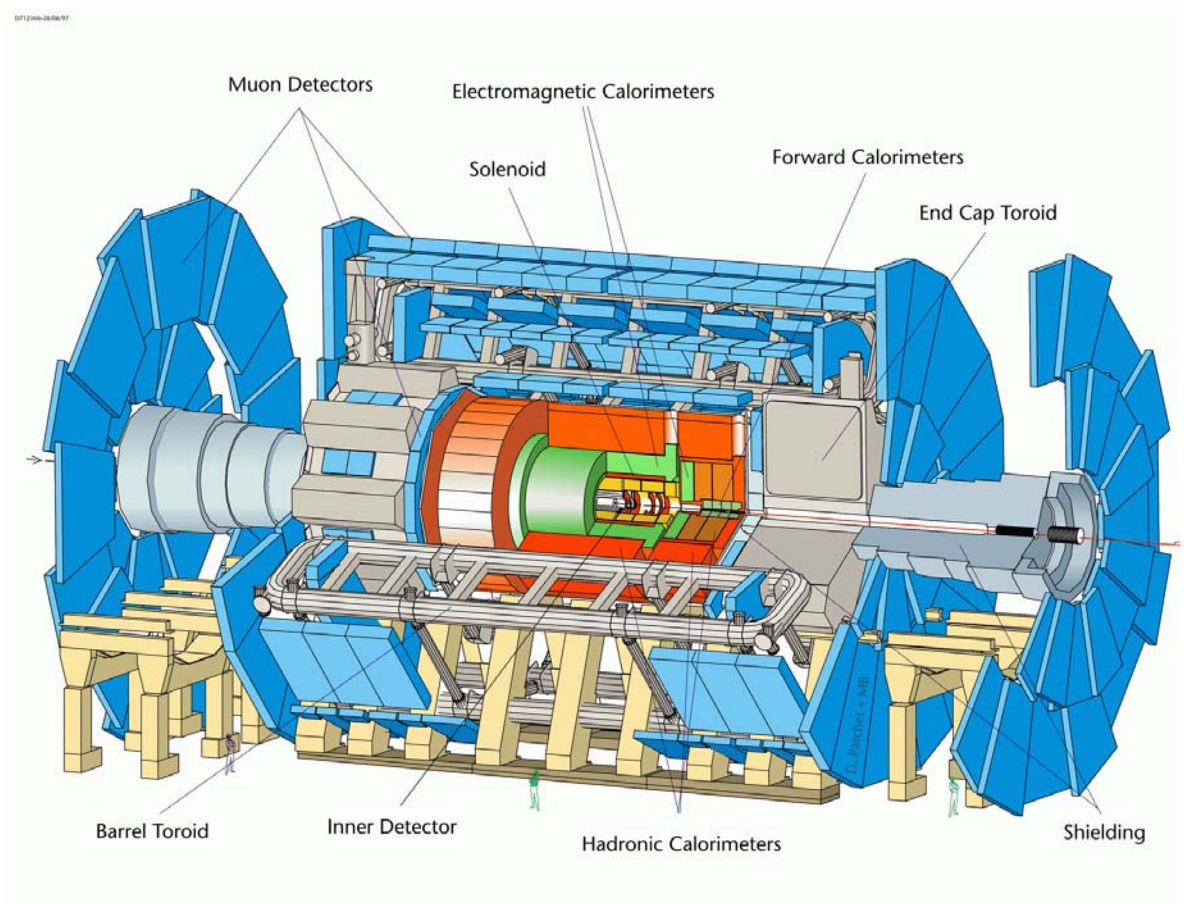
Appendix 2.B

U.S. ATLAS Detector Construction Project Management Plan



US ATLAS PROJECT

PROJECT MANAGEMENT PLAN

Revision 2.0 – December, 2002

Submission and Approvals

This is a Revision of the U.S. ATLAS Project Management which was approved jointly by the U.S. Department of Energy and the National Science Foundation.

Submitted by:

William J. Willis
U.S. ATLAS Project Manager
Columbia University

Thomas B.W. Kirk
Associate Director
Brookhaven National Laboratory

James H. Yeck
U.S. LHC Project Manager
Department of Energy

Marvin Goldberg
Associate U.S. LHC Program Manager
National Science Foundation

Morris Pripstein
U.S. LHC Program Manager
Department of Energy

Approved by the DOE/NSF Joint Oversight Group:

John W. Lightbody
Executive Officer, Physics Division
National Science Foundation

John R. O'Fallon
Director, Division of High Energy Physics
Department of Energy

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LIST OF ABBREVIATIONS

ACWP	Actual Cost of Work Performed
ALD	BNL Associate Laboratory Director
APM	Associate Project Manager for Physics and Computing
AY	At Year (referring to a dollar value)
BCP	Baseline Change Proposal
BCWP	Budgeted Cost of Work Performed
BCWS	Budged Cost of Work Schedules
BHG	Brookhaven Group
BNL	Brookhaven National Laboratory
CB	ATLAS Collaboration Board
CCB	Change Control Board
CERN	European Laboratory for Particle Physics
CH	Chicago Operations Office
DHEP	Division of High Energy Physics
DOE	Department of Energy
EDIA	Engineering Design, Inspection and Assembly
EDMS	Engineering Data Management System
ES&H	Environmental Safety and Health
HEP	DOE Headquarters Office of High Energy Physics
IB	Institutional Board
IMOU	Interim Memorandum of Understanding
JOG	Joint Oversight Group
LHC	Large Hadron Collider
LHCC	CERN LHC Committee
MOU	Memorandum of Understanding
MRE	Major Research Equipment
NSF	National Science Foundation
PAP	Project Advisory Panel
PBS	Product Breakdown Structure
PCAP	Physics and Computing Advisory Panel
PL	ATLAS Project Leader
PM	U.S. ATLAS Project Manager
PMCS	Project Management Control System
PMP	Project Management Plan
PO	U.S. ATLAS Project Office
QAP	Quality Assurance Plan
R&D	Research and Development
RRB	ATLAS Resource Review Board
SC	DOE Office of Science
SM	U.S. ATLAS Subsystem Manager
TDR	Technical Design Report
TRT	Transition Radiation Tracker
WBS	Work Breakdown Structure

1 Introduction

1.1 Overview of the Project Management Plan

The U.S. Department of Energy and National Science Foundation are supporting the U.S. involvement in the two large detectors for the CERN Large Hadron Collider (LHC), ATLAS and CMS, through the fabrication of equipment and systems for those detectors as well as the U.S. involvement in the research program. The research program is not specifically addressed here, but is covered in a separate plan. The fabrication effort is being carried out at, or under the supervision of, U.S. universities and national laboratories, under terms and conditions described in the International Collaboration Agreement (signed in Washington on December 8, 1997) and its Experimental Protocol (signed at CERN on December 19, 1997), between CERN, and the DOE and NSF. According to these agreements, fixed total dollar contributions, to be expended over a period of about 9 years, are separately specified for DOE and NSF. These funds are to be used by the U.S. ATLAS and CMS collaborators to supply equipment and systems for the detectors. The ATLAS Collaboration has prepared international Memoranda-of-Understanding (MOUs) agreed to by all the funding agencies involved in each detector. These include Interim Memoranda of Understanding (IMOUs) covering work to be done in 1996 and 1997, and MOUs (prepared in 1998) defining responsibilities for the full detector construction effort. The U.S. concurrence with the MOU (Appendix 1) was expressed in the form of a list of deliverables with the Complete Goals for U.S. Deliverables (Appendix 2) and the Initial Approved Scope of U.S. Deliverables (Appendix 3).

This Project Management Plan (PMP) is relevant to the design and fabrication of equipment and systems (the U.S. ATLAS Construction Project) to be supplied by the U.S. ATLAS Collaboration for the ATLAS detector. Separate management plans will be prepared for the research program. This PMP defines the organization, systems and processes employed to manage the U.S. ATLAS Construction Project. The U.S. ATLAS Collaboration presently consists of scientists and engineers from 29 U.S. universities and three national laboratories, and is part of the international ATLAS Collaboration that has overall responsibility for the ATLAS detector. The Host Laboratory for the U.S. ATLAS Construction Project is Brookhaven National Laboratory, where the Project Office is located.

The DOE and NSF have chosen to treat the totality of activities necessary for the U.S. to execute the construction of the scientific and technical components agreed to by the DOE, NSF, and CERN as a single project, the U.S. LHC Construction Project. The U.S. LHC Construction Project includes three elements, the U.S. ATLAS, U.S. CMS, and the U.S. LHC Accelerator Construction Projects. The management structures, roles, and responsibilities are described in the U.S. LHC Project Execution Plan (PEP). The PEP takes precedence over this Project Management Plan.

Since the U.S. ATLAS Construction Project is funded by both DOE and NSF, a Joint Oversight Group has been formed by the two agencies to perform periodic reviews and assess technical, schedule and cost performance. The specific responsibilities of the JOG are addressed in a Memorandum of Understanding between the DOE and the NSF on U.S. Participation in the LHC Program.

1.2 Construction Project Description

The ATLAS detector consists of an inner tracking system with silicon pixels, silicon strips and a transition radiation tracker (TRT); a liquid argon electromagnetic and forward calorimeter; a scintillating tile hadronic calorimeter; a muon spectrometer; and a trigger and data acquisition system. There are superconducting solenoid and toroid magnets to allow sign determinations and momentum measurements for charged particle products of the collisions. U.S. groups are involved in almost all of these components of the ATLAS detector, which is being built by a large international collaboration. Detailed descriptions of all these systems are given in the Technical Design Reports (TDRs) which for most subsystems have been reviewed by the CERN LHC-Committee (LHCC) and approved by the Director General of CERN.

2 ATLAS Objectives

2.1 Scientific Objectives

The fundamental unanswered problem of elementary particle physics relates to the understanding of the mechanism that generates the masses of the W and Z gauge bosons and of quarks and leptons. To attack this problem, one requires an experiment that can produce a large rate of particle collisions of very high energy. The LHC will collide protons against protons every 25 ns with a center-of-mass energy of 14 TeV and a design luminosity of 10^{34} cm^{-2} s^{-1}. It will probably require a few years after turn-on to reach the full design luminosity.

The detector will have to be capable of reconstructing the interesting final states. It must be designed to fully utilize the high luminosity so that detailed studies of rare phenomena can be carried out. While the primary goal of the experiment is to determine the mechanism of electroweak symmetry breaking via the detection of Higgs bosons, supersymmetric particles or structure in the WW scattering amplitude, the new energy regime will also offer the opportunity to probe for quark substructure or discover new exotic particles. The detector must be sufficiently versatile to detect and identify the final state products of these processes. In particular, it must be capable of reconstructing the momenta and directions of quarks (hadronic jets, tagged by their flavors where possible), electrons, muons, taus, and photons, and be sensitive to energy carried off by weakly interacting particles such as neutrinos that cannot be directly detected. The ATLAS detector is designed to have all of these capabilities.

2.2 Technical Objectives

The ATLAS detector is designed to perform a comprehensive study of the source of electroweak symmetry breaking. It is expected to operate for twenty or more years at the CERN LHC, observing collisions of protons, and recording more than 10^7 events per year. The critical objectives to achieve these goals are:

- Excellent photon and electron identification capability, as well as energy and directional resolution.
- Efficient charged particle track reconstruction and good momentum resolution.
- Excellent muon identification capability and momentum resolution.
- Well-understood trigger system to go from 1 GHz raw interaction rate to ~100 Hz readout rate without loss of interesting signals.
- Hermetic calorimetry coverage to allow accurate measurement of direction and magnitude of energy flow, and excellent reconstruction of missing transverse momentum.
- Efficient tagging of b-decays and b-jets.

2.3 Cost Objectives

The U.S. ATLAS construction project cost objective is $163.75M. The detailed cost baseline is presented in Appendix 8-1.

2.4 Schedule Objectives

The ATLAS construction project was initiated in FY 1996, and is scheduled for a 10-year design and fabrication period beginning in the first quarter of FY 1996, and finishing in the fourth quarter in FY 2007. This period is to be followed by the first collisions at the LHC. The Major Project Milestones are given in Appendixes 5 and 6. The milestones in Appendix 6 (Level 4) are the completion of U.S. Deliverables in the baseline. The Major Project Milestones given in Appendix 5 require approval of the DOE/NSF Project Manager. These milestones form the initial schedule baseline. In Appendix 4 CD-4A identifies the completion of 97% of the U.S. ATLAS deliverables. The items extending beyond this point are some installation tasks and the completion of U.S. deliverables for the Trigger/DAQ system (WBS 1.6).

3 ATLAS Organization

3.1 Introduction

The U.S. ATLAS Construction Project operates within the context of the internationally funded ATLAS experiment located at CERN. The general responsibilities of the U.S. participants are described in Article VI of the Experiments Protocol signed between CERN, and DOE and NSF. In essence, they have responsibilities for R&D, engineering design, prototyping, fabrication, installation and normal maintenance and operation of detector systems and components as agreed to and described in the IMOU, the MOU, and their addenda. The responsibilities of the CERN management are described in Article VIII of the same Protocol.

The U.S. ATLAS Construction Project is managed by the U.S. ATLAS Project Office, located at Brookhaven National Laboratory (BNL), under the direction of the designated U.S. ATLAS Project Manager (hereafter referred to as the Project Manager or PM). The Project Manager has the principal authority for day-to-day management and administration of all project activities. The Director of BNL, or his/her designee, is responsible for management oversight of the project and DOE and NSF jointly provide requirements, objectives and funding.

3.2 The International ATLAS Project and its Management

The large general-purpose LHC experiments rank among the most ambitious and challenging technical undertakings ever proposed by the international scientific community. The inter-regional collaborations assembled to design, implement and execute these experiments face unprecedented sociological challenges in marshaling efficiently their enormous, yet highly decentralized, human and economic resources. The overall ATLAS approach to this challenge is to base most of the ATLAS governance on the collaborating institutions rather than on any national blocks. Thus the principal organizational entity in ATLAS is the Collaboration Board (CB), consisting of one voting representative from each collaborating institution, regardless of size or national origin.

The CB is the entity within ATLAS that must ratify all policy and technical decisions, and all appointments to official ATLAS positions. It is chaired by an elected Chairperson who serves for a non-renewable two-year term. The Deputy Chairperson, elected in the middle of the Chairperson's term, succeeds the Chairperson at the end of his/her term. The CB Chairperson has appointed (and the CB ratified) a smaller advisory group with whom he/she can readily consult between ATLAS collaboration meetings.

Executive responsibility within ATLAS is carried by the Spokesperson who is elected by the CB to a renewable three-year term. The Spokesperson is empowered to nominate one or two deputies (there is presently one) to serve for the duration of the Spokesperson's term in office. The Spokesperson represents the ATLAS Collaboration before all relevant bodies, and carries the overall responsibility for the ATLAS Detector Project.

The ATLAS central management team also includes Technical and Resource Coordinators, both CERN staff members whose appointments to their roles require CERN management approval. The Technical Coordinator has the overall responsibility for the technical aspects of the detector construction. This includes responsibility for the integration of the ATLAS subsystems and for coordinating the CERN infrastructure, including the installation of the experiment in the surface and underground areas. The Resource Coordinator is responsible for budget and manpower planning, including securing the Common Projects resources, and for negotiating the MOUs with the various funding agencies.

The ATLAS Spokesperson chairs an Executive Board (EB), consisting of high-level representatives of all the major detector subsystems plus the Technical and Resource Coordinators. The Executive Board directs the execution of the ATLAS project according to the policies established by the Collaboration Board.

Each ATLAS subsystem has a Project Leader directly and ultimately responsible for ensuring that the design and construction of the corresponding subsystem are carried out on schedule, within the cost ceiling, and in a way that guarantees the required performance and reliability. Each major ATLAS subsystem is overseen by a technically-oriented Steering Group, with expertise in all the relevant technical areas.

It is understood that the U.S.-ATLAS management must operate within the regulations imposed by the U.S. funding agencies, the funding appropriated by the U.S. Congress, and the terms of the U.S.-CERN Protocol on LHC Experiments. Subject to these limitations, it is expected that the U.S.-ATLAS management implements all decisions taken by the ATLAS Resource Review Board (RRB) and the Collaboration Board. The RRB comprises representatives from all ATLAS funding agencies and the managements of CERN and the ATLAS Collaboration. The U.S. has DOE and NSF representatives. The RRB meets twice per year, usually in April and October.

The role of the RRB includes:

- reaching agreement on the ATLAS Memorandum of Understanding
- monitoring the Common Projects and the use of the Common Funds
- monitoring the general financial and manpower support
- reaching agreement on a maintenance and operation procedure and monitoring its functioning
- endorsing the annual construction and maintenance and operation budgets of the detector

As far as project execution is concerned, decisions by the ATLAS Executive Board (EB) should also be adopted directly or, if not compatible with the U.S. operating procedures, adapted so as to match the EB decision as closely as possible. In the latter case ATLAS management should be consulted and informed about the detailed U.S. implementation.

ATLAS has adopted procedures for quality control and change requests valid for all Collaboration partners. For example, a Product Breakdown Structure (PBS/WBS) structure has been established and a global Engineering Data Management System (EDMS) is used to manage documents pertaining to ATLAS Technical Coordination, the ATLAS Detector, General Facilities, Assembly and Test Areas and Offline Computing. A CERN Drawing Directory (CDD) is used to manage all drawings. It is understood that the U.S. institutions use these management procedures and tools at the same level as all the other ATLAS institutions.

3.3 Membership of the U.S. ATLAS Collaboration

The U.S. ATLAS Collaboration consists of physicists and engineers from all U.S. institutions collaborating on the ATLAS experiment at the CERN LHC. Table 3-1 shows a list of the participating institutions. Individuals from these institutions share responsibility for the construction and execution of the experiment with collaborators from the international high-energy physics community outside the U.S.

Table 3-1: U.S. ATLAS Participating Institutions

(Agency support shown in parentheses)

Argonne National Laboratory (DOE)
University of Arizona (DOE)
Boston University (DOE)
Brandeis University (DOE/NSF)
Brookhaven National Laboratory (DOE)
University of California, Berkeley/Lawrence Berkeley National Laboratory (DOE)
University of California, Irvine (DOE/NSF)
University of California, Santa Cruz (DOE/NSF)
University of Chicago (NSF)
Columbia University (Nevis Laboratory) (NSF)
Duke University (DOE)
Hampton University (NSF)
Harvard University (DOE/NSF)
University of Illinois, Urbana-Champaign (DOE)
Indiana University (DOE)
Iowa State University (DOE)
Massachusetts Institute of Technology (DOE)
University of Michigan (DOE)
Michigan State University (NSF)
University of New Mexico (DOE)
State University of New York at Albany (DOE)
State University of New York at Stony Brook (DOE/NSF)
Northern Illinois University (NSF)
Ohio State University (DOE)
University of Oklahoma/Langston University (DOE)
University of Pennsylvania (DOE)
University of Pittsburgh (DOE/NSF)
University of Rochester (DOE/NSF)
Southern Methodist University (DOE)
University of Texas at Arlington (DOE/NSF)
Tufts University (DOE)
University of Washington (NSF)
University of Wisconsin, Madison (DOE)

3.4 The U.S. ATLAS Management Organization

To facilitate interactions with the U.S. funding agencies and for effective management of U.S. ATLAS activities and resources, a project management structure has been established with the Project Office located at BNL. Appendix 7-1 shows the organization chart for U.S. ATLAS. This organization is headed by a U.S. ATLAS Project Manager supported by a Project Office along with U.S. Subsystem Managers for each of the major detector elements in which the U.S. is involved. The organization also includes an Institutional Board with representation from each collaborating institution, and an Executive Committee. The responsibilities of each will be described below. The U.S. ATLAS planning and management is being done in close cooperation with the overall ATLAS management. The U.S. Subsystem Managers interact closely with the corresponding overall ATLAS Subsystem Project Leaders, and the U.S. ATLAS Project Manager maintains close contact with the ATLAS Spokesperson, and the Technical and Resource Coordinators.

3.4.1 U.S. ATLAS Project Manager

The U.S. ATLAS Project Manager (PM) has the responsibility of providing programmatic coordination and management for the U.S. ATLAS Construction Project. Responsibilities for the Research Program are addressed in separate documents. He/she represents the U.S. ATLAS Project in interactions with overall ATLAS management, CERN, DOE, NSF, the universities and national laboratories involved and BNL, the Host Laboratory. The PM is appointed by the Director of BNL and with concurrence of the DOE and NSF upon recommendation from the U.S. ATLAS Collaboration. The PM will serve as long as there is the continuing confidence of the Collaboration and the funding agencies. He/she reports to the BNL Director (or his/her appointed representative). The PM is advised in this role by an Executive Committee, which includes all U.S. Subsystem Managers, as described below. The PM may select a Deputy to assist him. With respect to technical, budgetary, and managerial issues, the U.S. Subsystem Managers, augmented by the Institutional Board Convener, act as a subcommittee of the Executive Committee to provide advice to the PM on a regular basis. Consultation with this subcommittee is part of the process by which the PM makes important technical and managerial decisions. An example of such a managerial decision would be a modification of institutional responsibilities.

The management responsibilities of the U.S. ATLAS Project Manager include:

1. Appointing, after consultation with the Collaboration, of U.S. Subsystem Managers (SMs) responsible for coordination and management within each detector subsystem. The SMs will serve with the PM's continuing concurrence.

2. Preparing the yearly funding requests to DOE and NSF for the anticipated U.S. ATLAS activities.

3. Recommending to DOE and NSF the institution-by-institution funding allocations to support the U.S. ATLAS efforts. These recommendations will be made with the advice of the SMs, and the U.S ATLAS Executive Committee.

4. Approving budgets and allocating funds in consultation with the SMs and managing contingency budgets in accord with the Change Control Process in Section 7.

5. Establishing, with the support of BNL management, a U.S. ATLAS Project Office with appropriate support services.

6. Working with BNL management to set up and respond to whatever advisory or other mechanisms BNL management feels necessary to carry out its oversight responsibility.

7. Keeping the BNL Director or his chosen representative well informed on the progress of the U.S. ATLAS effort, and reporting promptly any problems whose solutions may benefit from the joint efforts of the PM and BNL management.

8. Interacting with CERN on issues affecting resource allocation and availability, preparation of the international MOUs defining U.S. deliverables and concurring in these MOUs.

9. Advising the DOE and NSF representatives at the ATLAS Resource Review Board meetings.

10. Negotiating and signing the U.S. Institutional MOUs representing agreements between the U.S. ATLAS Project Office and the U.S. ATLAS collaborating institutions specifying the deliverables to be provided and the resources available on an institution-by-institution basis.

11. Periodically reporting on project status and issues to the Joint Oversight Group.

12. Conducting, at least twice a year, meetings with the U.S. ATLAS Executive Committee to discuss budget planning, milestones, and other U.S. ATLAS management issues.

13. Making periodic reports to the U.S. ATLAS Institutional Board to ensure that the Collaboration is fully informed about important issues.

14. Overseeing ES&H Management.

The channels for funding, reporting, and transmission of both types of MOUs are shown in Appendix 7-2. DOE funding will be a mixture of grants and Research Contracts through BNL. NSF funding will be through subcontracts through Columbia University. Further details on the identities and roles of the various participants in the U.S. ATLAS Collaboration governance are given below.

3.4.2 Institutional Board

The U.S. ATLAS Collaboration has an Institutional Board (IB) with one member from each collaborating institution and a Convener elected by the Board. The Convener serves for a two-year renewable term. The IB will normally meet several times per year. Under normal circumstances the meetings are open to the Collaboration, although closed meetings may be called by the Convener to discuss detailed or difficult issues. All voting is by IB members only, except in the case of the absence of a member when the missing member may appoint an alternate.

The IB members represent the interests of their institutions and serve as points of contact between the U.S. ATLAS management structure and the collaborators from their institutions. They are selected by the ATLAS participants from their institutions.

The Institutional Board deals with general policy issues affecting the U.S. ATLAS Collaboration. As chairman of this board the Convener will organize meetings on issues of general interest that arise and will speak for U.S. ATLAS on issues that affect the Collaboration. The Convener also will recommend for ratification to the Institutional Board the ad hoc committees charged with running the elections for the Convener and for the membership of the Executive Committee, as described in the next section. The Convener will recommend to the Institutional Board the establishment of any standing committees to deal with collaboration wide issues if the need arises. The Institutional Board also provides its recommendation on the appointment of the Project Manager to the BNL Director, and DOE and the NSF.

3.4.3 Executive Committee

The Executive Committee advises the Project Manager on global and policy issues affecting the U.S. ATLAS Collaboration or the U.S. ATLAS Construction Project. It also deals with issues external to the U.S. ATLAS Construction Project such as education, computing, physics analysis etc. The Executive Committee has meetings at least twice per year. Its membership is the following:

- The Deputy Project Manager,
- Associate Project Manager for Physics and Computing
- Subsystem Managers,
- The Subsystem Representatives from each subsystem in which U.S. groups are playing a major role, their number being given in parentheses:
    - Semiconductor tracker (1),
    - TRT (1),
    - Liquid argon calorimeter and forward calorimeter (2),
    - Tile calorimeter (1),
    - Muon spectrometer (2),
    - Trigger/DAQ subsystems (1),
- The Education Coordinator,
- The U.S. members of the overall ATLAS Executive Board,
- The Convener of the Institutional Board.

The Subsystem Representatives are elected for two-year renewable terms by the IB members whose institutions are associated with the given subsystem.

The Education Coordinator, also elected for a two-year renewable term by the IB, is expected to actively promote educational programs associated with ATLAS and with the U.S. member institutions, and to report to the Executive Committee on these issues. He/she will also act as liaison to DOE and NSF for educational activities. The intended audiences for these education activities are a) the general public, b) secondary school students, c) undergraduates, and d) primary and secondary school teachers.

3.4.4 Associate Project Manager for Physics and Computing

The Associate Project Manager for Physics and Computing (APM) is responsible for the technical, schedule and cost aspects of the U.S. ATLAS Computing Project. (The scope of the U.S. ATLAS Computing Project is part of the U.S. preparations for participation in the ATLAS research program and is not part of the U.S. ATLAS Construction Project.) The Computing Project will follow all the features of this Project Management Plan in terms of defining a WBS for the deliverables, a detailed cost estimate and resource loaded schedule, controls and reporting. The APM develops the budgets for the institutions participating. The U.S. ATLAS Project Manager appoints the APM with concurrence from the Executive Committee. The APM appoints Software, Facilities and Physics Subsystem Managers with the concurrence of the Executive Committee.

3.4.5 Subsystem Managers

The Subsystem Managers are responsible for the technical, schedule, and cost aspects of their subsystems. They develop the budgets for the institutions participating in their subsystems. They are appointed by the U.S. ATLAS Project Manager upon recommendation of the IB members whose institutions are involved in that subsystem. The Subsystem Managers, augmented by the Institutional Board Convener, also act as a subcommittee of the Executive Committee advising the PM on technical, budgetary, and managerial issues relevant to the U.S. ATLAS Project. Prior to making important technical and managerial decisions, the PM will consult with this subcommittee.

3.4.6 Brookhaven National Laboratory (BNL) and Columbia University

The DOE and NSF have assigned BNL management oversight responsibility for the U.S. ATLAS Construction Project, as well as the U.S. ATLAS Research Program. The BNL Director has the responsibility to assure that the detector effort is being soundly managed, that technical progress is proceeding in a timely way, that technical or financial problems, if any, are being identified and properly addressed, and that an adequate management organization is in place and functioning. The BNL Director has delegated certain responsibilities and authorities to the Associate Laboratory Director for High Energy and Nuclear Physics. The Associate Director is responsible for day-to-day management oversight of the Construction Project and the U.S. ATLAS Project Manager reports to him. Specific responsibilities of the BNL Directorate include:

1. Acting on recommendations of the U.S. ATLAS Collaboration, appoint the U.S. ATLAS Project Manager, subject to the concurrence of the Joint Oversight Group;
2. Establish an advisory structure external to the U.S. ATLAS project for the purpose of monitoring both management and technical progress for all U.S. ATLAS activities;
3. Assure that the Project Manager has adequate staff and support, and that U.S. ATLAS management systems are matched to the needs of the project;
4. Consult regularly with the Project Manager to assure timely resolution of management challenges;
5. Concur with the International Memorandum of Understanding specifying U.S. deliverables for the U.S. ATLAS project funded by DOE and NSF.
6. Concur with the institutional Memoranda of Understanding for the U.S. ATLAS collaborating institutions that specify the deliverables to be provided and the resources available for each institution;
7. Ensure that accurate and complete project reporting to the DOE and NSF is provided in a timely manner.

The NSF Division of Physics has delegated financial accountability to Columbia University inclusive of line management authority, responsibility and accountability for overall project implementation, and contract administration. The Director of Nevis Laboratory is responsible for dispersal of NSF funds according to the allocations recommended by the U.S. ATLAS Project Manager and consistent with NSF Major Research Equipment (MRE) policies.

3.4.7 Project Advisory Panel

The Project Advisory Panel (PAP) is appointed by the Brookhaven Associate Laboratory Director, High Energy & Nuclear Physics. The role of the PAP in the U.S. ATLAS Detector Project is to provide oversight of the work performed in the Project plus advice to Laboratory management on the rate of progress in and adherence to the project plan as it relates to cost, schedule and technical performance. The primary mechanism for performing this oversight role is attendance at the Project Manager's periodic technical reviews of the U.S. ATLAS subsystems, followed by discussions among the attending PAP members with Project principals and Subsystem Managers. If necessary, additional other mechanisms may be employed as deemed necessary to exercise the oversight function. These may include special reviews or meetings and attendance at Department of Energy/National Science Foundation (DOE/NSF) reviews of the U.S. ATLAS Project. The PAP reports to Laboratory management by means of oral discussions plus a written report following each significant PAP review. PAP reports are transmitted to DOE and NSF.

3.4.8 Physics and Computing Advisory Panel

The Physics and Computing Advisory Panel (PCAP) is appointed by U.S. ATLAS Project Manager. The role of the PCAP in the U.S. ATLAS Detector Project will be to provide advice to the PM on the rate of progress in and adherence to the Computing project plan as it relates to cost, schedule and technical performance. The activities of the PCAP are described in more detail in the project management plan for U.S. ATLAS Software and Computing.

3.5 Department Of Energy (DOE) and National Science Foundation (NSF)

The Department of Energy (DOE) and the National Science Foundation (NSF) are the funding agencies for the U.S. ATLAS Construction Project. As such they monitor technical, schedule, and cost progress for the program. The organizational structure is shown in Appendix 7-3.

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

The U.S. ATLAS Project receives substantial support from both DOE and NSF. Almost all the subsystems involve close collaboration between DOE and NSF supported groups. It is therefore essential that DOE and NSF oversight be closely coordinated. The DOE and NSF have agreed to establish a Joint Oversight Group (JOG) as the highest level of joint U.S. LHC Program management oversight. The JOG has responsibility to see that the U.S. LHC Program is effectively managed and executed so as to meet the commitments made to CERN under the International Agreement and its Protocols. The JOG provides programmatic guidance and direction for the U.S. LHC Construction Project and the U.S. LHC Research Program and coordinates DOE and NSF policy and procedures with respect to both. The JOG approves and oversees implementation of the U.S. LHC Project Execution Plan (PEP) and individual Project Management Plans which are incorporated into the PEP including the U.S. ATLAS Construction Project Management Plan.

All documents approved by JOG are subject to the rules and practices of each agency and the signed Agreements and Protocols.

The U.S. LHC Program Office and U.S. LHC Project Office are established to carry out the management functions described in the PEP. As the DOE has been designated lead agency for the U.S. LHC Program, the U.S. LHC Program Manager and the U.S. LHC Project Manager, who respectively head the program and project offices, will generally be DOE employees. The Associate U.S. LHC Program Manager will generally be an NSF employee.

U.S. LHC Program Office
The U.S. LHC Program Office has the overall responsibility for day-to-day program management of the U.S. LHC Program as described in the PEP. In this capacity, it reports directly to the JOG and acts as its executive arm. The office is jointly responsible with the U.S. LHC Project Office for preparation and maintenance of the PEP, and interfaces with the DOE Division of High Energy Physics and the NSF Division of Physics, which are the respective agency offices charged with responsibility to oversee the U.S. LHC Program. The Program Manager and Associate Program Manager are responsible for coordination between the agencies of the joint oversight activities described in the Memorandum of Understanding between DOE and NSF and in the PEP.

U.S. LHC Project Office
The U.S. LHC Project Office is responsible for day-to-day oversight of the U.S. LHC Projects as described in the PEP. In this capacity, the U.S. LHC Project Manager reports to the U.S. LHC Program Manager, and routinely interfaces with the Project Managers for each of the U.S. LHC Projects. These managers represent the contractors and grantees to DOE and NSF. These contractors and grantees have direct responsibility to design, fabricate, and provide to CERN the goods and services agreed in the International Agreement and Protocols.

3.6 Detector Responsibilities
General responsibilities for the design and fabrication of the detector components have been assigned through the traditional process of matching interests, capabilities, and resources of the members of the U.S. ATLAS Collaboration. These responsibilities are specified in the international Memorandum of Understanding (MOU) agreed to by all the relevant funding agencies. U.S. institution-by-institution responsibilities are detailed in Institutional Memoranda of Understanding (MOUs) executed by the Project Office with the individual U.S. institutions. Appendix 7-4 lists by detector system the U.S. institutions participating in the design, fabrication and testing of U.S. ATLAS Construction Project deliverables. Responsibilities for physics and computing are addressed in separate documents.

4 Work Breakdown Structure

All work required for the successful completion of the U.S. ATLAS Construction Project is organized into a Work Breakdown Structure (WBS). The WBS completely defines the scope of work, the deliverables, and is the basis for planning, cost and schedule estimates, and performance measurement.

The WBS has been expanded to a level sufficient to allow definition of individual tasks/elements for which cost can be reasonably estimated. Appendix 7-5 shows the WBS Index at Level 3, which includes the breakdown of individual subsystems and other support functions such as Common Projects, Education and Project Management. Appendix 6 shows to Level 4 of the WBS Dictionary. Individual subsystems have been further expanded to include WBS Levels 4 and 5 to define work down to the design, prototype, production and installation phases of the project.

The Pixel subsystem, WBS 1.1.1, and the Trigger/DAQ subsystem, WBS 1.6, are initially funded as level-of-effort R&D. These subsystems will be included in the project technical baseline as soon as the ATLAS Technical Design Reports for these systems are approved.

Cost estimates have been generated at the most detailed level of the WBS and summed to the top level to determine the total cost for the U.S. ATLAS Construction Project. The WBS also provides a basis for resource-loaded schedules to be prepared with durations assigned to each task at the detailed level. Interdependencies (project logic) will be defined between the WBS elements to generate detailed schedules that time-phase each task. The integration of schedule and cost data provides a time-phased budget that can be used for performance measurement.

A complete list of goals for U.S. deliverables has been derived from key tasks in the WBS and is shown in Appendix 2. This list forms the basis of the MOU with ATLAS.

To take into account uncertainties in the cost estimates, contingency amounts based on a risk analysis for each WBS element, are added to the costs. The result is a large contingency which has been created to avoid the risk of overruns on this project. A significant level of management contingency is also identified for each Level 2 WBS item. Certain items in each subsystem have been identified in Appendix 2, the Full Goals of U.S. ATLAS Deliverables, but not listed in Appendix 3, the Initial Approved Scope of Deliverables. The items in Appendix 3 are the Technical Baseline approval by the DOE/NSF Joint Oversight Group.

All installation of U.S. ATLAS deliverables is to be covered by the Construction Project. Installation is defined as the act of inserting the U.S. ATLAS deliverable into ATLAS. Some of the installation tasks are included in the current baseline – Appendix 3, while others are still in our goals – Appendix 2. We have a process for managing baseline changes (see section 7.3).

5 Project Schedules and Milestones

Schedules for the U.S. ATLAS are generated at three levels of detail based on the WBS. Detailed, intermediate and summary schedules are generated using commercially-available project management software. All milestones are tracked in the Milestone Log including those in Appendix 4 and 5.

5.1 Detailed Schedules

The detailed schedules have been generated by each Subsystem Manager to show timelines and project logic for all efforts associated with design, prototype, production, delivery and installation of all deliverables required to be provided for that subsystem. Activity duration, start and completion dates are coordinated with ATLAS schedule activities to ensure that the completion date for ATLAS is maintained. These activities are logically interconnected to form networks with all other elements that comprise the subsystem. These schedules are maintained by the Subsystem Managers and are kept consistent with the current cost estimate. The detailed schedules from each subsystem will be used to generate both the intermediate and summary schedules that are used for the schedule and cost baseline.

5.2 Intermediate Schedules

Specific milestones are selected from the detailed schedules to define transition points that are used to integrate all elements of the U.S. ATLAS Construction Project into the overall ATLAS schedule. These schedules mimic the detailed schedules but are limited in detail to WBS Level 5 or above. Relationships between activities of the different subsystems and the constraining ATLAS milestones form a network that is used to calculate critical paths. Cost estimates are summarized to the level of these intermediate schedules to form a time-phased budget that is used for performance measurement. These baseline schedules and the time phased costs are maintained by the Project Office and are subject to baseline controls. Schedules are updated by the Project Office on a periodic basis using turnaround documents filled in by the Subsystem Managers.

5.3 Summary Schedule

Key ATLAS milestones and selected milestones from the baseline schedules are incorporated into a summary milestone schedule that is used for reporting purposes. This summary schedule addresses all subsystems and provides an overview of work in process. A summary logic network is also maintained to show critical paths. These schedules are updated based on status inputs to the intermediate schedules, and used for periodic reporting.

5.4 Milestones

Appendix 5 lists high level critical milestones for the Project. Appendix 6 gives the dates when U.S. deliverables in our current baseline are complete and arrive at CERN. All these milestones will be completed within CD-4A (Appendix 4). New milestones for the remaining installation tasks and items outside the baseline will be created as part of the change control process.

6 Cost Estimate

6.1 Cost Objectives

The total estimated cost of the U.S. ATLAS detector components is presented in Appendix 8-1. The common projects are specified in the ATLAS experiment to represent 44% of the total deliverables, as measured in Swiss-Franc CERN accounting. Part of the U.S. obligation to the Common Projects are the barrel cryostat and feedthroughs in WBS 1.3, Liquid Argon Calorimeter; and computing equipment included in WBS 1.6, Trigger/DAQ. Institutional Dues and other items to be resolved (or Common Fund) are in WBS 1.7. The Institutional Dues are 100kCHF/institution spread over 8 years starting in FY 1997.

Cost estimates are prepared by the Subsystem Managers using the WBS. All estimates were initially made in FY 1997 dollars and include all labor and material required to complete the work comprising the U.S. ATLAS Project and specified in the international MOU. The contingency calculation has been based on a combination of the design maturity, and the technical, cost, design and schedule risks associated with each element of the WBS. These costs are summed to a single line that will be controlled by the Project Office. Escalation is based on the latest DOE factors. A breakdown of the costs by Level 2 systems is shown in Appendix 8-1 and the funding profile from the DOE and NSF by fiscal year in Appendix 8-2 in At Year Dollars (AY$).

A Management Contingency has been defined to reserve funds for the items that are in Appendix 2 but not in Appendix 3. Starting in FY 2000, baseline scope increases will be considered to be funded from the Management Contingency assuming performance in that subsystem indicates that sufficient funds will remain at completion.

7 Management and Control System

The U.S. ATLAS project management control system (PMCS) incorporates three primary elements:

- Baseline Development - Defining project scope and establishing the necessary cost and schedule baselines and work execution plans.
- Project Performance - Project status monitoring, reporting and performance analysis.
- Change Control - Management of project baselines and contingency funds.

7.1 Baseline Development

The cost and schedule baseline and the hierarchical relationships are defined in a Work Breakdown Structure. Detailed cost estimates have been developed using appropriate standard estimating methodologies, and integrated with the work scope definition. Schedules and plans have been developed using a disciplined approach that integrates the work scope with the cost estimate. Resources defined in the detailed estimate are applied to the tasks established in the schedule to generate a time-phased budget. These resource-loaded schedules are then aligned to the budget profile and this establishes the schedule and cost baseline. This baseline establishes the Budgeted Cost of Work Scheduled (BCWS) which is used to measure project performance.

7.2 Project Performance

Project performance integrates the work authorization with the funds management and accounting processes to provide a performance analysis capability that is used for reporting to both management and the DOE/NSF.

Funds management is based on funds authorized by both the DOE and NSF that are allocated to the individual institutions in accordance with the baseline estimate and the needs of the project. Funding is planned to occur twice each year. Work authorization is provided for each institution through the U.S. Institutional MOU process which defines the full work scope, including deliverables, and establishes the fiscal year funding. A yearly amendment to the Institutional MOU specifies the funding ceiling to each institution for each subsystem. Standard accounting processes are used to collect actual costs for completed work and to define the funds available for the remainder of the fiscal year. Performance analysis is provided through processing the schedules where comparisons are made between Budgeted Cost of Work Performed (BCWP) and (BCWS) as well as between BCWP and Actual Cost of Work Performed (ACWP). These comparisons provide a determination of project status, and help identify potential problems that cause schedule and cost variances.

The rudiments of performance analysis are embedded in the PCMS. The resource-loaded schedules generated during baseline development are statused on a monthly basis and a comparison of BCWP and BCWS will yield a Schedule Variance (SV) that can be isolated to the specific task or tasks causing the variance. Also a comparison of BCWP and ACWP will yield a Cost Variance that can be attributed to the specific task or tasks causing the variance. This information can be used to establish work-arounds that will hopefully mitigate the problems.

A status report is issued each month that contains the following information:

- U.S. ATLAS Project Managers overview and assessment of the project
- A narrative describing the status of technical work, significant project accomplishments, problems and corrective action if applicable
- A milestone schedule and status report at WBS level 2, identifying completed milestones, slippage and the percentage planned and completed based on cost performance data
- Milestone Log
- Critical path items will be identified for each WBS level 2 Subsystem
- A Cost Schedule Status Report (CSSR) at WBS level 2 identifying BCWS, BCWP, ACWP, SV, CV, Budget at Completion (BAC), Estimate at Completion (EAC) and Variance at Completion
- Variance analysis and corrective action plans where applicable

7.2.1 Reporting

I. Technical Progress

The responsible person in each institution for each subsystem writes the progress by Level 3 WBS each month. Each item should refer to the appropriate Level 5 WBS element and any relevant milestones which are completed. This is due on the 5th of the next month and is sent to the Subsystem Manager. Each Subsystem Manager collates the input and sends it to the Project Manager by the 15th of the month. The Project Manager collates the text, writes an introduction, and finishes the report by the 25th of the month. Reports are placed on usatlas.phy.bnl.gov in
e:/pub/Incoming/Project_Management/REPORTING/Project Status Report.

II. Costs

Each institution reports on each Level 5 item which is active in the following categories: The reports are placed on usatlas.phy.bnl.gov in: /pub/Incoming/Project_Management/Reporting/ Financial_Reporting. This is due on the 15th of the month in the Project Office. Reports are provided to the Subsystem Managers.

III. Performance

Each Subsystem Manager provides an estimate of the progress of each WBS Level 5 item by percentage by the 15th of the month. This is accomplished by updating EXCEL spreadsheets located on usatlas.phy.bnl.gov 2 in /Project_Office/Reporting/Status. These reports of schedule and cost variance can be rolled up to any higher level.

IV. There are schedule status and turn-around documents. These are standardized for schedules and performance measurements at Level 5 of the WBS.
Reporting processes are employed to provide timely, accurate periodic progress reports which enable analysis, evaluation, and corrective action of work scope, schedule, and cost performance against the approved baseline.

Procurements
The U.S. ATLAS Construction Project has defined procurements over $100k as major and subject to PO tracking and control. U.S. ATLAS is working closely with the ATLAS Technical Coordinator in making sure that proper design reviews are conducted at the following stages: conceptual, critical, final. The conceptual stage is when the design has a complete requirements document, there are detailed interface specifications, and there is a model of how to meet these needs. The critical design review is held when the design has progressed enough to produce prototypes. The final design review is scheduled just before the full production is started. U.S. ATLAS Project Manager approval is required before a bid is solicited for a major procurement. The U.S. ATLAS Project Manager or his Deputy are notified at least two days prior to an actual contract award.

7.3 Change Management

The Change Control Process outlined in Figure 7-1 is used to control changes to the Technical, Cost and Schedule Baselines. The membership of the Change Control Board (CCB) consists of the following:

- Chair - Project Manager
- Subsystem Managers
  - Silicon
  - TRT
  - Liquid Argon
  - Tile
  - Muon
  - Trigger/DAQ
- Project Office
  - Mechanical Engineer
  - Electrical Engineer
  - Project Planning Manager

Baseline Change Proposals (BCP) for changes to the detector Technical, Cost and Schedule baselines are referred to the CCB. The following changes are required to be submitted for consideration by the CCB:

> Any change that affects the interaction between various detector systems, the interaction region, the hall safety issues. Such changes also require the concurrence of the ATLAS Change Control Board.
>
> Any change that impacts the performance, the cost or schedule baselines within established thresholds, of the U.S. deliverables.
>
> Any change to the project contingency budget.

The CCB considers the change and its impact, consulting, when necessary, with appropriate outside technical experts. Thresholds for the approval of changes to the detector configuration, cost and schedule are summarized in Table 7-2 along with those responsible for each level of change. After the CCB recommends action on the BCP, the PM approves or rejects the BCP. The BNL Associate Laboratory Director is also required to approve all BCPs involving a cost or schedule change. Upon approval, the change is incorporated into the baseline. An audit trail is provided for each change.

Contingency funds are held by the U.S. ATLAS Project Manager. Contingency funds may be allocated in response to requests for funds required in excess of the base cost. Such requests are reviewed and approved in accordance with the change control procedures.

Table 7-1: U.S. ATLAS Change Control Process

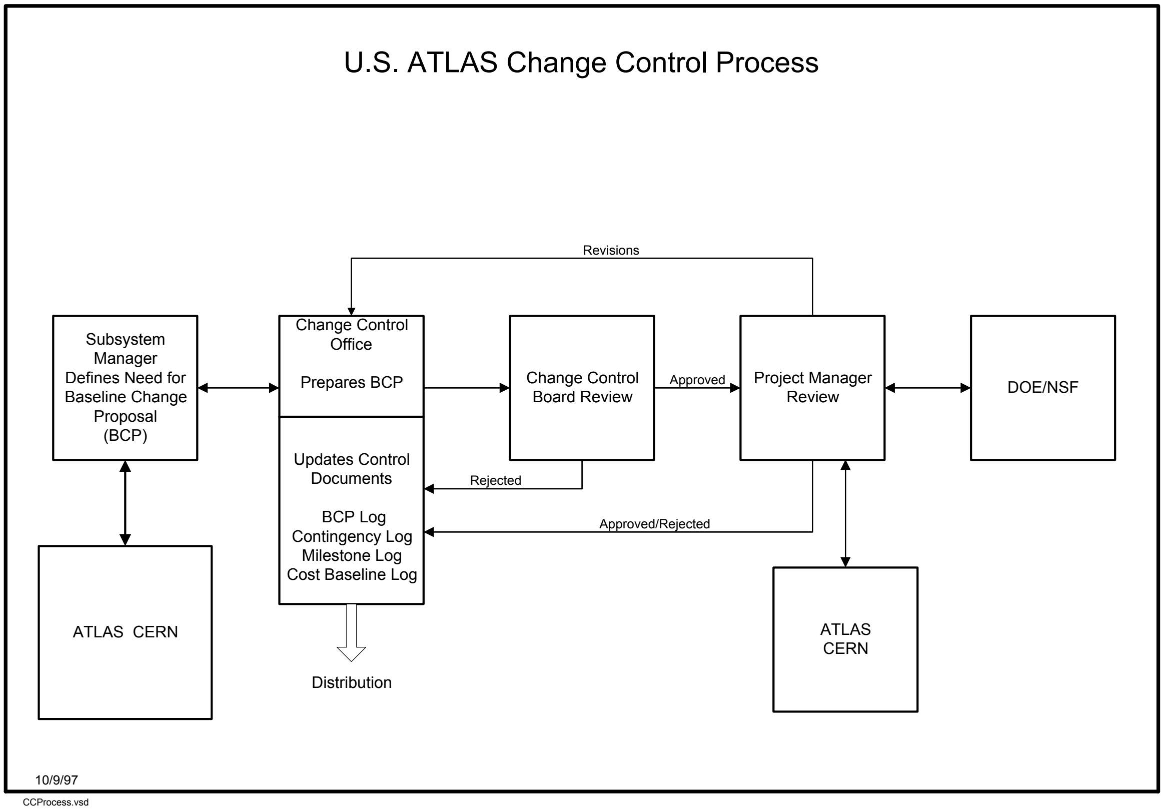


Table 7-2: U.S. ATLAS Change Control Thresholds

	Level 1 DOE/NSF Joint Oversight Group	Level 2 DOE/NSF Project Manager	Level 3 U.S. ATLAS Project Manager and BNL Associate Laboratory Director
Technical	Changes to the project purpose or goals. [Ref. U.S./CERN Agreement and Experiments Protocol]	Changes to the baseline list of deliverables. [Ref. Appendix 3: Initial Approved Scope of U.S. Deliverables]	Changes that do not affect the Level 1 and Level 2 control items. [Ref. U.S. ATLAS Dictionary, U.S. ATLAS 98-03]
Cost	Changes to the Total Project Cost. [Ref. Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate]	Changes to the Level 2 Cost Baseline. [Ref. Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate]	Changes to the cost baseline at WBS Level 3. [Ref. U.S. ATLAS Cost Estimate, U.S. ATLAS 98-04]
Schedule	Greater than 6-month change in a Level 1 milestone [Ref. Appendix 4: U.S. ATLAS Major Project Milestones (Level 1)]	Greater than 3-month change in a Level 2 milestone. [Ref. Appendix 5: U.S. ATLAS Major Project Milestones (Level 2)]	Any change in a Level 3 milestone. [Ref. Appendix 6: U.S. ATLAS Major Project Milestones (Level 3)]

7.4 Host Laboratory Oversight

As discussed earlier, the BNL Director has been charged by DOE and NSF with management oversight responsibility for the U.S. ATLAS activities, and he may delegate this responsibility to the BNL Associate Laboratory Director, High Energy and Nuclear Physics. The Associate Laboratory Director (ALD) has appointed a Project Advisory Panel (PAP) consisting of individuals outside of the U.S. ATLAS Collaboration with expertise in the technical areas relevant to the Project and the management of large projects, to assist him in carrying out his oversight responsibility. The PAP meets at least once per year, or more frequently if required, and its report to the ALD is also transmitted to the DOE/NSF Joint Oversight Group and to the U.S. ATLAS Project Manager. The ALD works with the PM to address any significant problems uncovered in a PAP review.

7.5 Meetings with DOE and NSF

There are regular coordination meetings between the DOE/NSF Project Manager, the Joint Oversight Group, the ALD, and U.S. ATLAS project management personnel for problem identification, discussion of issues, and development of solutions. Written reports on the status of the U.S. ATLAS Construction Project are submitted regularly, as specified in Table 7-3.

Table 7-3: Periodic Reports to DOE and NSF

REPORT	FREQUENCY	SOURCE	RECIPIENTS
Project Status	Monthly	U.S. ATLAS Collaboration	DOE/NSF Program/Project Staff BNL Associate Laboratory Director PAP, Executive Committee Institutional Representatives

7.6 Periodic Reviews

Peer reviews, both internal and external to the Collaboration, provide a critical perspective and important means of validating designs, plans, concepts, and progress. The Project Advisory Panel, appointed by the BNL Associate Laboratory Director provides a major mechanism for project review. The DOE and NSF will set up their own Technical, Management, Cost and Schedule Review Panels to review the research, development, fabrication, assembly and management of the project. In addition, the PM sets up internal review committees to provide technical assessments of various U.S. ATLAS activities, as he/she considers appropriate. Normally, all review reports are made available to members of the U.S. ATLAS Collaboration. However, if a particular report contains some material that, in the opinion of the authority to which the report is addressed, is too sensitive for general dissemination, that material may be deleted and replaced by a summary for the benefit of the Collaboration.

8 Supporting Functions

8.1 Quality Assurance

The overall ATLAS Management has established a Quality Assurance Plan (QAP) at CERN to assure that the detector systems will achieve the technical requirements and reliability needed for operation at the LHC. A general description of the ATLAS QAP is given in ATLAS Document ATL-GE-CERN-QAP-0101.00. It assigns overall responsibility to the ATLAS Spokesperson, assisted by the Technical Coordinator. Furthermore, each ATLAS Project Leader (PL) is assigned the responsibility of implementing a Quality Assurance Plan relevant to his/her subsystem. Each PL is expected to designate a Quality Assurance Representative (QAR) with the authority and organizational freedom to identify potential and actual problems that could result in a degradation of quality, to recommend corrective actions, and to verify implementation of solutions.

Quality Assurance is an integral part of the design, procurement, fabrication, assembly and test of all the systems that are part of the U.S. ATLAS Construction Project. The U.S. ATLAS Project Manager has the overall responsibility for quality assurance. In general, the U.S. ATLAS Subsystem Managers have the quality assurance responsibilities for their subsystems including the following aspects of quality control:

- Identification of those areas, concepts and components which require in-depth studies, prototyping and testing
- Incorporation of necessary acceptance tests into plans and specifications.
- Verification of system performance requirements.
- Documentation of procedures and test results for the fabrication and procurement phase.

8.2 Environmental Safety & Health

The overall ATLAS Management has established an ES&H program at CERN to assure that the detector systems conform to the safety standards in force CERN at the time of delivery to CERN. Again, the U.S. ATLAS Project Manager has the overall responsibility for ensuring that the systems comprising part of the U.S. ATLAS Project satisfy all relevant ATLAS-specified safety regulations and that all institutional ES&H requirements are fully met for U.S. ATLAS work performed in those institutions. In general the U.S. ATLAS Subsystem Managers have responsibility for ES&H issues within their own subsystems including the following:

- Reviewing designs, procedures and practices to identify ES&H potential hazard considerations.
- Assuring that ES&H requirements are met and procedures are followed correctly.

8.3 Property Management

All property will be managed in accordance with established practices of the participating U.S. ATLAS institutions. Property transferred to CERN will be subject to the provision of the International Agreement.

9 Organization of the U.S. ATLAS Project Office (PO)

The U.S. ATLAS Project Office is located at the Host Laboratory, Brookhaven National Laboratory. The PO provides technical coordination, financial and project management support to the Project Manager. The Deputy Project Manager provides direction to PO staff and manages the day to day operations of the PO.

There are two Project Engineers, one mechanical engineer and one electrical engineer, that provide the required technical coordination and support for the overall U.S. ATLAS project. Their duties and responsibilities include:

- Reviewing and validating the rationale and accuracy of technical subsystem cost estimates and schedule baselines.
- Establishing procurement plans.
- Reviewing the feasibility and accuracy of production plans and technology choices.
- Coordinating Quality Assurance, Environmental, Safety and Health issues and compliance.
- Assessing technical and work progress at the collaborating institutions and their vendors.
- Assisting in overall ATLAS detector integration and installation.
- Serving as members of the Change Control Board.

The Administrative Office of the Physics Department at BNL provides the required administrative support for the PO. Specifically the duties and responsibilities are:

- Coordinating and generating the monthly financial report.
- Providing the necessary labor resources to assure the efficient operation of the PO.
- Executing all labor, material and travel purchase actions initiated by the PO.

The Project Planning Manager manages the Project Management Support Group. In addition to directing the activities of this group, he/she has the following duties and responsibilities:

- Developing and maintaining the integrity of the Budget Baseline, Milestone Baseline, Contingency, Baseline Change Proposal (BCP) Logs.
- Establishing the annual funding requirements for each Institution.
- Serving as a member of the Change Control Board.

The Assistant Project Planning Manager, within the Project Management Support Group has primary responsibility for the development and maintenance of the Earned Value portion of the project performance system. Specifically the duties and responsibilities include:

- Developing and validating the accuracy of the Earned Value reporting system
- Establishing Cost Performance Report Formats
- Reporting cost performance
- Doing Variance Analysis

The Senior Project Planning Specialist, within the Project Management Support Group has primary responsibility for the integrity of the U.S. ATLAS schedules. His/her duties and responsibilities include:

- Developing and maintaining the resource loaded project schedules
- Validating consistency of resource loaded schedules with project funding profile
- Establishing schedule links and verifying schedule logic
- Accessing, on a monthly basis, the status of both Earned Value and activity progress of project schedules on a monthly basis
- Performing Critical Path Analysis by identifying and reporting to management critical path items for remedial action and reporting on a monthly basis

10 Review and Modification of this Project Management Plan

After its adoption, this Project Management Plan is periodically reviewed by the Project Manager and the Subsystem Managers as part of the preparation for reviews by the PAP. Proposals for its modification may be initiated by the PM, the Executive Committee, the BNL Associate Laboratory Director, and the funding agencies. Revisions will be endorsed by the U.S. ATLAS Project Manager, the Brookhaven National Laboratory Director or Associate Director for High Energy & Nuclear Physics, the U.S. LHC Project Manager, the Program Manager and Associate program Manager for the U.S. LHC Program, and jointly approved by the Director of the DOE Division of High Energy Physics and the Executive Officer of the NSF Physics Division.

Appendix 1: Letter to Prof. Foa

BROOKHAVEN NATIONAL LABORATORY **UPTON, NEW YORK 11973-5000**

BROOKHAVEN SCIENCE ASSOCIATES
U.S. ATLAS PROJECT OFFICE

April 23, 1998

Professor Lorenzo Foa, Research Director
CERN, CH-1211
Geneva 23, Switzerland

Dear Professor Foa:

The U.S. ATLAS Collaboration Baseline Cost and Project Management Plan (PMP) have now been approved by the DOE and the NSF through their Joint Oversight Group. This good news means that we are ready to proceed on the MOU for the April RRB Meeting. You will recall that at the time of the IMOU signing, the U.S. ATLAS Management and BNL, as the host laboratory in the U.S., were not able to sign the IMOU as such, but were able to achieve the equivalent effect by supplying in a letter a commitment to a specific list of deliverables.

Our situation now is similar, but with some new elements. The U.S.-CERN International Collaboration is now signed, with provisions dealing with a number of issues that are also mentioned in the MOU. The present MOU has a list of deliverables as a central feature of its content. Attached to the present letter is a list of deliverables (labeled "Appendix 2: Complete Goals for U.S. Deliverables" from our PMP) that has carefully been determined to be equivalent to the list in the MOU, but modeled in accordance with the instructions given in Recommendations of our DOE/NSF Baseline Cost Review. We also attach a list of commitments (a subset of Appendix 2 and labeled "Appendix 3: Initial Approved Scope of U.S. Deliverables"). Our Reviewers judged that there are sufficient resources available to commit now to the deliverables in Appendix 3. Furnishing this list of Commitments and Goals then accomplishes one of the goals of the MOU. For the other conditions of the participation in the experiment, we refer to the details in the U.S.-CERN Agreement. It is important to note that the Common Projects already allocated by the RRB, the Barrel Cryostat and signal and high voltage feedthroughs, are included in our commitments. By signing this letter, we believe that we have achieved the goals of the MOU.

We must explain the concepts behind the distinction between Commitments and Goals in our list of deliverables. The origin is the provision of a fixed total sum of funds available for U.S. ATLAS as fixed in the U.S.-CERN Agreement, combined with a desire of the whole ATLAS Collaboration to obtain the full list of deliverables needed for the experiment. A method of optimizing the final set of deliverables was presented to the first meeting of our DOE/NSF Baseline Review by the ATLAS and U.S. ATLAS managements last May. We proceed in two steps. We define a set of goals, and a more restricted set of commitments that we can safely undertake now. We, the U.S. ATLAS leadership, undertake to control the cost and schedule performance of our work well enough so that at a later time, planned to be in 2000 and 2001, we will be able to extend our firm commitments to reach the full goals. We will, of course, continue to involve the ATLAS management in these decisions as we do in all our decision making and reviews.

Sincerely yours,

Thomas B.W. Kirk — Associate Laboratory Director

William J. Willis — U.S. ATLAS Project Manager

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

Silicon 1.1

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.1.1	Pixel System				Deliverables: The U.S. will provide the pixel disk system, with some components being supplied by non-U.S. ATLAS. The deliverables described below are preliminary, since an ATLAS TDR will only be ready by May 1998.
					Definition of interfaces: Components for the disk system will be provided by non-U.S. ATLAS as summarized below
1.1.1.1	Pixel Mechanics	8 disks	1.1.1.2 100% 1.1.1.3 25%	 320 100	Deliverables: (1) complete design of pixel disk support/cooling structure and interface definition of these elements to the overall supporting structure; (2) fabrication and delivery of the 8 pixel disk/supporting elements with modules attached; (3) level-of-effort contribution to common-fund-supported design of overall pixel support structure by Hytec, Inc; and (4) level-of-effort support of LBNL engineering at CERN for pixel design and integration.
					Definition of interfaces: (1) support structure and related mounts by ATLAS and (2) cooling system from ATLAS
1.1.1.2	Pixel Sensors	250 wafers	1.1.2.2 20%	 228	Deliverables: (1) Level-of-effort design and testing (approximately 30% of total effort); (2) level-of-funding(approximately 20% of total) of two prototype orders; and (3) funding of common procurement of production sensors, 250 wafers.
					Definition of interfaces: (1) common procurement of wafers containing both barrel and disk sensors and (2) testing procedures
1.1.1.3	Pixel Electronics	8,500 good IC chips	1.1.2.1 20.5%	 1357	Deliverables:(1) Level-of-effort design and testing(approximately 50% of total effort); (2) funding of prototype orders and (3) funding of procurement of wafers that yield 8,500 good IC chips.
					Definition of interfaces: (1) design requirements and specifications; (2) procurement of full order of ICs and (3) testing procedures.
1.1.1.4	Pixel Hybrids	1,000	1.1.2.4 11%	 372	Deliverables:(1) Prototype(demonstrator) hybrid in Cu-on Kapton technology; (2) prototype disk module hybrids and (3) production disk module hybrids(1,000 good) and connecting cables up to disk sector hybrid.
					Definition of interfaces: (1) Module Clock and Control chip to be provided by others and (2) disk sector hybrids to be provided by others, including all optical links.
1.1.1.5	Pixel Modules	1,000			Deliverables: (1) Level-of-effort for development of bump bonding;(2) dummy prototype module wafers and modules; (3) level-of-funding contribution to bump bonding of modules; (4) testing of all disk modules(1,000 good).
					Definition of interfaces: (1) procurement of prototype and (2) production bump bonding procurement.
1.1.1.6	Pixel Common Items	Level-of-funding	1.1.3.3 16.3% 1.1.4 10%	 284 10	Deliverables: (1) Level-of-funding contribution($200K FY97) to pixel common fund items(eg. crates) Module 0
					Definition of interfaces: Common procurements.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.1.2	Silicon Strip System				Deliverables (1): Integrated circuit(IC) electronics(about 50%);(2) design of barrel module hybrid;(3) components other than detectors for fabrication of 670 (delivered) modules in U.S.;(4) fabrication of modules resulting in 670 modules delivered.
					Definition of interfaces: (1) Design and common procurement of IC electronics;(2) 2950 detectors from non-U.S. ATLAS
1.1.2.1	IC Electronics	39,975 chip sets or chips	1.2.2.1 65%	2945	Deliverables: (1) Level-of-effort design; (2) Funding for prototype chip orders; and (3) 39,975 [BCP 56] chips.
					Definition of interfaces: (1) Design and common procurement.
1.1.2.2	Hybrids	727	1.2.3 15.8%	623	Deliverables:(1) Barrel module hybrid design and (2) hybrid components for assembly yielding 727 good hybrids for module assembly
					Definition of interfaces: (1) Design review and agreement by ATLAS
1.1.2.3	Modules	670 (w/o thermal baseboards)	1.2.4 15.2%	331	Deliverables: 670 barrel modules delivered to UK assembly site. BCP 29 changes this deliverable to Modules without thermal baseboards.
					Definition of interfaces: (1) Production process agreement within ATLAS and (2) 2950 detectors from non-U.S. ATLAS
1.1.3	ReadOut Drivers	345	1.1.3.2 100% 1.2.7 75%	560 1133	Deliverables: (1) Test beam support of SCT and pixels consisting of 50 DSP VME boards, 16 multimodule VME boards (preprototype RODs) and three iterations of pixel support cards and (2) 256 production SCT RODs and 89 production pixel RODs, along with prototypes necessary for the design of production units. This amounts to 100% of ROD production units.
					Definition of interfaces: (1) Design agreement by non-U.S. ATLAS and (2) Tested ASICS(16x256x1.1x1.1=4,956) from the UK to be mounted on SCT ROD cards.
	Cable Extensions, Pixels		1.4.5.2 16%	16	

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

TRT 1.2

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.2.1	Barrel Mechanics				
1.2.1.1	Barrel Module	102	1.3.1.2 49% 1.3.1.4 94%	1185	Production and testing 100% of the barrel modules. 34 of each type including 2 spares.
					Some module components provided by non-U.S. ATLAS **Straws: From CERN. U.S. pays the cost** **Tension Plates: From Lund. U.S. does not pay the cost.**
1.2.1.1.	Cables		1.3.3.1 6%	90	Responsible for $60,000, cables.
1.2.1.2	Gas/Systems and Power Supplies		1.3.4.3 43%	447	Responsible for $300,000 of the production cost. U.S. is not responsible for the design or prototypes.
1.2.1.3	Installation	Level of effort			Testing of the modules at CERN (100% U.S. responsibility), assembly of the modules in the space frame (shared work with other TRT collaborators) and final installation in the experimental area (shared work with other TRT collaborators)..
1.2.5	Electronics				
1.2.5.1	ASDBLR	425,000 channels	1.3.2.1 57%	1698	100% of the ASDBLR for the entire TRT system..
1.2.5.2	DTMROC	Level of effort			Responsible for the design, and prototyping of receiver, driver and DAC section of DTMROC.
1.2.5.3	PCB	106,000 channels	1.3.2.4 38%	121.6	Responsible for designing and prototyping of the endcap TRT front-end PCBs. Responsible for 1/3 of the production and testing of endcap PCBs.
					DTMROC is provided by LUND.
1.2.5.4	Common Electronics		1.3.3.1 13%	195	Responsible for $164,000 of the common items, cables.
1.2.5.6	Installation*	Level of effort			Installation and testing of the TRT electronics with other TRT collaborators..

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

Liquid Argon Calorimeter 1.3

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.1	Barrel Cryostat	1			Barrel Cryostat including: Rails for calorimeter, tracker; support and interface to the magnet.
					Definition of interfaces. ATLAS will take over once the cryostat is at CERN.
1.3.2	Feedthrough				100% Signal, calibration and HV transfer feedthroughs for Barrel Cryostat.
1.3.2.1	Signal	3 - Test	2.9.2.4 50% 2.9.3.3 50% 2.9.3.6 100%	123 30 20	Three feedthrough assemblies for the test beam cryostat.
1.3.3	Cryogenics	1 N_2 Ref. 1 15kl N_2 dewar 2 transfer lines 17 Quality Meters			BCP 25 defines the US deliverables for this WBS as: 1 - Liquid Nitrogen Refrigerator, consisting of Compressor Station, Nitrogen Cold Box, Phase Separator Dewar, Cryogenic Instrumentation and Controls, Compressor Piping, Transfer Lines, Warm Piping, and Capacity Measuring Equipment. Excluded is Vent Piping, Compressor piping for PX16 Shaft, Process Control System, Process control Wiring in PX16 Shaft 2 - Liquid Nitrogen Transfer Lines between ground level dewar and Phase Separator Dewar, Nitrogen Gas Supply Buffer Storage Tank. 1 – 15,000 liter Liquid Nitrogen Storage Dewar 17 - Quality Meters
1.3.4	Readout Electrodes & Mother-boards				Contribution to the readout electrodes and the motherboards system for the Barrel EM calorimeter
1.3.4.1	Readout Electrodes	Level of Effort	2.2.2.4 and 2.4.2. 25%	3690 max cap	U.S. will participate in the design at a level of effort. R&D on large electrodes, industrial prototypes and production. Contribution is capped at 3.69 MCHF. BCP 26 increased the US contribution to ~3.69M CHf, ($2.555M).
					Non-U.S. ATLAS is responsible for the procurement, testing of the readout electrodes
1.3.4.2	Motherboards	100% EM Barrel	2.2.3.1 100%	1230	This include 100% of the summing boards (SB), alignment boards (AB), motherboards (MB) and high voltage (HV) boards for the barrel EM calorimeter. We will deliver the number of boards stated below + 5% which should cover any spoilage during installation.
1.3.4.2.3.1	Summing Boards	7168 224			SB for barrel EM. SB for module 0.
1.3.4.2.3.2	Motherboard	960 30			MB for barrel EM. MB for module 0.
1.3.4.2.3.3	Alignment Boards	960 30			AB for barrel EM AB for module 0.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 30, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.4.2.3.4	HV Boards	498 14			HV Boards for Barrel EM HV boards for module 0
					Non-U.S. ATLAS will do the installation of the motherboard system on the detector. U.S. will supply a level of effort help in the installation. **Define Interfaces.**
1.3.5	Preamps and Calibration				
1.3.5.1	Preamps	 100hybrids 1000hybrids 28500hybrids	2.8.4.1 50%	833	Design and optimization of preamps for the EM and Forward calorimeters (100%): Pre-prototype hybrids: 4 channels/hybrid Module 0 and assorted tests. Enough to equip the barrel EM and the Forward calorimeters.
1.3.5.2	On Board Calibration	For 846 Boards	2.8.4.8		100% of the design, components for the on board calibration for EM and Forward calorimeters (100%).
1.3.5.3	Precision Calibration	Level of effort	2.8.4.8		Participate in the design of the precision calibration. Radiation tolerance studies.
1.3.6	System Crate				Design and specification for the System crate: 100% Barrel EM and Forward Calorimeter. Design should be able to accommodate also EndCap EM and Hadronic readouts. The physical deliverables are for the Barrel EM and Forward calorimeters. U.S. will play a major part in the installation of the system crates and the overall readout chain.
1.3.6.1	Pedestals	32 26	2.8.2.1 100%		BCP 27 increased the US commitment to 58 as follows: 32 - Barrel EM 26 - End Cap and Forward Calorimeter
1.3.6.2	Warm Cables & Base Plane	4300 Cables 116 Base Pl.	2.8.2.1 100%		BCP 27 increased the US commitment to 4300 cables and 116 Barrel EM baseplanes
1.3.6.3	Crates	5 32 26	2.8.2.1 59% 2.10.2.1 100%		BCP 27 increased the US commitment to 58 as follows: 32 - Barrel EM 26 - End Cap and Forward Calorimeter
1.3.6.4	Power Supplies	For 34 Crates +5	2.8.2.2 59%	 1434 40	Barrel EM Forward Module 0, Barrel, EM and Forward, Barrel EM, Forward.
1.3.6.5	Cooling	For 70 Crates	2.8.2.1 100%		Cooling includes the manifolds on the crates, as well as the radiators attached to the front end boards for the Barrel EM and Forward. Design and prototyping only. BCP 27 increased this to 60 crates. BCP 53 increases this scope to 70 crates.
1.3.6.5.4					ATLAS will help in the installation, integration of the system and supply of water for the cooling system, power etc.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.7	FEB				Include the Front End Boards (FEB). This include all design , prototype, assembly, testing and installation of the boards.
1.3.7.1.2.1	Analog FEB Boards	4			Design and deliver analog boards for test beams.
1.3.7.1.2.2	FEB Boards for Module 0	40	2.10.4.1 68%	401	Deliver 5000 channels equivalent of FEB.
					Expect shapers and controllers to come from non-U.S. ATLAS Collaborations
1.3.7.1.3	FEB	832 EM 14 For. 846 Tot.	2.8.4.7 2.8.4.8 2.8.4.9 59%	3008	U.S. will deliver enough FEB for the EM barrel and the forward calorimeter.
1.3.7.2	SCA	120,000 channels	2.8.4.5 59%	1248	Switch Capacitor Array (SCA) Shared design and production with Orsay/Saclay. U.S. part is 120K channels. **DMILL design by Orsay/ Saclay** - share production cost 50/50%
1.3.7.4	Links to ROD	846 Cards	2.8.7.1 35%	396	Links to ROD including the fiber and transmitter.
1.3.8	Level I Trigger Interface				Includes Layer Sums, and Level I interface in the counting room. Design, prototype, production and installation.
1.3.8.1	Layer Sums	3441 Boards	2.8.4.4 100%	350	Layer Sums for the EM and Forward calorimeter. Both for Module 0 and for final ATLAS experiment.
1.3.8.2	Level I interface	192 Boards	2.8.5.2 100%	490	Interface for Level I for the EM and Forward calorimeters.
1.3.9	ROD			205	Readout Drivers (RODs) and Mapping Boards for the equivalent of the EM barrel and Forward calorimeter.
1.3.9.1	ROD Boards	10Proto. 500Final	2.8.7.3 30% 2.10.7.2 20%	965 43	ROD Boards for the Barrel EM Calorimeter. Covers about 50% of the Barrel EM + Forward.
1.3.9.2	Remapping Boards	10Proto. 125Final	2.8.7.3	*	Remapping boards for the Barrel EM Calorimeter. Covers about 50% of the Barrel EM + Forward. *In appendix 3 there is an entry "241", 43.
1.3.10.1	Forward Calorimeter.	2	2.7.1.1	465	EM Section of the Forward Calorimeter -
1.3.10.2		2	2.7.2.1 100% 2.7.3.1 25% 2.7.3.2 100%	310 120 35	Cold electronics, cables, Motherboards, decoupling capacitors for the full Forward calorimeter. Shipping Tools for assembly.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

Tile Calorimeter 1.4

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.4.1.1.1 1.4.1.2.1 1.4.1.2.4 1.4.1.3.1	Submodule design Module design Module Installation Fixt. & Tool. design	3.3 FTEyr			Mechanical Design (level of effort)
1.4.1.1.2 1.4.1.2.2	Submodule prot. Module prot.				All master plate stamping, four submodules and instrumentation effort for Barrel Module 0 All master plate stamping for two Extended Barrel Module 0s Mechanical and optical assembly of one Extended Barrel Module 0
1.4.1.1.3. 2.1-3	Master plates	37,225 plates **102,355** **166 kCHF**	3.1.1 29% 3.1.2.2 100%	680 210	Master plates for two Extended Barrel Calorimeters, including purchase of sheet steel and die stamping **Spacer plates for one extended barrel calorimeter - supplied by non-U.S. collaborations** **Financial contribution toward extended barrel master plates - supplied by non-U.S. collaborations**
1.4.1.1.3. 2.3	Master pl ship	18,610	3.1.3.2 50%	463	Master plates shipped to Barcelona for EB production
1.4.1.3 1.4.2.3	Fixtures and tooling		3.1.4 22%	 112	Tooling for submodule and module assembly
1.4.1.1.3 1.4.1.2.3 1.4.2.2.3	Submod prod Mod. prod.	64 mods **236,000** **18,610** **2**	3.1.6.2 100% 3.1.7 14%	 210 21	Mechanical and optical assembly of 576 submodules for 64 modules for one Extended Barrel calorimeter **Scintillator tiles, installed in Tyvek wrappers** **Wavelength-shifting fiber installed in guide profiles for one extended barrel calorimeter** **Two facing machines for fiber bundle optical couplers**
1.4.1.4	Module testing	64 **2**			Testing of 64 assembled modules with Cs sources **Two drawer assemblies with readout electronics for module testing**
1.4.1.2.3. 3.3	Ship to CERN	64			Shipping of 64 modules to CERN
1.4.2.1.1 1.4.2.2.1	EB Scint. design EB Fiber design	0.4 FTEyr			Optics R&D (level of effort)
1.4.2.1.3.1	Scint. wrappers	472,000	3.2.6 100%	 100	Tyvek wrappers for all scintillator tiles for the Barrel and two Extended Barrel calorimeters (shipped to Protvino)
1.4.3.2. 1-2	FE Elect des/prot				Design of the front-end 3-in-1 card (Lead, shared with Stockholm and Barcelona)
1.4.3.4. 1-2	Dig Elect des/prot				Design of links of digitizing electronics to TTC and Detector Control Systems

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.4.3.4. 1-2	Dig Elect des/prot	0.7 FTEyr			Other design of digitizing electronics (level of effort)
1.4.3.1 1.4.4.1.3.6	PMT block	3,328 **3,328** sets	3.3.2 33% 3.3.3 25%	 920 9	photomultiplier tubes, tested and assembled in PMT blocks **Non-PMT Parts for PMT block assembly**
1.4.3.2.3	FE Prod	10,020 ch	3.3.5 88%	598	88% Module 0 PMTs front end electronics procurement (plus contribution from Barcelona, mechanism depends on final design)
1.4.3.5.3	System control	1 module			VME Control module
1.4.4.1	Gap submods	128	3.1.6.4 100%	60	ITC Plug special submodules for both Extended Barrel Calorimeters, with end plates
1.4.4.2	Cryostat scint.	140 each assy	100%	0	ITC Plug and cryostat scintillator assemblies for both Extended Barrel Calorimeters, including installation

Muon 1.5

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.7	MDT Chambers	320	4.1.2.1 to 4.1.2.6 100%	3630	Complete Monitored Drift Tube Chambers including the in-plane alignment system. Total number of fabricated tubes is 105,472 (+5% wastage). Required number of endplugs (210,944+5%) to be provided by Pavia.
1.5.7.10	MDT Installation		4.5.1.5 25%	600	Contribution limited to level of effort.
1.5.8.2.1	MDT Kinematic Mounts	168 sets			Design, development and fabrication of 168 sets of kinematic mounts required for the installation of the 320 MDT “logical” chambers.
1.5.8.2.2	MDT Chamber Connectors	384			Design, development and fabrication of 384 chamber connectors.
1.5.9.1.2	Hedgehog PC Boards	4400			Design, development and fabrication of 4400 Hedgehog printed circuit boards needed for the MDT Chambers to be constructed by the U.S. groups.
1.5.9.1.2	Mezzanine PC Boards	15,479	4.1.3.1 100%	2435	Design, development and fabrication of 15479 Mezzanine PC boards required for the entire Muon Spectrometer. The 15479 required TDC chips will be provided by the Japanese groups.
1.5.9.4	Signal Patch Panels	640			Design, development and fabrication of 640 signal patch panels required for the U.S. MDT Chambers.
1.5.9.2.2	High Voltage Patch Panels	640			Design, development and fabrication of 640 HV patch panels required for the U.S. MDT Chambers.
1.5.9.1.1	Additional ASD ASIC	19387			An additional 19387 IC’s will be fabricated (about 20% above what is needed) to account for wastage and spares.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.4.4.1	CSC1	32	4.2.1 46%	129	Design, development and fabrication of 32 CSC Modules of Design 1.
1.5.4.4.2	CSC2	32	4.2.1 46%		Design, development and fabrication of 32 CSC Modules of Design 2.
1.5.4.7	Installation		4.5.1.6 41%	33	Installation/commissioning at CERN will be limited to level of effort.
1.5.11.1.1	ASM Boards	1280	4.2.3 97% ...		Design, development and fabrication of 1280 PC Boards required for fully equipping the CSC Chambers.
1.5.11.1.2	DCC Boards	64	4.2.3 97%...	total 1370	Design, development and fabrication 64 Data Collection and Control boards.
1.5.11.1.3	HV Boards	64	4.2.3 97%...		Design, development and fabrication 64 Data High Voltage boards.
1.5.11.2.1	Readout Drivers (ROD)	8	4.2.3 97%...		Design, development and fabrication 8 Data Readout Driver modules.
1.5.11.2.2	DCS Modules	2	4.2.3 97%...		Design, development and fabrication 2 Detector Control Modules.
1.5.11.2.3	TTC Modules	2	4.2.3 97%...		Design, development and fabrication 2 Trigger/Timing/Calibration Modules.
1.5.11.2.4	VME Crates	2	4.2.3 97%...		Provide the 2 VME crates with their controllers needed for the CSC off-chamber electronics.
1.5.12.2	Operational Test Stand	1 Octant			Provide 1 Octant of one End Cap Alignment System setup in the H8 test beam at CERN [BCP 5]
1.5.12.3.1	Alignment Bars	80	4.5.1.2 47%	542	Provide the 80 Alignment bars needed for the Forward Alignment System.
1.5.12.3.2	Three-point Systems	1504	4.5.1.2 100%		Provide 1504 three-point systems for the Forward Alignment System.
1.5.12.3.3	Multipoint Systems	2144	4.5.1.2 28%		**Provide 2144 multi-point systems for the Forward Alignment System. The transparent silicon sensors needed for this item are to be provided by the Max Planck Institute.**
1.5.12.5	Installation				Installation at CERN limited to level of effort.

Trigger and Data Acquisition 1.6

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.6.1	LVL2 Supervisor & RoI Builder	1	5.2.1.5 100%	845	100% of design, development, procurement, fabrication, and installation.
					Design will be compatible with chosen level 2 architecture.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.6.2	LVL2 Calorim. Trigger		5.2.1.1 45.5%	851	Contribution to the LVL2 Calorimeter Trigger. This contribution is targeted to provide 50% of the effort and materials required for design, development, procurement, fabrication, and installation.
					ATLAS collaborators will provide the remaining 50% of the effort and materials.
1.6.2.1	Design	Level of Effort			U.S. will participate in design of LVL2 Calorimeter Trigger at a level of effort estimated to be 50% of the total effort required.
1.6.2.2	Developme nt & Prototypes	Level of Effort			U.S. will participate in development and prototyping of LVL2 Calorimeter Trigger at a level of effort estimated to be 50% of the total effort required. U.S. will also provide a portion of the equipment required for prototyping on a level of effort basis.
1.6.2.3	Production		5.2.1.3 28.4%	1305	Contribution to production of LVL2 Calorimeter Trigger. This contribution is targeted to provide 50% of the effort and materials required to produce the final trigger.
1.6.2.3.1	Production EDIA	Level of Effort			U.S. will participate in procurement and fabrication of LVL2 Calorimeter Trigger at a level of effort estimated to be 50% of the total effort required.
1.6.2.3.2	Production Equipment	Level of Effort			U.S. will provide 1025 FY97 K$ for procurement of equipment for the production LVL2 Calorimeter Trigger and associated Readout Buffers.
1.6.2.4	Install & Commissio n	Level of Effort			U.S. will participate in installation and commissioning of LVL2 Calorimeter Trigger at a level of effort estimated to be 50% of the total effort required.
1.6.3	LVL2 SCT Trigger				Contribution to the LVL2 SCT Trigger. This contribution is targeted to provide 50% of the effort and materials required for design, development, procurement, fabrication, and installation.
					Non-U.S. ATLAS collaborators will provide the remaining 50% of the effort and materials.
1.6.3.1	Design	Level of Effort			U.S. will participate in design of LVL2 SCT Trigger at a level of effort estimated to be 50% of the total effort required for design.
1.6.3.2	Developme nt & Prototypes	Level of Effort			U.S. will participate in development and prototyping of LVL2 SCT Trigger at a level of effort estimated to be 50% of the total effort required. U.S. will also provide a portion of the equipment required for prototyping on a level of effort basis.
1.6.3.3	Production				Contribution to production of LVL2 SCT Trigger. This contribution is targeted to provide 50% of the effort and materials required to produce the final trigger.
1.6.3.3.1	Production EDIA	Level of Effort			U.S. will participate in procurement and fabrication of LVL2 SCT Trigger at a level of effort estimated to be 50% of the total effort required.
1.6.3.3.2	Production Equipment	Level of Effort			U.S. will provide 1205 FY97 K$ for procurement of equipment for the production LVL2 SCT Trigger and associated Readout Buffers.
1.6.3.4	Install & Commissio n	Level of Effort			U.S. will participate in installation and commissioning of LVL2 SCT Trigger at a level of effort estimated to be 50% of the total effort required.

Appendix 2: Complete Goals for U.S. Deliverables

[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.6.4	Architectural Design & LVL2 Global Trigger		5.2.1.4 18.2%	289	Contribution to the overall architectural design and development of the LVL2 Trigger System and contribution to the procurement and fabrication of the LVL2 Global Trigger.
					Non-U.S. ATLAS collaborators will provide the remaining effort and materials.
1.6.4.1	Architectural Design	Level of Effort			U.S. will participate in overall architectural design of LVL2 Trigger System at a level of effort.
1.6.4.2	LVL2 Global Trigger Production	Level of Effort			U.S. will provide 232 FY97 K$ for procurement of equipment for the production LVL2 Global Trigger. This contribution is targeted to provide 25% of the equipment required.
1.6.5	T/DAQ Common Projects	Level of Effort			U.S. will provide 5967 FY97 k$ for procurement of T/DAQ equipment which has been defined as ATLAS Common Project. U.S. will provide associated procurement effort.

Technical Coordination 1.10

WBS #	Task	Quantity	MoU ref.#	CORE value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.10	Technical Coordination	LOE			BCP 52 increases this scope to $1,300k Level of Effort.

Appendix 3: Approved Scope of U.S. Deliverables
[BCP 1, 9/8/98 through BCP 60, November 8, 2002]

Silicon 1.1

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.1.1	Pixel System				Deliverables: The U.S. will provide the pixel disk system, global support tube/endplug, cables and piping interior to the Inner detector, IC and module electronic test systems, flex hybrids and optical hybids with some components being supplied by non-U.S. ATLAS.
					Definition of interfaces: Components for the disk system will be provided by non-U.S. ATLAS as summarized below
1.1.1.1	Pixel Mechanics	6 disk structures (sectors, rings, and mounts	1.1.1.11.1.1.2 1.1.1.1.3 100%	420	Deliverables: (1) complete design of 6 pixel disk structures, global support frame, SCT mounts, Support tube/endplug, first patch panel (PPO), type II cables and services support structure for a partial 2-hit Pixel System, cooling structure and interface definition of these elements to the overall structure, (2) fabrication and delivery of the 6 pixel disk structure supporting elements with modules attached; (3) level-of –effort support of LBNL engineering for pixel and integration.
					Definition of interfaces: (1) support structure and related mounts by ATLAS and (2) cooling system from ATLAS
1.1.1.2	Pixel Sensors	400 Tiles	1.1.1.2.2	37	Deliverables: (1) Partial funding (20% of total) of preproduction fabrication; (2) testing of about 25% of preproduction wafers. BCP 50 adds the production and testing of 400 tiles to the approved scope.
1.1.1.3	Pixel Electronics	25 IBM wafers, 2 optical IC wafers, 20 test systems	1.1.1.2.1	452	Deliverables:(1) Design of front-end IC (about 2/3 of total effort) and design of optical Ics (about 50% of total effort); (2) Procurement of TSMC and IBM test chips; (2) 50% of procurement of optical IC Prototypes; (3) procurement of 25 8” IBM wafers; (4) testing of 112 8” IBM wafers; (5) 20 test systems; (6) 25% contribution to minimum Atmel order of optical Ics; (7) testing of 50% OPTICAL ic WAFERS (4 WAFERS).
					Definition of interfaces: (1) design requirements and specifications;
1.1.1.4	Pixel Hybrids	477 flex hybrids in detector, 204 disk pigtails, 17 optical hybrids	1.1.1.2.4	50	Deliverables:(1) Design and layout of flex hybrid; (2) design and layout of optical hybrids for disk region; (3) procurement and testing of flex hybrids, passive components and loading to provide 477 in detector; (4) procurement and testing of optical hybrids, passive components and loading to provide 17 in the detector; (5) procurement and testing of all disk pigtails and connectors.
					Definition of interfaces: (1) Module Clock and Control chip to be provided by others and (2) disk sector hybrids to be provided by others, including all optical links.
1.1.1.5	Pixel Modules	Thinning of 224 wafers, Dicing of 224 wafers. 298 modules		50	Deliverables: (1) Design of module assembly and testing; (2) thinning of 224 8” wafers; (3) dicing of 224 wafers; (4) assembly and testing to yield 298 modules in detector; (5) attachment of all modules to disk sectors.
					Definition of interfaces: (1) procurement of prototype and (2) production bump bonding procurement.

Silicon 1.1
(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.1.1.6	Beam/System Tests Pixel Common Items	Level-of-funding	1.1.1.3.3 1.1.1.4	35	Deliverables: (1) Level of-effort support of beam tests and system tests at CERN Deliverables: (1) Level of-effort support of beam tests and system tests at CERN
					Definition of interfaces: Common procurements.
1.1.2	Silicon Strip System				Deliverables (1): Integrated circuit (IC) electronics(2) mounting ICs on hybrids and testing for US delivered modules; (3) Fabrication of 670 (delivered) modules in U.S.;
					Definition of interfaces: (1) Design and common procurement of IC electronics;(2) 2950 detectors from non-U.S. ATLAS
1.1.2.1	IC Electronics	39,975 chips	1.1.2.2.1 65%	2651	Deliverables: (1) Level-of-effort design; (2) Funding for prototype chip orders; and (3) 39,975 [BCP 56] chips.
					Definition of interfaces: (1) Design and common procurement.
1.1.2.2	Hybrids		1.1.2.3	0	Deliverables:(1) Barrel module hybrid design and (2) hybrid prototypes. Production hybrids are from non-U.S. ATLAS.
					Definition of interfaces: (1) Design review and agreement by ATLAS
1.1.2.3	Modules	670 (w/o thermal baseboards)	1.1.2.4 15.4%	331	Deliverables: 670 barrel modules delivered to UK assembly site. BCP 29 changes this deliverable to Modules without thermal baseboards.
					Definition of interfaces: (1) Production process agreement within ATLAS and (2) 2950 detectors from non-U.S. ATLAS
1.1.3	Read Out Drivers	113	1.1.1.3.2 100% 1.2.7	631	Deliverables:(1) Test beam support of SCT and pixels consisting of 50 DSP VME boards, 16 multimodule VME boards (preprototype RODs) and three iterations of pixel support cards and (2) 113 production RODs along with prototypes necessary for the design of production units..
					Definition of interfaces: Design agreement by non-U.S. ATLAS.

TRT 1.2

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.2.1	Barrel Mechanics				
1.2.1.1	Barrel Module	71	1.3.1.2 49% 1.3.1.4 94%	825	Initial scope is production and testing of 70% of the barrel modules required. Total barrel modules required is 34 of each of three types, which includes 2 spares of each type. BCP 58 provides authority and funding to complete the mechanics for 102 modules, but the delivery of completed modules is not increased. **Some module components provided by non-U.S. ATLAS** **Straws: From CERN. U.S. pays the cost** **Tension Plates: From Lund. U.S. does not pay the cost.**
1.2.1.1.	Cables		1.3.3.1 6%	90	Responsible for $60,000 of the cables.
1.2.5	Electronics				
1.2.5.1	ASDBLR	425,000 channels	1.3.2.1	1698	Initial scope is 65% of total of the ASDBLR for the entire TRT system. BCP 55 increases the approved scope to 100%
1.2.5.2	DTMROC	Level of effort			Responsible for the design, and prototyping of receiver, driver and DAC section of DTMROC.
1.2.5.3	PCB	106,000 channels	1.3.2.4 38%	122	Responsible for designing and prototyping of the endcap TRT front-end PCBs. Responsible for 1/3 of the production and testing of endcap PCBs.
					DTMROC is provided by LUND.
1.2.5.6	Installation	Level of effort			Installation and testing of the TRT electronics with other TRT collaborators. Initial scope is 65% of total.

Liquid Argon 1.3

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.1	Barrel Cryostat	1			Barrel Cryostat including: Rails for calorimeter, tracker; support and interface to the magnet. **ATLAS will take over once the cryostat is at CERN.**
1.3.2	Feedthrough				100% Signal, calibration and HV transfer feedthroughs for Barrel Cryostat.
1.3.2.1	Signal	3 - Test			Three feedthrough assemblies for the test beam cryostat, including installation.
		68-Production			64 completed production assemblies, and 4 spares, are required for the barrel cryostat. We will supply the components and assembly (apart from the pigtails). The feedthroughs will be fully tested before and after installation. **Pigtails to be provided at no cost to US, enough pigtails + spares - amount depending on the reliability and failure rate of the cables during tests and installation.(Not less than 68 sets+5% for spoilage)**

Liquid Argon 1.3

(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.2.2	HV	7 Production			HV feedthroughs for barrel(2) and endcap (4) + 1 spare ~800 channels per feedthrough. Feedthrough will end on one side with bare cable and on the other side at the decoupling box. ATLAS will help in the installation and the routing of cables.
1.3.3	Cryogenics	1 Refrigerator. 1 15kl N_2 storage dewar, 2 cryogenic liquid transfer lines, 17 liquid quality meters			BCP 25 defines the US deliverables for this WBS as: 1 - Liquid Nitrogen Refrigerator, consisting of Compressor Station, Nitrogen Cold Box, Phase Separator Dewar, Cryogenic Instrumentation and Controls, Compressor Piping, Transfer Lines, Warm Piping, and Capacity Measuring Equipment. Excluded is Vent Piping, Compressor piping for PX16 Shaft, Process Control System, Process control Wiring in PX16 Shaft 2 - Liquid Nitrogen Transfer Lines between ground level dewar and Phase Separator Dewar, Nitrogen Gas Supply Buffer Storage Tank. 1 – 15,000 liter Liquid Nitrogen Storage Dewar 17 - Quality meters
1.3.4	Readout Electrodes & Mother-boards				Contribution to the readout electrodes and the design, fabrication and delivery of the motherboards system for the Barrel EM calorimeter
1.3.4.1	Readout Electrodes	Level of Effort	2.2.2.4 and 2.4.2. 32%	3690 max cap	U.S. will participate in the design at a level of effort. R&D on large electrodes, industrial prototypes and production. Contribution is capped at 3.69 MCHF. BCP 26 increased the US contribution to ~3.69M CHf, ($2.555M).
					Non-U.S. ATLAS is responsible for the procurement, testing of the readout electrodes
1.3.4.2	Motherboard System	100% EM Barrel	2.2.3.1 100%	1230	This include 100% of the summing boards (SB), alignment boards (AB), motherboards (MB) and high voltage (HV) boards for the barrel EM calorimeter. We will deliver the number of boards stated below + 5% which should cover any spoilage during installation.
1.3.4.2.3.1	Summing Boards	7168 224			SB for barrel EM. SB for module 0.
1.3.4.2.3.2	Motherboards	960 30			MB for barrel EM. MB for module 0.
1.3.4.2.3.3	Alignment Boards	960 30			AB for barrel EM AB for module 0.
1.3.4.2.3.4	HV Boards	448 14			HV Boards for Barrel EM HV boards for module 0
					Non-U.S. ATLAS will do the installation of the motherboard system on the detector. U.S. will supply a level of effort help in the installation. Define Interfaces.

Liquid Argon 1.3

(Continued)

WBS #	11 Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.5	Preamps and Calibration				
1.3.5.1	Preamps	100 hy. 1000 hy. 29700 hy.	2.8.4.1 50%	833	Design and optimization of preamps for the EM and Forward calorimeters (100%): Pre-prototype hybrids (hy): 4 channels/hybrid , Module 0 and assorted tests. Enough to equip the barrel EM and the Forward calorimeters.
1.3.5.2	Precision Calibration	Level of effort	2.8.4.8 100%		Participate in the design of the precision calibration. Radiation tolerance studies.
1.3.6	System Crate			759	Design and specification for the System crate: 100% Barrel EM and Forward Calorimeter. Design should be able to accommodate also EndCap EM and Hadronic readouts. The physical deliverables are for the Barrel EM and Forward calorimeters. U.S. will play a major part in the installation of the system crates and the overall readout chain.
1.3.6.1	Pedestals	32 26	2.8.2.1 100%		BCP 27 increased the US commitment to 58 as follows: 32 - Barrel EM 26 - End Cap and Forward Calorimeter
1.3.6.2	Warm Cables & Base Plane	4300 Cables 116 Base Pl.	2.8.2.1 100%		BCP 27 increased the US commitment to 4300 cables and 116 Barrel EM baseplanes
1.3.6.3	Crates	5 32 26	2.8.2.1 59% 2.10.2.1 100%		BCP 27 increased the US commitment to 58 as follows: 32 - Barrel EM 26 - End Cap and Forward Calorimeter
1.3.6.4	Power Supplies		2.8.2.2 59%		Design and Prototyping effort.
1.3.6.5	Cooling	For 70 Crates	2.8.2.1 100%		Cooling includes the manifolds on the crates, as well as the radiators attached to the front end boards for the Barrel EM and Forward. Design and prototyping only. BCP 27 increased this to 60 crates. BCP 53 increases this scope to 70 crates.
1.3.6.5.4					ATLAS will help in the installation, integration of the system and supply of coolant for the cooling system, power etc.
1.3.7	FEB				Include the Front End Boards (FEB). This include all design, and prototyping,
1.3.7.1.2.1	Analog FEB Boards	4			Design and deliver analog boards for test beams.
1.3.7.1.2.2	FEB Boards for Module 0	50	2.10.4.1 68%	401	Deliver 5000 channels equivalent of FEB.
					Expect shapers and controllers to come from non-U.S. ATLAS Collaborations

Liquid Argon 1.3

(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.3.7.1.3	FEB	ADC Chips 50% Associated FEB Components 100%	2.8.4.7 2.8.4.8 2.8.4.9 59%	2407	As a result of BCP 47, U.S. will deliver enough FEB for the EM barrel and the forward calorimeter. ATLAS FEB Cost Sharing Plan reapportions the deliverables, including previously unassigned deliverables, as follows: ADC Chip - 50%. Gain Selector Chip, COTS, PC Board Fabrication, Front Panel, Al plate for VR, Optical Links, Configuration Controller, PreAmp RF Shield, BP Connector Shield, BP Connectors, Power Connector, Power Comb, Ground Pins, Conductive Tape, and PC Board Assembly Labor – 100%.
1.3.7.2	SCA	0	2.8.4.5 59%	1247	Switched Capacitor Array (SCA). Shared design and production with Orsay/Saclay. U.S. part is 120K channels. 32 x # FEBs. Reduced to zero by BCP 47.
1.3.7.4.3	Optical Links	Links to 846 Boards	2.8.7.1 35%	396	BCP 47 adds G Links, and Misc. Optical Link Components to the approved scope.
1.3.8	Level I Trigger Interface				Includes Layer Sums, and Level I interface in the counting room. Design, prototype, production and installation.
1.3.8.1	Layer Sums	3400 Boards	2.8.4.4 100%	350	Layer Sums for the EM and Forward calorimeter. Both for Module 0 and for final ATLAS experiment.
1.3.8.2	Level I interface	192 Boards	2.8.5.2 100%	490	Interface for Level I for the EM and Forward calorimeters.
1.3.9	ROD				Readout Drivers (RODs) and Mapping Boards for the equivalent of the EM barrel and Forward calorimeter.
1.3.9.2	Remapping Boards	10 Proto.	2.8.7.3 30% 2.10.7.2 20%	241 43	Design and prototyping the Remapping boards for the Barrel EM Calorimeter.
1.3.10	Forward Calorimeter				
1.3.10.1		2	2.7.1.1	465	EM Section of the Forward Calorimeter -
1.3.10.2		2	2.7.2.1	310	Cold electronics, cables, Motherboards, decoupling capacitors for the full Forward calorimeter.
1.3.10.2			2.7.3.1 25% 2.7.3.2	120 35	Shipping Tools for assembly

Tile Calorimeter 1.4

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.4.1.1.1 1.4.1.2.1 1.4.1.2.4 1.4.1.3.1	Submodule design Module design Module Installation Fixt. & Tool. design	4.0 FTEyr			Mechanical Design (level of effort) BCP 54 increases this scope to include design and procurement support for the Calorimeter Support.
1.4.1.1.2 1.4.1.2.2	Submodule prot. Module prot.				All master plate stamping, four submodules and instrumentation effort for Barrel Module 0 All master plate stamping for two Extended Barrel Module 0s Mechanical and optical assembly of one Extended Barrel Module 0
1.4.1.1.3.2.3	Master pl ship	18,610	3.1.3.2 50%	463	Master plates shipped to Barcelona for EB production
1.4.1.3 1.4.2.3	Fixtures and tooling		3.1.4 22%	112	Tooling for submodule and module assembly
1.4.1.1.3 1.4.1.2.3 1.4.2.2.3	Submod prod Mod. prod. Girder Proc.	64 **236,000** **18,610** **2**	3.1.6.2 100% 3.1.7 14%	131 21	Mechanical and optical assembly of 64 [BCP 39] complete modules for one Extended Barrel calorimeter. **Scintillator tiles, installed in Tyvek wrappers** **Wavelength-shifting fiber installed in guide profiles for one extended barrel calorimeter** **Two facing machines for fiber bundle optical couplers** BCP 18 Increased the number of Girders to 64 with one spare.
1.4.1.4	Module testing	64 **2**			Testing of assembled modules with Cs sources **Two drawer assemblies with readout electronics for module testing**
1.4.1.2.3.3.3	Ship to CERN	64			Shipping of 64 modules or components to CERN. Initial scope is 63% of total.
1.4.2.1.1 1.4.2.2.1	EB Scint.& Fiber Design	0.4 FTEyr			Optics R&D (level of effort)
1.4.2.1.3.1	Scint. Wrappers	472,000	3.2.6 100%	100	Tyvek wrappers for all scintillator tiles for the Barrel and two Extended Barrel calorimeters (shipped to Protvino)
1.4.3.1	PMT block	**3,397**	3.3.2	464	Photomultiplier tubes, tested and assembled in PMT blocks. Non PMP parts for PMT block assembly. Initial scope is 72% of total. BCP 57 increases this scope to 3,397 PMT.
1.4.3.2.3	All 3-in-1 cards + motherboard	10,300 ch	3.3.5 100%	598	44% of front end electronics procurement (jointly with Stockholm plus contribution from Barcelona, mechanism depends on final design). BCP 11 changes this scope to 100% of the 3-in-1 cards with Stockholm becoming responsible for 100% of the Digitizers. US will provide 85% of the ADC chips, eliminating any cost impact in this exchange. BCP 28 increased the authorized scope to 100% for Motherboards.

Tile Calorimeter 1.4

(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.4.3.4.3	Interface Board	277			BCP 49 adds 277 Interface Boards to the approved scope.
1.4.3.5.3	System control	1 module			VME Control module
1.4.4.1	Gap submodules	128	3.1.6.4 100%	36	ITC Plug special submodules for both Extended Barrel Calorimeters, with end plates. BCP 39 increases the production authorization to 128.
1.4.4.2.3	Cryostat Scintillaor Mechanics	Mechanics only			Entire scope of mechanics shall be provided [BCP 39]. This allows for eventual upgrade of Tile Calorimeter by fabrication and installation of scintillators.

Muon 1.5

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.7.7	MDT Chambers – BMC	80	4.1.2.1 to 4.1.2.6		Complete Monitored Drift Tube Chambers including the in-plane alignment system. These consist of 16 each of Chamber series EIL1, EIS1, EIS2, EIL2-3, and EMS1. Total number of fabricated tubes is 26,880 + spares. Engineering design, development of chambers and associated assembly tooling shared throughout all U.S. MDT Groups.
1.5.7.8	MDT Chambers – U.Michigan	80	4.1.2.1 to 4.1.2.6		Complete Monitored Drift Tube Chambers including the in-plane alignment system. These consist of 16 each of Chamber series EMS5, EMS4, EML3, EML4, and EML5. Total number of fabricated tu4s is 30,720 + spares. Engineering design, development of chambers and associated assembly tooling shared throughout all U.S. MDT Groups.
1.5.7.9	MDT Chambers – U.Wash.	80	4.1.2.1 to 4.1.2.6		Complete Monitored Drift Tube Chambers including the in-plane alignment system. These consist of 16 each of Chamber series EML2, EMS2, EMS3, EIL4, and EML1. Total number of fabricated tubes is 30,720 + spares. Engineering design, development of chambers and associated assembly tooling shared throughout all U.S. MDT Groups.
1.5.7.10.1	Install MDT Chambers		4.5.1.5	300	Level of effort limited to 300k CHF
1.5.7.10.2	Certify MDT Chambers		4.5.1.5	300	Level of effort limited to 300k CHF
1.5.8.2.1	MDT Kinematic Mounts	240 sets			Design, development and fabrication of 240 sets of kinematic mounts required for the installation of the 240 MDT "logical" chambers. Kinematic mounts to be delivered are detailed as follows: Type 121 (EI Chambers) 108 Lateral Assy. 132 Axial Assy. Type 170 (EM Chambers) 220 Lateral Assy. 260 Axial Assy.

Muon 1.5
(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.8.2.2	MDT Chamber Connectors	240 sets			Design, development and fabrication of 720 chamber mount struts (one strut for each chamber mount to install chambers onto end cap structure).
1.5.9.1.1	MDT-ASD Chip	444,787 Channels			Design and fabrication of ASD chips needed for entire ATLAS Muon Spectrometer + 20% spares.
1.5.9.1.2	MDT Mezzanine PCB	15,444			Design, development and fabrication of 15,444 Mezzanine PC boards required for the entire ATLAS Muon Spectrometer. The 15,444 TDC chips required will be supplied by the Japanese groups.
1.5.9.1.2	Signal HH Boards	3,680			Design, development and fabrication of signal hedgehog boards needed for the 240 U.S. MDT chambers.
1.5.9.2.2	HV HH Boards	Prototype			Design and development of High Voltage hedgehog boards. Fabrication not U.S. responsibility.
1.5.9.3	Mezz-CSM Cables	3,680			Layout and production of 3,680 + spare cables and connectors which connect the Mezzanine cards with the CSM card for 240 U.S. MDT chambers.
1.5.9.4	CSM Development	Prototype			Design and development of CSM (Chamber Service Module) for MDT readout. Level of Effort ($120k in FY01)
1.5.4.4.1	CSC1	16	4.2.1	65	Design, development and fabrication of 32 CSC Modules of Design 1. Initial production reduced to 50%.
1.5.4.4.2	CSC2	16			Design, development and fabrication of 32 CSC Modules of Design 2. Initial production reduced to 50%.
1.5.4.7	Installation	LOE	4.5.1.6 41%	16	Installation/commissioning at CERN will be limited to level of effort.
1.5.11	CSC Chamber Electronics			13290	
1.5.11.2.1	ASM I electronics	640	2.3 97%		Design, development and fabrication of amplifier/shaper module I (ASM I) for readout of 32 CSC chambers, including 7200 custom preamplifier/shaper chips. This module interfaces to chamber and to ASM II.
1.5.11.1.2	ASM II electronics	160			Design, development and fabrication of amplifier, shaper module II (ASM II) for readout of 32 CSC chambers. This module interfaces to ASM I and to off-detector electronics. It contains SCA and ADC chips.
1.5.11.3.1	LV power, cooling & cabling	1			Specification of low voltage power, cooling, and cabling for CSC electronics. Procurement of power and cabling infrastructure.
1.5.11.4	Sparsifiers	16	4.2.3 97%		Design, development and fabrication of 9U-VME Sparsifier modules needed for 32 CSCs.
1.5.11.5	Readout Drivers	2			Design, development and fabrication of 9U-VME Readout Driver modules needed for two CSC endcaps.

Muon 1.5
(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.11.6	Support electronics	2			Provide 9U-VME crates w/ CPU & timing module for CSC off-chamber electronics. Layout of custom crate backplane is included.
1.5.11.7	Readout software	1			Design and implement software embedded in off-detector electronics for readout of CSCs.
1.5.11.8	HV Supplies	128 channels	4.2.3 97%		Procurement of high voltage supplies for 32 CSCs. (CAEN)
1.5.11.9	Electronics installation	1			Installation of CSC on-chamber electronics (ASMs) at CERN.
1.5.11.4.2.1	Readout Drivers (ROD)	0	4.2.3 97%		Design, development and fabrication 0 Data Readout Driver modules. This scope was reduced to zero by BCP 51.
1.5.11.4.2.2	DCS Modules	1	4.2.3 97%		Design, development and fabrication 1 Detector Control Modules.
1.5.12.3.1	Alignment Bar Instrumentation	80 sets	4.5.1.2 50%	268	Internal Bar Monitors, Image Sensors, and Masks – 240 each Survey Mounts – 160 Thermistors – 421
1.5.12.3.2	Proximity Monitors	240 Sets - Chambers 80 Sets -Bars			Design, development and fabrication of 240 sets of Proximity Monitors for the MDT Chambers. This includes: Proximity Chamber Mounts – 960 Proximity Cameras – 720 Proximity Masks – 120 Proximity Sources – 120 Design, development and fabrication of 80 sets of Proximity Masks for mounting on the Alignment Bars. This includes: Proximity Masks – 480
1.5.12.3.3	Multi-Point System (BCAM)	800	4.5.1.2 100%		Provide 800 BCAMs for the Multi-Point Alignment System. These are itemized as follows: Polar BCAMs – 160 Radial BCAMs – 160 Azimuthal BCAMs – 480 Azimuthal BCAMs are further itemized as follows: EO Layer – 192 EM Layer – 160 EI Layer – 64 CSC - 64
1.5.12.3.4	DAQ	4341 Elements			Design, development and fabrication of DAQ to operate all deliverable Alignment elements. This includes: DAQ Headers – 4341 Multiplexers – 543 Drivers - 55
1.5.12.4	In-plane System	240 sets			Design, development and fabrication of 240 sets of In-plane alignment for the MDT Chambers. This includes: In-plane Image Sensor – 480 In-plane Masks – 480 In-plane Lenses - 960

Muon 1.5
(Continued)

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.5.12.2	Operational Test Stand	1 Octant			Provide 1 Octant of one end cap Alignment System setup in the H8 test beam at CERN [BCP 5]
1.5.12.5	Installation	LOE			Installation at CERN limited to level of effort. $22k

Technical Coordination 1.10

WBS #	Task	Quantity	MoU ref.#	CORE Value (kCHF)	Short Description of U.S. ATLAS Goals for U.S. Deliverables & Expectation from Non-U.S. ATLAS Collaborators
1.10	Technical Coordination	LOE			BCP 52 increases this scope to $1,300k Level of Effort.

Appendix 4

U.S. ATLAS Major Project Milestones (Level 1)

Description	Baseline Schedule	Forecast (F) Date	Actual (A) Date
Project Start CD-4A 97% Project Complete	01-Oct-95 30-Sep-05	01-Oct-95 (F) 30-Sep-05 (F)	01-Oct-95 (A)
CD-4B 100% Project Complete	30-Sep-08	30-Sep-08 (F)	

Appendix 5

U.S. ATLAS Major Project Milestones (Level 2)

Subsystem	**Schedule Designator**	**Description**	**Baseline Schedule**	**Forecast (F) / Actual (A) Date**
Silicon (1.1)	SIL L2/1	Start Full Silicon Strip Electronics Production	06-Jul-01	15-Jul-01 (A)
	SIL L2/2	Start Full Strip Module Production	12-Apr-02	05-Aug-02 (A)
	SIL L2/3	ROD Design Complete	17-Apr-02	**15-Apr-03 (F)**
	SIL L2/4	Complete Shipment of Silicon Strip Module Production	17-Oct-03	17-Oct-03 (F)
	SIL L2/5	ROD Production/Testing Complete	13-Mar-03	13-Mar-03 (F)
	SIL L2/6	Pixels 1st IBM Prototype Submitted	26-Jul-01	12-Nov-01 (A)
	SIL L2/7	Pixels Start IBM Production	12-Jun-03	12-Jun-03 (F)
	SIL L2/8	Pixels Start IBM Outer Bare Module Prod	29-Jan-04	29-Jan-04 (F)
	SIL L2/9	Pixels Disk System at CERN	20-Jan-05	20-Jan-05 (F)
TRT (1.2)				
Mechanical	TRT L2/1	Final Design Complete	31-Dec-98	07-Dec-98 (A)
	TRT L2/2	Module Production Complete (CUM 102)	31-Dec-03	31-Dec-03 (F)
	TRT L2/3	Barrel Construction Complete	10-Mar-04	10-Mar-04 (F)
Electrical	TRT L2/4	Select Final Elec Design	15-Jun-01	30-Aug-00 (A)
	TRT L2/5	Start Production of ASICS	09-Jul-02	**01-Feb-03 (F)**
	TRT L2/6	Installation Complete	04-Jan-05	04-Jan-05 (F)
LAr Cal (1.3)	LAr L2/1	Cryostat Contract Award	24-Jul-98	05-Aug-98 (A)
	LAr L2/2	Barrel Feedthroughs Final Design Review	30-Sep-98	02-Oct-98 (A)
	LAr L2/3	Start Electronics Production (Preamps)	30-Jun-00	30-Jun-00 (A)
	LAr L2/4	FCAL Mechanical Design Complete	14-Dec-98	15-Dec-99 (A)
	LAr L2/6	Level 1 Trigger Final Design Complete	30-Mar-02	30-May-02 (A)
	LAr L2/7	ROD Final Design Complete	12-Dec-02	**12-May-03 (F)**
	LAr L2/8	Motherboard System Production Complete	30-Sep-02	30-Sep-02 (A)
	LAr L2/9	Cryostat Arrives at CERN	15-May-01	02-Jul-01 (A)
	LAr L2/10	Barrel Feedthroughs Production Complete	01-Jun-02	25-Mar-02 (A)
	LAr L2/11	FCAL-C Delivered to EC	15-Jan-03	**01-Dec-03 (F)**
	LAr L2/12	FCAL-A Delivered to EC	04-Nov-03	04-Nov-03 (F)

U.S. ATLAS Major Project Milestones (Level 2) (Continued)

Subsystem	Schedule Designator	Description	Baseline Schedule	Forecast (F) / Actual (A) Date
Tile Cal (1.4)	Tile L2/1	Start Submodule Procurement	01-Sep-97	01-Sep-97 (A)
	Tile L2/2	Technology Choice for F/E Electronics	15-Nov-97	15-Nov-97 (A)
	Tile L2/3	Start Module Construction	01-May-99	20-Sep-99 (A)
	Tile L2/4	Start Production of Motherboards	01-Apr-01	30-Mar-01 (A)
	Tile L2/5	All Electronic Components Delivered to CERN	01-Oct-02	**01-Mar-03 (F)**
	Tile L2/6	Module Construction Complete	30-Sept-02	30-Oct-02 (A)
	Tile L2/7	All Modules Delivered to CERN	02-Dec-02	31-Jan-03 (F)
Muon (1.5)	Muon L2/1	Start MDT Chambers Lines 1 and 3	17-Jul-00	15-Sep-00 (A)
	Muon L2/2	Start CSC Chamber Production	01-Sep-01	01-Oct-01 (A)
	Muon L2/3	MDT Electronics ASD PRR	01-Apr-02	30-Aug-02 (A)
	Muon L2/4	Final Design of Global Alignment Devices Complete	01-Aug-02	01-Mar-03 (F)
	Muon L2/5	CSC IC Production Complete	31-Oct-02	30-Apr-03 (F)
	Muon L2/6	Kinematic Mount Design Complete	30-Jan-01	30-Jan-01 (A)
	Muon L2/7	MDT Chambers (U.S.) Production Complete	14-Sep-04	14-Sep-04 (F)
	Muon L2/8	Kinematic Mount Production Complete	22-Sep-03	22-Sep-03 (F)
	Muon L2/9	CSC ROD Production Complete	05-Nov-03	05-Nov-03 (F)
	Muon L2/10	MDT Elec.'s Mezzanine Production Complete	26-Sep-03	26-Sep-03 (F)
	Muon L2/12	Global Alignment System Final Delivery	30-Sep-04	30-Sep-04 (F)
Trigger/ DAQ (1.6)	TDAQ L2/1	Select Final LVL2 Architecture	31-Dec-99	31-Mar-00 (A)
	TDAQ L2/2	LVL2 Trigger Design Complete	31-Dec-02	31-Dec-02 (F)
	TDAQ L2/3	LVL2 Trigger Prototype Complete	30-Sep-02	30-Mar-03 (F)
	TDAQ L2/4	Start Production	08-Jan-03	08-Jan-03 (F)
	TDAQ L2/5	Start Installation & Commissioning	05-Mar-03	05-Mar-03 (F)
	TDAQ L2/6	Production Complete	30-Jul-05	30-Jul-05 (F)
	TDAQ L2/7	LVL2 Installation & Commissioning Complete	30-Sep-05	30-Sep-05 (F)

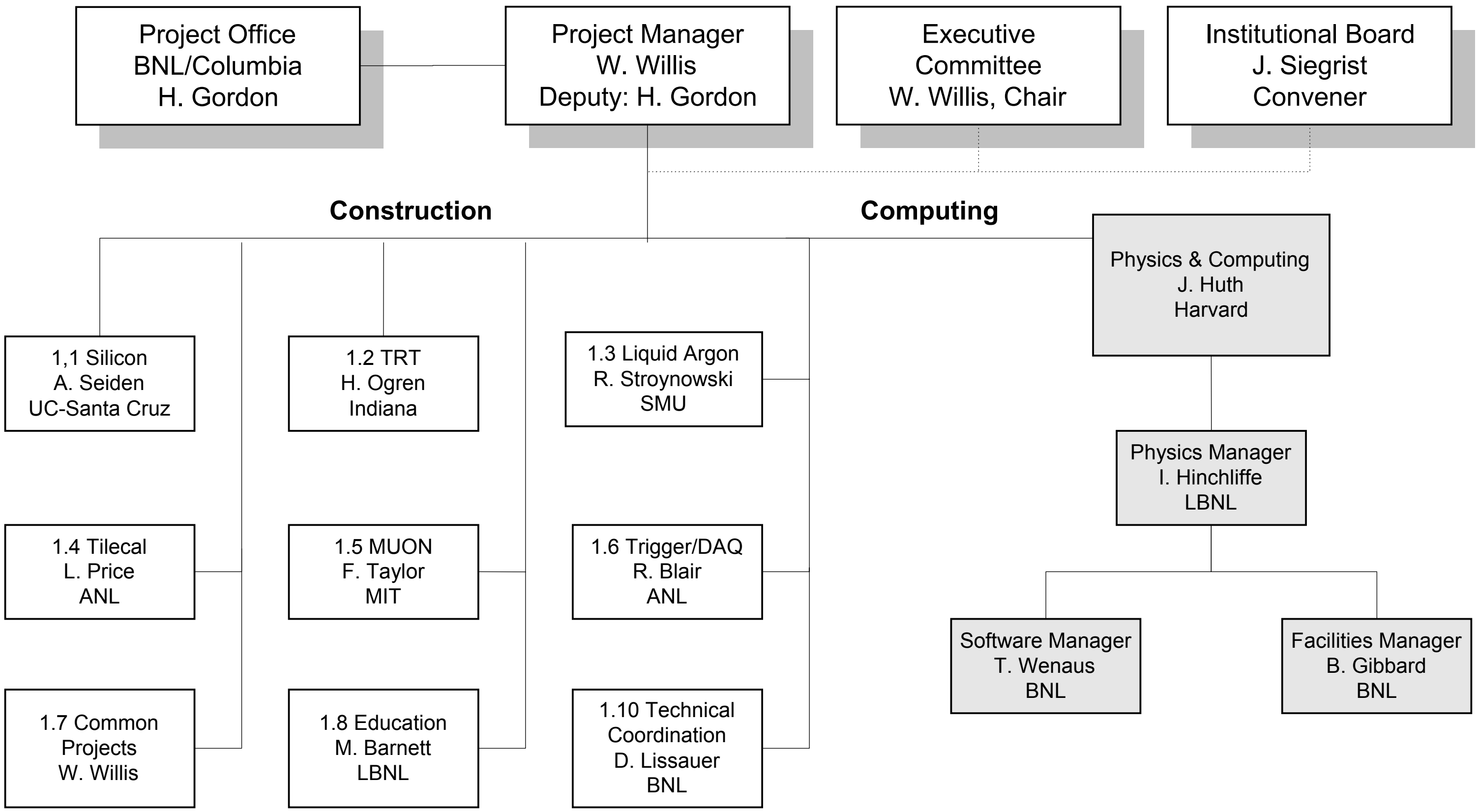
Appendix 6: U.S. ATLAS Major Project Milestones (Level 4)

WBS	Schedule Designator	U.S. ATLAS Responsibility Completion Description	ETC02 Baseline Scope Planned Completion Date	Forecast (F)/ Actual (A) Baseline Scope Completion Date	ATLAS Required Date	Baseline Scope Planned Float (Months)
Silicon						
1.1.2	Sil L4/1	Complete Shipping of Silicon Strip Prod Modules	10/03	10/03	12/03	2
1.1.3	Sil L4/2	RODs 45% Production Complete	12/02	12/02	6/03	6
1.1.1	Sil L4/3	Pixels 'Disk System at CERN'	1/05	1/05	4/05	4
TRT						
1.2.1	TRT L4/1	Barrel Modules Ship to CERN Complete	8/03	8/03	7/03	-1
1.2.5	TRT L4/2	ASDBLRs Ship to LUND Complete	12/02	12/02	6/03	6
	TRT L4/3	ASDBLRs Ship to CERN Complete	3/03	3/03	6/03	3
	TRT L4/4	PCB-Endcaps Ship to CERN Complete	4/03	4/03	7/03	3
LAr						
1.3.1	LAr L4/1	Cryostat Final Acceptance Test Complete	8/01	8/01 (A)	11/01	N/A
1.3.2	LAr L4/2	Signal FT Installation Complete	12/02	5/02 (A)	10/02	N/A
	LAr L4/3	HV FT End-Cap C Install Complete	9/02	7/03 (F)	7/03	10
	LAr L4/4	HV FT Barrel Install Complete	5/02	12/02 (F)	12/02	0
	LAr L4/5	HV FT End-Cap A Install Complete	9/03	9/03	12/03	3
1.3.3	LAr L4/6	LAr Cryogenics Vendor Install Complete	9/03	9/03	6/04	9
1.3.4.1	LAr L4/7	Last Del of Readout Electrodes	12/02	5/03 (F)	3/03	-2
1.3.4.2	LAr L4/8	MBs Ship to Annecy,Saclay (France)	9/02	12/02 (F)	3/03	3
1.3.5.1	LAr L4/9	Preamp Deliveries to FEB Complete	5/03	5/03	3/04	10
1.3.6.1	LAr L4/12	Barrel Pedestals Ship to CERN Complete	10/02	10/02 (A)	7/03	9
	LAr L4/13	EC Pedestals Ship to CERN Complete	10/02	3/03 (F)	3/03	5

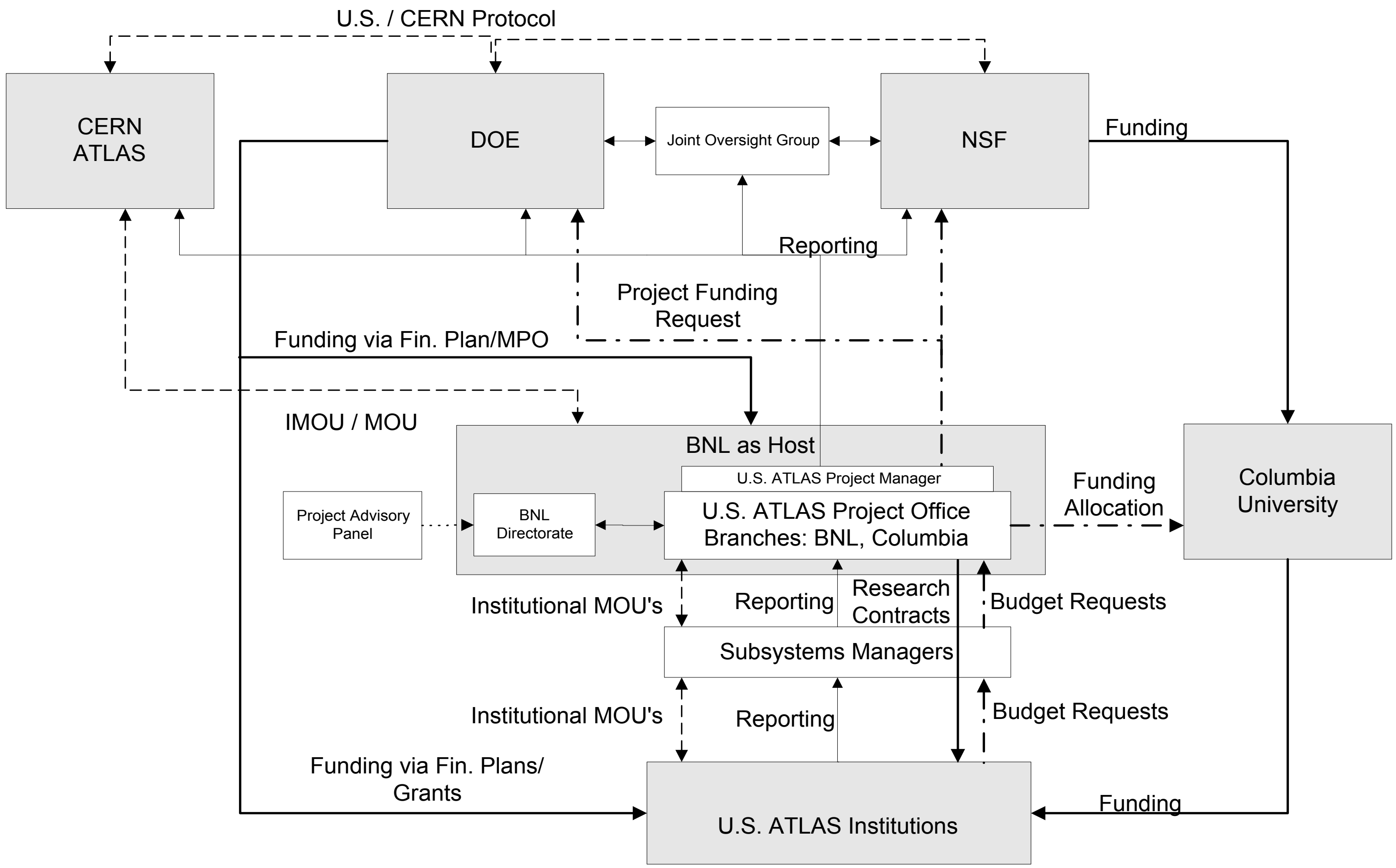
WBS	Schedule Designator	U.S. ATLAS Responsibility Completion Description	ETC02 Baseline Scope Planned Completion Date	Forecast (F)/ Actual (A) Baseline Scope Completion Date	ATLAS Required Date	Baseline Scope Planned Float (Months)
Lar (Continued)						
1.3.6.2	LAr L4/14	Cables Shipping Complete	10/02	2/03 (F)	5/03	7
	LAr L4/15	Baseplane Last Delivery to CERN Complete	10/02	2/03 (F)	5/03	7
1.3.6.3	LAr L4/16	EC Crates Last Delivery to CERN Complete	10/02	7/03	10/04	15
	LAr L4/17	Barrel Crates Last Delivery to CERN Complete	10/02	10/03	10/04	12
1.3.6.4	LAr L4/18	Controls Ship to CERN Complete	9/03	9/03	5/04	8
1.3.6.5	LAr L4/21	Thermal Contacts (Proto) Last Delivery Complete	9/02	2/03 (F)	10/03	13
1.3.7.1	LAr L4/22	FEB Last Delivery Complete	10/04	10/04	1/05	3
1.3.7.4	LAr L4/24	Last Driver Delivery to FEB Complete	4/04	4/04	5/04	1
1.3.8.1	LAr L4/26	Layer Sums Last Delivery to FEB Complete	12/02	12/02	3/04	15
1.3.8.2	LAr L4/27	I/F to Level 1 Ship to CERN Complete	9/04	9/04	12/04	3
1.3.9	LAr L4/28	ROD System Final Prototype Complete	8/02	9/04	9/05	37
1.3.10	LAr L4/29	Deliver Finished FCAL-C to EC	1/03	1/03	5/03	4
	LAr L4/30	Deliver Finished FCAL-A to EC	11/03	11/03	11/03	0
	LAr L4/31	FCAL Elec.'s Summ Bds Ready for Installation	7/02	3/03 (F)	5/03	10
	LAr L4/32	FCAL Elec.'s Cold Cables Testing Complete	10/01	5/02 (A)	2/02	N/A
Tile						
1.4.1	Tile L4/1	Submodules Construction Compl (Original Baseline Scope –Qty. 45)	7/01	3/01 (A)	8/01	N/A
	Tile L4/2	EB Module Ship to CERN Complete (Qty. 40)	12/01	1/02(A)	7/02	N/A
1.4.2	Tile L4/3	Optics Instrumentation at ANL & MSU Complete	10/02	2/03 (F)	11/02	-3
1.4.3	Tile L4/4	PMT Ship to ATLAS Complete	1/02	1/03 (F)	7/03	6
1.4.3	Tile L4/5	Readout Ship to ATLAS Complete	8/02	2/03 (F)	7/03	5

WBS	Schedule Designator	U.S. ATLAS Responsibility Completion Description	ETC02 Baseline Scope Planned Completion Date	Forecast (F)/ Actual (A) Baseline Scope Completion Date	ATLAS Required Date	Baseline Scope Planned Float (Months)
1.4.4	Tile L4/6	Gap Submodules Ship to ANL & BCN Compl (Original Baseline Scope-Qty. 77)	7/01	4/01 (A)	8/01	N/A
1.4.1	Tile L4/7	Submodule Construction Compl (Qty. 576)	3/02	3/02 (A)	7/02	N/A
1.4.1	Tile L4/8	EB Module Ship to CERN Complete (Qty. 64)	12/02	1/03 (F)	1/03	0
1.4.4	Tile L4/9	Gap Submodules Ship to ANL & BCN Compl (Qty. 128)	7/02	5/02 (A)	7/02	N/A
Muon						
1.5.7 (1)	Muon L4/1	MDT Chamber Prod Complete (BMC Qty. 80)	7/04	7/04	3/05	8
		MDT Chamber Prod Complete (Mich Qty. 80)	7/04	7/04	9/04	2
		MDT Chamber Prod Complete (Seattle Qty. 80)	7/04	7/04	9/04	2
1.5.8 (2)	Muon L4/2	MDT Mounts Prod Complete/Delivered to Chambers	9/03	9/03	2/04	5
1.5.9 (3)	Muon L4/3	MDT Elec.'s Mezzanine Bd Production Complete	9/03	9/03	4/04	7
	Muon L4/4	MDT Elec.'s Hedgehog Production Complete	3/03	3/03	4/04	13
1.5.4	Muon L4/5	CSC Chambers Production Complete	4/03	4/03	3/05	23
1.5.11 (5)	Muon L4/6	ASMs Production Complete	6/03	6/03	4/04	10
	Muon L4/7	Sparsifiers Ship to CERN	N/A	N/A	N/A	N/A
	Muon L4/8	RODs Ship to CERN	3/04	¾	10/04	7
	Muon L4/9	Support Electronics Ship to CERN	3/04	¾	10/04	7
1.5.12 (6)	Muon L4/10	Align Bars Ship to CERN	8/04	8/04	9/04	1
	Muon L4/11	Proximity Monitors Ship to CERN	4/04	4/04	9/04	5
	Muon L4/12	Multi-Point System Ship to CERN	6/04	6/04	9/04	3
	Muon L4/13	DAQ Ship to CERN	9/04	9/04	9/04	0
Trig/DAQ						

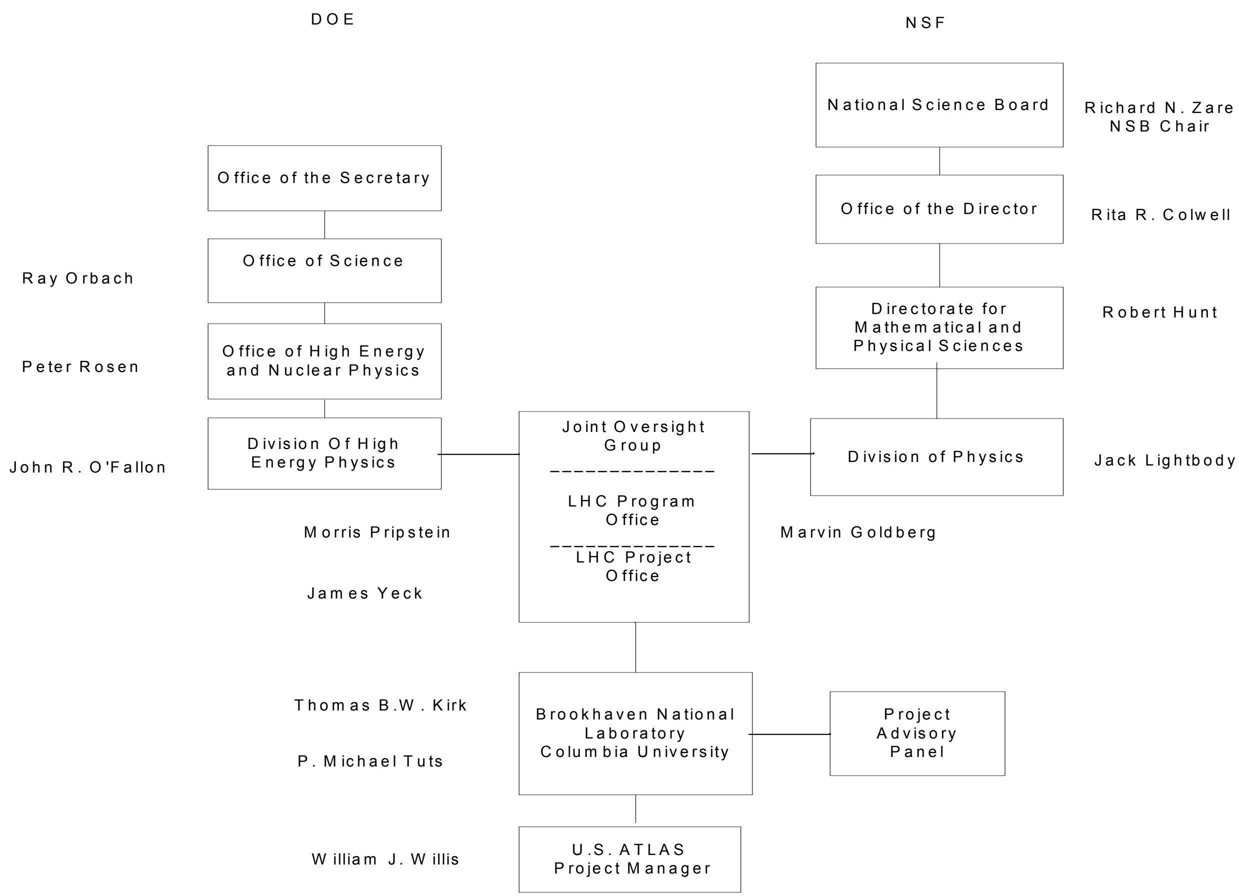
Appendix 7-1
U.S. ATLAS Organization



Appendix 7-2: MOU, Funding and Reporting Process



Appendix 7-3: DOE-NSF-U.S. ATLAS Organization



Appendix 7-4: U.S. ATLAS Detector Institutional Responsibility by System

Subsystem	Institutions
Silicon	UC-Berkeley/LBNL, UC-Santa Cruz, Iowa State, New Mexico, Ohio State, Oklahoma, SUNY-Albany, Wisconsin
TRT	Duke, Hampton, Indiana, Michigan, Pennsylvania
Liquid Argon Calorimeter	Arizona, BNL, Columbia, Pittsburgh, Rochester, Southern Methodist U., SUNY-Stony Brook
Tile Calorimeter	ANL, Chicago, Illinois-Champaign/Urbana, Michigan State, UT-Arlington
Muon Spectrometer	Boston, BNL, Brandeis, Harvard, MIT, Michigan Northern Illinois, SUNY-Stony Brook, Tufts, UC-Irvine, Washington
Trigger and DAQ	ANL, UC-Irvine, Michigan State, Wisconsin
Common Projects	All institutions

Appendix 7-5: U.S. ATLAS Project WBS Index Cost Books

Level			WBS Title	Responsible Physicists	Responsible Engineer
1	2	3			
1			U.S. ATLAS	W. Willis	N/A
	1.1		Silicon	A. Seiden	
		1.1.1	Pixel System	M. Gilchriese	
		1.1.2	Silicon Strip System	A. Seiden	
		1.1.3	Read-Out Drivers		R. Jared
	1.2		TRT	H. Ogren	
		1.2.1	Barrel Mechanics	H. Ogren	J. Callahan
		1.2.2	Barrel Structure	ATLAS	ATLAS
		1.2.3	Endcap Wheel	ATLAS	ATLAS
		1.2.4	Wheel Structure	ATLAS	ATLAS
		1.2.5	Electronics	H. Williams	R. VanBerg
	1.3		Liquid Argon Calorimeter	R. Stroynowski	
		1.3.1	Barrel Cryostat	D. Lissauer	J. Sondericker
		1.3.2	Feedthroughs	R. Hackenburg	T. Muller
		1.3.3	Cryogenics	D. Lissauer	J. Sondericker
		1.3.4	EM Electrodes/MB System	S. Rajagopalan	S. Rescia
		1.3.5	Preamp/Calibration	S. Rajagopalan	S. Rescia
		1.3.6	System Crate Integration	F. Lanni	D. Makowiecki
		1.3.7	Front End Board	J. Parsons	W. Sippach
		1.3.8	Level 1 Trigger	W. Cleland	J. Rabel
		1.3.9	ROD System	W. Cleland	N/A
		1.3.10	Forward Calorimeter	J. Rutherfoord	L. Shaver
		1.3.11	Test Beams	H. Takai	N/A
	1.4		Tile Calorimeter	L. Price	
		1.4.1	Extended Barrel Mechanics	J. Proudfoot	V. Guarino
		1.4.2	Extended Barrel Optics	J. Huston	R. Richards
		1.4.3	Tile Cal Readout	J. Pilcher	H. Sanders
		1.4.4	Intermediate Tile Calorimeter	K. De	J. Li
	1.5		Muon Spectrometer	F. Taylor	
		1.5.7	MDT Chamber	F. Taylor	R. Coco
		1.5.8	MDT Supports	H. Lubatti	C. Daly
		1.5.9	MDT Electronics	G. Brandenburg	J. Oliver
		1.5.4	CSC Chambers	V. Polychronakos	T. Muller
		1.5.11	CSC Electronics	V. Gratchev	P. O'Connor
		1.5.12	Global Alignment System	J. Bensinger	K. Hashemi
	1.6		Trigger/DAQ	R. Blair	
		1.6.1	LVL 2 SRB	R. Blair	J. Dawson
		1.6.2	LVL 2 Calorimeter Trigger	M. Abolins	Y. Ermolin
		1.6.3	LVL 2 SCT Trigger	A. Lankford	R. Jared
		1.6.4	Architectural & Global Trigger	R. Blair	J. Dawson
		1.6.5	Common Projects	A. Lankford	
	1.7		Common Projects	W. Willis	N/A
		1.7.1	Total Equivalent Cash	W. Willis	N/A
		1.7.2	Total Institutional Dues	W. Willis	N/A
	1.8		Education	M. Barnett	N/A
	1.9		Project Management	H. Gordon	N/A
		1.9.1	DOE	H. Gordon	Kane/Premisler
		1.9.2	NSF	J. Dodd	N/A
	1.10		Technical Coordination	D. Lissauer	A. Gordeev

Appendix 8-1: U.S. ATLAS Project Summary Cost Estimate

U.S.ATLAS Project Summary Cost Estimate

Presented in (AY$ x 1000)

WBS No.	Description	Base Cost
	Technical Baseline	
1	U.S. ATLAS	
1.1	Silicon	18,993.3
1.2	TRT	9,934.7
1.3	LAr Calorimeter	44,348.1
1.4	Tile Calorimeter	10,282.7
1.5	Muon Spectrometer	26,386.2
1.7	Common Projects	9,179.1
1.8	Education	286.5
1.9	Project Management	8,279.0
1.10	Technical Coordination	1,300.0
	Subtotal	**128,989.6**
1.6	Trigger/DAQ Pre-Technical Baseline	3,133.2
	Subtotal	**3,133.2**
	Management Contingency	**5,287.6**
	Contingency	**18,500.1**
	Subtotal	**23,787.7**
	Technical Baseline	**155,910.5**
Items Outside of Approved Technical Baseline		
1.1.1	Pixels	-
1.6	Trigger/DAQ	**7,839.5**
	Subtotal	**7,839.5**
	Total Project Cost**	**163,750.0**

Assumes funding profile of Prior Years=$119.445M, FY03=$24.706M, FY04=$8.990M, FY05=$5.489M, FY06=$3.24M, FY07=$1.880M.
97% project completion in 2005 and 100% project completion in 2008.
Includes cost changes through BCP 60

Appendix 8-2: U.S. ATLAS Funding Profile

(Presented in AY$ × 1,000)

FY	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
DOE Project	1,700	3,710	10,050	8,999	16,494	14,475	10,507	17,416	8,990	5,490	3,239	1,880	102,950
NSF Project				16,630	11,940	12,290	12,650	7,290					60,800
Total U.S. ATLAS	1,700	3,710	10,050	25,629	28,434	28,797	27,850	22,890	8,990	5,490	3,239	1,880	163,750

Glossary

ATLAS (A Toroidal LHC ApparatuS) - A general-purpose particle detector to be installed at Point 1 of the LHC ring. Distinctive features of ATLAS are a large volume, air-core toroidal magnet providing good momentum resolution and sign discrimination for muons and a fine-grained liquid argon electromagnetic calorimeter.

CERN (European Organization for Nuclear Research) - An intergovernmental organization established by Convention signed in Paris on 1 July 1953, revised on 17 January 1971. Also known as the European Organization of Particle Physics.

CERN Council - The governing body of CERN, made up of representatives of all Member States.

CERN-U.S. Co-operation Committee- A committee established by the International Co-operation Agreement of December 1997 between CERN and the DOE and NSF concerning Scientific and Technical Co-operation on Large Hadron Collider Activities. The charge to the Committee is to monitor and facilitate activities undertaken under the agreement, with particular emphasis on matters relating to areas of involvement of U.S. contractors and grantees. The CERN Co-Chair is the CERN Director General. The U.S. Co-Chair is the Associate Director for High Energy and Nuclear Physics of the Office of Science in the DOE. The NSF is represented on the Committee by the Assistant Director for Mathematical and Physical Sciences.

CMS (Compact Muon Solenoid) - A general purpose particle detector to be installed at Point 5 of the LHC ring. A distinctive feature of CMS is a high field solenoid surrounding a precision tracker providing high precision spatial information for decay vertices and particle tracking.

Host Laboratory - A designated DOE laboratory that has management oversight responsibilities for U.S. LHC Accelerator, U.S. ATLAS, or U.S. CMS activities.

JOG (DOE/NSF Joint Oversight Group) - The combined DOE/NSF operating group for the U.S. LHC Program. The Director of the DOE Division of High Energy Physics and the Director of the NSF Division of Physics serve as co-chairs of the JOG.

LHC (Large Hadron Collider) - A particle accelerator at CERN that will collide two counter-rotating beams of protons, each with an energy of up to 7 trillion electron volts. The beams will collide at four intersection points at which appropriate particle detectors will be located. The accelerator will be fed by an existing cascade of lower-energy accelerators.

LHC Activities - The LHC project, the exploitation of the LHC accelerator and the LHC experiments and supporting research and development, and other LHC-related activities. International Agreement, Article I, 1.6)

LHC Program - The program for carrying out LHC Activities.

LHC Project - The activities by CERN to build the LHC accelerator and to contribute to the construction of, and to provide co-ordination and support for, the LHC experiments. (International Agreement, Article I, 1.5)

RRB (Resource Review Board) - An oversight board, with representatives of the concerned funding agencies and the CERN management, for each of the LHC detectors, ATLAS, CMS, which reviews and allocates resources required for the project to proceed on cost and schedule. The Co-Chairs of the U.S. DOE/NSF JOG are ex-officio members of the RRB.

U.S. LHC Construction Project - U.S. participation in the construction of the LHC accelerator and in the design and fabrication of the ATLAS and CMS detectors. Funding in the amount of $450M has been provided in the DOE budget plan and $81M in the NSF budget plan. Details of the U.S. "deliverables" are found in the respective Project Management Plans.

U.S. LHC Program - U.S. participation in construction of the LHC Accelerator and construction and operation at CERN of the ATLAS and CMS detectors. The U.S. LHC Program has two components, the U.S. LHC Construction Project and the U.S. LHC Research Program.

U.S. LHC Research Program - U.S. participation in the operation of the LHC detectors and in the physics investigations enabled by the detectors, following completion of the facility and commissioning of the detectors. This includes support for computing, maintenance and development operations and research for future upgrades.