Status of ITER and CODAC

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ITER Organization

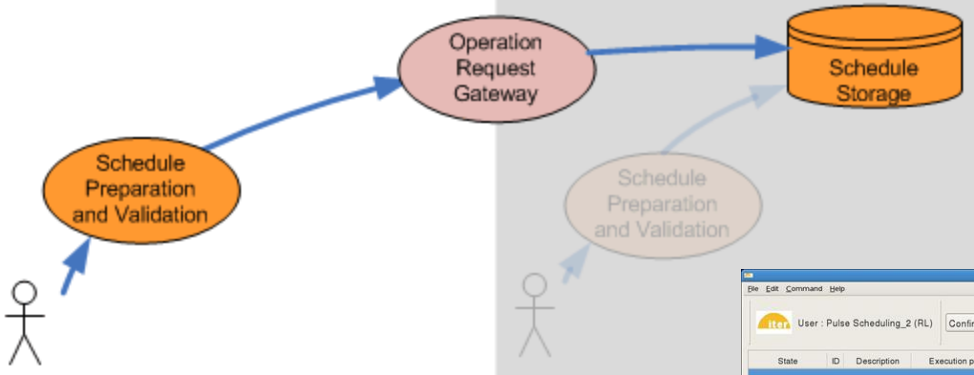
Control System Division

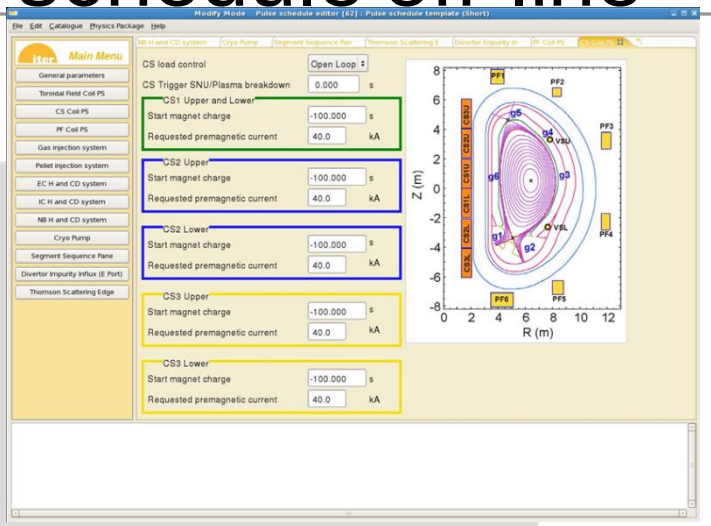
Disclaimer: The views and opinions expressed herein do not necessarily reflect those of the ITER Organization

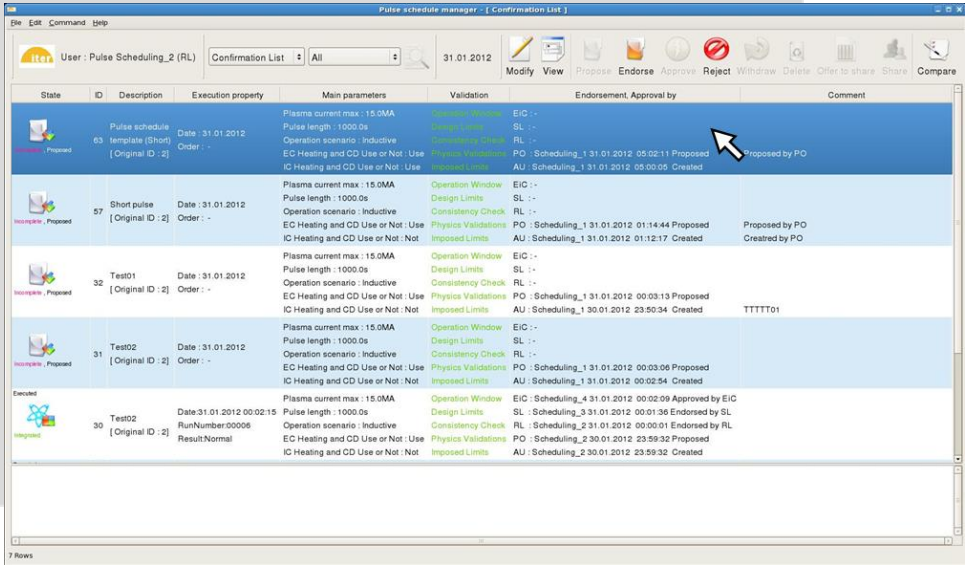
The Final Goal: Integrated Operation

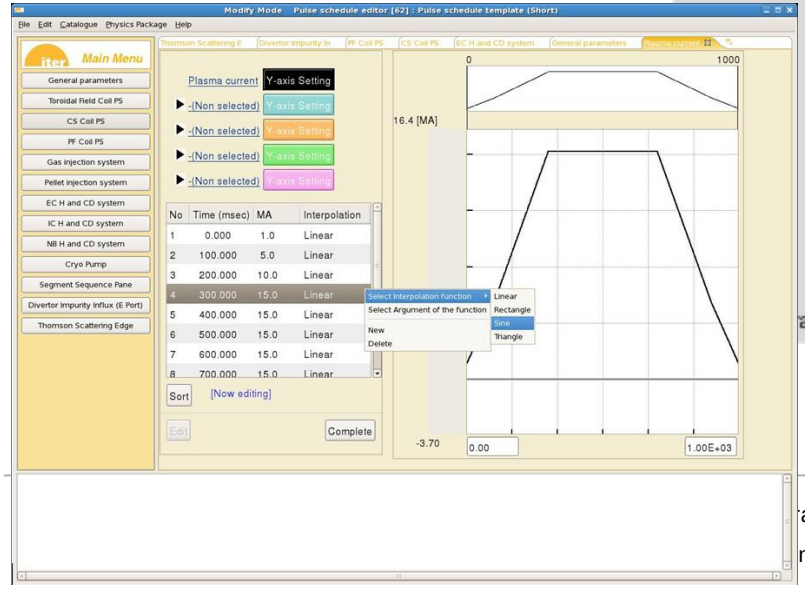
B71 Control building

Step 1 : Prepare the operation schedule off-line

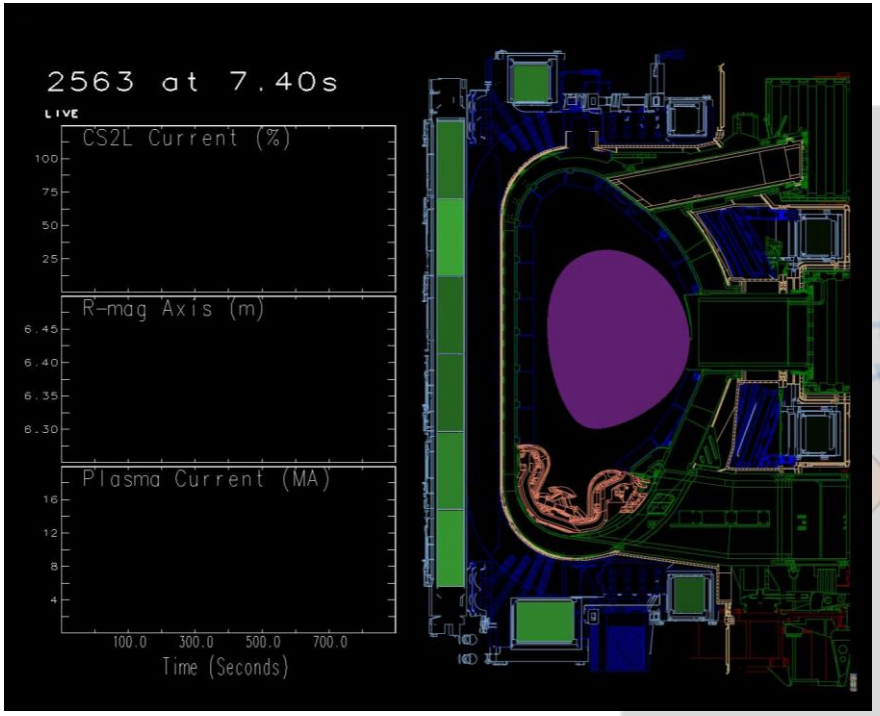


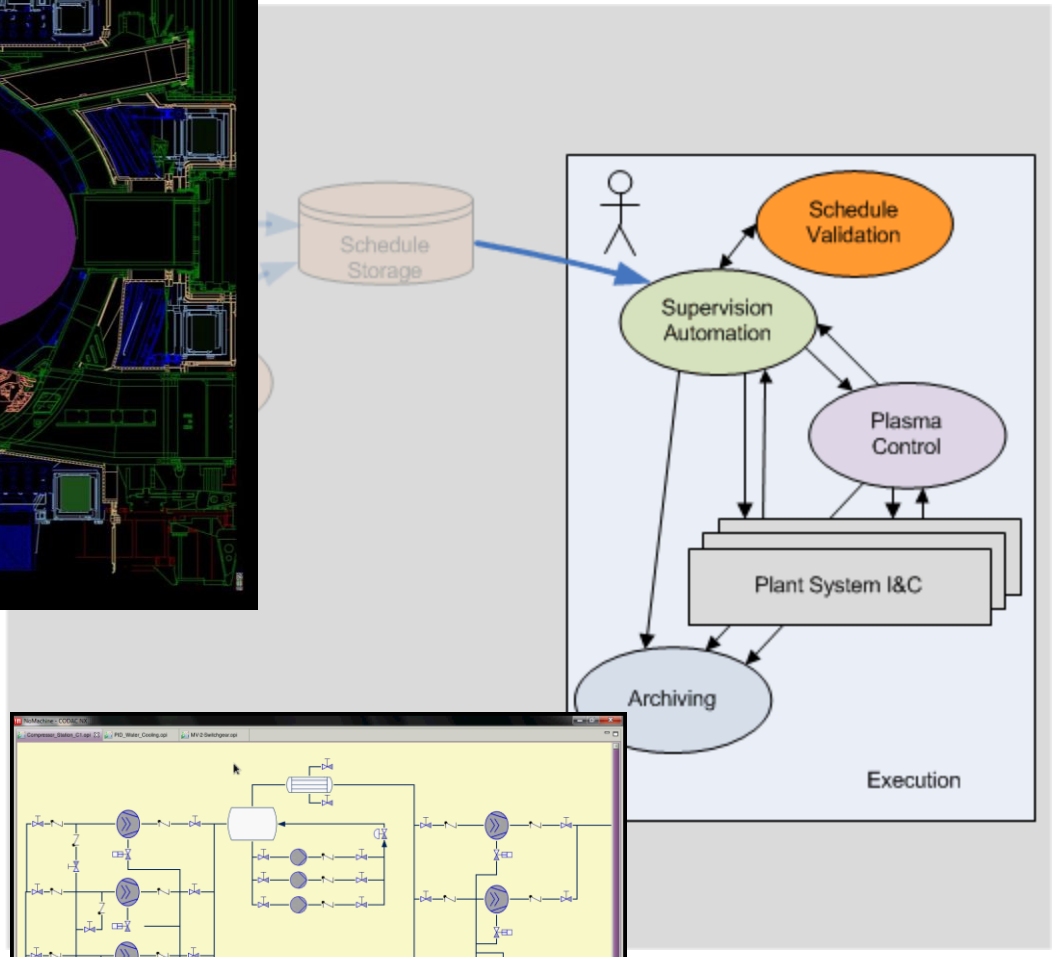


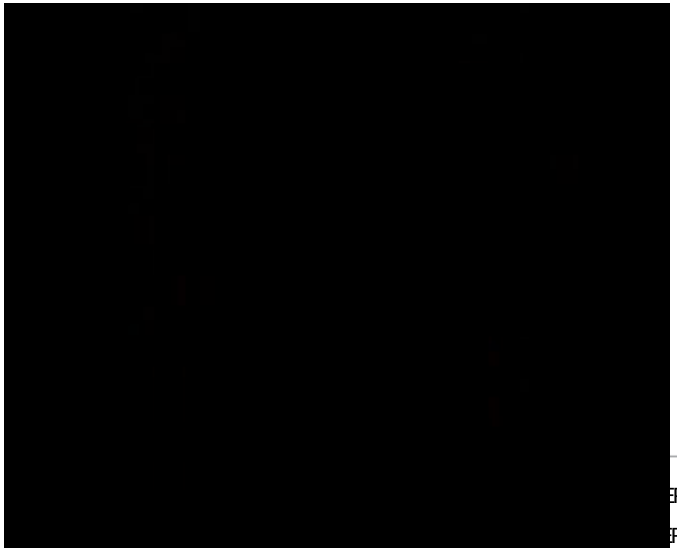




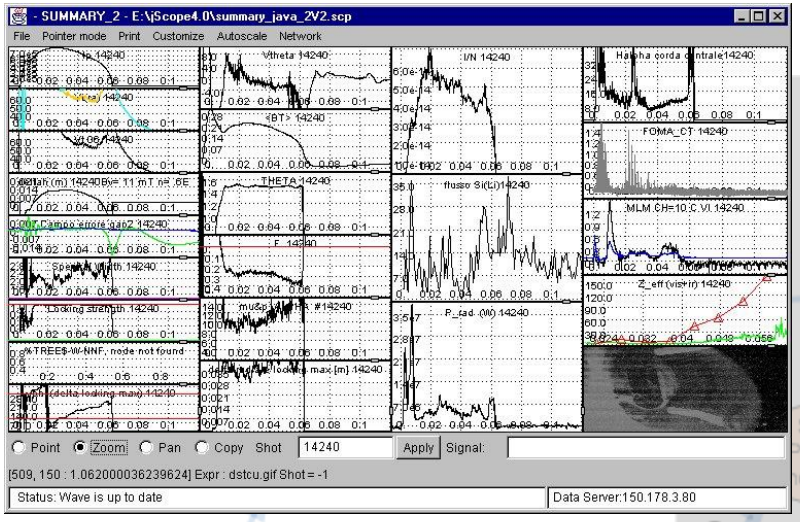
Step 2 : Execute

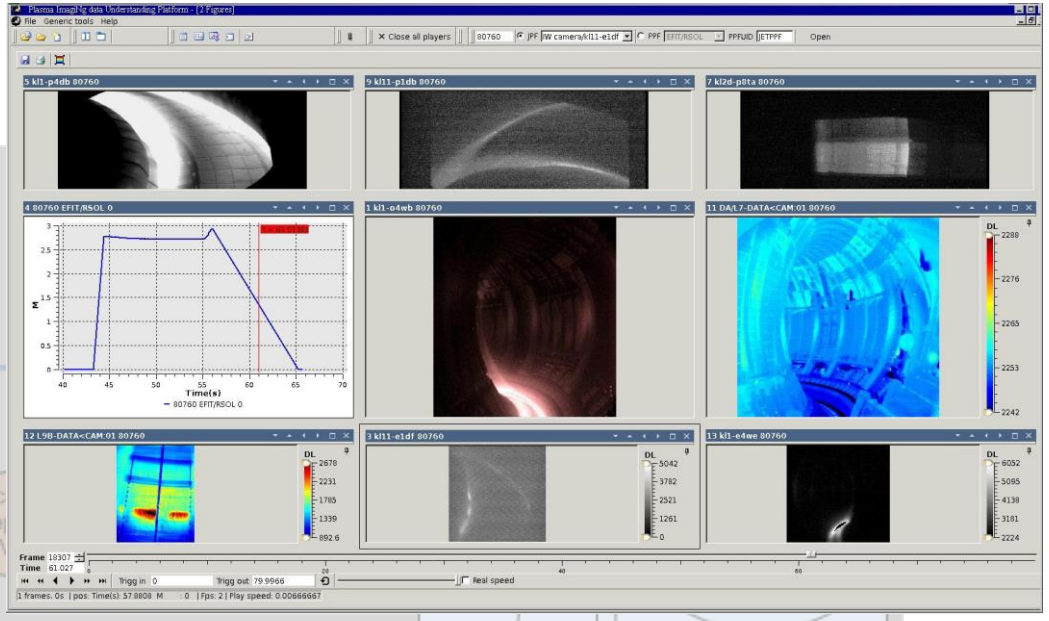


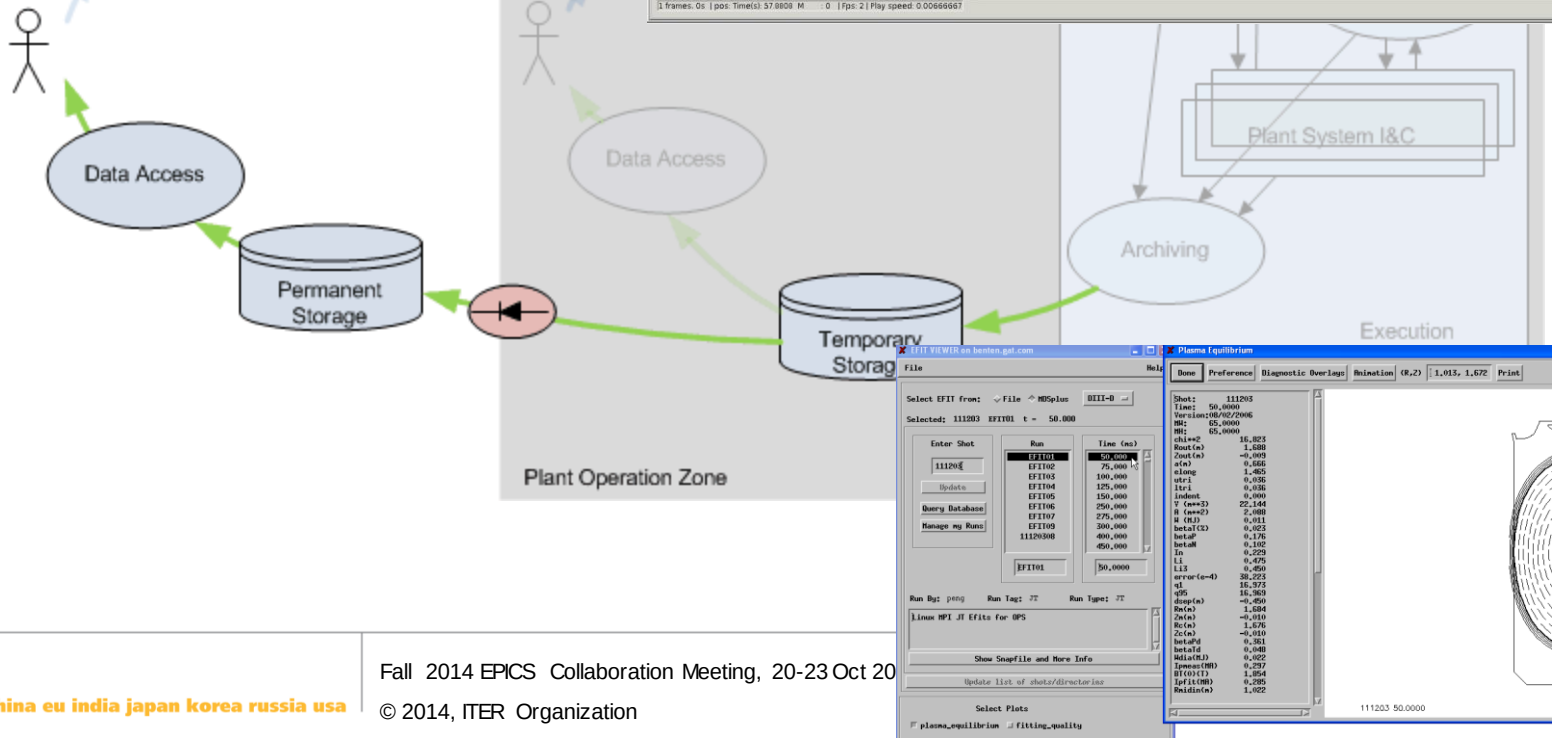




Step 3 : Analyze the data

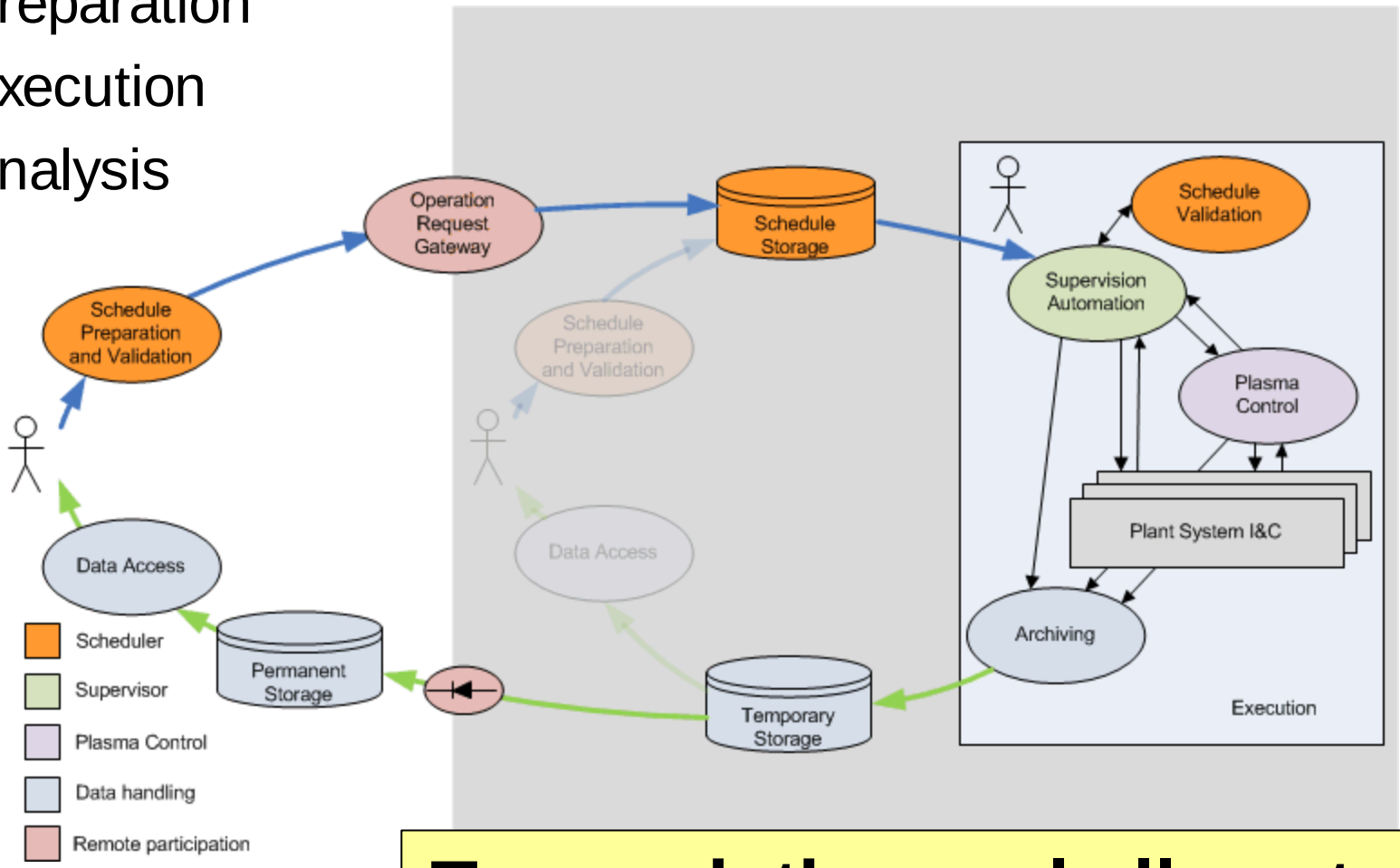






Data Flow Model

1. Preparation
2. Execution
3. Analysis



To reach the goal all systems need to communicate

Many different networks for different purposes

All, except nuclear safety and quench loop, based on Ethernet

Plant Operation Network (PON)

- General purpose command, status, archive,… (Gbps Ethernet)

Synchronous Databus Network (SDN)

- Distributed feedback control (10 Gbps UDP multi-cast)

Time Communication Network (TCN)

- Absolute time synchronization (IEEE 1588 2008)

Data Archiving Network (DAN)

- High volume data archiving (10 Gbps Ethernet)

Central Interlock Network (CIN)

- Industrial Ethernet, Hardwired

Central Safety Networks (CSN)

- Industrial Ethernet, Hardwired

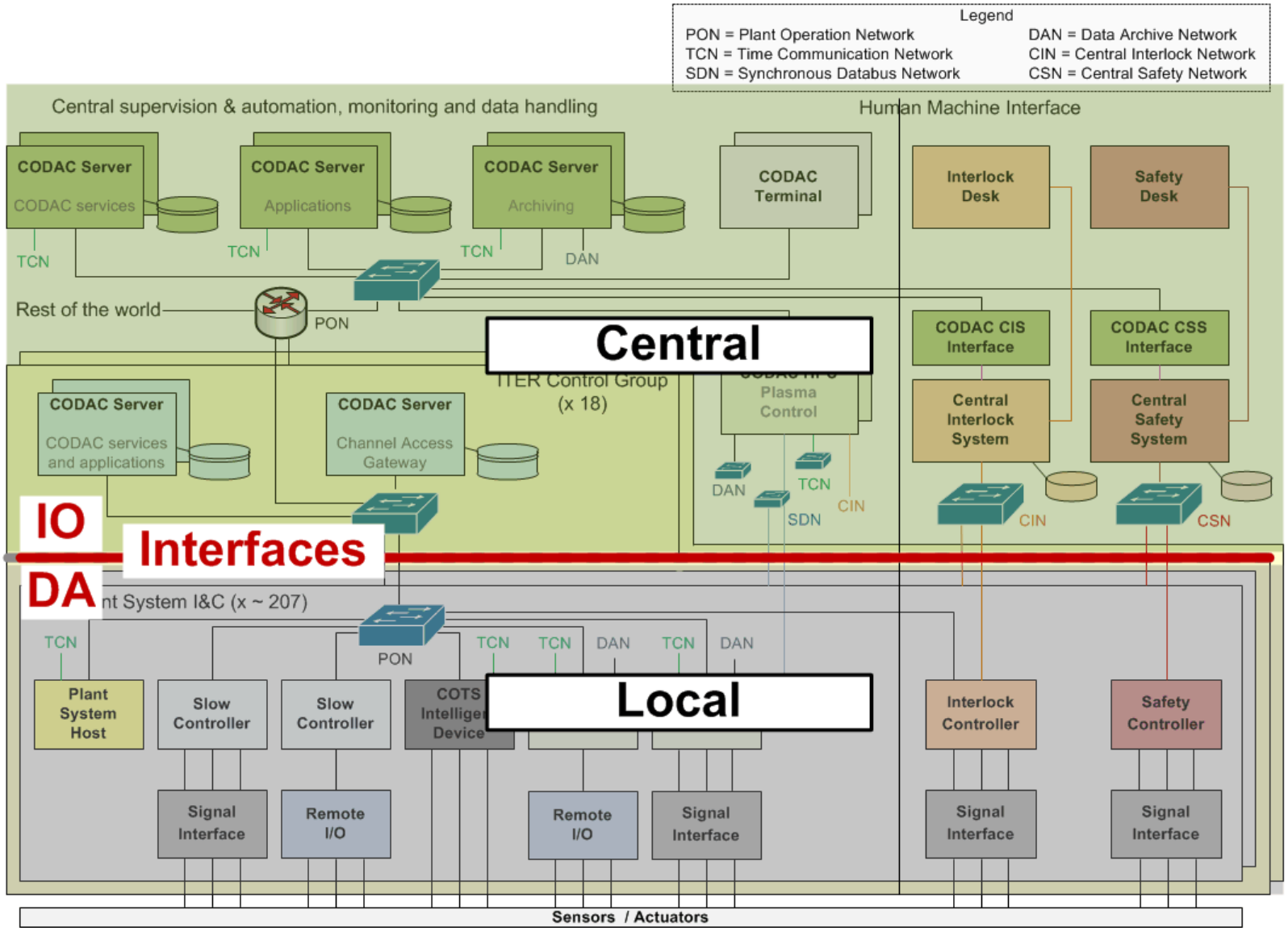
Mainstream industrial standards

CODAC Parameters

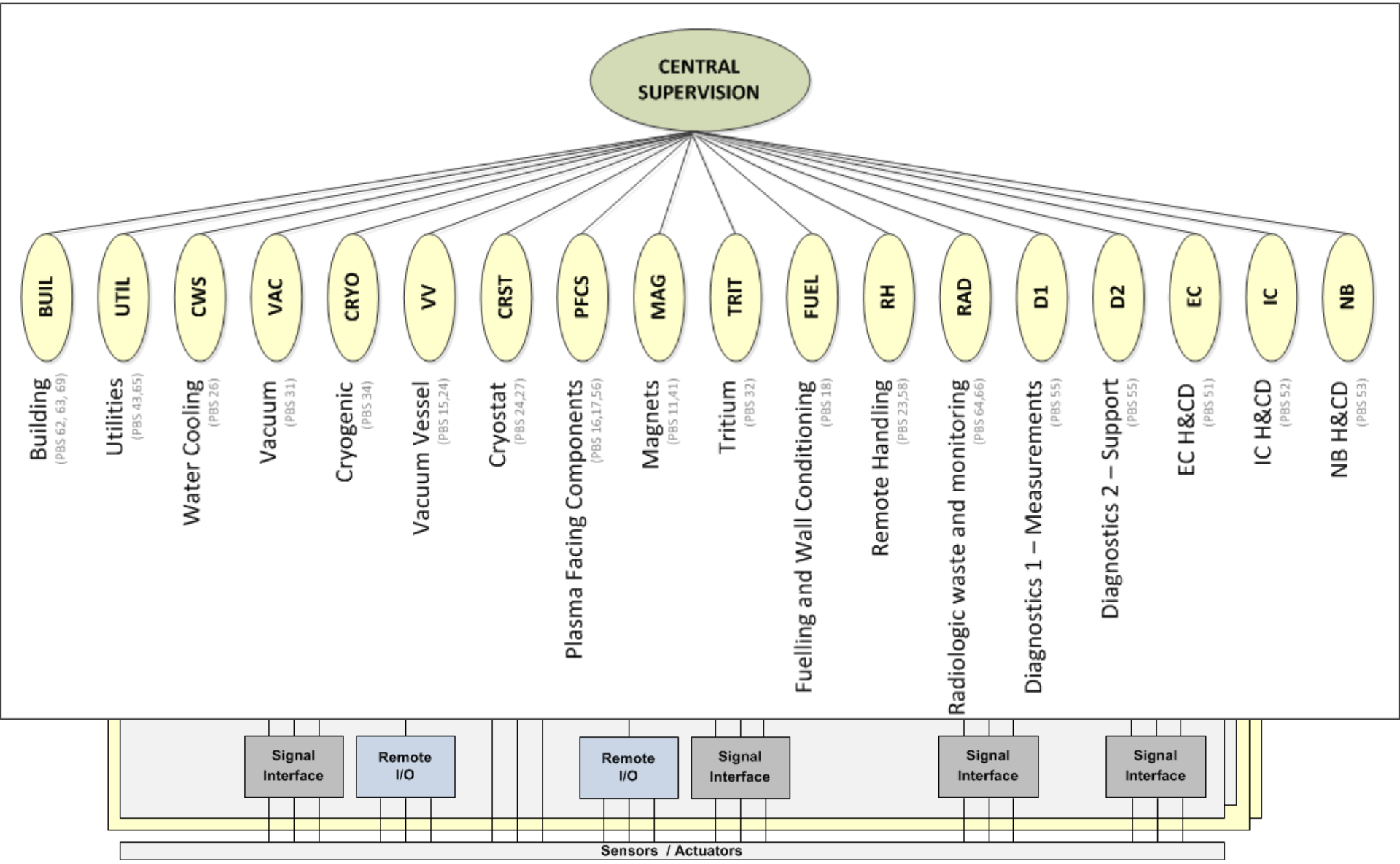
Parameter	Value
Total number of computers	1.000
Total number of signals (wires)	100.000
Total number of process variables	1.000.000
Maximum sustained data flow on PON	50 MB/s
Total PON archive rate	25 MB/s
Total DAN archive rate (initial)	2 GB/s
Total DAN archive rate (final)	50 GB/s
Total archive capacity	90-2200 TB/day
Accuracy of time synchronization	50 ns RMS
Number of nodes on SDN	100
Maximum latency asynchronous events	1 ms
Maximum latency application to application (SDN)	50 µs
Maximum sustained data flow on SDN	25 MB/s

Achievable with today's COTS technology

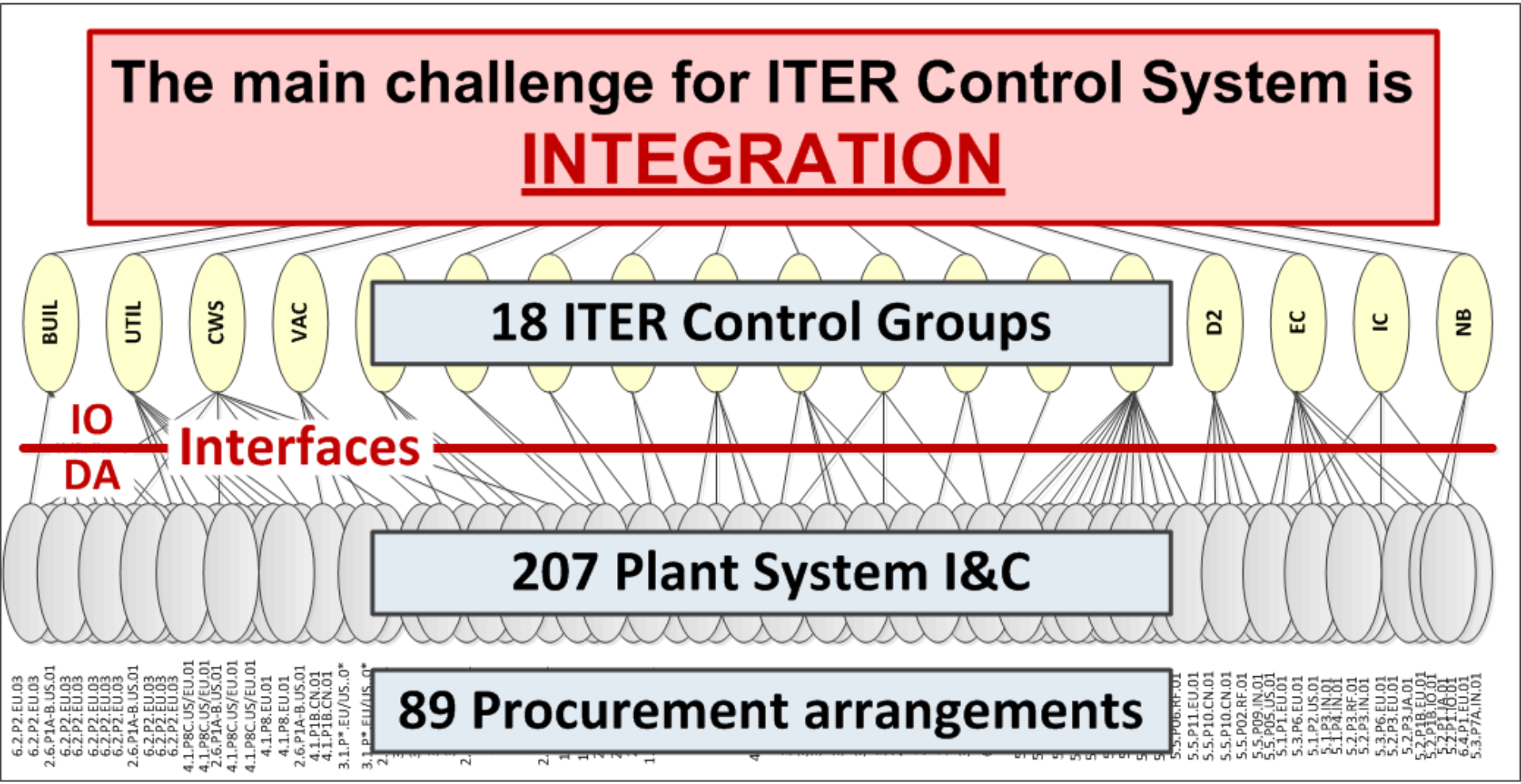
Architecture



Architecture



Architecture



- ITER control system is broken down in 18 ITER control groups (CBS level 1)
- An ITER control group contains many Plant System I&C (CBS level 2)
- A Plant System I&C is a deliverable from a procurement arrangement (IN-KIND)
- A procurement arrangement delivers a part, one or many Plant System I&C

Integration

The main challenge for ITER Control System is

INTEGRATION

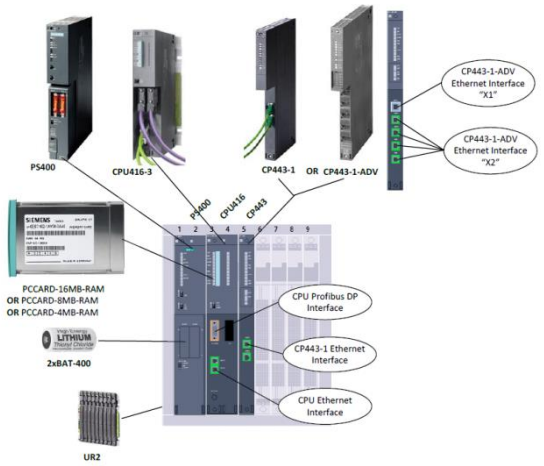
MITIGATION

- Define standards, specifications and interfaces applicable to all plant systems instrumentation and control (PCDH)
- Develop and distribute a control system framework that implements standards defined in PCDH and guarantees that the local control system can be integrated into the central system (CODAC Core System)
- Provide user support
- Organize training; PCDH campaign,
  CODAC Core System hands-on workshops
- Provide I&C Integration Kit free of charge (PSH, Mini-CODAC, switch)
- Demonstrate system on pilot projects

I&C standards – catalogue products

Slow control

- ✓ Siemens S7-300 and S7-400 products
- ✓ ET200M and ET200S for remote I/O
- ✓ Covering standard industrial signals

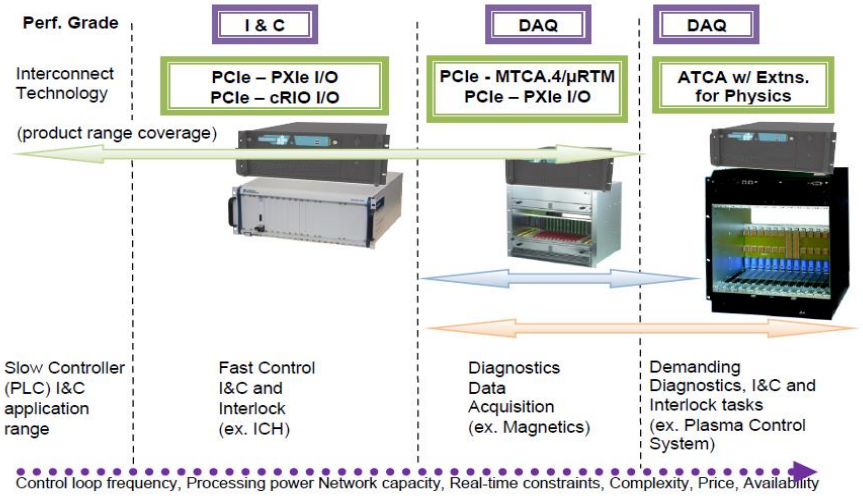


Cubicles

- ✓ Schneider Electric products
- ✓ Address floor standing and wall mounted cubicles
- ✓ Address Standard and EMC protected.

Fast control

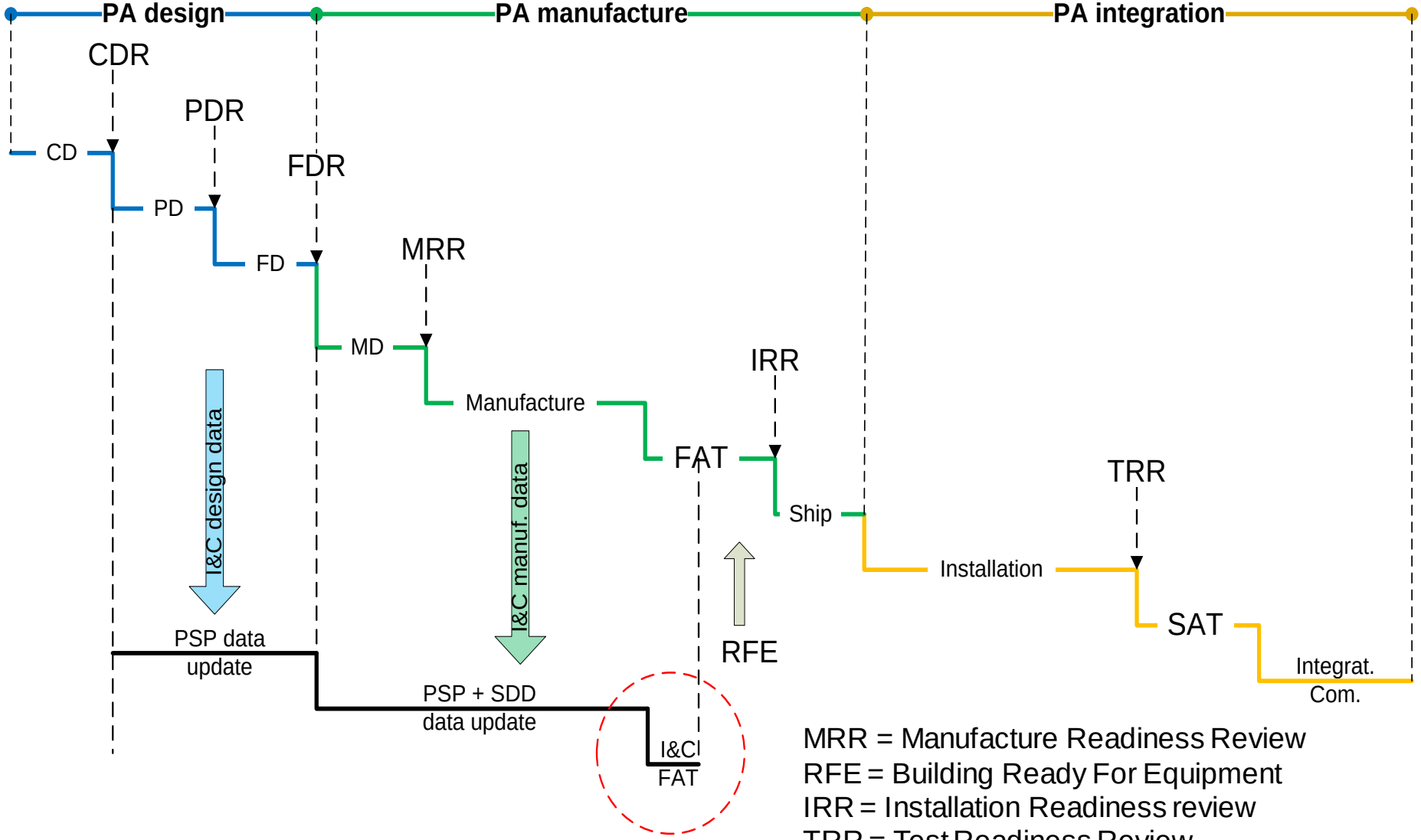
- ✓ PCI Express. CPU and I/O segregated
- ✓ Mainly National Instruments products
- ✓ Covering acquisition and control > 50 Hz



CODAC Core System: based on Open Source

- The selected operating system is **Red Hat Enterprise Linux** for the x86-64 architecture (RHEL x86_64)
- The infrastructure layer is **EPICS**, used in hundreds of projects world-wide: light sources, high energy physics, fusion (KSTAR, NSTX), telescopes
- The CODAC services layer is **Control System Studio** used at many EPICS and other sites and including HMI, alarming, archiving etc.
- ITER **specific software** such as configuration (system description), state handling, drivers, networking, etc.
- 6 month release cycle (major + minor release every year), extensive testing procedures

ITER Model of Plant System Integration



MRR = Manufacture Readiness Review
RFE = Building Ready For Equipment
IRR = Installation Readiness review
TRR = Test Readiness Review

Current Activities

- CODAC Core System release: 5.0 (2015)
  - RHEL 6.5
  - EPICS Base 3.15
  - EPICS V4 (evaluation only)
- IO takes EPICS Support development responsibility
- New S7 communication drivers
- Design of real-time framework for plasma control
- Design of pulse configuration system
- Preparing tools to be used in FAT tests

What's Next?

- Continue development and support of CODAC Core System
- Continue design of high level operation applications
- Continue design of Interlock and Safety
- Start implementing network infrastructure
- Engage with users (plant system I&C developers)
- Detail interfaces with plant system I&C
- Develop integration schedule and procedures