Industrial Controls &
Safety Systems
Beams Department

UNICOS: UNIFIED INDUSTRIAL CONTROL SYSTEM
CPC (CONTINUOUS PROCESS CONTROL)

BASIC COURSE
SESSION 0:
UCPC FROM SPECS TO IMPLEMENTATION

UNICOS-Continuous Process Control

CERN, UNICOS team

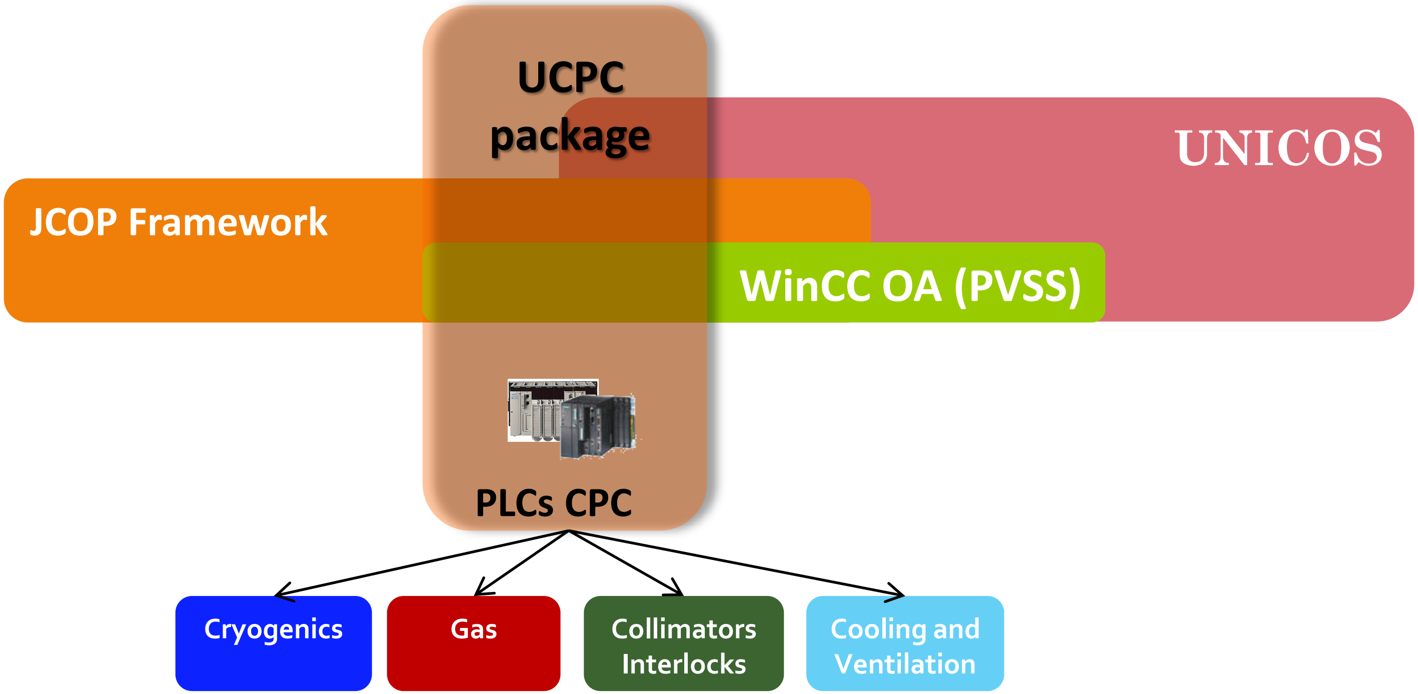
UNICOS AND CPC

- ***Process***. Methods of changing or refining raw materials to create end products.
- Process control refers to the methods that are used to control process variables when manufacturing a product.
- Manufacturers control the production process for several reasons:
  - Reduces variability: increase **quality**
  - Increases **efficiency**: increase profits
  - Ensures **safety**: optimize conditions

UNICOS AND CPC

- **UNICOS** is a framework to create control applications.
- **UNICOS-CPC** (**Continuous Process Control**) is basic package to develop integrated PLC based process control applications.

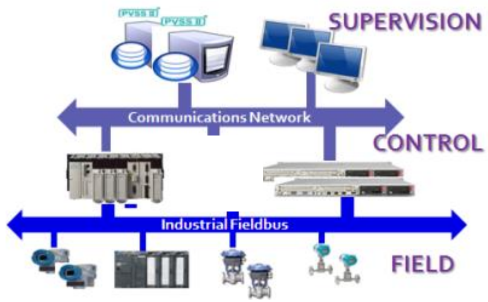
UNICOS, JCOP AND UNICOS-CPC



Process Control applications

A LOOK TO THE PAST

- **[1998] UNICOS** (**UN**ified **I**ndustrial **C**ontrol **S**ystem) was born at CERN as a need to develop the LHC cryogenics control system. The **goal** was to create an industrial control system covering the three layers of the typical automation pyramid.



- **[2002]** UNICOS replace the PcVue SCADA and adopt ETM's PVSS under the CERN recommendation.
- **[2004]** UNICOS offered the choice of creating applications based on SIEMENS S7 PLCs
- **[2009]** UNICOS turned into *de facto* **standard framework** to develop industrial control applications at CERN:

  Cryogenics, Cooling, HVAC, Vacuum, Interlocks,…

- **[2010]** The UNICOS framework has been extended to other kinds of applications (i.e.: supervisory: [QPS,SURVEY], monitoring, …)

- **[2012] Re-engineering** process

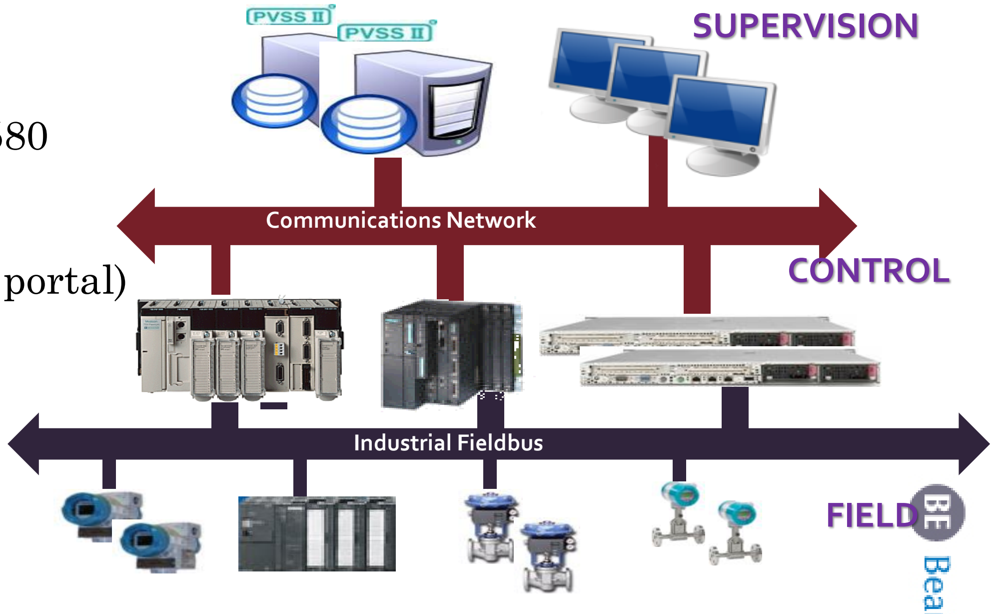
Technologies

Supervision Layer
- WinCC OA SCADA

Control Layer
- Siemens S7-300, S7-400, *S7-1500*
- Schnedier Premium, Quantum, M580
- Codesys (Somachine, TwinCat3)

Local operation
- Simatic HMI (WinCC flexible, TIA portal)
- Schneider Magelis

Industrial communications
- Profibus, Profinet, Ethernet/IP
- Modbus TCP



Applications

- LHC Cryogenics
- Detector and Test facilities cryogenics
- Magnet Control System
- Vacuum installations : ATLAS, CMS, ISOLDE
- LHC collimators: Environmental temperatures
- ATLAS Big wheels (motion)
- AMS servomotors control
- Detector gas control systems
- Cooling and HVAC installations
- Winding machines: HTS cable (hybrid with a Safety system)
- SM18 Magnet test bench protection system.

UNICOS-CPC ESSENTIALS

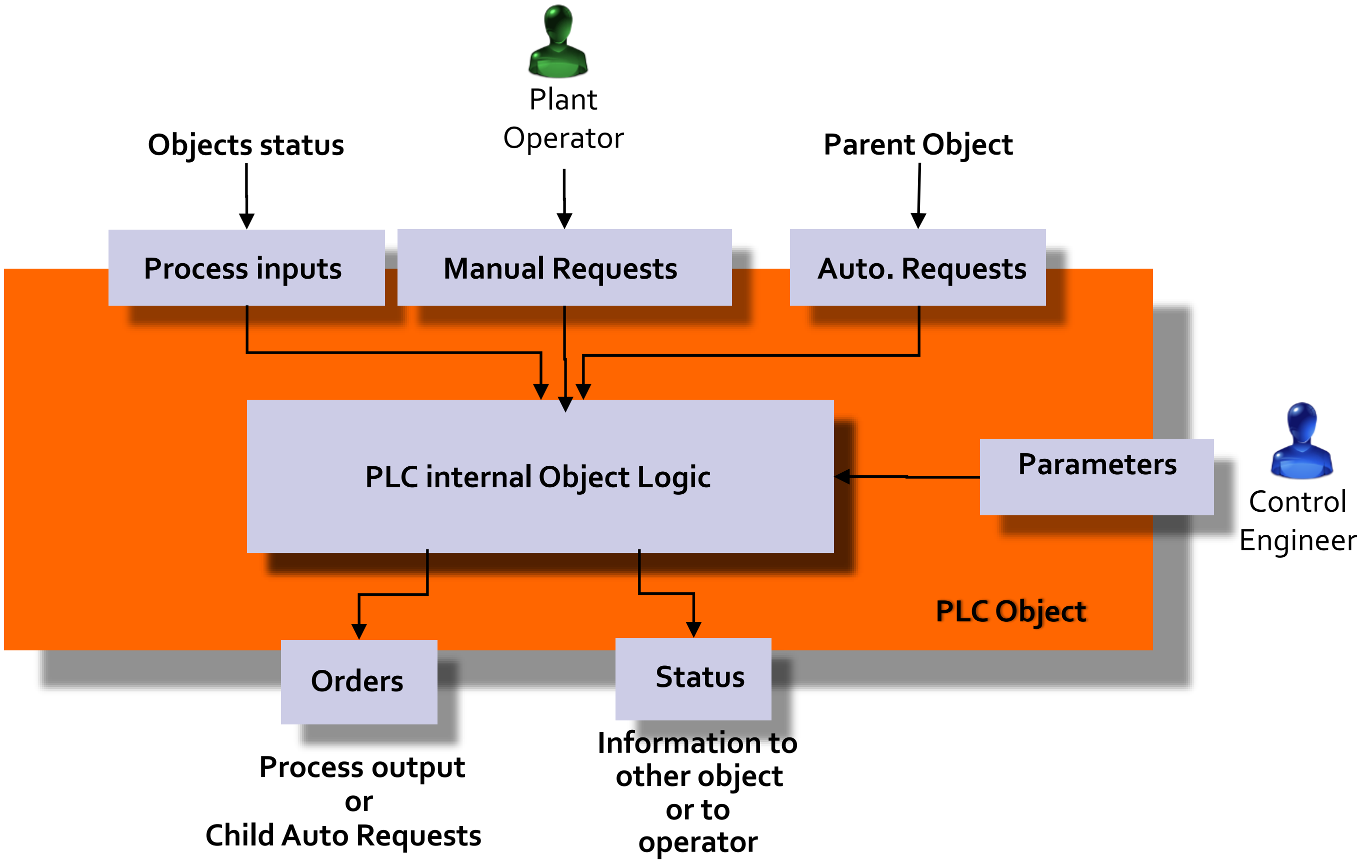
- UNICOS CPC provides libraries (control and supervision layers)

- A well defined set of **standard device types** (objects), modeling most of the **equipment** and needs of continuous processes and the **relationships** between them.

  - **I/O Objects**
    - Digital I/O
    - Analog I/O
  - **Field Objects**
    - OnOff
    - Analog
    - AnalogDigital
    - Local
    - AnaDO
  - **Control Objects**
    - Controller
    - Alarms
    - Process Control Object
  - **Interface Objects**
    - Parameter (Digital, Word, Analog)
    - Status (Word, Analog)

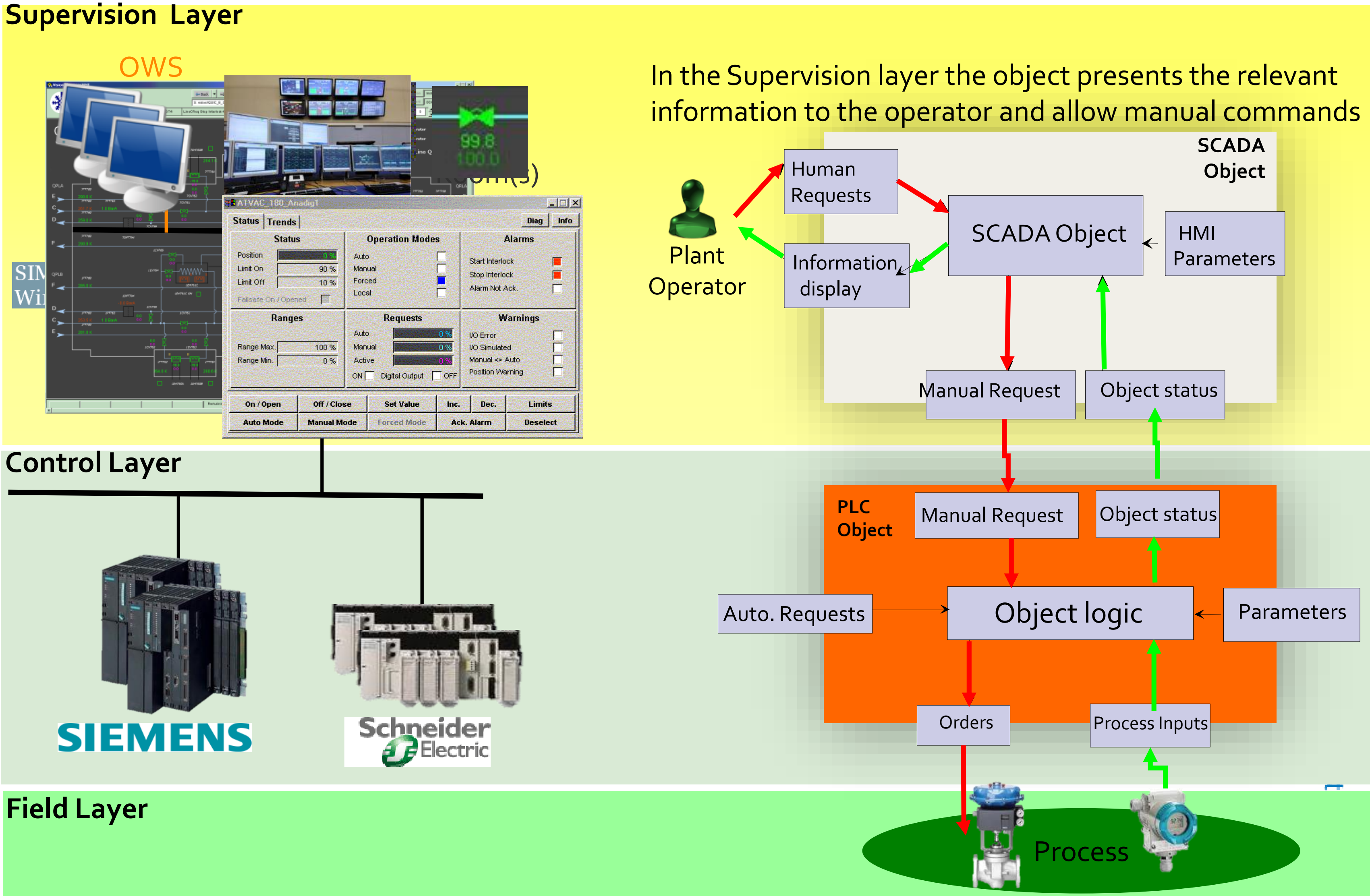
- A **formalized** way of :
  - Define the **control units** of a process (ISA-88 standard: Batch processes)
  - **Programming** the **specific process logic** for those units

UNICOS CPC Object model



Objects & Layers Integration

In the Supervision layer the object presents the relevant information to the operator and allow manual commands



UNICOS-CPC OBJECTS

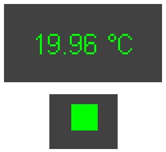
- **I/O Objects**
- **Field Objects**
- **Control Objects**
- **Interface Objects**

I/O OBJECTS

- **Functionality**
  - Base components
  - PLC Periphery interface and/or internal memory variables

- **Types**
  - AI, AIR: Analog Input or Analog Input Real
    (e.g. temperature transmitter)
  - DI: Digital Input
    (e.g. end contact)
  - AO,AOR: Analog Output or Analog Output Real
    (e.g. control valve position order)
  - DO: Digital Output
    (e.g. onoff valve position order)

Widget examples



Field Objects

- **Functionality**
  - Model the real field equipments (e.g. pumps, valves…)
  - As a general rule, the field objects are connected to the I/O Objects. No direct connection to the PLC periphery.

- **Types**
  - *OnOff*: Binary Objects
    (e.g. on/off valve, motor, pump)
  - *Analog*: Analog objects
    (e.g. control valve, heater)
  - *Anadig*: Analog inputs and Digital outputs objects
    (e.g. valves/heaters controlled by on/off pulses)
  - *AnaDO : Similar functionality of an OnOff + Analog object*
    (Motor with VFD, Thyristor, Heater, etc.)
  - *Local:* Field localized objects *:*
    (e.g. manual valve)

Widget examples

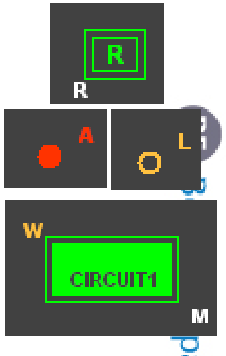
CONTROL OBJECTS

- **Functionality**
  - Main objects holding the control logic
  - Feedback controllers
  - Handle the abnormal situations: Alarms and interlocks

- **Types**
  - *PCO*: Process Control Objects/Unit. It implements the control logic (*e.g. Compressor Station*)
  - *Controller*: feedback control objects *(e.g. PID controller)*
  - *AA, DA*: Analog/Digital Alarm Objects. It models alarms and interlocks. Analog alarms include alarm and warning thresholds (*e.g. Temperature Too High*)

    Options for an AA:
    - Explicit threshold: Initialized in PLC and then modified from SCADA
    - Logic: Set by control logic in the PLC
    - APAR : Linked object APAR sets the value

Widget examples



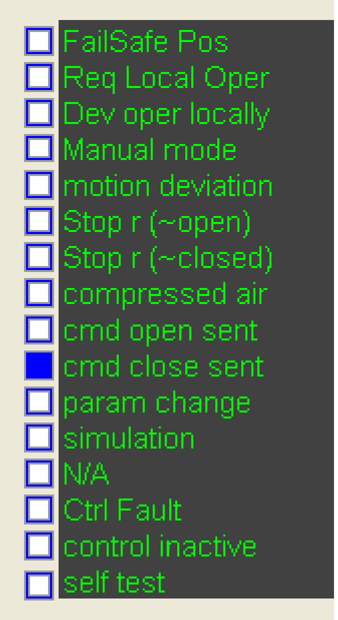
Interface Objects

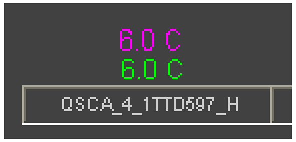
- **Functionality**
  - Parameterization and status
  - Can be connected to the periphery
  - Light objects

- **Types**
  - *DigitalParameter, WordParameter, AnalogParameter*: Parameters (*e.g. Threshold*)
    Can be set by an operator (SCADA -> PLC)

  - *WordStatus, AnalogStatus*: Status
    (e.g. stepper position, PA valve feedback)
    PLC ->SCADA

Widget examples

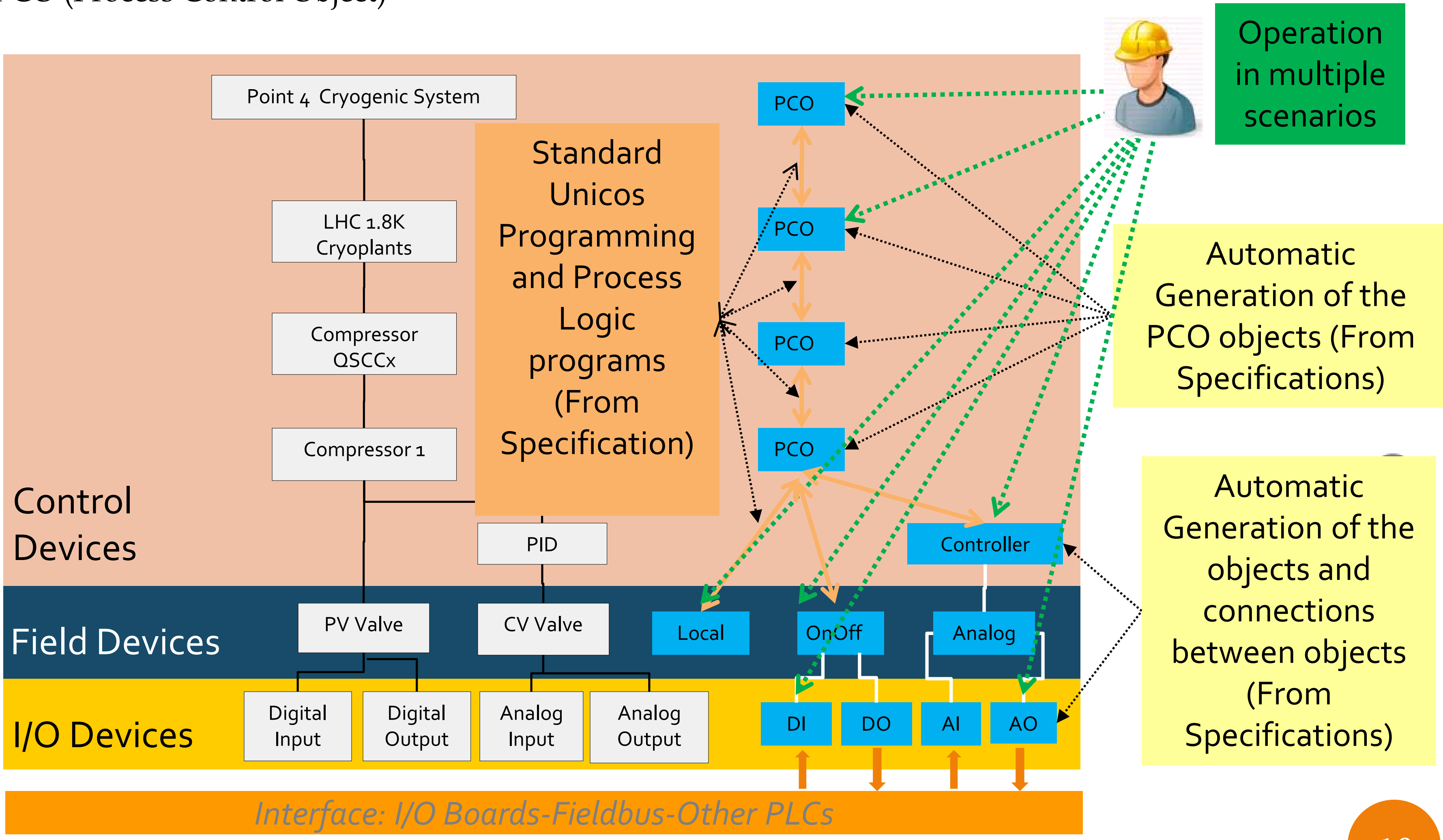




BE Beams Department

Process vs. Control

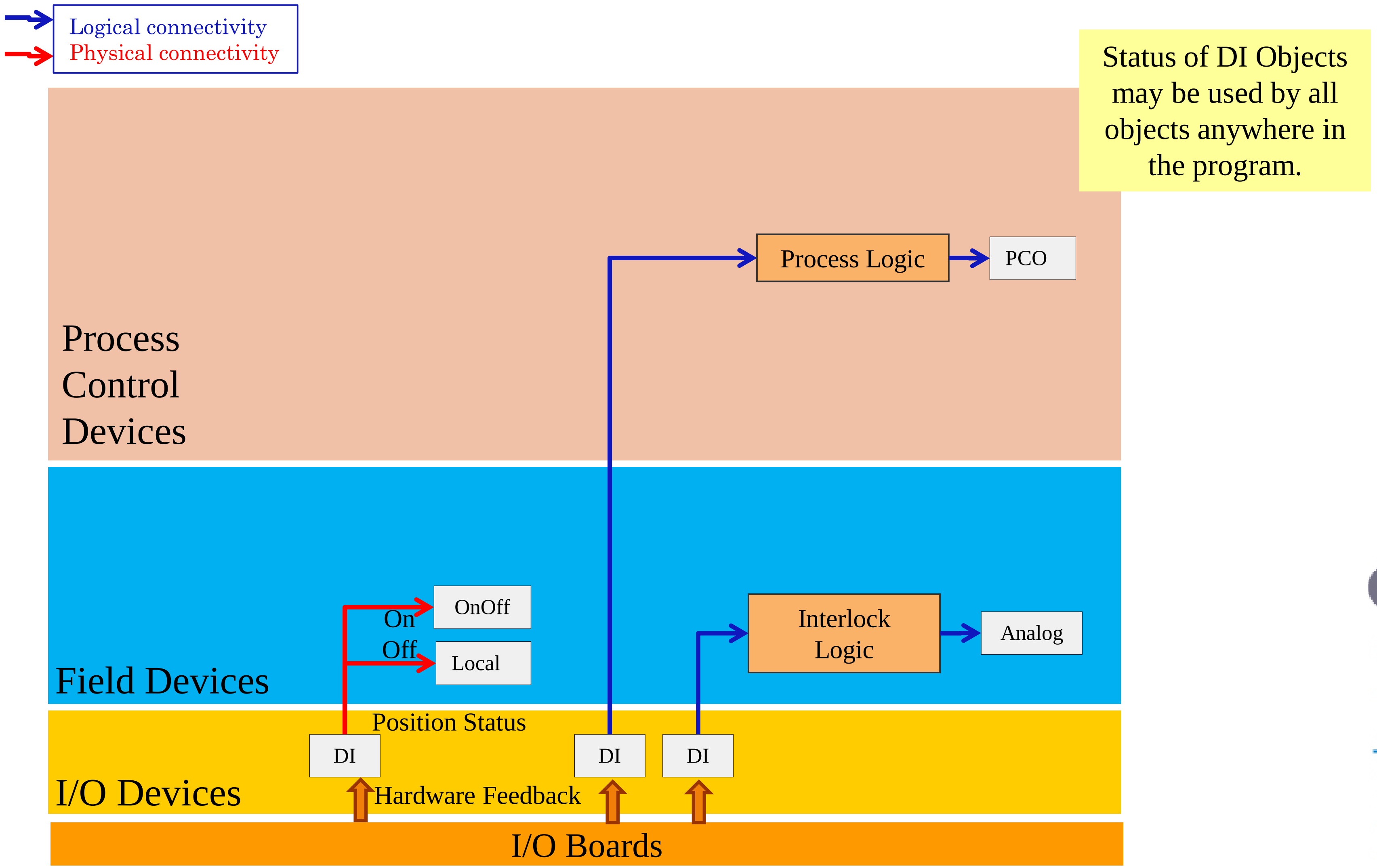
-Each control module or equipment module is a device
-Equipment modules and Units are embedded in a unique object class:
PCO (Process Control Object)



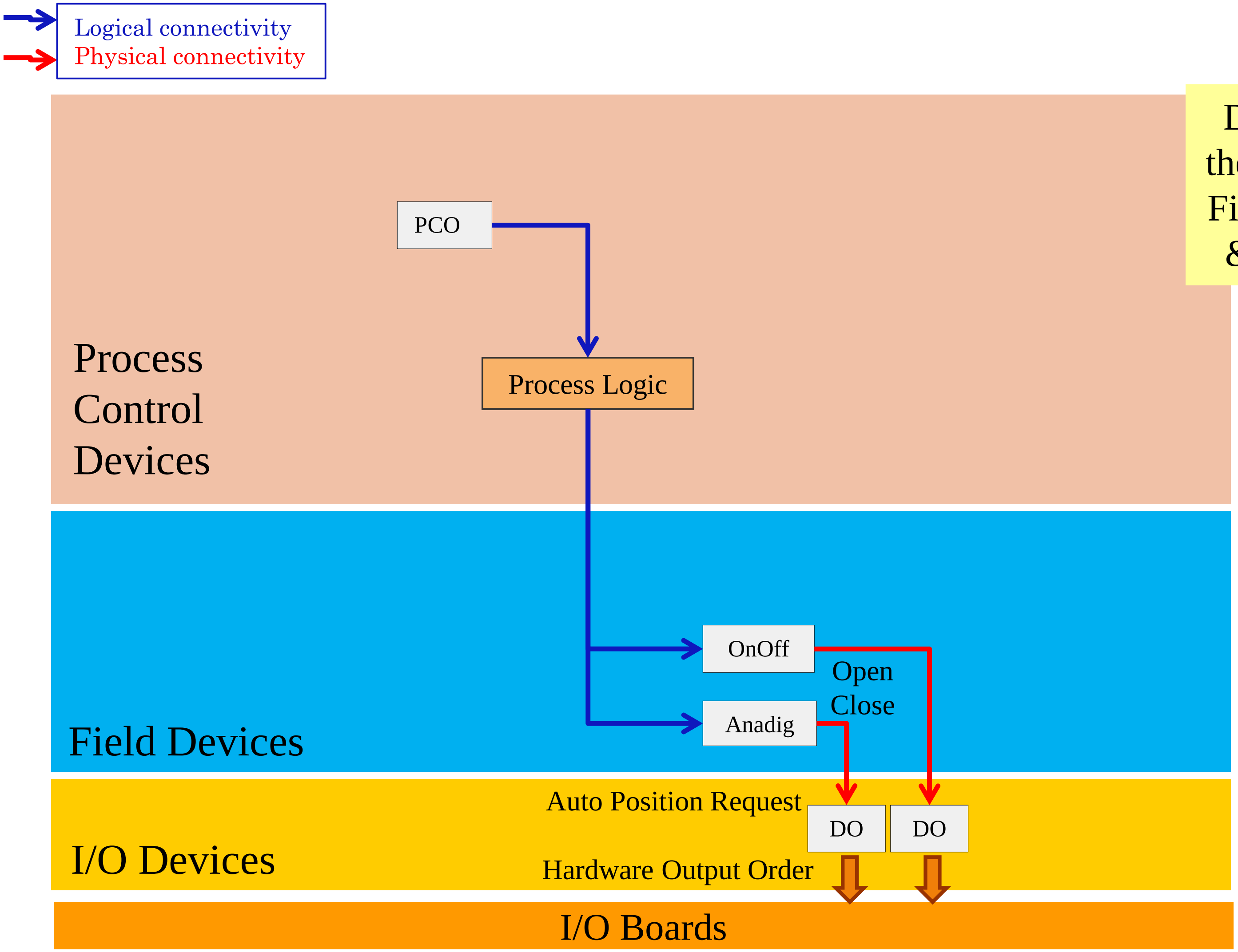
OPERATION MODES

- **Auto Mode**
  - The object is driven by the control logic of a higher object of the hierarchy.
  - Interlocks apply to the request
- **Manual Mode** (requested by operators via the OWS)
  - The automatic return to the auto mode is possible by the control logic.
  - Interlocks apply to the request
- **Forced Mode** (requested by operators via the OWS)
  - The automatic return to the auto mode is impossible by the control logic.
  - Interlocks apply to the requests.
- **Local mode**
  - **Hardware Local Mode**
    - The object is driven locally by the process field (activated via a DI)
    - E.g. maintenance purposes
  - **Software Local Mode** (requested by operators via the Local panels)
    - The Local software is writing directly in the manual requests of the objects
    - **Priority** over "Auto" and "Manual" mode. The "forced mode" setup by the normal SCADA can override the software local mode.
    - Interlocks apply to the requests.

DI Object Connectivity



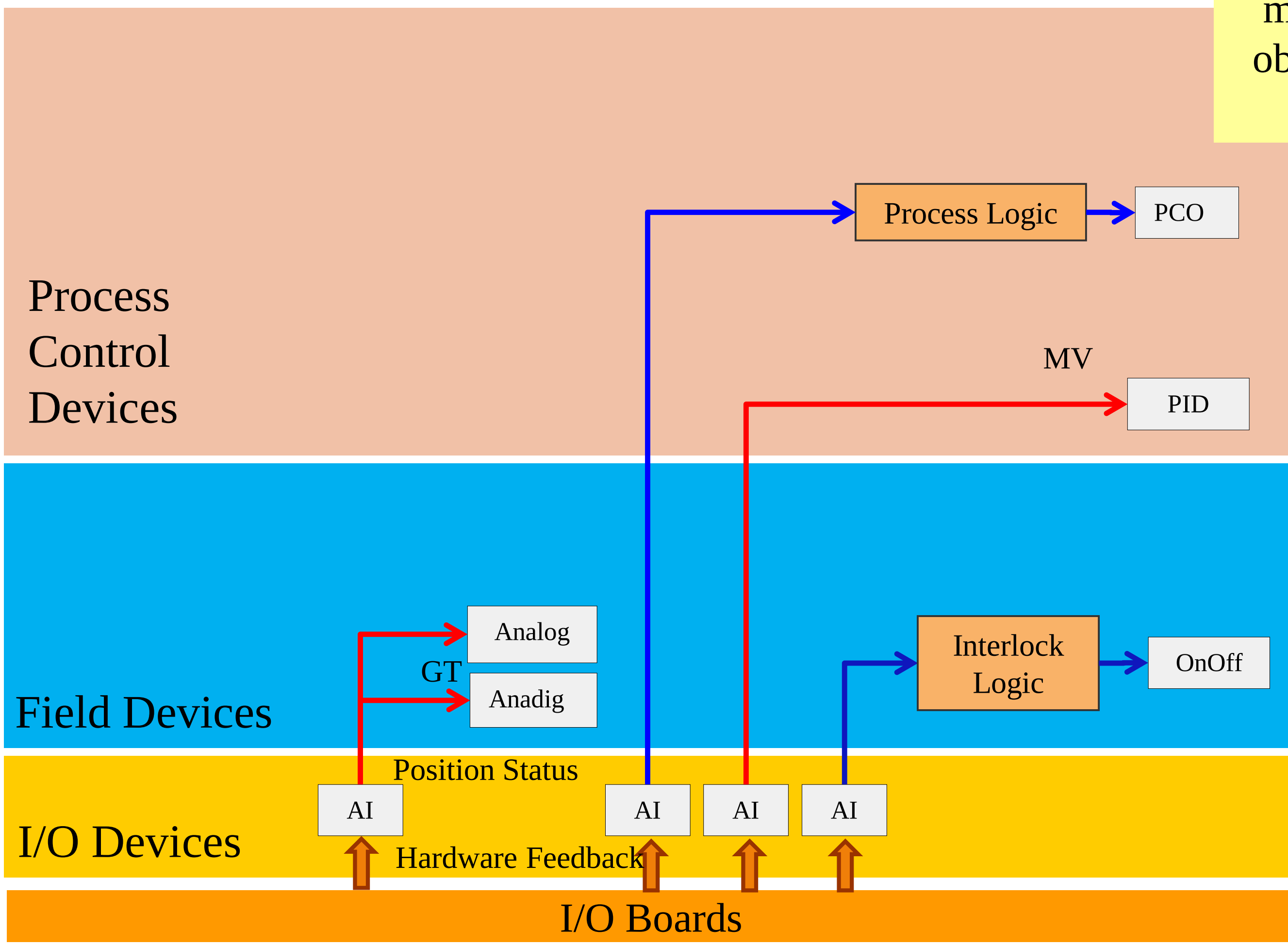
DO Object Connectivity



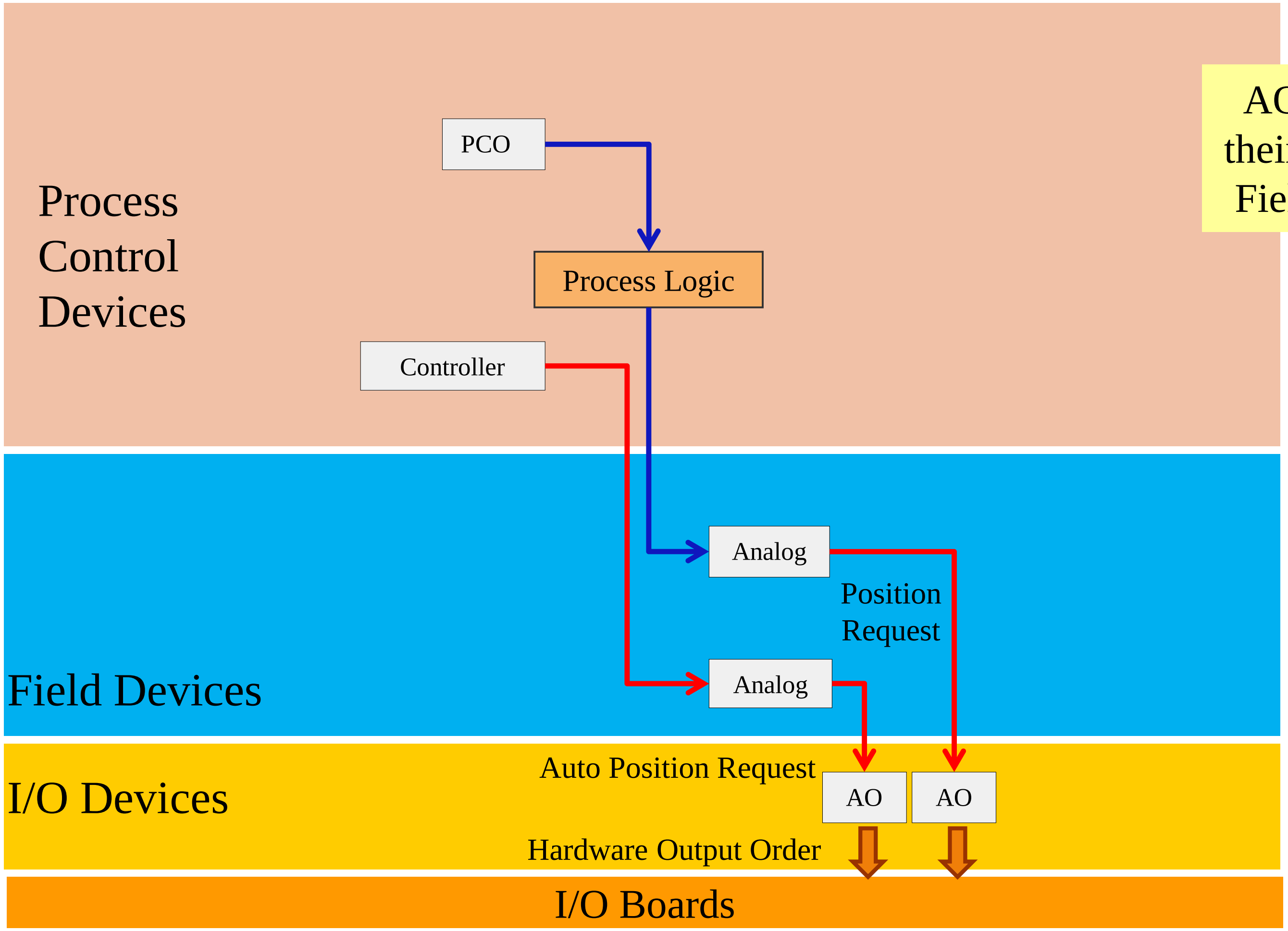
DO Objects receive their orders only from Field Devices (OnOff & Anadig, AnaDO)

AI Object Connectivity

Status of AI Objects may be used by all objects anywhere in the program.

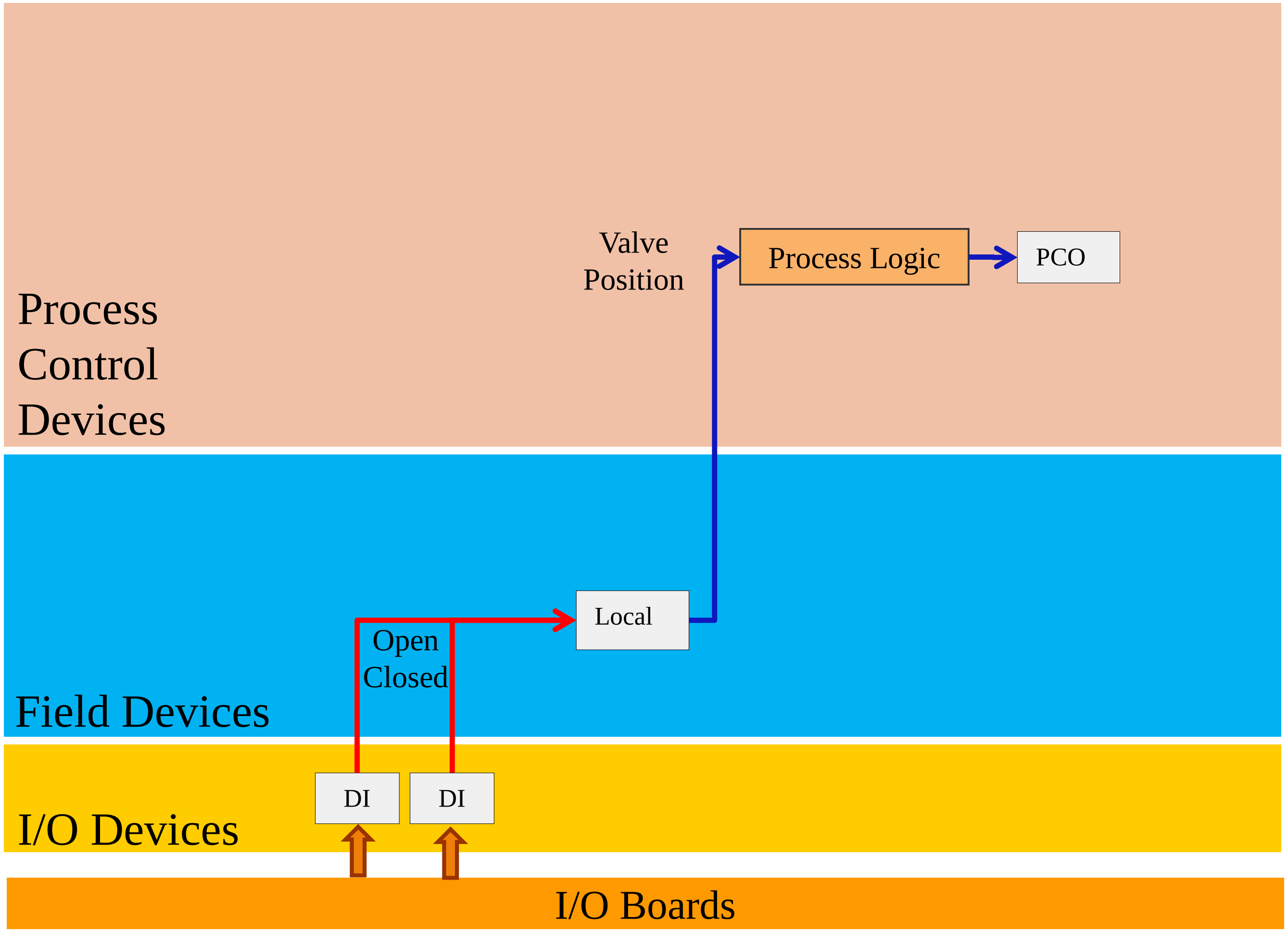


AO Object Connectivity



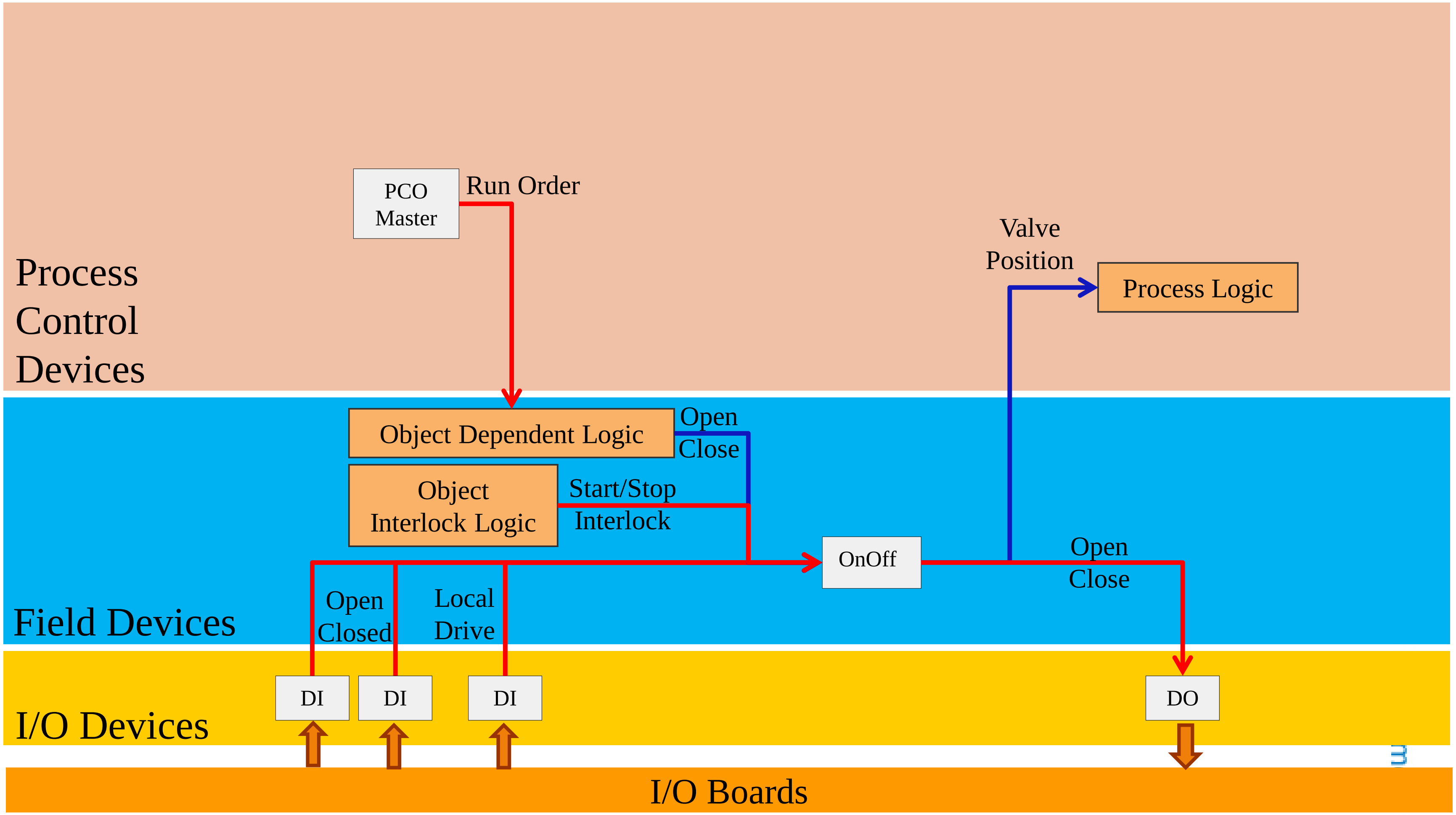
AO Objects receive their orders only from Field Device Analog

LOCAL OBJECT CONNECTIVITY

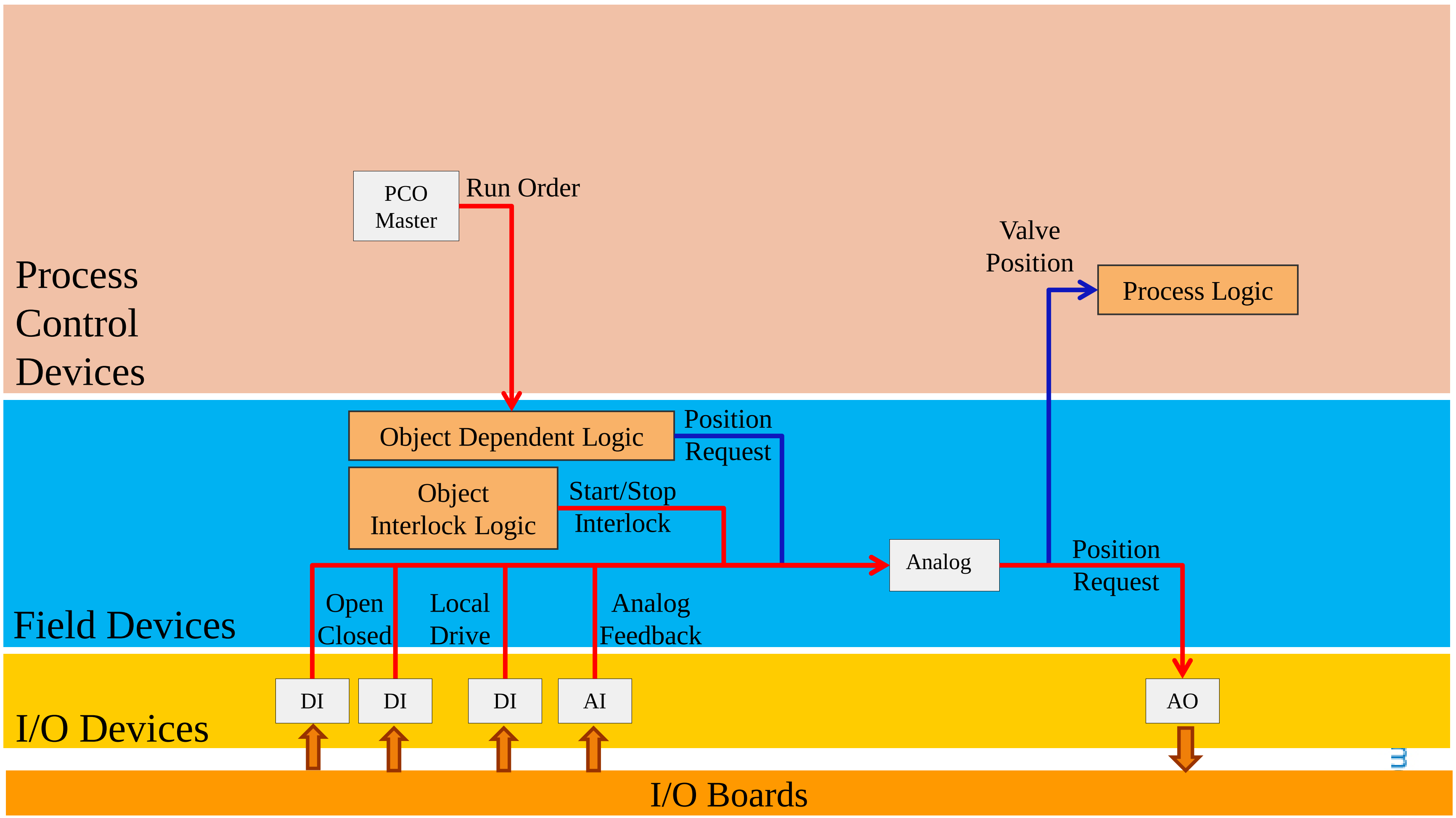


Status of Local Objects may be used by all objects anywhere in the program.

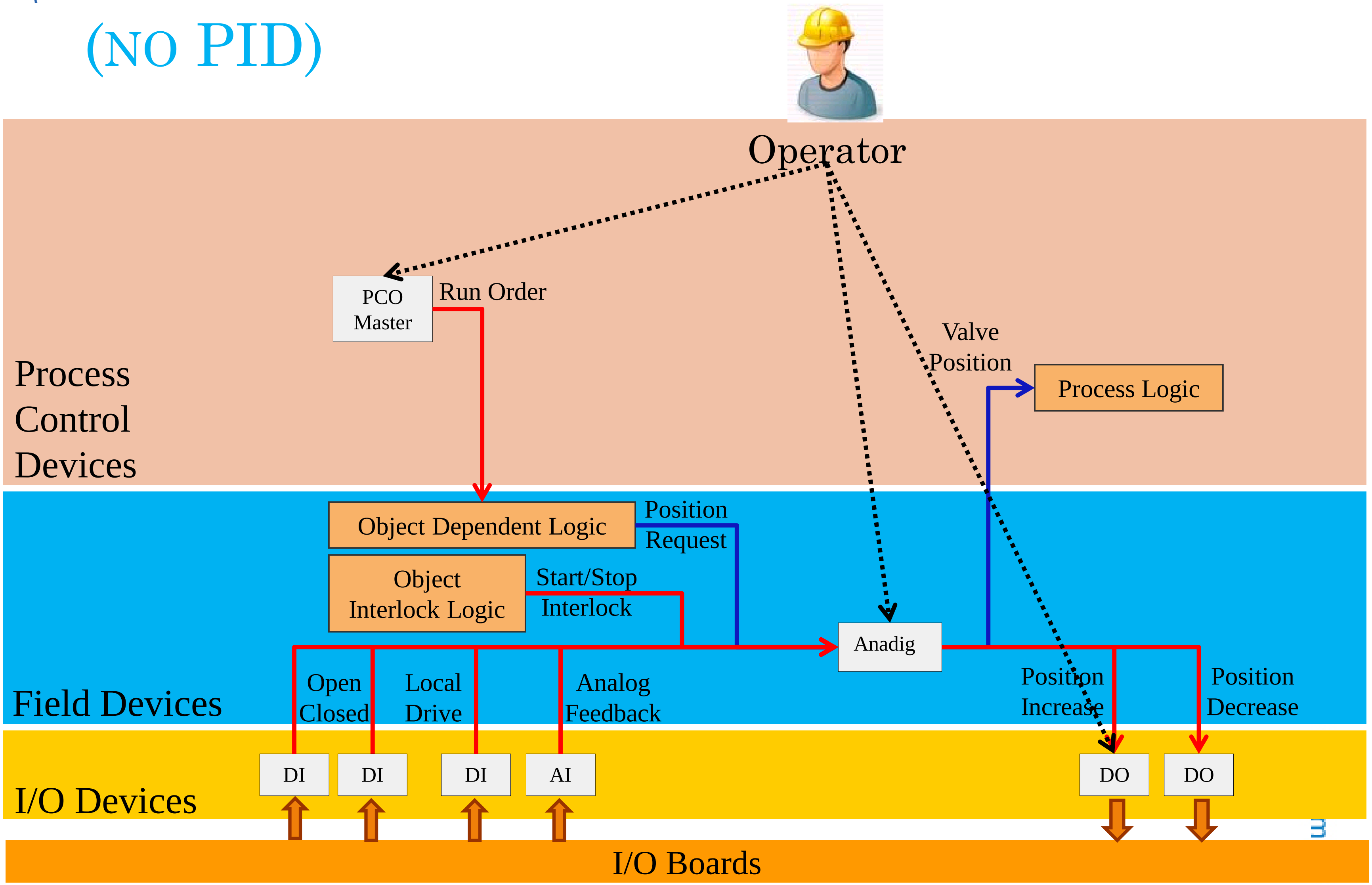
ONOFF OBJECT CONNECTIVITY



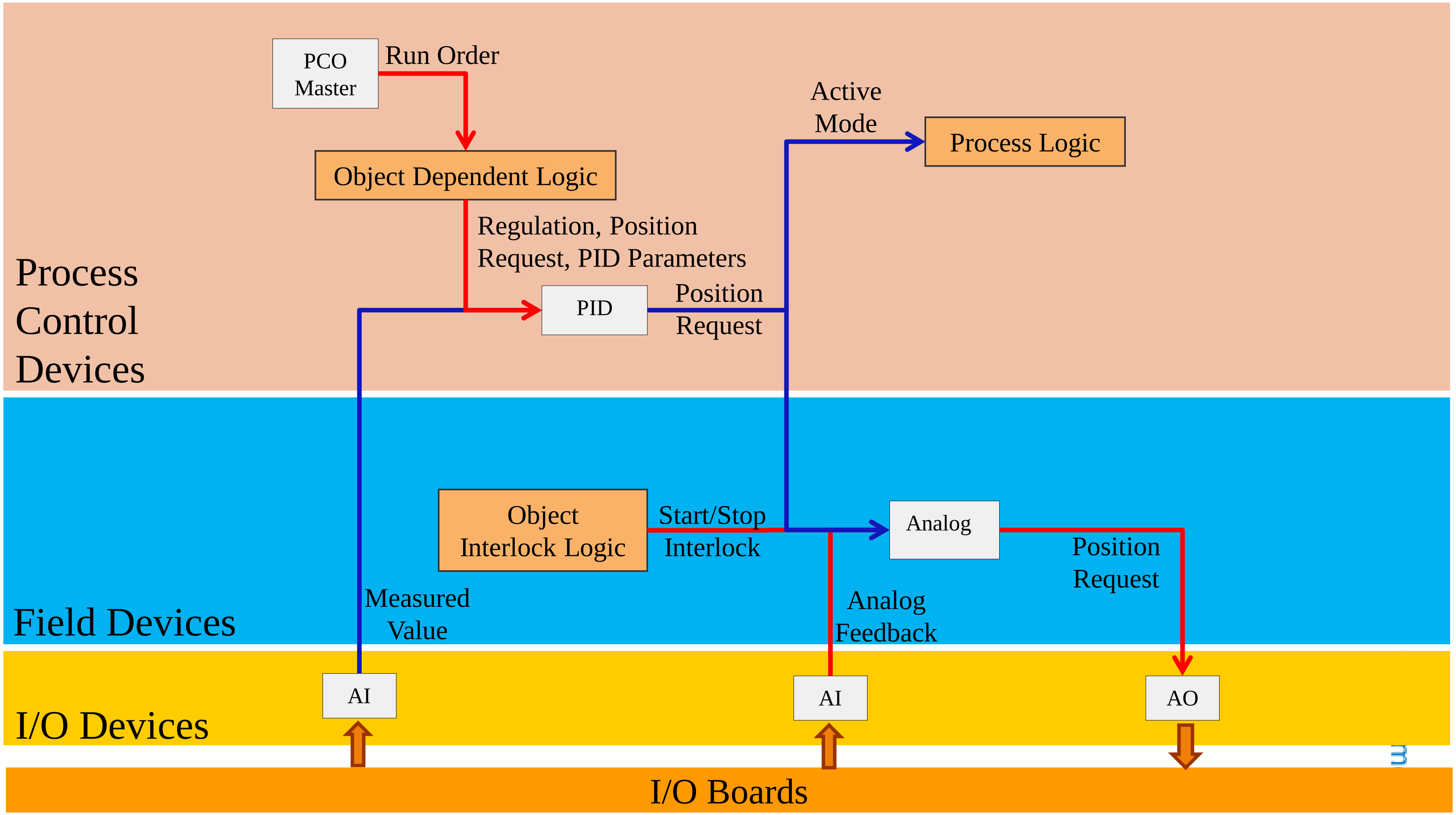
Analog Object Connectivity (no PID)



Anadig Object Connectivity (no PID)

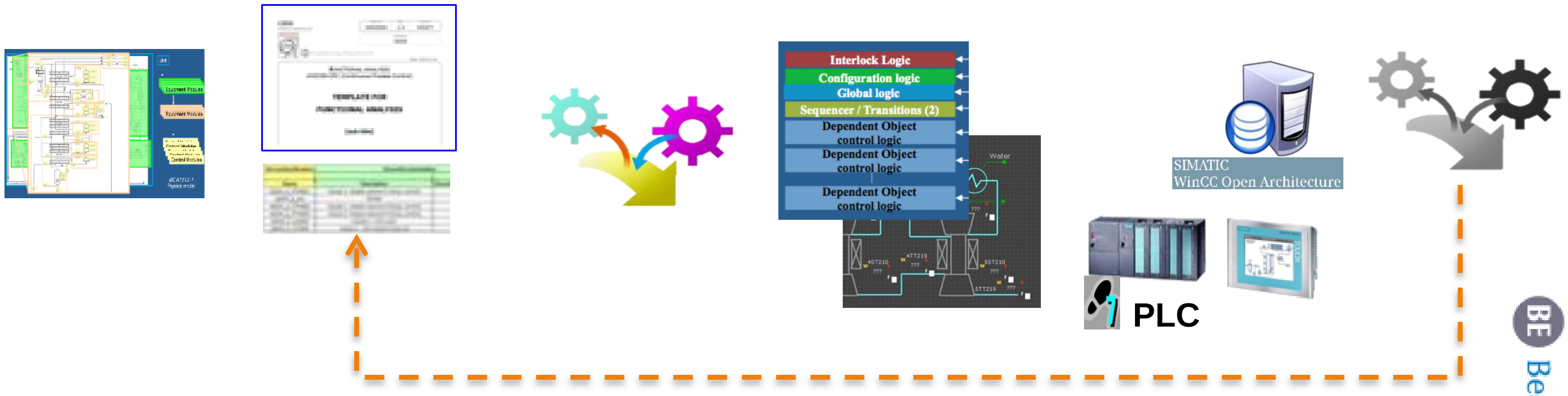


Controller Object Connectivity

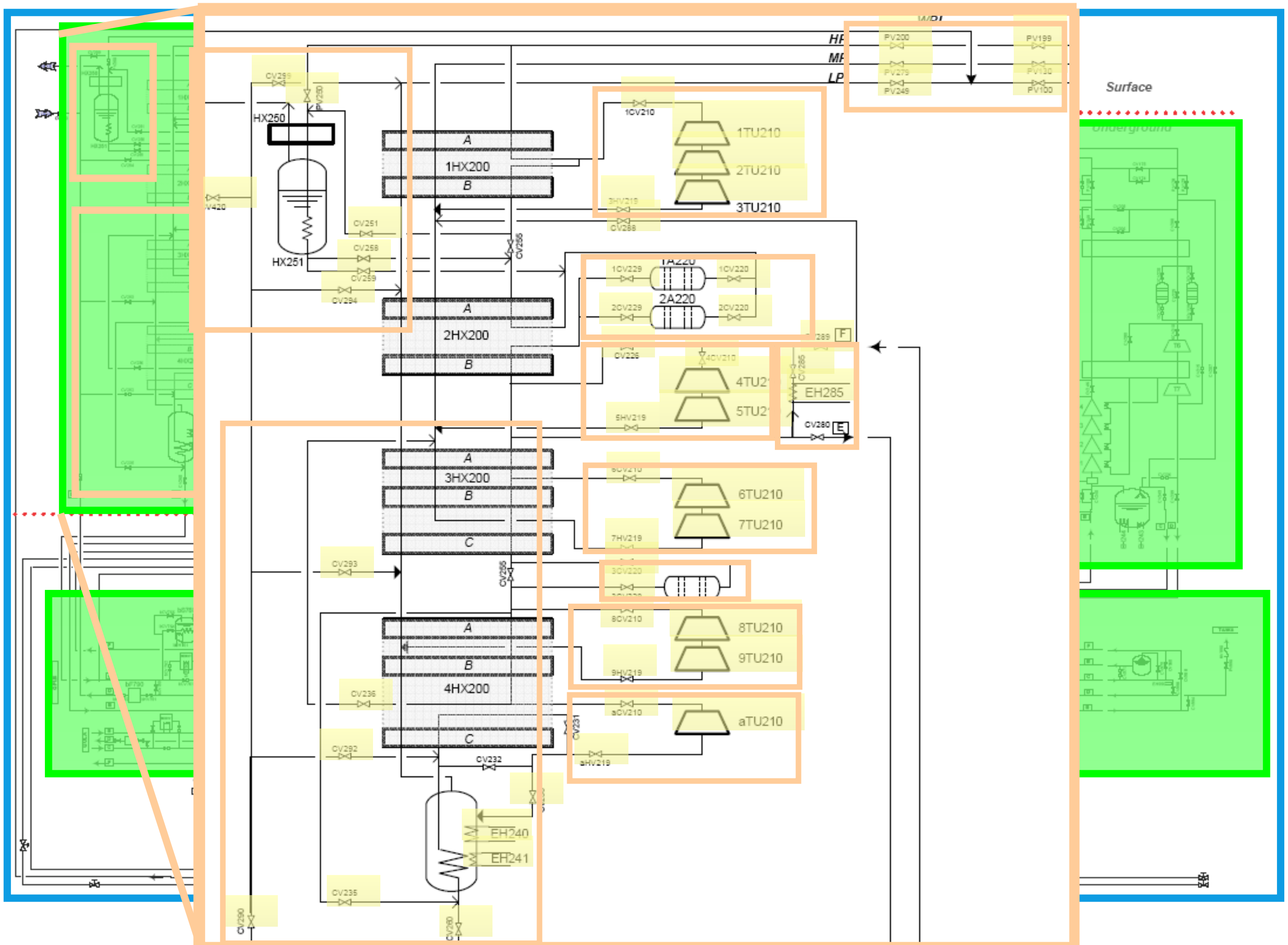


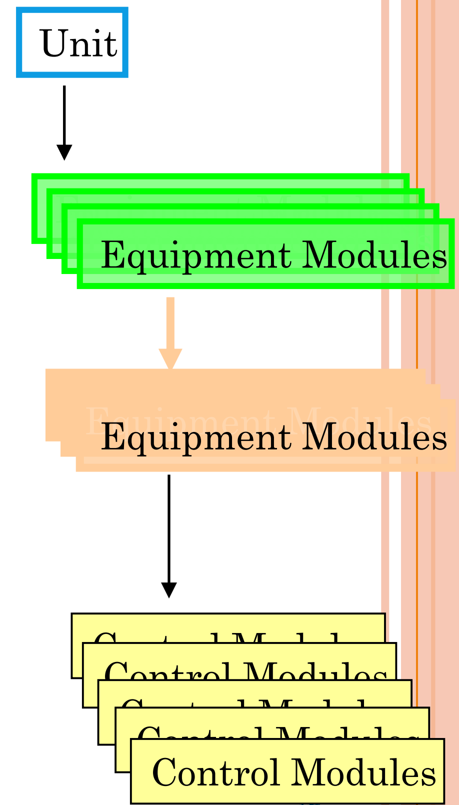
UNICOS CPC
ENGINEERING LIFE CYCLE

Decomposition | Specifications | Automatic Code Generation | Logic specifics & Synoptics | Deployment | Reverse Engineering



DECOMPOSITION METHOD





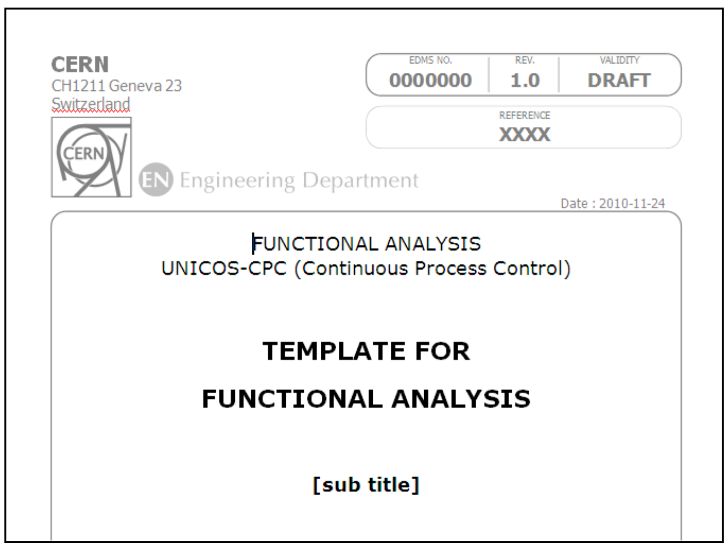
IEC 61512-1
Physical model

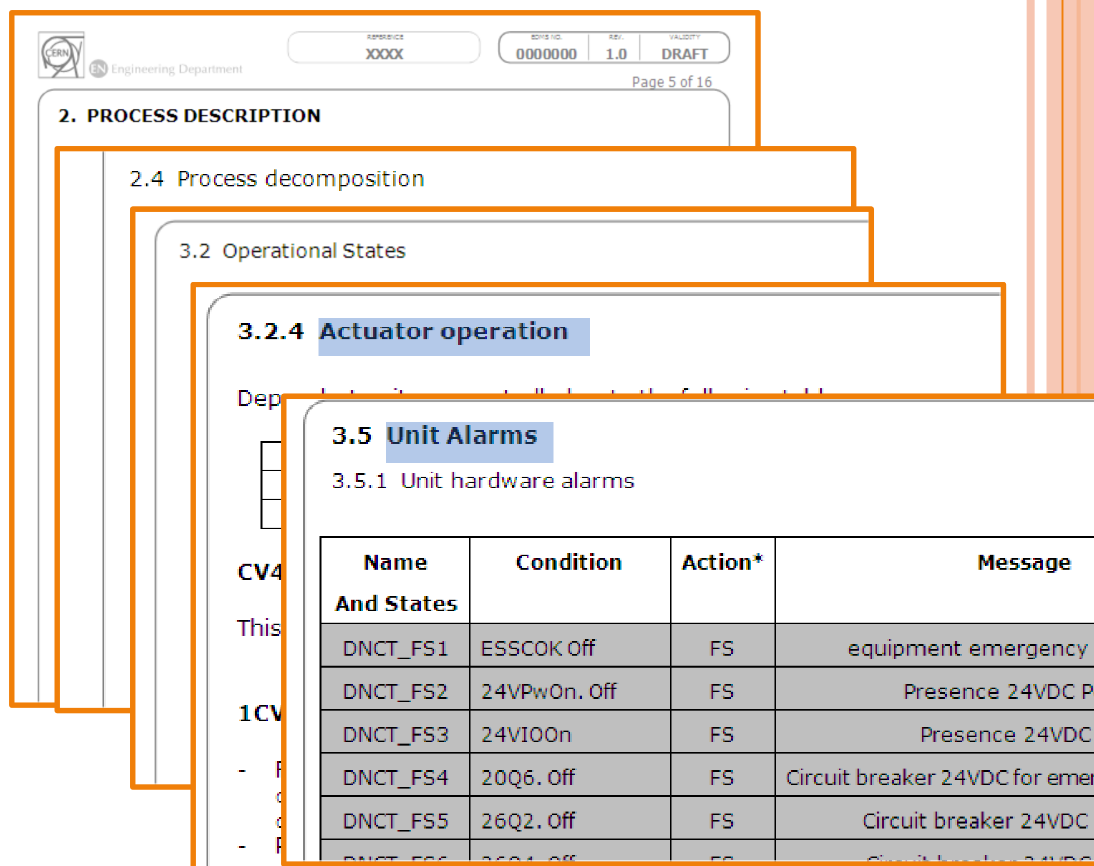
SPECIFICATIONS

DeviceIdentification	DeviceDocumentation			FEDeviceIOConfig		FEDeviceParameters				
					FEChannel					
Name	Description	Electrical Diagram	Remarks	FE encoding type	InterfaceParam1	Range Min	Range Max	Raw Min	Raw Max	DeadBand (%)
QSDN_4_1TT4001	Vessel 1- Heater section1-Temp. control	AI1.0			%IW1.1.0	80	350	0	10000	0.025
QSDN_4_AI1	SPARE	AI1.1			%IW1.1.1	0	100	0	10000	0.025
QSDN_4_1TT4002	Vessel 1- Heater section2-Temp. control	AI1.2			%IW1.1.2	80	350	0	10000	0.025
QSDN_4_1TT4003	Vessel 1- Heater section3-Temp. control	AI1.3			%IW1.1.3	80	350	0	10000	0.025
QSDN_4_1LE400	Vessel 1- LN2 Level	AI1.4			%IW1.1.4	0	1350	0	10000	0.025
QSDN_4_1PT400	Vessel 1- LN2 Vessel Pressure	AI1.5			%IW1.1.5	0	4.0	0	10000	0.025

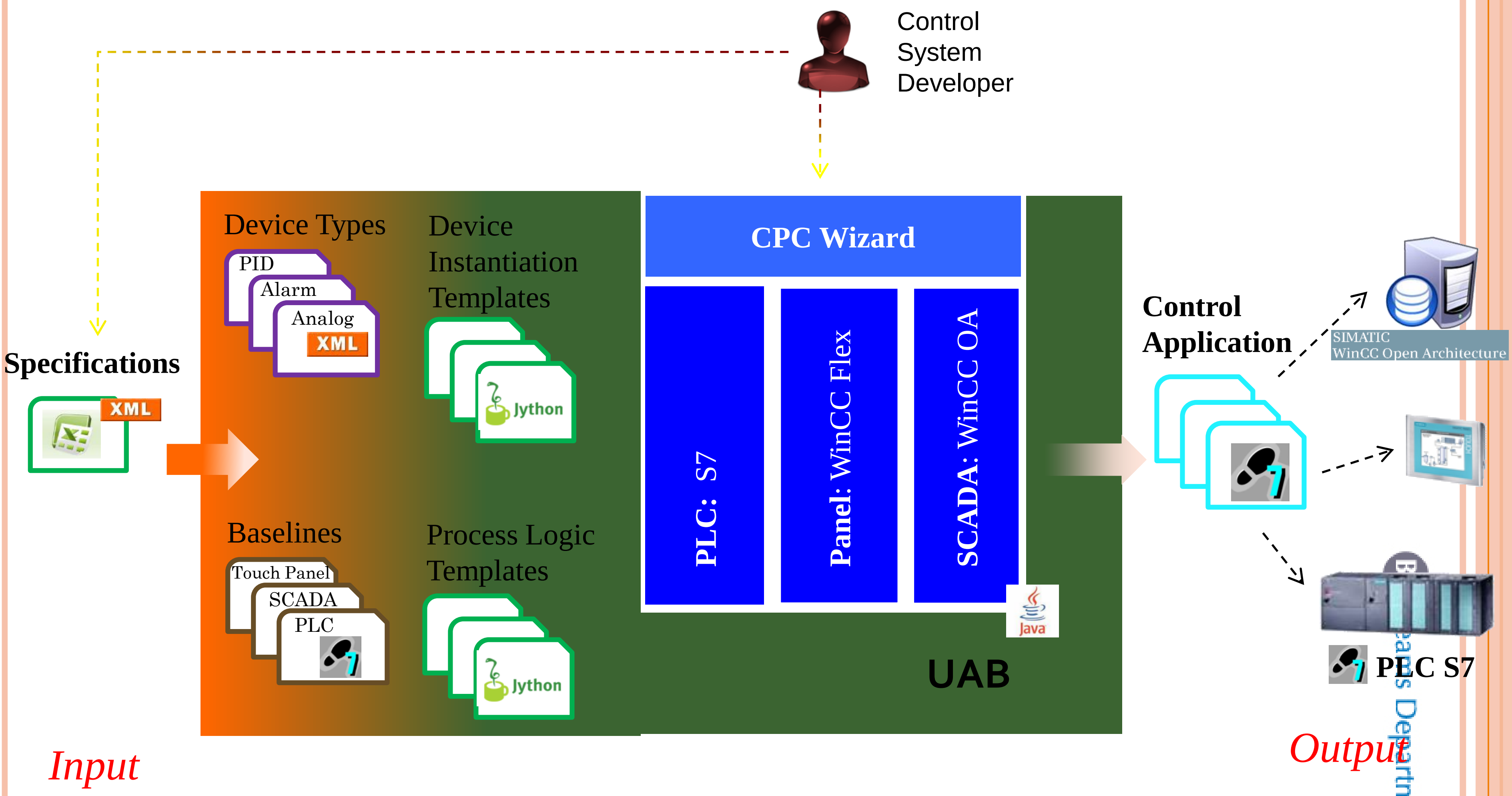
UNICOS CPC Specs (xls/xml file)

Functional Analysis + Logic specification (Word templates)

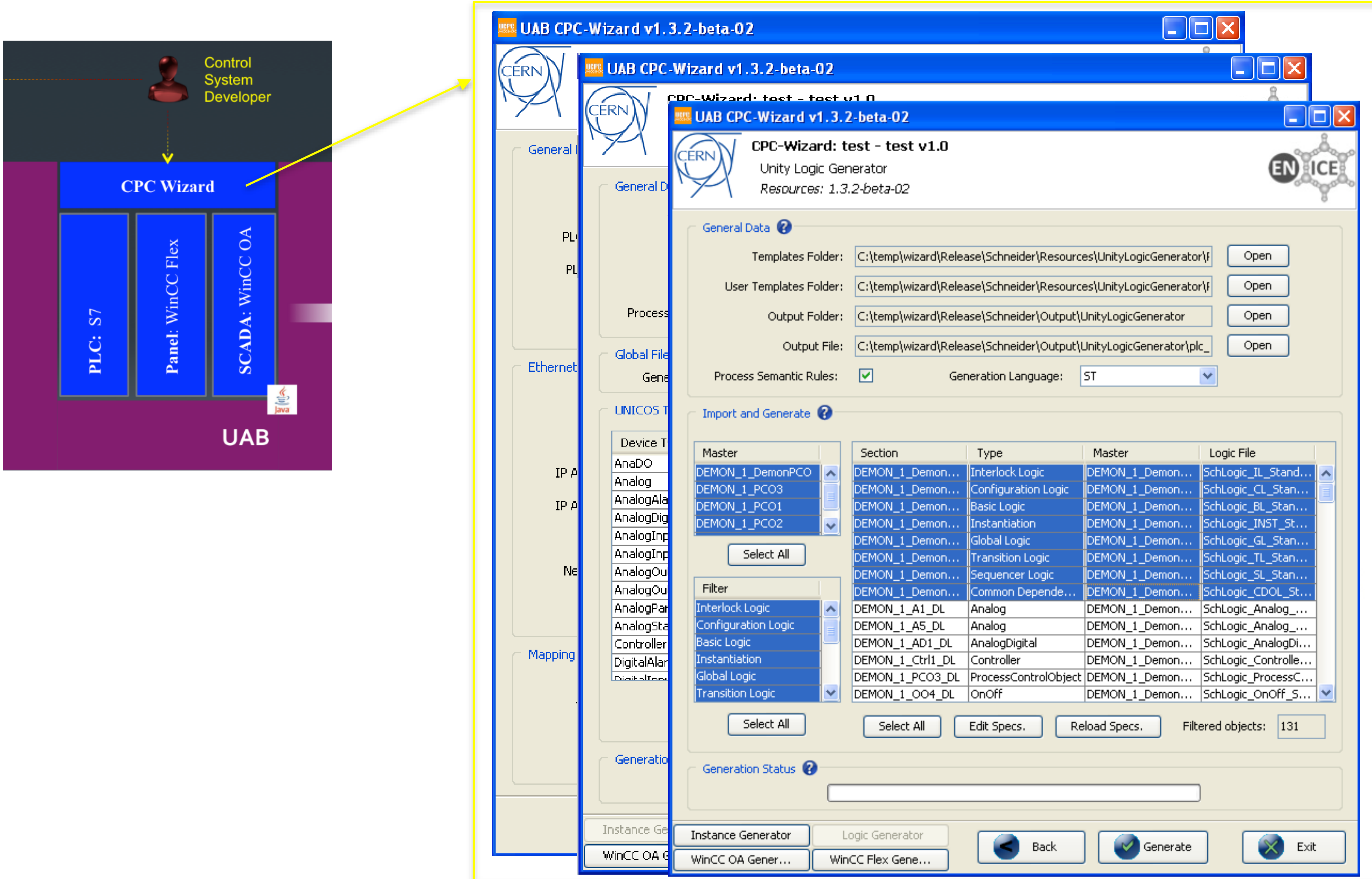




UAB: UNICOS APPLICATION BUILDER

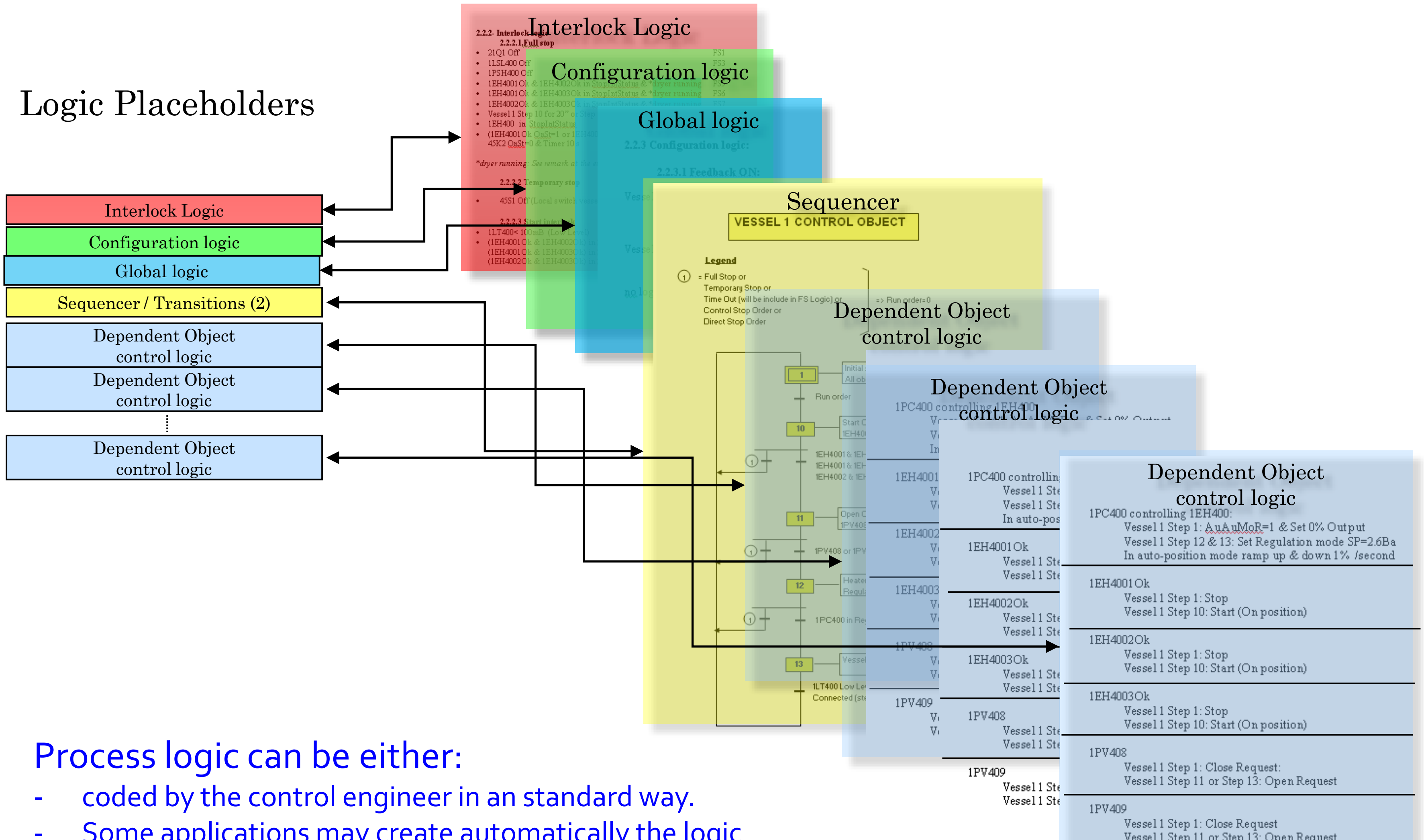


WORKFLOW BASED ON WIZARDS



UNICOS CPC LOGIC PLACEHOLDERS

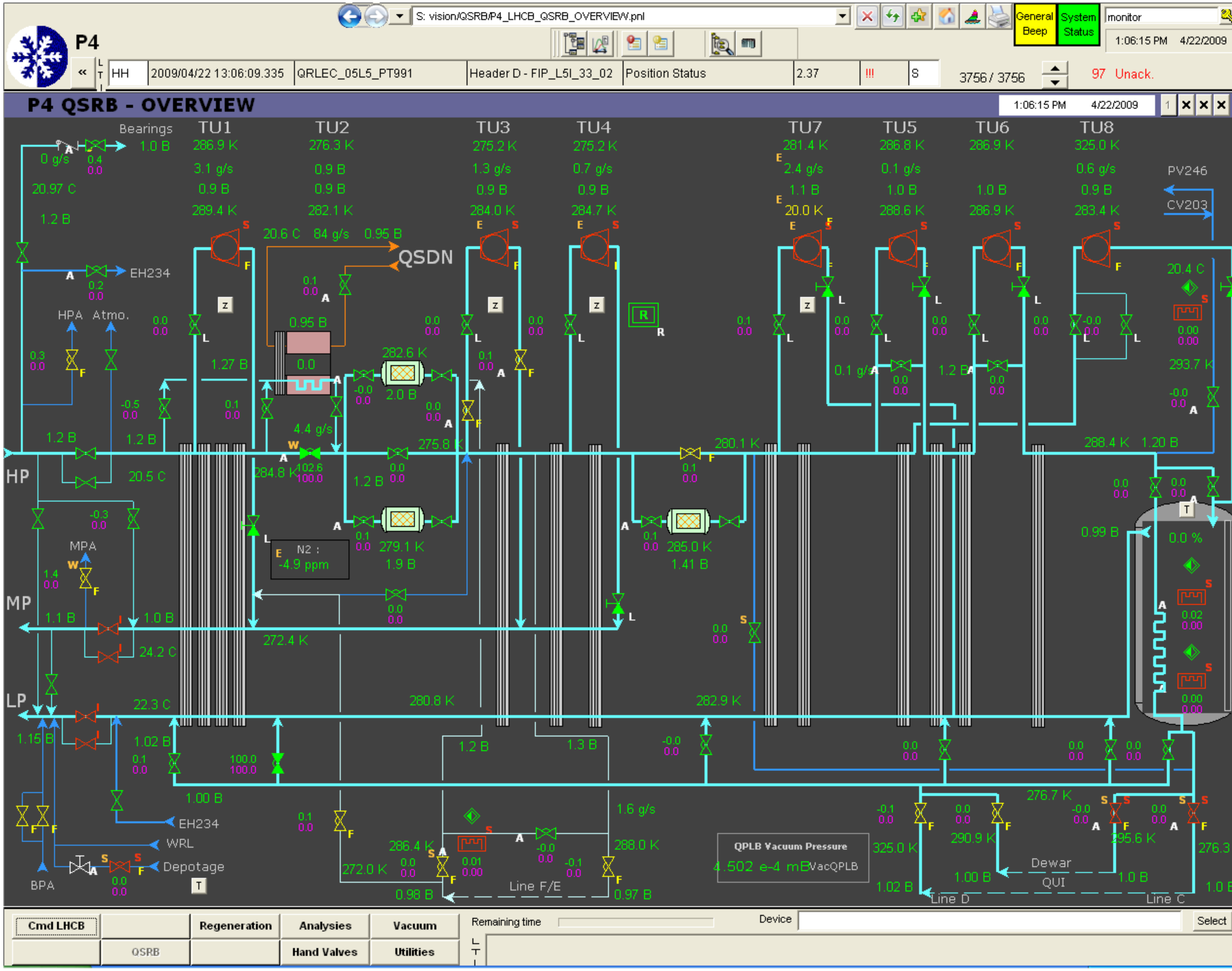
Logic Placeholders



Process logic can be either:

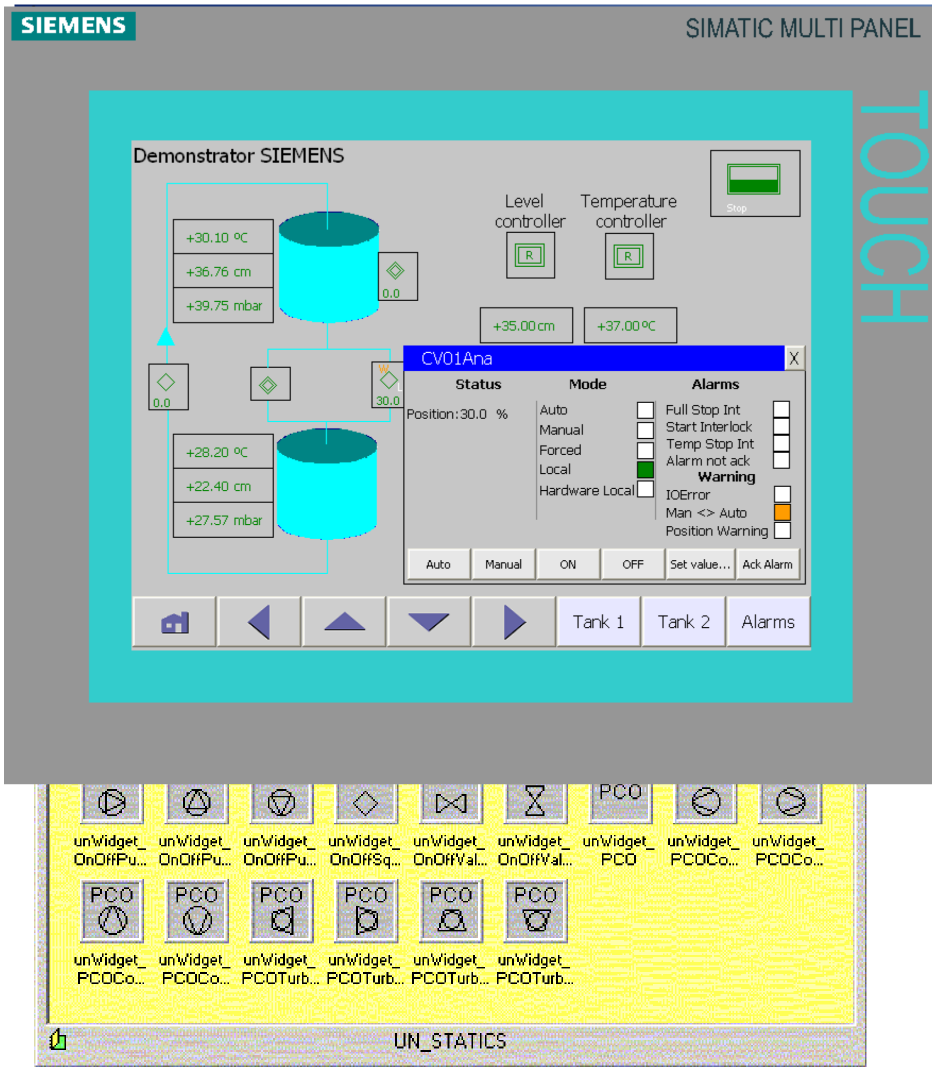
- coded by the control engineer in an standard way.
- Some applications may create automatically the logic based on **templates**. These templates are based on Phyton

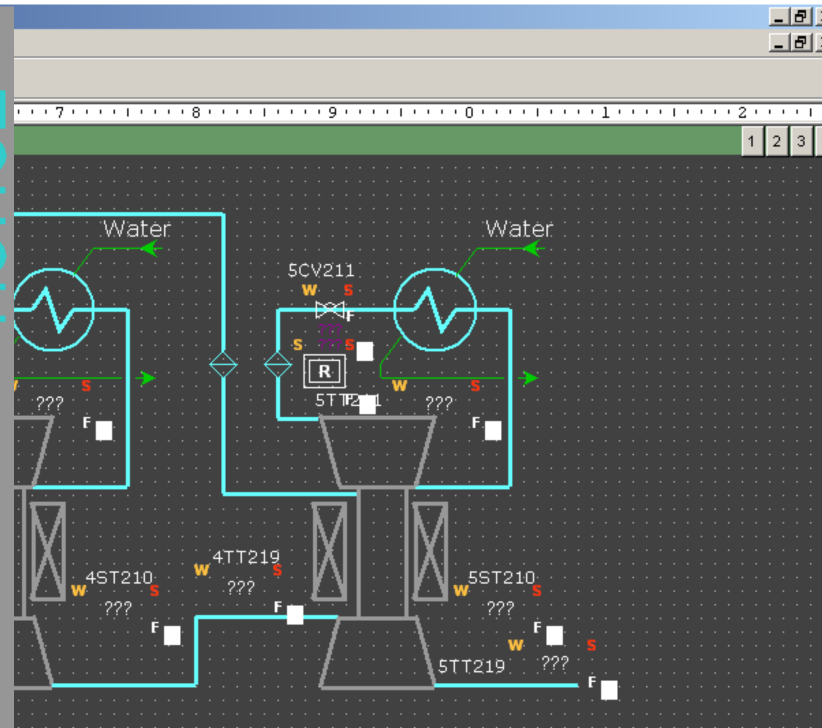
UNICOS CPC HMI



HMI SYNOPTICS

- Manual intervention (or automatic if known a priori)





Synoptic design
- by drag & drop (manual operation)
- Automatically created (xml)

More Information

- Check out the web page:
  - http://www.cern.ch/unicos