Department of Energy/
National Science Foundation
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

U.S. LHC ATLAS DETECTOR PROJECT

June 2002

EXECUTIVE SUMMARY

The Department of Energy (DOE) and the National Science Foundation (NSF) conducted a review of the U.S. ATLAS Construction Project on June 3-4, 2002. The review was completed at the request of the U.S. Large Hadron Collider (LHC) Joint Oversight Group co-chairs, Dr. John R. O'Fallon, Director DOE Division of High Energy Physics, and Dr. John W. Lightbody, Jr., Physics Division, NSF Mathmatical and Physical Sciences Directorate. The Review Committee was charged to assess technical progress in each subsystem, progress towards completing the U.S. deliverables on schedule, newly revised plans for pre-operations (2002-2004), and adequacy of the cost to complete and project contingency.

ATLAS (A Toroidal LHC Apparatus) will be a large, general purpose detector used to observe very high energy proton-proton collisions at the Large Hadron Collider, now under construction at CERN, the European Laboratory for Particle Physics, near Geneva, Switzerland. The detector is being built by a large international collaboration. This collaboration includes over 200 U.S. physicists from 33 universities and three national laboratories. The U.S. ATLAS collaborators comprise nearly one-fifth of the ATLAS collaboration and expect to provide a corresponding fraction of the physical detector. U.S. physicists are participating in practically all aspects of the detector, including important management roles.

Since the last full review in March 20-22, 2001 and mini-review conducted on September 30, 2001, the U.S. ATLAS project has demonstrated significant technical progress. The project is mostly in the fabrication stage with great forward momentum. While the completion date of the overall LHC machine is projected to slip over one and a half years to 2007, the U.S. ATLAS project intends that its baseline deliverables will be completed, delivered to CERN, and installed (where applicable) on the original schedule within budget.

The DOE and NSF conducted a review of the U.S. LHC Research Program maintenance and operations (M&O) component on April 9-11, 2002. While additional attention was devoted to scrubbing the requirements and costs associated with the activities necessary to maintain and operate the detector equipment, the Committee believes the collaboration must review each ATLAS maintenance and operation element in greater detail with the intent to reduce the overall M&O budget.

The Committee was provided with a revised estimate to complete that highlighted minor cost differences from the previous estimate. A formal risk analysis was recently performed by project team members and is reflected in the current levels of contingency established for project work elements. The Committee expressed significant concern in the estimation, management, and tracking of project contingency. Over the past 14 months, the amount of contingency as a percentage of remaining work has been consistently above 40 percent, but has been reduced since January 2002 due to contingency usage. The Committee is concerned by the nature of some management contingency items and the potential that release of contingency funds for a number of management contingency items, if approved later this fiscal year and next, could reduce the level of contingency to approximately 25 percent.

Overall the schedule is reasonable with very few items at or near the critical path. Several subcommittees have identified technical and delivery issues that could affect U.S. ATLAS components. The Committee supports the project's decision to maintain the baseline schedule despite the CERN LHC schedule changes.

The project faces significant technical and managerial challenges. The timing and nature of these challenges may place achievement of scientific goals at risk. The Committee urges the project to maintain its excellent technical progress and to work with other collaborators in a manner to make certain that U.S. and collaboration physicists have a detector that is functional for the intended physics research purposes. Success will depend in large part on the execution of an effective end game plan that guides the project transition from construction through assembly and installation to start-up operations. The design and implementation of the end game plan will be a major focus of the next full review.

CONTENTS

1. INTRODUCTION

The Large Hadron Collider (LHC), a hadron-hadron collider to be installed in the LEP tunnel at the CERN Laboratory (the European Laboratory for Particle Physics outside Geneva, Switzerland), will be a unique facility for basic research. It will provide the world's highest energies to probe the structure of matter and the forces that control it. CERN has committed itself to the construction of the LHC accelerator with start-up projected in the year 2006 (now forecasted to slip into 2007). The ATLAS detector will be one of two large, general purpose detectors designed to find and study a wide variety of new phenomena made possible by the unprecedented LHC proton-proton collision energies and intensities.

The U.S. scientific community has strongly and repeatedly recommended United States involvement in the LHC program. Recommendations received bipartisan support in Congress and the Administration. On December 8, 1997 the U.S. Department of Energy (DOE), the National Science Foundation (NSF), and CERN signed an agreement on U.S. participation in the LHC program, including U.S. participation in ATLAS.

The LHC will be the highest energy accelerator in the world for many years following its completion. It will provide two proton beams, circulating in opposite directions, at an energy of 7 TeV each. These beams will collide with an event rate 1,000 times higher than that presently achieved at the Tevatron proton/anti-proton collider, currently the world's most energetic proton accelerator (nearly 1 TeV per beam) at Fermi National Accelerator Laboratory (Fermilab) outside Chicago. Two large detectors, ATLAS (A Toroidal LHC Apparatus) and CMS (Compact Muon Solenoid) will detect and record the results of interesting collisions. These detectors will be among the largest and most complex devices for experimental research ever undertaken, and the events that they record are expected to point to exciting, even revolutionary advances in the understanding of matter and forces.

The ATLAS detector will be very large and complex: 42-meters long, 22-meters in diameter, and will weight 7,000 tons. It will be the first detector to use superconducting air-core toroid magnets of this size, and it will push technological development in areas such as electronics, real-time computing, networking, and database management. DOE and NSF are working with the collaboration to maximize use of scarce resources by cooperative efforts within the broader high energy physics community in areas of commonality of functions, especially in networking and database management.

The ATLAS collaboration is exploring new ground in the management of large international scientific undertakings, involving scientists from 147 institutions in 35 nations. With DOE and NSF supporting over 200 ATLAS scientists from 33 U.S. institutions, the U.S. group comprises nearly one-fifth of the full collaboration and plans to provide a comparable portion of the detector. U.S. physicists are contributing to many aspects of the detector, including taking important management roles.

The project is mostly in the fabrication stage with great forward momentum, however, the project faces significant remaining technical and management challenges. Greater attention is being focused on the project end game plan that will guide the project's transition from construction through assembly and installation to start-up of operations.

In an April 17, 2002 memorandum (Appendix A), Dr. John R. O'Fallon, Director, DOE Division of High Energy Physics, and Dr. John W. Lightbody, NSF Mathematical and Physical Sciences Directorate, requested the Office of Science, Construction Management Support Division to conduct a review of the U.S. efforts on the ATLAS detector.

The DOE/NSF Review Committee for U.S. ATLAS was chaired by Daniel R. Lehman of DOE's Construction Management Support Division, Office of Science. The Committee was organized into seven subcommittees with members drawn from DOE national laboratories, U.S. universities, and DOE. In addition, there were observers from DOE, NSF, and CERN. The committee membership and subcommittee structure are found in Appendix B. The review took place June 3-4, 2002 at Fermi National Accelerator Laboratory.

2. TECHNICAL SYSTEMS EVALUATIONS

2.1 Silicon Trackers (WBS 1.1)

2.1.1 Findings

Technical progress on the Semi-Conductor Tracker (SCT) has been good. Application specific integrated circuit (ASIC) production commenced in July 2001 with a yield of 25 percent, and is proceeding on schedule. There has been substantial preparation for module construction, and full production will commence around July 2002—two or three months behind the current schedule. Delivery of all modules is currently planned for October 2003. There is no installation necessary for the SCT.

The current Pixel system baseline has two layers. Space for services supporting a future upgrade to three layers has been planned.

Technical progress on the Pixel system has been good. Substantial design and prototyping work has been completed on most aspects of the system, including mechanics and assembly, electronics, hybrids, and related components. Submission and receipt of the first batch of sensors has occurred. Prototypes of the electronics read out chain have been tested and are undergoing radiation qualification. Two more electronics submissions are planned to complete the project. A substantial testing program has been developed. Delivery of the Pixel disks is planned for January 2005, one month later than the current schedule.

Technical progress on the ROD (Read Out Driver) has been good. A pre-production board has been completed and is undergoing testing and final validation. The Final Design Review is scheduled for completion around July 2002, about three months behind schedule. The completion of 45 percent of the SCT RODs is scheduled for December 2002, about six months ahead of the current schedule.

Resources for the Silicon subsystem amounting to $2.6 million (without contingency) appear outside the baseline, mostly in "Management Contingency." The current cost to complete the baseline is $9.2 million.

The contingency (not including "Management Contingency" items) is $2.8 million.

2.1.2 Comments

The Committee commends the ATLAS silicon group for substantial progress over the past year, and for their informative presentations.

Funding for spare SCT chips and RODs has been added to maintenance and operations (M&O) costs. The proposed level of funding appears not to provide for procurement of sufficient spares. Some spares may become unavailable in a relatively short amount of time.

The schedule slippages in all systems will not necessarily be absorbed when a new schedule that incorporates LHC slippage is approved.

The pixel project is a cutting edge endeavor, subject to substantial cost and schedule risk. The current contingency percentage appears to be low. Additionally, the contingency on items outside the existing baseline appears to have been omitted.

Substantial support for the Silicon effort comes from the U.S. Base Program. Reductions in the U.S. Base Program present cost risk for the Silicon effort.

2.1.3 Recommendations

1. Finalize the Pixel (and related ROD) baseline scope, and in doing so, respond to March 2001 review recommendations 1,3,5,6,7,and 9, by August 2002.

2. Increase contingency on the Pixel portion of the subproject.

3. Assess and include contingency on items currently outside the baseline scope.

4. Procure adequate SCT and Read Out Chips spares promptly.

2.2 Transition Radiation Tracker (WBS 1.2)

2.2.1 Findings

The Committee conducted extensive discussions with the U.S. ATLAS Transition Radiation Tracker (TRT) Subsystem managers and heard reports on status of the main issues for

TRT mechanics and electronics. Despite a wire-joint problem discovered in the ageing studies, significant technical progress has been achieved in all areas.

The U.S. ATLAS TRT project is responsible for delivering the barrel TRT and the front-end electronics for the entire TRT system. A collaboration of Indiana University, Duke, and Hampton Universities is responsible for the design, production, and testing of the TRT barrel with the University of Pennsylvania responsible for the read out electronics. The TRT front-end electronics project also contains collaborators from non-U.S. institutions such as Lund University and CERN.

The Technical Design Report version of the TRT barrel contains 52,544 straw tubes arranged in 96 modules. Six spare modules (two of each type) are considered for the full detector. The current baseline scope is 71 modules. In FY 2002, additional funds of $233 K have been released by U.S. ATLAS management towards a 96-module system. Funds, for completing the last 30 percent of the Barrel TRT, have not been released by U.S. ATLAS management.

The Barrel Mechanics (WBS 1.2.1) is produced at three U.S. “factory” sites: Duke University, Indiana University, and Hampton University. The factories are established and production is underway for all varieties all of TRT modules.

The Hampton facility, responsible for procurements and preparations of a majority of module components, continues to be significantly stressed despite the addition of manpower last year.

Wire stringing of TRT barrel straw tubes was stopped in October 2001 when it was discovered that the CF4 component of the TRT gas mixture damaged the glass wire joint. Damaged joints failed, released the anode wire and shorted the straw tube. Two solutions were considered: 1) replacing the CF4 component in the gas mixture, or 2) replacing the glass bead with a polyimide (kapton) wire-divider.

A testing program was started to study both solutions. The program used resources that would normally have been used to produce straw tube components. After a number of months the TRT group has decided that the active TRT gas will not have a CF4 component.

Even though the TRT group has made a decision to change the active chamber gas, R&D issues remain related to using CF4 as a component in a short term cleaning gas. Study of this issue is ongoing.

The TRT group has presented data of straw tube factory production rates that show a clear shortfall in the rate of straw tube preparation. To meet the January 2005 barrel completion date, the factory at Hampton must prepare straw tubes at a rate of 3,200 per month. For the last few months the preparation work rate has fallen to 2,800 per month.

The University of Pennsylvania is responsible for the production of TRT Electronics (WBS 1.2.5). The U.S. deliverables include custom chips (ASDBLR and DTMROC) and front-end printed circuit boards for the TRT barrel and endcap wheels.

There is a convergence of TRT mechanics and front-end electronics items in the TRT schedule. It is necessary that both completed straw tubes and production electronics are available at CERN for the start of the barrel assembly in fall 2003.

ASICs have successfully been made in a Deep Sub-Micron (DSM) process. Large quantities of the ASDBLR and DTMROC are not yet available. Versions of the ASDBLR and DTMROC chips made in the DMILL process will have to be used for the system integration tests.

The TRT barrel front-end electronics systems test scheduled for summer 2001 has not taken place due to a number of delays including technical problems with the flex board that was to carry the ASDBLR and STMROC chips

The Barrel and Endcap Front-End Boards (the rigid-flex design) have been designed but yields were significantly below expectations. The barrel board has been redesigned to use a new approach, a three-stack board and Full Ball Grid Array (FBGA). The three-stack is being fabricated.

The contingency on the estimate-to-complete of the TRT is 26 percent.

2.2.2 Comments

The Committee appreciates the open discussions with the members of the U.S. ATLAS TRT subsystem. Every effort should be made to fabricate TRT components and modules at the full production rate in order to minimize delays and cost.

The U.S. ATLAS should make a final decision soon on the baseline scope of the TRT. The current scope of the TRT barrel is 71 modules. The configuration planned by the TRT group for these 71 modules (with additional funds of $233 K in FY 2002) would not constitute a useful detector. The TRT group should consult with U.S. ATLAS management to produce a plan for a viable detector configuration.

Based on schedules presented, it is important to restart the wiring of the straw tubes by August 1, 2002 or earlier, if possible.

Despite increases to the Hampton workforce in the last year, the manpower there may not be sufficient for maintaining the necessary straw tube production schedule. The shortfall appears to be in both the areas of parts prepping and physicist oversight.

The production rate of prepped straw tubes need to be addressed immediately at Hampton University. The production rate should be increased to the rate necessary to meet the TRT barrel completion date of January 2005.

Production of most mechanical parts (wire-joints, straws, HV/Tension plates, radiator kits, outer wire supports, divider kits, shell sub-assemblies) are well established and have little variance. However, the schedule is reaching the point when most, if not all, these components are delivered just-in-time. This is likely to generate additional delays in the future.

The Committee believes the TRT group has made the correct decision to not use CF4 as an active gas component in the straw tubes gas mixture.

It is possible that the group's total concentration on the CF4/glass bead problem resulted in smaller but still important technical issues being neglected.

The TRT Electronics (WBS 1.2.5) at the University of Pennsylvania has made excellent technical progress. The U.S. deliverables (primarily ASDBLR chips for the barrel and endcap wheels and printed circuit boards for the endcap wheels) may be behind schedule which could cause additional schedule stress on testing.

The front-end electronics schedule is tight and could potentially delay completion of the TRT barrel. There is a need to make more front-end electronics channels available for the detector module testing as early as possible to enable large-scale integration tests. Action should be taken to minimize the impact of just-in-time deliveries of chips so that TRT modules can be installed in the space-frame at CERN as scheduled (starting in October 2003).

Large-scale system tests using the pre-production modules electronics should be pursued vigorously and conducted as early as possible. The goal is to identify system problems early in the integration process.

The contingency of 26 percent of the estimate-to-complete seems adequate at this stage of the construction.

2.2.3 Recommendations

1. Work with U.S. ATLAS management to identify a baseline scope by August 1, 2002, which will deliver a useful, functional TRT detector.

2. Identify the new TRT active gas mixture as early as possible, but no later than August 1, 2002.

3. Re-start the stringing of straw tubes to avoid further delays. Start by August 1, 2002 or earlier if possible.

4. Conduct a large-scale system integration test with fully instrumented read out modules using the pre-production version of the front-end electronics by December 31, 2002.

5. Optimize the schedule of the front-end electronics and mechanics to develop some schedule float and minimize just-in-time deliveries.

2.3 Liquid Argon Calorimeter (WBS 1.3)

2.3.1 Findings

The past year has seen much progress in the Liquid Argon Calorimeter system. Many detector components have been completed and many others are in production. Those with late delivery dates are in design. Schedule and cost risk center on the Front-End Board (FEB).

The barrel cryostat has been delivered to CERN and passed acceptance tests. Signal feedthrough production has been completed. The barrel signal feedthroughs have been installed. The endcap feedthroughs await arrival of the endcap cryostats at CERN. High voltage feedthroughs have been installed in the barrel and cables will be installed this summer in the barrel and in September in the first of the two endcaps. Liquid argon quality meters are in production. Cryogenic design is complete.

Component fabrication will begin soon. Control software design is in progress. This task is complicated by the need to control the system during both the test on the surface and the test in the pit (where the liquid nitrogen coolant is re-circulated).

The read out electrodes, long a cause of concern, have all been purchased. Assembly of the calorimeter modules, which contain these electrodes, will be complete by the end of the year. Production of the motherboards was complicated by the need to add diode protection circuitry to the board after it was discovered that sparking damaged the calibration resistor network. This rework increased the cost of the motherboards. Production and delivery will be completed on schedule at the end of August 2002.

Installation of the barrel pedestals, which support the System Crate that contains the front-end electronics and the cables between the warm feedthrough and the System Crate base plane, will be completed in August 2002. The base plane and warm cables have been produced and installation will be completed by March 2003. The System Crate design is complete and parts are in production. Completion of production awaits verification that the performance of the front-end electronics system meets specification. This is scheduled to occur at the end of the year, in advance of the Production Readiness Review (PRR) scheduled for February 2003.

The crate cooling system has been designed. Prototype cooling plates were manufactured. A replacement vendor has been found for production of the cooling plates. Production is expected to meet schedule.

Radiation-hard, low-voltage power supplies have been developed by a new vendor. Funds for procurement of production run supplies are held in management contingency, though release of these funds is expected this month. This is a $1.08 million increase in scope.

The FEB provides signal processing and digitization on the calorimeter. It carries preamplifiers, shapers, switched capacitor array (SCA) analog pipelines, ADCs, control logic, and an optical link to off-detector electronics.

The preamplifier production is proceeding. It will be completed this year, ahead of the current need date. Layer sum board production is complete.

Prototypes of nine ASICs in radiation-hard technologies have been produced and tested. All performed well. This led to a successful PRR allowing them to go into production. Half of the SCA wafers have been produced, with packaging and testing beginning at the time of this review. Delivery of the ADC (production contract shared with other LHC experiments) begins in a few months. The PECL driver, GLink serializer have been produced and radiation qualified. Use of deep sub-micron technology on several ASICs has led to cost reductions. The optical links have been integrated into the FEB.

The FEB requires 20 radiation-hard regulators for each board. Development of these regulators is a continuing problem. CERN has contracted with STm to develop these critical devices. Positive voltage regulators were due in April 2001, while negative voltage regulators were due in June 2001. Positive prototypes were delivered in December 2001 and were used successfully. Negative regulator prototypes have not yet been delivered. The electronics team has identified a negative regulator by Intersil. Initial results are encouraging. This solution is not ideal because of higher cost and additional control logic development, but evaluation will continue. The STm setback with the negative voltage regulator will probably require delaying the FEB PRR from December 2002 until summer 2003. Delivery of FEBs for installation in 2005 in the pit at CERN will be tight.

Radiation-hardness qualification of electronics for ionizing radiation, neutrons, and single event upsets has been done at the Harvard Cyclotron Laboratory, which ceased operations this month. Alternate facilities are available, but some delays may result in the extensive program of qualification tests. The extensive radiation qualification tests may not have been fully budgeted.

The Forward Calorimeter electromagnetic section production continues. The first module has been completed and will be delivered to CERN this month. The assembly of the second module has begun. Cold testing of cables is complete. The final prototype summing board is in testing. Production boards will be delivered in mid-July 2002. The U.S. effort is on schedule.

The estimated cost to complete remains essentially unchanged in the past year. Many of the 11 WBS elements have experienced minor changes. The cryogenics (software), System Crate and FEBs have seen more substantial increases. Savings on the cost of preamps and electrodes have offset these increases. The cost estimates include payments for facility preparation and use at CERN (e.g., crane). M&O estimates for 2003 and 2004 appear to be reasonable.

2.3.2 Comments

The calorimeter team is to be commended for the excellent progress over the past year, making good recovery from problems that had been encountered around the time of the last review and those which have arisen over the past year in items that appeared to be secure. The team has kept costs under control and has kept to a schedule that meets the ATLAS in-pit installation schedule. The estimate-to-complete appears adequate, with the possible exception of radiation testing. The radiation testing costs should be re-evaluated. The contingency appears to be adequate.

The extensive radiation-hardness testing needed to qualify electronics requires immediate attention for selecting another facility at which these components can be tested. The electronics team should consider using a facility that is available immediately rather than pinning hope on a facility that is not guaranteed to be available when it is required.

FEB progress remains critically tied to the availability of voltage regulators. The principal schedule issue here is availability of front-end electronics at the time that the liquid argon calorimeter is installed in the pit. The team has identified an alternative source for the problematic negative voltage regulator. Evaluation of this component should continue expeditiously. These tests should include the full front-end system crate test if the regulator has otherwise been qualified. Although a negative voltage regulator from STm would simplify FEB design, this may not be available in time to avoid danger to the calorimeter installation schedule. A decision date for choice of negative regulator should be set consistent with avoiding delays in calorimeter completion after installation in the pit.

2.3.3 Recommendation

1. Determine the last possible date for selection of a radiation-hard negative voltage regulator that avoids delay in the installation of the calorimeter in ATLAS. Take all necessary steps to select and procure the regulator.

2.4 Tile Calorimeter (WBS 1.4)

2.4.1 Findings

The tile calorimeter construction task has made substantial progress on delivering the components that are within the currently defined scope. Forty-eight of a total of 57 modules of the extended barrel calorimeter have already been delivered to CERN while the remaining assembly work is on schedule for completion in September 2002. The quality of delivered modules meets design criteria. Good progress has been made in delivery of read out components. Testing has been completed for 2,250 of 3,500 photomultiplier tubes, and remaining work appears to be on schedule. All front-end cards have been built and tested with repairs needed on some. All motherboards have been delivered and 68 percent tested. The optical interface cards are not yet produced and a recent decision has been taken to reassign the production contract in order to avoid additional schedule delays on these components. The production of intermediate calorimeter submodules is almost done.

To date, actual costs are $7.8 million with a current $1.7 million estimate-to-complete. In the last year, a draw on contingency of $221 K was made. This brings the total contingency use on the original scope to $991 K or 15 percent of the original estimate of $6.5 million. Remaining contingency on the estimate-to-complete is seven percent. The current total cost of the subproject ($9.5 million) is greater than the original estimate due to addition of scope.

Some items associated with the tile calorimeter remain in "Management Contingency" and are not part of the current scope of this task. The specific items are installation at $862 K and cryostat scintillators at $260 K. Additional work has been defined for current and future years and is assigned under the categories of pre-operations for a total of $2.5 million and M&O at $1.2 million through FY 2007. These categories of work have not been reviewed except to evaluate whether some of the work might properly be included within the construction project.

2.4.2 Comments

Progress on all fronts in the current scope is good. The cost performance is reasonable and consistent with similar construction projects. The contingency estimate of seven percent on the estimate-to-complete appears slightly optimistic; perhaps nine percent is better. The recent management decision to re-assign the production of the optical interface cards is appropriate and prudent. The performance of produced modules meet design specifications. The bottom line is that the current in-scope work appears to be in good shape.

The Committee has been advised of guidance from DOE that the construction project should generally include installation of detector systems at CERN, but not the following commissioning work. The Committee attempted to evaluate the additional scope that this guidance implies. It appears that the currently defined installation in management contingency of $862 K clearly should be assigned to construction project scope under this guidance. The

Committee has also evaluated whether work currently assigned to pre-operations and M&O is consistent with the guidance. Because the guidance is not completely specific, the Committee acknowledges that differences in opinion are possible regarding whether any specific task not yet defined in the scope fits within "future construction scope." In addition, because such tasks are not within the current scope they remain somewhat poorly defined and therefore clear evaluation is difficult. It is the Committee's opinion that roughly 75 percent of the work designated for pre-operations should not be included in the construction project according to DOE guidance. However, roughly 25 percent of the work appears consistent with "construction installation" per DOE guidelines. This should be specifically negotiated and defined. A substantial task that the Committee finds consistent with the construction project is the pre-installation work to be done at CERN. It is important that at the same time the installation in the construction project is better defined that the remaining work to be assigned to pre-operations and M&O be better defined so that a complete picture is visible for bringing this system into full physics operation.

2.4.3 Recommendations

1. Keep the production work for the defined scope on schedule. Assure that all cost increases are essential to meet defined performance specifications.

2. Define and document Tile Calorimeter installation scope within the construction project that is consistent with the DOE guidance by September 2002.

3. Define and document pre-operations and M&O work associated with the Tile Calorimeter by September 2002.

2.5 Muon Chambers (WBS 1.5)

2.5.1 Findings

Good technical progress by the muon various subgroups during the last year was demonstrated by many well-prepared talks provided to the Committee at the breakout session. MDT production is proceeding according to schedule. Problems with the CSC chamber planarity were resolved but this resulted in a delay of one year for the production start (that has not yet commenced).

Uncertainties in the cost estimate include costs associated with chamber production, Read Out Driver (ROD) cards, and the final design of the global alignment system. The group estimated it would need $500 K of contingency to cover potential cost overruns.

Integration of the endcap muon system especially as it relates to global alignment continues to be a concern to the Committee.

There is uncertainty in the availability of a suitable work area for chamber testing and staging at CERN beginning in fall 2002.

Lack of storage space at the University of Washington and the University of Michigan and lack of production electronics will force the final assembly and testing of 110 MDT's to be done at CERN. The group plans to use M&O funds to complete this final assembly.

The group's efforts on stretching and squeezing the M&O budget resulted in no reduction in cost but rather a movement of many items to later years.

The group plans on taking responsibility for the Chamber Service Module (CSM) cards. This is sensible given the successful prototype developed by the University of Michigan group. In doing R&D on the cable connecting the CSM and Mezzanine cards, the group identified the need for the cost of these cables to be included in the non-U.S. MDT cost estimates. The cost of the cables for non-U.S. MDT's is approximately $600 K.

2.5.2 Comments

The Committee finds no significant technical risks. No U.S. deliverables are on the critical path. In particular, changes in the CSC design appear to present no significant risks. CSC chambers of the new design will be tested this summer.

The Committee feels that the completion of all baseline deliverables as they are currently conceived by the muon group will be difficult to achieve given the cost cap imposed by U.S. ATLAS. The Committee would like to see more value engineering analyses performed by the muon group.

The $500 K contingency the subproject estimated it would need to cover possible cost overruns of the current design may be too low.

The Committee agrees that CERN should provide suitable space for testing and staging on site.

The Committee feels that the final assembly of chambers is properly part of the construction project.

2.5.3 Recommendations

1. Develop a plan in concert with project management and within the cost cap that will ensure the delivery of an endcap muon detector that is useful for doing physics. The plan should be completed by August 15, 2002.

2. Improve communication with the Technical Coordination Group to address muon endcap integration issues. The Technical Coordination Group should act on the muon group's longstanding request for integration engineering support.

3. Work with ATLAS to develop a credible space plan for chamber testing and staging at CERN. The funding agencies should communicate with CERN management supporting this request.

4. Develop an M&O plan that will meet the funding agency guidance.

5. Make ATLAS aware of the costs of cables between the CSM and Mezzanine cards.

2.6 Trigger and Data Acquisition (WBS 1.6)

2.6.1 Findings and Comments

The Trigger and DAQ project in the U.S. ATLAS baseline is primarily a level-of-effort for research and development leading to a baseline design and a Technical Design Report.

The Technical Design Report is scheduled for completion by June 2003.

U.S. ATLAS management has reserved $7.8 million in scope beyond the baseline for Trigger and DAQ construction, however, about $2.8 million of this scope may be eliminated by U. S. ATLAS management to cover other ATLAS costs.

The U.S. ATLAS Trigger and DAQ group has made good technical progress and has contributed significantly to the progress of the ATLAS Trigger and DAQ effort in the areas of high-level trigger and event filtering software development, and the development of the Region of Interest Builder (RoIB) and Level 2 Supervisor.

The effects of descoping the Trigger and DAQ data taking capability has been studied, however, the single plot of speed versus cost does not identify the uncertainties and assumptions used to create it, and some of the scenarios have more technical risk. The most draconian descoping scenario jeopardizes the high p_T program at high luminosity.

2.6.2 Recommendation

1. U.S. ATLAS management should make clear to ATLAS management that descoping the contribution to Trigger and DAQ will result in substantially reduced performance of the Trigger and DAQ system, and will have to be restored in order to operate with the highest LHC luminosity.

Intentionally Blank

3. COST ESTIMATE

3.1 Findings

The U.S. ATLAS Cost and Schedule Monthly Report dated March 31, 2002 indicates the project is 65 percent complete. The project's Total Project Cost remains at $163.75 million. Contingency as a percentage of remaining work is 49 percent.

U.S. ATLAS provided the Committee a variety of summary cost tables to support and selectively illustrate various aspects of current project cost performance including a detailed estimate package containing the 2002 Estimate to Complete. This package contained funding profiles, cost back-up information and summary schedules for most sub-systems. A comparison of project costs from the 2002 Estimate to Complete (plus actuals to June 2002) for each WBS Level 2 subsystem compared to the costs from the March 2001 review is provided in Table 3-1.

Table 3-1. Level 2 Comparison – March 2001 to June 2002

ETC Comparison (At Year $ in Thousands)				
WBS No.	Description	March 2001 Review	June 2002 Review	Difference
1.1	Silicon	17,755.1	18,725.3	970.2
1.2	TRT	9,194.0	9,434.7	240.7
1.3	Liquid Argon Calorimeter	42,171.6	43,783.9	1,612.3
1.4	Tile Calorimeter	9,148.2	9,510.7	362.5
1.5	Muon Spectrometer	26,391.2	26,386.2	-5.0
1.6	Trigger/DAQ	3,118.0	3,133.2	15.2
1.7	Common Projects	9,179.1	9,179.1	0.0
1.8	Education	286.5	286.5	0.0
1.9	Project Management	8,279.0	8,279.0	0.0
1.10	Technical Coordination	450.0	450.0	0.0
	Subtotal	125,973	129,169	3,196
	Contingency	29,938	26,742	-3,196
	Technical Baseline	155,911	155,911	0
	Trigger/DAQ (Outside Approved Baseline)	7,839	7839	0
	Total Project Cost	163,750	163,750	0

Risk analyses have been conducted by the project team. The risk analyses methodology and results were illustrated using project specific examples to describe the process and portray typical results. The risk analyses are reflected in the contingency amounts contained in the ETC for 2002.

The major cost changes in ETC for 2002 were outlined and cost impacts of recent Baseline Change Proposals were provided and discussed at a separate breakout session.

3.2 Comments

The two recommendations from the March 2001 review have been adequately addressed by the project.

The Committee expressed significant interest in the estimation, management, and tracking of project contingency. Although it has been a useful management tool for the U.S. ATLAS management team, the partitioning of contingency by the project into contingency and management contingency categories creates great opportunity for misinterpretation. Efforts should be made in future reviews to clarify the nature and magnitude of each contingency category.

Over the past 14 months, contingency as a percentage of remaining work consistently exceeded 40 percent, however, the Committee is concerned the nature of some management contingency items and the time frame for release may cause this level to drop significantly.

Priorities have been established for releasing management contingency. Within these priorities, requests (including decision dates) totaling approximately $9 million have been identified. If approved, these management contingency priority items may reduce the level of contingency to approximately 25 percent.

The Committee feels that decisions on these management contingency items should be made soon. Delaying these decisions as a strategy to maintain contingency at an artificially high level may have negative consequences.

3.3 Recommendation

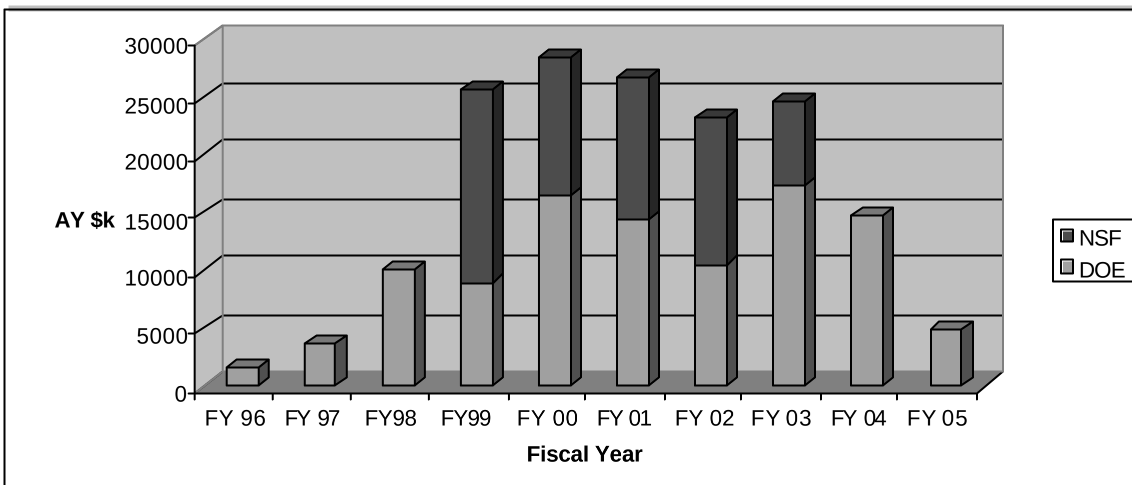
1. Make decisions on the remaining management contingency items as soon as possible, report these decisions at the time of the next quarterly review, and present them at the next full review.

Intentionally Blank

4. SCHEDULE AND FUNDING

4.1 Findings

The overall project construction schedule is consistent with the original baseline and finishes on September 30, 2005. The DOE Project Manager's indicated a minor concern with the project schedule in the last quarterly report prepared on May 14, 2002. The current funding profile is provided in Figure 4-1.



AY k$

Agency	FY 96	FY 97	FY98	FY99	FY 00	FY 01	FY 02	FY 03	FY 04	FY 05	Total
DOE	1700	3710	10050	8999	16494	14475	10507	17416	14690	4909	102950
NSF				16630	11940	12290	12650	7290			60800
Total	1700	3710	10050	25629	28434	26765	23157	24706	14690	4909	163750

Figure 4-1. U.S. ATLAS Funding Profile

4.2 Comments

U.S. ATLAS has made a good decision to maintain the baseline schedule even if CERN LHC schedule changes.

Overall, the schedule is reasonable with very few items at or near the critical path. However, several subcommittees have identified technical issues that may affect on-time delivery of specific U.S. ATLAS components.

4.3 Recommendation

1. Re-evaluate the subproject schedules considering the comments and concerns in other sections of this report and present results at the next quarterly status review.

5. MANAGEMENT (WBS 1.7)

5.1 Findings

Due to a technical problem arising from the delivery of superconducting cable from industry, the completion date of the LHC machine was delayed by about one and a half years. CERN is also facing severe funding difficulties, mostly arising from the overrun in cost of the LHC machine and detector construction. The new schedule is to be formally adopted by the CERN Council in its June 2002 meeting. In spite of this delay, the U.S. ATLAS group intends to complete the deliverables baselined to date by the end of September 2005 as planned in the baseline schedule.

Since the March 2001 DOE/NSF review, the U.S. ATLAS project has made significant technical progress toward the goal of delivering the agreed upon baseline items on schedule and within cost. The change in the cost to complete these items has been relatively small. The overall schedule appears to be consistent with the goal stated above, although some subsystem reviewers expressed some scope and schedule concerns.

The report of the March 2001 DOE/NSF review stated that the U.S. ATLAS has begun to make plans for the End-Game of the construction project. In this meeting the strategy for formulating the End-Game was presented. The strategy includes:

?? Intent to finish the U.S. ATLAS construction, including further obligations made from management contingency, by the end of 2005. The schedules allow completion of the baseline deliverable, except for the Trigger and DAQ.

?? Operation of the detectors subsystems at CERN must start as soon as possible after delivery, using the M&O part of the research program budget.

The Technical Coordination Group began functioning and is having a positive impact on the planning of the International ATLAS activities.

5.2 Comments

The Committee recognizes that the U.S. ATLAS project, as a whole, has made significant progress toward the goal of fabricating the items that were baselined as deliverables under the Memorandum of Understanding, delivering them to CERN and installation, where applicable. In view of the fact that the construction funds are capped, the project is mostly in the fabrication stage with a great forward momentum, and since the announced LHC delay is only a little over one and a half years, it makes good sense to maintain the present construction schedule in order to avoid the cost increase that is inevitable with this type of schedule delay.

The U.S. ATLAS project intends to achieve the above-mentioned goal on schedule and within budget. The principal objective of this collaboration, however, is to provide U.S. physicists with an opportunity to carry out forefront research at the energy frontier at the LHC. Therefore, the detector subsystems delivered must be functional for the physics research purposes. The collaboration must identify methods to ensure achievement of this primary goal. Namely, the U.S. ATLAS must make certain that the supplementary equipment that will make the subsystem function will either come from other collaborators or other sources of funding. If this method includes the use of the U.S. ATLAS contingency, either regular or management contingency, the itemized estimate of the exposure must be prepared to reflect an actual state of the contingency.

U.S. ATLAS management should decide relatively soon on the remaining management contingency items with the goal of ensuring that the U.S. provides systems sufficiently integrated for LHC physics. This will also help subsystem managers to plan remaining construction activities.

It was stated, “in agreement with the International ATLAS, the U.S. ATLAS Muon Subsystem is subject to a funding cap, possibly reducing the number of chambers provided, as part of the ATLAS staging; at this time the plans allow the full complement to be provided.” Hopefully, savings can be found to expand the present capped scope to a full system. In any event, U.S. ATLAS should make certain that the delivered system is functional for physics.

The Committee applauds strengthening of the ATLAS Technical Coordination Group with well-defined tasks, documentation, and procedures and commends the U.S. ATLAS management for its effective and valuable contribution, both financial and technical, to this important effort. Now that the integration and installation of detector subsystems is to begin soon, and only a few years are available to complete the assembly of the very complex, mammoth detector, well-organized technical coordination is the key to its success. Knowing the very tight financial situation of the ATLAS project, sound technical coordination is also essential to minimize the installation cost risk.

With the technical coordination efforts being initiated in earnest, and the End-Game strategy presented, the U.S. and International ATLAS must be able to develop the actual End-Game to transition from the construction phase to the operations phase. The development of the End-Game plan may also help delineate a number of questions brought out in this review.

Physics research funding request (the sum of pre-operations, M&O, computing, etc.) presented in April 2002 was to be scrubbed to meet the funding guidance provided. The new numbers appear to be the result of shifting near term spending to later years with appropriate escalation. The collaboration must go through the request item by item and justify the need for each function and the funding required with intent to reduce the overall budget before the next review.

DOE and NSF have supported the U.S. LHC detector projects jointly with a funding ratio of about three to one. Continued funding from NSF, as well as DOE for maintenance and operation of U.S. ATLAS is critical for a sound physics program.

Since there is a very close coupling between the construction activities and pre-operations activities during the next five years, the Committee recommends that the next construction review and "M&O/pre-operations" review be combined into one with sufficient time to do both properly. This must a comprehensive review including all aspect of the ATLAS operation including DOE and NSF supported research.

5.3 Recommendations

1. Make decisions on the remaining management contingency items as soon as possible, report these decisions at the time of the next quarterly review, and present them at the next full review. These decisions must be made with conscious intent to make certain that the U.S. deliverables will be functional for physics.

2. Conduct a combined, three-day review of U.S. ATLAS Construction and Pre-operations in one year with a mini review in six months.

3. Develop U.S. ATLAS end-game plan that is consistent with the International ATLAS End-Game plan before the next full review.

4. Work with the agencies to refine the definition of project completion and present the result at a mini-review in six months.

Intentionally Blank