ITER & CODAC Status Update

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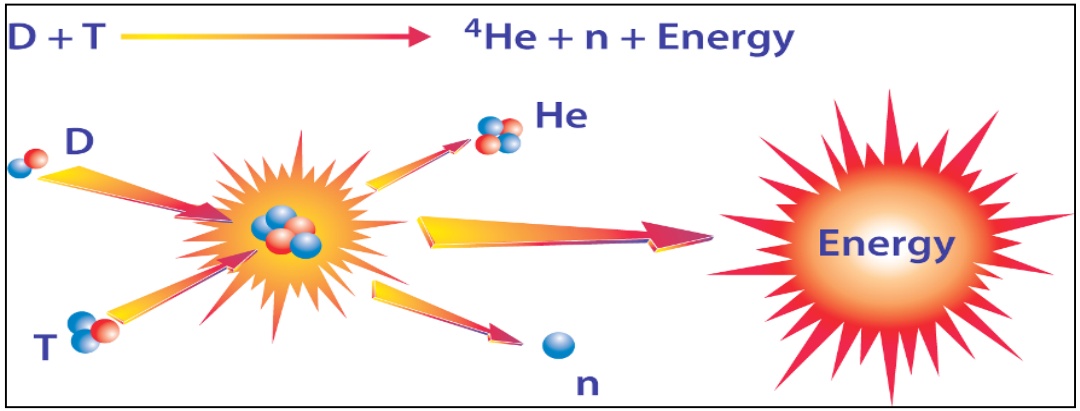
ITER Organization

Disclaimer: The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

Introduction

- Demonstrate technical feasibility of nuclear fusion as energy source



- Lawson criterion: Temperature * Density * Time > Big Number

- ITER is an international project based on in-kind contributions

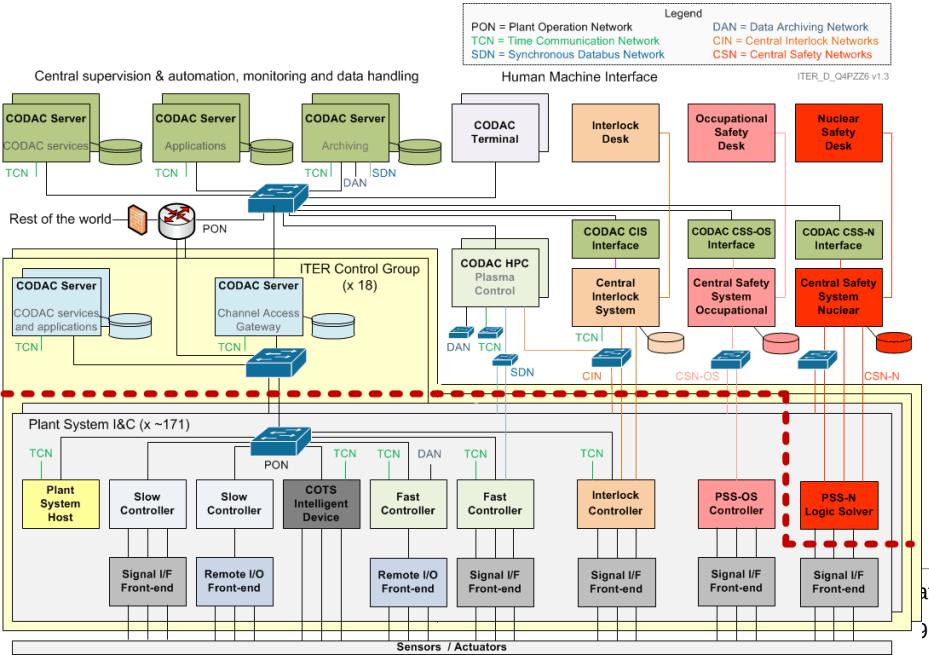
Introduction

The big news since last EPICS collaboration meeting:

ITER Control System
started 24/7 operation on
January 26, 2019

ITER Control System Architecture recap.

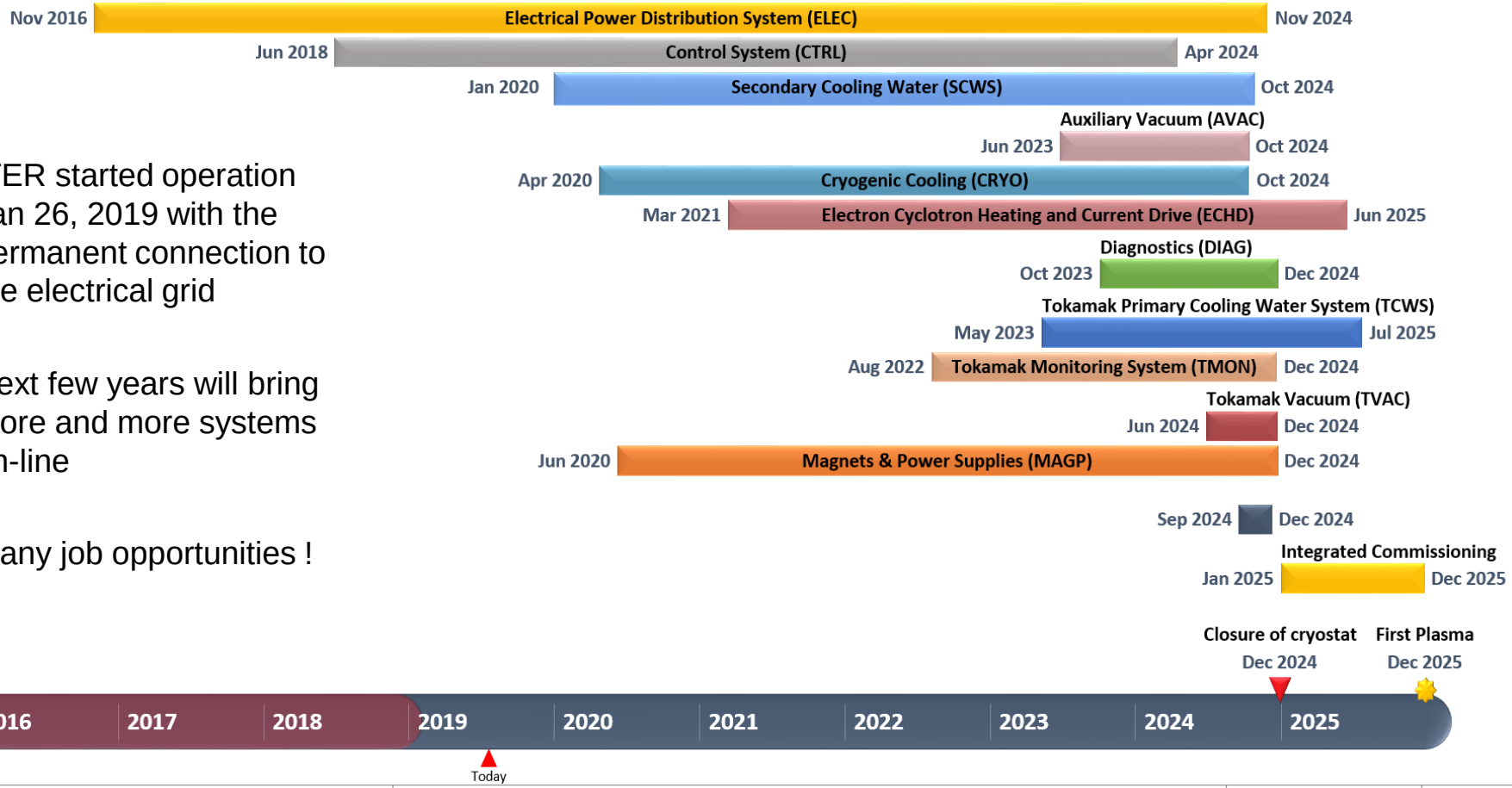
- 18 subsystems
- 171 local control system
- 101 in-kind suppliers
- Millions of PV’s



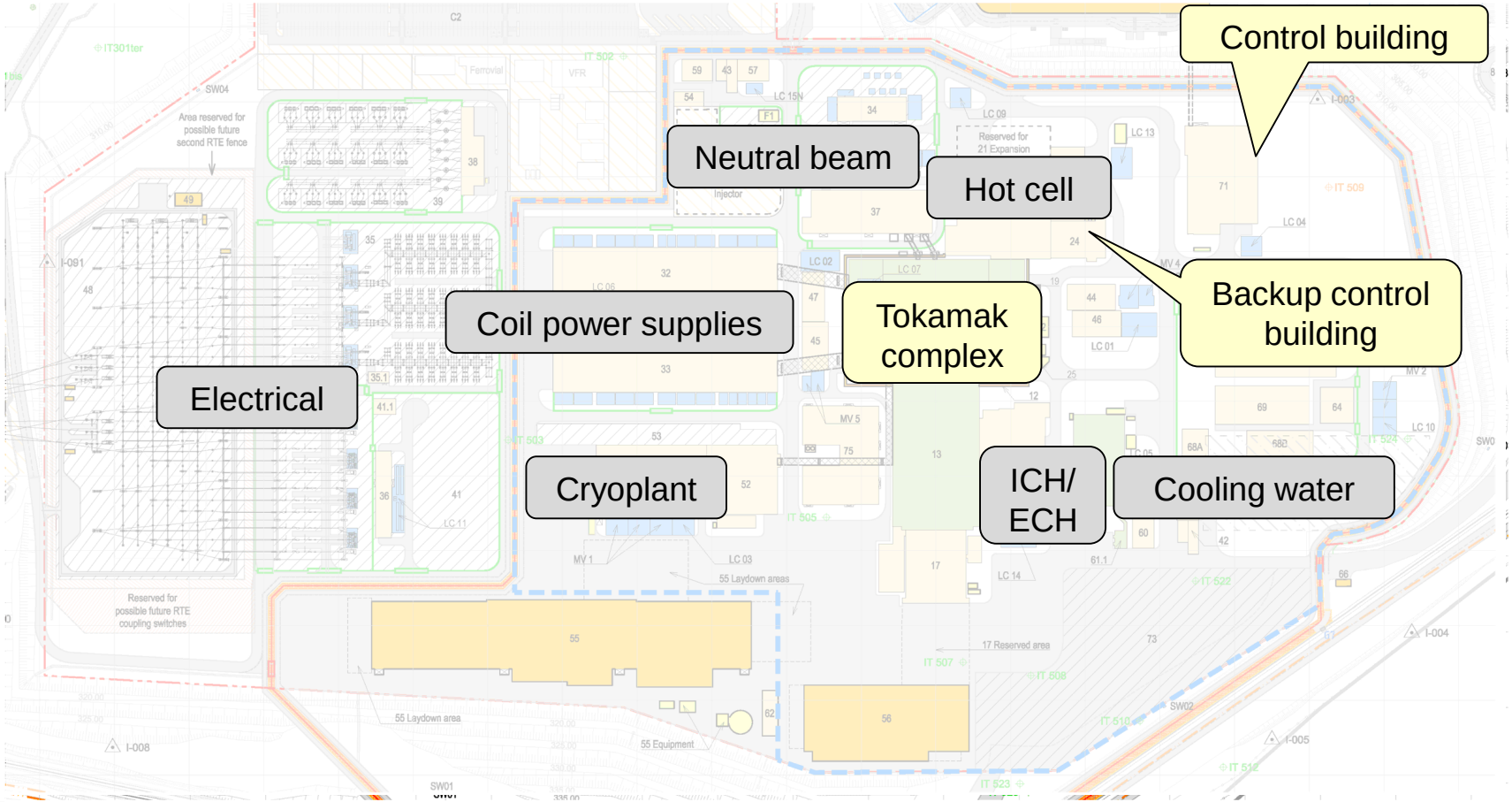
- Our EPICS distribution is called CODAC Core System, released yearly (latest v6.1) and distributed to all in-kind suppliers
- We are starting exploring EPICS 7 for higher level applications

Commissioning Schedule

- ITER started operation Jan 26, 2019 with the permanent connection to the electrical grid
- Next few years will bring more and more systems on-line
- Many job opportunities !

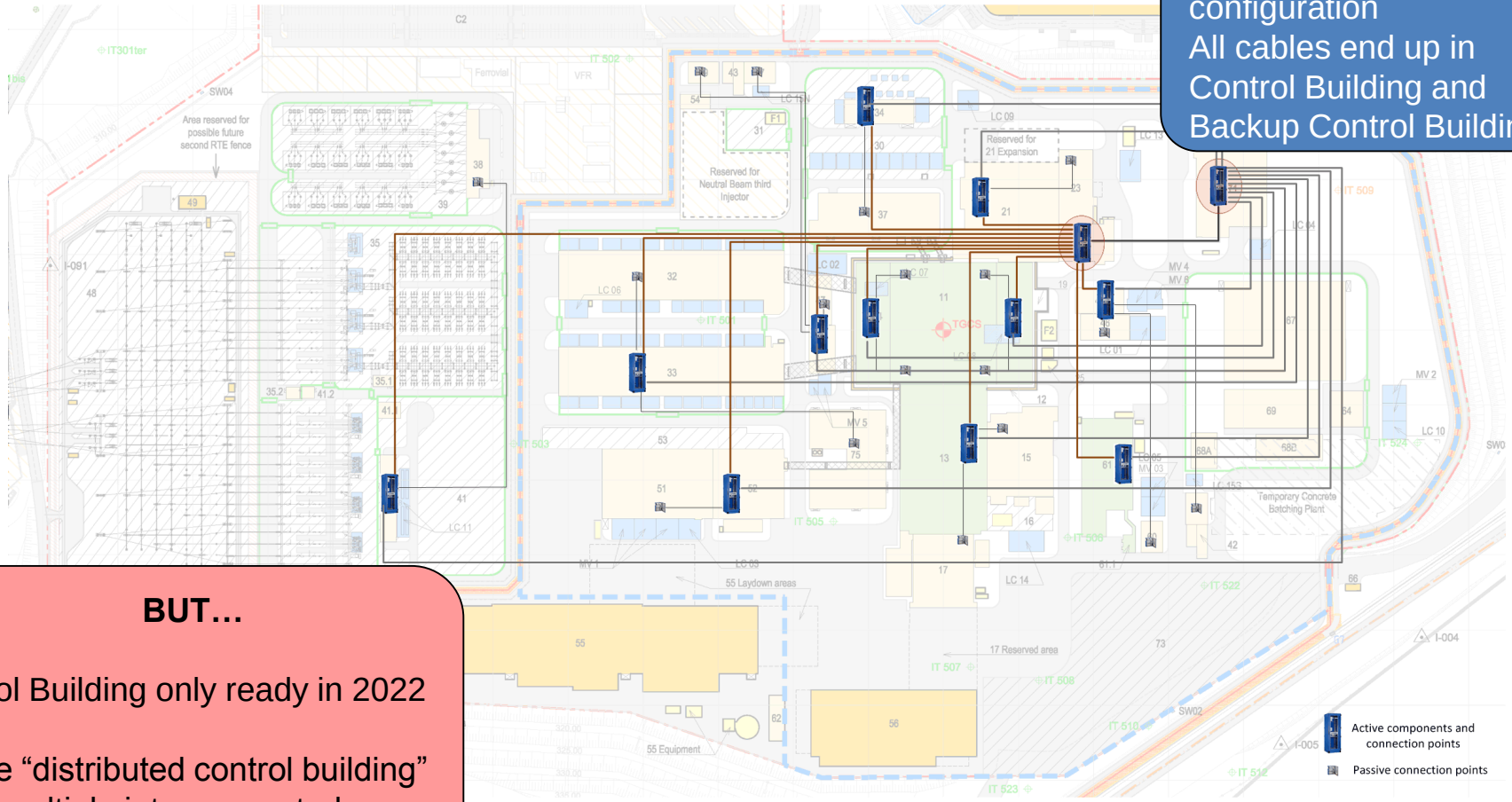


Infrastructure



Infrastructure

Redundant dual star configuration
All cables end up in Control Building and Backup Control Building



BUT…

Control Building only ready in 2022

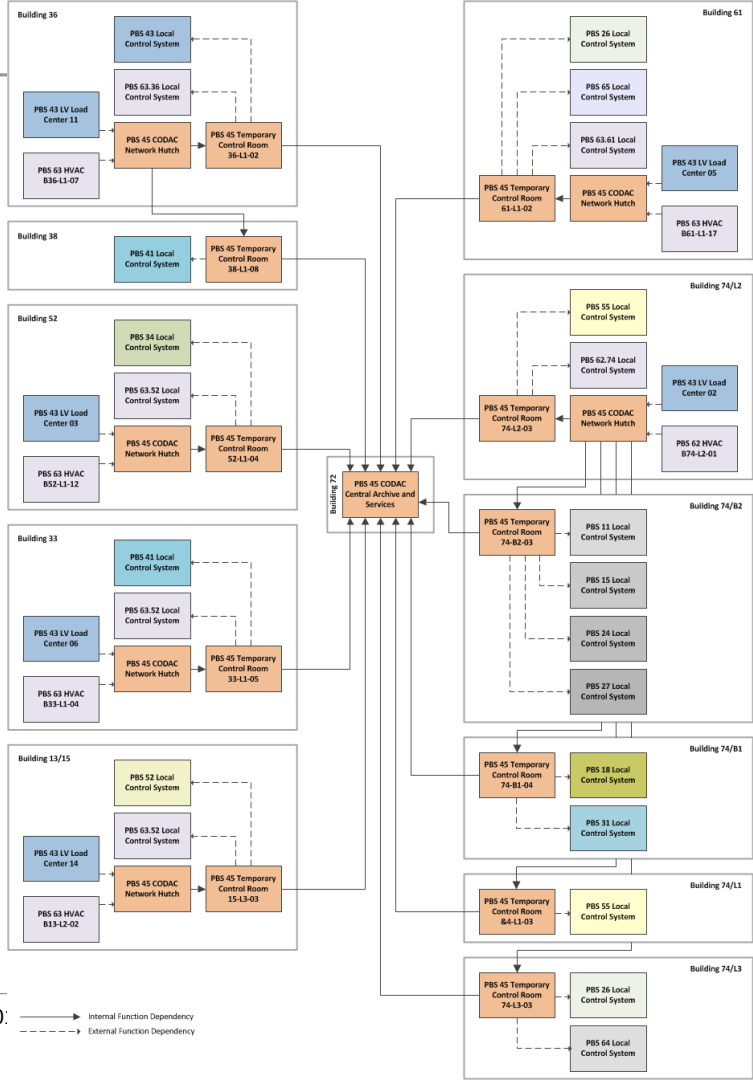
Create “distributed control building” using multiple interconnected “Temporary Control Rooms”

Temporary Control Rooms

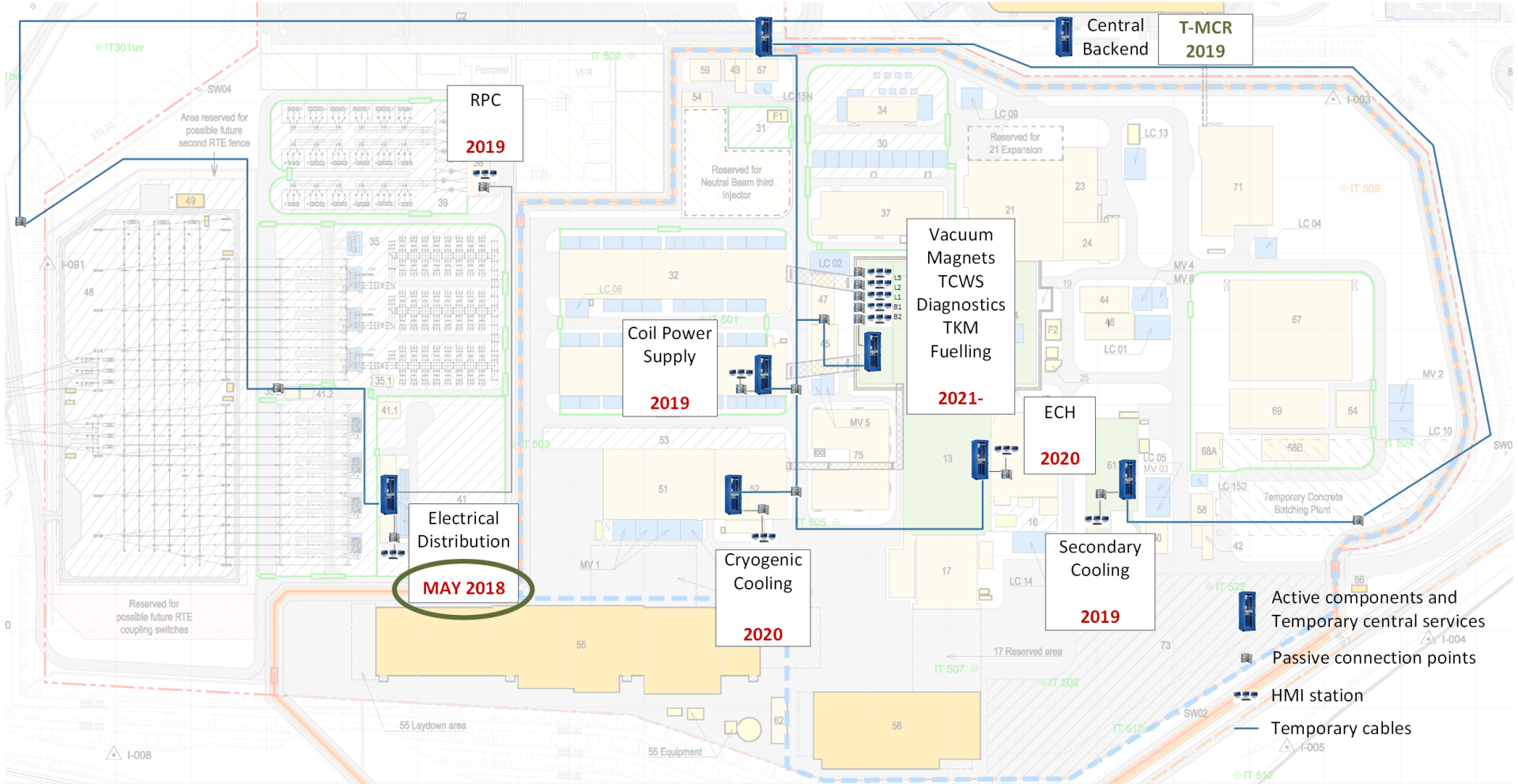
11 TCR's in 6 buildings interfacing all first plasma plant systems

Functions provided as services to the plant systems:

- Human Machine Interface
- Data handling including archiving, storage and access
- Inter plant communication
- Role based access control
- Alarm handling including notification
- Time synchronization
- Electronic logbook
- Access to central software repository and issue tracking (configuration control)
- Development stations for software updates (fast turn-around)
- Central supervision and monitoring
- Access to archived data from office



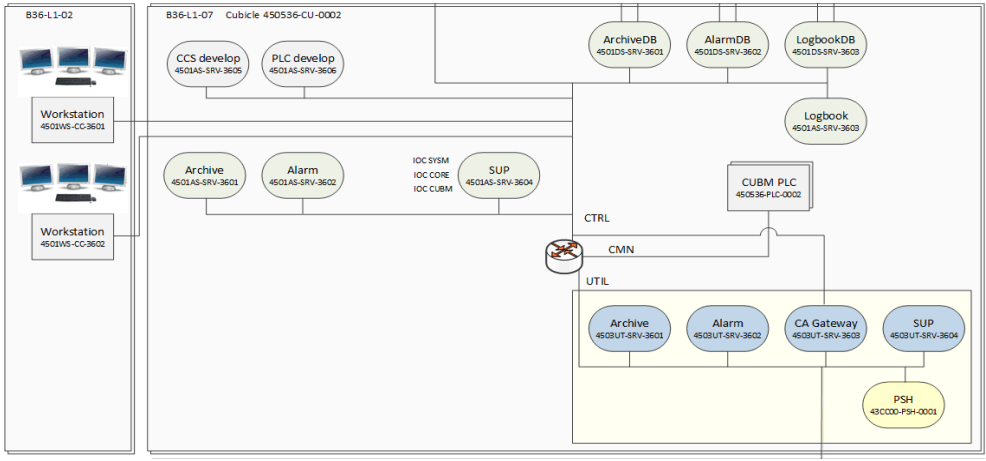
Temporary Control Rooms - Schedule



Electrical – First plant system

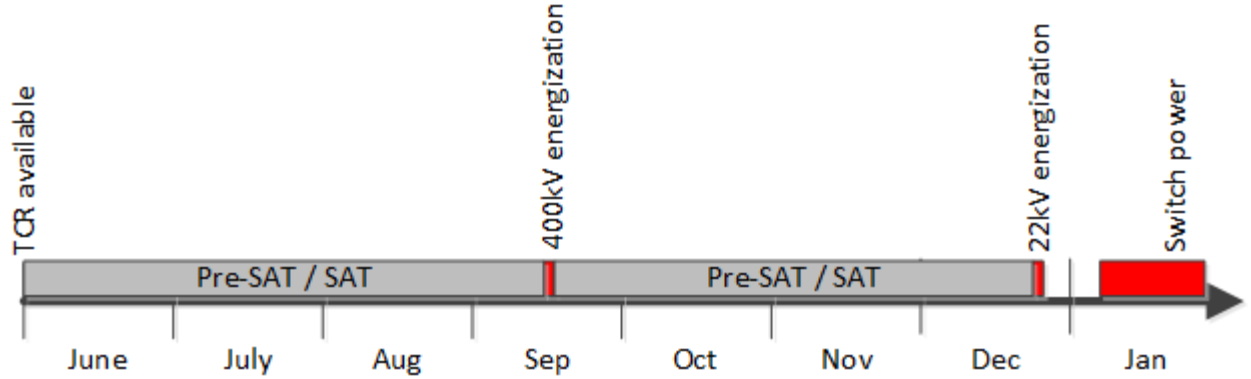
Central back-end in B07/B72 providing central archive, remote monitoring and alarm relaying

Temporary control room located in B36 with around 15 servers (VM) and two HMI workstations



UTIL-HV plant system comprising 88 Intelligent Electronic Devices (IED's) connected together by an IEC 61850 network using 21 switches and interfaced to CODAC via a WinCC-OA gateway using OPC-UA. It has a total of 6873 process variables, 2533 defined alarms and 35 Operator Interface (OPI) panels.

Electrical – First plant system in operation



Major milestones:

- Jun 1, 2018 – B36 TCR operational
- Sep 17/18, 2018 – 400 kV energization
- Dec 21, 2018 – 22 kV energization
- Jan 26, 2019 – Switch off CEA power

Many Actors:

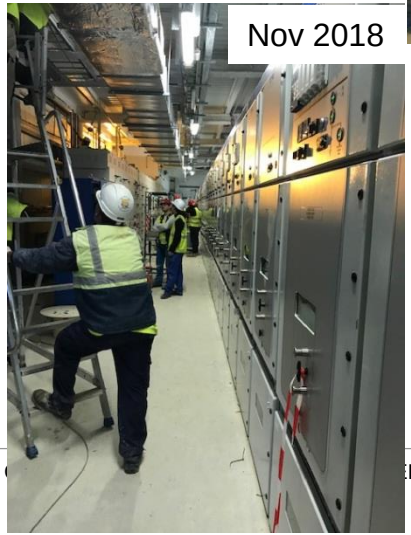
- F4E I&C
- GTD
- Engage
- SSEN I&C
- CSD I&C and codac_adm
- TCS
- TB06
- TB06 subcontractors (Siemens etc.)
- SSEN client
- Commissioning and Operation

Electrical – First plant system


July 2018

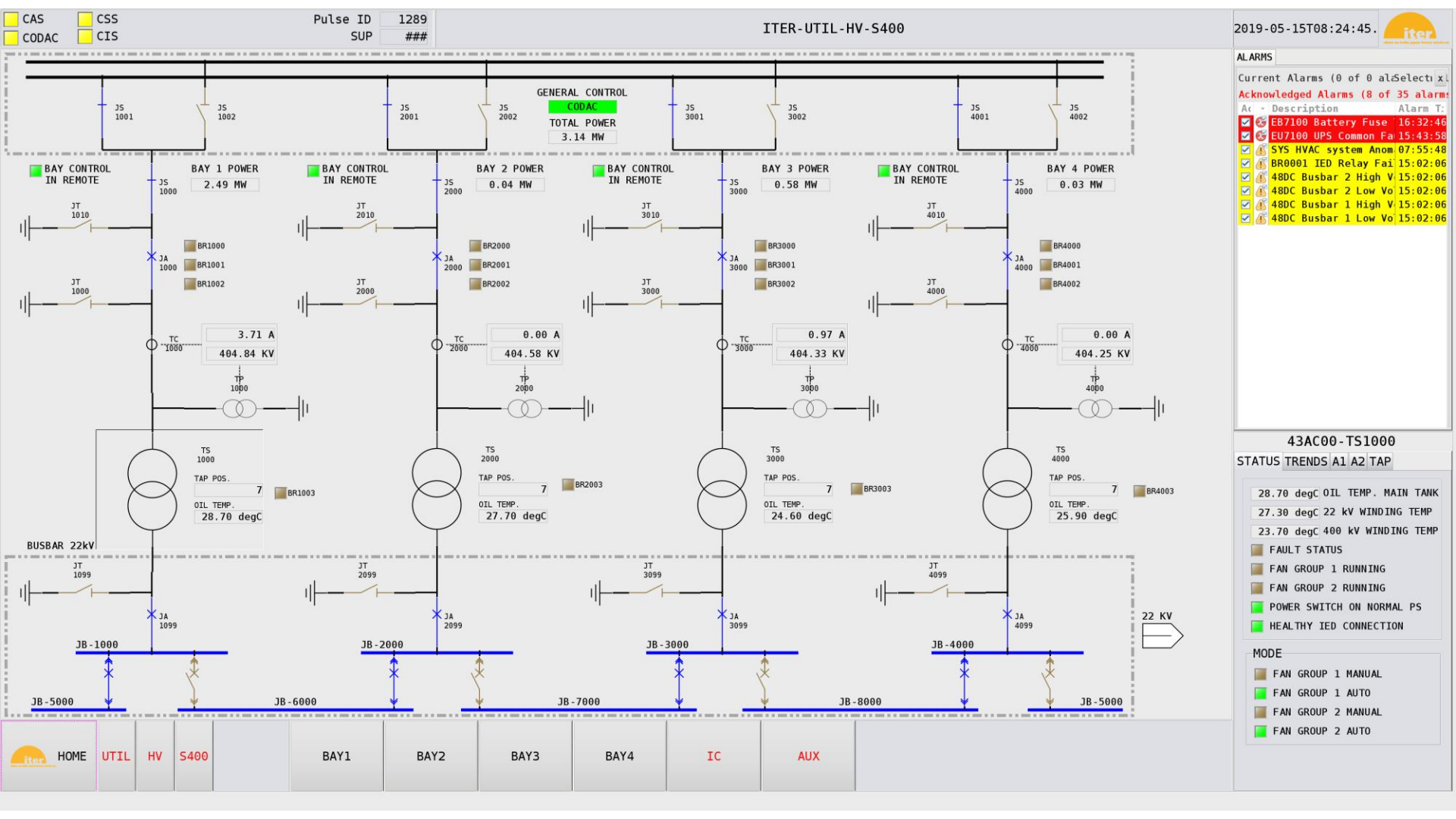

July 2018

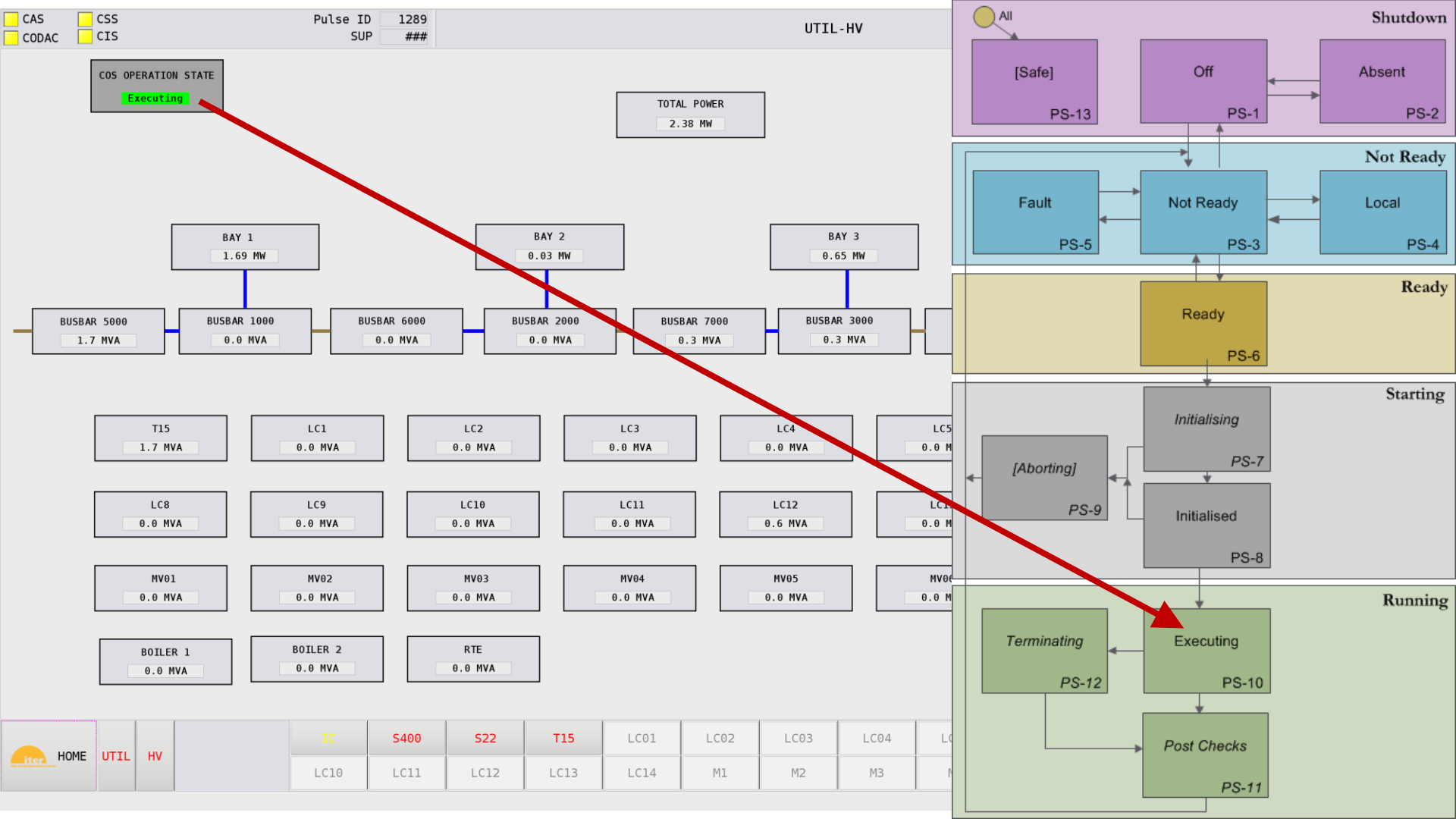

Sep 2018


Nov 2018

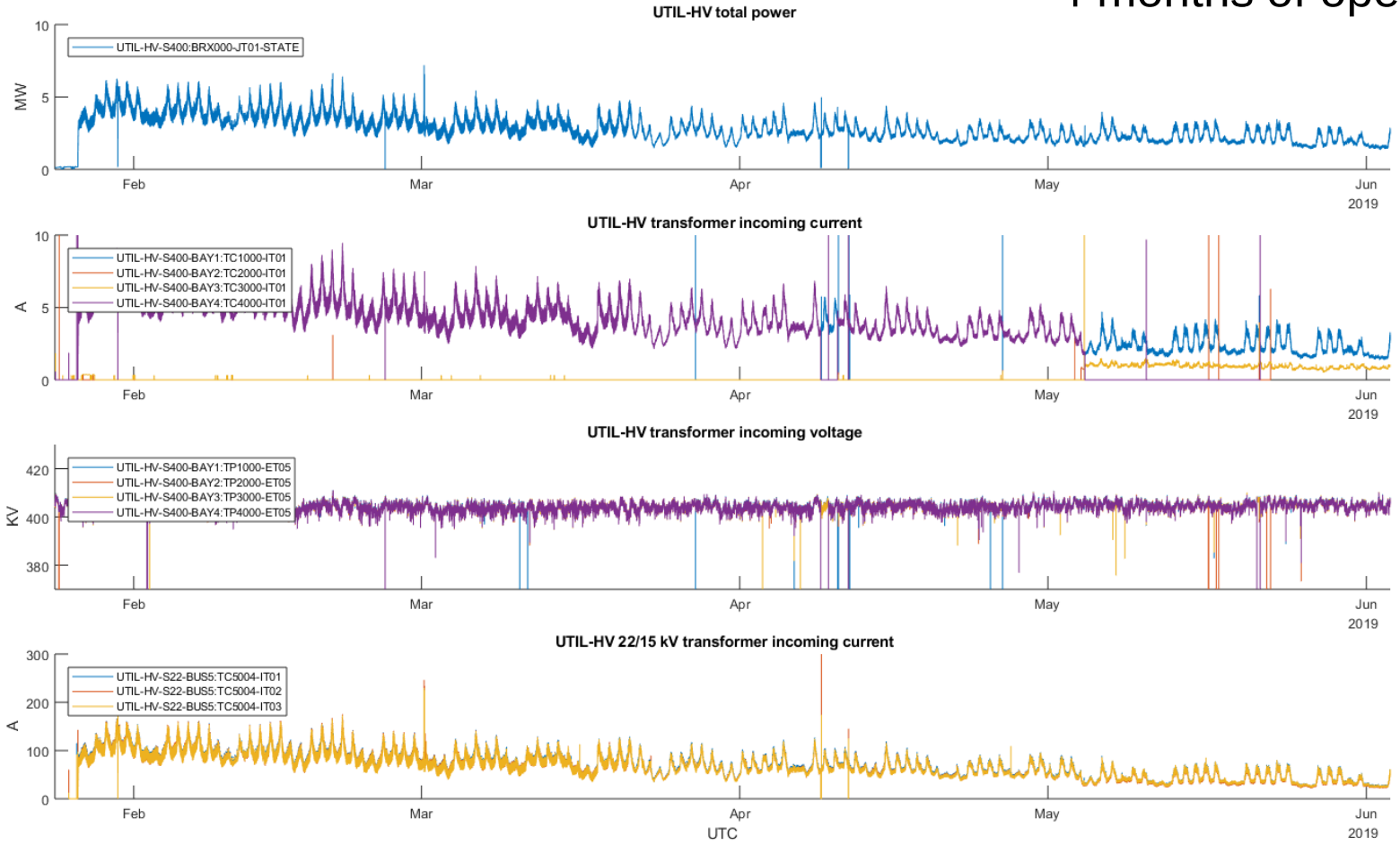

Nov 2018

Electrical – First plant system


CAS
CODAC
CSS
CIS
Pulse ID 1289
SUP ###
ITER-UTIL-HV-S400
2019-05-15T08:24:45.
ALARMS
Current Alarms (0 of 0 al
Selecti
Acknowledged Alarms (8 of 35 alarms
Ac - Description Alarm T
EB7100 Battery Fuse 16:32:46
EU7100 UPS Common Fa 15:43:58
SYS HVAC system Anom 07:55:48
BR0001 IED Relay Fai 15:02:06
48DC Busbar 2 High V 15:02:06
48DC Busbar 2 Low Vo 15:02:06
48DC Busbar 1 High V 15:02:06
48DC Busbar 1 Low Vo 15:02:06
GENERAL CONTROL
CODAC
TOTAL POWER
3.14 MW
JS 1001
JS 1002
JS 2001
JS 2002
JS 3001
JS 3002
JS 4001
JS 4002
BAY CONTROL IN REMOTE
BAY 1 POWER
2.49 MW
BAY 2 POWER
0.04 MW
BAY 3 POWER
0.58 MW
BAY 4 POWER
0.03 MW
JS 1000
JS 2000
JS 3000
JS 4000
JT 1010
JT 2010
JT 3010
JT 4010
JT 1000
JT 2000
JT 3000
JT 4000
JA 1000
JA 2000
JA 3000
JA 4000
BR1000
BR1001
BR1002
BR2000
BR2001
BR2002
BR3000
BR3001
BR3002
BR4000
BR4001
BR4002
TC 1000
TC 2000
TC 3000
TC 4000
3.71 A
404.84 KV
0.00 A
404.58 KV
0.97 A
404.33 KV
0.00 A
404.25 KV
TP 1000
TP 2000
TP 3000
TP 4000
TS 1000
TS 2000
TS 3000
TS 4000
TAP POS.
7
OIL TEMP.
28.70 degC
27.70 degC
24.60 degC
25.90 degC
BR1003
BR2003
BR3003
BR4003
BUSBAR 22kV
JT 1099
JT 2099
JT 3099
JT 4099
JA 1099
JA 2099
JA 3099
JA 4099
22 KV
JB-1000
JB-2000
JB-3000
JB-4000
JB-5000
JB-6000
JB-7000
JB-8000
JB-5000
43AC00-TS1000
STATUS
TRENDS
A1
A2
TAP
28.70 degC OIL TEMP. MAIN TANK
27.30 degC 22 kV WINDING TEMP
23.70 degC 400 kV WINDING TEMP
FAULT STATUS
FAN GROUP 1 RUNNING
FAN GROUP 2 RUNNING
POWER SWITCH ON NORMAL PS
HEALTHY IED CONNECTION
MODE
FAN GROUP 1 MANUAL
FAN GROUP 1 AUTO
FAN GROUP 2 MANUAL
FAN GROUP 2 AUTO
HOME
UTIL
HV
S400
BAY1
BAY2
BAY3
BAY4
IC
AUX

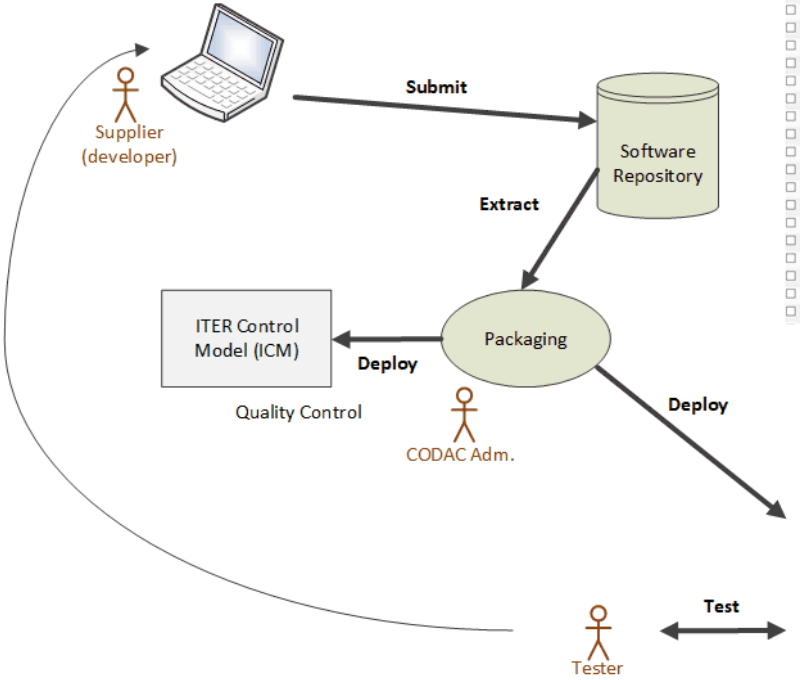

CAS
CODAC
CSS
CIS
Pulse ID 1289
SUP ###
UTIL-HV
COS OPERATION STATE
Executing
TOTAL POWER
2.38 MW
BAY 1
1.69 MW
BAY 2
0.03 MW
BAY 3
0.65 MW
BUSBAR 5000
1.7 MVA
BUSBAR 1000
0.0 MVA
BUSBAR 6000
0.0 MVA
BUSBAR 2000
0.0 MVA
BUSBAR 7000
0.3 MVA
BUSBAR 3000
0.3 MVA
T15
1.7 MVA
LC1
0.0 MVA
LC2
0.0 MVA
LC3
0.0 MVA
LC4
0.0 MVA
LC8
0.0 MVA
LC9
0.0 MVA
LC10
0.0 MVA
LC11
0.0 MVA
LC12
0.6 MVA
MV01
0.0 MVA
MV02
0.0 MVA
MV03
0.0 MVA
MV04
0.0 MVA
MV05
0.0 MVA
BOILER 1
0.0 MVA
BOILER 2
0.0 MVA
RTE
0.0 MVA
HOME
UTIL
HV
TC
S400
S22
T15
LC01
LC02
LC03
LC04
LC10
LC11
LC12
LC13
LC14
M1
M2
M3
All
Shutdown
[Safe]
PS-13
Off
PS-1
Absent
PS-2
Not Ready
Fault
PS-5
Not Ready
PS-3
Local
PS-4
Ready
Ready
PS-6
Starting
Initialising
PS-7
[Aborting]
PS-9
Initialised
PS-8
Running
Terminating
PS-12
Executing
PS-10
Post Checks
PS-11

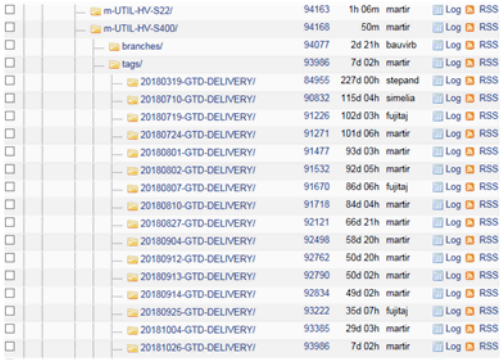
4 months of operation

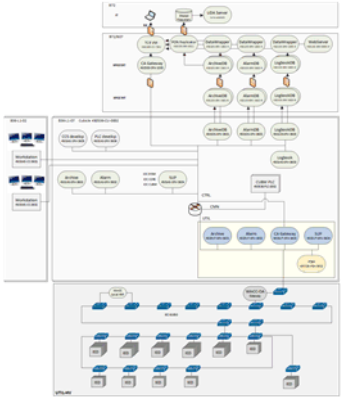


Software Configuration Control (Work flow)

Wed May 29, 2019







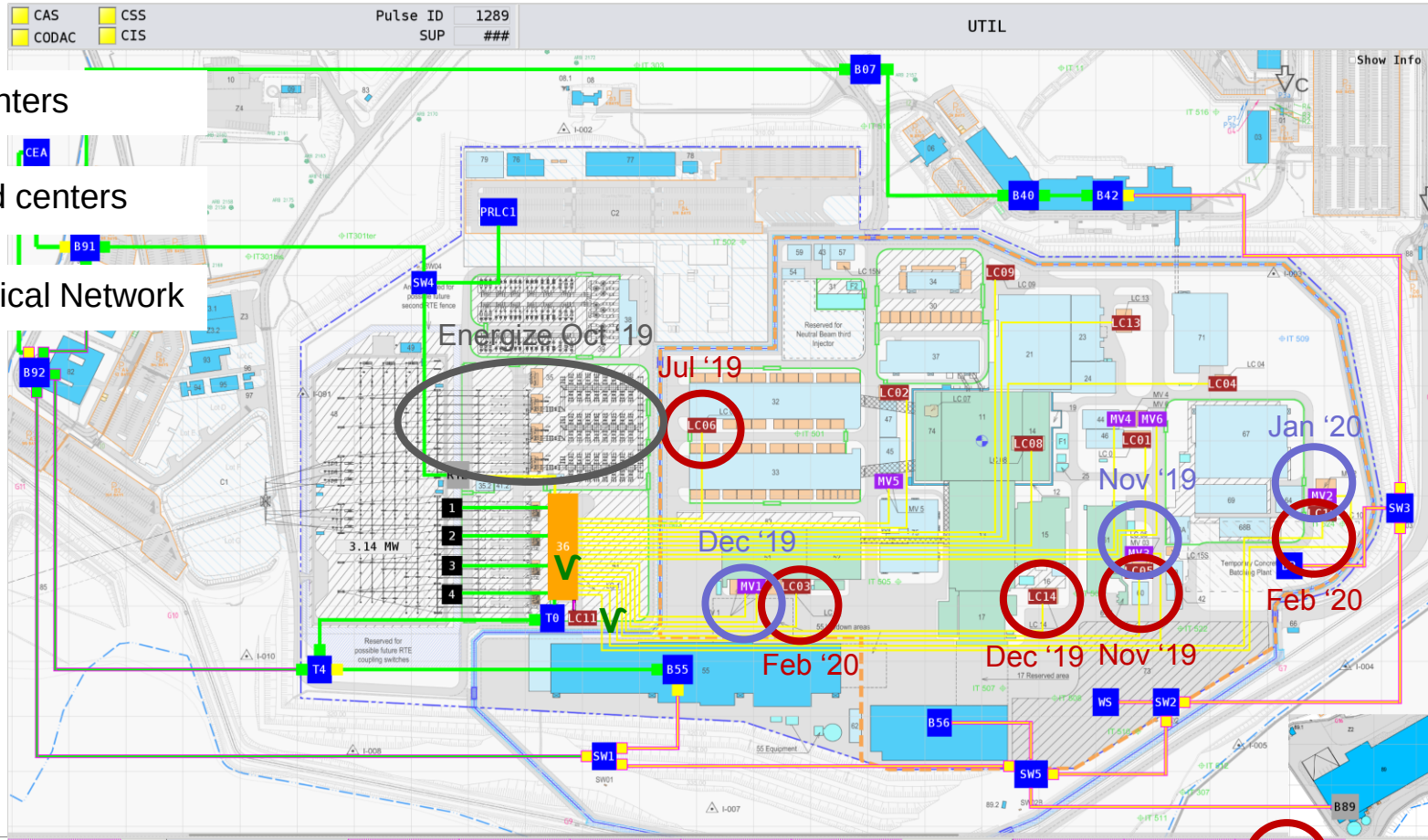
More details Thursday (Bustos)

Coming up for Electrical…

Low voltage load centers

Medium voltage load centers

Pulsed Power Electrical Network

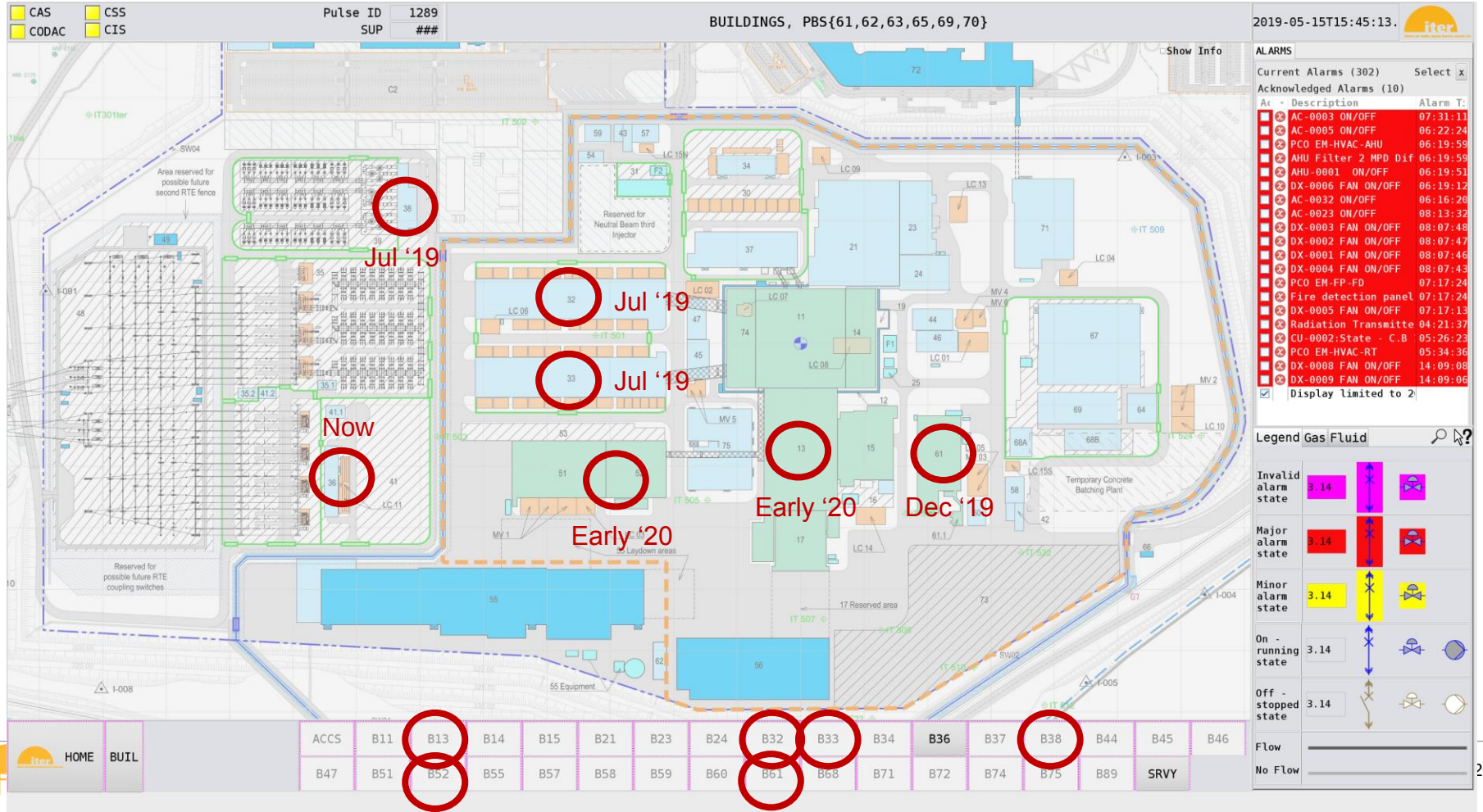


Building Services

- HVAC, electricity, lighting, compressed air, demineralized water, fire monitoring…, but also some instrumented occupational safety functions …

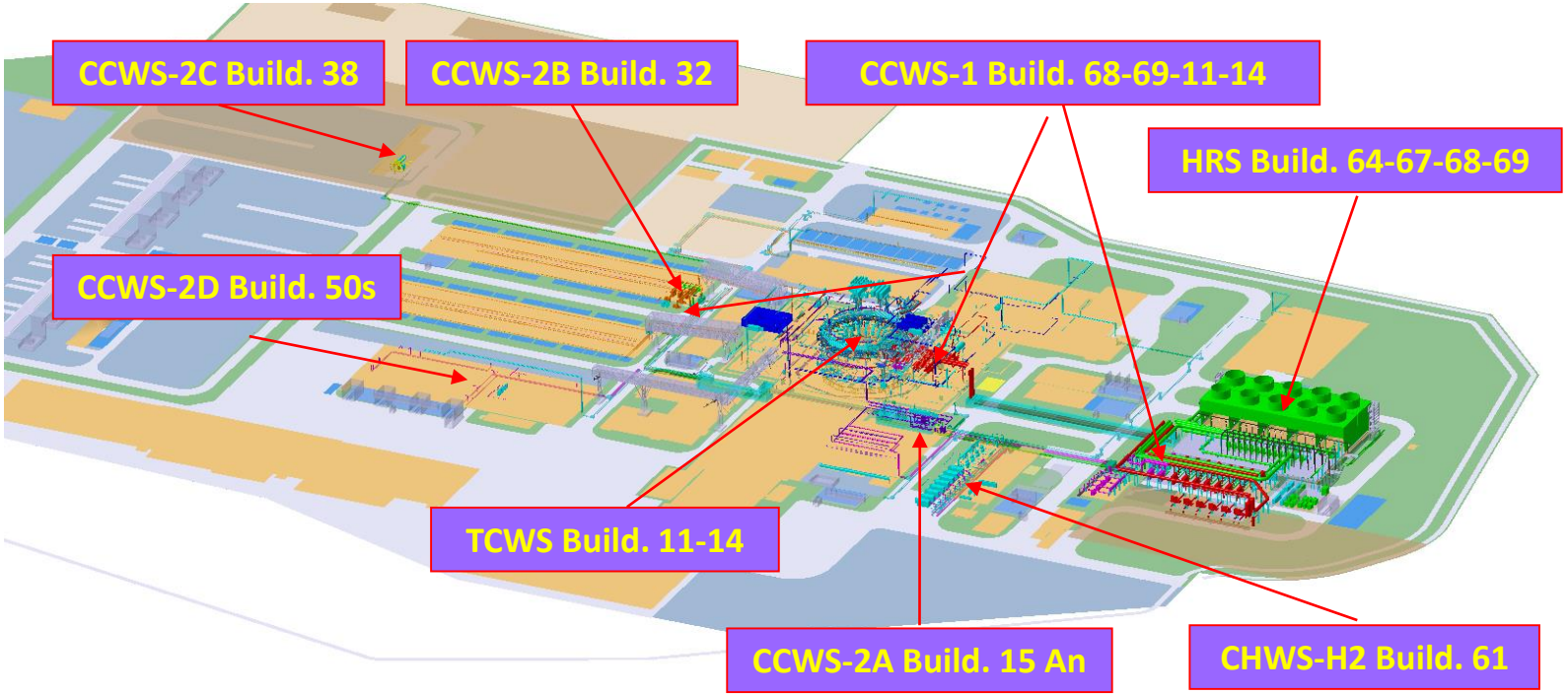
- Delivered as part of buildings by Europe

Coming up for Building Services…



Secondary Cooling Water

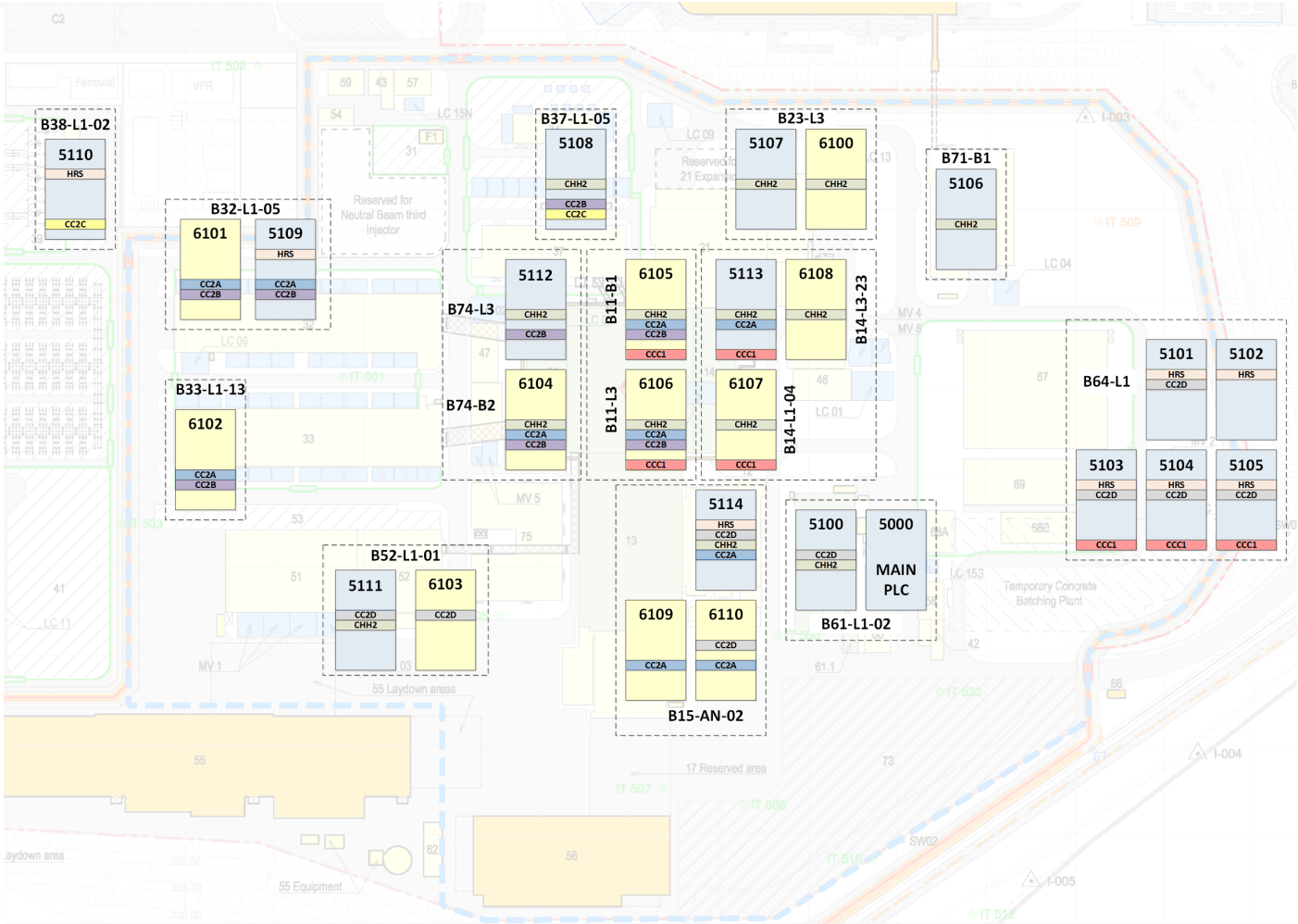
- High level design as of 2017
- Multiple component cooling water loops, chilled water loops and heat rejection



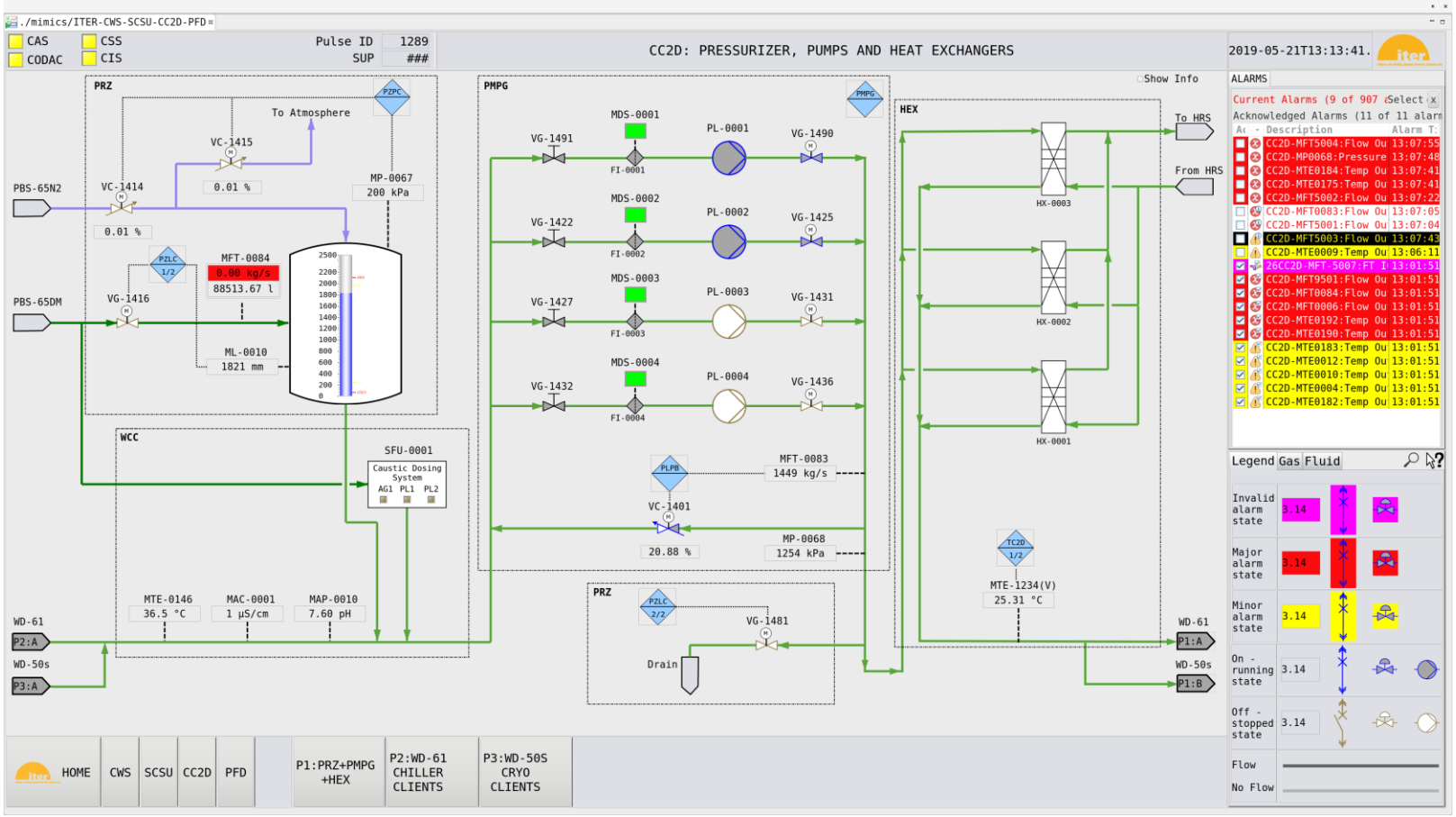
Secondary Cooling Water

- 16 blue cubicles delivered by India
- 11 yellow cubicles in IO scope to interface clients
- Most cubicles interface to multiple loops
- Software for HRS, CC2D and CHH2 developed and under test

- Single PLC controlling everything
- Commissioning loop X when loop Y operating ???

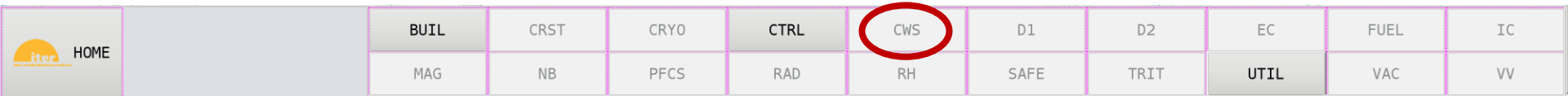


Secondary Cooling Water

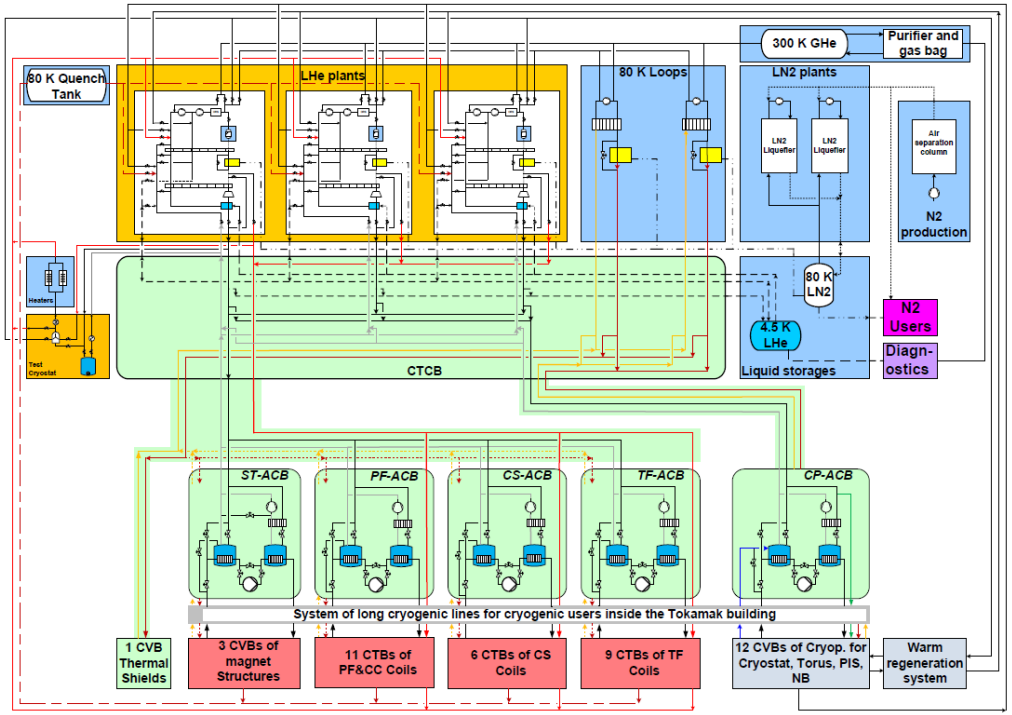


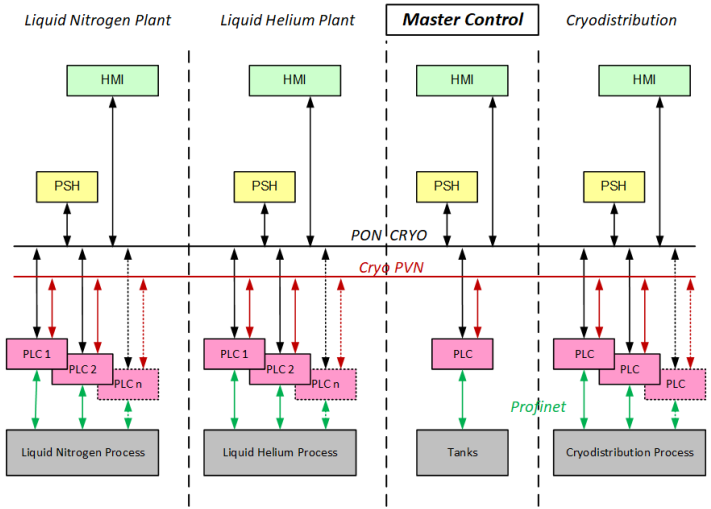
Coming up for Secondary Cooling Water…

- Lab tests of “early operation” for cryoplant (now)
- Install B61 TCR and establish external connectivity (late 2019)
- Start of commissioning for “early operation” in B61 (late 2019)
- Plan for version 2 to separate cooling loops (multiple PLC’s, rewiring,…)



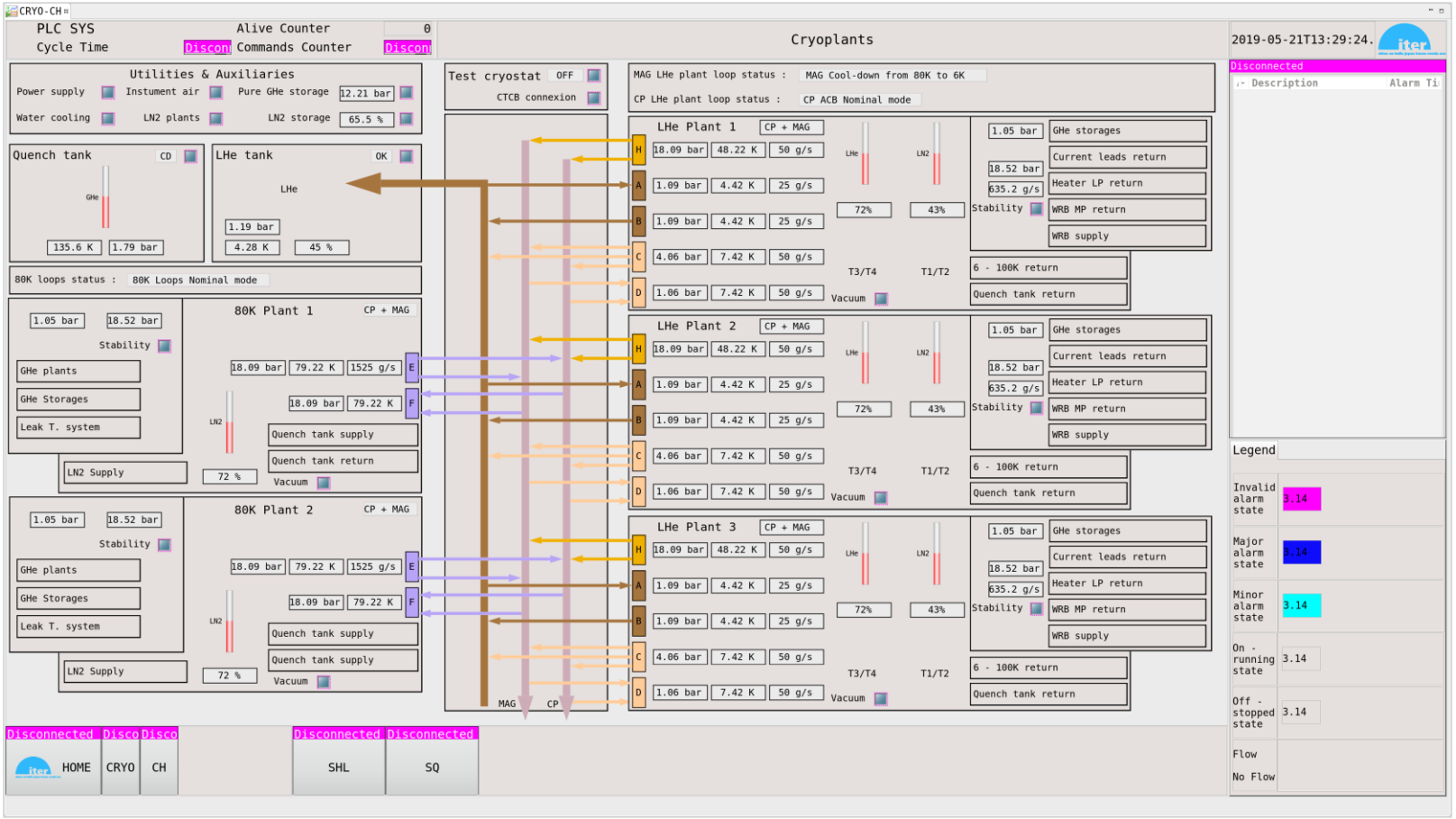
Cryogenics





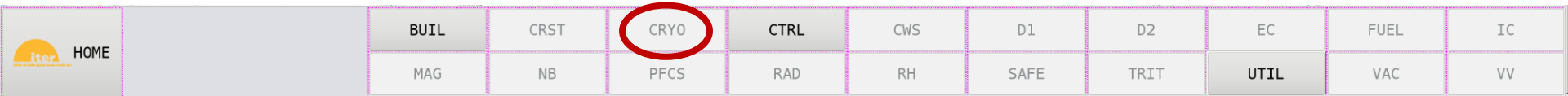
- Good mapping between suppliers (Europe, India, IO) and systems
- Common library
- LN2 plant control FAT two years ago
- Strong control group, but main developer just left

Cryogenics

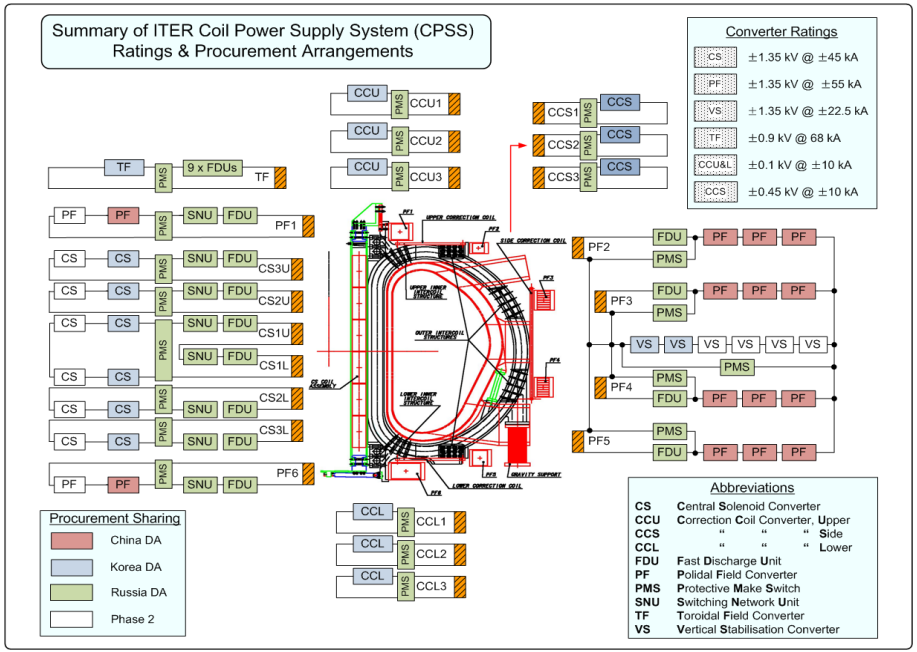


Coming up for Cryogenics…

- Install B52 internal network, TCR and establish external connectivity (early 2020)
- Start of commissioning in B52 (2020)

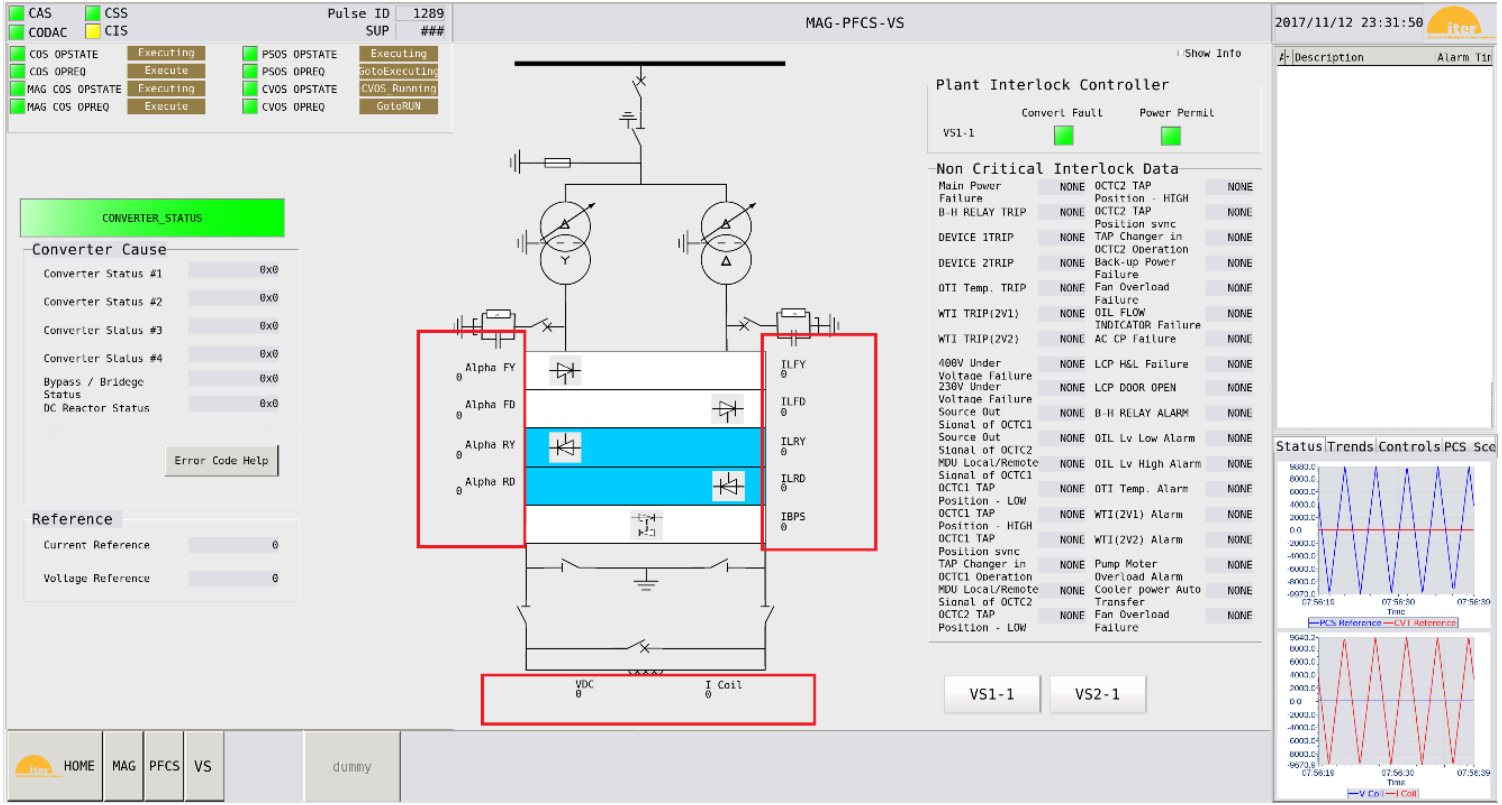


Coil Power Supplies and Reactive Power Compensation (RPC)



- Installations of transformers and converters started (18 months)
- Many control FAT's done, some more to come
- High Performance Networks (SDN, DAN)
- Active control group

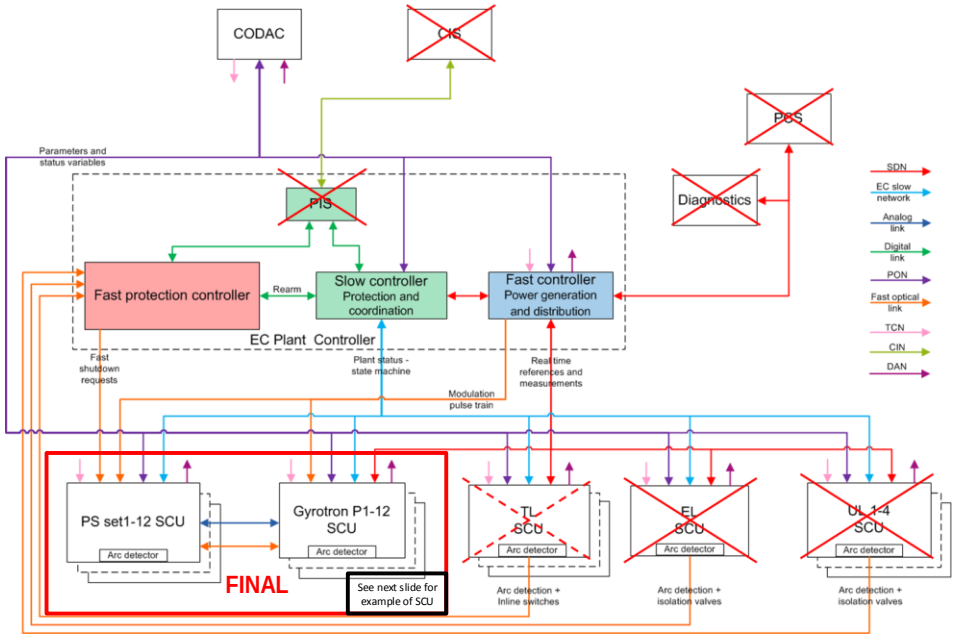
Coil Power Supplies



Coming up for Coil Power Supplies and Reactive Power Comp…

- Install B30's network, TCR's and establish external connectivity (now). To first service B32, B33, B38 BMS and later RPC and CPSS
- Mechanical installations until end of 2020
- Lab tests in 2020
- Start commissioning Reactive Power Compensation in 2020 and Coil Power Supplies in 2021

Electron Cyclotron Heating and Current Drive



- Many different suppliers with Europe responsible control system integration
- Falcon gyrotron test facility in Lausanne in operation since two years
- High Performance Networks

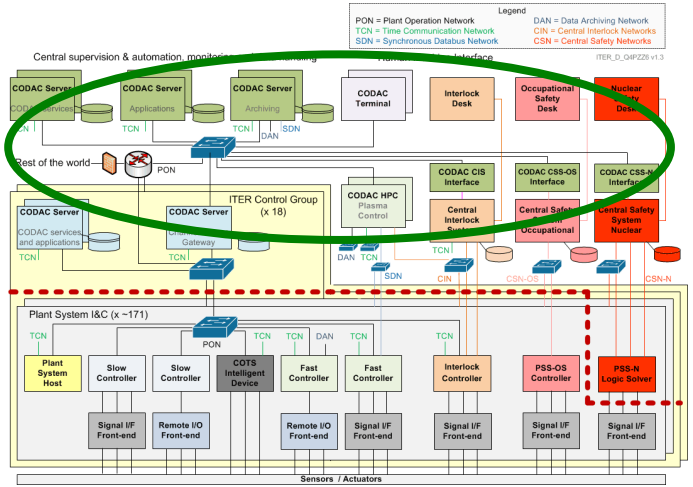
Electron Cyclotron Heating and Current Drive

Coming up for Electron Cyclotron Heating and Current Drive…

- Install B13/B15 network, TCR's and establish external connectivity 2020.
- Waiting for B15 Ready For Equipment to start mechanical installations
- Continue tests at Falcon (Europe)
- Lab tests in 2020
- Start commissioning Electron Cyclotron Heating in 2021

- And then we move into the Tokamak Complex

- And build functionality on top

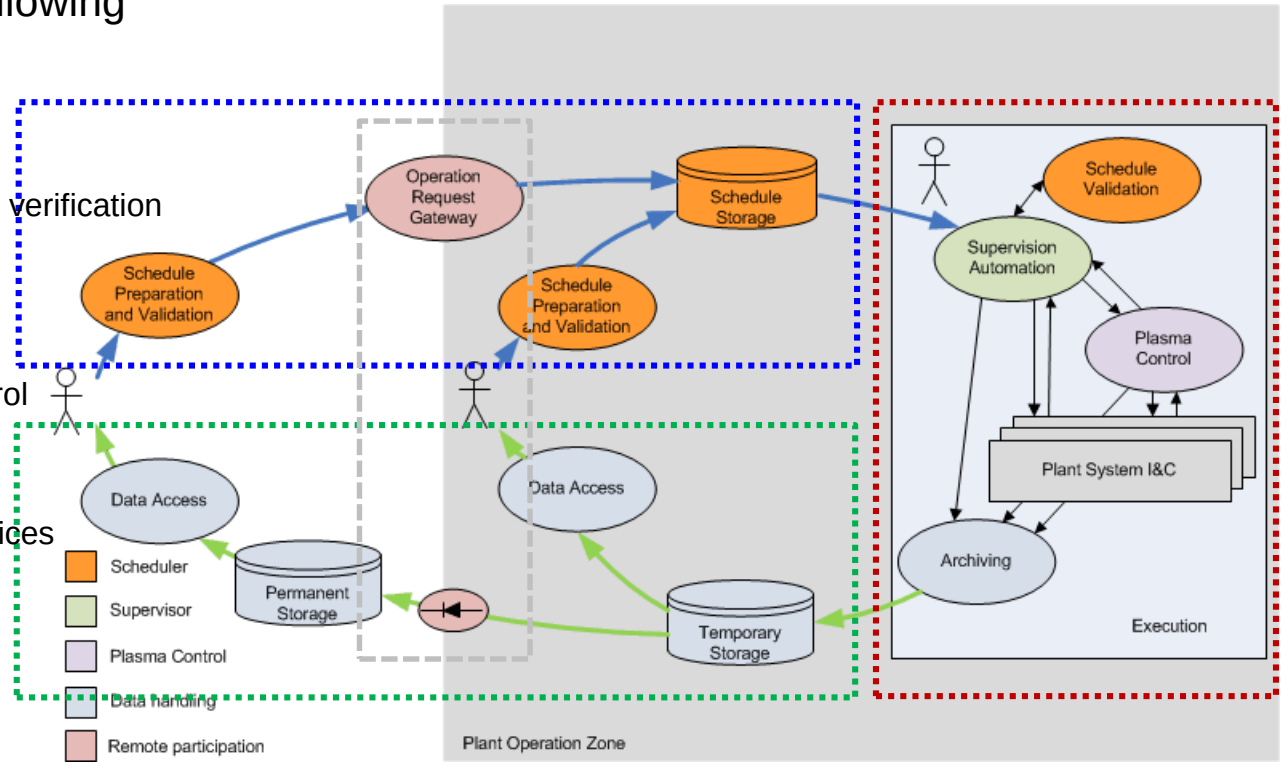


CODAC Operation Applications

The software suite for supporting plant system commissioning, tokamak operation and plasma experiments by delivering the following functions:

- Preparation
  - Pulse configuration, validation & verification
- Execution
  - Supervision & Automation
  - Plasma real-time feedback control
- Analysis
  - Data archiving, access and services
- Remote participation

Exploring EPICS 7 for "Execution" (Bauvir, Neto this afternoon)



Conclusions

- ITER Control System is in operation
- Over the coming years more and more systems will be commissioned and put into operation
- Serious work started using EPICS 7

- Many control system job opportunities coming up https://www.iter.org/jobs