ATLAS COMPLETION & OPERATION PLAN 2002 – 2007 (REVISION)

Conclusions and Recommendations

Note: This internal ATLAS document summarizes the planning prepared for the April 2002 RRB. It assumes start-up in 2006. Thus, it does not include the measures endorsed by the RRB in that meeting. It is hoped that the present document facilitates discussions between the ATLAS Collaboration and its Funding Agencies

ATLAS Collaboration

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1. EXECUTIVE SUMMARY

1.1 Introduction

Since the fall of 2000, ATLAS has carried out internal reviews to bring up-to-date the detector completion and pre-exploitation costs. The results have been submitted to the LHCC Core Review Committee and to the RRB in 2001 - 2002. The revised cost estimates result from several changes which have occurred since laying out the original cost planning assumptions for the 475 MCHF (in 1995 prices), described in the ATLAS CORE construction Memorandum of Understanding (RRB-D 98-44 rev.).

These changes are as follows:

1. **Technical services charged to the Collaboration**. A number of services provided by CERN as Host Laboratory (in the days of LEP) are now being charged to the Collaboration (e.g. cryogenics operation, electricity, services such as crane operation, heavy handling etc.);
2. **Availability of technical manpower at CERN during the commissioning and integration period**. Due to the decrease in global manpower at CERN and in absence of adequate technical manpower in external institutes available for working at CERN to fill the identified manpower gap, a series of tasks need to be outsourced to external service provider companies;
3. **Technical developments**. Changes in original detector design, in the nature of required assembly tooling and in the scope of laboratory operations supporting planned construction activities in the experimental area. This has resulted in additional CORE and non-CORE items which were not foreseen in the CORE construction MoU.

1.2 Financial Overview

A. Construction completion costs (2002 – 2005), amounting to **68.1 MCHF** (2001 prices)

- Over costs in Common Projects (magnets, LArCC, infrastructure): 29.7 MCHF
- Non-covered CORE MoU funding (missing contributions): 4.4 MCHF
- Additional CORE items: 6.3 MCHF
- Additional non-CORE items: 6.9 MCHF
- Commissioning & Integration (C&I): 20.8 MCHF

The above cost estimates assume physics start-up in 2006. The first four items can be grouped together as supplementary construction costs. The cost to completion thus comprises the supplementary and C&I costs.

Over costs associated with the deliverables are assumed to be handled by the respective Funding Agencies, their efforts being gratefully acknowledged by the Collaboration. These are presented by the national communities directly to their Funding Agencies.

The planned total payment profile of the 68 MCHF cost to completion is as follows (MCHF):

Nature of cost	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
Supplementary	9.9	22.1	11.5	3.7	0	0	**47.3**
C&I	2.6	5.7	7.6	5.0	0	0	**20.8**
TOTAL	**12.5**	**27.8**	**19.1**	**8.7**	**0**	**0**	**68.1**

The above costs as well as the planned payment profile is being reviewed on a continuous basis. A number of actions are being taken to further optimize the existing resources. New pledges are being requested from the Funding Agencies.

Financial planning is under way to secure the completion of the initial detector concept in 2006. Two models are being developed; one assuming 56 MCHF as new income w.r.t to the 68 MCHF needed and another one assuming only 37 MCHF available to complete the initial detector.

The sharing of costs is based on the CORE investments for the systems-specific items. Some of the Common Project items which are associated with identified additional costs, notably the magnet system, are now on the critical path.

The above costs do not include the operation (i.e. Maintenance and Operation or M&O) costs nor off-line computing. The M&O activities are handled within the framework of a new Memorandum of Understanding for M&O, anticipated to be accepted by the RRB for signature in April, 2002. The total planned operation costs up to 2007 for the Collaboration is estimates at 57 MCHF. As to the computing costs, it is too early to provide a reliable cost estimate at the moment. First tentative estimates suggest an investment cost of up to 45 MCHF until 2006.

2. INTRODUCTION

2.1 Background and Purpose

This internal ATLAS document builds upon a set of recent, complementary papers on ATLAS completion and (pre)operation costs.

It is an update of the background paper "ATLAS Completion Plan 2002 – 2007" (ARN 2-01; last update on February 10, 2002) which summarized the status of planning for the October 2001 RRB meeting and was thus in line with the documents submitted by ATLAS to that meeting. This present document is in line with the documents submitted to the April 2002 RRB, in particular with documents CERN-RRB-2002-018, CERN-RRB-2002-021, CERN-RRB-2002-022, CERN-RRB-2002-023, CERN-RRB-2002-025, CERN-RRB-2002-026, CERN-RRB-2002-027, CERN-RRB-2002-035, CERN-RRB-2002-036 and CERN-RRB-2002-047. These documents can be found at:
committees.web.cern.ch/Committees/LHCRRB/ATLAS/

The basic financial information covering the baseline costs of the ATLAS detector are given in the ATLAS Cost Planning Book (version 7.0, released on January 31, 1998) and the ATLAS construction Memorandum of Understanding (MoU; RRB-D 98 44 rev.) which are based on the cost estimates endorsed by the CORE committee.

The purpose of this document is to provide the ATLAS Collaboration with a summary view for a completion plan for the ATLAS detector. It is updated annually and is made available to the Collaboration as background information. Hopefully, it facilitates discussions with the ATLAS Funding Agencies.

2.2 Terminology used in the Document

The following terminology is applied throughout this document, with more details found as referenced in Table 1:

Table 1. Terminology used in the document

#	Terminology	Definition
1	Additional CORE	Items left out from the CORE MoU (RRB-D 98 44 rev.) for one reason or another, needed to complete the construction. These items include e.g. tooling, mock-ups, assembly, installation, test stations, detector equipment
2	Baseline CORE	CORE value of the full detector as defined in the CORE MoU without any additional costs
3	Category A	M&O/C&I items to be charged to the entire Collaboration for magnets, cryogenics, Technical coordination and TDAQ. List of items is provided in Appendix 3
4	Category B	M&O/C&I items to be charged to the systems (ID, LAr, TileCal, Muons). List of items is provided in Appendix 3
5	Category C	M&O/C&I items to be charged to CERN as the Host Lab. List of items is provided in Appendix 3
6	Commissioning & Integration (C&I)	Activities supporting construction and installation tasks on-site before 2006 of the initial detector, outside the pit and excluding test beam activities
7	CORE cost over-runs	CORE cost over-runs are identified increases on cost items included in the CORE Cost book 7.0. These include both deliverables and Common Fund items
8	Deliverables	Specific detector items committed to by Funding Agencies in the CORE MoU
9	Infrastructure	On-site items which are needed to support detector construction and operation activities. These include dedicated surface buildings (e.g. clean room areas, active and passive storage areas), mechanical constructions (e.g. detector access &support structures and tools)
10	Initial detector	Version of the detector ready for first physics run in 2006, missing staged items
11	Maintenance & Operation (M&O)	Activities associated with operating and maintaining the detector from 2006 onwards and support to common items (magnet, cryogenics, TDAQ, TCn) and test-beam activities before 2006
12	Non-covered CORE items	Non-covered CORE items are those identified in the MoU but which are not covered by any FA
13	Spares	Components obtained and stored for possible future use. Some types of spares can't be obtained after original component purchase because of availability or cost and thus need to be obtained as a part of initial purchase
14	Staging	Items left out from the initial detector configuration for first physics run in 2006. These are items the installation of which can be delayed with an affordable impact on the physics discovery potential of the initial detector
15	Supplementary costs	Overall title for additional CORE, cost over runs and non-covered CORE costs to complete the initial detector, excluding technical manpower
16	Technical manpower	Technical manpower needed to carry out installation tasks at CERN. They are mainly associated with the identified M&O and C&I costs. Technical manpower includes both institute and hired manpower, excluding physicists
17	System (i)	In this document, ATLAS systems include: Inner Detector (ID), Liquid Argon Calorimeter (LAr), Tile Calorimeter (TileCal), Muon Spectrometer (Muons), Trigger & Data Acquisition (TDAQ), Magnet System and the Technical Coordination (TCn).

2.3 Structure of the Document

The present document is a compilation of several papers produced for internal use within the ATLAS Collaboration as well as for the RRB (see section 2.1).

The resources analysis starts by analyzing the initial detector configuration from the point of view of its impact on the physics significance and establishes an affordable cut-off limit. This is elaborated upon in Chapter 3.

The installation schedule and impact of staging is discussed in Chapter 4.

In Chapter 5, the corresponding CORE value for the staged detector is estimated.

Chapters 6 and 7 address the costs to completion, both in terms of the construction efforts and Maintenance & Operation and Commissioning & Integration.

Chapter 8 describes the present human resources situation.

Chapter 9 provides a financial summary, indicating the overall budgetary shortfall and its annual distribution.

Chapter 10 provides recommendations made by the ATLAS Management, endorsed by the Executive Board.

Appendices 1 – 12 provide more detailed information in support to the above chapters.

3. ATLAS PHYSICS GOALS AND DETECTOR DESCRIPTION

3.1 Introduction

The ATLAS Collaboration is constructing a general-purpose pp detector which is designed to exploit the full discovery potential of the Large Hadron Collider (LHC).

An overriding goal for the initial detector configuration and installation plan is to be ready for the LHC commissioning starting in January 2006, for the first collisions in the April 2006 pilot run, and for the first real LHC physics run commencing in August 2006. This plan is also exploring the flexibility available to face future changes that may be imposed by various constraints.

The LHC offers a large range of physics opportunities, among which the origin of mass at the electroweak scale is a major focus of interest for ATLAS. The detector optimization is therefore guided by physics issues such as sensitivity to the largest possible Higgs mass range. Other important goals are the searches for heavy W- and Z-like objects, for supersymmetric particles, for compositeness of the fundamental fermions, as well as the investigation of CP violation in B-decays, and detailed studies of the top quark. The ability to cope well with a broad variety of possible physics processes is expected to maximize the detector's potential for the discovery of new, unexpected physics.

Many of the interesting physics questions at the LHC require high luminosity, and so the primary goal is to operate at high luminosity (10^{-34} cm^{-2} s^{-1}) with a detector that provides as many signatures as possible using electron, gamma, muon, jet, and missing transverse energy measurements, as well as b-quark tagging. The variety of signatures is considered to be important in the high-rate environment of the LHC in order to achieve robust and redundant physics measurements with the ability of internal cross-check.

Emphasis is also put on the performance necessary for the physics accessible during the initial lower luminosity running (10^{-33} cm^{-2} s^{-1}), using more complex signatures such as tau-lepton detection and heavy-flavour tags from secondary vertices.

Finally, the detector is conceived for assured performance even at the highest possible luminosities (in excess of 10^{-34} cm^{-2} s^{-1}) which ultimately could be delivered by the LHC.

3.2 Overall Detector Configuration

Magnet. The magnet configuration is based on an inner superconducting solenoid around the inner detector cavity, and large superconducting air-core toroids consisting of independent coils arranged with an eight-fold symmetry outside the calorimetry. This concept offers:

- Almost no constraints on calorimetry and inner detector allowing noncompromised technological solutions;
- A high-resolution, large-acceptance and robust stand-alone muon spectrometer.

Inner Detector. The inner detector is contained within a cylinder of length 6.80 m and radius 1.15 m, with a solenoidal magnetic field of 2 T. Pattern recognition, momentum and vertex measurements, and enhanced electron identification are achieved with a combination of

discrete high-resolution pixel and strip detectors in the inner part and continuous straw-tube tracking detectors with transition radiation capability in the outer part of the tracking volume.

Liquid Argon Calorimeter. Highly granular Liquid Argon (LAr) electromagnetic (e.m.) sampling calorimetry with excellent performance in terms of energy and position resolutions covers the pseudorapidity range $|\eta| < 3.2$. In the end-caps the LAr technology is also used for the hadronic calorimeter, sharing the cryostats with the e.m. end-caps. The same cryostats also house the special LAr forward calorimeters which extend the η coverage to $3.2 < |\eta| < 4.9$.

Tile Calorimeter. The bulk of the hadronic calorimetry is provided by a novel scintillator tile calorimeter which is separated into one large barrel and two extended barrel cylinders on each side. The whole calorimeter system contributes to the very good jet and E^{miss}_T performance of the detector.

The LAr calorimetry is contained in a cylinder with an outer radius of 2.25 m and extends to ± 6.65 m along the beam axis. The outer radius of the tile calorimeter is 4.25 m and its length is ± 6.10 m. The total weight of the calorimeter system, including the solenoid flux return iron yoke, which is integrated into the tile calorimeter support structure, is about 4000 tons.

Muon Spectrometer. The calorimetry is surrounded by the muon spectrometer. The air-core toroid system, with a long barrel and two inserted end-cap magnets, generates a large field volume and strong bending power with a light and open structure. Multiple scattering effects are therefore minimal, and an excellent muon momentum resolution is achieved with three stations of high-precision tracking chambers. The muon instrumentation is complemented with fast trigger chambers.

The muon spectrometer defines the overall dimensions of the ATLAS detector. The outer chambers of the barrel are at a radius of about 11 m. The length of the barrel toroid coils is ±13 m, and the third layer of the forward muon chambers, mounted on the cavern wall, is located at ±21 m from the interaction point. The overall weight of the ATLAS detector is about 7000 tons.

3.3 Staged Detector

3.3.1 Physics Priorities

The physics priorities for the first physics run in 2006 have been extensively studied. A detector concept to address the great potential for even the initial year of running was arrived at based on:

- SUSY potential (after a few days only already) requires full calorimeter coverage;
- Standard Model Higgs searches, including the low mass region overlapping with the LEP limit, imply electron and muon detection and measurement over a large rapidity range (rather than a full radial high-luminosity redundancy over limited rapidity) and high-performance b-tagging;
- MSSM Higgs searches need in addition tau-lepton identification already at low luminosity.

The present expectations are that the LHC luminosity will reach within only a few years the design value (high-luminosity), and studies have been initiated by CERN to explore the enhancement of the physics potential for even higher luminosities in a future LHC upgrade. The detector planning must make it also possible to meet this future challenge with upgrades.

3.3.2 Initial Detector Configuration

A meaningful detector needs the full Magnet System, no reasonable staging has been identified that would be possible in this case. Furthermore one has to recall that the construction of the barrel toroid is critical for the overall schedule, and in order to have a balanced magnetic force configuration it would not be possible to consider temporary operation with only one end-cap toroid.

The initial Inner Detector configuration will defer one of the three pixel layers (but not the B-layer) and its associated read-out electronics as well as the outermost end-cap TRT wheels. A pixel layer instead of an SCT layer was chosen for staging in order to minimize the future re-installation down-time.

Full Calorimeter coverage is required for the initial LHC physics, in particular for the important Higgs and SUSY searches. As a side-remark it is also needed mechanically to shield the muon chambers within the ATLAS air-core magnet system. The limited staging that is implemented concerns a reduction of read-out drivers (RODs) and possibly a reduced redundancy in HV power supplies. Further staging will be implemented for the instrumentation with the so-called cryostat-gap scintillators used for energy corrections in the transition regions between barrel and end-caps.

The staging in the Muon System affects the so-called EES and EEL MDT chambers, including supports and electronics, in the transition region between barrel and end-caps and part of the end-cap end-wall MDT chambers. Only half of the CSC layers (mechanics and electronics) will be part of the lower luminosity initial detector.
Further staging will concerns eventually part of the outermost barrel chambers if the installation time would impose this.

The High Level Trigger and DAQ System will be initially designed to the reduced costs, in a way that it can be readily upgraded. Furthermore also the processor farm that is part of the Common Projects will be implemented in an expandable way, starting from a reduced system.

3.3.4 Physics Implications of the Initial Detector Configuration

For the complete detector as described in the ATLAS Technical Design Reports (TDRs) Figure 1 shows the expected significance for a Standard Model Higgs signal as a function of mass over the region $m_H < 200$ GeV. This region is particularly crucial because it is favoured by the fit to the LEP/Tevatron/SLC electroweak data and because it is the most difficult one at the LHC. It can be seen that for masses below 130 GeV discovery (i.e. a signal significance of at least 5σ) can be achieved with only 10 fb^{-1} of integrated luminosity, i.e. during the first physics run in 2006-2007, by combining ATLAS and CMS. For masses larger than 130 GeV, where the gold-plated $H \rightarrow 4\ell$ channel becomes accessible, 5σ discovery is possible by the individual experiments with the same integrated luminosity.

In the region $m_H < 130$ GeV, two complementary channels provide most of the sensitivity: $H \rightarrow \gamma\gamma$ (which requires precise EM calorimetry over $|\eta| < 2.4$) and ttH production followed by $H \rightarrow bb$, which requires calorimetry, muon trigger chambers and high-performance b-tagging. Both these channels contribute in a similar way to the expected signal significance in ATLAS.

Table 2 summarizes the physics impact of staging in terms of loss in significance.

Table 2. Physics impact of the staging for the initial detector configuration

Staged items	**Main impact expected on**	**Loss in significance**
One pixel layer	$ttH \rightarrow ttbb$	~ 8%
Outermost TRT wheels + MDT	$H \rightarrow 4\mu$	~ 7%
Cryostat Gap scintillators	$H \rightarrow 4e$	~ 8%
MDT	$A/H \rightarrow 2\mu$	~ 10% for m ~ 300 GeV

The main conclusion is that the discovery potential for a Higgs signal in several final states will be degraded by about 10%. Although this result is acceptable, it means that 20% more luminosity (i.e. 20% more LHC running time) will be needed to compensate for this loss. This might enhance the advantage of the Tevatron, which, on the time scale of 2007, might reach enough integrated luminosity for a 5σ discovery of a Higgs boson of mass below 120 GeV.

It should also be noted that possible penalties on the pattern recognition performance (e.g. track reconstruction efficiency and fake rates) coming from the less robust tracking systems have not been included in the studies shown here. These penalties are expected to be acceptable in the initial phase at low luminosity and much more significant when running at the LHC design luminosity.

Finally, the staging of part of the calorimeter RODs is expected to have an impact mainly on the maximum affordable trigger rate, which will be limited to ~50 kHz at the first level trigger. This will leave ATLAS with no safety margin on the expected rate predictions for the initial run.

3.4 Conclusions

The staging adopted by the ATLAS Collaboration for the initial detector configuration for the first LHC physics run starting in Summer 2006 aims at an integrated luminosity of 10 fb^{-1}. The staging strategy has been carefully chosen such as to preserve as much as possible the main goals and opportunities of the LHC. Yet some losses are unavoidable, in particular the Higgs signal significance in several final states will be degraded by about 10%. Although this result is acceptable, it means that 20% more luminosity (or running time of the LHC) will be needed to compensate for this loss. Furthermore, robustness and redundancy in the pattern recognition had to be sacrificed in order to achieve this overall staging compromise for the initial luminosity detector configuration.

To exploit the full and very rich physics potential of the LHC high-luminosity running will be mandatory. This regime is expected to be reached gradually as from mid-2007 onwards. In order to cope with the expected background conditions the full robustness and redundancy of

the ATLAS detector will be required, according to its design criteria as specified in the Technical Design Reports. This means restoring both the pattern recognition capabilities and the resolutions for the large variety of expected and unexpected signals. Otherwise the planned increase in luminosity of the machine could not be exploited. The staged components must therefore be installed in Spring 2007 after the initial run.

Additional staging for the initial phase has been studied for several test cases. It has been found that this would lead to unacceptable cuts into the physics reach, to a point that the interest and opportunities of a first physics run in 2006 would be severely put into question, and with the risk that the resources needed to operate the LHC would be wasted to a large extent.

A more detailed account of the physics implications of the staged detector is provided in Appendix 1.

4. DETECTOR INSTALLATION PLAN

4.1 Introduction

This Chapter summarizes the installation sequence and key activities in the ATLAS underground experimental area. The planned work is part of the construction effort defined in the construction MoU and the related cost estimates were based on set of assumptions described in Chapter 6 of the present document. As the installation tasks became better defined, it emerged that a number of related tasks were either forgotten or assumed to be covered by the Host Lab. These activities included, for example, the preparatory installation tasks on the surface, cryogenics operation, crane manipulation, system controls and service integration work. These identified missing resources attached to the installation contributed to the Commissioning and Integration costs (see section 6.3.3).

4.2 Planned Installation Sequence

The total installation period for the detector is about 30 months and comprises 15 phases, each one covering a notional two-month period. These phases are split into the following steps:

Phase 1. Start of the General Facilities

Phase 2. Completion of the 1st Part of the Infrastructure

Phase 3. Assembly Start: Support Feet and Barrel Toroid

Phase 4. Start of the barrel calorimeter assembly

Phase 5. Start of the barrel liquid argon calorimeter installation

Phase 6. Solenoid connections

Phase 7. End-cap calorimeter C assembly

Phase 8. Connections to the barrel calorimeter, side C

Phase 9. End-cap calorimeter A assembly

Phase 10. Preparation for solenoid and barrel toroid tests

Phase 11. Start of inner detector installation

Phase 12. Start of muon chamber installation

Phase 13. Muon chamber 'big-wheels' installation

Phase 14. Installation of the end-cap toroids

Phase 15. Completion of the ATLAS installation

More details are provided in Appendix 2.

4.3 Impact of the Staged Detector on the Installation Plan

The staged detector can be installed within the revised installation schedule. It is assumed that in 2007 there will be a long shutdown period during which the equipping of the detector for the remaining components can be completed.

5. FINANCIAL IMPACT OF THE STAGED DETECTOR

Chapter 3 provided the boundary conditions for a staged detector scenario, driven by both financial and technical considerations.

Based on Chapter 3, it is apparent that a loss of significance much beyond 10% will strongly reduce the physics discovery potential of ATLAS. A feasible staged detector scenario thus must be based on acceptable limits to reduced physics detection capabilities. The financial cost estimate of a staged detector is based on the following basic assumptions (Table 4):

Table 4. Assumptions used in the cost estimate

#	**Assumption**
1	Maximum acceptable physics loss in significance is ca. 10%
2	Initial detector is installed by December 2005 in time for first low-luminosity physics run in April 2006. The full detector, as defined in the Technical Design Review (TDR), is to be installed by Summer 2007 for full luminosity physics run
3	US provides its deliverables as listed in the CORE MoU ('goals deliverables' in US terminology), over and above their committed baseline deliverables, as 'upgrades'
4	Staging does not generate additional costs (e.g. assembly, production costs) w.r.t original CORE plan
5	Any possible cost over runs associated with the identified deliverables will be covered by the respective Funding Agencies and are not included in the analysis

Table 5 summarizes the staged detector items in each system, indicating the associated CORE value (MCHF, 1995 prices) for each system.

Table 5. Description of the staged ATLAS detector and its associated costs (MCHF, 1995 prices)

#	**System**	**Description of staging**	**MCHF (1995)**
1	Inner Detector (ID)	3rd pixel layer, some RODs; TRT end wheel C, some electronics	6.3
2	Liquid Argon (LAr)	Some RODs, power supplies	1.5
3	Tile Calorimeter (TileCal)	Gap scintillators	0.6
4	Muons	MDT: EEL, EES, ECT; part of EOS, EDL	3.5
5	TDAQ	Some processors (Common Fund share 3.8 MCHF and Future upgrade 3.9 MCHF)	7.7
6	Magnets	(No staging possible)	0
7	Access & infrastructure	Parts of high luminosity radiation shielding (to be confirmed)	1.0
		TOTAL	**20.6**

It should be noted that in Table 5, the line 'upgrade' for the TDAQ system refers to the reduction of the original TDAQ design by 4 MCHF, due to a withdrawal of an institute from the TDAQ. The planned upgrade will thus complete the TDR detector with respect to the original CORE cost estimate. The staging of part of the radiation shield is still under review and needs to be confirmed.

Table 6 shows the annual distribution of the above staged items.

Table 6. Annual distribution of the staged detector payments (MCHF, 1995 prices)

#	System	2004	2005	2006	2007	Total
1	Inner Detector (ID)	1.0	3.0	2.3	0	**6.3**
2	Liquid Argon (LAr)		0.7	0.8		**1.5**
3	Tile Calorimeter (TileCal)			0.6		**0.6**
4	Muons		1.7	1.8		**3.5**
5	TDAQ (staging, upgrade)			3.8	3.9	**7.7**
6	Magnets					
7	Access & infrastructure			1.0		**1.0**
	TOTAL	**1.0**	**5.4**	**10.3**	**3.9**	**20.6**

It is observed in Tables 5 and 6 that the CORE value of the staged components amount to 21 MCHF, up to 2007, including the upgrade of the TDAQ to full costs. The above staging effect is split between the deliverables (16 MCHF) and Common Project items (5 MCHF).

Over 40% of the staging is associated with US deliverables which are earmarked as part of the so-called Management Contingency. These specific items are outside the present US baseline commitments and are instead part of the US 'goals deliverables' which are enlisted in the CORE MoU. Some 15% of the staged items are linked to Russian deliverables which are expected to be provided with later funding. The remaining responsibilities are distributed across Funding Agencies from many countries. About 8 MCHF worth of the staged items can be made available for deferrals.

Based on the principle of deliverables, the respective Funding Agencies associated with the items in question in the CORE MoU are expected to find ways to secure adequate resources for providing the remaining components to complete the full detector by 2007.

The staging of Common Project items (TDAQ processors, shielding elements) permits the ATLAS Management to make new commitments worth 4 MCHF over and above the approved original Common Project cost ceiling of 208 MCHF. A priority list for urgent items have been drafted for Common Project items (e.g. the magnet system) and this is reviewed on a regular basis in consultation with the RRB Chair.

6. COST TO COMPLETION

6.1 Introduction

The ATLAS Collaboration carried out a rather extensive cost-to-completion review in 2001 and updated cost estimates were submitted to the LHCC CORE Review (CERN/LHCC 2001-027) and MAG in September, 2001. The ATLAS Management presented the overall financial situation to the RRB in October, 2001 (ATLAS RRB-D 2001-121). The Technical Coordination part of the reported supplementary costs were also reviewed by the Collaboration (see Appendix 13).

6.2 Changes in the Original Assumptions

The ATLAS CORE costing was carried in 1995 and 1996 and it was based on the following basic assumptions (Table 7):

Table 7. Assumptions used in the original CORE cost estimate

#	**Assumption**
1	Each participating institute commits to the deliverables it signs up for in the MoU
2	The cost-equivalent of the deliverables in Swiss Francs is based on fixed exchange rates as of September, 1995
3	Adequate competitive forces keep the manufacturing costs at 1995 levels
4	Inter-sectorial LHC services needed by ATLAS will be provided without additional costs to the Collaboration (e.g. the cryogenics support moved from EP to LHC continuing to serve the experiments without extra costs)
5	The overall distribution of CERN resources for the experiments follow the 'Long Term Plan' (SPC/722), i.e. ATLAS detector construction resources as shown in Table 2 in that document and LEP programme ending in 1999, liberating resources for the LHC experiment construction
6	The available HEP infrastructure (i.e. non-CORE resources) and available manpower remains at the 1995 level
7	LHC starts producing physics in mid-2005

Up to date, the following changes in the above assumptions have taken place (Table 8):

Table 8. Changes since 1996

#	Change
1	Technical developments w.r.t originally designed and costed detector components
2	The English Pound, Japanese Yen and US Dollar have gained strength wrt to the 1995 Swiss Franc by some 35%
3	Cost variation indices for manufacturing in dominant industrial ATLAS countries have varied between 2 - 3% per year (i.e. cumulative effects up to 2001 ca. 13%)
4	The scope of available services at CERN has reduced, resulting in external contracting for missing technologies (e.g. vacuum, cryogenics, controls)
5	LEP programme was extended up to the end of 2000 delaying the liberation of resources for LHC experiments
6	LHC starts producing low luminosity physics in Autumn 2006 and high luminosity physics in 2007

The effect of unfavourable exchange rate developments and inflation is difficult to quantify for the deliverables due to the complex international network of transactions within the Collaboration. For the Common Projects part, the above effect is currently estimated at 10% of planned cash payments from the Common Fund.

The largest impact on completion costs results from the various technical developments that have taken place since 1996. Following the outcome of targeted R&D and prototyping programs carried out on several critical detector items, a number of components have either been re-designed or their manufacturing plans distinctly modified. Subsequently, the nature and scope of pre-assembly and assembly tooling needed for detector assembly and installation tasks has also changed. These developments could not be anticipated in full at the time of the original CORE costing.

6.3 Completion Cost Categories and Estimates

6.3.1 Baseline CORE

The CORE MoU (RRB-D 98-44 rev.) lays out an annual payment profile to reach detector configuration as defined in the Technical Design Review (TDR; CERN/LHCC/94-43), amounting to 474.7 MCHF in 1995 prices. This profile is defined here as the 'baseline CORE' excluding additional costs or cost over runs which need to be covered to reach the initial detector configuration. Table 9 shows the planned annual baseline CORE payments profile as shown in the CORE MoU, as well as the present planned baseline payment profile as part of the initial detector ('baseline update'), ready for the first low-luminosity physics run in early 2006. It also shows the additional payment profile to complete the full (TDR) detector by 2007 ('staging').

The approved ATLAS construction budgets have been transformed into 1995 prices by using CERN cost variation indices for capital investments in line with section 4.9 in the CORE MoU. These indices are 3.92% from 1995 to 1996, 5.16% from 1996 to 1997, -1.52% from 1997 to 1998, -0.71% from 1998 to 1999, -0.68% from 1999 to 2000 (estimate) and -.074% from 2000 to 2001 (estimate). It should be underlined that this approach is only indicative as the approved annual budgets are a mix of current prices and 1995 prices, due to the different accounting practices used by the Funding Agencies. Moreover, up to date, the income has not been indexed.

Table 9. Baseline CORE payments (MCHF, 1995 prices)

	'95 -'00	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Tot.**
Baseline (as in MoU)	239.9	78.4	64.0	48.4	35.5	8.5	0	0	**474.7**
Baseline (update); *- on which staging to reach the TDR detector in performance* *- on which TDAQ upgrade to reach TDR in cost*	152.2	61.1	93.1	79.5	46.0 *1.0*	19.9 *5.4*	 *10.3*	 *3.9*	**451.9** ***16.7*** ***3.9***

In Table 9, the updated payment profile of the initial detector matches the expected income which, at present, is estimated at 452 MCHF in 1995 prices. This follows the new income of 5 MCHF over and above the MoU income of 472 MCHF minus reductions in contributions to the Common Projects (3 MCHF) due to a withdrawal of an institute from TDAQ and a reduction in Russian deliverables (1 MCHF) minus the CORE value of the staged detector components (ca. 21 MCHF). Adding the staged components to the initial detector extends the payments to 2007 with respect to the original baseline MoU cost plan. Despite the reduced cost of the TDAQ by 4 MCHF, it is anticipated that adequate data processing power can be provided for the initial detector. In order to reap the full benefits of the high luminosity physics runs, an upgrade of the TDAQ system is planned for 2007.

The initial detector configuration described in Chapter 3 permits to absorb some of the additional costs until 2004. Thereafter, the staged items need to be paid for and produced – implying that funding needs to be secured well before – in order to reach the full (TDR) detector in 2007. As noted in Chapter 5, about 40% has already been used to cover cost increases associated with US baseline deliverables. These are not included in the reported CORE costs up to date. It is assumed that the US will be able to provide their 'goals deliverables' with new, additional funding. About 8 MCHF of the 21 MCHF is expected to be available for making new, urgent commitments in the understanding that the Funding Agencies associated with the staged items make their funds available in the case supplementary funding is not available on time to pay for the new commitments.

An updated version of the Funding Agency baseline CORE contributions is provided in Appendix 4, including the new and withdrawing institutes in the system.

6.3.2 Supplementary Costs

The following four cost categories are defined for the time period 2002 – 2005 to complete the initial detector:

1. CORE Over Costs. These costs refer to CORE items where cost increases have taken place since the signing of the MoU. As explained above, these cost increases result from changes in exchange rates, prototyping and production costs and because of shortfall of available institute manpower. These cost over-runs can be further divided into two sub-categories; the first includes the deliverables and the second sub-category covers the cash part of the Common Project items (i.e. the Common Fund).

Originally, 56% of the construction budget was planned as deliverables; over time this has evolved close to 80% including in-kind contributions for the Common Projects. Based on the principle of deliverables, the Funding Agencies commit themselves to the components they subscribe to in the MoU even if the final, true costs are higher than recorded in the MoU. So far, this principle has worked remarkably well.

The ATLAS management is fully aware of over costs already absorbed by the Funding Agencies and gratefully acknowledges these special efforts made by them. Given the operative practices adopted within the principle of deliverables the absence of a homogenous cost accounting and reporting system across all Funding Agencies, it has not been possible to obtain a complete view of the situation. The first input given by the systems for the LHCC CORE Cost Review in Autumn, 2000 (see CERN/LHCC 2000-040) was collected to signal to LHCC unavoidable cost increases but the data collection methodology was not homogenous throughout the different systems. One can only conclude that the known CORE deliverables cost over-runs (including those possibly associated with staged deliverables) amount to over 15 MCHF. Due to the nature of these costs, they are not included in the reported missing completion resources.

The second sub-category includes the cash part of the Common Projects. This is used to cover parts of the magnet construction (both Barrel Toroid and the two End Cap Toroids), the cryogenics for the LAr, the TDAQ as well as the support, access and shielding structures for the detector. Based on the expected future in-kind contributions to the Common Projects and the remaining items planned to be charged to the Common Fund, a total cost increase of 30 MCHF has been identified. This represents 14% of the total value of the Common Projects items. Of this increase, 22 MCHF are associated with the Magnet Project and the LAr cryogenics. The remaining 8 MCHF is for detector supports, access and shielding structures.

More detailed information on over costs in the CORE Common Projects is provided in Appendix 5.

2. Additional CORE Items. Additional CORE items include items which, for one reason or another, were not included in the CORE MoU. These comprise detector elements, tooling, test stations, assembly, integration, commissioning and transport. A total of 7 MCHF is identified as missing through 2005. The total has increased by 0.6 MCHF since October, 2001. This results from the recommendations made by the joint LHCC-RRB Scrutiny Group on C&I which requested ATLAS to move TileCal certain activities from the C&I pre-assembly to the supplementary construction budget. As these items are not deliverables associated with any specific funding agencies, these costs will be borne by the entire (sub)systems in question on a collective basis. Unlike the over costs in deliverables, additional CORE items are well identified and costed.

3. Non-covered CORE Funding. Non-covered CORE funds refer to contributions left unassigned in the CORE MoU. These include installation tooling for the Inner Detector (ID) and mainly electronics from the Liquid Argon Calorimeter (LAr), as well as the shortfall of 2.3 MCHF in the Common Projects following a withdrawal of an institute from the TDAQ. These uncovered cost amount to 4 MCHF through 2005, taking into account contributions from new institutes having joined ATLAS since the signing of the MoU in 1998. More information is provided in Appendix 6.

4. Additional Non-CORE Items. Additional non-CORE items are needed for supporting assembly, installation, commissioning and integration activities at CERN. These include items such as air-controlled assembly areas, storage and test areas as well as laboratory areas for repairing damaged detector elements. It also covers tasks carried out by the Technical Coordination such as electrical distribution, vacuum chambers, electrical distribution, flexible support carriers, racks, gases and safety detectors. The total value of missing non-CORE items amount to 6 MCHF. In comparison with the October 2001 reporting, the total has reduced by 5.4 MCHF due to generated savings in the Inner Detector SR-building (0.5 MCHF) and due to the LHC machine paying for 5 MCHF of items previously included in the experimental area budget.

Appendix 7 provides further details on additional CORE and non-CORE supplementary items.

Table 10 summarizes the foreseen annual evolution of the planned supplementary payments for the time period 2001 – 2005 (in MCHF, in 2001 prices):

Table 10. Evolution of annual supplementary payments 2002 – 2005 by cost nature (MCHF, in 2001 prices)

#	Category	2002	2003	2004	2005	TOTAL
1	Common Project (CP) over costs	7.0	15.0	6.4	1.4	**29.7**
2	Additional CORE (systems excl. CP)	0.8	2.5	2.9	0.7	**6.9**
3	Non-covered CORE	1.1	1.6	1.4	0.3	**4.4**
4	Additional non-CORE	1.1	3.1	0.8	1.3	**6.3**
	TOTAL	**9.9**	**22.1**	**11.5**	**3.7**	**47.3**

Table 11 gives the previous payment evolution per system (MCHF, 2001 prices).

Table 11. Evolution of annual supplementary payments 2002 – 2005 by system (MCHF, in 2001 prices)

#	System	2002	2003	2004	2005	TOTAL
1	Inner Detector	0.8	2.1	1.0	0	**4.0**
2	Liquid Argon	1.0	0.5	0.5	1.6	**3.6**
3	Tile Calorimeter	0.4	0.8	0.6	0.1	**1.8**
4	Muon Spectrometer	0.1	0.2	1.4	0.6	**2.3**
5	Common items	7.6	18.6	8.1	1.4	**35.6**
	TOTAL	**9.9**	**22.1**	**11.5**	**3.7**	**47.3**

Tables 10 and 11 show that the peak payment year is in 2003 amounting to 22 MCHF, then reducing to 4 MCHF by 2005. Tables 10 and 11 do not include associated technical manpower; this is addressed in Chapter 8 (Human Resources). The financing of the Hall 180 clean room facilities for the LAr cryostat (1.2 MCHF) in Table 11 is an on-going activity but appears as one payment in 2005 for accounting reasons, only. It should be noted that the planned payment of 10 MCHF for 2002 includes also some over costs already incurred in the magnet project. This amounts to ca. 4 MCHF. It is assumed that an additional delay in the project will not influence the above supplementary cost estimates.

6.3.3 Commissioning and Integration (C&I) Costs

The Commissioning and Integration (C&I) costs originate from changes in the initial assumptions used in CORE cost planning (see Table 8) as to the availability of technical manpower from CERN free of charge; underestimations in the complexity - and therefore cost - of integration the detector system in the pit; and from selecting a decentralized assembly and integration strategy for the various detector components instead of carrying out all integration tasks in the pit area. In general, C&I activities are defined as being associated with integration tasks outside the pit area, excluding test beam activities, and taking place before 2006 when the detector is assumed to be in operation.

The C&I costs were separated by the RRB Scrutiny Group as a new cost category from the original M&O cost estimates provided by ATLAS (ATLAS ARN 5-00). These costs were scrutinized by a joint LHCC-RRB Scrutiny Group in early 2002 (see CERN-RRB-2002-047). The total of the two cost categories (M&O, C&I) remains more or less unchanged w.r.t the original ATLAS plan after updating it in line with the LHC machine schedule for physics start-up in 2006. For the Collaboration, these activities are as important as the construction or M&O activities. From a practical operational point of view, there is very little difference between C&I and M&O activities but following the methodology adopted by the RRB Scrutiny Group, C&I is now treated together with the supplementary costs as part of cost to completion. ATLAS stresses that without adequate funds for C&I, the installation and commissioning of ATLAS will not take place as presently planned.

Table 12 summarizes the nature of C&I costs, as defined by the RRB Scrutiny Group. These are split between Category (A) and (B) activities.

Table 12. C&I sub-headings across Categories A and B

#	**Sub-heading (Category A)**	**Sub-heading (Category B)**
1	Detector related costs (e.g. detector integration, cooling, gases)	Mechanics
2	Communications (e.g. mobile communications, remote internet access)	Gas systems
3	On-line computing (e.g. processors, LAN connections, software)	Cryo-systems
4	Laboratory operations (e.g. lab equipment, support)	Electronics (front-end, standard electronics such as power supplies, crates, read-out modules) and Controls (DCS, DSS)
5	General services (e.g. cranes, transport, storage, cooling & ventilation)	Areas, Communications, Store Items
6	Consultancy (e.g. technical studies)	Technical Manpower (from companies, institutes)

The total integrated C&I costs from 2002 to 2005 amount to 21 MCHF when hired institute manpower is expressed in Swiss Francs (the LHCC-RRB Scrutiny Group treats them in Full-Time-Equivalents or FTEs). In addition, ATLAS institutes have already spent ca. 1.8 MCHF on activities prior to 2002 for C&I. This has been covered from the running budgets of the institutes.

The C&I cost drivers are the integration activities for the magnet systems and the for Inner Detector (ID). These two activities represent ca. 65% of all C&I activities in terms of cost.

Technical coordination is responsible for Category A activities, with the exception of the TDAQ although the latter is classified as an 'A' activity. This includes the overall integration of the detectors in the various assembly areas as well as acting as the technical interface between the systems and the infrastructure and technical services (e.g. transportation, heavy handling, piping & cabling services) provided by CERN as a host lab. After 2003, the main task will be coordinating the installation activities in the pit, including mounting of support structures, providing special installation tooling, moving of shielding elements, pipe fitting and electrical work. The installation work is described in Chapter 4. The integrated payments are planned at 5 MCHF by the end of 2005.

The magnet integration work is starting in Hall 180. The operation of the magnet system has already commenced in 1999 for the testing of the B00 model coils. Following the successful operation of the B0 coil in 2001, the reception and testing of the eight barrel toroid, two end cap coils and the solenoid gets under way before moving them into the pit in 2003 - 2004. The integrated payments for magnet C&I activities amount to 5 MCHF.

TDAQ (on-line computing) C&I activities are geared to support TDAQ test bed systems for each sub-detector. C&I items comprise mostly hardware components for read-out boards and infrastructure consumables such as cables and connectors. The integrated payments amount to less than 1 MCHF by the end of 2005.

Category B activities in ATLAS result from the decentralized assembly and integration strategy ATLAS chose while optimizing the costs associated with the experimental areas construction in the early phase of the project.

Inside the so-called SR-building (B2175) where ca. 540 m^2 of dedicated, temperature and humidity controlled assembly area is available for the integration of the entire ID system (Pixels, TRT, SCT) which will be finished there before lowering it down into the pit in 2004. The integrated payments for ID C&I activities amounts to less than 4 MCHF by 2005.

The assembly and integration of the Liquid Argon (LAr) barrel cryostat is gaining speed in Hall 180, where installing of 64 barrel feedthroughs are in progress. The integration work on the two end caps starts in 2002. The related C&I work amounts to 3 MCHF by the end of 2005.

For the Muon Spectrometer, on-going engineering work is proceeding to ensure full compatibility across the neighboring detectors and support structures. This work is carried out in close collaboration with the Technical Coordination. As the various detector components (MDT, TGC, CSC, RPC) start arriving at CERN, the installation and integration starts gearing up to prepare the detector modules for installation in the pit. The cumulative payments of these activities reach 2 MCHF by the end 2005.

TileCal C&I activities are centralized in buildings B175 and B185 where the pre-assembly of the first extended barrel starts in early 2002. This work continues until 2003, in parallel with calibration and cooling activities for the TileCal electronics. The installation work in the pit starts at the end of 2003. In total, 3 MCHF is required the complete the C&I activities.

Table 13 shows the annual evolution of planned C&I payments for each system (Category A and B). Planned in-kind institute manpower contributions are estimated in Swiss Francs for at 91.25 kCHF/FTE, based on guidelines given by the RRB Chair. In the scrutiny document CERN-RRB-2002-047 these contributions are included in the totals for institute manpower and accounted for in FTEs, instead.

Table 13. Evolution of annual C&I payments 2002– 2005 (MCHF, in 2001 prices)

#	System	Cat	2002	2003	2004	2005	TOTAL
1	Inner Detector	B	0.8	1.1	1.2	0.7	**3.8**
2	LAr	B	0.5	0.6	0.8	0.6	**2.5**
3	TileCal	B	0.3	0.6	0.7	0.7	**2.3**
4	Muons	B	0.2	0.5	1.1	0.5	**2.3**
5	TDAQ	A	0	0	0.1	0.5	**0.6**
6	Magnets	A	0.3	1.8	2.1	0.5	**4.7**
7	Technical Coordination	A	0.6	1.0	1.7	1.5	**4.8**
	TOTAL		**2.6**	**5.7**	**7.6**	**5.0**	**20.8**

One observes in Table 13 that the costs are split equally between Category A and B. Moreover, the peak payment year is in 2004 when the installation work is in full speed in the ATLAS pit. In the magnet system, the cryogenics integration activities get completed in 2004 and the standard operation of the equipment starts (accounted for in the M&O activities). The last year for planned C&I payments is 2005. More details are provided in Appendix 14.

6.*3.4 Cost Sharing Principle, Budget Endorsing and Reporting Mechanism*

Costs common to the Collaboration comprise the Common Items in the supplementary and Category A items in C&I. Following the sharing principle established for the baseline Common Project costs, these are shared in proportion to the CORE contributions in the construction MoU. Contributions to the supplementary costs will also include the extended annual member ship fee up to 2006 (i.e. three additional years). For system-specific costs, the sharing is based on the respective CORE contributions of the Funding Agencies in the systems concerned.

The updated baseline CORE sharing is shown in Appendix 4. The estimated share of supplementary costs per the Funding Agency is shown in Appendix 8. It should be stressed that the detailed sharing within the systems are currently been verified and that minor adjustments take place continuously. Appendix 9 gives the estimated sharing of C&I costs 2002 – 2005 by Funding Agency; the recommendations made by the LHCC-RRB Scrutiny Group are not yet incorporated due to technical reasons.

The budget estimates for the following year are submitted for RRB approval in each October meeting of the present year. Final payments are submitted for RRB approval in each April meeting for the past year. This mechanism applies to both Category A, B, Common Items (in supplementary) and system-specific (in supplementary) items. The B and systems-specific items are first approved by the respective (sub)system Institute Boards prior submitting them to the RRB for final approval.

The payments related to the supplementary items will be centrally handled through the existing construction accounts. All transactions associated with these costs are tagged and reported to the RRB by the ATLAS Resources Coordinator.

System-specific C&I accounts have been set up for monitoring both Category A and B payments. These dedicated accounts are operated jointly by the ATLAS Resources Coordinator and the Project Leaders. The Resources Coordinator is in charge of the annual book closing of these accounts and the registered payments for the past year will be reported to the RRB in April of each year.

Unlike the M&O budget estimates, C&I and supplementary costs are not subject to regular scrutiny by the RRB. This will be done by the Collaboration on a regular basis.

6.3.5 Issue of In-kind Contributions

Institutes and Funding Agencies can make in-kind contributions within the calculated share of supplementary and C&I costs. This can apply to cost increases associated with items Funding Agencies are already contributing to.

Hardware in-kind contributions are to be agreed by the (sub)system Institute Board in question (for Category B) and with the ATLAS Management (for Category A). The level of possible in-kind contributions for the supplementary items remains yet to be determined as the planning for deferrals is still under way.

Funding Agencies can also come forward with specific manpower in-kind contributions for C&I which are not included of their CORE construction obligations (deliverables). As noted earlier, for budget planning purposes, a technical person to be hired from an ATLAS institute by the Collaboration is valued at 91.25 kCHF/FTE per year. The actual credited value to a Funding Agency is to be agreed by the (sub)system Institute Board in question (for Category B) and with the ATLAS Management (for Category A). The estimated share of hired manpower costs in the 21 MCHF of C&I is about 12 MCHF, spread equally between Category A and B.

While most of the hired manpower is n Category A is in cryogenics operation and heavy handling services which CERN at present provides through industrial service companies working on the site, ca. 30% of the Category A and 50% of Category B costs could possibly be provided by institute manpower sent to CERN. Thus, in-kind contributions could roughly represent that sharing of the total calculated contributions for a given Funding Agency. The Category A activities are mostly linked to detector integration tasks in the pit and Category B related to (sub)system-specific assembly and integration tasks (see Appendix 14 for more details).

Based on guidelines received from the CERN management, institute manpower can be freely used by the Collaboration for ATLAS-specific tasks which industrial service companies are not presently carrying out on the CERN site (for example, cryogenics operators, system managers, crane operators, surveyors). In exceptionalcases, institute manpower could be integrated in the present industrial services teams but this would require prior approval from the CERN management and ATLAS would nevertheless continue paying the established CERN rates to the CERN-group providing the service. In the absence of additional

information, the net advantage to ATLAS in this type of an arrangement remains unclear at the moment.

It should be noted that there is only limited technical manpower associated with the supplementary costs (in practice, all in Technical Coordination) and these costs are based on current practices employed in executing the baseline construction activities. In-kind manpower contributions are possible but the cost attribution mechanism would fall outside the scope of that for C&I or M&O.

6.3.6 Issue of Extraordinary Contributions

The ATLAS Management is also working on a scheme which permits recognition of extraordinary contributions from Funding Agencies, exceeding the value of originally agreed C&I or supplementary contributions. This is expected to happen in some cases, typically associated with deliverables. These extra contributions would be formally recognized by the end of the construction phase, supported by well documented use of such resources allocations.

6.3.7 Contingencies

The above cost estimates include no explicit contingencies. The reported supplementary and C&I cost estimates are thus vulnerable to several factors which can still influence the above estimates. These factors are summarized in Table 14:

Table 14. Factors influencing the accuracy of the cost estimates

#	**Factor**
1	Possible further changes in the scope and volume of available resources at CERN
2	Inadequate technical manpower (availability, volume, quality)
3	Unforeseen major technical problems during manufacturing, assembly, installation or commissioning

Efforts are being made by both the ATLAS and EP Division management to prevent further reductions in the available technical support by CERN to the experiment. Concerning point 3 in Table 14, the ATLAS Management has started to assess, in close collaboration with the systems, the possible risk factors that could jeopardize the success of the project and is drafting counter measures to reduce the probability of this happening. The results of this analysis will be included in the revised version of the present completion plan for the October 2002 RRB.

6.3.8 Compensatory measures for 2002

Should the proposed budget for supplementary and C&I costs be only partially available in 2002, a plan for compensatory measures has been drafted. This comprises the following actions (Table 15):

Table 15. Compensatory measures for 2002

#	**Action**
1	Prioritize new commitments against the obtained new pledges (in particular for the magnet project)
2	Delay and/or re-negotiate payments (in particular for internal services rendered by CERN)
3	Swap between supplementary and future baseline items, tagging the latter for future pledges

In case no new pledges can be made available in the near future, a far-reaching choice must be made between either delaying the project or staging further the detector. The latter option would imply crippling the physics discovery potential of the initial detector.

6.4. Computing

The cost of (off-line) computing is not included in the above figures. It is still too early to draft solid cost estimates. The LHCC Computing Review (CERN/RRB-D 2001-3) provided a tentative, first total cost estimate of 240 MCHF up to 2006 which are currently being updated and revised – the ATLAS share including computing at CERN and Tiers 2 and 3 all around the world, represents ca. 45 MCHF up to the end of 2005, assuming start-up in 2006. The annual operation costs are estimated at some 20 MCHF from 2007 onwards. LHC computing is addressed by a new, dedicated computing RRB which meets for the first time in April 2002.

7. OPERATION COSTS

7.1 Introduction

The ATLAS Collaboration reviewed the ATLAS (pre)operation (Maintenance and Operation or M&O) activities and related costs in an internal exercise in 2000 (ATLAS ARN 05-00). These cost estimates were updated before submitting them to the RRB Scrutiny Group in Summer 2001 and then again in early 2002.

Pre-operation costs are linked to certain activities the Collaboration needs to carry out before 2006, both in on-site surface buildings and in the ATLAS underground caverns. These activities take place in parallel to the detector completion tasks and not covered in the baseline CORE MoU. In the construction MoU, these types of activities were left to be later defined and covered in a separate, dedicated MoU. Following the preparatory work of almost 18 months, a MoU for M&O has finally been submitted to RRB for approval in April 2002 (CERN-RRB-2002-035).

The operation activities of ATLAS differ from those for supplementary and C&I. The latter two are associated with capital costs, i.e. completing successfully the detector construction phase. The running costs of the detector start when the assembled detector elements get tested at CERN and maintained in a (semi)operation mode until the entire detector is commissioned. It should be stressed that operation costs are thus not additional costs or cost over-runs w.r.t to the construction MoU; they were simply excluded from the original CORE construction cost framework.

Table 16 depicts the range of activities from baseline construction to stable operation over in time.

Table 16. The continuum of activities from detector construction to full operation phase

Detector completion			**Operation (M&O)**	
Construction (baseline)	**Supplementary**	**C&I**	**Pre-operation**	**Operation**
1995 - 2006 (initial detector)	2002 - 2005	Before 2005	before 2005	after 2006 (up to 2020?)

The pre-operation costs have two important origins, in addition to test beam activities and infrastructure support functions which have been taking place already since 1999. These costs have been covered from existing institute exploitation budgets. At the moment, there is no clear indication whether these resources are available in the future. The two above contributing factors are summarized in Table 17.

Table 17. Important factors contributing to pre-operation costs

#	Cost contributing factor
1	Technical services charged to the Collaboration. A number of services provided by CERN as Host Laboratory (in the days of LEP) are now being charged to the Collaboration. These include activities such as vacuum and cryogenics operation for the magnet system, electricity and cooling & ventilation both in surface buildings and in the pit, crane operation and heavy handling
2	Availability of technical manpower at CERN before 2006. Due to the decrease in global manpower at CERN and in absence of adequate technical manpower in external institutes available for working at CERN to fill the identified manpower gap, a series of tasks need to be outsourced to external manpower companies (e.g. integration work, detector survey, laboratory operations)

The M&O cost estimates are based on the following assumptions (Table 18):

Table 18. Assumptions used for drafting the M&O cost estimates

#	Assumption
1	ATLAS is in a stable operation mode by 2008 (magnet system already in 2006)
2	The scope and basis of charging of technical services provided by the accelerator, technical and administrative sectors will remain as communicated to the Collaboration by August, 2001
3	Technical services charging within the Research sector (e.g. magnet controls) is based on hired manpower costs at CERN
4	Cost of locally hired manpower is 80 kCHF/man-year for less skilled technical support and 100 kCHF/y for skilled technical support and 120 kCHF/man-year for qualified engineering support
5	For using hired institute manpower, an average cost of 91.25 kCHF/FTE/y is applied for planning purposes (similarly to C&I)
6	The cost of consumables, rents, spares, repairs etc. are based on rates available for CERN
7	Cost of (off-line) data recording media not included in the estimates

The M&O item lines are split between three cost categories (A, B and C). As for C&I, Category A is shared across the Collaboration and B across the institutes in a given system (i). Category C is provided by CERN as the Host Lab. Category A includes the magnet system, TDAQ and Technical Coordination (including General Services as presented in ATLAS ARN 5-00). Category B includes the ID, LAr (LAr cryostat up to 2006), TileCal and the Muons systems. Further details on the splitting of the items between the above three categories, as defined by the CERN Management, is provided in Appendix 10.

The RRB Scrutiny Group scrutinized in early 2002 Category A and B costs and considered them as being 'sound'. It is expected that the RRB accepts the M&O MoU in April 2002 for signatures and that the M&O activities will continue based on annually scrutinized and approved budget proposals.

7.2 M&O Costs

Whereas C&I activities included only Categories A and B (i.e. responsibility limited to the Collaboration and its institutes), M&O comprises also technical support provided by CERN as the host lab (Category C).

Most of the Category A activities (i.e. TCn , magnet, TDAQ/on-line computing) start picking up in 2004 as the C&I activities give way to commissioning in the pit. There are, however, some M&O activities already in 2002 related to the magnet operation in Hall 180 as well as general technical support provided by TDAQ for the systems related to test-beam infrastructure.

M&O Category B items start in 2004 except for the test-beam activities which have been on-going since 1999. Under this heading one includes items such as electronics and DAQ, counting & control rooms, gases, irradiations and electronics poolrentals.

M&O Category C items are included in the sub-heading 'Laboratory operations'. They include activities such as safety & radioprotection, INB compliance, radioactive waste disposal, access systems, elevators, guards, insurance and (partly) cleaning. Although these costs were reported by the RRB Scrutiny Group in CERN-RRB-2002-036, they are nevertheless not included in this document as these costs are not visible to the Collaboration.

The M&O (A) headings are identical to those of C&I (A) in Table 12 except for the additional lines of the secretariat, test beams and outreach. For accounting purposes, these are included under Technical Coordination. The M&O (B) template is identical to that of C&I (B).

The cost drivers of M&O activities during the time period 2002 – 2005 are the Technical Coordination and the Inner Detector (similarly to C&I). Together, they represent ca. 40% of all M&O activities during that time priod.

Technical Coordination supports the detectors by operating or providing gas distribution systems, moving hydraulic systems, heavy transport, cranes, cooling & ventilation and power. This amounts to 14 MCHF over the time period 2002 – 2005. A large share of these payments is electrical power which represents 0.1 MCHF in 2002 and ca. 2 MCHF by 2005.

The magnet M&O activities mainly include the operation of the external cryogenics system in Hall 180. This activity remains more or less on a constant level until 2004 when all the coils and solenoid have been moved to the pit area. As the cryogenics system in the pit gets ready, M&O tasks start to keep the units operational. This results in an increase in payments, exceeding 1 MCHF in 2005. In total, the magnet M&O activities add up to 3 MCHF by the end of 2005.

The TDAQ M&O activities comprises support for the systems during beam tests, offering technical assistance and providing modified equipment, both for hardware and software needs. A central farm of processors is being currently operated by two or three operators within industrial services contracts. In 2004, M&O costs start rapidly to increase in proportion to the installed capital investment of the TDAQ processors (these are covered in the baseline budget). By then, ca. 60% of the ROBs will be operational. In total, TDAQ M&O activities amount to almost 4 MCHF by the end of 2005.

For the remaining systems (i.e. Category B), M&O activities reduce in line with decreasing module testing activities until 2004. For the Inner Detector, payments strongly increase in 2005 as the SR-building is manned for full-fledged routine M&O tasks. These activities will amount to 2 MCHF in total up to 2005. The TileCal, due to its early stage of installation in the pit, will reach full M&O mode already in 2006. The total for all M&O (B) activities up to the end of 2005 amounts to 5 MCHF.

Table 19 shows the annual evolution of M&O costs up to 2005 for Categories A and B.

Table 19. Evolution of annual M&O payments 2002 – 2007 (MCHF, in 2001 prices)

#	System	Cat	2002	2003	2004	2005	2006	2007	TOTAL
1	Inner Detector	B	0.4	0.4	0.4	1.1	2.6	3.5	**8.3**
2	LAr	B	0.1	0.1	0	0.6	1.0	1.8	**3.7**
3	TileCal	B	0.1	0.1	0.1	0.1	0.6	0.7	**1.7**
4	Muons	B	0.3	0.3	0.3	0.5	1.6	1.7	**4.5**
5	TDAQ	A	0.4	0.4	0.8	1.8	3.6	4.6	**11.6**
6	Magnets	A	0.3	0.4	0.4	1.4	1.8	1.8	**6.3**
7	Technical Coordination	A	0.4	1.6	2.6	3.5	6.3	6.4	**20.9**
	TOTAL		**2.3**	**3.2**	**4.7**	**9.0**	**17.6**	**20.4**	**57.3**

A steady annual increase is seen in Table 19 up to 2004, then nearly doubling in 2005 to 9 MCHF and 18 MCHF in 2006 by which time the detector systems are all mounted in the pit and the full commissioning has started. The total pre-operation payments up to 2005 amount to 19 MCHF. This is to be compared to 20 MCHF in 2007 when ATLAS reaches the steady-state operational phase. Table 19 does not include past M&O payments which amount to 4 MCHF. This has been paid from the running budgets of the ATLAS institutes.

It should be noted that options for certain critical spares (LAr, ID, TileCal) are included in the M&O budgets submitted to the RRB Scrutiny Group. The planned value of the spares is up to 6 MCHF In table 19, a large share of the payments will occur only after 2005. The financing of these critical spares is acute as they need to be purchased soon while the technology still exists and costs are optimal. A scheme has been put in place with the help of the RRB Chair where CERN permits ATLAS to make contractual commitments against firm pledges from the responsible system institutes or Funding Agencies, allowing an adequate time frame for the systems to amortize these costs. First such arrangement has now been successfully implemented (for the LAr FEB spares).

A more detailed description of the M&O activities within each system for the time period 2002 – 2007 for Category A and 2002 – 2010 for Category B is provided in Appendix 10.

7.3 Cost Sharing Principle, Budget Endorsing and Reporting Mechanism

The cost sharing mechanisms for M&O costs is described in the M&O Memorandum of Understanding (CERN-RRB-2002-035). M&O (A) is to be shared based on the number of qualified authors (PhD physicists, engineers with corresponding degrees), excluding PhD students. On April 2, 2002, ATLAS had in total 1 384 qualified authors. The sharing of M&O (B) costs is up to the Collaborations to decide and for the years 2002 – 2005 ATLAS will use the updated CORE baseline contribution table (see Appendix 4). From 2006 onwards,

ATLAS considers to use the number of qualified authors as a basis for also sharing Category B costs.

As described in the M&O MoU, the annual M&O budget is endorsed by the RRB after the budget figures have been scrutinized by the RRB Scrutiny Group. The group scrutinizes not only the proposed budget for the coming year but takes a forward look up to the fourth planned pre-exploitation year. The budget estimates are thus reviewed within a four-year revolving budget plan. ATLAS does, however, provide the RRB Scrutiny Group cost estimates for Category B items up to 2010.

Appendix 11 shows the calculated share of 57 MCHF for M&O for Categories A and B per Funding Agency. The sharing of B costs are system-specific, i.e. across those Funding Agencies in the respective systems and in proportion to their CORE contributions. The figures do not include energy cost adjustments made for those Funding Agencies which contribute to the LHC machine construction. The cumulative value of these adjustment, to be reduced from the calculated shares, is estimated at 5 MCHF in total during 2002 – 2007.

System-specific M&O accounts have been set up for monitoring both Category A and B payments. These dedicated accounts are operated jointly by the ATLAS Resources Coordinator and the Project Leaders. The Resources Coordinator is in charge of the annual book closing of these accounts and the registered payments for the past year will be reported to the RRB in April of each year.

7.4 Issue of In-kind Contributions

Some 18 MCHF of the 57 MCHF of (pre)operation costs before 2007 is for hired manpower, nearly all planned for service contracts managed centrally through CERN. A large share of these costs is associated with activities such as detector (re)integration, general technical services, magnet cryogenics operations and running of the system specific laboratories and workshops. It is envisaged that institutes could provide at least part of this required manpower as in-kind contributions.

Similarly to the case of C&I costs (see section 6.3.5), such contributions – including also hardware contributions - would be recognized as part the Funding Agency contributions towards their calculated share of the M&O costs. The maximum share of in-kind w.r.t cash contributions could be between 30 and 50% of the total calculated share per Funding Agency. All in-kind contributions need to be agreed by the (sub)system Institute Boards (for Category B) and with the ATLAS Management (for Category A).

7.5 Contingencies

The pre-exploitation costs addressed above do not include any explicit contingencies.

8. HUMAN RESOURCES NEEDED FOR DETECTOR COMPLETION AND OPERATION

8.1 Introduction

The global manpower needed to construct, commission and operate ATLAS has not been included in the annual budget reporting mechanism for the RRB. The construction budget does not include related manpower costs.

8.2 Construction Related Manpower

The ATLAS Cost Planning Book (version 7.0, released on January 31, 1998) provides estimates of the human resources associated to each sub-system construction efforts. The total manpower estimate for the construction (including commissioning) of the ATLAS detector amounts to ca. 5 300 man-years. A breakdown per system and Funding Agency was presented in the RRB in 1998 (An update is provided in Appendix 12). These estimates are not, however, part of the CORE-endorsed construction budget and are thus not followed and reported in the RRB. They are therefore treated as a non-CORE issue.

So far, the manpower estimates needed to complete the baseline detector construction have not been reviewed. There are, however, indications that the changes in original assumptions which are summarized in Table 8, have also had a major impact on the original manpower estimates. In particular, this appears to be an issue for the Muon project which has carried out an analysis of missing construction manpower. Up to now, the other systems have not indicated as critical shortages in construction manpower.

A human resources management tool is currently being evaluated by the Resources Coordinator as a pilot project with two ATLAS systems (EP2). Should this pilot prove to be helpful in monitoring and securing necessary human resources, it will be made available for all ATLAS (sub)systems.

The ATLAS Management proposes that the costs associated with uncovered manpower for both construction and installation manpower are handled at the Institute Board level within each concerned (sub)system and that they are treated in a similar fashion to cost over runs on deliverables. The ATLAS Management is prepared to contact the Funding Agencies implied to request them to help to solve the identified shortfall, if needed. Human resources matters could also be reported periodically in the RRB, if deemed necessary.

8.3 Technical Manpower for Installation

The technical manpower needed at CERN for installing the detector systems has been assessed by all systems. These estimates are being reviewed on a regular basis. The resulting resources needs have been incorporated in the C&I and M&O budget requests accordingly (see CERN-RRB-2002-036, CERN-RRB-2002-047).

Table 20 shows the technical manpower needed for C&I and M&O activities, expressed in man-years. It is divided into three categories; manpower to be hired locally (i.e. industrial service companies), manpower hired from institutes (i.e. to be recognized as contribution

from Funding Agencies) and sent institute manpower which is covered within the framework of deliverables.

For industrial manpower hired locally from service companies on CERN site , an average cost of 80 kCHF/m-y is assumed for one man-year equivalent; for specialized in-kind institute manpower credited to the sending home institute, the average of 91.25 kCHF/m-y is applied. The institute manpower sent to CERN for installation activities as part of the deliverables is already expressed in the M&O and C&I budget requests in man-years. This latter category includes technical staff already planned for be sent to CERN as part of fulfilling the institute obligations. It is therefore not included in the sharing of the M&O and C&I costs.

Table 20. Evolution of technical manpower at CERN 2002 – 2007 (in man-years)

#	Type of manpower	Cat	2002	2003	2004	2005	2006	2007	TOTAL
1	**Industrial manpower**		**28**	**53**	**72**	**69**	**68**	**61**	**350**
2	*C&I*	*A*	*9*	*26*	*37*	*22*			***93***
3	*C&I*	*B*	*10*	*13*	*13*	*7*			***43***
4	*M&O*	*A*	*8*	*13*	*20*	*31*	*47*	*46*	***165***
5	*M&O*	*B*	*1*	*1*	*2*	*9*	*21*	*15*	***49***
6	**In-kind manpower credited to Institutes**		**2**	**5**	**8**	**8**	**5**	**7**	**35**
7	*C&I*	*A*							
8	*C&I*	*B*	*2*	*5*	*8*	*7*			***22***
9	*M&O*	*A*							
10	*M&O*	*B*				*1*	*5*	*7*	***13***
11	**Institute manpower associated with deliverables**		**36**	**53**	**50**	**44**	**22**	**22**	**227**
12	*C&I*	*A*							
13	*C&I*	*B*	*32*	*48*	*40*	*19*			***139***
14	*M&O*	*A*							
15	*M&O*	*B*	*4*	*5*	*10*	*25*	*22*	*22*	***88***
	TOTAL		**66**	**113**	**130**	**121**	**95**	**90**	**613**

From Table 20 one sees that the total manpower effort for installation activities amounts to about 610 man-years; of this ca. 225 m-y is already foreseen in the original manpower planning (i.e. the 5 300 m-y). The net increase in required installation manpower is thus ca. 385 man-years, up to 350 m-y of which could be interpreted as “missing” from ATLAS institutes (including CERN).

9. SUMMARY VIEW OF THE FINANCIAL SITUATION

9.1 Introduction

As explained in Chapters 6 – 8, the additional costs required to complete the ATLAS detector include the supplementary and C&I costs, amounting to 68 MCHF. The M&O activities are dealt within the framework of the M&O MoU, expected to be accepted by the RRB for signature in April, 2002.

Table 21 summarizes the cost to completion, i.e. the supplementary and C&I costs, split between commonly shared items and system-specific items during the time period 2002 – 2005.

Table 21. Summary of supplementary and C&I costs 2002– 2005 (MCHF, 2001 prices)

#	System	System-specific		Common items		Total
		Suppl.	C&I	Suppl.	C&I	
1	Inner Detector	4.0	3.8			**7.8**
2	Liquid Argon (+cryogenics)	3.6	2.5	2.3		**8.4**
3	Tile Calorimeter	1.8	2.3			**4.1**
4	Muons	2.3	2.3			**4.6**
5	TDAQ			0.0	0.6	**0.6**
6	Magnet			19.6	4.7	**24.3**
7	Technical Coordination (infrastructure)			11.4	4.8	**16.2**
8	Common Fund (non-covered income)			2.3		**2.3**
	Sub-total	**11.6**	**10.8**	**35.6**	**10.0**	
	TOTAL	**22.5**		**45.6**		**68.1**

While comparing the cost to completion estimate of 68 MCHF with the previous version of the present document, one observes a reduction of 30 MCHF from the original value of 98 MCHF in the document ATLAS ARN 2-01. In short, this difference stems from the removal of M&O costs up to 2005 (25 MCHF) and part of the experimental area costs to be covered by the LHC machine (5 MCHF).

From Table 21 it is concluded that one third of the total additional costs (including both supplementary and C&I costs) is system-specific and two-thirds is to be shared across the whole Collaboration. The two largest cost items in the common items are related to the magnet system and detector infrastructure (access systems, shielding, structures and supports). The construction of the mechanical structures like the Feet and Rails and the barrel magnet and end cap magnets need first to be finished and installed in the pit before the mounting of the detectors can start.

Table 22 shows the annual payments evolution of the above system-specific and common items.

Table 22. Annual evolution of payments for system-specific and common items 2001 - 2005 (MCHF)

#	Cost nature	2002	2003	2004	2005	Total
1	System-specific	4.0	6.5	7.2	4.8	**22.5**
2	Common items	8.5	21.4	12.0	3.9	**45.6**
	TOTAL	**12.5**	**27.8**	**19.1**	**8.7**	**68.1**

In Table 22 one sees that the payment profile for the common items peaks at 21 MCHF in 2003 whereas for the systems, 7 MCHF peaks in 2004. This reflects the priority in completing first the cavern and the magnet system items in time for the installation of the other systems, as described in Chapter 4.

Table 23 summarizes all the costs reported up to date to reach the TDR detector (in performance) in 2007, excluding future computing costs discussed in Chapter 6. For methodological reasons, all costs are expressed in 2001 prices using CERN investment indices given in section 6.3.1. It should be stressed that the indexed baseline cost in Table 23 should be interpreted as an accounting value since such indexing has so far not been applied to the income.

Table 23. Annual evolution of total ATLAS payments 2002 – 2007 (MCHF, in 2001 prices)

#	Cost type	'95-'01	2002	2003	2004	2005	2006	2007	Total
1	Baseline part of construction payments (TDR)	226.7	98.1	83.7	49.5	26.7	10.8		**495.5**
2	Supplementary payments to complete initial detector	3.7	6.2	22.1	11.5	3.7			**47.3**
3	C&I payments to complete initial detector	1.8	2.6	5.7	7.6	5.0			**22.6**
	TOTAL	**232.2**	**106.9**	**111.5**	**68.6**	**35.4**	**10.8**		**565.4**

Table 23 shows the total capital cots to complete the TDR detector to amounts to 565 MCHF. It is assumed that the staged components are provided by the concerned Funding Agencies, in some cases requiring additional funding to cover the associated costs. As explained in Chapter 6, these costs are not included in the above budgets. It should be noted that the C&I costs in Table 23 include also the past payments for 1999 – 2001 which are not included in the total C&I budget of 21 MCHF for the time period 2002 – 2005. These amount to 2 MCHF in total which have already been paid by the Collaboration. Table 23 excludes the operation (M&O) costs which up to 2007 amount to 61 MCHF.

9.2 Cost Covering Scenarios

9.2.1 Introduction

The RRB Chair requested ATLAS Management in October 2001 to prepare two funding scenarios for the April 2002 RRB; one assuming – 20 MCHF and the second – 40 MCHF available w.r.t to the original total of 98 MCHF (which, however, also included the M&O). As the M&O is expected to be dealt with within the framework of the new MoU, it is excluded from the scope of the scenario analysis.

The equivalent models are then – 11 MCHF and – 31 MCHF w.r.t to the 68 MCHF completion costs, respectively. In addition to the availability of new pledges to cover the missing funds, the cash flow management needs also be addressed. The two scenarios are based on the following assumptions (Table 24):

Table 24. Assumptions used for cost covering scenarios

#	**Assumption**
1	Baseline CORE income (469 MCHF, in 1995 prices) is available for the initial detector configuration
2	Funding Agencies collectively agree (via RRB) that deferrals requested by ATLAS Management from the systems will be restored as fresh funding becomes available
3	The baseline income can be made available by the Funding Agencies earlier than the corresponding payments
4	Flexibility is granted by the RRB to ATLAS to manage the cash flow by allowing temporary transfers between baseline, supplementary, C&I and M&O funding

While discussions are on-going between the ATLAS Collaboration and the Funding Agencies, several models are being developed to assess the evolution of the annual financial position of the project. Their purpose is to match planned payments to complete the full TDR detector w.r.t the anticipated new income from Funding Agencies and to obtain a crude view of the budget balance evolution as well as the overall possible deficit.

9.2.2 Model A

The first financial model is based on a scenario where 56 MCHF is available for cost to completion. In this model, 8 MCHF liberated by the staging scenario (see Chapter 5) will be first used for covering the supplementary costs in the magnet project. Second, a set of cuts (3 MCHF) will be applied on the system supplementary costs. In this model, C&I activities would remain as presently planned. More details can be found in CERN-RRB-2002-025.

This model suggests that the full TDR detector will not be in place by 2007 unless new, additional funding over and above the 56 MCHF becomes available before the end of 2003.

This scenario is summarized by the following input parameters (Table 25):

Table 25. Input parameters for Model A

#	Parameter
1	Total payment profile: as in Table 23 except advancement of 6 MCHF from 2006 to 2004 as staging is not expected to be completed as originally planned
2	Baseline income: 469 MCHF (1995 prices); 496 MCHF (2001 prices), annual profile as presently planned
3	C&I (B) income as in Table 13; C&I (A) with 1 year delay
4	Supplementary income: one year delay and flat w.r.t the planned payments in Table 23
5	No new pledges over and above 56 MCHF available before 2003

Based on the above parameters, the following evolution in the budget balance is foreseen (Table 26):

Table 26. Annual evolution of ATLAS budget balance 2002 – 2007 (MCHF, in 2001 prices)

#	Nature	'95-'01	2002	2003	2004	2005	2006	2007	Total
1	Payments (total)	232.2	105.6	108.0	74.2	34.2			**554.2**
2	Income (baseline)	251.7	92	77.5	50.7	17.8	5.8		**495.5**
3	Income (C&I)	1.8	1.7	3.8	6.5	6.3	2.5		**22.6**
4	Income (suppl.)			9.1	9.0	9.0	9.0		**36.1**
	Balance	**21.3**	**-11.9**	**-17.6**	**-8.0**	**-1.1**	**17.3**	**0**	
	Cumulative balance	**21.3**	**9.4**	**-8.2**	**-16.2**	**-17.3**	**0**	**0**	

Based on Model A, a cumulative budgetary shortfall of 17 MCHF is projected by 2005, to be balanced in 2006. The cumulative balance would be negative already in 2003.

The model would imply some form of an arrangement with CERN where it, as the host lab, helps to manage the deficit in accordance with the Funding Agencies committing to reimburse the deficit by 2006. Discussions are taking place with the CERN management to see how this could be arranged.

The proposed sharing of the deferred contributions by Funding Agencies to cover the gap between available and needed funding (i.e. 11 MCHF), is shown in Appendix 15.

9.2.3 Model B

In the second financial model one assumes that only 37 MCHF is available for cost to completion.

In this model, not only would the scope of the full TDR detector be postponed well beyond 2007, the physics detection capabilities of ATLAS would also be seriously degraded.

First, the deferrals and cuts applied in Model A would be incorporated in Model B. The work on staged items would not resume in the foreseen future.

Second, the only remaining system to offer adequate resources for deferral purposes is the TDAQ. In Model A, 4 MCHF is already removed from TDAQ processors. The remaining CORE value of the TDAQ, after a withdrawal of an institute, is 43 MCHF.

ATLAS would ask TDAQ to make available 15 MCHF for the magnet project. This would drastically cut into the trigger rates and processing power; the total CORE value of the data acquisition and high level trigger is 25 MCHF. Model B would only leave 10 MCHF available for the entire ROBs, networks and processors, i.e. approximately 30% of what was originally foreseen. Much of this reduced system would be required for detector commissioning, but some benefit will be possible by delaying the purchasing of the equipment as long as possible to gain from Moore's law which predicts ca. 30% reduction in processor costs for a given performance in one year. The TDAQ community would also have to assume that the data from LAr could be produced using less read-out links from the ROD than initially foreseen.

Third, a cut of 5 MCHF would be needed in the C&I activities 2002 – 2005. This equals to a 25% reduction in the scope of C&I tasks. Achieving such cuts can be achieved only by delaying the integration activities in the pit in 2004-2005 by one year (e.g. the cryogenics system and the SR-building) and by assuming that partial optimization is allowed with the use of M&O resources due to the imposed delay. The model therefore assumes a delay up to 1 year and the availability of personnel working on M&O tasks in the pit to switch over to C&I activities within the agreed framework. Whether this could be achieved in practice remains yet to be verified. If not, one must conclude that the initial ATLAS detector cannot be constructed within the resources available in Model B.

Model B is based on the following input parameters (Table 27):

Table 27. Input parameters for Model B

#	**Parameter**
1	Baseline payment profile: extended to 2007 (only TDAQ payments in 2007)
2	Supplementary payment profile: extended to 2006
3	C&I payment profile: -25% of C&I in Table 18
4	Baseline income: 469 MCHF (1995 prices); 496 MCHF (2001 prices), annual profile as presently planned by the systems
5	C&I income: extended to 2007, 20% delay w.r.t to payment profile
6	Supplementary income: from 2004 onwards (when the TDAQ deferral funds has been spent), flat
7	No new pledges over and above 56 MCHF available before 2008

Based on the above parameters, the following evolution in the budget balance is foreseen (Table 28):

Table 28. Annual evolution of ATLAS budget balance 2002 – 2007 (MCHF, in 2001 prices)

#	**Nature**	**'95-'01**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
1	Payments (baseline)	226.7	97.8	88.2	39.7	15.9	8.5	3.7	**480.5**
2	Payments (suppl.)	3.7	4.9	20.0	11.4	2.5	1.8		**44.3**
3	Payments (C&I)	1.8	2.6	3.7	4.6	3.7	1.2		**17.6**
4	Income (baseline)	251.7	92.0	85.0	45.0	12.0	5.8	4.0	**495.5**
5	Income (suppl.)				10.0	10.0	9.3		**29.3**
6	Income (C&I)	1.8	1.7	2.5	3.5	4.0	3.0	1.1	**17.6**
	Balance	**21.3**	**-11.6**	**-24.4**	**2.8**	**3.9**	**6.6**	**1.4**	**0**
	Cumulative balance	**21.3**	**9.7**	**-14.7**	**-11.9**	**-8.0**	**-1.4**	**0**	

Table 28 shows, similarly to Table 27, a deficit starts building up in 2003, reaching 15 MCHF in 2003 and 12 MCHF in 2004. In model B, the deficit is fully reimbursed by 2007.

Appendix 16 illustrates one possible deferral sharing and cost cutting scenario to liberate the required resources.

The above two models would imply a funding shortfall up to 17 MCHF, depending on the assumptions used. In both models, the annual deficit would incur already in 2003. These models are obviously very crude and indicative at best, as the availability and timing of additional funding from the Funding Agencies is presently not known. In particular, the feasibility of imposing a 5 MCHF cut on C&I activities (assuming parallel optimization of M&O resources) remains unclear at the moment. Nevertheless, some general conclusions can be made. These are summarized in Table 29.

Table 29. Conclusions of the models

#	**Conclusion**
1	Depending on the assumptions used, the project is expected to enter in a negative balance in 2003
2	The induced maximum deficit is estimated at 17 MCHF
3	CERN would have to be asked to help in managing the negative budget balance
4	The incurred deficit is reimbursed by 2007
5	In model A, the full TDR detector could still be completed in 2007 if new pledges become available in 2003; in model B this would be pushed much beyond 2007

9.3 Deferral Strategy

Assuming that the overall financing of the project needs to be arranged along - or similarly to - one of the two models described above, the process of financial covering of individual cost items needs to be established. Based on first feedback from the Funding Agencies, it appears that all Funding Agencies will not be able to pledge for their total calculated share in the immediate future. Tentative discussions indicate that some 48 MCHF could possibly be expected as new pledges in the first income phase. Some of these new commitments will be made in-kind. A book keeping system needs to be established to tag the financially uncovered items with the obtained new pledges.

As new pledges (over and above the expected 48 MCHF) become available, the deferred items in Models A and B get restored. Assuming that some 48 MCHF could be obtained as new pledges in the first income phase, a financial plan based on a model between A and B is to be developed for October 2002. In any case, additional staging over and above the 10% significance loss level will seriously reduce the physics discovery potential of ATLAS as shown in Chapter 3.

On its part, the ATLAS Collaboration is looking constantly ways to reduce the supplementary and C&I costs. These costs were drafted based on a set of homogenous assumptions in “CERN-prices” and linked to the present construction schedule, without any contingency. As noted earlier, in-kind contributions are expected. In some cases, e.g. for manpower and some equipment and materials, the true costs can be smaller than budgeted in the above tables. Should the Funding Agencies agree to recognize them at their proper values, the total will

reduce accordingly. As the share of planned paid manpower is about 30% of the total up to the end of 2005, some scope for cost reduction can hopefully be still found. Moreover, efforts are being made to cover some of the uncovered items within host lab activities. There are indications that this can be possible for certain infrastructure items.

Table 30 summarizes the strategy for deferrals.

Table 30. Proposed deferral strategy

#	**Strategy**
1	Prioritize all uncovered cost items
2	Factorize the cost types based on the anticipated funding solution for a given cost item (i.e. in-kind contributions, cash, external budgets etc.)
3	Explore possibilities to reduce costs by attracting competitive in-kind contributions or seeking ways to cover part of costs within CERN as a host lab
4	Collect pledges from Funding Agencies (FA's) and tag them to specific cost items
5	Prepare a financial plan for the October 2002 RRB to complete the initial detector
6	As new pledges become available (i.e. over & above the first round of income used as the basis for the financial plan), restore the deferred items

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The present document proposes a financial plan how to successfully complete and commission the initial ATLAS detector. To achieve this, a mix of actions are taken, including cost reductions, payment delays, staging, re-assignment of commitments from baseline to supplementary costs and shuffling of resources between the different cost categories.

10.2 Recommendations

Based on the above analysis and the set of identified options available, the ATLAS Collaboration puts forward the following recommendations to its Funding Agencies (Table 31):

Table 31. The recommendations

#	Recommendation
1	ATLAS will set priorities to the detector items needed to be completed, including the installation sequences
2	Funding Agencies endorse the proposed deferral scenarios and extended member ship fees 2004 - 2006
3	Funding Agencies acknowledge that 'Model B' (- 31 MCHF available w.r.t to the identified completion costs of 68 MCHF) would be devastating to ATLAS and that firm pledges would be made towards the full 68 MCHF even if cash is not available in the coming next few years
4	The RRB gives the flexibility to arrange transfer of resources on a temporary basis across the different cost categories (baseline/supplementary/pre-exploitation)
5	Verify the baseline income plans with each Funding Agency
6	Enter in a pro-active dialogue with the Funding Agencies concerning the availability and profile of additional contributions over and above the baseline budget
7	The RRB asks help from CERN to manage the foreseen temporary deficit
8	For M&O CORE contributions are used as a basis for cost sharing for Category B items until 2006; thereafter the number of qualified authors
9	Institute manpower issues are handled at the system Institute Board level, communication directly with the concerned Funding Agencies

The ATLAS Collaboration gratefully acknowledges the efforts its Funding Agencies are making to ensure the planned success of ATLAS. The Collaboration is also making every effort on its side to reduce costs and reorganize its work in order to reduce the identified financial gap as much as possible. Comparing the financial overview shown in the present document w.r.t to the situation reported in October 2001, steps have already been taken in the good direction. Nevertheless, the Collaboration must emphasize that unless adequate missing funds are made available, the project will be either delayed or, in the worst case, finish with an initial detector with severely crippled physics performance which will be very hard to restore to its original design.

APPENDIX 1

A1. PHYSICS IMPLICATIONS OF A REDUCED DETECTOR

A1.1 Introduction

The limited availability of resources as well as technical and schedule constraints have led the ATLAS Collaboration to revise its construction plans for the initial LHC detector. The current plan foresees that the completion of some detector components will be deferred by one to two years during the initial lower luminosity running of the LHC. A thorough evaluation of the physics potential has strongly guided the choice of the staging concept along the various other constraints.

This chapter documents the physics potential and performance of the initial detector in comparison to the complete detector performance required at the nominal LHC luminosity. In spite of some appreciable degradation the staged ATLAS detector will still allow the Collaboration to investigate the major physics topics for the initial physics run at the LHC. It will also be recalled from the Technical Design Reports that in order to cope with the full design luminosity of the machine, necessary to cover the enormous discovery potential of LHC, the complete detector will be required.

Furthermore, the note will also address the impact that further staging would have on the physics reach. No possibility has been found to extend temporarily the degradation of the detector in a smooth way. The studies have shown that further missing components would jeopardize the performance to a point that major parts of the LHC physics potential would become inaccessible.

A1.2 General Considerations and Constraints for the Initial Detector

An overriding goal for the initial detector configuration and installation plan is to be ready for the LHC commissioning starting in January 2006, for the first collisions in the April 2006 pilot run, and for the first real LHC physics run commencing in August 2006. This plan is also exploring the flexibility available to face future changes that may be imposed by various constraints.

A1.2.1 Technical Constraints

The technical constraints include the following aspects. There is a 9 month delay projected in the availability of the cavern (civil engineering delay) that affects directly the installation time. Today it is apparent that it would not be possible to install the full detector in the remaining time left before closure of the LHC ring at the end of 2005. The sequence of installation is highly conditioned by the minimal size of the cavern, designed such as to minimise the civil engineering costs.

There are also some of the detector components that are on an extremely tight construction schedule, and in spite of dedicated efforts ATLAS might not be able to recover all these delays safely. Finally, when planning for the initial detector one has to keep in mind the limited accessibility to the detector in order to insert missing

components later, the risks of dismantling and reinstallation, as well as the significant LHC down-time that could be involved when completing the detector.

A1.2.2 Resources and Funding Constraints

There are several resources and funding constraints that are faced by ATLAS, and that have been presented in a preliminary form to the RRB in April 2001 and are further discussed in Chapter 5. The expenditures on CORE items are affected by the fact that technical difficulties with industries required in several cases to renegotiate and replace contracts, usually at larger costs than initially planned, as well as by the purchasing power evolution since the initial 1995 cost evaluations. Finalizing the detector design, reacting to test and prototype experience, and understanding better the installation procedures also resulted in the need for some additional items not included in the initial detector cost evaluation.

The construction experience also shows that some of the non-CORE costs are higher than initially expected, in particular for common assembly infrastructure and for manpower needs at the construction sites in the Institutes and centrally at CERN.

A1.2.3 Physics Priorities

The physics priorities for the first physics run in 2006 have been extensively studied. A detector concept to address the great potential for even the initial year of running was arrived at based on:

- SUSY potential (after a few days only already) requires full calorimeter coverage;
- Standard Model Higgs searches, including the low mass region overlapping with the LEP limit, imply electron and muon detection and measurement over a large rapidity range (rather than a full radial high-luminosity redundancy over limited rapidity) and high-performance b-tagging;
- MSSM Higgs searches need in addition tau-lepton identification already at low luminosity.

The present expectations are that the LHC luminosity will reach within only a few years the design value (high-luminosity), and studies have been initiated by CERN to explore the enhancement of the physics potential for even higher luminosities in a future LHC upgrade. The detector planning must make it also possible to meet this future challenge with upgrades.

A1.2.4 Initial Detector Configuration

A meaningful detector needs the full Magnet System, no reasonable staging has been identified that would be possible in this case. Furthermore one has to recall that the construction of the barrel toroid is critical for the overall schedule, and in order to have a balanced magnetic force configuration it would not be possible to consider temporary operation with only one end-cap toroid.

The initial Inner Detector configuration will defer one of the three pixel layers (but not the B-layer) and its associated read-out electronics as well as the outermost end-

cap TRT wheels. A pixel layer instead of an SCT layer was chosen for staging in order to minimize the future re-installation down-time.

Full Calorimeter coverage is required for the initial LHC physics, in particular for the important Higgs and SUSY searches. As a side-remark it is also needed mechanically to shield the muon chambers within the ATLAS air-core magnet system. The limited staging that is implemented concerns a reduction of read-out drivers (RODs) and possibly a reduced redundancy in HV power supplies. Further staging will be implemented for the instrumentation with the so-called cryostat-gap scintillators used for energy corrections in the transition regions between barrel and end-caps.

The staging in the Muon System affects the so-called EES and EEL MDT chambers, including supports and electronics, in the transition region between barrel and end-caps and part of the end-cap end-wall MDT chambers. Only half of the CSC layers (mechanics and electronics) will be part of the lower luminosity initial detector. Further staging will concerns eventually part of the outermost barrel chambers if the installation time would impose this.

The High Level Trigger and DAQ System will be initially designed to the reduced costs, in a way that it can be readily upgraded. Furthermore also the processor farm that is part of the Common Projects will be implemented in an expandable way, starting from a reduced system.

A1.3 Physics Implications of the Initial Detector Configuration

A1.3.1 Introduction

Figure A1 shows the expected significance for a Standard Model Higgs signal as a function of mass over the region $m_H < 200$ GeV. This region is particularly crucial because it is favoured by the fit to the LEP/Tevatron/SLC electroweak data and because it is the most difficult one at the LHC. It can be seen that for masses below 130 GeV discovery (i.e. a signal significance of at least 5σ) can be achieved with only 10 fb^{-1} of integrated luminosity, i.e. during the first physics run in 2006-2007, by combining ATLAS and CMS. For masses larger than 130 GeV, where the gold-plated $H \rightarrow 4\ell$ channel becomes accessible, 5σ discovery is possible by the individual experiments with the same integrated luminosity.

In the region $m_H < 130$ GeV, two complementary channels provide most of the sensitivity: $H \rightarrow \gamma\gamma$ (which requires precise EM calorimetry over $|\eta| < 2.4$) and ttH production followed by $H \rightarrow bb$, which requires calorimetry, muon trigger chambers and high-performance b-tagging. As it can be seen from Table 2, both these channels contribute in a similar way to the expected signal significance in ATLAS.

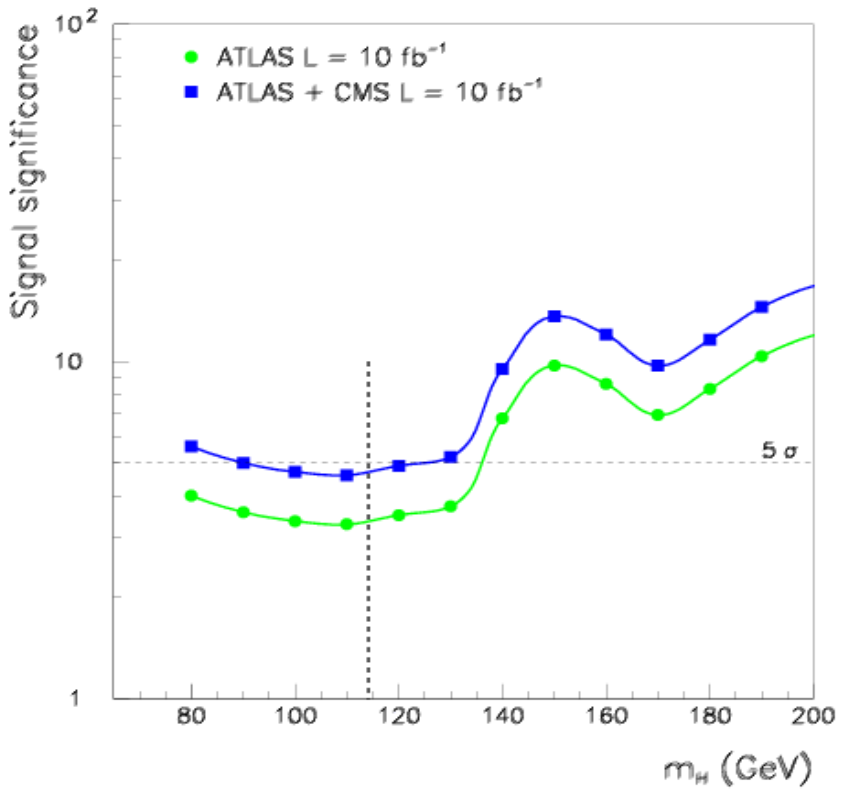


Figure A1. Expected significance for a SM Higgs signal as a function of mass with the complete (TDR) ATLAS detector (circles) and by combining ATLAS and CMS (squares) for an integrated luminosity of 10 fb^{-1} per experiment. The dashed vertical line indicates the lower limit set by LEP (114.1 GeV).

Table A1. Expected number of signal events (S), background events (B), signal-to-background ratio (S/B) and signal significance (SÖB) in ATLAS for a SM Higgs of mass ~115 GeV, for an integrated luminosity of 10 fb^{-1} and for the complete detector (TDR)

	H ® gg	**ttH ® tt bb**	**Both channels**
S	150	15	
B	3900	45	
S/B	0.04	0.3	
S/ÖB	2.4	2.2	3.2

The physics implications of staging detector parts are discussed one by one below.

A1.3.2 Staging of One Pixel Layer

The impact of one missing pixel layer (which is not the B-layer) has been studied with a full GEANT-based simulation of Higgs signal and background events. For a fixed b-tagging efficiency of 50%, the rejection against light-quark (u, d, s) jets deteriorates by ~30% with a 2-layer pixel detector compared to a 3-layer detector. The impact on the ttH channel is a significance loss of about 8%, which can be compensated by accumulating 15% more luminosity.

A1.3.3 Staging of the Outermost End-Cap TRT Wheels

Staging of these wheels, which cover the rapidity range $1.7 < |\eta| < 2.4$ and improve the momentum resolution provided by the precision layers by typically a factor of 1.5, will imply a deterioration of the track momentum resolution by a factor of 1.5 over about 20% of the Inner Detector acceptance.

The most serious physics implication in the initial run is expected to be a loss in significance for the $H \rightarrow 4\mu$ signal over the mass region $m_H < 200$ GeV. Indeed, in this region the mass resolution obtained by combining the Inner Detector and the Muon Spectrometer ($\sigma_m \sim 1.4$ GeV for $m_H = 130$ GeV) is driven by the Inner Detector ($\sigma_m \sim 1.6$ GeV with the Inner Detector alone for $m_H = 130$ GeV, compared to $\sigma_m \sim 2.1$ GeV from the Muon Spectrometer alone). This is because the decay muons have typical momenta of smaller than 40 GeV, an energy range where multiple scattering in the calorimeters limits the Muon Spectrometer performance.

A study performed with a full GEANT-based simulation of the $H \rightarrow 4\mu$ channel for $m_H = 130$ GeV has shown that , due to the limited rapidity coverage of the outermost end-cap TRT wheels, the mass resolution degrades marginally in the staged TRT scenario compared to the full TRT detector. However this is only true if the complete Muon Spectrometer is available. If, in addition, one includes the staging of the MDT chambers over the same rapidity region, then the mass resolution degrades by ~15% and therefore the $H \rightarrow 4\mu$ significance by ~7%.

Although this effect might seem to be marginal, given the availability of the $H \rightarrow 4e$ channel (which is not affected by the staging of the tracking systems), it is important to stress that in the case of an early discovery with only a few signal events, observation of a convincing excess in both channels (4e *and* 4μ) would increase the robustness of the discovery and the confidence that the observed signal is indeed new physics.

A1.3.4 Staging of the Cryostat-Gap Scintillator

This detector covers the rapidity region $1.0 < |\eta| < 1.6$ and together with other devices (LAr end-cap presampler, Intermediate Tile Calorimeter) contributes to improving the energy measurements for electrons, photons and jets in the transition region between the barrel and the end-cap calorimeters. Without these devices the energy resolution would be seriously deteriorated by the large amount of material (e.g. coming from the cryostat walls). For instance, the energy resolution for electrons of energy 30 GeV

would deteriorate from 5% to 20% at $|\eta| \sim 1.5$ if both the presampler and the gap scintillator were absent.

To evaluate in a conservative way the impact of the missing gap scintillators, it was assumed that electrons hitting the transition region are discarded because their energy resolution would be too much degraded. The impact on a possible $H \rightarrow 4e$ signal will be a loss in significance of about 8%. It should be noted that no loss is expected for $H \rightarrow \gamma\gamma$ since photons crossing the region $1.4 < |\eta| < 1.6$ have been discarded in Table 1 because the calorimeter performance in this region is not good enough to provide the needed rejection against the reducible jet backgrounds to a possible $H \rightarrow \gamma\gamma$ signal.

Finally, the implications of the missing scintillator on physics channels involving jets and missing energy (e.g. SUSY final states) are expected to be small.

A1.3.5 Staging of Precision Chambers in the Muon System

First, we note that the trigger chambers are necessary right from the beginning over the full envisaged rapidity coverage since they provide the trigger for final states containing muons.

The staging of part of the precision chambers, along the lines described in the previous Section, is expected to have an impact mainly on new heavy particles decaying into high-momentum muons, for which the momentum resolution is driven by the external Muon Spectrometer. This is the case for instance of the heavy Higgs bosons of the MSSM (A and H bosons) for masses around 250 GeV or larger, which should be detected over a large fraction of the parameter space through their decays into two muons. For example, the mass resolution for a possible $A/H \rightarrow \mu\mu$ signal with mass 300 GeV is 10.8 GeV if the information of the Inner Detector and the Muon Spectrometer is combined, 12 GeV with the Muon Spectrometer alone and 20 GeV with the Inner Detector alone. Therefore, missing chambers in the Muon Spectrometer are expected to have a clear impact on this channel.

The staging of the transition chambers (EES/EEL) and of the end-wall MDT chambers will cause a degradation of the momentum resolution of the Muon Spectrometer alone by up to a factor of 4 over the relevant rapidity region. If also the information of the Inner Detector is used to reconstruct the muons, the loss in significance for a A/H signal with mass 300 GeV will be smaller than 5% if only the EES/EEL chambers are missing and about 10% if also the end-wall MDT chambers are missing.

The absence of half of the CSC chambers was found to have negligible impact on the physics performance (e.g. pattern recognition) in the initial LHC phase at low luminosity.

A1.3.6 Summary of the Staging Impact on Physics

Table A2 summarises the main expected physics implications of the proposed staging for the initial detector configuration during the first physics run.

Table A2. Physics impact of the staging for the initial detector configuration

Staged items	**Main impact expected on**	**Loss in significance**
One pixel layer	$ttH \rightarrow ttbb$	~ 8%
Outermost TRT wheels + MDT	$H \rightarrow 4\mu$	~ 7%
Cryostat Gap scintillators	$H \rightarrow 4e$	~ 8%
MDT	$A/H \rightarrow 2\mu$	~ 10% for m ~ 300 GeV

The main conclusion is that the discovery potential for a Higgs signal in several final states will be degraded by about 10%. Although this result is acceptable, it means that 20% more luminosity (i.e. 20% more LHC running time) will be needed to compensate for this loss. This might enhance the advantage of the Tevatron, which, on the time scale of 2007, might reach enough integrated luminosity for a 5σ discovery of a Higgs boson of mass below 120 GeV.

It should also be noted that possible penalties on the pattern recognition performance (e.g. track reconstruction efficiency and fake rates) coming from the less robust tracking systems have not been included in the studies shown here. These penalties are expected to be acceptable in the initial phase at low luminosity and much more significant when running at the LHC design luminosity, as discussed in the next Section.

Finally, the staging of part of the calorimeter RODs is expected to have an impact mainly on the maximum affordable trigger rate, which will be limited to ~50 kHz at the first level trigger. This will leave ATLAS with no safety margin on the expected rate predictions for the initial run.

A1.4 High Luminosity Reach and Requirements

Running at the LHC design luminosity requires not only complete angular coverage, but also radially complete tracking devices, for several reasons:

- In order to exploit at best the LHC potential, efficient and precise reconstruction of very high-p_T muons, such as those produced in the decay of heavy objects (e.g. a Z', heavy Higgs bosons), is needed. This requires a complete Muon Spectrometer, since if the third station of chambers were missing, the momentum resolution would be degraded by more than a factor of 3 for muons of p_T = 100 GeV and the measurement and identification would be very poor for 1 TeV muons.

- Robust pattern recognition in the presence of the pile-up and radiation expected at the design luminosity requires high redundancy, especially for the stiff high-momentum tracks. The number of layers in the tracking devices presented in the ATLAS TDR was carefully optimised taking into account background levels (i.e. radiation damage and occupancy), reconstruction efficiency and fake-track rates. It should be noticed that there are large uncertainties (up to a factor of 10) on the expected background levels, for instance in the external Muon Spectrometer. As an example, if there were only 3x2 layers in the first station of the Muon Spectrometer (as initially planned before the optimisation studies done for the Muon TDR), instead of the 4x2 layers presently under construction, and the occupancy in this station were a factor of ten larger than expected, then the reconstruction efficiency for muons of a few hundred GeV would decrease by about 2% and the fake track rate would increase by a factor ~1.5. The impact would be larger if the luminosity increased to beyond 10^{34} cm^{-2} s^{-1}, as it could be expected from a natural optimisation of the machine performance or as a consequence of specific LHC machine upgrades.

- The possibility of performing efficient b-tagging depends on the number of precision layers in the Inner Detector. It has already been mentioned that for ttH events with a Higgs mass around 100 GeV the b-tagging performance deteriorates by ~30% if one pixel layer is missing. This loss in performance is larger for higher p_T (and therefore denser) b-jets, such as those which might be produced in SUSY events or in the decays of heavy exotic resonances that will be looked for during the phase at high luminosity. For instance, for b-jets of p_T~200 GeV the b-tagging performance is degraded by more than 50% in a detector with only two pixel layers compared to the complete ATLAS detector. One should also take into account that inevitable losses in the detector efficiency will occur during the ATLAS lifetime. On the other hand, the machine performance may improve with time and therefore the LHC may deliver luminosities in excess of the design value. Both these factors justify even further the need for a robust layout.

A1.5 Physics Impact of Staging Scenarios Beyond the Initial Detector Configuration

Additional staging of detector components has been considered, and five test cases have been studied. These are discussed below.

A1.5.1 Staging of Calorimetry in One End-Cap

If one of the LAr end-cap calorimeters (EM, HEC, FCAL) were not ready, then the full calorimetry in one of the two end-caps would be staged, since the EM, HEC, and FCAL calorimeters are housed in the same cryostat. This would have a dramatic impact on both Higgs and SUSY searches. For instance, the signal significance of both $H \rightarrow \gamma\gamma$ and $H \rightarrow 4e$ would be degraded by 30%, which would require a factor of 1.6 more luminosity to compensate, because the significance for both these channels decreases essentially linearly with decreasing detector coverage.

The main expected signatures for SUSY are events with many hard jets and large missing transverse energy. If calorimetry is missing in one end-cap, then the missing

energy signature would be lost because events with a priori no escaping particles (like QCD multi-jet production) will have a larger missing transverse energy due to particles lost in the uncovered region. This is illustrated in Figure A2, which shows the distribution of the event effective mass (a variable related to the scalar sum of the missing transverse energy and the transverse energy of the leading jets in the event) for ATLAS with full calorimetry coverage (i.e. over $|\eta| < 5$) and for a detector without LAr calorimetry in one end-cap (i.e. over the region $1.4 < \eta < 5$). In this latter case, the SUSY signal produced by squarks and gluinos, here shown for masses of ~ 700 GeV, would be overwhelmed by the QCD background.

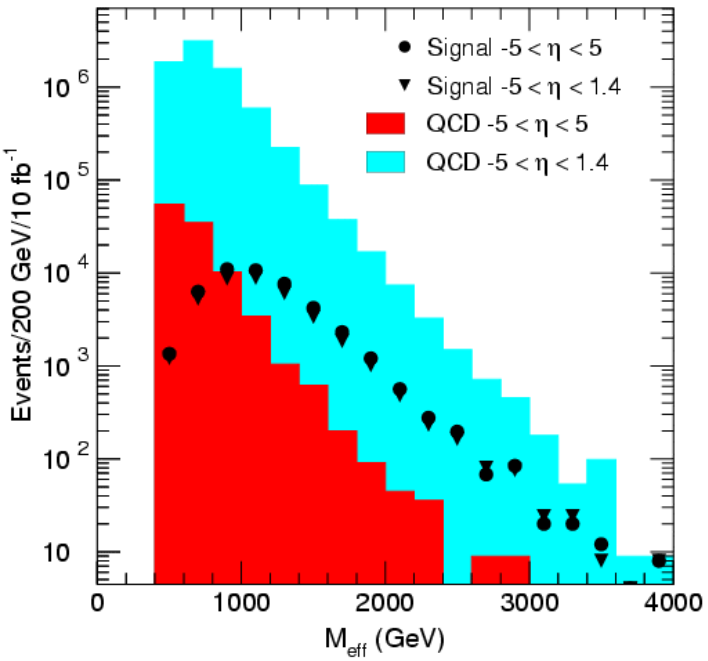


Figure A2. Expected distribution of the "effective mass" variable (see text) for the SUSY signal (points) and the QCD background (histograms) for the full calorimeter coverage and for a scenario with no LAr calorimetry in one end-cap.

A1.5.2 Further Staging of the Pixel Detector

If two or three pixel layers were staged, the capability of tagging b-jets would be lost. The main consequence is that the ttH → ttbb channel could not be detected and therefore the total ATLAS sensitivity to a Higgs signal for masses below 130 GeV would decrease from 3.2 to 2.4 (see Table 1). This not only means that 18 fb^{-1} instead of 10 fb^{-1} would be needed to recover for this loss, but also that the robustness provided by two independent channels would be lost. Similar conclusions apply to the observation of the Higgs bosons of the MSSM and to SUSY signatures involving b-jets. In addition top-quark physics, which is one of the main LHC goals in the initial phase at low luminosity, will be jeopardised.

A1.5.3 Further Staging of the TRT

If the full TRT detector were absent, the track momentum resolution would be degraded by a factor of 1.5-2 over the full coverage of the Inner Detector. This alone, i.e. even neglecting pattern recognition, level-2 trigger and electron identification problems, would cause a degradation of the significance for the $H \rightarrow 4\mu$ channel by 15%, and also impact, to a lesser extent, other physics channels with muons in the final state.

A1.5.4 Further Staging of Muon Precision Chambers

If the precision chambers of the Muon Spectrometer (MDT, CSC) were absent, ATLAS would jeopardise the capability of discovering an early signal due to the heavy Higgs bosons of the MSSM. For instance, the significance of a possible $A/H \rightarrow \mu\mu$ signal would decrease by more than 35%. It should be noted that this physics channel, together with A/H → ? ? , is one of the few processes available to observe a heavy Higgs signal over a large fraction of the MSSM parameter space.

A1.5.5 No Muon Instrumentation in One End-Cap

If both, precision and trigger chambers were missing in one end-cap toroid, e.g. over the region $\eta > 1.1$, then the acceptance for final states relying on muon trigger and identification would be strongly reduced. As an example, Figure A3 shows the rapidity distribution of the muon with the largest rapidity for $H \rightarrow 4\mu$ events after kinematics cuts. It can be seen that in most events at least one muon is in the region

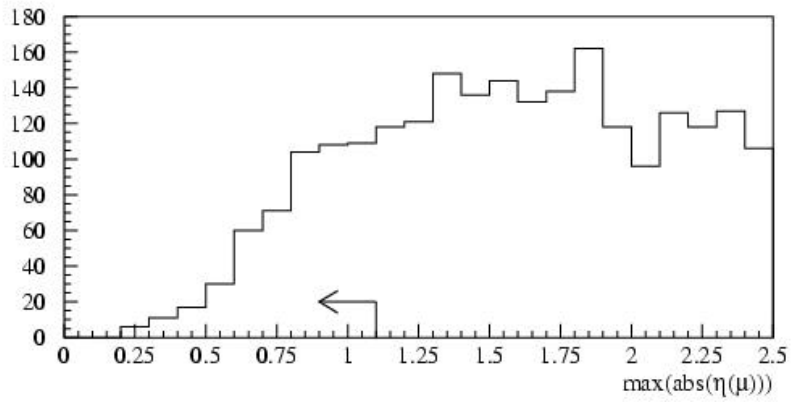


Figure A3. *Rapidity distribution of the muon with the largest |h| in H ® 4m events with m_H = 130 GeV.*

$|\eta| > 1.1$. Therefore, assuming that events where two or more muons escape in the non-instrumented region are lost, because they cannot be identified efficiently, the signal significance would degrade by 20%.

We note that the impact would be very strong also on any high mass exploratory physics (for example $Z' \rightarrow \mu\mu$) that could become accessible in case the LHC luminosity would exceed the current expectation for the first physics run.

In conclusion, additional staging of the ATLAS detector, which in some cases such as calorimetry or TRT implies a full block of detectors missing, would lead to unacceptable implications on physics, thereby questioning the interest and opportunity of a first physics run in 2006. Indeed, the significance for a Higgs signal in the most promising channels would be degraded by about 30%, requiring a factor 1.5-2 more luminosity to reach the same discovery potential, and the detector might become blind to SUSY particles.

A1.6 Conclusions

This note summarizes the main physics impact of the staging adopted by the ATLAS Collaboration for the initial detector configuration for the first LHC physics run starting in Summer 2006 and aiming at an integrated luminosity of 10 fb^{-1}. The staging strategy has been carefully chosen such as to preserve as much as possible the main goals and opportunities of the LHC. Yet some losses are unavoidable, in particular the Higgs signal significance in several final states will be degraded by about 10%. Although this result is acceptable, it means that 20% more luminosity (or running time of the LHC) will be needed to compensate for this loss. Furthermore, robustness and redundancy in the pattern recognition had to be sacrificed in order to achieve this overall staging compromise for the initial luminosity detector configuration.

To exploit the full and very rich physics potential of the LHC high-luminosity running will be mandatory. This regime is expected to be reached gradually as from mid-2007 onwards. In order to cope with the expected background conditions the full robustness and redundancy of the ATLAS detector will be required, according to its design criteria as specified in the Technical Design Reports. This means restoring both the pattern recognition capabilities and the resolutions for the large variety of expected and unexpected signals. Otherwise the planned increase in luminosity of the machine could not be exploited. The staged components must therefore be installed in Spring 2007 after the initial run.

Additional staging for the initial phase has been studied for several test cases. As also described briefly in this note it has been found that this would lead to unacceptable cuts into the physics reach, to a point that the interest and opportunities of a first physics run in 2006 would be severely put into question, and with the risk that the resources needed to operate the LHC would be wasted to a large extent.

APPENDIX 2

ATLAS DETECTOR INSTALLATION PLAN

Updated February '02

A2.1. Introduction

The installation of the ATLAS systems in Pit 1 starts in Nov 2003. The underground installation area consists of the following elements:
- UX 15 main cavern housing the experiment;
- USA 15 service cavern housing the cables, racks and electronics;
- US 15 service cavern housing additional racks and electronics;
- shafts PX14 and PX16 to connect UX 15 to surface building SX1;
- shaft PX 15 to connect USA 15 to surface building SX1;
- shaft PM 15 to connect US 15 to surface building SX1.

The total volume of these areas amounts to 101 500 m^3. On the surface in the Pit 1 area, several buildings are erected to house different technical on-site activities. The main buildings above the experimental cavern are: SX1 (experimental hall), SD (access building), SU (ventilation building), SH (helium compressor building), SDX (access building), SUX (ventilation building) and SCX (ATLAS control rooms). The total volume of these buildings is ca. 70 400 m^3. Closely to this building cluster are situated SF1 (cooling towers), SE (electrical building) and SR1 (ID assembly and reintegration facility).

A2.2. Planned Installation Sequence

The total installation period for the detector and infrastructure is about 43 months and comprises 16 phases that are split into steps.

Phase 1a: Infrastructure in UX15

Step 0
This corresponds to the first installation milestone when the underground cavern is handed over by the civil engineers to CERN. The date for this handover of the UX is currently scheduled for 17 Mar 2003. At this time civil engineering work is planned to continue in the surface building SX, the handover of which is scheduled for 29 April 2003. Access through this building is required to allow the lowering of items into the UX cavern.

Step 1
When the cavern is handed over to CERN work then starts on the general facilities, or infrastructure. The aim is to complete the overhead travelling crane, large storage vessels, and end-wall and side-wall structures before the go ahead is given for work to start on the assembly of ATLAS.

As neither the surface or underground travelling cranes will be ready at this stage, the temporary cranes are required, both on the surface and underground. The first activity will be the assembly of the definitive underground travelling crane. The temporary

surface crane will be used for the lifting of the underground travelling crane beams onto their rails. At the same time the definitive 280t crane is being assembled on the surface.

Step 2
As soon as the 280t surface crane is ready the material for the end-wall structures is lowered down. Work will then start on the installation of the duct risers on the end walls, followed by the end-wall structures and incorporating Alimak type lifts at each end. When the end-wall structures are complete, the duct risers on the side walls will be installed followed by the walkways. When this is complete, circulation, at height, will be possible from one end of the cavern to the other and from one side to the other.

Step 3
When one of the underground travelling cranes is available it can be used for the handling of the large cryogenic storage vessels which are then put into position. Also the return air plenums and the definitive lighting can be installed in the vault of the cavern.

Step 4
With the large cryogenic reservoirs in position work then starts on the installation of the stanchions of the surrounding HS structure. This is the structure that will eventually surround the ATLAS detector and provide support for racks and services as well as giving a means of access at different levels. Platforms from the stanchions and towards the detector will also be installed. When this is done, work on the installation of the ATLAS feet can begin. At the same, on the side walls, the work on the cryogenic installation begins with the fixing of transfer lines.

Phase 1b: ATLAS Bedplates and Feet

The assembly of the ATLAS detector starts with the feet and rails system. This system serves two functions; a floor support for the barrel toroid and the main means of support for all the central detectors. The work starts with the fixing of the feet bedplates onto the concrete. The floor of the cavern is horizontal. The bedplates are at an angle, to provide the necessary slope to the beam, to which the detector will be perpendicular. The support feet will be lowered in assembled pairs. They will be in two parts. The first part will be open to receive the first two barrel toroid coils.

Phase 2a: Barrel Toroid

Step 1
When the open part of the support feet are all assembled then work on the barrel toroid installation can start. The barrel toroid coils are lowered individually using the surface building overhead travelling cranes. When the coil arrives in the cavern there is then a progressive changeover to the UX travelling cranes. The coils are then adjusted to their required angular positions and lowered into place on the open half of the support feet. Once in position the support feet are closed around the coils. During the assembly of the barrel toroid, work carries on in parallel on the cryogenic and vacuum installation.

Step 2
Once the first two barrel toroid coils are in position work then starts on the warm structure of the barrel toroid. This is the interconnecting structure between the coils. The assembly of these interlinks is made such that they are ready to receive the next two coils. In order to provide access, it is intended to assemble definitive access structures both inside and outside the barrel toroid volume. These are the HS and HXT structures.

Step 3
Both of the barrel toroid coils 3 and 4 are lowered, positioned, and then connected to the warm structure that links them to coils 1 and 2.

Phase 2b: Barrel Calorimeter

Step 1
Once the fourth barrel toroid coil is in position the intention is to start with the barrel calorimeter assembly under the small shaft C. The reasons for this are as follows:
- After the assembly of the fourth coil, the barrel toroid assembly team should have gained sufficient experience to be in an optimum working mode and ready to accept other assembly teams working in the cavern;
- The barrel toroid occupies a central position in the cavern. There is space below the shaft C to allow for the assembly of the barrel calorimeter. The barrel toroid components are lowered down the large shaft on side A. Therefore, the assembly under the small shaft on side C should not affect the barrel toroid assembly;
- The barrel calorimeter is required in its final position, inside the barrel toroid, as early as possible.

The barrel calorimeter assembly itself starts with the lower half of the tile calorimeter. Ten tile modules are assembled together with the support feet on the surface. The limitation on the number of modules is given by the capacity of the surface building travelling crane, 280 tonnes. This tile support assembly is then lowered down shaft C onto a support truck. There are a number of such trucks foreseen. They allow for the support and movement of the different detectors. They are to move on the floor of the cavern and have rails that allow for the detectors to move off the truck and onto the rails inside the barrel toroid.

Step 2
The barrel calorimeter support saddle is moved, on its truck, to the USA15 side of the cavern. Tile modules are then lowered and stored on the floor of the cavern.

Step 3
Individual tile calorimeter modules are lifted with the underground travelling crane and assembled together, one by one, until 32 of the 64 total have been completed. When this stage is reached the supports for the LAr barrel calorimeter are attached in preparation for its arrival. In the meantime the barrel toroid assembly is progressing.

Step 4
The completed lower half of the barrel tile calorimeter is moved to be below the small shaft, side C. The liquid argon calorimeter is then lowered into position. Initially it will rest on hydraulic jack supports until adjustments in position will then allow it to rest on the purpose-designed supports, either end of the barrel tile calorimeter.

Step 5
When the LAr calorimeter is fixed to its support structure the truck is moved to the USA15 side of the cavern to allow for the tile calorimeter modules to be lowered and stored underground. This in preparation for the assembly of the tile modules around the LAr cryostat.

Step 6
The tile modules are assembled around the liquid argon cryostat until it is encased by them and the barrel tile assembly is complete. The ends of the LAr cryostat, the feedthrough region, are accessible. At this stage the electrical feedthroughs have, in the main, their pedestals connected to them. These pedestals provide a protective cover for the delicate electrical connectors that protrude from the warm flange of the electrical feedthrough. In addition, they provide a base from which the front-end electronic crates are attached. These crates will be fitted below ground, once the barrel is in its final position. This is to avoid the risk of damage during the handling and assembly operations.

Step 7
When the barrel toroid and the surrounding structure are completed the next stage is to introduce the chimney of the solenoid. The chimney contains the superconducting cables and helium cooling pipes for the solenoid magnet that is housed within the vacuum vessel of the barrel LAr cryostat. These services need to pass through the barrel toroid and muon chamber system and this is done with the chimney. In order to minimize the number of in situ field connections the chimney comes in one piece. Although relatively large, 7×3.5 m, it can pass in the bore of the barrel toroid before being lifted into a temporary position between the top two barrel toroid coils. When the above operation has been completed the barrel calorimeter can then move on the rails to its final, central, position. The chimney is then lowered to enable the connection with the solenoid services that exit the cryostat. When this is done, work can start on the connection of the control dewar at the top end of the chimney.

Step 8
As soon as the barrel calorimeter has moved off its truck to pass inside the barrel toroid the shielding nose monoblock is lowered and installed on side C after which the end- cap calorimeter C assembly can start.

Step 9
When the barrel calorimeter is in its final position work continues on the installation of the front-end electronics crates on the pedestals and connection of the services. Since the equipping of the FE crates with the electronics cards and the associated testing is a lengthy operation we are aiming to do it parallel on both sides of the barrel.

Phase 3a: End-cap Calorimeter C

Step 1
The assembly sequence for the end-cap calorimeters is the same as for the barrel: a tile calorimeter support, together with some modules attached on the surface, is lowered into the cavern. Then tile modules are lowered and stored underground.

Step 2
The lower half of the tile calorimeter is assembled (in the case of the end-caps it is a few modules short of a half). When this is done the supports for the LAr end-cap cryostat are fixed in preparation for its arrival.

Step 3
The liquid argon end-cap C cryostat is lowered onto its supports at each end of the tile end-cap. As with the barrel, jacks will be used in a first instance to take the load and then, once the required adjustments are made, the cryostat will be lowered onto its supports. During this time work proceeds with the service connections to the barrel calorimeter.

Step 4
Once the cryostat is resting on its supports the modules of the tile calorimeter are lowered and stored on the floor of the cavern.

Step 5
The tile modules are assembled around the liquid argon cryostat until the assembly of the tile calorimeter is completed.

Phase 3c: Muon Barrel

Step 1
When the barrel calorimeter is moved inside the barrel toroid the work on the muon barrel services can start and the services for the Tile barrel, LAr barrel and inner detector can be completed. The muon barrel services must be on place before the chambers are installed.

Step 2
The barrel muon chambers are split, for installation purposes, into two halves: side C and side A. This is because the services fan out of ATLAS in a radial fashion at the centre, $z = 0$, thereby splitting the detector into two halves. Chambers will be slid, from the ends, onto previously installed rails inside the barrel toroid. These rails will be fitted once the HXT access structure and barrel toroid are completed. The chamber installation will begin on side A and will concern the three layers of muon chambers around the barrel toroid. Work will be from the innermost ring, BIS & BIL, outwards to BMS & BML, then BOS & BOL. Once in place the chambers will have their service connections made. The major part of the services will have already been installed. In addition to these horizontal chambers the vertical chambers EES and EEL will be installed. At the same time the assembly of the end-cap calorimeter C continues on side C. During the installation of the BIS and BIL chambers the inner detector services to patch panels PP2 will be installed.

Step 3
When the barrel, side A is completed, and the extended calorimeter C is ready and moved inside the barrel toroid, the assembly team and tooling will be moved to side C where work on the barrel, side C, chambers will commence. At the same time, and on side A, work will start on the assembly of the end-cap calorimeter A

The current installation schedule is based on the barrel chambers, side A, being completed before the start of the barrel installation on side C. In order to load the barrel toroid warm structure and coils uniformly it might be necessary to do this work at the same time. This would not only require doubling of the resources but it would also block both sides of the detector such that parallel assembly of the end-cap calorimeter A is no longer possible.

Phase 4a: End-cap Calorimeter A

Step 1
When the muon barrel side A is completed the space under the shaft is free and the tile end-cap A calorimeter is lowered and assembled in the same way as the end-cap C.

Steps 2 and 3
As the assembly follows the same sequence as for end-cap C, Phase 3a, steps 2 and 3 are not described.

Step 4
The shield disc is lowered on side C. This shield disc provides a radiation shield for the muon chambers that are attached to the outside face of it. In addition it provides a return path for the magnetic field of the solenoid. The reason for bringing it below ground at this stage is to prepare for the magnetic field tests of the solenoid. Field measurements are required prior to the installation of the inner detector. The shield disc C is put into the closed position once all the service connections are completed on that side.

Step 5
The completed end-cap calorimeter A is moved into the closed position on that side. When this is done the shield disc on side A can be lowered onto the truck and moved into the closed position.

Step 6
With all the services to the barrel calorimeter and solenoid connected, preparations can be made for testing the solenoid. Once the cryostat and feedthrough vacuum systems are tested and operational the cooling down of the liquid argon calorimeter can take place. When this is done the solenoid coil can be cooled down and the power switched on to the magnet. Measurements will then be made of the magnetic field produced from the solenoid. This data is necessary prior to the installation of the inner detector. At the same time the services to the barrel toroid will be completed and so use can be made of this moment for carrying out a magnet test of the barrel toroid.

Phase 5a: Big Wheels

Step 1
The completion of the installation of barrel muon chambers should be followed, shortly after, by the completion of the muon chambers on the big wheel side C. When the big wheel chambers on side C are completed they can be moved against the wall.

Step 2
When the big wheel, side C is completed and the end-cap calorimeter is moved inside the barrel toroid, the big wheel assembly team and tooling will be moved to side A where work on the big wheel chambers A will commence. At the same time the work still continues on connecting the services to the end-cap calorimeter A

Phase 5b: Inner Detector

Step 1
When the solenoid and barrel toroid magnet tests have been completed the shield discs can be moved back and lifted to the surface. Then the work continues on the connection of the services to end-cap calorimeter A which is moved out from the barrel toroid and onto the support truck.

Step 2
With the end-cap calorimeters in their open position work can then continue on the connection of the services of the end-cap calorimeter A. Also, the first pre-assembly of the inner detector, the barrel ID, can be lowered and fixed into position inside the bore of the liquid argon cryostat. Once in position, work starts on the connection of the services from this barrel part of the inner detector to the services patch panel PPB1, services having already been connected to the patch panels PPB2 and PPF2.

Step 3
The next step is the installation of the inner detector end-caps C. This end-cap is in two parts: a first part that includes the forward SCT and TRT, and a second part of TRT wheels only. For the initial detector only the first part will be installed. Each part is supported from a "squirrel cage" that completely surrounds the assembly and allows for the attachment of services. Each squirrel cage, complete with services, is slid into position on the rails that are attached to the walls of the cryostat. Once in position the service "pig-tails" are connected to the services patch panel PPF1, to be found at the entrance cone of the cryostat bore. The installation of the end-cap A is scheduled immediately after the installation of end-cap C.

Step 4
The beam pipe is assembled with the pixel detector on the surface in the SR building. It is then lowered into ATLAS and inserted in the pixel support tube.

Phase 6a: End-cap Toroid

Step 1
The end-cap toroids being, apart from the forward muon chambers, furthest from the interaction point they are the last sub-detector to be lowered. They are large objects and, once underground, will restrict access. Particularly so when they are moved into

the closed position as this will require the closing up of all other sub-detectors. From this point on no further access between calorimeters and inner detector will be possible. This is one consideration in the determination of the assembly sequence. Another, is the 40-day cool down time of the end-cap toroids. The aim is, therefore, to move the end-cap toroids into their closed position and cool them down. During this cool down the installation of muon chambers on the wall structure can take place. The work starts with the lowering of the end-cap toroid C.

Step 2
The end-cap toroids have a services turret and tower arrangement that extends from the top of the toroid up through the three layers of muon chambers. Because of its size, the services tower is installed underground. With the end-cap toroid in the garage position, sections of the beam pipe are lowered, slid through the extended calorimeters, and connected to the inner detector section. Once fitted with its turret and tower, the end-cap toroid C is moved into the closed position. The toroid section of the beam pipe is installed and connected to the calorimeter section. Shielding is inserted inside the end-cap toroid C.

Step 3
The end-cap toroid C is in the closed position allowing for the installation of muon chambers on the end wall structure, side C, to start. The big wheel chambers on side A are completed. This allows them to be moved against the wall so that the end-cap toroid A can be lowered and moved into the garage position.

Step 4
Both end-cap toroids are in the closed position and being cooled down. Work on the wall chambers continues. It should be noted that it is currently envisaged to use the definitive proximity cryogenic installation for the testing of the end-cap toroids on the surface. This places a further constraint: this proximity cryogenic installation cannot be lowered and installed underground until the second end-cap toroid has been successfully tested on the surface. The arrangement of the equipment in the cavern has to be made with this in mind. Once the installation of the big wheel muon chambers is complete, tests can start on the TGC trigger chambers. These are the last elements of the level-1 trigger system. When these first tests are complete, therefore, global tests can be made on the trigger system.

Phase 6b: Small Wheels and Toroid Shielding

Step 1
The shield disc is lowered onto the support truck complete with muon chambers that have previously been attached on the surface. Note that up to this time access is still available inside the bore of the barrel toroid for work on the calorimeters and inner detector to continue, if necessary.

Step 1
The muon chamber installation is completed once the last chambers have been installed on the end walls. When this is done the tooling in this area can be removed and work can start on connecting the last sections of the beam pipe.

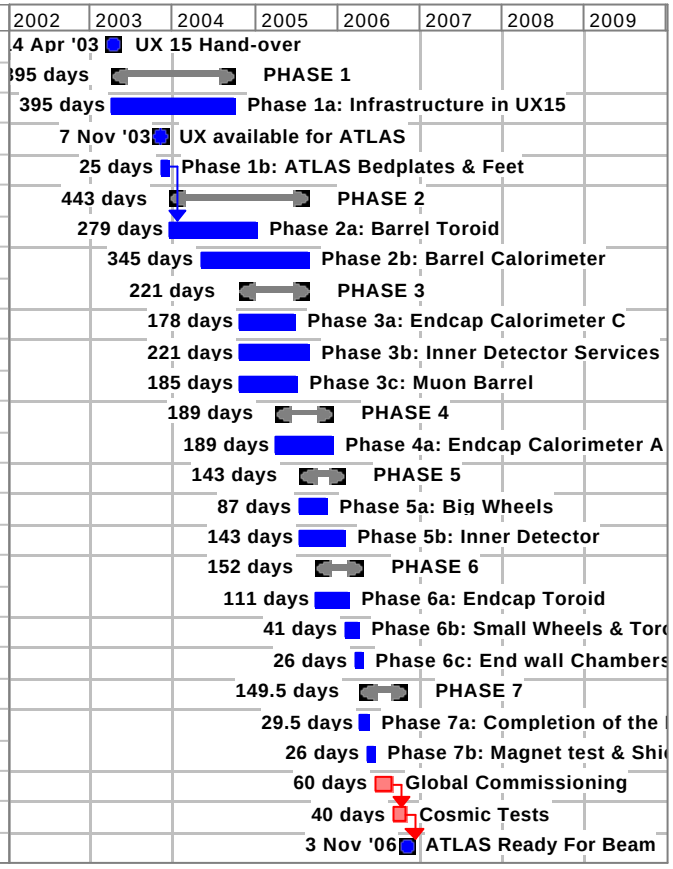
Step 2
When all the sections of the beam pipe have been connected the bake-out and pumping equipment can be installed so that the pumping down and bake-out of the vacuum beam pipe can take place. When completed this equipment is removed and the trucks in the forward regions are lowered in preparation for the lowering of the shielding blocks. Shielding blocks are first lowered on side C.

Step 3
Forward shielding on side C is completed. Shielding on side A is under way.

Step 4
The last shielding blocks are lowered and positioned. This signals the end of the ATLAS installation phase.

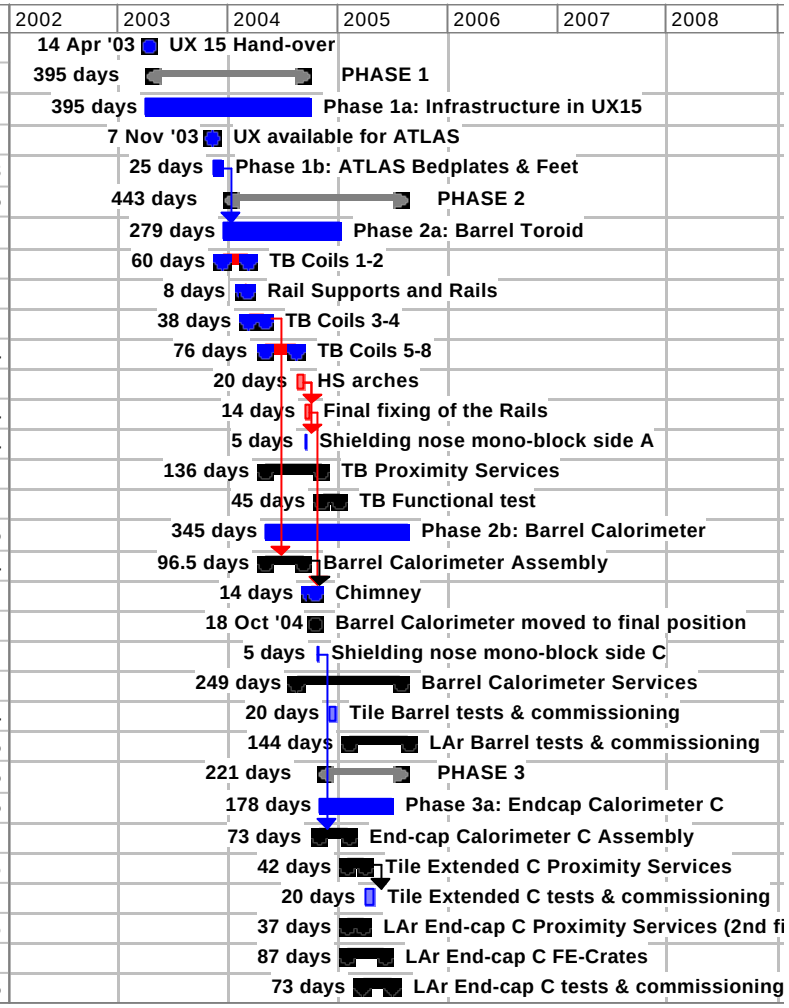
Installation V. 4.04 Summary

Task Name	Start	Finish
UX 15 Hand-over	14 Apr '03	14 Apr '03
PHASE 1: Infrastructure & Feet	29 Mar '03	1 Oct '04
Phase 1a: Infrastructure in UX15	29 Mar '03	1 Oct '04
UX available for ATLAS	7 Nov '03	7 Nov '03
Phase 1b: ATLAS Bedplates & Feet	7 Nov '03	12 Dec '03
PHASE 2: Barrel Toroid & Barrel Calorimeter	15 Dec '03	24 Aug '05
Phase 2a: Barrel Toroid	15 Dec '03	6 Jan '05
Phase 2b: Barrel Calorimeter	28 Apr '04	24 Aug '05
PHASE 3: End-cap Calorimeter C & Muon Barrel	20 Oct '04	24 Aug '05
Phase 3a: Endcap Calorimeter C	25 Oct '04	30 Jun '05
Phase 3b: Inner Detector Services	20 Oct '04	24 Aug '05
Phase 3c: Muon Barrel	20 Oct '04	5 Jul '05
PHASE 4: End-cap Calorimeter A	28 Mar '05	16 Dec '05
Phase 4a: Endcap Calorimeter A	28 Mar '05	16 Dec '05
PHASE 5:Big Wheels & Inner Detector	19 Jul '05	3 Feb '06
Phase 5a: Big Wheels	19 Jul '05	17 Nov '05
Phase 5b: Inner Detector	19 Jul '05	3 Feb '06
PHASE 6: Toroid End-Caps & Small Wheels	22 Sep '05	24 Apr '06
Phase 6a: Endcap Toroid	22 Sep '05	25 Feb '06
Phase 6b: Small Wheels & Toroid Shielding (JT)	6 Feb '06	3 Apr '06
Phase 6c: End wall Chambers (EO)	20 Mar '06	24 Apr '06
PHASE 7: Beam Vacuum, Closing, Shielding	7 Apr '06	3 Nov '06
Phase 7a: Completion of the Beam Vacuum	7 Apr '06	19 May '06
Phase 7b: Magnet test & Shielding	11 May '06	16 Jun '06
Global Commissioning	16 Jun '06	8 Sep '06
Cosmic Tests	8 Sep '06	3 Nov '06
ATLAS Ready For Beam	3 Nov '06	3 Nov '06



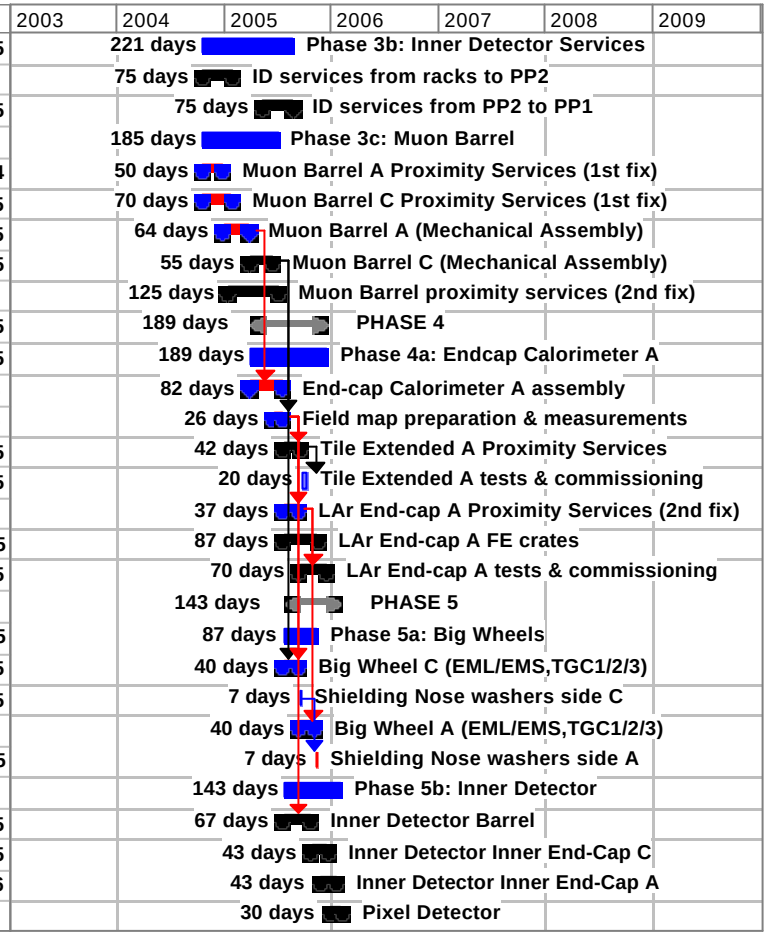
Installation v. 4.04 1/3

Task Name	Start	Finish
UX 15 Hand-over	14 Apr '03	14 Apr '03
PHASE 1: Infrastructure & Feet	29 Mar '03	1 Oct '04
Phase 1a: Infrastructure in UX15	29 Mar '03	1 Oct '04
UX available for ATLAS	7 Nov '03	7 Nov '03
Phase 1b: ATLAS Bedplates & Feet	7 Nov '03	12 Dec '03
PHASE 2: Barrel Toroid & Barrel Calorimeter	15 Dec '03	24 Aug '05
Phase 2a: Barrel Toroid	15 Dec '03	6 Jan '05
TB Coils 1-2	15 Dec '03	5 Mar '04
Rail Supports and Rails	23 Feb '04	3 Mar '04
TB Coils 3-4	8 Mar '04	28 Apr '04
TB Coils 5-8	29 Apr '04	12 Aug '04
HS arches	13 Aug '04	9 Sep '04
Final fixing of the Rails	10 Sep '04	29 Sep '04
Shielding nose mono-block side A	10 Sep '04	16 Sep '04
TB Proximity Services	29 Apr '04	4 Nov '04
TB Functional test	4 Nov '04	6 Jan '05
Phase 2b: Barrel Calorimeter	28 Apr '04	24 Aug '05
Barrel Calorimeter Assembly	28 Apr '04	10 Sep '04
Chimney	29 Sep '04	19 Oct '04
Barrel Calorimeter moved to final position	18 Oct '04	18 Oct '04
Shielding nose mono-block side C	19 Oct '04	25 Oct '04
Barrel Calorimeter Services	13 Aug '04	27 Jul '05
Tile Barrel tests & commissioning	30 Nov '04	27 Dec '04
LAr Barrel tests & commissioning	4 Feb '05	24 Aug '05
PHASE 3: End-cap Calorimeter C & Muon Barrel	20 Oct '04	24 Aug '05
Phase 3a: Endcap Calorimeter C	25 Oct '04	30 Jun '05
End-cap Calorimeter C Assembly	25 Oct '04	3 Feb '05
Tile Extended C Proximity Services	2 Feb '05	31 Mar '05
Tile Extended C tests & commissioning	1 Apr '05	28 Apr '05
LAr End-cap C Proximity Services (2nd fix)	2 Feb '05	24 Mar '05
LAr End-cap C FE-Crates	2 Feb '05	2 Jun '05
LAr End-cap C tests & commissioning	22 Mar '05	30 Jun '05



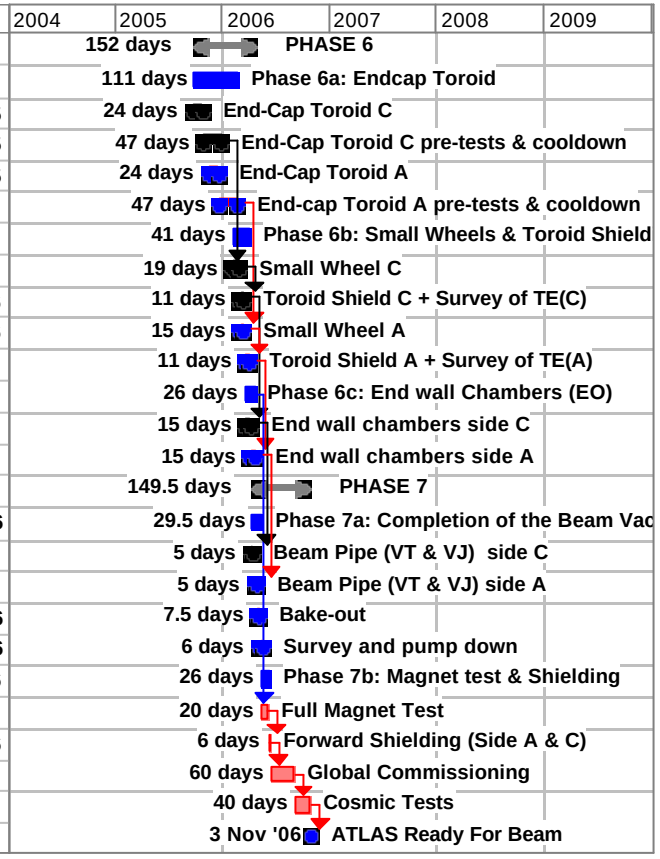
Installation v. 4.04 2/3

Task Name	Start	Finish
Phase 3b: Inner Detector Services	20 Oct '04	24 Aug '05
ID services from racks to PP2	20 Oct '04	1 Feb '05
ID services from PP2 to PP1	12 May '05	24 Aug '05
Phase 3c: Muon Barrel	20 Oct '04	5 Jul '05
Muon Barrel A Proximity Services (1st fix)	20 Oct '04	28 Dec '04
Muon Barrel C Proximity Services (1st fix)	20 Oct '04	25 Jan '05
Muon Barrel A (Mechanical Assembly)	28 Dec '04	28 Mar '05
Muon Barrel C (Mechanical Assembly)	28 Mar '05	13 Jun '05
Muon Barrel proximity services (2nd fix)	12 Jan '05	5 Jul '05
PHASE 4: End-cap Calorimeter A	28 Mar '05	16 Dec '05
Phase 4a: Endcap Calorimeter A	28 Mar '05	16 Dec '05
End-cap Calorimeter A assembly	28 Mar '05	20 Jul '05
Field map preparation & measurements	14 Jun '05	19 Jul '05
Tile Extended A Proximity Services	20 Jul '05	15 Sep '05
Tile Extended A tests & commissioning	16 Sep '05	13 Oct '05
LAr End-cap A Proximity Services (2nd fix)	21 Jul '05	9 Sep '05
LAr End-cap A FE crates	21 Jul '05	18 Nov '05
LAr End-cap A tests & commissioning	12 Sep '05	16 Dec '05
PHASE 5:Big Wheels & Inner Detector	19 Jul '05	3 Feb '06
Phase 5a: Big Wheels	19 Jul '05	17 Nov '05
Big Wheel C (EML/EMS,TGC1/2/3)	19 Jul '05	13 Sep '05
Shielding Nose washers side C	14 Sep '05	22 Sep '05
Big Wheel A (EML/EMS,TGC1/2/3)	13 Sep '05	8 Nov '05
Shielding Nose washers side A	9 Nov '05	17 Nov '05
Phase 5b: Inner Detector	19 Jul '05	3 Feb '06
Inner Detector Barrel	19 Jul '05	20 Oct '05
Inner Detector Inner End-Cap C	20 Oct '05	20 Dec '05
Inner Detector Inner End-Cap A	22 Nov '05	20 Jan '06
Pixel Detector	26 Dec '05	3 Feb '06



Installation v. 4.04 3/3

Task Name	Start	Finish
PHASE 6: Toroid End-Caps & Small Wheels	22 Sep '05	24 Apr '06
Phase 6a: Endcap Toroid	22 Sep '05	25 Feb '06
End-Cap Toroid C	22 Sep '05	26 Oct '05
End-Cap Toroid C pre-tests & cooldown	27 Oct '05	31 Dec '05
End-Cap Toroid A	17 Nov '05	21 Dec '05
End-cap Toroid A pre-tests & cooldown	22 Dec '05	25 Feb '06
Phase 6b: Small Wheels & Toroid Shielding	6 Feb '06	3 Apr '06
Small Wheel C	6 Feb '06	2 Mar '06
Toroid Shield C + Survey of TE(C)	2 Mar '06	17 Mar '06
Small Wheel A	27 Feb '06	17 Mar '06
Toroid Shield A + Survey of TE(A)	20 Mar '06	3 Apr '06
Phase 6c: End wall Chambers (EO)	20 Mar '06	24 Apr '06
End wall chambers side C	20 Mar '06	7 Apr '06
End wall chambers side A	4 Apr '06	24 Apr '06
PHASE 7: Beam Vacuum, Closing, Shielding	7 Apr '06	3 Nov '06
Phase 7a: Completion of the Beam Vacuum	7 Apr '06	19 May '06
Beam Pipe (VT & VJ) side C	7 Apr '06	14 Apr '06
Beam Pipe (VT & VJ) side A	25 Apr '06	1 May '06
Bake-out	2 May '06	11 May '06
Survey and pump down	11 May '06	19 May '06
Phase 7b: Magnet test & Shielding	11 May '06	16 Jun '06
Full Magnet Test	11 May '06	8 Jun '06
Forward Shielding (Side A & C)	8 Jun '06	16 Jun '06
Global Commissioning	16 Jun '06	8 Sep '06
Cosmic Tests	8 Sep '06	3 Nov '06
ATLAS Ready For Beam	3 Nov '06	3 Nov '06



Appendix 4

Update of the ATLAS Detector funding by Funding Agency

(CORE MoU, in 1995 ATLAS MCHF)

revision October 24, 2001

Funding Agency	Inner Det.	LAr Cal.	Tile Cal.	Muon cham.	Trigger/ DAQ/con.	Common Projects	**Total**
Armenia			0.1			0.1	**0.2**
Australia	1.4					1.1	**2.5**
Austria					0.3	0.3	**0.6**
Azerbaijan						0.1	**0.1**
Belarus						0.2	**0.2**
Brazil			0.1			0.1	**0.2**
Canada	0.1	8.4				6.6	**15.1**
China NSFC+MSTC		0.3		0.3		0.4	**1.0**
Czech Republic	0.5		0.5			0.6	**1.6**
Denmark	0.9				1.0	1.4	**3.3**
Finland						0.1	**0.1**
France IN2P3	2.1	17.8	2.1			17.0	**39.0**
France CEA*		5.7		2.2		5.8	**13.7**
Georgia						0.1	**0.1**
Germany BMBF	7.9	3.2		2.5	4.7	14.2	**32.5**
Germany MPI	1.7	1.6		0.9		3.3	**7.5**
Greece				1.0		0.7	**1.7**
Israel				2.5	0.4	2.1	**5.0**
Italy	5.0	3.7	1.3	9.3	5.9	19.8	**45.0**
Japan	6.8			6.8	4.5	14.0	**32.1**
Morocco		0.2				0.1	**0.3**
Netherlands	1.8			3.0	0.9	6.7	**12.4**
Norway	2.4					1.8	**4.2**
Poland	0.4				0.2	0.4	**1.0**
Portugal			1.0		0.3	0.9	**2.2**
Romania			0.3			0.3	**0.6**
Russia	3.4	4.7	1.1	3.5		8.0	**20.7**
JINR	0.5	0.7	0.8	1.0	0.1	2.3	**5.4**
Slovak Republic		0.3				0.2	**0.5**
Slovenia	0.8					0.7	**1.5**
Spain	1.2	2.3	2.0			4.3	**9.8**
Sweden	3.1	1.5	0.9		0.6	4.7	**10.8**
Switzerland	4.9	1.1			4.0	8.5	**18.5**
Taipei	1.0	0.7				1.3	**3.0**
Turkey					0.2	0.2	**0.4**
United Kingdom	13.1				5.9	15.0	**34.0**
US DOE + NSF	12.0	16.9	3.6	8.8	4.0	35.5	**80.8**
CERN	9.0	8.6	3.0	1.5	11.5	27.4	**61.0**
Total	80.0	77.7	16.8	43.3	44.5	206.3	**468.6**
Rev. CORE detector cost	78.5	80.0	15.2	42.5	45.9	208.7	**470.8**
Total - cost	1.5	-2.3	1.6	0.8	-1.4	-2.4	-2.2

Comment: A number of Funding Agencies have indicated possible additional contributions to the Common Projects
* This contribution by CEA does not include a special contribution of 1MCHF concerning engineering of the barrel toroid, to be considered as an advance on any possible future contributions

Appendix 5 - SUPPLEMENTARY COSTS ITEM LIST

		Cost (MCHF)		RRB to:		
Nature of Cost	**Item Description**	**System specific**	**Common items**	**De-cide**	**Agree**	**Notes**
1 CORE over-run (CP)	**Cost over-runs on CORE items**	**0**	**29.7**			
1.1 Barrel Toroid Magnet	Engineering & Inspection		1.2	yes		Additional engineering work requested from LASA and US
	Warm structure		1.5	yes		Cost increase in Aluminium (boxes, bolts). Under negotiation
	Coil casing		2.0	yes		Cost increase in Alu. and welding. Sharing under negotiation
	Integration 1 & 2		0.6	yes		Additional manpower needed wrt original planning
	Vacuum vessels		0.5	yes		Transportation option in contract necessary to use
	Tie rods		0.6	yes		Add. material (heads), proof loading testing
	Cryoring		0.5	yes		Design and cost update
	Installation in cavern		1.0	yes		Additional manpower needed wrt original planning
1.2 End Cap T. Magnet	Engineering & Inspection (contract eng.)		2.1	yes		Additional manpower needed wrt original planning
	Engineering & Inspection		2.9	yes		Exchange rate effects (contract in Pounds)
	Cold mass		1.0	yes		Redundant cooling system, manufacturing cost increase
1.3 Common Systems	Engineering of Common Cryogenics		1.7	yes		Additional engineering requested wrt origanl scope of work
	Assembly, integration and controls		2.0	yes		Additional manpower needed wrt original planning
	Cryogenics/External system		1.0	yes		Design and cost update
	Cryogenics/Proximity & Installation		1.0	yes		Additional manpower needed wrt original planning
1.4 LAr Cryostat & Cryo.	Various items		1.0	yes		Design and cost update
	Integration		1.3	yes		Add. mpower needed wrt original planning. Under negotiation)
1.5 Infrastructure	Shielding elements		1.2	yes		Refined design
	Shielding elements		1.0	yes		Reduction in Russian deliverables
	Traction system to move BT, Calorimeters		1.9	yes		Refined design, manufacturing cost increase
	Access structures (lifts inside detector)		0.8	yes		Refined design and access scenarios
	Support structures		1.4	yes		Refined design,
	Muon wheel supports		1.5	yes		Refined design, overcosts related to deliverables

Appendix 5 - SUPPLEMENTARY COSTS ITEM LIST

		Cost (MCHF)		RRB to:		
Nature of Cost	**Item Description**	**System specific**	**Common items**	**De-cide**	**Agree**	**Notes**
2 Additional CORE	**Resulting from R&D work, new items**	**6.74**				
2.1 Systems	ID tooling, test stations, assembly	2.5			yes	Refined designs, not included in the MoU
	LAr integration parts, cryostat transports	0.6			yes	Refined designs, not included in the MoU
	TileCal tooling, cooling, trigger cables	1.8			yes	Refined designs, not included in the MoU
	Muon CSM modules, small wheels supp.	1.8			yes	Refined designs, not included in the MoU
3 Non-covered CORE	**Missing funding in construction MoU**	**2.1**	**2.3**			
3.1 Systems	ID installation tooling	0.3			yes	Originally planned as a swap with Russian deliverables
	LAr EM End Cap components	0.8			yes	Funding for various components not covered
	LAr Electronics	1.0			yes	Funding for various components not covered
3.2 Common Projects	Missing contributions to Common Fund		2.3	yes		Funding missing after 2 new institutes, one withdrawal
4 Additional non-CORE	**Installation support activities at CERN**	**2.8**	**3.64**			**Items originally not considered as Collab. responsibility**
4.1 Systems	ID SR-building for (pre-)assembly, integr.	1.1			yes	Planned to be arranged as M&O advancement
	LAr integration clean room area in B180	1.2			yes	Arranged as a payment advancement within community
	Muons storage areas, equipped labs	0.5			yes	Lack of available storage facilities at CERN
4.2 Tech. Coordination	Electrical distribution		0.2	yes		Assumed as a CERN responsibility
	Vacuum chamber		0.6	yes		Changes in design, R&D production of prototypes
	Cooling & ventilation		0.0	yes		Assumed as a CERN responsibility
	Flexible support carriers		1.4	yes		Changes in design, more complex
	Varia - racks, gas etc.		0.7	yes		Assumed in part as a CERN responsibility
	Safety detectors		0.7	yes		Fire detection/extinguishing in detector area
	TOTAL	**11.6**	**35.6**	**47.3**		

Appendix 6

Non-covered CORE costs 2002- 2005

Introduction

This document provides an update and a more detailed assessment of the non-covered CORE costs. These cost items were included in the CORE budget estimates (RRB-D 98-44 Rev.) but were not covered by financial pledges at the time.

Assumptions

The cost assessment carried out below is based on the following assumptions (Table 1):

Table 1. Assumptions used for assessing non-covered CORE costs

#	Assumption
1	The cost estimates are independent of possible staging scenarios.
2	The cost estimates are independent of US Management Contingency scenarios.
3	TDAQ will be designed to cost, following the withdrawal of Saclay.

Results

The following non-covered CORE costs have been identified for the time period 2002 – 2005 (Table 2):

Table 2. Summary of non-covered CORE costs (kCHF) 2002 - 2005

#	Cost item	2002	2003	2004	2005	Tot.
1	ID Inst. tooling	0	200	80	0	280
2	LAr	900	300	300	300	1800
	EM EC	*700*			*0*	*700*
	HEC	*100*				*100*
	Electronics	*100*	*300*	*300*	*300*	*1000*
3	Common Fund	150	1100	1050	0	2300
	TOTAL	**1050**	**1600**	**1430**	**300**	**4380**

Continued on next page

Table 2 shows an integrated cost of 4.4 MCHF up to 2005, including the shortfall in the Common Fund, generated by an institute withdrawal from the TDAQ. Table 2 does not include the subsequent shortfall of 3.9 MCHF in TDAQ deliverables. TDAQ is expected to design to cost.

The non-covered CORE in LAr amounts to 1.8 MCHF, of which 1.0 MCHF for the electronics. The total assumes that the issues of the missing LAr spares can be dealt with separately.

Cost sharing strategy

Efforts are made to cover the identified non-covered CORE expenditures. First, attempts are made to use possible surplus pledges in other systems to cover the gaps. Second, new institutes are being invited to share the costs. Third, if the missing funds are not found, staging will be applied to the systems.

Should these measures still result in a net deficit, the remaining uncovered costs are proposed to be charged to the Funding Agencies as follows (Table 3).

Table 3. Cost sharing strategies for non-covered CORE costs in each system

#	System	Cost sharing strategy
1	ID	Shared within the system.
2	LAr	Shared within relevant sub-system (EMC).
3	Common Fund	Shared in proportion to CORE contributions.

Continued on next page

Conclusions The conclusions are summarized in Table 4:

Table 4. Conclusions

#	**Conclusion**
1	The non-covered CORE costs are assumed to be independent of possible staging scenarios and US Mgmt contingency discussions.
2	The integrated costs up to 2006 amount to 4.4 MCHF.
3	The above cost estimates are to be considered as tentative only, awaiting further verification.
4	Despite a best-effort basis to cover the costs, the cost sharing strategy for any remaining gap is proposed to follow the CORE construction cost sharing within the systems and in the Common Projects.

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ANNEX 7.0 **SUPPLEMENTARY PAYMENTS FOR ALL SYSTEMS (kCHF)**

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**1030**	**3030**	**600**	**1200**	**0**	**5860**	
ID	530	530	0	0	0	1060	
LAr	0	0	0	1200	0	1200	
TileCal	0	0	0	0	0	0	
Muons	0	0	0	0	0	0	
General/Common items	500	2500	600	0	0	3600	
Additional CORE	**7765**	**17490**	**9445**	**2160**	**200**	**37060**	
ID	315	1390	925	0	0	2630	
LAr	100	180	220	100	0	600	
TileCal	350	780	600	100	0	1830	
Muons	50	190	1300	560	200	2300	
General/Common items	6950	14950	6400	1400	0	29700	
Non-covered CORE	**1050**	**1600**	**1430**	**300**	**0**	**4380**	Funding missing from the original CORE
ID	0	200	80	0	0	280	
LAr	900	300	300	300	0	1800	
General/Common items	150	1100	1050	0	0	2300	
TOTAL	**9845**	**22120**	**11475**	**3660**	**200**	**47300**	

ANNEX 7.1

SUPPLEMENTARY PAYMENTS FOR ID (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**530**	**530**	**0**	**0**	**0**	**1060**	
General/TCn	530	530				1060	SR-building ventilation ; to be arranged internally?
Additional CORE	**315**	**1390**	**925**	**0**	**0**	**2630**	
Tooling	100	275	175	0	0	550	
TRT	*100*	*150*	*0*			250	EC wheel and barrel TRT assembly tools in B154 and SR
Pixel	*0*	*125*	*175*			300	Tooling to assembly Pixel disks and barrels in general Pixel support
Test stations	170	1040	650	0	0	1860	
TRT	*50*	*200*	*150*			*400*	Test-stations for TRT barrel sectors and wheels in the SR-building
							Smaller test stations of fewer modules in the assembly area for evaluation
							Acceptance tests, thermal and electrical tests, X-ray, readout, powering, cooling and services
Pixel	*0*	*300*	*300*			*600*	Test station for Pixel detector test area of the SR-building
SCT	*120*	*540*	*200*			*860*	Test station for SCT barrels and EC disks in the SR-building test area
							Acceptance tests, thermal and electrical tests, X-ray, readout, powering, cooling and services
Assembly	45	75	100	0	0	220	
Pixel	*45*	*75*	*100*			*220*	Mostly tools to handle complete Pixel detector with its services and cost of final CMM survey
Integration						0	
Non-covered CORE		**200**	**80**			**280**	Missing "Russian amplification" 300 kCHF
TOTAL	**845**	**2120**	**1005**	**0**	**0**	**3970**	

ANNEX 7.2

SUPPLEMENTARY PAYMENTS FOR LAr (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**0**	**0**	**0**	**1200**	**0**	**1200**	
CE,C&V for B180				1200	0	1200	Arranged by a payment advancement
General/TCn						0	
Additional CORE	**100**	**180**	**220**	**100**	**0**	**600**	
Tooling							
Test stations							
Integration	50	130	160	100	0	440	
B180	*50*	*90*	*40*	*20*	*0*	200	HV system. Calibration & Read-out
ATLAS		*40*	*120*	*80*		240	Cooling system for front-end crates and PS
Assembly							
Commissioning						0	
HV System	50	50	60	0	0	160	
Cryostat	*50*	*50*	*60*		*0*	*160*	Calibration units and read-out devices for HV system
Non-covered CORE	**900**	**300**	**300**	**300**	**0**	**1800**	
EM End-Cap	700						
HEC	100						
Electronics	100	300	300	300			
TOTAL	**1000**	**480**	**520**	**1600**	**0**	**3600**	

ANNEX 7.3

SUPPLEMENTARY PAYMENTS FOR TILECAL (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**0**	**0**	**0**	**0**	**0**	**0**	
Infrastructure						0	
General/TCn						0	
Additional CORE	**350**	**780**	**600**	**100**	**0**	**1830**	
Tooling	100	100				200	Installation tooling, pins, bolts etc.
Test stations							
Detector eqpm.	250	680	600	100	0	1630	
Cooling			*220*			220	The cooling system for readout electronics in the drawers was not included in original CORE
Trigger & optical cables			*80*	*100*		180	Doubling of digitized readout channels => doubling of low voltage PS wrt to original CORE
LV Power supplies		*300*	*300*			600	256 Low Voltage PS inside the fingers, 8 voltage levels
Saddles	*250*	*380*				630	Part of cradle, non magnetic steel saddles
Non-covered CORE	**0**	**0**	**0**	**0**	**0**	**0**	
TOTAL	**350**	**780**	**600**	**100**	**0**	**1830**	

ANNEX 7.4

SUPPLEMENTARY PAYMENTS FOR MUONS (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**0**	**0**	**0**	**0**	**0**	**0**	
Storage, test areas						0	
Modifications/repairs						0	
Modeling (services)						0	
General/TCn						0	
Additional CORE	**50**	**190**	**1300**	**560**	**200**	**2300**	
Tooling						0	Assumed to be CERN deliverables
Test stations							
Detector equipment		90	1150	560	200	2000	Electronics modules CSM
Assembly							
Integration	50	100	150	0	0	300	
Small wheels	*50*	*100*	*150*			*300*	
Non-covered CORE	**0**	**0**	**0**	**0**	**0**	**0**	
TOTAL	**50**	**190**	**1300**	**560**	**200**	**2300**	

Note: Manpower worth 970 kCHF -> C&I

ANNEX 7.5

SUPPLEMENTARY PAYMENTS FOR COMMON ITEMS (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
Non-CORE infrastr.	**500**	**2500**	**600**	**0**	**0**	**3600**	
Storage, test areas						0	
Modifications/repairs						0	
Modeling (services)						0	
General/TCn	500	2500	600	0		3600	LHC machine pays 4.9 MCHF of EA infra
Additional CORE	**6950**	**14950**	**6400**	**1400**	**0**	**29700**	
Tooling						0	
Test stations							
Detector equipment	6950	11950	3000	0	0	21900	
Magnet	*6950*	*9650*	*3000*			*19600*	
LArCC		*2300*				*2300*	
Infrastructure	0	3000	3400	1400		7800	
Non-covered CORE	**150**	**1100**	**1050**	**0**	**0**	**2300**	
TOTAL	**7600**	**18550**	**8050**	**1400**	**0**	**35600**	

Note: In 2002, non-covered CORE is to cover the magnet

ANNEX 7.6

NATURE OF PAYMENTS FOR ALL SYSTEMS (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
CP overcosts	6950	14950	6400	1400	0	**29700**	
Additional CORE (systems)	815	2540	3045	760	200	**7360**	
Non-covered CORE	1050	1600	1430	300	0	**4380**	
Additional non-CORE (infra)	1030	3030	600	1200	0	**5860**	
TOTAL	**9845**	**22120**	**11475**	**3660**	**200**	**47300**	

47300

ANNEX 7.7

SUPPLEMENTARY PAYMENTS FOR ALL SYSTEMS (kCHF)

	2002	2003	2004	2005	2006	Total	Notes
System	**9845**	**22120**	**11475**	**3660**	**200**	**47300**	
ID	845	2120	1005	0	0	3970	
LAr	1000	480	520	1600	0	3600	
TileCal	350	780	600	100	0	1830	
Muons	50	190	1300	560	200	2300	
Common items	7600	18550	8050	1400	0	35600	

Systems (excl. CI)	2245	3570	3425	2260	200	11700
Common items	7600	18550	8050	1400	0	35600

Proposed Sharing of Supplementary Construction Costs for ATLAS Detector by Funding Agency (kCHF)

Appendix 8

Funding Agency	System-specific (for IB)			Common items (for RRB)			
	Infrastr; add. CORE (excl. TCn)	Non-covered CORE (excl. CI)	TOTAL (kCHF)	Infra-structure (TCn part)	Missing CORE CI (over costs, non-covered)	TOTAL (kCHF)	GRAND TOTAL (kCHF)
Armenia	10	0	**10**	2	16	**17**	**28**
Australia	45	5	**49**	19	172	**191**	**240**
Austria	0	0	**0**	5	47	**52**	**52**
Azerbaijan	0	0	**0**	2	16	**17**	**17**
Belarus	0	0	**0**	2	16	**17**	**17**
Brazil	9	0	**9**	2	16	**17**	**27**
Canada	195	157	**352**	116	1030	**1146**	**1498**
China NSFC+MSTC	23	6	**28**	7	62	**69**	**98**
Czech Republic	82	2	**83**	11	94	**104**	**188**
Denmark	48	3	**51**	25	218	**243**	**294**
Finland	0	0	**0**	0	0	**0**	**0**
France IN2P3	828	583	**1410**	298	2652	**2951**	**4361**
France CEA	246	107	**353**	102	905	**1007**	**1360**
Georgia	0	0	**0**	2	16	**17**	**17**
Germany BMBF	659	88	**747**	249	2216	**2465**	**3212**
Germany MPI	181	36	**216**	58	515	**573**	**789**
Greece	52	0	**52**	12	109	**122**	**173**
Israel	134	0	**134**	37	328	**365**	**499**
Italy	1143	87	**1231**	348	3089	**3437**	**4667**
Japan	575	24	**599**	246	2184	**2430**	**3029**
Morocco	5	4	**9**	2	16	**17**	**26**
Netherlands	230	6	**237**	118	1045	**1163**	**1400**
Norway	69	8	**77**	32	281	**312**	**390**
Poland	17	1	**19**	7	62	**69**	**88**
Portugal	109	0	**109**	16	140	**156**	**266**
Romania	33	0	**33**	5	47	**52**	**85**
Russia	574	99	**673**	140	1248	**1389**	**2062**
JINR	174	17	**191**	40	359	**399**	**590**
Slovak Republic	7	6	**13**	4	31	**35**	**47**
Slovenia	27	3	**30**	12	109	**122**	**151**
Spain	307	151	**458**	75	671	**746**	**1204**
Sweden	265	39	**304**	82	733	**816**	**1120**
Switzerland	183	37	**220**	149	1326	**1475**	**1695**
Taipei NSC	48	17	**65**	23	203	**226**	**290**
Turkey	0	0	**0**	4	31	**35**	**35**
United Kingdom	407	46	**453**	263	2340	**2604**	**3056**
US DoE + NSF	1884	358	**2242**	623	5539	**6162**	**8403**
CERN	1020	192	**1212**	463	4119	**4582**	**5795**
total	**9590**	**2080**	**11670**	**3600**	**32000**	**35600**	**47270**

Notes

1. IB refers to Institute Boards where system-specific decisions are to be made
2. CI refers to Common items (mostly Common Projects related)
3. TCn refers to common items under the responsibility of Technical Coordination
4. The above sharing is the upper limit as cost items ca. 5 MCHF will be paid outside the Collaboration

Table 1

Estimated C+I Cost Sharing for ATLAS 2002-2005 by Funding Agency (kCHF)

Funding Agency	Category A C&I	Category B C&I	TOTAL kCHF
Armenia	4	15	**19**
Australia	43	35	**78**
Austria	12	0	**12**
Azerbaijan	4	0	**4**
Belarus	4	0	**4**
Brazil	4	14	**18**
Canada	261	313	**574**
China NSFC+MSTC	16	33	**48**
Czech Republic	24	113	**136**
Denmark	55	70	**125**
Finland	0	0	**0**
France IN2P3	671	1265	**1936**
France CEA	229	369	**598**
Georgia	4	0	**4**
Germany BMBF	561	854	**1415**
Germany MPI	130	242	**372**
Greece	28	70	**98**
Israel	83	183	**266**
Italy	782	1616	**2398**
Japan	553	657	**1210**
Morocco	4	8	**12**
Netherlands	265	289	**554**
Norway	71	53	**124**
Poland	16	21	**37**
Portugal	36	161	**197**
Romania	12	48	**60**
Russia	316	834	**1150**
JINR	91	251	**342**
Slovak Republic	8	11	**19**
Slovenia	28	21	**49**
Spain	170	433	**603**
Sweden	186	362	**548**
Switzerland	336	163	**498**
Taipei	51	51	**102**
Turkey	8	0	**8**
United Kingdom	592	315	**908**
US DOE + NSF	1402	2651	**4053**
CERN	1043	1478	**2521**
total (as reported in Oct '01)	**8,100**	**13,000**	**21,100**
RRB SG recommendations yet to be incorporated	**1,900**	**(2,160.00)**	**20,840**

Note: LHCC-RRB SG recommendations not yet incorporated in estimates

ATLAS RC Note Appendix 10

Comments on revised ATLAS M&O Cost Estimates 2002 - 2007

Introduction

Following the request of the RRB Scrutiny Group (SG) in June 2001, ATLAS submitted to SG its M&O (A, B, C) cost estimates 2002 – 2007 in August further scrutiny. The results of the scrutiny were presented in the October 2001 RRB where 30% of M&O (A) was approved.

This document provides comments and clarifications to the updated M&O cost estimates 2002 – 2007 submitted to SG in February, 2002 and approved by the RRB In April, 2002.

Methodology

The methodology used to collect the M&O cost estimates is summarized in Table 1:

Table 1. Methodology

#	Step
1	Update the cost estimates from October 2001 by systems using the original template
2	For M&O (A), use the original template (with minor modifications)
3	For M&O (B), use the new template and guidelines provided by SG, using a "transformation matrix" to ensure a homogenous approach to cost item recording across the different systems (Annex 1)
4	For M&O (B), provide cost estimates up to 2010 in order to include amortization of certain spares or infrastructure items 2007 – 2010 purchased under special financial arrangements before 2005 due to component availability and favorable cost
5	Collect plans on Institute technical manpower to be sent to CERN for installation and integration activities; identify what share is expected to be offered by Funding Agencies as in-kind contributions

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Assumptions The assumptions made while providing the updated cost estimates are summarized in Table 2:

Table 2. Assumptions

#	Assumption
1	The initial ATLAS detector is ready for the first colliding beams in Spring 2006
2	Special funding arrangements set up for certain critical spares or infrastructure items are amortized between 2007 - 2010
3	Institute technical manpower includes technicians (and possibly engineers) sent to CERN for maintaining the respective systems
4	Institute manpower for installation and integration work at CERN already originally planned for and included within the recognized integrated manpower effort of 5 315 man-years is not credited
5	Institute manpower to be recognized as contribution from a Funding Agency is accounted for at 91.25 kCHF/FTE/y
6	Hired manpower includes industrial personnel recruited locally at CERN. The recognized value of a technician is 80 kCHF/year and for a qualified engineer (e.g. systems manager) 120 kCHF/year

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M&O (A) The following comments and clarifications are made to the collected M&O (A) cost estimates (Table 3):

Table 3. Comments, clarifications to M&O (A)

#	Comment
1	Gas consumption is for ID (SR-building) and for the Muons; profile revised and reduced
2	Hydraulic systems: 2 operators are required for moving magnet and LArCC elements by pressurized air pads. Consumables ca 2% of capital value
3	Detector safety systems: 2% of capital value
4	UPS maintenance: Magnet & cryogenics supported by single unit (6 kVA) in B180 and two units (20 kVA) in USA15
5	Counting & control rooms: Counting room equipment under Category B, control rooms M&O 5% of capital value / year
6	Communications: includes GSMs for 10 persons (TCn and TDAQ)
7	Detector controls: electronics support to system test beam activities
8	Common Desktop: Activities before 2005 moved into C&I
9	Test beam / General operations: System specific activities (Cat B)
10	Common electronics: M&O levels reduce after 2005 to 20 kCHF / y (TDAQ ROBs,PCs, monitors etc.)
11	Power: Profile changed and reduced based on revised estimates (Annex 2)
12	Cranes: More costs shifted to ATLAS (6 crane operators required in 2003 / 2004)
13	Survey: 3 persons (PJAS) for monitoring the positioning of all detector elements

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The revised M&O (A) estimates for 2002 are lower by ca. 900 kCHF w.r.t the projected cost estimates from October 2001. The difference is mostly due to changes in electricity profile , gas and hydraulic systems, laboratory operations and heavy transport.

The cumulative difference, mostly due to revised electricity cost estimates, amounts to 4 MCHF up to 2007.

M&O (B)

The revised M&O (B) cost estimates are provided using the new template. Annex 1 shows the guidelines used to translate the previous cost estimates from the original template.

Despite trying to ensure a homogenous approach across the different ATLAS systems, a number of apparent inconsistencies remained in the draft figures submitted to SG in early February.

Following its meeting on March 15, the ATLAS Executive Committee has further elaborated upon the cost estimates by systems in line with the endorsed detector deferral (staging) scenarios. These comments or corrections are summarized in Table 4:

Continued on next page

Table 4. Comments, clarifications to M&O (B)

#	Comment
1	ID: a. Under the new deferral plans, the Pixel B-layer is to be considered as an upgrade and is thus excluded from the cost estimates b. Some institute personnel is expected to be provided as technical manpower after 2006 (5 FTE / y)
2	LAr: a. Power supply spares are included in electronics pool rentals (20 kCHF / year after 2005) b. Some institute manpower offered as (hired) in-kind after 2005 (3 FTE / y)
3	TileCal: Some institute personnel expected to be provided as technical manpower after 2006 (2 FTE / y)
4	Muons (Revised estimates provided in new tables): a. Estimates for 2008 - 2010 at 1250 kCHF / y b. Provided technical manpower estimates include also personnel in institutes, overlap with hired (institute) manpower and are thus revised c. Spares advancement arrangement managed internally

In the tables provided (ID, LAr, Muons), item lines associated with special financial arrangements to obtain critical spares before 2005 are highlighted (in green). Actual planned payment profiles are provided for below the tables. In the case of the Muons, this is managed internally without requiring arrangements such as already in place for the LAr spares and what is being planned for the ID.

Concerning the distinction between offered institute in-kind (hired) and technical manpower, a global ATLAS policy is being developed for discussion in the Collaboration Board. Any suggestions from SG would be welcome.

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Conclusions The following conclusions are made (Table 5):

Table 5. Conclusions

#	Conclusion
1	Comments and corrections are made to the M&O tables submitted to SG for further scrutiny

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EXPERIMENT: ATLAS						New M&O(B) format								
Previous M&O(B) format	Mech	Gas-s	Cryo-s	Cool	FE-el	Std-e-PS	Std-e-Cr	Std-e-R	Ctrls	Sub-d	Areas	Comm	Store	Hire-mp
Detector related costs														
Power supply						x								
Gas systems		x												x
Gas consumption		x												x
Cooling systems				x										
Cooling fluids(above –50°C)				x										
Cryogenic fluids (below –50°C)			x											
Moving/hydraulic systems	x													
Detector safety system									x					
Detector specific radiation protection									x					
Shutdown activities														x
Detector (re-)integration & survey	x													x
General Technical support					x		x						x	x
UPS maintenance						x								
Electronics pool rentals							x							
Counting & control rooms									x					
Communications														
GSM phones												x		
On-line computing														
System management														x
Detector controls									x					
Computers/processors/LANs								x						
Software licenses								x						
Test beams, calibration facilities														
General operation											x			x
Common electronics							x							
Counting & control rooms									x					
Proximity cryogenics			x											
Irradiations										x				
Electronics pool rentals							x							
Laboratory operations														
Assembly areas, clean rooms, active storage areas											x			
Workshops											x			x
Laboratory instruments							x							
Electronics pool rentals							x							
General services														
Cranes														x
Survey														x
Consultancy														
Engineering														x

ATLAS POWER CONSUMPTION ESTIMATION

Prepared by :			***Checked by :***		***Approved by :***
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1. Introduction

We are summarizing here the present knowledge of the power consumption for ATLAS in point 1 and in the assembly buildings year by year starting in 2002 up to 2006. For this exercise we base our self on the present LHC schedule, with a pilot run in April 2006.

2. Power consumption inside ATLAS during normal operations

LV power consumption

- ID (see ATL-IC-EN-0009 – Inner Detector Thermal Management page 19)
  - LV power supplies are in USA15
  - Total power consumption is in the order of 140 kW (including electronics, cables, heaters) Cost 35 wks = 823200 kWh + additional 17 wks to keep SCT&Pixel cold 15kW > 37800 kWh , > TOTAL ~ 861000 kWh
- LAr
  - 255 kW to be cooled in the electronics boxes so it has to be delivered. If including some efficiency of PS and losses in cables around 300 kW should be delivered in 35 wks 1764000 kWh
- TileCal
  - 77 kW to be cooled in superdrawers, including efficiency of PS 80% around 100 kW to be delivered. 100 in 35 wks > 588000 kWh
- Muon (information from the table "Power consumption of the ATLAS Muon system")
  - Total power delivered by PS 132 kW , 132 in 35 wks > 776160 kWh
- Magnet - separately treated (section 3)

Total - 3989160 kWh

LAr cryo

- 300 kW for the refrigerator + 225 kW for the cryo control 555 kW 52 wks > 4586400 kWh
- 150 kW is the power installed in bldg. 180 for the tests

Cooling systems consumption

- Heat load inside UX15 – 900 kW – power consumption will not exceed 10% so 90 kW is a maximum 90 in 52 weeks > 786240 kWh
- Electronics racks 2500 kW – power consumption around 300 kW 52 wks > 2620800 kWh
- Dumps circuit 350 kW – power consumption ~30 kW 35 wks > 176400 kWh
- Bus bars circuit 225 kW – power consumption 20 kW 35 wks > 117600 kWh

Total - 3701000 kWh

HVAC funs and heaters

- USA 15
  - Fans motors 140 kW 52 wks > 1223040 kWh >
  - Heating 450 kW *(the assumption is that during running heaters will not be necessary, let say 10% during shutdown)* 5wks > 378000 kWh

    Total - 1601040 kWh

- UX15
  - Fans motors 240 kW 52 wks > 2096640 kWh
  - Heaters 700 kW 5 wks > 588000 kWh

    Total - 2684460 kWh

- Others surface buildings
  - Fans motors 390 kW 52 wks > 3415776 kWh
  - Heaters 1505 kW 50% 20 wks >2528400 kWh

    Total > 5944176 kWh

Chilled water production for SUX1

(from the document F310/ST/LHC-LS/1/005, updated 23/01/01)), 2575 kW installed power

- Pumps 500 kW 35 wks > 2940000 kWh
- Chillers 2000 kW 35 wks > 11760000 kWh

  Total 14700000 kWh

SF1 Cooling Towers

(CERN POMPAGE IT 2522/ST/LHC from 23/02/01), 1026 kW installed power

- Cooling towers
  - Pumps 330 kW 40 wks > 2217600 kWh
  - Funs 180 kW (100% 6 months + 40% 4 months) > 756000 kWh + 193536 kWh > 949536 kWh

  T0tal 3167136 kWh

Cranes & Lifts

631 kW installed power, assumes 30% opearation time in average, peak activity in 2004

- Cranes SDX1=45 kW, SUX1=11 kW, SH1=14 kW, SX1=271 kW, UX15=216 kW
- Hoist USA15 = 14 kW , Lifts SCX1=16 kW, PX15=44 kW

3. Magnet power consumption

A) Power consumption during Magnet testing in H180 (excl building infrastructure, ligths, cranes etc)

Item	P[KW]	BT1-8	year	B1-2	BT3-4-5-6+CS	BT7-8	ECT1-2
		Hrs		**2002**	**2003**	**2004**	**2005**
				kWh	kWh	kWh	kWh
power supply	50	40		4000	15200	10000	8000
water cooling	5	40		400	1520	1000	800
vacuum	10	1190		23800	90440	59500	47600
controls 2.5+UPS 0.5	3	8736	52wks	26208	26208	26208	26208
cryotests	510	672	6wks	342720			
cryogenics standby	3	8736	52wks	26208	99590	65520	52416
cryog. cooling (510 frig+160 prec)	670	500	3wks	335000	1273000	837500	670000
cryogenics normal	510	336	3wks	171360	651168	428400	342720
sums	1761			929698	2157130	1428131	1147746

B) Power consumption in Point 1 (BT + 2 ECT + CS)

Item	P[KW]	test L'AL		test Linde		system test		at50%		at100%	
		2003		**2004**		**2005**		**2006**		**2007**	
		wks	kWh	wks	kWh	wks	kWh	wks	kWh	wks	kWh
power supply	110					2	36960	20	369600	30	554400
water cooling	0					2		20		35	
vacuum	30					20	100800	52	262080	52	262080
controls 4.5+UPS 0.5	5					20	16800	52	43680	52	43680
proximity cryogenics	15					10	25200	26	65520	35	88200
cryogenics test	0	6	2903040	8	4892160						
cryogenics standby	780					14	1834560	26	3407040	17	2227680
cryogenics cooling	3640					4	2446080	2	1223040	2	1223040
cryogenics normal	2880					2	967680	24	11612160	33	1596672
sums	7460		2903040		4892160		5428080		16983120		20365800

4. Power cost figures

This table summarizes the electricity cost figure for year 2000 and is valid until 2003. For our estimation in we will use an average of 0.055 CHF / kWh .

Prix contractuel valable jusqu'au 1-07-2003 sous conditions suivantes:

Fourniture 0MWH par EDF du 15-11 au 15-03

Fourniture 0MWH par EOS du 01-04 au 1-11

TARIFS EDF au 01/07/2000

Type d'heures	Periodes	c.E/KWH
EJP	22 jours du 1-11 au 31-03 ,18 heures par jour de 7h a 1h le lendemain	12.942
HH	Decembre-janvier- fevrier-hors EJP 24 heures par jour	4.964
HD	Mars et novembre hors EJP 24 heures par jour	3.052
HPE	Avril-mai-juin-septembre-octobre de 7h a 1h	3.043
HCE	Avril-mai-juin-septembre-octobre de 1h a 7h ,samedi-dimanche et jours feries toute la journee	1.852
JA	Juillet et Aout 24 heures par jour	1.758

TARIFS EOS au 01/07/2000

du 01-11 au 31-03	Tarif unique	3,8 c.E/KWH
du 01-04 au 31-10	Pas de livraison d'energie par EOS	

5. Consumption table

	power installed [KW]	2002 Mwh	2003 Mwh	2004 Mwh	2005 Mwh	2006 Mwh	>=2007 Mwh
Test Areas:							
magnets bld 180	1761	930	2157	1428	1148		
LAr bld 180	150	197	655	262			
other bld	50	220	220	220	220		
total	1911	1127	2812	1690	1148		
Point 1:							
Detector:							
magnets	7460		2903	4892	5428	16983	20366
LAr	555			1834	3210	586	4586
LV detector	672			1197	2394	990	3990
Cooling	460			1100	2221	3701	3701
infrastructure:							
cranes+lifts	631	169	1102	1837	1470	601	601
Chilledwater SUX1	2575		1470	2940	5880	14700	14700
SF1 cooling towers	1026		95	190	380	950	950
HVAC (fans & heaters):							
USA15	590	160	1601	1601	1601	1601	1601
UX15	940		1074	2684	2684	2684	2684
Others buildings	1895		2378	5944	5944	5944	5944
contingency 10%	33		1062	2423	3121	5574	5912
total point 1		362	11685	26653	34333	61314	65035
Grand TOTAL		**1709**	**14717**	**28563**	**35701**	**61314**	**65035**

Using an average cost per KWh of 0.055 CHF we obtain the following cost estimation:

2002	94 kCHF
2003	809 kCHF
2004	1571 kCHF
2005	1964 kCHF
2006	3372 kCHF
2007 >	3577 kCHF

M&O Cost Estimates in kCHF **ATLAS M&O (A) ESTIMATES (kCHF) SUMMARY (Magnets, TDAQ, TCn)**

M=Maintenance/Repairs
O=Operations
C=Consumables
EP-ATO/mn/070302

			2002	*2003*	*2004*	*2005*	*2006*	*2007*	**TOTAL**	
Detector related costs	Type		19	242	457	2,107	4,413	4,413	11,651	
Magnet	A	O	0	0	0	40	40	40	120	Magnets: 0.5 FTE/y (engineer) < 05, 0.3 FTE/y thereafter
	A	C	0	0	0	50	50	50	150	Magnets: Repairs for 3 pumps < 05, 10 active thereafter
Magnet controls	A	O	0	0	0	210	180	180	570	Magnets: Numbers from D Schinzel
	A	C	0	0	0	59	45	45	149	Magnets: Numbers from D Schinzel
Magnet power supply	A	O	4	12	12	8	8	8	52	Magnets: Numbers from D Schinzel
	A	C	5	15	15	75	75	75	260	Magnets: Numbers from D Schinzel TDAQ: ROBs in power
Gas systems	A	O	0	0	50	50	50	50	200	TCn-Gen: Service contract
	A	C	0	0	0	50	100	100	250	
Gas consumption	A	O	0	0	0	0	0	0	0	
	A	C	0	70	70	150	200	200	690	TCn-Gen: Gas consuption for ID and muons. Starts with SR1 and assembly halls for muons in 2003
Cooling systems	A	O	0	10	120	120	120	120	490	Magnets: 0.1 FTE/y (technician) TCn-Gen: 1 FTE/y (technician).
	A	C	0	5	10	45	45	45	150	Magnets: Pumps, filters, cooling towers TCn-Gen: 2% of investment running time
Cooling fluids(above –50°C)	A	O	5	5	5	5	5	5	30	
	A	C	5	5	25	25	75	75	210	Magnets: Demin & tap water pumps,filters TCn-Gen: Demineralized water, carbo-fluids etc.
External cryogenics	A	O	0	0	0	700	1,040	1,040	2,780	Magnets: Numbers from D Schinzel.M&O + C&I for Point
	A	C	0	0	0	320	430	430	1,180	Magnets: M&Ofor Cryogenics spares, fluids etc. Liquid He, N
Cryogenic fluids (below –50°C)	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Moving/hydraulic systems	A	O	0	100	100	100	50	50	400	TCn-Gen: LAr/Magnet from B180&191
	A	C	0	20	20	20	40	40	140	TCn-Gen: 2% of the capital investment
Detector safety systems	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	30	60	60	150	TCn-Gen: 2% of capital value
Shutdown activities	A	O	0	0	0	0	400	400	800	TCn-Gen: Crew to operate and prepare shutdown and to run general maitenance of ATLAS. 4 FTE @ 100 kCHF/y, starting at running time.
	A	C	0	0	0	0	50	50	100	TCn-Gen: Consumables (mechanical shop)
General Technical support	A	O	0	0	0	0	300	300	600	TCn-Gen: Crew to operate and maintain ATLAS technical
	A	C	0	0	0	0	660	660	1,320	TDAQ: 5% of ROBs&infra installed. Independent of staging.
UPS maintenance	A	O	0	0	0	0	0	0	0	
	A	C	0	0	30	50	50	50	180	TCn-Gen: 2% of capital investment
Electronics pool rentals	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Beam pipe & vacuum	A	O	0	0	0	0	120	120	240	TCn-Gen: Numbers from T Camporesi
	A	C	0	0	0	0	120	120	240	
Counting & control rooms	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	100	100	200	TCn-Gen: 5% of capital investment. Counting room eqpm in B
Secretariat	Type		40	110	155	215	270	290	1,080	
Secretarial assistance	A	O	0	45	90	140	140	140	555	TCn-Gen: 2 FTE @ 75 kCHF/y (D Schinzel guideline)
	A	C	0	0	0	0	0	0	0	
Economat	A	O	0	0	0	0	0	0	0	
	A	C	10	15	15	15	20	20	95	
Fax, photocopiers, printers	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Printing and publication	A	O	0	0	0	0	0	0	0	

	A	C	30	50	50	60	110	130	430	TCn-Gen: Pens, folders, transparencies, note paper
Communications	*Type*		*0*	*10*	*15*	*15*	*15*	*15*	*70*	
GSM phones; on-call service	A	O	0	0	0	0	0	0	0	
	A	C	0	10	10	10	10	10	50	TDAQ: Included in TCn TCn-Gen: TDAQ:5 persons + TCN:5 persons; 1kCHF/y
Automatic call-back	A	O	0	0	0	0	0	0	0	
	A	C	0	0	5	5	5	5	20	TCn-Gen: 10 persons on call
On-line computing	*Type*		75	75	530	1,690	2,925	3,945	9,240	
System management	A	O	0	0	120	480	600	600	1,800	TDAQ: In 06, (2 FTE/farm x2 + 1FTE/shift)@120kCHF/y; 1FTE/300 boxes
	A	C	0	0	0	0	0	0	0	
Data storage, (temporary on disk)	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Detector controls	A	O	0	0	0	0	0	0	0	
	A	C	20	20	20	30	30	30	150	TCn-Gen: DCS (PCB, cabling, connectors, interfaces)
Computers/processors/LANs	A	O	0	0	0	0	0	0	0	
	A	C	0	0	300	1,000	2,040	3,060	6,400	TDAQ: <15-20%> repl./y. 25% repl. rate on processors TCn-Gen: DCS (test beam instrumentation, radiation testing)
Software licenses	A	O	0	0	0	0	0	0	0	
	A	C	55	55	90	150	225	225	800	TDAQ: For LVL2 (1000), EF (1000), servers (50); code-checking
Common desktop infrastructure	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	30	30	30	90	TCn-Gen: PCs, WS, terminals for on-line mgmt tasks
Test beams, calibration facilities	Type		720	710	785	140	65	65	2,485	
General operation	A	O	240	240	240	0	0	0	720	TDAQ: On-line computing mgmt for test beams
	A	C	0	0	0	0	0	0	0	
Common electronics	A	O	0	0	0	0	0	0	0	
	A	C	85	95	95	95	20	20	410	TDAQ: ROBs, PCs, monitors, terminals TCn-Gen: DCS (test beam instrumentation, radiation testing outside CERN)
Electronics pool rentals	A	O	0	0	0	0	0	0	0	
	A	C	60	60	60	45	45	45	315	TDAQ: RIO2,NIM
Gas systems	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Gas consumption	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
External cryogenics	A	O	260	260	340	0	0	0	860	Magnets: Hall 180
	A	C	75	55	50	0	0	0	180	Magnets: Hall 180
Laboratory operations	Type		20	80	130	115	75	75	495	
Assembly areas, clean rooms, active storage areas	A	O	0	0	0	0	0	0	0	
	A	C	0	50	100	50	0	0	200	
Workshops	A	O	0	0	0	0	0	0	0	
	A	C	0	10	10	10	20	20	70	
Laboratory instruments	A	O	0	0	0	0	0	0	0	
	A	C	20	20	20	55	55	55	225	TDAQ: Lab eqpm in B513,32,40 (VME, network). PCs, testers
General services	*Type*		288	1,186	1,863	2,461	3,959	4,024	13,781	
Cooling & ventilation	A	O	36	73	109	146	182	182	728	TCn-Gen: D Schinzel/M Wilhelmson input

	A	C	36	73	109	146	182	182	728	TCn-Gen: D Schinzel/M Wilhelmson input
Power	A	O	0	0	0	0	0	0	0	
	A	C	80	560	1,030	1,470	2,820	3,010	8,970	TCn-Gen: See separate note by M Nessi 10-01-2002
Power distribution system	A	O	0	0	0	0	0	0	0	
	A	C	0	20	25	25	35	35	140	TCn-Gen: Service contract (ST) for periodic inspection of power connections
Heavy transport	A	O	0	60	60	60	60	60	300	TCn-Gen: Area mgmt (safety, cleaning, storage)
	A	C	0	0	0	0	0	0	0	
Cranes	A	O	0	60	60	60	120	120	420	TCn-Gen: 7 cranes in Pit 1, 6 operators @60kCHF/FTE '03-05 of
	A	C	5	30	60	60	60	60	275	TCn-Gen: 1.5% of capital value/y
Cars	A	O	0	0	0	0	0	0	0	
	A	C	0	30	30	30	30	30	150	TCn-Gen: CERN cars for TCn operate at Point 1
Cleaning	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Survey	A	O	60	110	210	210	110	60	760	TCn-Gen: See note from C Lasseur
	A	C	0	0	0	0	0	0	0	
Passive storage space	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Common desktop infrastructure	A	O	0	0	0	0	0	0	0	
	A	C	20	20	20	30	30	30	150	TCn-Gen: PCs, WSs, terminals for technical crews
Academic subsistence	A	O	0	100	100	100	130	130	560	Academic subsistence. Entry requested by SG
	A	C	0	0	0	0	0	0	0	
Outreach	A	O	0	0	0	50	100	50	200	TCn-Gen: PJAS to run website (media events)
	A	C	50	50	50	75	100	75	400	TCn-Gen: Material for schools, public
GRAND TOTALS			1,162	2,413	3,935	6,743	11,722	12,827	38,802	

M&O Cost Estimates in kCHF **ATLAS M&O (Cat C) ESTIMATES (kCHF) SUMMARY (Magnets, Tl**

M=Maintenance/Repairs

O=Operations

C=Consumables

EP-ATO/mn/310102

			2002	*2003*	*2004*	*2005*	*2006*	*2007*	**TOTAL**
General services	*Type*		570	560	675	635	755	815	4,010
Cooling & ventilation	C	O	16	31	47	62	78	78	312
	C	C	16	31	47	62	78	78	312
Safety & radioprotection	C	O	0	0	0	0	0	0	0
	C	C	0	0	0	0	30	60	90
INB compliance	C	O	160	160	160	120	80	80	760
	C	C	10	10	10	10	10	10	60
Radioactive waste disposal	C	O	0	0	0	0	0	0	0
	C	C	0	0	0	0	30	60	90
Access system	C	O	0	0	0	0	0	0	0
	C	C	20	20	60	60	60	60	280
Elevators	C	O	0	0	0	0	0	0	0
	C	C	15	15	30	30	30	30	150
Gerant de site	C	O	250	250	250	250	250	250	1,500
	C	C	10	10	10	10	10	10	60
Flood control	C	O	0	0	0	0	0	0	0
	C	C	30	20	20	20	20	20	130
Insurance (CERN standard)	C	O	0	0	0	0	0	0	0
	C	C	50	50	100	100	200	200	700
Cleaning	C	O	10	10	15	15	15	15	80
	C	C	0	0	0	0	0	0	0
Office space	C	O	0	0	0	0	0	0	0
	C	C	15	15	20	20	20	20	110
GRAND TOTALS			570	560	675	635	755	815	4,010

M&O Cost Estimates in kCHF
M=Maintenance/Repairs
O=Operations
EP-ATO/mn/300102

ATLAS M&O ESTIMATES (kCHF) FOR MAGNETS

			2002	*2003*	*2004*	*2005*	*2006*	*2007*	**TOT**	**Notes**
Detector related costs	*Type*		*19*	*52*	*57*	*1,432*	*1,838*	*1,838*	*5,236*	
Magnet	A	O				40	40	40	120	0.5 FTE/y (engineer) < 05, 0.3 FTE/y thereafter
	A	C				50	50	50	150	Repairs for 3 pumps < 05, 10 active thereafter
Magnet controls	A	O				210	180	180	570	Numbers from D Schinzel
	A	C				59	45	45	149	Numbers from D Schinzel
Magnet power supply	A	O	4	12	12	8	8	8	52	Numbers from D Schinzel
	A	C	5	15	15	10	10	10	65	Numbers from D Schinzel
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Cooling systems	A	O		10	10	10	10	10	50	0.1 FTE/y (technician)
	A	C		5	10	15	15	15	60	Pumps, filters, cooling towers
Cooling fluids(above –50°C)	A	O	5	5	5	5	5	5	30	
	A	C	5	5	5	5	5	5	30	Demin & tap water pumps,filters
External cryogenics	A	O				700	1,040	1,040	2,780	Numbers from D Schinzel.M&O + C&I for Point 1.Note: Hall 180 activities are under Test beams
	A	C				320	430	430	1,180	M&Ofor Cryogenics spares, fluids etc. Liquid He, N
Proximity cryogenics	A	O							0	
	A	C							0	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O							0	
	A	C							0	
Detector safety systems	A	O							0	
	A	C							0	
Detector-specific radiation protection	A	O							0	
	A	C							0	
Shutdown activities	A	O							0	
	A	C							0	
Detector (re-)integration & survey	A	O							0	
	A	C							0	
General Technical support	A	O							0	
	A	C							0	
UPS maintenance	A	O							0	
	A	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Beam pipe & vacuum	A	O							0	
	A	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Secretariat	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Secretarial assistance	A	O							0	
	A	C							0	
Economat	A	O							0	
	A	C							0	
Fax, photocopiers, printers	A	O							0	
	A	C							0	
Printing and publication	A	O							0	
	A	C							0	
Communications	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
GSM phones	A	O							0	
	A	C							0	
GSM phones	B	O							0	
	B	C							0	
Automatic call-back	A	O							0	
	A	C							0	
Automatic call-back	B	O							0	
	B	C							0	
On-line computing	*Type*		0	0	0	0	0	0	0	
									0	
System management	A	O							0	
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C							0	
Computers/processors/LANs	A	O							0	
	A	C							0	
Software licenses	A	O							0	

	A	C							0	
Common desktop infrastructure	A	O							0	
	A	C							0	
Test beams, calibration facilities	*Type*		335	315	390	0	0	0	1,040	
General operation	A	O							0	
	A	C							0	
Common electronics	A	O							0	
	A	C							0	
Electronics and DAQ	B	O							0	
	B	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Gas systems	B	O							0	
	B	C							0	
Gas consumption	B	O							0	
	B	C							0	
External cryogenics	A	O	260	260	340				860	Hall 180
	A	C	75	55	50				180	Hall 180
Proximity cryogenics	A	O							0	
	A	C							0	
Safety & radioprotection	A	O							0	
	A	C							0	
Irradiations	B	O							0	
	B	C							0	
Modifications	A	O							0	
	A	C							0	
Modifications	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
Laboratory operations	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C							0	
Assembly areas, clean rooms, active storage areas	B	O							0	
	B	C							0	
Workshops	A	O							0	
	A	C							0	
Workshops	B	O							0	
	B	C							0	
Laboratory instruments	A	O								
	A	C								
Laboratory instruments	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
General services	*Type*		0	0	0	0	0	0	0	
Cooling & ventilation	A	O							0	
	A	C							0	
Power	A	O							0	
	A	C	0	0	0	0	0	0	0	
Power distribution system	A	O							0	
	A	C							0	
Heavy transport	A	O							0	
	A	C							0	
Cranes	A	O							0	
	A	C							0	
Cars	A	O							0	
	A	C							0	
Cars	B	O							0	
	B	C							0	
Safety & radioprotection	C	O							0	
	C	C							0	
INB compliance	C	O							0	
	C	C							0	
Radioactive waste disposal	C	O							0	
	C	C							0	
Access system	C	O							0	

	C	C							0
Elevators	C	O							0
	C	C							0
Gerant de site	C	O							0
	C	C							0
Flood control	C	O							0
	C	C							0
Insurance (CERN standard)	C	O							0
	C	C							0
Cleaning	A	O							0
	A	C							0
Cleaning	C	O							0
	C	C							0
Survey	A	O							0
	A	C							0
Survey	B	O							0
	B	C							0
Passive storage space	A	O							0
	A	C							0
Passive storage space	B	O							0
	B	C							0
Common desktop infrastructure	A	O							0
	A	C							0
Office space	C	O							0
	C	C							0
Consultancy	*Type*		0	0	0	0	0	0	0
Reviewing	A	O							0
	A	C							0
Engineering	A	O							0
	A	C							0
Training	A	O							0
	A	C							0
Outreach	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Outreach	A	O							0
	A	C							0
GRAND TOTALS			354	367	447	1,432	1,838	1,838	6,276
A TOTAL			354	367	447	1,432	1,838	1,838	6,276
B TOTAL			0	0	0	0	0	0	0
C TOTAL			0	0	0	0	0	0	0

SUMMARY OF ATLAS MAGNETS PER TYPE

Magnets		***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***Total***	
Mechanics	O	5	15	15	55	55	55	200	Incl. Gen services
	C	5	10	15	70	70	70	240	
Electronics	O	4	12	12	218	188	188	622	
	C	5	15	15	69	55	55	214	
Cryogenics	O	260	260	340	700	1,040	1,040	3,640	
	C	75	55	50	320	430	430	1,360	
TOTALS		354	367	447	1,432	1,838	1,838	6,276	

M&O Cost Estimates in kCHF
M=Maintenance/Repairs
O=Operations
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ATLAS M&O ESTIMATES (kCHF) FOR TDAQ

			2002	2003	2004	2005	2006	2007	TOTAL	Notes
Detector related costs	*Type*		*0*	*0*	*0*	*65*	*675*	*675*	*1,415*	
Dummy	A	O							0	
	A	C							0	
Dummy	A	O							0	
	A	C							0	
Magnet power supply	A	O							0	
	A	C				65	65	65	195	ROBs in power crates, Racks for LVL1
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Cooling systems	A	O							0	
	A	C							0	
Cooling fluids(above –50°C)	A	O							0	
	A	C							0	
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O							0	
	A	C							0	
Detector safety systems	A	O							0	
	A	C							0	
Detector-specific radiation protection	A	O							0	
	A	C							0	
Shutdown activities	A	O							0	
	A	C							0	
Detector (re-)integration & survey	A	O							0	
	A	C							0	
General Technical support	A	O							0	
	A	C					610	610	1,220	5% of ROBs&infra installed. Independent of staging. Cables, connectors
UPS maintenance	A	O							0	
	A	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Beam pipe & vacuum	A	O							0	
	A	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Secretariat	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Secretarial assistance	A	O							0	
	A	C							0	
Economat	A	O							0	
	A	C							0	
Fax, photocopiers, printers	A	O							0	
	A	C							0	
Printing and publication	A	O							0	
	A	C							0	
Communications	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
GSM phones	A	O							0	
	A	C	0	0	0	0	0	0	0	Included in TCn
GSM phones	B	O							0	
	B	C							0	
Automatic call-back	A	O							0	
	A	C							0	
Automatic call-back	B	O							0	
	B	C							0	
On-line computing	*Type*		*15*	*15*	*470*	*1,580*	*2,755*	*3,775*	*8,610*	
									0	
System management	A	O	0	0	120	480	600	600	1,800	In 06, (2 FTE/farm x2 + 1FTE/shift)@120kCHF/y; 1FTE/300 boxes
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C							0	
Computers/processors/LANs	A	O							0	
	A	C			300	1,000	2,000	3,020	6,320	<15-20%> repl./y. 25% repl. rate on processors
Software licenses	A	O							0	
	A	C	15	15	50	100	155	155	490	For LVL2 (1000), EF (1000), servers (50); code-checking 02/03

Common desktop infrastructure	A	O							0	
	A	C							0	
Test beams, calibration facilities	*Type*		*340*	*340*	*340*	*70*	*20*	*20*	*1,130*	
General operation	A	O	240	240	240				720	On-line computing mgmt for test beams
	A	C							0	
Common electronics	A	O							0	
	A	C	70	70	70	70	20	20	320	ROBs, PCs, monitors, terminals
Electronics and DAQ	B	O							0	
	B	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Gas systems	B	O							0	
	B	C							0	
Gas consumption	B	O							0	
	B	C							0	
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Safety & radioprotection	A	O							0	
	A	C							0	
Irradiations	B	O							0	
	B	C							0	
Modifications	A	O							0	
	A	C							0	
Modifications	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C	30	30	30				90	RIO2,NIM
Electronics pool rentals	B	O							0	
	B	C							0	
Laboratory operations	*Type*		*50*	*50*	*50*	*100*	*100*	*100*	*450*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C							0	
Assembly areas, clean rooms, active storage areas	B	O							0	
	B	C							0	
Workshops	A	O							0	
	A	C							0	
Workshops	B	O							0	
	B	C							0	
Laboratory instruments	A	O							0	
	A	C	20	20	20	55	55	55	225	Lab eqpm in B513,32,40 (VME, network). PCs, testers
Laboratory instruments	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C	30	30	30	45	45	45	225	RIO2
Electronics pool rentals	B	O							0	
	B	C							0	
General services	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Cooling & ventilation	A	O							0	
	A	C							0	
Power	A	O							0	
	A	C							0	
Power distribution system	A	O							0	
	A	C							0	
Heavy transport	A	O							0	
	A	C							0	
Cranes	A	O							0	
	A	C							0	
Cars	A	O							0	
	A	C							0	
Cars	B	O							0	
	B	C							0	
Safety & radioprotection	C	O							0	
	C	C							0	
INB compliance	C	O							0	
	C	C							0	
Radioactive waste disposal	C	O							0	
	C	C							0	
Access system	C	O							0	
	C	C							0	

Elevators	C	O							0
	C	C							0
Gerant de site	C	O							0
	C	C							0
Flood control	C	O							0
	C	C							0
Insurance (CERN standard)	C	O							0
	C	C							0
Cleaning	A	O							0
	A	C							0
Cleaning	C	O							0
	C	C							0
Survey	A	O							0
	A	C							0
Survey	B	O							0
	B	C							0
Passive storage space	A	O							0
	A	C							0
Passive storage space	B	O							0
	B	C							0
Common desktop infrastructure	A	O							0
	A	C							0
Office space	C	O							0
	C	C							0
Consultancy	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Reviewing	A	O							0
	A	C							0
Engineering	A	O							0
	A	C							0
Training	A	O							0
	A	C							0
Outreach	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Outreach	A	O							0
	A	C							0
GRAND TOTALS			*405*	*405*	*860*	*1,815*	*3,550*	*4,570*	*11,605*
A TOTAL			405	405	860	1,815	3,550	4,570	11,605
B TOTAL			0	0	0	0	0	0	0
C TOTAL			0	0	0	0	0	0	0

SUMMARY OF ATLAS TDAQ PER TYPE

TDAQ		***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***Total***
Mechanics	O	240	240	240	0	0	0	720
	C	0	0	0	0	610	610	1,220
Electronics	O	0	0	120	480	600	600	1,800
	C	165	165	500	1,335	2,340	3,360	7,865
Cryogenics	O	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0
TOTALS		405	405	860	1,815	3,550	4,570	11,605

M&O Cost Estimates in kCHF **ATLAS M&O ESTIMATES (kCHF) FOR TECH. COORD & GENERAL**

M=Maintenance/Repairs
O=Operations
C=Consumables

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			2002	2003	2004	2005	2006	2007	TOTAL	Notes
Detector related costs	*Type*		*0*	*190*	*400*	*610*	*1,900*	*1,900*	*5,000*	
Magnet	A	O							0	
	A	C							0	
Magnet controls	A	O							0	
	A	C							0	
Magnet power supply	A	O							0	
	A	C							0	
Gas systems	A	O	0	0	50	50	50	50	200	Service contract
	A	C				50	100	100	250	
Gas consumption	A	O							0	
	A	C	0	70	70	150	200	200	690	Gas consuption for ID and muons. Starts with SR1 and assembly hall
Cooling systems	A	O	0	0	110	110	110	110	440	1 FTE/y (technician).
	A	C				30	30	30	90	2% of investment running time
Cooling fluids(above –50°C)	A	O							0	
	A	C			20	20	70	70	180	Demineralized water, carbo-fluids etc.
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O	0	100	100	100	50	50	400	LAr/Magnet from B180&191
	A	C		20	20	20	40	40	140	2% of the capital investment
Detector safety systems	A	O							0	
	A	C				30	60	60	150	2% of capital value
Detector-specific radiation protection	A	O							0	
	A	C			0	0	0	0	0	Incl. in safety
Shutdown activities	A	O					400	400	800	Crew to operate and prepare shutdown and to run general maitenance
	A	C					50	50	100	Consumables (mechanical shop)
Detector (re-)integration & survey	A	O							0	
	A	C								
General Technical support	A	O	0	0	0	0	300	300	600	Crew to operate and maintain ATLAS technical services, example su
	A	C	0	0	0	0	50	50	100	Consumables (mechanical shop)
UPS maintenance	A	O							0	
	A	C		0	30	50	50	50	180	2% of capital investment
Electronics pool rentals	A	O							0	
	A	C							0	
Beam pipe & vacuum	A	O					120	120	240	Numbers from T Camporesi
	A	C					120	120	240	
Counting & control rooms	A	O							0	
	A	C					100	100	200	5% of capital investment. Counting room eqpm in B
Secretariat	*Type*		*40*	*110*	*155*	*215*	*270*	*290*	*1,080*	
Secretarial assistance	A	O		45	90	140	140	140	555	2 FTE @ 75 kCHF/y (D Schinzel guideline)
	A	C							0	
Economat	A	O							0	
	A	C	10	15	15	15	20	20	95	
Fax, photocopiers, printers	A	O							0	
	A	C							0	
Printing and publication	A	O							0	
	A	C	30	50	50	60	110	130	430	Pens, folders, transparencies, note paper
Communications	*Type*		*0*	*10*	*15*	*15*	*15*	*15*	*70*	
GSM phones	A	O							0	
	A	C	0	10	10	10	10	10	50	TDAQ:5 persons + TCN:5 persons; 1kCHF/y
GSM phones	B	O							0	
	B	C							0	
Automatic call-back	A	O							0	
	A	C	0	0	5	5	5	5	20	10 persons on call
Automatic call-back	B	O							0	
	B	C							0	
On-line computing	*Type*		60	60	60	110	170	170	630	
									0	
System management	A	O							0	
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C	20	20	20	30	30	30	150	DCS (PCB, cabling, connectors, interfaces)
Computers/processors/LANs	A	O							0	
	A	C					40	40	80	DCS (test beam instrumentation, radiation testing)
Software licenses	A	O							0	
	A	C	40	40	40	50	70	70	310	DCS SCADA, design

Common desktop infrastructure	A	O							0	
	A	C	0	0	0	30	30	30	90	PCs, WS, terminals for on-line mgmt tasks
Test beams, calibration facilities	*Type*		15	25	25	25	0	0	90	
General operation	A	O							0	
	A	C							0	
Common electronics	A	O							0	
	A	C	15	25	25	25			90	DCS (test beam instrumentation, radiation testing outside CERN)
Electronics and DAQ	B	O							0	
	B	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Gas systems	B	O							0	
	B	C							0	
Gas consumption	B	O							0	
	B	C							0	
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Safety & radioprotection	A	O							0	
	A	C							0	
Irradiations	B	O							0	
	B	C							0	
Modifications	A	O							0	
	A	C							0	
Modifications	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
Laboratory operations	*Type*		*0*	*60*	*110*	*60*	*20*	*20*	*270*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C	0	50	100	50			200	
Assembly areas, clean rooms, active storage areas	B	O							0	
	B	C							0	
Workshops	A	O							0	
	A	C		10	10	10	20	20	70	Special cleaning of lab areas (SR)
Workshops	B	O							0	
	B	C							0	
Laboratory instruments	A	O							0	
	A	C							0	
Laboratory instruments	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
General services	*Type*		238	1,036	1,713	2,236	3,629	3,769	12,621	
Cooling & ventilation	A	O	36	73	109	146	182	182	728	D Schinzel/M Wilhelmson input
	A	C	36	73	109	146	182	182	728	D Schinzel/M Wilhelmson input
Power	A	O							0	
	A	C	80	560	1,030	1,470	2,820	3,010	8,970	See separate note by M Nessi 10-01-2002
Power distribution system	A	O	0	0	0	0	0	0	0	
	A	C	0	20	25	25	35	35	140	Service contract (ST) for periodic inspection of power connections
Heavy transport	A	O	0	60	60	60	60	60	300	Area mgmt (safety, cleaning, storage)
	A	C	0						0	
Cranes	A	O	0	60	60	60	120	120	420	7 cranes in Pit 1, 6 operators @60kCHF/FTE '03-05 of which 1 for sa
	A	C	5	30	60	60	60	60	275	1.5% of capital value/y
Cars	A	O	0	0	0	0	0	0	0	
	A	C	0	30	30	30	30	30	150	CERN cars for TCn operate at Point 1
Cars	B	O							0	
	B	C							0	
Safety & radioprotection	C	O							0	
	C	C							0	
INB compliance	C	O							0	
	C	C							0	
Radioactive waste disposal	C	O							0	
	C	C							0	
Access system	C	O							0	
	C	C							0	

Elevators	C	O							0	
	C	C							0	
Gerant de site	C	O							0	
	C	C							0	
Flood control	C	O							0	
	C	C							0	
Insurance (CERN standard)	C	O							0	
	C	C							0	
Cleaning	A	O							0	
	A	C		0	0	0	0	0	0	
Cleaning	C	O							0	
	C	C							0	
Survey	A	O	60	110	210	210	110	60	760	See note from C Lasseur
	A	C	0	0	0	0	0	0	0	
Survey	B	O							0	
	B	C							0	
Passive storage space	A	O							0	
	A	C							0	
Passive storage space	B	O							0	
	B	C							0	
Common desktop infrastructure	A	O	0	0	0	0	0	0	0	
	A	C	20	20	20	30	30	30	150	PCs, WSs, terminals for technical crews
Office space	C	O							0	
	C	C								
Consultancy	*Type*		0	100	100	100	130	130	560	
Reviewing	A	O							0	
	A	C							0	
Engineering	A	O	0	100	100	100	130	130	560	Academic subsistence. Entry requested by SG
	A	C							0	
Training	A	O							0	
	A	C							0	
Outreach	*Type*		*50*	*50*	*50*	*125*	*200*	*125*	*600*	See separate note (M Barnet)
Outreach	A	O				50	100	50	200	PJAS to run website (media events)
	A	C	50	50	50	75	100	75	400	Material for schools, public
GRAND TOTALS			403	1,641	2,628	3,496	6,334	6,419	20,921	
A TOTAL			403	1,641	2,628	3,496	6,334	6,419	20,921	
B TOTAL			0	0	0	0	0	0	0	
C TOTAL			0	0	0	0	0	0	0	

SUMMARY OF ATLAS TECHNICAL COORD. PER TYPE

TCn & General

		2002	*2003*	*2004*	*2005*	*2006*	*2007*	*Total*
Mechanics	O	96	548	889	1,026	1,872	1,772	6,203
	C	131	408	549	761	1,357	1,352	4,558
Electronics	O	0	0	0	0	0	0	0
	C	175	685	1,190	1,710	3,105	3,295	10,160
Cryogenics	O	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0
TOTALS		403	1,641	2,628	3,496	6,334	6,419	20,921

30-May-02

SUMMARY OF M&O(B) kCHF

EXPERIMENT: ATLAS											
Subsystem:	**ID&TileCal&LAr&Muons**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**
	Mechanics	0	0	0	40	205	205	200	200	200	**1050**
	Gas-system	65	85	105	280	660	660	660	660	660	**3835**
	Cryo-system	10	10	5	5	30	30	30	30	30	**180**
	Cooling system	0	0	0	65	265	315	315	315	315	**1590**
	FE electronics	0	0	0	100	580	1330	780	780	780	**4350**
	Standard electronics, PS (LV, HV)	25	25	25	95	290	290	390	390	390	**1920**
	Standard electronics, Crates	365	245	180	175	355	475	565	565	565	**3490**
	Standard electronics, RO Modules	100	70	40	70	225	460	460	460	460	**2345**
	Controls, (DCS, DSS)	25	25	20	25	165	195	195	195	195	**1040**
	Sub-Detector Spares	0	0	0	0	0	800	800	800	700	**3100**
	Areas	230	250	235	290	650	650	650	240	240	**3435**
	Communications	0	0	0	0	20	20	20	20	20	**100**
	Store Items	10	10	10	240	305	355	355	350	350	**1985**
	Hired Manpower @ CERN (CHF)	85	95	145	740	1,680	1,180	1,180	1,980	1,180	**8265**
	Hired Inst. MP @ 90 kCHF/FTE	0	0	0	90	450	630	630	630	630	**3060**
	Technical Manpower @CERN (FTE)	4	5	10	25	22	22	17	17	17	**139**
	TOTALS (excl. FTEs)	**915**	**815**	**765**	**2215**	**5880**	**7595**	**7230**	**7615**	**6715**	**39745**

Spares paym.advcment profile	2900	2034	1803	733	0	0	100	0	0	7570

10-Mar-02

M&O(B) kCHF

EXPERIMENT: ATLAS												
Subsystem: ID		**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
	Mechanics	0	0	0	0	0	0	0	0	0	**0**	
	Gas-system	40	40	40	190	380	380	380	380	380	**2210**	See SS note
	Cryo-system	0	0	0	0	0	0	0	0	0	**0**	
	Cooling system	0	0	0	65	65	65	65	65	65	**390**	See SS note
	FE electronics (spares)	0	0	0	0	0	400	400	400	400	**1600**	FE spares, arranged as payment advance
	Standard electronics, PS (LV, HV)	0	0	0	0	90	90	240	240	240	**900**	5% of CORE (PSs: LV and HV/bias, PatchPanel3, PP2)
	Standard electronics, Crates	60	35	20	20	70	140	140	140	140	**765**	5% of CORE (ROD/alignment crates)+pool rentals,multimeters,oscilloscopes
	Standard electronics, RO Modules	40	30	20	20	145	230	230	230	230	**1175**	5% of CORE of readout modules+PCs+software licences
	Controls, (DCS, DSS)	20	20	15	10	40	40	40	40	40	**265**	5% of CORE of DCS/ELMBs,safety equipment
	Sub-Detector Spares	0	0	0	0	0	750	750	750	650	**2900**	Production of spares, arranged as payment advance, see comment
	Areas											
	SR-maintenance facility (buildup)	0	0	0	0	410	410	410	0	0	**1230**	See SS note
	SR-maintenance facility (operation)	0	0	70	180	180	180	180	180	180	**1150**	Cleanroom maintenance and consumables, for staged items, PIXEL B-layer replacements and maintenance activities
	Testbeam and irradiation	120	120	50	50	50	50	50	50	50	**590**	Testbeam and PS irradiation facilty consumables, all three subsystems
	Systemtests	80	115	100	50	0	0	0	0	0	**345**	Systemtest consumables for the systemtest in all three subsystems
	Communications	0	0	0	0	5	5	5	5	5	**25**	
	Store Items	0	0	0	120	170	170	170	170	170	**970**	
	Hired Manpower @ CERN (CHF)											
	Standard tasks	30	30	50	360	550	550	550	550	550	**3220**	Manpower: see SS note
	Special interventions	0	0	0	0	450	0	0	800	0	**1250**	Manpower to install staged items in 2006 (PIXEL 3rd layer and TRT-C wheels), and major intervention in 2009 (example) when the entire ID is taken to
	Technical Manpower @CERN (FTE)	1	1	2	2	4	4	4	4	4	**26**	See SS note
	TOTALS (excl. FTEs)	**390**	**390**	**365**	**1065**	**2605**	**3460**	**3610**	**4000**	**3100**	**18985**	
	Spares paym.advcment profile	1100	1134	1533	733	0	0	0	0	0	4500	

27-Mar-02

M&O(B) kCHF

These comments are mostly for after 2005
Before 2006 all is test beam; this activity continues also thereafter.

EXPERIMENT: ATLAS											
Subsystem: TileCal	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
Mechanics (incl. optics)					55	55	50	50	50	**260**	repairs and modifications to tools to extract the drawers; small part replacements
Gas-system (Cs137-hydraulic drive)	5	5	5	5	25	25	25	25	25	**145**	pumps, valves, filters, monitors for Cs source system
Cryo-system										**0**	
Cooling system					25	25	25	25	25	**125**	similar to the Cs radiaoctive source system
FE electronics					30	30	30	30	30	**150**	THIS LINE AND THE FOUR FOLLOWING LINES ARE TO BE CONSIDERED TOGETHER.
Standard electronics, PS (LV, HV)	25	25	25	25	80	80	80	80	80	**500**	Total of 5 lines equal 330 kCHF/yr, of this 90 k/year is test beam as pre-2006, the remainder
Standard electronics, Crates	40	40	40	40	95	95	95	95	95	**635**	is 240 k/year for FE electr. repairs, maint. /replacements of HV and f LV PS, pool
Standard electronics, RO Modules	20	20	20	20	30	30	30	30	30	**230**	rentals for USA15, laser system maint. and repairs, ROD crate maintenance, PCs,
Controls, (DCS, DSS); ELMBs for test-beam	5	5	5	5	95	95	95	95	95	**495**	software licences and DCS electronics.
Sub-Detector Spares						50	50	50	50	**200**	100 k - PMT spares, parts of PMT blocks, connectors etc.
Areas					10	10	10	10	10	**50**	Local lab for repairs; equipment rentals
Communications					5	5	5	5	5	**25**	Videoconferencing, GSM
Store Items	10	10	10		25	25	25	20	20	**145**	General operations for test beams and local repair labs.
Hired Manpower @ CERN (CHF)					150	150	150	150	150	**750**	Acces: 1/3 y x 4.5 FTE = 1.5 FTE @ 100 kCHF
Technical Manpower @CERN (FTE)	1	1	1	1	5	5	5	5	5	**29**	1 sys. mger (DCS), 1 general operations, 1 DAQ, 1 Calibr. Data, 1 electronics, mostly rad. Source
TOTALS (excl. FTEs)	**105**	**105**	**105**	**95**	**625**	**675**	**670**	**665**	**665**	**3710**	

Spares paymt. advanced profile		100	100	200

Detailed breakdown of 5 electronics lines in "steady state" as given in reply to SG	**After 2005**
Replacement parts for drawer electronics repairs	**30**
Repairs and replacements of LV and HV power supplies:	50-55
Test beam (see 2002)	25
	80
Electronic pool rentals for USA15	50-55
Test beam (see 2002)	40
	95
ROD crate and ROD maintenance:	10
Test beam (see 2002)	20
	30
PCs, software licences (DCS)	40-45
Laser system maintenance and repairs	15-20
ELMB maintenance and replacements	20-25
Test beam (see 2002)	5
	95

6-Mar-02

M&O(B) kCHF

EXPERIMENT: ATLAS											
Subsystem: Muons	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
Mechanics				40	150	150	150	150	150	**790**	5% of CORE.Replacement of materials, moving parts (big wheels)
Gas-system	20	40	60	85	255	255	255	255	255	**1480**	Gases (Ar,C)2,N-Pentane; components 5% of capital CORE. Gas volume 900 m3
Cryo-system										**0**	
Cooling system					125	125	125	125	125	**625**	5% of capital CORE; for trigger electronics in pit. Outside shielded
FE electronics (spares)				100	550	550	0	0	0	**1200**	Replacement of electronics in modules, fibre optics, RO
Standard electronics, PS (LV, HV)				70	100	100	50	50	50	**420**	10% of capital CORE up to '07, 5% thereafter. Replacement of electronics in modules; el. po
Standard electronics, Crates	180	130	100	0	110	110	200	200	200	**1230**	PCs, DAQ fibre optic trans/receiver eqpm. replacements; el. pool rentals (VMEs).Staging fin
Standard electronics, RO Modules	40	20								**60**	Electronics pool rentals for test beams
Controls, (DCS, DSS)						30	30	30	30	**120**	ELMBs, safety eqpm.
Sub-Detector Spares										**0**	
Areas										**0**	
Communications					5	5	5	5	5	**25**	GSM phones
Store Items										**0**	
Hired Manpower @ CERN (CHF)	40	60	90	180	330	330	330	330	330	**2020**	From 2006, shutdown activities, gas & cooling operations, feasibility studies
Technical Manpower @CERN (FTE)	2	2	2	15	10	13	8	8	8	**68**	
TOTALS (excl. FTEs)	**280**	**250**	**250**	**475**	**1625**	**1655**	**1145**	**1145**	**1145**	**7970**	

Spares paym.advcment profile	600	600	270	0	0	0				1470

Note: The spares payment advancement is managed within the Muon system

30-May-02

M&O(B) kCHF

EXPERIMENT: ATLAS Subsystem: LAr	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTALS	
Mechanics	0	0	0	0	0	0	0	0	0	**0**	
Gas-system										**0**	
Cryo-system	10	10	5	5	30	30	30	30	30	**180**	LAr 1.2 CHF/l; also FEC cooling gases
Cooling system					50	100	100	100	100	**450**	Cooling for FEC systems and power supplies
FE electronics (spares)						350	350	350	350	**1400**	FEB spares; arranged as payment advancement
Standard electronics, PS (LV, HV)					20	20	20	20	20	**100**	Replacement of 1 PS per year
Standard electronics, Crates	85	40	20	115	80	130	130	130	130	**860**	Electr. pool rentals; test beam electr (VMEs); DVMs,TDRs,oscilloscopes
Standard electronics, RO Modules				30	50	200	200	200	200	**880**	On-line computing epm (PCs,RODs,links, software licences)
Controls, (DCS, DSS)				10	30	30	30	30	30	**160**	Replacement of local DCS/ELMBs; safety equipment
Sub-Detector Spares										**0**	
Areas	30	15	15	10						**70**	Test beam oper. consumables
Communications					5	5	5	5	5	**25**	GSM phones, call-back
Store Items				120	110	160	160	160	160	**870**	Sheet metal for repairs
Hired Manpower @ CERN (CHF)	15	5	5	200	200	150	150	150	150	**1025**	System managers, technicians, welders, cleaners
Hired Inst. MP @ 90 kCHF/FTE				90	450	630	630	630	630	**3060**	
Technical Manpower @CERN (FTE)		1	5	7	3	0	0	0	0	**16**	
TOTALS (excl. FTEs)	**140**	**70**	**45**	**580**	**1025**	**1805**	**1805**	**1805**	**1805**	**9080**	

Spares paym.advcment profile	1200	200	0	0	0	0	0	0	0	1400

Estimated M+O Cost Sharing for ATLAS 2002-2007 by Funding Agency (kCHF)

Funding Agency	Category A M&O	Category B M&O	TOTAL kCHF
Armenia	56	10	**66**
Australia	198	108	**305**
Austria	198	0	**198**
Azerbaijan	198	0	**198**
Belarus	226	0	**226**
Brazil	198	9	**206**
Canada	1213	399	**1612**
China NSFC+MSTC	395	46	**441**
Czech Republic	734	102	**836**
Denmark	198	139	**337**
Finland	0	0	**0**
France IN2P3	1975	1349	**3325**
France CEA	593	497	**1090**
Georgia	198	0	**198**
Germany BMBF	2511	1247	**3758**
Germany MPI	649	346	**995**
Greece	649	103	**752**
Israel	480	268	**748**
Italy	3951	1965	**5916**
Japan	1552	1240	**2792**
Morocco	226	10	**235**
Netherlands	452	470	**922**
Norway	339	169	**508**
Poland	705	47	**753**
Portugal	254	102	**356**
Romania	282	31	**313**
Russia	1834	1171	**3006**
JINR	1101	274	**1374**
Slovak Republic	198	14	**212**
Slovenia	169	65	**234**
Spain	818	403	**1221**
Sweden	536	524	**1060**
Switzerland	395	431	**826**
Taipei	226	110	**336**
Turkey	169	0	**169**
United Kingdom	3894	989	**4883**
US DOE + NSF	7139	3495	**10634**
CERN	4148	2057	**6205**
total	**39,055**	**18,190**	**57,245**

Note: C&I is shared proportionally to CORE

Table 5

Planning of Manpower for the full ATLAS Detector

revised October 24, 2001

(in man-years)

	Inner Det.	LAr Cal.	Tile Cal.	muon cham.	trigger/ DAQ/cor	Common Projects	**total**
Armenia			5				**5**
Australia	48						**48**
Austria					10		**10**
Azerbaijan							**0**
Belarus			3				**3**
Brazil			3				**3**
Canada		125				2	**127**
Czech Republic	40		14		8		**62**
Denmark					4		**4**
Finland							**0**
France IN2P3	41	405	40		12	15	**513**
France CEA		75		40	20	20	**155**
Georgia							**0**
Germany BMBF	107	25			70	1	**203**
Germany MPI		35		82			**117**
Greece				51			**51**
Israel				87	11		**98**
Italy	80	30	24	140	46	75	**395**
Japan	42			26		17	**85**
Kazakhstan							**0**
Morocco							**0**
Netherlands	70			85	48	20	**223**
Norway	69						**69**
Poland	98				16		**114**
Portugal			19		4		**23**
Romania			1		3		**4**
Russia	315	115	47	116	30		**623**
JINR	115	30	39	73	36		**293**
Slovak Republic		2	4				**6**
Slovenia	8						**8**
Spain	76	16	44				**136**
Sweden	36	8	5		3		**52**
Switzerland	32				24		**56**
Turkey					4		**4**
United Kingdom	293				90		**383**
US DoE + NSF	214	160	50	162	28	25	**639**
CERN	200	90	28	27	185	130	**660**
total	1884	1116	326	889	652	305	**5172**
CORE manpower needs	1900	1130	325	880	740	335	**5310**
total - needs	-16	-14	1	9	-88	-30	-138

Appendix 13 - A Brief Review of Technical Coordination Activities

D. Fournier, T. Kondo, J. Pilcher (chair), K. Smith

15 February, 2002

1. Introduction

Recent ATLAS reviews have identified cost increases associated with common project items, commissioning and integration of detector elements, and completion of the detector elements themselves. These lead to a total cost which is larger than the approved figure of 475M CHF. CERN management has required that ATLAS defer enough construction activity to cover the increases until additional funding can be assured. The spokesperson has made specific requests to each project leader to achieve these reductions. Since a significant fraction of the cost increases are associated with common project items and infrastructure, a number of ATLAS members have asked that a review be done of the budget and planning of the Technical Coordination Group.

To complete the review in a timely way and with a modest level of overhead for the Technical Coordination management, a small committee was set up consisting of four members of the ATLAS Executive Board. They are Daniel Fournier, Taka Kondo, Jim Pilcher (chair), and Kenway Smith. It was not intended that this be a comprehensive, in-depth review of individual budget items but rather an overview of the tasks and problems, together with an evaluation of the planning and budget control of the Technical Coordination Group.

Other outside reviews of Technical Coordination activity have taken place recently. They include:

- A review of magnet costs by the LHCC MAG committee in October 2001
- A review of costs to completion in September 2001 by the CORE committee
- A review by the RRB scrutiny committee of the pre-operation costs
- A review of the US involvement in Technical Coordination together with its overall structure, in October 2001.

Before its first meeting the present committee was provided with the following documents:

1. A summary of ATLAS TC infrastructure costs divided into 16 categories with each category further subdivided into 3 additional levels of detail. For each category the current cost was shown, the funding from various sources, the necessary commitment and payment schedules, and the possible costs which could be staged until after 2004.

2. A summary of funding short-falls divided among common project items, infrastructure, and reduced common fund payments. One additional level of detail was given for each item. The principal funding agencies were identified, the type of contract (in-kind or cash), the contract number, the necessary commitment date, and the time profile of the cost increase. This has already been made available to the national contact physicists and is summarized below in Table 1.

3. A summary of the status of the magnet system resources as presented by Herman ten Kate at the magnet ASSO on 2 November 2001.

4. A summary of costs for the magnet common project divided into 10 categories with one additional level of detail for each category. For each item the original cost was shown, the current cost which is assured, the estimated final cost, the source of the increases, and the funding sources involved.

5. A table of unfunded items in the experimental area, at the interface of the experiment and the LHC machine.

6. A 20-page summary prepared by Marzio Nessi which outlined the infrastructure costs and Technical Coordination planning.

The committee met in two sessions. The first was on 12 December 2001 from 9:00 to 14:00 and the second on 13 December from 17:30 to 18:30. Marzio Nessi, Markus Nordberg, and Peter Jenni were present for most of the discussion, however, an executive session of only the committee members was held at the conclusion of each session. Further meetings of the committee took place in telephone conferences.

2. Infrastructure Costs

Infrastructure in the experimental area covers a broad range of items and overlaps with responsibilities for the construction and equipping the area, in addition to items associated with the LHC machine.

Nessi pointed out that the infrastructure costs must be met through four different budgets. These are the ATLAS Common Fund of 28 MCHF, a CERN infrastructure budget of 15 MCHF for minimally equipping the experimental area, an area budget under control of the LHC project, and an exploitation budget associated with the CERN team in ATLAS. The latter covers the operating costs for CERN personnel, the cost of CERN services, the payment of subsistence allowances to non-CERN technical personnel, and many miscellaneous expenses. In case of further reductions of CERN funding, the latter budget is the most likely to be affected.

This budget structure is complex, with different people responsible for different aspects of the infrastructure budget. There appears to be little documentation or formal agreement. However, it does provide flexibility and room for creative solutions, given constructive working arrangements among the individuals responsible for each budget. This seems to be the case. Nessi reported that work is underway to further clarify items covered by the LHC area budget and useful progress is being made.

The cost to completion of items expected to be covered by the first two budgets described above is 53.8 MCHF and an additional 8.4 MCHF is assumed to be covered by the CERN area budget. It has been assumed that 4% of the 53.8 MCHF can be deferred until after 2004. The infrastructure overcosts of 16.3 MCHF were part of the request presented at the October RRB.

The committee reviewed the status of several key areas of infrastructure.

(a) Shielding

Within the past year there have been important simplifications of the forward shielding design with a view to reducing its cost. Unfortunately the price per kilo is still high. The estimated overcost has been reduced to 2.0 MCHF (38%) but no major contracts have been placed to date. Some staging has been planned and further options for partial staging are being investigated. The present staging amounts to 16% of the currently estimated cost. Several components of the shielding may be suitable for in-kind contributions. It appears that the LHC project is already funding all the shielding needed to protect the machine elements and ATLAS is only funding the shielding needed for acceptable backgrounds in the muon system.

Procurement is presently planned for 2002. **It is recommended that a year's delay be considered provided this has no major influence on the overall installation schedule. This would allow time for further engineering which might reduce the cost, as well as time for further negotiations which might lead to in-kind contributions.**

(b) Feet and Rails

The main contract is ready to be signed and the cost is close to the available funds.

(c) Movement systems and detector interfaces and access

The overcosts here are large because of many complex requirements. They currently amount to an additional 6.9 MCHF or 250%. Contracts for the metal walkways on the walls of the cavern have been placed and amount to ~20% of the total cost. Designs for the balance are being optimized and items amounting to ~50% of the estimated cost will be reviewed in 2002, with a view to committing funds shortly thereafter.

(d) Vacuum Pipe

There are substantial overcosts (82%) driven by the long Be pipe. A new cost estimate is expected in mid-2002. There is a potential cost reduction if the length of the Be section is shortened to be closer to what is used by CMS. This is being held in reserve to cover possible additional overcosts.

It is recommended that the physics implications of a shorter beam pipe be evaluated so the trade-offs are clearly understood and a decision can be made promptly.

(e) Cooling and Ventilation

This category falls into both the ATLAS budget and the LHC area budget. Work continues to define and limit these costs but items such as rack cooling and detector cooling infrastructure do legitimately fall to ATLAS and involve an overcost of 0.85 MCHF.

Good technical solutions were found for detector and rack cooling in the LEP experiments. **Consultation with some of the individuals responsible for this earlier work is encouraged.**

(f) Safety

There are overcosts of 1.6 MCHF here driven by externally imposed requirements which are continuing to evolve. Costs for fire and gas detection have been proposed for the LHC area budget but not yet approved. R&D is being done by CERN on the gas sniffer system.

The cost of safety systems should be a host lab responsibility, particularly since the conditions are imposed by the host lab. Similarly, R&D on safety systems should be funded by the host lab.

(g) Racks, cable trays, pipes, gas

Overcosts here stem mainly from the number of racks and cable trays being requested and amount to 0.8 MCHF (23%). The number of racks is limited by available space and will be ~30% less that the originally requested number.

It is clearly in the interest of the collaboration to provide accurate and lean estimates of the requirements. **These should be organized and scrutinized within each system before being passed to TC. Since the requested number of racks exceeds the number available, continued interaction between TC and the detector systems will be needed to assign the racks in an optimal way.**

3. Magnet Costs

The magnet project has advanced well and the bulk of the work is now under contract. The estimated overcost is 19.6 MCHF or 14% of the original budget. Containing this overcost has required a great deal of creativity from the teams involved as well as an major effort from the funding agencies making in-kind contributions to the magnet project. The technical effort has been noted by several expert reviews, including the LHCC MAG committee.

Several important steps remain. The cold mass of the endcap toroid is under contract but not progressing well. There could be further delays and/or cost increases. The integration of the barrel toroid coils into the cryostats is well planned but has not yet started. This is a labor intensive task and uncertainties will remain large until there is experience from the first coil. The installation and commissioning of the barrel toroid in the underground area is a challenging and time critical task. For all these reasons **the magnet project needs continued care and attention. It is clear that the success of the magnet system is vital to the entire experiment.**

Part of the cost overrun is associated with additional engineering costs in the participating magnet labs. At present ATLAS is paying these costs from the common fund and negotiations are underway for a third phase of the work. **The funding agencies with a central involvement in the magnet designs should be urged to help complete these systems even if this means an expanded role. ATLAS management is urged to negotiate with these funding agencies to secure this support.**

4. Manpower Costs and Planning

There has been a vigorous effort by CERN management to transfer to the experimental collaborations many of the costs traditionally born by CERN as the host lab. This change has had a significant impact on both the materials budget and the manpower needed by ATLAS Technical Coordination. Extra manpower has to be brought in from commercial firms at a cost which is now around 80 KCHF/year/person but is likely to grow to 100 KCHF/year within the ATLAS installation period. A further complication arises from new legislation under which teams of hired labour must be supervised by a foreman from the commercial firm who is paid through the same contract. Human resources for assisting in the installation process appear to be available in a number of ATLAS institutions but the subsistence payments needed to relocate them to CERN are not readily available. The **ATLAS management is urged to negotiate with ATLAS funding agencies and with CERN in order to take full benefit of these potential resources**.

Already in 2002, TC has to face the need to supply teams of crane operators, (two per crane), to supplement the one man offered by CERN to supervise the hired operators. ATLAS needs crane facilities at Pit 1, both on the surface and in the cavern, as well as for the near-continuous assembly activities of LAr and TileCal. CERN is also imposing limits on the transport facilities which will be provided and ATLAS must foresee significant charges for commercial firms to move large pieces of equipment from storage to assembly areas. Insurance costs during such moves amount to 0.8 per mille of the equipment value and are presently billed to ATLAS, although there may be some hope of recovering such costs in the future. For items moved by the CERN transport service the maximum insured value is limited to 100 KCHF.

Thanks to the prudence of previous Technical Coordinators, who took full advantage of the CERN-ATLAS group's exploitation budget, the ATLAS MOU installation budget is essentially intact. While acknowledging that this is probably the least understood of the Technical Coordination tasks, Nessi estimates that the manpower levels required for general installation work amount to 50 staff years over the period 2003-2005. Installation of services is reckoned to require 40 staff years during this same period, including 10 additional designer staff years between 2002 and 2004. The costs of hiring these is put at 6.6 MCHF. Unforeseen additional work involving engineering, designers and shift work, priced at 2.5 MCHF, brings the manpower total during the installation phase to 9.1 MCHF. The hired manpower, divided into teams, will have to be supplemented by additional manpower from the individual detector systems. TC plans to initiate discussions with the systems teams to clarify the issues and numbers involved.

In addition to manpower required for the installation of ATLAS, there is an estimated 33 staff years (or ~ 2MCHF) of missing manpower for the Magnet Project, according to Herman ten Kate's projections in a recent ASSO overview.

While the above numbers need to be studied in much more detail than was possible in this review, it is very clear that provision and supervision of TC manpower is a major task. The associated costs justify a wide-ranging discussion within the ATLAS community about possible ways meet them. It might be appropriate to **have a member of the Technical Coordination team with direct responsibility for**

gathering and coordinating human resources for the team, particularly those contributed by outside institutes.

Even if more human resources are found, it is likely that TC will remain understaffed for some time. If not properly handled this could lead to excessive delays in the construction, installation, or commissioning of the detectors, and of the experiment overall. Because of this we recommend that **priorities should be clearly established in TC and brought for approval** by the relevant body.

5. Conclusions

1. Degree of "ownership" of costs by ATLAS management

For the construction and infrastructure tasks a substantial and continuing effort is being made by Technical Coordination to identify and contain costs. Creative approaches are being taken and there is an on-going dialog with LHC machine groups on many issues. **Some cost savings have been achieved and staging options are being actively pursued. These tasks are well in hand.**

Costs and planning of the installation phase are also being addressed but are less well understood at the present time. This area needs further attention and coordination with detector groups.

2. Redefinition by CERN of its role as host-lab

ATLAS is now responsible for many costs which in the past have been assumed by CERN as part of its host-lab responsibility. This situation has continued to evolved since the original approval of ATLAS and is responsible for many cost increases. The change falls most heavily on Technical Coordination.

3. Interaction of Technical Coordination with the detector systems

Many tasks of the Technical Coordination group are to satisfy requirements and constraints from the detector groups. **Less stringent requirements and a reduced level of convenience in the initial period might result in reduction or deferral of costs.**

4. Exposure to further cost increases

As described above, the principal exposure to further cost increases comes from the toroid magnet system, unfavorable decisions on which items are covered by the CERN "Area" budget (currently estimated at 8.4 MCHF), and in the installation process. Unfortunately Technical Coordination must work with no contingency in its budget. It is also clear that the CERN financial problems may put further pressure on the funds available for Technical Coordination.

5. Proposals to deal with the cost increases

It is clear that these problems will only be solved by a combination of approaches, both internal and external to the ATLAS physics collaboration.

First, to have the support of the funding agencies, ATLAS must be seen as acting responsibly and decisively to deal with the cost increases. Technical Coordination is already doing this but the following points might help further.

- **The experimental area and its time-evolution should be critically reviewed with a view to relaxing requirements during the installation and early operation of the experiment. This work should involve system experts interacting with Technical Coordination management**
- **The Technical Coordinator, in consultation with the spokesperson, should have the authority to veto or defer requests for services from the detector systems**
- **Global resources must be used as efficiently as possible.** This could involve detector groups assisting with some Technical Coordination responsibilities, deferring some services requested, or reducing requirements. The use of any financial resources saved should be decided by the spokesperson in order to assure optimal reallocation.

ATLAS management has been actively engaged with the funding agencies for some time to negotiate additional support. A document with explicit proposals to the funding agencies has recently been presented to the national contact physicists.

It is clear that Technical Coordination has an enormous work load whose execution will strongly affect the early success of the experiment. Creative approaches are already being taken and there is every indication that this will continue. Continuing interaction with the detector system groups is essential to simplify the tasks of Technical Coordination and to set priorities.

Table 1. SUPPLEMENTARY COSTS ITEM LIST V2.2 , 21/11/01 (MCHF)

Nature of Cost	Item Description	Original cost	Overcost
1.1. Barrel Toroid Magnet	1.1.1. Engineering		**1.2**
	1.1.2. Warm structure	**2.6**	**1.5**
	1.1.3. Coil casing	**10.5**	**2.0**
	1.1.4. Integration 1&2	**5.0**	**0.6**
	1.1.5. Vacuum vessels	**5.3**	**0.5**
	1.1.6. Tie rods	**0.5**	**0.6**
	1.1.7. Cryoring	**1.1**	**0.5**
	1.1.8. Installation	**1.4**	**1.0**
1.2. End Cap Toroid Magnet	1.2.1. Engineering & inspection	**7.8**	**2.9**
	1.2.2. Additional central engineering		**2.1**
	1.2.3. Cryogenics engineering		**1.7**
	1.2.4. Cold mass		**1.0**
	1.2.5. Assembly, integration and controls		**2.0**
	1.2.6. Cryogenics / External system	**10.5**	**1.0**
	1.2.7. Cryogenics / Proximity & Installation	**3.5**	**1.0**
1.3. LAr Cryostat & Cryogenics	1.3.1. Various items		**1.0**
	1.3.2. Integration		**1.3**
1.4. TC Infrastructure	1.4.1. Shielding elements	**5.2**	**1.2**
	1.4.2. Shielding elements		**1.0**
	1.4.3. Traction systems	**0.5**	**1.6**
	1.4.4. Access structures	**0.4**	**1.1**
	1.4.5. Support structures	**0.1**	**1.4**
	1.4.6. Muon wheel supports		**1.5**
	1.4.7. Electrical distribution		**1.0**
	1.4.8. Vacuum chamber		**2.0**
	1.4.9. Cooling & ventilation		**2.0**
	1.4.10. Flexible support carriers		**1.4**
	1.4.11. Varia - racks, cable trays,..	**1.8**	**0.7**
	1.4.12. Safety detectors		**1.4**
1.7 Common Projects	1.7.1. Missing contributions to Common Fund		**2.3**
	TOTAL Overcost for TC Related Items		**40.5**

ATLAS RC Note **Appendix 14**

Comments on revised ATLAS C&I Cost Estimates 2002 - 2005

Introduction

Following the request of the RRB Scrutiny Group (SG) in June 2001, ATLAS submitted to SG its M&O (A, B, C) and C&I (A, B) cost estimates 2002 – 2007 in August further scrutiny. The results of the partial scrutiny of C&I (A) were presented in the October 2001.

This document provides comments and clarifications to the updated C&I cost estimates 2002 – 2005 (with a time frame up to 2010 although 2005 is the last year of C&I payments) submitted to the joint LHCC-RRB SG in February, 2002.

Methodology

The methodology used to collect the C&I cost estimates is summarized in Table 1:

Table 1. Methodology

#	Step
1	Update the cost estimates from October 2001 by systems using the original template
2	For C&I (A), use the original template of M&O (A)
3	For C&I (B), use the new template and guidelines provided by SG, using a “transformation matrix” to ensure a homogenous approach to cost item recording across the different systems (Annex 1)
4	Collect plans on Institute technical manpower to be sent to CERN for installation and integration activities; identify what share is part of the planned baseline and what is expected to be offered by Funding Agencies as in-kind contributions

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 Continued on next page

Assumptions The assumptions made while providing the updated cost estimates are summarized in Table 2:

Table 2. Assumptions

#	Assumption
1	The initial ATLAS detector is ready for physics data taking by April 2006
2	Institute technical manpower includes technicians (and possibly engineers) sent to CERN for maintaining the respective systems
3	Institute manpower for installation and integration work at CERN already originally planned for and included within the recognized integrated manpower effort of 5 315 man-years is not credited
4	Institute manpower to be recognized as contribution from a Funding Agency is accounted for at 91.25 kCHF/FTE/y
5	Hired manpower includes industrial personnel recruited locally at CERN. The recognized value of a technician is 80 kCHF/year and for a qualified engineer (e.g. systems manager) 120 kCHF/year

C&I (A) The following comments and clarifications are made to the collected C&I (A) cost estimates (Table 3):

Table 3. Comments, clarifications to C&I (A)

#	Comment
1	Magnet integration in B180 and in Pit 1: Estimates given by D Schinzel/F Haug
2	Detector integration work: design work for final configuration control and services integration
3	General technical support: Operation of the traction system, cooling plant and TDAQ
4	Heavy transport: Moving of magnet and detector elements to the pit
5	Crane drivers: 2-5 crane drives needed to operate 7 cranes in Pit 1

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C&I (B)

The revised C&I (B) cost estimates are provided using the new template.

Despite trying to ensure a homogenous approach across the different ATLAS systems, a number of apparent inconsistencies remained in the draft figures submitted to SG in early February. Revised cost estimates, as well as additional clarifications, are attached to this document.

These comments or corrections are summarized in Table 4:

Table 4. Comments, clarifications to C&I (B)

#	Comment
1	ID: a. Assumptions related to the cost and use of NMR probes have been clarified b. Technical manpower from institutes originally included physicists. They have been removed from the revised figures c. Communications costs added 5kCHF/y to be consistent with other systems
2	LAr: a. Hired manpower has increased in 2002 and 2003 due to agreed transfer of resources from the CORE construction budget to C&I (ca. 300 kCHF in 2002) b. Heavy transport (200 kCHF in 2004) moved to C&I (A)
3	TileCal: a. Revision of C&I estimates in line w.r.t supplementary costs, in order to avoid double-counting b. Non-magnetic steel (630 kCHF) moved to supplementary costs c. See separate note on cost drivers
4	Muons: a. Revision of C&I estimates to clearly separate M&O activities (unclear allocations of TB electronics, gas & cooling expenses) b. Communications costs added 5kCHF/y to be consistent with other systems

 Continued on next page

Conclusions The following conclusions are made (Table 5):

Table 5. Conclusions

#	Conclusion
1	Comments and corrections are made to the C&I tables submitted to LHCC-RRB SG for further scrutiny

Continued on next page

EXPERIMENT: ATLAS						New C&I(B) format								
Previous C&I(B) format	Mech	Gas-s	Cryo-s	Cool	FE-el	Std-e-PS	Std-e-Cr	Std-e-R	Ctrls	Sub-d	Areas	Comm	Store	Hire-mp
Detector related costs														
Power supply						x								
Gas systems		x												x
Gas consumption		x												
Cooling systems				x										x
Cooling fluids(above –50°C)				x										
Cryogenic fluids (below –50°C)			x											
Moving/hydraulic systems	x													x
Detector (re-)integration & survey	x													
General Technical support	x												x	x
UPS maintenance						x								
Electronics pool rentals							x							
Counting & control rooms									x					
Communications														
GSM phones												x		x
On-line computing														
System management														x
Detector controls									x					
Computers/processors/LANs								x						
Software licenses								x						
Laboratory operations														
Assembly areas, clean rooms, active storage areas											x			
Workshops											x			x
Laboratory instruments							x							
Electronics pool rentals							x							
General services														
Cranes														x
Heavy transport	x													
Survey	x													x
Consultancy														
Engineering														x

M&O Cost Estimates in kCHF **ATLAS C&I (A) ESTIMATES (kCHF)**

M=Maintenance/Repairs
O=Operations
C=Consumables
EP-ATO/mn/080302

			2002	*2003*	*2004*	*2005*	*2006*	*2007*	**TOTAL**	**Notes**
Detector related costs	*Type*		*665*	*1,870*	*2,885*	*1,965*	*0*	*0*	*7,385*	
Magnet	A	O	60	60	60	0	0	0	180	
	A	C	25	25	25	0	0	0	75	
Magnet controls	A	O	150	150	150	0	0	0	450	
	A	C	30	45	50	0	0	0	125	
Magnet power supply	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Gas systems	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Gas consumption	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Cooling systems	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Cooling fluids(above –50°C)	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
External cryogenics	A	O	0	640	1,060	400	0	0	2,100	
	A	C	0	350	495	110	0	0	955	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O							0	
	A	C							0	
Detector safety systems	A	O							0	
	A	C							0	
Shutdown activities	A	O							0	
	A	C							0	
Detector (re-)integration & survey	A	O	200	300	500	500	0	0	1,500	
	A	C	0	0	0	0	0	0	0	
General Technical support	A	O	160	240	320	320	0	0	1,040	
	A	C	40	60	225	635	0	0	960	
UPS maintenance	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Electronics pool rentals	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Beam pipe & vacuum	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Counting & control rooms	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Secretariat	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Secretarial assistance	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Economat	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Fax, photocopiers, printers	A	O	0	0	0	0	0	0	0	

	A	C	0	0	0	0	0	0	0	
Printing and publication	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Communications	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
GSM phones; on-call service	A	O							0	
	A	C							0	
Automatic call-back	A	O							0	
	A	C							0	
On-line computing	*Type*		*30*	*30*	*30*	*0*	*0*	*0*	*90*	
									0	
System management	A	O							0	
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C							0	
Computers/processors/LANs	A	O							0	
	A	C							0	
Software licenses	A	O							0	
	A	C							0	
Common desktop infrastructure	A	O							0	
	A	C	30	30	30	0	0	0	90	
Test beams, calibration facilities	*Type*		50	485	250	0	0	0	785	
General operation	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Common electronics	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Electronics pool rentals	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Gas systems	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
Gas consumption	A	O	0	0	0	0	0	0	0	
	A	C	0	0	0	0	0	0	0	
External cryogenics	A	O	0	265	100	0	0	0	365	Hall 180. Data from D Schinzel
	A	C	50	220	150	0	0	0	420	
Laboratory operations	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C							0	
Workshops	A	O							0	
	A	C							0	

Laboratory instruments	A	O							0
	A	C							0
General services	*Type*		*120*	*390*	*740*	*550*	*0*	*0*	*1,800*
Cooling & ventilation	A	O							0
	A	C							0
Power	A	O							0
	A	C							0
Power distribution system	A	O							0
	A	C							0
Heavy transport	A	O	0	90	440	250	0	0	780
	A	C	0	0	0	0	0	0	0
Cranes	A	O	120	300	300	300	0	0	1,020
	A	C							0
Cars	A	O							0
	A	C							0
Cleaning	A	O							0
	A	C							0
Survey	A	O							0
	A	C							0
Passive storage space	A	O							0
	A	C							0
Common desktop infrastructure	A	O							0
	A	C							0
Academic subsistence	A	O							0
	A	C							0
Outreach	A	O							0
	A	C							0
GRAND TOTALS			865	2,775	3,905	2,515	0	0	10,060

M&O Cost Estimates in kCHF
M=Maintenance/Repairs
O=Operations
EP-ATO/mn/300102

ATLAS C&I ESTIMATES (kCHF) FOR MAGNETS

			2002	2003	2004	2005	2006	2007	TOT	Notes
Detector related costs	*Type*		*265*	*1,270*	*1,840*	*510*	*0*	*0*	*3,885*	
Magnet	A	O	60	60	60				180	H180. Numbers from D Schinzel
	A	C	25	25	25				75	H180. Numbers from D Schinzel
Magnet controls	A	O	150	150	150				450	H180. Numbers from D Schinzel
	A	C	30	45	50				125	H180. Numbers from D Schinzel
Magnet power supply	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Cooling systems	A	O							0	
	A	C							0	
Cooling fluids(above –50°C)	A	O							0	
	A	C							0	
External cryogenics	A	O		640	1,060	400			2,100	Point 1.Numbers from D Schinzel.
	A	C		350	495	110			955	Point 1.Numbers from D Schinzel.
Proximity cryogenics	A	O							0	
	A	C							0	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O							0	
	A	C							0	
Detector safety systems	A	O							0	
	A	C							0	
Detector-specific radiation protection	A	O							0	
	A	C							0	
Shutdown activities	A	O							0	
	A	C							0	
Detector (re-)integration & survey	A	O							0	
	A	C							0	
General Technical support	A	O							0	
	A	C							0	
UPS maintenance	A	O							0	
	A	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Beam pipe & vacuum	A	O							0	
	A	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Secretariat	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Secretarial assistance	A	O							0	
	A	C							0	
Economat	A	O							0	
	A	C							0	
Fax, photocopiers, printers	A	O							0	
	A	C							0	
Printing and publication	A	O							0	
	A	C							0	
Communications	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
GSM phones	A	O							0	
	A	C							0	
GSM phones	B	O							0	
	B	C							0	
Automatic call-back	A	O							0	
	A	C							0	
Automatic call-back	B	O							0	
	B	C							0	
On-line computing	*Type*		0	0	0	0	0	0	0	
									0	
System management	A	O							0	
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C							0	
Computers/processors/LANs	A	O							0	
	A	C							0	
Software licenses	A	O							0	
	A	C							0	

Common desktop infrastructure	A	O							0	
	A	C							0	
Test beams, calibration facilities	*Type*		50	485	250	0	0	0	785	
General operation	A	O							0	
	A	C							0	
Common electronics	A	O							0	
	A	C							0	
Electronics and DAQ	B	O							0	
	B	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Gas systems	B	O							0	
	B	C							0	
Gas consumption	B	O							0	
	B	C							0	
External cryogenics	A	O	0	265	100				365	Hall 180. Numbers from D Schinzel
	A	C	50	220	150				420	Hall 180. Numbers from D Schinzel
Proximity cryogenics	A	O							0	
	A	C							0	
Safety & radioprotection	A	O							0	
	A	C							0	
Irradiations	B	O							0	
	B	C							0	
Modifications	A	O							0	
	A	C							0	
Modifications	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
Laboratory operations	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C							0	
Assembly areas, clean rooms, active storage areas	B	O							0	
	B	C							0	
Workshops	A	O							0	
	A	C							0	
Workshops	B	O							0	
	B	C							0	
Laboratory instruments	A	O								
	A	C								
Laboratory instruments	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
General services	*Type*		0	0	0	0	0	0	0	
Cooling & ventilation	A	O							0	
	A	C							0	
Power	A	O							0	
	A	C							0	
Power distribution system	A	O							0	
	A	C							0	
Heavy transport	A	O							0	
	A	C							0	
Cranes	A	O							0	
	A	C							0	
Cars	A	O							0	
	A	C							0	
Cars	B	O							0	
	B	C							0	
Safety & radioprotection	C	O							0	
	C	C							0	
INB compliance	C	O							0	
	C	C							0	
Radioactive waste disposal	C	O							0	
	C	C							0	
Access system	C	O							0	
	C	C							0	

Elevators	C	O							0
	C	C							0
Gerant de site	C	O							0
	C	C							0
Flood control	C	O							0
	C	C							0
Insurance (CERN standard)	C	O							0
	C	C							0
Cleaning	A	O							0
	A	C							0
Cleaning	C	O							0
	C	C							0
Survey	A	O							0
	A	C							0
Survey	B	O							0
	B	C							0
Passive storage space	A	O							0
	A	C							0
Passive storage space	B	O							0
	B	C							0
Common desktop infrastructure	A	O							0
	A	C							0
Office space	C	O							0
	C	C							0
Consultancy	*Type*		0	0	0	0	0	0	0
Reviewing	A	O							0
	A	C							0
Engineering	A	O							0
	A	C							0
Training	A	O							0
	A	C							0
Outreach	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Outreach	A	O							0
	A	C							0
GRAND TOTALS			315	1,755	2,090	510	0	0	4,670
A TOTAL			315	1,755	2,090	510	0	0	4,670
B TOTAL			0	0	0	0	0	0	0
C TOTAL			0	0	0	0	0	0	0

SUMMARY OF ATLAS MAGNETS PER TYPE

Magnets		***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***Total***	
Mechanics	O	60	60	60	0	0	0	180	Incl. Gen services
	C	25	25	25	0	0	0	75	
Electronics	O	150	150	150	0	0	0	450	
	C	30	45	50	0	0	0	125	
Cryogenics	O	0	905	1,160	400	0	0	2,465	
	C	50	570	645	110	0	0	1,375	
TOTALS		315	1,755	2,090	510	0	0	4,670	

C&I Cost Estimates in kCHF **ATLAS C&I ESTIMATES (kCHF) FOR TECH. COORD & GENERAL**

M=Maintenance/Repairs
O=Operations
C=Consumables

EP-ATO/mn/070302

			2002	2003	2004	2005	2006	2007	TOTAL	Notes
Detector related costs	*Type*		*400*	*600*	*945*	*945*	*0*	*0*	*2,890*	
Magnet	A	O							0	
	A	C							0	
Magnet controls	A	O							0	
	A	C							0	
Magnet power supply	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Cooling systems	A	O							0	
	A	C							0	
Cooling fluids(above –50°C)	A	O							0	
	A	C							0	
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Cryogenic fluids (below –50°C)	A	O							0	
	A	C							0	
Moving/hydraulic systems	A	O							0	
	A	C							0	
Detector safety systems	A	O							0	
	A	C							0	
Detector-specific radiation protection	A	O							0	
	A	C							0	
Shutdown activities	A	O							0	
	A	C							0	
Detector (re-)integration & survey	A	O	200	300	500	500			1,500	Designers and design engineering manpower for final configuration c
	A	C								
General Technical support	A	O	160	240	320	320			1,040	Technical support for integrate and commission traction system, cooli
	A	C	40	60	125	125			350	Materials & consumables
UPS maintenance	A	O							0	
	A	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Beam pipe & vacuum	A	O							0	
	A	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Secretariat	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Secretarial assistance	A	O							0	
	A	C							0	
Economat	A	O							0	
	A	C							0	
Fax, photocopiers, printers	A	O							0	
	A	C							0	
Printing and publication	A	O							0	
	A	C							0	
Communications	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
GSM phones	A	O							0	
	A	C							0	
GSM phones	B	O							0	
	B	C							0	
Automatic call-back	A	O							0	
	A	C							0	
Automatic call-back	B	O							0	
	B	C							0	
On-line computing	*Type*		30	30	30	0	0	0	90	
									0	
System management	A	O							0	
	A	C							0	
Data storage, (temporary on disk)	A	O							0	
	A	C							0	
Detector controls	A	O							0	
	A	C							0	
Computers/processors/LANs	A	O							0	
	A	C							0	
Software licenses	A	O							0	
	A	C							0	

Common desktop infrastructure	A	O							0	
	A	C	30	30	30				90	
Test beams, calibration facilities	*Type*		0	0	0	0	0	0	0	
General operation	A	O							0	
	A	C							0	
Common electronics	A	O							0	
	A	C							0	
Electronics and DAQ	B	O							0	
	B	C							0	
Counting & control rooms	A	O							0	
	A	C							0	
Gas systems	A	O							0	
	A	C							0	
Gas consumption	A	O							0	
	A	C							0	
Gas systems	B	O							0	
	B	C							0	
Gas consumption	B	O							0	
	B	C							0	
External cryogenics	A	O							0	
	A	C							0	
Proximity cryogenics	A	O							0	
	A	C							0	
Safety & radioprotection	A	O							0	
	A	C							0	
Irradiations	B	O							0	
	B	C							0	
Modifications	A	O							0	
	A	C							0	
Modifications	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
Laboratory operations	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Assembly areas, clean rooms, active storage areas	A	O							0	
	A	C							0	
Assembly areas, clean rooms, active storage areas	B	O							0	
	B	C							0	
Workshops	A	O							0	
	A	C							0	
Workshops	B	O							0	
	B	C							0	
Laboratory instruments	A	O							0	
	A	C							0	
Laboratory instruments	B	O							0	
	B	C							0	
Electronics pool rentals	A	O							0	
	A	C							0	
Electronics pool rentals	B	O							0	
	B	C							0	
General services	*Type*		120	390	740	550	0	0	1,800	
Cooling & ventilation	A	O							0	
	A	C							0	
Power	A	O							0	
	A	C							0	
Power distribution system	A	O							0	
	A	C							0	
Heavy transport	A	O		90	440	250			780	Each transport 30 kCHF. Just special transports above 20 tons each us
	A	C							0	
Cranes	A	O	120	300	300	300			1,020	7 cranes in Pit 1, 6 operators @60kCHF/FTE '03-05 of which 5 for C
	A	C							0	
Cars	A	O							0	
	A	C							0	
Cars	B	O							0	
	B	C							0	
Safety & radioprotection	C	O							0	
	C	C							0	
INB compliance	C	O							0	
	C	C							0	
Radioactive waste disposal	C	O							0	
	C	C							0	
Access system	C	O							0	
	C	C							0	

Elevators	C	O							0
	C	C							0
Gerant de site	C	O							0
	C	C							0
Flood control	C	O							0
	C	C							0
Insurance (CERN standard)	C	O							0
	C	C							0
Cleaning	A	O							0
	A	C							0
Cleaning	C	O							0
	C	C							0
Survey	A	O							0
	A	C							0
Survey	B	O							0
	B	C							0
Passive storage space	A	O							0
	A	C							0
Passive storage space	B	O							0
	B	C							0
Common desktop infrastructure	A	O							0
	A	C							0
Office space	C	O							0
	C	C							0
Consultancy	*Type*		0	0	0	0	0	0	0
Reviewing	A	O							0
	A	C							0
Engineering	A	O							0
	A	C							0
Training	A	O							0
	A	C							0
Outreach	*Type*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Outreach	A	O							0
	A	C							0
GRAND TOTALS			550	1,020	1,715	1,495	0	0	4,780
A TOTAL			550	1,020	1,715	1,495	0	0	4,780
B TOTAL			0	0	0	0	0	0	0
C TOTAL			0	0	0	0	0	0	0

SUMMARY OF ATLAS TECHNICAL COORD. PER TYPE

TCn & General

		2002	*2003*	*2004*	*2005*	*2006*	*2007*	*Total*
Mechanics	O	480	930	1,560	1,370	0	0	4,340
	C	40	60	125	125	0	0	350
Electronics	O	0	0	0	0	0	0	0
	C	30	30	30	0	0	0	90
Cryogenics	O	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0
TOTALS		550	1,020	1,715	1,495	0	0	4,780

30-May-02

SUMMARY OF C&(B) kCHF

EXPERIMENT: ATLAS											
Subsystem:	**ID&TileCal&LAr&Muons**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**
	Mechanics	30	35	113	60	0	0	0	0	0	**238**
	Gas-system	50	120	245	125	0	0	0	0	0	**540**
	Cryo-system	0	70	70	120	0	0	0	0	0	**260**
	Cooling system	40	185	345	275	0	0	0	0	0	**845**
	FE electronics	20	50	120	100	0	0	0	0	0	**290**
	Standard electronics, PS (LV, HV)	0	0	70	100	0	0	0	0	0	**170**
	Standard electronics, Crates	20	120	230	140	0	0	0	0	0	**510**
	Standard electronics, RO Modules	0	0	0	30	0	0	0	0	0	**30**
	Controls, (DCS, DSS)	30	75	70	25	0	0	0	0	0	**200**
	Sub-Detector Spares	0	0	0	0	0	0	0	0	0	**0**
	Areas	472	494	426	265	0	0	0	0	0	**1657**
	Communications	20	20	20	20	0	0	0	0	0	**80**
	Store Items	106	209	209	55	0	0	0	0	0	**579**
	Hired Manpower @ CERN (CHF)	765	1060	1070	585	0	0	0	0	0	**3480**
	Hired Inst. MP @ 90 kCHF/FTE	180	450	720	630						**1980**
	Technical Manpower @CERN (FTE)	32	48	40	19	0	0	0	0	0	**139**
	TOTALS (excl. FTEs)	**1733**	**2888**	**3708**	**2530**	**0**	**0**	**0**	**0**	**0**	**10859**

7-Mar-02

C&I (B) kCHF

EXPERIMENT: ATLAS												
Subsy	**ID**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
	Mechanics	20	25	23	10						**78**	NMR probes for field monitoring
	Gas-system	25	75	100							**200**	Gas for SR; B154
	Cryo-system										**0**	
	Cooling system	40	180	280	180						**680**	Fluids, for cooling in assembly setups, SR and during commissioning
	FE electronics (spares)										**0**	
	Standard electronics, PS (LV, HV)										**0**	
	Standard electronics, Crates										**0**	
	Standard electronics, RO Modules										**0**	
	Controls, (DCS, DSS)	30	25	20	15						**90**	
	Sub-Detector Spares										**0**	
	Areas										**0**	
	SR-maintenance facility (buildup)	238	163	60	60						**521**	Setup of SR-facility, primary cooling, racks and plumbing for racks, UPS systems, static floor, laser room with ventilation, saf
	SR-maintenance facility (operation)	234	331	336	205						**1106**	Pool items, scopes, multimeters, small instruments, cleaning, cleanroom clothing, PCs, DCS and control for cooling and gas, l
	Testbeam and irradiation										**0**	
	Systemtests										**0**	
	Communications	5	5	5	5						**20**	GSM phones
	Store Items	66	89	89	55						**299**	Store
	Hired Manpower @ CERN (CHF)										**0**	
	Standard tasks	115	220	270	200						**805**	Manpower for SR and installation, preparation and installation of services, piping and patchpanels, same for gas and cooling
	Special interventions										**0**	
	Technical Manpower @CERN (FTE)	1	2	3	1						**7**	
	TOTALS (excl. FTEs)	**773**	**1113**	**1183**	**730**	**0**	**0**	**0**	**0**	**0**	**3799**	

30-May-02

C&I (B) kCHF

EXPERIMENT: ATLAS											
Subsystem: TileCal	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
Mechanics (incl. optics)										**0**	
Gas-system (Ce-hydraulic drive)	15	15	25	25						**80**	1/4 of the full Cs source drive and monitoring system
Cryo-system										**0**	
Cooling system										**0**	
FE electronics										**0**	
Standard electronics, PS (LV, HV)			70	100						**170**	200 V PS to supply LV PS
Standard electronics, Crates										**0**	
Standard electronics, RO Modules										**0**	
Controls, (DCS, DSS); ELMBs for test-beam		50	50							**100**	Local monitor boards and their motherboards
Sub-Detector Spares										**0**	
Areas										**0**	
Communications	5	5	5	5						**20**	videoconferencing, GSM phones
Store Items										**0**	
Hired Manpower @ CERN (CHF)	60	100	100	100						**360**	Preassembly and installation manpower:
Hired Inst. MP @ 90 kCHF/FTE	180	450	450	450						**1530**	
Technical Manpower @CERN (FTE)	2	5	5	5	0	0				**17**	
TOTALS (excl. FTEs)	**260**	**620**	**700**	**680**	**0**	**0**	**0**	**0**	**0**	**2260**	

30-May-02

C&I (B) kCHF

EXPERIMENT: ATLAS											
Subsystem: LAr	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
Mechanics	10	10	10	10	0					**40**	Air pads (services)
Gas-system										**0**	
Cryo-system		70	70	120						**260**	Cryo system B180 (small parts), liquid argon for cold tests of three cryostats
Cooling system		5	5	5						**15**	Cooling power supplies, FE crates
FE electronics (spares)										**0**	
Standard electronics, PS (LV, HV)										**0**	
Standard electronics, Crates	20	90	90	100						**300**	Lab.equipment (DVM's, oscilloscopes,TDRs), tpecial test/measuring devices
Standard electronics, RO Modules				30						**30**	Programs licences (Labview, DSP programs, compiler, …), replacement of in crate comp.hardware
Controls, (DCS, DSS)				10						**10**	Replacement of components for local DCS (ELMBs,sensors,…)
Sub-Detector Spares										**0**	
Areas										**0**	
Communications	5	5	5	5						**20**	GSM phones (1 kCHF/FTE/y)
Store Items	40	120	120							**280**	Stores (sheet metal, elec.components,…)
Hired Manpower @ CERN (CHF)	385	335	195	165						**1080**	Technicians & welders, C&C technicians included. In 2004, heavy transport in C&I (TCn). Tech. Manpower delegated fron
Hired Inst. MP @ 90 kCHF/FTE			270	180						**450**	
Technical Manpower @CERN (FTE)	26	35	13	0						**74**	Tech. Manpower delegated from LAr institutes for detector integration in B180 & EHN1
TOTALS (excl. FTEs)	**460**	**635**	**765**	**625**	**0**	**0**	**0**	**0**	**0**	**2485**	

19-Mar-02

C&I (B) kCHF

EXPERIMENT: ATLAS											
Subsystem: Muons	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTALS**	
Mechanics	0	0	80	40						**120**	Survey, tools for transporting
Gas-system	10	30	120	100						**260**	Gases (Ar,C)2,N-Pentane for testing assembled detectors
Cryo-system										**0**	
Cooling system			60	90						**150**	Operation of assebled detectors. 3% of CORE value
FE electronics	20	50	120	100						**290**	Electronics for testing chamber modules
Standard electronics, PS (LV, HV)										**0**	
Standard electronics, Crates	0	30	140	40						**210**	Testing eqpm for chambers(scintillators, PMS, R-O)
Standard electronics, RO Modules										**0**	
Controls, (DCS, DSS)										**0**	
Sub-Detector Spares										**0**	
Areas			30							**30**	Transport structures for chanbers
Communications	5	5	5	5						**20**	GSM phones
Store Items										**0**	
Hired Manpower @ CERN (CHF)	205	405	505	120						**1235**	Eng. studies, gas system op, integration work, transport
Technical Manpower @CERN (FTE)	3	6	19	13						**41**	Assembly of detectors at CERN
TOTALS (excl. FTEs)	**240**	**520**	**1060**	**495**	**0**	**0**	**0**	**0**	**0**	**2315**	

6/18/2002

Appendix 15
Proposed Sharing of Deferral Costs
by Funding Agency and Cuts by System (kCHF)

Funding Agency	Inner Detector	LAr	TileCal	Muons	TDAQ	Common Projects	TOTAL
Armenia	0						0
Australia	0						0
Austria	0						0
Azerbaijan	0						0
Belarus	0						0
Brazil	0						0
Canada	0						0
China NSFC+MSTC	0						0
Czech Republic	50						50
Denmark	0						0
Finland	0						0
France IN2P3	510						510
France CEA	0						0
Georgia	0						0
Germany BMBF	1020						1020
Germany MPI	0						0
Greece	0						0
Israel	0						0
Italy	1120						1120
Japan	0						0
Morocco	0						0
Netherlands	300						300
Norway	0						0
Poland	0						0
Portugal	0						0
Romania	0						0
Russia	0						0
JINR	0						0
Slovak Republic	0						0
Slovenia	0						0
Spain	0						0
Sweden	0						0
Switzerland	0						0
Taipei NSC	0						0
Turkey	0						0
United Kingdom	0						0
US DOE + NSF	0						0
CERN	500						500
Common Fund						4800	4800
Cuts in Supplementary		2000	300	200			2500
total	3500	2000	300	200	0	4800	10800

Notes

1. No indexation applied
2. ID = Staging of Pixels (3 MCHF) and TRT End Wheel C (0.5 MCHF)

Table 1

7/19/2002

Appendix 16
Model B - Proposed Sharing of Deferred Contributions by Funding Agency and Cuts by System (kCHF)

Funding Agency	Inner Detector	LAr	TileCal	Muons	TDAQ	Common Projects	TOTAL
Armenia	0				0		**0**
Australia	0				0		**0**
Austria	0				177		**177**
Azerbaijan	0				0		**0**
Belarus	0				0		**0**
Brazil	0				0		**0**
Canada	0				0		**0**
China NSFC+MSTC	0				0		**0**
Czech Republic	50				24		**74**
Denmark	0				590		**590**
Finland	0				0		**0**
France IN2P3	510				0		**510**
France CEA	0				0		**0**
Georgia	0				0		**0**
Germany BMBF	1020				1059		**2079**
Germany MPI	0				0		**0**
Greece	0						**0**
Israel	0				35		**35**
Italy	1120				1947		**3067**
Japan	0				885		**885**
Morocco	0						**0**
Netherlands	300				383		**683**
Norway	0						**0**
Poland	0				88		**88**
Portugal	0				177		**177**
Romania	0						**0**
Russia	0				59		**59**
JINR	0						**0**
Slovak Republic	0						**0**
Slovenia	0						**0**
Spain	0						**0**
Sweden	0						**0**
Switzerland	0				2359		**2359**
Taipei NSC	0						**0**
Turkey	0				88		**88**
United Kingdom	0				1309		**1309**
US DOE + NSF	0				2340		**2340**
CERN	500				3481		**3981**
Common Fund						**4800**	**4800**
Cuts in Supplementary		**2000**	**300**	**200**			**2500**
Cuts in C&I	**1000**	**600**	**150**	**750**		**2500**	**5000**
total	**4500**	**2600**	**450**	**950**	**15000**	**7300**	**30800**

Notes

1. No indexation applied
2. ID = Staging of Pixels (3 MCHF) and TRT End Wheel C (0.5 MCHF)

Table 1