



UNICOS

Automating the Automation

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on behalf of the UNICOS team*

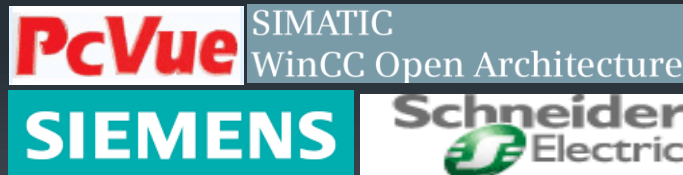
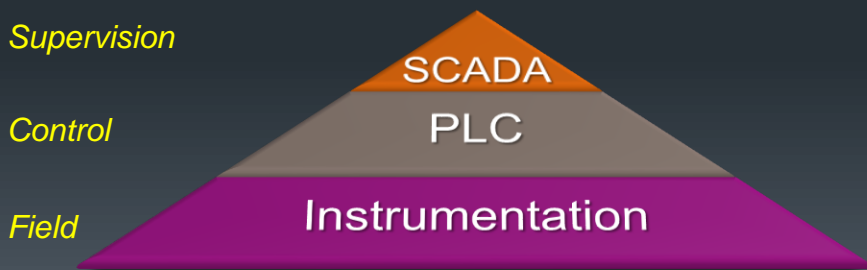
Outline

- UNICOS foundation
- Device model
- Methodology
- Automatic control systems generation
- Conclusions

A look to the past

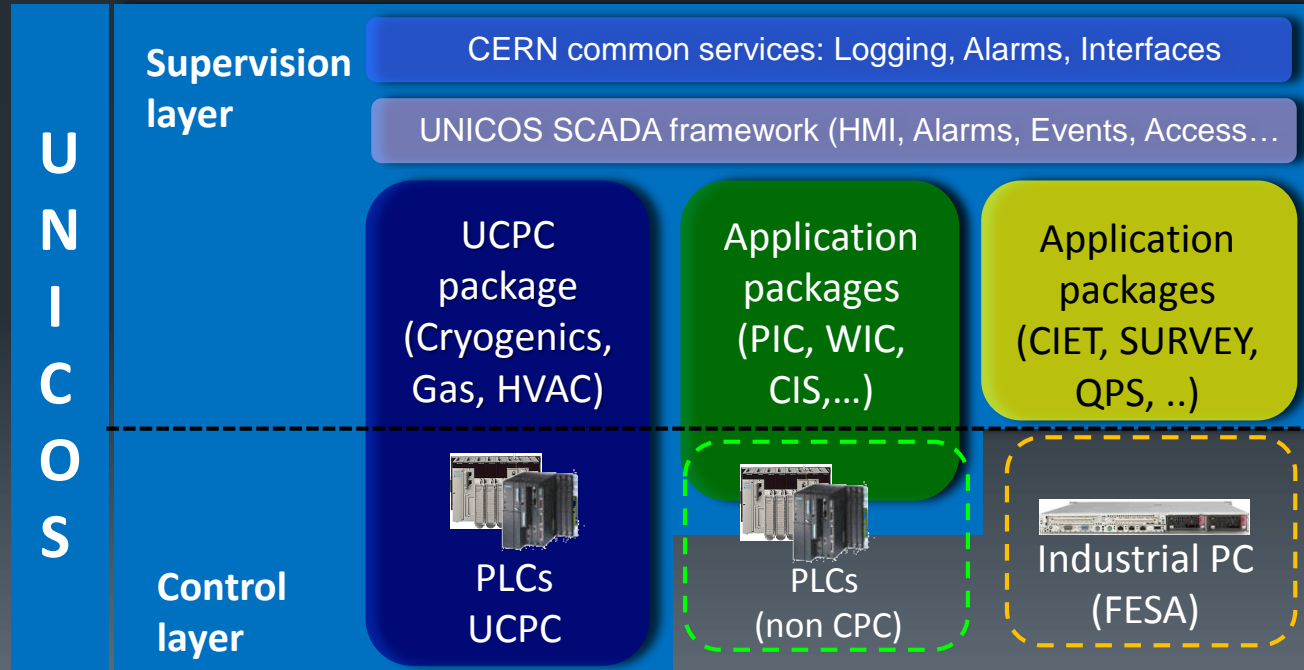
[1998] **UNICOS** (**UN**ified **I**ndustrial **C**ontrol **S**ystem) was born at CERN as a need to develop the LHC cryogenics control system

The goal was to create an industrial control system covering the upper two layers of the typical **automation** pyramid.



UNICOS

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



UNICOS-CPC framework basics

- A collection of standard **devices types (objects)**
 - **CPC**: Generic library covering most of the equipment of continuous processes
- **Methodology**
 - Modeling of the process by control modules based on a **decomposition** method (ISA-88)
 - A formalized and standard way of programming the specific process logic
- **Operation**
 - Standard HMI allowing an homogenized operation (navigation, trends, access control...)
 - Suite of standard CERN systems: Alarms, DB Logging, Middleware communications...
 - Diagnose capabilities (process alarms, events, system integrity...)
- Versatile suite of **development tools (UAB: UNICOS Application Builder)**
 - Automatic instantiation of the devices and logic code

UNICOS CPC applications scope

Process Control

- LHC Cryogenics
- C&V: Cooling and HVAC projects
- LHC Gas Control System
- AWAKE plasma cell

Interlocks

- LHC Collimator Temperature Interlocks
- LHC Test benches facilities
- FAIR magnets testbenchs interlocks

Motion

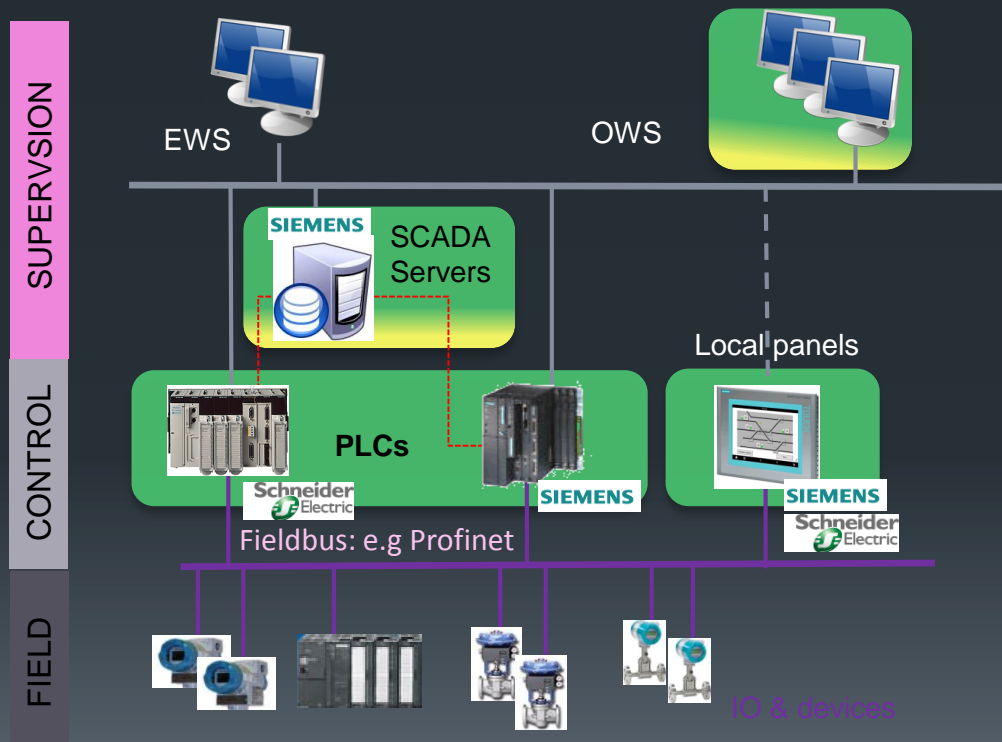
- HTS winding machine
- ATLAS big wheels
- LHC elevators
- AMS beam test servo systems

Vacuum

- LHC Detector vacuum: ATLAS, CMS
- REX vacuum control
- ISOLDE Vacuum control

Industrial Controls Components

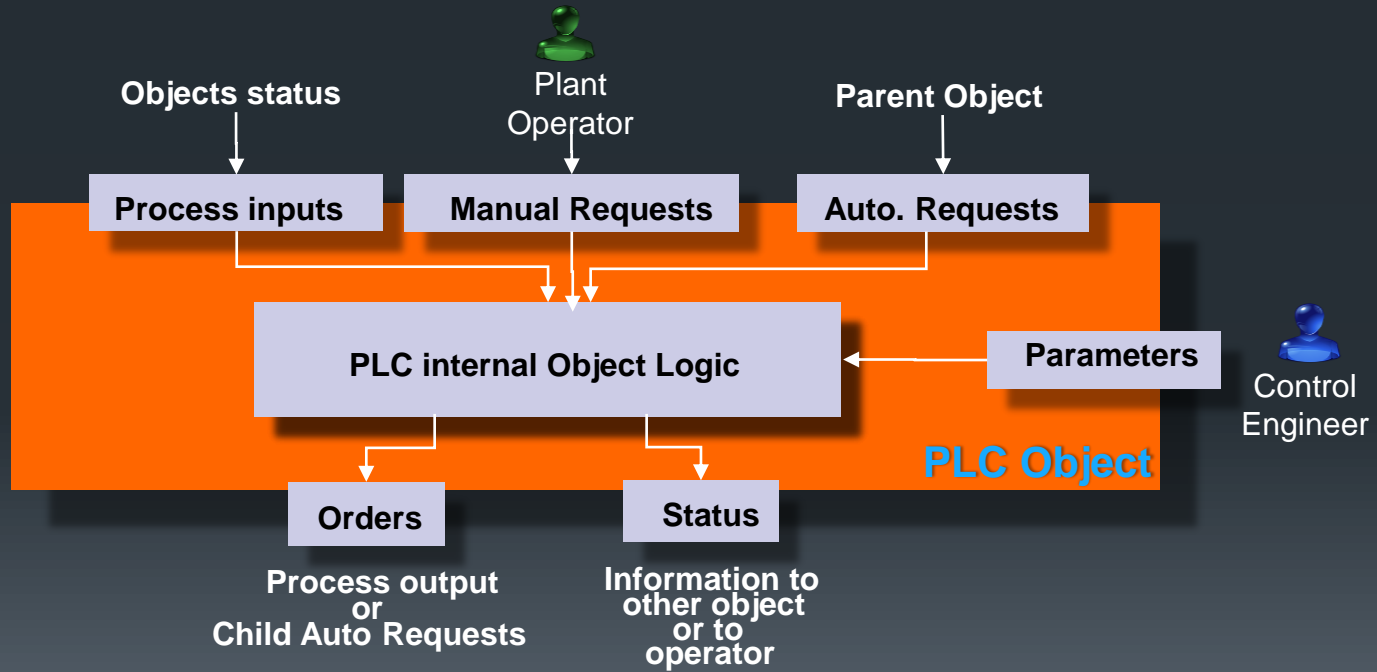
- **UNICOS** relies on industrial off-the-shelf components
 - **SCADA**: WinCC OA
 - Touch panels: Siemens, Schneider
 - **PLCs**: Siemens, Schneider, Codesys-based



Outline

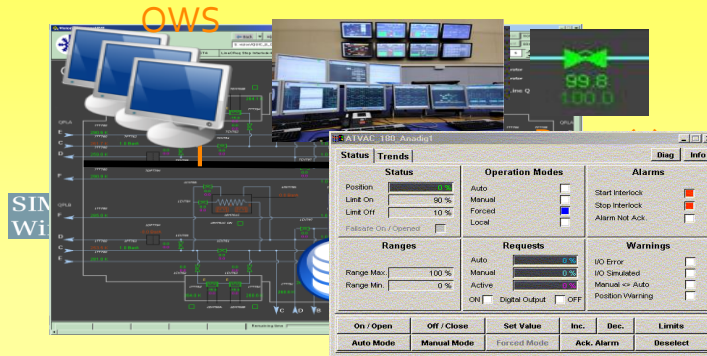
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UNICOS CPC Object Model

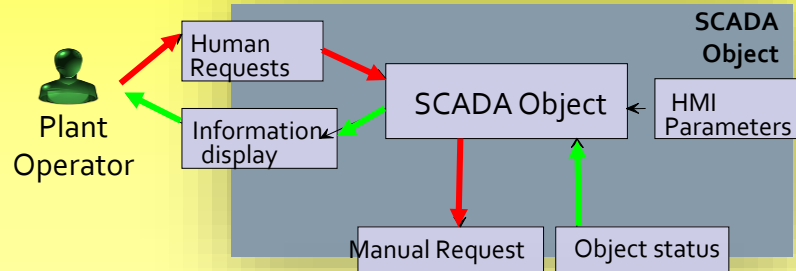


Objects & Layers Integration

Supervision Layer



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



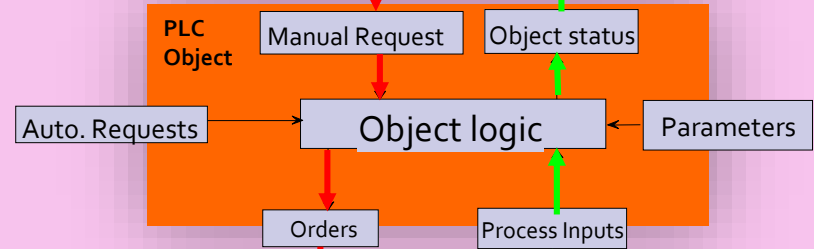
Control Layer



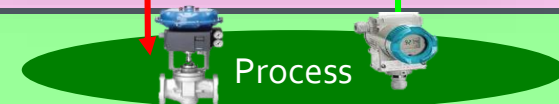
SIEMENS



Schneider Electric



Field Layer



Process

Not only a bunch of objects

- 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, AnaDig
 - ✓ Local
 - ✓ AnaDO
 - **Control Objects**
 - ✓ Controller
 - ✓ Alarms
 - ✓ Process Control Object
 - **Interface Objects**
 - ✓ Parameter (Digital, Word, Analog)
 - ✓ Status (Word, Analog)
 - ✓ **Motion**
 - ✓ Stepping Motor
 - ✓ Encoder
- UNICOS CPC provides libraries (control and supervision layers)
- A **formalized methodology** to:
 - **Define the control units** of a process (ISA-88 standard: Batch processes)
 - **Programming the specific process logic** for those units

A flavor in objects: Field objects

- **Functionality**

- Model the real field equipments (e.g. pumps, valves...)

- **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)

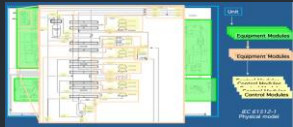


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- **Methodology**
- Automatic control systems generation
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UNICOS Engineering life cycle

Decomposition



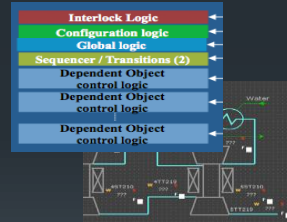
Specifications



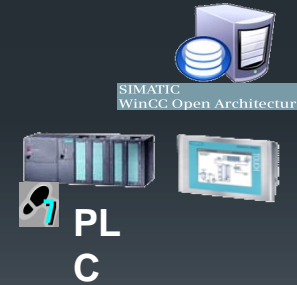
Automatic Code
Generation



Control Logic
specifics
& Synoptics



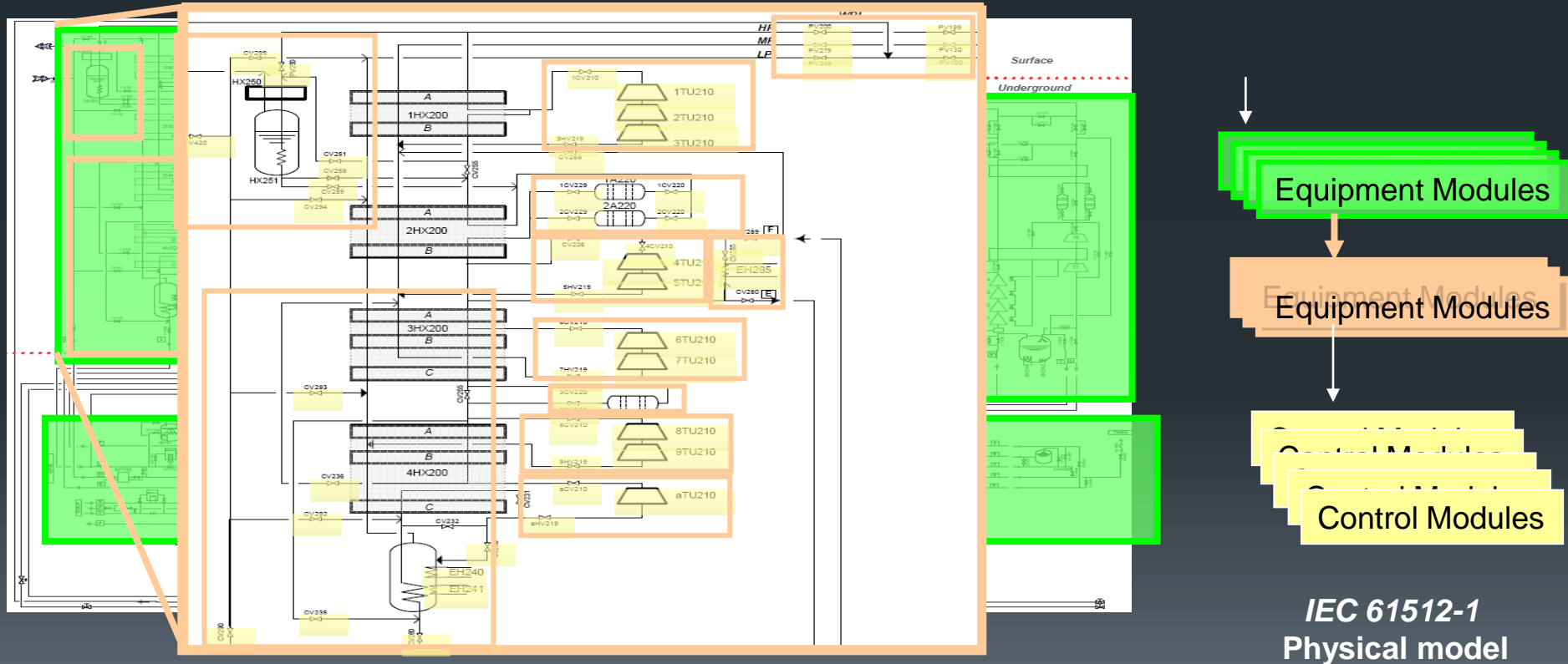
Deployment



Reverse
Engineering



Process Analysis: Decomposition



Specifications

UNICOS CPC Specs (xls/xml file)

DeviceIdentification	DeviceDocumentation			FEDeviceIOConfig		FEDeviceParameters					
	Name	Description	Electrical Diagram	Remarks	FE encoding type	FEChannel 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

Functional Analysis + Logic specification (Word templates)

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EN Engineering Department

Date : 2010-11-24

EDMS NO. **0000000** REV. **1.0** VALIDITY **DRAFT**

REFERENCE **XXXX**

FUNCTIONAL ANALYSIS
UNICOS-CPC (Continuous Process Control)

TEMPLATE FOR
FUNCTIONAL ANALYSIS

[sub title]

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2. PROCESS DESCRIPTION

2.4 Process decomposition

3.2 Operational States

3.2.4 Actuator operation

Dep

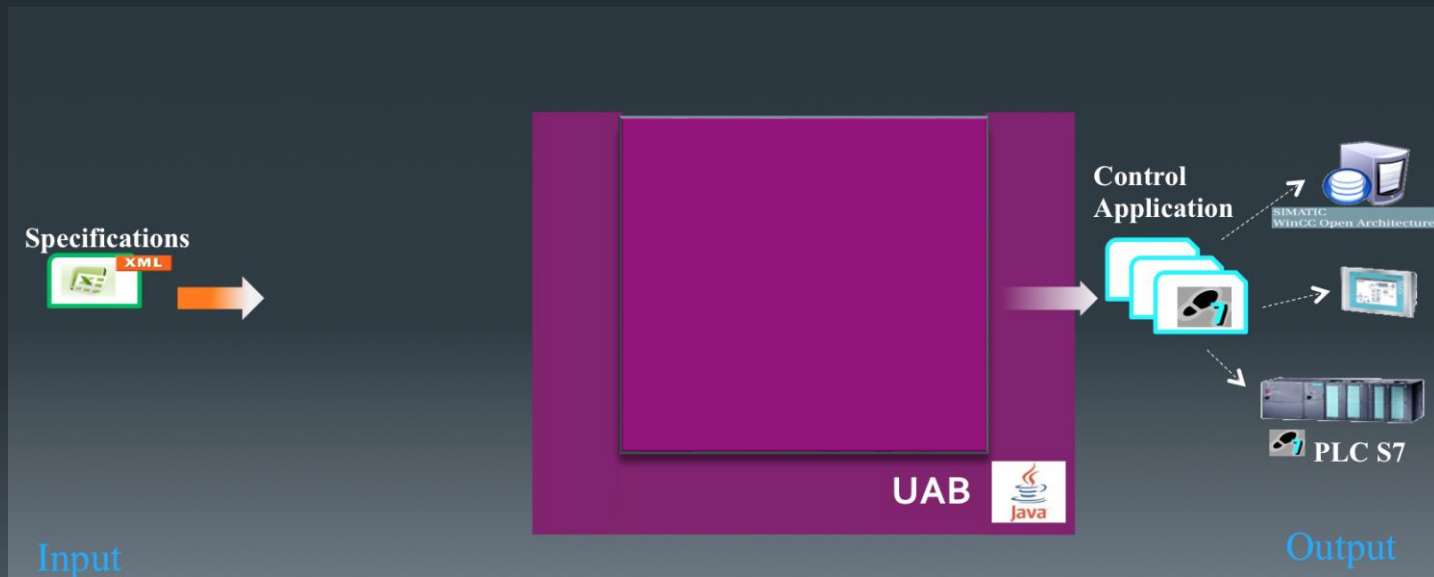
3.5 Unit Alarms

3.5.1 Unit hardware alarms

Name	Condition	Action*	Message
DNCT_FS1	ESSCOK Off	FS	equipment emergency s
DNCT_FS2	24VPwOn. Off	FS	Presence 24VDC Po
DNCT_FS3	24VIOOn	FS	Presence 24VDC I
DNCT_FS4	20Q6. Off	FS	Circuit breaker 24VDC for emerg
DNCT_FS5	26Q2. Off	FS	Circuit breaker 24VDC D

Automatic code generation

- In a minute...



HMI synoptics

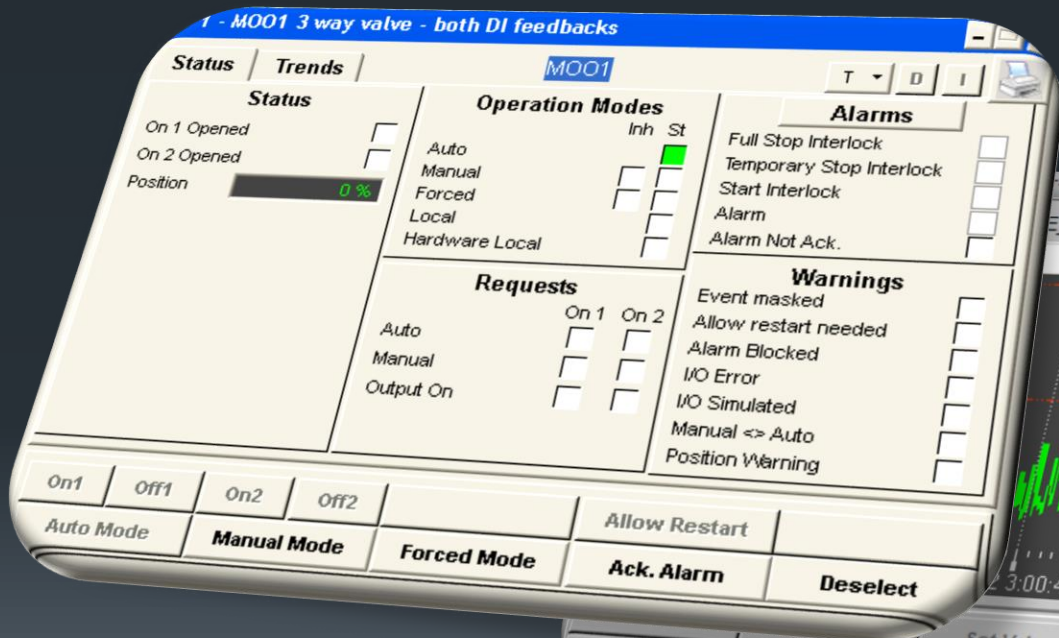
- Manual intervention (or automatic if known a priori)

The screenshot shows the SIMATIC Multi Panel graphical editor. The main window displays a synoptic design for a 'Demonstrator SIEMENS' with two tanks. The top tank shows a level of +36.76 cm and a temperature of +30.10 °C. The bottom tank shows a level of +22.40 cm and a temperature of +28.20 °C. A 'CV01Ana' control window is open, showing status (Position: 30.0 %) and mode (Auto) settings. The background features a detailed electrical synoptic diagram with components like 5CV211, 5ST210, 4TT219, and 5ST219, connected to 'Water' lines. A large vertical text 'TOUCH' is overlaid on the right side of the interface.

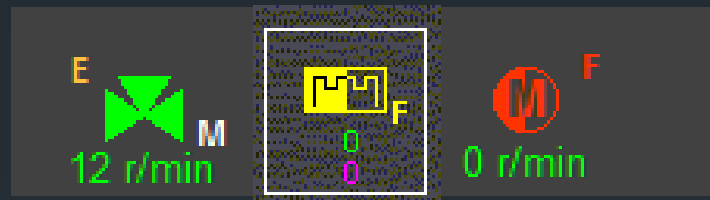
Synoptic design

- by drag & drop (manual operation)
- automatically created (xml)

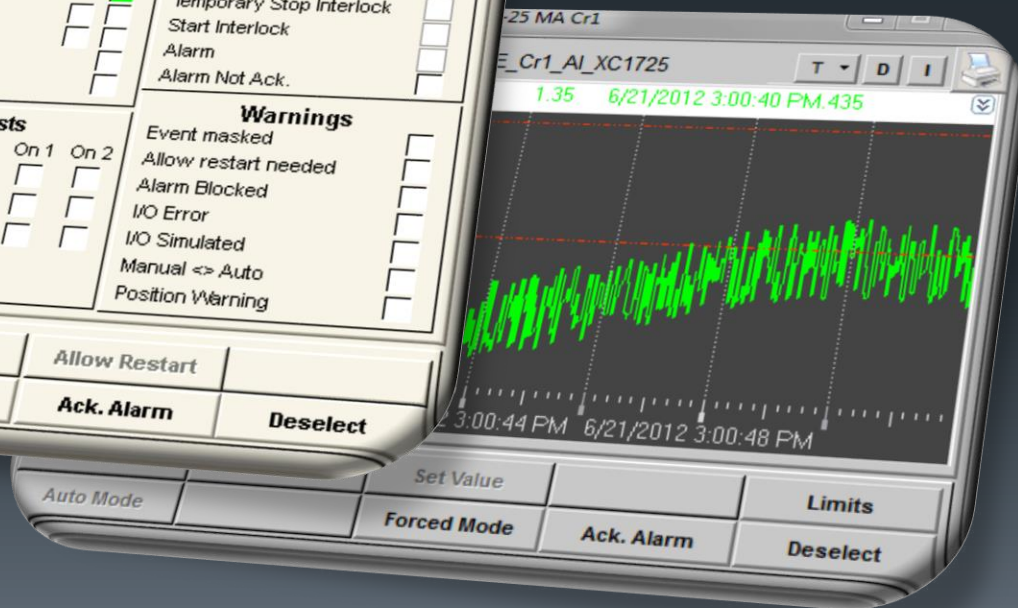
UNICOS HMI



Faceplate

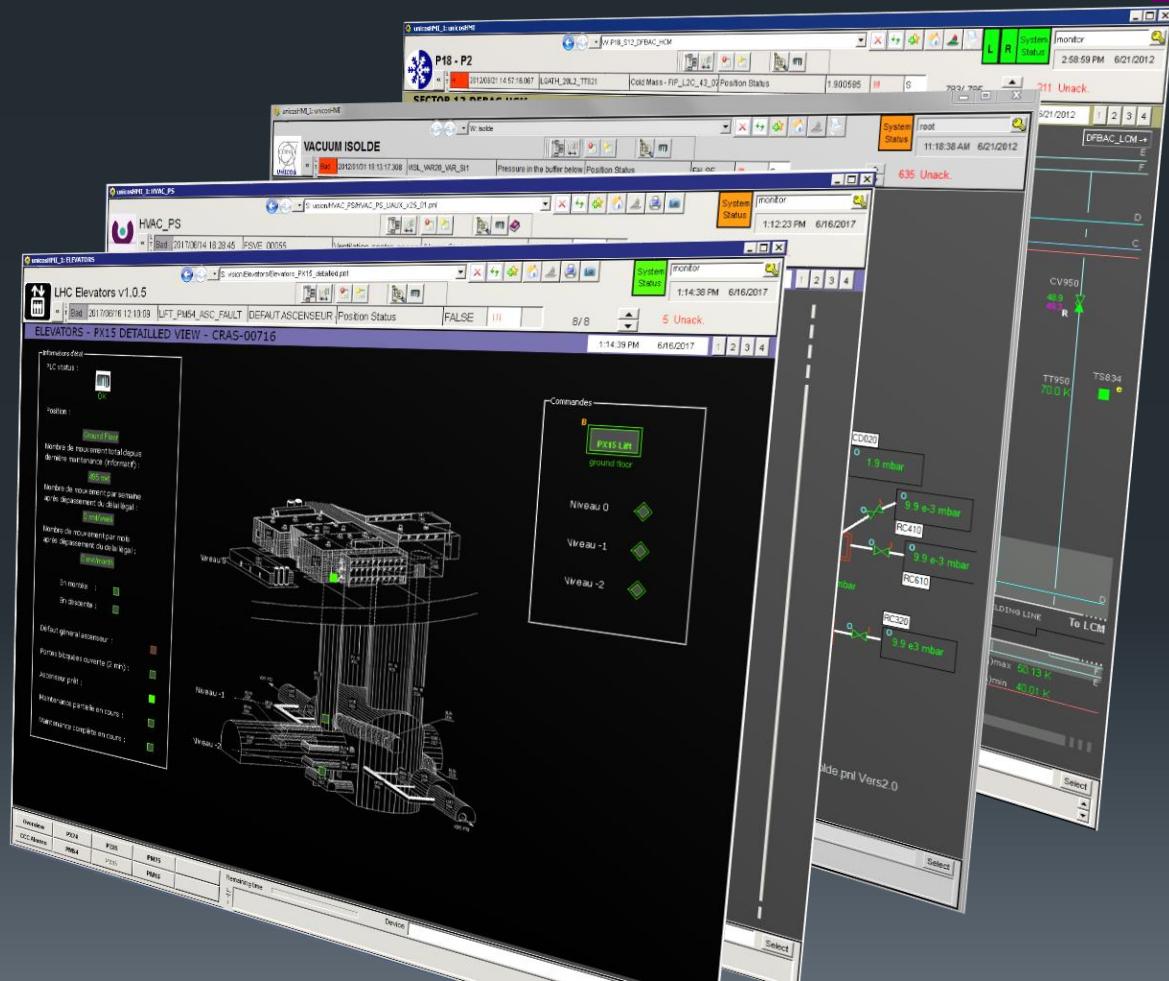


Widgets



UNICOS HMI

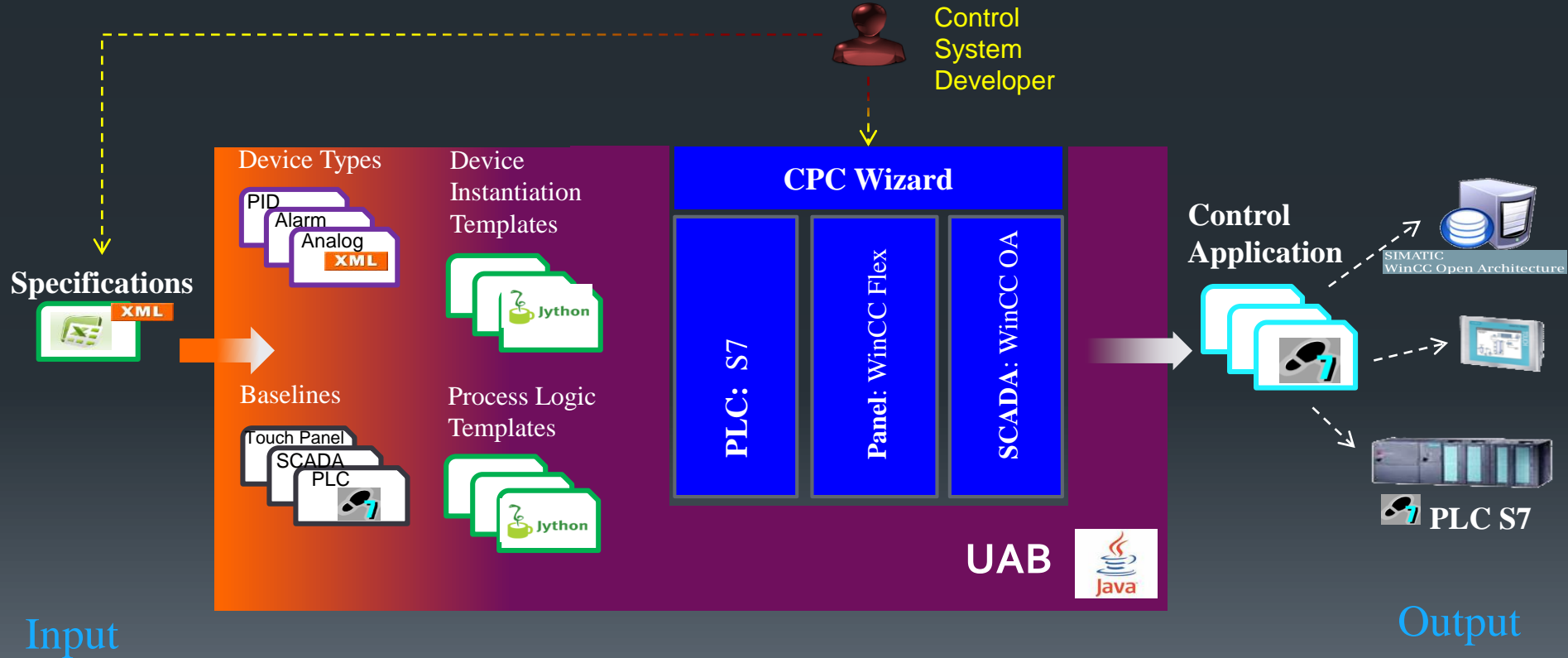
- HMI
- Alarms
- Events
- Navigation
- Trends
- System integrity
- BEEP
- Access control
- Contextual buttons
- Uniform look & feel



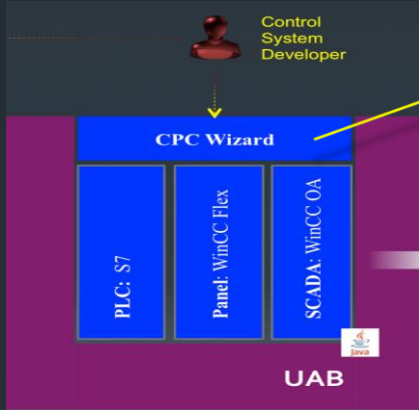
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UAB: UNICOS Application Builder



Workflow based on wizards



UAB CPC-Wizard v1.3.2-beta-02

CPC-Wizard: test - test v1.0

Unity Logic Generator
Resources: 1.3.2-beta-02

General Data

Templates Folder: C:\temp\wizard\Release\Schneider\Resources\UnityLogicGenerator\ Open

User Templates Folder: C:\temp\wizard\Release\Schneider\Resources\UnityLogicGenerator\ Open

Output Folder: C:\temp\wizard\Release\Schneider\Output\UnityLogicGenerator Open

Output File: C:\temp\wizard\Release\Schneider\Output\UnityLogicGenerator\plc_ Open

Process Semantic Rules: Generation Language: ST

Import and Generate

Master	Section	Type	Master	Logic File
DEMON_1_DemonPCO	DEMON_1_Demon...	Interlock Logic	DEMON_1_Demon...	SchLogic_IL_Stand...
DEMON_1_PCO3	DEMON_1_Demon...	Configuration Logic	DEMON_1_Demon...	SchLogic_CL_Stan...
DEMON_1_PCO1	DEMON_1_Demon...	Basic Logic	DEMON_1_Demon...	SchLogic_BL_Stan...
DEMON_1_PCO2	DEMON_1_Demon...	Instantiation	DEMON_1_Demon...	SchLogic_INST_St...
	DEMON_1_Demon...	Global Logic	DEMON_1_Demon...	SchLogic_GL_Stan...
	DEMON_1_Demon...	Transition Logic	DEMON_1_Demon...	SchLogic_TL_Stan...
	DEMON_1_Demon...	Sequencer Logic	DEMON_1_Demon...	SchLogic_SL_Stan...
	DEMON_1_Demon...	Common Depend...	DEMON_1_Demon...	SchLogic_CDOL_St...
	DEMON_1_A1_DL	Analog	DEMON_1_Demon...	SchLogic_Analog_...
	DEMON_1_A5_DL	Analog	DEMON_1_Demon...	SchLogic_Analog_...
	DEMON_1_AD1_DL	AnalogDigital	DEMON_1_Demon...	SchLogic_AnalogDi...
	DEMON_1_Chr1_DL	Controller	DEMON_1_Demon...	SchLogic_Controlle...
	DEMON_1_PCO3_DL	ProcessControlObject	DEMON_1_Demon...	SchLogic_ProcessC...
	DEMON_1_OO4_DL	OnOff	DEMON_1_Demon...	SchLogic_OnOff_S...

Generation Status

Instance Generator Logic Generator

WinCC OA Gener... WinCC Flex Gene...

Back Generate Exit

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UNICOS benefits

- **Proven industrial technologies**
 - Standard CERN PLC suppliers: Siemens, Schneider (PLCs and Touch Panels)
 - Standard CERN SCADA (WinCC OA)
- **Standardization**
 - Based on industrial standards: ISA-88 / IEC-61512: Batch control
 - Uniform and maintainable code (IEC languages is not enough)
 - Optimized maintenance and development backup with a central support
 - Same look & feel (and functionality) optimizes operation in the control room
- **Rapid development**
 - Automatic generation of applications
 - Early commissioning availability. No SCADA development

Conclusions

<http://www.cern.ch/unicos>

UNICOS framework composed of

- Generic set of reusable devices
- Analysis and development method
- Programming structure
- A rich functionality in a homogenized HMI

CERN Accelerating science

Unified
Industrial Control
System
UNICOS

UNICOS

*Facilitate the task of the automation engineer by allowing him/her in **focusing only in the automation duty** and not in the software production itself: Automatic generation of code.*