
MONSOON –Torrent
Production Readiness Review
Functional and Electrical Description 1
Peter Moore

Torrent Pedigree from the MONSOON "*Functional and Performance Requirements*" Document - MNSN-AD-04-0001.

System Purpose

The MONSOON Image Acquisition System will be a scalable, multi-channel, high-speed image acquisition system. MONSOON must meet or exceed all of the needs of the currently defined, or anticipated in the next ten years, next generation NOAO systems requiring image acquisition capabilities regardless of wavelength or underlying detector technology.

It is fortunate that, the basic needs for these systems are constant regardless of detector technology.

- The need for an interface to the user with the ability for image acquisition parameter definition and image request.
- The need to interface to the technical staff for system configuration and system diagnostics.
- The need for interface to the telescope, instrument, and observatory to acquire status for FITS header information.
- The need to acquire "detector limited" images in an efficient manner which maximizes "open shutter" or integration time.
- The need to interface to the image handling system to pass the packaged FITS image off to the observatory system and observer.

See http://www.noao.edu/ets/monsoon/techdoclist.html

Torrent Requirements - Document TRNT-AD-11-0001

Area of application

This self contained detector controller shall have sufficient functionality to replace actual detector controllers in use through the astronomical community without compromising existing performance.

Advantage / motivation

Replace unreliable or high maintenance hardware.

Replace hardware that cannot be repaired because of obsolete components.

Unify detector controller architectures to reduce maintenance burden.

Applied to new instrumentation without risk of 'single source' components.

Project lifecycle

Project Phase	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Development		xx	xxx	xxx									
Evaluation			xx	xxx	xx								
Production				x	xxx	x							
Deployment					xxx	xxx	x						
Enhancement					xx	xx					x		
Operational Life					xx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx
Obsolescence											????		

Torrent Requirements - Document TRNT-AD-11-0001

Generic qualities

The application of the controller to specific functionality shall be through selection of a board suite, hardware configuration, and 'runtime' configuration options. The hardware assembly shall be called the Detector Head Electronics (DHE) package. Current plans for board suite selection for the DHE are:

- Generic Local Control Board.
- CCD Analog Front End board.
- IR Analog Front End board.
- Power supply board.
- Utility Board (Temperature control, Shutter).
- Preamp board (or Current Source board for IR).

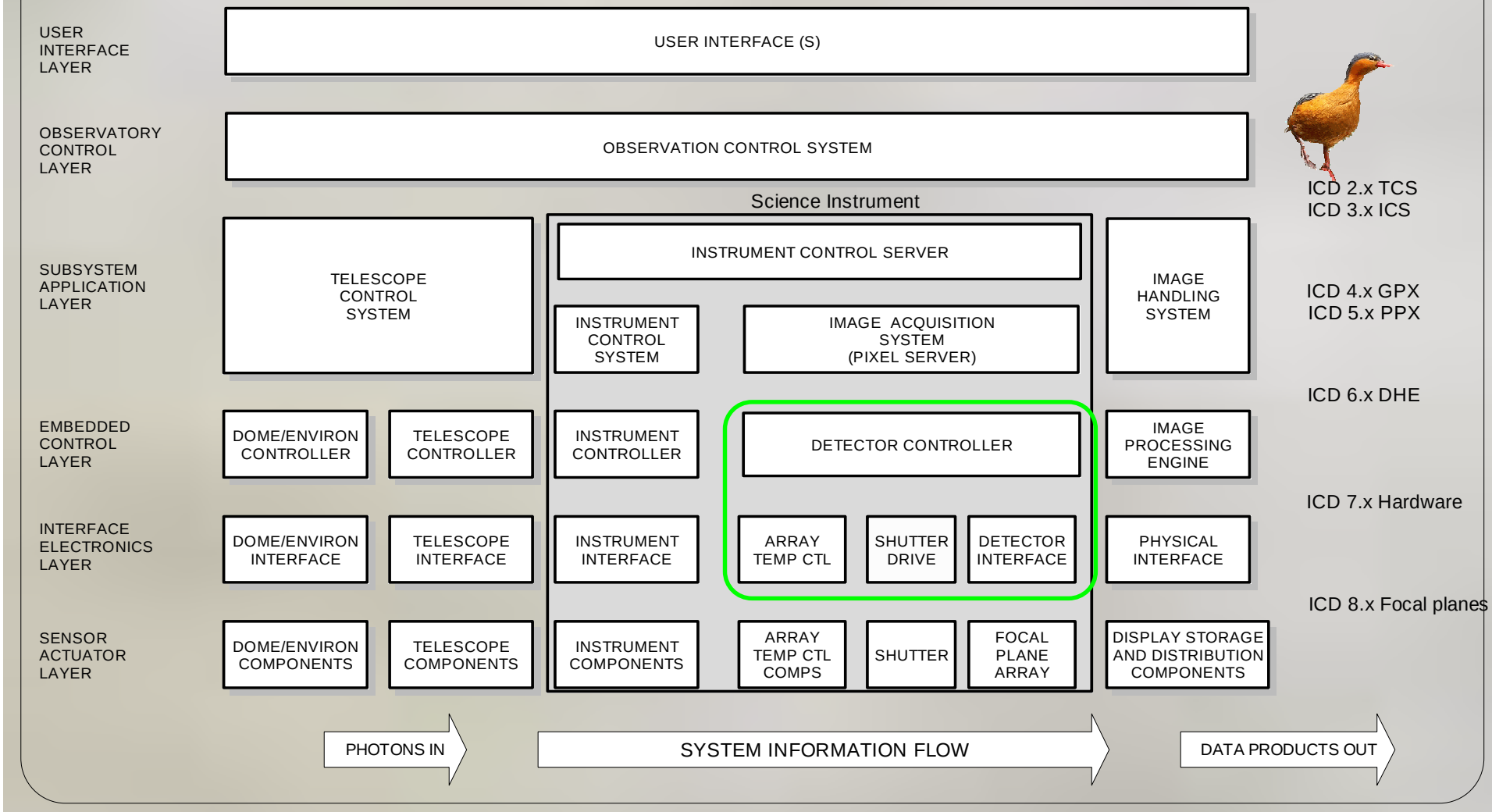
The cost to purchase shall be consistent to the required capabilities i.e. cost should scale with number of video channels, etc. Baseline cost for a four channel CCD system is $10k

- The controller hardware will be compatible with existing Pixel Acquisition Node (PAN) hardware and software.

- Support for card serial numbers, auto-configuration, and auto-calibration using expanded NOAO software suite, support for comprehensive telemetry sensing, support for card temperature sensing.

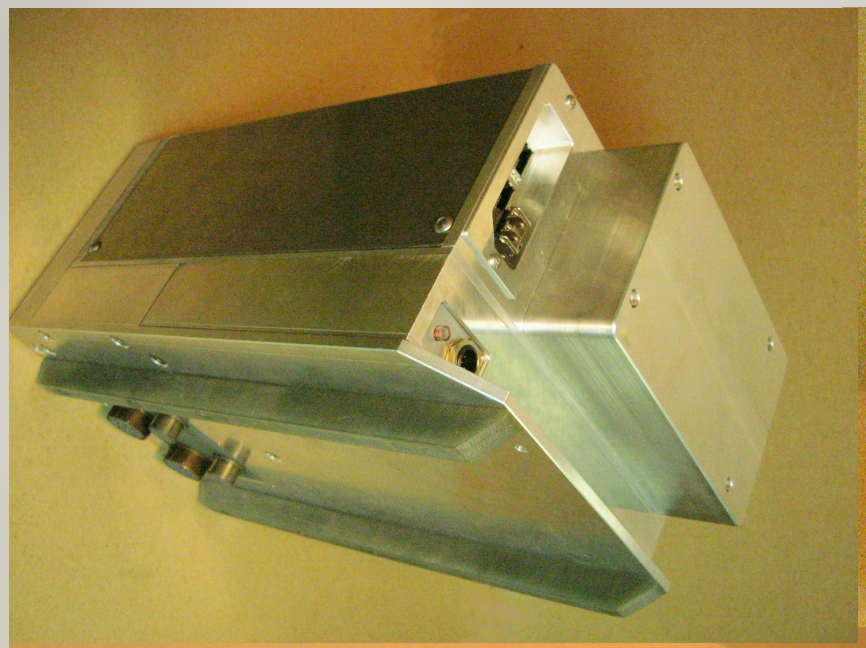
Torrent Design – Based On Interface Control Documents (ICD)

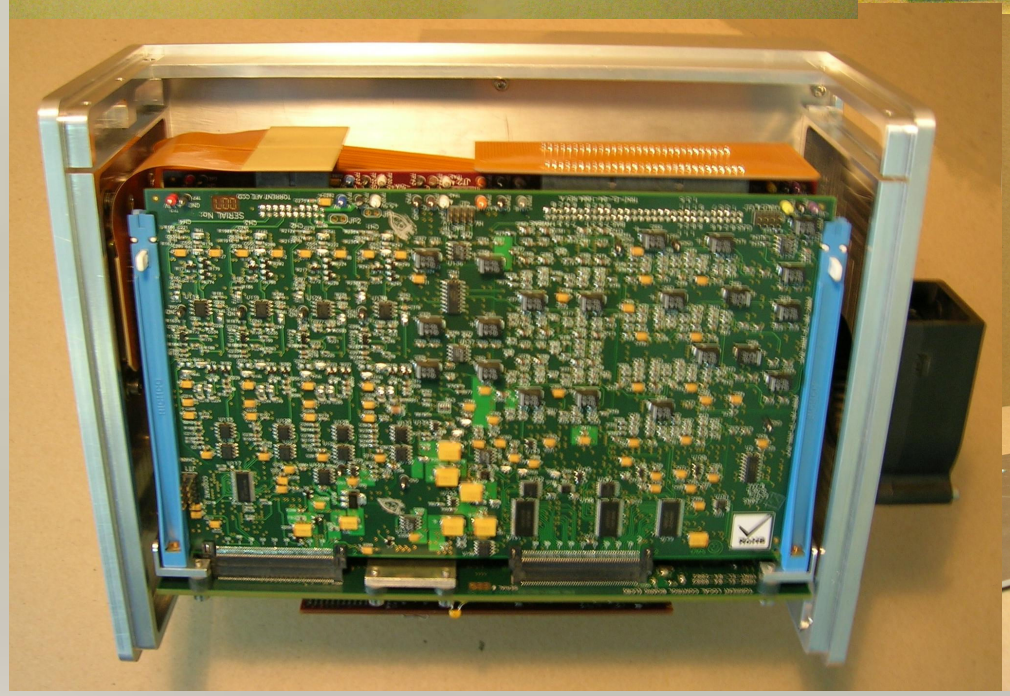
OBSERVATORY SYSTEM REFERENCE MODEL

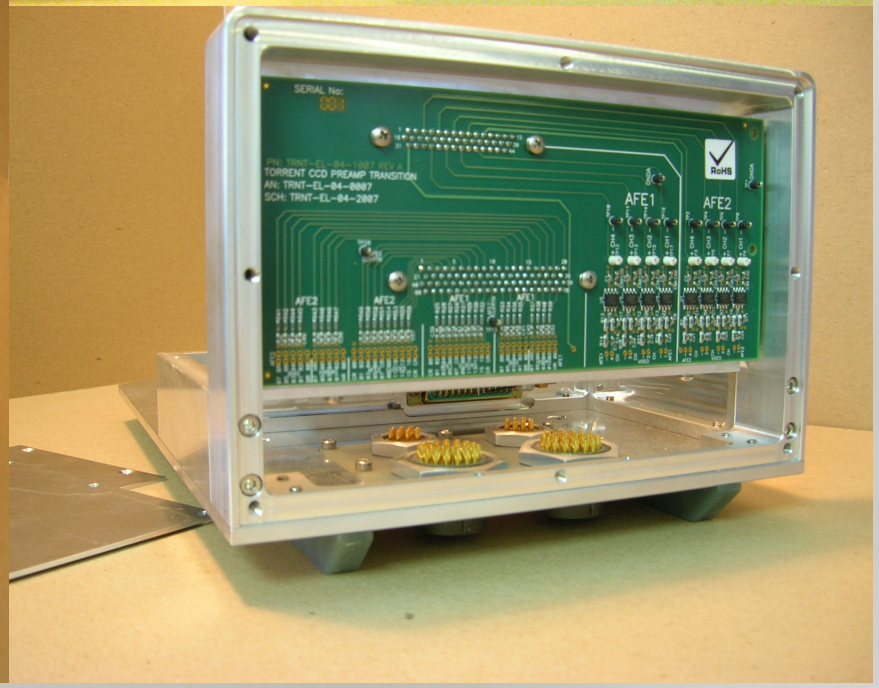


See http://www.noao.edu/ets/monsoon/ICD.html

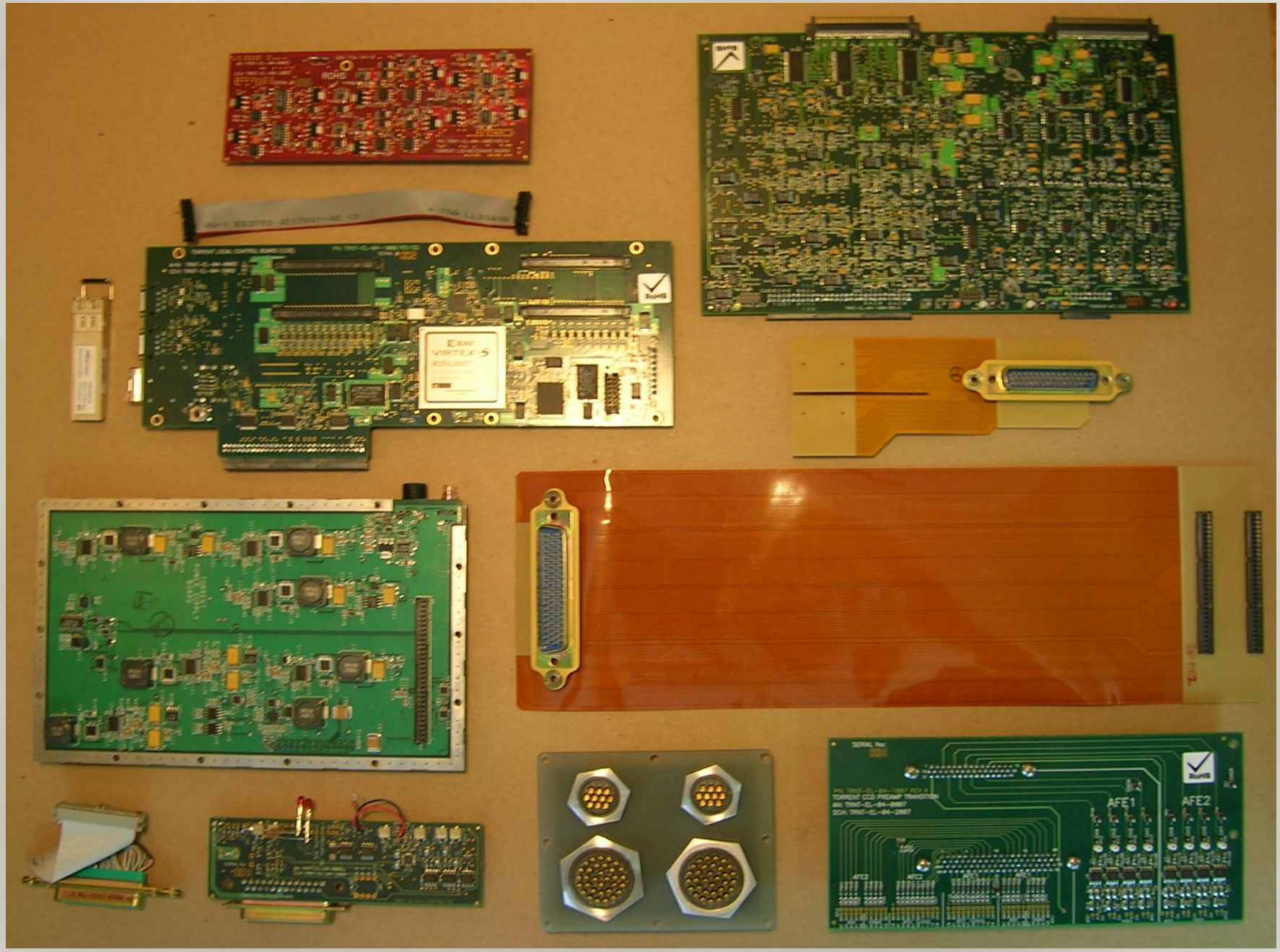
Torrent Design – DHE Survival and Access







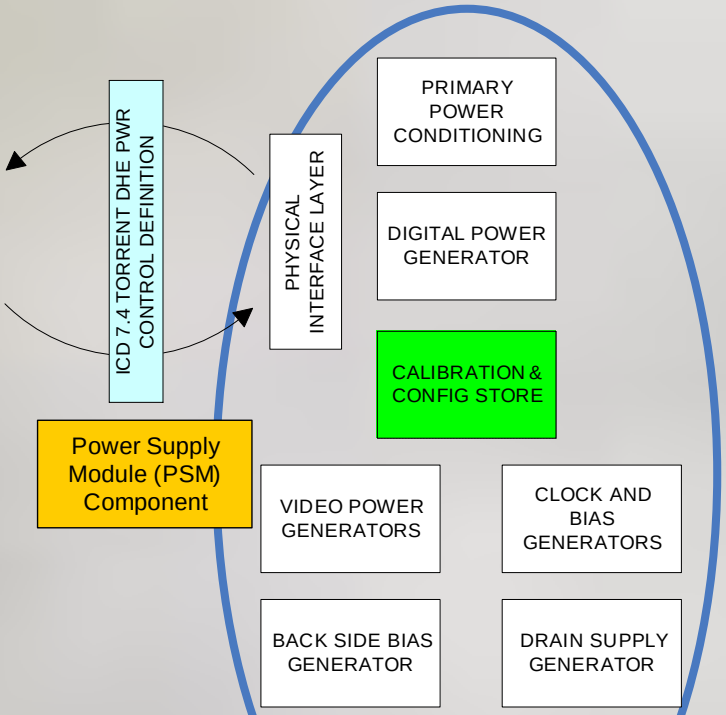
Torrent Design – DHE Hardware Board Set



Torrent Design

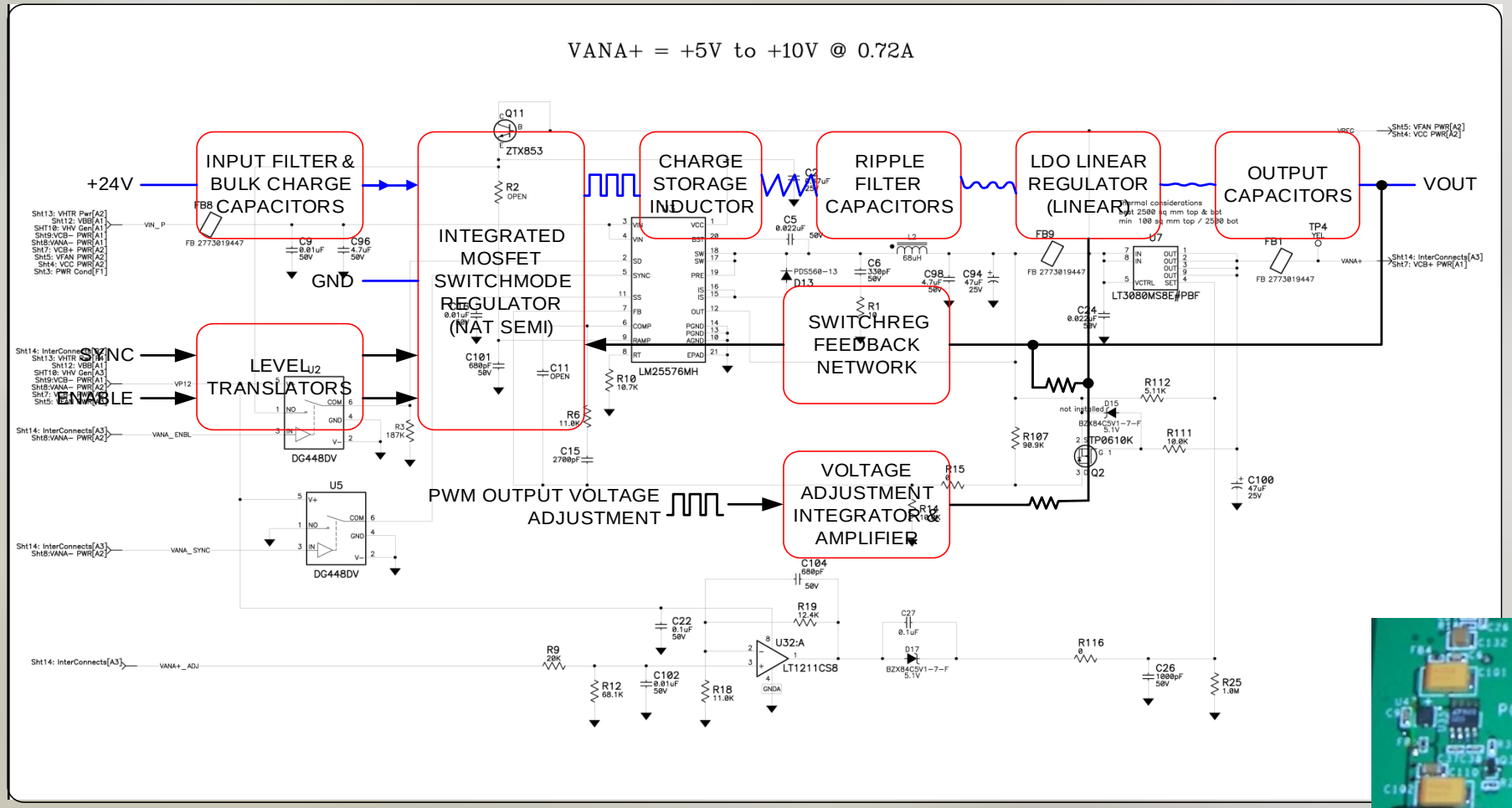
Detector Head Electronics (DHE) System

Torrent Design – Power Supply Module (PSM)



Supply	In/Out	Voltage	I Nom (ma)	I max (ma)	Description
VRAW	INPUT	22 to 26	1000	2500	Primary power input
VCC	OUTPUT	+3.3	1130	3000	Digital logic supply
VFAN	OUTPUT	+7 to +14	300	400	DHE temperature control
VANA+	OUTPUT	+5 to +10	400	720	Video circuits +ve rail
VANA-	OUTPUT	-5 to -10	250	720	Video circuits –ve rail
VCB+	OUTPUT	+9 to +18	350	650	Clock and low voltage bias circuits +ve
VCB-	OUTPUT	-9 to -18	350	650	Clock and low voltage bias circuits –ve
VHV+	OUTPUT	+30 or +5	120	200	High voltage bias circuits +ve
VHV-	OUTPUT	-30 or -5	120	200	High voltage bias circuits –ve
VBB	OUTPUT	+/- 8 to 65	2	10	Back side bias supply
VHTR	OUTPUT	0 to 22		500	Detector temperature control

Torrent Design – PSM Switch Mode Regulators



- Conservative, efficient and common switch mode design
- Voltage adjustment using PWM signal
- Enable/disable capability
- Synchronization across 1 octave of frequency range
- Post regulation for DC precision and ripple rejection

Torrent Design – PSM Synchronization and System Ground

f KHz	f x 2	f x 3	f x 4	f x 6	f x 8
70		210		420	
80	160	240		480	
90	180			540	720
100	200	300		600	800
110	220	330		660	880
120	240	360		720	960
125	250	375		750	1000
130		390		780	1040
140		420		840	1120
150	300	450		900	1280
160	320			960	1320
165	330		660	990	1360

Supply	Min KHz	Max KHz
VCC	300	600
+/-VANA	660	1000
+/-VHV	125	250
Vlogic	750	2250

Ripple Mitigation

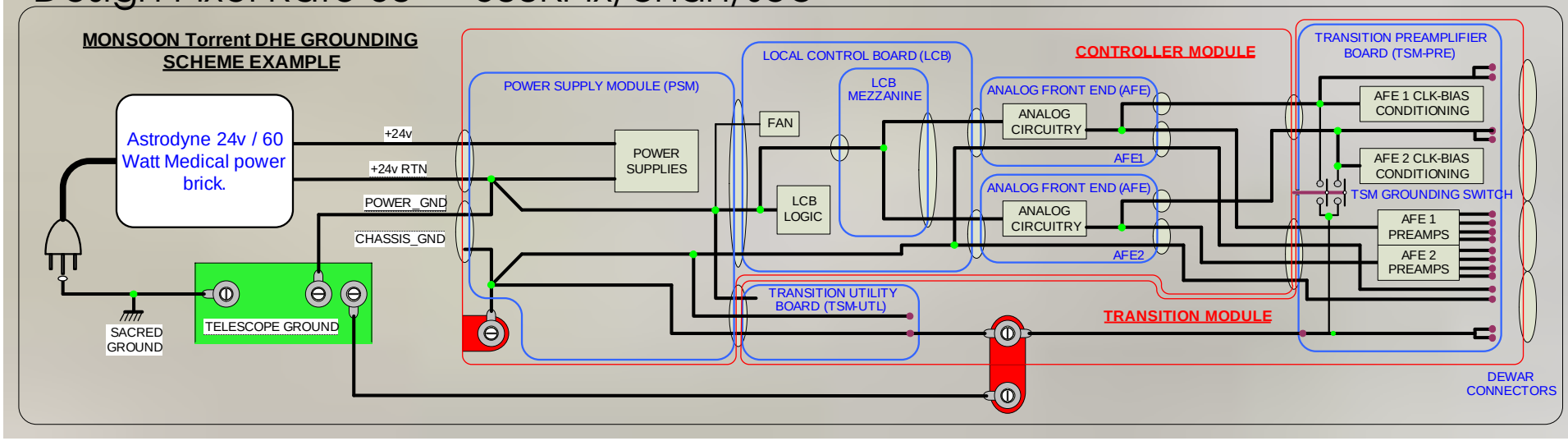
Ripple ΔV dependent on load and frequency.

Constant load and freq.

Regulator and amplifier PSRR

Synchronous 'noise' is DC offset

Design Pixel Rate 50 — 500KPix/chan/sec



Torrent Design – PSM Switcher Pros & Cons

Higher Efficiency

Less heat

Increased reliability

Higher Frequency

Reduced size

Less weight

Inherent Ripple Voltage

Synchronization makes this a DC offset on data

High Frequency 'spikes'

Controlled (slower) switching edges on sensitive supplies

At source filtering using ferrite magnetics

Torrent Status – PSM

Prototype PSM Performance

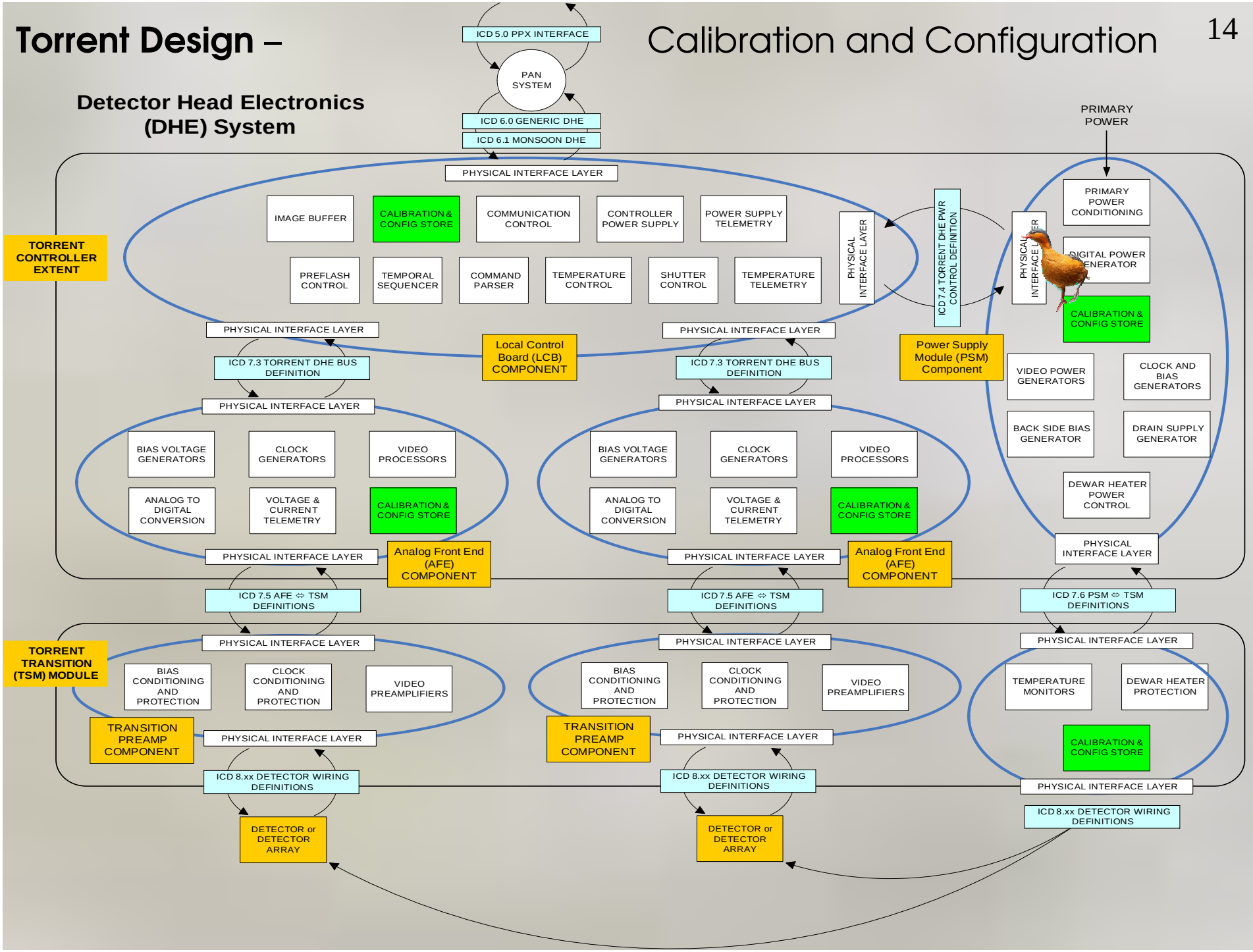
- ✓ Over 8 months of service. 2 failures. Both human error. Both repairable.
- ❑ Regulator voltage/current limits of synchronization and load met except +/- VHV load (70ma limit).
- ✓ xx% efficient. Low heat generation. Conductive heat transfer works.
- ✓ No detectable difference in noise levels between lab supply and PSM supply using shorted input tests.
- ✓ Power supply overcurrent, input over/under voltage protection works.

Rev –A – Differences

- Inclusion of the Vbb supply. Prototype tested.
- Redesign of VHV magnetics to meet 200ma limit
- Interdependence of power supplies removed – VANA & VHV.
- Problem on enables during power off fixed – change in enable polarity.

Torrent Design – Calibration and Configuration

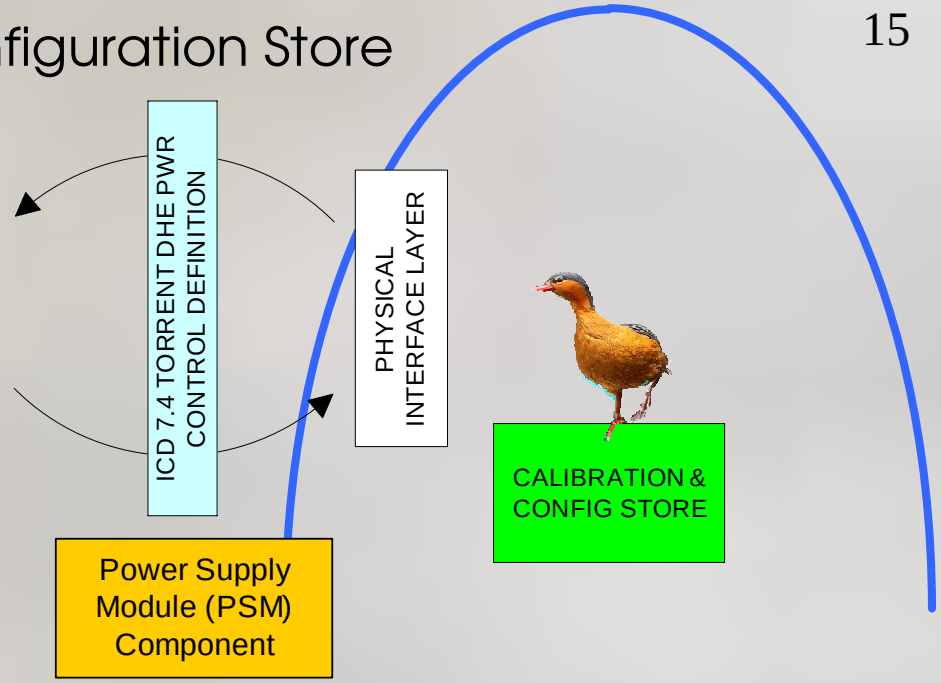
Detector Head Electronics (DHE) System



Torrent Design – Calibration and Configuration Store

Function

- ✓ Store board calibration constants
- ✓ Supply unique hardware identifier
- ✓ Sense temperature of DHE boards



Use

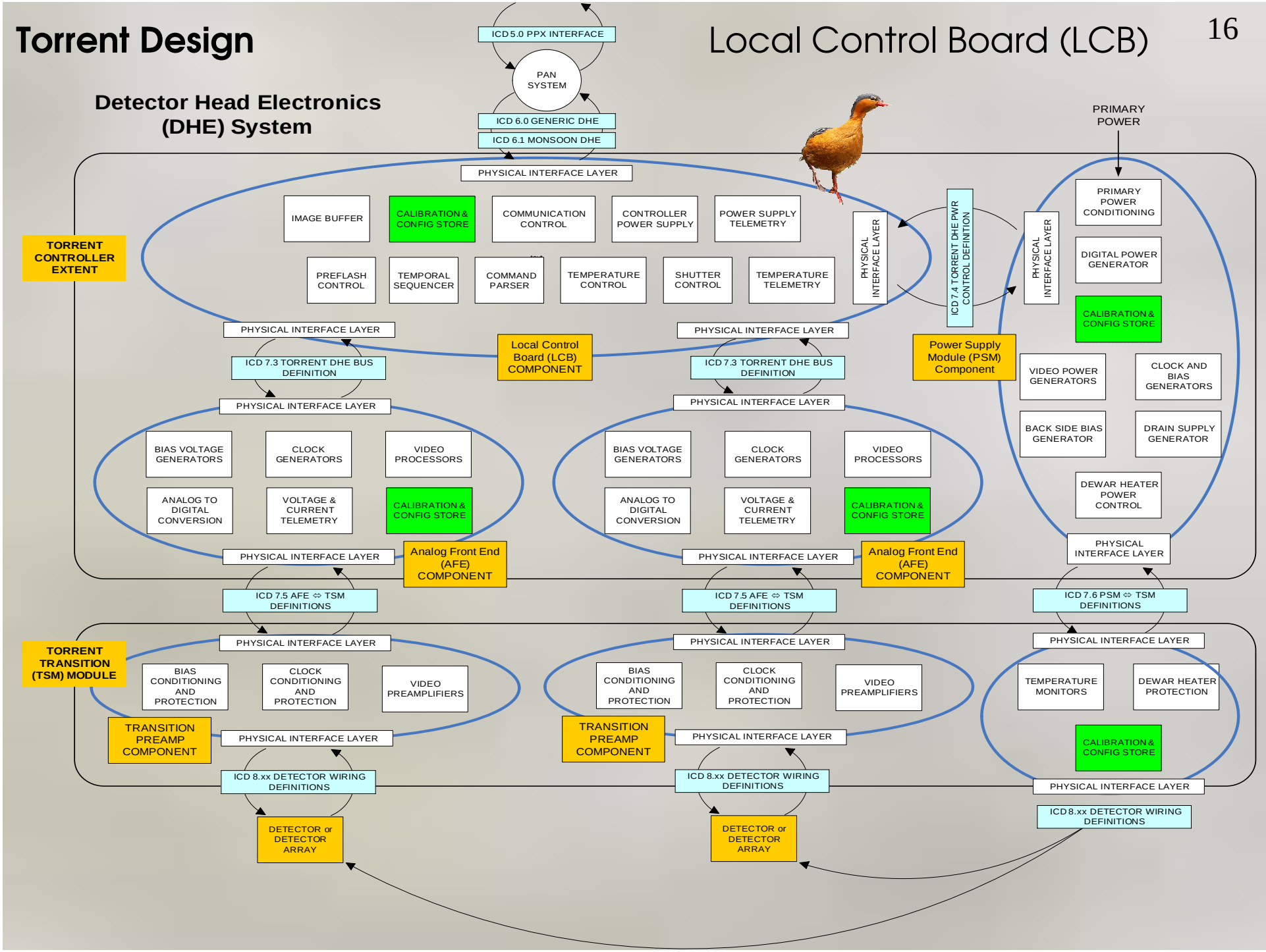
- ➢ Software builds dynamic DHE configuration at run time - Maintenance
- ➢ Software identifies detector system from Transition, carries safe limits
- ➢ Temperature telemetry for diagnostics

Hardware

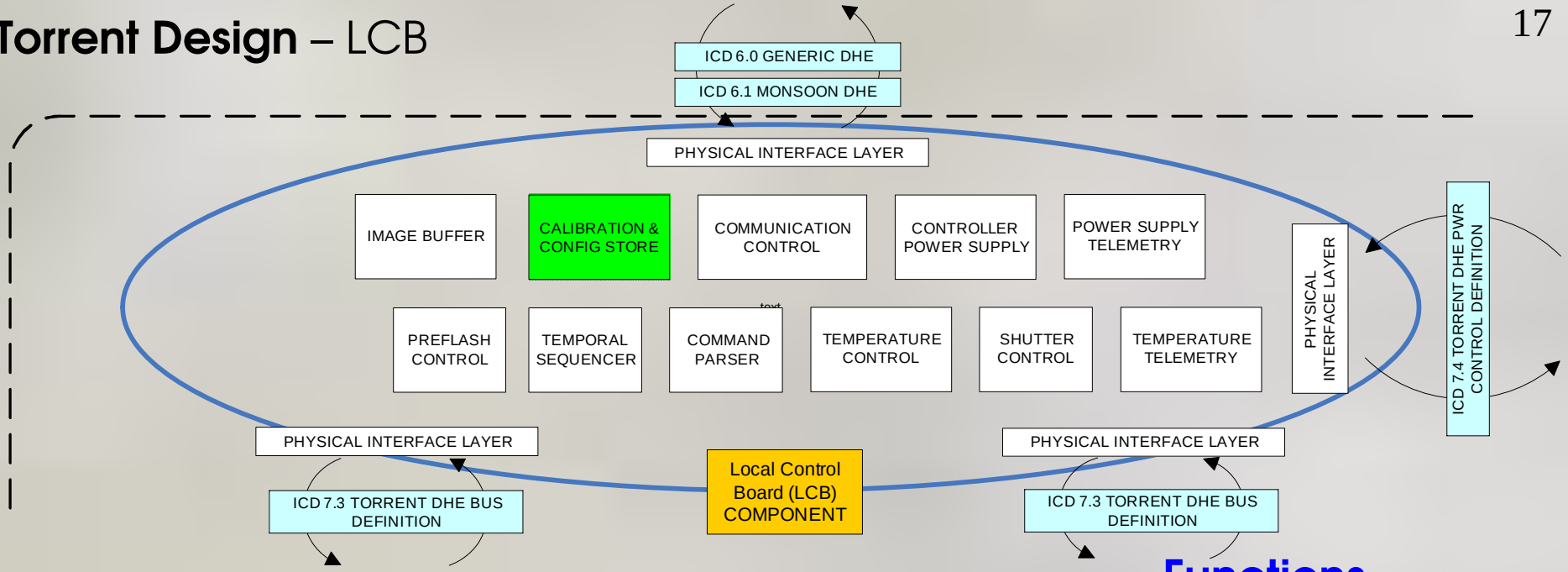
- ➢ Standard hardware circuit configuration for each DHE circuit board
- ➢ Uses I2C bus to test presence of board and to interrogate I2C devices
- ➢ isolated serial data line pull-up supply to prevent noise feed through

Torrent Design

Local Control Board (LCB)



Torrent Design – LCB



Functions

- Communications
- DHE Control
- Temporal Sequencing
- Image Buffering
- Telemetry
- PSM & Temp Servos

Physical Interface Layer

✓ Optical Fiber – Systran SL100 – 1GBit/sec duplex – Fiberlink protocol

✓ Ethernet – GIGe option – 1Gbit/sec – GIGe protocol on IEEE 802.3

❑ High Speed Serial – 53MBit/sec – Via Sync port cables – Proprietary

✓ RS232 – 9600 baud – 3-wire debug and development port

Command / Message formats

Optical Fiber – ICD 6.1 – 32-bit direct read/write to DHE address space

Ethernet –Command interpreter – 8-bit ASCII wrapped version of ICD 6.1

RS232 – Command interpreter – 8-bit ASCII wrapped version of ICD 6.1

➢ Command stream echo disable capability via command attribute

➢ Command / Message copy to any comms port via software attribute

➢ Pixel data routing through any comm port

Torrent Design – LCB Image Buffer

256 Mbytes 2-port dynamic memory designed to support pixel data FIFO mode or full image buffering mode

Organized as 128M x 16-bit words or 64M x 32-bit words depending on detector mode (NIR or CCD)

Capacity to buffer a 2Kx2K NIR array for a complete pre/post integration cycle using 16 Fowler reads and 32 digital averages

Capacity to buffer an 8Kx8K CCD mosaic in 18-bit data format

- ❑ Pixel data descrambling in full image buffer mode
- ✓ Pixel statistics logged during readout – available as attributes
- ✓ Frame and Line strobes available for GIGe and Systran data streams
- ❑ Power down available if stream mode employed
- ✓ 18-bit or scaled 16-bit data format
- ✓ Data path accommodates 80MPix/sec (limited by communication path to 25MPix/sec)

Torrent Design – LCB Command Parser

Implements ICD 6.1 with four commands:

- Read 32-bit value – as a variable by attribute name
- Write 32-bit value – As a variable or as a function trigger by attribute
- Asynchronous command – Used to synchronize DHE to PAN
- Start Exposure command – with 8-bit start vector to sequencer.

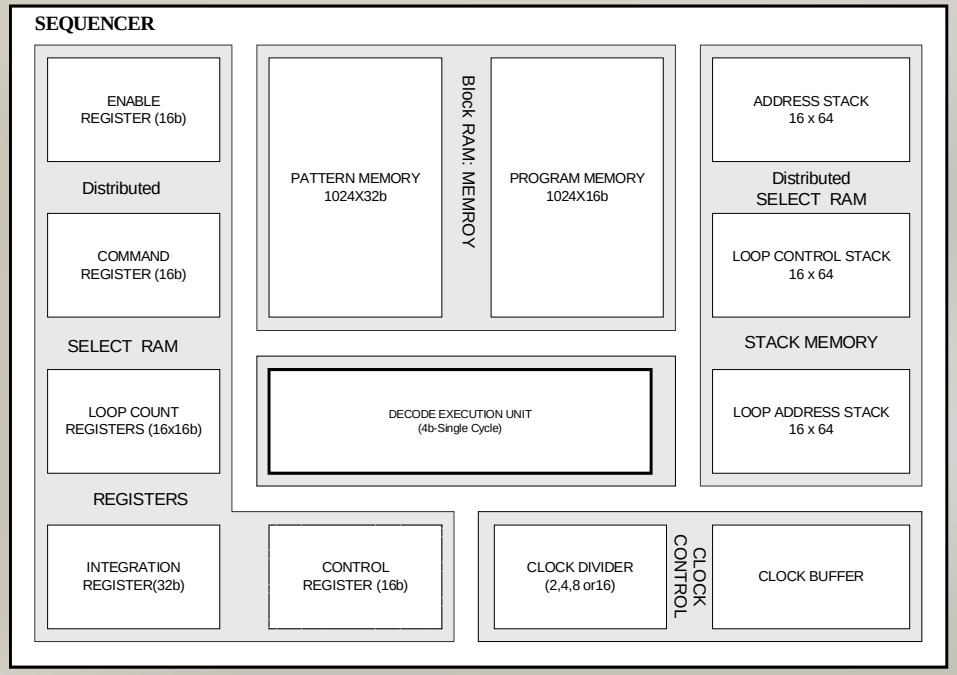
- ✓ Emulates MONSOON Orange protocol
- ✓ Multi-user – commands / messages through any comms port
- ✓ Echo acknowledgement to commands
- ✓ Internal bus uses six `module' addresses instead of eight slot addresses (LCB, PSM, CFG, PIX, AFE, CLK) with fixed address assignment
- ✓ Automated extraction of DHE register space via VHDL source code comments field

Torrent Design – LCB Temporal Sequencer

- ✓ Emulates MONSOON Orange MCB sequencer

  Orange assembler code usable but requires:

  - Module address space used instead of Slot Address
  - Timebase change for DSC command (38ns Torrent vs 50ns Orange)
  - New assembler (Tasm) to account for 32-bit word space
  - Orange micro-sequencer for CDS functions not needed

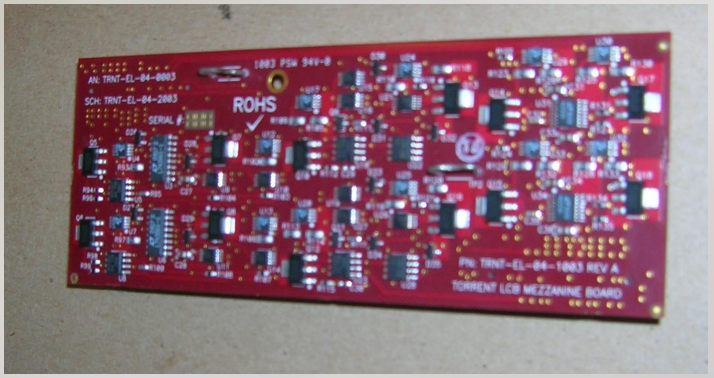


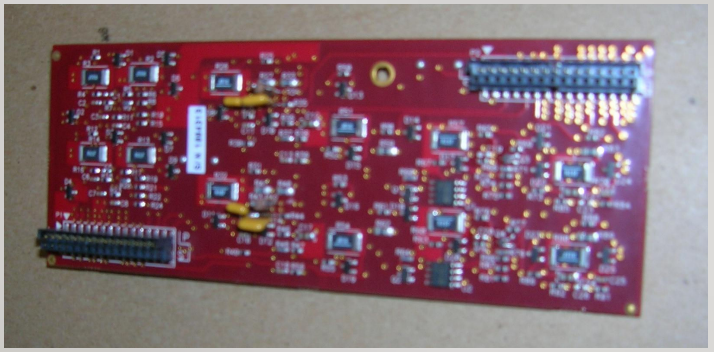
Torrent Design – LCB AFE Control interface

- ✓ Implements ICD 7.3 and 7.4 for CCD and NIR AFE boards
  - Describes complete signal groups and interface mechanisms
  - All digital interface, synchronous to one clock source (80 MHz)
  - Separate power supply system for AFEs – no signal return path mixing
  - Minimal digital logic on AFE – only signal latches
  - Digital noise barrier using voltage translators and intermediate interface voltage supply
  - Allows separate or ganged control of multiple AFE boards
- ✓ Flexible interface configured entirely by firmware
- ✓ All signals are input/output/bi-directional capable (> 160 I/O circuits)
- ✓ Controlled delay characteristics for LCB input data signals

See http://www.noao.edu/ets/monsoon/ICD.html

Torrent Design – LCB Power Control





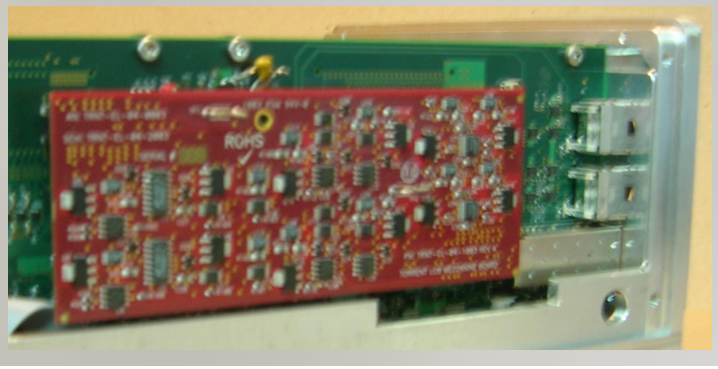
LCB board – Digital functions

- ✓ Individual enable/disable of AFE power supply potentials
- ✓ Controls AFE power on with sequenced delays and status check

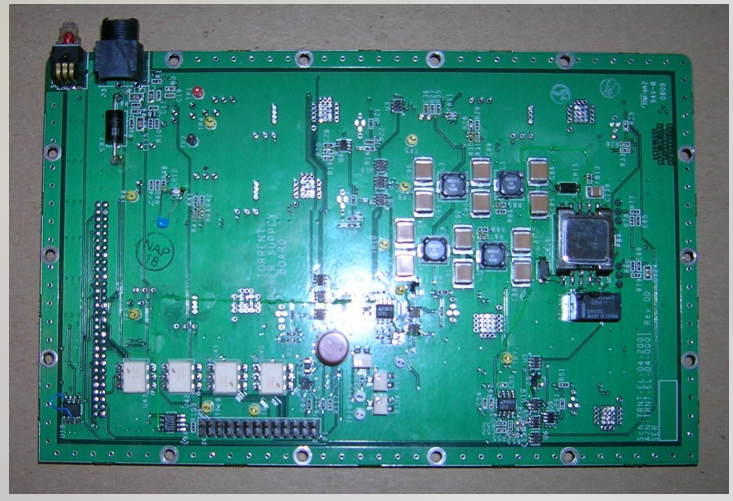
LCB-MEZ board – Analog functions

Plugs directly into LCB as a mezzanine board

- ✓ Provides separation of digital and analog grounds back to the PSM
- ✓ Provides current telemetry for each AFE board supply
- ✓ Provides hardware under voltage and over current protection
- ✓ Provides supply status for safeguarding DHE and detector



Control of Power Supply Module (PSM)



- ✓ PSM detector high voltage polarity
- ✓ PSM analog supply enables
- ✓ PSM analog voltage adjustment
- ✓ PSM Synchronization to pixel rate

✓ Reads PSM voltage telemetry

❑ Servos PSM analog voltages to eliminate temperature drift and load variance

✓ DHE temperature control servo for fan supply regulator (DHE temperature stabilization)

❑ Detector temperature control servo for detector heater current supply

Torrent Design – LCB Telemetry

Detector Voltage Telemetry

Scanned every 200ms (adjustable / allows disable during read)

- ✓ Bias and clock voltages
- ✓ AFE circuit reference and supply voltages

DHE Telemetry

Fixed scan rate

- ✓ Integration status - Shutter status, Integration time remaining, etc.
- ✓ Temperatures – DHE, Boards, Detector, heater power, etc.
- ✓ Power supply status – Power good, Power active
- ✓ AFE power supply voltages
- ✓ AFE power supply currents

➢ Available as read-only attributes

➢ Calibration values for engineering units carried on each board

Torrent Status – LCB

Prototype LCB Performance

- ✓ All communications proved – nonexistent transmission errors
- ✓ Pixel data path proved – no loss of data observed in 5 months
- ✓ DHE Control structure proven on all firmware modules
- ✓ Sequencer tested and verified
- ✓ AFE Power control operational – fault modes verified
- ❑ Power supply control working – small amount of ripple on servos

Work to be done

- Hardware respin required to correct: clock generator filter, GIGe ⇔ LCB interface connector, memory power supply problem, etc.
- Firmware work required for: synch port comms and sync port timing calibration, power supply servo ripple, Image buffer memory descrambler.
- Firmware documentation to be written

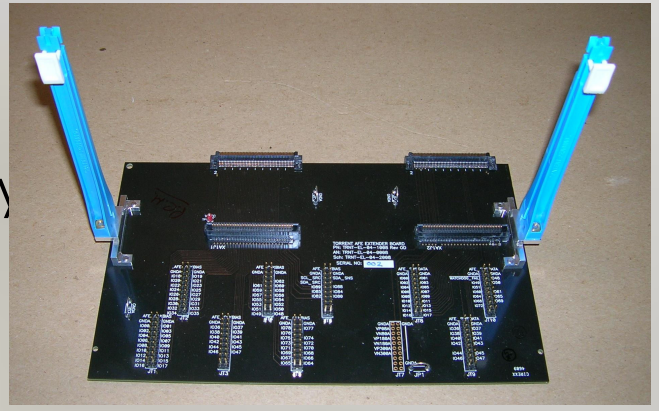
Torrent Maintenance

Front Line Tools

- ❑ Software filters (checkState)
- ✓ Engineering console: full access to attributes (controlled access)
- ✓ Two indicators for DHE operational state on external panel
- ✓ Power condition indicator
- ? Controller exchange at detector cryostat using generic module
- ❑ Full documentation available

Second tier Tools

- ? Common module spares – plug and play
- ✓ Extender board for access to AFE board
- ✓ Debug comms port – always available
- ✓ Multiplexed debug port for firmware support – Test ports for AFE
- ❑ Board & Controller functional test HW and SW available
- ❑ Documented module / board histories

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Mark Hunten