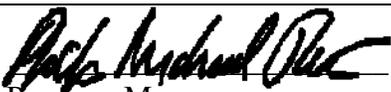
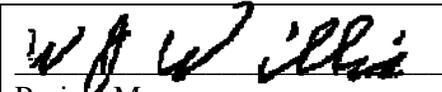
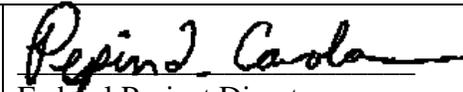


U.S. Large Hadron Collider (LHC) Project Critical Decision- 4A (CD-4A) Closure Report

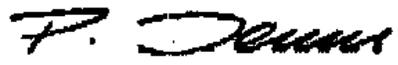
1) Project Title: U.S. ATLAS	2) Project Host Laboratory: Brookhaven National Laboratory	3) DOE Reference Number: XX-SC-XXX-1																								
<p>4) Project Purpose and Scope (include WBS to Level 2, and see attachments for more detail): The U.S. ATLAS Project consists of the activities to design, supply and install the U.S. portion of the ATLAS detector. The detector will become part of the Large Hadron Collider (LHC) at CERN, the European Laboratory for Particle Physics. The ATLAS detector is being designed to understand the dynamics of electroweak symmetry breaking, with the capability of reconstructing the momenta and directions of quarks (hadronic jets, tagged by their flavors where possible), electrons, muons, taus, and photons, and sensitivity to energy carried off by weakly interacting particles such as neutrinos that cannot be directly detected. The Work Breakdown Structure (WBS) is:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">1.1 Silicon Subsystem</td> <td style="width: 50%;">1.6 Trigger/DAQ Subsystem</td> </tr> <tr> <td>1.2 TRT Subsystem</td> <td>1.7 Common Projects</td> </tr> <tr> <td>1.3 LAr Calorimeter Subsystem</td> <td>1.8 Education Outreach</td> </tr> <tr> <td>1.4 Tile Calorimeter Subsystem</td> <td>1.9 Project Management</td> </tr> <tr> <td>1.5 Muon Spectrometer Subsystem</td> <td>1.10 Technical Coordination</td> </tr> </table>			1.1 Silicon Subsystem	1.6 Trigger/DAQ Subsystem	1.2 TRT Subsystem	1.7 Common Projects	1.3 LAr Calorimeter Subsystem	1.8 Education Outreach	1.4 Tile Calorimeter Subsystem	1.9 Project Management	1.5 Muon Spectrometer Subsystem	1.10 Technical Coordination														
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<p>5) Project Completion Baseline through CD-4A</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">Project WBS Item</th> <th style="text-align: right; border-bottom: 1px solid black;">Budgeted Cost of Work Performed (through CD-4A)</th> </tr> </thead> <tbody> <tr><td>1.1 Silicon Subsystem</td><td style="text-align: right;">\$23,937.9k</td></tr> <tr><td>1.2 TRT Subsystem</td><td style="text-align: right;">\$11,878.3k</td></tr> <tr><td>1.3 LAr Calorimeter Subsystem</td><td style="text-align: right;">\$47,522.3k</td></tr> <tr><td>1.4 Tile Calorimeter Subsystem</td><td style="text-align: right;">\$11,552.3k</td></tr> <tr><td>1.5 Muon Spectrometer Subsystem</td><td style="text-align: right;">\$30,185.7k</td></tr> <tr><td>1.6 Trigger/DAQ Subsystem</td><td style="text-align: right;">\$5,170.6k</td></tr> <tr><td>1.7 Common Projects</td><td style="text-align: right;">\$15,313.5k</td></tr> <tr><td>1.8 Education Outreach</td><td style="text-align: right;">\$135.2k</td></tr> <tr><td>1.9 Project Management</td><td style="text-align: right;">\$8,380.2k</td></tr> <tr><td>1.10 Technical Coordination</td><td style="text-align: right;">\$3,095.3k</td></tr> <tr><td>TOTAL U.S. ATLAS Project</td><td style="text-align: right;">\$157,171.3k</td></tr> </tbody> </table> <p>Completion Date (Actual): 9/30/2005</p>			Project WBS Item	Budgeted Cost of Work Performed (through CD-4A)	1.1 Silicon Subsystem	\$23,937.9k	1.2 TRT Subsystem	\$11,878.3k	1.3 LAr Calorimeter Subsystem	\$47,522.3k	1.4 Tile Calorimeter Subsystem	\$11,552.3k	1.5 Muon Spectrometer Subsystem	\$30,185.7k	1.6 Trigger/DAQ Subsystem	\$5,170.6k	1.7 Common Projects	\$15,313.5k	1.8 Education Outreach	\$135.2k	1.9 Project Management	\$8,380.2k	1.10 Technical Coordination	\$3,095.3k	TOTAL U.S. ATLAS Project	\$157,171.3k
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<p>6) Overview of work remaining through CD-4B, if any: The work remaining for CD-4B includes Pixel Mechanics Production, completion of Silicon service panel components, Trigger/DAQ Production and Software Development, remaining installation of some systems, and completion of CD-4A punch-list items (see section 9 below).</p>																										
<p>7) Status of Project Turnover/Acceptance (including for Maintenance & Operations of detectors):</p>																										
<p>8) Key Learning Points and Recommendations:</p> <ul style="list-style-type: none"> • Specifically define a list of Deliverables in MOUs. Definitions in terms of percentages or levels of effort can keep increasing in cost, as we saw in this project. • Management Contingency concept worked to keep cost increases down and allowed for optimal management of scope to maximize the U.S. contribution to the detector. • Do not rely on sole source procurements if possible. • We never made a visit to a collaborator or a vendor which was not productive – make more trips. • System engineering (aka Technical Coordination in ATLAS) is critical early in a large Project and should not be underestimated. • Reviews are useful. 																										
<p>9) CD-4A Punch-list Items, Actions Assigned, if any:</p> <ul style="list-style-type: none"> • Complete installation of LAr WBS 1.3.6.4 Power Supplies and WBS 1.3.7.1 Front-End Boards. Although installation has started this FY, the completion will slip into FY06, but should complete by Jan 2006. There will be no impact on the international ATLAS schedule. • Complete production of Muon WBS 1.5.11.5, 1.5.11.6, 1.5.11.10 (ROD's, Support Electronics and Transition Modules); holding weekly meetings with subsystem managers to insure that design, layout and prototype are completed by September 2005, with production planned for completion in February 2006. There will be no impact on the international ATLAS schedule. 																										

10) Certification that Project is physically completed as described in attachments, and Maintenance & Operations planning/transition is sufficient for this stage of completion:

WBS 1.1 Silicon Strips and RODs are in pre-operations and being commissioned. The pixels will be installed later in FY06 and then begin pre-operations and commissioning. WBS 1.2 Transition Radiation Tracker is installed and in pre-operations and commissioning. WBS 1.3 Most of the Liquid Argon Calorimeter is installed and all components are in pre-operations and commissioning. The rest of the Front-End Boards and Low Voltage Power Supplies will be installed in early FY06. WBS 1.4 Tile Calorimeter will finish installation in FY06 but all components are already in pre-operations and commissioning. WBS 1.5 All components of the Muon System are in pre-operations and commissioning, with installation continuing into FY06. WBS 1.6 has work already for the Trigger/DAQ subsystem in pre-operations and commissioning. There are no deliverables for WBS 1.7 Common Fund and WBS 1.8 Education Outreach. WBS 1.9 U.S. ATLAS Project Office has transitioned to the U.S. ATLAS Program Office. WBS 1.10 Technical Coordination has transitioned to the U.S. ATLAS Research Program.

 Program Manager <u>10/12/05</u> Date	 Project Manager <u>12 Oct. 2005</u> Date	 Federal Project Director <u>10-13-05</u> Date
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11) Acceptance by the user organization of the Project deliverables as described in attached project baseline documents

 User Organization representative	<u>18 Oct 2005</u> Date
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12) Listing of Attachments (one set with further breakdown for each Level 2 WBS item):

- ATTACHMENT USATLAS 1.1 – Silicon Subsystem (Parts 1 and 2)
- ATTACHMENT USATLAS 1.2 – Transition Radiation Tracker Subsystem (Parts 1 and 2)
- ATTACHMENT USATLAS 1.3 – Liquid Argon Calorimeter Subsystem (Parts 1, 2 and 3)
- ATTACHMENT USATLAS 1.4 – Tile Calorimeter Subsystem (Parts 1 and 2)
- ATTACHMENT USATLAS 1.5 – Muon Subsystem (Parts 1 and 2)
- ATTACHMENT USATLAS 1.6 – Trigger/Data Acquisition Subsystem
- ATTACHMENT USATLAS 1.7-9 – Common Funds/Education Outreach/Project Management Subsystems
- ATTACHMENT USATLAS 1.10 – Technical Coordination Subsystem

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: WBS 1.1 Silicon Subsystem

3) Subsystem/WBS Level 2 Item Description:

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.1.1.1	Pixels Mechanics	\$6,279.7k	6/1/2006 (F)	99	1 global support structure 6 disk support structures 192 disk modules on disk sectors 1 pixel support tube 8 service panel assemblies 180 CHF towards procurement of Type II/III/IV cables	Deliverables: (1) complete design of 6 pixel disk structures, global support frame, SCT mounts, Support tube/endplug, first patch panel (PPO), type I 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 192 modules attached; (3) level-of-effort support of LBNL engineering for pixel and integration. 137.4k (180k CHF) for production of Pixel Subsystem cables. Type I cables/connectors and associated support structures for a 3-hit pixel system and provides funds in \$ to maintain the 180 kCHF for Type II/III/IV cables procurement.
1.1.1.2	Pixels Sensors	\$728.9k	12/31/2004 (A)	100	Testing of 400 Tiles	Deliverables: (1) Partial funding (20% of total) of preproduction fabrication; (2) testing of about 25% of preproduction wafers. Production and testing of 400 tiles.
1.1.1.3	Pixels Electronics	\$2,822.4k	4/30/2005 (A)	100	112 FE wafers probed 20 module test systems	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).

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.1.1.4	Pixels Hybrids	\$1,414.7k	9/30/2005 (A)	100	1744 flex hybrids in detector 200 optical hybrids	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 1744 Flex Hybrids and in detector; (4) procurement and testing of optical hybrids, passive components and loading to provide 200 in the detector
1.1.1.5	Pixels Modules	\$1,397.0k	9/1/2005 (A)	100	Thinning of 224 wafers. Dicing of 224 wafers. 192 modules	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 192 modules in detector; (5) attachment of all modules to disk sectors. Reprobe of the FE ICs (15000)
1.1.1.6	Beam/System Test Support	\$196.6k	8/1/2005 (A)	100	Level-of-funding	Deliverables: (1) Level-of-effort support of beam tests and system tests at CERN
1.1.2	Silicon Strip Modules Shipped to CERN	\$7,463.4k	9/25/2004 (A)	100	39,975 chips 670 modules	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.; Deliverables: (1) Level-of-effort design; (2) Funding for prototype chip orders; and (3) 39,975 chips. Deliverables:(1) Barrel module hybrid design and (2) hybrid prototypes. Production hybrids are from non-U.S. ATLAS. Deliverables: 670 barrel modules delivered to UK assembly site. Thermal Boards to be provided by Non-USATLAS for assembly onto Modules.
1.1.3	Pixel/SCT RODs	\$3,635.1k	8/31/2005 (F)	100	92 RODs for the SCT, 86+46 RODs for the Pixels. 8 crates for RODs.	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) 92 production RODs along with prototypes necessary for the design of production units for the SCT. 86+46 RODs for the full 3 layer pixel system. Crates for the RODs.
TOTAL CD-4A Cost		\$23,937.9k				
4) Estimated work remaining through CD-4B, if any: Completion of service panel components and assembly Installation at CERN						

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):

1.1.1.1 Mechanics

Global support frame – ready for insertion of local supports at CERN and LBNL

Disk support structures(rings) – ready for local supports

192 modules have been mounted on disk sectors

Pixel support tube at CERN(August 2005)

Service panel assemblies under fabrication

Final procurement of Type II/III/IV cables in progress

1.1.1.2 Sensors

400 tiles tested and integrated into modules

1.1.1.3 Electronics

112 wafers probed and delivered to vendors for bump bonding

20 test systems delivered

1.1.1.4

Fabrication of flex hybrids to yield 1744 in detector complete. Hybrids integrated into modules in US complete and continue to be integrated into modules in EU

200 optical boards(September 2005)

1.1.1.5 Modules

Assembly and testing complete to yield 192 modules in detector

1.1.1.6 Beam and System Tests

Beam tests at CERN and system tests at LBNL complete

1.1.2

All SCT modules and chips have been delivered. Mounting into barrels and disks proceeding well, with good functionality of U.S. deliverables.

1.1.3

RODs are functioning as planned when delivered to CERN.

6) Key Learning Points and Recommendations:

Undergraduate students have been very cost effective doing testing of components after tests have been debugged. The division of labor between institutions was not optimum initially and had to be adjusted over time. More attention to this at an early stage would have been advantageous.

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

Alvanham Peters

10/12/05

W J Willi

12 Oct. 05

Level 2 Manager

Project Manager

8) Attached Photographic Documentation

WBS 1.1.1.1 Global Support Frame

WBS 1.1.1.1 Disk Support Rings, 6 Production, 1 Preproduction

WBS 1.1.1.1 Modules mounted on disk support structures

WBS 1.1.1.1 Pixel Support Tube

WBS 1.1.1.1 Service panel assembly

WBS 1.1.1.2 Silicon sensor wafer

WBS 1.1.1.4 Flex hybrid mounted on module

WBS 1.1.1.4 Optical hybrid, one of 200

WBS 1.1.1.5 Assembled and tested modules mounted on disk sectors

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem



WBS 1.1.1.1 Global Support Frame

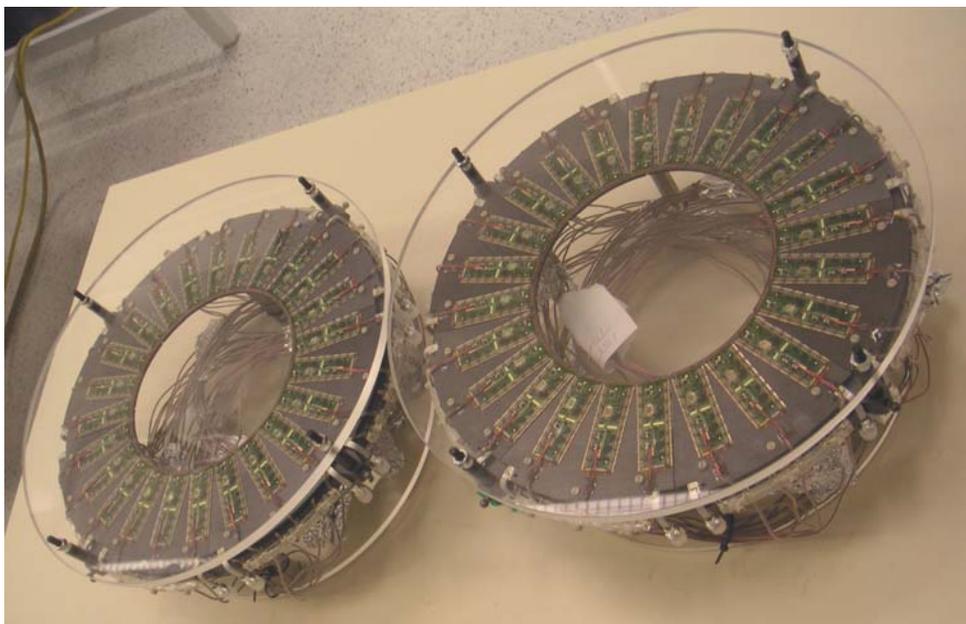


WBS 1.1.1.1 Disk Support Rings, 6 Production, 1 Preproduction

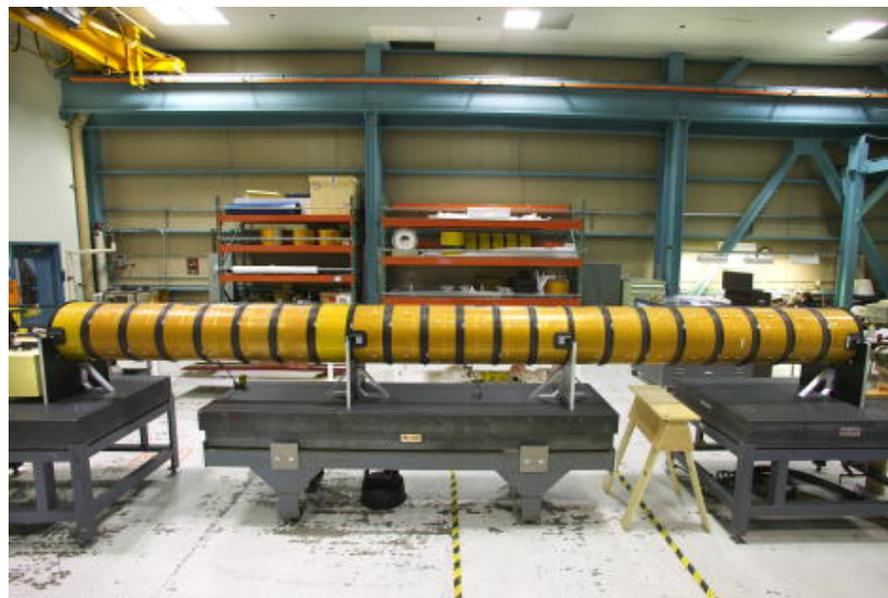
U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
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1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem



WBS 1.1.1.1 Modules mounted on disk support structures

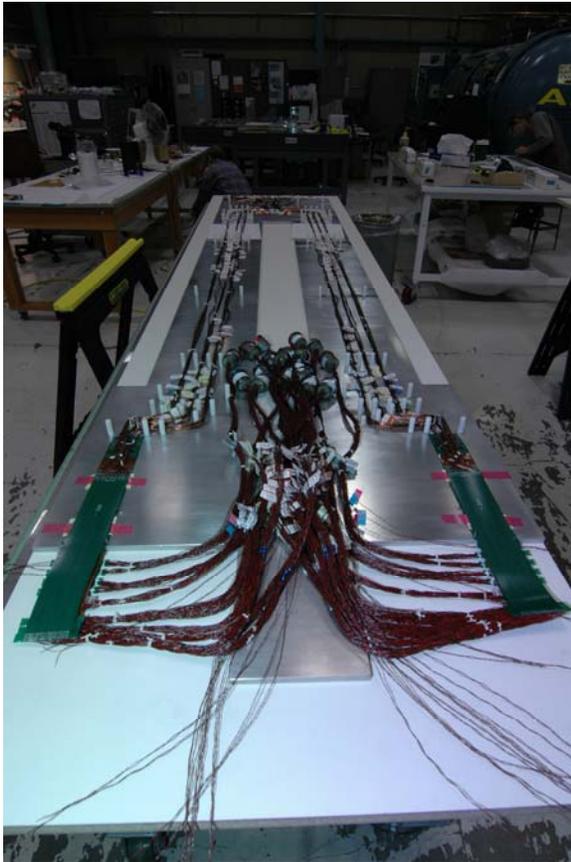


WBS 1.1.1.1 Pixel Support Tube

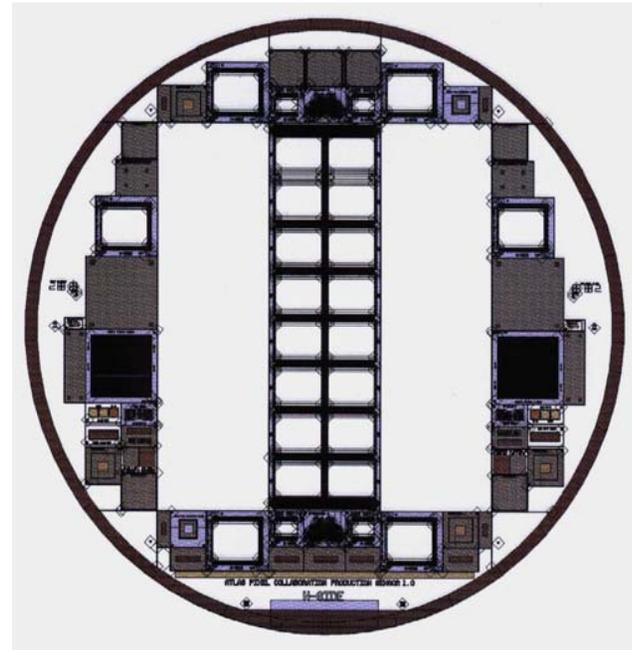
U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
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1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem



WBS 1.1.1.1 Service panel assembly

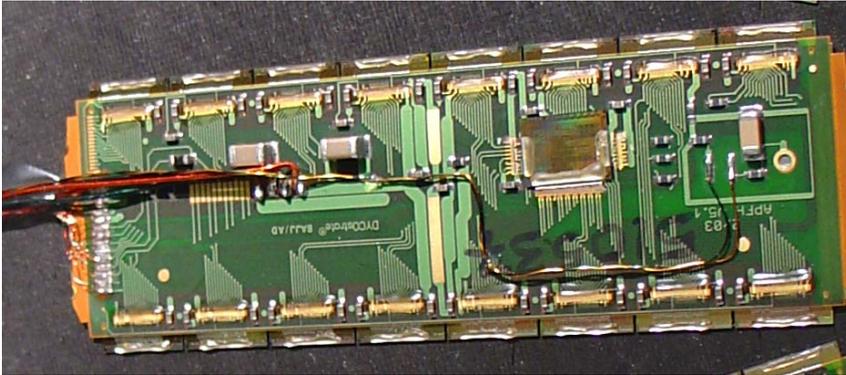


WBS 1.1.1.2 Silicon sensor wafer

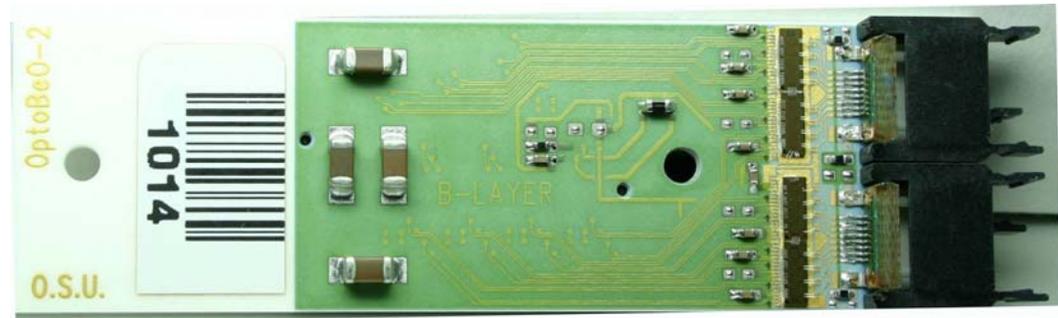
U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem



WBS 1.1.1.4 Flex hybrid mounted on module

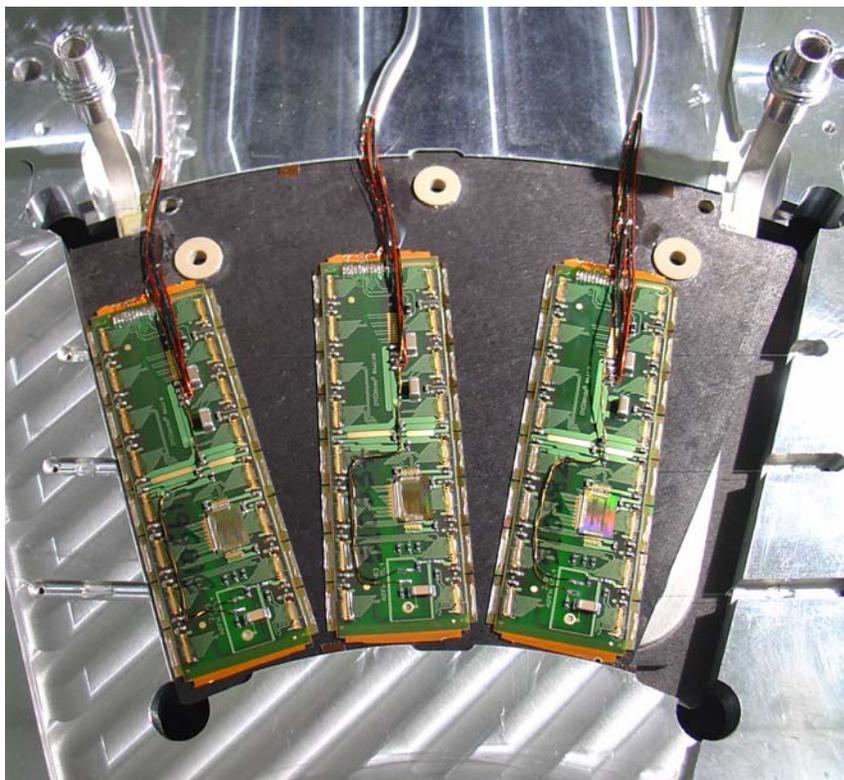


WBS 1.1.1.4 Optical hybrid, one of 200

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem



WBS 1.1.1.5 Assembled and tested modules mounted on disk sectors

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.1
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.1 Silicon Subsystem

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U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.2

1) Project: U.S. ATLAS

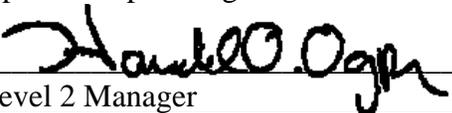
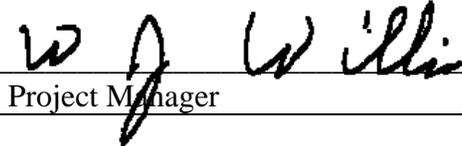
2) Subsystem/WBS Level 2 Item: WBS 1.2 Transition Radiation Tracker (TRT) Subsystem

3) Subsystem/WBS Level 2 Item Description:

This WBS covers the construction and installation of the Barrel TRT tracker including services, front end electronics, and a portion of the readout electronics (RODS).

The Barrel TRT is a drift chamber tracker that uses 4 mm diameter drift tubes to track charged particles, and in addition records the high pulse height events that are produced by transition radiation from electrons as they traverse the fiber radiator between the drift tubes. The 52,000 drift tubes (1.5 meter long straws) are filled with a Xe gas mixture. They are axially aligned in a cylinder spanning a radius from 0.5 meters to 1.1 meters from the interaction point. The straws are grouped in three cylindrical layers each containing 32 modules. The readout electronics consists of an amplifier-discriminator-shaper (ASDBLR) and a digitizer pipeline, (DTMROC) that are mounted on printed circuit boards on both ends of the 96 modules. The digital pipeline output is read by the downstream readout electronics (RODs) that are located outside of the ATLAS detector.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.2.1.1	Barrel Modules Production Ship to CERN	\$7,595.9k	4/30/2004 (A)	100	102 Barrel Modules Gas System (\$86k Fixed Contribution)	Production and testing of 102 of the barrel modules. Total barrel modules required is 34 of each of three types, which includes 2 spares of each type. 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. US ATLAS provides a fixed \$86k to the design and fabrication of the Inner Detector Gas System.
1.2.1.3	Barrel Modules Installation	\$551.9k	9/4/2005 (A)	100	Level of Effort	Level of Effort for installation of the modules.
1.2.5.1	ASDBLR Production	\$1,754.9k	4/20/2005 (A)	100	355,725 channels	83.7% of total of the ASDBLR for the entire TRT system.
1.2.5.2	DTMROC Design/Prototyping	\$268.3k	Complete	100	Level of effort	Responsible for the design, and prototyping of receiver, driver and DAC section of DTMROC.
1.2.5.3	PCB Design/Prototyping/ Production	\$728.0k	9/30/2005 (A)	100	106,000 channels 480 boards (less DTMROC)	Responsible for designing, prototyping and production of 480 of the Barrel production Boards, less the DTMROC, and 160 bare printed circuit boards for the endcap. DTMROC is provided by LUND.
1.2.5.6	TRT Electronics Installation	\$374.5k	9/1/2005 (A)	100	Level of effort	Installation and testing of the Barrel TRT electronics with other TRT collaborators.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.2.5.4, 5,7	TRT Electronics Support Activities	\$270.3k	9/30/2005 (A)	100	Level of effort	Level of effort to support TRT Electronics Support Activities
1.2.5.8	RODs Production	\$334.5k	10/31/2005 (F)	98	54.9% 63 RODs	This effort will include design of the TRT Read-Out Drivers (RODs) and procurement of the components for 54.9% of the requirement, or 63 RODs.
TOTAL CD-4A Cost		\$11,878.3k				
4) Estimated work remaining through CD-4B, if any: None						
5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors): 1.2.1.1 102 Barrel modules certified for use. 96 installed, 6 spares. 1.2.1.3 96 modules installed in barrel 1.2.5.1 355,725 channel delivered, complete. 1.2.5.2 Design of DTMROC completed, all have been produced. 1.2.5.3 100% completed and delivered- 480 boards 1.2.5.6 Front end electronics installation on barrel completed 1.2.5.4,5,7 Electronics support of barrel installation supplied, work is completed 1.2.5.8 ROD designed, 54.9% of componets for 63 boards was purchased.						
6) Key Learning Points and Recommendations: <ul style="list-style-type: none"> System testing should be completely and formally conducted and documented to determine all possible effects of design gas on system components. Gluing operations require more testing and adherence to strict procedures to increase yield and quality. 						
7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion: <div style="display: flex; justify-content: space-between; align-items: flex-end; margin-top: 10px;"> <div style="text-align: center;">  10/11/05 Level 2 Manager </div> <div style="text-align: center;">  12 Oct. 05 Project Manager </div> </div>						

8) Attached Photographic Documentation

1 – Inner Tracker Diagram

2 – Photograph of Barrel Modules in Space frame

3 – Photograph of electronics assembly with cooling plate mounted on the Barrel tracker

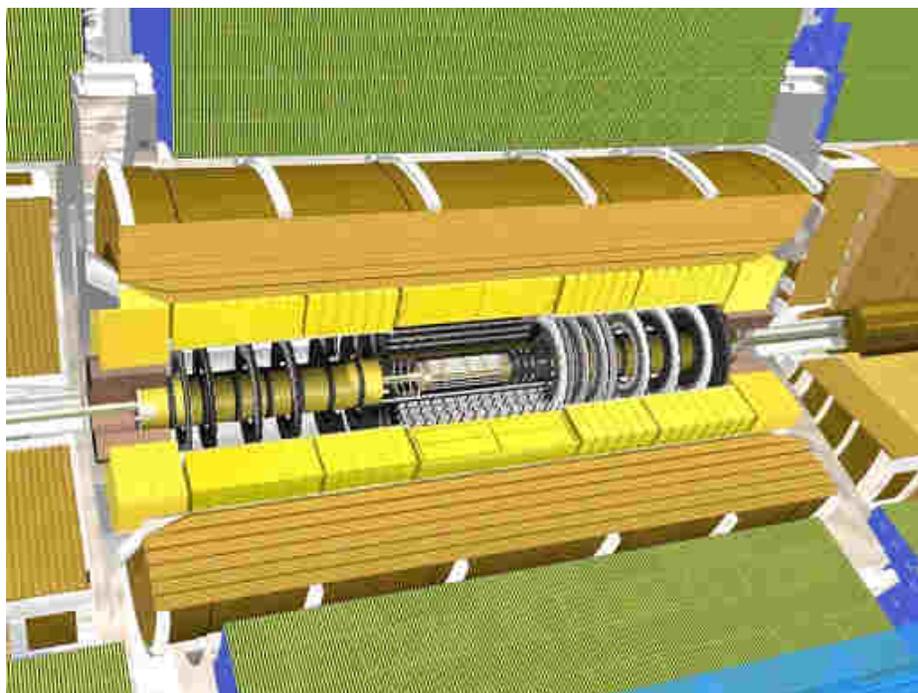
4 – Photograph of electronics printed circuit board with electronics chips attached

5 – Online picture of a track through a section of the barrel tracker

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.2
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Transition Radiation Tracker/WBS 1.2



Inner tracker, with the pixel, SCT, and TRT barrel cylinders surrounding the interaction point. (WBS 1.2)



Barrel modules inserted in Support frame. Inside row of installed electronics can be seen. (Feb-2005) (WBS1.2.1)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.2
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Transition Radiation Tracker/WBS 1.2

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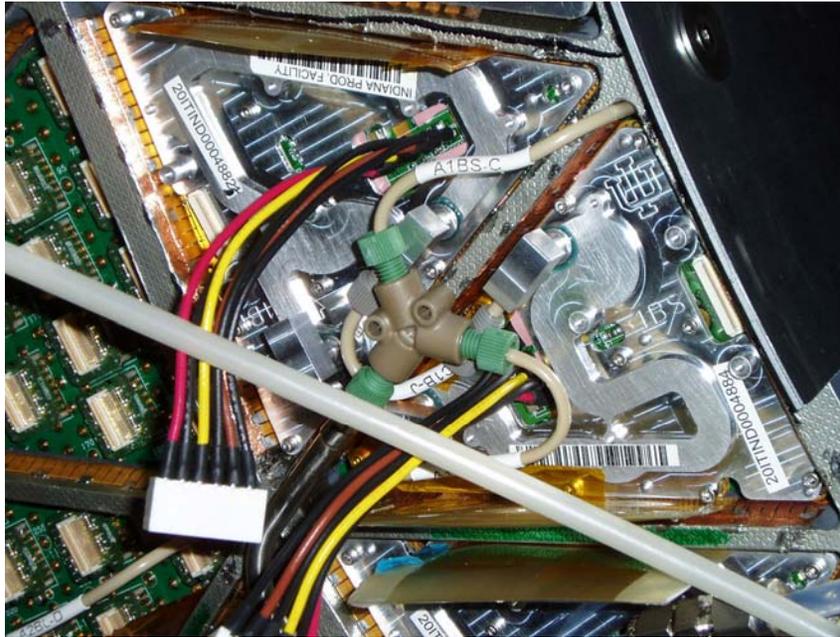


Barrel Modules ready for installation of Electronics
(WBS 1.2.1)

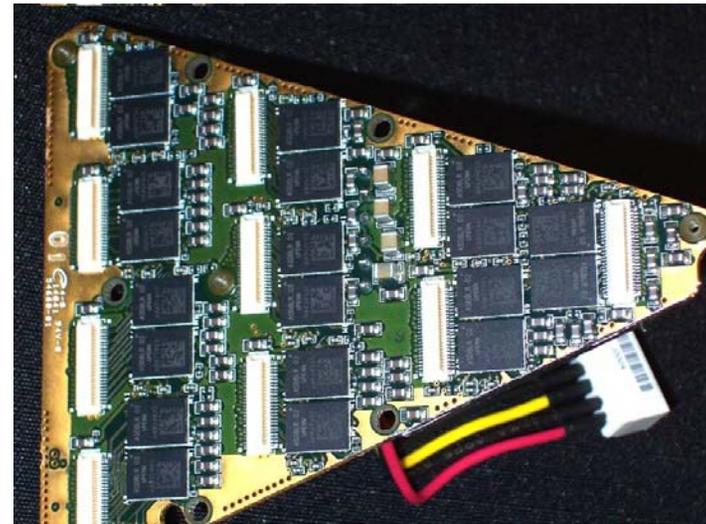
U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.2
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Transition Radiation Tracker/WBS 1.2



Detail of electronics assembly with cooling plate mounted on the Barrel tracker. (WBS 1.2.5)



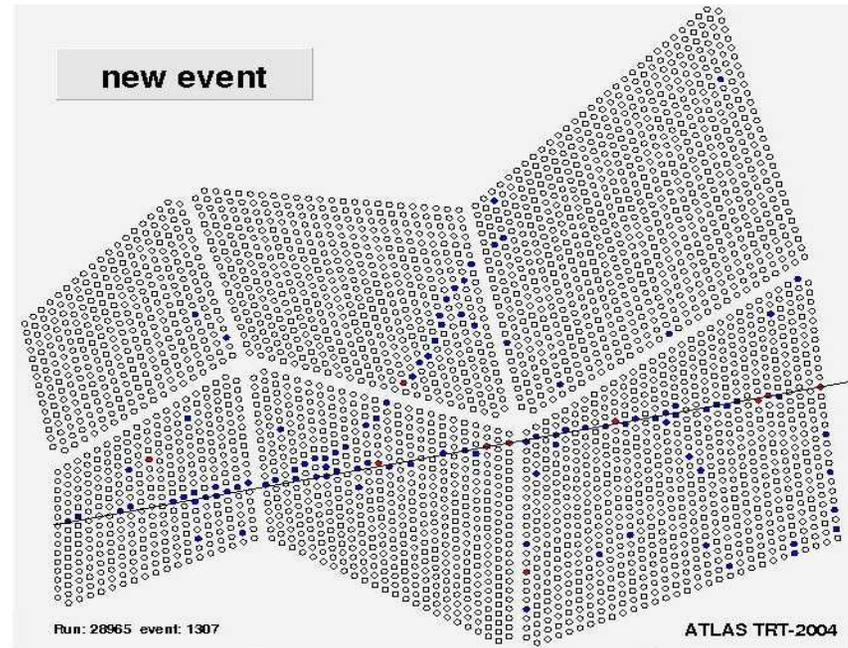
One electronics printed circuit board with electronics chips attached. (WBS 1.2.5)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.2
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Transition Radiation Tracker/WBS 1.2

-
-



Online picture of a track through a section of the barrel tracker, taken during the combined test beam run, Fall-2004 (WBS 1.2)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: WBS 1.3 Liquid Argon Calorimeter Subsystem

3) Subsystem/WBS Level 2 Item Description:

Liquid Argon calorimeter system will measure energies of electromagnetic showers deposited in the detector by electrons and photons. The system consists of 3 cryostats (central barrel and 2 forward Endcaps) containing detector modules. In the central and forward regions, each module consists of a stack of harmonica shaped absorber plates and readout electrodes. Endcap cryostats contain also Forward calorimeter consisting of copper absorber plates and tubular readout electrodes. Initial summation of the collected charges is done on each detector module. Signal processing is done by the Front End electronics located on the warm side of the cryostat. Back-end electronics, located about 150 meters away from the detector, provides additional signal processing and selective trigger capabilities. US groups are responsible for ~20% of the total cost and are involved at various levels in all aspects of the subsystem construction.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.1.5	Cryostat Final Acceptance Test	\$7,647.2k	8/31/2001 (A)	100	1 Liquid Argon Cryostat	Barrel Cryostat including: Rails for calorimeter and tracker; support and interface to the magnet.
1.3.2.1	Signal FT Installation	\$4,917.3k	5/31/2002 (A)	100	3 Signal Feedthroughs – Test 68 Signal Feedthroughs – Production	Three Signal feedthrough assemblies for the test beam cryostats, including installation. Sixty four Signal feedthrough assemblies, and 4 spares, are for the barrel cryostat. US supplied the components and assembly (apart from the pigtails). The feedthroughs are fully tested before and after installation. Pigtails are provided by non-US collaborators.
1.3.2.2	HV FT Installation	\$1,369.9k	12/31/2004 (A)	100	7 Production High Voltage Feedthroughs	HV feedthroughs for barrel(2) and endcap cryostats (4) + 1 spare. Approx. 800 channels per feedthrough. HV 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.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.3	Cryogenics	\$3,600.9k	9/30/2005 (A)	100	1-Refrigerator 1-15kl N ₂ Storage Dewar 2-Cryogenic Liquid Transfer Lines 17-Liquid Quality Meters	US deliverables for this WBS are: 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. One – 15,000 liter Liquid Nitrogen Storage Dewar Seventeen Quality Meters
1.3.4.1	Readout Electrodes	\$2,305.7k	1/31/2003 (A)	100	Level of Effort	U.S. will participate in the design, R&D, industrial prototyping and production of large readout electrodes at a level of effort. Non-U.S. ATLAS is responsible for the procurement and testing of the electrodes

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.4.2	Motherboards Production/Shipping	\$2,116.5k	10/31/2002 (A)	100	7168 SB for barrel EM. 224 SB for module 0. 960 MB for barrel EM 30 MB for module 0 960 AB for barrel EM 30 AB for module 0 448 HV Boards for Barrel EM 14 HV boards for module 0	This includes 100% of the summing boards (SB), alignment boards (AB), motherboards (MB) and high voltage (HV) boards for the barrel EM calorimeter and prototype modules. Deliverables include the number of boards indicated, plus 5% for spoilage during installation. 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.
1.3.5.1	Preamps Delivery	\$1,605.0k	5/31/2003 (A)	100	100 hybrids (Design and Optimization) 1000 hybrids (Preprototype) 29811 hybrids (Barrel EM and Forward Module)	Design and optimization of preamps for the EM and Forward calorimeters (100%): Pre-prototype hybrids: 4 channels/hybrid , Module 0 and assorted tests. Enough hybrids to equip the barrel EM and the Forward calorimeters.
1.3.5.2	Precision Calibration Design (LOE)	\$163.0k	9/30/2003 (A)	100	For 846 Boards	100% of the design and components for the on-board calibration for EM and Forward calorimeters (100%).
1.3.5.3	On-Board Calibration	\$76.0k	9/30/2003 (A)	100	Level of effort	Participate in the design of the precision calibration and Radiation tolerance studies.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.6	System Crate					Design and specification for the System crate: 100% Barrel EM and Forward Calorimeter. Design should be able to accommodate 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. The System Crate comprises the following equipment:
1.3.6.1	Pedestals Production	\$611.7k	4/30/2003 (A)	100	32 Pedestals 26 Pedestals	Design and production of 58 pedestals as follows: 32 - Barrel EM 26 - End Cap and Fwd Calorimeter
1.3.6.2	Cables/Baseplane Delivery to CERN	\$1,548.9k	4/30/2003 (A)	100	4300 Cables 116 Base Planes	Design and production of 4300 cables and 116 Barrel EM baseplanes
1.3.6.3	EC/Barrel Crates Production	\$1,133.4k	3/31/2005 (A)	100	5 crates Module 0 32 crates Barrel EM 26 crates End Cap and FCAL	Design and production of 58 Crates as follows: 32 - Barrel EM 26 - End Cap and Forward Calorimeter
1.3.6.4	Power Supplies Production	\$3,318.3k	8/31/2005 (A)	100	41 Power Supplies	Design, Prototyping and Production of 59% of 68 power supplies (\$!).
1.3.6.4	Power Supplies Installation	\$28.6k	1/31/2006 (F)	19	Level of Effort	Installation of the Power Supplies on the barrel calorimeter.
1.3.6.5	Cooling Plate Deliveries to FEB Complete	\$1,713.9k	5/31/2005 (A)	100	Cooling For 70 Crates	Design and production of Cooling System 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. Design and production of 70 crates. Installation on the barrel calorimeter only.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.7.1	FEB Production	\$8,576.5k	9/29/2005 (A)	100	4 Analog FEB boards for Test beams 50 FEB Boards for Module 0 50% of ADC Chips 100% Associated FEB Components	This includes all design, prototyping, assembly and testing of the Front End Boards. Design and delivery of analog boards for test beams. Delivery of 5000 channels equivalent of FEB. U.S. will deliver enough FEB for the EM barrel and the forward calorimeter. ATLAS FEB Cost Sharing Plan reapportions the 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%. Non-US ATLAS is responsible for delivery of remaining components.
	FEB Installation	\$93.7k	1/31/2006 (F)	62	Level of Effort	Installation of the Front End Boards on the barrel calorimeter.
1.3.7.4	Optical Links Production	\$935.0k	9/15/2005 (F)	100	Links to 846 Boards	G Links and Misc. Optical Link Components to the approved scope.
1.3.8	Trigger Summation	\$1,543.0k	9/30/2005 (A)	100	3270 Layer Sum Boards 192 Level I Interface Boards	Design, prototype, production and installation of Layer Sums and Interface for Level I for the EM and Forward Calorimeter for Module 0 and for final ATLAS experiment.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.3.9	ROD System Final Prototype Complete	\$435.4k	7/31/2004 (A)	100	10 Prototype Remapping Boards	Design and prototyping of the Readout Driver boards for the Barrel EM Calorimeter.
1.3.10.1	Forward calorimeter (FCAL) Modules	\$2,253.1k	3/31/2005 (A)	100	2 FCAL Modules	EM Sections of the Forward Calorimeter
1.3.10.2	FCAL Electronics Ready for Installation	\$951.8k	12/31/2003 (A)	100	Electronics for 2 FCAL Modules	Cold electronics, cables, Motherboards, decoupling capacitors for the full Forward calorimeter. Includes Shipping and Tools for assembly
1.3.11	Liquid Argon Support Activities	\$577.5k	9/30/2005 (A)	100	Level of Effort	Level of Effort for installation support.
TOTAL CD-4A Cost		\$47,522.3k				
4) Estimated work remaining through CD-4B, if any: Completion of the acceptance testing and installation of the DC power supplies only.						
5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):						
1.3.1	Barrel cryostat - construction completed, accepted by CERN, operated by the CERN crew in consultation with BNL experts, integration with the LHC cryogenics operation software continues.					
1.3.2.1	Signal Feedthroughs - production and installation completed, operated together with cryostats.					
1.3.2.2	High Voltage Feedthroughs - fabrication and installation completed, operated together with the detector.					
1.3.3	Cryogenics - fabrication and installation completed, accepted by CERN, operated by the CERN crew in consultations with BNL experts. Integration with LHC cryogenics software continues.					
1.3.4.1	Readout electrodes - fabrication and detector assembly completed. Installed inside cryostats. No maintenance needed.					
1.3.4.2	Mother boards - fabrication and on-detector assembly completed. Installed inside cryostats. No maintenance needed.					
1.3.5	Preamps - fabrication completed. Installation on the front end boards will be completed in October. Commissioning of the complete readout electronics continues.					
1.3.6	System crates and services - fabrication completed. Installation of pedestals, crates and cooling infrastructure on the barrel is complete. Integration with readout electronics continues. Power supplies integration with the electronics readout continues.					
1.3.7	FEBs and optical links - fabrication completed, integration with the completed readout electronics system continues.					

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors) (Continued):

- 1.3.8 Level 1 Trigger sums - fabrication completed, integration with readout electronics and with trigger system continues.
- 1.3.9 Readout Driver - prototype completed, production and installation done by other collaborators, commissioning of the back end readout system continues.
- 1.3.10 Fabrication and installation completed, integration of the readout electronics and commissioning continues.
- 1.3.11 Test beams - 2002 and 2004 runs completed. Analyses of the collected data continue.

6) Key Learning Points and Recommendations:

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

R. [Signature] 10/12/05
Level 2 Manager

W. J. [Signature] 12 Oct. 05
Project Manager

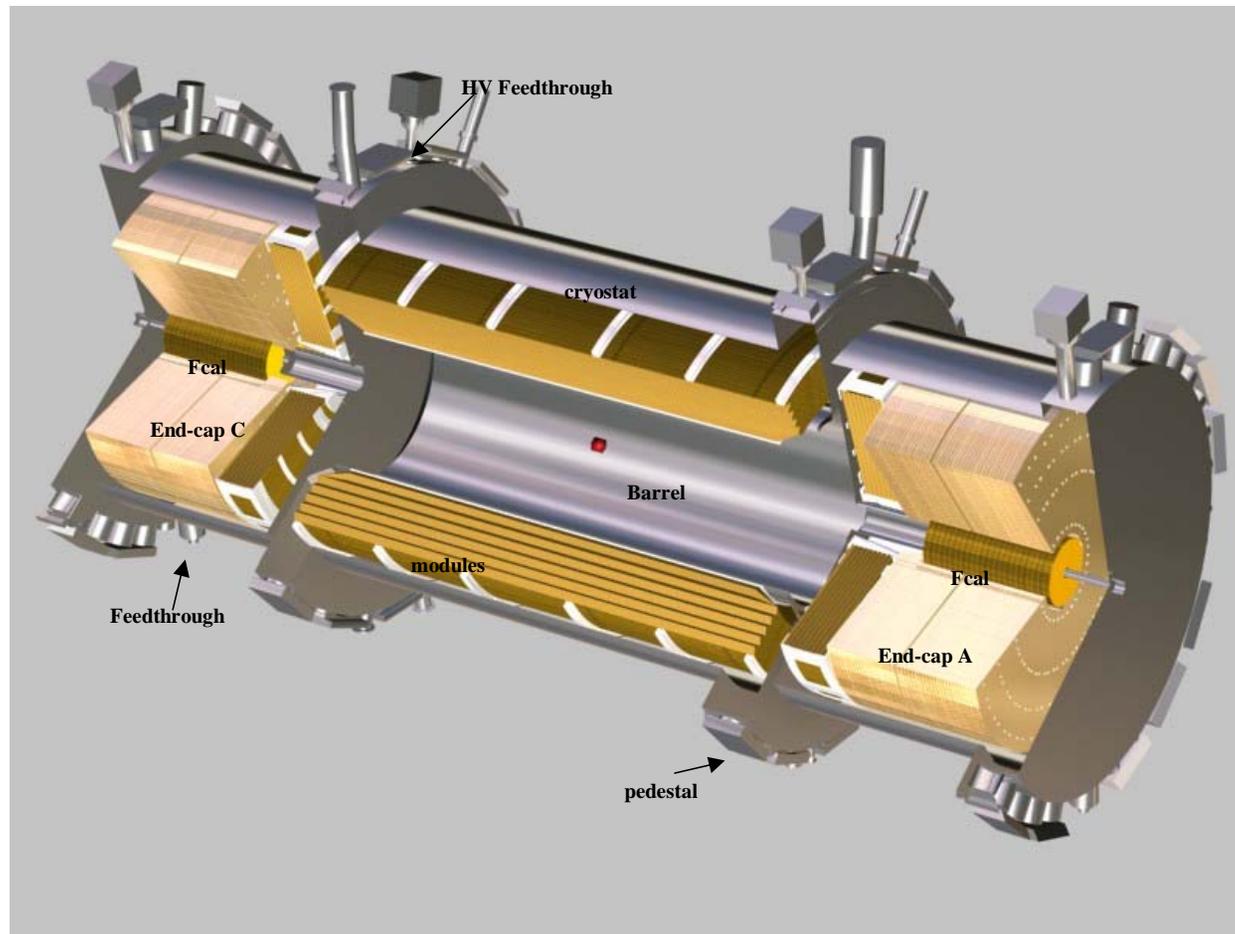
8) Attached Photographic Documentation

- WBS 1.3 Liquid Argon Calorimeter – in cut-away
- WBS 1.3.1 Liquid Argon Barrel Cryostat
- WBS 1.3.3 Liquid Argon Cryogenic System
- WBS 1.3.3 Liquid Argon Cryogenic System
- WBS 1.3.2.1 Signal Feedthrough
- WBS 1.3.2.2 High Voltage Feedthrough
- WBS 1.3.4.1 Readout Electrodes and WBS 1.3.4.2 Motherboards
- WBS 1.3.4.1 Readout Electrodes
- WBS 1.3.10 Forward Calorimeter
- WBS 1.3.6 System Crate
- WBS 1.3.6.5 Cooling Plate WBS 1.3.6.2 Cables
- WBS 1.3.7 Front-End Board
- WBS 1.3.7 Front-End Board
- WBS 1.3.8.1 Level 1 Trigger Interface
- WBS 1.3.8.2 Level 1 Receiver

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem



WBS 1.3 Liquid Argon Calorimeter – in cut-away

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.1 Liquid Argon Barrel Cryostat

Construction



Feedthrough assembly



Transport



Testing



Integration

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.3 Liquid Argon Cryogenic System



Separation Dewar



Quality meter

Proximity piping



U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.3 Liquid Argon Cryogenic System

**Helium main
refrigerator
compressor
station**

**Helium shield
refrigerator
compressor
station**



**Nitrogen
refrigerator
compressor
station**

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

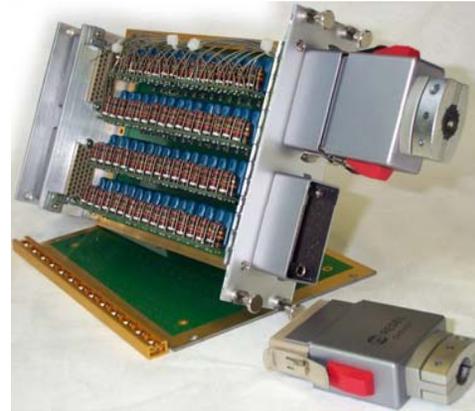
2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.2.1 Signal Feedthrough

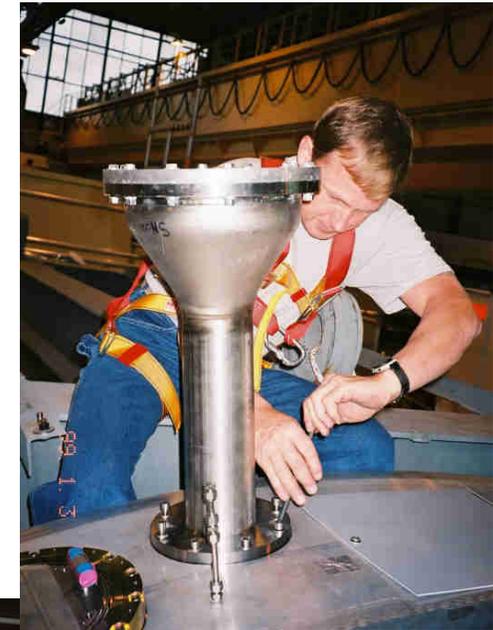


Signal Feedthrough

WBS 1.3.2.2 High Voltage Feedthrough



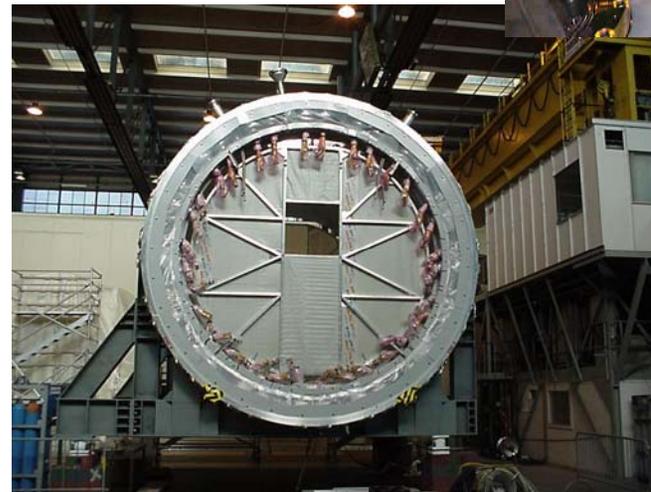
HV Feedthrough filter box



HV Feedthrough



Signal Feedthrough –ready for installation



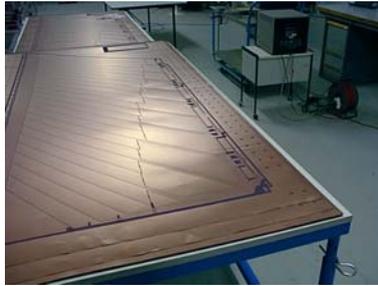
**Feedthrough's
installation completed**

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

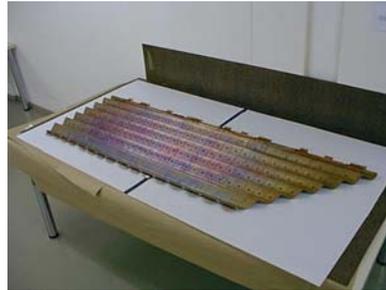
1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.4.1 Readout Electrodes and WBS 1.3.4.2 Motherboards



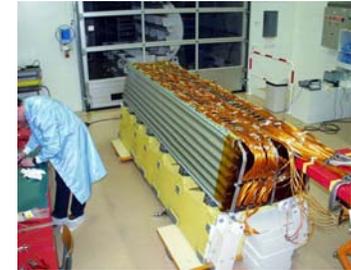
Electrode



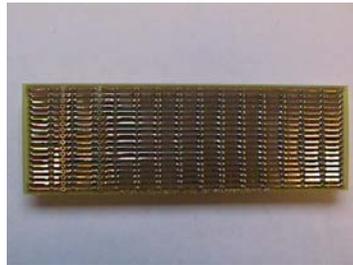
Electrode bending



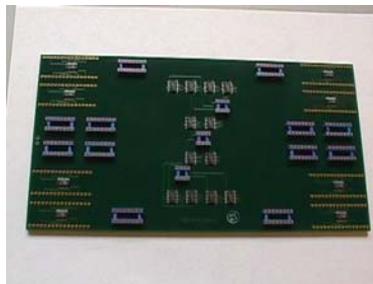
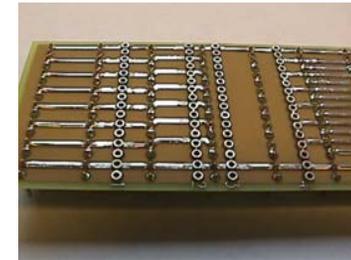
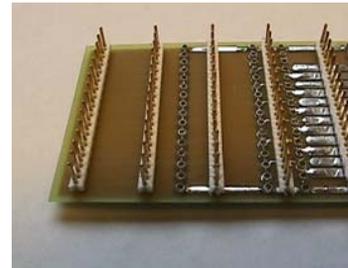
Module assembly



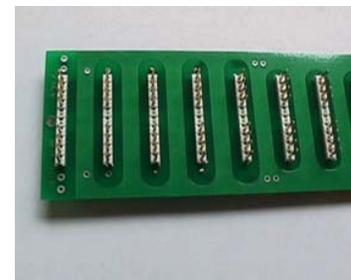
Completed module



Summing boards



Mother boards



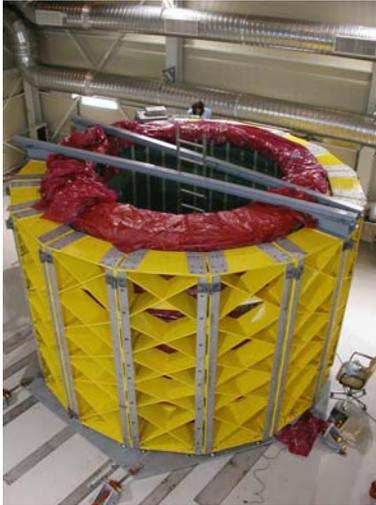
HV boards

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

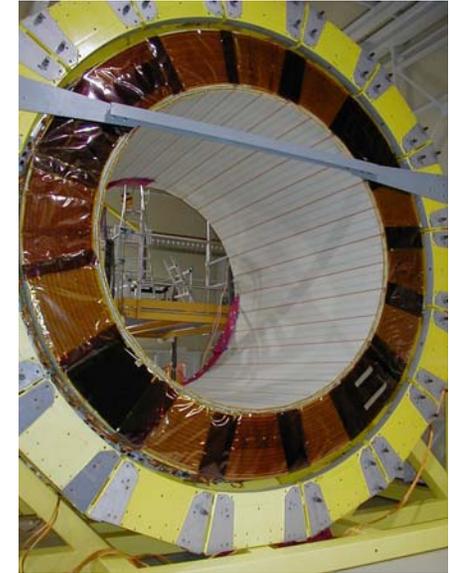
1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

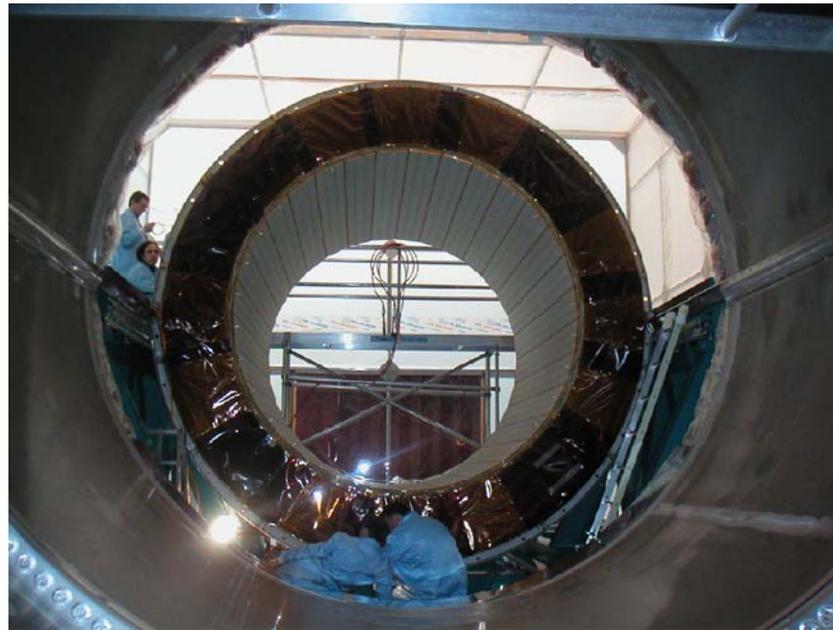
WBS 1.3.4.1 Readout Electrodes



**Half-barrel wheel assembly
16 modules**



**Installation into the
cryostat**



**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

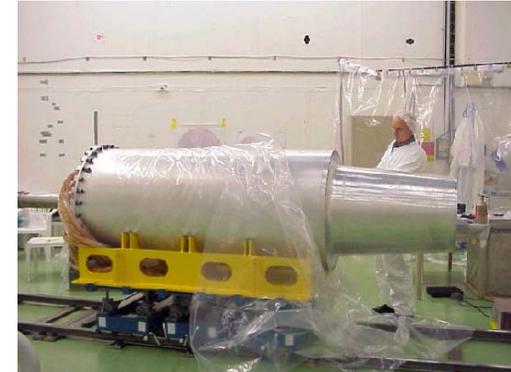
WBS 1.3.10 Forward Calorimeter



First module



Module assembly



Ready for installation



**WBS 1.3.10.2
Summing board**



Installation



**WBS 1.3.10.2
Electronics installation**



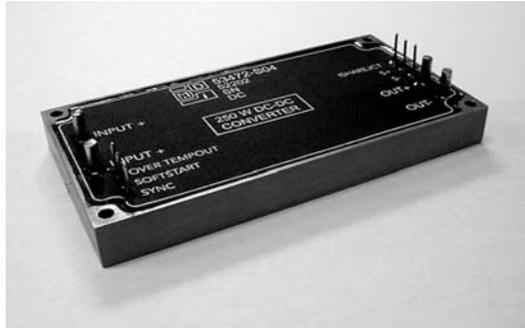
Endcap assembly complete

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.6 System Crate



DC-DC converter module



Power supply unit



Power supply installed



Front End crate

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

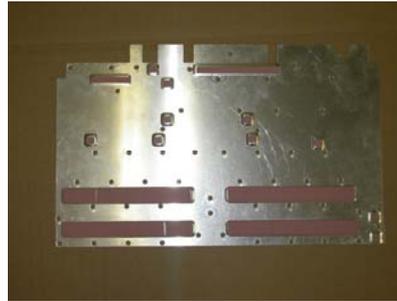
1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

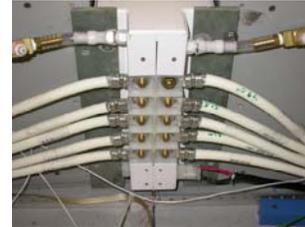
WBS 1.3.6.5 Cooling Plate WBS 1.3.6.2 Cables



Cooling plate



Heat transfer plate



Low voltage cables and connectors



Cooling pipes, cable trays and local cables



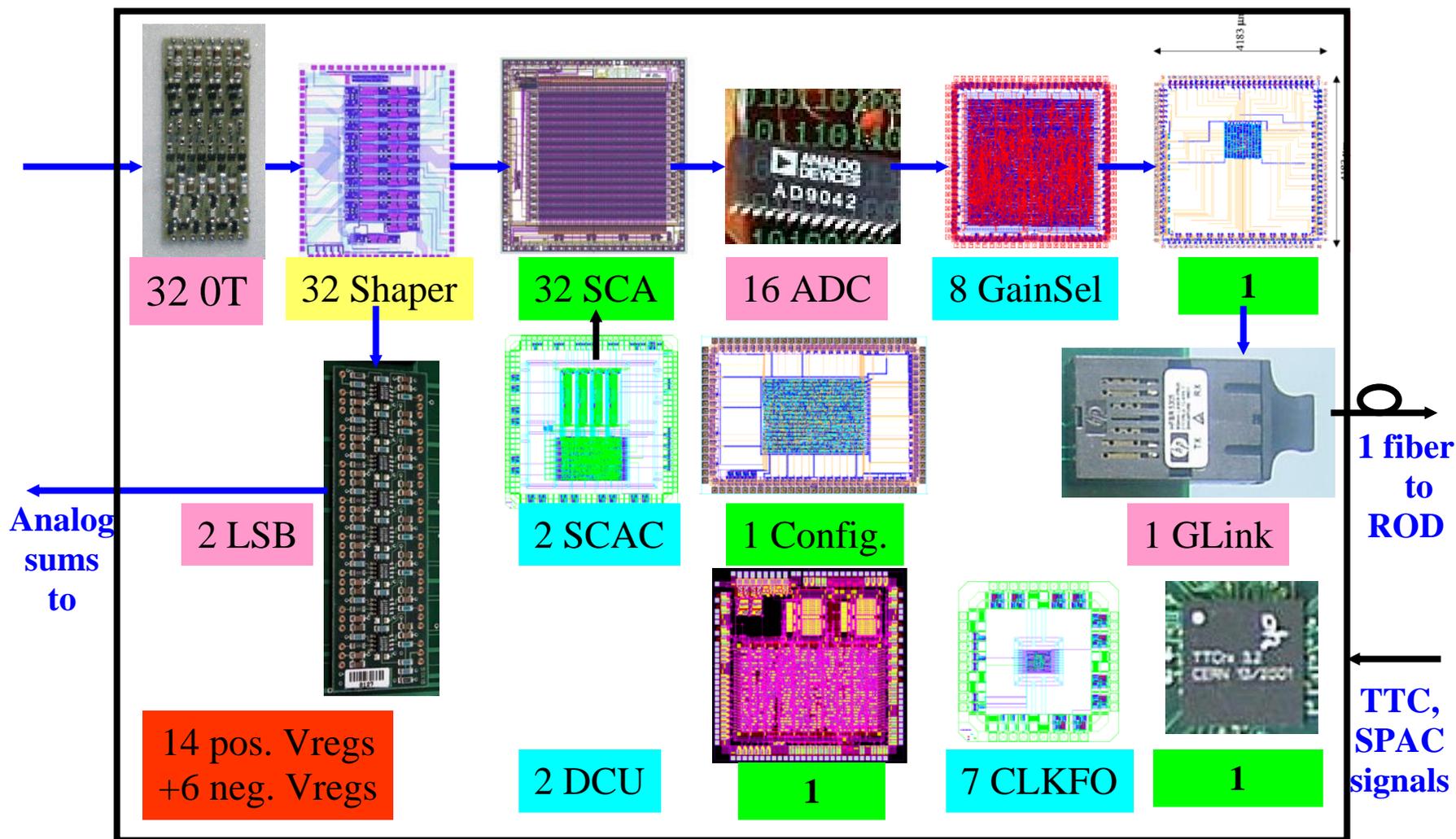
Cable trays for the calorimeters services

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.7 Front-End Board



**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.7 Front End Board and 1.3.6.5 Cooling Plate



FEB



Cooling Plate being installed on FEB



FEB in Test



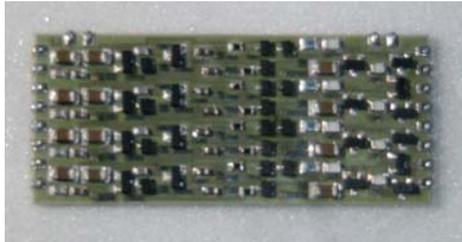
FEB in System Crate

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USA TLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

WBS 1.3.8.1 Level 1 Trigger Interface



Preamplifiers



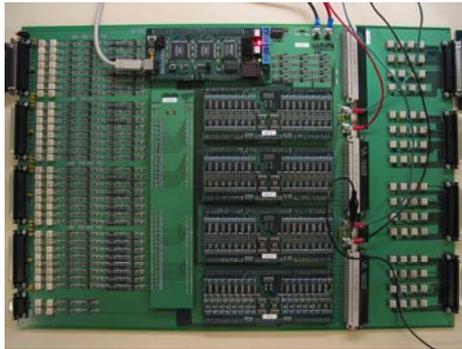
Layer sums board

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.3
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

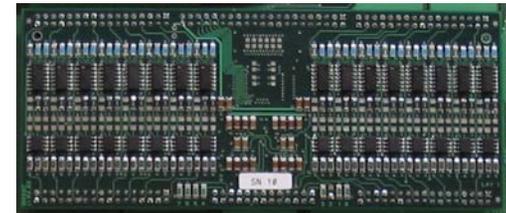
1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.3 Liquid Argon Calorimeter Subsystem

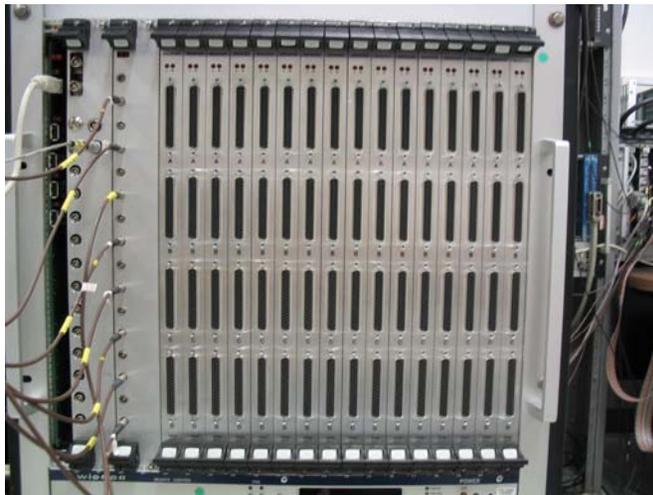
WBS 1.3.8.2 Level 1 Receiver



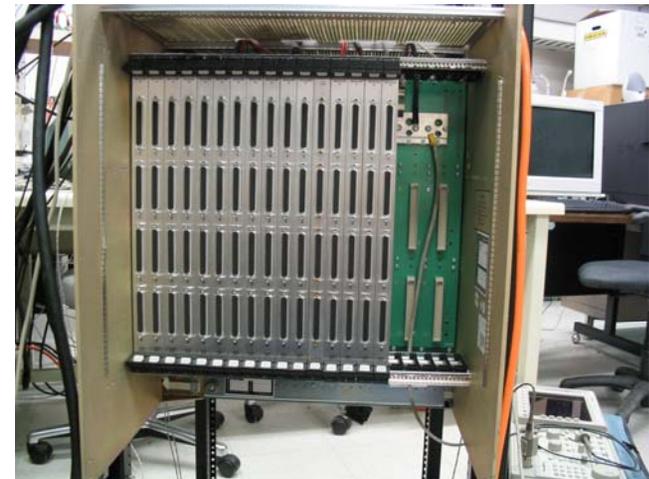
LV1 Receiver board



Variable Gain Amplifier



Front



Back

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.4

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: WBS 1.4 Tile Calorimeter Subsystem

3) Subsystem/WBS Level 2 Item Description:

The ATLAS Scintillating Tile Hadronic Calorimeter is composed of layers of steel and plastic scintillator, arranged to give accurate and geometrically complete measurement of the energy of hadronic particles that enter it from collisions of LHC protons. The scintillator tiles are read out by capturing the light produced in them in adjacent wavelength-shifting fibers routed to photomultiplier tubes. The photomultiplier tubes, in turn, are connected to front-end shaping and amplifying electronics and thence to digital electronics for interfacing to the ATLAS data acquisition system. The structure of the calorimeter comprises a 6 meter long "Barrel" cylinder and two 3 meter long "Extended Barrel" cylinders, with special calorimeter designated at "ITC" collecting energy in the gaps between Barrel and Extended Barrels. Each cylinder is made up of 64 azimuthal modules. Readout electronics are housed in "drawers" that fit in the hollow girders that provide structure at the outer radius of each module.

The Tile Calorimeter is built by an international sub-collaboration of the ATLAS Collaboration. Five institutions in the U.S. had responsibility for providing

- a) Purchase of "Master Plates" for both Extended Barrel cylinders. The other kind of plates that made up the steel fabric of the calorimeter, "Spacer Plates" were bought by European groups and half of each type of plate was exchanged.
- b) Modules for one Extended Barrel Cylinder
- c) Front-end readout electronics for the whole calorimeter
- d) ITC sections attached to each module of both Extended Barrels
- e) Light reflecting wrapping for all scintillator tiles in the Calorimeter and other specialized pieces of the device.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.4.1	EB Production/Ship to CERN	\$5,497.1k	4/30/2003 (A)	100	4.0 FTE yr 41,220 master plates 18,610 Master plates shipped 64 Extended Barrel Submodules 236,000 Scintillator tiles 18,610 Wavelength-shifting fiber installed 2 facing machines for fiber bundle optical couplers	Mechanical Design (level of effort) and procurement support for the Calorimeter Support. 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 for Module 0 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 18,610 Master plates shipped to Barcelona for

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.4.1 (Cont'd)					65 Girders Shipping of 64 EB Submodules	EB production Tooling for submodule and module assembly Mechanical and optical assembly of 64 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 64 Girders with one spare for Submodule support and electronics installation. Testing of assembled modules with Cs sources Two drawer assemblies with readout electronics for module testing Shipping of 64 modules or components to CERN.
	EB Production Installation	\$571.6k	3/30/2006 (F)	70	Level of Effort	Level of Effort for installation of Tile EB Modules.
1.4.2	EB Optics Production	\$1,296.5k	2/28/2003 (A)	100	0.4 FTEyr 472,000 Tyvek Wrappers	Optics R&D (level of effort) Tyvek wrappers for all scintillator tiles for the Barrel and two Extended Barrel calorimeters (shipped to Protvino)
1.4.3	Readout Ship to CERN	\$2,177.1k	3/31/2003 (A)	100	3,397 Photomultiplier Blocks 10,300 channels of 3-in-1 cards + motherboard 277 Interface Boards 1 System control module	Photomultiplier tubes, tested and assembled in PMT blocks. Non PMP parts for PMT block assembly. 3-in-1 cards and Motherboard procurement. 277 Interface Boards to the approved scope. VME Control module (System Control)
1.4.4.1	Gap Submodules	\$1,870.7k	5/31/2002 (A)	100	128 Gap Submodules	ITC Plug special submodules for both Extended Barrel Calorimeters, with end plates.
1.4.4.2	Cryostat Scintillators Mechanics	\$139.3k	9/30/2005 (A)	100	128 Modules	Design and fabrication of 128 modules.
TOTAL CD-4A Cost		\$11,552.3k				
4) Estimated work remaining through CD-4B, if any: Completion of Installation only						

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):

All deliverables from U.S. groups will be completed and delivered to CERN in tested and operational condition by the end of FY 2005. Assembly of the Barrel Calorimeter is complete and assembly of the Extended Barrels will be underway. Installation of services, integration with the rest of ATLAS and commissioning will remain to be completed.

6) Key Learning Points and Recommendations:

Close cooperation and feedback with vendors, including well-agreed inspection and QA procedures are important for key components. This (well-known) lesson was learned in both positive and negative ways.

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

Lawrence E. Price 10/12/05
Level 2 Manager

W J Willis 12 Oct. 05
Project Manager

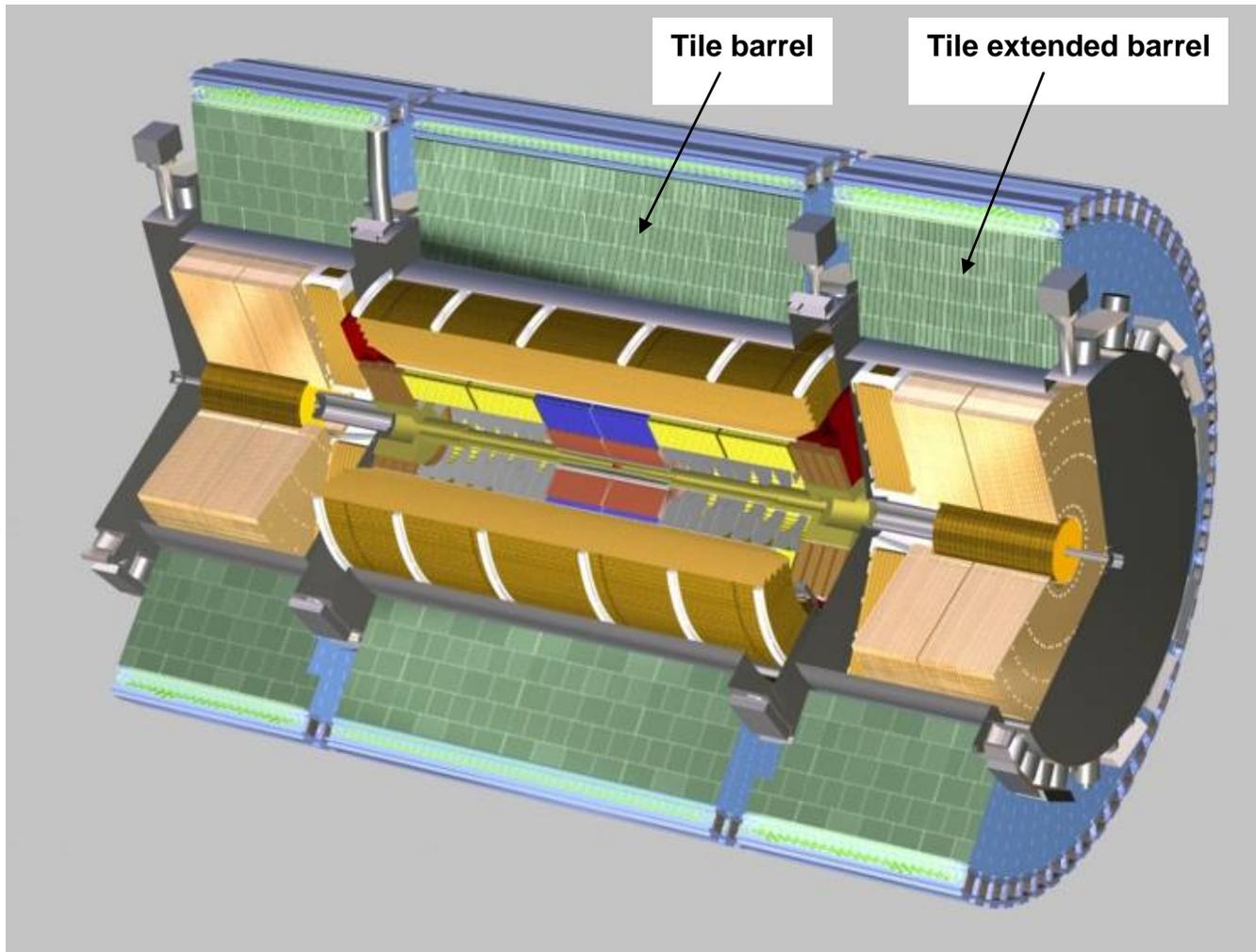
8) Attached Photographic Documentation

- 1 – Scintillating Tile Hadronic Calorimeter in cutaway view
- 2 – Mechanical structure of the Barrel Calorimeter
- 3 – Tile Calorimeter photomultiplier assembly, including PMT base and shield and the front-end 3-in-1 card with connecting cables
- 4 – Tile Calorimeter Drawer, containing photomultiplier tubes and readout electronics
- 5 – Lowering of the initial eight modules of the Barrel Tile Calorimeter into the ATLAS underground cavern

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.4
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Tile Calorimeter WBS 1.4

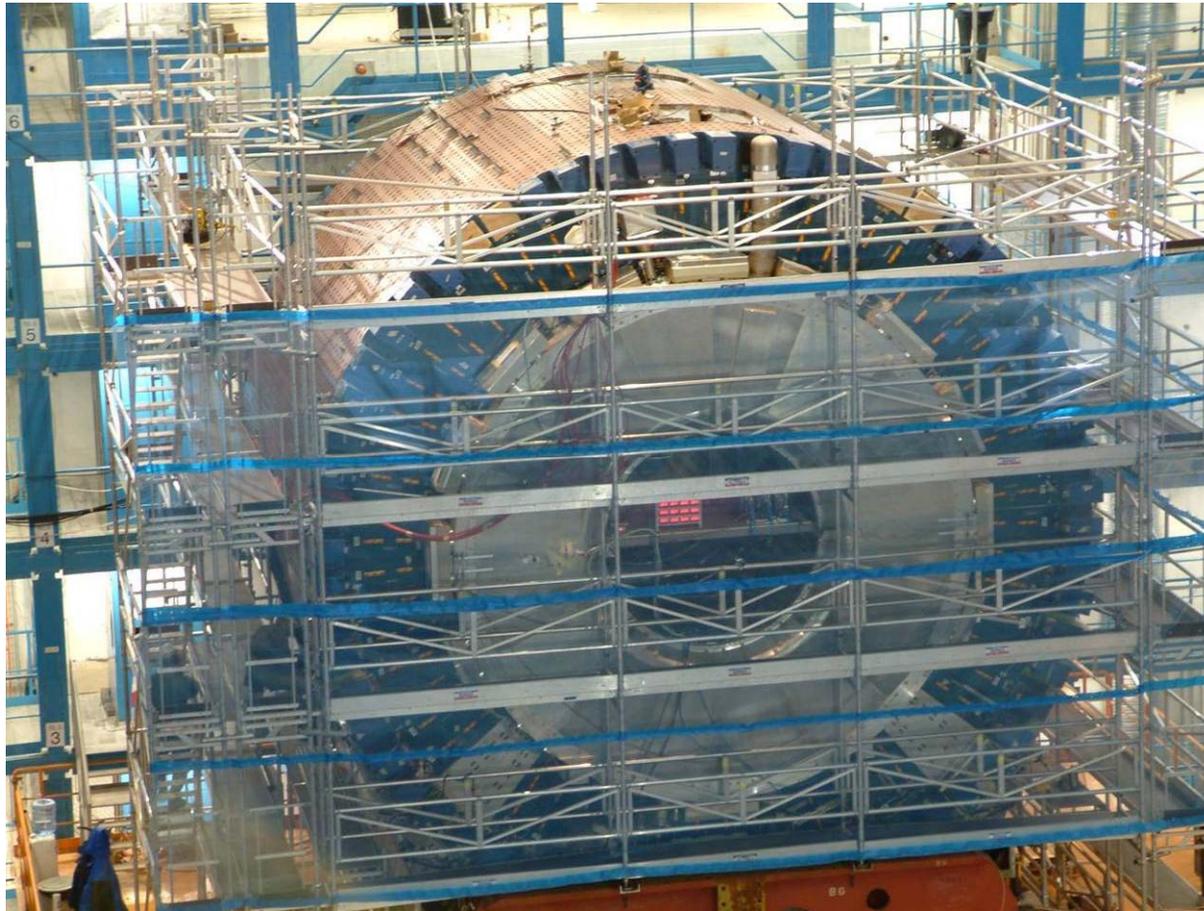


Scintillating Tile Hadronic Calorimeter in cutaway view of the ATLAS Detector, shown in green with blue exterior. The Tile Calorimeter surrounds and supports the Liquid Argon Calorimeter, the Barrel Solenoid, and the Inner (tracking) Detector. (WBS 1.4)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.4
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Tile Calorimeter WBS 1.4

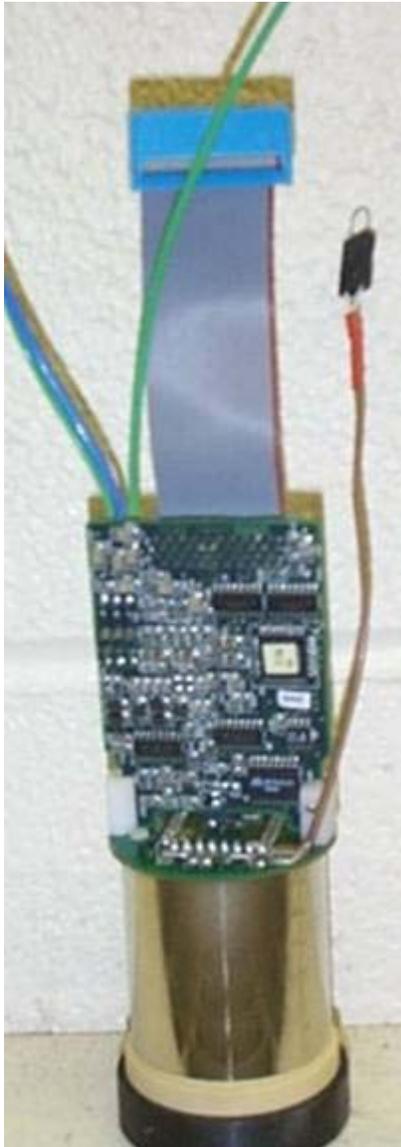


The mechanical structure of the Barrel Calorimeter was completed in December 2004. In this photo, it is surrounded by the scaffold used in the assembly and now for initial testing and commissioning of the calorimeter. The modules with blue ends comprise the Tile calorimeter, while the stainless material is the end of the cryostat containing the barrel solenoid and Liquid Argon Calorimeter. The Barrel Calorimeter was constructed at one end of the detector and will be moved to its final position at the center of the detector in August or September 2005, when Barrel Toroid installation is completed. (WBS 1.4)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.4
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Tile Calorimeter WBS 1.4.3 Electronics



Tile Calorimeter Drawer, containing photomultiplier tubes and readout electronics. The drawer is shown partially withdrawn from its operational position in the hollow girder at the outer radius of a Tilecal module. This photograph was taken during pre-assembly of the Calorimeter in a surface building at CERN. (WBS 1.4.3)

Tile Calorimeter photomultiplier assembly, including PMT base and shield and the front-end 3-in-1 card with connecting cables. (WBS 1.4.3.1)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.4
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: Tile Calorimeter WBS 1.4.1 Installation



Lowering of the initial eight modules of the Barrel Hadronic Calorimeter into the ATLAS underground cavern on March 1, 2004. These were the first active detector elements to be installed in the ATLAS detector. (WBS 1.4.1)

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.5

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: WBS 1.5 Muon Spectrometer Subsystem

3) Subsystem/WBS Level 2 Item Description:

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.5.4.4	CSC Chamber Production	\$2,556.9k	12/31/2004 (A)	100	16 Cathode Strip Chambers (CSC) (Design 1) 16 Cathode Strip Chambers (Design 2)	Design, development and fabrication of 16 CSC Chambers of Design 1 and 16CSC Modules of Design 2.
	CSC Chamber Electro-Mechanical Integration	\$239.7k	10/31/2005 (F)	92	32 Integrated Cathode Strip Chambers	Electro-Mechanical Integration of 16 CSC Chambers of Design 1 and 16 CSC Modules of Design 2.
	CSC Installation Complete		9/30/2006 (F)	0	Level of Effort	Installation of 32 CSC Chambers
1.5.7.1 thru 10	MDT Chambers Production	\$15,520.8k	12/31/2004 (A)	100	240 Monitored Drift Tube Chambers with 88,320 tubes End plugs and tubes for EE MDT Chambers purchased but not constructed	Complete Monitored Drift Tube Chambers including the in-plane alignment system. These consist of 16 each of the following Chamber series: EIL1, EIS1, EIS2, EIL2-3, EMS1, EMS5, EMS4, EML3, EML4, EML5, EML2, EMS2, EMS3, EIL4, and EML1. Total number of fabricated tubes is 88,320 + spares. Engineering design, development of chambers and associated assembly tooling shared throughout all U.S. MDT Groups. Complete Monitored Drift Tube Chambers including the in-plane alignment system. U.S. contribution to the production of the Small Wheel, which will support the MDT chambers. Procurement of end plugs and tubes for the EE chambers.
1.5.7.11	MDTs Installation	\$1,201.7k	1/29/2007 (F)	33	Level of Effort	Level of effort for Installation for the MDT. The installation depends on availability of support structure elements, space at CERN and the overall ATLAS schedule. All of these items are not within US control.

1.5.8	MDT Supports	\$587.6k	7/31/2005 (A)	100	Kinematic Mounts and Chamber Connectors for a total of 240 chamber sets	Design, development and fabrication of 240 sets of kinematic mounts required for the installation of the 240 MDT 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. Design, development and fabrication of 720 chamber connectors (one connectors for each chamber mount to install chambers onto end cap structure).
1.5.9.1	Mezzanine Card Production	\$1,628.0k	12/31/2004 (A)	100	444,787 Channels of ASD Chips 17,242 Mezzanine Boards	Design and fabrication of ASD chips needed for entire ATLAS Muon Spectrometer, plus 20% spares. Design, development and fabrication of 17,242 Mezzanine PC boards required for the entire ATLAS Muon Spectrometer. The 17,242 TDC chips required will be supplied by the Japanese groups. Israel will contribute manufacturing for U.S. [BCP 61]
1.5.9.2	Hedgehog Card Production	\$424.7k	12/31/2004 (A)	100	3,680 Signal Hedgehog Boards Prototype HV Hedge Hog Boards	Design, development and fabrication of signal hedgehog boards needed for the 240 U.S. MDT chambers. Design, development and Prototype of High Voltage hedgehog boards. Fabrication is not a U.S. responsibility.
1.5.9.3	CSM Cables	\$243.7k	9/30/2004 (A)	100	3,680 Cable Sets	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	CSMs	\$1,195.5k	7/15/2005 (A)	100	Prototype and 276 CSM4 Modules	Design, development and production of CSM (Chamber Service Module) for MDT readout for US MDT chambers.
1.5.9.5	Detector Control System	\$38.6k	9/30/2003 (A)	100	Modification of DCS units to allow readout of Seattle T-sensors	Design, development and modification of Detector Control Modules for EML, EMS and EIL4 chambers to readout Seattle T-sensors.
1.5.9.6	MDT Electronics Support Activities	\$708.4k	9/30/2004 (A)	100	Level Of Effort	Support of MDT electronics through installation

1.5.11.1	ASM1 Boards Production	\$1,622.4k	3/31/2005 (A)	100	320 ASM I Boards	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.
1.5.11.2	ASM2 Boards Production	\$111.0k	5/31/2005 (A)	100	160 ASM II Boards	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	LV Power, Cabling Production	\$208.4k	12/31/2005 (F)	87	32 pairs of gauge 2 wires to be bought through CERN	Specification of low voltage power, cooling, and cabling for CSC electronics. Procurement of power and cabling infrastructure.
1.5.11.5	RODs Production	\$579.3k	2/7/2006 (F)	94	16 Modules	Design, development and fabrication of 9U-VME Readout Driver modules needed for two CSC endcaps.
1.5.11.6	Support Electronics Production	\$67.2k	1/9/2006 (F)	91	2 9U Crates 1 6U Crate 3 CPUs 2 TIM modules 2 backplanes	Provide 9U-VME crates w/ CPU & timing module for CSC off-chamber electronics. Layout of custom crate backplane is included. Provide 6U-VME crate w/ CPU & ATLAS standard timing modules.
1.5.11.7	Readout Software	\$291.1k	9/30/2004 (A)	100	Software	Design and implement software embedded in off-detector electronics for readout of CSCs.
1.5.11.8	HV Supplies Production for CSCs	\$60.6k	9/30/2005 (A)	100	128 channels	Procurement of high voltage supplies for 32 CSCs. (CAEN), ordered through CERN which will invoice BNL
1.5.11.10	Transition Modules Production	\$100.0k	2/7/2006 (F)	85	16 modules	Design, development and fabrication of 9U-VME transition modules for two CSC endcaps.

1.5.12.3	Global System Production Ship to CERN	\$2,258.9k	3/31/2006 (F)	99	64 sets of Alignment bar internal optics 544 Azimuthal BCAMs 256 Polar BCAMs 864 Bar Masks (480/384EO) 208 Chamber Masks (112/96EO) 456 On-chamber LASER Sources (264/192EO) 1070 Proximity Cameras (590/480EO) 672 LWDAQ Multiplexers (416/256EO) 86 LWDAW Drivers (VME)	Internal Bar Monitors, Image Sensors, and Masks for 64 Alignment Bars Provide 800 BCAMs for the Global Multi- Point Alignment System. These are itemized as follows: Polar BCAMs – 160 Radial BCAMs – 160 Azimuthal BCAMs – 480 Design, development and fabrication of 240 sets of Proximity Monitors for the MDT Chambers. This includes: Proximity Cameras – 590 Proximity Chamber Masks – 112 Proximity Bar Masks – 480 Laser Sources – 264 Design, development and fabrication of 192 sets of Proximity Monitors for the MDT EO Chambers. This includes: Proximity Cameras – 480 Proximity Chamber Masks – 96 Proximity Bar Masks – 384 Laser Sources – 192 Readout for Alignment System, including: 672 LWDAQ Multiplexers 86 LWDAW Drivers (VME)
1.5.12.4	MDT Inplane Monitor Production	\$418.7k	9/30/2004 (A)	100	240 sets 192 sets (EO)	Design, development and fabrication of 240 sets of In-plane alignment for the MDT Chambers. This includes: In-plane Image Sensor – 480/ +384 EO In-plane Masks – 480/+384 EO In-plane Lenses – 960/+768 EO
1.5.12.5	Global System Prod Installation at CERN	\$122.5k	1/17/2007 (F)	20	Level of Effort	Installation at CERN limited to level of effort.
TOTAL CD-4A Cost		\$31,185.7k				

4) Estimated work remaining through CD-4B, if any:

- Final assembly run and production testing of CSC ROD, backplane, and Transition Module.
- Installation of CSC, MDT and Alignment deliverables only. Schedule dependent on items beyond US control.

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):

1.5.4 CSC Chambers - All 32 chambers have been integrated with electronics, Faraday cages and cooling. Installation scheduled for 2006.

1.5.7 MDT Chambers - All 240 chambers have been certified with cosmic rays at CERN and are ready for installation. Installation has begun, and will continue through 2006.

1.5.8 MDT Supports - All items are made and shipped to CERN.

1.5.9.1 Mezzanine Cards - All mezzanine cards are installed on the 240 MDT chambers.

1.5.9.2 Hedgehog Cards - All hedgehog cards are installed on the 240 MDT chambers.

1.5.9.4 CSMs - All units are made and acceptance tested for 240 US chambers. CSMs are mounted and tested on those chambers that have passed the 'Phase 1.9 Commissioning' (80/240 chambers).

1.5.9.5 Detector Control System - Constructed and mounted on all Phase 1.9 certified chambers.

1.5.11.1 ASM1 Boards - Complete. All boards are mounted on CSC chambers and tested. Production prototype boards were tested in X5-GIF and H8 test beams at CERN that validated design.

1.5.11.2 ASM2 Board - All boards are mounted on CSC chambers and tested.

1.5.11.3 LV Power, Cabling - Delivery of items and integration with chambers will follow installation of the SWs in early 2006.

1.5.11.5 RODs - Undergoing late stages of design, a prototype was tested on a operating CSC chamber at BNL.

1.5.11.6 Support Electronics - Specified and most parts purchased.

1.5.11.7 Readout Software - Complete.

1.5.11.8 HV Supplies for CSCs - Specified and ordered.

1.5.11.10 Transition Modules Production - In final stages of design.

1.5.12.3 Global System - Complete, with the exception of the EO devices, and some sources. Component availability at CERN has been ahead of critical path.

1.5.12.4 MDT Inplane Monitor - Complete and integrated in all 240 chambers, and commissioned during Phase I for the chambers.

6) Key Learning Points and Recommendations:

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

J. E. Taylor 12-Oct-05.
Level 2 Manager

W J Willie 12 Oct. 05
Project Manager

8) Attached Photographic Documentation

WBS 1.5.12 MDT BW Alignment Bar at CERN during certification check in clean room in B184 @ CERN

WBS 1.5.7 University of Washington Team working on EIL4 support frame in B180 at CERN

WBS 1.5.12 First BW alignment bar being inserted in first BW-L sector in B180 at CERN

WBS 1.5.7 Student working on installation of chamber services on BW-L sector in B180 @ CERN

WBS 1.5.7 A-frame tooling to hold BW-L sector vertical for chamber insertion under load certification in B180 @ CERN

WBS 1.5.7 EIL4 constructed by University of Washington Seattle under final test prior to installation in support structure in B180 @ CERN

WBS 1.5.7 MDT Installation Tooling in B180 @ CERN

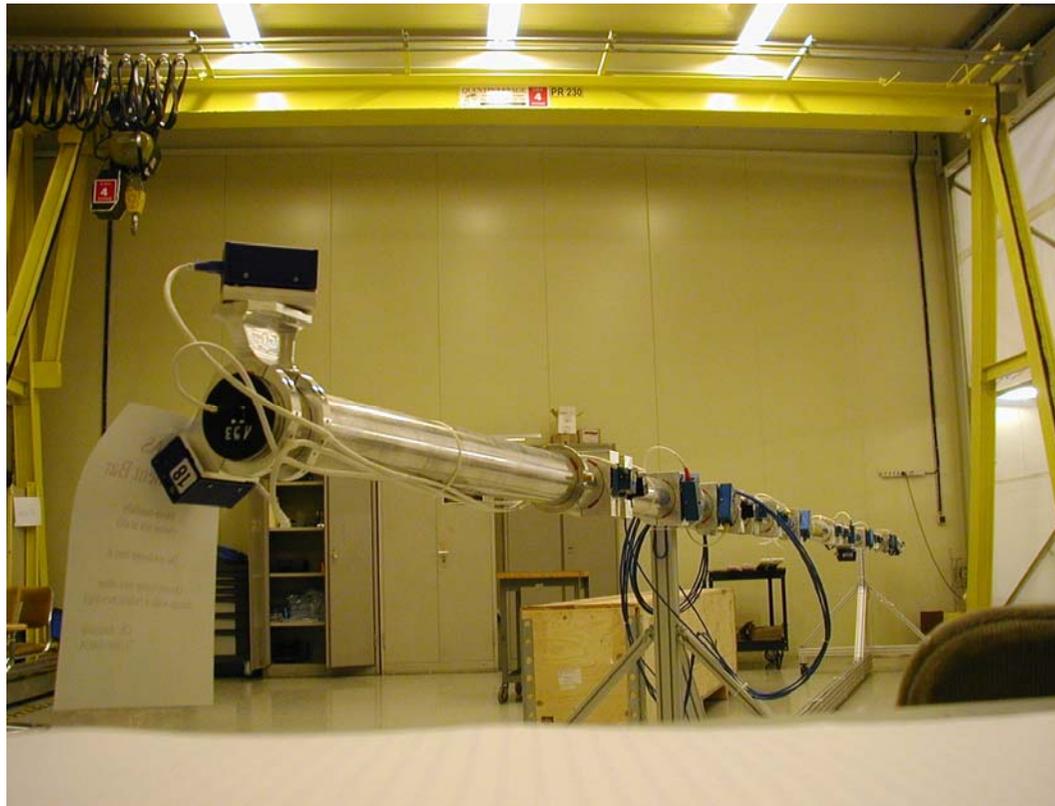
WBS 1.5.7 Chamber verticalizer tooling certified for use in B180 @ CERN

WBS 1.5.4 Integrated CSC chamber under final testing at BNL

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



MDT BW Alignment Bar at CERN during certification check in clean room in B184 @ CERN WBS 1.5.12

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U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



University of Washington Team working on EIL4 support frame in B180 at CERN WBS 1.5.7

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



First BW alignment bar being inserted in first BW-L sector in B180 at CERN WBS 1.5.12

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



Student working on installation of chamber services on BW-L sector in B180 @ CERN WBS 1.5.7

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem

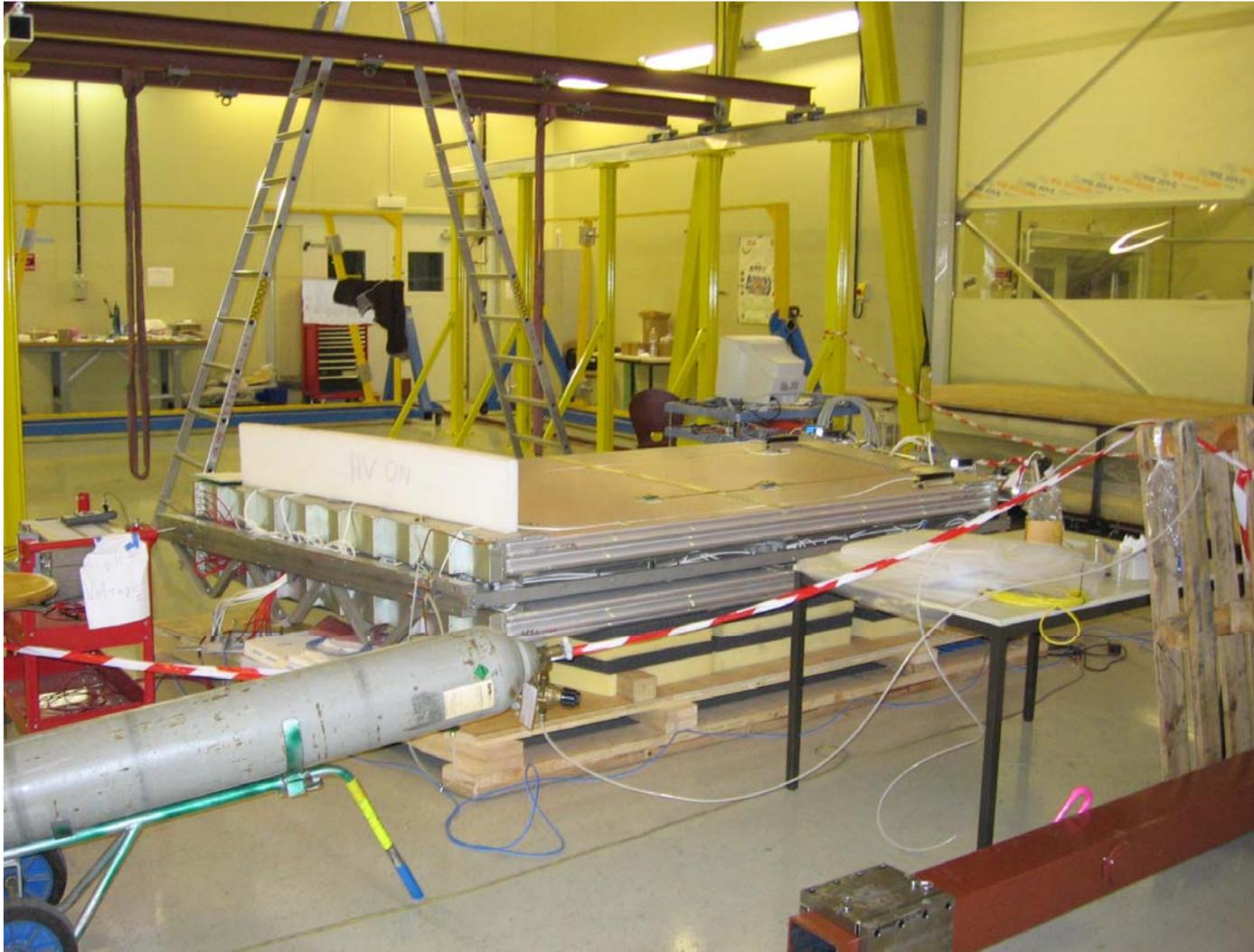


A-frame tooling to hold BW-L sector vertical for chamber insertion under load certification in B180 @ CERN WBS 1.5.7

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



EIL4 constructed by University of Washington Seattle under final test prior to installation in support structure in B180 @ CERN WBS 1.5.7

**U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items**

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



MDT Installation Tooling in B180 @ CERN WBS 1.5.7

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem

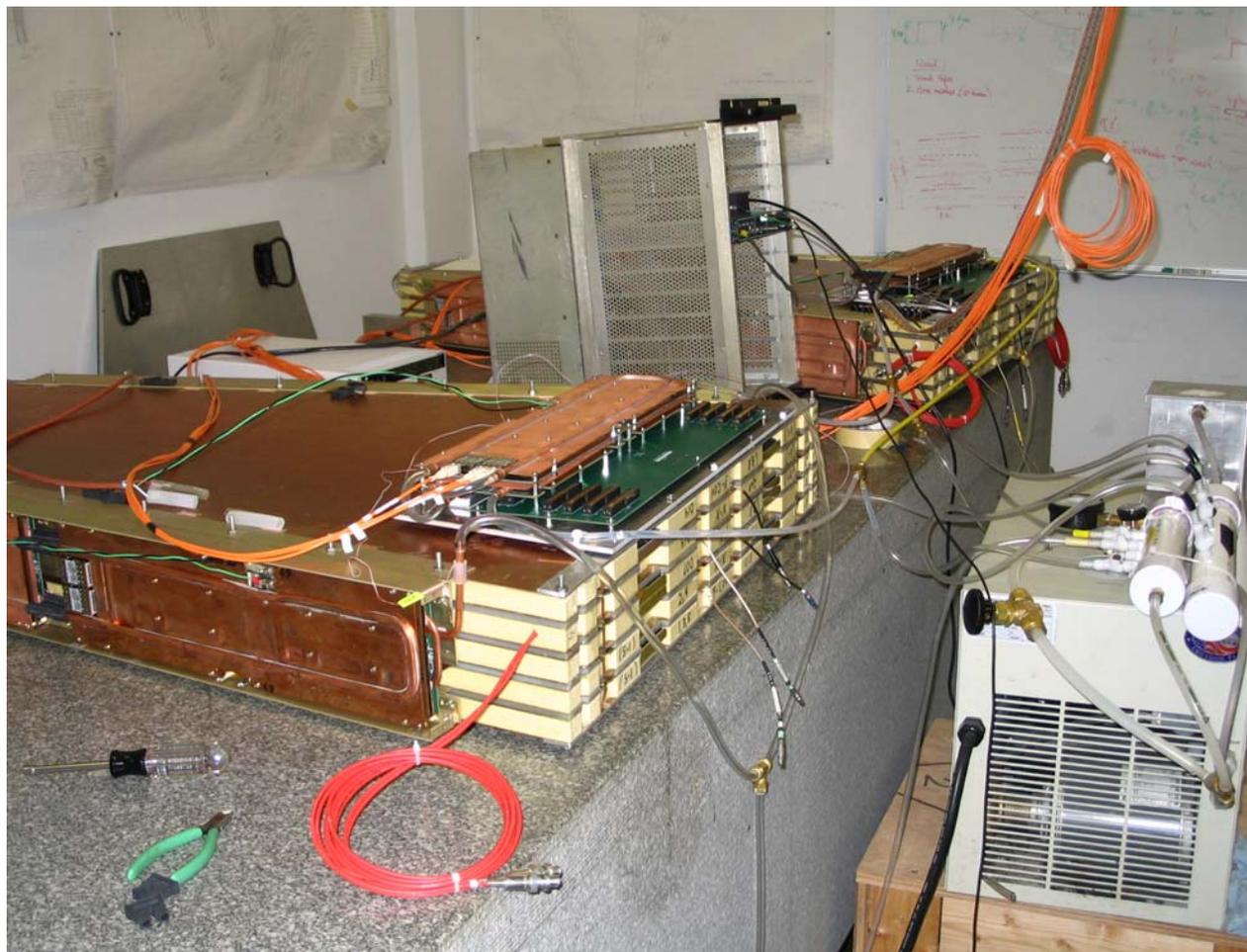


Chamber verticalizer tooling certified for use in B180 @ CERN WBS 1.5.7

U.S. LHC Project CD-4A Closure Report, ATTACHMENT US ATLAS 1.5
Sampling of Photographic Documentation of completed WBS/Subsystem Items

1) Project: U.S. ATLAS

2) Subsystem/WBS Number(s) and Item(s) Depicted: WBS 1.5 Muon Spectrometer Subsystem



Integrated CSC chamber under final testing at BNL WBS 1.5.4

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.6

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: WBS 1.6 Trigger/Data Acquisition (TDAQ) Subsystem

3) Subsystem/WBS Level 2 Item Description:

The ATLAS Trigger and Data Acquisition System transports data from detector-specific front-end electronics systems to trigger processors, performs event selection, and transports selected event data to archival storage. U.S. ATLAS contributions consist of full responsibility for the custom and commercial hardware for the Region-of-Interest Builder and LVL2 Supervisor subsystem (1.6.1), which controls the Level 2 Trigger; shared responsibility (at level of effort) for Data Acquisition Software (1.6.2), which transports data, and High Level Trigger Software (1.6.3), which performs event selection; and shared responsibility (fixed dollar contribution) for Network and Farm Infrastructure (1.6.4) hardware, which is comprised principally of commercial network and processor components.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.6.1	Supervisor RoI Builder				Level of Effort	100% of design, development, procurement, fabrication, and installation of hardware and software of LVL2 Supervisors and Region-of-Interest Builder. ATLAS will provide interface definitions.
1.6.1.2	RoI Production	\$1,635.7k	3/31/2006 (F)	88	15 Input boards 14 Builder boards 9 backplanes 9 TTC LDCs	100% of design, development, procurement, fabrication, and installation of custom hardware of Region-of-Interest Builder.
1.6.1.3	Supervisor RoIB Equipment	\$346.1k	4/30/2007 (F)	47	40 LDCs 22 LSCs 20 S32PCI64 20 PCs 4 single brd CPUs 3 crates 3 file servers 2 racks 24 cables	100% of specification, procurement, assembly, and installation of commercial and ATLAS standard equipment of LVL2 Supervisors and Region-of-Interest Builder. 100% of design, development, implementation, integration, and testing of software for LVL2 Supervisors.
1.6.2	Data Acquisition Software (LOE)	\$934.0k	9/30/2007 (F)	69	Level of Effort DAQ SW Development DAQ SW Integration & Testing	Contribution of effort to development, integration, and testing of data acquisition software. ATLAS collaborators will provide the remainder of the required effort. Contribution of effort to the development of data acquisition software. Contribution of effort to the integration and testing of data acquisition software.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.6.3	High Level Trigger Software (LOE)	\$1,345.3k	9/30/2007 (F)	74	Level of Effort High Level Trigger Software HLT SW Development HLT SW Integration & Testing	Contribution of effort to development, integration, and testing of high level trigger software. ATLAS collaborators will provide the remainder of the required effort. Contribution of effort to the development of high level trigger software. Contribution of effort to the integration and testing of high level trigger software.
1.6.4	Network & Farm Infrastructure Production	\$909.5k	9/30/2007 (F)	33		Network & Farm Infrastructure Production defined as follows:
1.6.4.1	Pre-series				56 CPUs 4 switches	Deliverable: 62.8% of Pre-series HLT/DAQ system. Italy, Switzerland, UK, and CERN will provide remainder. ATLAS will provide technical specifications.
1.6.4.2	Network Infrastructure				86 ports (Level 2 Network) 1 switch (Event Building Network) 43 ports (Online Network)	Deliverable: 16.3% of central switches. See 1.6.4.2.1 and 1.6.4.2.3 below. Deliverable: 33% of LVL2 central switch, including hot replacement units. UK and CERN will provide remainder. ATLAS will provide technical specifications. Deliverable: DFM switch Deliverable: 17% of switching equipment for Online Network, including hot replacement units. Japan, Switzerland, UK, and CERN will provide remainder. ATLAS will provide technical specifications.
1.6.4.3	DAQ Processors				14 CPUs (Event Filter I/O) 1 switch (Event Filter I/O) 1 server (Event Filter I/O) 1 rack (Event Filter I/O) 2 CPUs (PseudoROS)	Deliverable: 18.2% of complete EFIO racks, including licenses and links to computer center. Italy, Switzerland, and CERN will provide remainder. ATLAS will provide technical specifications. Deliverable: PCs for PseudoROS.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.6.4.4	High Level Trigger Subfarms				Level 2 Subfarms: 58 CPUs 12 switches 2 servers 2 racks Common Project Processors: 281 CPUs 13 switches 13 servers 13 racks	Deliverable: 21.2% of LVL2 processor racks, including licenses (Level 2 Subfarms). Czech Rep., Denmark, Israel, Italy, Poland, UK, and CERN will provide remainder. ATLAS will provide technical specifications. Deliverable: 35% of Event Filter processor racks, including licenses (Common Project Processors). This deliverable is credited 93% towards ATLAS Common Projects. Non-U.S. ATLAS collaborators will provide remainder. ATLAS will provide technical specifications.
TOTAL CD-4A Cost		\$5,170.6k				
4) Estimated work remaining through CD-4B, if any: All Trigger/DAQ Subsystem effort will continue into CD-4B						
5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):						
<p>1.6.1.2 RoIB Production Input boards, Builder boards, and Backplanes – design and prototyping complete, awaiting PRR TTC LDCs – procurement awaiting PRR Pre-series RoIB system delivered and installed.</p> <p>1.6.1.3 Supervisor RoIB Equipment Procurement awaiting PRR. Pre-series Supervisor delivered and installed.</p> <p>1.6.2 Data Acquisition Software (LOE) Software development, integration, and testing proceeding according to schedule. Much software already in pre-operations and commissioning. Ready for detector commissioning. Final software release planned for end FY07.</p> <p>1.6.3 High Level Trigger Software (LOE) Software development, integration, and testing proceeding according to schedule. Much software already in pre-operations and commissioning. Final software release planned for end FY07.</p> <p>1.6.4.1 Pre-Series CPUs and switches delivered, installed, and commissioned. Pre-series system operating in support of software commissioning and ready for detector commissioning. 2nd (of 2) central file servers to be procured when specification complete</p>						

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors) (Continued)

1.6.4.2 Network Infrastructure

Technical specification for procurement in progress. Procurements planned for FY07.

1.6.4.3 DAQ Processors

Technical specification for procurement in progress. Procurements planned for FY07.

1.6.4.4 High Level Trigger Subfarms

Technical specification for procurement in progress. Procurements planned for FY07.

6) Key Learning Points and Recommendations:

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

Andrew J. Sanford 10/12/05
Level 2 Manager

W J Willis 12 Oct. 05
Project Manager

8) Attached Photographic Documentation

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.7-9

1) Project: U.S. ATLAS 2) Subsystem/WBS Level 2 Item: 1.7-1.9 Common Funds/Education Outreach/Project Management

3) Subsystem/WBS Level 2 Item Description: Common Funds, Education Outreach, and Project Management.

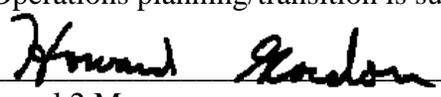
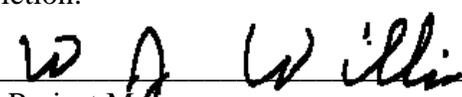
Common Costs or Common Projects is the WBS used to fund the U.S. contribution to the common items and infrastructure of the ATLAS Experiment. These include Institution dues, toroidal magnet production, Trigger and Data Acquisition, and other infrastructure of the experiment.

U.S. ATLAS has supported a broad range of Education and Outreach activities as part of the Construction Project. All U.S. ATLAS institutions are active participants in the NSF- and DOE-funded QuarkNet program since it's inception in 1999. The program aims to involve U.S. high school teachers and students in current high energy physics research. Institutions have expanded the scope and reach of their QuarkNet programs with the help of U.S. ATLAS funds, including: Brandeis University, the University of California at Irvine, the University of California at Santa Cruz, Hampton University, Michigan State University, Southern Methodist University and the State University of New York at Stony Brook. Most of the U.S. ATLAS groups have had significant undergraduate and graduate student involvement in their detector construction projects and their research activities.

Project Management is the WBS used to fund the costs for budget and schedule management of the US ATLAS Construction Project. This includes salary and travel for a Project Director, Deputy Project Director and 2 Project Engineers, and 1-1/2 to 2 Budget and Schedulers and a Secretary. Activities include Monthly reporting for technical and financial progress, budget and schedule administration, oversight of Subsystem progress, and participation in periodic reviews with Funding Agencies, CERN, and ATLAS.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.7	Common Projects Common Projects (NSF Final Payment)	\$14,968.5k \$345.0k	7/31/2005 (A) 9/30/2005 (A)	100 100	In kind Contribu- tion and USD	CERN-RRB-2005-017, <i>Proposals for In-Kind Contributions and Status of the ATLAS Common Projects and Construction Completion</i> documents the Common Costs allocation among the Collaborators for the ATLAS Detector. The US contribution is defined as 35,500 CHF, with 15,150 CHF being In-Kind Contributions and 12,759 CHF being Cash Contributions, plus dues for each collaborating institution of 100 CHF/institution, totaling 3,712.5 CHF. In-Kind Contributions are: - design of LAr barrel cryostat (WBS 1.3.1)

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
						<ul style="list-style-type: none"> - construction of LAr barrel cryostat (WBS 1.3.1) - signal feedthroughs for LAr barrel (WBS 1.3.2.1) - high voltage feedthroughs for LAr barrel and end-cap cryostats (WBS 1.3.2.2) - engineer for central magnet project team - parts of LAr prox. and external cryogenics (WBS 1.3.3) - extension of supply for LAr cryogenics (WBS 1.3.3) - TDAQ processors (WBS 1.6.4.4.2) <p>The costs for the In-Kind contributions are attributed to the WBS suffix where indicated. This WBS contains the costs for the cash contributions and the salary for the magnet engineer.</p>
1.8	Education Outreach	\$ 135.2 k	6/30/2005 (A)	100%	Level of Effort	<p>U.S. ATLAS funds have supported the production of two ATLAS Outreach videos, for lay audiences, and suitable also for high school students. The first of these, "The ATLAS Experiment", has won numerous awards at film festivals around the world. It is available on the World Wide Web, and has been distributed in CD format to schools across the U.S. A second video, currently nearing completion at the University of California at Santa Cruz, includes a dramatic 3D animation and "fly-through" of both the ATLAS experiment and the LHC accelerator, and is expected to further broaden the reach of our Outreach programs, especially to younger audiences.</p>

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
						We have funded the production and distribution of a series of ATLAS Outreach posters, highlighting the exciting physics program of the LHC, the construction and operation of the mammoth ATLAS detector, and providing a glimpse into the workings of an international collaboration of more than 2,000 scientists from all corners of the globe. U.S. ATLAS funds have also supported the production of a widely-distributed U.S. ATLAS brochure, and a number of activities for the general public, including a public talk by award-winning author Dava Sobel, organized as part of an ATLAS Collaboration Meeting at Brookhaven National Laboratory.
1.9	Project Management	\$ 8,380.2 k	9/30/2005 (A)	100%	Level of Effort	Management of the US contribution to the ATLAS Detector
TOTAL CD-4A Cost		\$ 23,828.9 k				
4) Estimated work remaining through CD-4B, if any: Common Costs						
5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors): 1.7 Not Applicable 1.8 Not Applicable 1.9 The U.S. ATLAS Project Office has transitioned to the U.S. ATLAS Program Office.						
6) Key Learning Points and Recommendations: None						
7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion: <div style="display: flex; justify-content: space-between;"> <div style="text-align: center;">  _____ Level 2 Manager </div> <div style="text-align: center;"> 10/12/05 </div> <div style="text-align: center;">  _____ Project Manager </div> <div style="text-align: center;"> 12 Oct. 05 </div> </div>						
8) Attached Photographic Documentation See applicable WBS Level 2 for photographs of In-Kind Contributions.						

U.S. LHC Project CD-4A Closure Report, ATTACHMENT USATLAS 1.10

1) Project: U.S. ATLAS

2) Subsystem/WBS Level 2 Item: Technical Coordination/WBS 1.10

3) Subsystem/WBS Level 2 Item Description: The Technical Co-ordinator:

- coordinates and/or executes the construction of the ATLAS detector (TC monitors the (sub)system construction, and is responsible for all the Common Projects and infrastructure construction)
- coordinates the installation and commissioning of ATLAS (TC will coordinate the (sub)system installation and execute the installation and the commissioning at the global scale)
- oversees all ATLAS technical issues
- oversees the construction, integration, installation, commissioning of all items ending up in the ATLAS experimental zone.

US ATLAS provides personnel and other resources for management of the Technical Coordination Project Office.

WBS	Task	BCWP through CD-4A Date	Completion Date	% Complete through CD-4A	Baseline Quantity or Itemization	Deliverable Description
1.10	Level of Effort Support and staff the Technical Coordination Office	\$3,095.3k	12/31/2004 (A)	100%	LOE	US technical coordination is embedded in ATLAS technical coordination and supplied support in critical areas. Among the major contributions of the US were: Configuration control, Installation and access tooling, Calorimeter Movement hardware and control, Beam pipe installation and support.
TOTAL CD-4A Cost		\$3,095.3k	Complete	100%		

4) Estimated work remaining through CD-4B, if any:
None

5) Status of Subsystem/Deliverable Turnover/Acceptance (including for Maintenance & Operations of detectors):

1.10 Work on Technical Coordination has transitioned to the U.S. ATLAS Research Program.

6) Key Learning Points and Recommendations:

Early establishment and empowerment of an effective Technical Coordination effort is essential for the timely completion of any large-scale project like the ATLAS detector.

7) Certification that Project sub-system is physically completed as described in this attachment, and (for detectors only) Maintenance & Operations planning/transition is sufficient for this stage of completion:

Dave Lussan

10/12/05

W J Willi

12 Oct. 05

Level 2 Manager

Project Manager

8) Attached Photographic Documentation:

Not Applicable