems are designed and produced. The GEM goal, which flows down from the higher level SSC specification tree, is to design a detector with an availability of 0.8.

The elements of Specialty Engineering are described in Appendix O.

12.0 QUALITY ASSURANCE

This section describes the approaches and methods for Quality Assurance (QA) to be applied during final design, fabrication, installation, testing and start up of the detector. QA is a line management responsibility and will be implemented down through the subsystem management organizations.

12.1 OVERVIEW

Due to the complexity of the GEM detector, and of the organization and number of participants who will complete various elements of the detector, QA on the GEM Project is not a simple matter of establishing requirements, measuring performance and meeting specifications. Rather, a clear understanding is needed of the technical performance objectives of individual components and subsystems, as well as the physics objectives of the overall detector systems.

While technical specifications, functional performance requirements, and well documented designs are needed to engineer and fabricate equipment, scientific perspective is necessary at all stages. That is, the physicists and other scientists participating in the Collaboration must provide the perspective, reviews and assurance that the necessary performance will be attained. Ultimately QA becomes the shared responsibility of everyone participating on the project.

The QA approach on the GEM Project will satisfy the requirements of the PRD QA program. The primary basis for GEM QA, however, will be scientific oversight and reviews for all aspects of the project. It is the responsibility of the GEM Project Manager to insure that the scientific oversight provided by the greater GEM Collaboration is the ultimate basis for GEM QA.

12.2 GEM QUALITY OBJECTIVES

As stated in the SSCL QA Program Description, "Quality must be defined by the users of the products or services . . ." In the case of the GEM Detector the users are the same scientists who have proposed the detector and are proceeding with the design. Additional users will include other members of the world's high energy physics (HEP) community.

The following quality objectives are therefore established for the GEM Project:

- To provide a major detector and related systems, as described in the Technical Design Report, which will allow exploration of the best possible physics, within the time and funds available.

- To ensure that the systems, subsystems and components are designed, fabricated, installed, tested and operated to the specifications established by GEM.

12.3 QA IMPLEMENTATION

12.3.1 GEM QA Policy

GEM Project participants shall plan and conduct all activities necessary to ensure that detector systems, subsystems and components are designed, fabricated and will perform as needed to achieve GEM Project objectives. The GEM Project is committed to providing a major detector which will allow the best possible physics, within the design, time and cost constraints established.

12.3.2 GEM Approach to Quality Implementation

Achievement of technical performance goals and high quality shall be a line management responsibility, assigned to GEM engineers and scientists responsible for providing individual subsystems and components. For engineering, fabrication, construction, integration and testing purposes, appropriate technical documentation will be prepared to ensure that specifications and requirements are well defined and that all necessary processes and activities are understood. The implementation of systems engineering, including well defined technical procedures, technical performance measurement, and appropriate testing and evaluation, will also help to ensure necessary quality.

For in-kind contributions or activity at institutions other than the SSCL, special strategies will be implemented, including scientific and technical reviews, component and systems documentation and testing, and institutional agreements. For all aspects of the GEM Project, scientific oversight, reviews, and test procedures will be established to ensure that detector systems perform as required.

12.3.3 QA Responsibilities

The GEM Project Manager has overall responsibility for completion of the GEM detector with the established performance requirements. Individual GEM subsystem project managers will be responsible for ensuring necessary technical documentation is completed; for planning and conducting tests, evaluations and reviews; and for ensuring that the components and subsystems perform as required.

The GEM QA Coordinator shall be responsible for reviewing plans, procedures and technical documents for quality issues; for coordinating implementation of the GEM QA approach; and for responding to issues, needs or requests as directed by the GEM Project Manager. The PRD QA manager at the SSCL shall coordinate implementation of the PRD QA Program and shall support the GEM QA Coordinator.

12.3.4 GEM Quality Implementation Plans

The QIP will identify the special procedures, methods, responsibilities and documentation related to QA on the various GEM subsystems as described above. These plans will be developed concurrent with design and installation plans.

12.3.5 Quality Control

Quality Control (QC) includes those activities and processes related to checking actual technical performance or products to specifications and requirements. For GEM, QC will be embodied in the technical performance measurement (TPM), test and evaluations, and systems engineering processes to be planned and conducted on the GEM Project. (See Section 11.0 of this PMP.)

12.3.6 QA Documentation

Major QA documents to be utilized on the GEM Project include the GEM QIP and the PRD QA Plan. All documents which demonstrate the achievement of QA on GEM, which are considered Quality Records by DOE, will be maintained at the SSCL as described in Attachment 5.

Quality records include those documents which describe the GEM technical configuration, procedures, plans, inspection records, qualifications, etc., which demonstrate the actual implementation of the GEM QA policy and activity. For the most part these records will include documents to be prepared in the normal process of design, engineering, testing, and configuration management. Subsystem project managers are responsible for documenting and maintaining these records.

The GEM QA coordinator will establish and maintain QA records for each major subsystem of the detector. GEM QA records to be controlled will be identified in the GEM Project QIP.

12.4 QA COMPLIANCE

GEM Project QA implementation will comply with DOE Order 5700.6C and the PRD QA Plan.

12.5 QUALITY AWARENESS/TRAINING

The scientists, managers and technical experts working on the GEM project understand the importance of high quality for ensuring the needed performance of the GEM subsystems. Certain aspects of GEM QA Implementation, however, will need to be communicated to all key GEM Project participants. Some QA issues will require special communications (i.e., reviews at

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foreign institutions, QA requirements in contract documents, testing procedures during installation, etc.) Quality implementation will therefore be included as an element of project management briefing and training sessions to be conducted by the GEM QA coordinator.

12.6 DESIGN QUALITY

Design quality is achieved during the design process through diligent application of applicable standards and practices by individual designers. Assurance of design quality is accomplished through (1) a structured system of internal and external reviews, including reviews for the purpose of approval, peer reviews and formal technical/design reviews; (2) manufacture of development hardware using product baseline design disclosure to assure producibility aspects of the design and to prove manufacturing capability and processes; and, (3) inspection and test of development hardware, including development inspection, design evaluation/qualification testing, and acceptance testing.

There are other considerations or features of the design process which are essential to effective design quality assurance. These features include the following:

12.6.1 Inspectability and Testability

Inspectability and Testability involves (1) selecting and identifying design characteristics or parameters which must be verified by inspection or test to determine the quality of the end product; (2) ensuring that these parameters are, in fact, measurable and testable; (3) selecting the measurement methods and techniques to be used; and, (4) identifying unusual or unique measurement needs to permit timely design and fabrication or procurement of the necessary test systems or equipment. This inspectability and testability analysis of the design will be routinely accomplished by the designers as the design evolves.

12.6.2 Test and Inspection Equipment Quality

Test and inspection equipment will be evaluated to provide the measurement capabilities and accuracies required to ascertain that the design, components, and construction specified has been achieved. This evaluation will include an error analysis prior to release of the design and verification testing of the equipment. The error analysis will predict test and inspection errors (e.g., repeatability, accuracy, stability) based on manufacturers specifications for commercial equipment, on data available from previously used unique circuits, and on engineering estimates for new design equipment. Verification testing will be conducted to determine inherent errors in the first units of test and in inspection equipment containing new design or critical measurement circuits and to verify errors that cannot be verified thorough the error analysis process.

Formal review and approval of specially developed test equipment drawings, specifications, operating and maintenance procedures, calibration requirements, and similar characteristics will be as rigorous as the design review process of level 4 product designs.

12.6.3 Subcontractor/Supplier Design Quality

Assurance of subcontractor/supplier design quality will be accomplished by applying essentially the same techniques discussed above for in-house design activities.

13.0 UTILITIES FOR THE GEM DETECTOR

13.1 GENERAL

The design and installation of utilities for detectors is arranged by agreement between the CCD and the PRD. Utilities installed during civil construction are by agreement referred to as conventional utilities, and their design and installation are coordinated by the CCD. GEM and PRD are responsible for writing the functional requirements for conventional utilities. Utilities installed after civil construction is complete, primarily for support of the detectors, are called technical utilities. The overall requirements and preliminary specifications for GEM systems are outlined below. The detailed specifications are presented in the Element Specifications in the GEM Experimental Facilities User Requirements (GEFUR) (GCT-000001).

13.2 SITE PLAN

The overall layout of the IR-5 surface facilities is shown in Fig. 13-1. The configuration has been developed to support the assembly, installation and operation of the GEM detector. There are six permanent building structures planned for this site. They include:

- South Assembly Building
- North Assembly Building
- Installation Shaft Headhouses
- Utility Building
- Personnel and Equipment Access Building
- Gas Mixing Building

13.3 OVERALL GEM UTILITY REQUIREMENTS

13.3.1 Natural Gas

Natural gas will be used for space heating and dehumidification. The gas is supplied to the Utility Building, where it is used as boiler fuel for producing heating hot water. Hot water is then distributed to the various facilities to be used in the heating units serving each building.

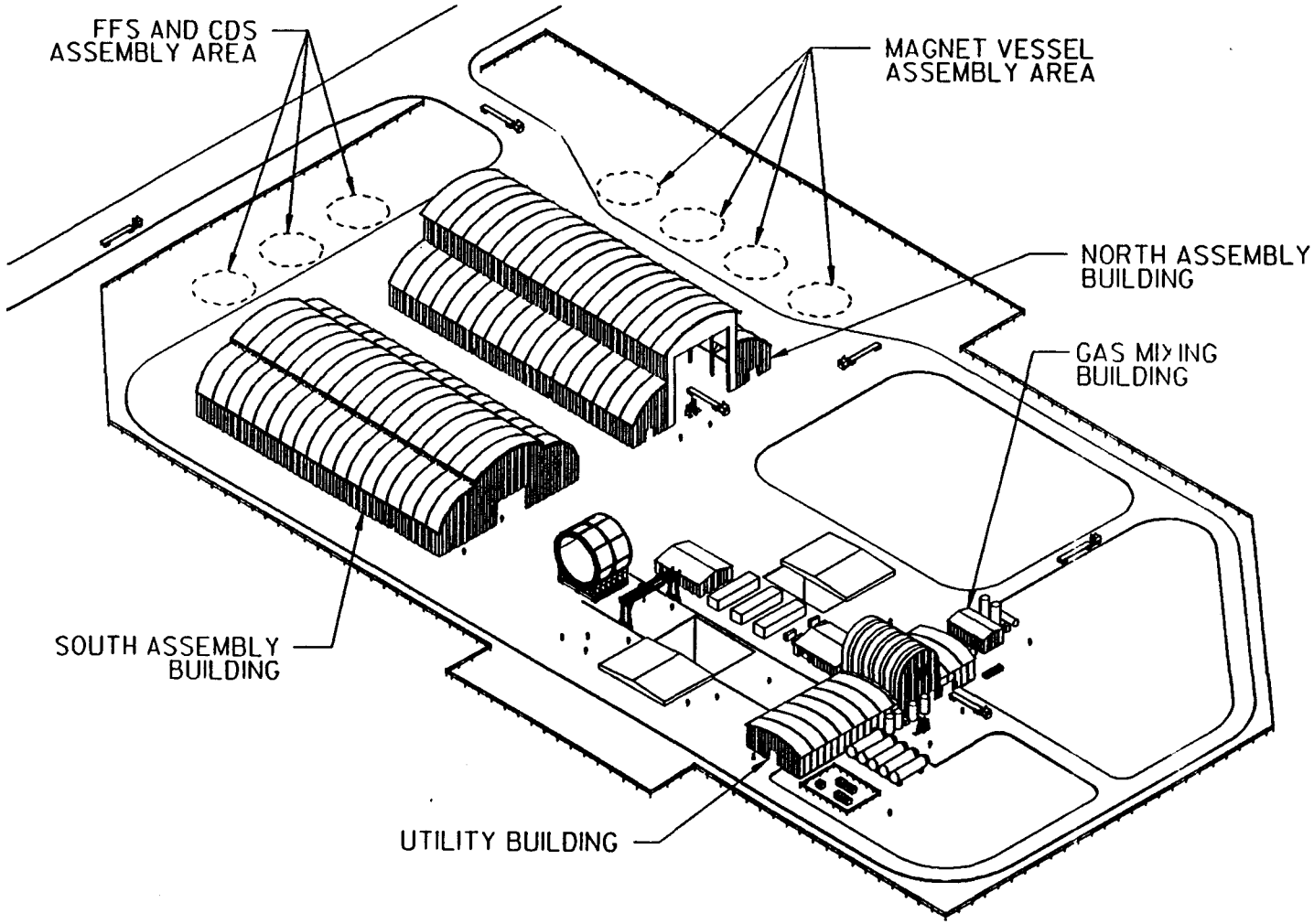

Figure 13-1. IR-5 Surface Facilities

13.3.2 Domestic Water

Domestic water will be delivered to three of the buildings in the IR-5 facilities where permanent occupancies are planned. Total occupancy for the site after the detector is commissioned and operational in 1999 is estimated at 156 people.

13.3.3 Cooling Pond and Cooling Tower Water

The majority of the waste heat rejected to the cooling water systems will be transferred to the atmosphere by means of evaporative cooling systems: cooling ponds, cooling towers, or a combination of both. For reasons of location and/or other factors, it may be necessary to use air-cooled sensible heat exchangers to reject some portion of the cooling water system load.

13.3.4 Wastewater Facilities

Provisions shall be made for a wastewater collection system, gravity sewers, pumping stations (if required) and force mains to collect and convey domestic and industrial wastewater to a wastewater treatment plant at a location to be determined by this activity. The final location of the WWTP shall be agreed to by the TNRLC; who shall also provide for the design and construction of the plant. Wastewater loads (hydraulic, biological, chemical, etc.) and schedules for those loads shall be furnished to TNRLC by PB/MK.

The wastewater facilities shall be designed and constructed to be consistent with the SEIS and in accordance with the requirements of the US EPA, US DOE, Texas Water Commission and other applicable federal, state and county agencies.

13.3.5 Power and Lighting

Electrical infrastructure consists of the following: From the Main East Side substation three feeders will be routed to the IR-5 main substation using the utility corridors. One feeder will be dedicated to serve electronics loads. The IR-5 main substation will provide high voltage distribution to all IR-5 facilities and site and street lighting using underground duct bank systems. Design loads for cable and duct systems will be based on the estimated IR-5 site load of 15.2 MW.

13.3.6 Communications

A system of underground duct banks for communications, fire alarm, data transmission and controls will be required to house fiber and cable systems that will be used to interconnect the facilities. These utility corridors will be made available to the commercial communications provider. A direct interconnect system will also be required between East and West Campuses.

The infrastructure requirements shall be in accordance with the following: EMCS Report; the site Master Plan; the Communications Working Group; ES&H Office; and SSCL Controls Group.

13.3.7 Hall HVAC

To cool the Experimental Hall, multiple air handling units shall be located on the surface near the Utility Building. A stand-by unit shall be provided. Each of the units shall be sized for a portion of the required emergency airflow (4 air changes per hour). During normal operation, several of the units shall operate and one shall be standby. Normal operation shall be defined as 2 air changes per hour. During emergency operation, all units (including stand-by) shall be brought on line at full airflow. Each of these units shall have both supply and return (or exhaust) fans and shall be capable of operating in an economizer mode, i.e. using 100% outside air when environmental conditions permit. All units shall be served with chilled and hot water as cooling and heating mediums. Additional cooling coils shall be provided to further reduce the hall relative humidity in the event of a water spill in the hall. These drying coils shall be direct expansion type.

13.3.8 Detector HVAC

The detector air conditioning system shall consist of multiple supply A/C units (one stand-by) and multiple exhaust fans (one stand-by). The air handling units serving the detector shall be located on the surface near the Utility Building. The exhaust fans shall be located on the roof of the Utility Building. The supply A/C units shall serve the detector with 100% outside air that has been cooled and dehumidified. The dew point of the environment in the detector shall be 55°F or less.

14.0 ADVANCE ACQUISITION

14.1 INTRODUCTION

This section describes the approach and plans for acquisition of the GEM detector. This process will involve in-kind contributions requiring no dollar transfer of U.S. funds, co-funded acquisitions involving certain foreign countries, as well as normal procurement and subcontract management on the GEM Project. It outlines the major types of procurement actions needed to obtain the equipment, components, subsystems and services required to complete the GEM Detector. Policy issues are also addressed. Detailed acquisition planning is outlined in the Advanced Acquisition or Assistance Plan attached to this PMP.

Of the total costs estimated for GEM, approximately 60% will be for manufactured materials, components and equipment. While most large procurements will be administered by the SSCL, many materials and components will also be supplied by participating collaboration institutions as in-kind or co-funded contributions. In addition, Memoranda of Understanding (MOUs), Memorandum Purchase Orders (MPOs), Interlaboratory Agreements, and normal contracts will be required to provide for participation by universities and institutions from around the world. All these requirements point to a substantial subcontract administration effort by GEM, PRD and the SSCL.

14.2 MAJOR PROCUREMENT POLICY CONSIDERATIONS

14.2.1 GEM Participation Policy

GEM consists of over 85 institutions, involving hundreds of scientists and engineers who will participate in design and fabrication of the GEM Detector and related subsystems. Each institution involved in the detector construction will require execution of a written agreement with the SSCL which addresses scope of work, responsibilities, funding, schedules, reporting requirements, and other issues. These agreements will be in the form of MOUs between the SSCL and participating institutions, which delineate the cooperative working relationship, and other instruments of various kinds (contracts, Memorandum Purchase Orders, etc.) that will constitute the contractual basis for work performance.

The process whereby the GEM Detector was approved also constitutes approval for GEM members to participate. The detector selection process is described in the "Summary of Process for Establishing Detector Collaborations," signed by Dr. Fred Gilman, AD/PRD at the SSCL, and transmitted to DOE in December 1991. This document is the justification for establishing MOUs with GEM member institutions for participation on the GEM project. The GEM Detector selection process is also summarized in section 1.4 of this PMP.

The Organization Plan for GEM defines requirements for membership in the Collaboration. Specific contributions and participations by individual collaborative members are approved by the GEM Project Manager and Cospokesmen, and are based on expertise, availability of resources, funding and GEM requirements. The organization and management of the Collaboration are described in Section 3.5 of this PMP.

14.2.2 Major Procurement Policy

Major GEM-related procurements which are funded by the SSCL will be processed and administered by the SSCL, utilizing SSCL procurement practices and procedures. Major procurements are defined as those which normally require DOE approval or concurrence, as defined by the SSCL Procurement Standard Practices Manual.

Major procurements funded by other institutions or governments, for inclusion into in-kind contributions to GEM, will be governed by the regulations and procedures at the respective institutions. In-kind contributions, however, must meet technical, safety and other requirements established for operation at SSCL. These requirements are addressed in Sections 6.0, 11.0, and 12.0 of this Plan.

14.3 GEM PROCUREMENT OBJECTIVES

The following objectives have been established for elements of the GEM detector acquired with SSCL funds and associated with SSCL based Procurement and Subcontract Management:

- To provide for adequate advance planning of all GEM-related procurement activities.
- To identify and facilitate major procurements in support of the GEM schedule.
- To facilitate the plan and intent of MOUs with GEM participants, and agreements related to in-kind contributions, in support of GEM technical, cost and schedule objectives.
- To support the selection of highest quality and most competitive suppliers and vendors for all GEM procurements, in accordance with SSCL and DOE guidelines and requirements.
- To provide ongoing procurement and subcontract administration expertise and support to GEM Project Management and personnel.

14.4 GEM PROCUREMENT APPROACH

14.4.1 Acquisition Plans

The GEM detector construction will utilize two distinct kinds of written documents that function together to establish the working relationships and funding allocations between the SSCL and SSCL collaboration members: 1)Memoranda of Understanding (MOUs); 2) legal contracts and other contracting instruments. Both kinds of documents are necessary because of the complexity and diversity of acquisition methods that are used in the detector construction. We distinguish the documents and their purposes here and detail their use in the Advanced Acquisition or Assistance Plan (Attachment 5).

14.4.2 MOUs with Participating Institutions

The contributions of collaboration participants from universities and laboratories will be key to successful detector design and construction. In order to facilitate these contributions, Memoranda-of-Understanding (MOUs) will be prepared by the institutions and GEM management, establishing formal agreements between the SSCL and participating institutions to carry out agreed-upon tasks and to define other aspects of the collaborative working relationship.

Participation in the construction of the GEM detector by US and non-US institutions by GEM participants will take place in accordance with SSCL and DOE policy and practice. Each MOU will describe the scope of work and schedule for the institutional participation, and will identify the funding to be provided by the SSCL. Management, technical and reporting requirements will also be spelled out in each individual MOU. Because of the number of collaboration participants, a standard format will be used.

14.4.3 Contracts and Other Acquisition Instruments

Complementary to the MOUs that establish the overall basis for cooperation by GEM institutions with SSCL, there will be a variety of legal instruments that make specific the procurement of equipment and services for which SSCL funds are expended. These instruments are expected to include: regular contracts and purchase orders, Memorandum Purchase Orders (used with DOE laboratories), and Interlaboratory Agreements and their Attachments (used with countries approved for co-funded project participation). In addition, SSCL funds may be provided directly to US institutions in the form of grants administered by the DOE Office of the SSC.

All these contracting methods have already been utilized successfully during the Detector R&D phase of SSC. It is expected that these methods will continue to suffice during GEM construction.

14.4.4 SSCL Procurement Approach

SSCL Procurement policies and procedures, embodied in the SSCL Procurement Department's Standard Practice Manual, will be utilized for all procurement actions originated at the SSCL.

The SSCL Procurement Standard Practice Manual establishes compliance with DOE and Federal Acquisition Regulations, and ensures the use of competitive procurement techniques and small disadvantaged business subcontracting, to the maximum extent possible. SSCL Procurement procedures also ensure the protection and accountability of government owned and/or furnished property.

All major procurements required for GEM will be identified, according to the GEM WBS and by responsible institution. Those procurements are laid out in the GEM Advance Acquisition or Assistance Plan. The procurement actions required for each major procurement will be included.

Minor procurement of materials, supplies and services by the SSCL will be in accordance with the SSCL Procurement Standard Practice Manual. Procurement related responsibilities are described in Section 14.4.5 below.

14.4.5 Process for In-Kind Contributions

In-kind contributions from institutions outside the US are vital to the success of the GEM project. Memoranda of Understanding will be established between the SSCL and those institutions which will provide in-kind contributions to the GEM project. These MOUs will be prepared and executed by the participating institutions and SSCL and will detail the in-kind contribution to GEM as well as cover the obligations noted in 14.4.2. No other contracting document will be required for in-kind contributions.

14.4.6 Procurements by Participating Universities and Laboratories

Procurements of materials and supplies by participating universities and Laboratories are expected. Those procurements will be planned and budgeted by the respective institutions, and identified in MOUs with the SSCL. When materials, equipment, supplies or services are procured by other institutions, their existing procurement systems, procedures and practices will be utilized. Large dollar value contracts will normally be executed by SSCL with technical work directed by the appropriate persons in the institutions responsible for the work in the governing MOU.

14.4.7 Responsibilities

This section describes the procurement related responsibilities of the GEM management.

GEM Project Manager

The GEM Project Manager (PM) is responsible for ensuring that all aspects of the GEM project are planned and managed successfully, including all procurement actions, MOUs, and Interlaboratory Agreements. The GEM PM will approve procurement plans, procedures and practices implemented on the GEM Project. The GEM PM shall approve agreements and contracts associated with in-kind contributions, major contracts with industrial companies, and MOUs with participating GEM member institutions.

GEM Procurement Office

The GEM Procurement Office, consisting of procurement personnel assigned to the GEM Project from the SSCL Procurement Department, shall be responsible for preparing, facilitating and administering the procurement documentation associated with major GEM procurements from industry. The GEM Procurement Office will also administer and facilitate the MPOs and normal POs associated with participating universities and laboratories, and will support the development of Interlaboratory Agreements with non-US participants in countries where these are appropriate. Where appropriate the GEM Procurement Office will ensure compliance with SSCL Procurement policies and the SSCL Procurement Standard Practice Manual. Assigned Subcontract Administrators will assist GEM subsystem project managers with directing, managing, reviewing and monitoring subcontractor performance.

The GEM Procurement Office will work with SSCL Administration Division personnel assigned to PRD with respect to processing, facilitation and tracking routine procurements and purchases of materials, supplies, equipment and services.

GEM Subsystem Project Managers

Subcontracts and procurements associated with individual detector subsystems will be initiated on approval by the GEM Subsystem Project Managers. Subsystem project managers will facilitate and monitor subsystem contracts and institutional in-kind contributions. Working closely with GEM subcontract administrators, the subsystem project managers will be responsible for ensuring that all procured components, systems and services are produced and delivered as required to support the GEM project objectives. The SMs will also provide technical direction and oversight of these contracts and procurements.

Compliance

GEM Project procurement activities initiated by the SSCL will comply with the SSCL Procurement Departments Standard Practice Manual. Procurements initiated by other institutions shall be conducted in accordance with policies and procedures in place at those institutions.

Procurements conducted by institutions outside the USA will be conducted in accordance with the laws, policies and procedures existing at those locations. All components, systems and equipment, including in-kind contributions by non-US participants, utilized on the GEM Project shall meet the requirements for operation at the SSCL as addressed in Sections 6.0, 11.0 and 12.0 of this Plan.

14.5 MAJOR ACQUISITIONS FROM INDUSTRY

All procurements from industry shall be in accordance with standard competitive procurement practices, as discussed in Section 14.4 above. All major procurements and subcontracts, with the exception of in-kind contributions, will be administered by the SSCL.

15.0 GLOSSARY

15.1 ACRONYMS

AAAP	Advance Acquisition or Assistance Plan
AD	Associate Director
AD/PRD	Associate Director for Physics Research
AE/CM	Architect-Engineer/Construction Manager
ASD	Accelerator Systems Division (SSCL)
ATPR	Acceptance and Test Plan Review
BA	Budget Authority
BCE	Baseline Cost Estimate
CCB	Change Control Board
CCD	Conventional Construction Division (SSCL)
CCP	Change Control Panel
CDR	Critical Design Review
CHW	Chilled Water
CM	Configuration Management
CMP	Configuration Management Plan
C/SCSC	Cost and Schedule Control Systems Criteria
DCC	Document Control Center
DOE	Department of Energy
DRD	Design Requirements Document
DSEMP	Detector Systems Engineering Management Plan
DSC	Detector Safety Coordinator
EAC	Estimate at Completion
EMP	Engineering Management Plan
EOI	Expression of Interest
EPA	Environmental Protection Agency
ES&H	Environment, Safety, and Health
FTP/A	Field Task Proposal & Agreement
GEFUR	GEM Experimental Facilities User Requirements
HEP	High Energy Physics
HVAC	Heating, Ventilating and Air Conditioning

ICD	Interface Control Documents
ICFA	International Committee on Future Accelerators
~~ICW~~	~~Industrial Cooling Water~~
LAN	Local Area Network
LOI	Letter of Intent
LTLCW	Low Temperature Low Conductivity Water
LTS	Laboratory Technical Services (Division of SSCL)
MIS	Management Information Systems
MOU	Memorandum of Understanding
MPR	Monthly Progress Report
MSD	Magnet Systems Division (SSCL)
NSF	National Science Foundation
OMB	Office of Management and Budget
ORR	Operational Readiness Review
OSSC	Office of the Superconducting Super Collider (DOE)
PAC	Program Advisory Committee
PB/MK	Parsons Brinkerhoff/Morrison Knudsen
PDR	Preliminary Design Review
PDRR	Preliminary Design Requirements Review
PMB	Performance Measurement Baseline
PM	Project Manager
PMO	Project Management Office (SSCL)
PMP	Project Management Plan
PMPD	Project Management Plan for Detectors
PMS	Performance Measurement System
PRD	Physics Research Division (SSCL)
QA	Quality Assurance
QC	Quality Control
QIP	Quality Implementation Plan
R&D	Research and Development
SAR	Safety Analysis Report
SEIS	Site-specific Environmental Impact Statement

SPC	Scientific Policy Committee
SSC	Superconducting Super Collider
SSCL	Superconducting Super Collider Laboratory
SSCPO	On-Site Project Office (DOE)
TDR	Technical Design Report
TeV	Tera Electron Volt
TNRLC	Texas National Research Laboratory Commission
TPC	Total Project Cost
TPM	Technical Performance Measurement
TSRP	Technical Safety Review Panel
URA	Universities Research Association, Inc.
WAN	Wide Area Network
WBS	Work Breakdown Structure
WWTP	Waste Water Treatment Plant

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Temple University: S. H. Kettell, W. K. McFarlane

Texas A&M: C. Gagliardi, G. Glass, Y. Lu, R. Tribble, R. C. Webb

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University of Pittsburgh: W. E. Cleland, V. J. Sonnadara, E. Stern

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University of Tennessee: S. Berridge, W. M. Bugg, Y. C. Du, R. Kroeger, I. Tsveybak, A. Weidemann

University of Texas, Austin: C. C. Allen, G. W. Hoffmann, K. Lang, M. R. Marcin, J. L. Ritchie

University of Washington: V. Cook, J. Eisenberg, D. Forbush, P. M. Mockett, S. Sutlief, F. Toeus

Vanderbilt University: R. J. Panvini, J. P. Venuti

Variable Energy Cyclotron Center, India: R. Bhandari, B. Simha

Vassar College: C. Schwartz

Wonkwang University, Japan: S. Y. Bahk

Yale University: R. K. Adair, C. Baltay, R. Ben-David, W. Emmet, H. Kasha, S. L. Manly, S. Sen, J. Turk

APPENDIX B—GEM ORGANIZATION PLAN

The GEM collaboration is made up of individual members (collaborators) and collaborating institutions. The Organization includes a Collaboration Council, a Spokesman or Spokesmen, an Executive Committee, an International Committee, a Project Manager with a management office, and Subsystem Organizations. The interrelationship of these components are indicated in the GEM Organization Chart.

This Organization Plan is designed primarily for the period after the approval of the GEM Technical Design Report. In the past there has been an evolution of several interim organizations. The first one, with two Cospokesmen and a Steering Committee, prepared the GEM EOI (Expression of Interest). The second, adding the Collaboration Council, prepared the GEM LOI (Letter of Intent). The third interim organization, which is in effect at this time, is preparing the GEM Technical Design Report. It consists of two Spokesmen, the Collaboration Council, the Executive Committee, an Acting Project Manager, and an initial set of Subsystem Groups. The intention is that the present interim organization will evolve smoothly into the final GEM Organization described in this Plan. This Plan is expected to undergo further changes at the end of the construction phase of the detector, when GEM turns into an operating experiment.

MEMBERSHIP

Scientists with an interest in the research program of the SSC (Ph.D. physicists, graduate students, and engineers) of any nationality are eligible to be members of the GEM Collaboration provided that they are contributing a significant fraction of their research effort (averaged over a period of several years) to the GEM program.

Collaborating institutions can be universities, National Laboratories, or other institutions that have one or more members in the GEM collaboration. GEM collaborators may be involved in other experiments or activities, but are expected not to be members of approved competing SSC or LHC Experiments.

THE COLLABORATION COUNCIL

The GEM Collaboration Council will consist of one representative from each collaborating institution. The Collaboration Council will deal with general issues that concern the collaboration. It will serve as a forum for informing the collaboration and will provide input and guidance for all major scientific, technical and fiscal matters. In particular the collaboration, through the Collaboration Council, will approve the GEM Organization Plan, the Publication Policy, Management Plan, and other major concerns of the collaboration. It will also approve the selection of the Spokesmen, the Project Manager, the Executive and International Committees, and

the Subsystem leadership. The Collaboration Council will have open meetings typically once every one or two months. The Collaboration Council, through its chairman, with consultation with the Spokesmen, will organize collaboration meetings typically twice a year.

a) The Collaboration Council Representatives will be chosen by each institution. The term of office of the Representatives will be at the pleasure of each institution.

b) The Collaboration Council will elect its own chairman. The chairman will guide the affairs of the Collaboration Council. In particular, he or she will organize and run the meetings of the Collaboration Council and the general Collaboration meetings; will be responsible for keeping an up to date list of the membership of the Collaboration and the Collaboration Council Representatives; and will administer the voting of the Collaboration Council on relevant issues.

   i) The term of office of the Collaboration Council chairman will be two years, not renewable.

   ii) Nominations for the chairman will be from the floor at a Collaboration Council meeting or by letter to the outgoing chairman.

   iii) The outgoing chairman will check that the nominees are willing to run, and distribute the ballot for vote by the Collaboration Council Representatives by mail or E-mail with at least two weeks notice.

   iv) If no candidate gets a majority, the top two candidates will stand for a run-off election.

THE GEM SPOKESMEN

The Spokesmen will be responsible for the scientific, technical, fiscal, and managerial concerns of the Collaboration. It is mainly the spokesmen's responsibility to have a well designed and functioning detector ready at the turn-on of the SSC. The Spokesmen, in consultation with the Executive Committee and the Project Manager, will direct the technical and engineering design, physics integration and technical implementation of the detector.

a) There will be one spokesman or two co-spokesmen as maybe deemed appropriate by the Nominating Committee (see Paragraph c-i below).

b) The Spokesmen have a fixed 3-year term of office, with no prejudice or limit on the number of terms served.

c) The Spokesmen will be selected, soon after the GEM Technical Design Report is approved, by the following process:

i) There will be a Nominating Committee consisting of 9 members of the GEM Collaboration. Of the 9 members, 4 will be chosen by the Collaboration Council, 2 by the SSC Laboratory, and 3 will be selected by the Executive Committee to provide balance. The Nominating Committee will select its own chairman.

ii) The Nominating Committee will consult extensively with members of the collaboration, the present interim Spokesmen, the SSC Laboratory, the subsystem leaders, etc., and will nominate a single slate.

iii) The slate thus nominated will be put up for approval or rejection by the Collaboration Council. The chairman of the Collaboration Council will solicit one vote from each Collaboration Council Representative by mail or E-mail, allowing at least two weeks between the presentation of the slate and the balloting. A majority vote will be required for approval.

d) This selection process will be repeated every three years. A new Nominating Committee will be constituted each time as specified in Section 3 c-i above.

e) A petition signed by two thirds of the Executive Committee followed by a majority vote of the Collaboration Council or visa versa can trigger this selection process at any time under unusual circumstances.

THE EXECUTIVE COMMITTEE

The Executive Committee will advise the Spokesmen and the Project Manager on scientific, technical, fiscal and managerial decisions relevant to the design, construction and operation of the GEM Detector. The Executive Committee will serve as the Configuration Change Control Board.

a) The Executive Committee will consist of between one and two dozen members of the GEM Collaboration. The members of the Executive Committee will be nominated by the Spokesmen after wide consultation with the collaboration. The nominated slate will be approved or rejected by the Collaboration Council (using the procedure of Section 3 c-iii above).

b) The terms of office of the Executive Committee will be the same as that of the Spokesmen.

c) The Project Manager, the GEM Chief Engineer, the chairman of the Collaboration Council, and the leaders of the various GEM Subsystems will be members of the Executive Committee.

d) The Spokesmen will serve as chairmen of the Executive Committee.

e) The Executive Committee will meet at least once every one to two months.

f) The membership of the Executive Committee can be re-evaluated by the Spokesmen as appropriate, with the approval of the Collaboration Council.

THE GEM PROJECT MANAGER

The responsibility of the Project Manager is to provide technical, administrative, management, and budget coordination to insure the efficient and timely construction of the GEM detector. The Project Manager is responsible to both the GEM Spokesmen and Executive Committee and the SSC Laboratory Management. The Project Manager is also the head of the SSC GEM Project Department.

a) The Search Committee for the Project Manager will consist of

   i) The Chairman of the Collaboration Council

   ii) Two SSC Lab representatives chosen by the SSC Lab management

   iii) Four or five other members, including the chairman of the search committee, selected by the GEM Spokesmen.

b) The search committee will conduct a search, with extensive consultation with members of the Collaboration, the SSC Lab, the DOE, and the GEM Subsystem Leaders, and will select a single candidate to be approved or rejected by the Collaboration Council (same procedure as defined in Section 3 c-iii above).

c) It is anticipated that the Project Manager will serve with indefinite term to the completion of the construction of the GEM detector. However, the Spokesmen can initiate the formation of a new Search Committee at any time if necessary.

THE GEM CHIEF ENGINEER

The GEM Chief Engineer is responsible to work with the GEM Spokesmen and the Executive Committee, and the Project Manager, to develop the engineering design for the detector, the detector experimental hall and the detector support infrastructure, and to carry out that design in an efficient and timely fashion.

a) The Chief Engineer will be nominated by the Spokesmen and the Project Manager after extensive consultation with the Gem Executive Committee and the SSC

Laboratory Management. The nominee will be approved or rejected by the Collaboration Council (using the procedure of Section 3 c-iii).

b) It is anticipated that the Chief Engineer will serve with indefinite term to the completion of the GEM detector. However the Spokesmen can initiate a new nomination process if necessary.

THE INTERNATIONAL COMMITTEE

The International Committee will advise the Spokesmen on fiscal matters, especially in the area of international contributions, coordination of work responsibilities between various countries, international agreements, and other related issues.

a) The International Committee will consist of one or two members from each collaborating country.

b) The members of this committee will be selected by the Collaboration Council Representatives from each individual country after consultation with the GEM Spokesmen.

c) The terms of office of the International Committee members is up to each individual country. The spokesmen can suggest changes or additions as appropriate, with the approval of the Collaboration Council Representatives of the relevant country.

d) Initially the International Committee will be chaired by one of the GEM spokesmen. Later the Committee may wish to have a rotating chairman to be elected by the Committee.

THE GEM SUBSYSTEMS

The GEM detector, as far as design and construction is concerned, can be divided by the Spokesmen into a number of subsystems such as the Magnet, Calorimeter, Muon Detector, Central Tracker, Electronics, Computing, and Physics Simulations. Each subsystem organization will be coordinated by a Subsystem Leader, assisted by a Steering Committee, a subsystem Project Manager and a Subsystem Chief Engineer. The Subsystem Leader will serve as the chairman of the Steering Committee.

a) The Subsystem Leaders will be nominated by the GEM Spokesmen, in consultation with the Collaboration, especially with the key members of each subsystem. The nominated slate will be approved or rejected by the Collaboration Council (same procedure as in Section 3 c-iii above).

b) The term of office of the Subsystem Leaders is at the pleasure of the Spokesmen. The Spokesmen can recommend changes in Subsystem leadership under unusual circumstances, with the approval of the Collaboration Council.

c) The Subsystem Steering Committee and the Subsystem Project Manager, will be selected by the Subsystem Leader in consultation with the GEM Spokesmen, the GEM Project Manager, and the GEM Chief Engineer. The Subsystem Chief Engineer will be selected by the Subsystem Leader and the GEM Chief Engineer in consultation with the GEM Spokesmen and the GEM Project Manager.

d) The Subsystem Leaders are primarily responsible to the GEM Spokesmen. The Subsystem Project Manager and the Subsystem Chief Engineer are responsible to their Subsystem Leader, and will be responsive to the GEM Project Manager and GEM Chief Engineer.

ADMISSION OF NEW COLLABORATORS INTO GEM

a) Up to the time of the approval of the GEM Technical Design Report GEM will have an open membership policy.

   i) Any qualified institution can join the Collaboration by notifying the Chairman of the Collaboration council or one of the Spokesmen of their intention in writing.

   ii) New members can join an institution that is already a GEM Collaborator at the discretion of that institution. It is the responsibility of the Collaboration Council Representative from each institution to notify the chairman of the Collaboration Council of any changes in membership.

b) After the GEM Technical Design Report is approved the following procedures should be used for the admission of new collaborators to GEM:

   i) A new institution that desires to join the collaboration should enter into negotiations with the GEM Spokesmen and possibly one of the Subsystem Leaders if appropriate to discuss the contributions and role of the new institution. If these negotiations reach a satisfactory conclusion the new institution should write a letter to the chairman of the Collaboration Council or to one of the Spokesmen stating their desire to join GEM, listing the individual members of their group, and explaining their anticipated role in GEM. The chairman of the Collaboration Council will present their case at the next Collaboration Council meeting. A favorable vote from a majority of the Collaboration Council Representatives will be required for admission (using the procedure of Section 3 c-iii above).

ii) Individuals who wish to join GEM at an institution that is already a GEM Collaborator can do so at the discretion of that institution. It is the responsibility of each Collaboration Council Representative to keep the chairman of the Collaboration Council informed of changes in membership at his or her Institution.

c) Withdrawal from the Collaboration. The membership of an individual collaborator will terminate when the Collaboration Council Representative from his or her institution informs the chairman of the Collaboration Council that the individual is no longer associated with GEM. An institution can withdraw from the collaboration (provided it has satisfied whatever construction responsibilities that it has agreed to) by informing the chairman of the Collaboration Council of its intention in writing. Collaborators who are no longer members of GEM may still be listed as authors on GEM papers if appropriate. This issue will be dealt with in the GEM Publication Policy which is beyond the scope of this Organization Plan.

ADOPTION OF THIS ORGANIZATION PLAN

This Organization Plan will go into effect when approved by a majority vote of the Collaboration Council (using the procedure of Section 3 c-iii).

AMENDMENTS TO THIS ORGANIZATION PLAN

A petition for a change or amendment to this organization plan after it has been adopted can be initiated either by the Spokesmen or by a letter to the chairman of the Collaboration Council signed by at least 50 members of the collaboration. Following such a petition the Spokesmen will set up a committee to study the desirability of such a change and to draft a specific proposal. The change or amendment will go into effect when approved by a majority vote of the Collaboration Council (using the procedure of Section 3 c-iii).

APPENDIX C—REFERENCE DOCUMENTS

DOE Documents

DOE 4330.4A Maintenance Management Program
DOE 4700.1 Project Management System
DOE 5480.1B Environmental Protection, Safety and Health Protection Program for DOE
DOE 5480.19 Conduct of Operations Requirements for DOE Facilities
DOE 5480.7 Fire Protection
DOE 5481.1B Safety Analysis and Review System
DOE 6430.1A General Design Criteria
DOE Contract DE-AC02-89ER40486, Dated 1-18-89.
DOE 5700.6C Quality Assurance and DOE-ER-STU 6001
DOE/ER-0468P Report of the Superconducting Super Collider Cost and Schedule Baselines, dated TBD.
DOE 2250.1C Cost and Schedule Control System Criteria.
DOE 6430.1A General Design Criteria.
DOE 5440.1D National Environmental Policy Act.
DOE 1500.3 Foreign Travel Authorization.
DOE Order 5400, Chapter III Environmental Protection Implementation Plan.
DEAR 970.71 Management and Operating Contractor Purchasing.

MIL-STD-490A Specification Practices
MIL HDBK-245C Preparation of Statement of Work
MIL-STD-1629 Procedures for Performing a Failure Mode Effects and Criticality Analysis
MIL-STD-2155 Failure Reporting, Analysis and Corrective Action System
OSHA 1910 (safety requirements)
OSHA 926 (safety requirements)
NFPA 101 Life Safety Codes

SSCL Documents

SSCL P40-000021 Project Management Plan (PMP) for SSC
SSCL P40-000003 SSCL Part Numbering system
SSCL P40-000004 Engineering Drawing Formats
SSCL P40-000016 Supplement to the Engineering Drawing Preparation
SSCL P40-000017 Engineering Drawing Preparation Standards
SSCL P40-000029 Engineering Release Package
SSCL P40-000030 Parts List Preparation
SSCL P40-000031 Configuration Management Plan
SSCL P40-000032 Drawing Review and Authentication
SSCL P40-000137 Identification Marking of Parts and Assemblies
SSCL P40-000156 Color Scheme for Identification and Marking

SSCL P40-000157 Preparation of Document Specific to Pressure and Vacuum Vessels
SSCL P40-000163 Part Number, Type/Group Codes for Commercially Procured Components and Parts
SSCL P40-000165 The Use of Bar Coding at the SSCL
SSCL P40-000176 Standards Parts Handbook
SSC Site-Specific Conceptual Design Report dated July 1990, SSCL-SR-1056.
Project Management Plan for the Superconducting Super Collider, (January 28, 1991.)
SSC -Site Specific Environmental Impact Statement.
SSC Baseline Report.
SSCL-Quality Assurance Manual (D70-000001)
SSCL-Procurement Dept. Standard Practice Manual
SSCL-PMRS Planning Manual
SSCL-Environmental, Safety & Health Manual
Site Specific Conceptual Design Report, SSCL-SR-1056

Letters and Memoranda

Memorandum of understanding dated November 9, 1990, between DOE and TNRLC.
DOE EH Memorandum "Emergency Egress from the Tunnel," dated September 27, 1990.
DOE Memorandum from William Happer, Director of the Office of Energy Research, to ER employees, dated October 15, 1991 re: Reorganization of the Office of the Superconducting Super Collider.
SSCL Letter from George O. Provencher, Acting Director of Procurement, to Mr. Terrell C. Cone, Contracting Officer for DOE-SSCPO, dated December 17, 1991 re: Blanket Justification for Acquisition of Supplies and Services in support of the GEM and GEM Detector Programs.
DOE-SSCPO Letter from Terrell C. Cone to Mr. George Provencher, SSCL, dated 8 January, 1992 re: Blanket Justification for Acquisition of GEM and GEM Detector Programs.

PRD Documents

Project Management Plan for Detectors R00-000002.
PRD Quality Implementation Plan.
Configuration Management Policy for Detectors.
PRD WBS Dictionary.

GEM Documents

GEM Letter of Intent, GEM-92-00049, dated November 30, 1991.
GEM Experimental Facilities User Requirements (GEFUR), GCT-000001.
GEM Technical Design Report, GEM-TN-93-262 May 1, 1993.
GEM Baseline , GEM-TN-92-231
GEM ES&H Implementation Plan

APPENDIX D—GEM ORGANIZATION

COSPOKESMEN

Barry Barish	California Institute of Technology
Bill Willis	Columbia University

PROJECT MANAGER

Gary Sanders **(Acting)**	Los Alamos National Laboratory

EXECUTIVE COMMITTEE

Charlie Baltay	Yale University
Barry Barish	California Institute of Technology
Jim Brau	University of Oregon
I. Golutvin	Joint Institute for Nuclear Research (JINR), (Dubna)
Ya-Nan Guo	IHEP, Beijing, China
Mike Harris	Superconducting Super Collider Laboratory
Dan Marlow	Princeton University
Michael Marx	Superconducting Super Collider Laboratory
Ken McFarlane	Superconducting Super Collider Laboratory
Harvey Newman	California Institute of Technology
Frank Paige	Superconducting Super Collider Laboratory
Frank Plasil	Oak Ridge National Laboratory
Nicholas Samios	Brookhaven National Laboratory
Gary Sanders	Los Alamos National Laboratory
Mike Shaevitz	Columbia University —Nevis Laboratory
Ren-Chen Shang	Tsinghua University, China
Ryszard Stroynowski	Southern Methodist University
Frank Taylor	Massachusetts Institute of Technology
Bill Willis	Columbia University

APPENDIX E—WORK BREAKDOWN STRUCTURE

To be provided at a later date.

APPENDIX F—PROJECT SUMMARY COST ESTIMATE

To be provided at a later date.

APPENDIX H—RESPONSIBILITY MATRIX

To be provided at a later date.