Industrial solutions trends for the control of Hi-Res spectrograph@E-ELT

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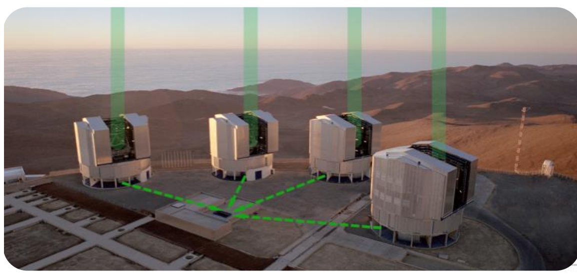
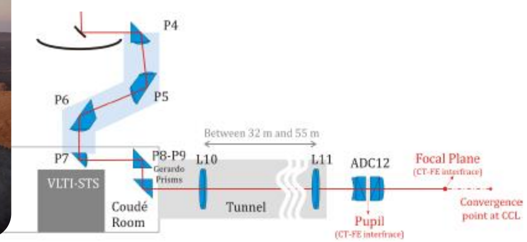
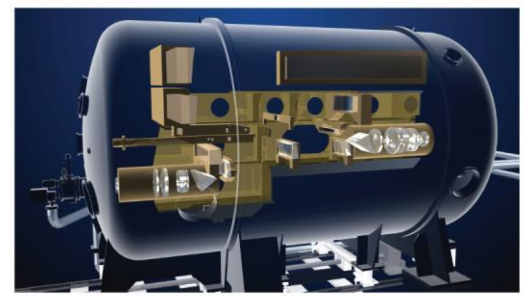
on behalf of INAF-OATs HiRes team

Outline of the talk

- Motivations
- Standardized industrial solution choices
- The working example: ESPRESSO (Echelle SPectrograph for Rocky Exoplanets and Stable Spectral Observations)



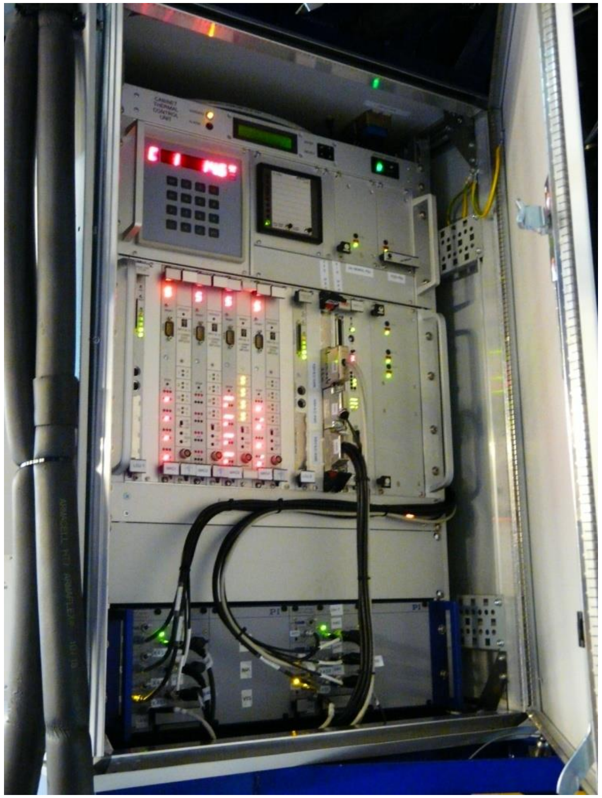
- The HiRes case
- Future steps

Motivations

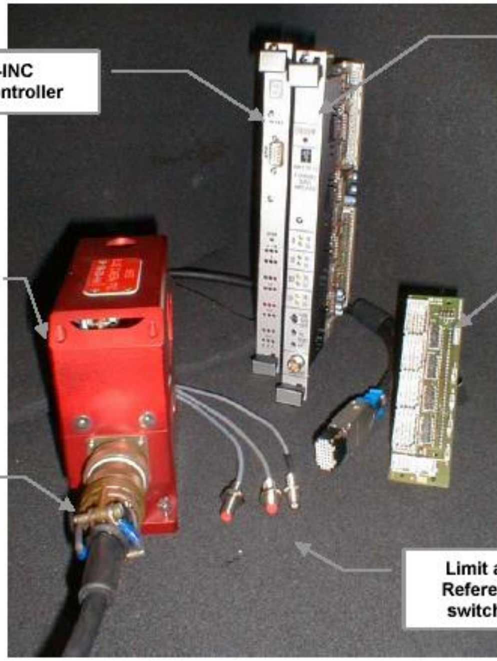
- Obsolescence issue (technology is advancing very fast)
- Custom solutions are expensive both to develop/implement them as well as to maintain (especially in the long term)
- Market offers a variety of solution that could be chosen to fit instrumental needs boosting performance, easing integration and lowering the costs
- Moving towards E-ELT (from the VLT) requires the most up-to-date hw/sw solutions to cope with the new Observatory requirements

"Current" VLT standard is heavily based on the concept of *VME-based LCU* (Local Control Unit) dedicated to the control of sub-systems hardware. Even though the VME bus is an international standards there are several limitations in the way it has been used at ESO, in particular:

- the strong hw/sw coupling;
- deployment and distribution issues;



Motor/Lamp/Sensors



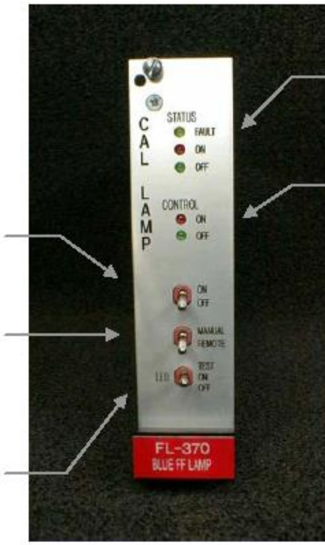
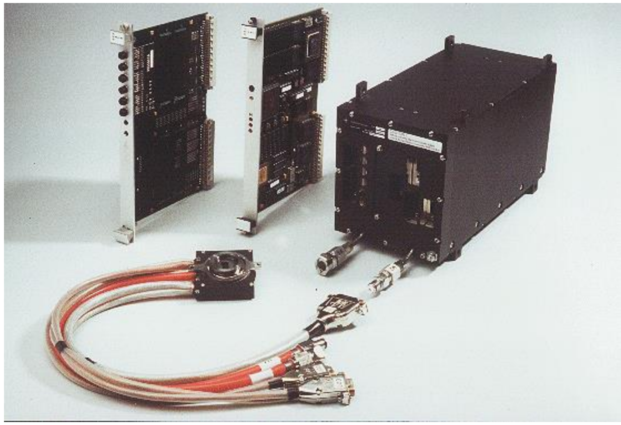


Figure 20- CFC control electronics sub-rack

TCCD@ESO

INAF-OATs



The first generation TCCD in the early 1990's was a joint collaboration between ESO and Dornier Jena Optik: it encompassed ad-hoc VME boards and array control electronics built on INMOS transputers and Russian frame transfer CCD detectors.

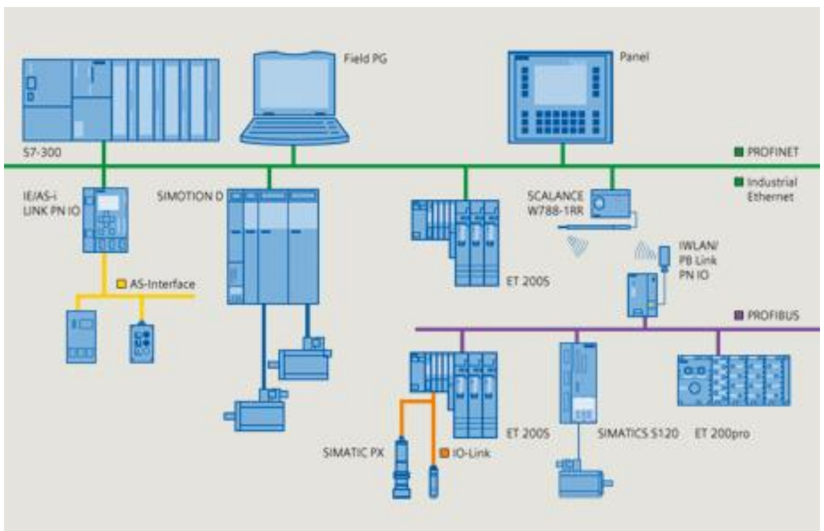
The second generation was introduced in 2005 and was based on the San Diego State University (SDSU) systems deploying DSPs on PCI bus bridged to Motorola PowerPC VME boards and e2v detectors integrated in ESO made camera heads.

⇨ expensive in terms of costs, manufacturing, integration and maintenance

Industrial standards: fieldbuses

Industrial Ethernet i.e. Ethernet based industrial communication systems with extensions for real-time communications. Aim is to replace several possible open or proprietary protocols such as *Modbus*, *CANopen*, *Profibus* … to made systems more inter-operable and reuse the “ubiquitous” Ethernet infrastructure.

Current expertise in Profinet (for Siemens systems) and EtherCAT (for Beckhoff systems).

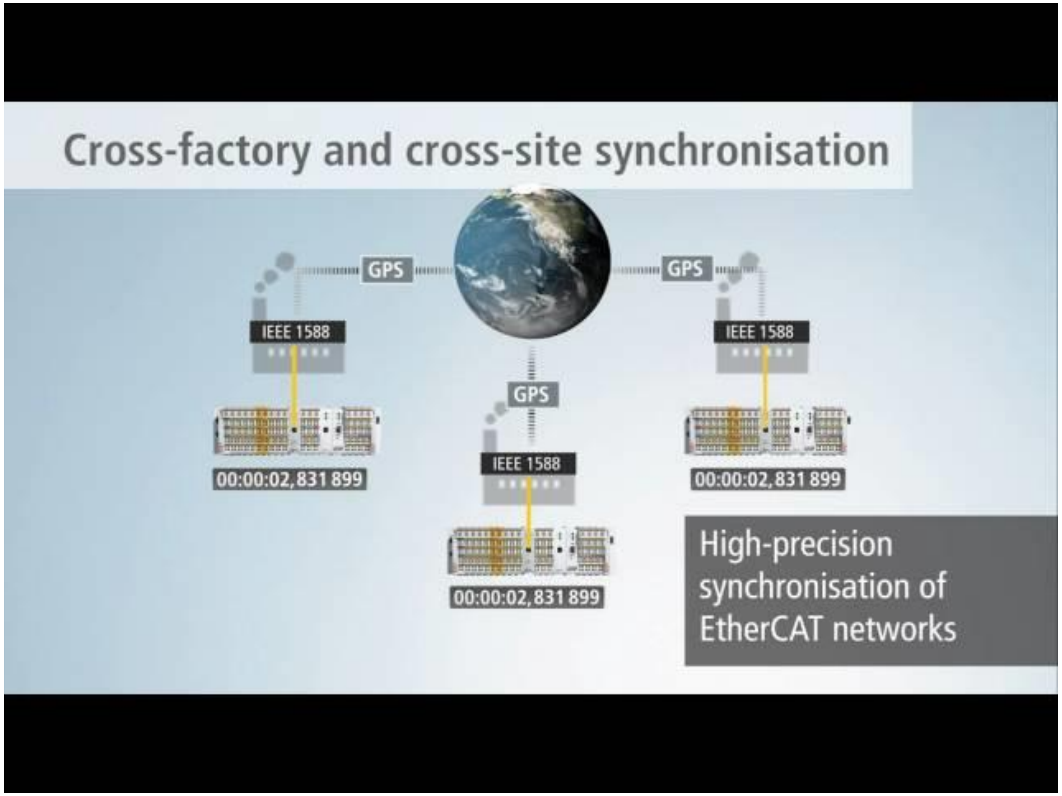


GigE Vision interface industrial standard for high-performance industrial cameras which provides a framework for transmitting high-speed video and related control data over *Ethernet* networks (members: AVT, DALSA, BASLER AG …)

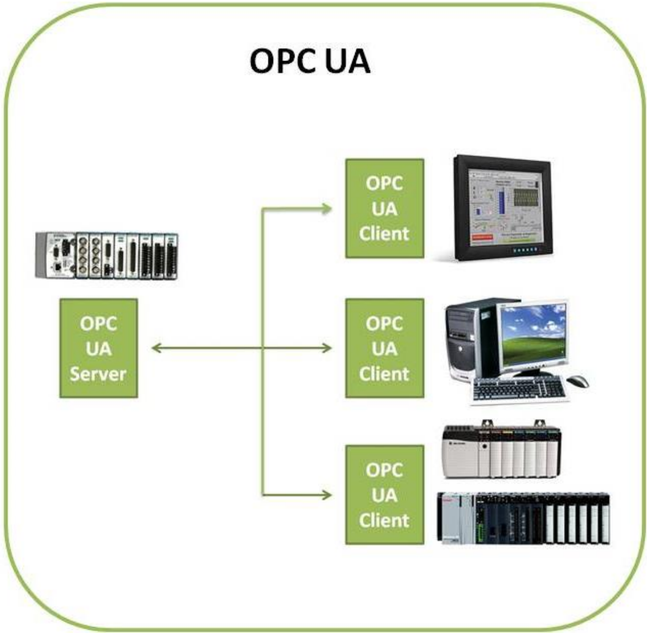
At higher abstraction level, the GenICam™ standard provides a generic programming interface for all kinds of cameras and devices no matter what interface technology (GigE Vision, USB3 Vision, Camera Link, 1394 DCAM, etc.)

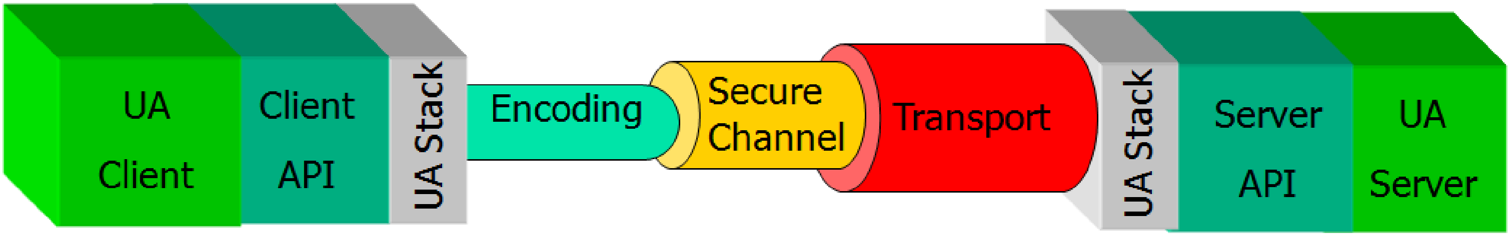
Bigeye	G-132 NIR Cool
Interface	IEEE 802.3 1000baseT
Resolution	1280 x 1024
Sensor	Sony ICX285
Sensor type	CCD Progressive
Sensor size	Type 2/3
Cell size	6.45 µm
Cooling temperature	-20 °C
Dark noise	tdb
Dark current	tbd
Saturation capacity	tbd
Dynamic range	tbd
Lens mount	C-Mount
Max frame rate at full resolution	12.5 fps
A/D	12 bit
On-board FIFO	32 MB
	Output
Bit depth	12 bit
Mono modes	Mono8, Mono12, Mono12Packed
	General purpose inputs/outputs (GPIOs)
TTL I/Os	1/1
Opto-coupled I/Os	3/3
RS-232	2
	Operating conditions/Dimensions
Operating temperature	0 °C ... 35 °C
Power consumption (12 V)	max. <36 W, typ. <18 W
Mass	1270 g
Body Dimensions (L x W x H in mm)	100.8 x 90 x 99 mm incl. connectors, w/o lens
Regulations	CE, RoHS (2002/95/EC)

IEEE 1588 is the standard defining the *PTP* (precision time protocol), which is able to achieve sub-microsecond range clock accuracy. Its is the time synchronization system foreseen for the E-ELT.

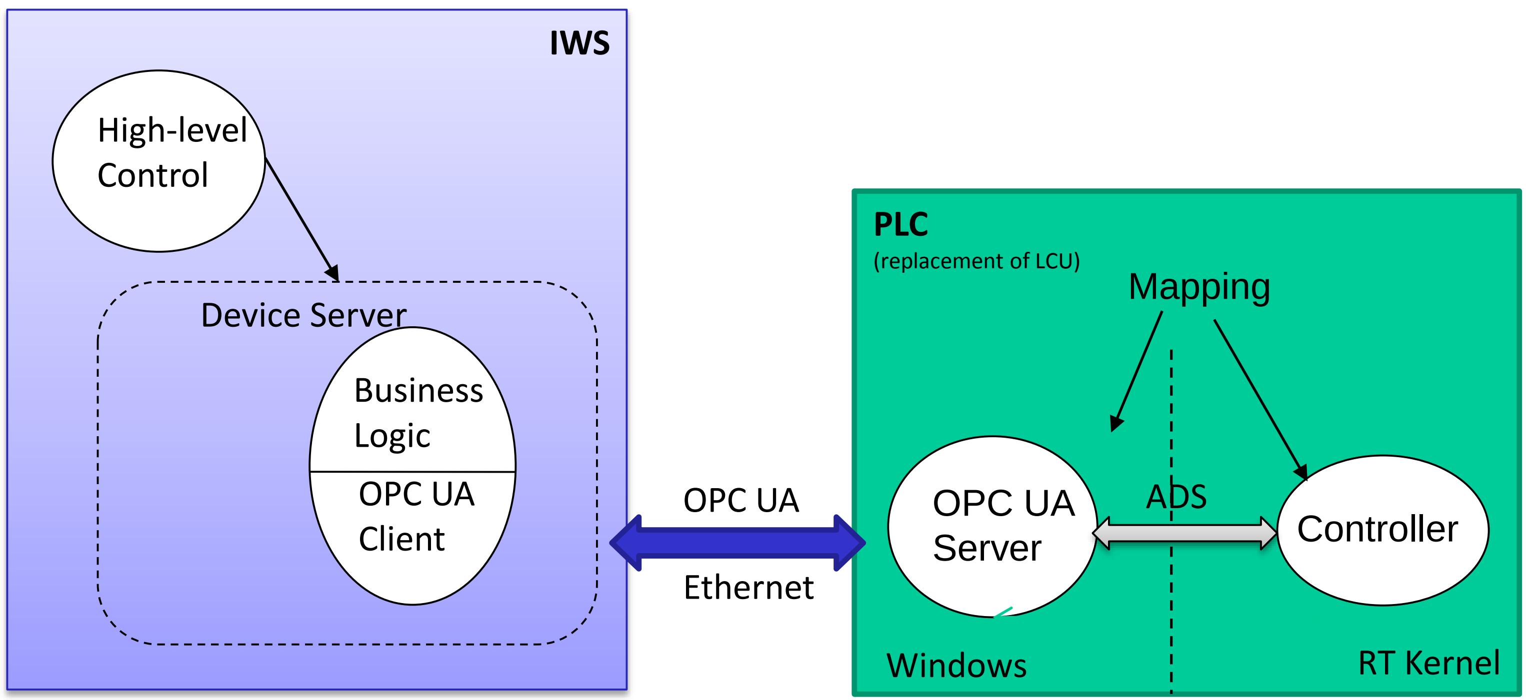


OPC Unified Automation is an industrial communication protocol developed for interoperability by the OPC foundation.

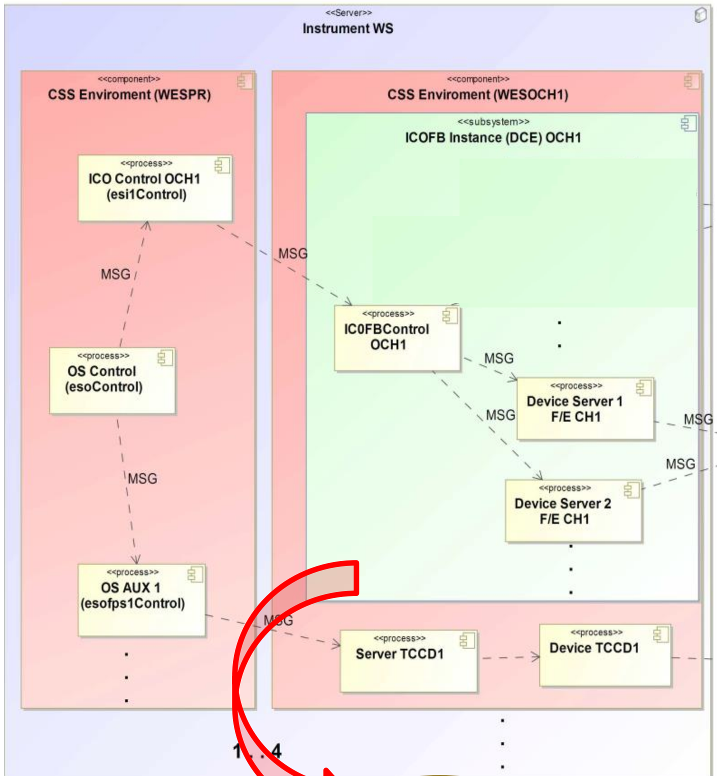




OPC-UA architecture



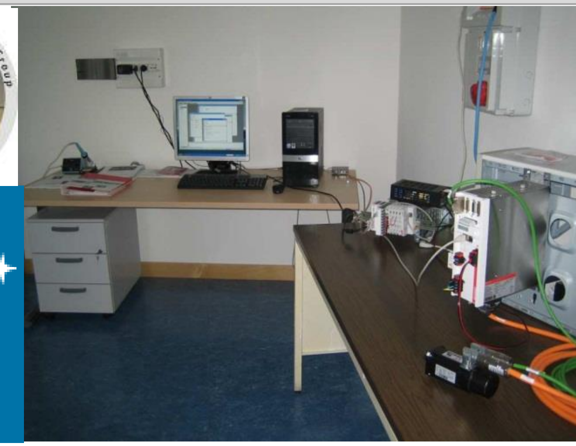
OPC-UA @ OATs

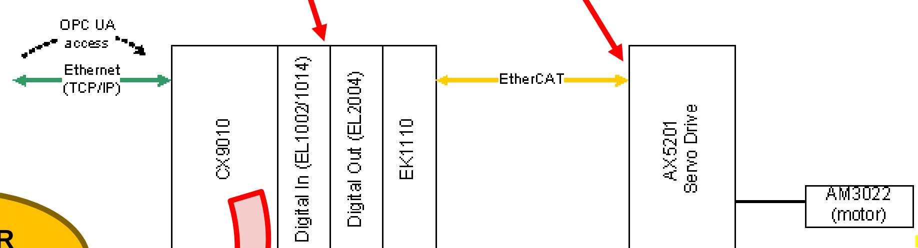


CLIENT OPC-UA

Unified Architecture

First Laboratory Instrument which uses OPC-UA

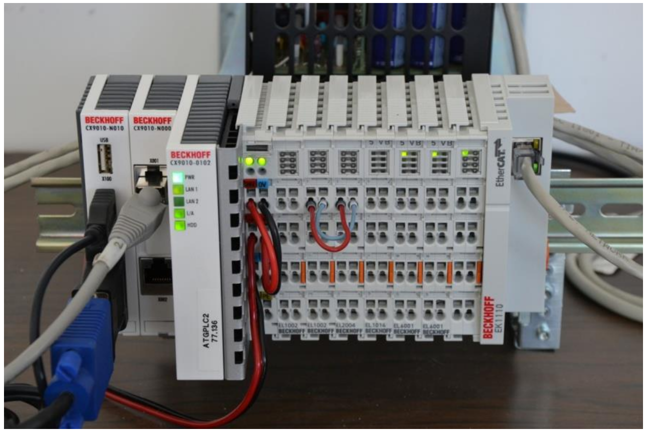




SERVER OPC-UA

PLCs

A programmable logic controller, PLC, or programmable controller is a digital computer used for automation of typically industrial processes.

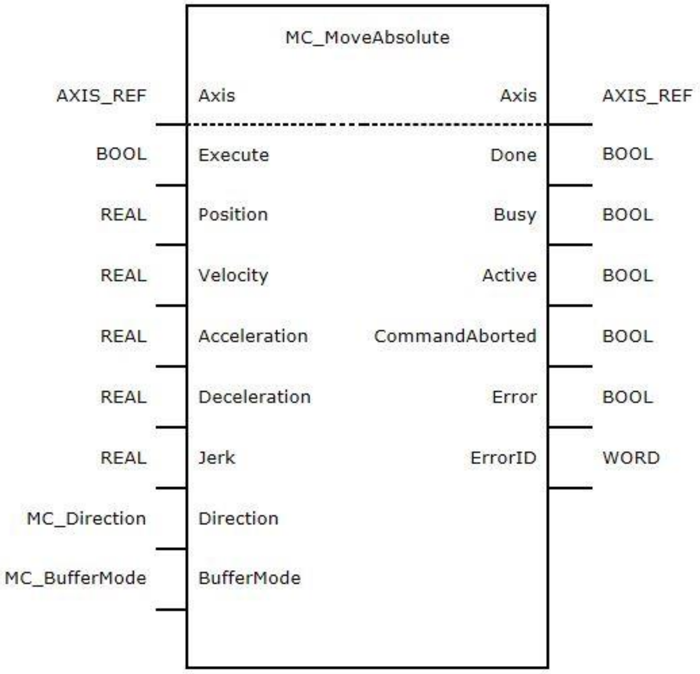


PLC Open MC

PLCopen motion standard provide a way to have standard application libraries that are reusable for multiple hardware platforms. It offers in particular function blocks based on the IEC 61131 languages to create efficient, flexible code that is vendor- and product-independent.

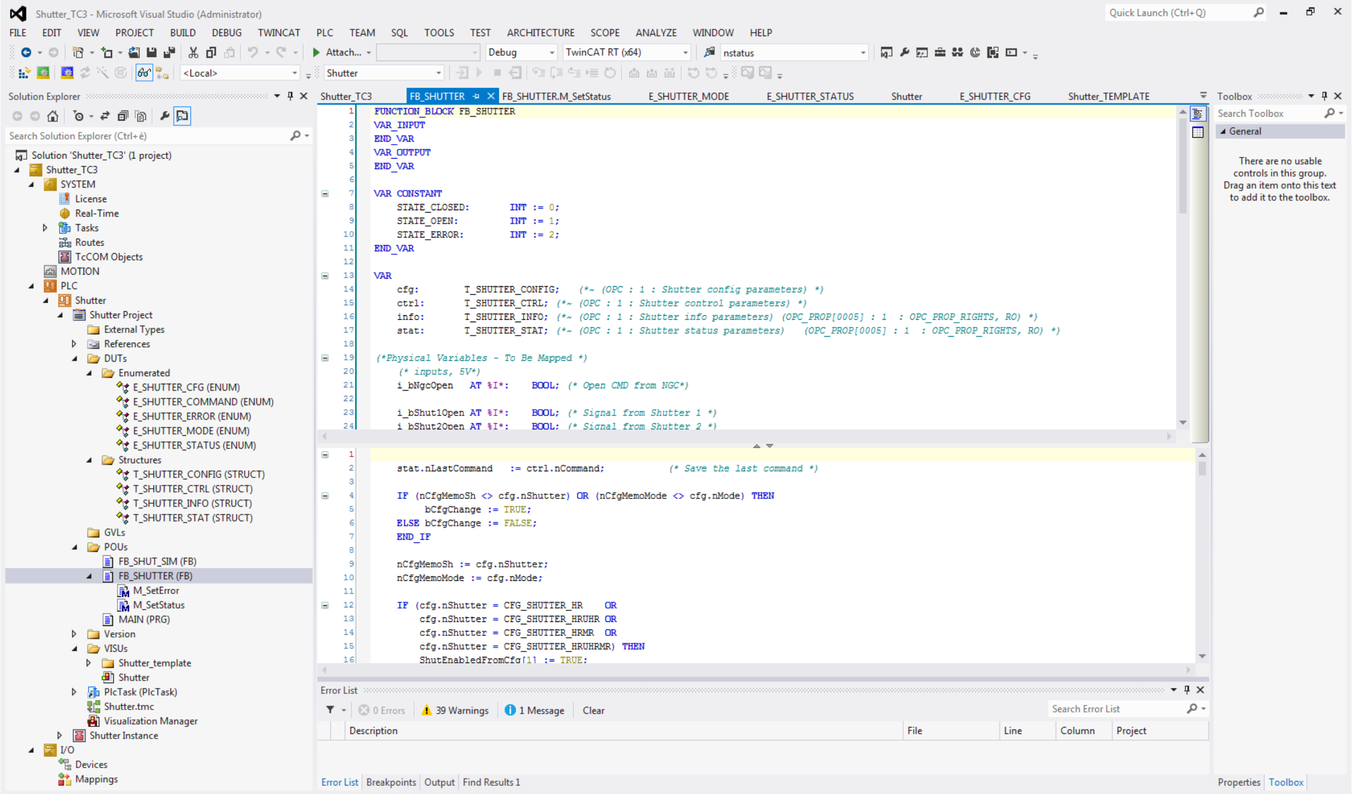
FB-Name	**MC_MoveAbsolute**
This function block commands a controlled motion at a specified absolute position.	

Graphical representation:

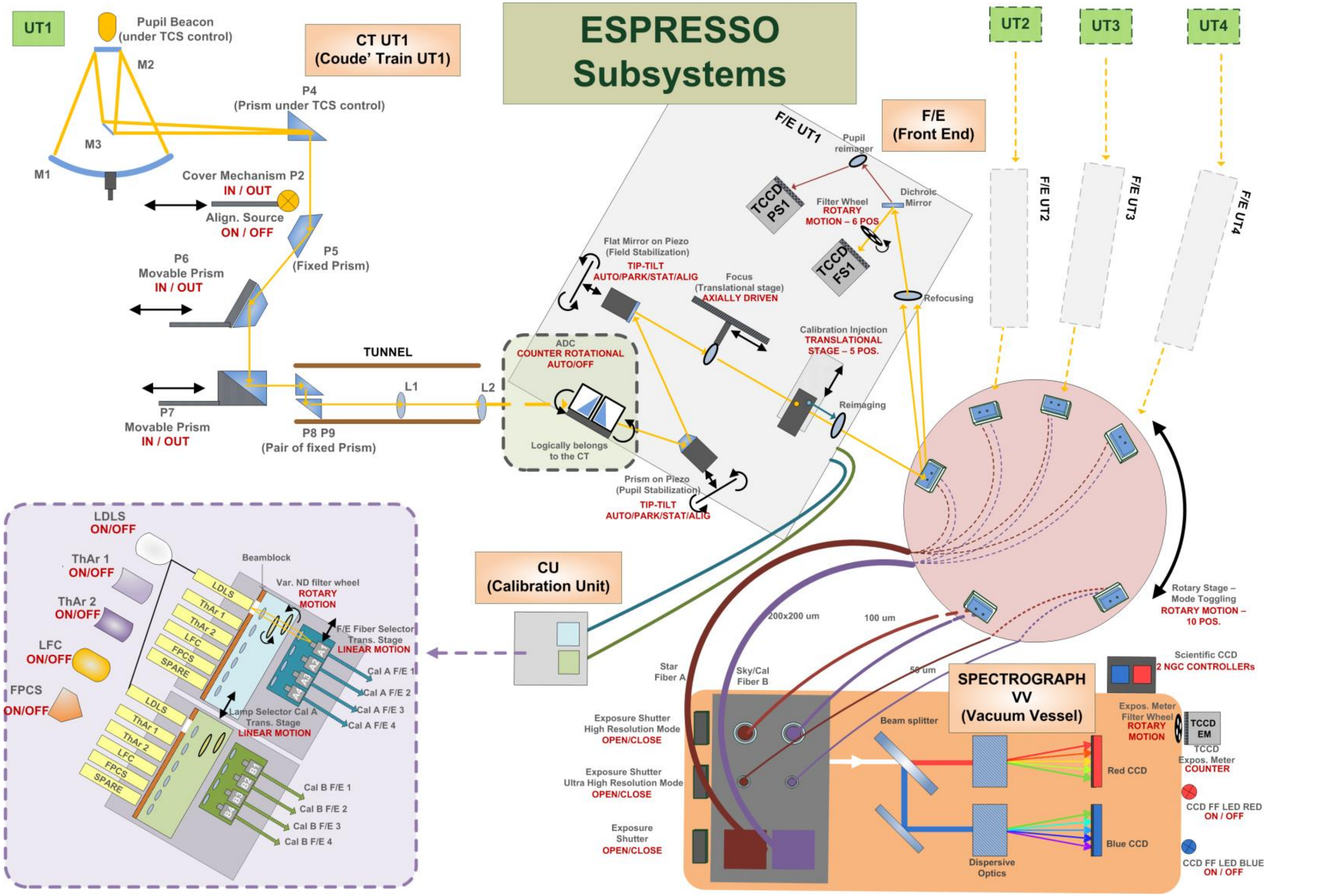


IEC 61131-3 deals with PLC programming languages and defines two graphical and two textual PLC programming language standards (among others):

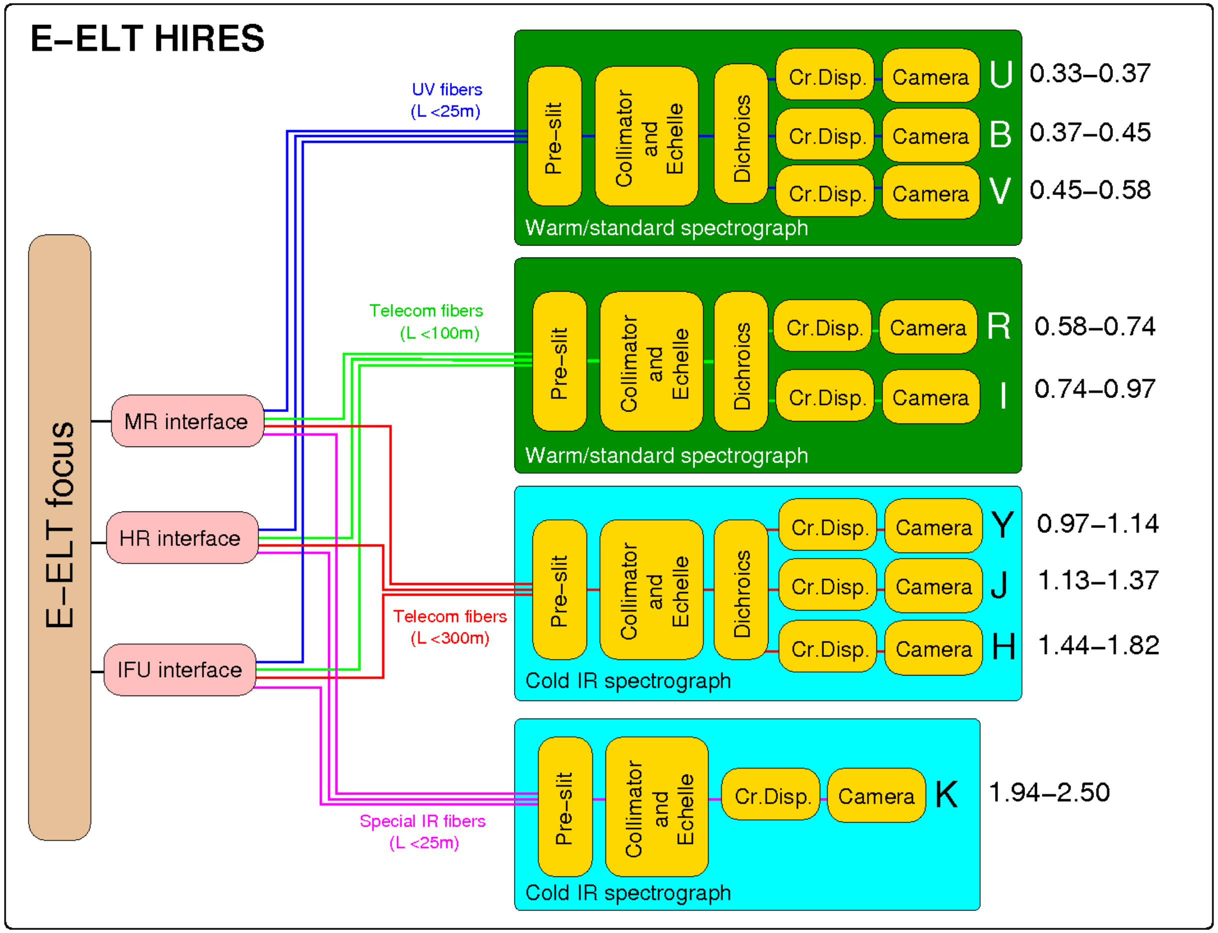
- Ladder programming;
- Functional Block Diagram;
- Structured Text;
- Instruction List.



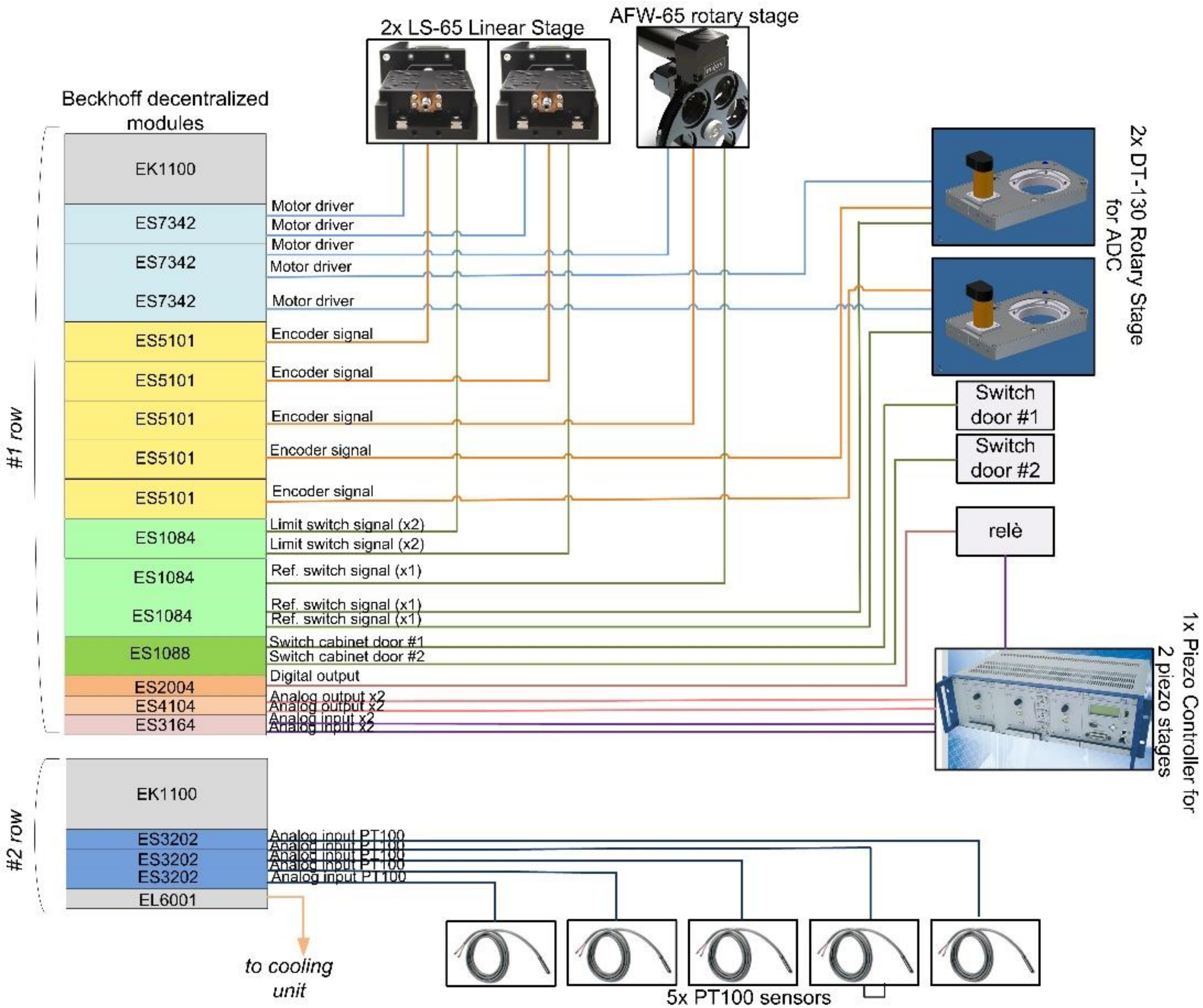
ESPRESSO instrument



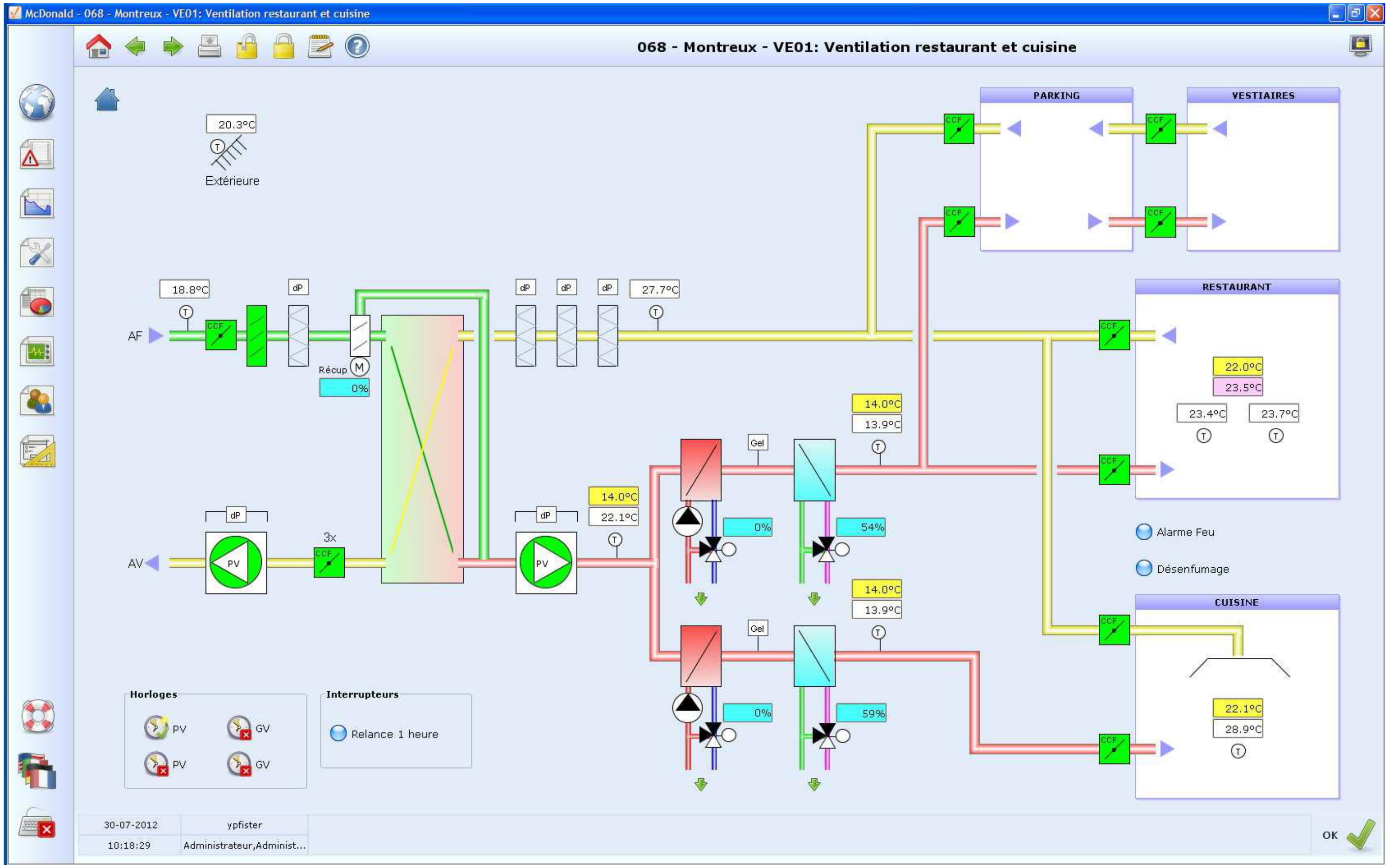
HiRes comparison



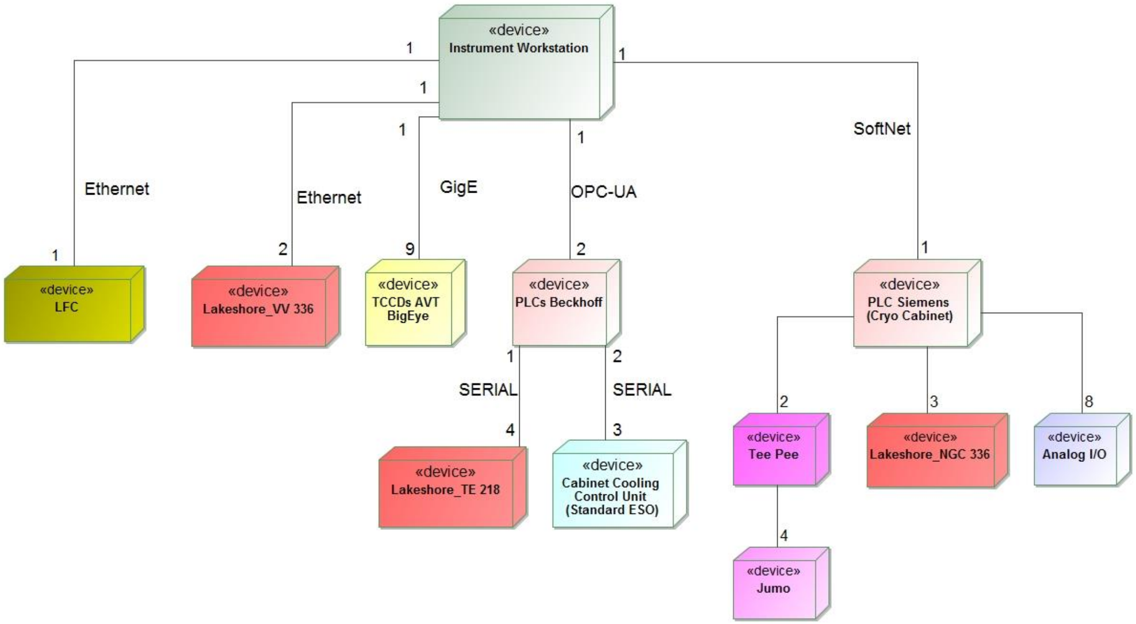
Taken form the blue-book; partially superseded, but still gives an idea ...


2x LS-65 Linear Stage
AFW-65 rotary stage
Beckhoff decentralized modules
EK1100
ES7342
ES7342
ES7342
ES5101
ES5101
ES5101
ES5101
ES5101
ES1084
ES1084
ES1084
ES1088
ES2004
ES4104
ES3164
#1 row
Motor driver
Motor driver
Motor driver
Motor driver
Motor driver
Encoder signal
Encoder signal
Encoder signal
Encoder signal
Encoder signal
Limit switch signal (x2)
Limit switch signal (x2)
Ref. switch signal (x1)
Ref. switch signal (x1)
Ref. switch signal (x1)
Switch cabinet door #1
Switch cabinet door #2
Digital output
Analog output x2
Analog output x2
Analog input x2
Analog input x2
2x DT-130 Rotary Stage for ADC
Switch door #1
Switch door #2
relè
1x Piezo Controller for 2 piezo stages
EK1100
ES3202
ES3202
ES3202
EL6001
#2 row
Analog input PT100
Analog input PT100
Analog input PT100
Analog input PT100
Analog input PT100
to cooling unit
5x PT100 sensors

ESPRESSO Device control II



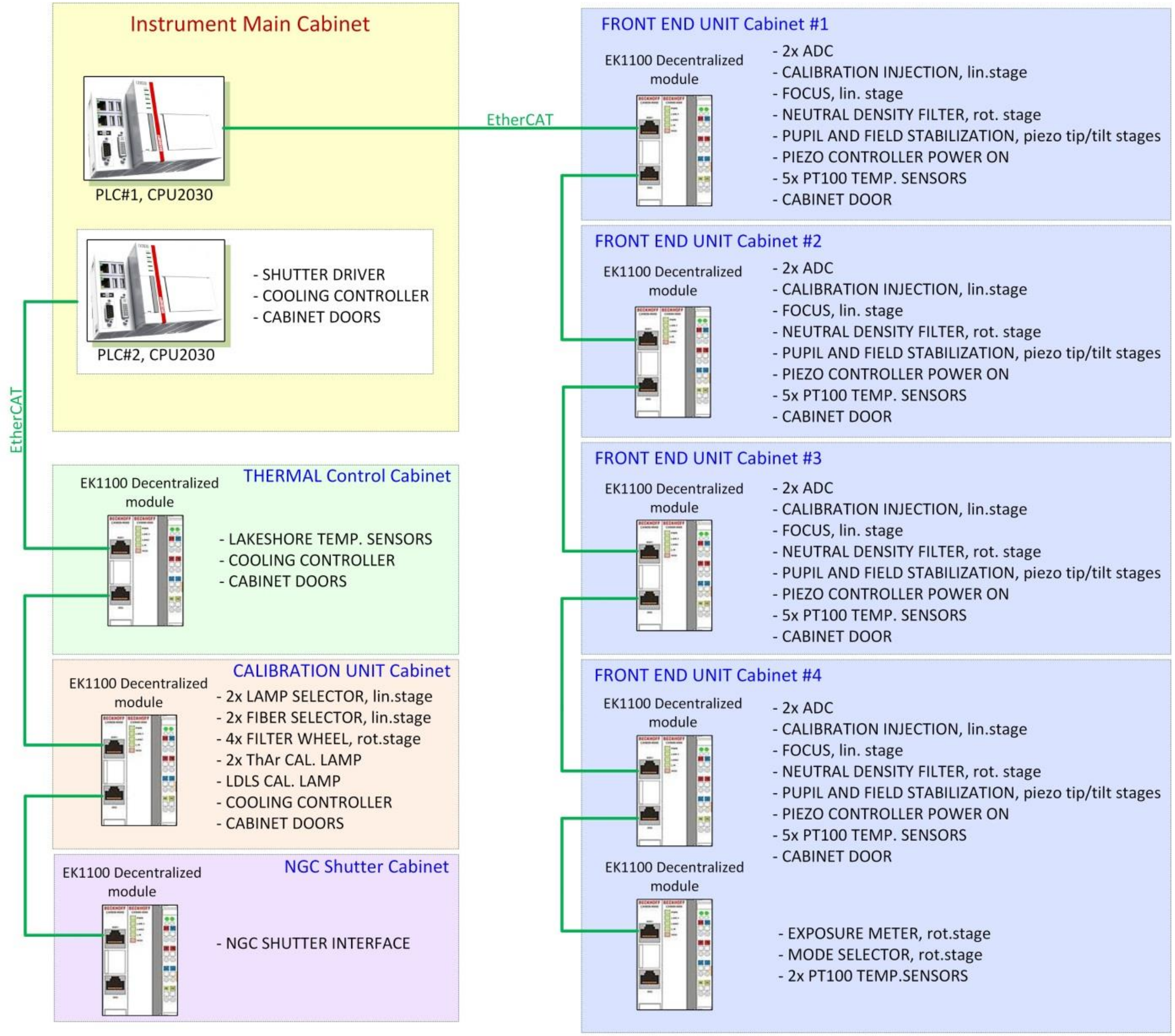
ESPRESSO SW protocols



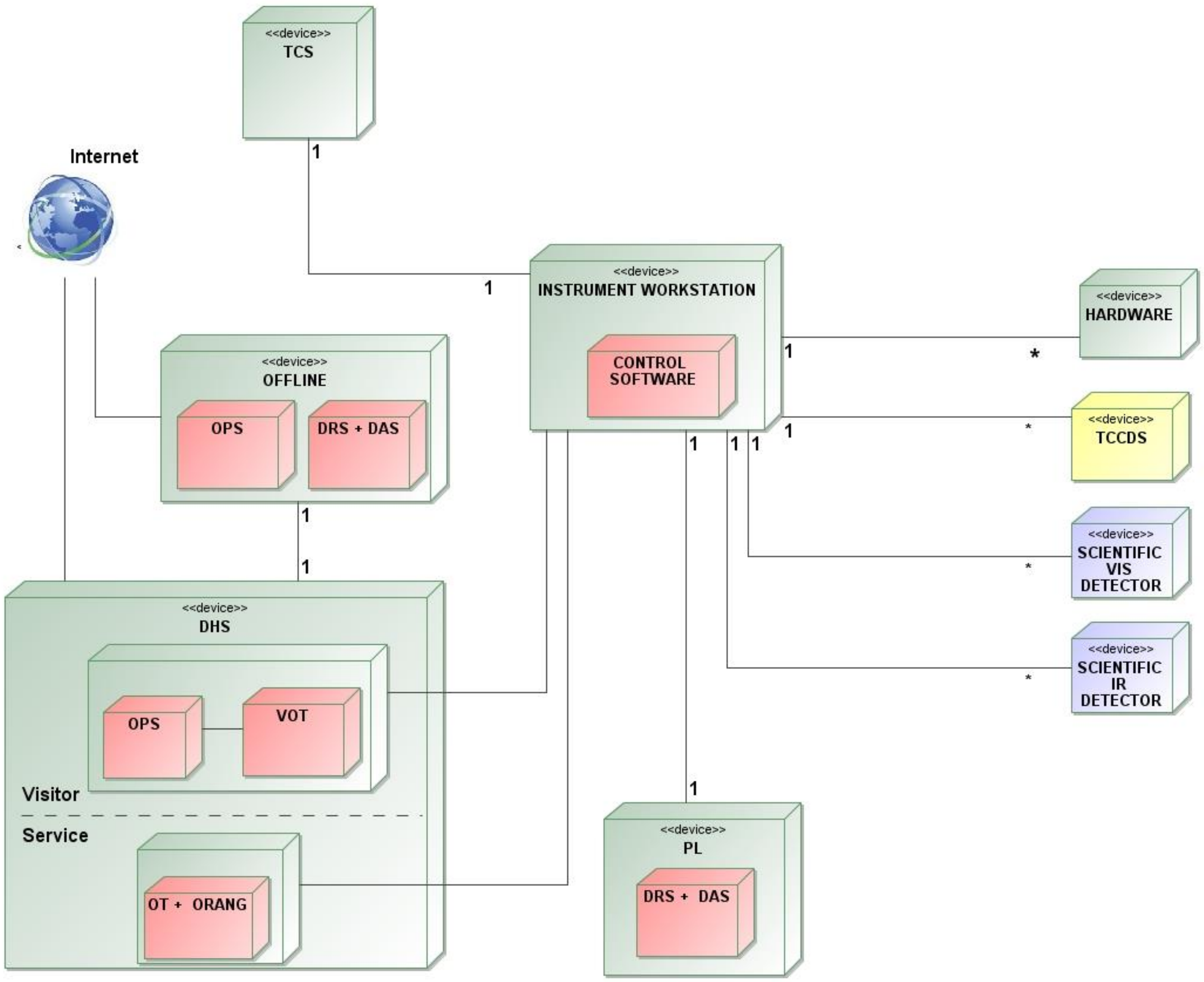
Motor	Type	N.
Linear Stage	MICOS LS-65	**8**
Linear Stage	VT-80	**4**
Rotary Stage	AFW - 65	**9**
Rotary Stage	DT-130	**8**
Rotary Stage	PRS - 200	**1**
Piezo Tip-Tilt	PI – E500	**8**
TOT		**38**

Device	Type	N.
Digital/ Analog Sensors	• Lakeshores 218, 336 • Sensor for Vacuum and Cryo system • PT100 Temp. sensors • Cabinet door sensors • Power piezo controller	**~100**
ThAr Lamp		**2**
LDLS lamp		**2**
Laser Frequency Comb	TBD	**1**

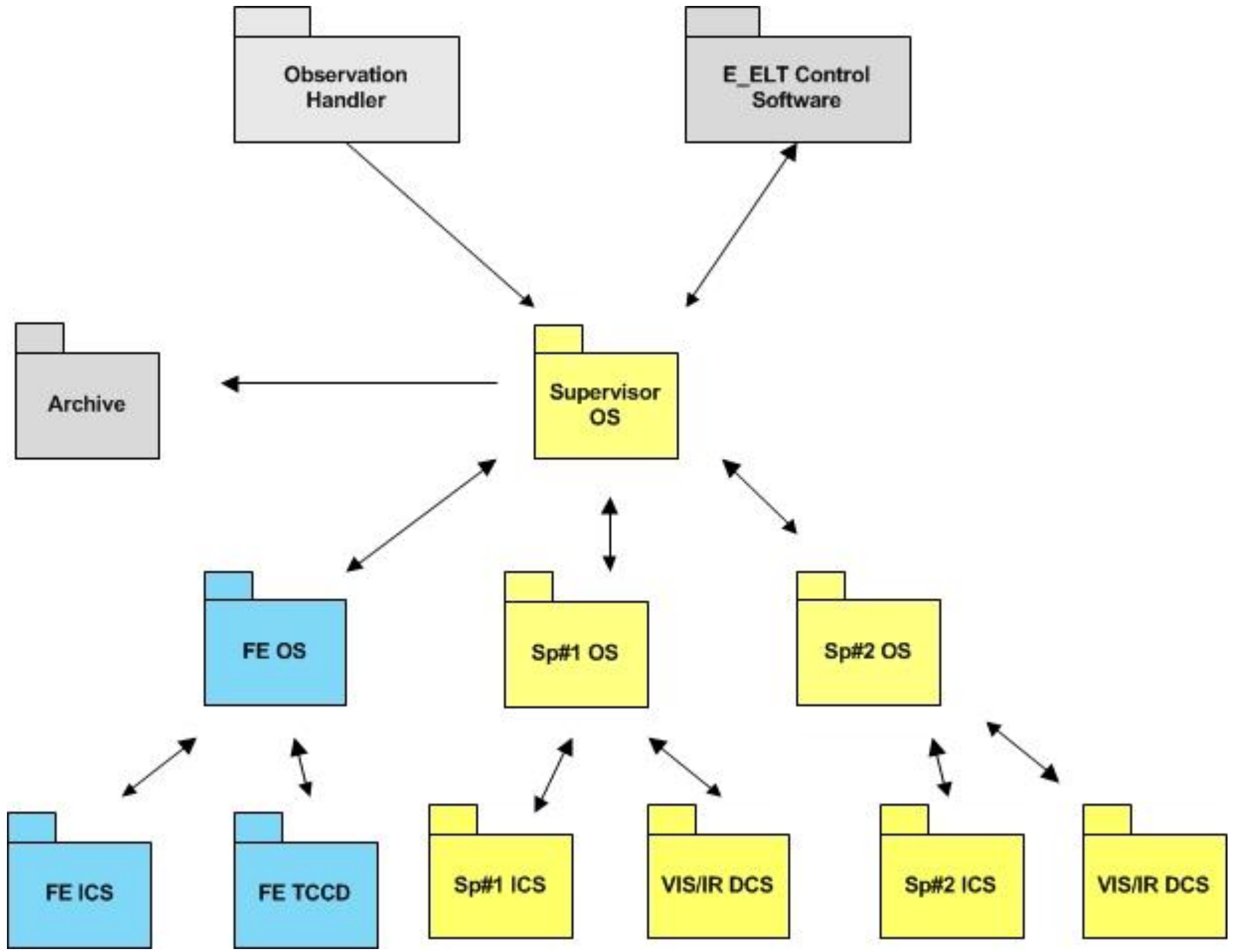
ESPRESSO device distribution



HiRes overall sw infrastructure



Hires modular and distributed approach



Conclusions

Although the industrial market is evolving fast the adoption of COTS industrial standard solution seems a possible way to overcome obsolescence issues. However periodic market surveys is also necessary to keep up to date with the latest developments in the various fields (control, image vision etc.).

The adoption of the high level communication protocol (e.g. GigE Vision and possibly its abstraction e.g. GenICam^{TM}) is considered as the correct path to minimize the development and maintenance costs.

The choice of industrial standards separating the business logic from the device specificity (e.g. OPC UA) will allow the integration of new products at almost no cost and reduce the maintenance effort.

The ESPRESSO case study will hopefully serve as a test bed for future E-ELT instruments.