10-April-1998

# Report on the CTP/TTC review

## 1.0 Members of the review panel

| | |
|---|---|
| R. Blair | LVL2 Trigger |
| J. Colas (chair) | LAr |
| N. Gee | LVL1 Calorimeter Trigger |
| A. Grillo | Inner Detector |
| A. Konig | Muons |
| G. Mornacchi | DAQ |
| E. Petrolo | LVL1 Muon Trigger |
| I. Vichou | Tiles |

The panel composition ensures a good representation of the various ATLAS sub-detectors.

## 2.0 General comments

### *2.1 Usefulness of the review*

It will be up to the members of the trigger team to assess for themselves the usefulness of the review, however, the panel would like to underline already that the review was useful for the various sub-detectors which were presented with the tools (CTP and TTC) which they will have to work with in ATLAS. This was a good opportunity to check that the various sub-detectors requirements are fulfilled.

### *2.2 Scope of the review*

This was the very first review of the CTP/TTC system. The goal was restricted to check the main functionalities. It is a good first step and the panel would like to thank those who contributed. This clearly should be followed by more technical reviews which will have the task of understanding detailed implementation, construction schedule, etc.

### *2.3 Documentation*

The panel would like to thank the central trigger group for the useful documentation which was made available before the review and is easily accessible from the WEB. Some documents are already in very good shape, some others would have benefited from more time and will need to be improved or completed. Examples of topics which would benefit from a better description: partitioning of the system, interfaces to the

RUN-CONTROL and BUSY signals. More information than that available in the documentation was indeed given during the presentations and it would be nice if this could be included in later revisions of the documents.

The panel would like to note that to be useful this documentation should be updated regularly and, also, very importantly, should receive feedback from the various sub-detectors. May be a contact person in each sub-detector group has to be identified. In the meantime, if the trigger team considers that this might be useful, the panel members would agree to read and check new versions which might be produced before the TDR.

### *2.4 Relation to DAQ/RUN-CONTROL*

The CTP/TTC systems will need strong interactions with the DAQ/DCS systems. Discussions between the central trigger group and the DAQ/DCS groups have to be organized to clarify and specify for both the CTP and the TTC systems which control operations have to be supported by the DCS and which ones have to be supported by the DAQ Run Control system. It is also suggested to document these operations, for example the setup of the Busy logic and the configuration of the partitions.

## 3.0 Comments on specific topics

### *3.1 Number of input bits to the CTP:*

The CTP trigger design involves taking various multiplicity counts from each of the Level1 Trigger systems and transforming them via a number of seven bit look up tables fed by eighteen inputs. This is then followed by a programmable logic decoder. This scheme results in 96 independently scalable and pre-scaled triggers. The mapping between the inputs and these independent triggers is quite complex and assuring that there is enough flexibility to accommodate all the triggers and tags needed is essential. It is important that the group demonstrate that this scheme can be used for a reasonably complete physics trigger menu, and that there is sufficient headroom to add unforeseen trigger combinations which are independent. The 30 additional uncommitted bits seemed to be adequate for future hardware expansion. For instance, less than 16 bits seem to be enough to cover the need for test-pulse triggers from the various sub-detectors. However, this has to be confirmed by dialog with the various subgroups.

The CTP trigger system has been designed, trying to minimize latency, on a single board, avoiding board to board communication. This brings some limitation to the number of input bits as discussed above - 128 in the current design, a number which looks reasonable. However, the panel would like to warn the ATLAS community that to increase this number significantly would probably require a major rethinking of the system. This or a significant amount of additional logic in front of the CTP would be needed if, for instance, one requires a topology trigger that fires on patterns in different spatial zones.

*3.2 Pre-scaling:*

The scheme proposed for pre-scaling seems to be generally satisfactory, except for the handling of pre-scaling factors greater than 4095. The proposed scheme involves use of a single random bit to generate a large pre-scaling factor. We recommend that this be looked at again with the intention to provide, in a clean way, a few pre-scaling counters capable of reducing a 40 MHz signal to an acceptably low rate without bias. More than one such scaler might be needed. If a random signal is used for this, it should be via one or more separate inputs so that the random trigger input is not over-subscribed. It should be easy to change the pre-scaling factor to follow any changes in machine luminosity.

*3.3 Dead-time and luminosity monitoring:*

Two dead-time algorithms are proposed. The first one introduces 4 dead crossings after each Level1 Accept. A more complex one limits the number of triggers in a sliding window in time, e.g. no more than 8 triggers in 80 μs. This seems to be adequate to avoid overflowing front-end buffers.

The CTP is proposed to include scalers to count each of the input data bits and also to count each of the trigger candidates before and after vetoes and pre-scaling have been imposed. Scalers are also planned for the L1A, external vetoes and dead-time vetoes. The review panel believes that this set of scalers is sufficient to monitor the dead-time and thereby correct cross-section calculations. It is assumed that luminosity monitors will be present as part of the detector and that the CTP will scale or integrate such monitors.

Mention was made of possible extra scalers to monitor luminosity and background bunch-by-bunch. The panel believes that this is very important and should be included. The appropriate subset of quantities to scale in this way and the technique selected could be reviewed at a later date with the detector and machine experts.

*3.4 ROD_Busy:*

The function of ROD_Busy as an inhibit to Level1 Triggers is not clearly described or defined. In addition, this signal has to be understood as a veto coming not only from the RODs but also more generally from the DAQ. The name ROD-Busy might, therefore, be misleading. Discussions with the Trigger group revealed that there is the intention to have a common module to "OR" ROD_Busy from all the RODs of a sub-detector or partition into one signal to be passed to the CTP. This module would also provide a mechanism to mask out certain RODs and to monitor which RODs where causing ROD_Busy to be asserted. Such a common module with an interface to the Run Control is very important in order to maintain uniformity of the system. It would be helpful if such a module were described in the documentation of the CTP. Furthermore, it would be helpful to the understanding of the detector community if the operation of the ROD_Busy were described in at least three different run scenarios that can be thought of:

- All detector partitions running and collecting physics data.
- At least two different partitions running under different conditions (e.g. one running in a diagnostic mode)
- At least one partition running in a diagnostic mode independent of the normal TTC and CTP operation.

*3.5 Test pulses in physics runs:*

Several sub-detectors require test-pulses in physics runs either in the gap or in the "active" bunch crossings. For calorimeters (Tiles - LAr) it is important that these calibration pulses are fired "randomly" in time to sample uniformly the beam condition in the various crossings.

Such "calibration" events require a sequence of 2 signals: the test-pulse command followed after a fixed number of bunch crossings by a Level1 Accept.

The panel would like to ask the trigger team to implement this facility in the CTP which presently generates only the Level1 Accept and not the test-pulse command itself.

The test-pulse command might then be fed into the TTCvi module which should encode the command to be distributed on the TTC network.

More detailed questions like:

- Should the other sources of trigger be vetoed to let the calibration sequence go?
- Are extra delays needed to accommodate different pipeline lengths (i.e. in the TTCvi module)?

should be discussed with the various detectors groups.

*3.6 Timing alignment of the various sub-detectors:*

The current strategy is to wait for particles to align in time the various detectors. The panel acknowledges that particles will indeed provide the final alignment in time with the beam. However, the panel would like to underline the advantages of aligning the various sub-detectors, one with respect to the other using test-pulses injected at the front-end electronics. These pulses should be timed such as to mimic pulses coming from the interaction point. This would require a common source for the pulsers as described in 3.5 and that the detectors control the timing of the distribution of their test-pulse command. It would then be possible to check that the information comes in time into the CTP and also in time in the read-out chain. Obviously, the whole question of synchronization is something of enormous complexity which goes beyond the CTP/TTC system alone. This requires detailed discussions between the central trigger group and the various detector teams.

*3.7 Latency:*

The panel would like to compliment the trigger group on their strong attempts to keep the Level1 Latency within their target specification of 2 μs.

We also note that the CTP + TTC system latency is estimated to be 8 clock cycles plus connecting cables. The TTC latency has probably not been allowed for in previous latency estimates (i.e. the muon and calorimeter trigger latency as given in the open presentations), but we understand that it has already been reduced and that further reductions are unlikely. The cable delay from the CTP to the TTC system may introduce extra latency (2 ticks were suggested). Detailed tables, consistent with these estimates, should be produced for all sub-detectors. We also recommend that the TTC distribution system be moved close to the CTP for the detectors requiring the shortest latencies (e.g. LAr) and that the routing of the TTC fibers from the TTC system to the front-ends be watched carefully.

*3.8 Partitioning:*

A large system like ATLAS needs to be partitioned so that different sub-detectors or partitions within sub-detectors can run concurrently i.e. during the setup phase or for debugging purposes. When connected to the central system, a partition receives its input from the CTP. In local mode, a "local trigger processor" becomes the source of the trigger.

As explained during the review, a partition would consist of a VME module (TTCvi) and a TTC crate with its associated distribution network. This is OK if the number of partitions per sub-detector is "small" as indicated in the table shown during the open presentation but is probably not cost effective if the number of partition is large as envisaged by the LAr team in their TDR. It is also not clear if the number of partitions indicated in the transparencies is the wish of the trigger team or is endorsed by the sub-detector groups. Discussions between the various parties should allow all groups to come to agreed numbers which should then appear in the "Use of the TTC in ATLAS" document.

The panel would also like to underline that the whole issue of partitioning needs good contact with the RUN-CONTROL which will have to configure the system and with the DAQ which may have to acquire the data. All of this is not very well defined yet.

*3.9 Precision required in the timing distribution:*

The Liquid Argon calorimeter seems to set the most stringent requirement on the precision of the timing distribution: 100 ps. The $\pm$ 1 ns requirement appearing in the TTC URD is not satisfactory.

*3.10 TTCRx:*

The range of timing adjustment within a zone as set by the TTCRx is 16 BC. Some sub-detectors might make use of a larger span if this should become available.

The panel positively acknowledges the fact that now the internal registers of the chips are accessible by a local bus.

### *3.11 Use of the Long Interbunch Gap:*

A few groups have expressed interest in use of the long gap in between trains of bunches for calibration and test purposes. There is a need for all requirements to be collected and considered together. Hardware support may be needed to control the sequence of operations, and the CTP is an obvious place where this might be done. We suggest that the CTP group oversee the collection of this information and it's subsequent discussion.