SCT Off-Detector Electronics
Requirements Document

Draft 0.1

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Abstract

This document is an incomplete draft version of the requirements upon the SCT off-detector electronics. This early draft is made available for comments and contributions by the SCT community.

Please direct comments to offdet@lankford.ps.uci.edu.

Editor's Note

This draft is nowhere complete and some sections are quite sketchy. These sections will get filled in as time goes on. We would welcome contributions to fleshing out of the draft and completing the requirements, as well as questions and comments concerning the requirements already included.

The format which we have adopted for the requirements in this draft includes some mandatory fields. These are: name, requirement, justification, and status. "Name" is a short name by which the requirement can be refered. "Requirement" is a complete and clear but concise statement of the requirement. "Justification" states the basis for the requirement. It is an important field because it states the basis for imposing the requirement; therefore, it contains the history of the thinking behind the requirement. It also documents the assumptions that went into the requirement; hence, it states the assumptions that may be questioned should a designer find thata given requirement is difficult or impossible to meet. "Status" states the current status or completeness of the requirement. It is also important to the interpretation and possible questionning of a given requirement. For instance, a requirement whichcontains approximate values of parameters should not be misunderstood as containing exact or final values. This format also contains some optional fields (explanation, notes, comments) I would say that an "explanation" explains the requirement, in case the concise statement in the "requirements" field might not be clear by itself. I would say that "notes" contains references or additional information concerning a requirement. And I would say that "comments" are generally of a temporary nature and can be somewhat editorial. Text in square brackets are intended to be very temporary comments, reminders, or editorial notes.

The format which we have adopted here may be changed for a future draft. For instance, we might consider changing to the ESO standard being used by some of the T/DAQ group.

Table of Contents

I Introduction

[introduces the purpose of this document]

[The SCT off-detector electronics includes all electronics associated with the SCT which is not mounted on the detector with the exception of:

1. the system of power supplies and other electronics which provide DC services to the SCT, including their control system and cables,
2. the system for environmental monitoring and control of the SCT,
3. the clock and control links and data links connecting the off-detector and detector-mounted electronics, including the drivers and receivers at the off-detector end of the links.]

II Brief Description of SCT

[this section will contain text which briefly describes the purpose, layout, and data bandwidths of the SCT

III Overview of Off-Detector Electronics

[this section will contain text which introduces the functionality and likely physical layout of the off-detector electronics

IV Essential Requirements

IV.A Requirements regarding detector-mounted electronics

IV.A.1 Receipt of data

The off-detector electronics receives data from the on-detector electronics. The data received can be any of three different types: event data, calibration data, or register data. The following requirements pertain to receipt of data of any of the three types.

The interface between the off-detector electronics and the detector-mounted electronics is defined to be at the output of data link receiver circuitry which is to be provided by SCT Data Transmission group. For instance, if the data link is optical, then the link receiver circuitry does opto-electrical conversion, outputting a serial data stream.

IV.A.1.a All data types

The following requirements apply to the receipt of data of any data type.

Source of input data streams

1) The off-detector electronics must receive input data streams from the detector-mounted electronics.

Justification:
Receipt of data from the detector-mounted electronics is one of the primary missions of the off-detector electronics.

Status:
Firm.

Number of input data streams per SCT detector module

2) In the SCT, two input data streams must be received from each detector module.

Justification:
Each detector module is instrumented with two output data streams in order to offer a degree of redundancy in case of failure of one data stream.

Explanation:
Each detector module is instrumented with two output data streams. During normal operation, each data stream reads out the data from one-half of the channels on the module. If one data stream fails, thedetector-mounted electronics can be reconfigured such that the remaining operational data stream reads out all of the channels on the module, however, at reduced aggregate bandwidth.

Status:
Firm.

Total number of input data streams

3) In the SCT, the total number of input data streams is 8176.

Justification:
The total number of SCT detector modules is 4088. Since two input data streams exist per detector module, 8176 data streams exist in total.

Status:
Incomplete and not firm.
The total number of input data streams xxx and the number of SCT detector modules must be filled in. The number of SCT detector modules depends upon the layout of the SCT. The current layout has been stable for a some months and

is considered to be a baseline design. Nonetheless, the number of SCT detector modules may change by as much as 10-20% in the future.

Masking of input data streams - 1

4) The off-detector electronics must be capable of being configured under program control so as to eliminate data from any specified set of input data streams. All data on the specified set of data streams should be eliminated from the time that the off-detector electronics is so configured until it is reconfigured to accept data on those input streams.

Justification:

Detector-mounted electronics may fail in a mode which produces meaningless or excessive data on some of the input data streams to the off-detector electronics. The off-detector electronics must be able to eliminate such data in order to not overly burden the data bandwidth capabilities of subsequent portions of the readout chain. It is necessary to have this functionality in the off-detector electronics because the failure of the detector-mounted electronics may not allow disabling of the failed elements directly.

Notes:

Only two states, accept data or eliminate data, are required for each input data stream. In the eliminate data state, all data is eliminated (*i.e.* data is not eliminated selectively). In the accept data state, all data is accepted if it meets all other acceptance criteria. In order to avoid undue complexity in the off-detector electronics, states in which some data is eliminated and some is accepted according to some criteria such as the type of data are not required (unless explicitly demanded by some other requirement).

There may be circumstances (as demanded by some other requirement) that result in certain data records on some input data streams to be eliminated. For instance, a data record with an identified error in its header may be eliminated. Under these circumstances, a flag will be inserted into the output data stream from the off-detector electronics. When the off-detector electronics is configured according the requirement stated here, it is not required to insert a flag into the output data stream.

Once configured to eliminate data on a specified set of data streams, the off-detector electronics should continue to eliminate all data on that set of streams in order that the response of the off-detector electronics to data on those streams is well-defined.

Status:

Firm.

Masking of input data streams - 2

5) The off-detector electronics must be capable of being configured under program control such that it can operate normally if no signal is received on any one of a specified set of input data streams.

Justification:

Detector-mounted electronics may fail in a mode which provides not data on some input data streams to the off-detector electronics. In addition, some data stream inputs to the off-detector electronics may not be connected to detector-mounted electronics (*i.e.* some inputs may not be utilized). The off-detector electronics must be capable of receiving and processing data on all other data streams normally under these circumstances.

Comment by AJL:

I am not certain that this requirement needs to be implemented separately from "Masking of input data streams - 1".

Status:

Firm.

Input data types

6) The off-detector electronics must be capable of receiving data of three data types (event data, calibration data, and register data) on each input data stream.

Justification:

The detector-mounted electronics produces these three data types. Consequently, the off-detector electronics must be capable of receiving all three types.

Notes:

The processing required of the off-detector electronics in response to receipt of each data type is elaborated in subsequent requirements.

At this time, it is assumed that a fourth data type for monitor data is not required.

Explanation:

Some text here should explain what these three data types are and to what commands they are responses.

Status:

The requirement to receive these three data types is firm. It is not yet out of the question that additional data types will be required as well.

Media of input data streams

7) The off-detector electronics must be capable of receiving input data streams from receiver circuitry provided by the SCT Data Transmission group. The

characteristics of the input signals will be specified in the interface specifications document for the SCT data links.

Justification:
Notes:
Further summary of signal characteristics would be useful here.
Status:

Baud rate of input data streams

8) The off-detector electronics must be capable of receiving data transmitted at 40Mbs (*i.e.* 40 Mbits/s) on the input data streams.

Format of input data

9) The off-detector electronics must be capable of receiving data on the input data streams which is formatted according to the protocol defined in the specifications of the on-detector electronics.

Justification:
Notes:
[Provide a description of the data format here; however, refer to the appropriate document for the specifications.]
Status:

Flow control of input data streams

10) The off-detector electronics must be capable of receiving data on the input data streams without any direct flow control mechanism.

Justification:
Explanation:
[include an explanation of what is meant by no direct flow control mechanism, *i.e.* that the detector-mounted electronics pushes the data whenever it feels like it.]
Status:

Negligible data loss

11) The off-detector electronics must be capable of receiving all data on the input data streams without loss of any data, except in very unusual circumstances.

Justification:
Explanation:
[explain here why it is always the case that data may be lost]
Comment:

We should try to quantify “very unusual circumstances”. A reasonable criteria might be significantly less data loss than results from inadequate buffering in the detector-mounted electronics.
Status:

Data loss

12) In the case of data loss during very unusual circumstances, the loss of data must be flagged in the output data stream.

Justification:
Note:
[describe the proposed method of flagging data loss]
[We may choose to require the counting the number of times data is lost on each input data stream.]
Status:

Recognition of data type

13) The off-detector electronics must interpret the data protocol of the input data streams in order to recognize the data type and in order to respond appropriately to the data type received.

Justification:
Comment:
We should probably clarify what is meant by “respond appropriately” in either the requirement or an explanation field.
Status:

Protocol errors

14) The off-detector electronics must recognize protocol errors in the input data stream, and it must flag the occurrence in the output data stream.

Justification:
Status:

Recognition of error flags

15) The off-detector electronics must recognize error flags in the incoming data stream.

Justification:
Notes:
[include a description of possible error flags]

Status:

Monitoring of errors in input data stream

16) A local CPU in the off-detector electronics must monitor the occurrence and frequency in each data stream of protocol errors and of error flags.

Justification:
Status:

Synchronization of input data streams

17) The off-detector electronics must provide a mechanism which adjusts the phase of data on each input data stream relative to the clock which operates the off-detector electronics.

Justification:
Status:

Disabling of error checking

18) The off-detector electronics must be capable of being configured by program control to disable error checking on any set of input data streams.

Justification:
Status:

IV.A.1.b Event data

Event data generally consists of data records associated with physics triggers. More specifically, event data consists of data records associated with L1Accept commands but which are not associated with CalStrobe commands.

The following requirements pertain to the processing of event data but not to both the processing of calibration data and of register data.

Merge event data streams

1) The off-detector electronics must merge event data records from multiple input data streams into output event data records on output data streams.

Justification:
Comment:

If there is a requirement upon the number of input data streams merged into a single ouput data stream, then that number should be included in the requirement defined here.

Status:

Buffering of event data

2) The off-detector electronics must buffer output event data records for transmission to Readout Buffers.

Justification:
Status:

No loss of buffered event data

3) The off-detector electronics must not overwrite or otherwise lose output event data records before they are transmitted to Readout Buffers.

Justification:
Comment:

This requirement as written dictates that data is not overwritten, implying that data which would cause overflow is dropped. An alternative to dropping data from new events is to overwrite old events (as is done in the ABC).

Status:

Local access to event data records

4) The off-detector electronics must buffer output event data records for access by a local CPU for monitoring purposes.

Justification:
Status:

Monitoring of event data

5) The off-detector electronics must provide local computing to monitor output event data records in order to monitor detector performance.

Justification:
Explanation: [explain “local”, “computing”, “monitor”]
Status:

Communication of monitoring results

6) Local CPUs provided to monitor output event data records must report the monitor results to the SCT subsystem of the DAQ control system.

Justification:
Status:

IV.A.1.c Calibration data

Calibration data consists of data records associated with L1A commands which are preceded immediately by CalStrobe commands.

The following requirements pertain to the processing of calibration data but not to both the processing of event data and of register data.

Merge calibration data streams

1) The off-detector electronics must merge calibration data records from multiple input data streams into output calibration data records.

Justification:
Status:

Local access to calibration data records

2) The off-detector electronics must buffer output calibration data records for access by local computing for monitoring purposes.

Justification:
Status:

No loss of buffered calibration data

3) The off-detector electronics must not overwrite or otherwise lose output calibration data records before they are accessed by a local CPU, unless calibration data loss is enabled under program control.

Justification:
Status:

Processing of calibration data

4) The off-detector electronics must provide computing to process calibration data, store calibration data locally for control purposes, and report summaries of calibration results to the SCT subsystem of the DAQ control system.

Justification:
Note:
Some examples of local use of calibration data for control purposes are identifying channels that should be masked and determining settings of threshold voltages.
Status:

IV.A.1.d Register data

Register data consists of data records associated with commands which operate on registers in the detector-mounted electronics.

The following requirements pertain to the processing of register data but not to both the processing of event data and of calibration data.

Merge register data streams

1) The off-detector electronics must be capable of merging register data records from multiple input data streams into output register data records when the detector-mounted electronics responds to commands by simultaneously producing register data on multiple input data streams.

Justification:
Explanation:
For instance, in response to a broadcast command to read a register in each front-end chip of each module.
Comment:
Do we have such commands?
Status:

Respond to a single register data stream

2) The off-detector electronics must be capable of receiving register data on a single input data stream under circumstances in which not all other input data streams are disabled.

Justification: IV.B.2.a.2 "SCT standard TTC system". It defines an interface between the SCT off-detector electronics and the standard TTC system which conforms to the specification of the standard system. It is also implied by Rule 7.3.
Notes:
The standard TTC links will be provided by the T/DAQ group. The receivers for the standard TTC links (See Rule 7.3.), along with the SCT-specific TTC extension are the responsibility of the SCT group (See Rule 7.4.).
The standard ATLAS TTC links are specified in document xxx.
Comments:IV.B.2.a.2 "SCT standard TTC system". It defines an interface between the SCT off-detector electronics and the standard TTC system which conforms to the specification of the standard system. It is also implied by Rule 7.3.

Notes:

The standard TTC links will be provided by the T/DAQ group. The receivers for the standard TTC links (See Rule 7.3.), along with the SCT-specific TTC extension are the responsibility of the SCT group (See Rule 7.4.).

The standard ATLAS TTC links are specified in document xxx.

Comments:

This requirement does not specify how the SCT TTC subsystem receives ATLAS TTC links. It is likely that standard ATLAS TTCrx receiver ASICs will be used; however, it is not clear whether these TTCrx's will be implemented at the level of the ROD crates or individual off-detector boards.

Status:

TTCrx ASICs

2) The SCT TTC subsystem is not required to use standard TTCrx ASICs.

Justification:

The interface to the SCT standard TTC system and its standard TTC links can be provided by receivers other than the TTCrx ASICs.

Notes:

The TTCrx ASICs will be designed by the T/DAQ group. If TTCrx ASICs are used in the SCT off-detector electronics, then they must be provided by the SCT group (See Rule 7.4 in"Trigger & DAQ Interfaces with Front-End Systems: Requirements Document", Version 1.0.)

Status:

IV.B.2.c Signals from TTC

The following requirements describe the signals which must be received by the SCT TTC susbsytem. These requirements are dictated by Rule 7.2 of "Trigger & DAQ Interfaces with Front-End Systems: Requirements Document", Version 1.0.

List of TTC signals

1) The SCT TTC subsystem must receive certain TTC signals from the ATLAS TTC system. These signals include:

BC	40MHz clock of programmable phase
BCR	Bunch Crossing Reset
L1A	Level 1 Trigger Accept
ECR	Event Counter Reset
ROD_L1ID	24-bit identification of L1A number
ROD_BCID	12-bit identification of BC number
various	Synchronous Command Signals
various	Asynchronous caommands and data

Justification:

The requirement to receive standard TTC signals is imposed by the T/DAQ group, as specified in “Trigger & DAQ Interfaces with Front-End Systems: Requirements Document”, Version 1.0, Rule 4.2. It is also implied by Rule 7.1. The list of signals is derived from Rule 7.2, along with the assumption that all of these signals will be implemented in the off-detector electronics.

Note:

To “receive” certain signals means here that, if any of these signals are used in the off-detector electronics, then the internal signal implemented is derived from the standard TTC signal. It also means that, if any of these signals are not used in the off-detector electronics,then the presence of the signal(s) in the ATLAS TTC system will not cause undesirable response in the off-detector electronics.

Comment:

Further description of these signals and their action should be included in this document (although it is assumed that they are specified in another document).

Status:

The requirement to receive certain signals is well established and stable; however, the list of signals which must be received is not completely established.

[for the following, state that signal is required, describe it, and describe what it is used for.]

BC

2)

BCR

3)

L1A

4)

ECR

5)

Synchronous comand signals

6)

Asynchronous commands and data

7)

IV.B.2.d Flow control to LVL1

The ATLAS mechanism for control of data flow from front-end electronics into the Trigger/DAQ system is one of “back pressure”. In this model, when input buffer in any Readout Buffer (ROB) module fills, that ROB asserts an XOFF bit via the Readout Link to the Readout Driver (ROD) which sends it data. In response to the XOFF bit, the ROD stops the transmission of data. If any of the buffers of any ROD fill, such that the ROD is unable to accept further input data from detector-mounted electronics, then that ROD must assert a ROD_BUSY signal which is logically ORed with all other possible ROD_BUSY signals into a global ROD_BUSY signal which is sent to the Central Trigger Processor (CTP) in order to block the issuance of further L1A signals.

Global ROD_BUSY signal

1) The off-detector electronics must provide output of a global ROD_BUSY signal to the Central Trigger Processor.

Justification:

This requirement is dictated by Rule 4.6 in “Trigger & DAQ Interfaces with Front-End Systems: Requirements Document”, Version 1.0.

The global ROD_BUSY signal provides a mechanism to request that the Central Trigger Processor (CTP) not accept any further events (*i.e.* not issue any further L1A signals. This mechanism allows the off-detector electronics to protect against buffer overflow due to a variety of causes.

Note:

The global ROD_BUSY signal is a composite (*i.e.* maskable, logical OR) of individual ROD_BUSY signals generated within the off-detector electronics.

Status:

Protection against buffer overflow

2) The off-detector electronics may assert its global ROD_BUSYsignal in order to protect its event data buffers from overflow. In determining the time to assert its global ROD_BUSY signal, the off-detector electronics must account for the number of events which may be accepted while the ROD_BUSY propagates to the Central Trigger Processor and the number of events which may already have been accepted by the Central Trigger Processor but not yet triggered in the front-end.

Justification:

Note:

The rate at which a ROD can empty its event data buffers depends upon (1) the rate at which it can transmit data on its Readout Link(s) and (2) the rate at which the ROB(s) which receives its Readout Link(s) can receive data. (ROBs control the rate at which they receive data by use of the XOFF bit which they send to the RODs.) The rate at which the event data buffers in a ROD fill depends upon (1) the rate at which it receives input data from the detector-mounted electronics and (2) the rate at which it empties the buffers. The purpose of the ROD_BUSY signal is to provide a mechanism by which, during normal operating conditions, a ROD can avoid having its buffers overflow because its associated ROB is unable to receive data. The ROD_BUSY signal also provides a mechanism to avoid buffer overflow due to temporary large fluctuations in its input rate which cause the input rate to greatly exceed the output rate; however, the ROD should be designed so as to minimize the likelihood of such a condition. (An overall deadtime of about 0.1% is allowed due to this condition anywhere inthe SCT. This overall allowance implies an allowance of only approximately 0.0004% for each ROD, assuming 256 RODs. In turn, the allowance for any one ROD input data link is 0.00001%, *i.e.* one part in ten million.)

SCT detector-mounted electronics will occasionally (but presumably rarely) malfunction so as to produce sustained, abnormally high data rates. Such occurences should not cause deadtime for ATLAS as a whole, particularly since the data from a single input data stream is not invaluable to physics analysis. The system as a whole should provide some mechanism to promptly disable assertion of the ROD_BUSY signal associated with the malfunctioning input stream. In addition, large fluctuations in the normal (*i.*e no malfunctions) input data rate may be more frequent than anticipated, and hence cause more deadtime than allowed. In this circumstance, it should be possible to configure the RODs so as to not assert ROD_BUSY.

The implications of the above discussion are that:

1. A ROD should assert its ROD_BUSY if it is receiving XOFF from its associated ROB, its buffers near overflow, and input data rates are normal on all its enabled input data links.
2. A ROD may assert its ROD_BUSY, even if it is not receiving XOFF, if its buffers near overflow due to a temporary large fluctuation in its input data rate.
3. A ROD should not assert its ROD_BUSY if it is not receiving XOFF and its buffers near overflow due to a malfunction of the detector-mounted electronics which causes an abnormally high (sustained) input data rate. In this case, it should discard the data on the malfunctioning input stream.
4. The ROD design should allow the possibility to enable assertion ROD_BUSY only when XOFF is asserted. It should also allow the possibility to disable assertion of ROD_BUSY even when XOFF is asserted.

Status:

Excessive deadtime due to overflow protection

x) The off-detector electronics should not assert its global ROD_BUSY signal such that it causes excessive deadtime for ATLAS as a whole during normal operating conditions. Excessive deadtime is more than 0.1% deadtime resulting from the SCT. Normal operating conditions are conditions during physics data taking for which the L1A rate is less than 100kHz and there are no large scale malfunctions of the SCT or of other components of ATLAS.

Justification:

[Localized malfunctions do not so severely compromise ATLAS performance that they should be allowed to cause excessive deadtime.]

[0.1% is chosen in order that several such contributions are below 1% when combined.]

Note:

Normal operating conditions include running at maximum LHC luminosity.

Different restrictions on the allowed amount of deadtime apply when there are large scale malfunctions of the SCT or of other ATLAS components.

Large scale malfunctions of the SCT are ones in which a significant localized region (greater than 1% in a single layer over the full solid angle) or a significant fraction of the full angular coverage (5% of all layers over the full solid angle) have efficiency less than 50% or ones which result in tracking efficiency for tracks passing the LVL1 electron or muon trigger to be less than 90% in a significant localized region or a significant fraction of the full angular coverage (as defined above).

Large scale malfunctions of other ATLAS components, as they apply here, are ones which cause a ROB associated with the SCT to assert its XOFF signal in a sustained or frequent fashion.

Limits on loss of event data

x) The global ROD_BUSY mechanism should operate so as to limit loss of event data under normal operating conditions in all Readout Drivers in which the ROD_BUSY mechanism is enabled. Local loss of event data should be limited to no more than 1% on any enabled (and properly functioning) input data stream. Overall loss of event data should be limited to no more than yyy% when summed over all enabled (and properly functioning) input data streams.

Justification:

Note:

The ROD design, particularly its buffer sizes, must be appropriate in order to allow both this requirement and the previous requirement to be simultaneously met.

Clarification:

For RODs whose ROD_BUSY is not fully enabled (*i.e.* ROD_BUSY with XOFF is enabled and ROD_BUSY without XOFF is enabled and ROD_BUSY with Malfunction is enabled), this requirement applies to the subset of event data for which ROD_BUSY is enabled. For instance, if ROD_BUSY with Malfunction is disabled, then event data on malfunctioning input data streams is not limited. Similarly, if ROD_BUSY without XOFF is disabled, then event data lost due to the input rate of data exceeding the output rate capability of the ROD is not limited.

Monitoring of frequency of global ROD_BUSY

4) The off-detector electronics must monitor the frequency of the assertion of the global ROD_BUSY.

Justification:
Status:

Monitoring of frequency of global ROD_BUSY contributions

5) The off-detector electronics must monitor the frequency of occurrence of any condition which contributes to the assertion of the global ROD_BUSY signal.

Justification:
Note:
Conditions which can contribute to the assertion of the global ROD_BUSY signal include all the ROD_BUSY signals of individual RODs.
Status:

Monitoring of fractional time of global ROD_BUSY

6) The off-detector electronics should monitor the fraction of time that the global ROD_BUSY is asserted.

Justification:
Status:

Monitoring of fractional time of global ROD_BUSY contributions

7) The off-detector electronics should monitor the fraction of time that any condition exists that contributes to the assertion of the global ROD_BUSY signal.

Justification:
Status:

Masking of contributions to global ROD_BUSY

8) The off-detector electronics must be configurable under program control so as to provide a mechanism to disable the inclusion of conditions which can contribute to the assertion of the global ROD_BUSY signal.

Justification:

Status:

Reset of contributions to global ROD_BUSY

9) The off-detector electronics must provide a mechanism to reset any condition

Justification:
Status:

ROD_BUSY signal

x) Each Readout Driver must provide as an output a ROD_BUSY signal which can contribute to the global ROD_BUSY condition.

Justification:
Status:

Disable for ROD_BUSY with XOFF

x) Each Readout Driver must be configurable under program control so as to provide a mechanism to disable its assertion of its ROD_BUSY signal.

Justification:
Status:

Disable for ROD_BUSY without XOFF

x) Each Readout Driver must be configurable under program control so as to provide a mechanism to disable its assertion of its ROD_BUSY signal for all conditions when XOFF is not asserted on its output Readout Link.

Justification:
Status:

Disable for ROD_BUSY without Malfunction

x) Each Readout Driver must be configurable under program control so as to provide a mechanism to disable its assertion of its ROD_BUSY signal for buffer full conditions which are caused by a malfunction of detector-mounted electronics which causes an abnormally high (sustained) input data rate on one or more of its input data streams.

Justification:
Status:

ROD_BUSY conditions - 1

x) Each Readout Driver should assert its ROD_BUSY signal when all of the following set of conditions are satisfied:
   1. XOFF is asserted on its output Readout Link,
   2. Its event data buffers are too full to receive data from another event without possibility of buffer overflow, or its data buffers are so full that data from subsequent triggers is likely to overflow the buffers,
   3. Input data rates to the Readout Driver are normal on all its enabled data links,
   4. Assertion of ROD_BUSY is enabled.

Justification:
Note:
It is irrelevant under these circumstances whether ROD_BUSY without XOFF is enabled or disabled. It is also irrelevant under these circumstances whether ROD_BUSY without Malfunction is enabled or disabled.
Status:

ROD_BUSY conditions - 2

x) Each Readout Driver should assert its ROD_BUSY signal when all of the following set of conditions are satisfied:
   1. XOFF is **NOT** asserted on its output Readout Link,
   2. Its event data buffers are too full to receive data from another event without possibility of buffer overflow, or its data buffers are so full that data from subsequent triggers is likely to overflow the buffers,
   3. The cause of the data buffers being full or nearly full is a temporary large fluctuation in its input data rate on one or more of its input data streams,
   4. Assertion of ROD_BUSY is enabled,
   5. Assertion of ROD_BUSY without XOFF is enabled.

Justification:
Note:
It is irrelevant under these circumstances whether ROD_BUSY without Malfunction is enabled or disabled.
Status:

ROD_BUSY conditions - 3

x) A Readout Driver should **NOT** assert its ROD_BUSY signal when all of the following set of conditions are satisfied:
   1. XOFF is **NOT** asserted on its output Readout Link,
   2. Its event data buffers are too full to receive data from another event without possibility of buffer overflow, or its data buffers are so full that data from subsequent triggers is likely to overflow the buffers,

3. The cause of the data buffers being full or nearly full is a malfunction of the detector-mounted electronics which causes an abnormally high (sustained) input data rate,
4. Assertion of ROD_BUSY is enabled,
5. Assertion of ROD_BUSY without Malfunction is disabled.

Justification:
Note:
It is irrelevant under these circumstances whether ROD_BUSY without XOFF is enabled or disabled.
Under these circumstances, input event data may be lost. The ROD will flag the loss of event data.
Status:

x) The off-detector electronics must assert its global ROD_BUSY signal at a time which is sufficiently early to prevent loss of event data anywhere in the SCT in less than 1% of events.
Note: 1% chosen to match derandomizer losses.
[move]

2) Each Readout Driver must output an individual ROD_BUSY signal.
Justification:
This requirement is dictated by Rule 4.6 in "Trigger & DAQ Interfaces with Front-End Systems: Requirements Document", Version 1.0.
Status:
[move to functional requirements]

3) The off-detector electronics must implement logic to combine the individual ROD_BUSY signals from all RODs in a logical OR in order to form the global ROD_BUSY signal.
[move to functional requirements]

4) Each individual ROD_BUSY signal must be maskable and resettable.
[move to functional requirements]

5) Each individual ROD_BUSY signal must be monitored.
[move to functional requirements]

6) Each ROD must assert its ROD_BUSY signal in order to:

[which is routed to the LVL1 Trigger System in order to avoid buffer overflow.
Justification:
The
A ROD_BUSY signal is required in order to avoid buffer overflow and in order to hold off triggers while
Status:
text

[move to functional requirements]

IV.B.3 Data Acquisition System (DAQ)

IV.B.3.a Configuration

[Include a requirement for an SCT DAQ LAN in the functional requirements. (or does it belong here because it is required of us by the DAQ group?]

DAQ configuration

1) The data acquisition aspects of the off-detector electronics must be configurable under the control of the Data Acquisition System.

Justification:
Note:
"Data acquisition aspects"refers to all aspects of the off-detector electronics which relate directly to the flow of event data through the off-detector electronics from the detector-mounted electronics to the Trigger/DAQ System. For instance, data flow through the Readout Drivers and configuration of the detector-mounted electronics are data acquisition aspects.
Status:

IV.B.3.b Monitoring of data flow

DAQ monitoring

2) The off-detector electronics must provide facility for the Data Acquisition System to monitor the flow of event data through the off-detector electronics.

Justification:
Status:

Data flow error reporting

3) The off-detector must provide a mechanism to report errors in the flow of data to the Data Acquisition System.

Justification:
Status:

IV.B.4 Detector Control System (DCS)

[This section is the location for any requirements which there may be upon the off-detector electronics arising from DCS. However, since power supplies and