ADCSS-2014 workshop Day 3

ESTEC – October 29, 2014

WE LOOK AFTER THE EARTH BEAT

Standardisation of PF/PL interfaces TAS point of view

30/10/2014

Ref.:

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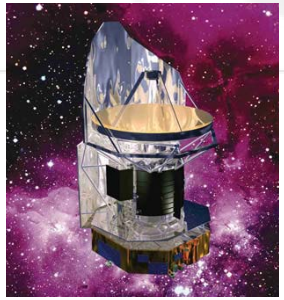
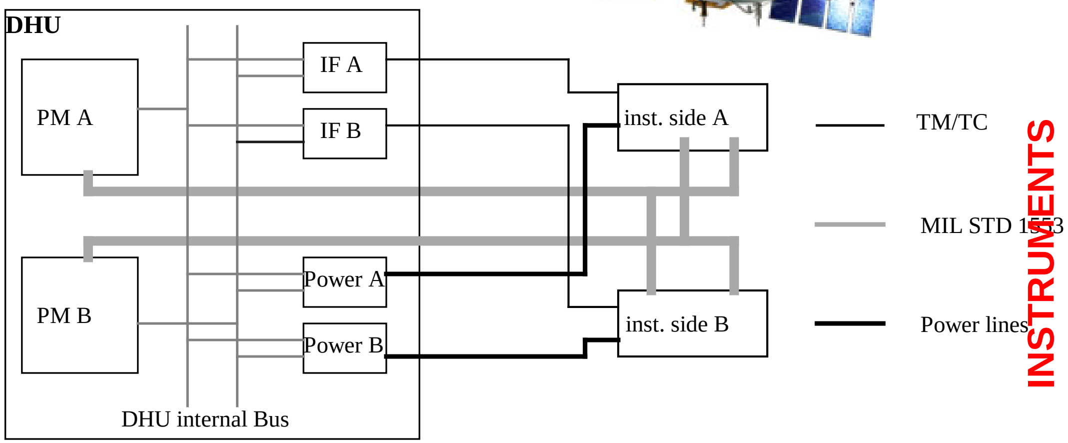
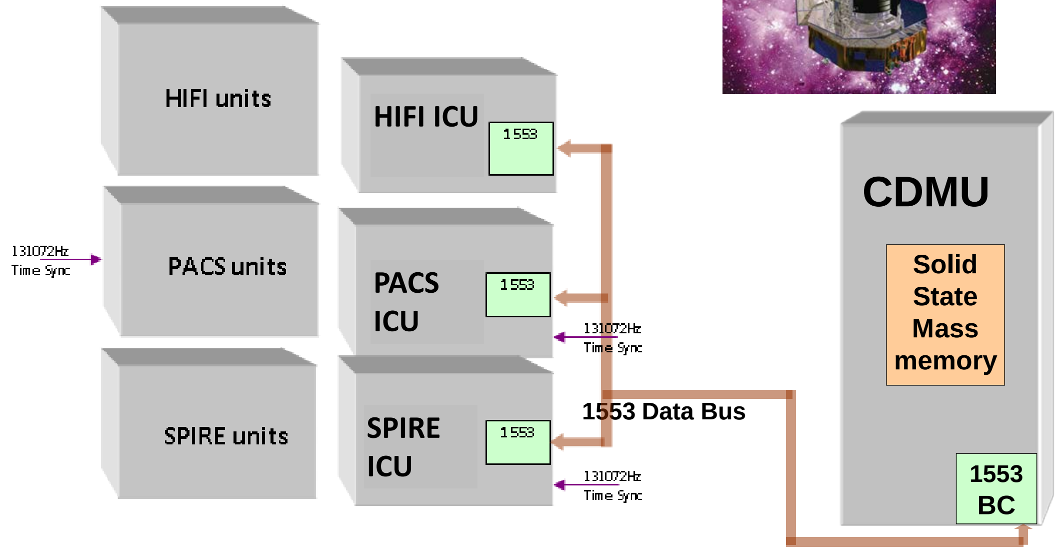
Agenda

- For Proteus, H/P, Sentinel 3, Telecom, the following points will be exposed
  - PF/ PL architecture
  - IF PL Command/control
    - Data bus
    - Discrete lines
    - FDIR
  - Validation IF PL
- Summary of lessons learned and recommendations

Proteus PF/PL architecture - Herschel and Planck PF/PL architecture







- A multi-mission Platform (5/6 missions with Proteus PF), accommodating several instruments per mission.
- ICU/DPU for each Instrument and a mass memory included in PF computer
- Science data via 1553 bus : data rate frozen early and made consistent with ground/space interface constraint (maximum downloading capacity of data volume)

Proteus – H/P PF/PL interface

Main characteristics

Discret signal		- Acquisition : analogue, temperature, status - Commands : HLC and LLC	
Synchronisation		discrete PPS + date sent on broadcast on 1553	on HP, date sent also th rough PUS time service
Bus type		1553 bus : 200 kbps data rate	on Proteus a serial line (10 MHz) was also available but never used
Exchange	type	Telecommands HK TM packets - Science packets	
	protocol	generic protocol level 3 for 1553 : - CCSDS packets received by PF computer on 1553 and stored in mass memory.	Frozen early in program (phase B)
MM storage	Data type	-HK PF TM -HK PL TM - Science Packet TM	A common mass Memory embedded in central computer
Autonomy/FDIR		Centralized FDIR by DHU => instrument put in safe state with continuous mission for the rest for the spacecraft Basic monitoring by PF and possibility to introduce gradual recovery on PL request HP : internal FDIR with capability of limited recovery Anomalies event reports sent to PF to trigger recovery actions programmed in OBCP	

- Robust 1553 protocol, early defined, consistent with download capability

Proteus – H/P PF/PL interface

- Validation
  - One 1553 simulator :
    - delivered to each Instrument supplier
    - Include protocol test plan
  - EM instruments on Avionics test Bench
    - Full campaign with representative HW and SW

- Operations data
  - Proteus : All data delivered by the instruments in the form electronic files
    - Iterations on the file content (naming).
  - H/P : PL people responsible of data delivery and population in System data base

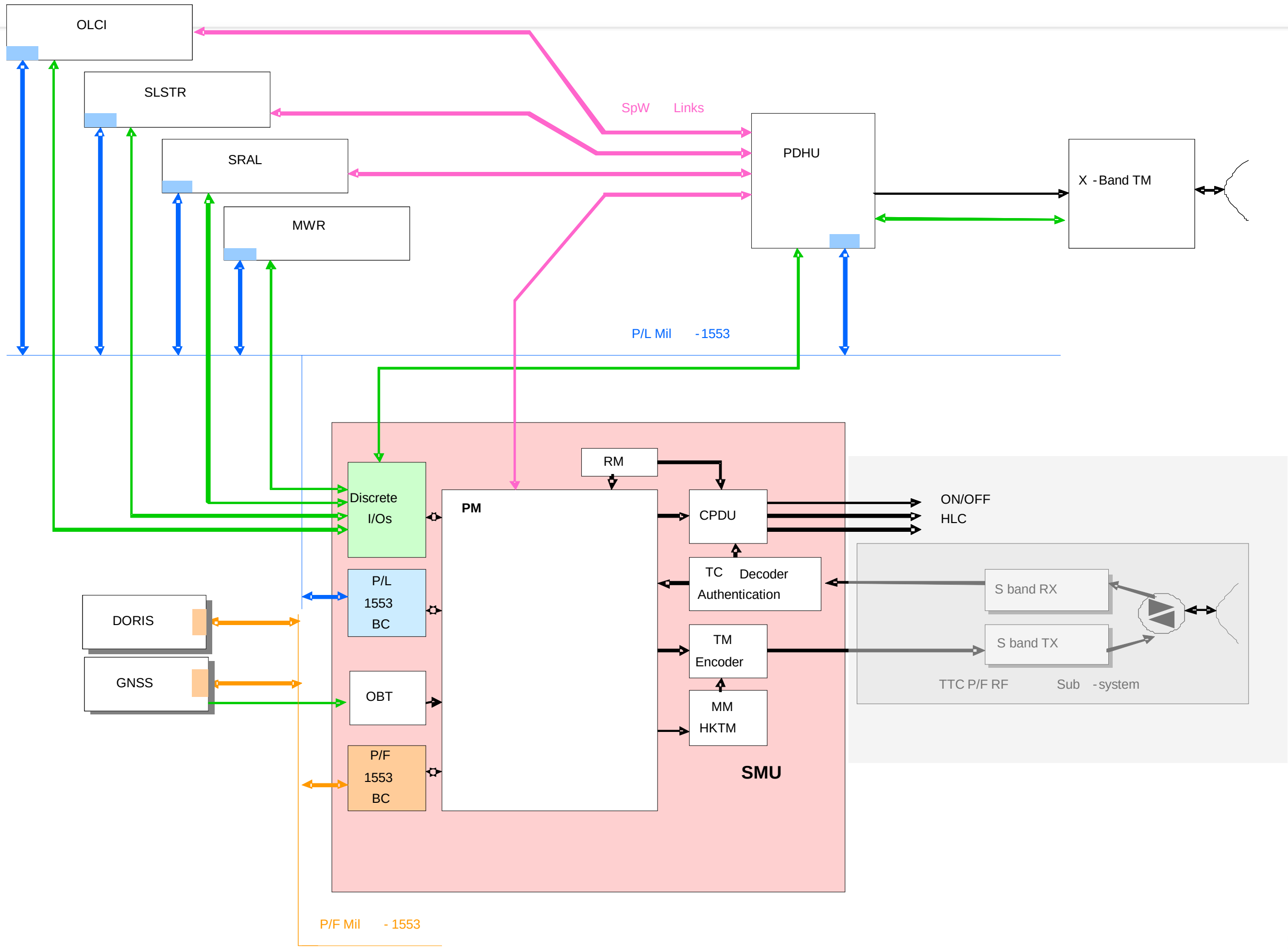
Lessons learned from Proteus – H/P

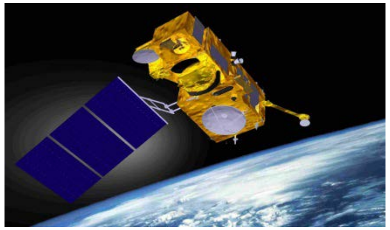
- Architecture
  - Robust 1553 protocol, early defined, consistent with download capability : minimise integration risks and freeze data rate
  - Flexibility in design for PL FDIR : as per OBCP usage, to keep avionics development rather independent of late PL FDIR definition

- EM on ATB : mandatory for the elements connected on the bus.

- Early implication of PF prime in interface specification and verification (typically phase B of PL instruments) :
  - To assist suppliers to understand protocol (1553 or ..)
  - Time synchronisation misunderstanding avoidance

Sentinel 3 PF/PL architecture





- A Platform accommodating 6 Instruments, with two 1553 buses : PL and PF.
- ICU/DPU for each Instrument and a PDHU (320 Gbits) organized in Packet-stores and transmit science data through band X justified by the data rate of the instruments
- Science data via 1553 bus and SpW

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S3 PF/PL interface

Main characteristics

Discrete signals		- Acquisition : analogue, temperature, status - Commands : HLC and LLC	
Synchronisation		discrete PPS + date sent on broadcast via 1553	
Bus type		1553 bus	CC via 1553 + Science data for GNSS - DORIS MWR (OTS)
		SpW	Science data
Exchange	type	Telecommands HK TM packets - Science packets	All based on PUS std
	protocole	- block exchange - PUS packets	Specific Protocol developped for S3 (before ECSS availability) - using Deep adressing
MM storage	Data type	-HK PF TM -HK PL TM - Science Packet TM + Auxiliary TM	In SMU mass Memory In PDHU
Autonomy/FDIR		Failure detection by Instruments Anomalies event reports sent to PF : either to trigger recovery actions (PL off),or for report	ASEQ use : flexibility face to inaccurate and/or late specifications

- Two 1553 buses :
  - Protocol – scheduling – electrical reasons
- Science data sent to Mass Memory
  - through SpW : when data throughput justifies it
  - Through Mil-1553 for low data-rates

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Sentinel 3 PF/PL interface

- Validation
  - Performed on the Avionic Test bench fitted with one ICU of each instrument and one PDHU (mass memory). This allows validating:
    - the Mil-Bus high-level Protocol (packet oriented)
    - the Cmd/Ctrl interface (mainly PUS services)
    - The Science Data transfer to PDHU and then to ground
  - This has allowed identifying some discrepancies (Local Time handling, PUS implementation)
- Operations data
  - All data delivered by the instruments in the form of a database (xml file), after validation at their level
  - Instruments Data merged in the whole S/C Database before delivery to ESA

Lessons learned from Sentinel 3

- Architecture :
  - 2nd 1553 bus for P/L : mandatory for implementing packet oriented protocol and for electrical reasons (high number of stubs on a short length)

- Validation :
  - 1553 simulator tool used to perform early protocol and interface checks at Instrument level

- Supplier management :
  - Time synchronisation to be well explained to instrument supplier
  - PUS applicability and implementation to be strictly specified to avoid inconsistencies in the implementation (e.g. optional fields)
  - Instrument database : the SCOS2K MIB ICD shall be made applicable to the suppliers to avoid NC w.r.t. SCOS2K

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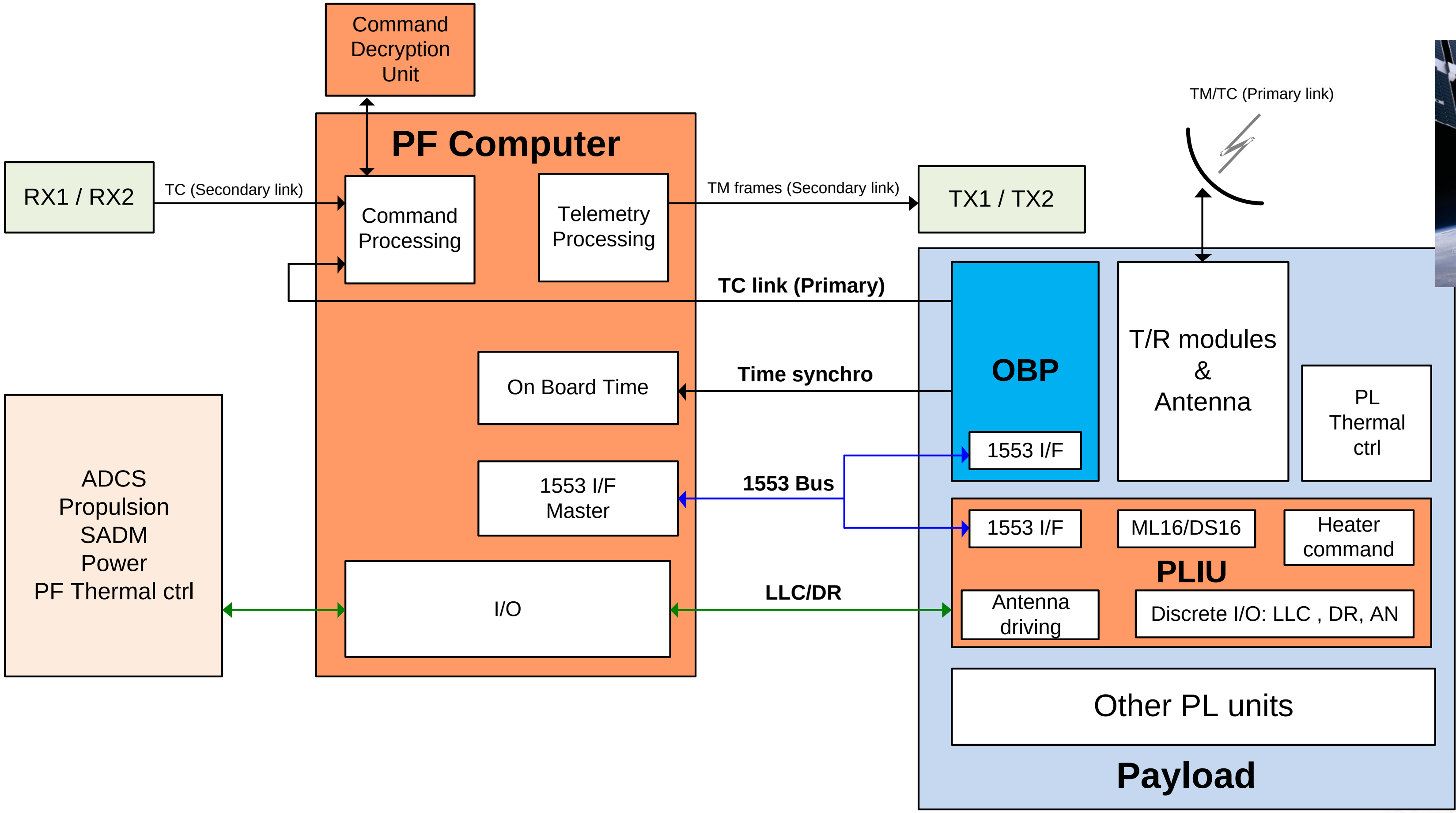
Iridium Next PF/PL architecture



- A Platform accommodating a telecom payload, used in a constellation network
- PL with its own computer (OBP), and direct TM/TC link (primary) used also by PFC
- A PL Interface Unit to control PL units and Antenna
- Antenna pointing controled by PF computer through PLIU

Iridium Next PF/PL interface

Main characteristics

Discrete signals		- Acquisition : analogue, temperature, status - Commands : HLC and LLC	
Synchronisation		PPS provided by the PL (stable oscillator) Time provided by PL	T0 provided by PF
TC link with Primary link		PL TC decoded by PL PF TC transmitted to PF Encrypted PL TC transmitted to PF decoder for decyphering and retransmit via 1553	PF TC can be encrypted
Bus type		1553 bus : ~100 kpbs ML16/DS16	Used for PFC IF with PLIU and OBP Bus managed by PLIU to control PL units
Exchange	type	- Telecommands (decrypted) - PF/PL HK and events TM packets - PL context - Antenna Pointing request/status	to PL (secondary link and primary link) to PL with TM encryption from/to PL (on request) from/to PL
	protocole	- Block exchange (ECSS-E-ST-50-13C) - PUS packets	
Autonomy/FDIR		FDIR PL shared between PL computer and PF computer. PF responsible in transition to safe mode and gradually switch off the PL	

- 1553 bus sufficient for the traffic between PF and PL
  - Mainly loaded by acquisition of TM packets and emission of TM frames
- ML16DS16 to interface simple PL units (through PLIU)

Iridium Next PF/PL interface

- Validation
  - Avionics test bench
    - With representative PF computer model (EM)
    - Mainly with simulated PL computer (OBP)
      - Use of a representative OBP model (EM) for key validation steps
  - System validation (constellation and ground)
    - Several semi representative SC models:
      - Representative PL models
      - PF computer simulator
        - With PF OBSW and IF boards for 1553, synch and TC
    - 1 representative and complete S/C model

- Operations data
  - 2 Separated data Base for PF and PL
    - A reduced set of PL data included in PF SDB

Lessons learned from Iridium

- Architecture :
  - 1553 bus protocol based on block transfer for high level data exchange (TM/TC packet)

- Validation :
  - Use of PFC simulator with real SW for system integration of PL
  - Use of HW element of the PL on the ATB : determinant for the PL interface validation at avionics level.

Lessons learned from MTG

- Pros ☺ :
  - Early specification of 1553 PF/PL bus profile
    - Reduces PF and PLs software dependency
  - Standardized PUS TM/TC exchange for instrument through PF
    - Ease parallel development without strong PF/PL relationship
  - Specification of SpW time skew&jitter allocation (Tx,Rx, harness)
  - FPM scan/AOCS APC based on lookup tables in MM
    - Minimize OBSW complexity & development and space/ground upload
- Cons ☹ :
  - Clearly specify duration for averaging for data rate allocation
  - If not, PLs continuously increase amount of data to be acquired
    - With higher peak over a lower period
    - Leading to difficulties to size counter-part buffer, with the risk that buffers are oversized for unrealistic limits based on link max capability

PL/PF Interface – TAS recommendations

- Standards :
  - We’ve got already the mandatory standards to built an efficient PF/PL interface :
    - Data bus : 1553, CAN, SpW
    - Data exchange : PUS
  - Considering SpW network
    - Need of CC protocol on SpW, to get correct PUS data with sufficient QoS
    - Electrical specification (skew/jitter)
    - Data rate to be frozen and consistant with capability of data volume that can be finally downloaded

PL/PF Interface – TAS recommendations

- Instrument management :
  - Early involved of Prime in Instrument development, with objective to well explain the interface standard and verify the applicability of these standards :
    - Time synchronisation
    - PUS applicability and implementation : same PUS library
    - Instrument database

PL/PF Interface – TAS recommendations

- Validation strategy :
  - Interface "suit case" for early interface tests at instrument supplier level
    - CC data protocol check
  - Real HW Instruments elements present on the avionics test bench
    - Mandatory for validation of the CC interface
  - Instrument Acceptance tests to be defined by Prime