Building and Utilities maintenance at ALBA

Lluís Miralles

CELLS Engineering Division Head

Talk outline

- Overview of ALBA Building and utilities.
- Building and utilities current maintenance approach.
- Computing and control current maintenance approach
- Condition Based Maintenance introduction study

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ALBA site


North Atlantic Ocean
© 2011 Europa Technologies
© 2011 Tele Atlas
US Dept of State Geographer
© 2011 Google
41°29'01.97" N 2°06'39.87" E elev 34 m
Eye alt 5445.15 km
Google

ALBA site

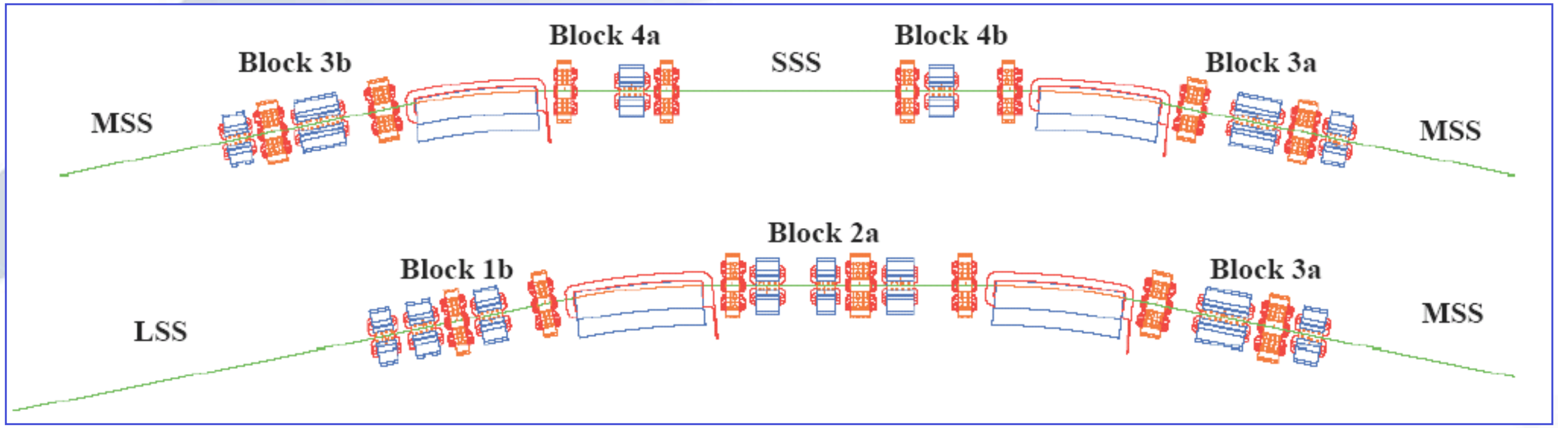
ALBA Site

Lattice

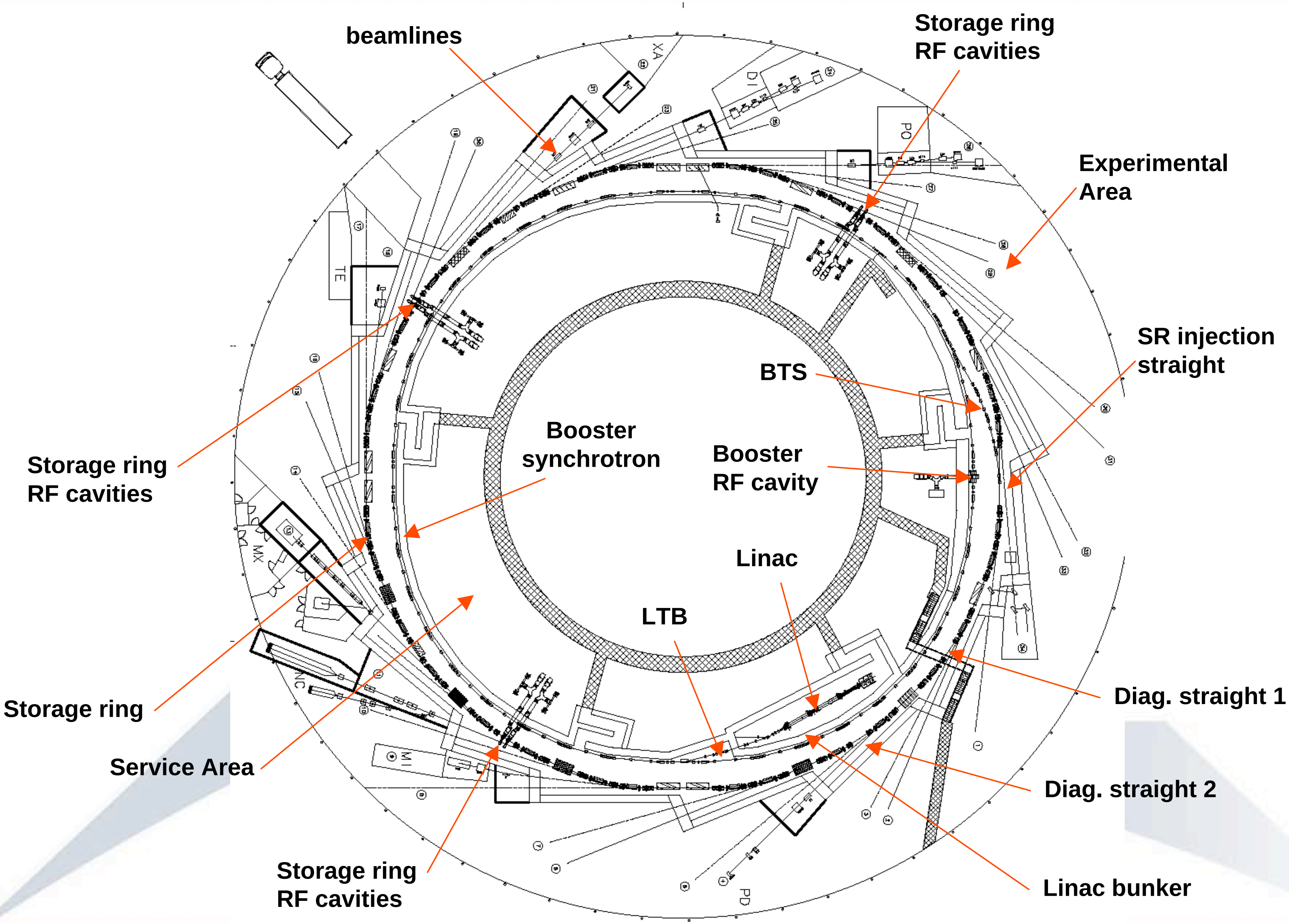
Energy	GeV	3.0
Nominal current	mA	250
Design current	mA	400
Horizontal Emittance	nm.rad	4.3
Lattice		Expanded DBA
Storage ring Circumference	m	268.8
No. of dipoles		32
Bending angle	mrad	196.34
Radius of curvature	m	7.047042
Dipole magnetic field	T	1.42
Critical energy from dipole	keV	8.5
Total photon flux at the design current	Ph/sec	$9.7 \cdot 10^{20}$
Total power at the design current	kW	407
Harmonic number		448
Frequency	MHz	500
Momentum Compaction Factor		$8.8 \cdot 10^{-4}$
Chromaticity (Horizontal/Vertical)		-39.8/-25.6

Unit Cell

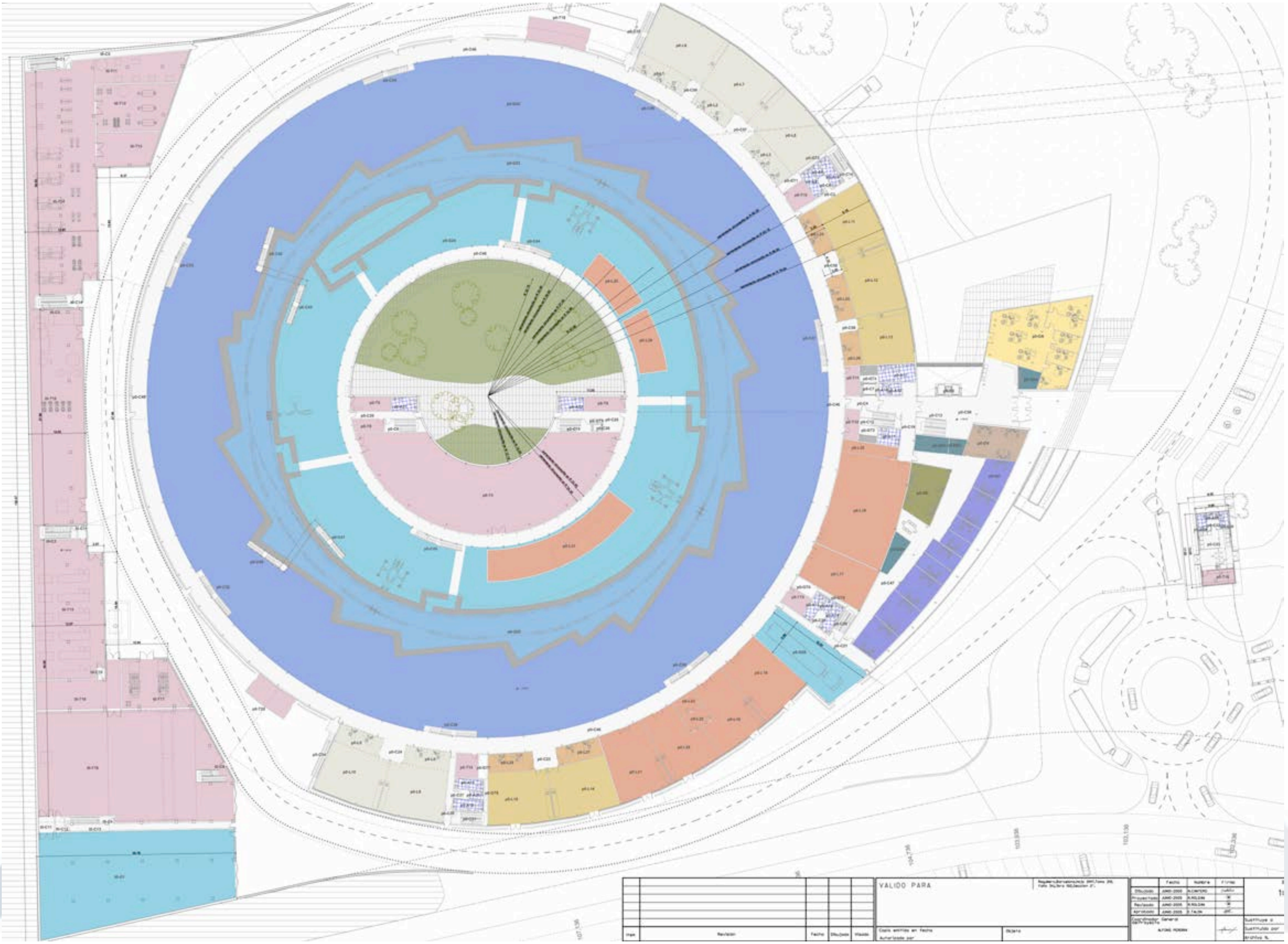
Matching Cell



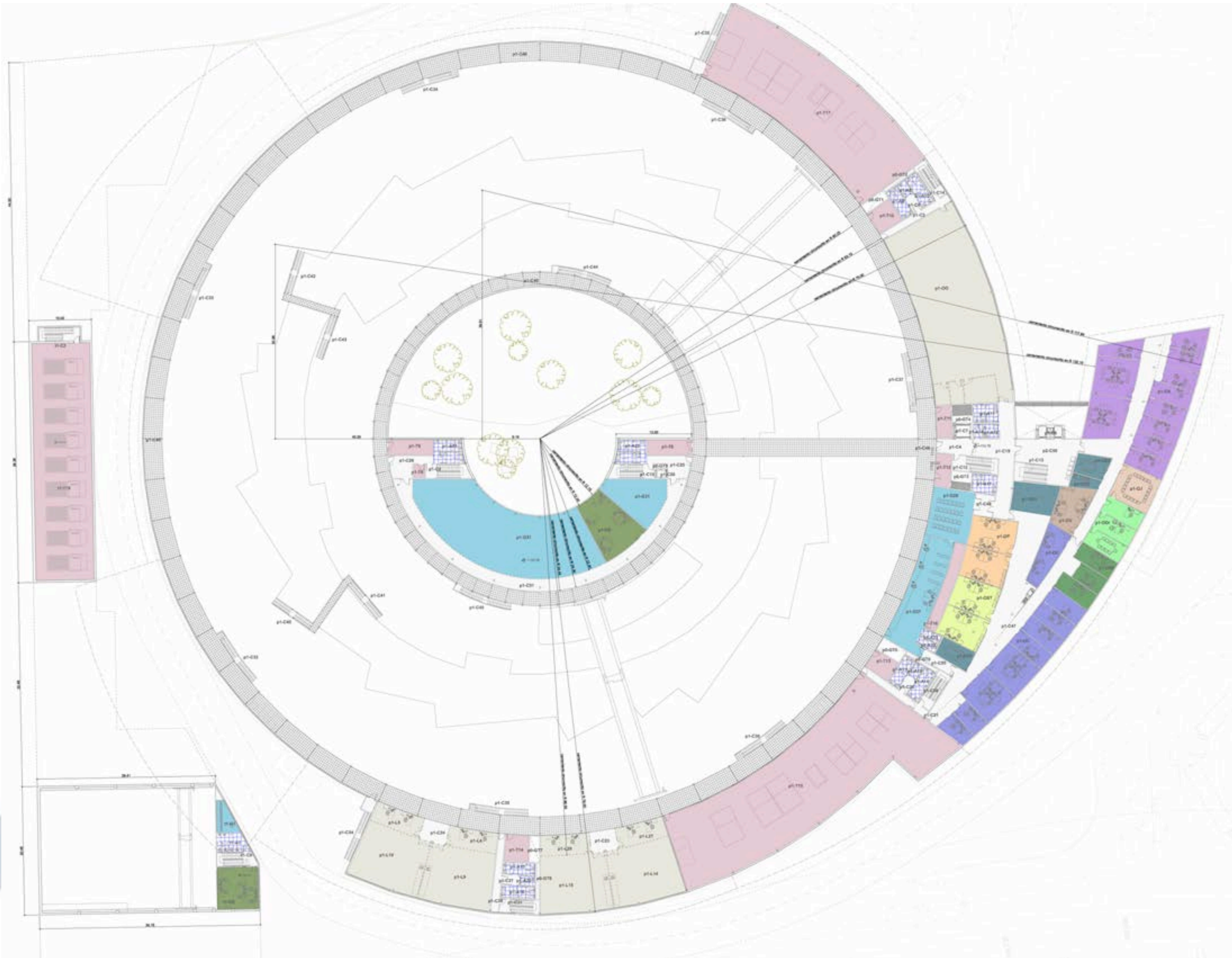
Accelerators layout



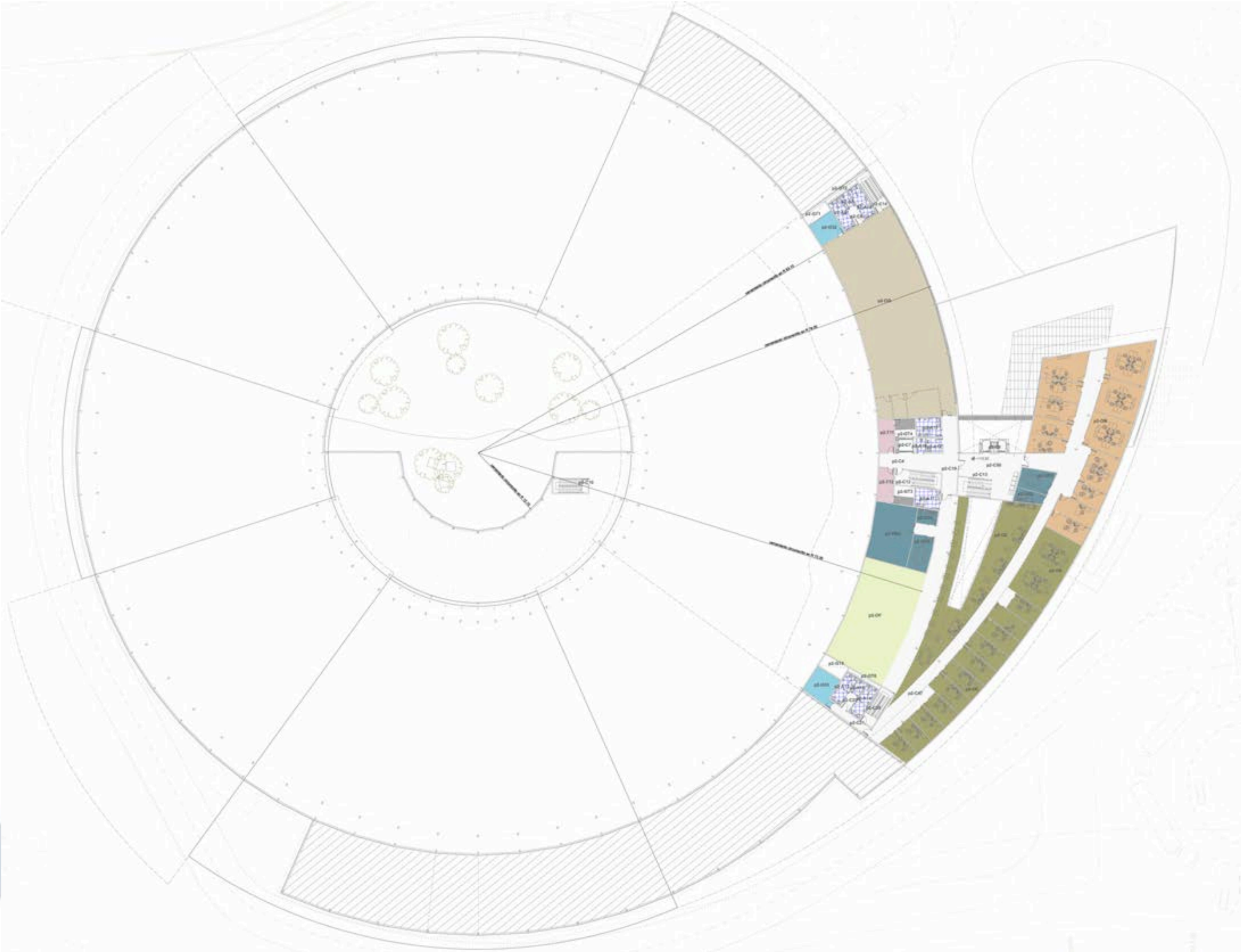
ALBA Site



ALBA Site



ALBA Site



ALBA Site

ALBA Site

ALBA Site

ALBA Site

CELLS Structure

Organization Scheme of CELLS

Rector Council

Executive Commission

Scientific Advisory Committee

Director

Machine Advisory Committee

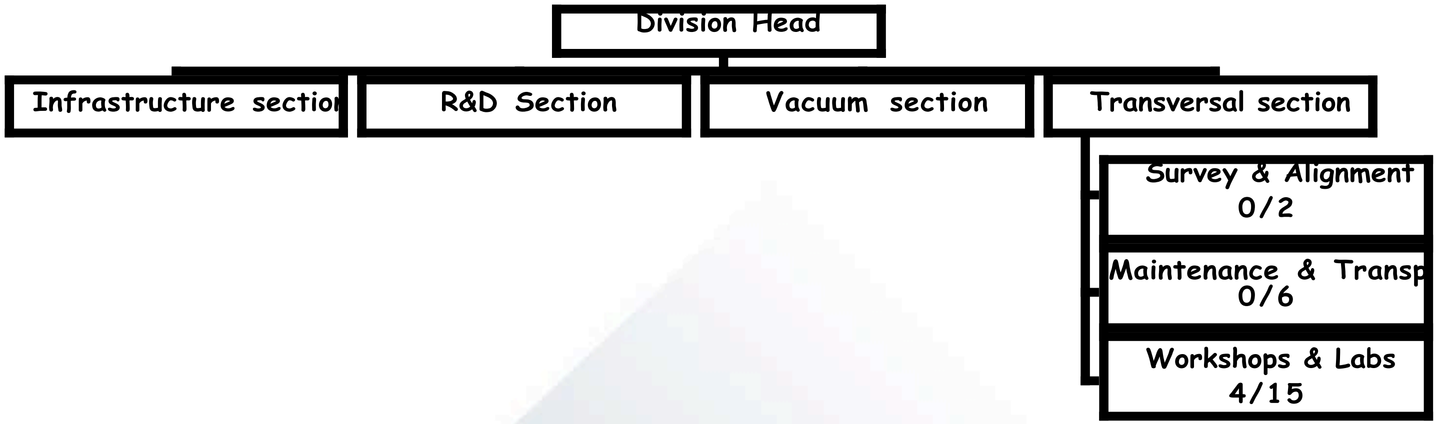
Management Board

Director

- Experiments Division (S.Ferrer)
- CC+DACQ Division (J.Klora)
- Administration Division (M.Sazatornil)
- Engineering Division (L.Miralles)
- Accelerator Division (D.Einfeld)

Engineering Division Structure

CELLS Engineering Support Division Organizational Chart



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Transversal section

Between others the mandate of the Transversal Section includes the following aspects

Management of the transversal human resources of the division. Technicians, designers, general calculations specialists and project managers are part of those resources.

- Management of the material resources of the division. Workshops, technical buildings, CAD/CAE generalist equipment, survey equipment are part of those resources.
- Production and follow-up of the master plan of the CELLS project.
- Coordination and follow-up of the activities projects in which the division is involved, being in charge of keeping up to date the schedules.

The transversal section is supposed to be the main responsible for the optimisation of the resources across the division.

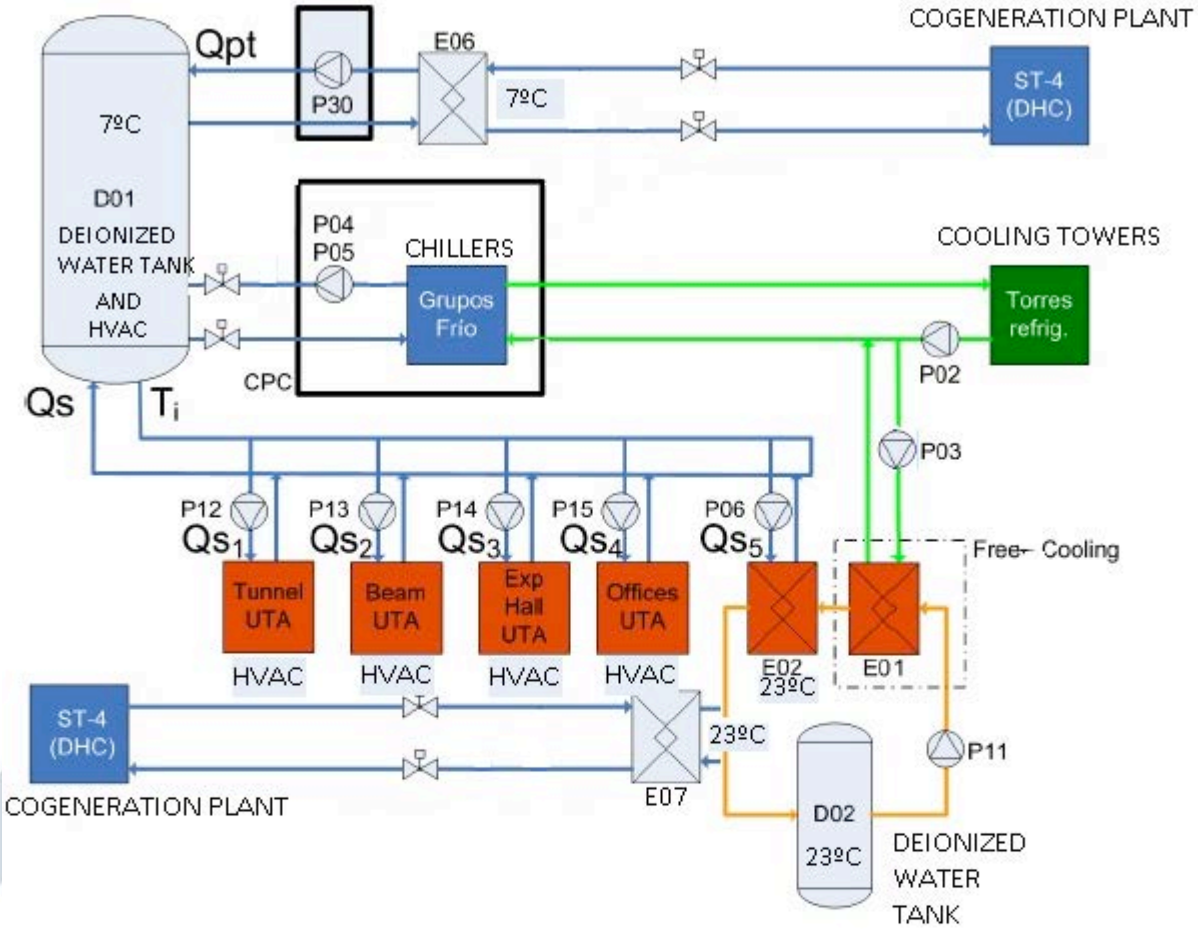
MAIN ENERGY PRODUCTION

•THERE ARE THREE ENERGY CIRCUITS:
- COOLING WATER, AT 7±05°C
- HOT WATER, AT 50±1°C
- DEIONIZED WATER, AT 23±0.2°C

THERE IS AN EXTERNAL POWER PLANT, REDUNDANT 100% LOCATED NEAR THE SITE, CALLED ST4 POLYCOGENERATION IS A DHC (DISTRICT HEATING AND COOLING)
POSSIBILITY OF SWITCHING FROM ONE SYSTEM TO THE OTHER INTERNAL PRODUCTION OR EXTERNAL PRODUCTION COGENERATION PLANT.

Some figures:
Cooling power: 8,750 kW
Heating power: 1,400 kW

MAIN ENERGY DIAGRAM



CHILLED WATER PRODUCTION

-COOLING SYSTEM IS MADE BY 4 CONDENSED WATER MACHINES.

- PRODUCE WATER AT 7ºC:

-2 UNITS: CENTRIFUGAL COMPRESSORS WITH **2,900** kW EACH

-2 UNITS: SCREW COMPRESSORS WITH **1,300 kW** EACH

A TOTAL OF **8,750 KW**

-CONDENSATION OF THESE MACHINES HAS BEEN MADE WITH 8 OPEN COOLING TOWERS **1,250 kW** EACH.

-THIS CHILLED WATER PRODUCTION IS USED TO COOL WATER THROUGH TWO PRIMARY PLATE EXCHANGERS (DW), **1,815 kW** EACH.

- TOTAL COOLINGS ARE:
1. THE SOURCE LIGHT **(3,627 kW)**
2. HVAC, HEATING VENTILATION AND AIR CONDITIONING, **(3,245 Kw)**

WATER TREATMENT

REQUERIMENTS:
Input temperature of the circuit in the ALBA tunnel, 23 ± 0.2°C.
Thermal loads to be dissipated by the water.
Circulation flow rates and pressure
Water with great purity, maximum conductivity of 0.20 µS/cm.
Filtered to 10 µ (micron)
Volume ring circuits about 100 m³, 4 closed rings with common return.

CHOSEN SOLUTION: decalcified units plus reverse osmosis equipment. More ecological in regard to the residual water but great attention, maintenance and care of the membranes.

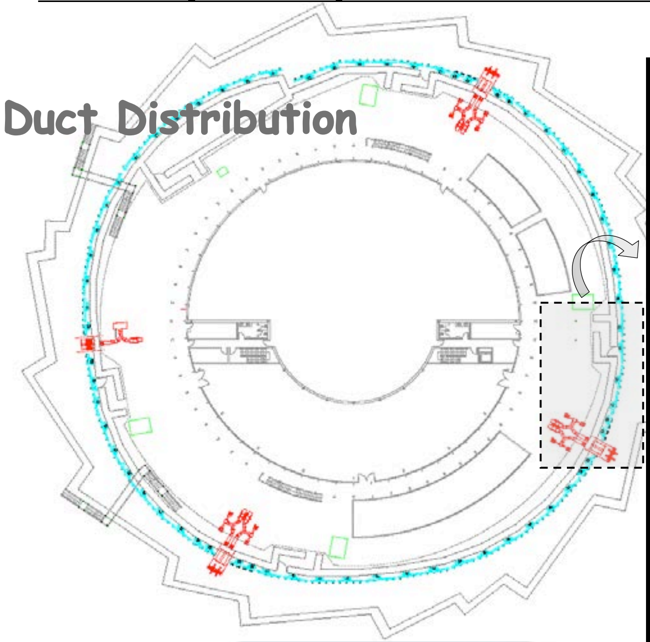
- Characteristics parameters of the INLET water supply from the urbanization net in Cerdanyola. (Barcelona)
- Decalcified unit, maximum production of 27 m3/h.
- Osmotic water production capacity of 2,5 m3/h.
- 2.000 l/h flow for maintenance of membranes.

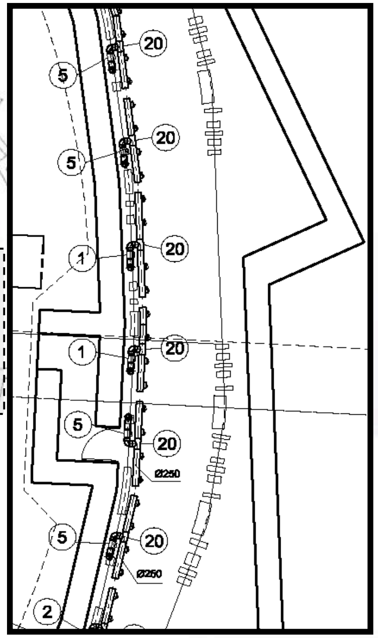
AIR CONDITIONING

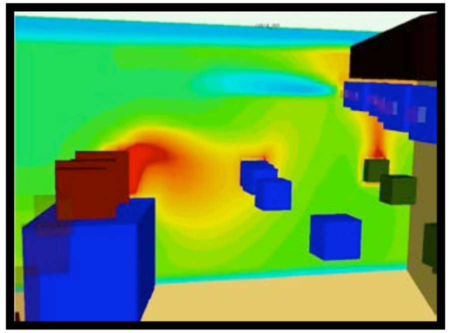
ALBA Tunnel: turbulent flow system.

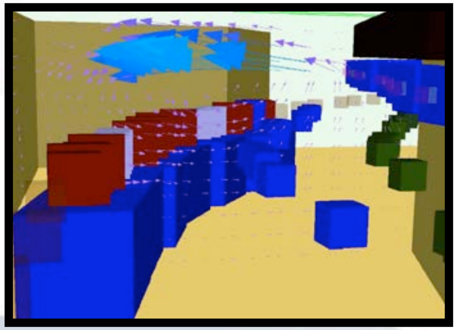
FIVE AIR CONDITIONING WITH COOLING CAPACITY OF 200 Kw, TOTAL AIR FLOW 68.000 m^3/h

Average temperature 23°C, variation Tmax-Tmin < 0'2°C









Hall Experimental: displacement flow system.

SIX AIR CONDITIONING WITH COOLING CAPACITY OF 1,160 Kw AND HEATING CAPACITY OF 450 Kw. TOTAL AIR FLOW IS 240.000 m3/h AND EQUIPPED WITH FREECOLING SYSTEM AND HUMIDIFIER BY SPRAYING

Average temperature 23°C, variation Tmax-Tmin < 1°C

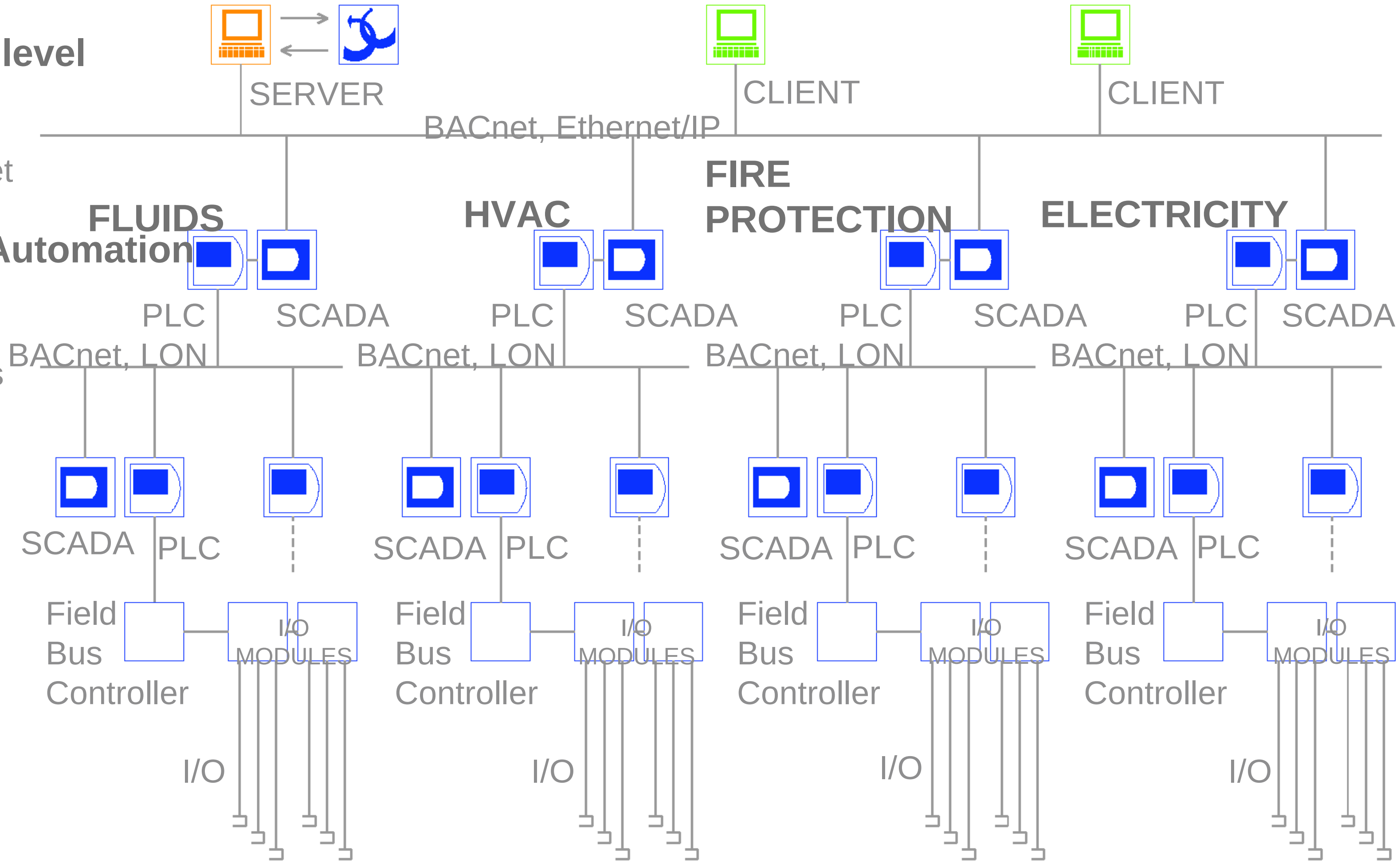
CENTRALIZED CONTROL OF INSTALATIONS - ARCHITECTURE

Management level
1. Server
2. Clients
3. Lan/Ethernet controllers

Global level Automation
1. PLC
2. SCADA
3. BACnet Bus
4. LON mark

Local level Automation

Field level
1. Values
2. Inverters
3. Sensors
4. Indicators



• ALBA IS DIRECTLY CONNECTED TO THE 220 KV HIGH VOLTAGE NET.

• THROUGH A 20 MVA TRANSFORMER, THE VOLTAGE IS REDUCED FROM 220 KV TO 25 KV, AND TRANSMITED TO ALBA.

• ALBA HAS 25 KV REDUNDANCY THROUGH A COGENERATION PLANT.

• AT ALBA, THE VOLTAGE IS FINALLY REDUCED FROM HIGH TO LOW VOLTAGE, FROM 25 KV TO 400 V.

220 KV

220 KV/25 KV TRANSFORMER

S.E. CODONYERS
220/25 KV

2 X 25KV

1,8 Km

2 X 25KV

1,8 Km

ALBA

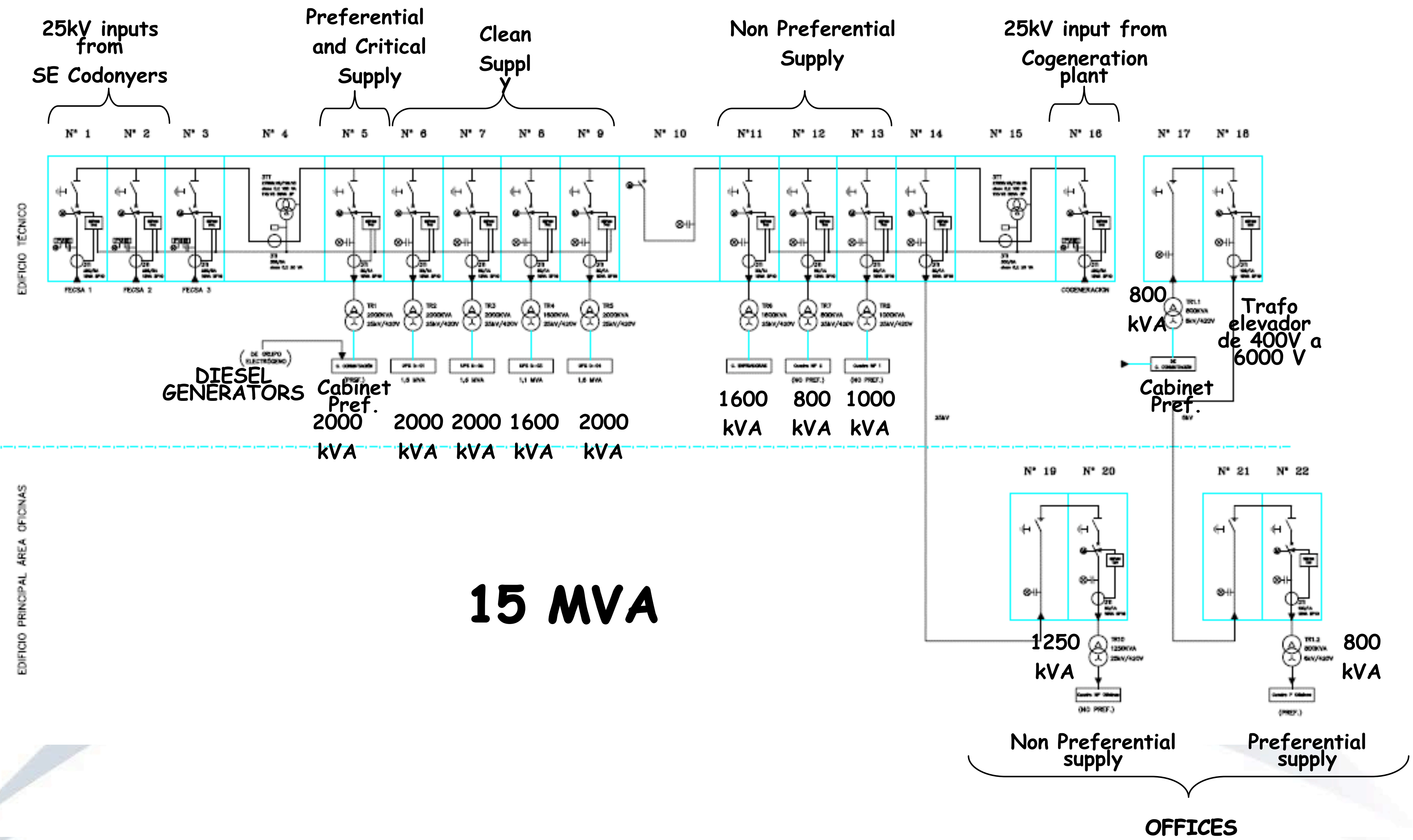
25KV

0,7 Km

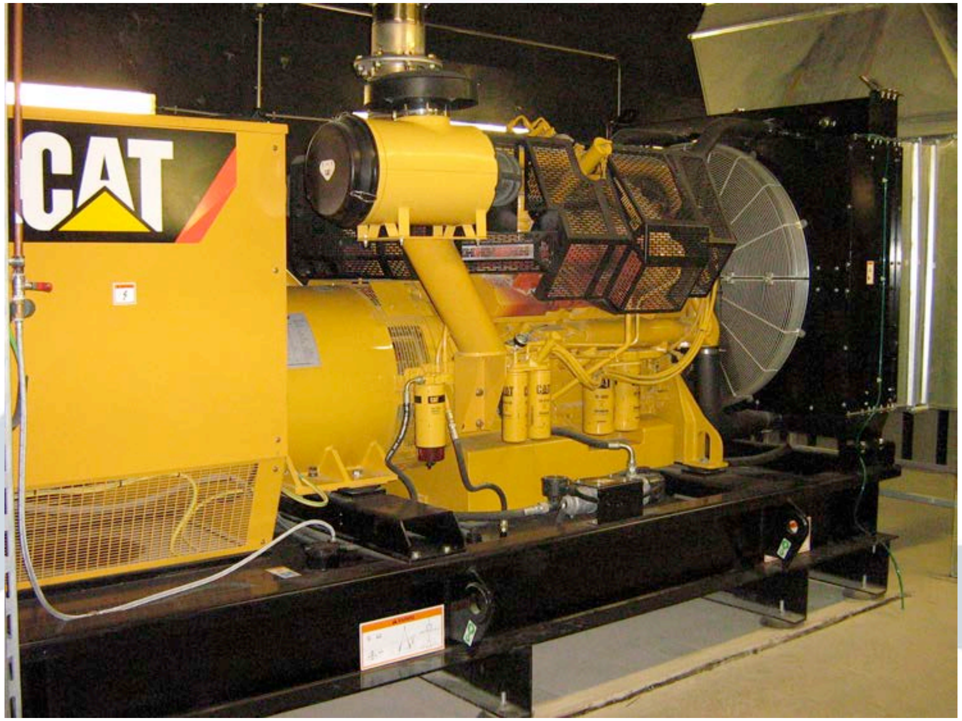
ST4 COGENERATION PLANT

11 DRY TYPE TRANSFORMERS

DIFFERENT POWERS (From 0,8 to 2 MVA)


25kV inputs from
SE Codonyers
Preferential and Critical Supply
Clean Supply
Non Preferential Supply
25kV input from Cogeneration plant
DIESEL GENERATORS
Cabinet Pref.
2000 kVA
2000 kVA
2000 kVA
1600 kVA
2000 kVA
1600 kVA
800 kVA
1000 kVA
800 kVA
Trafo elevador de 400V a 6000 V
Cabinet Pref.
15 MVA
1250 kVA
800 kVA
Non Preferential supply
Preferential supply
OFFICES

- SUPPLIES THOSE LOADS THAT CAN ADMIT SHORT POWER CUTS, UP TO 30 SECONDS.
- SUPPLY THROUGH DIESEL GENERATORS.
- USED FOR: LIFTS, HYDRAULIC CIRCUITS, PART OF THE LIGHTING, ETC.



2 Diesel generators at ALBA (720kW each)

- SUPPLIES THOSE LOADS THAT CAN NOT SUPPORT POWER CUTS.
- SUPPLY COMPOSED BY DIESEL GENERATOR + STATIC UPS.
- USED FOR: COMPUTING ROOM, CONTROL ROOM, BEAMLINES, ETC.

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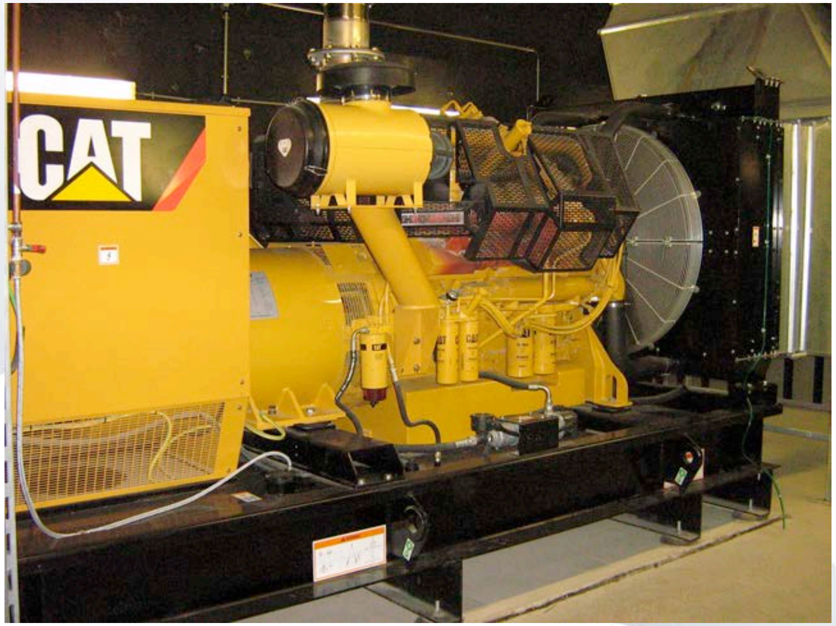

Static UPS's supplied through diesel generators

- SUPPLIES THOSE LOADS THAT NEED A HIGH QUALITY SUPPLY, WITHOUT POWER MICRO CUTS, VOLTAGE OSCILLATIONS OR DISTURBANCES.

- SUPPLY FILTERED BY DYNAMIC UPS.

- USED FOR: ACCELERATOR EQUIPMENT (MAGNETS, RF PLANTS, COOLING INSIDE TUNNEL).

4 Dynamic UPS (arround 6 MVA)

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Objective. Maximum reliability at minimum cost

Strategy

Keep in-house all knowledge necessary to operate and maintain the facility.

In-house management of the maintenance of the facility.

Optimize the maintenance cost related to personnel, spares and reposition.

Scheme

Team of in-house technicians (2) and engineers (4) trained and educated on all the disciplines related with maintenance.

Outsourcing to specialized companies the routine and normative maintenance of specific equipments. Corrective in function of volume.

Spares and components supply framework conditions with general and specialist suppliers (price and delivery time).

Outsourcing personnel support for preventive and routine corrective maintenance (2 FTE). Flexibility on the contract in order to absorb peak loads.

In-house

- Preventive and corrective of low voltage, cooling and HVAC distribution.
- Preventive and corrective on architecture.
- Supervision of all systems on dairy, weekly and monthly basis.

Outsourcing

- Medium voltage (25Kv) and high voltage (220Kv)
- Low voltage yearly normative
- Cranes and elevators normative
- Fire extinguishing normative and corrective
- Boilers 5 years normative and yearly preventive
- Chillers yearly preventive
- Cooling towers. Normative follow-up
- Dynamic UPS preventive (2/year)
- Static UPS yearly preventive
- Diesel generators yearly preventive
- Compressed air preventive (2/year)

Preventive maintenance approach by CMMS (Computerized Maintenance Management System)

Software PRISMA 3

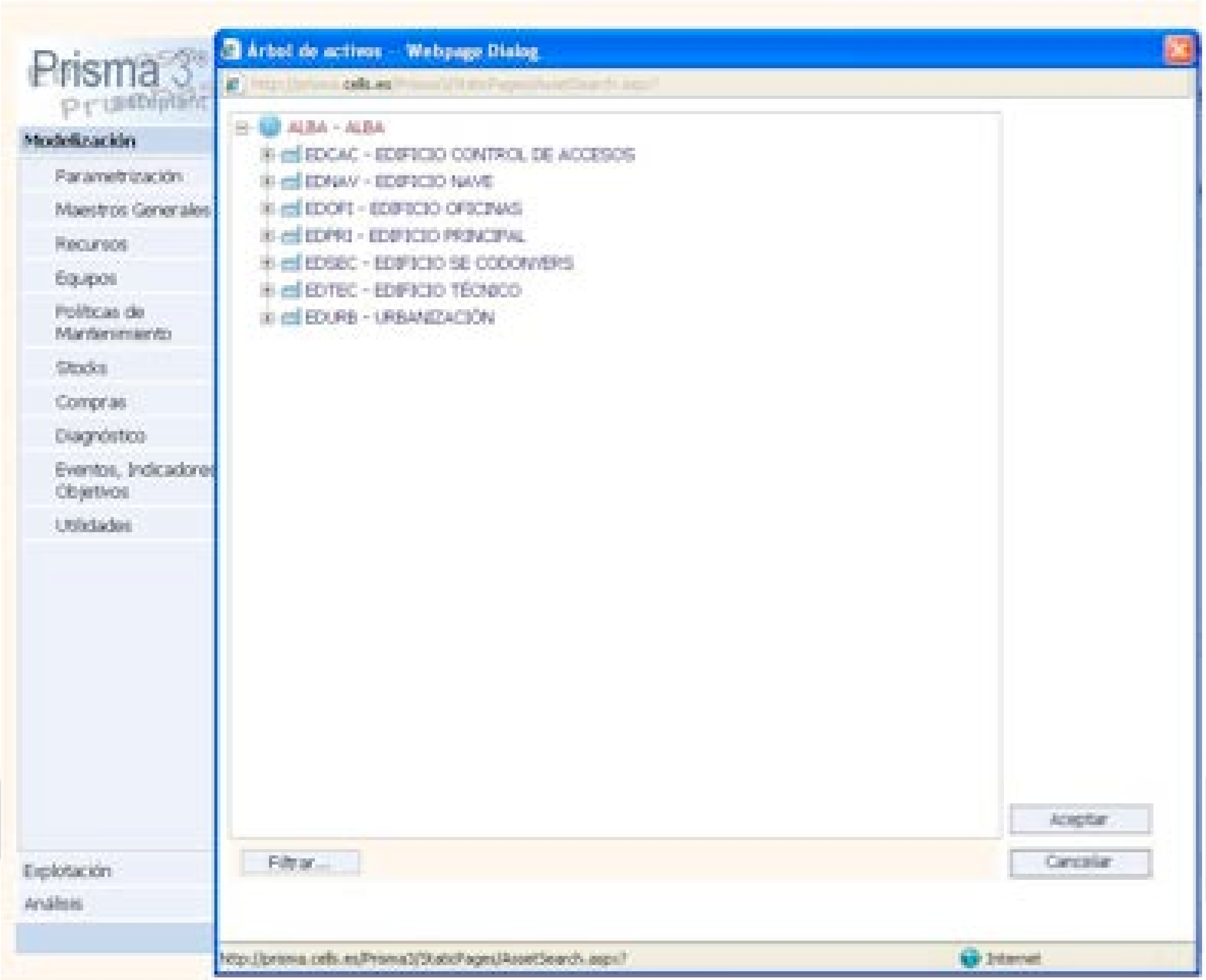
Main reasons driving the choice:

- Availability of the component database from the installation period.
- Experience from installation/exploitation period.
- In-house knowledge
- Widely implemented in industrial and technological environments
- Scalability
- Integration capabilities
- Potentiality
- Maturity

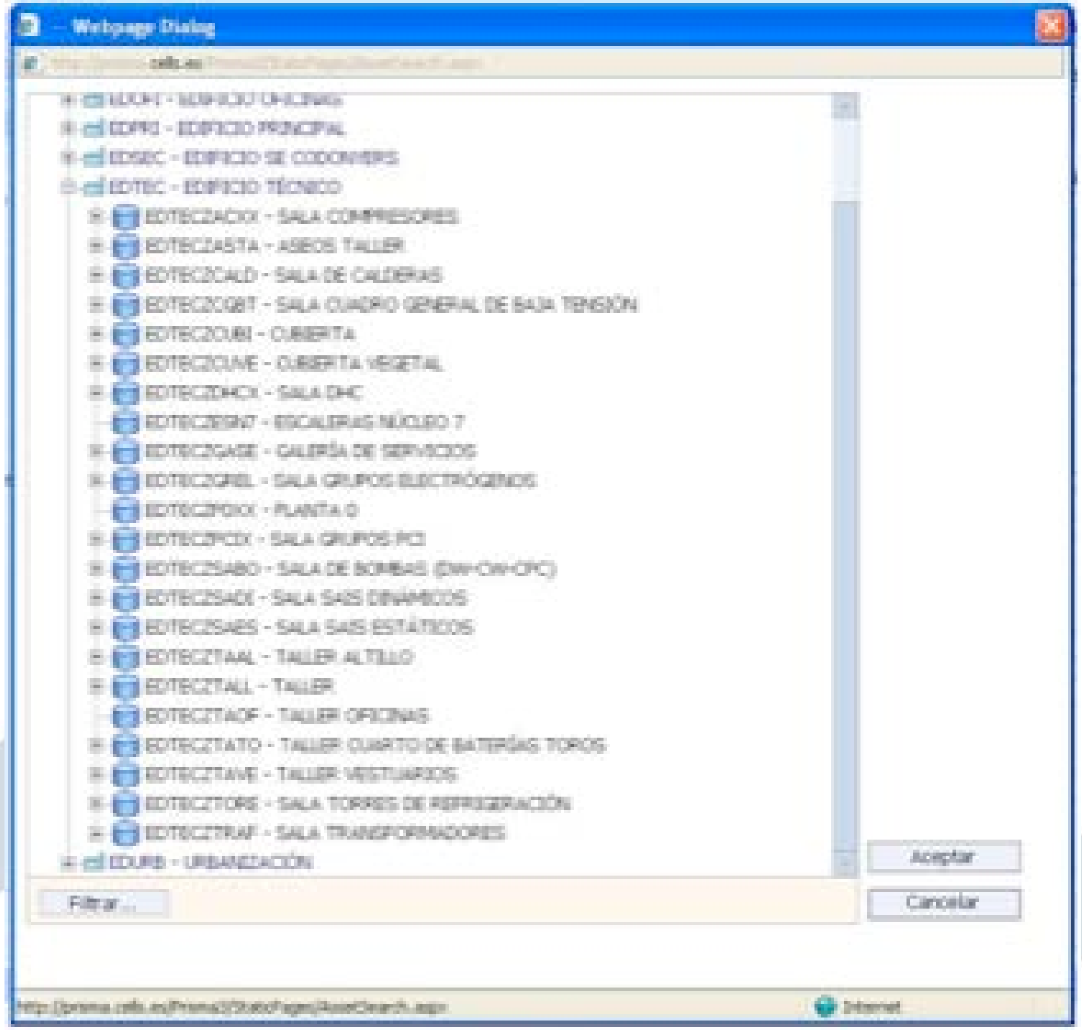
Installation description implemented in 5 levels

- Facility
- Building
- Zone
- System
- Component

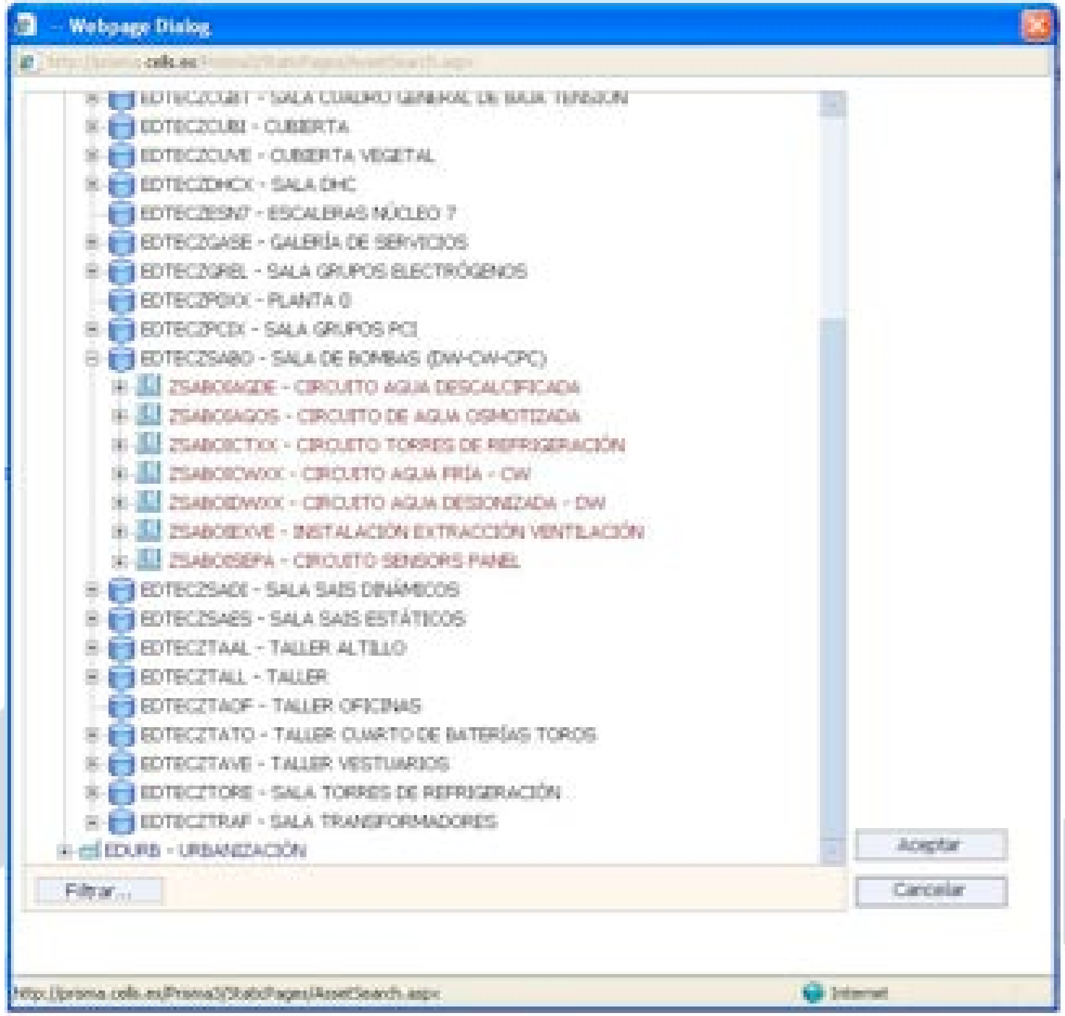
Building breakdown



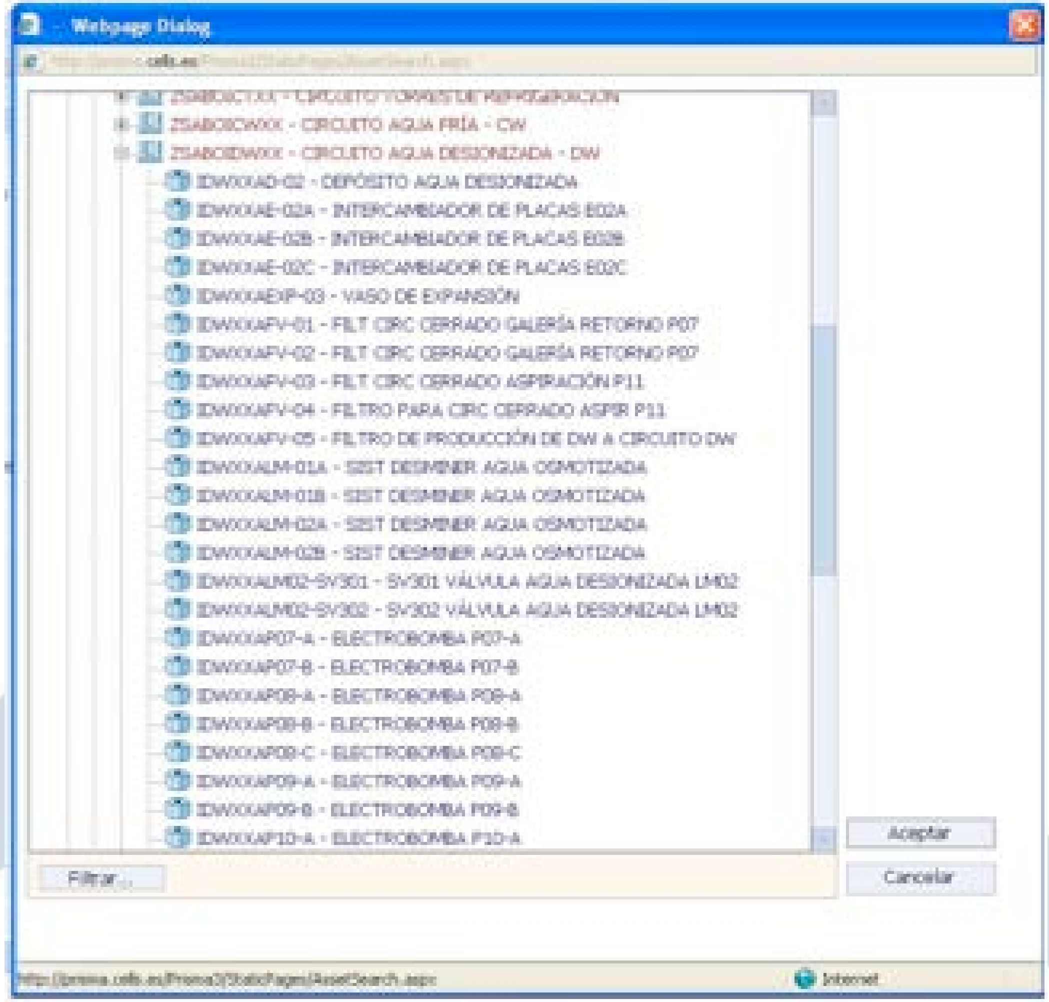
Technical Building zone breakdown



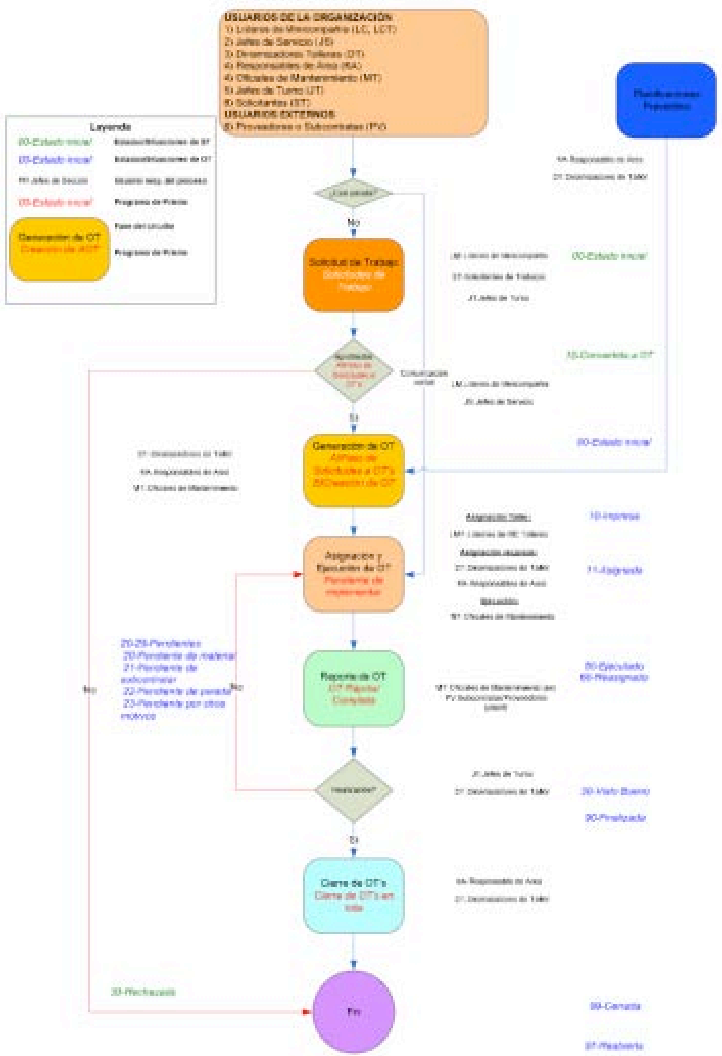
Pumping Zone breakdown



Deionized Water System breakdown

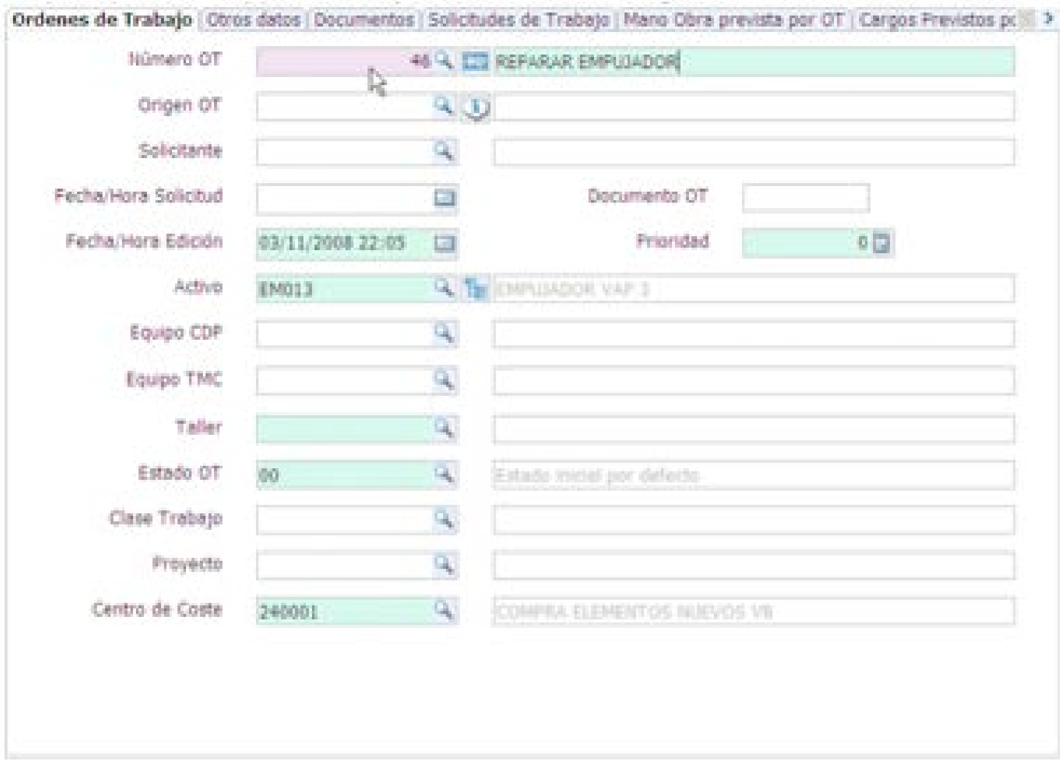


Work Flow in PRISMA. The work order process



Work order generated by user or preventive maintenance program

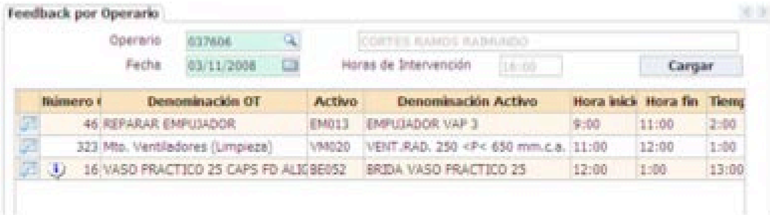
Work order



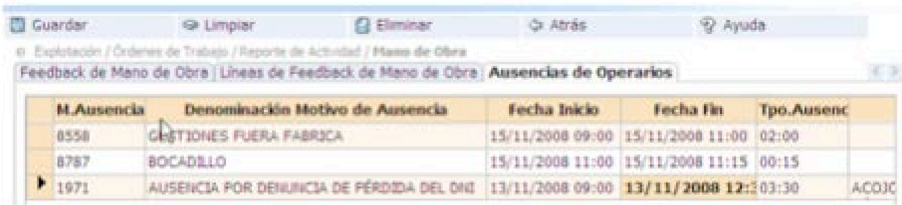
Wide spectra of information can be specified. Manpower and technical information specifications (Drawings, technical instructions, safety instructions, tooling,…)

Work order. Feedback tool

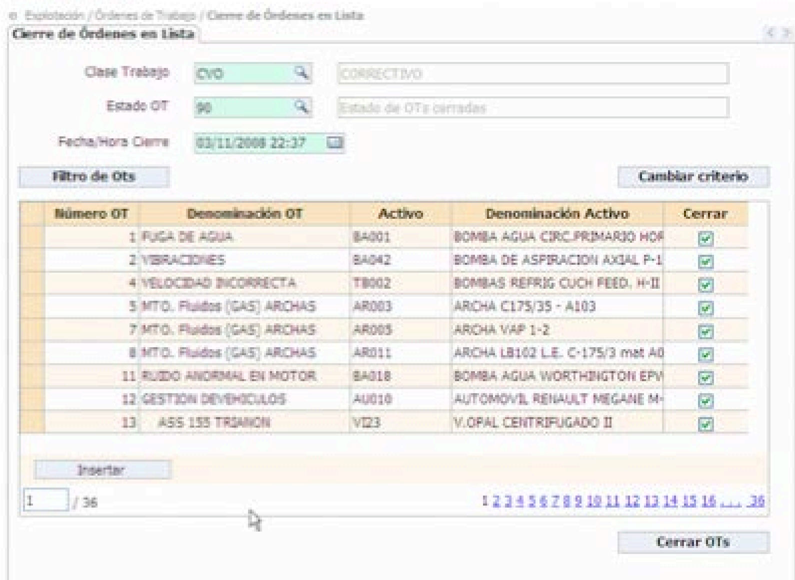
Execution time, incidences, comments,…



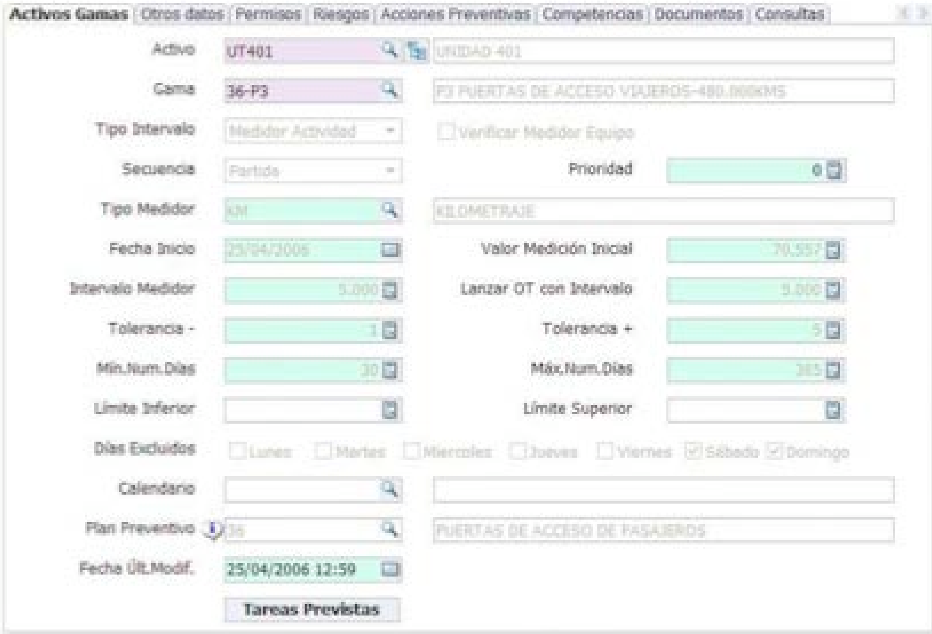
Reporte de las ausencias si existen para cuadrarlas con las horas de trabajo:

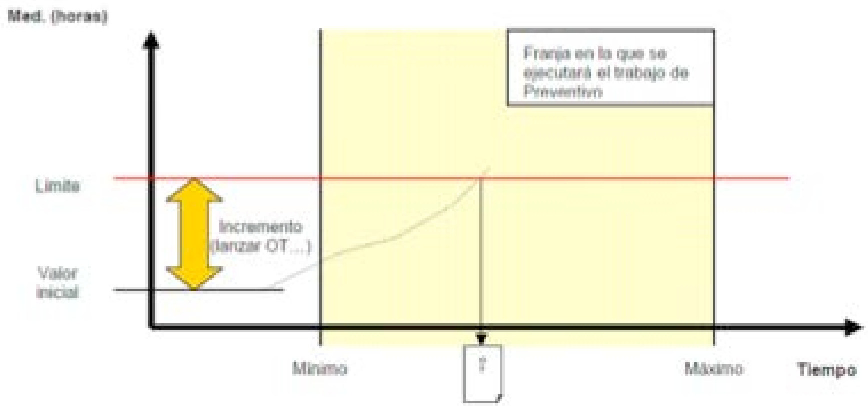


Cierre de ordenes de trabajo.

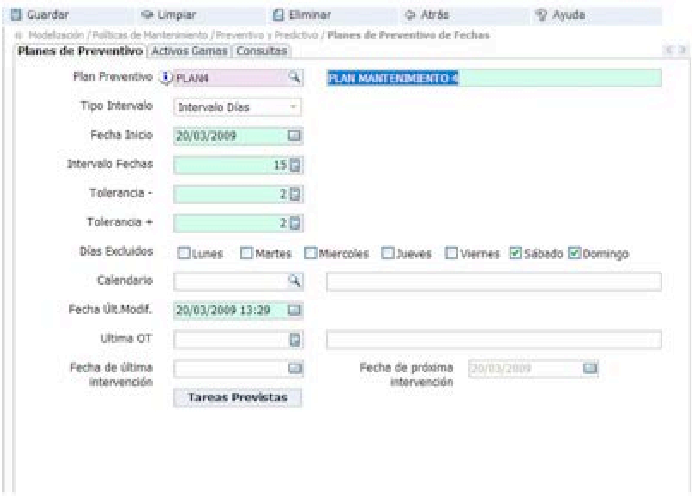


Work order. Generated by trigger

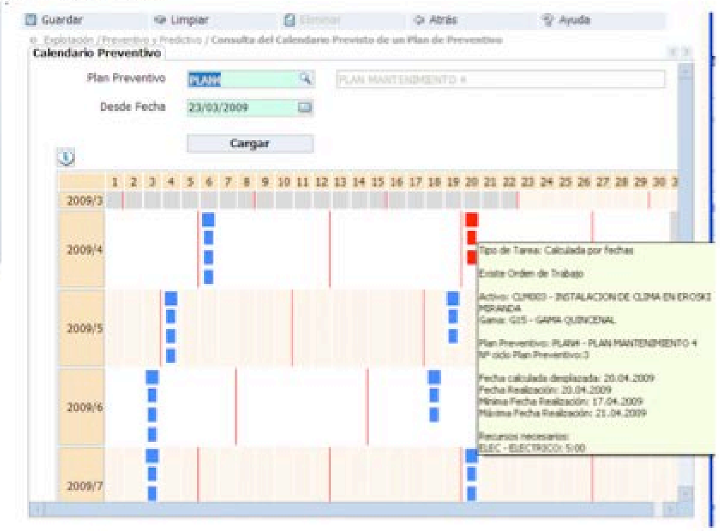




Work order. Generated by schedule

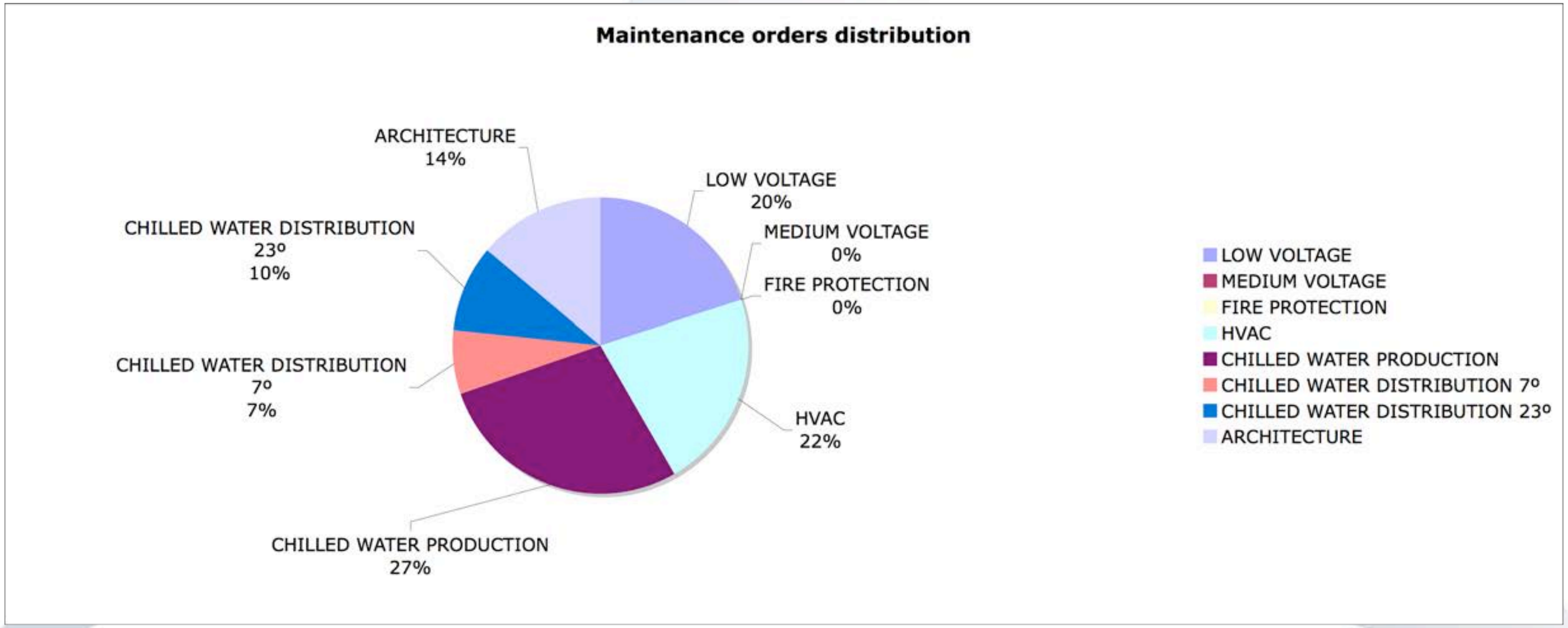


Calendario de acciones preventivas



Ordenes de una planificación

CLASS		TOTAL	CORRECTIVE	PREVENTIVE
LOW VOLTAGE	BT	185	170	15
MEDIUM VOLTAGE	MT	2	1	1
FIRE PROTECTION	CI	0	0	0
HVAC	CL	201	66	135
CHILLED WATER PRODUCTION	MP	261	33	228
CHILLED WATER DISTRIBUTION 7º	MD7	62	13	49
CHILLED WATER DISTRIBUTION 23º	MD23	90	15	75
ARCHITECTURE	A	128	128	0
TOTAL			426	503



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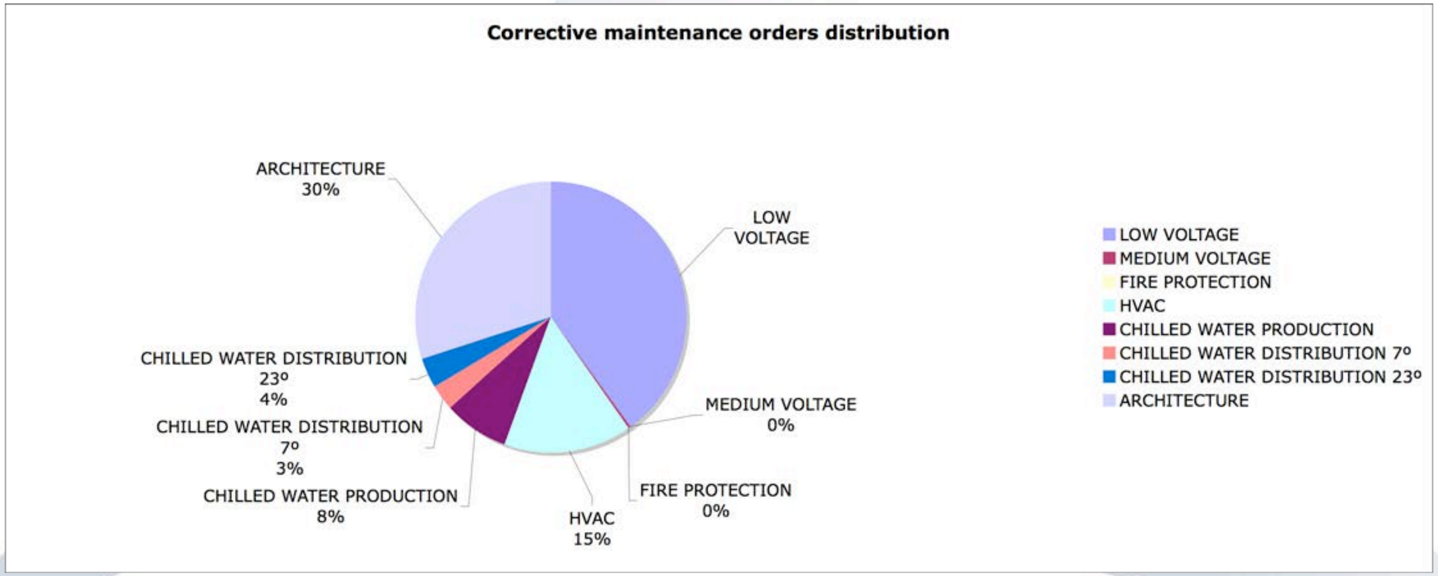

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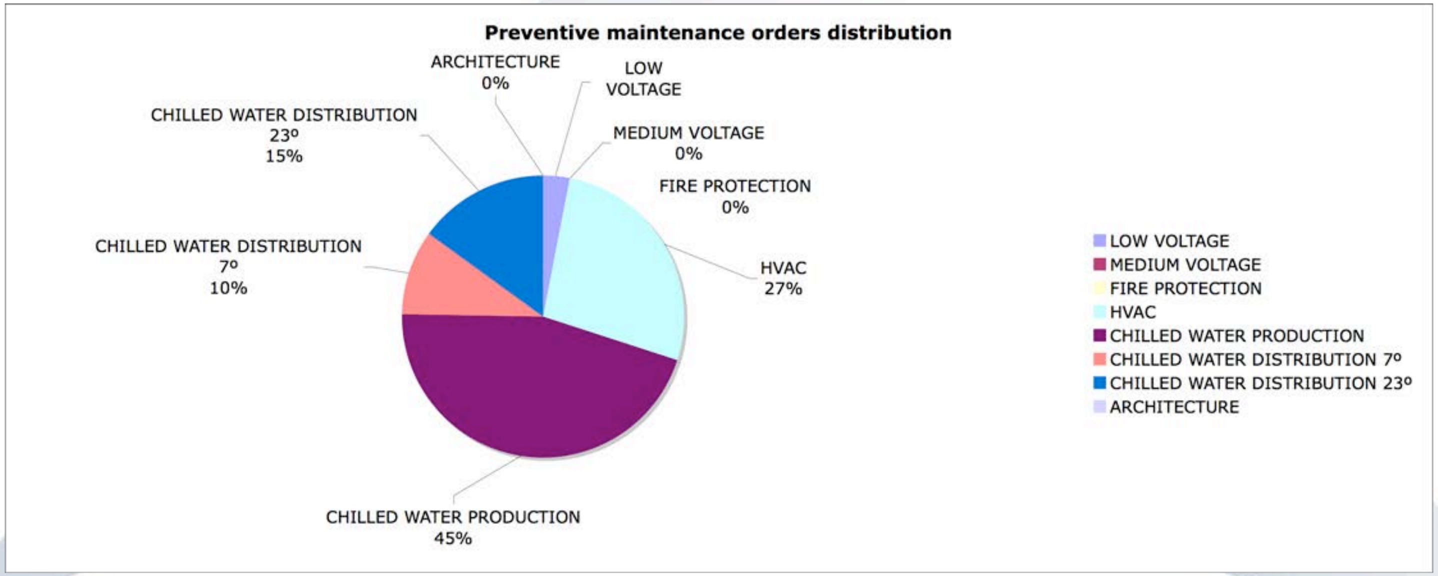

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Configuration Management

Centralized ccdb has been developed as main hardware repository:

Technical description of equipments, connectors and cable types.
Including datasheets, test procedures, installation logs… etc…

Instance of each equipment and cable of the machine following CELLS naming convention.

Some stats:

- 6377 Equipments instances
- 23099 cables instances (more than 167Km)
- 641 Equipments types (with all technical info)
- 294 Cable configuration (with all technical info)

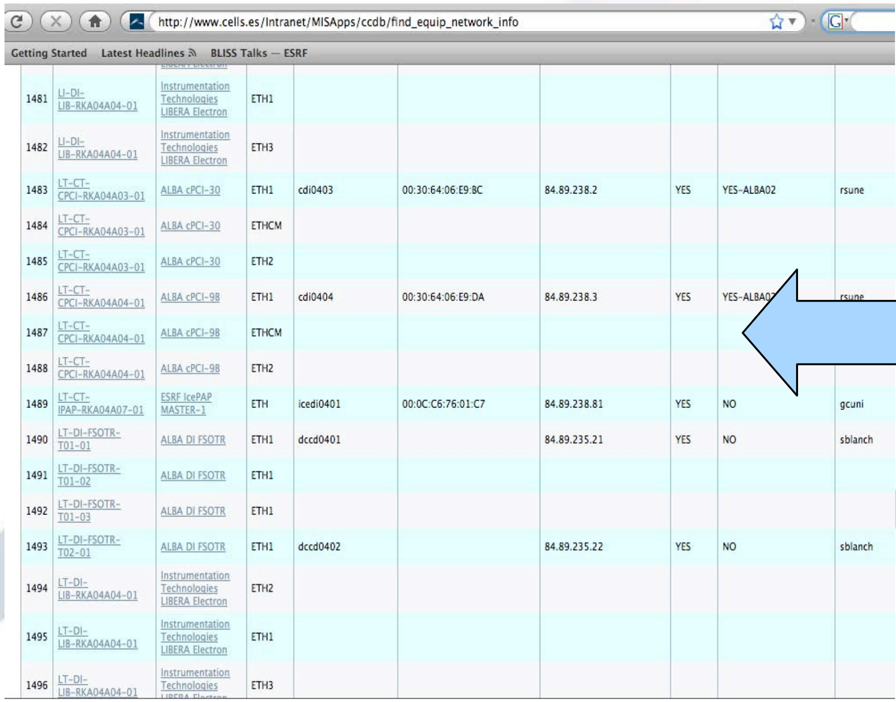
} > 5.000h invested.

Configuration Management

But ccdb is not only being used as a static repository:

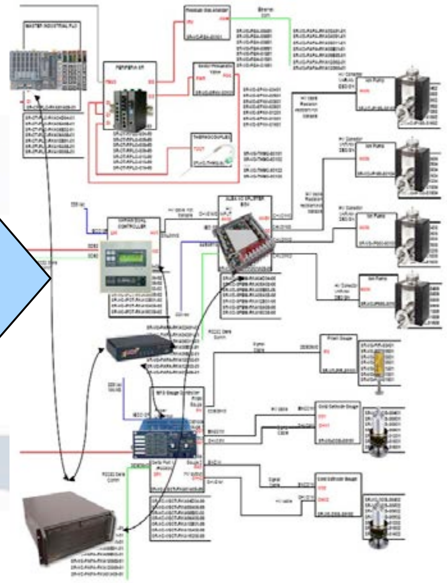
Automatic Network configuration

Automatic Controls code generation. Tango devices and attribute names.

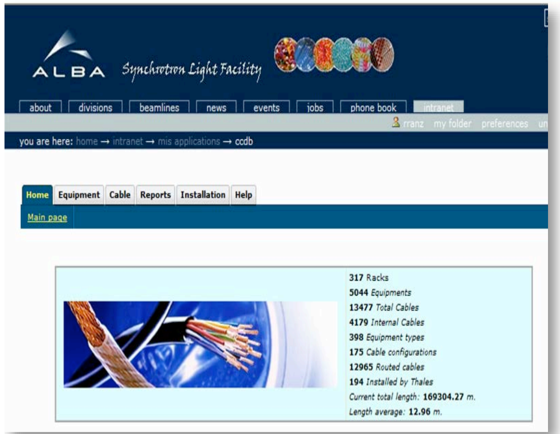

http://www.cells.es/Intranet/MISApps/ccdb/find_equip_network_info

Getting Started Latest Headlines BLISS Talks — ESRF

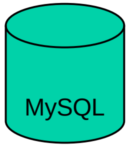
1481	LI-DI-LIB-RKA04A04-01	Instrumentation Technologies LIBERA Electron	ETH1						
1482	LI-DI-LIB-RKA04A04-01	Instrumentation Technologies LIBERA Electron	ETH3						
1483	LT-CT-CPCI-RKA04A03-01	ALBA cPCI-30	ETH1	cdi0403	00:30:64:06:E9:BC	84.89.238.2	YES	YES-ALBA02	rsune
1484	LT-CT-CPCI-RKA04A03-01	ALBA cPCI-30	ETHCM						
1485	LT-CT-CPCI-RKA04A03-01	ALBA cPCI-30	ETH2						
1486	LT-CT-CPCI-RKA04A04-01	ALBA cPCI-98	ETH1	cdi0404	00:30:64:06:E9:DA	84.89.238.3	YES	YES-ALBA0	rsune
1487	LT-CT-CPCI-RKA04A04-01	ALBA cPCI-98	ETHCM						
1488	LT-CT-CPCI-RKA04A04-01	ALBA cPCI-98	ETH2						
1489	LT-CT-IPAP-RKA04A07-01	ESRF IcePAP MASTER-1	ETH	icedi0401	00:0C:C6:76:01:C7	84.89.238.81	YES	NO	gcuni
1490	LT-DI-FSOTR-T01-01	ALBA DI FSOTR	ETH1	dccd0401		84.89.235.21	YES	NO	sblanch
1491	LT-DI-FSOTR-T01-02	ALBA DI FSOTR	ETH1						
1492	LT-DI-FSOTR-T01-03	ALBA DI FSOTR	ETH1						
1493	LT-DI-FSOTR-T02-01	ALBA DI FSOTR	ETH1	dccd0402		84.89.235.22	YES	NO	sblanch
1494	LT-DI-LIB-RKA04A04-01	Instrumentation Technologies LIBERA Electron	ETH2						
1495	LT-DI-LIB-RKA04A04-01	Instrumentation Technologies LIBERA Electron	ETH1						
1496	LT-DI-LIB-RKA04A04-01	Instrumentation Technologies	ETH3						



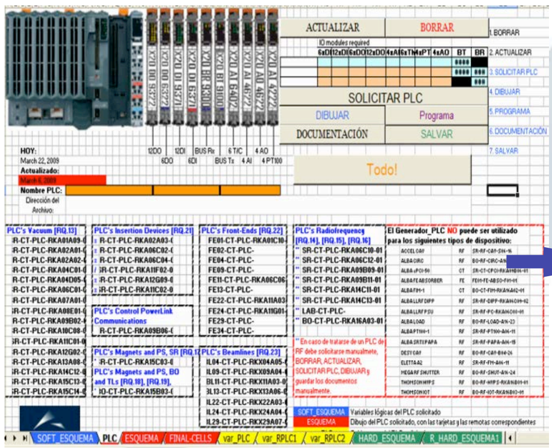
Configuration Management



ALBA ccdb DB



Automatic Equipment Protection System code generation (PLC)



XLS – VBasic script

VBasic

XLS

XLS files

PLC documentation: I/F with devices, I/O channels assignation, etc.

PLC code generation:

PLC variables declaration

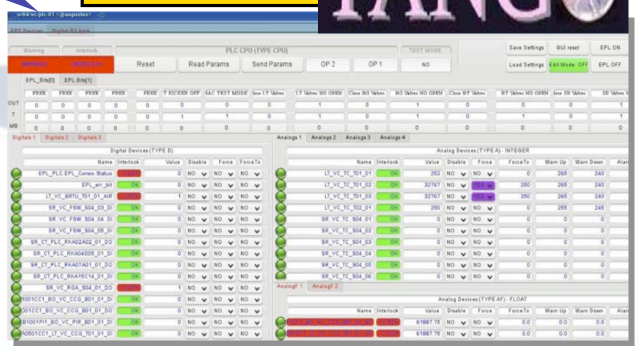
PLC Modbus mapping and variables allocation.

PLC standard services: disable and force variables, alarm/warning thresholds checking, permanent memory storage, etc.

Modbus Device Server

AlbaPLC Device Server

TANGO



Configuration Management

Currently ccdb does not implement:

- Traceability of each equipment position
- Traceability of each equipment instance
- Chronological logs of all changes.
- Stock management.

It is being studied the best way to implement the functionality linked with our current repository.

Configuration Management

Stock control:

An estimation of the initial stock of cabling and equipments needed have been done using Poisson distribution:

$$P = \sum_{n=0}^{s} \left[\frac{(K\lambda t)^n e^{-K\lambda t}}{n!} \right]$$

P= Probability of failure (different values depending if a part is considered critical)
K= Number of instances of each part
t= estimated delivery time
λ=1/MTBF
s= number of parts in stock

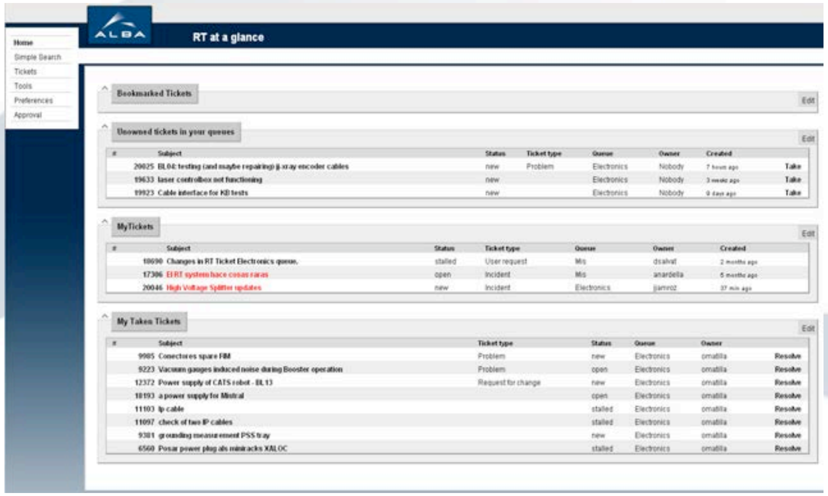
	Type	Installed Qty	ELECTRONICS	Electronics by Cells	CONTROLS	SYSTEM	PSS	RF	DIAGNOSTIC	FE	POWER SUPPLIES	Injection Devices	Engineering	VACUUM	BL04	BL09	BL11	BL13	BL22	BL24	BL29	BL34
48	ALBA COCON-1	15	YES								YES											
87	ALBA FIM-1	7	YES	YES																		
95	ALBA Interlock Board-1	32	YES						YES													
96	ALBA IPAP ENC-1	3	YES	YES																		
97	ALBA IPAP SWITCH-2	7	YES	YES																		
105	ALBA MUSHROOM PB-1	7	YES	YES											YES							
107	ALBA NT PAPA-1	308	YES												YES							
108	ALBA NT PAPA-2	217	YES			YES									YES							
109	ALBA PAPA ADC-1	29	YES	YES																		
110	ALBA PAPA ADC-3	12	YES	YES											YES							
111	ALBA PAPA BBB-1	1	YES	YES					YES													
112	ALBA PAPA BNC-1	2	YES	YES					YES													
113	ALBA PAPA BPM-1	120	YES	YES					YES													
114	ALBA PAPA BPM-2	3	YES	YES					YES													
115	ALBA PAPA CAT-1	7	YES	YES											YES							
116	ALBA PAPA CCD-1	24	YES	YES												YES						
117	ALBA PAPA DAC-2	7	YES	YES																		
118	ALBA PAPA DIO-1	4	YES	YES																		
119	ALBA PAPA FOFB-1	46	YES	YES					YES													
120	ALBA PAPA FRAME-1	27	YES	YES																		
121	ALBA PAPA GPIO-1	1	YES	YES																		
122	ALBA PAPA GPIO-2	3	YES	YES																		
123	ALBA PAPA LOCUM-1	12	YES	YES												YES						
124	ALBA PAPA RS485	7	YES	YES																		
125	ALBA PAPA Timing-1	1	YES	YES																		
126	ALBA PAPA Timing-2	27	YES	YES											YES							
127	ALBA PAPA Timing-3	84	YES	YES												YES						
128	ALBA PAPA VAC-1	1	YES	YES				YES														
130	ALBA PSITBO-2	38	YES																			
137	ALBA RGA PS	24	YES											YES								
138	ALBA SOCKET STRIP CTC-1	7	YES																			
140	ALBA TC TYPE T	561	YES																			
141	ALBA Timestamp Interface	1	YES																			
142	ALBA VC SPLITTER-1	20	YES																			
143	ALBA VC SPLITTER-2	63	YES																			

	Type	STOCK	SHELVES' POSITION	Price / unit	Total Cost Installed	Delivery Time (days)	Obsolete	Critical	Non Critical	Surface (m2)	Percentage of stock to purchase	Current Stock	Current Stock Cost	Initial Stock Target	Initial Stock to purchase	Initial Stock to purchase cost
48	ALBA COCON-1	#N/A	#N/A	500 €	7,500 €	90					10		0	2.0	2.0	1,000.0
87	ALBA FIM-1	#N/A	#N/A	2,000 €	14,000 €	90					10		0	1.0	1.0	2,000.0
95	ALBA Interlock Board-1	#N/A	#N/A	500 €	16,000 €	90					10		0	3.0	3.0	1,500.0
96	ALBA IPAP ENC-1	#N/A	#N/A	1,000 €	3,000 €	90					10		0	1.0	1.0	1,000.0
97	ALBA IPAP SWITCH-2	1	5B	1,000 €	7,000 €	90					10		0	1.0	1.0	1,000.0
105	ALBA MUSHROOM PB-1	#N/A	#N/A	1,000 €	7,000 €	90					10		0	1.0	1.0	1,000.0
107	ALBA NT PAPA-1	#N/A	#N/A	133 €	40,880 €	7	0	0			5	50	6,636	15.0	0.0	0.0
108	ALBA NT PAPA-2	#N/A	#N/A	30 €	6,510 €	7	0	0			5	50	1,500	11.0	0.0	0.0
109	ALBA PAPA ADC-1	0	4C	118 €	3,422 €	90					10		0	3.0	3.0	354.0
110	ALBA PAPA ADC-3	1	4B	120 €	1,440 €	90					10		0	1.0	1.0	120.0
111	ALBA PAPA BBB-1	#N/A	#N/A	90 €	90 €	90					10		0	1.0	1.0	90.0
112	ALBA PAPA BNC-1	4	4B	90 €	180 €	90					10		0	1.0	1.0	90.0
113	ALBA PAPA BPM-1	#N/A	#N/A	120 €	14,400 €	90					10		0	12.0	12.0	1,440.0
114	ALBA PAPA BPM-2	#N/A	#N/A	120 €	360 €	90					10		0	1.0	1.0	120.0
115	ALBA PAPA CAT-1	#N/A	#N/A	196 €	1,372 €	90					10		0	1.0	1.0	196.0
116	ALBA PAPA CCD-1	12	10B	180 €	4,320 €	90					10		0	2.0	2.0	360.0
117	ALBA PAPA DAC-2	#N/A	#N/A	120 €	840 €	90					10		0	1.0	1.0	120.0
118	ALBA PAPA DIO-1	#N/A	#N/A	120 €	480 €	90					10		0	1.0	1.0	120.0
119	ALBA PAPA FOFB-1	#N/A	#N/A	110 €	5,060 €	30	0	0			7		0	3.0	3.0	330.0
120	ALBA PAPA FRAME-1	#N/A	#N/A	80 €	2,160 €	30					7		0	2.0	2.0	160.0
121	ALBA PAPA GPIO-1	#N/A	#N/A	150 €	150 €	90					10		0	1.0	1.0	150.0
122	ALBA PAPA GPIO-2	2	4B	150 €	450 €	90					10		0	1.0	1.0	150.0
123	ALBA PAPA LOCUM-1	#N/A	#N/A	150 €	1,800 €	90					10		0	1.0	1.0	150.0
124	ALBA PAPA RS485	2	5A	150 €	1,050 €	90					10		0	1.0	1.0	150.0
125	ALBA PAPA Timing-1	#N/A	#N/A	853 €	853 €	30	0	0			7		0	1.0	1.0	853.0
126	ALBA PAPA Timing-2	#N/A	#N/A	205 €	5,535 €	30	0	0			7		0	2.0	2.0	410.0
127	ALBA PAPA Timing-3	#N/A	#N/A	80 €	6,720 €	30	0	0			7		0	6.0	6.0	480.0
128	ALBA PAPA VAC-1	#N/A	#N/A	150 €	150 €	90					10		0	1.0	1.0	150.0
130	ALBA PSITBO-2	1	5A	400 €	15,200 €	90					10		0	4.0	4.0	1,600.0
137	ALBA RGA PS	#N/A	#N/A	100 €	2,400 €	90					10		0	2.0	2.0	200.0
138	ALBA SOCKET STRIP CTC-1	#N/A	#N/A	90 €	630 €	90					10		0	1.0	1.0	90.0
140	ALBA TC TYPE T	#N/A	#N/A	10 €	5,610 €	30					7		0	39.0	39.0	390.0
141	ALBA Timestamp Interface	#N/A	#N/A	500 €	500 €	90					10		0	1.0	1.0	500.0
142	ALBA VC SPLITTER-1	#N/A	#N/A	2,000 €	40,000 €	90					10		0	2.0	2.0	4,000.0
143	ALBA VC SPLITTER-2	#N/A	#N/A	1,500 €	94,500 €	90					10	2	3,000	6.0	4.0	6,000.0

Maintenance procedures

Currently a complete tracking of all the interventions is done using an open software tool:

- Work orders generation (only electronically)
- Email & communication implementation
- Record time invested to solve each ticket
- Classify work orders as
  - Type: Problem, Incident, User request, request for change
  - Service: 22 different services
  - Unit: 29 different units (beamlines, RF, …)



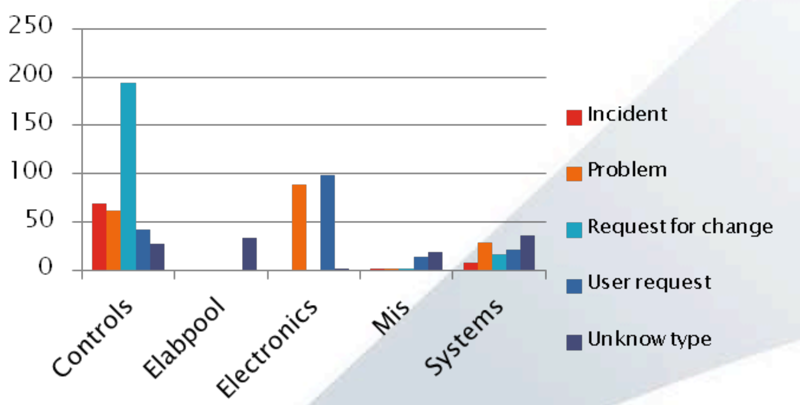
Maintenance procedures

Indicators measure are already implemented and periodically evaluated:

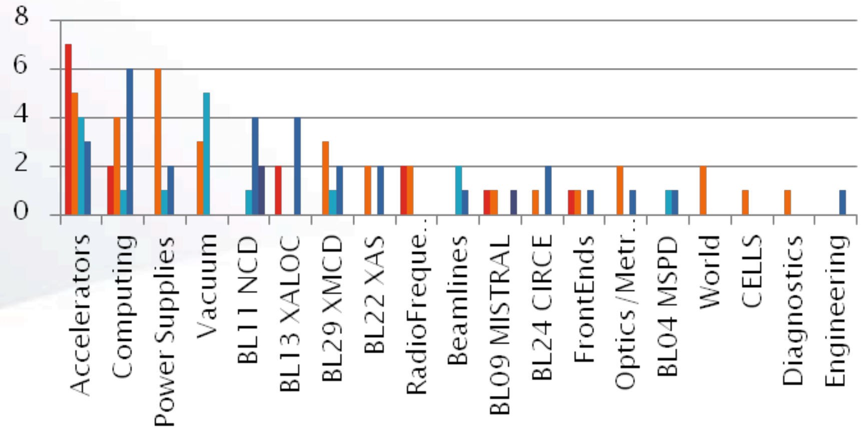
Time response

Resources invested in each unit

Average Time To Resolve (Hours)



Number of Request per Unit



Using this tool for implementing corrective maintenance seems a good option. But currently it has clear limitations for implementing preventive maintenance or calibration plan.

Maintenance procedures

A list of all maintenance operations have been done, and inserted in the accelerator operation calendar. Including:

- All control equipments.
- Equipment Protection System.
- Preventive earthing tests.
- Personal Safety System Maintenance – Directly agreed with CSN (2wk/year)
- Network maintenance.

Minimizing users impact as edges switches have redundant connections.

Conclusions:

- Different tools have been developed and successfully being used during installation & commissioning period.
- New exploitation phase involves new needs that currently are not fulfilled. It is currently being checked which of the possible solutions can be used to implement those needs.
- An estimation of the stock needs for initial exploitation phase has been done.
- The list of all maintenance activities for 2012 has been done and inserted in the accelerator operation calendar.

Talk outline

- Overview of ALBA Building and utilities.
- Building and utilities current maintenance approach.
- Computing and control current maintenance approach
- Condition Based Maintenance introduction study

Motivation to explore the viability of CBM approach implementation

- Particularities of the scientific research facilities operation and design (fast variable load, high availability, redundancy,..) brings to an scenario where the conventional industrial approach to maintenance is not adequate.
- Increase reliability.
- Decrease cost.
- Decrease at minimum not programmed shutdowns.
- Increase predictability to optimize the programmed shutdown activities.

Main requests to the system wrt failures.

- measure
- control
- alarm generation
- archiving
- diagnostic
- support to maintenance decisions

Three modules are defined.

- Measure system
- Alarm and diagnostic system
- Support to decision system

Modules to be implemented in the framework of the operations (SCADA) and maintenance (CMMS) ALBA scheme

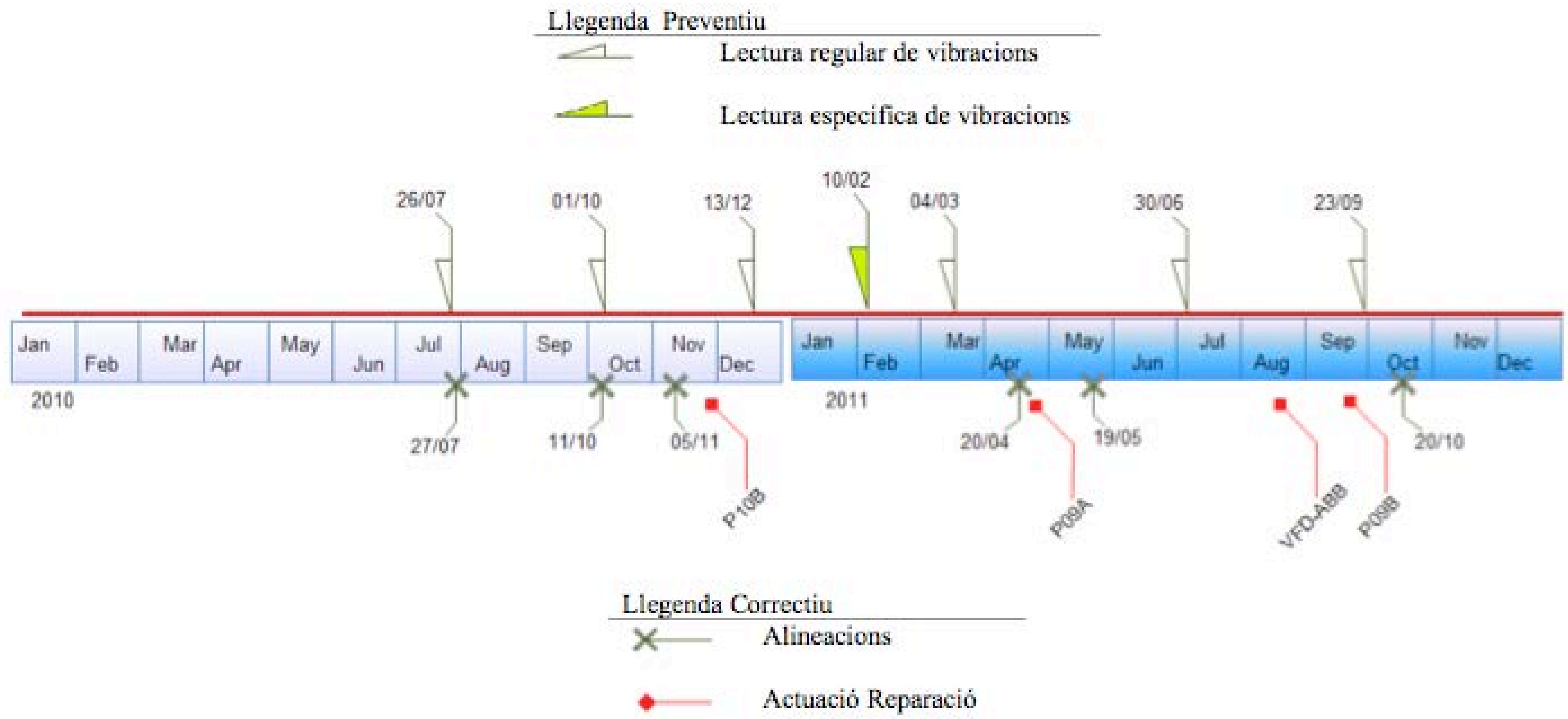
The pumps of the cooling and HVAC systems are choose as study case. Motivation

- critical for the facility
- literature availability
- real data availability

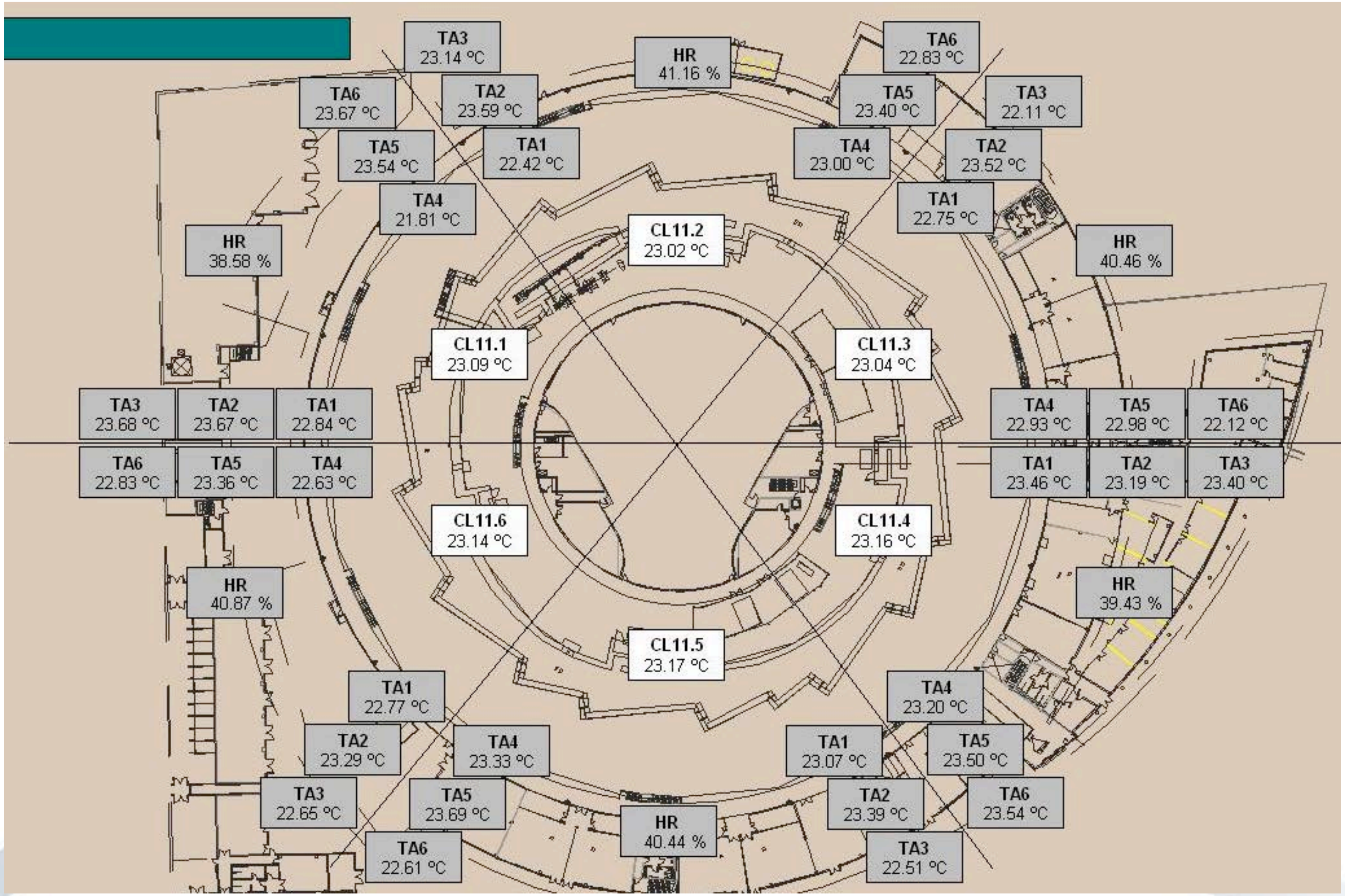
Measure system. Shall combine information coming from the instrumentation associated to the control utilities system and information coming from the field. The parameters considered are:

- pressure
- flow
- vibrations
- temperature
- power consumption
- Torque and rotation speed

Registre:



Llegenda Preventiu
Lectura regular de vibracions
Lectura especifica de vibracions
26/07
01/10
13/12
10/02
04/03
30/06
23/09
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2010
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2011
27/07
11/10
05/11
P10B
20/04
P09A
19/05
VFD-ABB
P09B
20/10
Llegenda Correctiu
Alineacions
Actuació Reparació

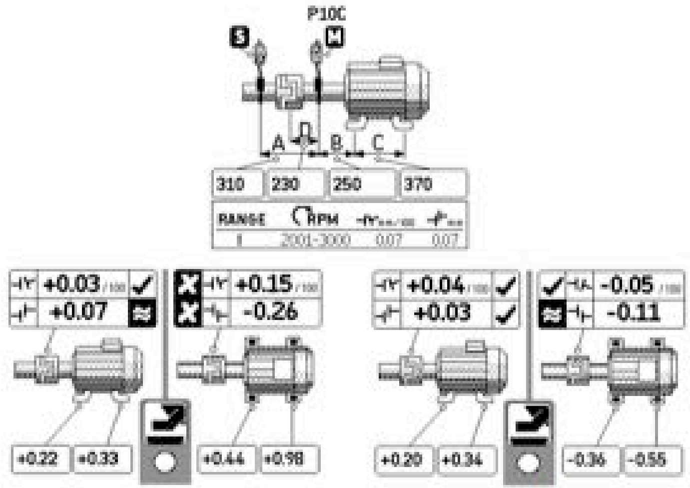

TA3 23.14 °C
HR 41.16 %
TA6 22.83 °C
TA6 23.67 °C
TA2 23.59 °C
TA5 23.40 °C
TA3 22.11 °C
TA5 23.54 °C
TA1 22.42 °C
TA4 23.00 °C
TA2 23.52 °C
TA4 21.81 °C
TA1 22.75 °C
CL11.2 23.02 °C
HR 38.58 %
HR 40.46 %
CL11.1 23.09 °C
CL11.3 23.04 °C
TA3 23.68 °C
TA2 23.67 °C
TA1 22.84 °C
TA4 22.93 °C
TA5 22.98 °C
TA6 22.12 °C
TA6 22.83 °C
TA5 23.36 °C
TA4 22.63 °C
TA1 23.46 °C
TA2 23.19 °C
TA3 23.40 °C
CL11.6 23.14 °C
CL11.4 23.16 °C
HR 40.87 %
HR 39.43 %
CL11.5 23.17 °C
TA1 22.77 °C
TA4 23.20 °C
TA2 23.29 °C
TA4 23.33 °C
TA1 23.07 °C
TA5 23.50 °C
TA3 22.65 °C
TA5 23.69 °C
HR 40.44 %
TA2 23.39 °C
TA6 23.54 °C
TA6 22.61 °C
TA3 22.51 °C

Actuacions de reparació:

- P10B
- P09A
- Variadors de freq. a les 12 bombes.
- P09B

Alineació (2010- 2011)

	P08B	P08C	P09A	P10A	P10B	P10C	P11A	P11B
1.		x					x	x
2.								x
3.				x	x			
4.	x	x		x	x			x
5.			x					
6.						x		



Abans després

Classificació Norma ISO-10816-3-2009

Severity		Range Limits and Machine Classes ISO Standard 10816.3 (2009)				Severity	
r.m.s. displacement µm	r.m.s. velocity mm/s	Group 2: Medium Sized Machines		Group 1: Large machines		r.m.s. velocity mm/s	r.m.s. displacement µm
		Rigid	Flexible	Rigid	Flexible		
22	1.4	A	A	A	A		
32	2.3	B	A	A	A	2.3	29
45	2.8	B	B	B	A		
71	4.5	C	B	B	A	3.5	45
		C	B	B	B	4.5	57
113	7.1	D	C	C	B	7.1	90
		D	D	D	C	11.0	140
		D	D	D	D		

Presentació estandar dels resultats seguint la norma ISO

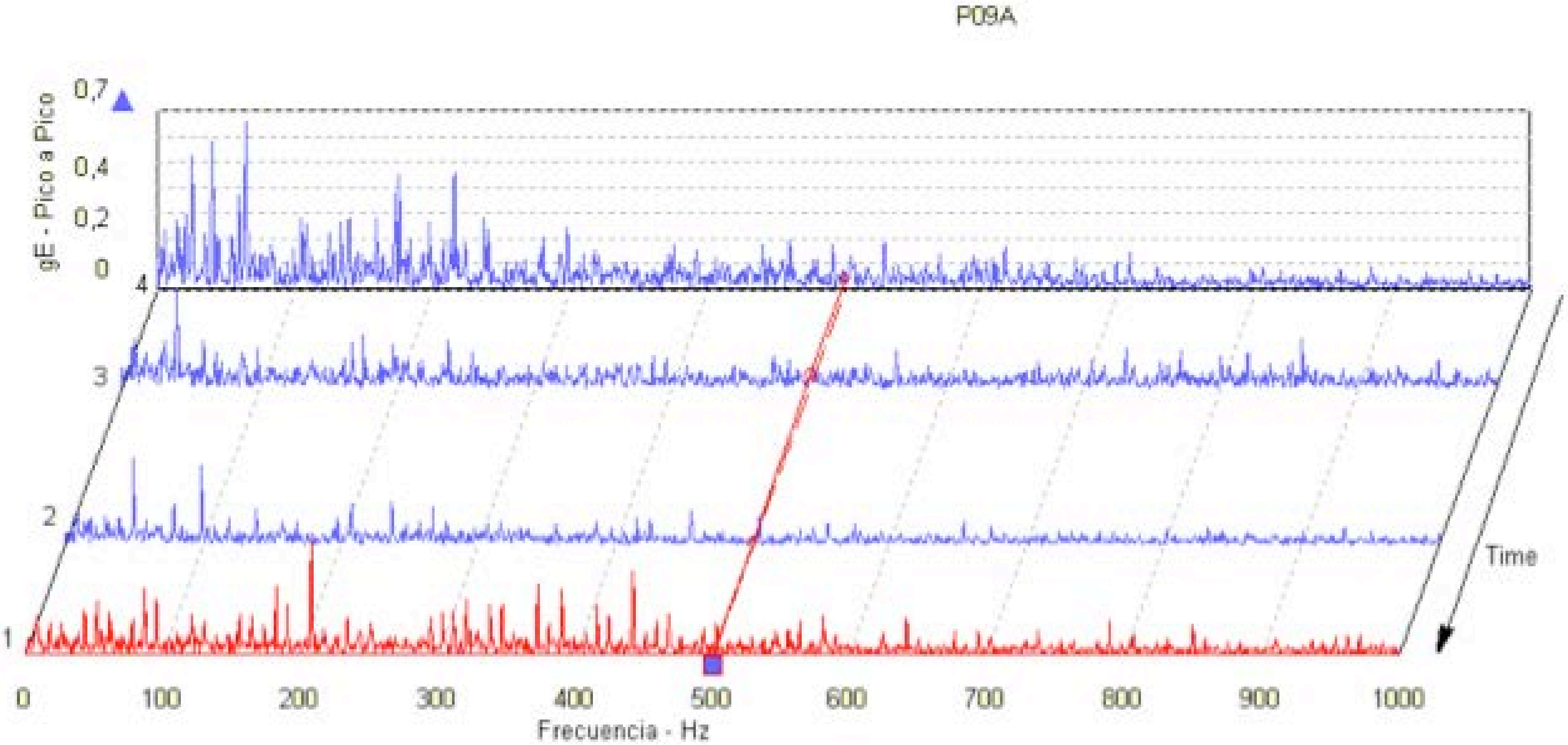
TABLA 1
Severidad en las ubicaciones siguientes de planta:

PLANTA	UBICACIÓN	ESTADO		
		Anterior	Actual	Alarma
AREA EXP	P07A	1	0	
	P07B	3	0	
STORAGE	P08A	3	3	
	P08B	3	3	
	P08C	1	3	
BOOSTER	P09A	3	3	
	P09B	1	1	A2
AREA SERVEI	P10A	3	3	
	P10B	1	1	A2
	P10C	1	1	A2
RETORN	P11A	3	3	
	P11B	3	3	
UTA´S TUNEL	P12A	3	3	
	P12B	3	3	
UTA´S BL	P13A	3	3	
	P13B	3	0	
UTA´S EXP	P14A	3	0	
	P14B	3	3	
UTA´S LABS OFF	P15A	3	3	
	P15B	3	0	
	P15C	3	3	

PLANTA	UBICACIÓN	ESTADO		
		Anterior	Actual	Alarma
UTA´S AREA EXP	P17A	3	3	
	P17B	3	0	
UTA´S LAB OFI	P18A	3	0	
	P18B	0	3	
INTER-TORRES	P20A	0	0	
	P20B	0	0	
FRED-COGEN	P30A	3	3	
	P30B	3	3	
	P30C	3	0	
CALOR - COGENER	P31A	2	3	
	P31B	3	0	

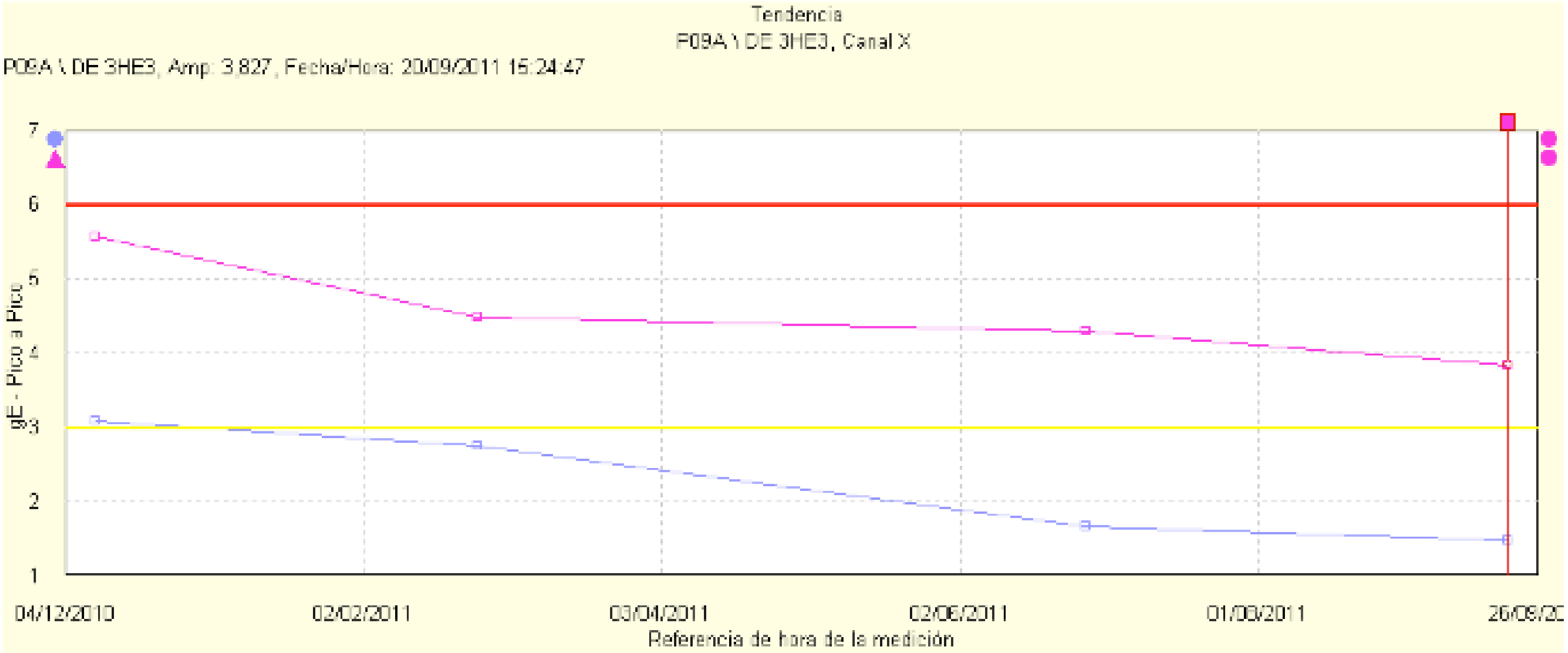
1	A2	Equipo en condiciones severas de vibración. Intervención inmediata.
	A1	Equipo con valores de vibración en estado de alarma. Seguimiento e intervenciones a medio/corto plazo.
2		Equipo en observación. Esperar a conocer su evolución.
3		Equipo en funcionamiento normal.
0		Equipo sin medición.

Exemple de espectre de vibracions de la bomba P09A en les quatre últimes mesures.



1 (vermell) → variadors de frequencia
2 → despres de reparació
3 → Després alineacio
4 → Estat a inici any

Evolució de vibració global de la bomba P09A en les ultimes 4 medicions.



Alarm generation and failure diagnostic system.

- alarm generation embedded in in the control system, generated from parameters internal and external parameters

- the limits of the parameters deviate from the control range, a potential failure alarm is generated. The alarm shall be considered wrt the historical data from the CMMS (work orders knowledge) and RCM (Reliability Condition Maintenance, reliability knowledge).

- the limits of the parameters deviate from the control range up to a critical level, a functional failure alarm is generated that implies the emergency stop of the equipment.

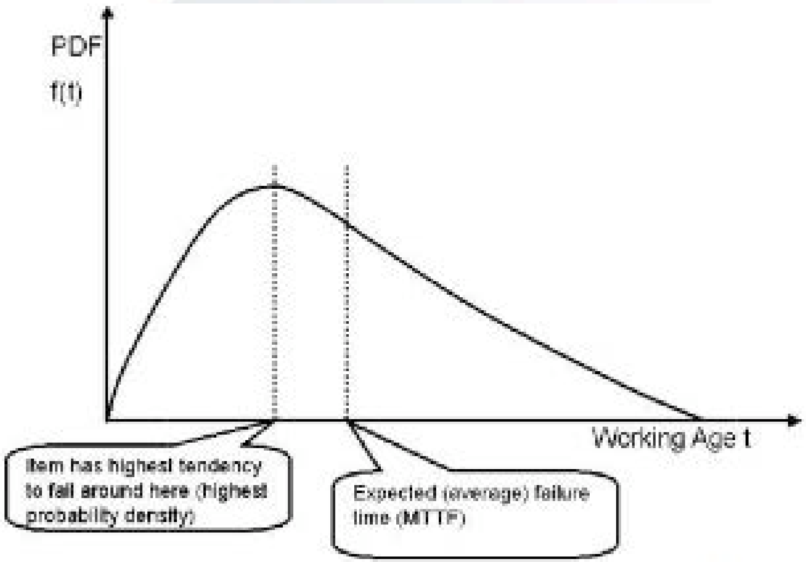


Figure 2 La función de densidad de probabilidad de fallo

Data Collection

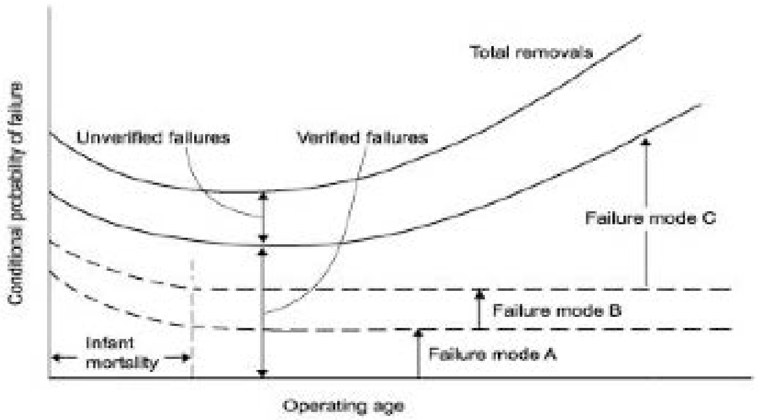


Figure 3 La probabilidad condicionada de fallo

Failure analysis

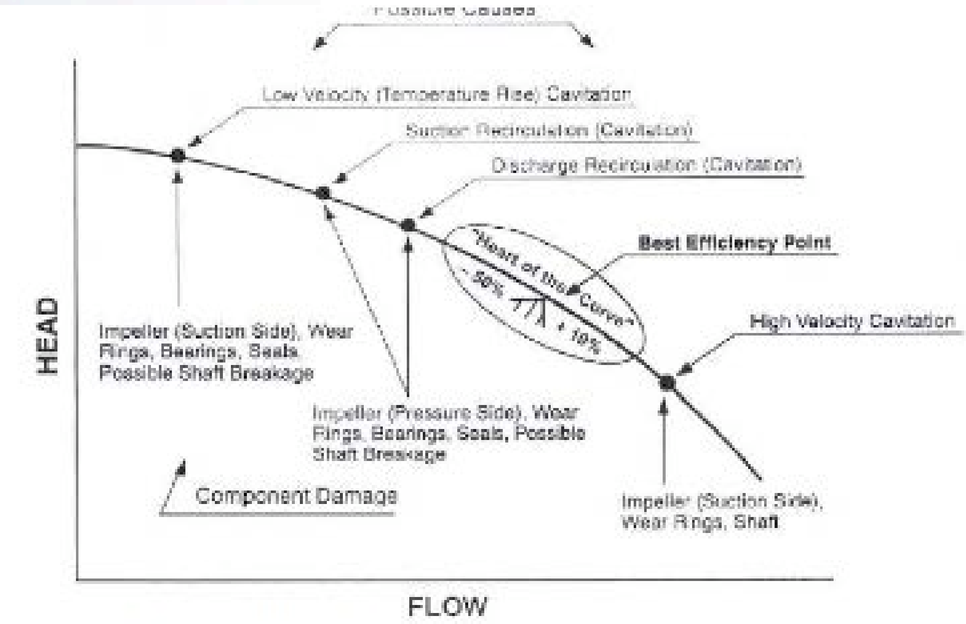


Figure 4 Gráfica para el análisis de causas de fallo según el punto de trabajo operativo de la bomba

Support to decision system. Once a potential failure alarm has been generated the system shall combine the following information

- component diagnostics based on the operative measurements of the component and the process.
- information about the lifetime behaviour of the component (CMMS historical data)
- Failure probability in the future. Weibull analysis.
- Estimation of remaining lifetime
- Data on the cost associated to unexpected failure and preventive maintenance.

Graphs are generated to asses the decision making process

Green. Continue operation

Yellow. Plan intervention

Red. Emergency intervention

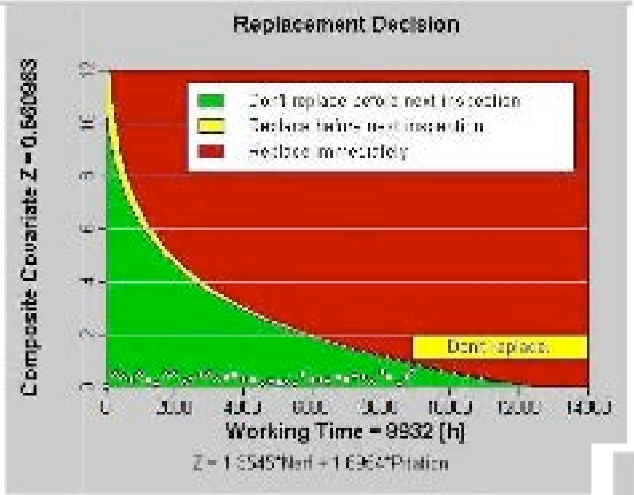


Figure 5 A Replacement Decision Report

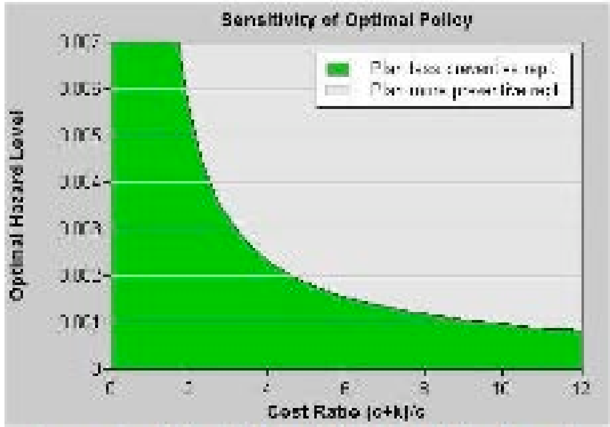


Figure 6 A Sensitivity of Optimal Policy Report

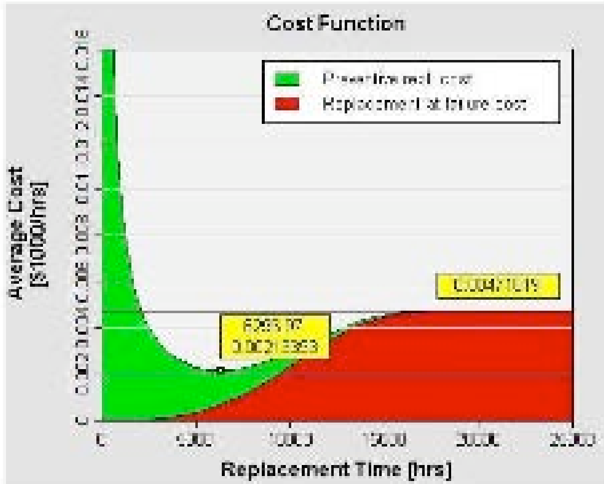


Figure 7 A Cost Function Report

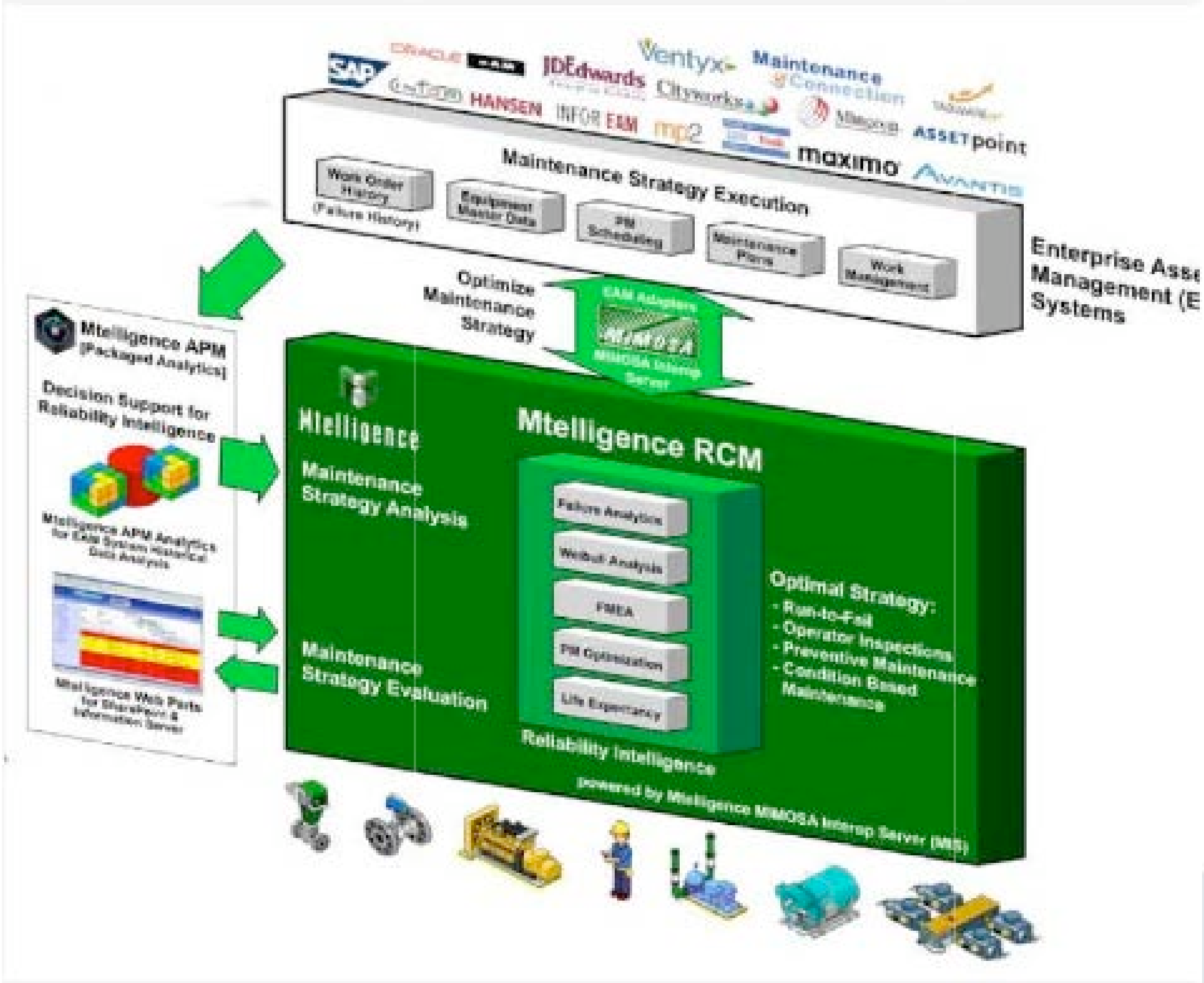


Figure 8 Mtelligence RCM

Current status.

- Commercial available software market survey done. Benchmarking going one.
- Data mining subroutines for the scada data extraction ready
- Vibrations analysis hardware market survey done and equipment selected.
- Collecting work orders data.
- In parallel, looking at the convenience of applying the methodology to scientific equipment (i.e. Power converters)