Towards a V1.0 Users' Requirements Document for FINAL FEDs by 28Feb

Proposed breakdown:

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1. Introduction

e.g. John's first slide

Assumptions about each FED

- **96-channel**
- **9U format**
- **VME [VIPA?]**

- **No on-board mP or network connection**
  - **so need some "crate controller"**

- **~18-20 FEDs per crate**

- **All FEDs identical**
  - **else system not "physicist proof" !**

2.
FED Operational Modes

1) Cluster Finding (aka Zero Suppression)

2) RAW Data

A mix of (1) and (2) needed for testing/monitoring.

a) Frame-finding

b) Scope mode

c) Multi-Mode (else why have it on the APV!)

Hardware Triggers {a,b,c}

Software Triggers (board testing, tick synchro) {b}

- **All triggers act at next clock edge.**

3.
VME Interface

- **FED is slave responding to A24D64 (?) single/block read/write, AMR.**

- **Board addressing**
  - –Define board address
  - –Allow geographic addressing
  - –Define VME memory space

- **Define command/status registers.**

- **Define commands to which board responds.**
  - **– e.g., set mode, fake i/p data (to FED or DAQ)**
  - **– e.g., send software TRGs & RSTs**
    - **...either to individual FED or to whole crate**
  - **– Read & Write“Constants”**
    - **e.g. Pedestals, Clusters thresholds, list of dead or noisy strips, list of dark fibres (?), delays.**

3. VME Interface

- Define output data.
  - –**OUT-OF-SYNCH signal {#chans…} => Run Control**
  - –**Some fraction of S-link data of single FEDs**
    - **If want same event from more than one FED, need to select via some (big!) prescaler, & whose counter can be zeroed by Reset ?**
    - **ZS Data needed for monitoring of clusters.**
  - **RAWD needed to determine peds & noise and during setting-up.**
  - **"Expanded" ZS Data, to include:**
    - **192 x {#BX_frame ?, #APV_pipe, APV error flags, common mode noise…}**
    - **Buffer occupancies**
  - **Histograms ? (Occupancy vs #BX etc.)**

4.
Input Data and Signals

- **96 fibres, analog signal**
  - **(some fibres may be “dark”)**
- **TTCrx**
  - **CLK, TRG (aka L1A), #EVNT(24 bits), #BX(0-3563), #ORBIT?, L1 Reset(flush & reset pointers), Hard Reset(longer, still only hardware reset)…..**
  - **APV Emulator address via Channel B ?**
- **FED-to-FED interface (since #FEDs < #S-links)**

5a.
Output Data and Signals

Must deliver something on each received trigger

- **S-link64 to DPMs and thence to the switch**
  - –8 bytes at 100? MHz
  - **Push (but back-pressure signal exists ?)**
  - **Header (inc error flags) + ZS or RAW data (never both?)**
  - **<Size> = 2kB for 100kHz triggers.**
  - **Peak rate 400 MB/s for << 1 sec.**
  - **Data likely to be from multiple FEDs**
  - **Test pattern transmit to check link.**
  - **Any useful compression of RAW or ZS data ?**
  - **RAW data is 10 bits…**
  - **RAW data needed for e.g. Heavy Ions**

- **FED-to-FED interface (since #FEDs < #S-links)**
  - **Almost the same as S-link output ?**
  - **Check that data is from the same event:**
    #EVT, #BX_trig, (#BX_frame ?), #APV_pipe
  - **Permitted for 1 FED in ZS, another in RAW.**
  - **Output data to FED in same crate only ?**
  - **Can this be made "physicist-proof" ?**

Needs "formal" specification ...

5b.
Output Data and Signals

- **TTStx**
  - **BUSY (e.g. during Reset),**
  - **THROTTLE (buffers filling)**
  - **ERROR (=BUSY ?) (buffer full, many APVs wrong)**
  - **READY (not busy and power on).**

- **Front-panel CLK output for setting-up ?**

6.
Detailed Data Formats

- **Based on TDR Chapter 5.5.4.1**
- **Incorporate Gabbi's**
  AL(LxD)AM(MxD)AN(NxD)…
- **Header contains error detection and flag bits.**
- **Data format must be specified via version number in the header.**

7. Header Finding & Clustering

- **Header finding looks for six ‘1’s (after seventy ‘0’ ?)**
- **Or find headers using edge detection ?**
- **Header finding must work on a channel where one of the two APVs has died.**
  Do we know which one has died ?
- **Can FED determine header thresholds itself ?**
- **Clustering is used only in frame-finding mode**
- **Clustering algorithm based on Ian’s recent work**

8. Requirements of Testing

at the board, crate, rack & system level

- **Output both ZS and RAW data for some events.**
- **Input fake data to front-end to test FED? (Difficult)**
- **Input APV calibration data to test FED ?**
- **Output fake data to test S-link ???**
- **How do we test 500 FEDs ?**
  - 2 SEQSI's ⇒ Electrical fanout ⇒ E→O converter ⇒96 optical fibres ⇒8 12xfibres ⇒FED ?
  - How test analogue response ? Pixel tester ?
- **Internal 40 MHz clock to test FED without TTC ?**
- **Boundary Scan.**

Costas...

9. Errors: Detection, Modes, Recovery & Resets

- **Within a FED {12x8} #APV_pipes disagree**
  - Flag bad APVs in data stream to Slink/Crate Controller.
  - Periodically send #wrong_channels to Crate Controller (at programmable frequency).
  - Optionally send 192 x #APV_pipe to Slink/ Crate Controller, for debug. (Tricky at full trigger rate).

  Use emulated pipe addr. on channel B ?

- **Within a FED {12x8} frames out of sync (#BX_frame disagree) - As above ...**

- **When an input is in error, create header without data for it, to keep DAQ in sync.**

- **When FED buffers filling, send trigger throttle.**

- **What errors can be spotted by the FED Crate Controller ?**
  - **e.g. monitoring tracker occupancy v/s #BX should give correct filled/empty, checking #BX between FEDs.**
- **What errors can only be spotted in merged tracker data ?**

  Can FED crate controllers speak to each other ?

10. Errors: Detection, Modes, Recovery & Resets

- **Does APV distinguish hard & soft resets ?**
- **How long do APV/FED take to reset ?**
- **What does FED do if APV reloads I2C params ?**
- **Will APV do local resets ? Is sync. then lost ?**

- **On receiving reset:**
  - Assert busy signal until reset finished.
  - Reset Event# (and Orbit# ?)
  - Send data in FED buffers if possible.
  - Send empty events for triggers without data.

- **FED merging:**
  - When merging data from several FEDs, how does merger time-out if one FED supplies no data for given event ?

11.
Systems Issues 1
Setting Up, Timing, Calibration

- **What are requirements of**
  - Setting up optical links ?
  - Synchronising APVs and FEDs ?
  - Noise & pedestal calibration ?
  - Measuring APV pulse shapes ?
- **Must FEDs be synchronised to each other ?**
- **Optical links & synchronisation need APV tick marks, so:**
  - Scope mode needed.
  - Triggers to FED but not APV.
    - If software, Bx of trigger must be known.
    - If hardware, FEC must suppress trigger to APV.
- **Noise & Pedestal monitoring needs**
  - Occasional RAW events during ZS run.
- **Does FED have calibrate mode to choose its thresholds and delays automatically ?**
- **Convenient if FED inputs have 1 ns step size, like APV PLL. Is 25 ns range enough ?**
- **TTCrx gives global delay for all FED inputs .**
- **All modes require data readout via VME.**

12.
Systems Issues 2
Crates, Partitions, Dynamic Range

- **9U VME (VIPA ?)**
- **Crates**
- **Power supplies**
- **Safety requirements**

- **S-link output to DAQ must combine several FEDs. - See Ian's note.**
  - These FEDs must be in same crate.

- **Must deliver 1 event / trigger.**
- **All events delivered in order & in << 1 sec.**

- **Dynamic ranges:**
  - RAW data: 10 bits
  - ZS data: 8 bits (out of range clamped)
  - Pedestals: ≥ 7 bits / channel ? (1.6 MIP variation)
  - Cluster cuts: ≥ 6 + 5 bits / channel ? (0.8-0.4 MIP cut)
  - CM cuts: unnecessary with median algorithm
  - Bad channels: flag with pedestal = 127 ?

- **LEDs to showVME, trigger, error, clock activity & identify data merger FEDs.**

13. Requirements for FED Support

- **Software to allow easy use of FED.**
- **Documentation of hardware & software.**
- **Agreement to maintain FEDs after production.**
- **Firmware and Software version readable from VME.**

13.
FED Requirements for Crate Controller & S-W

Crate controller must:

- Process setting-up and synchronisation data.
- Determine noise & pedestals every fill.
- Provide monitoring / error reporting.
  - e.g., # Clusters vs. #BX,
    # Triggers vs. #BX
    delays, APV_pipe dist.
- Download calibration constants & clustering cuts to FED and to offline.
- Set FED options. (Scope mode, raw data, thresholds ...).

- **Process RAW data => 610 KB/event/crate at ~ 100 events/sec.**

14.
FED Requirements on other parts of CMS

- **If synchronisation done with hardware triggers to FED, then FEC must suppress triggers going to APV.**

- **To synchronise without tracks, must know fibre lengths to < 1 ns for:**
  - APV $\rightarrow$ FED
  - TTC $\rightarrow$ FED

15. Requirements for 2002 Rod/Petal Testing

- **What are minimal requirements for rod/petal testing ?**
  - 96 channel FED with optical inputs.
  - RAW data.
  - VME output with block data transfers.
  - Software & hardware triggers.
  - Scope mode, frame finding, multi-mode.

16. Schedule of complete, final System

Rob Halsall ...

17. Unresolved Issues

- **Can FEC suppress triggers to APV ?**
- **TTCrx outputs:**
  - Does FED use TTCrx counters or its own ?
- **How do APV & FED react to Test/Calibration L1 triggers ? Empty event ?**
- **Does FED see 101's or normal CMS resets ?**
  (Does TTCRx event counter understand 101 ?)
- **Any requirements for laser alignment ?**
  (Assume not ...)
- **How are noise & pedestal sent offline ?**
  (For offline processing of RAW data & refinement of ZS data).
  From crate controller or with data from FED ?