**University of California, Irvine (UCI)**

# The New ROD Complex

For the ATLAS CSC Electronics

---

# Interface Specification


| | |
|---|---|
| Document Version: | 1.0 |
| Document Issue: | 1.0 |
| Document Edition: | English |
| Document Status: | Draft |
| Document ID: | ATLAS-CSC-2012-XXX |
| Document Date: | 21st September, 2012 |

## Abstract

This document presents the interface specification for the replacement of the current Cathode Strip Chamber (CSC) off-detector electronics, which encompass not only the readout electronics but also the hosting crates, power supplies, firmware, software, etc. This ensemble of elements is referred to as the ROD Complex and the new incarnation as the New ROD Complex (NRC).

## Purpose of the document

The purpose of this document is to serve as the basis for the design and implementation of the CSC New ROD Complex.

## Glossary, acronyms and abbreviations

| | |
|---|---|
| **ASM** | Amplifier-Shaper Module |
| **CSC** | Cathode Strip Chamber |
| **CTP** | Central Trigger Processor |
| **DCS** | Detector Control System |
| **L1A** | Level 1 Accept |
| **LTP** | Local Trigger Processor |
| **NRC** | New ROD Complex |
| **ROBIN** | Readout Buffer Input |
| **ROD** | Read-Out Driver |
| **ROL** | Read-Out Link |
| **ROS** | Read-Out Subsystem |
| **SCA** | Switched Capacitor Array |
| **TDAQ** | Trigger and Data Acquisition |
| **TTC** | Trigger, Timing and Control |

## References

1 J. Dailing et al., “Performance and radiation tolerance of the ATLAS CSC on-chamber electronics”, in proc. 6th Workshop on Electronics for LHC Experiments, Krakow, Poland, 11 - 15 September 2000, http://cdsweb.cern.ch/record/478868/files/p196.pdf

2 “Atlas muon spectrometer technical design report”, CERN / LHC / 97 – 22.

3 Gough Eschrich [for the ATLAS Muon Collaboration], “Readout Electronics of the ATLAS Muon Cathode Strip Chambers”, in Proceedings of the Topical Workshop on Electronics for Particle Physics (TWEPP08), Naxos, Greece, 15-19 September 2008, http://indico.cern.ch/getFile.py/access?contribId=66&sessionId=20&resId=0&materialId=paper&confId=21985

4 Steve Pier, “ROD/ASM II Interface”, http://positron.ps.uci.edu/~pier/csc/ROD_ASMII_Interface0.pdf

5 P. Borgeaud and E. Delagnes, "The ‘HAMAC’ rad-hard Switched Capacitor Array: A high dynamic range analog memory dedicated to ATLAS calorimeters.", http://www.nevis.columbia.edu/~atlas/electronics/asics/sca/DOC_HAMAC.pdf

6 P. O’Connor , "Review of ASM-2 readout for ATLAS CSC", http://www.inst.bnl.gov/~poc/CSC_Documents/Review%20of%20ASM%20readout%2005-10-01.doc

7 D. Tompkins, “CSC Pulser rev. H”, https://twiki.cern.ch/twiki/pub/Atlas/CscPulser/CSC_Pulser_H.pdf

8 “ATLAS Level-1 Trigger Technical Design Report (Chapter 16) “, http://atlas.web.cern.ch/Atlas/GROUPS/DAQTRIG/TDR/V1REV1/L1TDR_TTC.pdf

9 P. Farthouat, "LTP Interface", https://twiki.cern.ch/twiki/bin/viewfile/Main/MyATLASDocumentation?rev=1.1;filename=Interface_spec-v4.3.pdf

10 P. Gällnö, "ATLAS ROD Busy Module. Technical description and users manual", https://edms.cern.ch/file/319209/1/rod_busy_manual_2.pdf

11 “ATLAS Level-1 Trigger Technical Design Report (Chapter 20) “, http://atlas.web.cern.ch/Atlas/GROUPS/DAQTRIG/TDR/V1REV1/L1TDR_Deadtm.pdf

12 A. Anjos, H. P. Beck, B. Gorini, W. Vandelli, "The raw event format in the ATLAS Trigger & DAQ", https://edms.cern.ch/file/445840/4.0e/eformat.pdf

13 O. Boyle1, R. McLaren and E. v. der Bij, "The S-LINK Interface Specification", https://edms.cern.ch/file/110828/4/s-link.pdf

14 G. Lehmann, "ATLAS TDAQ Controls: Operations at Different Activity Stages", https://edms.cern.ch/file/675671/1/ATLAS_OperationsAndTransitions.pdf

15 I. Soloviev, "ATLAS TDAQ Config Packages", http://atlas-tdaq-sw.web.cern.ch/atlas-tdaq-sw/doxygen/tdaq/production/html/ConfigPackages.html

16 S. Kolos, "ATLAS TDAQ How to use the ERS package", http://atlas-tdaq-sw.web.cern.ch/atlas-tdaq-sw/doxygen/tdaq-common/production/html/main.html

17 http://atlasdaq.cern.ch/jnlp/logmanager/logmanager.jnlp

18 S. Kolos, "Information Service user's guide", http://atlas-tdaq-monitoring.web.cern.ch/atlas-tdaq-monitoring/IS/doc/userguide/is-usersguide.pdf

19 "Online Histogramming", http://atlas-onlsw.web.cern.ch/Atlas-onlsw/oh/oh.htm

20 "OHP Monitoring", https://twiki.cern.ch/twiki/bin/viewauth/Atlas/OhpMonitoring

21 A. Barriuso Poy et al., "ATLAS DCS Integration Guidelines", https://edms.cern.ch/file/685451//ATLAS_DCS_Integration_Guidelines.pdf

# Document Control Sheet

**Table 1** Document Control Sheet

| | | |
|---|---|---|
| **Document** | **Title:** | The New ROD Complex Interface Specification |
| | **Version:** | 0.4 |
| | **Issue:** | 1 |
| | **Edition:** | English |
| | **ID:** | ATLAS-CSC-2012-XXX |
| | **Status:** | Draft |
| | **Created:** | August 24th, 2012 |
| | **Date:** | September 21st, 2012 |
| | **Access:** | |
| | **Keyword:** | ATLAS, CSC, ROD, interface, specification |
| **Authorship** | **Coordinator:** | Raul Murillo-Garcia (UCI) |
| | **Written by:** | Richard Claus (SLAC), Michael Huffer (SLAC), Andy Lankford (UCI), Andrew Nelson (UCI), Ven Polychronakos (BNL), Michael Schernau (UCI). |

# Document Status Sheet

**Table 2** Document Status Sheet

| | | | |
|---|---|---|---|
| **Title:** | The New ROD Complex Interface Specification | | |
| **ID:** | ATLAS-CSC-2012-XXX | | |
| **Version** | **Issue** | **Date** | **Comment** |
| 0.1 | 1 | 08/24/2012 | First rough draft. |
| 0.2 | 1 | 08/31/2012 | Input from UCI. |
| 0.3 | 1 | 09/04/2012 | Input from SLAC. |
| 0.4 | 1 | 09/20/2012 | Input from the preparation meeting. |
| 1.0 | 1 | 09/21/2012 | First release for reviewers. |

# Chapter 1
# Overview

## 1.1 Introduction

The ROD Complex will orchestrate the retrieval of chamber data upon receipt of a Level 1 Accept (L1A) and forward the resulting feature extracted event to the Trigger and Data Acquisition (TDAQ) system.

The different systems with which the ROD Complex will interface to accomplish its required functionality are listed below and depicted in Figure 1.

a) The on-detector electronics: located on the detector, they amplify, shape and digitize the signals produced as a result of particles interacting with the CSC chambers.

b) The Local Trigger Processor (LTP): provides the ROD Complex with the signals necessary for timing and triggering.

c) Read-Out Subsystem (ROS): each ROS encapsulates as many as 4 Read-Out Buffer Inputs (ROBINs) and each ROBIN contains up to 3 Read-Out Links (ROLs). The CSC event data is transmitted over these links to the associated ROBINs.

d) The ROD-Busy module: transports and monitors the BUSY signal used to veto the ATLAS Central Trigger Processor (CTP) thus inhibiting L1As.

e) The TDAQ online system: a set of software interfaces that provides the ROD Complex with the functionality needed to be integrated within the RunControl hierarchy as well as facilities for data flow and performance monitoring, error reporting, etc.

f) The Detector Control System (DCS): a homogeneous interface to all sub-detectors that enables the coherent and safe operation of the ATLAS detector.

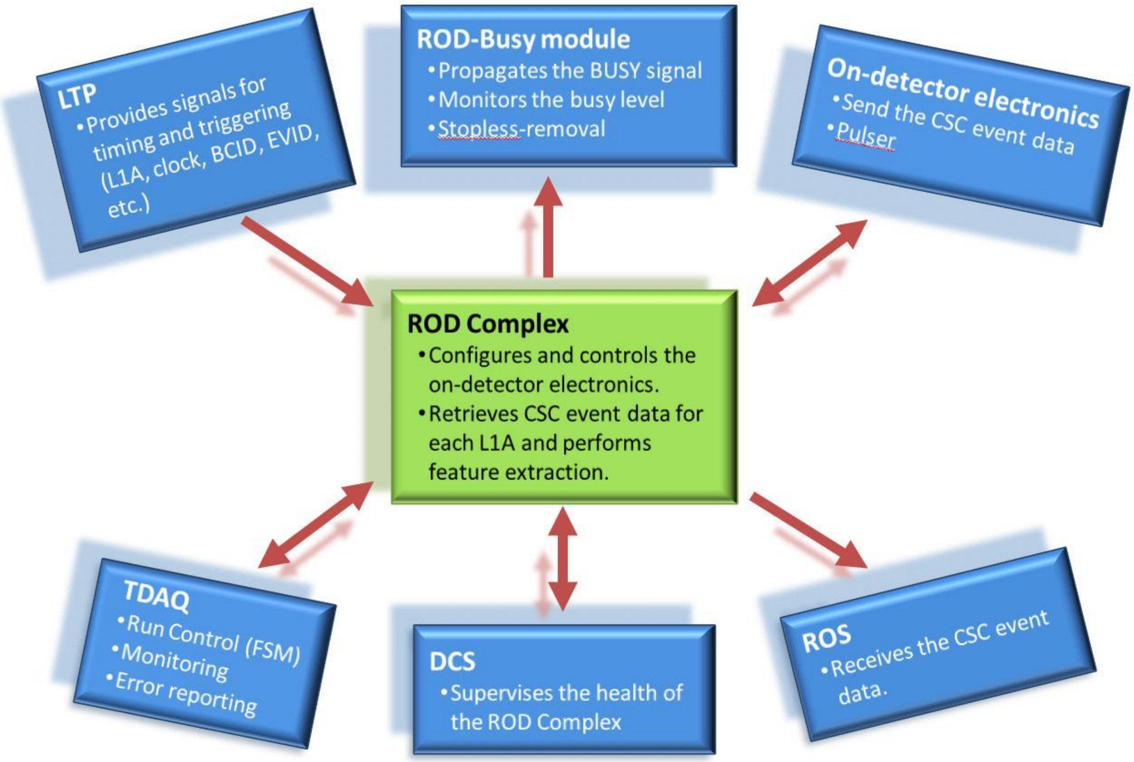


**Figure 1** interfaces of the ROD Complex.

# Chapter 2
# Interfaces

## 2.1 Interface to the on-detector electronics

The ATLAS CSC system consists of 32 chambers grouped in two end-caps. Each chamber has four layers, each layer providing 192 precision coordinate channels in the direction of magnetic curvature and 48 transverse coordinate channels in the less critical non-bending direction.

Due to severe radiation levels in the CSC environment, a minimum of electronics, known as the on-detector electronics, are located on the detector. For each chamber the on-detector electronics consist of 10 ASM-I boards and 5 ASM-II boards contained within Faraday shields along the narrow edges of the chamber. One ASM-II is designed to process 192 channels, that is, one precision layer or 4 transverse layers. Each of the 960 channels on a chamber is connected to a preamplifier and shaper circuit in the ASM-I, which forms a bipolar pulse with 140 ns shaping time. The shaped pulses are sampled every 50 ns, and the analogue information is stored in CMOS Switched Capacitor Array (SCA) in the ASM-II. Each channel is allocated 144 cells in the SCA, thus providing an effective pipeline depth of 288 bunch-crossings, larger than the trigger latency, which is estimated to reach 188 bunch crossings in the worst case scenario [1, 2, 3].

Each ASM-II board has 2 fiber-optic links, implemented with the G-Link chip set, to transmit chamber data. The downlink for one chamber includes 10 links grouped in a single 12 strand fibre-optic MPO cable. Each link is configured to operate with a 16-bit input word in the single frame mode at a frame rate of 40 MHz, resulting in 640 Mbits/second. The downlink throughput for one chamber is thus 6.4 Gigabits/second [1].

The uplink for one chamber requires 6 fibre-optic G-Links, 5 for the timing and control of the ASM-II boards and 1 for the control of the pulser module. The uplinks for 2 chambers are bundled together into 1 MPO cable.

The ROD Complex will orchestrate the writing to the SCA cells at the specified sample rate. Also, following a L1A, the ROD Complex will read out the appropriate cells, whose analogue information will be digitized into 12-bit values by the ASM-II board and transmit over the fiber-optic links. In order to access the SCA cells, either for writing or reading, the ROD Complex will send a clock and 17 parallel control bits as defined in [4, 5, 6] to the ASM-II boards via the uplinks.

In addition, the ROD Complex will provide the logic to control the chamber's pulser module as defined in [7].

## 2.2 Interface to the Local Trigger Processor

The LTP [8, 9] system will provide the ROD Complex with all the trigger and timing signals originated from the CTP. These include:

a) The Bunch-Crossing (BC) clock.

b) The Level 1 Accept signal.

c) The trigger-type word with each L1A.

d) The Bunch-Crossing Identifier (BCID) and Event Counter Identifier (EVID) words with each L1A.

e) The Bunch-Crossing Reset (BCR) and Event Counter Reset (ECR) signals, used for synchronization purposes.

f) Commands and data, including test and calibration pulses.

## 2.3 Interface to the ROD-Busy module

A BUSY signal will be asserted when the internal buffers of the ROD Complex are nearly filled. This signal will be sent through a two pole coaxial connector (LEMO® #00) [10] to the ROD-Busy module, which in turn will relay it to a subsequent ROD-Busy module in a tree-like structure until it reaches the CTP, thus inhibiting and throttling the L1A rate [11].

The BUSY signal should be asserted as infrequent as possible since it impedes data taking by inducing the so-called dead-time.

The ROD-Busy module also monitors and controls the busy levels during the run. This is crucial to identify pathological elements and determine if stop-less removal is necessary.

## 2.4 Interface to the Read-Out Links

The ROD Complex transmits the feature extracted data (compliant with the ATLAS event format [12]) to the Read-Out Subsystem via 16 Read-Out Links (ROL). A ROL is a single full-duplex fiber-optic link implemented as a Simple Link (S-Link) interface. An S-Link is a link complying with the specification defined in [13] and can be thought of as a virtual ribbon cable, moving 32 bit data words at 40.08 MHz (160 MBytes/second) from one point to another. In addition, the S-Link includes error detection, a return channel for flow control (XON/XOFF) and self-test functionality.

The XOFF signal is a data flow control mechanism for the ROBINs to assert back-pressure to the ROD Complex by inhibiting the transmission of event data. If the XOFF condition persists long enough, this back-pressure might result in the assertion of the BUSY signal.

## 2.5 Interface to the TDAQ online system

### 2.5.1 Trigger and data acquisition software release

The TDAQ software release will be accessible to the ROD Complex. Some of the packages are essential to integrate the CSC with the TDAQ infrastructure. For example a RunControl application will be present to control and configure the ROD Complex (2.5.2, 2.5.3). Other packages are required for monitoring purposes (2.5.4, 2.5.5, 2.5.6). The TDAQ release is installed in the network file system in P1.

### 2.5.2 TDAQ state model

The RunControl application, which bridges the ROD Complex with the TDAQ RunControl system, will respond to transition commands typically triggered by the Run Control shifter. The TDAQ Finite State Machine (FSM) is described in [14]. This document is slightly out-dated since the transition *PrepareForRun* was deprecated in TDAQ release 3.0.1 and the transitions *Pause* and *Resume* in release 4.0.1. In order to tailor the RunControl application to the needs of the ROD Complex the abstract methods in the ROS::ReadoutModule class will be defined in an extended class, for example CSCReadoutModule. Transition propagation is transparently handled by the Inter-Process Communication (IPC) service.

### 2.5.3 Configuration

The configuration that parameterizes the behaviour of the ROD Complex will be stored in the TDAQ configuration database [15]. This is important to retrieve the configuration associated to a given run. The RunControl application will read the configuration database to extract the CSC-specific parameters and forward them to the ROD Complex.

### 2.5.4 Error information

Unexpected errors detected by the ROD Complex will be relayed to the TDAQ infrastructure via the Error Reporting Service (ERS), whose interface is described in [16]. The ERS aims at simplifying and unifying error handling and error reporting. Messages are categorized as warnings, errors or fatal and sent to a set of pre-defined streams. One of these streams provides a back-end for permanent storage to a relational database, which can be browsed with the Log Manager [17].

### 2.5.5 Information service

The Information Service (IS) will be used to publish parameters that will be shared by other applications, such as monitoring applications. The interface to the IS is documented in [18]. As a side note, a currently on-going TDAQ project (pBeast) will provide permanent storage for the IS information. This might prove useful for debugging and perform analysis.

### 2.5.6 Histograms

The Online Histogramming Service (OHS) [19] will be used for publishing histograms that can later be browsed with the Online Histogram Presenter (OHP) [20]. This will be useful to understand the behaviour and performance of the ROD Complex.

## 2.6 Interface to the detector control system

The ATLAS DCS comprises the control of the sub-detectors, the common infrastructure of the experiment and the communication with the CERN services (cooling, ventilation, electricity distribution, safety etc.). The principal task of the DCS is to enable the coherent and safe operation of the detector and to serve as a homogeneous interface to all sub-detectors and to the technical infrastructure of the experiment.

The ROD Complex will adhere to the DCS interface definition [21] to provide functionality for control and monitoring, thus allowing users/shifters to signal any abnormal behaviour and initiate the necessary corrective actions.