Status of the ITER CODAC conceptual design

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2007 Icalepcs – October 2007, Knoxville, Tennessee, USA

The ITER - Icalepcs story so far

2003 “The ITER Project and its Data Handling Requirements”

- ITER project was not yet financed
- Description of the data handling needs
- Conclusion that timing, rates and volumes are less than HEP, but that complexity is high

2005 “The ITER Data System Challenges”

- Site selected, construction not yet started
- Round table on one primary issue – “in-kind” procurement

Today's talk

- Project status
- What we have done towards the conceptual design ?
- Wish list

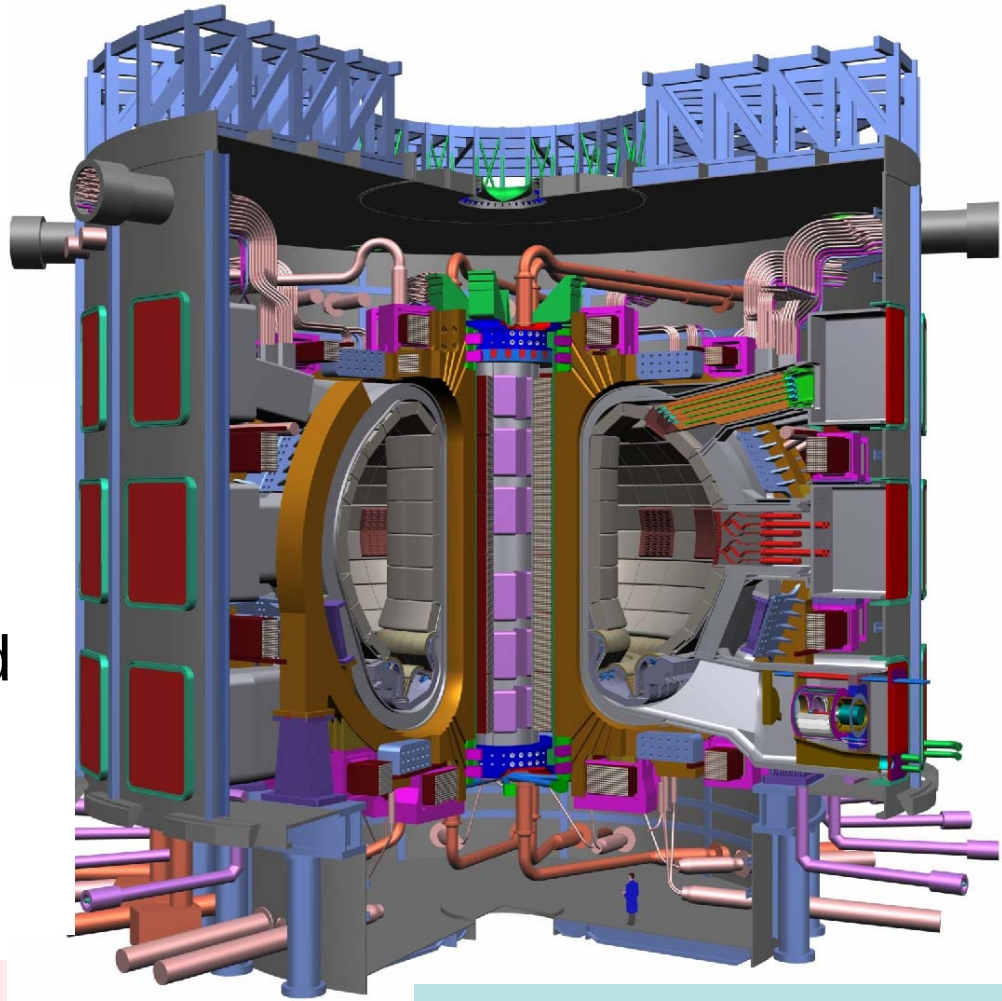
10 years to build

Startup planned for 2016

180 hectares now being cleared

18 buildings to be erected

10 Giga-Euros to build&operate



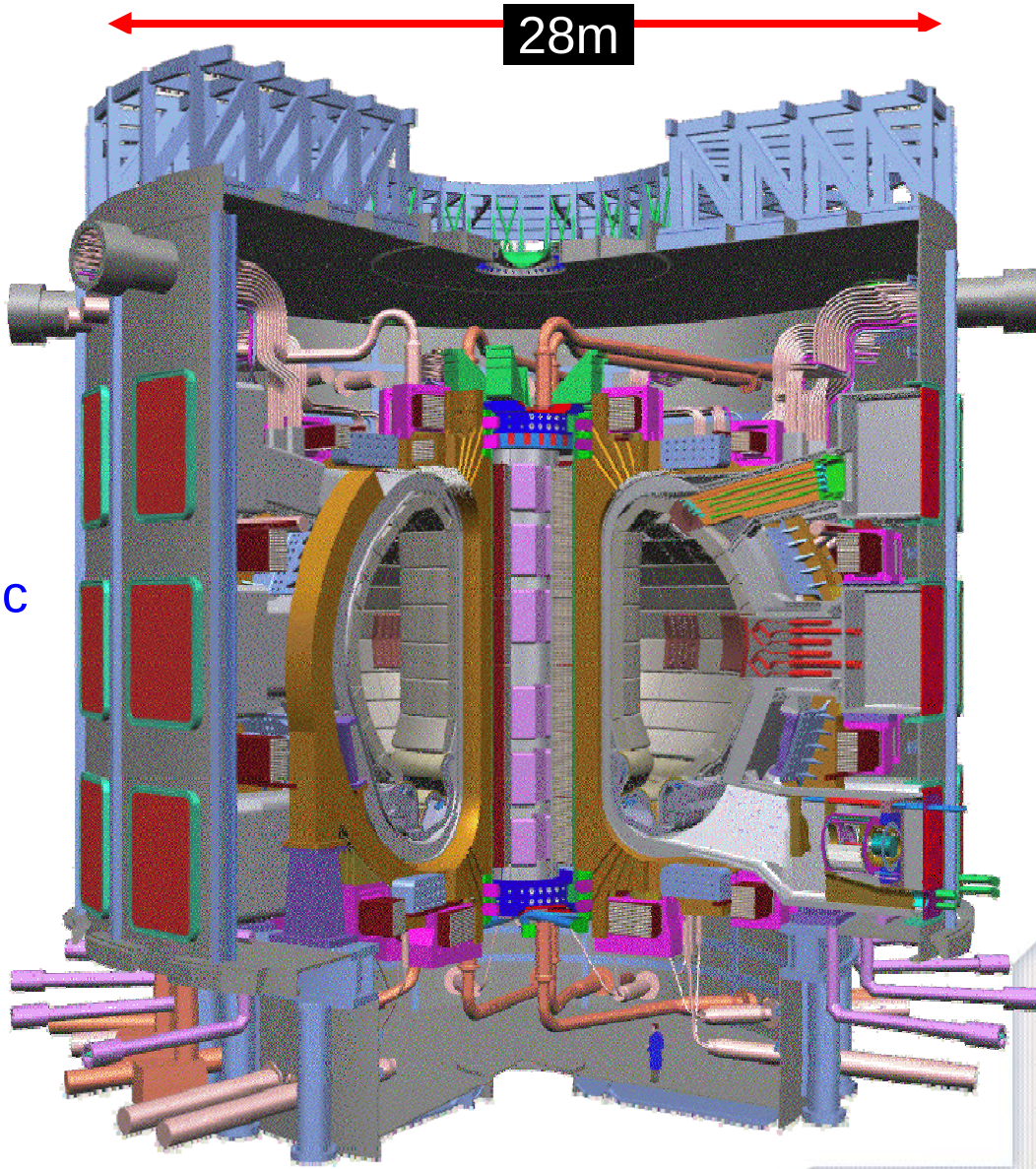
Design Construct Operate…

1990 2000 2010 2020 2030

8.5 years left ! *

ITER at a glance

Fusion Power	= 500MW
Plasma Current	= 15 Megamp
Plasma Volume	~ 840 m^3
Pulse lengths	up to 5000 sec
Supra coils	~ 8000 tons
Vessel	~ 5000 tons
Total in hall	~ 23,000 tons

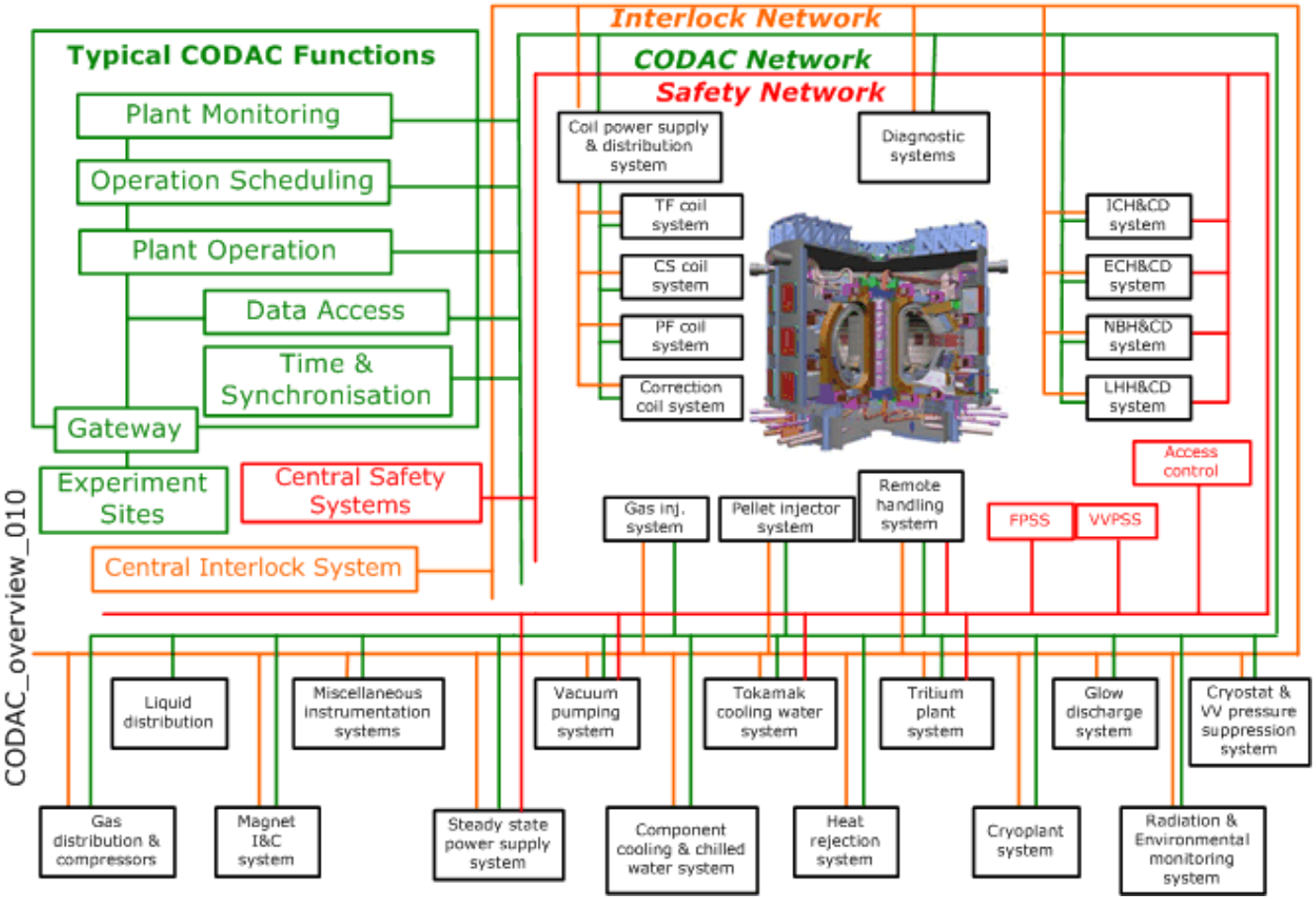


Status of the ITER project

- Organisation exists legally. A council was formed. Hiring has started. Outsourcing has started.
- A full design review was just completed – some changes made
- Current project challenge is to marry “on-cost”, “on-time” and “full-scope”
- Major critical paths are nuclear licensing, building construction and superconducting filament manufacture

ITER seen by CODAC

COntrol, Data Access and Communication



80-120 very different technical "Plant Systems", delivered in-kind

These include all science diagnostics

Blocks of "CODAC" functions which are software and "conventional" Information Technologies

Networks

CODAC is just like many other large and complex data systems *

Approach taken since 2005

- Identified the requirements
  - Avoid under-performing and gold-plating
  - Sign off by peer-review (November 2007)
- Identified the major challenges
  - Concentrate the small available effort
- Made first cut at functional breakdown
  - Define what we are talking about
  - Identify some design approaches
- Identified strawman solutions
  - Have we got at least one solution which meets the goal?
- Put all that into a document for multiple readers
  - Physicists, computer scientists, control engineers, project managers

Why concentrate on requirements and usage ?

- A first view shows that there are no technical challenges at the level of performance
- → there exists a multiplicity of solutions
- → failure will not be technical/performance
- → failure will come from
  - Unsuspected requirements
  - Wrong requirements
- → failure would look like
  - Inadequate availability
  - Slow integration
  - Unrealiability threatening the investment
- Danger !! Requirements-driven ➔ correct requirements become the major project requirement – a new risk

6 new challenges for fusion

- Where are the new challenges for fusion ?
  - Nuclear installation – new rules
  - “In-kind” procurement from 7 Parties
  - Reliability/availability higher than any previous fusion project
  - Internationally exploited experiment
  - Long timescale to construct, operate, maintain
  - Continuous operation rather than pulsed

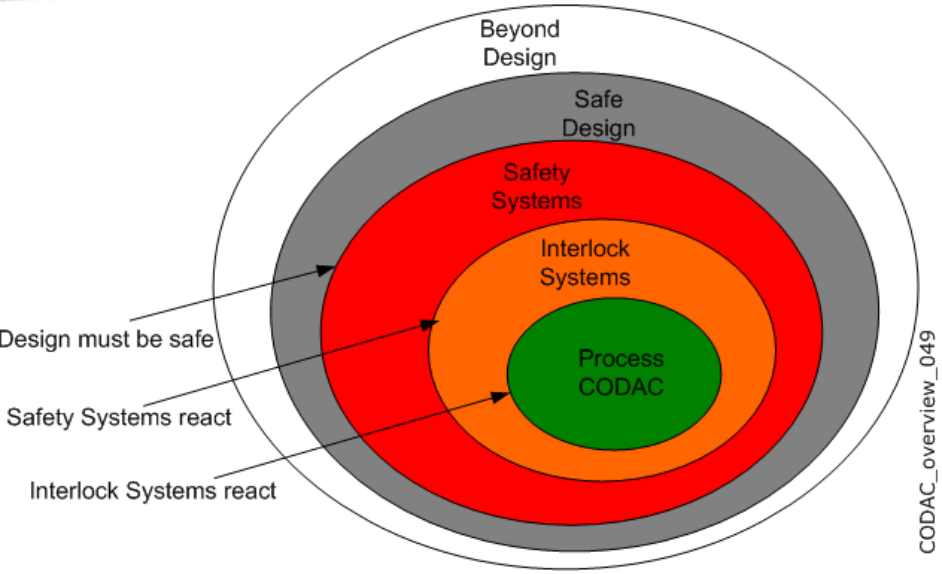
Yes, there are some specific challenges, but not performance *

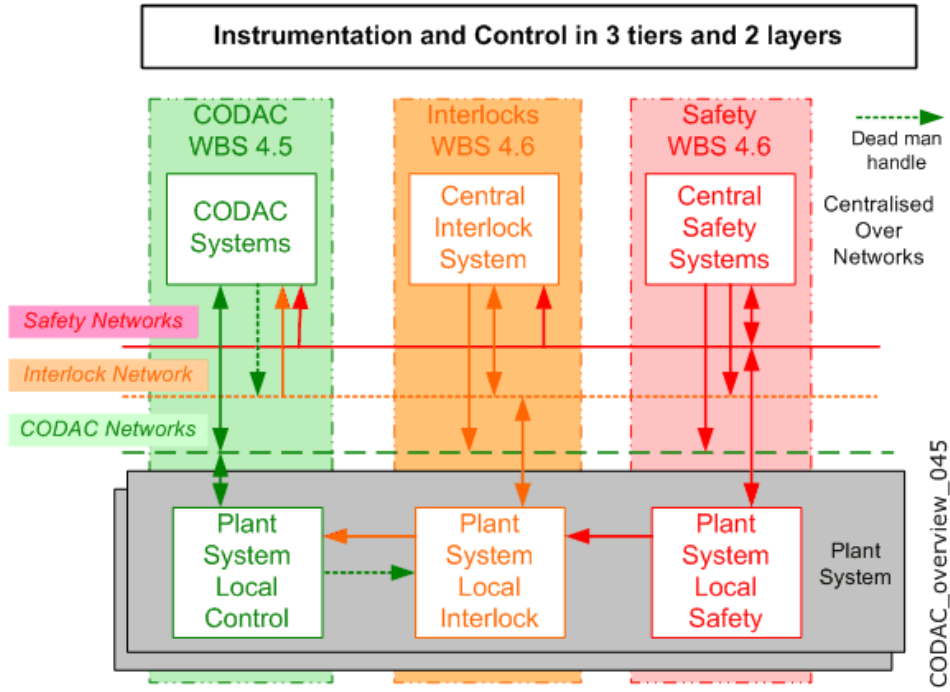
Why is performance not on the list ?

- Sustained data flow rates ~ 5GB/s
- Data archive rates ~ 1-5 PB / year
- Channel numbers ~ 300,000 – 500,000
- Number of semi-autonomous systems ~ 120
- Timing requirements ~10 nsec for fast time-stamping

These are tough, but not cutting edge, they are all beaten elsewhere *

Nuclear challenge – segregation of functions





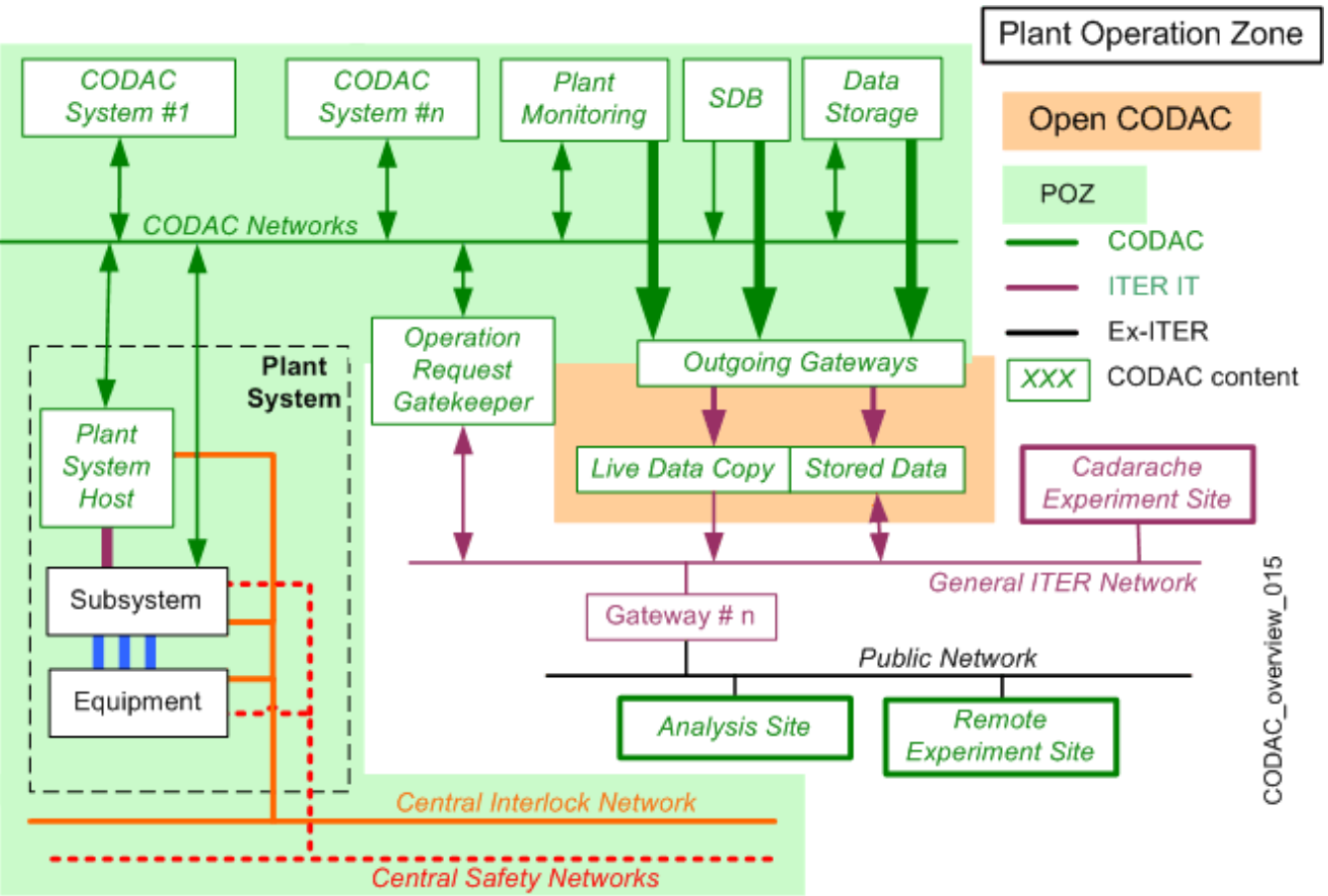
CODAC runs ITER operationally, 30 years * 365 days * 24 hours

Interlocks protect investment, disallowing some actions and imposing limits

Safety protects personnel against **conventional** risks and **nuclear** risks

Nuclear CODAC challenge needs segregation – Safety Report 2007-2008 *

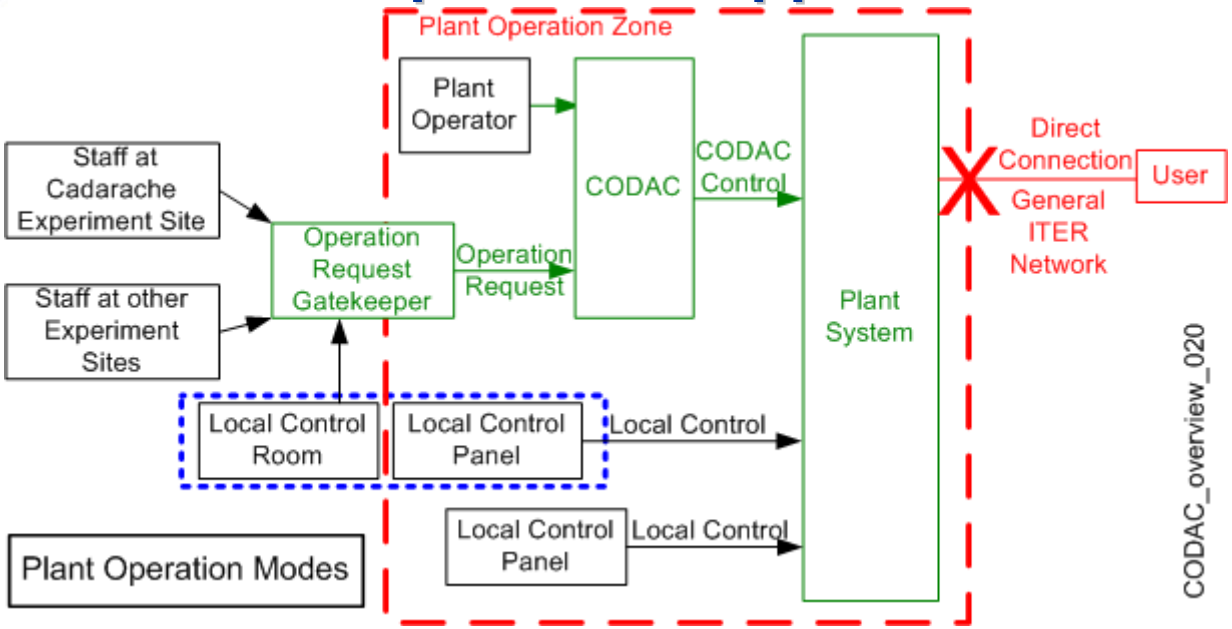
Plant Operation Zone - nuclear & exploitable



- The Plant Operation Zone "operates" ITER
- POZ is highly protected and must function isolated
- Live and archived data are pushed out from the POZ to all Experiment Sites
- Exploitation is international, not operation

Data flow **out** continuously to experimentalists – 2012 – testable now *

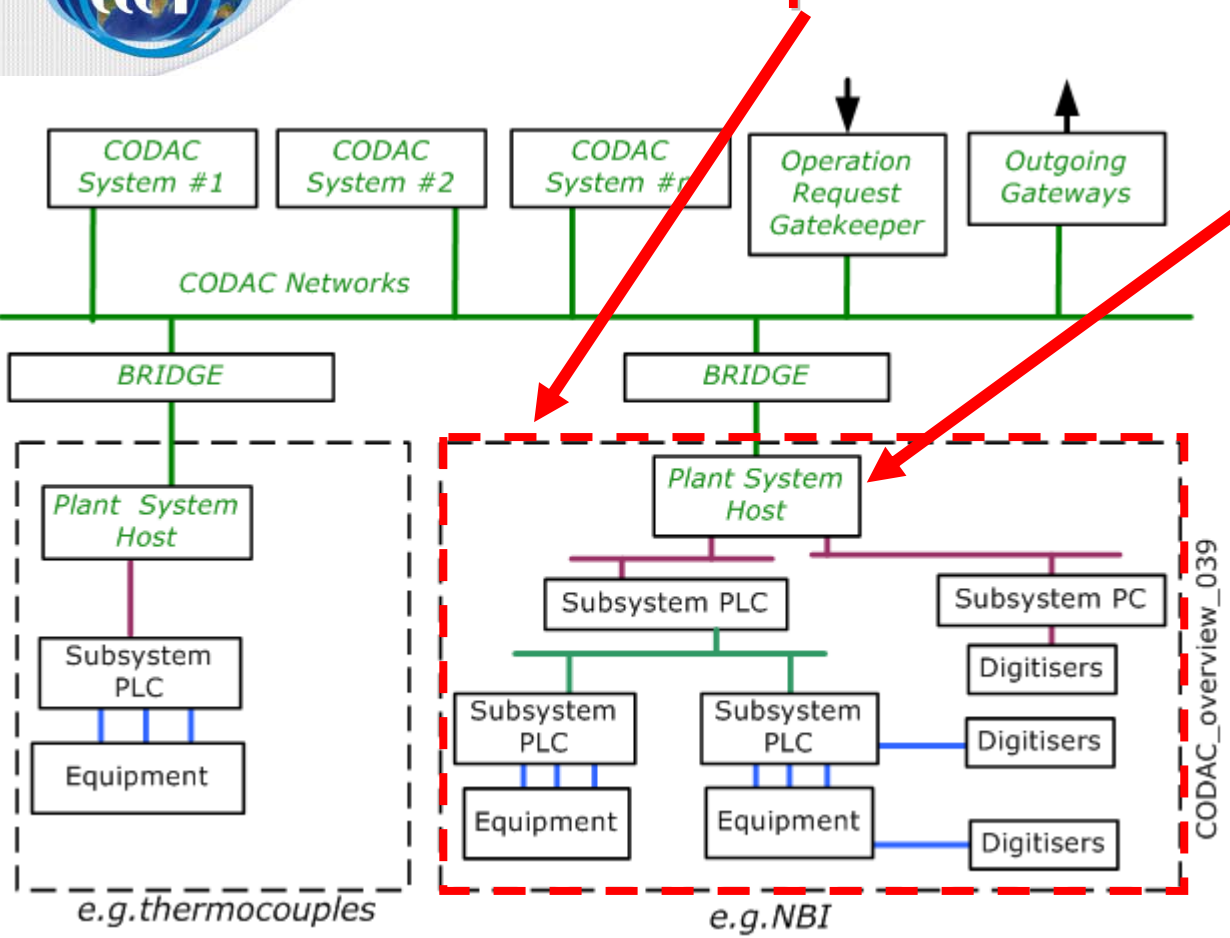
Remote exploitation approach



- All Experiment Control Rooms (ECR) are equal – one is in Cadarache
- Cadarache has one Main Control Room (MCR) and one Backup Control Room
- The MCR operates the device
- The ECR makes “polite requests” to submit commands, data
- The Gatekeeper decides by air-gap decision or rule-based decision
- !!! No logging in to your “own” device inside the nuclear island

International exploitation needs a gatekeeper and habit changes * – 2012 – testable now

Procurement perimeter and integration



A "Plant System Host" is the main point of entry

Creates a generic image of its Plant System

Delivers its "self-description"

Respects standard ITER communications

Marshalls experiment data

Free-issue to Plant Systems

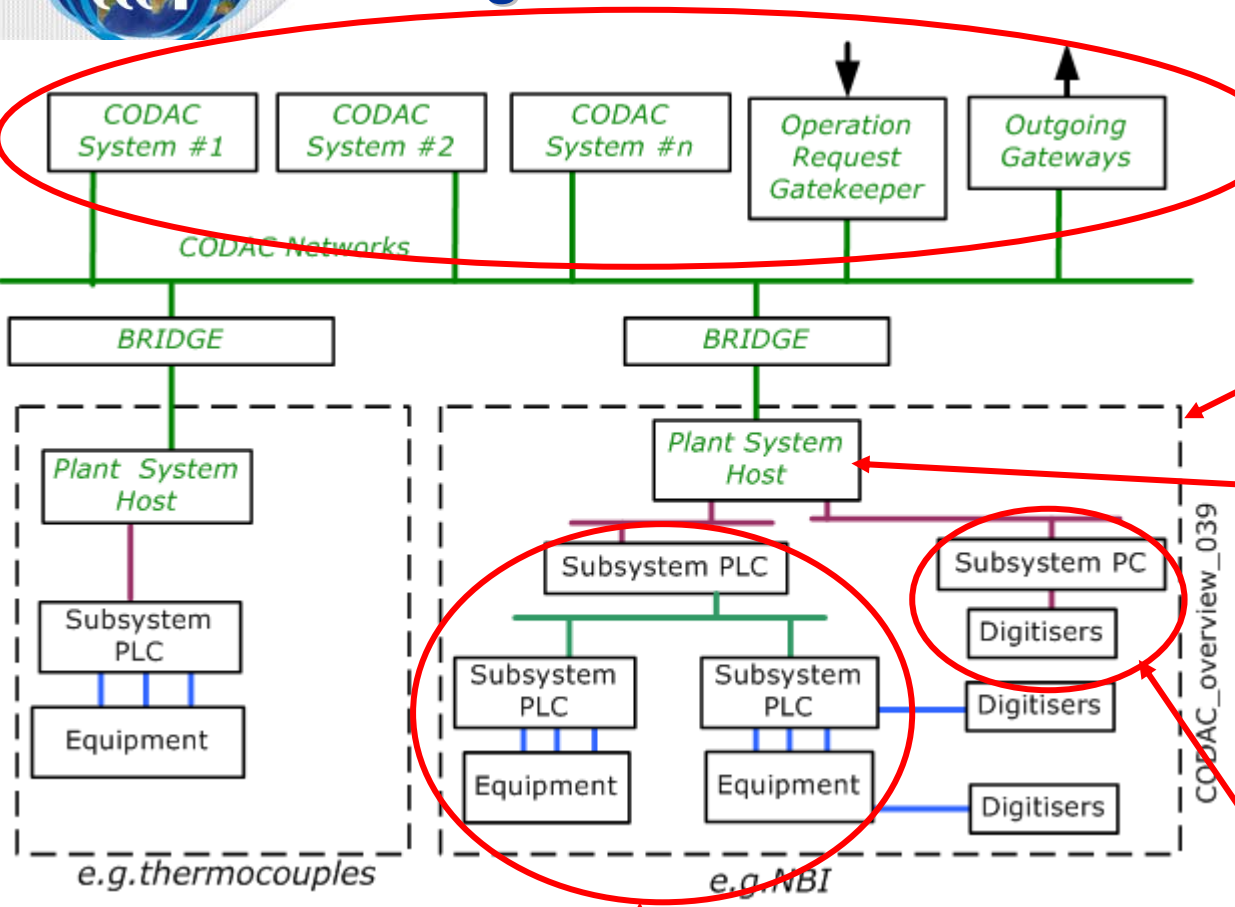
…but… we rely on strong Instrumentation and Control (I&C) standardisation INSIDE the Plant Systems

Q –- PLC suppliers, Operating Systems, fieldbuses, languages, cabling, racking ….

…. reduce complexity, allow maintenance

Integration challenge requires standardisation – Specifications 2007-2008 *

Integrate semi-autonomous Plant Systems



Supervision tools

Procurement package

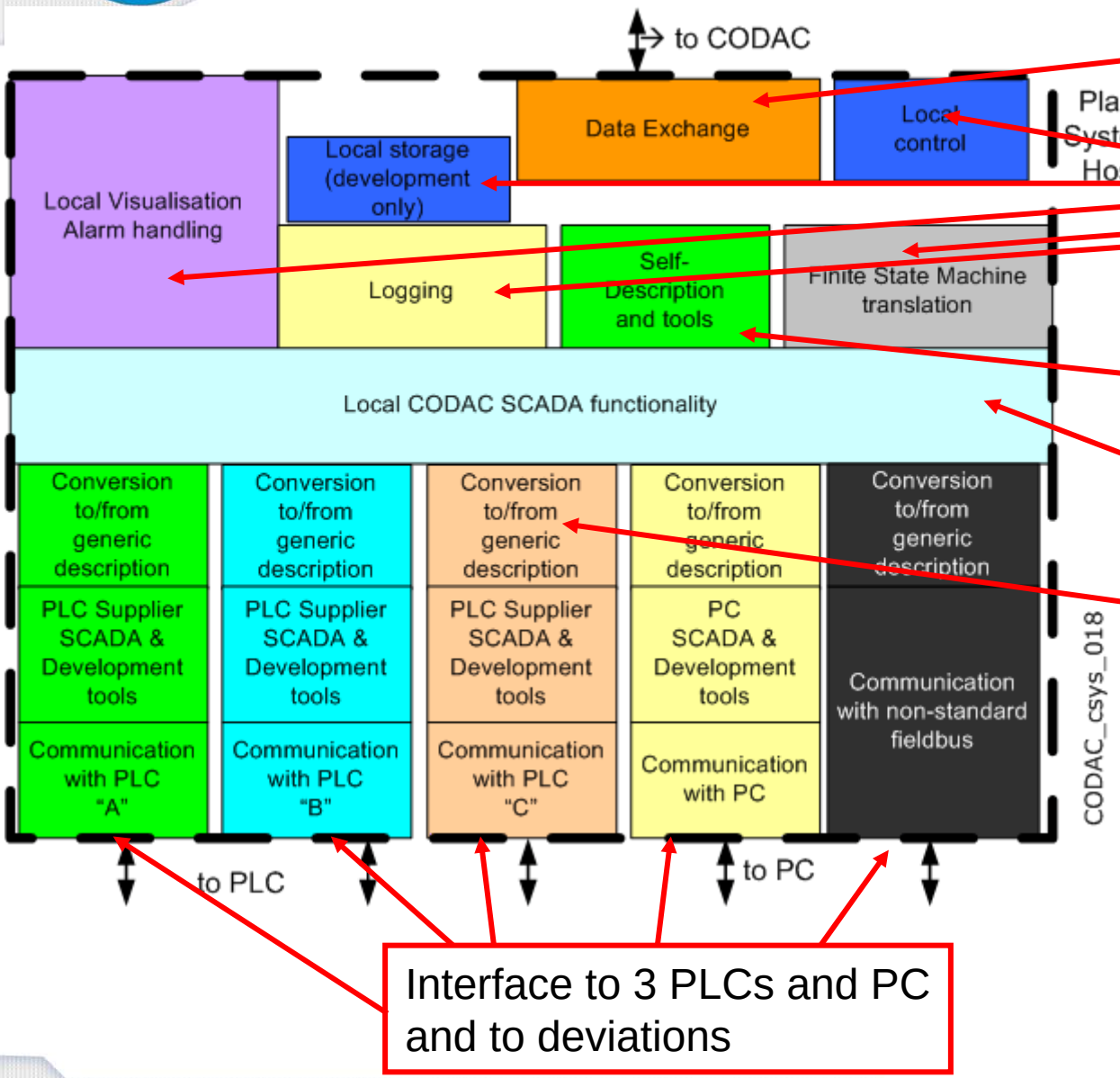
Plant System Host
Hides heterogeneity

PLC world, >5msec
SIL-2 or SIL-3
Structured methods

PC world, fast, high data rates
Less constrained methods

We've moved the problem into a free-issue Plant System Host *

What's inside the Plant System Host ?



Unique interface

Logging, alarms, HMI, Storage, FSM, control

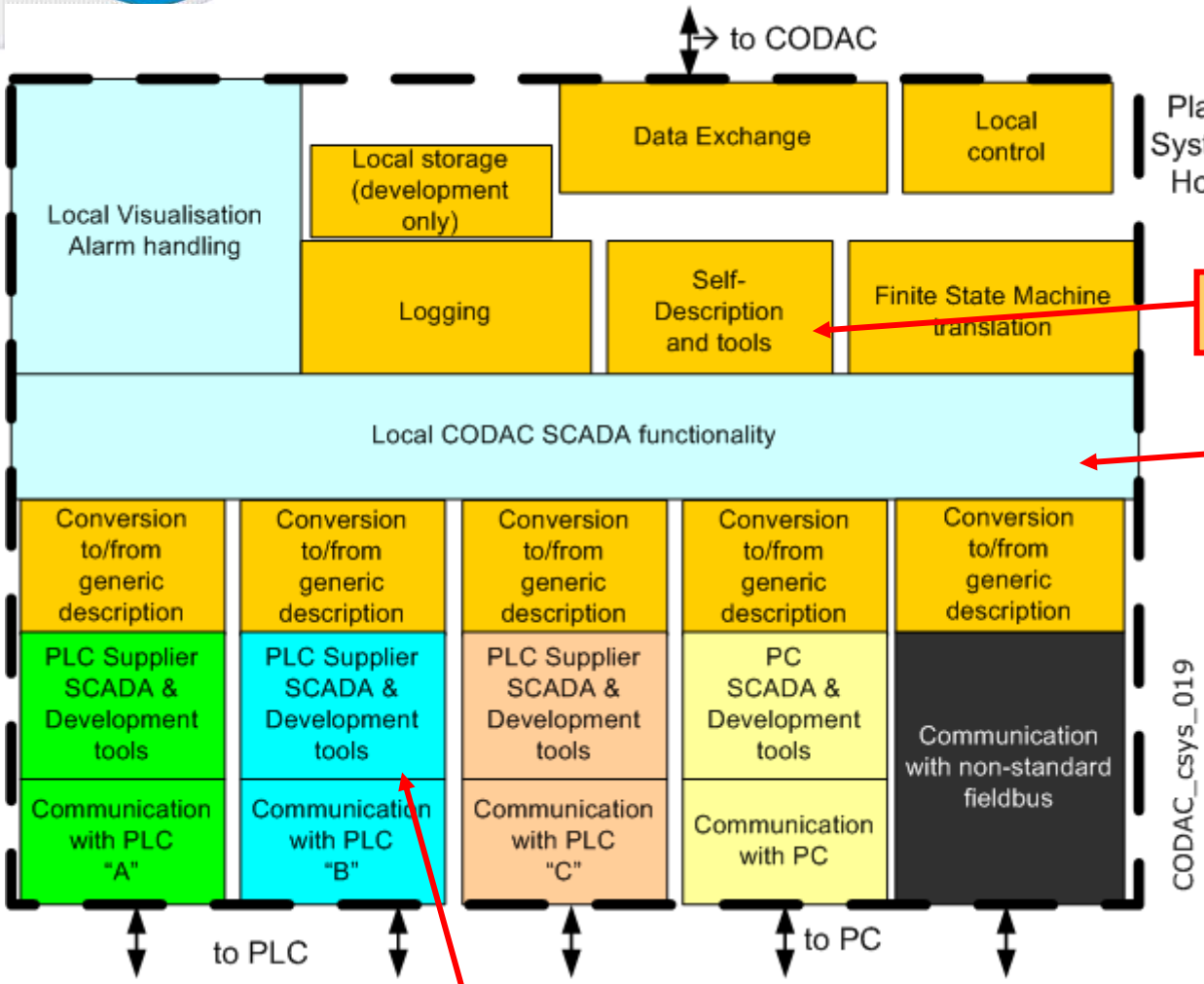
Self-description

SCADA

Proprietary to generic interfaces

Interface to 3 PLCs and PC and to deviations

Where do the pieces come from ?

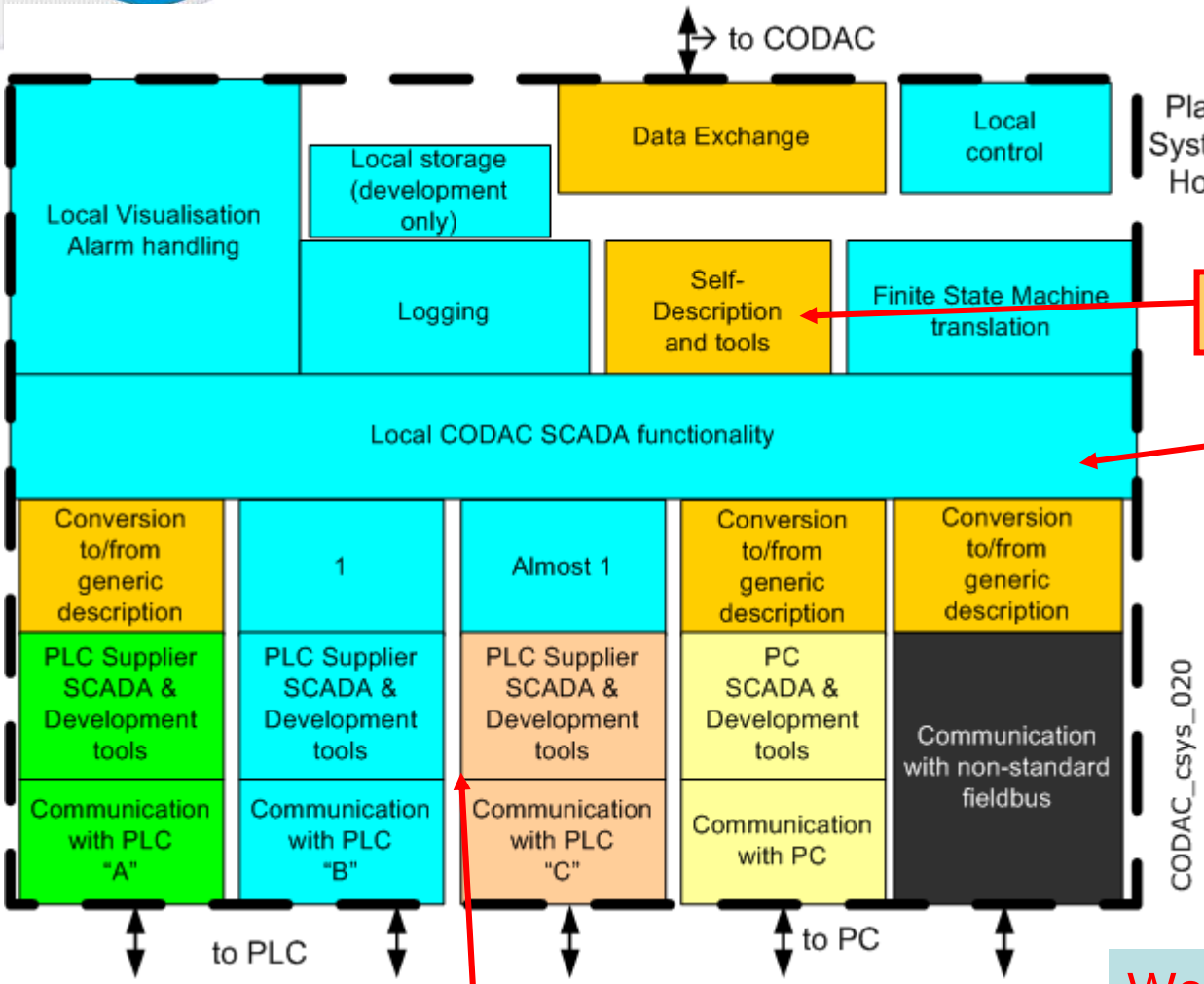


CODAC or integrate products

SCADA product

PLC Manufacturers

Can we do this with more COTS ?



CODAC or integrate products

PLC manufacturers
or
Mixed PC-PLC suppliers

PLC Manufacturers

We're looking for the best mix
Performance, flexibility, QA
evolution, maintenance *

Self-description – plug and play ?

- "Self-description" refers to the information flow from the in-kind supplier into CODAC

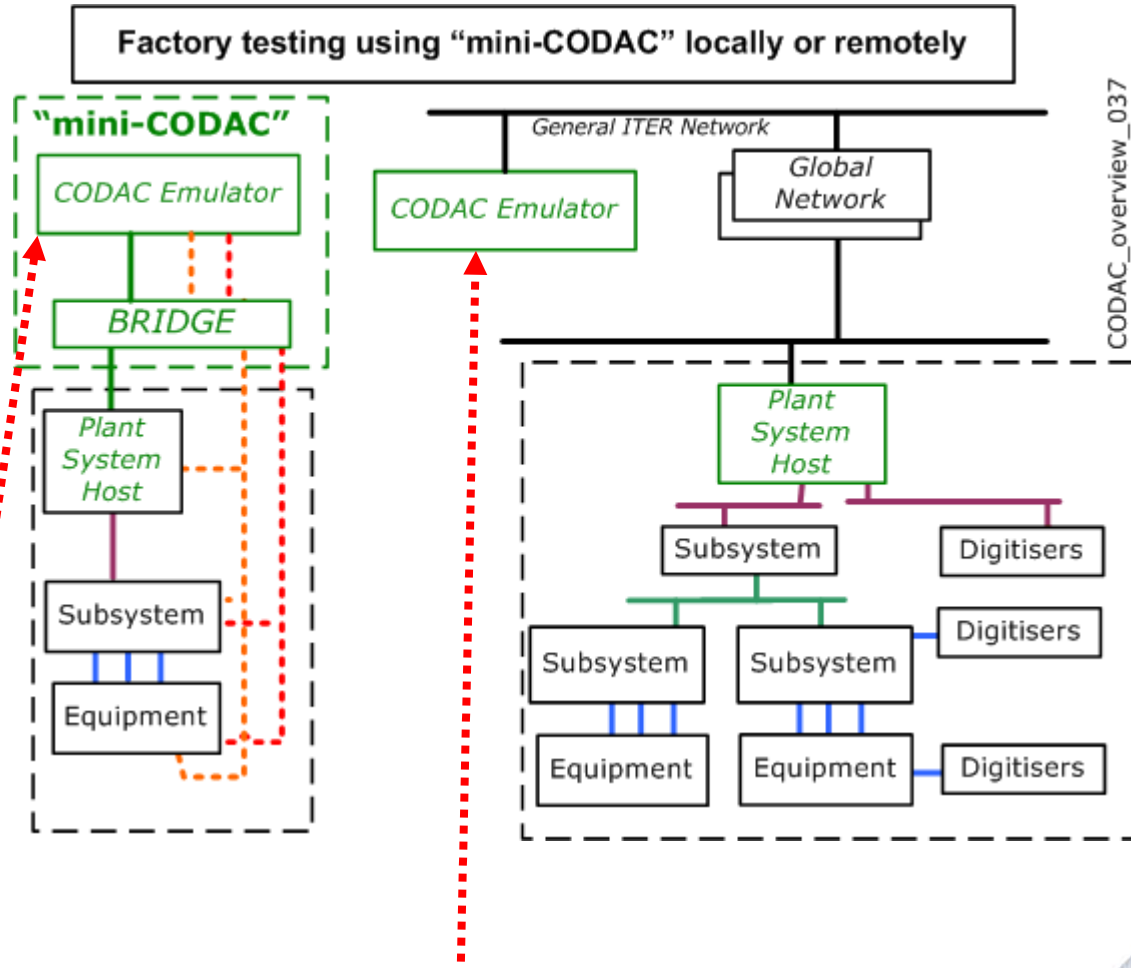
- CODAC specifies a set of XML schemas common to all Plant Systems
  - Signal list, resolution, sampling…
  - Dynamic behaviour of the plant as a Finite State Machine
  - Commands, set-points, limits, alarm values
  - Wiring, cabling, modules, racks
  - Documentation, process design output
  - Contacts, manufacturers, maintenance, drawings

- Orchestration of the full ITER plant by CODAC can then be dominantly data-driven

Integration challenge requires structured and complete information
– Interface Control Document 2007-2008 *

Factory development – “mini-CODAC”

- Suppliers develop their self-description using CODAC tools
- CODAC System functionality is deployed in a “Mini-CODAC” to help factory development
- An industrial case is identified



- “Mini-CODAC” tests **all** CODAC interfaces and functionality at the factory, where the competence is. Either uploaded or remote from Cadarache.

Integration risks aided by CODAC factory testing – Specifications 2007-2008 *

Real Time on ITER – slower than today

Synchronous DataBus *transverse peer to peer communication*

- Feedback assumes circulating <3000 analogue values
- Sensor to actuator <5msec is required for fast feedback → 1 msec cycle
- High availability is required – loss of control is expensive
- Real-time Ethernet looks adequate for speed and availability (e.g. Powerlink)

Time Communication *transverse communication*

- Time, synchronisation are distributed by Ethernet → NTP, PTP
- Triggers are produced by sending the time rather than a "wire" trigger
- Events have another network

Data reduction

- Analyse physics data in the front-ends, rather than circulating "wire" data

Simulations and alarms

- Calculate models for model-based control, or try predictive model control
- Compare simulated and real data to detect anomalies → early alarms

Real time will be met by off-the-shelf high reliability components *

– Interface Specifications 2007-2008

High Availability

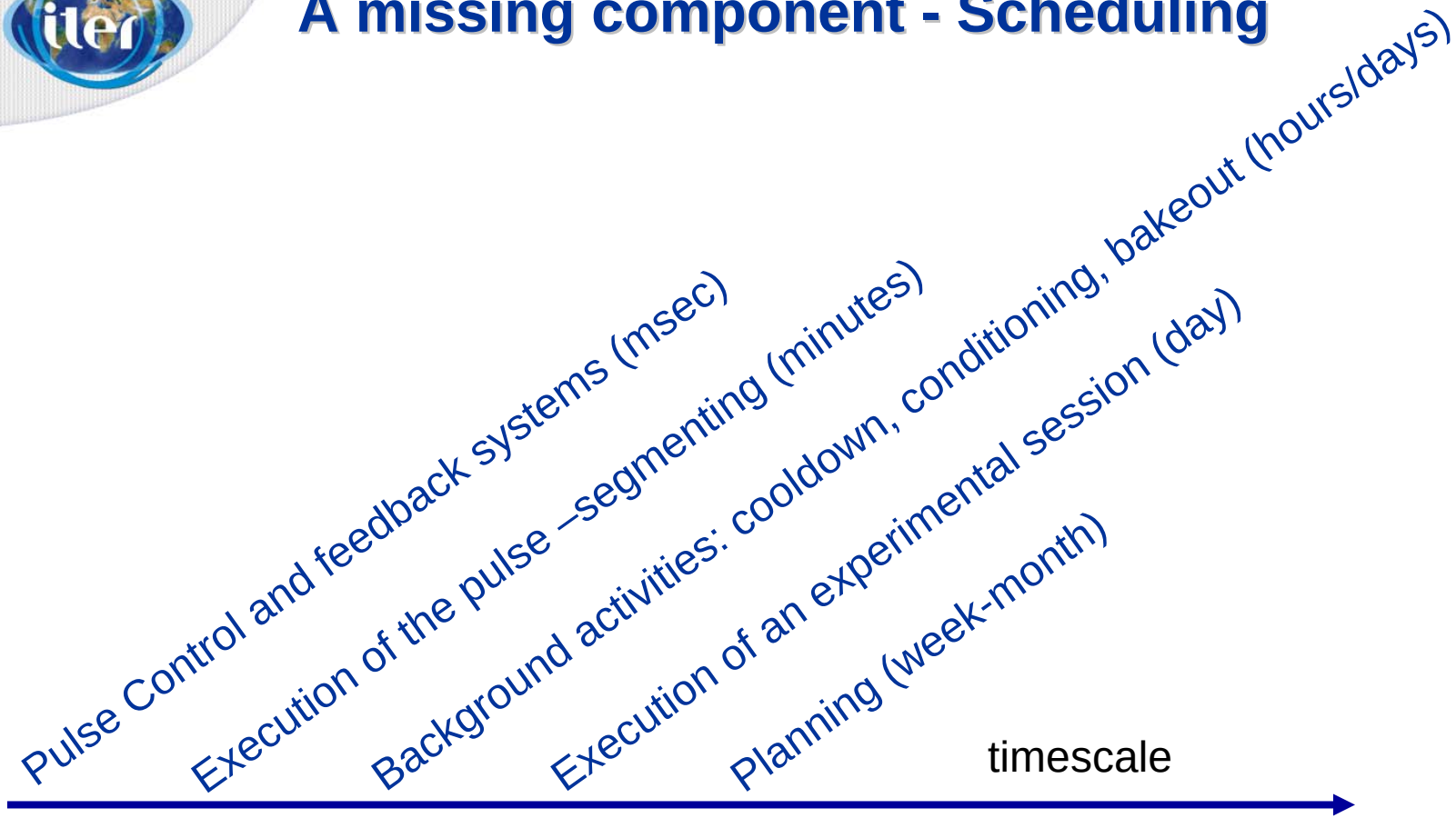
- High availability has NOT been the strength of the fusion physics community in general – we just did our best for our research
- CODAC is targeting industrial levels of availability
  - i.e. >99%
- Guarantee redundancy against single-point-of-failure in identified CODAC Systems, according to the cost of loss of functionality

Q – what is " CODAC must be as available as reasonable"

- A Reliability,Availability,Maintenance activity has been started project-wide

Availability will cost €€€€, but off-the-shelf – 2012-2014 *

A missing component - Scheduling



- We have not yet identified an appropriate tool, but we are looking at workflow products (Kepler)

Scheduling is an area where tools are developing *
S88 batch manufacturing standard ? – ready for 2012

CODAC evolution planned

• Conceptual design	2006 - 2007
• Engineering design of CODAC Systems	2007 - 2009
• Retrofitting CODAC design approaches ?	2007 - 2012
• Factory testing needs “mini-CODAC”	2009 - 2010
• Full prototype (maintain during operation)	2010…
• Production environment	2010 - 2012
• Full simulator using Plant System data	2012…
• No developments after…	2014

- In the end, we shall have spent ~70M€ allocated

Curiously, one challenge is to do this slowly, i.e. far in advance ! *

2007 Wish list

- Common XML FSM representation – e.g. SCXML (W3C)
- Common XML IEC 61131-3 representation
- Open XML device representation – e.g. CAXE
- Structured data representation of all Interface Control Documents
- COTS digitisers and timing cards under IEEE 1588
- Open XML representation of mimics – e.g. PVSS, jddd
- PLC ←→ PC common development environment
- XQuery/SQL efficient marriage – e.g. Oracle XML DB / DB2

The Cadarache ITER site

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Thank you for your attention… *