Verification and integration of the management and control software for the Near Infrared Spectrometer Photometer of the Euclid space mission

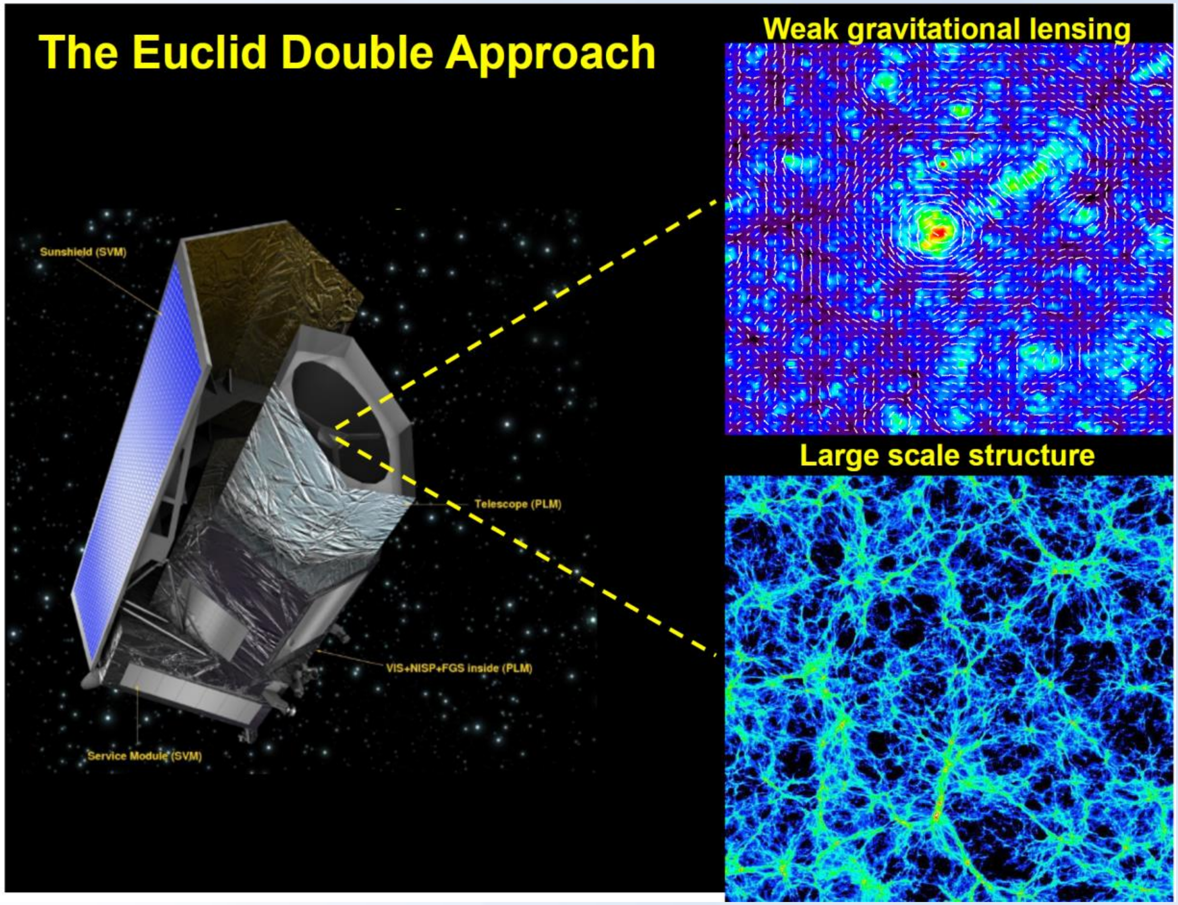
PhD : **Fulvio Laudisio**

Padova, 14 Settembre 2018 Seminars Room CISAS

OUTLINE

- The Euclid Mission
- NISP Instrument Warm Electronics
- AIV of the NISP Warm Electronics
- DPU ASW integration and DPU functional tests
- NISP AVM integration and test

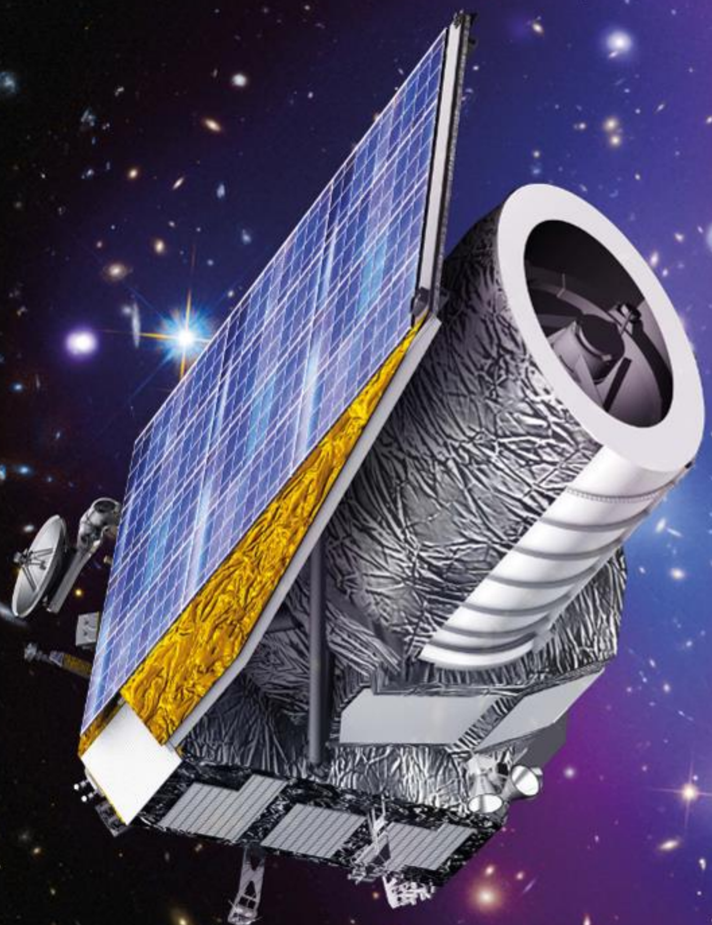
EUCLID MISSION



The Euclid mission will use two probes to study dark matter and dark energy 3D distribution

- **<u>Galaxy Clustering</u>:** measurement of the redshift distribution of galaxies from their Hα emission line using near-infrared slitless spectroscopy
- **<u>Weak Lensing</u>:** measurement of the distortion of the galaxy shapes due to the gravitational lensing caused by the dark matter distribution between distant galaxies and the observer. From the resulting galaxy shear can be deducted matter distribution.

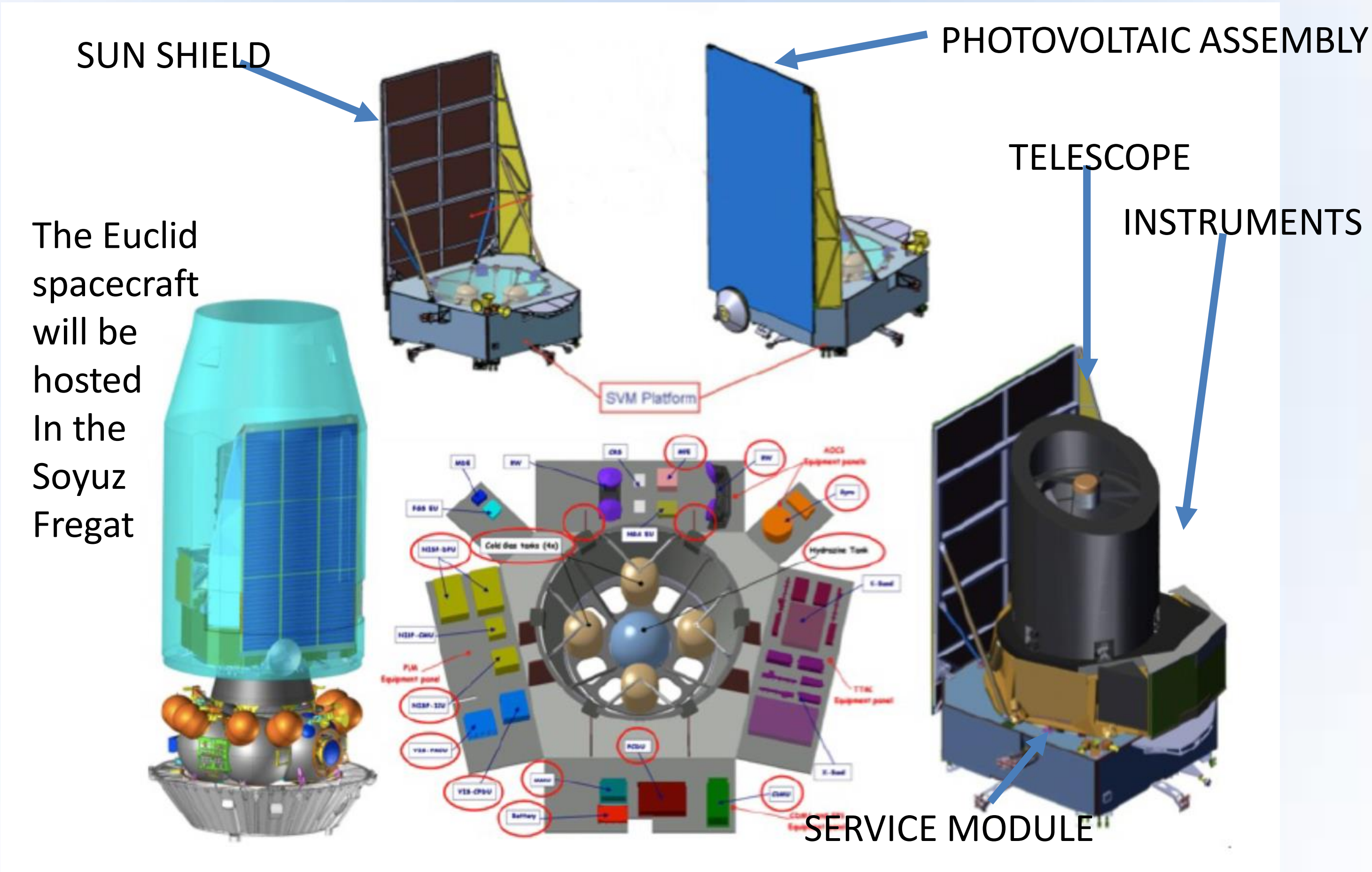
EUCLID MISSION



- **ESA mission**
- Selected in Oct. 2011 - Fully funded
- Partners: ESA, TAS, Airbus DS, Euclid Consortium (EC)
- Overall mass: ~2020 kg, Power : 1920 W (E0L)
- Data rate: 850 Gbit/day
- Telescope (T=125K, passive):
  - 1.2m aperture primary, 3 mirror Korsch anastigmat
- 2 Instruments (VIS, NISP) – T = 100-140 K (passive)
  - Wide field instrument, VIS: 36 e2v 4kx4k CCDs $0.55<\lambda<0.92$ µm, 576 M pixels, 0.11 arcsec/pix, 0.53 deg^2 FoV
  - Photom. (Y, J, H) +spectrom.: 16 H2GR HgCdTe detectors;
  - 64 Mpixels, 0.30 arcsec/pix, 0.53 deg^2 FoV (=VIS)
  - Grism slitless spectro (1B + 3R grisms) $0.92<\lambda<2.05$ µm, R>250
- Downlink Rate: X/X + K-band to Ground Station 55 Mbits/s. 850 Gbit/day to transfer 4hr/day.
- Ground Segment: ESA (50%,) EC (50%, EC leads science and external data): 1.5 billion galaxies for WL, 30 million redshifts, 12 billion sources (3sigma)
- L2 orbit
- Launch Vehicle – Soyuz-Fregat
- Launch date 2021, from Kourou space port
- 6.25 years mission + additional surveys (exopl, SN)
- Main surveys: 15,000 deg^2+40 deg^2 2 mag. deeper
- Science drivers: DE
- Science leads: Euclid Consortium

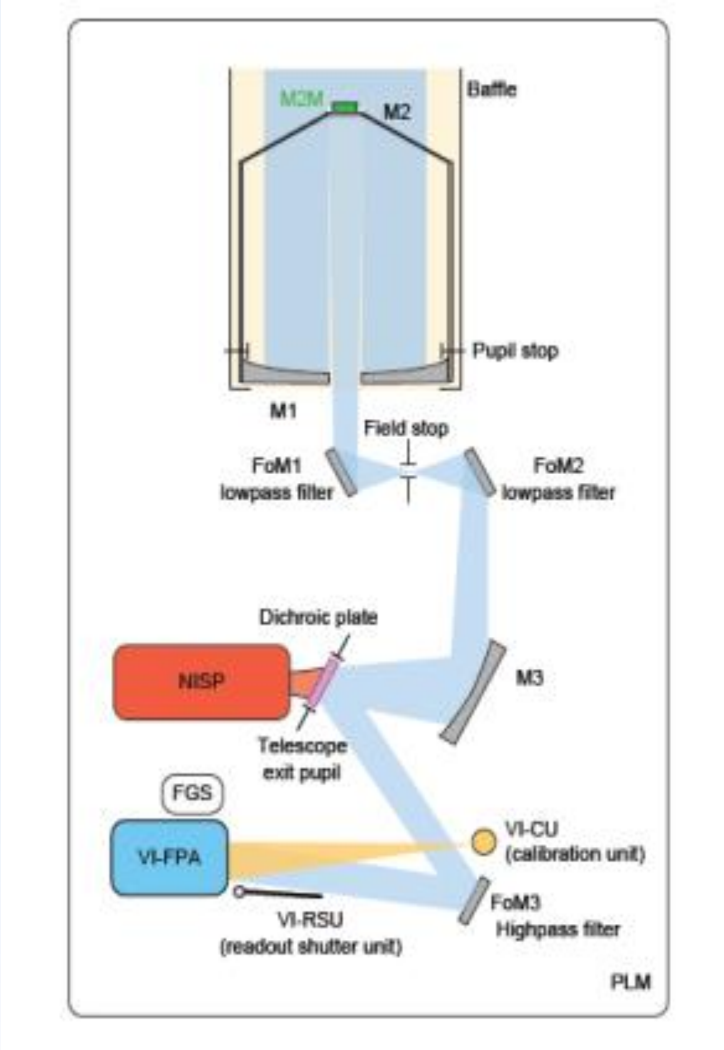
THE EUCLID SPACECRAFT

Being an ESA Medium class mission means that there are no mission specific developments, that will be used technologies with high TRL (>= 5) and moreover cost is a target and the realization of the main parts, telescope and spacecraft, is under industrial competition and follows ESA procurement rules and geographical return constraints



THE EUCLID PAYLOAD

1.2m Korsch Telescope (Three Mirror Anastigmat) with a field of view of 0.54 deg² and a focal length of 24.5m light is split to two instruments (VIS & NISP) by means of a dichroic filter



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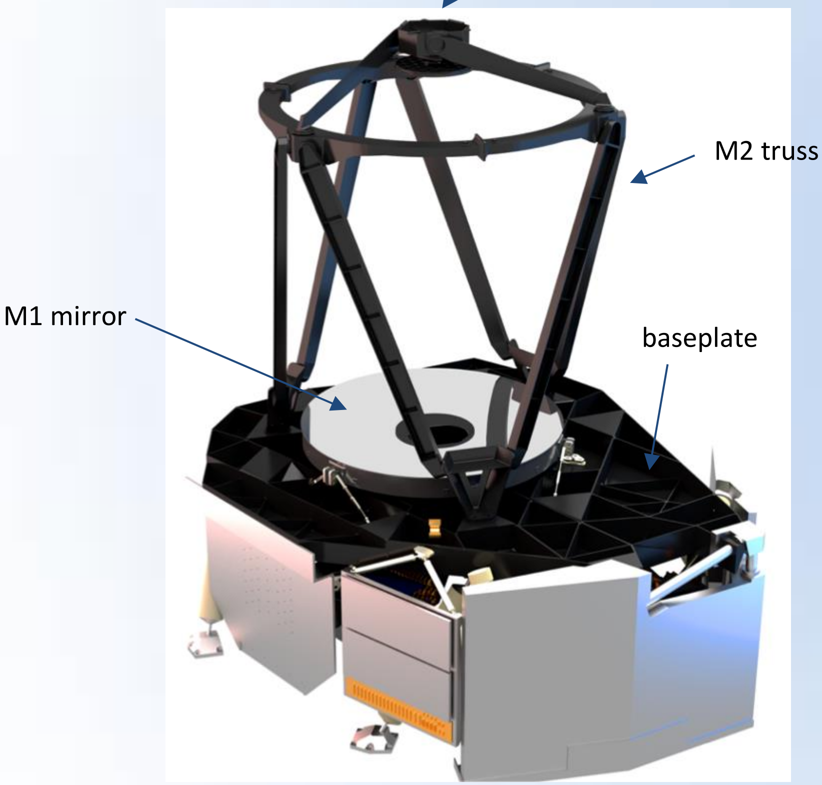
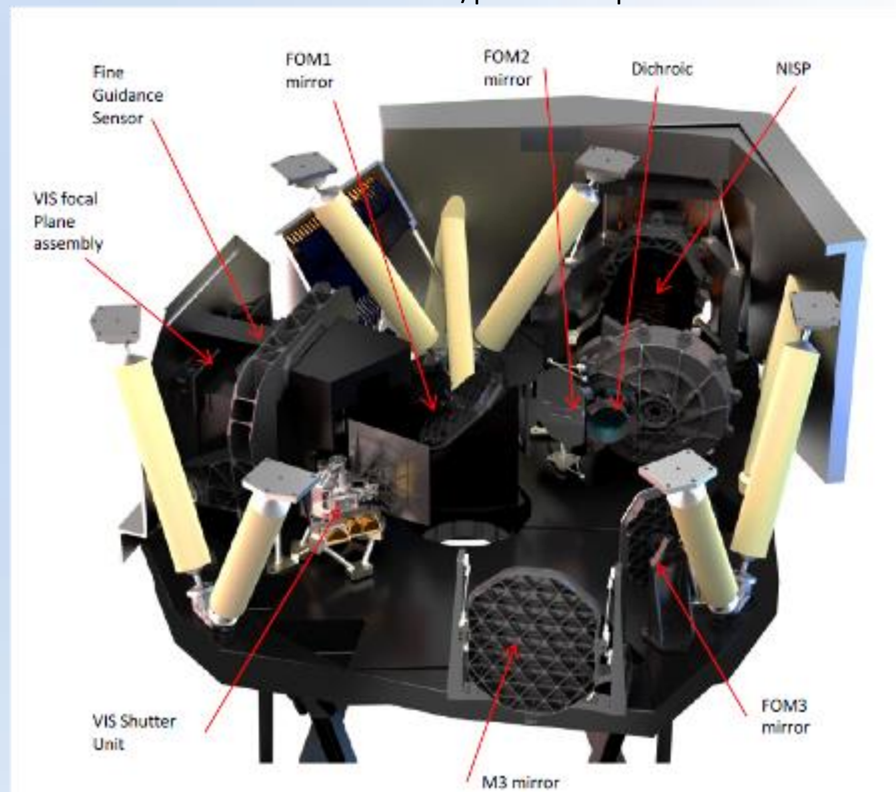
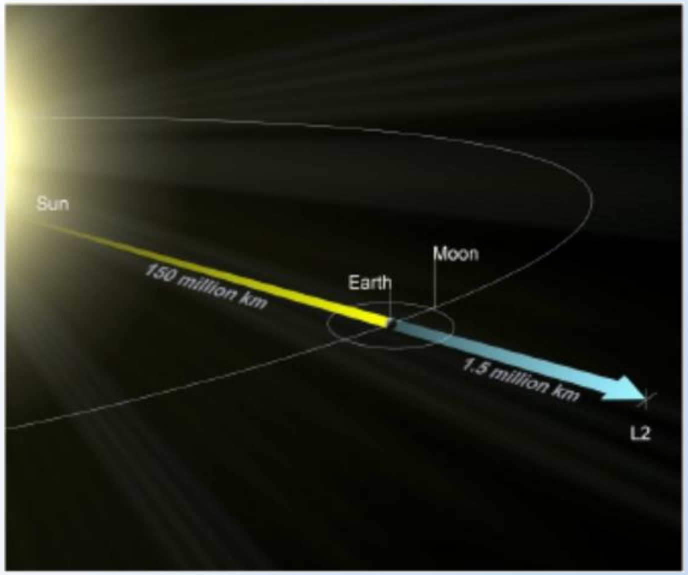


VIS (Visible Imager):
36 4k×4k CCD with 12µm pixels
0.1 arcsec/pixel Bandpass 550-900nm

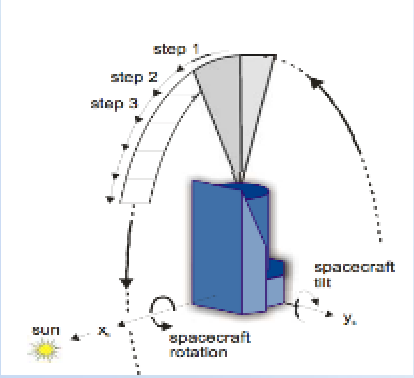


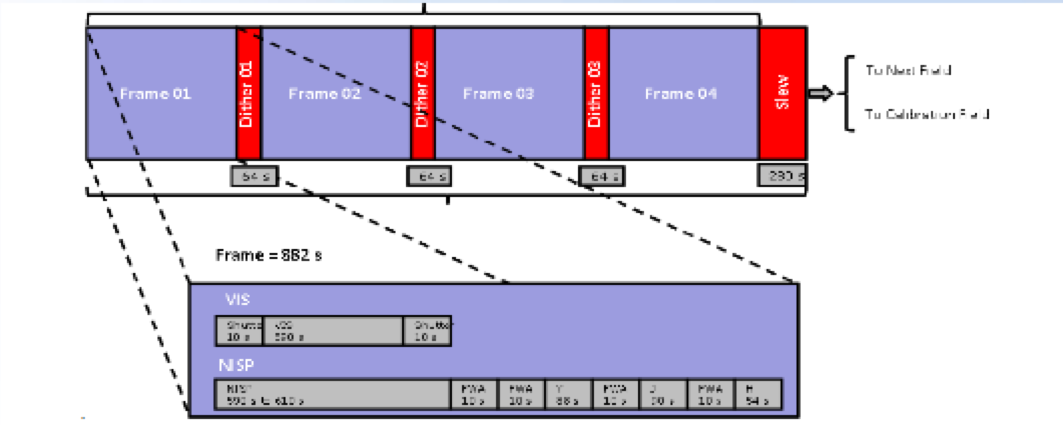
NISP (Near Infra-Read Spectro-Photometer):
16 HgCdTe NIR detectors 2k×2k pixel, 0.3 arcsec/pixel 18µm size
3 NIR filters: Y,J,H
4 Grism (1 «Blue»; 3 «Red»)

THE EUCLID MISSION

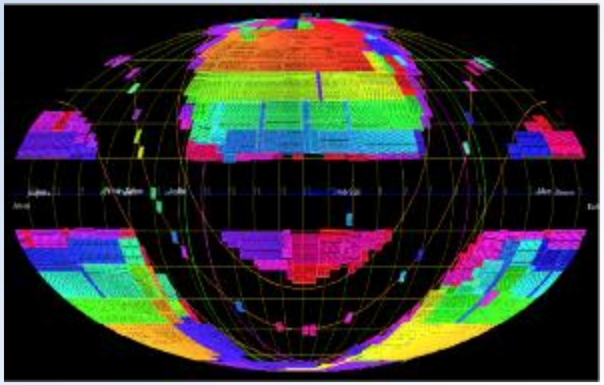


OBSERVATION STRATEGY





Sky coverage after 6.5 years survey

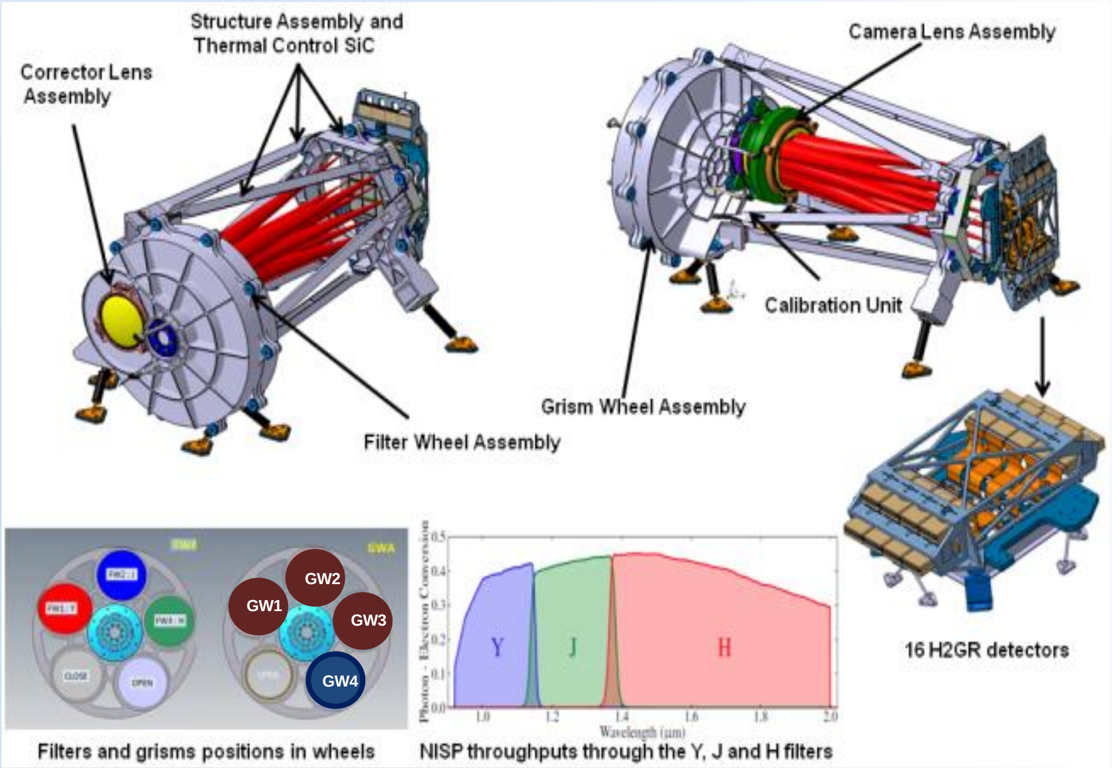


THE NISP INSTRUMENT

NI-OMA: Opto-Mechanical Assembly
Holds the optical elements, the focal plane array, the sensor chip electronics and the calibration unit in the satellite cold PLM (100K)

NI-DS: Detector System
The system provides detection of the NIR signal in photometric and spectrometric mode

NI-WE: Warm Electronics
It is located in the satellite warm (240K) Service Module (SVM) and it is composed by 2 Data Processing Units (DPU) and 1 Instrument Control Unit (ICU)

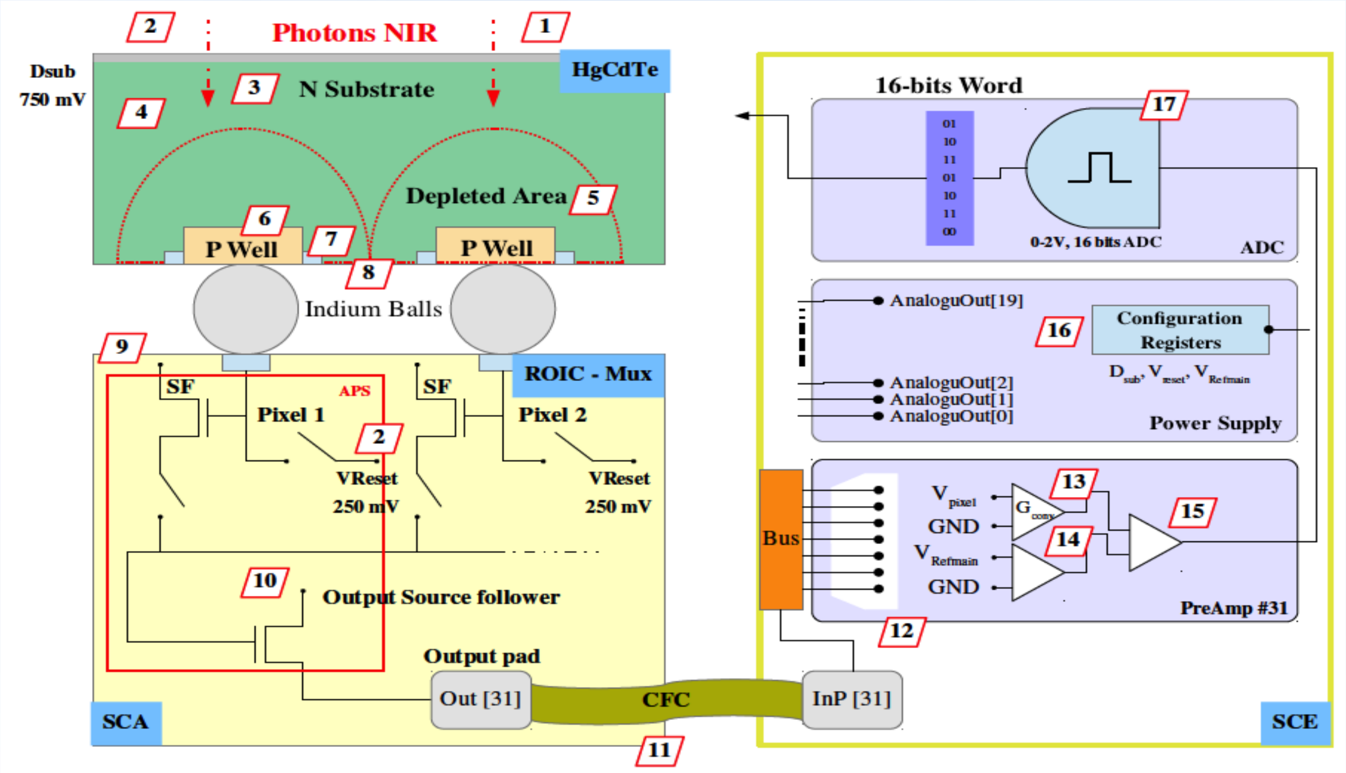


- Box Size: 1.0 x 0.5 x 0.5 m³
- Mass: 160 kg
- Power: 200 W

THE NIR DETECTORS

The NISP focal plane is composed by 16 H2RG detectors 2048 × 2048 pixels, 0.3 arcsec/pixel, by Teledyne, coupled with a dedicated readout electronics (SIDECAR ASIC)

A substrate of HgCdTe calibrated for sensitivity cutoff at 2.3μm is soldered on the silicon multiplexer.



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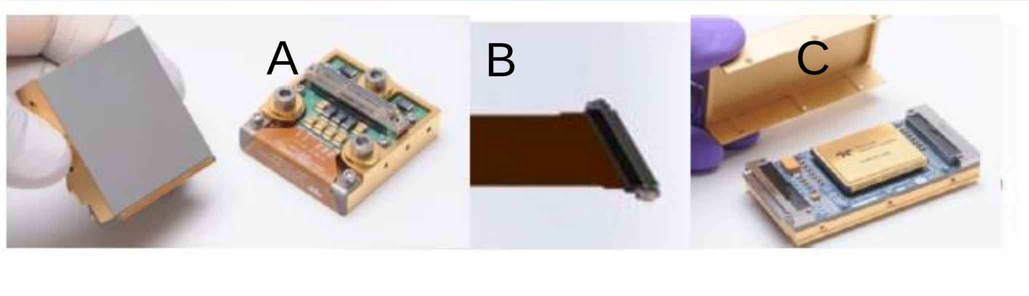


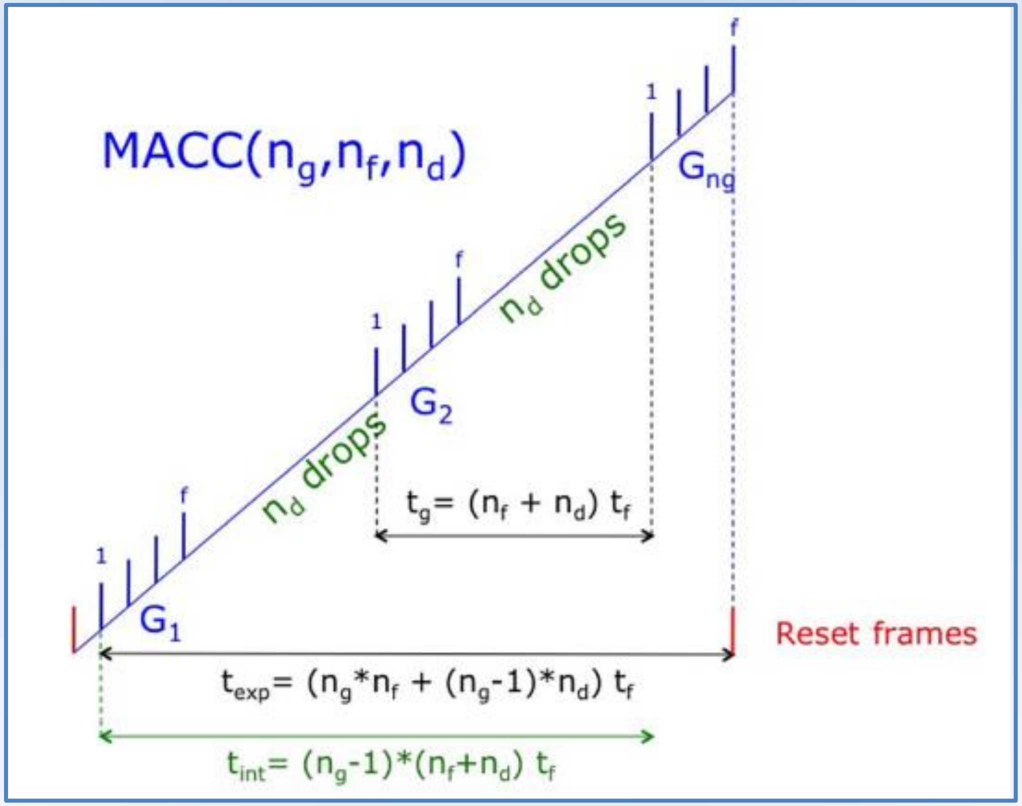
Detector triplet (SCS):

A - Sensor Chip Assembly (SCA) Teledyne HAWAII2RG
B - Flex Cryo Cable
C - Sensor Chip Electronic (Sidecar ASIC)

Each pixel can be read independently and the reading is non-destructive, so it is possible to perform several successive measurements and to average them in order to reduce the noise. (Multi Accumulation MACC)
SCE supports a readout mode that uses 32 parallel output amplifiers. Each output addresses a 64 × 2048 vertical sub-array in the SCA. The acquisition firmware yields a minimum exposure time of 1.41 s with a pixel rate of 100 kHz.

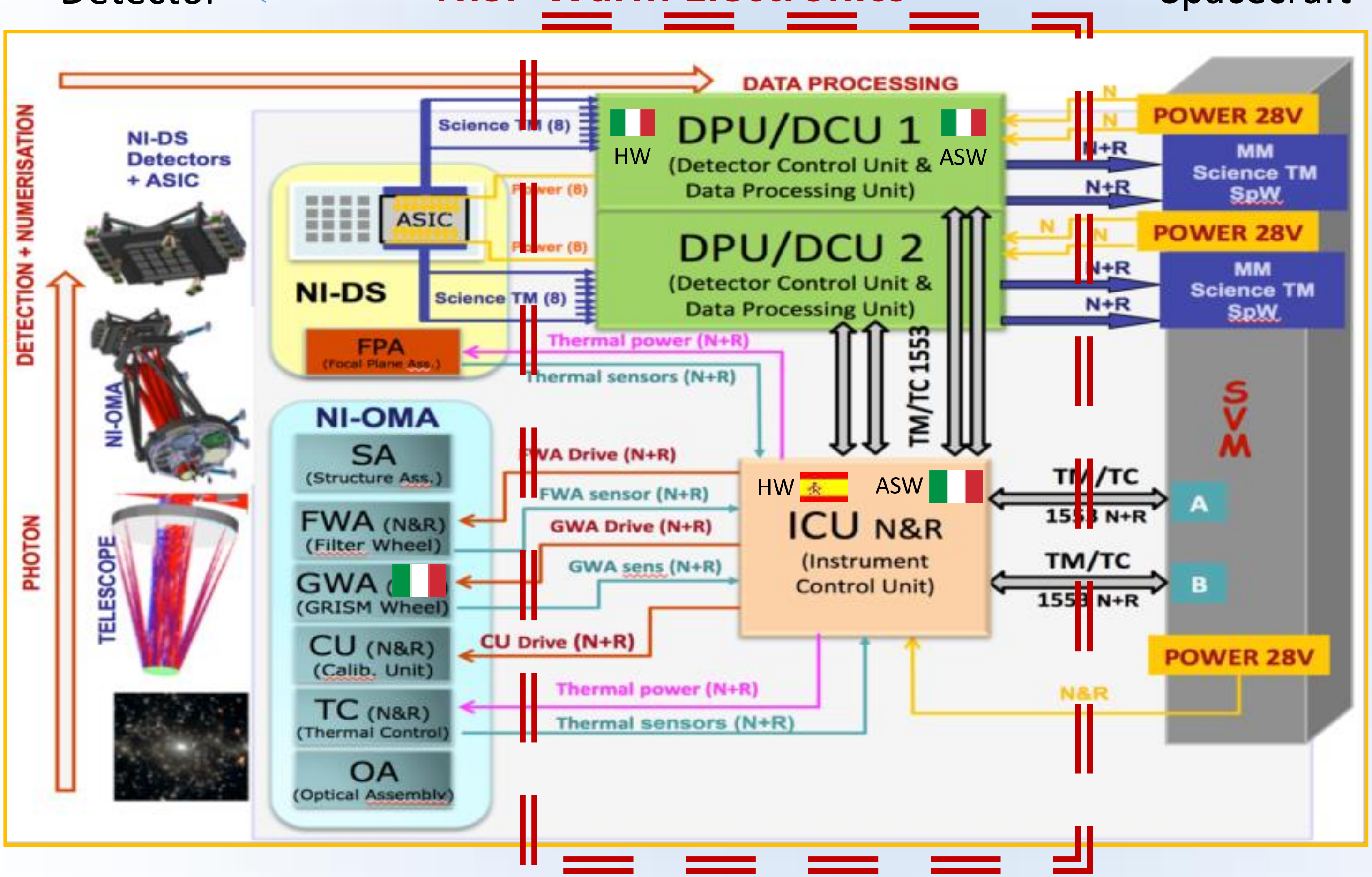
NIR DETECTORS READOUT

The readout technique is a multiple accumulated sampling MACC(n_g, n_f, n_d); n_g is the number of equally spaced groups sampled UTR, n_f is the number of frames per group and n_d is the number of dropped frames between two successive groups. Readout frames in the same group are mediated. This is called ***coadding,*** it has the advantage of reducing the Gaussian distributed pixel readout noise



THE NISP ARCHITECTURE

Detector ← **NISP Warm Electronics** → Spacecraft



DPU/DCU

- Data acquisition
- Data processing
- Data compression
- Data transfer to satellite memory

ICU

- Filter wheel & grism wheel control
- Telecommands dispatching
- Telemetry acquisition and transfer to SVM

DATA PROCESSING UNIT/DATA CONTROL UNIT

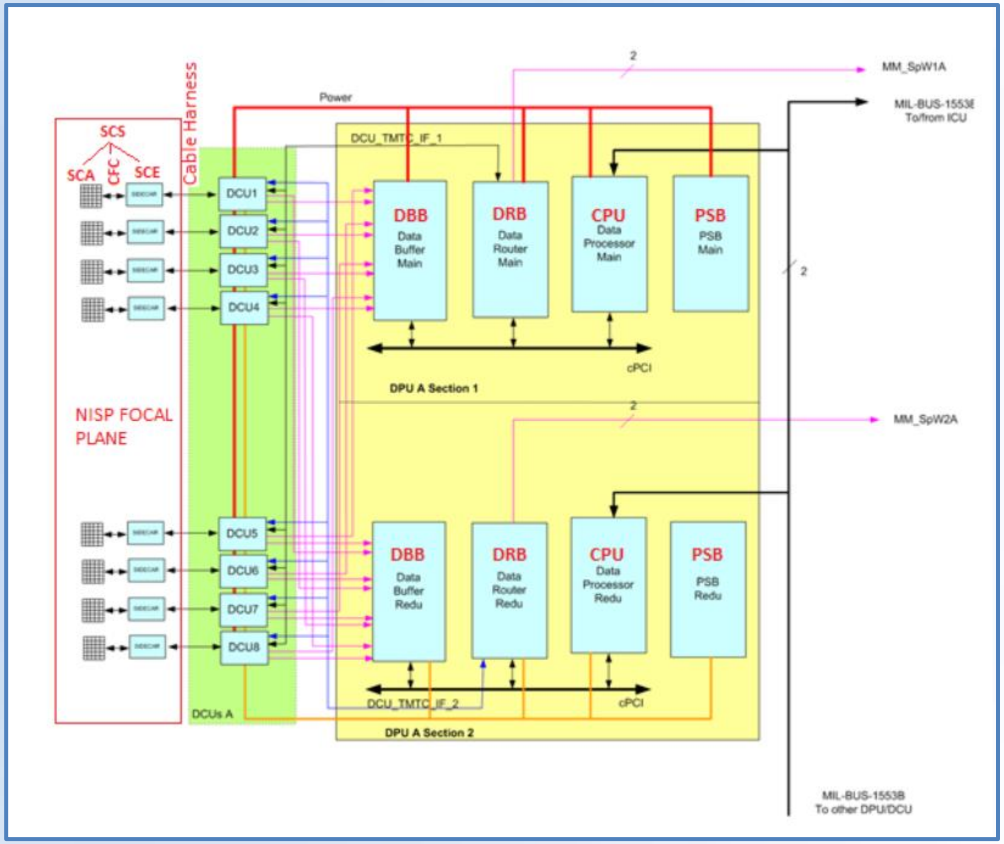
DPU/DCU Hardware supplied by OHB-I

A single DPU units hosts:

- NI-CPU Maxwell SCS750-PPC
- 8x Detector Control Units (DCU)
- Space Wire Router Board (N/R)
- Dual Ported Data Buffer Board (N/R)
- Power Supply Board (N/R)

Maximum daily data rate 290 Gbit/day

- Each DCU board is interfaced to one SCE
- Provides power to SCE in five isolated lines
- Performs frames coadding
- Stores coadded data in the Data Buffer Board
- Retrieves telemetries

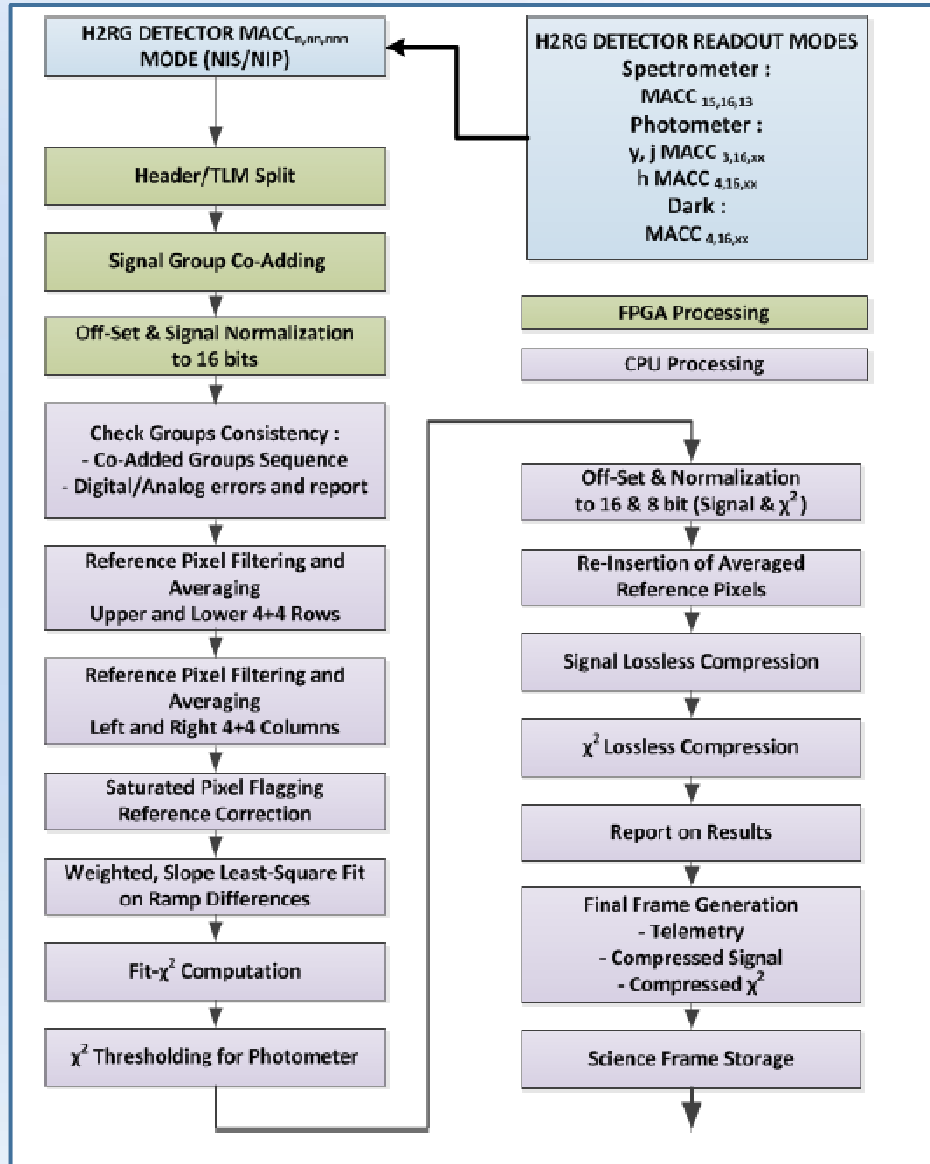


DPU/DCU FUNCTIONALITIES

Data acquisition performed by SCE (line by line)

Data collection in frames and groups coadding by DCU boards

DPU ASW : data processing , slope evaluation pixel by pixel, χ^2 computation, data compression and transmission to MMU



NI-ICU (Instrument Control Unit)

ICU Hardware supplied by CRISA (Spain)

Low Voltage Power Supply module:

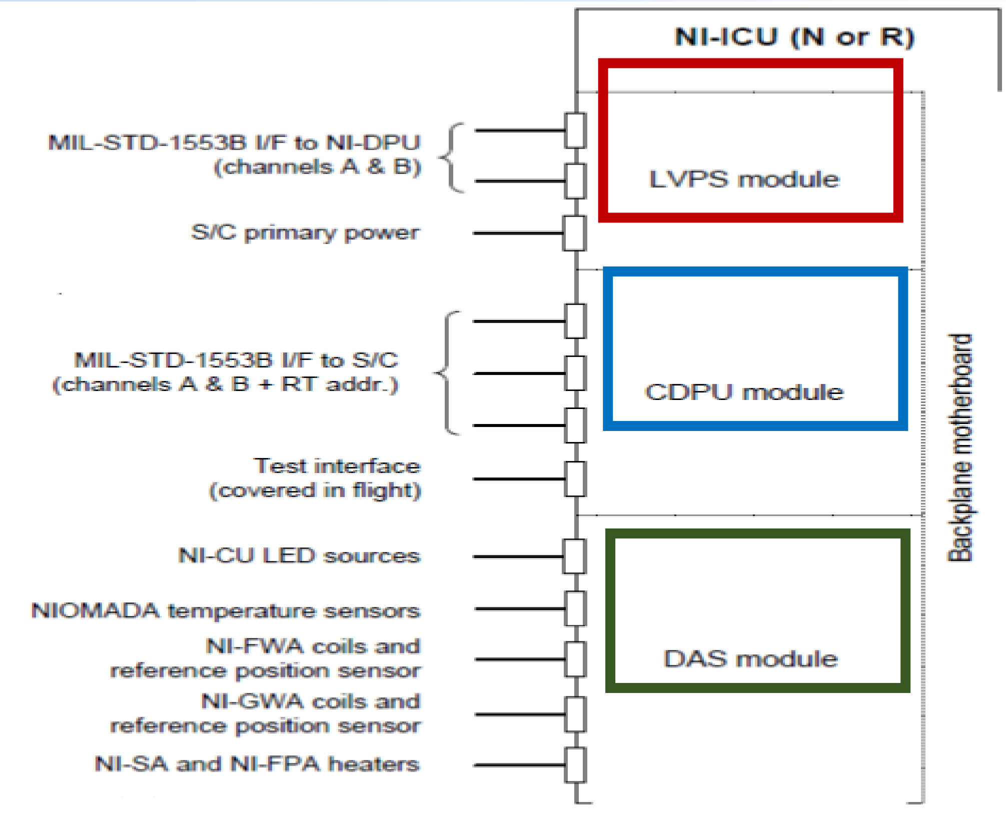
- DC/DC converters for power supplies
- 1553 transceivers for the NI-DPU link

Central Data Processing Unit module:

- Radiation tolerant FPGA with LEON2 processor (MDPA ASIC)
- 1553 transceivers for the S/C link

Data Acquisition System module:

- Control board of the FWA, GWA and CU
- Drivers for the heaters of NI-OMA and NI-FPA



NISP WARM ELETRONICS AIV

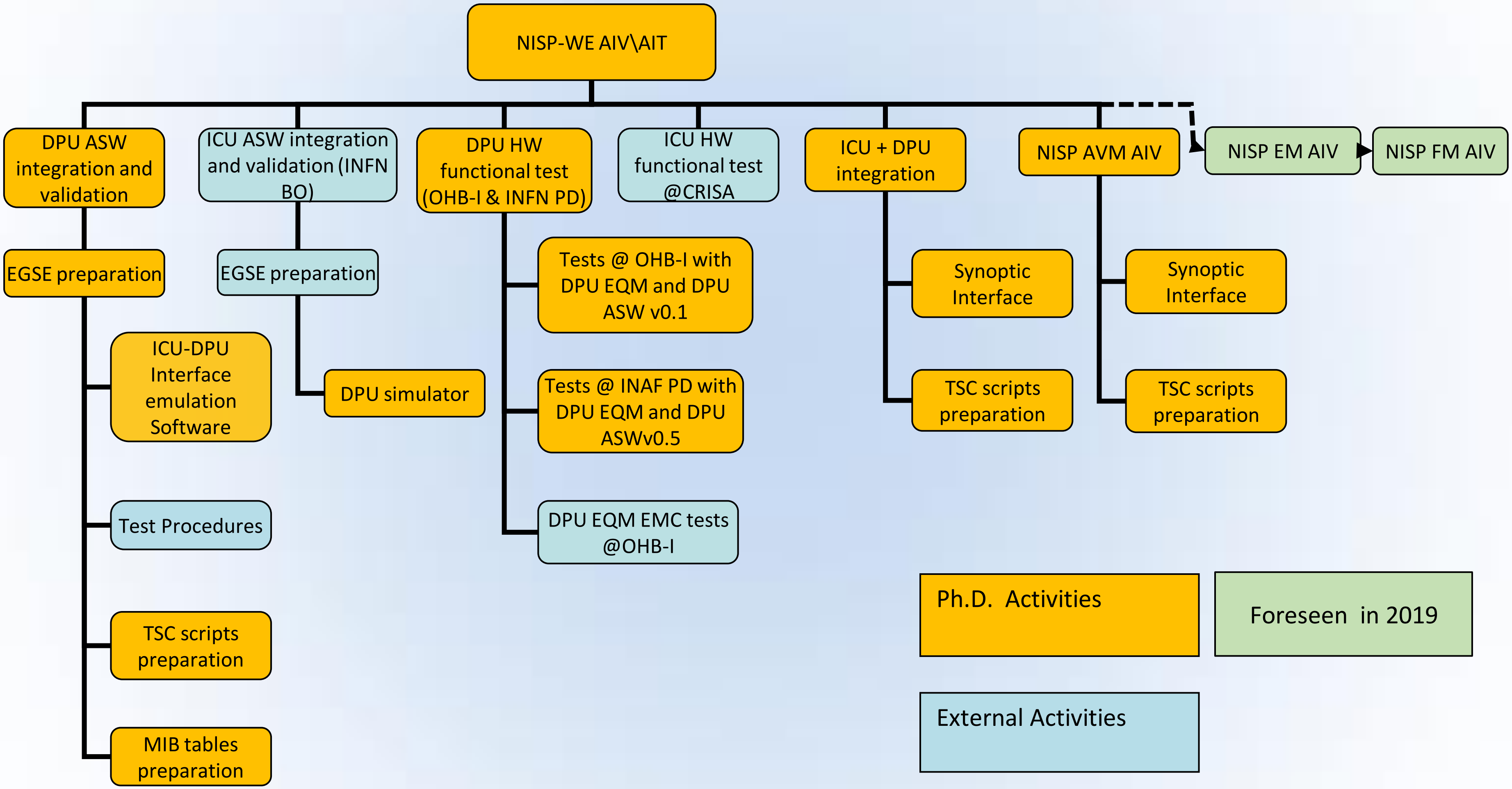
My activity was performed in the NISP WE AIV/AIT framework, which is in collaboration with:

- INAF (Padua Observatory) – DPU/DCU ASW development
- INAF (Turin Observatory) – ICU ASW development
- Department of Physics UNIPD - WE – AIV/AIT
- INFN (Padua and Bologna) - WE - AIV/AIT
- LAM (Marseille Astrophysics Laboratory) – NISP instrument validation
- Euclid Consortium- Scientific validation
- Industrial partners (OHB-I, CRISA, THALES-I)

AIV/AIT steps:

- Documentation and test-plan preparation
- Verify DPU & ICU ASW integration in the HW (unit level)
- Test TC/TM flow (DPU+ICU)
- Test end-to-end science data flow
- To be performed on EQM, AVM and FM models
- Up to now the NISP Instrument is in the Middle of Phase D and AIV\AIT activities are on-going up to the integration and delivery of the Flight Model

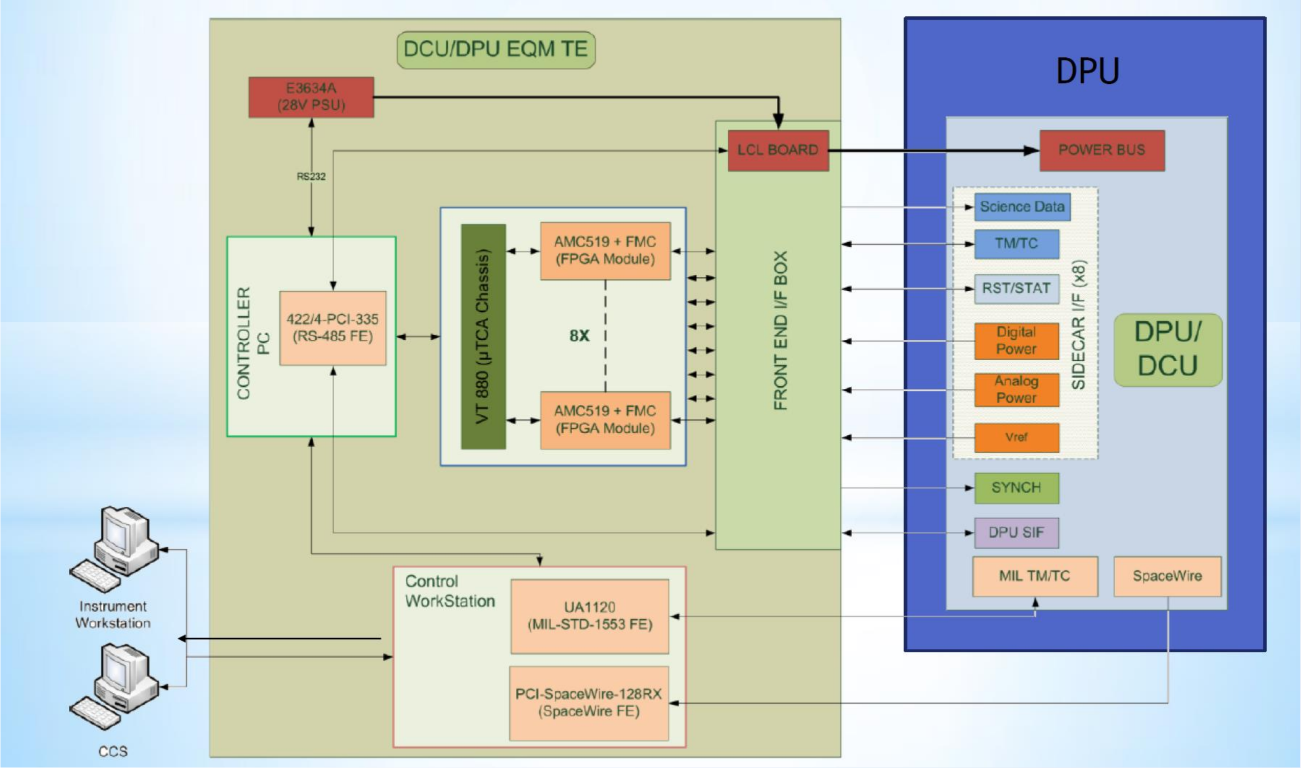
WBS OF THE NISP-WE AIV/AIT



DPU ASW INTEGRATION AND VALIDATION

EGSE

In order to test all the requirements, it is always necessary to produce dedicated equipment that simulates flight equipment or simplified models of them. This is necessary at every stage of the verification and of course it must take into account the development status of the unit under test. All this equipment, the simulators, the software, the testing framework and the testing facilities as well are normally referred as ***Electronic Ground Segment Equipment***.
In the specific case of the **DPU EQM** the following Test Equipment (DPU/DCU EQM TE) was prepared.

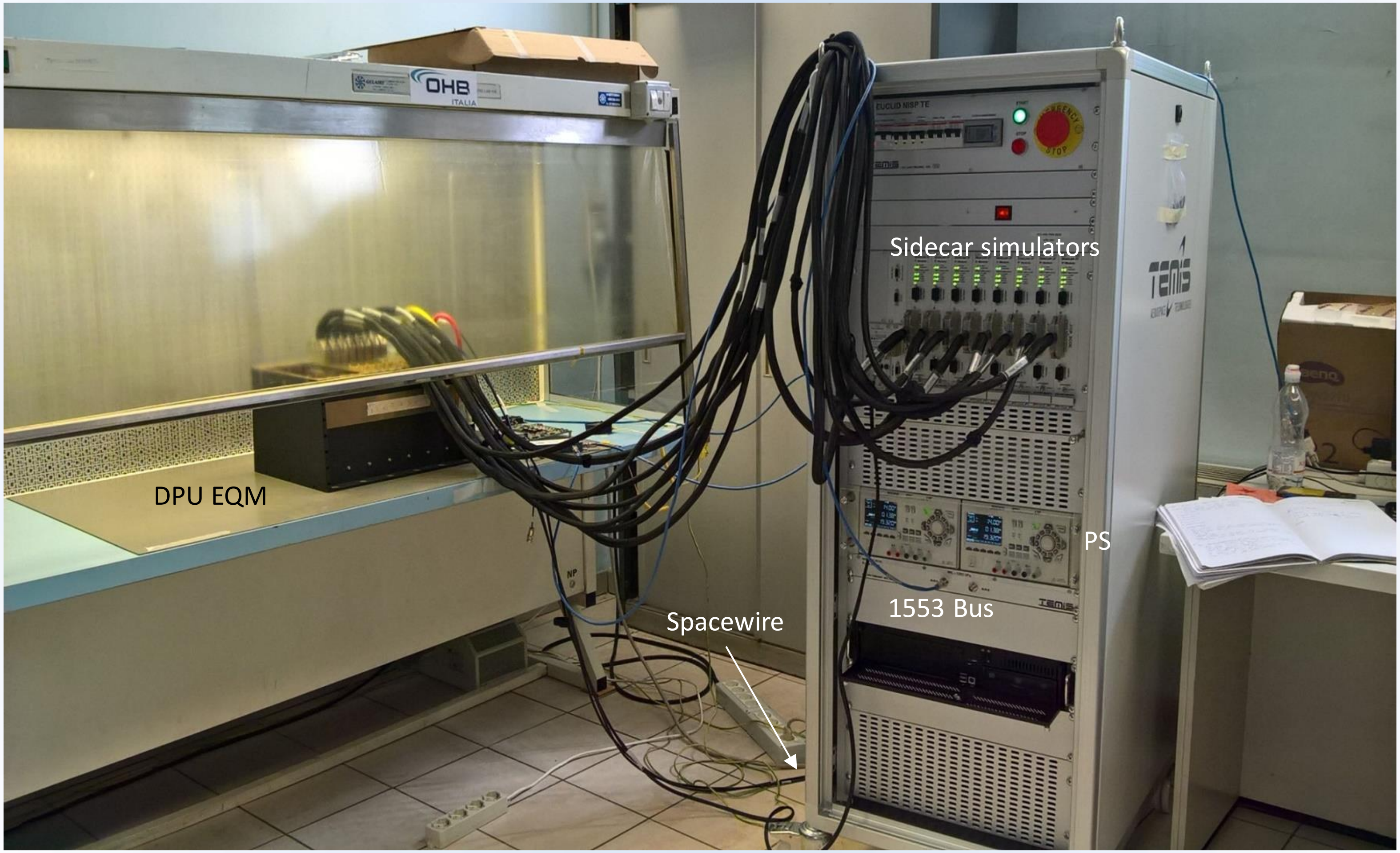


It provides:

- Power supply
- Control PC equipped with TSC EDEN interface
- MILBUS 1553 to test DPU-ICU TC/TM flow
- Spacewire I/F for scientific data transmission
- 8 Sidecar ASIC simulators

DPU ASW INTEGRATION AND VALIDATION

EGSE



Testing Facility at OHB-I Milan

DPU ASW INTEGRATION AND VALIDATION

1553 I\F SIMULATION

- In order to submit commands and configuration directives to the DPU and to retrieve digital and analogue Telemetries, through the MIL-STD-1553B bus, it was necessary to develop by scratch an interface between the TSC and the commercial hardware implementing the MILBUS.

- This interface is called “pus2dpu”, the major contribution of my work to the DPU unit test campaign.

- The hardware, chosen at preliminary design, is the Ballard® USB-1553 MILBUS UA1120 that is programmed by the application as Bus Controller.

- The pus2dpu exchanges TC/TM with the TSC from a TCP/IP connection in the form of PUS packets.

- It is mediated by a tool that is seen by the TSC as a SCOE implementing an EDEN communication that encapsulates/extracts PUS packets into/from EDEN packets.

DPU ASW INTEGRATION AND VALIDATION

1553 I\F Communication

The 1553 I\F has two elements:

- **Bus Controller (BC)**: Starts every communication on the bus
- **Remote Terminal (RT):** Receives and transmits messages, of at most 32 WORDs, from/to the BC to 30 Sub-Addresses on demand.

Additionally we can have :

- **Bus Monitor (BM):** listens to all messages and collects data

Every message that is transmitted on the bus is made up by three types of words:

- **command word**: specifies the function that the RT has to perform
- **data word**: the information carried by the message, a single message can carry a maximum number of 32 words
- **status word**: contains the information about the status of the communication

In our case :

- **ICU implements the MIL-1553 BC**
- **DPUs provide 4 MIL-1553 RTs (one for each DPU section).**

The TM\TC communication between ICU and DPU is a flow of 1553 messages arranged in a periodic schedule of 1s subdivided in 60 frames.
At the beginning of the schedule a sync signal is issued.
The link between the Spacecraft and the ICU is MILBUS 1553 too where the ICU is RT21.
It follows a similar schedule of 1s subdivided in 60 communication frames.

DPU ASW INTEGRATION AND VALIDATION

1553 I\F Documentation

The communication between ICU and DPU is described in the **DPU Interface Control Document** in which all the commands and telemetries parameters are explained.

Command to Power On\Off one DCU

Word #	Definition :	Comments :
0	**12850÷12857** **12858 for OFF broadcast (to be tested)**	DCUSCE ID# + 50x256 :
1	ICU REQUEST COUNTER (Bits 0÷15)	Wrap-Around Counter
2	ON/OFF Parameter	1 Selected DCU/SCE (See CMD_ID) ON 0 Selected DCU/SCE (See CMD_ID) OFF **Broadcast active only for general DCU/SCE OFF** **NOTE on mode 0**

Digital telemetry of the DPU ASW internal status

Word #	DEFINITION :	COMMENTS :
0	**10**	DPU_STATUS_TAB is ID : **10**
1	ASW REPORT COUNTER (Bits 0÷15)	ASW Internal Wrap-Around Counter
2	LOBT 1	Time, values $2^{31} - 2^{16}$ s
3	LOBT 2	Time, values $2^{15} - 2^{0}$ s
4	LOBT 3	subSeconds
5	ASW Processing Mode	Copy of Current Processing Mode as from Proc_Param_Tab
6	LSQ Fit ΔT	Last ΔT required for LSQ fit operation, units of 0.1*sec
7	Data + X^2 ΔT	Last ΔT required for compression operation, units of 0.1*sec
8	Data Compression Factor	Last achieved compression factor for data
9	X^2 Compression Factor	Last achieved compression factor for X^2
10	Current data under processing Header word 1	DCU data header first word (See Digital Control Unit Firmware ICD)
11	Current data under processing Header word 2	DCU data header second word (See Digital Control Unit Firmware ICD)

In order to achieve commanding trough the TSC we had to supply a specific Mission Data Base (MIB) for the pus2dpu.
This is an usual development strategy for Ground Segment Software.
Testing is then accomplished using scripts that are fully integrated in the environment.

DPU ASW INTEGRATION AND VALIDATION

1553 I\F Requirements

The requirements for the pus2dpu are:
The application shall drive a MIL-STD-1553B device as Bus Controller
The Bus Controller shall implement a periodic message schedule according to the requirements established for the ICU
The Bus Controller shall send messages in broadcast mode
The application is controlled as an EDEN device using an external EDEN-to-PUS packets converter provided by TEMIS
The application shall act as TCP/IP server and shall receive/transmit TCP/IP packets formatted as PUS packets
The application shall perform standard PUS packet checks
Commands described in the ICDs are encapsulated into PUS packets which are sent asynchronously to the application by TSC
The application shall interpret the PUS packet, translate the command into a MIL1553 message and send the MIL1553 message to the DPU according to the Bus Controller schedule
The application shall retrieve telemetries from the DPU, encapsulate the telemetries into PUS packets to be transmitted asynchronously to TSC
The application shall interface with both nominal/redundant units of two DPUs
The application shall communicate through both channels of the dual redundant MILBUS
The application shall manage PUS service 6,2 and 6,5 with the limitation of one memory block per packet. The block shall be no larger than 1024B
The application shall implement PUS service [17,1]
The application shall be configurable from TSC
The application shall be able to interrupt the traffic on the 1553 bus

DPU ASW INTEGRATION AND VALIDATION

1553 I\F Validation

- The software development was based on the GIT versioning framework, hosted in the INFN facility BALTIG.
- Since it is a deliverable tool to be used for the validation of Flight Models it was necessary to develop a test plan to verify each of his requirements.
- It is written according to the coding standards of C++ 14 and a continuous integration runs the tests to verify all the requirements
- the software could be compiled under Linux and under Windows.

All the requirements are checked using the following methods:

- The bus is monitored against a reference Log File while a test sequence issues a set of predefined commands

- A custom application connects as client to pus2dpu and feeds a reference set of commands in the form of PUS packets while the MILBUS is monitored and checked against a reference Log File

- Commands are fed to the application connected to the RT simulators. Bus is monitored and traffic is checked against reference

DPU ASW INTEGRATION AND VALIDATION

DPU/DCU Test Plan

The test plan has been defined by OHB-I (supplier of DPU/DCU) since the **Preliminary Design Review**, for the verification of all the electronic requirements of the DPU.
To verify some of these requirements it was necessary a stable version of the DPU ASW from the "Osservatorio Astronomico di Padova" group.
For each test procedure defined in the Test Plan we prepared a TCL script to put the equipment in the desired configuration and to demonstrate that all the verification criteria defined where met.

The procedures cover the verification of the following DPU\DCU features:
Overcurrent protections of DCU towards SCS lines and unit reboot
Nominal functionalities (exposure commanding, data acquisition and processing in different configurations)
Redundant MIL 1553 and Spacewire channels
Capability in one dither period (1048 sec) to complete acquisition, processing and transmission to MMU of one spectroscopic image and 3 photometric images
Capability to perform memory scrubbing via TC
Access to DPU/DCU health monitoring verifying that all telemetries are inside the validity range
Capability to perform a unit reboot without affecting powered DCUs
Capability to perform memory patches and dump

DPU ASW INTEGRATION AND VALIDATION

Test Plan

- Functional test have been performed at OHB-I on DPU/DCU EQM loading a prototype version of the DPU ASW to validate electronic requirements. During this test campaign emerged the need for ASW and Test Sequences improvement.

- To obtain a formal verification of the functionalities of DPU/DCU EQM it was necessary to update DPU ASW and to update the test sequences and then repeat at INAF OAPD all the test.

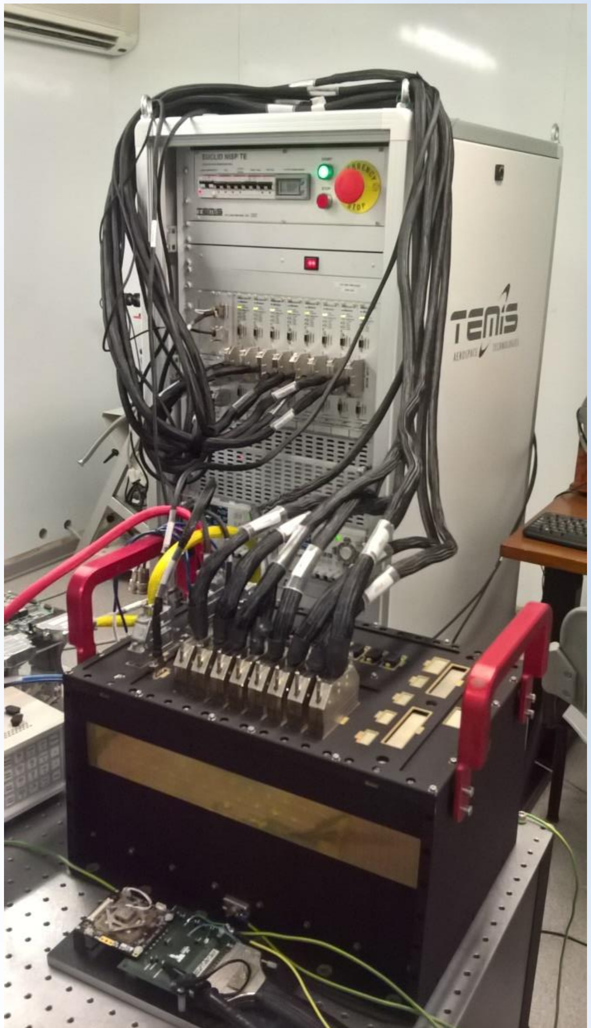
- Finally at OHB-I with the newly updated version of the DPU ASW all the tests have been successfully performed in presence of the product assurance and the customer

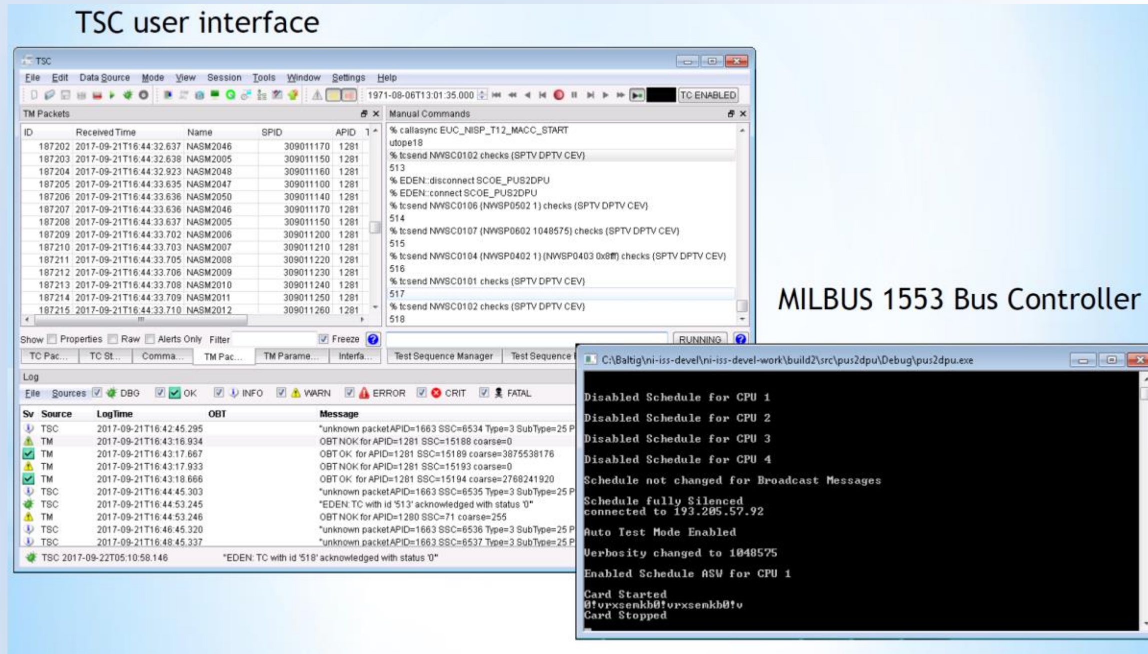
- All the tests gave positive results, the DPU EQM model was delivered to the NISP team for further integration tests with ICU and the NI-OMADA and the production of FM models was released.

- The pus2dpu software is currently in use for the DPU FM validation

DPU ASW INTEGRATION AND VALIDATION

Test Environment





List of executed commands provided by TSC (detail)

496	2017-09-21T16:17:51.899	2017-09-21T16:17:51.900	NASC7908	S	S	S	I	S	S
497	2017-09-21T16:17:52.992	2017-09-21T16:17:52.993	NASC5408	S	S	S	I	S	S
498	2017-09-21T16:17:54.107	2017-09-21T16:17:54.108	NASC4900	S	S	S	I	S	S
499	2017-09-21T16:18:00.500	2017-09-21T16:18:00.501	NASC4700	S	S	S	I	S	S
500	2017-09-21T16:18:07.781	2017-09-21T16:18:07.782	NASC5308	S	S	S	I	S	S
501	2017-09-21T16:18:09.900	2017-09-21T16:18:09.901	NASC1301	S	S	S	I	S	S
502	2017-09-21T16:18:12.029	2017-09-21T16:18:12.030	NASC7108	S	S	S	I	S	S

Clean Room at Osservatorio Astronomico Padova

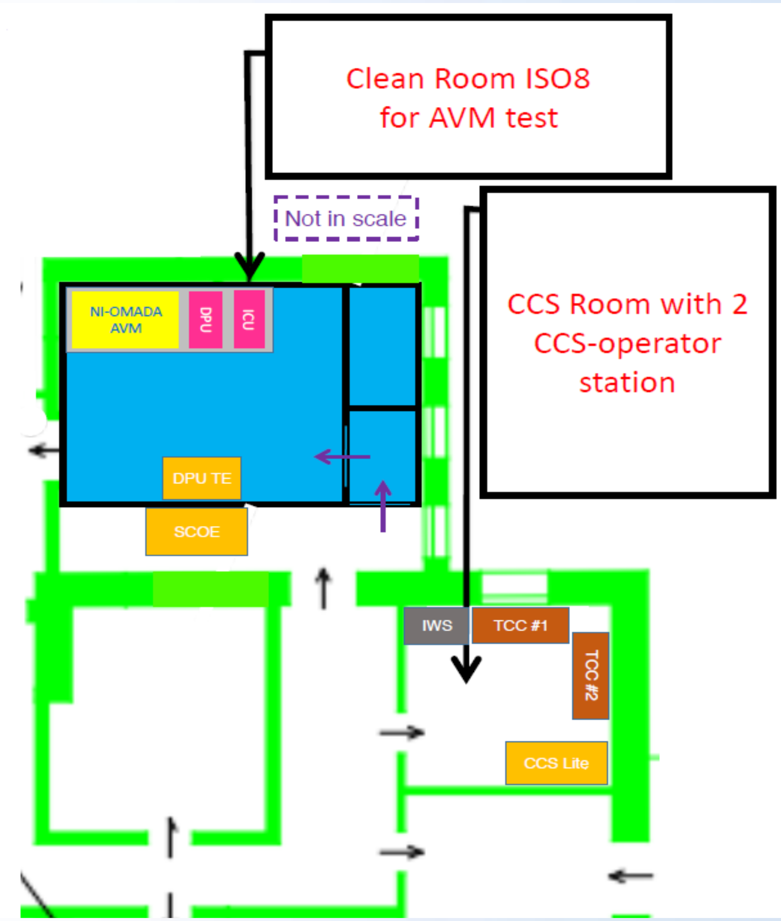
DPU ASW INTEGRATION AND VALIDATION

Test Example (Test EUC_NISP_T4_DCU_ON)

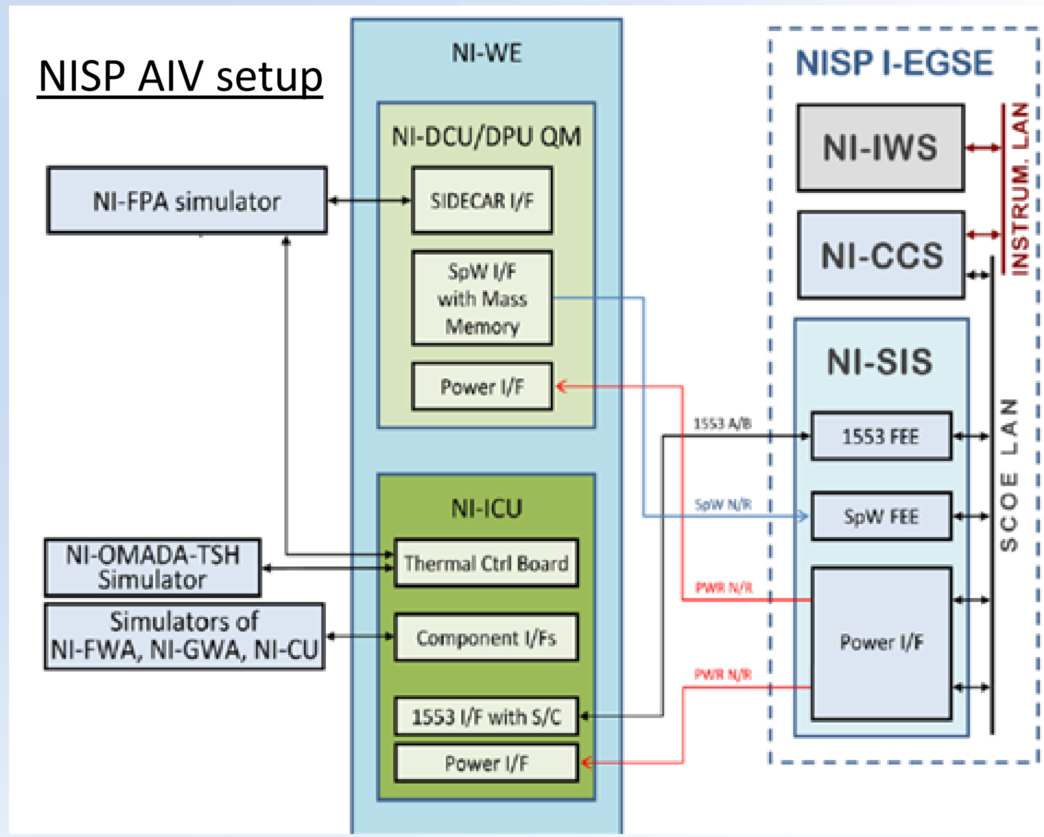
Test SCRIPT ID	Description	Note
DCU_ON	This script switches on the DCU boards. It is possible to switch on a single, a subset or all the DCUs and configure the analog parameters of the DCU. Script reads periodically HK produced by board verifying that values are in the allowed range reported Macro steps: a. Configure DCU board(s) VDDA and VDD2V5 **b. Verify correct readings of ASW HK parameters** c. Switch ON DCU board(s) d. Wait 3sec **e. Verify power consumption checking EUT current consumption** **f. Verify correct readings of ASW HK parameters**	Pre-requirements: • Run of DPU_OFF_ASW Script Parameters: - DCU ON (0 - 7 or ALL) - Vdda (2.8 - 3.8 V) - Vdd2V5 (2 - 2.8 V)

Test taken from official unit functional tests document. In bold are highlighted success criteria.
After the test a detailed test report is compiled and delivered to the customer.

NISP AVM INTEGRATION

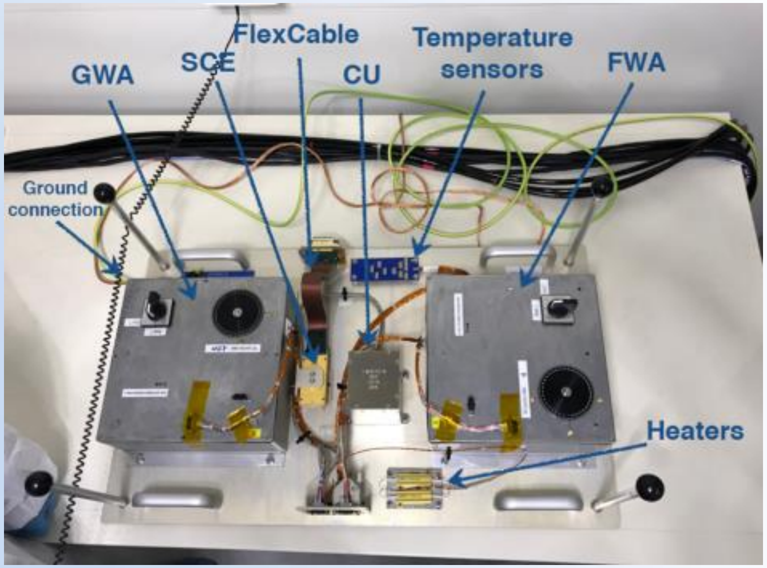


The activity was performed in a ISO 8 clean room prepared @UNIPD.



NISP AVM INTEGRATION AND VALIDATION

NIOMADA AVM



DPU EM & ICU EM

NI-FPA simulator: 1 SCE @ room temperature

- used to generate an electrically representative data flow
- parametric simulated data to verify the processing and data transmission

NI-TSH simulator: passive component to simulate thermal sensor and heaters.

NI-GWA/FWA simulator: simulation under a fixed operating condition (single coil impedance) and generation of signals to monitor the status of NI-FWA/GWA (home position sensor)

NI-CU simulator: simulates the behaviour of NI-CU under a fixed operating condition. The 5 nominal LEDs are simulated

NISP AVM TEST PLAN

The objectives of the AVM testing at room temperature are:

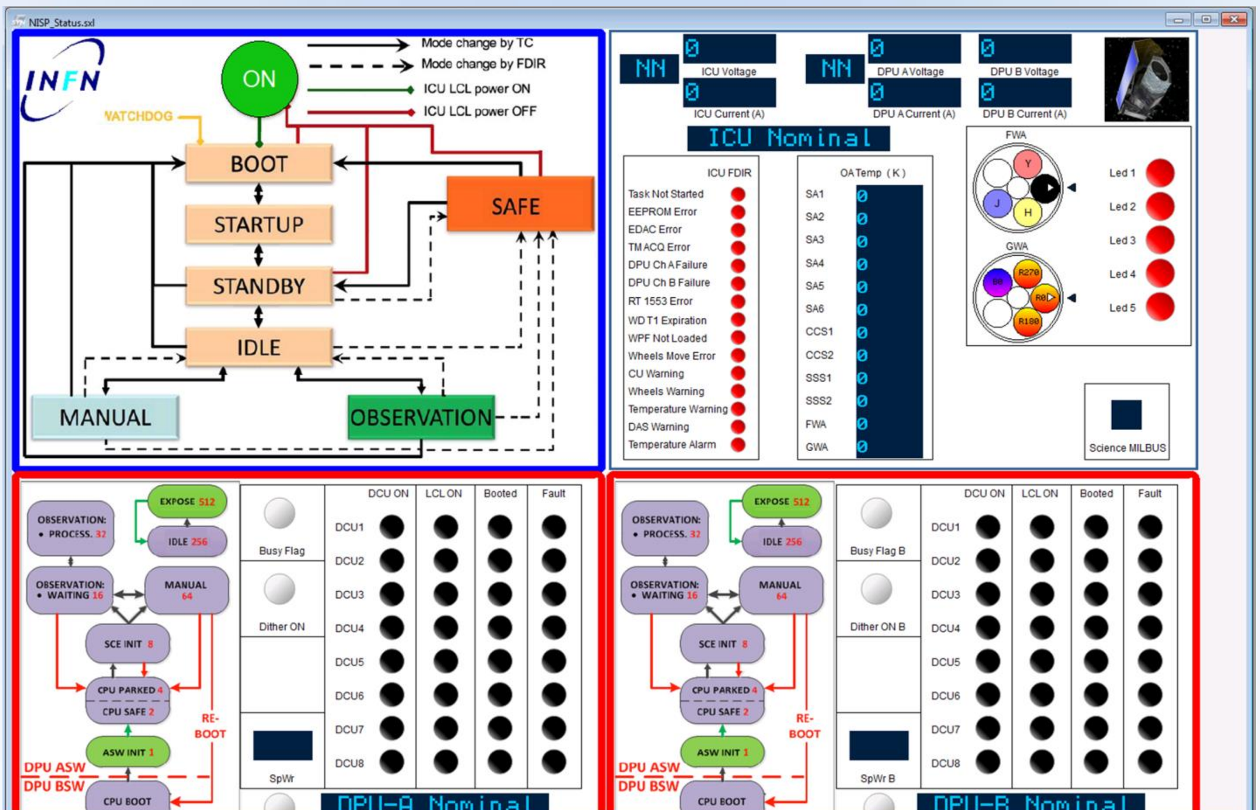
- Verify the NISP functional performances
- Verify TC and TM flow
- Verify the science data flow
- Verify the connection with the S/C and NIOMADA before further integration

The tests are divided in Short Functional Test (SFT) , Full Functional Test (FFT) and Robustness tests.

CDR level version of the DPU ASW and of the ICU ASW are installed on the AVM.

NISP AVM MODES

- Each transition between NISP operating modes is triggered by ground/Spacecraft TC
- Transitions between DPU/DCU/SCS different modes is driven by NI-ICU TCs.
- The DCU and SCS operating modes are managed internally by the DPU.
- A dedicated synoptic view was developed to monitor the operating modes during test execution in real time.



NISP AVM TEST SUCCESS CRITERIA

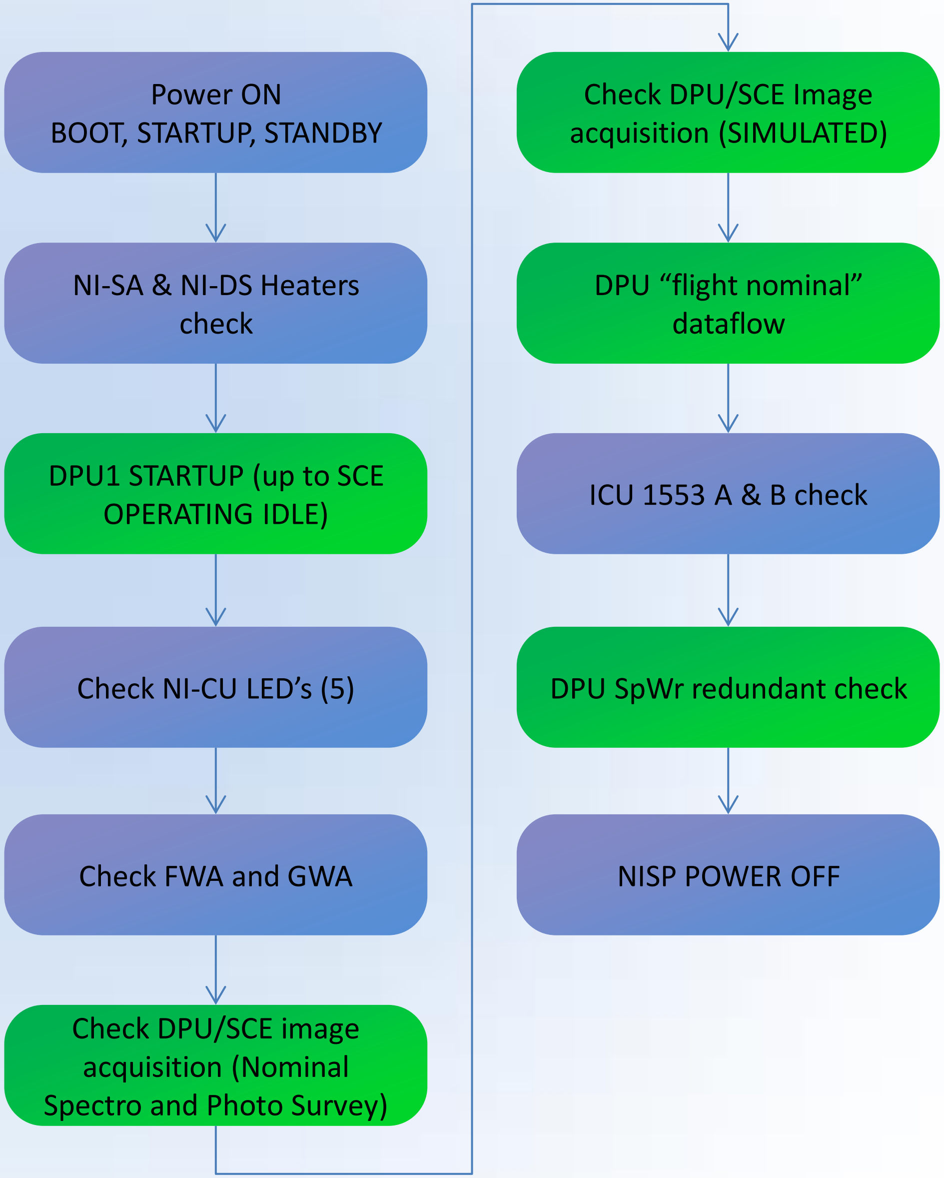
- **Telecommand History :**
  The complete telecommand history and their parameters must bye analysed at the end of each test. It must be strictly identical to the specified SFT and FFT sequence of telecommands.
- **Packet amount :**
  For all the different housekeeping packet, the number of packet received during SFT and FFT must be counted (from OFF start to OFF end). For the SFT, the number of TM(1,2),TM (1,8), TM(5,3) and TM(5,4) found must be equal to ZERO. The number of TM(5,2) is random and must be limited to DPU/SCE communication.
- **Analog Telemetry :**
  All the HK analog telemetries must be plotted and analysed for the whole duration of each test. The monitoring limits must never be exceeded during the whole duration of the test (including the yellow limits).
- **Digital Telemetry :**
  All the HK digital telemetries must be analysed for the whole duration of each test and included in the test report. They must be compared to the expected ones
- **Science Data :**
  One image acquired in NUMERICAL SIMULATED BY SCE PIXEL by PIXEL and one acquired in NUMERICAL SIMULATED BY SCE FRAME by FRAME shall be compared to expected ones. One image acquired during a nominal spectro exposure and during 3 nominal photo exposures shall be plotted in the test report with their main characteristics
- **Data Production :**
  The amount of science data and HK data production shall be determined for each test.

NISP AVM SFT

The SFT shall be executed in a fully automated mode.
No operator intervention is foreseen.

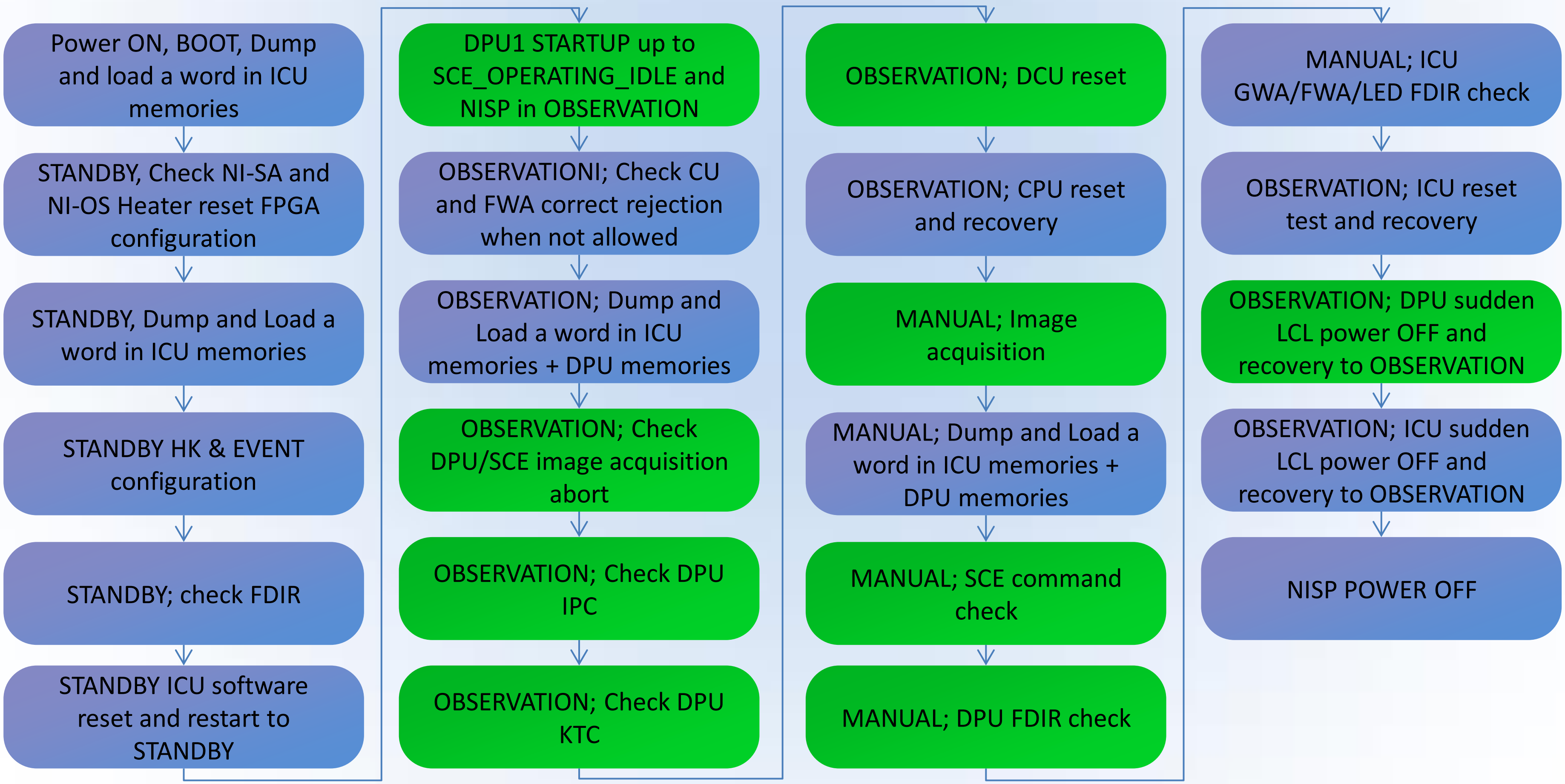
The objective is to test all TCs that will be used during the nominal operations and to check all nominal transitions between NISP modes.

The SFT is divided in 11 TCL scripts.



NISP AVM FFT

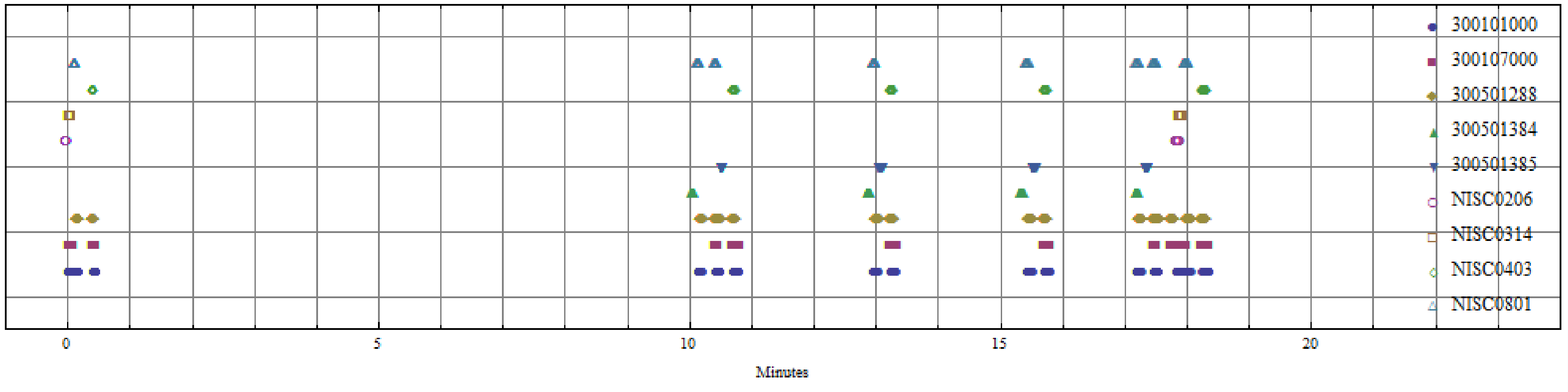
The objective of the FFT is to test NISP non nominal TCs including DPU re-boot and patch and dump of all the possible memories.
FDIR will be tested and PUS Service 3 for House keeping generation will be used.
The FFT shall be executed in a fully automated mode. No operator intervention is foreseen. The test is divided in 23 TCL scripts.



NISP AVM ROBUSTNESS TEST

- The NISP had to run robustness tests lasting more than 24 hours.
- The first one is the sequence mimicking the nominal wide survey.
- The last one is intended to test the NISP daily production of data.

Telecommand History Analysis



Telecommands

- NISC0206 : Set Planning ID
- NISC0314 : Send Dither Configuration
- NISC0403 : Start Exposure
- NISC0801 : Move Wheel

Telemetries

- 300101000 : TM(1,1) TC Acceptance Success
- 300107000 : TM(1,7) TC Execution Success
- 300501288 : TM(5,1) End of Wheel Rotation
- 300501384 : TM(5,1) End of exposure
- 300501385 : TM(5,1) End of MMU transmission

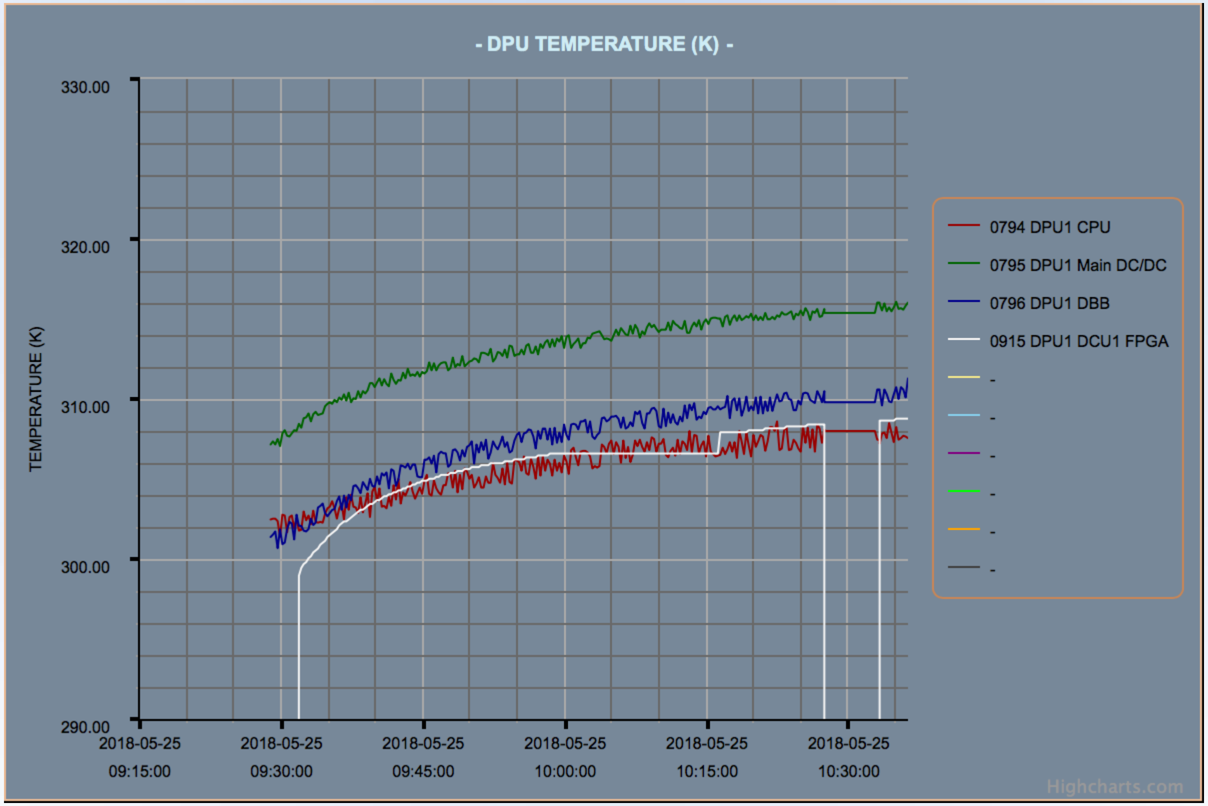
The expected number of files is produced and Image format is correct
Image Values have the expected statistical distribution

NISP AVM TEST REPORT (Telemetries)

SFT and FFT execution are reported in the Test Report, as agreed with customers during the Test Readiness Review (TRR). All the criteria were fulfilled.

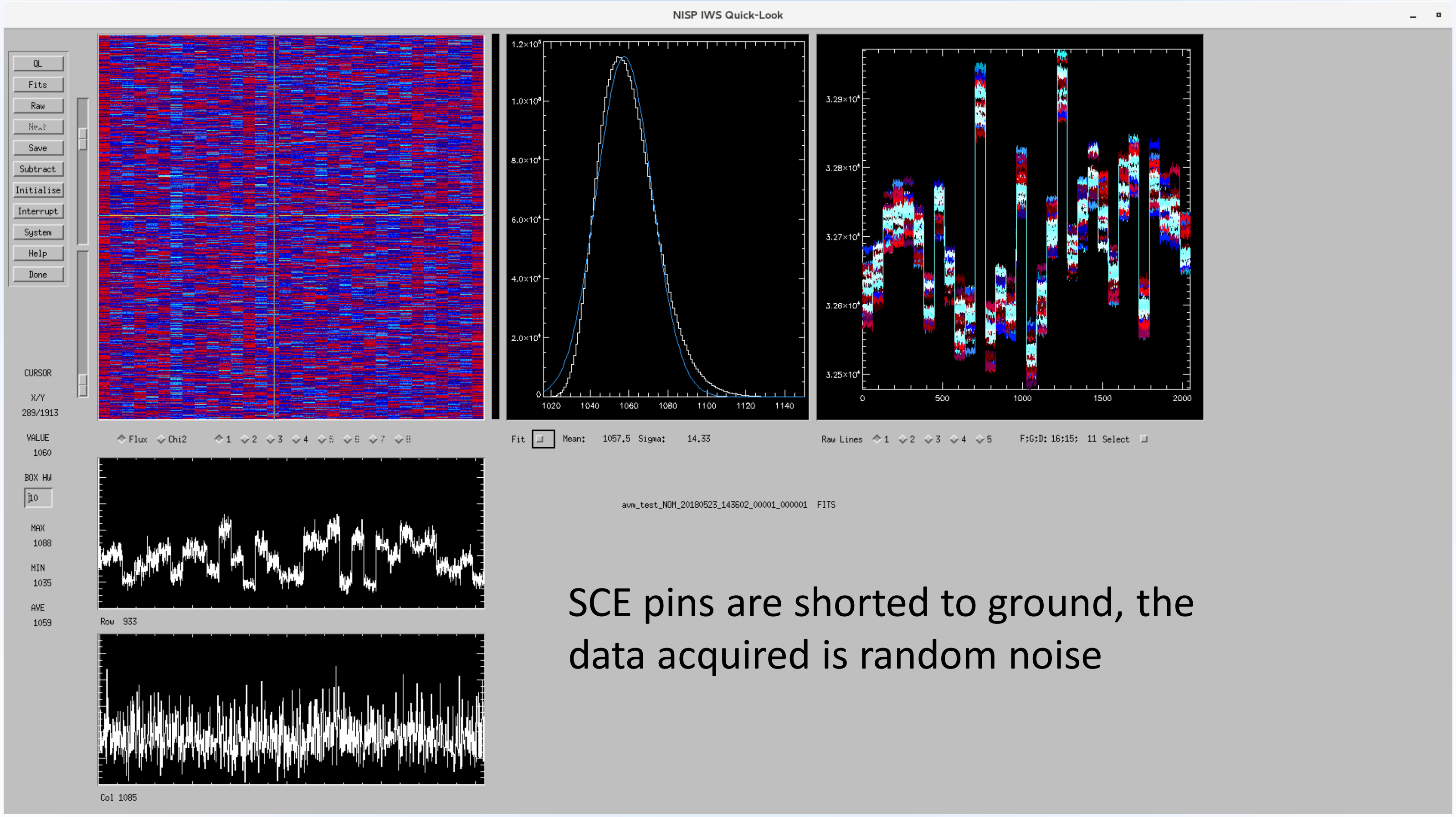
As an example here it is reported the DPU temperature during the FFT tests execution.

The monitoring of all the telemetries and housekeeping data is done trough the IWS data files, the values are inside the allowed ranges.



NISP AVM TEST REPORT (Science Data)

Science data are saved into .fits files by the IWS and can be analyzed in real time. A spectrometric image MACC(15,16,11) is reported here. After data check the success criteria regarding dataintegrity are fullfilled.



SCE pins are shorted to ground, the data acquired is random noise

CONCLUSIONS

After integration and test at INFN Padova Laboratory, the NISP AVM has been delivered to TAS-I for the integration with the Service Module in June 2018.

I have been involved in the AIV of the Warm Electronics for NISP Instrument of the Euclid mission with the INFN Padua Group, my main contributions are:

- development of a custom software able to emulate the MILSTD/1553 interface between the ICU and the DPU, such software is now used for the DPU FM AIV phase
- development of a DPU simulator, such tool is used for ICU ASW development and testing
- participation to the DPU ASW integration in the DPU EQM model (MIB and .tcl scripts preparation), such model has been fully tested and it is ready for integration in the NISP EM Instrument
- Participation to the NISP AVM Instrument integration and validation (synoptic view and .tcl scripts preparation)

PUBLICATIONS

- Agafonova N. et al. OPERA COLLABORATION, "Study of charged hadron multiplicities in charged-current neutrino-lead interactions in the OPERA detector", 78 (2018) THE EUROPEAN PHYSICAL JOURNAL. C, PARTICLES AND FIELDS, 10.1140/epjc/s10052-017-5509-y

- Agafonova N. et al. OPERA COLLABORATION, "Final Results of the OPERA Experiment on ντ Appearance in the CNGS Neutrino Beam", 120 (2018) PHYSICAL REVIEW LETTERS,
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- Euclid Collaboration, "The Euclid Near Infrared Spectro-Photometer (NISP) instrument and science", 314 (2017), The European Physical Society Conference on High Energy Physics
(EPS-HEP2017), 10.22323/1.314.0636

- T. Maciaszek et al, "Euclid Near Infrared Spectrometer and Photometer instrument concept and first test results obtained for different breadboards models at the end of phase C",
Proc. SPIE 9904, Space Telescopes and Instrumentation 2016: Optical, Infrared, and Millimeter Wave, 10.1117/12.2232941

- S. Ligori et al., "Detailed design and first tests of the application software for the instrument control unit of Euclid-NISP", PROCEEDINGS OF SPIE, THE INTERNATIONAL SOCIETY FOR
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- C. Bonoli et al., "On-board data processing for the near infrared spectrograph and photometer instrument (NISP) of the EUCLID mission", PROCEEDINGS OF SPIE, THE INTERNATIONAL
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10.1117/12.2234262

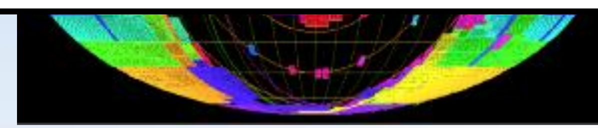
Thank you for your attention

THE EUCLID MISSION

OBSERVATION STRATEGY

SURVEYS In ~6 years		
	Area (deg2)	Description
Wide Survey	**15,000 deg²**	Step and stare with 4 dither pointings per step.
Deep Survey	**40 deg²**	In at least 2 patches of > 10 deg^2 2 magnitudes deeper than wide survey

PAYLOAD					
Telescope	1.2 m Korsch, 3 mirror anastigmat, f=24.5 m				
Instrument	VIS	NISP			
Field-of-View	0.787×0.709 deg^2	0.763×0.722 deg^2			
Capability	Visual Imaging	NIR Imaging Photometry			NIR Spectroscopy
Wavelength range	550– 900 nm	Y (920-1146nm),	J (1146-1372 nm)	H (1372-2000nm)	1100-2000 nm
Sensitivity	24.5 mag 10σ extended source	24 mag 5σ point source	24 mag 5σ point source	24 mag 5σ point source	3 10^{-16} erg cm-2 s-1 3.5σ unresolved line flux
	Shapes + Photo-z of n = 1.5 x10^9 galaxies			z of n=5x10^7 galaxies	



NISP AVM EGSE

The EGSE hardware used for AVM AIV/AIT is composed by three main parts:

NI-CCS (Central Checkout System), provided by ESA. It is the main control system, including Mission data Base, Test Sequences, TC/TM History Panels and Monitor displays

NI-SCOE (Special Check-Out Equipment), provided by ESA. It is the the S/C simulator supporting the payload under test, made of 3 modules: the 1553 I/F (as for the CDMU), the SpW I/F (as for the MMU), and the power supply

NI-IWS (Instrument WorkStation) ,provided by INAF/OAS-BO ; a specialized QL monitoring system that processes L0 raw data to generate the corresponding L1 FITS files (for both HK and Science data), to allow offline data analysis

NISP AVM INTEGRATION AND VALIDATION

Test Scripts

- The Test Sequences developed for the NISP AIV/AIT activities are compliant with a specific framework prepared by TAS-I for the Euclid EGSE software
- This framework foresees specific naming and programming conventions in a layer-based TCL/uTOPE coding architecture characterized by five growing levels of abstraction
- The two lower levels shall contain basic TSC\CCS SW functions and low-level and general purpose functions customized for Euclid AIV/AIT activities (developed and provided by TAS-I)
- The three upper levels are the so-called project layers containing the scripts related to the specific test campaign
- This approach guarantees a straightforward reuse of the developed TS in the subsequent Euclid AIV/AIT phases.

NISP AVM INTEGRATION AND VALIDATION

Test Plan

The NISP Avionic Model (AVM) is composed by the **DPU/DCU EM with only one DCU**, an **ICU EM**, a **NI-OMADA** electrical simulator and a **SCE Engineering model**, no redundancy is present.

The objective of the AVM is testing at room temperature:

- the NISP functional performances
- the command flow from SVM and the science data and housekeeping data production

CDR level version of the DPU ASW and of the ICU ASW are installed on the AVM.

After integration and test at INFN Padova Laboratory, the NISP AVM has been delivered to TAS-I for the integration with the Euclid Service Module.

NISP AVM NOMINAL EXPOSURE

NISP nominal observation cycle is composed by 4 groups (dithers) of exposures.
In each dither 4 exposures are taken: Spectro, Photometry Y filter, Photometry J filter, Photometry K filter.
Each dither uses a different red grism to change the orientation of the spectrum.
One dark exposure is inserted at the end of the last dither, during the slew to a new survey field.

	Exposure time	FWA	GWA	NI-CU	NI-DPU processing	NI-SCE configuration	Data output
Spectro	565 s	Open	red	off	Nominal Spectro	Nominal	1 full image + 1 Chi2 image
Photo Y	121 s	Y	open	off	Nominal Photo	Nominal	1 full image + 1 Chi2 image
Photo J	116 s	J	open	off	Nominal Photo	Nominal	1 full image + 1 Chi2 image
Photo H	81 s	H	open	off	Nominal Photo	Nominal	1 full image + 1 Chi2 image
Dark	TBD	Closed	open	off	Nominal Photo	Nominal	>=1 full image + >=1 Chi2 image

- NI-OMADA temperature is controlled
- After each exposure the HK is retrieved by NI-ICU from all the sub-systems
- Processed data are sent by DPU to MMU.
- Data integrity checks is performed at the end of the observation cycle on NI-IWS.

DPU ASW INTEGRATION AND VALIDATION

1553 I\F Workflow

TC\TM flow in the pus2dpu