Trigger & Dataflow Overview

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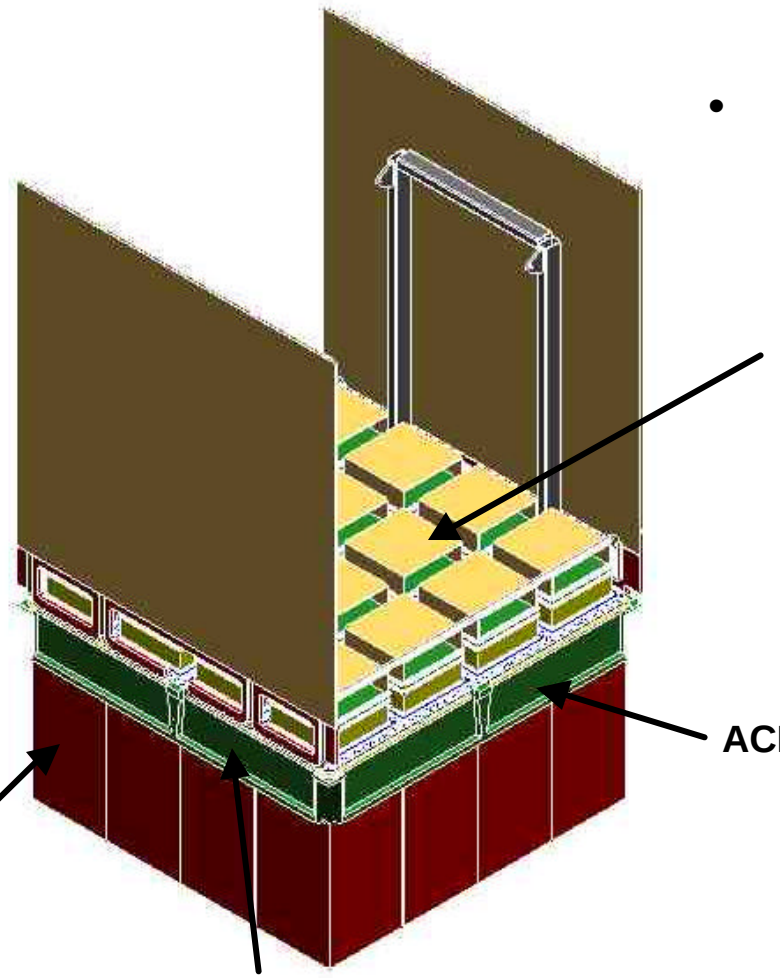
T&DF Objective

- **What does it do?**
  - **Commanding and messaging**
  - **Readout configuration and control**
  - **Triggering**
  - **Event data acquisition from sub-systems**
  - **Event building**
  - **On-board event reconstruction/event filtering (FSW)**
  - **On-board science analysis: transients (FSW)**
  - **Live-time monitor**
  - **Stream data to spacecraft**
  - **Instrument health monitoring**
  - **Support for sub-system electronics development**

Location of LAT Electronics



- **Distributed in boxes under the 16 towers (LAT shown upside-down):**
  - **Trigger & Dataflow (DAQ) Electronics**
  - **Power System**

ACD Elex on all 4 sides

TKR Elex on each of the 16 towers

CAL Elex on each of the 16 towers

Requirements (1)

Item	Description	Origin	Verification	Test Type	Metric
5.2.1 L1 Trigger Inputs	Accept inputs from ACD, TKR, CAL, and dataflow subsystems	LAT-SS-00019-D2	D		P/F
5.2.2 L1 Trigger Input Timing Adjust	Time-align all trigger inputs	LAT-SS-00019-D2	T	F	P/F
5.2.3 L1 Trigger Monitoring	Implement multiple overlapping triggers to allow cross-trigger monitoring.	LAT-SS-00019-D2	T	F	P/F
5.2.4 L1 Trigger Acknowledge Output	Generate L1TACK and trigger type	LAT-SS-00019-D2	D		P/F
5.2.5 L1 Trigger Logic	L1 trigger logic shall be reconfigurable via commanding	LAT-SS-00019-D2	D		P/F
5.2.6 L1 Trigger Latency	Generate L1Tack with latency of less than 1.3 μs (tbr)	LAT-SS-00019-D2	T	P	Dg
5.2.7 L1 Trigger Timing Jitter	L1 trigger contribution shall be less than ± 50 ns	LAT-SS-00019-D2	T	P	Dg
5.2.8 L1 Trigger Dead-time Contribution	Minimum spacing of L1TACK signal shall be down to the larger of: minimum dead-time imposed by the calorimeter system, or minimum dead-time imposed by the tracker system or 5 μs	LAT-SS-00019-D2	T	P	Dg
5.2.9 L1 Trigger Acknowledge Blocking	The L1 trigger system shall block L1TACK signals if any part of the instrument is not ready for capture of new event data	LAT-SS-00019-D2	D		P/F
5.2.10 L1 Trigger Live Time Measurement	The L1 trigger system shall record the global live time of the system	LAT-SS-00019-D2	D		P/F
5.2.11 L1 Trigger Dead Time Cause	The L1 trigger system shall provide output data to monitor contributions to dead-time	LAT-SS-00019-D2	D		P/F
5.2.12 L1 Trigger Event Data	The L1 trigger system shall provide trigger-specific event data to dataflow including event time and number	LAT-SS-00019-D2	T	F	P/F

Requirements (2)

Item	Description	Origin	Verification	Test Type	Metric
5.2.13 L1 Trigger Configuration	L1 trigger system shall be configurable	LAT-SS-00019-D2	D		P/F
5.3.1 Spacecraft Commanding Interface	The control system shall accept control commands and data from the spacecraft	LAT-SS-00019-D2	D		P/F
5.3.2 GBM Commanding Interface	The control system shall accept control commands from the GBM instrument	LAT-SS-00019-D2	D		P/F
5.3.3 Commanding Source	The control system shall be able to reconfigure and direct the operation of the instrument in a combination of interactive commanding by an operator, time sequenced operation by scripts, and automatic operation by the flight software.	LAT-SS-00019-D2	D		P/F
5.3.4 Configuration of Sub-Systems	The control system shall provide signals to configure the CAL, TKR, ACD, TRG, dataflow, and power supply system.	LAT-SS-00019-D2	D		P/F
5.3.5 Readback of Sub-Systems	The control system shall be able to read and record the configuration of the CAL, TKR, ACD, TRG, dataflow, and power supply system.	LAT-SS-00019-D2	D		P/F
5.4.1 Event Data Readout from Sub-Systems	The dataflow system shall transport all data accepted by the L1TACK signal	LAT-SS-00019-D2	D		P/F
5.4.2 Event Data Overwrite Protection	The dataflow system shall prevent event-data from being overwritten until readout and processing have been completed	LAT-SS-00019-D2	D		P/F
5.4.3 Event Data Filtering Function	The dataflow system shall reduce the event rate accepted by the L1T to an output rate commensurate with the downlink as specified in 433-IRD-0001, keeping events meeting the science objectives.	LAT-SS-00019-D2	D		P/F

Requirements (3)

Item	Description	Origin	Verification	Test Type	Metric
5.4.4 Event Data Filter Reconfiguration	The event-filtering algorithm shall be reprogrammable	LAT-SS-00019-D2	D		P/F
5.4.5 Event Dataflow to Spacecraft	The dataflow system shall transmit event data to the spacecraft as specified in 433-IRD-0001	LAT-SS-00019-D2	D		P/F
5.4.6 Passing of Unfiltered Events	The event filtering shall be able to pass a pre-scaled sample of un-filtered events for monitoring and analysis	LAT-SS-00019-D2	D		P/F
5.4.7 Filter Identified Transients	The event filtering shall provide real-time detection of transient events	LAT-SS-00019-D2	D		P/F
5.4.8 Pointing Data	The data flow system shall provide, when enabled, transient event source location pointing information to the spacecraft	LAT-SS-00019-D2	D		P/F
5.4.10 Event Dataflow Dead-Time for Average Orbital Conditions	The dataflow system shall contribute less than 5%(tbr) to the instrument dead time at a trigger rate of 10 kHz (tbr) when the real photon content is less than 30 Hz (tbr). Deadtime at higher trigger rates shall degrade gracefully to 80% (tbr) at 30 kHz (tbr) for similar photon fluxes.	LAT-SS-00019-D2	T	P	Ti
5.4.11 Event Dataflow Dead-Time During Photon Burst Conditions	The dataflow system shall contribute less than 5%(tbr) to the instrument dead time during a photon burst.	LAT-SS-00019-D2	T	P	Ti
5.4.12 Dataflow Monitoring	The dataflow system shall be monitored to provide data integrity checking and conditions change.	LAT-SS-00019-D2	D		P/F
5.4.13 Calibration	The dataflow system shall provide signals to calibrate and readout the sub-systems.	LAT-SS-00019-D2	D		P/F
5.5.1 Environmental Data Readout	The dataflow system shall readout and process environmental data from the instrument.	LAT-SS-00019-D2	D		P/F
5.5.2 Low-Rate Science Data Readout	The dataflow system shall readout and process low-rate science data (rate counters) from the instrument.	LAT-SS-00019-D2	D		P/F

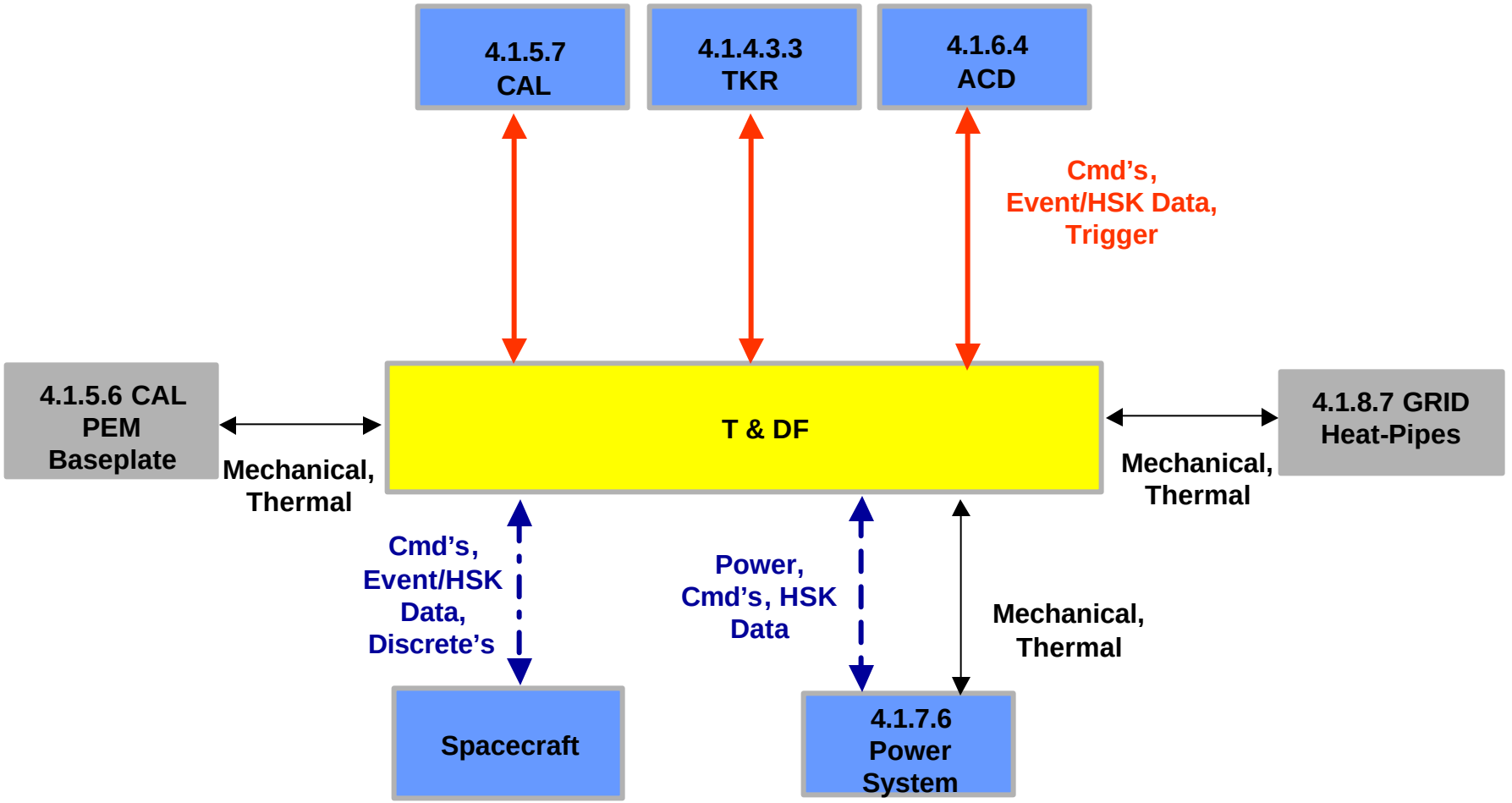
Requirements (4)

Item	Description	Origin	Verification	Test Type	Metric
5.5.3 Health Data Readout	The dataflow system shall readout and process health data from the CAL, TKR, ACD, TRG, dataflow, and power supply systems.	LAT-SS-00019-D2	D		P/F
5.5.4 Environmental Conditions	The trigger and dataflow system shall be capable of operation within specification after being subjected to the environmental conditions given in its ICD.	LAT-SS-00019-D2	T	F	P/F
5.5.5 EMC	The trigger and dataflow system shall comply with the EMC requirements of 433-RQMT-0005.	LAT-SS-00019-D2	T, A	F	P/F
5.5.6 South Atlantic Anomaly	The trigger and dataflow system shall support instrument configuration, monitoring, and recovery from a mode-save for SAA transits.	LAT-SS-00019-D2	D		P/F
5.7.1 Volume	The trigger and dataflow system shall not exceed a volume as specified in TBR	LAT-SS-00019-D2	I		P/F
5.7.2 Mass	The trigger and dataflow system shall not exceed a mass of 188 kg	LAT-SS-00019-D2	I		P/F
5.8.1 Average Power Constraint	The trigger and dataflow system shall consume not more than 142 W (tbr) orbit average	LAT-SS-00019-D2	T, A	F	P/F
5.8.2 Peak Power Constraint	The trigger and dataflow system shall consume not more than 242 W (tbr) averaged over 1 sec.	LAT-SS-00019-D2	T, A	F	P/F
5.9.1 Failures	The trigger and dataflow system shall not have any single-point failure modes, which can reduce the instrument to below the minimum effective area specified in LAT-SS-00010	LAT-SS-00019-D2	A		P/F
5.10 Support of Integration and Test	The trigger and dataflow system shall support integration and test of the instrument	LAT-SS-00019-D2	D		P/F

Verification Types : T: Test; I: Inspection; A: Analysis; D: Demonstration;

Test /Measurement Types: F: Functional; P/F: Pass/Fail; P: Performance;
Ti: Time; DR: Data Rate; An: Analog; Dg: Digital

T&DF External Interfaces



NOTE: Cables to/from T&DF System are responsibility of sub-systems

Interface Specifications

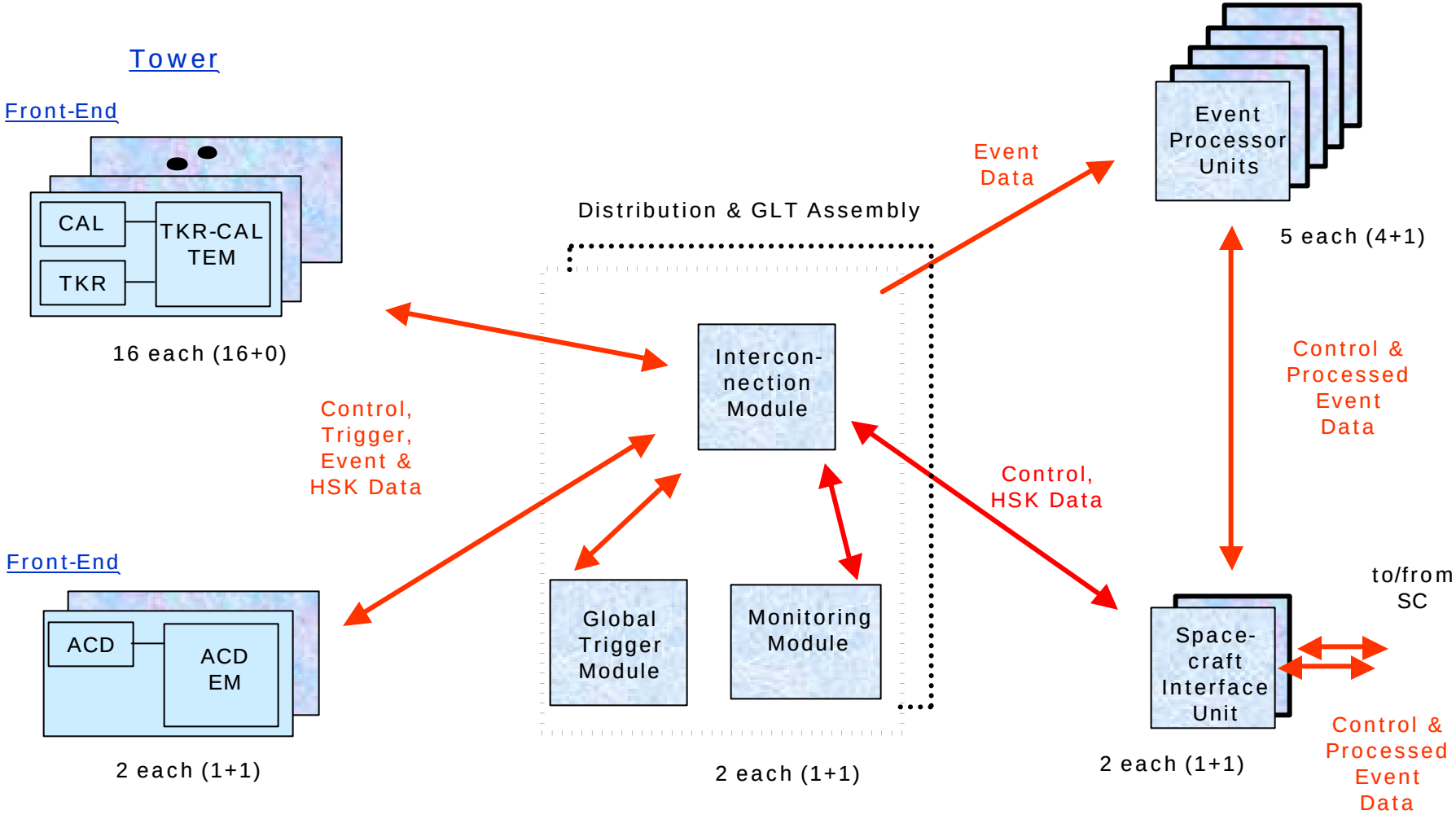
- Interfaces of T&DF to ACD, TKR, CAL sub-systems worked out
  - not by just defining and imposing interface at system level without knowing impact to both sides of interfaces
  - after sufficient conceptual design progress (sub-systems and TEM's) to allow
    - as much as possible common design and still
    - minimization of complexity and cost of complete system, hardware & software
- Interface to sub-systems presently part of sub-system documents, will be split off to stand-alone ICD LAT documents
- Interface to SC specified in 433-IRD-0005, being modified to include results from meetings with several spacecraft vendors

T&DF Modules for Flight

- 16 TKR-CAL Tower Electronics Modules (TEM) (16 Primary + 0 Secondary)
- 2 ACD Electronics Modules (1 P + 1 S)
- 2 Global Trigger Modules (1 P & 1 S)
- 5 Event-Processor Units (4 P & 1 S)
  - 750 Power-PC processor cPCI card
  - Event-Processor - LAT communication cPCI card
  - PCI Backplane
- 2 Spacecraft Interface Units (1 P & 1 S)
  - 750 Power-PC processor cPCI card
  - SIU - LAT communication cPCI card
  - SIU - Spacecraft communication cPCI card
  - PCI Backplane
- 2 LAT Monitoring Units (1 P & 1 S)

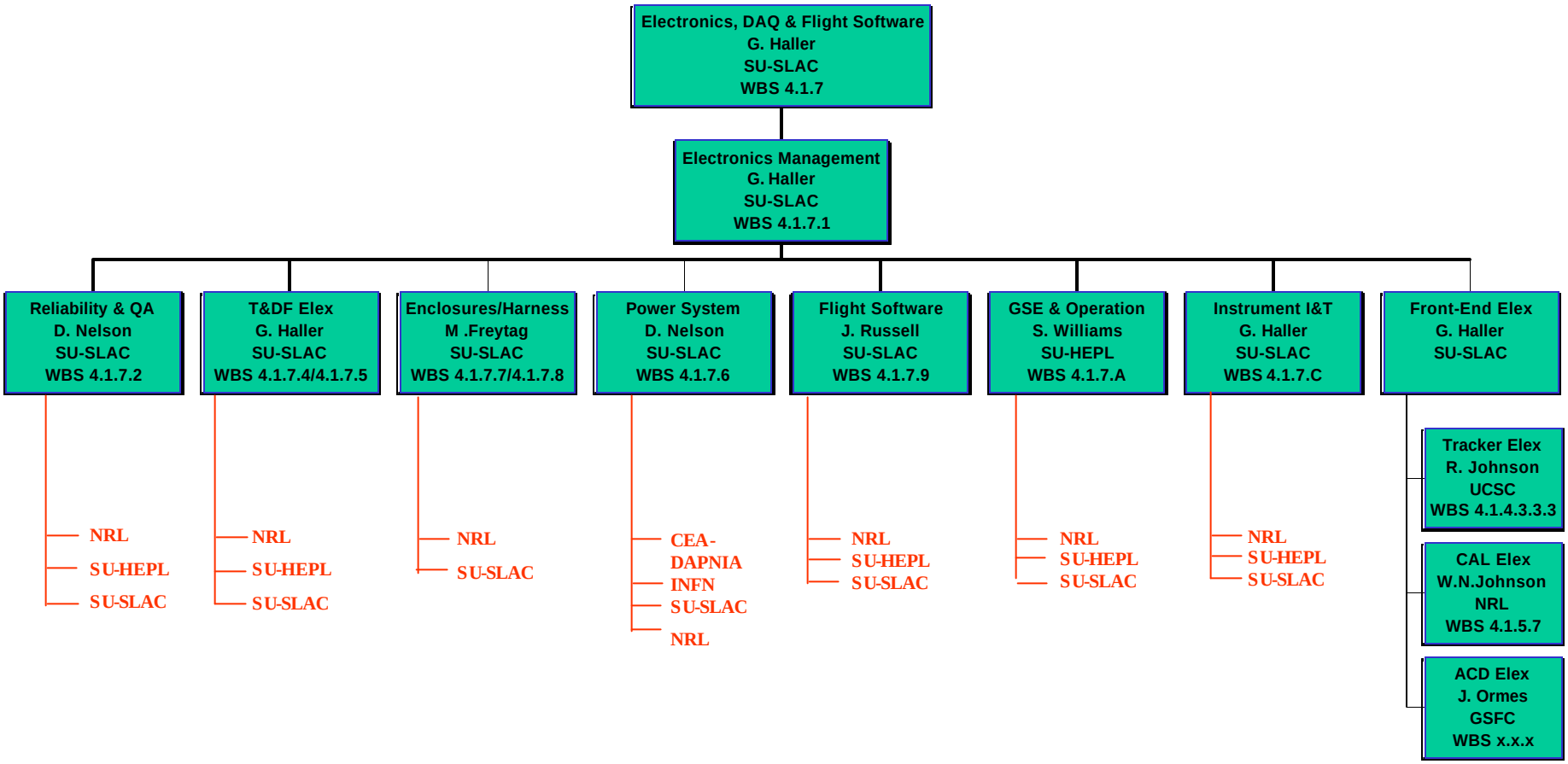
- *All modules/units contain power supplies -> see Power System*
- *Power Distribution Unit -> see Power System*

T&DF Architecture



* (1+1) = (1 Primary + 1 Secondary)

WBS Organization



System Documents

System Wide -- Technical Documents	
LAT-SS-00291	Grounding & Shielding Plan
GSFC-433-IRD-0001	Instrument-Spacecraft Interface Requirement Document
GSFC-433-RQMT-0005	Satellite Electromagnetic Interference Requirements Document
LAT-MD-00099-1	Parts Program Control Plan

T&DF Documents (1)

Trigger and Dataflow -- Specifications	
LAT-SS-00282	Trigger & Dataflow Document Reference Numbers

Trigger and Dataflow -- Specifications	
LAT-SS-00019	T&DF Level III Subsystem Specification
LAT-SS-00284	Trigger Level IV Subsystem Specification
LAT-SS-00285	Dataflow Level IV Subsystem Specification
LAT-SS-00293	T&DF Electrical Interface Specification
LAT-SS-00294	T&DF Interface Control Specification

Trigger and Dataflow -- Conceptual Design	
LAT-SS-00287	Conceptual Design Of The Electronics, Trigger & Dataflow System
LAT-SS-00286	Conceptual Design Of The Global Trigger
LAT-SS-00288	Conceptual Design Of The TKR-CAL Tower Electronics Module
LAT-SS-00289	Conceptual Design Of The ACD Electronics Module
Presentation	Spacecraft Interface Unit

T&DF Documents (2)

Trigger and Dataflow -- Technical Documents	
LAT-TD-00292	T&DF Mechanical Design
LAT-TD-00295	T&DF Reliability Analysis
LAT-SS-00298	T&DF Mechanical Parts And Material List
LAT-SS-00299	T&DF Electronics Parts List
LAT-TD-00296	T&DF Test System
LAT-TD-00297	T&DF Test Plan
LAT-SS-00300	T&DF Electrical Test Plan
LAT-TD-00331	Flight Software PDR

- Power System Documents see PS presentation
- PMCS Schedule on web includes T&DF, PS, EGSE & Flight Software