Final Design Review of Timing Control Module (TCM)
(ATLAS Level-1 Calorimeter Trigger)

Introduction

The Final Design Review (FDR) for the TCM was held on November 17th 2005 at RAL. Its purpose was to assess each function of the module, including its implementation, to ensure that the specifications fully met the specific requirements of each of the four calorimeter trigger sub-systems (PPr, CP, JEP and ROD). This was the final opportunity to add features or make minor changes to the design before commencing full production. As the total cost of the TCM production will be less than CHF200K, there was no requirement to hold a formal ATLAS Production Readiness Review (PRR), so the scope of this Review was extended to cover aspects of module production and testing.

It was intended to assess the module specifications from several different aspects, so the reviewers were chosen for having expertise in areas of electronics and system engineering, data acquisition and software. The Review panel consisted of:

Bruce Barnett *(RAL)*

Eric Eisenhandler *(QMUL)*

Tony Gillman *(RAL)* - Chair

Uli Schaefer *(Mainz)*

Richard Staley *(Birmingham)*

The module team were represented by:

Adam Davis *(RAL)*

Norman Gee *(RAL)*

Viraj Perera *(RAL)*

The designers provided to the reviewers a module specification document and a Test Plan:

ATLAS Calorimeter First Level Trigger – Timing Control Module, Draft 0.8_2
http://hepwww.rl.ac.uk/Atlas-L1/Modules/TCM/TCM_Draft_08_2.pdf

ATLAS Calorimeter First Level Trigger – Timing Control Module, Test Plan, Draft 0.4
http://hepwww.rl.ac.uk/Atlas-L1/Modules/TCM/TCM%20test%20plan%200.4.pdf

Introduction

Two of the reviewers had submitted in advance a number of comments on the documentation. Some of these had already been incorporated, and others were discussed during the Review itself. A compilation of these comments, and the agreed actions arising from them, can be found in the Appendix.

The Review started at 10:45 with Norman Gee presenting a comprehensive overview of the module specifications, and highlighting areas where decisions on design changes needed to be made. Although the original prototype TCM used two different Adapter Link Cards (ALCs) to accommodate both CP/JEP and VME64x crate environments, this new design achieves this by providing two physically different module designs. There is no longer any requirement for a Rear Transition Module.

The presentation was divided into four separate sections, corresponding to different aspects of module functionality (TTC signal handling, CANbus control, VME operations, VME64x(P) auxiliary backplane), and concluded with some comments on manufacturing and test procedures. The reviewers summarised their conclusions and recommendations after each section.

The following summaries of these four sections each conclude with the points raised in discussion and the subsequent reviewers' recommendations:

1. TTC Signal Distribution

The status of the incoming TTC signal is indicated by a front-panel LED and a VME register status bit, and the encoded TTC clock can be monitored via a front-panel coaxial socket. The encoded TTC signal path from input fibre to backplane fanout was described: 20 CP/JEP crate slots (1-20) and 18 VME64x crate slots (3-20) are fed, with source-terminated drivers to allow for unoccupied crate slots. For the CP/JEP crates the custom backplane provides point-to-point transmission line distribution of these signals, but for the VME64x (ROD) and VME64xP (PPr) crates an auxiliary custom backplane will be required, using non-bussed User-I/O pins on the J0 connectors.

Issues that arose in discussion:

a) Extension of the encoded TTC signal distribution in the VME64x(P) crates to include slot 2

Although no use was currently foreseen for this, the reviewers recommended that the TCM itself should provide sufficient TTC signal outputs to provide for it, if possible.

However, as it was unclear if two extra User I/O pins were available on slot 21 J0, the module team were asked to ascertain its feasibility without compromising the existing TTC signal distribution.

b) Capture of transient loss of optical TTC signal

The current scheme only indicates that optical power is instantaneously above threshold.

The reviewers recommended that transient falls below threshold should be captured in a status register, which should be readable and resettable via VME.

c) Removal of front-panel connectors supplying electrical encoded TTC signals, as provided on prototype modules

Although occasional use may be found for these signals, TCM front-panel space is very limited, and the TTC Fanout module now provides this function.

The reviewers recommended that these outputs should no longer be provided, but an AC-coupled version of the encoded TTC signal should continue to be made available via a front-panel coaxial socket to provide for scope monitoring.

d) Correct termination of encoded TTC signals distributed to all crate slots

To ensure correct operation of the extended-swing LVPECL TTC signals, the reviewers recommended that the termination scheme on all destination modules (PPMs, CPMs, JEMs, CMMs, RODs) should be a single resistor across the differential pair matching the characteristic impedance of the distributing backplane.

2. CANbus Interfacing

There are three CANbus sections controlled by the Level-1 Calorimeter Trigger DCS, one of which is the 16-crate ensemble of PPr and Processor modules. The bridge between this external CANbus and each internal crate CANbus is provided by the TCMs resident in the 16 crates. The external CANbus is driven by a PC-based Local Control Workstation, and connected to each TCM in a daisy-chain architecture. One port of a dual-port Fujitsu microcontroller resident in each TCM is optically coupled (for ground loop isolation) to the external CANbus, and the second port interfaces to the crate CANbus. Front-panel sockets provide diagnostic access to the internal and external CANbus, and for programming the microcontroller.

Each TCM regularly collects module data for temperatures, supply voltages and currents, and receives alarms when preset limits are exceeded, which it forwards to DCS via the external CANbus.

The CANbus architecture has been shown to operate satisfactorily so far with prototype modules using LabView software, and the distributed processing power in the microcontrollers has been demonstrated to be adequate. However, an appropriate interface to DCS must be developed for use in ATLAS. Options currently under consideration are CANOpen or a custom OPC server, and a suitable implementation should be ready by Q2 2006, and documented in EDMS.

Issues that arose in discussion:

a) Definition of gender and location of microcontroller programming socket for all modules

   This connector must be a 9-pin D socket (female). Although this socket is provided on the front-panel of most modules, the ROD and PPM have insufficient front-panel space. For the ROD, the socket will be located on the RTM, but for the PPM the location is currently unclear – either on the J0 auxiliary backplane or on the RGTM.

   The reviewers recommended that this issue be resolved as soon as possible.

b) Isolation of external CANbus cable grounds

   In order to avoid noise associated with ground loops, the reviewers recommended that the CAN_GND connection on the 9-pin D connector should be AC-coupled to TCM chassis ground via a 100nF capacitor.

   Grounding of any global cable shield connection should conform with general ATLAS grounding policy and be approved by Georges Blanchot.

   The reviewers also recommended that a separate DC-DC converter should be added to supply VCC to the CANbus optical isolators and to the CAN Controller Interface.

c) Dual-port memory size

   The reviewers recommended that the size of the dual-port memory should be doubled, from 1 to 2 kilobytes, requiring the routing of one extra address line.

d) Fujitsu MB90F594 Microcontroller Flash memory size

   The possible move to CANOpen may require more Flash memory for firmware code, which cannot be provided by additional external memory as there are no spare pins available.

   The reviewers recommended that a test should be made using actual CANOpen code from an ELMB to assess realistic memory requirements.

   (N.B. This test has now been carried out by Adam Davis, with the result that, even with both level-1 and CANOpen code embedded into the microcontroller, only 67% of the ROM and 38% of the RAM are filled.

e) Monitoring of CAN activity

It should be possible to monitor that the CANbus controller is active at all times, and various techniques for achieving this were discussed.

The reviewers recommended that a "watchdog" timer in conjunction with the CANbus Tx signal should be established. This should set a "CAN ACTIVE" bit in the Module Status Register, the CPLD for which would therefore require one extra input.

3. VME Interfacing

The TCM provides interfacing to the three different VME bus standards used in the level-1 calorimeter trigger processor: VME64x (ROD crates), VME64xP (PPr crates) and VME-- (CP and JEP crates). To accommodate the differences between these standards (J0, J1, J2, J3 connectors, protocol, crate GA setting and bus termination), two variants of the TCM will be designed, one for VME64x(P) *(TCM-VME)* and the other for VME-- *(TCM-CP/JEP)*.

Other facilities provided will be LED and hex displays of address/data lines and bus protocol signals. The upper part of the 2 kilobyte memory provided for CANbus data storage will also be accessible to provide a simple VME Read/Write test facility.

The VME address space includes Module ID, Control, Status and Test registers in addition to the CAN/VME memory.

Issues that arose in discussion:

a) Distribution of crate Geographical Address bits in VME64x(P) crates

These four bussed lines may be defined by a switch or by solder pads on the auxiliary crate backplane mounted behind J0.

The reviewers recommended that the simpler solder-pad solution should be provided, but that the footprint of the pads should be compatible with surface-mounting a switch if desired for use in a lab environment.

b) VME-- bus termination

The reviewers recommended that the VME-- bus termination resistor network should be identical to that provided on the VMM at the other end of the crate.

c) CAN/VME Test Memory

Full 32-bit Read/Write capability would be desirable for D32 cycle diagnostics. Although the 32 Data lines could be checked using the two Test Registers, this would provide no means of exercising the Address lines.

The reviewers recommended that the width of the CAN/VME dual-port Test Memory should be increased from 8 bits to 32 bits by the addition of three more memory devices. The full memory width would be visible only from VME, but only the lowest byte is required to be dual-ported as the CAN memory is byte-wide only.

d) VME cycles

The reviewers recommended that a check should be made to ensure that whenever a legal VME bus cycle occurs, it is always captured and displayed correctly in the TCM.

e) Dual-port memory arbitration

It is clearly important to prevent access contention to the dual-port CAN/VME Test Memory, with priority being given to the CAN port during normal operation.

The reviewers recommended that a simple arbitration scheme be adopted to prevent VME access to this memory whenever CANbus operations are in progress.

f) VME64xP J0 pinout

The reviewers recommended that the full definition of the J0 connector pinout should be provided in the TCM Specifications.

4. The Auxiliary Crate Backplane

The purpose of this component is to distribute the CANbus and the point-to-point TTC encoded signals to all of the modules in a VME64x(P) crate, where there is no custom backplane provided. In addition, it will be used to distribute the four crate Geographical Address bus lines, using solder pads on the backplane itself to define the bits *(see Recommendation 3a above).* It will mount on to the rear-facing through-pins of the J0 connectors, extending from Slots 2-21, with the CANbus terminated at its far end at Slot 2.

Issues that arose in discussion:

a) Slot coverage

The reviewers recommended that the auxiliary crate backplane in the VME64x(P) crates should be extended to cover Slot 2.

b) Geometrical constraints when using the auxiliary crate backplane

The reviewers recommended that the current S-link Rear Transition Modules on the ROD crates be checked for providing adequate clearance behind the J0 connector for the auxiliary crate backplane, and modified if necessary.

c) Mechanics

There was concern about the potentially high forces required to insert or remove the auxiliary backplane from J0. One option discussed was to manufacture it as a flexible PCB (e.g. a Kapton/Cu multi-layer laminate) rather than as a monolithic FR4 multi-layer laminate, thereby enabling insertion into each connector sequentially.

For reasons of robustness and reliability, the reviewers recommended that a conventional monolithic FR4 multi-layer laminate should be used to form the auxiliary backplane.

However, as very few pins are used on all of the crate slots except for the TCM, the reviewers recommended the use of custom connectors with only a small number of rows/columns to minimise insertion and removal forces.

5. Miscellaneous Issues

a) Numbers of modules to manufacture

The reviewers recommended that the following numbers of modules should be manufactured:

- ***i) TCM-CP/JEP – 13 modules (6 in ATLAS + 4 spares + 3 in Test Rigs)***
- ***ii) TCM-VME – 18 modules (10 in ATLAS + 4 spares + 4 in Test Rigs)***

Appendix* – Reviewers' specific comments *(resolved issues are shown italicised)

Table 1 - As discussed, total numbers are now 13 for CP/JEP and 18 for VME.

AGREED – TABLE 1 WILL BE CORRECTED

Section 3.2.1 – Second paragraph has too much implementation detail that should be moved into Section 5, such as part numbers for the internal distribution. Keep the signalling standard *i.e.* LVPECL with series termination.

AGREED – WORDING WILL BE CHANGED

Could the cable drivers be described as something like 'extended swing LVPECL' cable drivers? Either mention the device (SY10EP89V) or list the logic swing levels.

I remember the TCM was being designed with an option to bypass or short the series termination. Has this option been removed now, being unnecessary because of the extended/double swing cable drivers?

YES – IT HAS BEEN REMOVED

Section 3.2.2 (2nd bullet) – It is not decided that the node limits will always be downloaded at startup, rather than kept in the firmware. Perhaps soften this point to something like: "The TCM can load the individual node limits at system startup; details to be decided."

AGREED

Table 2 – Incorrect coding for Crate Nos 8, 9:

	GA8*	**GA7***	**GA6***	**GA5***
Crate 8	GND	Open	Open	**Open**
Crate 9	GND	Open	**Open**	**GND**

AGREED – TABLE 2 WILL BE CORRECTED

Figure 3 – The TCM-CP/JEP block should only show VME-- and the TCM-VME block should only show VME.

AGREED – FIGURE 3 WILL BE CORRECTED

Section 5.3 – No mention of TTC signals on backplane. The implementation details from section 3 should go here.

AGREED – SECTION WILL BE RE-WRITTEN

Figure 4 – I guess the lower rectangles are the 15-way D-types for the CAN. Please label.

AGREED – FIGURE 4 WILL BE CORRECTED

Section 5.7.4 – The CANuC Programming bit is missing (assuming the scheme adopted by the ROD and CPM is being followed). This will need another register as it is not a pulse function.

AGREED – VME REGISTER MAP WILL BE UPDATED

5.7.4.7 – Uli asked for more memory, as JEMs apparently can have up to 56 CANbus parameters. I am not very sympathetic to this, it's overkill. We should not read out huge quantities of data and send them to PVSS – we should realise that all that will come out of the voltage and temperature monitoring in the end is "ok", warnings, or a decision to turn the crate off. It's nice to have more info in order to study trends, but we should not go crazy.

NOT AGREED – CAN/VME MEMORY SIZE WILL BE DOUBLED (Section 2c above)

Appendix C (CANbus controller programming socket) – The table actually describes the PC end of the cable, but it should actually list how the pins on the TCM are used. *i.e.* for the CPM, maybe something like:

Pin	**Signal**	**Use**
1	DCD	not used
2	RxD	RS232 out
3	TxD	RS232 in
4	DTR	connected to pin6 as CAN Reset
5	GND	
6	DSR	connected to pin4 as CAN Reset
7	RTS	linked to pin8
8	CTS	linked to pin7

AGREED – APPENDIX C WILL BE CORRECTED

Improvements to the description

Section 1.2 para 1 line 3 – This should indicate division of responsibilities more clearly: "... and a separate subsystem (responsibility of central DCS) that controls and monitors rack environmental conditions."

Section 3.1 point d) – The need for TCM-VME to interface to BOTH VME64x and VME64xP would be made a bit clearer if this was slightly changed, to "Interface to the VME64x and VME64xP, or VME--, backplanes."

Section 3.1 point e): Likewise - "Provide LED and numeric displays of VME64x and VME64xP, or VME--, transactions."

Figure 3 – (a) caption has gone onto next page

(b) should indicate that the labels on the front panel apply to both versions

(c) TCM-VME doesn't show where its CANbus and power connections are - it should have a label on J0 as this is one of the main points being illustrated by the diagram

Figure 4 – would be much more informative if the CONNECTORS were labelled

Section 5.2.1 (line 1) – "The EXTERNAL CANbus signals ..." (important to distinguish clearly between external and internal CANbus). This section would be better moved back into section 5.3.2, where it used to be.

Section 5.3.2 – According to this section, there is a DB9 plug on the front panel that is the connection to the external CANbus, and a DB9 socket that allows the CAN microcontroller to be programmed. It would help the reader to see what's going on if:

- Section 5.2.1 were moved back to this section, where it used to be
- The distinction between the plug and the socket were described a bit more clearly in terms of gender (male/female)
- Figure 4 were labelled for the ST, DB9 plug and DB9 socket connectors. (It also needs the diagnostic points)

Section 5.3.3 para 1 line 3 – Again, be a bit more explicit: "... TTC timing signals and the internal crate CANbus signal pins."

Section 5.3.4 para 4 line 1 – "... the TTC and internal crate CANbus signals ..."

Section 5.3.8 para 5 line 2 – "... may be added at the top rear of the backplane ..." is what I think you meant

Section 5.4 line 2 – You moved the grounding from 5.3.2 to 5.2.1 – but above I suggested that you move it back! If not you MUST fix the reference.

Section 5.10 last line – "... the FDR/PRR stage." since there is no separate PRR

Section 6.2 line 1 – 18 is not correct. Safest would be to just say: "Initially four pre-production modules, two of each type, and following acceptance the remainder of the production modules (see Table 1), with the firmware ... At minimum, fix the "18" to match the numbers we agree for the table.

Section 6.7.1 – be sure the quantities match Table 1

Glossary – (1) Make it alphabetical

(2) missing items include "LCS", "CTP", "LTP", no doubt others ...

Section 8 – inconsistent heading styles; also add v0.8 and subsequent versions

ALL AGREED – CHANGES WILL BE IMPLEMENTED

Minor typos

Section 1 para under bullets line 4 - "**Timing, Trigger** and Control" not "Trigger Timing and Control"

Section 3.1 point g) – spurious long space after "VME--"

Section 3.2.1 para 1 line 4 – "**A** NIM" not "An NIM" since we say "nim" not "N-I-M"

Section 3.2.2 para 2 line 2 – "firmware" not "firmwa**q**re"

Section 3.2.4 para 1 line 5 – "backplane to" (space missing)

Table 2 – please set table properties so it doesn't break over a page

Section 5.1 line 1 – missing space in "VME-- bus"

Section 5.2 last para – "impleme**n**tation" (missing n)

Section 5.3.2 para 2 line 1 - "... is provided **to** program"

ALL AGREED – CHANGES WILL BE IMPLEMENTED