THE INAF CONTRIBUTION TO THE MOSAIC INSTRUMENT CONTROL SOFTWARE

S. Ligori, M. Carnerero Martin, V. Capobianco

(INAF – O.A. Torino)

and contributions from M. Larrieu (IRAP), lead of the EICS-HL team

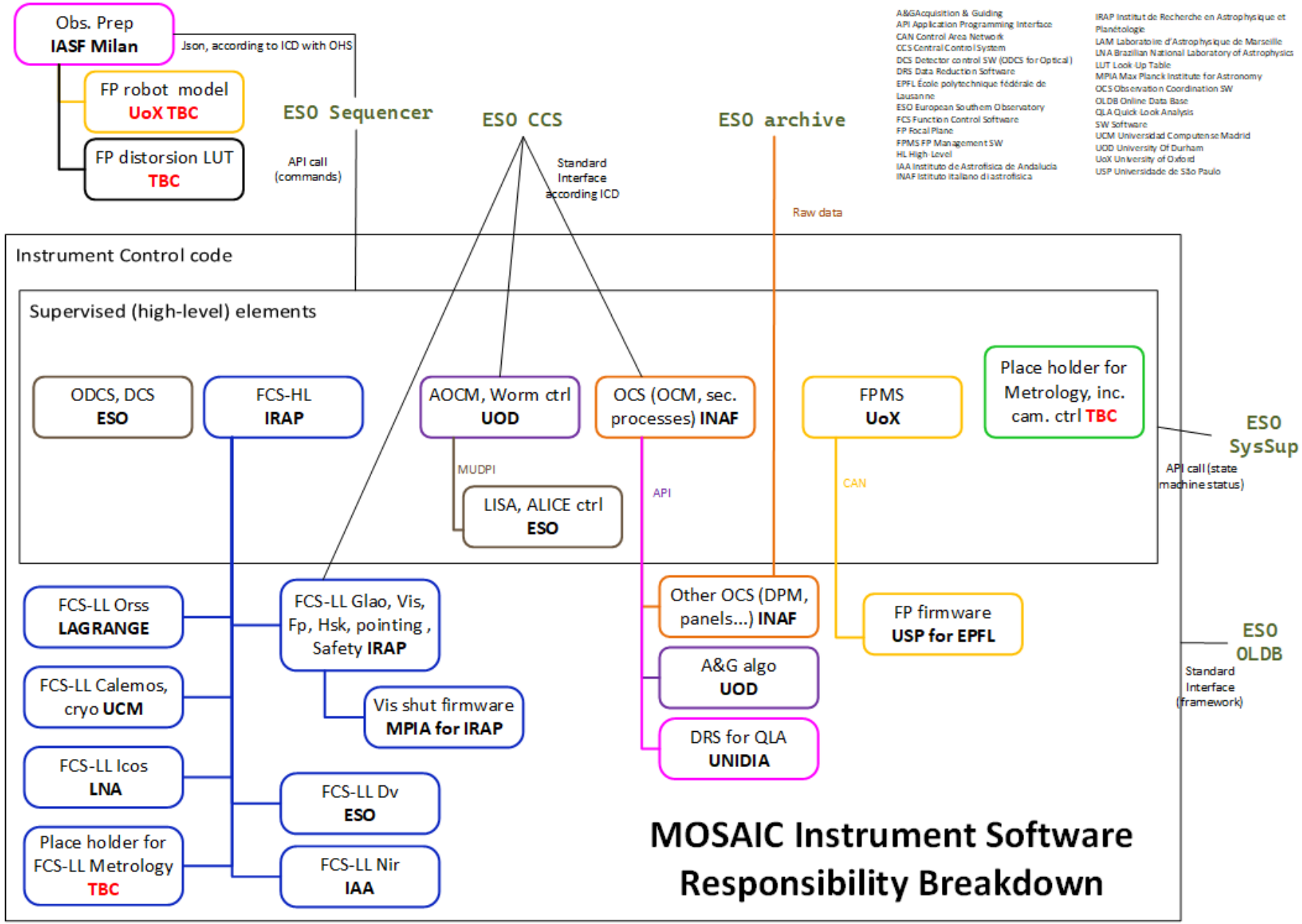
Overview

- INAF OATo Team introduction
- Mosaic ICS (Instrument Control System) overview
- ELT Instrument Framework installation and update
- Integration of simulated and real devices (Beckoff PLC/ESO IFW)
- Simulating NGCII controllers
- Remote integration experiment

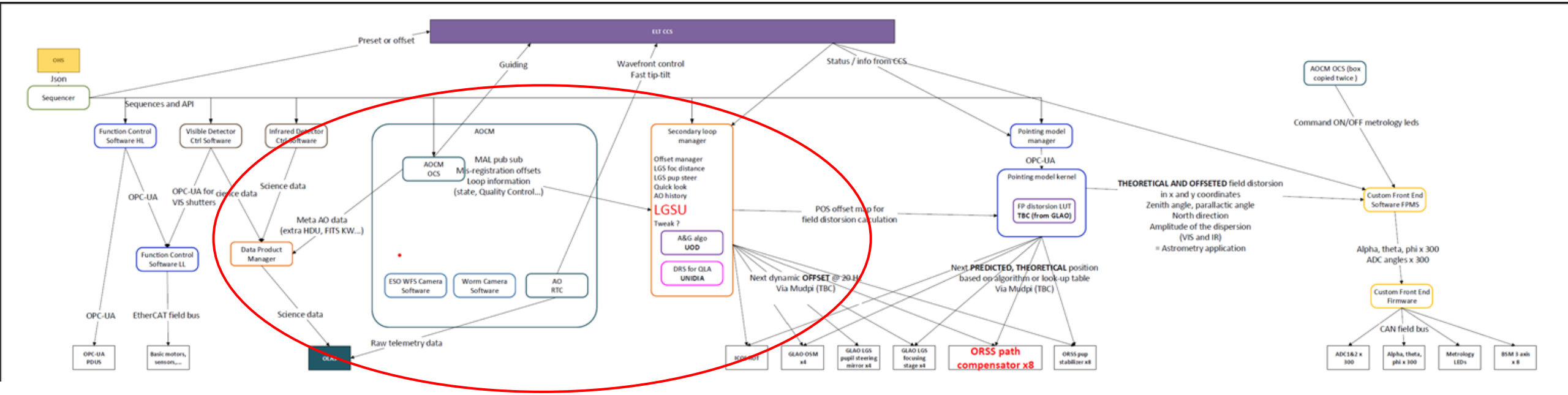
INAF OATo SW team

- S. Ligori, V. Capobianco mainly involved in Space projects (in the past, Euclid NISP Instrument control unit; currently ESA projects NewAthena and Ariel)
- Past experiences with ESO instrumentation (i.e.: MIDI@VLTI)
- M. Carnerero mostly involved with multi-wavelength astronomical data reduction (Vera Rubin-LSST, Gaia, WEBT…) and databases, currently under temporary contract for Mosaic
- Expertise in C/C++, Python programming fits well in the context of ESO SW

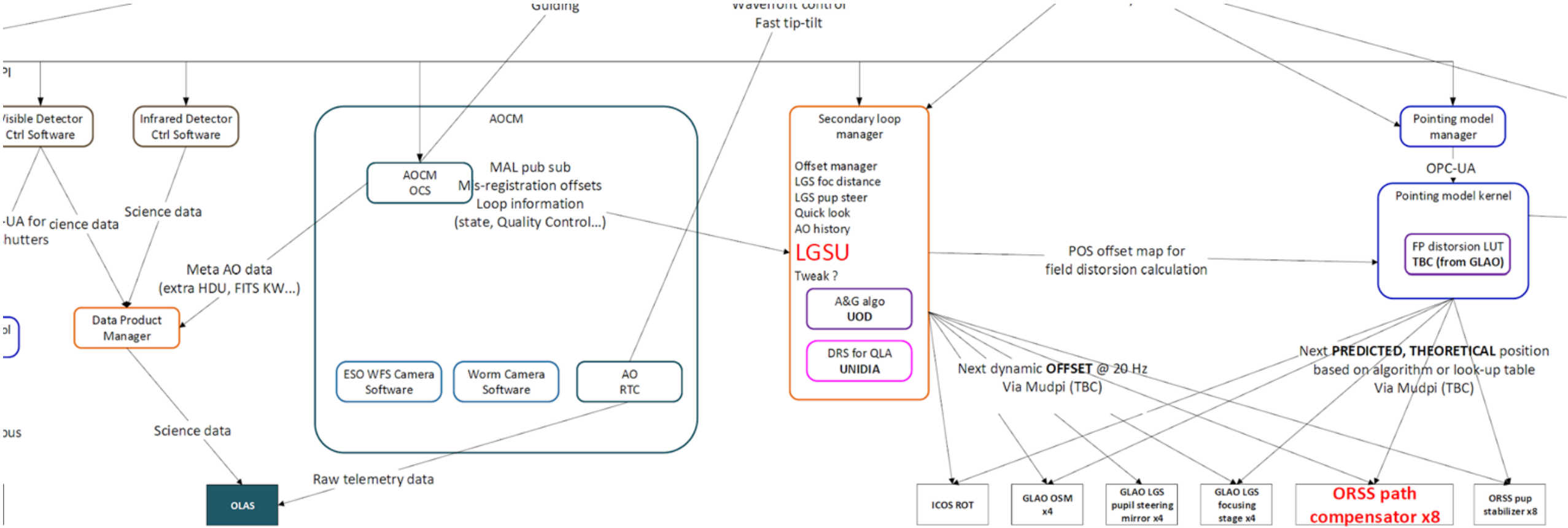
Mosaic Instrument software structure



OCS (Observation Coordination SW) Role



OCS Role


Guiding
Fast tip-tilt
Infrared Detector Ctrl Software
Science data
Data Product Manager
Meta AO data
(extra HDU, FITS KW...)
Science data
OLAS
AOCM
AOCM OCS
MAL pub sub
M s-registration offsets
Loop information
(state, Quality Control...)
ESO WFS Camera Software
Worm Camera Software
AO RTC
Raw telemetry data
Secondary loop manager
Offset manager
LGS foc distance
LGS pup steer
Quick look
AO history
LGSU
Tweak ?
A&G algo UOD
DRS for QLA UNIDIA
POS offset map for field distorsion calculation
Next dynamic OFFSET @ 20 Hz
Via Mudpi (TBC)
Pointing model manager
OPC-UA
Pointing model kernel
FP distorsion LUT TBC (from GLAO)
Next PREDICTED, THEORETICAL position
based on algorithm or look-up table
Via Mudpi (TBC)
ICOS ROT
GLAO OSM x4
GLAO LGS pupil steering mirror x4
GLAO LGS focusing stage x4
ORSS path compensator x8
ORSS pup stabilizer x8

Device control: Motors

Axis description	Part	SubSystem	Us...	Expected precision (UU)	Expected repeatability (UU)	MOSAIC SW devic...
LGSS focusing stage on GBOX 4	M-414.2DG	Ground Layer AO Su...	mm			motglao4lgsfoc
NGSS Object Steering Mirror on ...	H-811.I2 C-887.5330	Ground Layer AO Su...	mm			maxisglao1ngsosm
NGSS Object Steering Mirror on ...	H-811.I2 C-887.5330	Ground Layer AO Su...	mm			maxisglao2ngsosm
NGSS Object Steering Mirror on ...	H-811.I2 C-887.5330	Ground Layer AO Su...	mm			maxisglao3ngsosm
NGSS Object Steering Mirror on ...	H-811.I2 C-887.5330	Ground Layer AO Su...	mm			maxisglao4ngsosm
LGS1 pupil steering mirror (2 DoF)		Ground Layer AO Su...	mm			maxisglao1lgspup (T...
LGS2 pupil steering mirror (2 DoF)		Ground Layer AO Su...	mm			maxisglao2lgspup (T...
LGS3 pupil steering mirror (2 DoF)		Ground Layer AO Su...	mm			maxisglao3lgspup (T...
LGS4 pupil steering mirror (2 DoF)		Ground Layer AO Su...	mm			maxisglao4lgspup (T...
ORSS 1optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss1path
ORSS 2 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss2path
ORSS 3 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss3path
ORSS 4 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss4path
ORSS 5 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss5path
ORSS 6 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss6path
ORSS 7 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss7path
ORSS 8 optical path compensator	LIMES 170-1000-HiD...	Optical Relays sub-s...	mm	0.1	0.01	motorss8path
ORSS 1 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss1pup
ORSS 2 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss2pup
ORSS 3 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss3pup
ORSS 4 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss4pup
ORSS 5 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss5pup
ORSS 6 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss6pup
ORSS 7 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss7pup
ORSS 8 longitudinal pupil stabilizer	LIMES 84N-45-HiDS...	Optical Relays sub-s...	mm	0.1	0.01	motorss8pup
Instrument rotator	AM8051-wGyz	ICOS sub-system	Degree			rot
VIS blue grating exchange mech...	Model TBD	VIS Spectrograph	mm			motvisbluegrat
VIS red grating exchange mecha...	Model TBD	VIS Spectrograph	mm			motvisredgrat
VIS blue detector tip-tilt and focus		VIS Spectrograph	mm			maxisvisbluedet
VIS red detector tip-tilt and focus		VIS Spectrograph	mm			maxisvisreddet

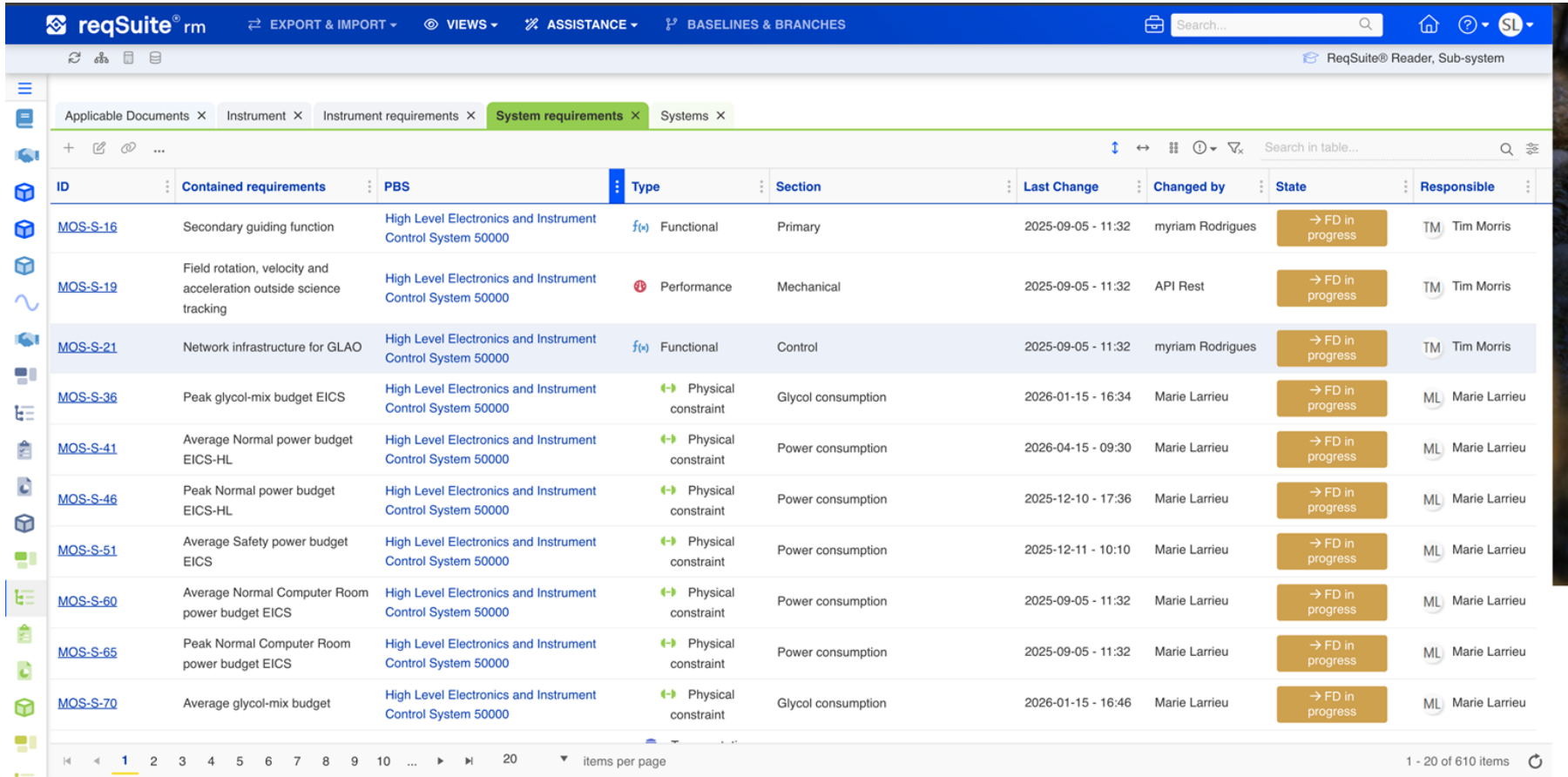
Device control: sensors

Name (SW)	Help text	Part list (sensor)	Expected accuracy (UU)	Expected repeatability (UU)	Nominal conditions
temp1	ORSS 1 temperature		1 °C	0.1°C	
temp2	ORSS 2 temperature		1 °C	0.1°C	
temp3	ORSS 3 temperature		1 °C	0.1°C	
temp4	ORSS 4 temperature		1 °C	0.1°C	
temp5	ORSS 5 temperature		1 °C	0.1°C	
temp6	ORSS 6 temperature		1 °C	0.1°C	
temp7	ORSS 7 temperature		1 °C	0.1°C	
temp8	ORSS 8 temperature		1 °C	0.1°C	
temp1	ICOS temperature 1				
temprot	Rotator temperature				
position1	Measure distance between ICOS structure and telescope...				
position2	Measure distance betwenn ICOS structure and telescope...				
doorswitches (TBC)	Interlocks?				
barrierswitches (TBC)	Interlocks?				
pres1					
pres2					
temp1	VIS DV temperature 1 used for monitoring				
temp2	VIS DV temperature 2 used for monitoring				
tempcl1	VIS DV temperature 1 used for closed loop				
tempcl2	VIS DV temperature 2 used for closed loop spare				
temp1	VIS spectrograph bench area 1 temperature	PT100 TS2239			
temp2	VIS spectrograph bench area 2 temperature	PT100 TS2239			
temp3	VIS spectrograph bench area 3 temperature	PT100 TS2239			
temp4	VIS spectrograph bench area 4 temperature	PT100 TS2239			
temp5	VIS spectrograph bench area 5 temperature	PT100 TS2239			
temp6	VIS spectrograph bench area 6 temperature	PT100 TS2239			
temp7	VIS spectrograph bench area 7 temperature	PT100 TS2239			
temp8	VIS spectrograph bench area 8 temperature	PT100 TS2239			
tempcl1	VIS spectrograph bench temperature 1 used for regulation				
tempcl2	VIS spectrograph bench temperature 2 used for regulation				
rhum	VIS spectrograph internal humidity sensor	DPK1010			
pres	VIS spectrograph internal pressure	DPK1010			

Project management tools

Mosaic has adopted a few tools for the different aspects of the project management:

- ReqSuite for the management of the requirements
- Taiga for issues and actions management and tracking
- Nuage as document repository



Road to PDR

The Mosaic PDR is currently foreseen for early 2028, but a system review for the EICS should occur in Q2 2027

Work is underway to identify, in particular for what concern OCS:

- all the network interfaces (protocols, data formats)
- the additional FITS keywords (and the source of the related information)
- control loops and related algorithms
- sampling frequency of all parameters
- etc...

PLC Integration

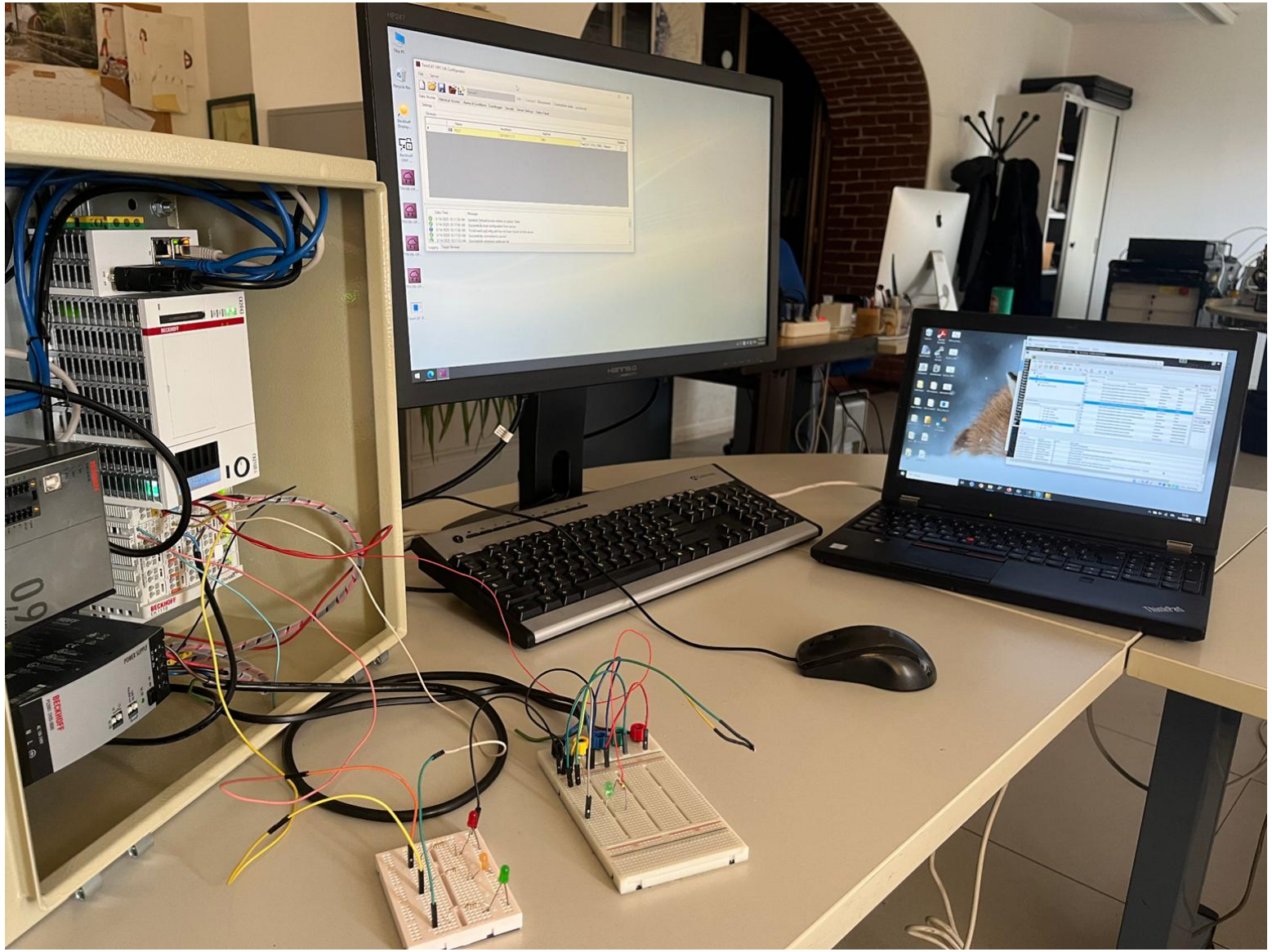
The system includes the following components:

- **EL3200** – Analog input module for precise measurement of sensor signals.
- **EL4002** – Analog output module for controlling actuators and other devices.
- **EL6070** – Licensing and configuration module for software-based functionalities.
- **EL1859** – Digital input/output module for handling various industrial control signals.

We installed TWINCAT, VIRTUALBOX with ESO FRAMEWORK

We install and configure the OPCUA Server Application

Direct connection with PLC via Ethernet link



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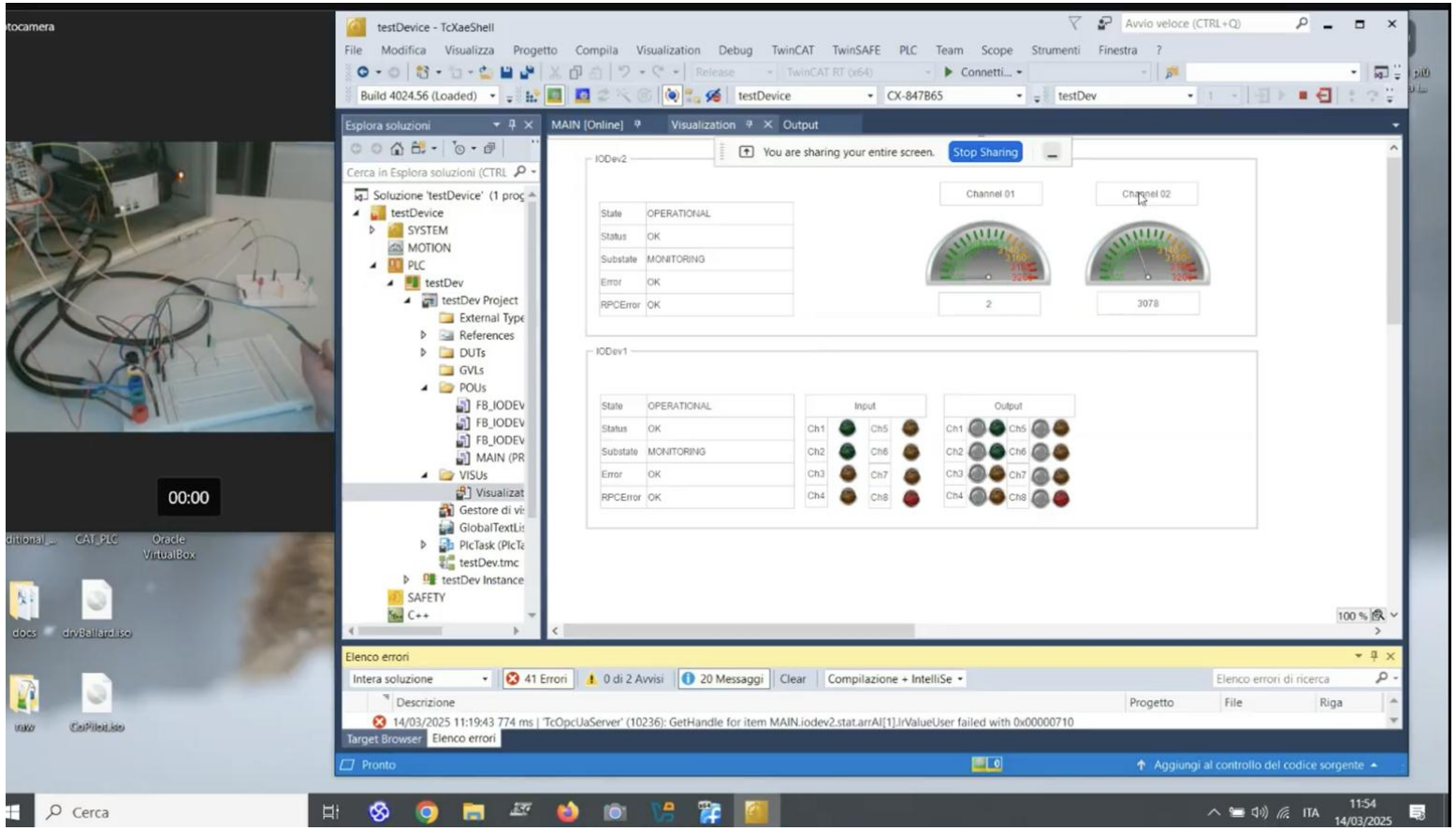

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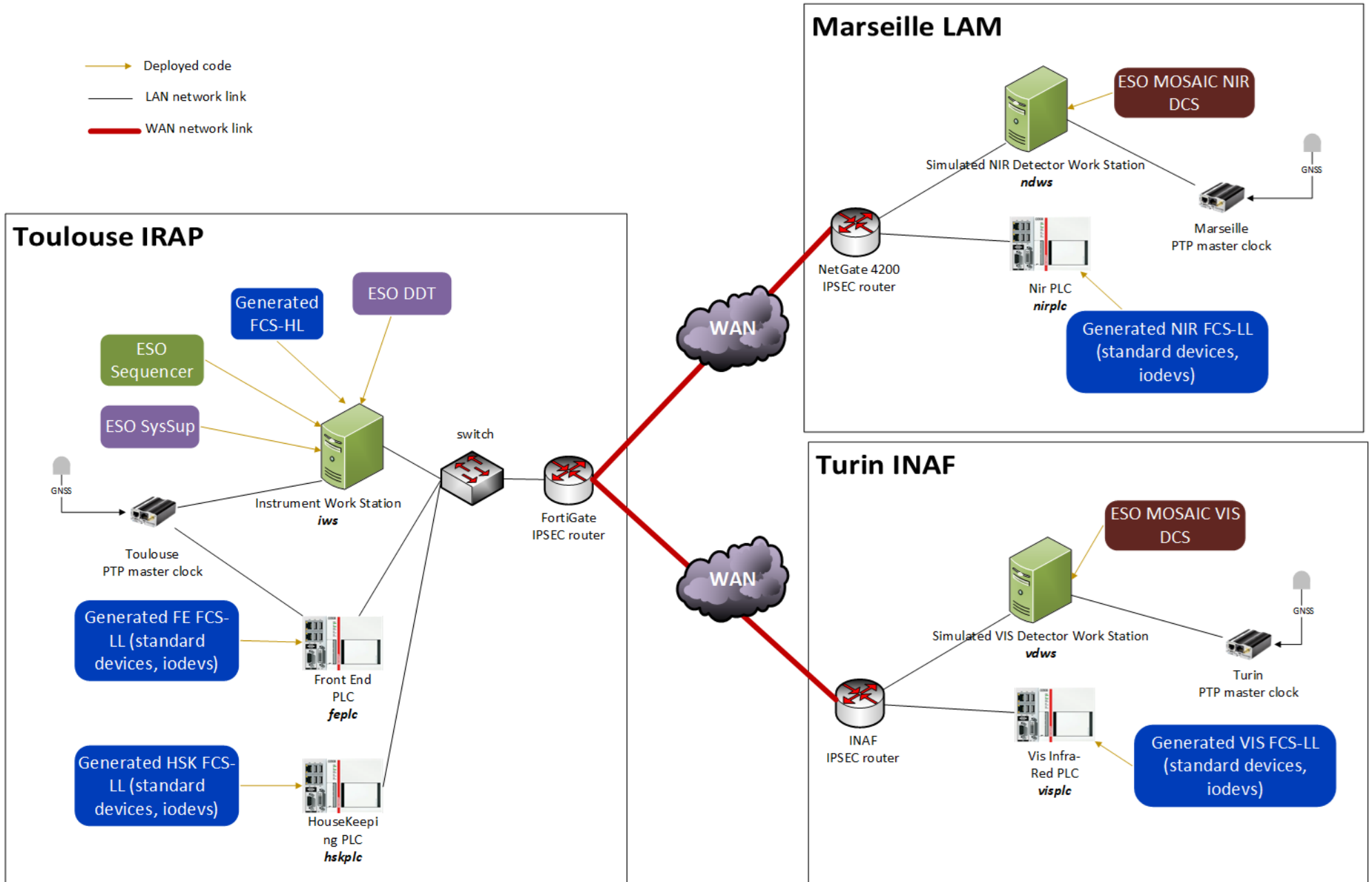
Framework ESO

The default structure when creating a new project in the IFW is the MICADO example. To be able to start a clean implementation with real devices, we removed the simulators from the structure. In order to do this:

- We started from the MICADO example to have the ESO infrastructure.
- We removed all devices that are not present on our PLC, including the simulators.
- To configure the devices with only generic input/output, we preferred to modify the mapping/iodev.yaml inside the framework, rather than creating a new device. We needed 8 digital I/Os.
- We configured the project using the devices by modifying the part of the fcs/server/cfg.yaml.
- We updated the Nomad and Consul services, considering that we removed the simulator part, and we also changed the startup.py file that is launched in the sequencer to start the instrument
- We defined our devices in the devmgr folder (one file for each device).
- We also configured the OLDB in config/oldb.yaml.

Remote integration experiment

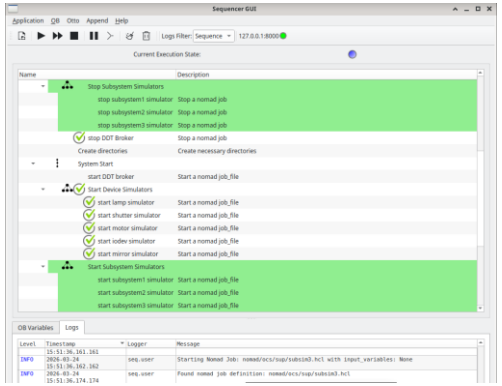


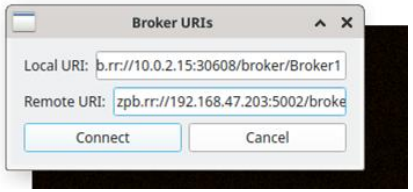
Remote operations on NGCII Simulated system

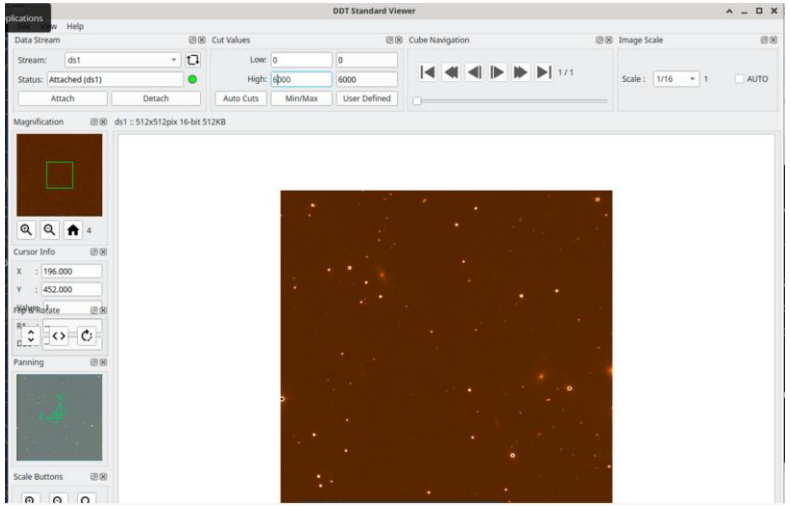
LOCAL PC
Local Broker → Publisher

REMOTE PC
Remote Broker → Subscriber → Viewer

ddtBroker → communication manager
ddtPublisherSimulator → data transmitter
ddtSubscriberSimulator → data receiver
ddtViewer → image visualization








```
[eltdev@elthost ~]$ ddtSubscriberSimulator -b zpb.rr://10.0.2.15:30608/broker/Broker1 --remote zpb.rr://192.168.47.203:5002
 --datastream ds1 --mode 1 --dump_data 1 --dump_folder /home_local/eltdev/test/ --debug
Logging properties exist: /elt/ddt/resource/config/log4cplus_ddtsubscribersimulator.properties
Debug triggered.
2026-03-24T15:41:21.179 DEBUG DdtSubscriberSimulator - DdtDataSubscriber: config file: /elt/ddt/resource/config/datatransfe
rlib.ini
2026-03-24T15:41:21.181 DEBUG DdtSubscriberSimulator - max age data sample [ms]: 10000
2026-03-24T15:41:21.181 DEBUG DdtSubscriberSimulator - reply time for MAL clients [s]: 6
2026-03-24T15:41:21.182 INFO  DdtSubscriberSimulator - DdtDataSubscriber: Broker URI: zpb.rr://10.0.2.15:30608/broker/Broke
r1
2026-03-24T15:41:21.182 INFO  DdtSubscriberSimulator - DdtDataSubscriber: Remote Broker URI: zpb.rr://192.168.47.203:5002/b
roker/Broker1
2026-03-24T15:41:21.243 DEBUG DdtSubscriberSimulator - DdtStatisticsClient: Broker connection established
2026-03-24T15:41:21.263 DEBUG DdtSubscriberSimulator - DdtDataTransferLib: Broker connection established
2026-03-24T15:41:21.389 DEBUG DdtSubscriberSimulator - DdtDataSubscriber parameters:
2026-03-24T15:41:21.389 DEBUG DdtSubscriberSimulator - subscriber_uuid: a46880f1-4010-459c-8bbe-cc4f9df31b4c
2026-03-24T15:41:21.389 DEBUG DdtSubscriberSimulator - data_stream_identifier: ds1
2026-03-24T15:41:21.389 DEBUG DdtSubscriberSimulator - remote_broker_uri: zpb.rr://192.168.47.203:5002/broker/Broker1
2026-03-24T15:41:21.389 DEBUG DdtSubscriberSimulator - latency [ms]: 10000
```

TETIS contribution

TETIS is a Coordination Unit within the INAF UTG-I OptNIR Division. It is meant as an instrument to improve coordination between INAF on the technologies used for control SW on Ground-based as well as space telescopes and instruments.

In the framework of our contribution to Mosaic, TETIS funded one course on Beckhoff PLC programming and usage, with an additional one planned for the autumn of 2026.

Our team (in particular V. Capobianco and M. Carnerero) have attended the first course and it has been particularly precious.

Further information on TETIS is available at

https://tetis.inaf.it