ATLAS Inner Detector – SR building DCS

ATLAS Project Document No:	Institute Document No.	Created: **26/8/02**	Page: **1 of 11**
ATL-IC-EN-xxxx		Modified: **3/26/03**	Rev. No.: **0.03**

Engineering Note

SR building DCS

Abstract

This document gives an outline of the DCS systems needed for the SR1 building in which the components of the ATLAS inner detector will be integrated and tested, and defines the work packages needed to set up and commission the DCS system.

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Distribution List

History of Changes

Rev. No.	*Date*	*Pages*	*Description of changes*
0.01	26/8/02		Initial version
0.02	11/9/02	9	Work package description for infrastructure and SCT
0.03	25/9/02	11	First complete version with outline work packages for all subdetectors

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1 Introduction

Much of the integration and testing of the components of the ATLAS inner detector will happen in the surface building SR1 at point 1. This work includes the assembly of the four barrels of the SCT into one unit, the assembly of TRT modules into the barrel and endcap support structures, the integration of SCT into TRT (both barrel and endcap), and the final assembly of the pixel detector. Extensive comissioning and system tests are planned at each stage. The SR building will also be used for maintainence, repair and upgrades of ID components removed from the experiment and brought to the surface.

The DCS (detector control system – slow controls) in the SR building, together with the related SR DAQ system, must support all the needs of the subdetector commissioning and testing, as well as the infrastructure of the building itself. A major challenge will be DCS integration – the various ID components will have to work together for the first time in the SR building and this should be achieved using a DCS system which is as similar as possible to the final one, avoiding subdetector-specific 'ad hoc' solutions.

This document gives an outline of the DCS systems required in the SR building, and a definition of the work packages required to achieve the final functioning system.

2 DCS system outline

The proposed system is based on a subset of the full ATLAS system, adding capabilities as and when necessary to support the subdetectors. It consists of a mastor supervisor station (a PC workstation) and several local control stations (either standard or rack-mounted PCs) connected using a local area network (Ethernet). The LCS systems are semi-automonous, and can either run standalone or as part of the global system, in which case they communicate with the supervisor station. The LCS connect to the hardware devices via CAN-bus, or other dedicated interfaces installed in each PC. ELMBs (embedded local monitoring boards) are used for low-level monitoring and control (ELMBS have analongue and digital inputs for monitoring and and digitial outputs for control. DACs can also be added). The high level software is based on SCADA and PVSS II. All these components are supported by the ATLAS DCS group and are the building blocks of the final ATLAS system.

An overview of the system required for the SR building is shown in Figure 1. There are partitions to control the various subdetectors, the evaporative cooling system, the monophase/thermal screen system, and the SR building infrastructure (racks etc). The various components are described below in more detail.

2.1 SR building infrastructure

This consists of the master/supervisor control station (a PC workstation), the LAN (Ethernet – for the SR building, where there are fewer safety implications than for the final ATLAS installation, this can simply use the already existing general-purpose network) , the connection to the SR DAQ (via the DDC module), and the LCS for the SR-building infrastructure itself. The infrastructure LCS monitors the SR-building racks, together with any local environmental parameters (temperature, pressure, humidity in the building ?). The dry air and N_2 systems could also be attatched here if it requires computer control/logging.

This should be the first system to be setup, and the infrastructure part should ideally be comissioned before any other components arrive in the SR building, initially as a standalone system. The more global control (supervisor, link to databases and DAQ) can come a bit later when there are several systems to be controlled. It may be advantageous to have several layers of global control, i.e. a master control station for doing combined SCT/TRT runs during integration, and separate SCT and TRT control stations for earlier work in the assembly areas. This 'two level' architecture is foreseen in any case for the final ATLAS system, and can be implemented in the SR building by attaching more PC workstations to the network and reconfiguring the system.

2.2 Evaporative cooling system

This system comprises the evaporative cooling for the SCT and eventually pixel detectors. A system using PVSS and a LCS to control the compressor, valves, regulators and heaters already exists for the phase II cooling prototype. This system will be setup in the SR building, requiring integration of the DCS hardware and software into the SR DCS system.

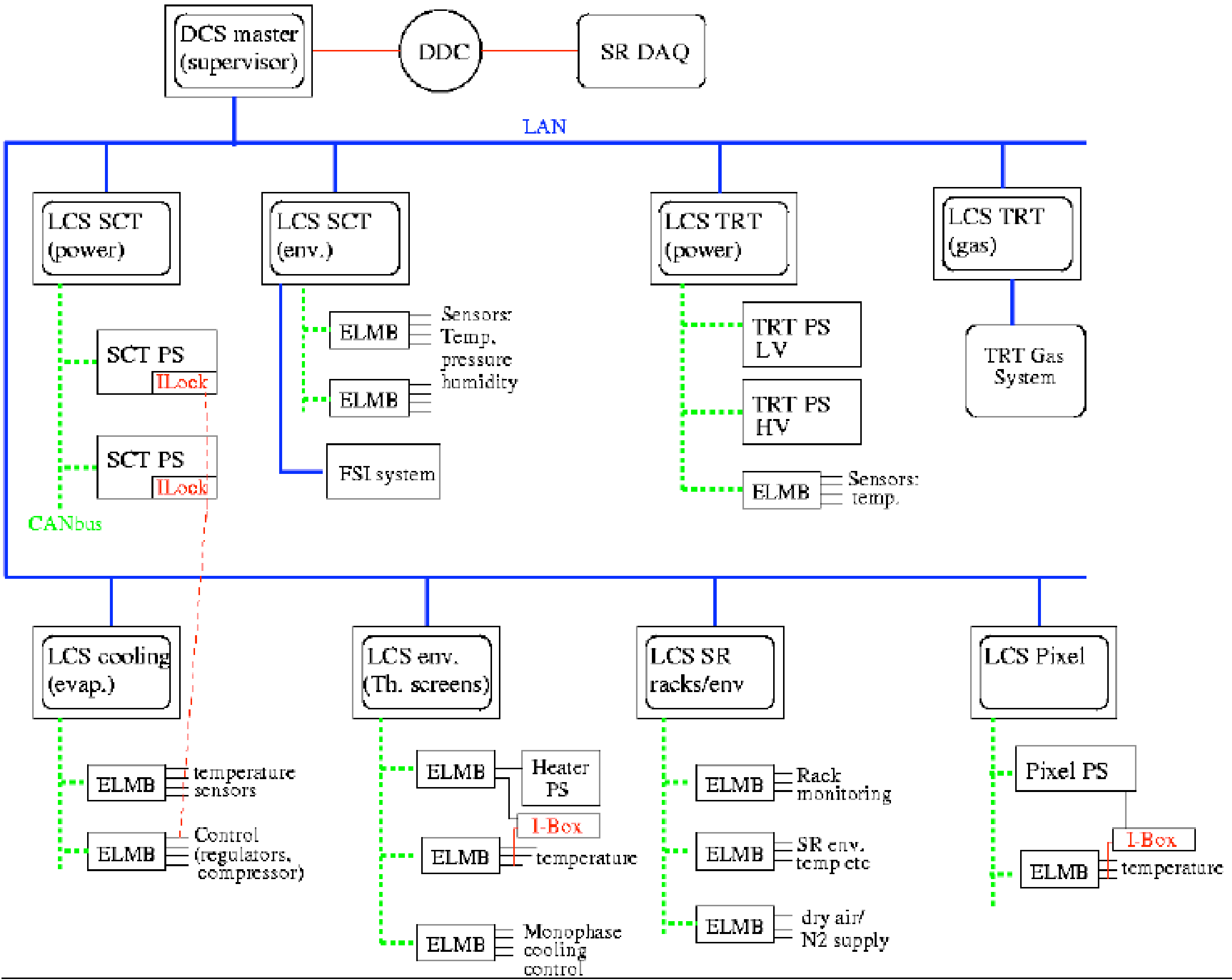

Figure 1: Outline of SR building DCS system

2.3 Thermal screens/monophase cooling

This LCS should control the SCT thermal screen heating and cooling (the cold monophase system), and the warm monophase system required for TRT and cable cooling (how much of this will be required in the SR building ?). The warm and cold monophases systems could be split if necessary (NB the cold monophase system may be replaced by an evaporative system for the thermal screens – presently under discussion).

It is not clear what, if any, of these systems already exist. There is basically nothing beyond conceptual design for the SCT thermal screen control system.

2.4 SCT power supplies

This LCS should control the SCT pwer supplies, via their CANbus interfaces. Connections and interlocks to the cooling and environmental monitoring systems will be needed, both in hardware and software. SCT calibration runs require coordinated action between the DAQ, power supplies and cooling. In the current system tests, this is achieved by controlling the power supplies directly from the DAQ, but for the SR building, the 'final' control via DAQ-DCS interactions should be used. In this scenario, the DAQ acts as master, sending commands to both the cooling system and the SCT power supplies and receiving status information.

2.5 SCT environment monitoring

This system comprises the ELMBs used for monitoring SCT temperatures and other envioronmental parameters (e.g. pressure and humidty inside the thermal screens). An interface to the FSI laser alignment system should also be attached to this LCS, though the FSI system is largely autonomous, and the connection to DCS should be used only for high level control and exchanging parameters and data. Note that the temperature sensors on the SCT evaporative cooling pipes which are used directly in the cooling system control are read out via the cooling system LCS (see section 2.2), and not via the SCT environment LCS.

2.6 TRT power supplies/environment monitoring

This LCS controls the power supplies for the TRT low (electronics) and high (straw) voltages, and also reads out the ELMBs for the TRT temperature monitoring. The two functions could be split on to separate LCS systems if necessary.

2.7 TRT gas system

The TRT gas system is largely autonomous, and will only interact with the SR-building DCS for high level control and recording monitoring data. The system should have its own LCS connected to the general DCS network.

2.8 Pixel power supplies/environment

The pixel system will arrive later in the SR building, and does not need to interact with the SCT and TRT for testing and integration purposes (no common data-taking runs etc). However, it shares the evaporative cooling system with the SCT, so it should eventually be connected to the common DCS system to allow coordinated control of pixel power and cooling. The pixel system itself has power supplies, temperature sensors and heaters which need to be controlled and monitored via the pixel LCS.

3 Work package definition

This section contains a breakdown of the complete SR DCS system into work packages, which can be assigned to different grooups of people for implementation and worked on more-or-less independently. For each work package, the deliverables, hardware and software requirements, schedule constraints, tests and safety implications are described, together with an indication of responsibilities. Finally, the relationship of each component to the corresponding system in the final ATLAS detector is given.

3.1 WP1 – basic infrastructure

This work package comprises the more basic parts of the SR building infrastructure, that can be put in place quickly and that are needed for any of the subsequent workpackages.

- **Deliverables:** The basic DCS infrastructre, control and monitoring of the racks and the SR-building environment.
- **Hardware:** The LAN ethernet, infrastructure LCS (PC workstation with CANbus interface), instrumentation of the SR-building racks (either vias ELMBs or using digitally-encoding temperature sensors directly in the racks) and associated CANbus connections. Other equipment may include monitoring of the environment (temperature, humidity, pressure) via sensors connected to ELMBs, and any monitoring/control of the dry air and N_2 gas systems.
- **Software:** Basic software for controlling and logging data with ELMBs, control of the racks, ‘lower level’ display software (panel definitions) to allow the system to be controlled and monitored from the LCS.
- **Schedule:** Needs to be ready before any `serious’ powering of the racks (at least if they are to be left unattended). First quarter 2003 ?
- **Tests:** Monitoring during stable running, provoke rack shutdowns due to faults.
- **Safety:** Should be on UPS ?
- **Relation to final system:** Racks in ATLAS caverns will be handled by central DCS, but SR-building needs to be kept functional for use in case of repair/upgrades to ID components.
- **People:** ID-gen with support from ATLAS-DCS group (and ST- doing rack preparation?).

3.2 WP2 – Global control, monitoring and databases

This work package covers the later phases of the general SR-building infrastrucure, and provides the 'high-level' environment for large scale tests and data taking, particularly those involving several detector components at once. It is more concerned with software (particularly databases and interfaces) than hardware, which is mainly provided through other work packages.

- **Deliverables:** Control and monitoring of lower level DCS components via the supervisor workstation(s) – in some phases it may be desirable to have separate supervisors for SCT and TRT, and even for barrel and endcaps. Use of configuration and conditions databases to setup systems and record monitoring data. Ability to partition and reconfigure the running systems. Ability to add new components. Interface to SR (and individual subdetector) DAQ systems to allow coordinated operation of DCS and DAQ via common run control.
- **Hardware:** control/supervisor PC workstation(s), additional PCs, disks etc for link to DAQ system. Some 'dummy' hardware to control may be useful when setting up the global->local functionality.
- **Software:** Higher level supervision/control software (PVSS/SCADA), interfaces to configuration and conditions databases, which will be used for all long-term storage, and to configure the internal PVSS database. Running instances of configuration and conditions databases will be needed (on DAQ PCs). Software to define and control partitions, and link to DAQ run control. Note that the database software situation, in particularly for the conditions database, is very unclear – it is not clear what will be available on a usable timescale, so it may make sense to have a separate database work package.
- **Schedule:** Ideally ready when first detector components (SCT barrel?) are ready to take data, to avoid 'bricolage' DAQ and DCS setups (last quarter 03). Functionality can be gradually added, until the first joint tests of the SCT and TRT barrels starting December 04.
- **Tests:** Check same functionality/results can be achieved from global as well as local control. Eventually complicated tests of several components interacting at once (SCT, TRT, cooling systems, heaters).
- **Safety:** Will untimately control a lot of systems, with complex interdependences and hardware interlocks. Must avoid incorrect running configurations (very non-trivial). Should be on UPS ?
- **Relation to final system:** Will be replaced by final DCS control system, but experience gained should be very useful, and many things will be in common.
- **People:** Collaboration between subdetectors, cooling system experts, DCS experts and ID-gen.

3.3 WP3 - Evaporative cooling system

This comprises the DCS for the evaporative cooling system running in SR1. The phase II cooling system is already running with a PVSS system elsewhere at CERN, so the integration into the SR-building DCS should be relatively straightforward.

- **Deliverables:** These can be divided into two phases (i) running the evaporative cooling system autonomously under its own LCS, with minimal interaction with the SR building DCS, and (ii) running it under control of the global supervisor, making use of the central configuration and data logging services (in previous cooling tests, the data logging was performed using internal PVSS tools.) The first phase is mainly hardware orientated, whilst the second has the emphasis on software integration, and requires substantial progress in WP2 above.
- **Hardware:** The cooling system itself, and associated LCS workstation, mainly assembled from elsewhere.
- **Software:** Low level control panels for autonomous operation, largely building on existing work, then higher and higher levels of integration with the global system, incorporating communication and interlocks with other systems (e.g. SCT power supplies LCS). Eventually operation via high-level 'shift crew like' operations (start, stop etc), and automatic setting of cooling parameters depending on cooling load.
- **Schedule:** Phase (i) when cooling system is installed (summer 03?), phase (ii) when needed. How much functionality is required for the SCT barrel 3 acceptance tests (last quarter 03).

- **Tests:** To be defined by cooling experts. Check same functionality can be achieved in local and global control, test interlocks with other systems, normal operation and emergency procedures.
- **Safety:** Thermal management/condensation issues; avoid overheated detectors. May require cooling system on UPS ?
- **Relation to other systems:** Smaller scale version of final system in cavern (which has more compressors). Test-bed to develop final control strategies.
- **People:** Cooling experts (Marek, Bosteels) in conjunction with DCS experts and ID-gen. SCT and pixel experts for interlocks and connection to other systems.

3.4 WP4 - Thermal screens, heaters and monophase cooling

This work package comprises all aspects of the thermal management excluding the evaporative cooling system. It includes the cold monophase system for the SCT thermal screens, the power supplies for the thermal screen heaters, temperature monitoring, heaters for feedthroughs and also the warm monophase system for the TRT and cable cooling (how much of this is needed in the SR building- will cable and TRT cooling be a big issue ?). There are still many open issues in the thermal and gas management in the SR building – how to maintain the correct operating environment for the detectors when not fully assembled, not with the final services and feedthroughs etc. Some thermal screen system should already be operational for pre-SR SCT tests in Oxford – we may be able to use some of that system – need details.

- **Deliverables:** The systems to control the SCT thermal screens, warm and cold monophase cooling, heaters and temperature monitoring (including ELMBs to link to the on-detector sensors for controlling the thermal screens, probably via hardware interlock boxes.
- **Hardware:** One or more local control stations, the monophase cooling chillers and compressors, power supplies for heaters, ELMBs for temperature monitoring and interlock boxes for heater control.
- **Software:** Low level software for autonomous control of the thermal screen system, running on the LCS. Higher level software for global control, including interaction with the evaporative cooling system, heater power supplies (changing in response to cable power load?) etc.
- **Schedule:** Thermal screen control needed for first cold tests of SCT barrel 3 (with temporary thermal enclosure?) – last quarter 03. Warm monophase cooling needed for TRT tests (date?) and final integration tests.
- **Tests:** Check stable running (proper control of temperature) and reaction to faults, e.g. failure of heating or cooling. Check interactions with other parts of DCS system.
- **Safety:** This system is critical for proper control of the cold dry SCT environment. Probably needs to be on UPS.
- **Relation to final system:** Should be very similar to final system, just scale up. Experience learned in SR building should be directly applicable.
- **People:** SCT thermal screen experts, DCS support, ID-gen.

3.5 WP5 – SCT power supplies

This work package comprises the control of the SCT power supply system from DCS. It will eventually be a substantial system in the SR building, since an entire SCT barrel or endcap needs to be powered at once for the X-ray survey.

- **Deliverables:** These fall into two phases: i) SCT LCS controlling power supply system autonomously, ii) Control from the global supervisor, implementation of complete ramp up/ramp down sequences for the whole detector, interaction with DAQ for calibration runs and evaporative cooling system for proper setting of cooling power.
- **Hardware:** SCT LCS, CANbus interface and cabling to the power supplies.
- **Software:** Low level control system, panel definitions etc for phase (i); Global control system, interaction with configuration database, cooling and run control for phase (ii). The latter is a complex software integration project.

- **Schedule:** Some functionality needed for first tests of SCT barrel 3 (last quarter 03). It would be desirable to have as much 'global' functionality as possible for barrel 3 tests, to avoid 'bricolage' solutions as presently used in the system tests. Final functionality for full SCT barrel tests in the second half of 04.
- **Tests:** Check basic functionality, control ramp up/down of system, interaction with cooling system, emergency procedures.
- **Safety:** Need to avoid dangerous situations with detectors powered but not cooled – interlocks to cooling system required.
- **Relation to final system:** The final system will be very similar, and not much bigger, since the entire SCT barrel or one endcap will be powered and controlled at once in SR building tests.
- **People:** SCT DCS and power supply experts, DCS support, cooling experts.

3.6 WP6 – SCT environmental monitoring

This work package includes all of the SCT environmental monitoring, including pressure, temperature and humidity sensing, and the connection to the FSI system.

- **Deliverables:** System to readout all the SCT environmental sensors, connection to global DCS to log data. High level control and data logging for FSI system.
- **Hardware:** SCT environmental LCS, ELMBs for data readout, CANbus and interface to FSI system (separate workstation on LAN ?).
- **Software:** Low level monitoring software to read out and log data from ELMBs, higher level software to interface to other parts of the DCS system – e.g. SCT cooling.
- **Schedule:** Desirable for SCT barrel 3 tests (last quarter 03), essential for tests of complete SCT barrel and subsequent SCT-TRT integration (second half 04), when FSI system interface will also be needed.
- **Tests:** Basic functionality (calibration needed?), proper functioning of FSI system interface.
- **Safety:** Proper functioning of temperature sensors for cooling system interlocks, laser safety issues for FSI.
- **Relation to final system:** The final system will be very similar, just scaled up. There will be proportionally more cable temperature monitoring in the cavern than in the SR building.
- **People:** SCT DCS experts, some DCS support for panel definition etc.

3.7 WP7 – TRT power supplies and environmental monitoring

This work package includes the control and monitoring of the TRT low and high voltage power supplies, plus any environmental monitoring sensors (e.g. temperature) on the TRT. It may be desirable to split this on two separate LCS workstations, as proposed for the SCT. What cooling is required for the TRT in the SR building work – electronics?

- **Deliverables:** System to control and monitor the TRT power supplies, and monitor the environmental sensors. Connection to global DCS system for high level control and logging of data. Unlike for the SCT, powering of large fractions of the entire TRT at once in the SR building is not foreseen, so the large scale automated control of 100s of modules at once is not required.
- **Hardware:** TRT LCS, ELMBs for data readout, CANbus and interfaces for power supplies.
- **Software:** Low level control and monitoring software for TRT LCS, some higher level software for global control of TRT power supply system.
- **Schedule:** Needed for TRT barrel and endcap module acceptance tests, starting in October 03.
- **Tests:** Basic functionality, control ramp up/down of groups of modules, reaction to faults and emergency procedures.
- **Safety:** High voltage interlocks, low voltage system interaction with TRT cooling.
- **Relation to final system:** Since only a relatively small number of modules will be powered at once, the final system will be a lot bigger and have more complex high level controls.
- **People:** TRT DCS experts, some DCS support for setting up, panel definitions etc. Cooling ?

3.8 WP8 – TRT gas system

This work package involves the integration of the TRT gas system into the SR building DCS infrastructure. This is mainly a communication issue, since the TRT gas system is relatively autonomous and self-contained.

- **Deliverables:** Integration of TRT gas system into SR building DCS, monitoring and logging via SR building DCS database.
- **Hardware:** TRT gas system LCS, connection interface to TRT gas system control.
- **Software:** High level control panels for simple gas operations, detailed expert control will be performed internally.
- **Schedule:** Needed for TRT tests in SR building, but this may not require global control of TRT gas system, since interaction with other systems are minimal.
- **Safety:** Handled internally by TRT gas system.
- **Tests:** High level functionality controllable from global DCS system.
- **Relation to final system:** Control functions similar, final gas system will have higher capacity.
- **People:** TRT gas experts, some support from central DCS group.

3.9 WP9 – Pixel DCS system

This work package includes control and monitoring of the pixel power supplies and environmental monitoring. Since the pixel construction starts later in the SR building, and they do not participate in common data taking runs with the SCT and TRT, less integration into the global system is needed. The main interactions with global DCS concern the evaporative cooling system, which will be shared with the SCT, and the power supplies for heaters on cables, the pixel support tube etc.

- **Deliverables:** Control of the pixel power supply system, first using the pixel LCS, then eventually using the global DCS system. Monitoring of environmental parameters via ELMBs, control of the cooling system to meet pixel cooling requirements.
- **Hardware:** Pixel LCS workstation (perhaps several depending on functionality required), CANbus interfaces to pixel power supplies, ELMBs for temperature monitoring.
- **Software:** Low level control software for power supplies and environmental monitoring/logging, then higher level control functions including coordinated control of power supplies and evaporative cooling system.
- **Schedule:** Needed for pixel assembly and test in SR builing. Dates?
- **Safety:** Avoidance of dangerous situations with detector modules powered but not cooled.
- **Relation to final system:** The final system will be similar, but scaled up, with more emphasis on controlling a large number of modules simultaneously.
- **People:** Pixel DCS experts, cooling experts, central DCS support.

4 Open issues

This section lists some issues which need clarification:

- Use of warm monophase cooling in SR building. In the final ATLAS system, this is used for cooling of TRT straws, TRT electronics and all cables. How much cooling will be required in the SR building – presumably cable cooling is minimal?
- Thermal screens in SR building. The requirements and solutions need to be better defined, in particular the operation of cooled SCT components, risk of condensation on external surfaces, need for temporary thermal shields etc.
- UPS requirements. What fraction of the systems should be on UPS – e.g. all the DCS components ? What class of UPS is available in the SR building wrt normal or secure input power, emergency stops etc.

- Database software. This area is very unclear, particularly with regard to the conditions database. A separate work package may be necessary to provide interfaces for the SR building equipment to the conditions database, if this turns out to be a large project.

There are probably many more issues which should be listed here.