11.13 Project Management

Because of the complexity of the SCT and the large number of institutes involved in its construction the project is organised as an independent sub-system, following the usual collaboration rules. All technical information is presented and discussed in open working meetings, workshops and reviews. Smaller subgroups have been formed in a number of areas in order to prepare the technical design and complete prototyping activities, and these will continue, where relevant, during the construction phase to co-ordinate and ensure uniformity. Institute meetings are held regularly, with one representative per institute, to approve or take decisions as required. A steering group, consisting of technical experts and broadly representing the geographical distribution of groups prepares and co-ordinates meetings and monitors the progress of the project.

Thirty eight institutes with more than three hundred physicists and senior engineers listed below have signed this TDR and are committed to the construction of the SCT. These institutes are supported by 15 independent funding agencies. At this stage the institutes have the support of their funding agencies to commit themselves to all the items and responsibilities discussed in the TDR.

11.13.1 Participating Institutes

The following lists all physicists and senior engineers from institutes who have contributed to this TDR and are committed to the construction of the SemiConductor Tracker project.

University of Bergen, Department of Physics
G. Eigen, A. G. Frodesen, A. Klovning, O. Maeland, R. Rongved and B. Stugu.
Contact person: B. Stugu

Laboratory for High Energy Physics, University of Bern
J. Beringer, K. Borer, M. Hess, R. Mommsen, T. Pal, K. Pretzl
Contact person: K. Pretzl

University of Birmingham
J. Dowell, D. Charlton, R. Homer, P. Jovanovic, I Kenyon, T. Mcmahon, S. Oglesby, N. Watson, J. Wilson
Contact person: J Dowell

Cavendish Laboratory, Cambridge
J.R. Batley, J.R. Carter, M.J. Goodrick, J.C. Hill, S. Katvars, D.J. Munday, M.A. Parker, D. Robinson, L. Drage, K.H. Wyllie
Contact person: J.R. Carter

CERN
F. Anghinolfi, D. Bloess, B. Boulter, E. Chesi, R. Fortin, J. Godlewski, P. Jarron, J. Kaplon, C. Lacasta, T. Niinikoski, C. Posch, P. Riedler, S. Roe, A. Rudge, P. Weilhammer, R. Wedenig
Contact person: P. Weilhammer

Institute of Nuclear Physics, Cracow
E. Gornicki, B. Madeyski, P. Malecki, S. Moszczynski, R. Szczygiel, M. Wolter
Contact person: P. Malecki

Faculty of Physics & Nuclear Techniques (FPNT), University of Mining & Metallurgy, Cracow
W. Bialas, W. Dabrowski, P. Grybos, M. Idzik, S. Koperny
Contact person: W. Dabrowski

Fakultaet fuer Physik, Albert-Ludwigs-Universitaet, Freiburg
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Contact person: J. Ludwig

DPNC, University of Geneva
R. Bonino, A.G. Clark, C. Couyoumtzelis, Ph. Demierre, H. Kanbara, R. Kowalewski, D. LaMarra, A. Leger, D. Macina, E. Perrin, J-P. Richeux, B. Vuaridel, X. Wu
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University of Glasgow
A. Doyle, V. O'Shea, C. Raine, D. Saxon, I. Skillicorn, K. Smith, A.S.Thompson
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Department of Physics, Hiroshima University
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KEK
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Contact person: Y. Unno

Kyoto University of Education
R. Takashima
Contact person: R. Takashima

University of California, Irvine (UCI)
T. Fahland, C. Hackett, A.J. Lankford, S. Pier, M. Schernau, D. Stoker
Contact person: A.J. Lankford

Lancaster University
T. J. Brodbeck, A. Chilingarov, R. C. W. Henderson, S. Holt, G. Hughes, R. W. L. Jones, I. Mercer, A. Muirhead, P. Ratoff, T. Sloan
Contact person: P Ratoff

LBL
S. Ciocio, M. Gilchriese, C. Haber, I. Kipnis, M. Shapiro, J. Siegrist, H. Spieler
Contact person: M. Gilchriese

University of Liverpool
P. P. Allport, P. S. L. Booth, P. A. Cooke, A. Greenall, M. A. Houlden, B. King, J. N. Jackson, T. J. Jones, S. Marti Garcia, S. J. Maxfield, A. Moreton, J. D. Richardson, N. A. Smith, P. Sutcliffe, P. R. Turner
Contact person: J. Jackson

Jozef Stefan Institute and Department of Physics, University of Ljubljana, Ljubljana
V. Cindro, G. Kramberger, M. Mikuz, M. Tadel, D. Zontar
Contact person: M. Mikuz

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School of Physics, The University of Melbourne
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Contact person: G. Taylor

Moscow State University Nuclear Physics Institute
G. Bachindjaguian, N.Baranova, S. Basiladze, G.Bogdanova, A. Erasov, D. Karmanov, A. Kalagov, E.Kunetzov, N. Korotkova, M. Merkin, A. Selikov, Y.Vetijtnev, V.Volkov, A. Voronin, E. Zverev
Contact person: S. Basiladze

MPI
The MPI Munich has the firm intention to participate in the SCT construction; its role in the project is still being discussed.
Contact person: V. Soergel

NIKHEF, National Institute for Nuclear Physics and High Energy Physics, Amsterdam
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Contact person: S. Pospisil

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Rutherford Appleton Laboratory (RAL)
R. Apsimon, J. Baines, D. Campbell, D. Cragg, M. Edwards, R. English, M. Gibson, J. Hart, S. Haywood, D. Hill, N. McCubbin, D. McPhail, M. Morrissey, W. Murray, A. Nichols, B. Payne, P.W. Phillips, A. Pilling, S. Quinton, P. Seller, G. Tappern, M. Tyndel, D. White
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University of California at Santa Cruz (UCSC)
D. Dorfan, T. Dubbs, A. Grillo, P. Poplevin, E. Spencer, H.F.W. Sadrozinski, A. Seiden
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Contact person: L. Peak

University College (UCL), London
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University of Uppsala
N. Bingefors, R. Brenner, O. Bystrom, T. Ekelof, P. Staaf
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IFIC, Centro Mixto Universidad de Valencia -- CSIC
F. Albiol, F. Ballester, J. Bernabeu, F. Campabadal, E. Farres, A. Ferrer, J. Fuster, C. Garcia, M. Lozano, J. Salt, J. Sanchez, J. Santander, A. Sebastia, M. Ullan
Contact person: J. Fuster

University of Wisconsin
E. Charles, D. Fasching, S. Gonzalez, O. Hayes, R. Jared, J. Nachtman, Y. Pan, I. Scott, S. L. Wu, H. Zobernig
Contact person: S. L. Wu

11.13.2 Organisation and Responsibilities

11.13.2.1 Design, development and common engineering

The organisation of the SCT project has evolved (and continues to evolve) to meet the needs of the project. The aim of the organisation is to co-ordinate and integrate the efforts of the participating institutes into a common project and to utilise the widely distributed expertise and effort. Initially the emphasis was on completing the required development, preparing the technical design and understanding the requirements and procedures for construction.

The following working groups are currently functioning. In each case the name of the current co-ordinator is followed by a list of institutes (or groups of institutes supported by the same funding agency) contributing:

Silicon detectors (P. Allport)

Australia, CERN, Germany, Japan, Norway, Russia, Switzerland, UK, USA, Valencia

Electronics (A. Grillo)

- FE ASICS (W Dabrowski)

  CERN, Cracow, Nikhef, Switzerland, UK, Uppsala, USA, Valencia

- Datalinks (R. Kowalewski)

  Switzerland, UK

- Off-detector (A. Lankford)

  UK, Switzerland, USA

- Power Supplies & Cables (P. Malecki)

  Cracow, Prague, Slovenia, UK

- Control and Monitoring (R. Brenner)

  Russia, Uppsala

Modules (A. Carter, N. Unno)

Australia, CERN, Cracow, Germany, Japan, Norway, Prague, Russia, Slovenia, Switzerland, UK, Uppsala, USA, Valencia

Engineering (E. Perrin, G. Tappern)

- Preparation for Module Construction (C Haber)

  Australia, CERN, Cracow, Germany, Japan, Norway, Prague, Russia, Slovenia, Switzerland, UK, Uppsala, USA, Valencia

- Barrel Structure and Assembly

  Japan, Switzerland, UK, Uppsala

- Forward Structure and Assembly

  Australia, Nikhef, Russia, Switzerland, UK

- Cooling

  CERN, Norway, UK

- Survey and Alignment (R. Nickerson)

  CERN, Nikhef, UK

Testbeam; H8 and Tracker Sector Prototype (S Stapnes)

Australia, CERN, Cracow, Germany, Japan, Nikhef, Norway, Prague, Russia, Slovenia, Switzerland, UK, Uppsala, USA, Valencia

Irradiation (R Wunstorf)

CERN, Germany, Prague, Slovenia, UK, USA

11.13.2.2 Construction

The construction of the SCT is a major engineering project and its organisation is complicated by the wide geographical distribution of the institutes. The organisation is based on the following principles:

- Central co-ordination of the design, specification, ordering and purchase of components and definition of assembly, testing and QA procedures.
- The construction of modules divided between 7 regional 'clusters' to benefit from the expertise and resources of the collaboration. An additional motivation is to facilitate day-to-day work by grouping institutes geographically. The co-ordinators of the clusters are responsible for QA.
- Individual institutes (or groups of institutes) to take responsibility for delivery of specified items and tasks wherever possible.

Table 11-44 provides an overview of the division of responsibilities agreed for the construction of the SCT. It summarises the contribution by funding agency, with entries showing the fraction of the project (in terms of the CORE cost estimate) undertaken.

The following paragraphs provide additional information to that summarised in Table 11-44. The basis of the work organisation is a 'bottom-up' approach to the construction of the SCT. It starts with the purchase of components (silicon detectors, FE ASICs etc), which after testing are built into modules. Modules are then assembled together with cables and datalinks into barrels and disks. The supply of cables, off-detector electronics, power supplies, cooling plant are organised as separate projects, as is the overall control and monitoring and alignment.

1. Silicon Detectors:

   The silicon detectors account for close to half of the total cost of the project. In general the institutes forming a cluster take responsibility for the purchase of the detectors for the modules they are constructing. In some cases, however, individual institutes concentrate their resources on areas in which they have particular interest and expertise. In this case, components such as detectors are, in some sense, exchanged for other components.

2. Frontend ASICs:

   As the testing of ASICs requires specialised equipment, this will be concentrated at 2 or 3 sites. The financial responsibility is shared between these institutes and the clusters assembling modules.

Project Plan Summary (Contribution/Country as fraction of Total)															
Country or Institutes :	**Aust**	**CERN**	**Cracow**	**Czech**	**Germany**	**Japan**	**Nikhef**	**Norway**	**Russia**	**Slovenia**	**Switz**	**UK**	**Uppsala**	**US**	**Valencia**
Cluster :	*CS*	*CS*	*CS*	*CS/GN*	*GN*	*J*	*GN*	*N*	*CS/GN*	*CS*	*CS*	*UB/UV*	*N*	*US*	*UV*
Detectors	0.01	0.02	-	-	0.16	0.26	-	0.10	0.05	-	0.08	0.29	-	-	0.03
Frontend Electronics	-	0.06	-	-	-	-	-	-	-	-	0.05	0.26	0.09	0.50	0.05
FE-Hybrids	-	0.06	-	-	0.09	0.14	0.09	-	0.02	-	0.06	0.26	0.09	0.16	0.04
Module Assembly	0.02	0.02	0.02	0.03	0.16	0.14	-	0.05	0.03	0.02	0.02	0.26	0.05	0.16	0.04
Data-Links	-	-	-	-	-	-	-	-	-	-	0.75	0.25	-	-	-
Cables	0.11	0.11	-	-	0.11	-	0.09	0.03	-	0.24	0.01	0.25	0.03	-	0.03
Offdetector Electronics	-	-	-	-	-	-	-	-	-	-	-	0.25	-	0.75	-
Power & Local Control	0.13	0.25	0.19	0.19	-	-	-	-	-	-	-	0.25	-	-	-
Cooling & Local Control	-	0.25	-	-	-	-	-	0.25	-	-	-	0.50	-	-	-
Alignment	-	0.17	-	-	-	-	0.33	-	-	-	-	0.50	-	-	-
Control & Monitoring	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-
Assembly & Testing - Barrel	-	0.02	-	-	-	0.21	-	0.01	0.01	-	0.09	0.40	0.19	0.05	-
Assembly & Testing - Disks	0.16	0.03	0.01	0.01	0.06	-	0.30	-	0.06	0.01	0.01	0.33	-	-	0.02
Integration & comissioning	0.04	0.58	-	-	-	0.04	0.04	0.04	-	-	0.08	0.08	0.04	-	0.04

Table 11-44 Division of Responsibilities (part of the contribution by Germany is under discussion, see statement on MPI participation on page 583).

3. Module Assembly:

   A module is a unit consisting of four silicon detectors with FE electronics and is a fully functional component of the final detector. The construction and testing of modules will be carried out by 7 regional clusters. In general, clusters have chosen to assemble, test and supply modules for a particular part of the detector. The part of the detector and the number of modules required (including anticipated losses during assembly) are shown in Table 11-45.

Table 11-45 List of institutions showing the planning for module construction.

Region of SCT	**Num. of modules**	**Cluster**	**Institutes**
Barrel 3	461	Nordic	Bergen, Oslo, Uppsala
Barrel 4	576+50	UK-B	Birmingham, Cambridge, Oxford, QMW, RAL
Barrel 5	691	Japan	Hiroshima, KEK, Kyoto
Barrel 6	756	USA	Irvine, LBL, UCSC
Forward - Disks 1,2,3	854	UK-V	Glasgow, Lancaster, Liverpool, Manchester, RAL, Sheffield, UCL, Valencia
Forward - Disks 4,5,6	~758	CS	Australia, CERN, Cracow, Geneva, Ljubljana, MSU, Prague
Forward - Disks 7,8,9	~758	CN	Freiburg, MPI[a], Nikhef, Prague, Protvino

a. under discussion, see statement on MPI participation on page 583.

   At this stage, the clusters are organising the distribution of work within the cluster, and preparing the infrastructure required for module assembly. Further iterations on dividing work between clusters to better match resources and expertise is expected after approval. The responsibility of each cluster will be to deliver fully tested modules to the assembly sites.

4. Data-links

   These will be supplied by Switzerland and the UK in the proportions shown in Table 11-44.

5. Cables

   The supply of the custom-designed low-mass cables is primarily the responsibility of the Ljubljana group, with some contributions from other institutes.

   The financing of the standard cables is divided between most institutes as shown in Table 11-44.

6. Off-detector Electronics

   This will be the responsibility of Switzerland, UK, USA.

7. Power supplies

   Responsibility for the power supplies is divided in such a way that one group takes the lead responsibility with additional contributions from other institutes (Prague (low voltage) and Cracow (detector bias)).

8. Cooling

   Responsibility shared between CERN, Norway and the UK. It is foreseen that this will be part of an integrated cooling system for the SCT and Pixel detectors.

9. Alignment

   Responsibility shared between CERN, Nikhef and the UK. Again it is foreseen that this will be part of an integrated system for the ID.

10. Assembly and Survey:

    The design of the SCT is highly modular to ease the problems of assembly and commissioning. Overall this is co-ordinated by the engineers and the project leader. Although details are still to be finalised, it will involve the following steps:

    a. Barrel pre-Assembly & Survey

       Support structures will be equipped with fixtures and fittings under the responsibility of Switzerland and Uppsala. Assembly of modules to local supports and barrels is the responsibility of Japan and the UK together with the clusters supplying the modules.

    b. Forward pre-Assembly & Survey

       Support structures will be equipped with fixtures and fittings under the responsibility of Australia, Nikhef and Russia. Assembly of modules to disks is the responsibility of Nikhef and the UK and the clusters supplying the modules.

    c. Final Assembly, Commissioning and Integration into the ID

       Preparation for this is still in the early stages. This work will be centred at CERN in a purpose-built clean room on the surface above the pit. It will involve all institutes and be co-ordinated by the SCT project leader and engineers working closely with the other ID sub-systems and the ATLAS technical co-ordination.

11. Testing, Integration and Comissioning:

    A major issue in the construction of the SCT is the scale of the project and how to prototype and guarantee the functionality of the full system. The strategy adopted is to benefit from the modularity of the SCT and, as time progresses, assemble and test increasingly large parts of the SCT. The following steps are planned:

    a. Module-0

       The first modules are constructed from the pre-production delivery of final components. A small number of modules will be built by each cluster and fully evaluated not only for performance, but also for uniformity between clusters.

    b. TSP (Tracker Sector Prototype)

       The first Module-0s will be built into 4 planes, as part of the overall TSP. This will give experience with the simultaneous operation and readout of ~ 20 modules. The performance of the complete tracking system - TRT, SCT and Pixels can be compared with simulation.

c. Barrel Local Support

A local support is the next level of complexity to the module, with 12 overlapping modules fully cabled and powered. Systematic performance studies will be used to confirm system issues such as grounding and electronic cross-talk. Long-term tests will follow to test the integrity of electrical and thermal connections.

d. (Partially) equipped Disk

The first forward modules will be brought together as soon as possible to (partially) equip a first disk. Again this will be used for system tests and long-term tests.

e. (Partially) equipped Barrel

In order to have a large scale system test, a prototype cylinder will be (partially) equipped and brought into operation as soon as possible to gain experience.

All of these tests are sufficiently complex, that they will be run as individual projects, with well defined goals. The success of these initiatives will rely on contributions from the whole collaboration.

11.13.3 Schedules and Milestones

The construction schedule is determined by

- Completion of technical design and prototyping

  The technical design and all prototyping is expected to be finished this year (1997), or be sufficiently advanced to allow the start of tendering for the critical items (silicon detectors and FE ASICs).

  If possible, the production orders will be placed with a phased delivery. A pre-production batch, to be delivered as soon as possible for construction of Module-0, will be followed by a period for evaluation. Depending on the outcome, either small modifications will be required or production can continue over the following 2-4 years.

- Start of Physics

  For ATLAS to be ready for physics in mid 2005, the construction, assembly and testing of the SCT needs to be complete by the end of 2002. The following 2 years are scheduled for the integration and commissioning of the Inner Detector, first on the surface and then in-situ.

- Funding profile

  Information on the available resource profile is not yet available. In planning the project, every effort has been made to keep the funding profile as flat as practical by extending the module construction period over 3 years.

Figure 11-122 shows the planned construction schedule. The prototyping currently underway is not indicated. For each line, there are 2 or 3 phases shown. Pre-production is the phase when the first “final” components are assembled into Module-0. This is then followed by production as explained above. In some cases (e.g. readout, power, cooling) some fraction of the items are required during assembly for testing and the production of these items is shown separately.

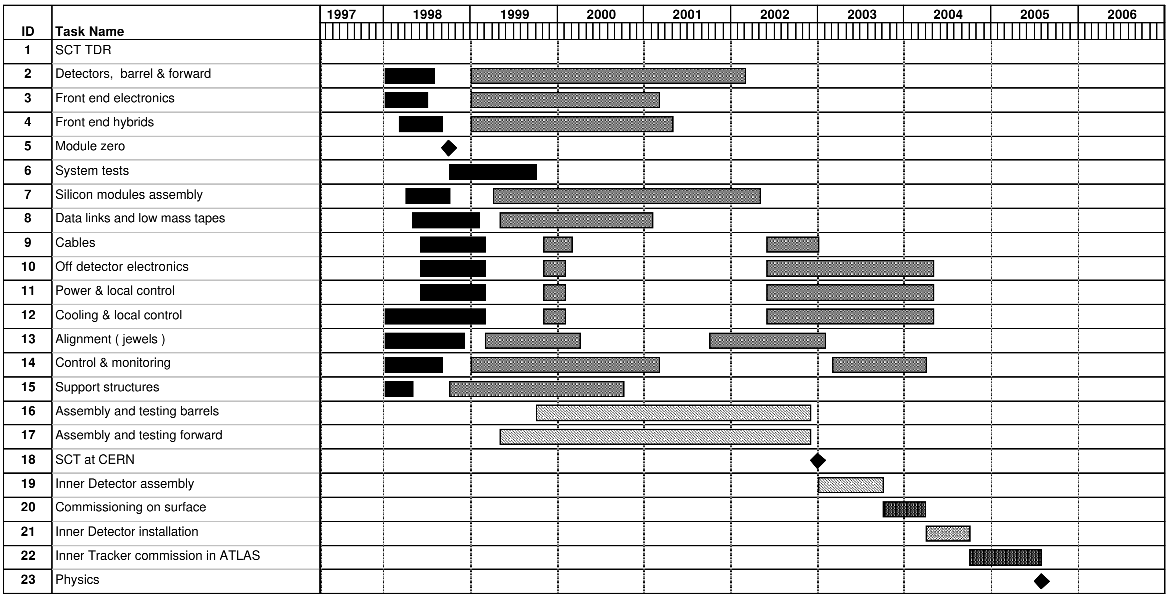

Figure 11-122 Construction Schedule showing pre-production followed by construction.

Key Milestones are

- April 1997 TDR
- December 1997 Final design reviews and tender for detectors and ASICS
- September 1998 Freeze support structure design
- October 1998 Module-0
- January 1999 Start ASIC, Detector production
- July 1999 System tests (TSP; local supports, proto-barrels and disks)
- March 2001 Complete ASIC production
- March 2002 Complete detector production
- January 2003 SCT at CERN
- September 2003 Assemble ID

11.13.4 Cost and Resources

The costing of the SCT follows the ATLAS budgeting rules and is described in more detail in the CORE (version 6.0). Table 11-46 shows a summary of the cost.

Table 11-46 Cost Summary for the SCT (CORE 6.0)

Activity	Total Cost (1995 kCHF)	Number of Units
Barrel Detectors	11,341	10,138
Forward Detectors	9,316	8,333
FE Electronics, Readout & Power	15,250	7,534,976
Module Assembly	1,832	4905
Structure, Assembly & Engineering	4,921	1

The cost of all ATLAS systems has been bounded in order to keep the overall project cost under control. The ceiling on the SCT is just under 43 MCHF.

The construction of the SCT relies on the large amount of manpower available in the 38 contributing institutes. In total, something of the order of 120 SY/year are available to the project over the construction period.

The resource planning for the construction of the SCT is laid out in Annex 4.2 of the Interim Memorandum of Understanding (ATLAS RRB-D 96-9, 19/3/96). Since that time, progress has been made on the sharing of responsibilities and an update is in preparation for the final Memorandum of Understanding. All aspects of the project are adequately covered, based on the estimates of financial resources and manpower supplied by the funding agencies.