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EUROfusion

# Preliminary Engineering Design of the Central Instrumentation and Control Systems for the IFMIF-DONES Plant


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# Outline

- Introduction
- Central Instrumentation and Control Systems: general architecture
- Main components identification
- Network Design
- Conclusion and future work

# DONES CICS Team

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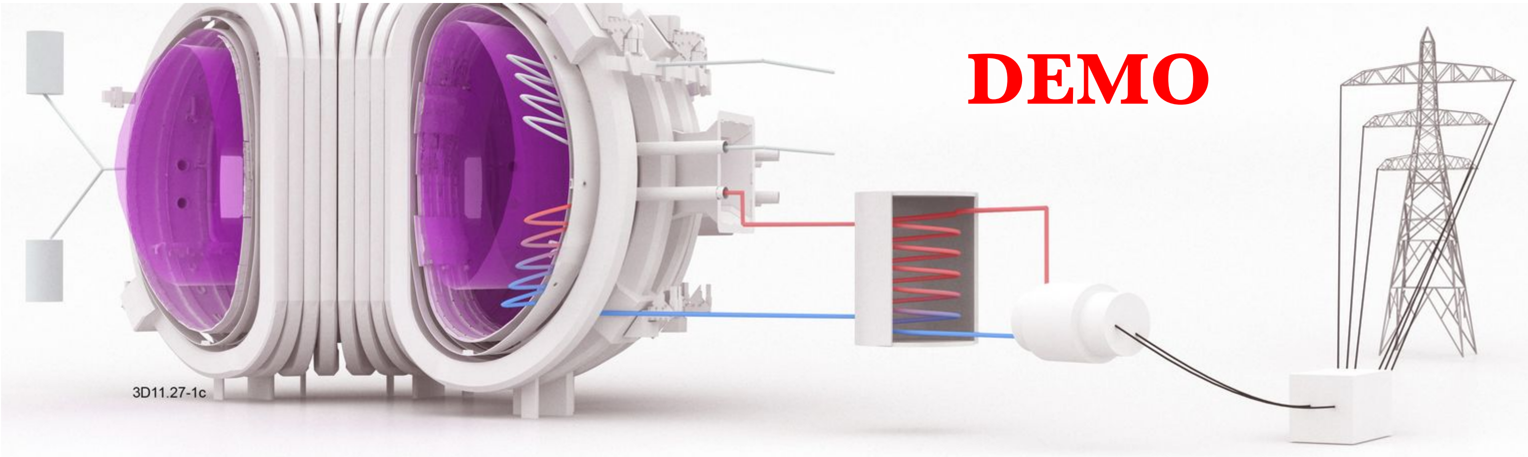
# The need of a neutron source




Fusion Power Plants (DEMO) are characterized by the presence of **14 MeV** fusion neutrons in the **first wall area.**

UNDERSTANDING THE **DEGRADATION OF THE MATERIALS**

**DESIGN** **SAFETY**

Presently available n sources are not adequate to reproduce fusion-like environment

- **Fission reactors:**

  **0.3 appm He/dpa**

- **Spallation sources:**

  **50-70 appm He/dpa, pulsed, light ions,...**

**A specific source for fusion neutrons is required**

Consensus on an accelerator-based neutron source **exploiting D-Li stripping reactions: Li(d, xn)**

## A 40-year long history

In the '80s
FMIT (Fusion Materials Irradiation Test) in the US
deuterons at 100 mA in CW and 35 MeV for a 0.01 l volume

In the '90s
ESNIT (Energy Selective Neutron Irradiation Test) in Japan
deuterons at 50 mA and 40 MeV for a 0.125 l volume

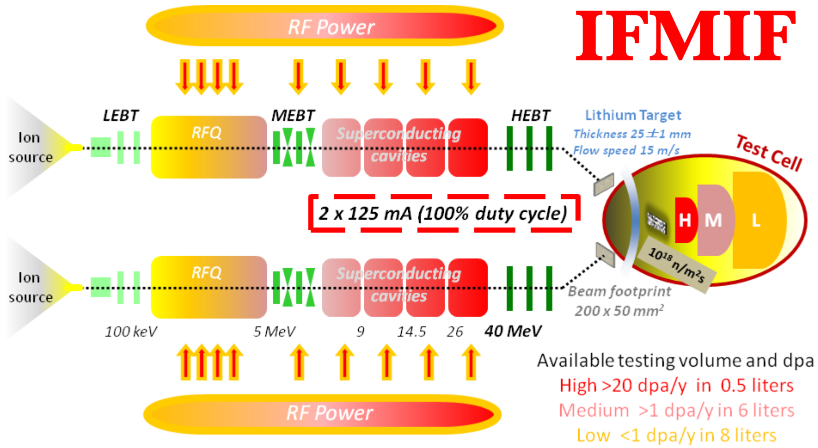
Since 1994
IFMIF (International Fusion Materials Irradiation Facility)
RF, US, **JA, EU** joined efforts and generated a baseline

Since 2007
IFMIF/EVEDA project included in the EU-JA Broader Approach Agreement
**JA, EU** joined efforts

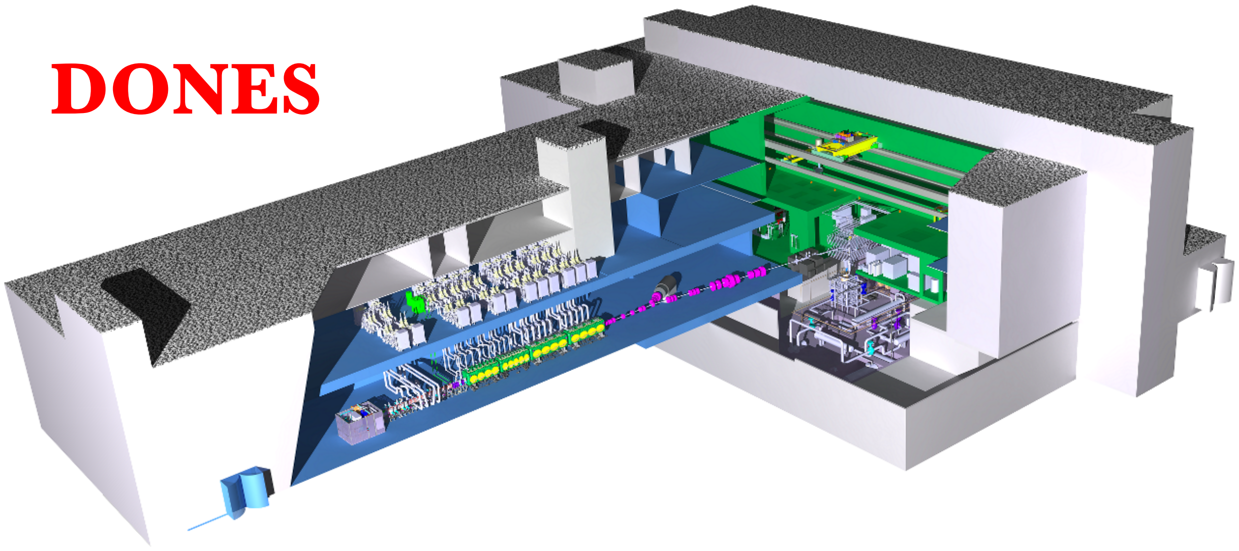
# From IFMIF to DONES

**IFMIF** (International Fusion Materials Irradiation Facility):

- **two** parallel deuteron accelerators
- **a neutron flux with a broad peak at 14 MeV**
- Li(d,xn) nuclear reactions: liquid Li target (20 cm x 5 cm)
- energy of the beam: **40 MeV**
- current of the parallel accelerators (2 x 125 mA)
- around 1000 small specimens




## DONES

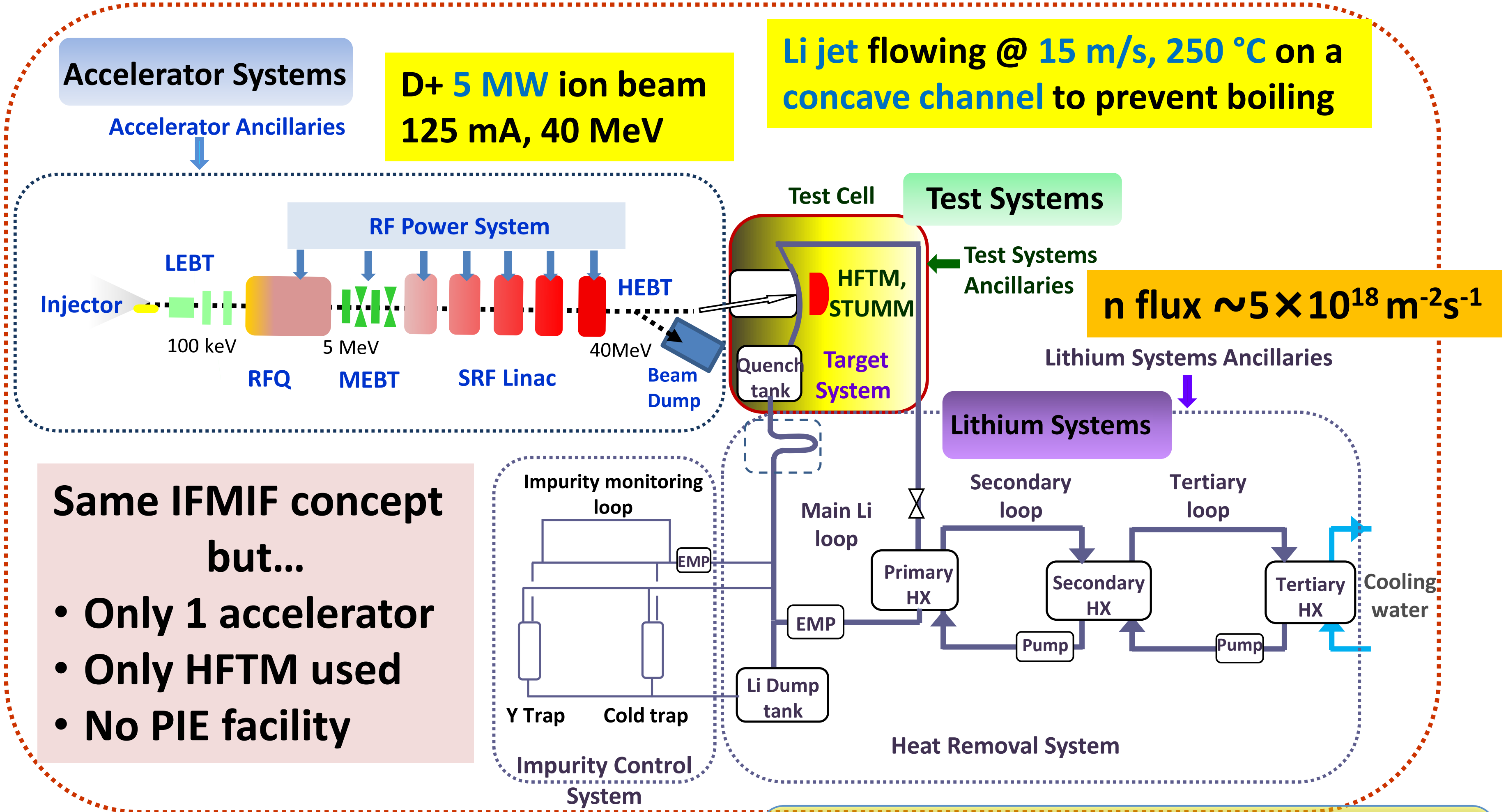


**DONES** (DEMO-Oriented Neutron Early Source)

Generation of materials irradiation test data for design, licensing, construction and safe operation of **DEMO**, as defined in the 2012 EU Roadmap.

- **one** full **IFMIF accelerator**,
- one D+ beam of 40 MeV,
- current intensity 125 mA
- 20 dpa/full power year (iron equivalent) in the materials.

# The WPENS/DONES project



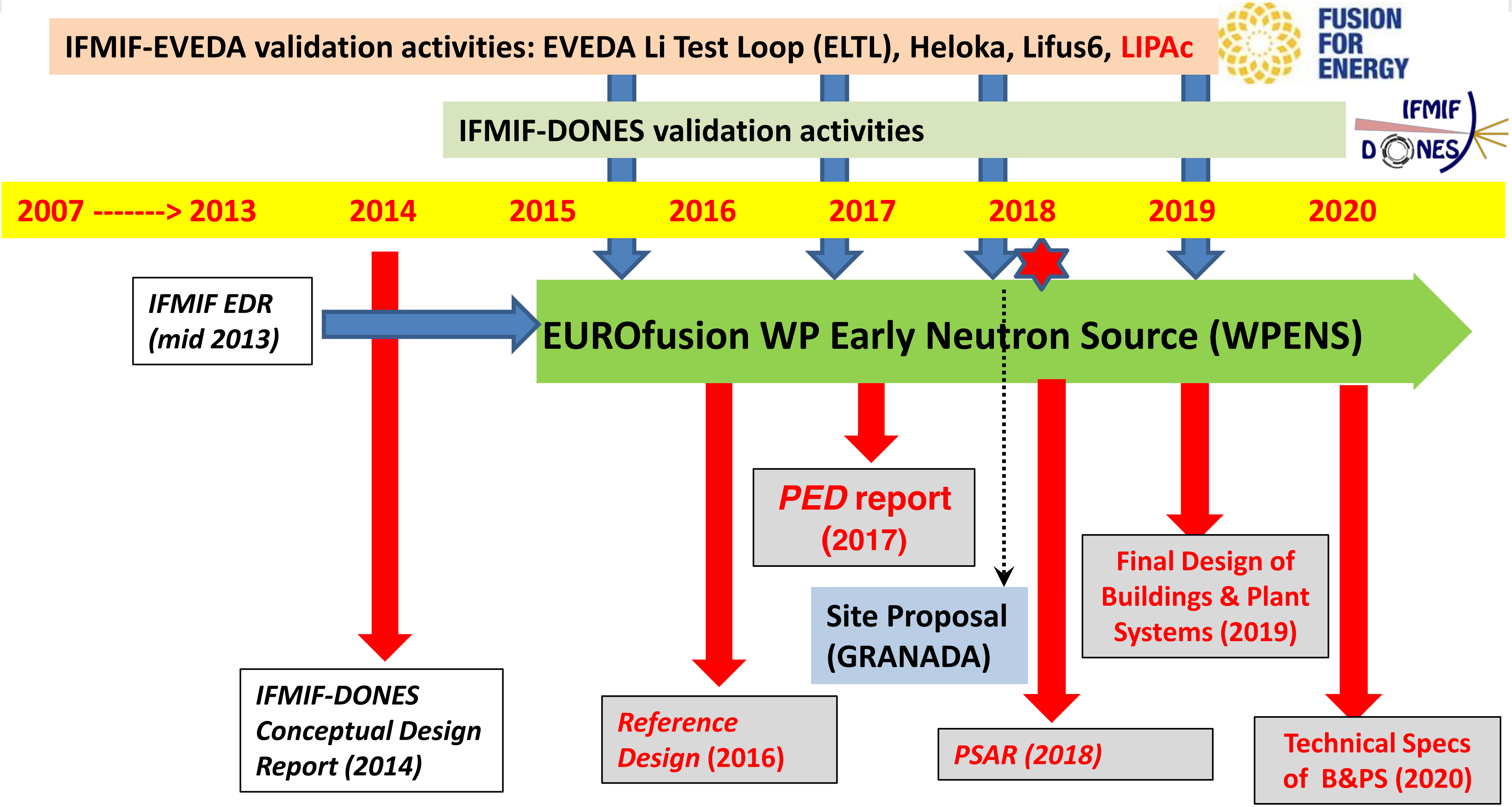

**Site, Buildings & Plant Systems**

- Layout & Site Infrastructures
- Buildings
- HVAC, Electrical Power Supply, HRS, etc.
- Remote Handling System

**Central Instrumentation and Control Systems**

- CODAC System
- Machine Protection System
- Safety Control System

# The WPENS/DONES project




Objectives of the WPENS project (as of EUROfusion Workprogramme):

**To be ready for IFMIF/DONES construction in early 2020s**

# CICS functional goals

CICS main objective:
control the **high-quality irradiation** of samples in a **safe** way, avoiding any damage, and supervising and monitoring all the plant parameters for **long time**

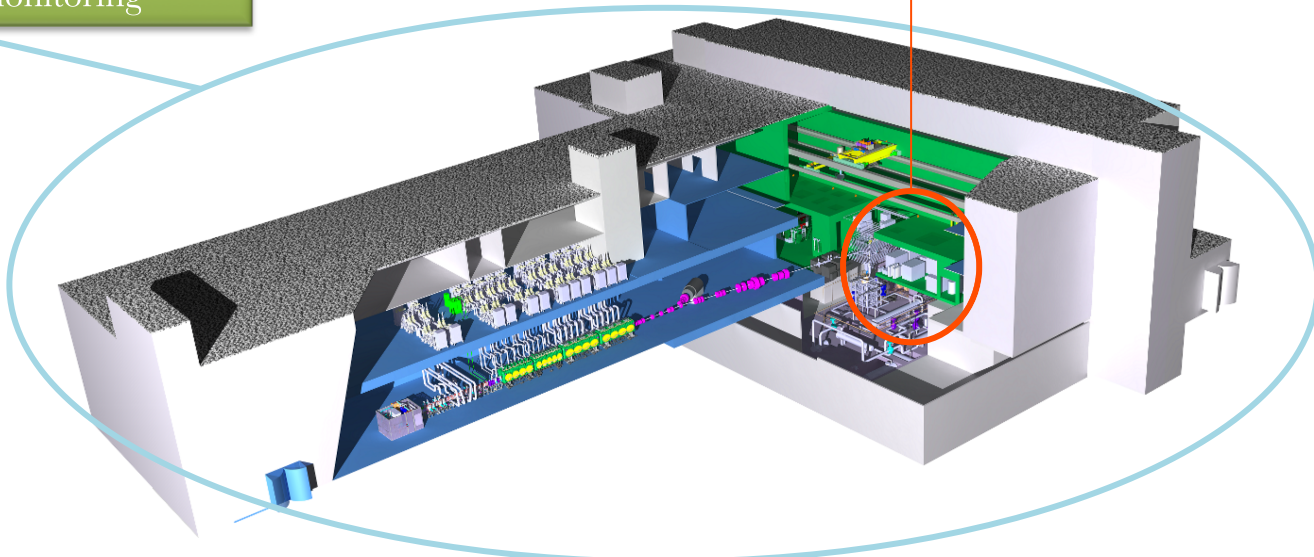
- **Ensure and maximize the operation success**
- **Provide full control of process and events**
- **Contribute to security and safety**
- **Guarantee protection (personal and machine)**
- **Guarantee functionality**
- **Avoid/predict accident (if any, mitigate it), misalignment/ malfunctioning**
- **Provide monitoring & acquisition of exp. data and control parameters**
- **Provide operation scenarios flexibility**
- **Guarantee synchronization and common temporal reference**

**Plant operation control and supervision**
Operation parameter control, visualization and monitoring

**Timing & Synchronization**

**Irradiation and quality control**
irradiation parameter, visualization and monitoring

**Data monitoring and management**



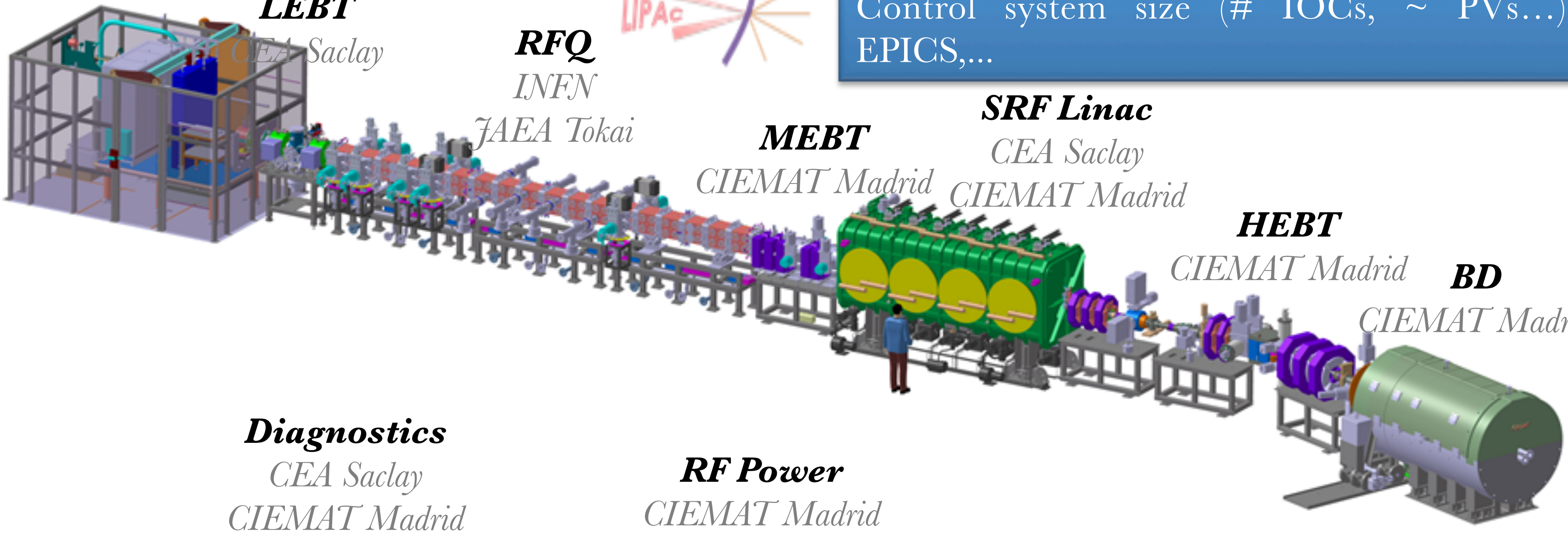
# Reference plants/facilities

## Return of experience: the LIPAc case

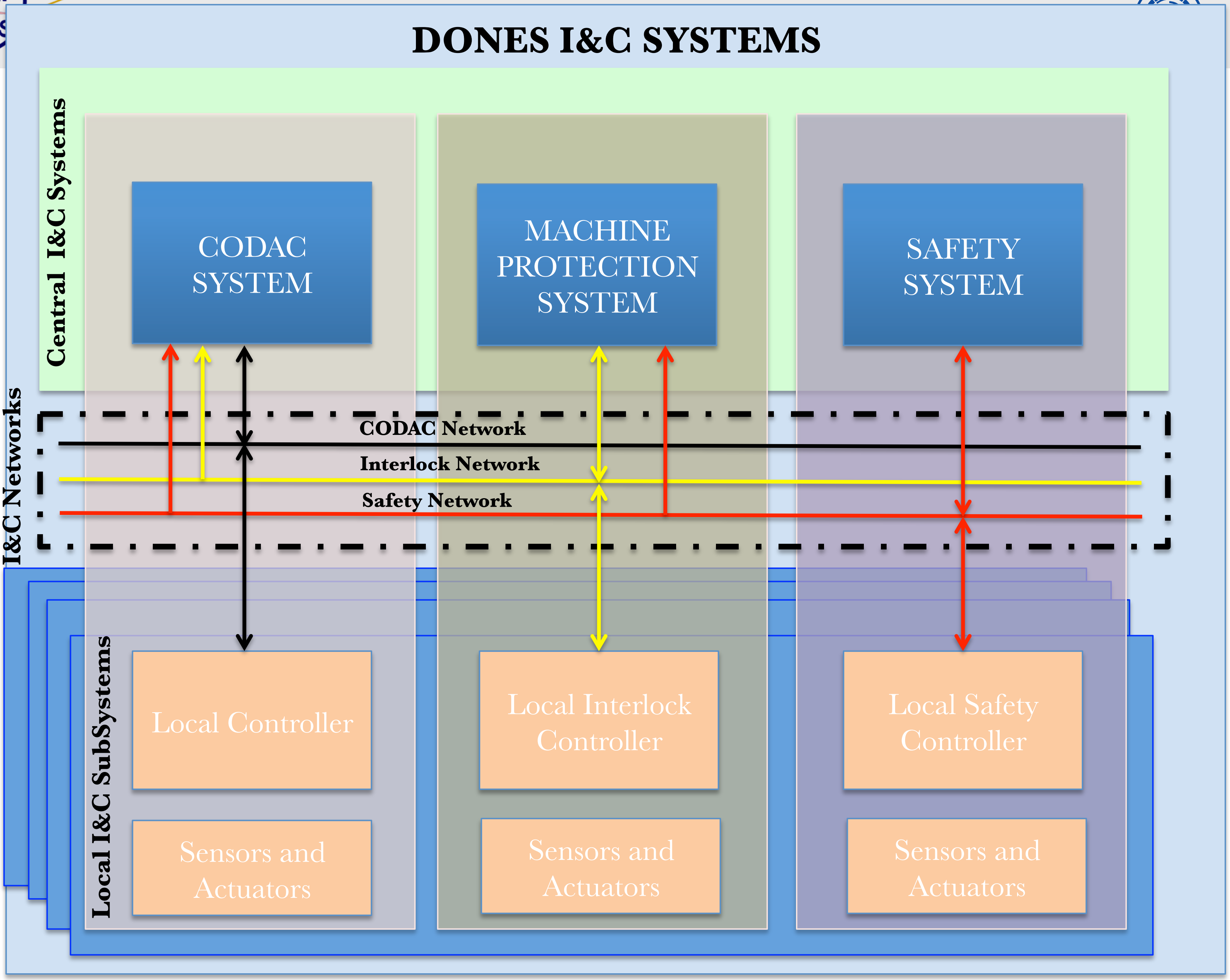
**Common points LIPAc – DONES (AF)**

Physics (MPS response, timing, acquisition)

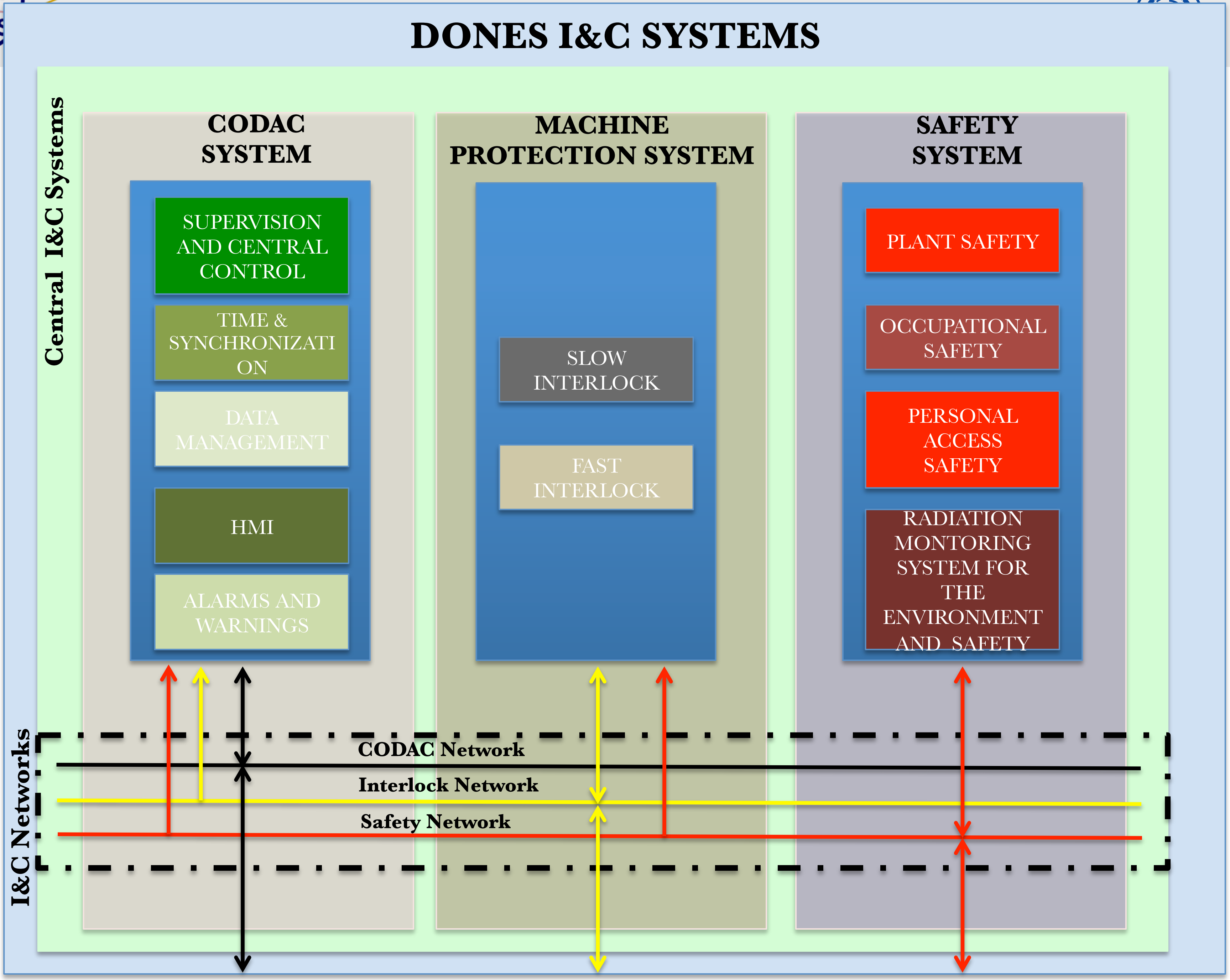
Control system size (# IOCs, ~ PVs…), EPICS,…



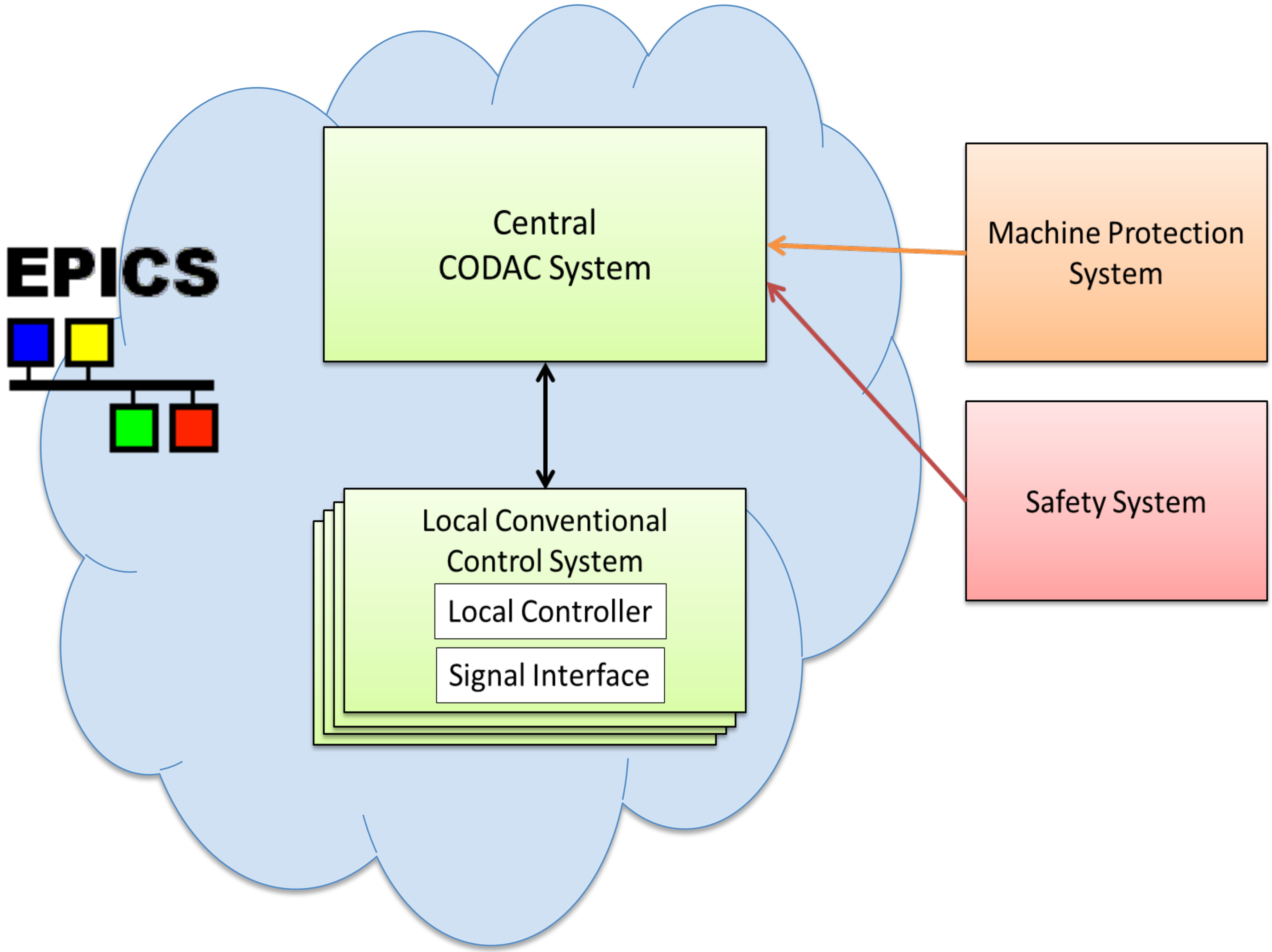
# DONES I&C ARCHITECTURE



DONES I&C ARCHITECTURE

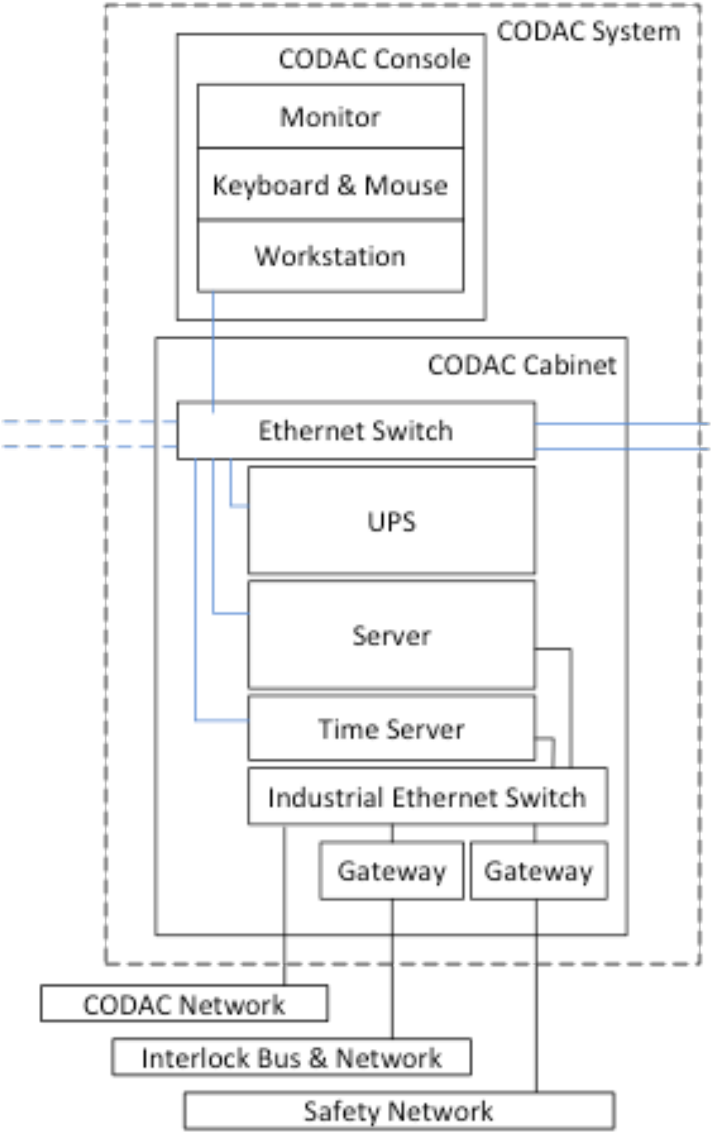


# Relations among Control Systems

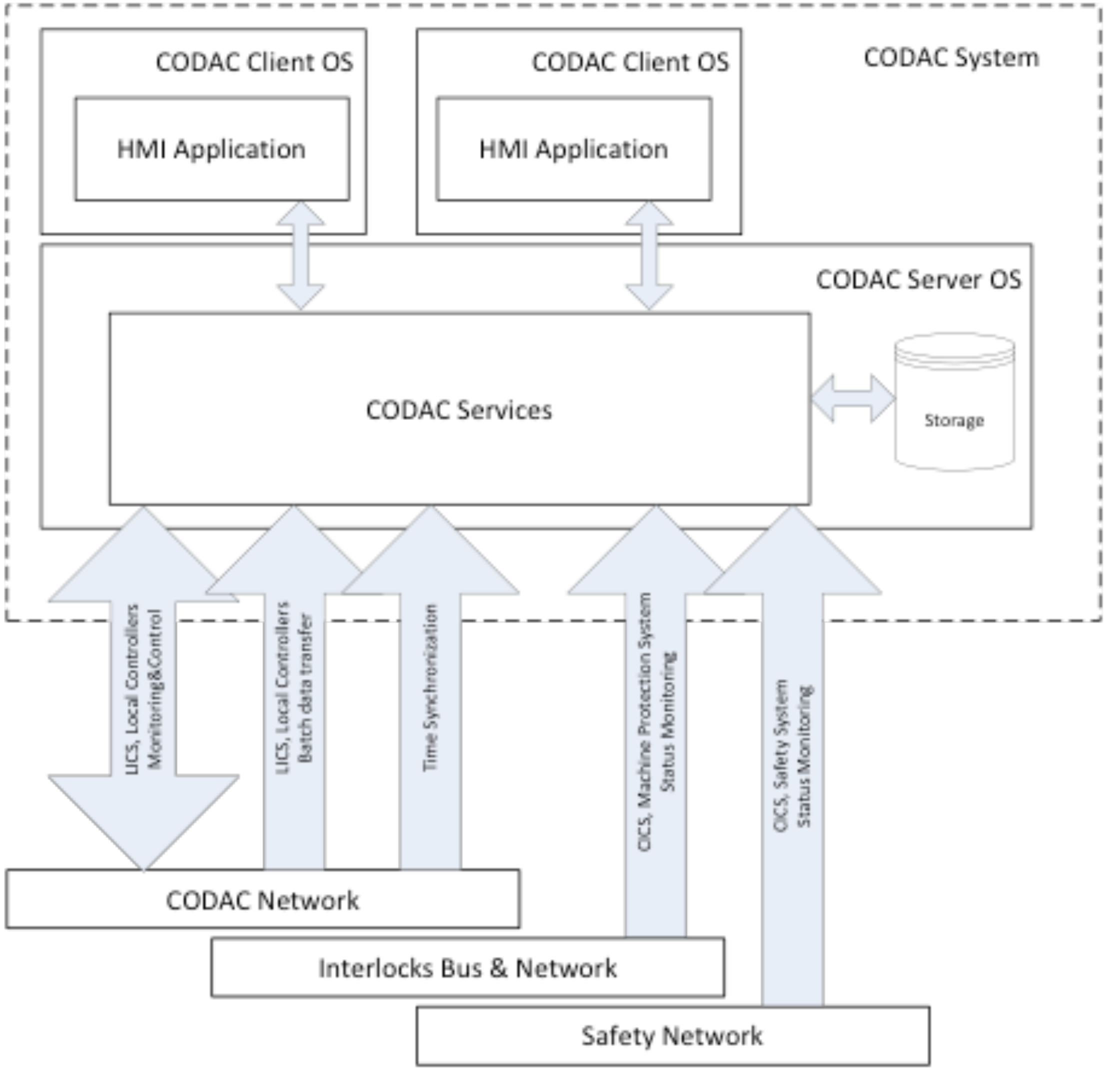


# CODAC - Main components identification

## Physical Architecture

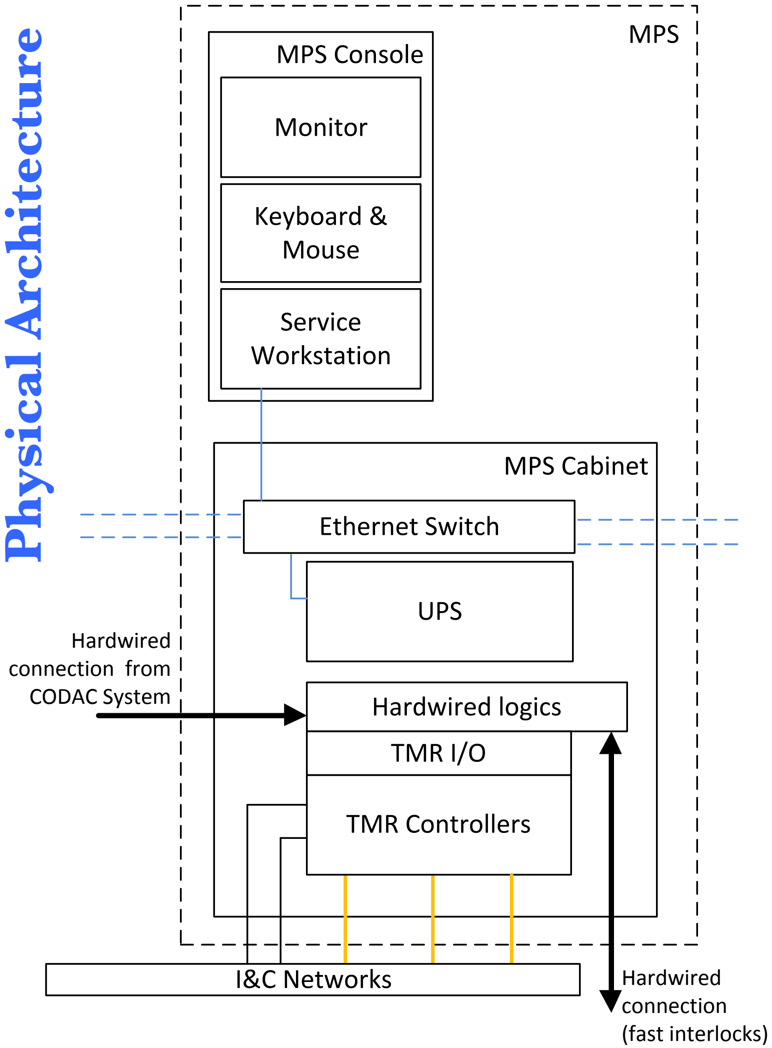



## Software Architecture



# MPS: Main Components Identification

## Physical Architecture

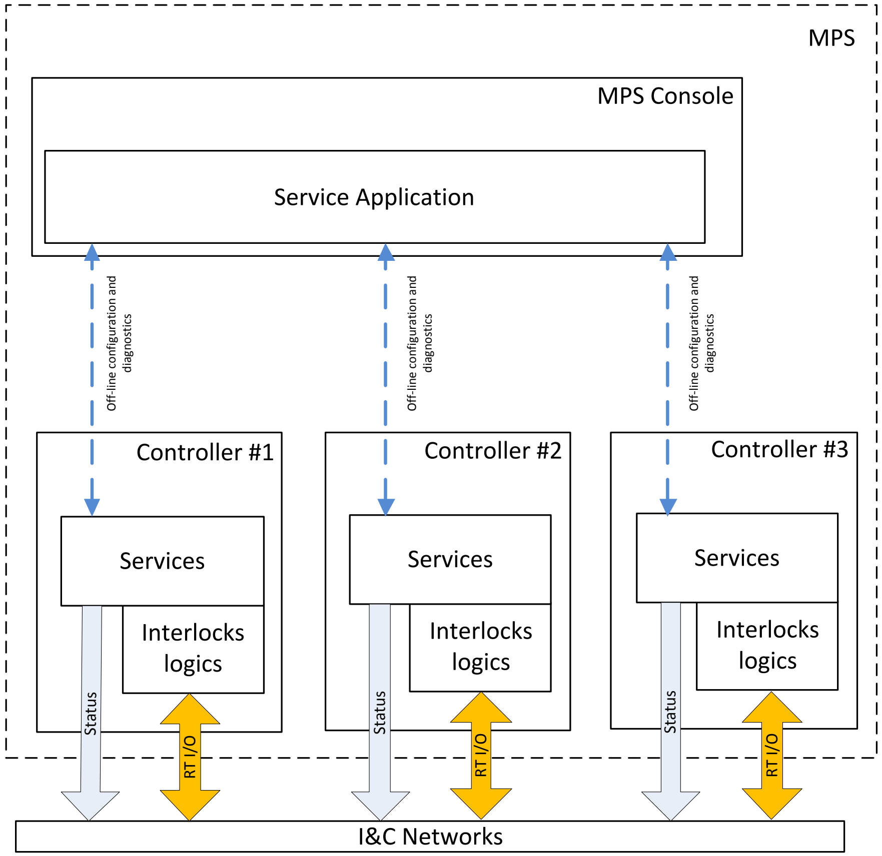



Three Modular Redundant (TMR) controller for slow interlocks

Hardwired logics for fast interlocks

Service workstation for configuration and management

## Software Architecture




Three identical control logics running in parallel

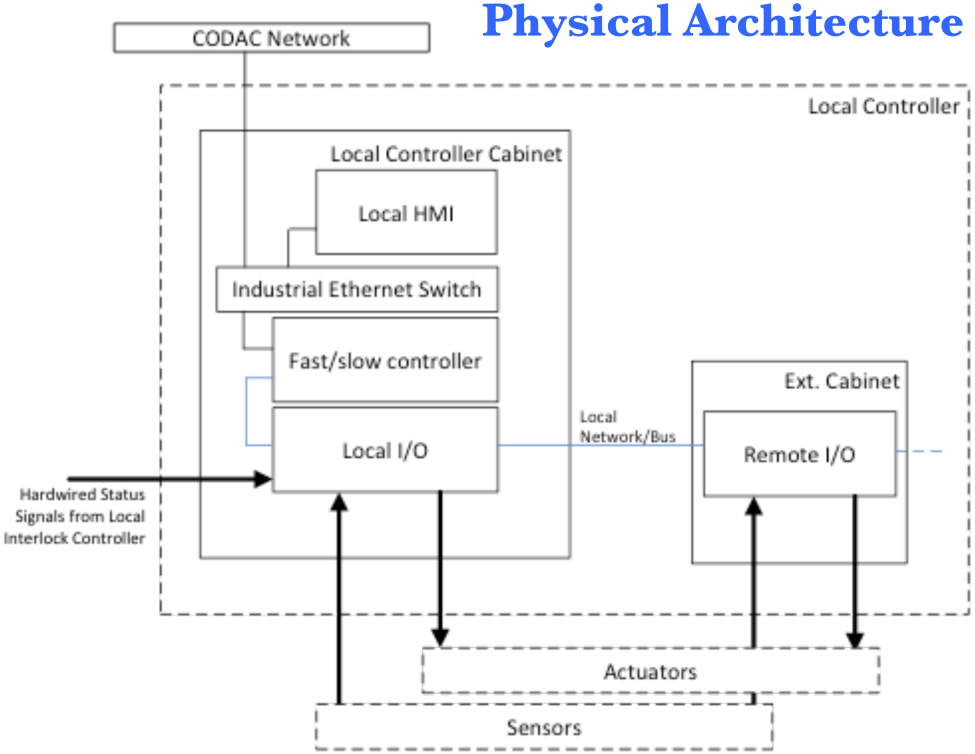
Voting system: logics 2oo3

# LICS – LOCAL CONTROLLER

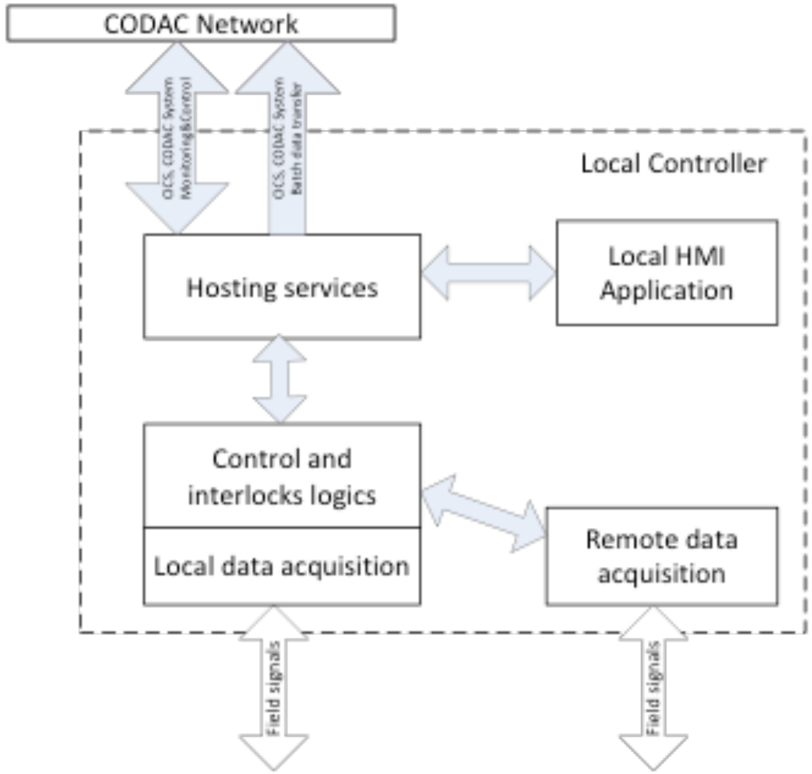
The typical Local Controller system consists of one Local Controller Cabinet and a set Extension Cabinets.

The Local Controller software have to provide the following operation:
Field data acquisition and generation;
Field data processing, control loops and soft interlocks execution;
Data exchange with the CODAC Server;
Local HMI.

## Physical Architecture




## Software Architecture

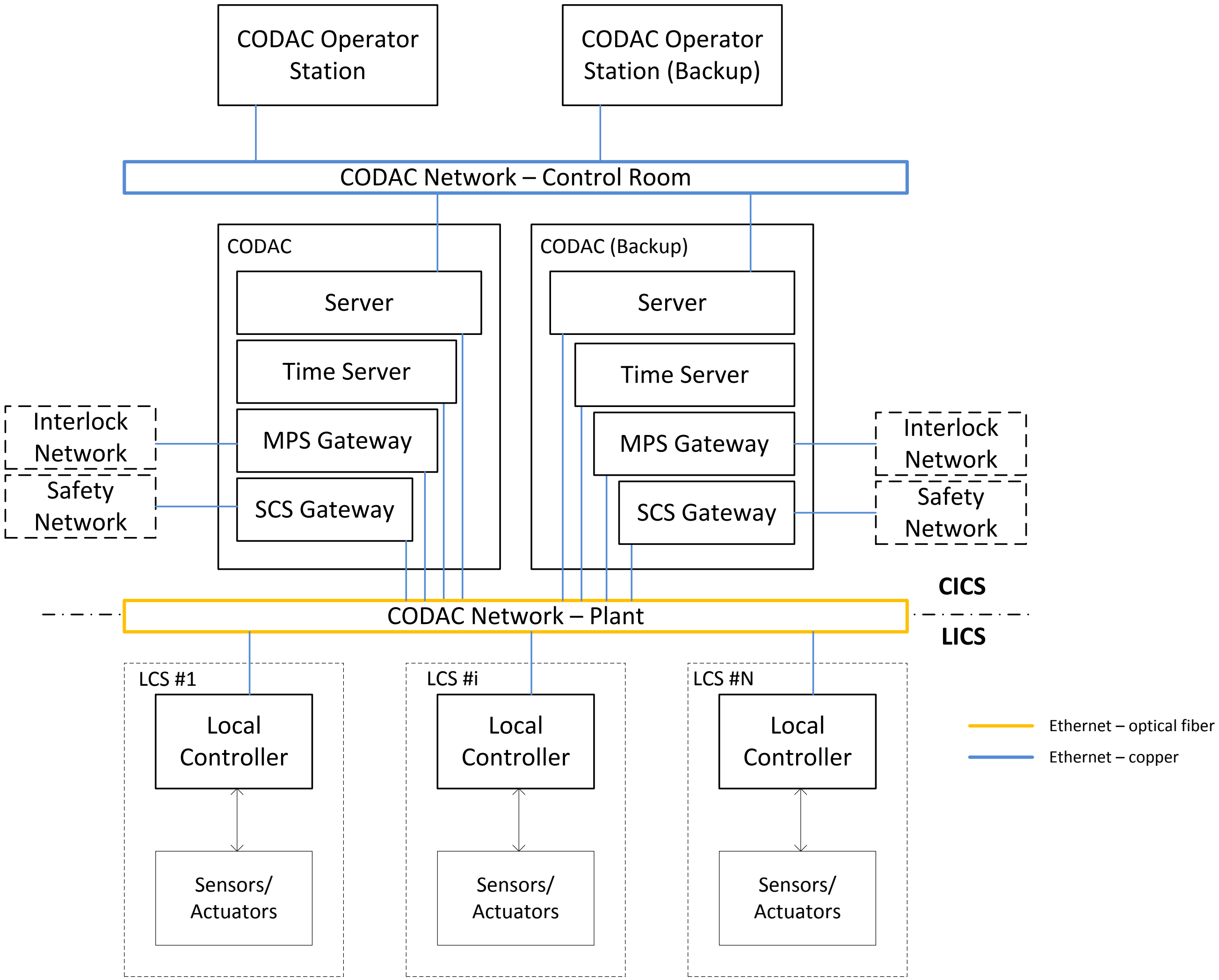


# CODAC Network - Architecture

Two layers for logical and physical segregation

**Main requirements**

- Gigabit Ethernet (10/100/1000)
- Ring-based redundant architecture
- Optical connection for plant section
- Copper for Control Room section



# Interlock Networks - Architecture

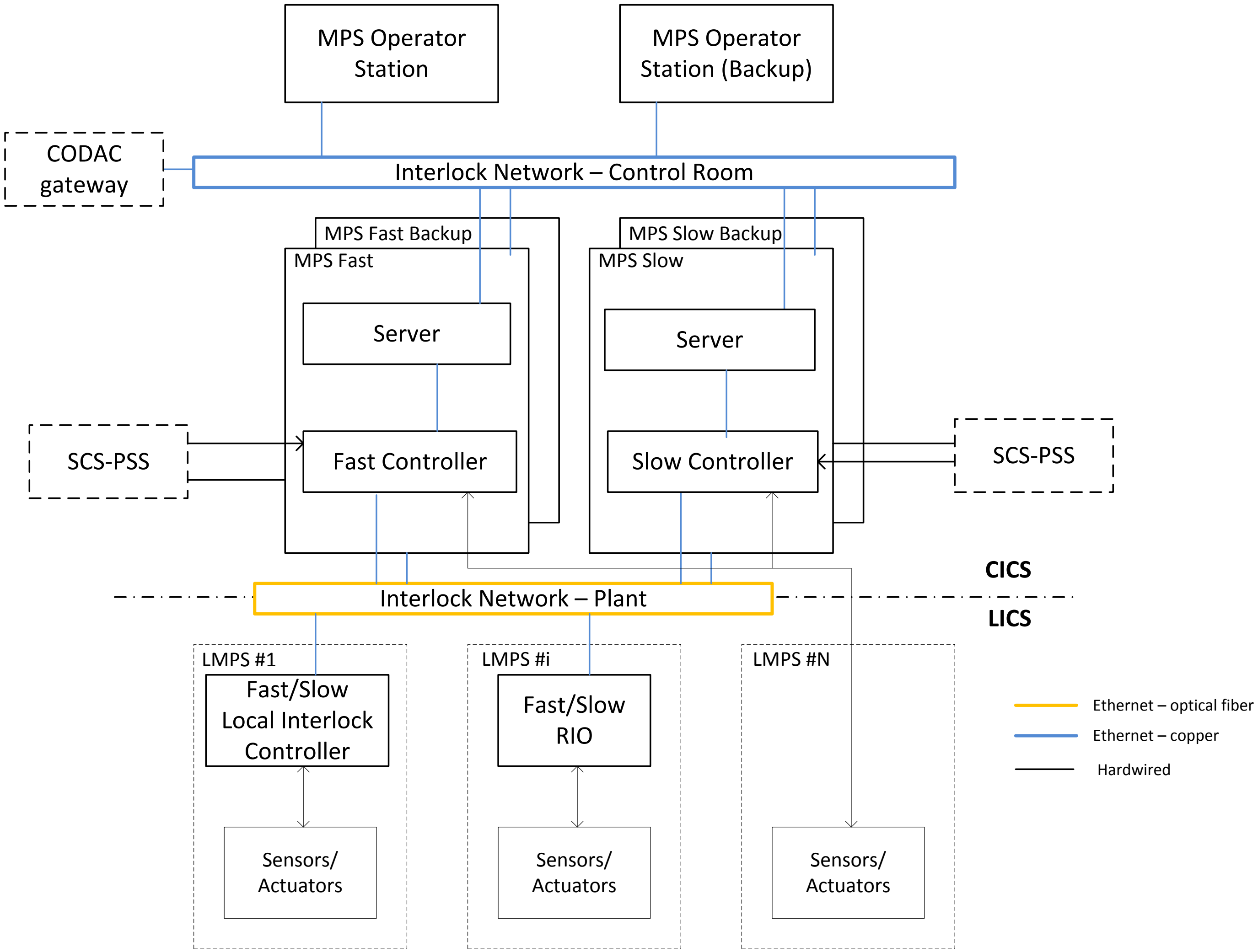
## Main requirements

- Gigabit Ethernet (10/100/1000)
- ring-based redundant architecture
- Optical connection for plant section
- Copper for Control Room section
- Virtualization for sharing plant section beetwen slow and fast data, assigning different QoS

## Hardwired connections

- LMPS and central fast controllers
- SCS and central fast controllers
- Central slow controller and central fast controller

Two layers for logical and physical segregation

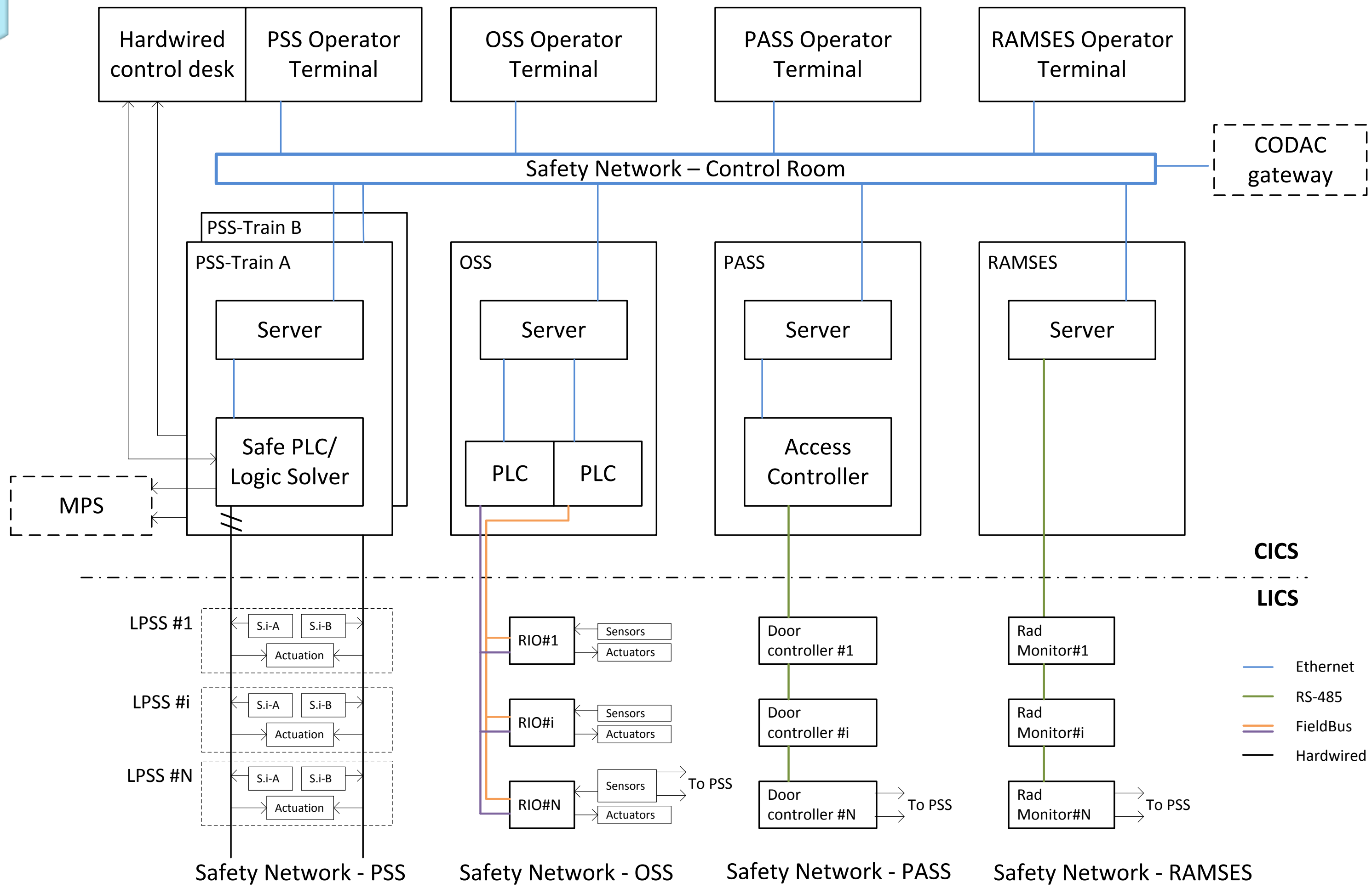


# SCS Networks - Architecture

*SEPARATION VS INTEGRATION*

**Different SIC classification**, but **access as a whole** from the operators:

- **lower part:** four separate "legs" (different for performance, configuration and physics).
- **upper part:** provides the seamless integration of the safety data to be accessed by the operator and by the CODAC gateway.




The **separation** between the different levels of the networks is always mediated by **servers** (separation layer between the operators and the safety controllers).

An **additional degree of separation** is created toward the interfacing CODAC system (not safety-classified), by means of the CODAC gateway.

# Safety Network – Plant Safety System

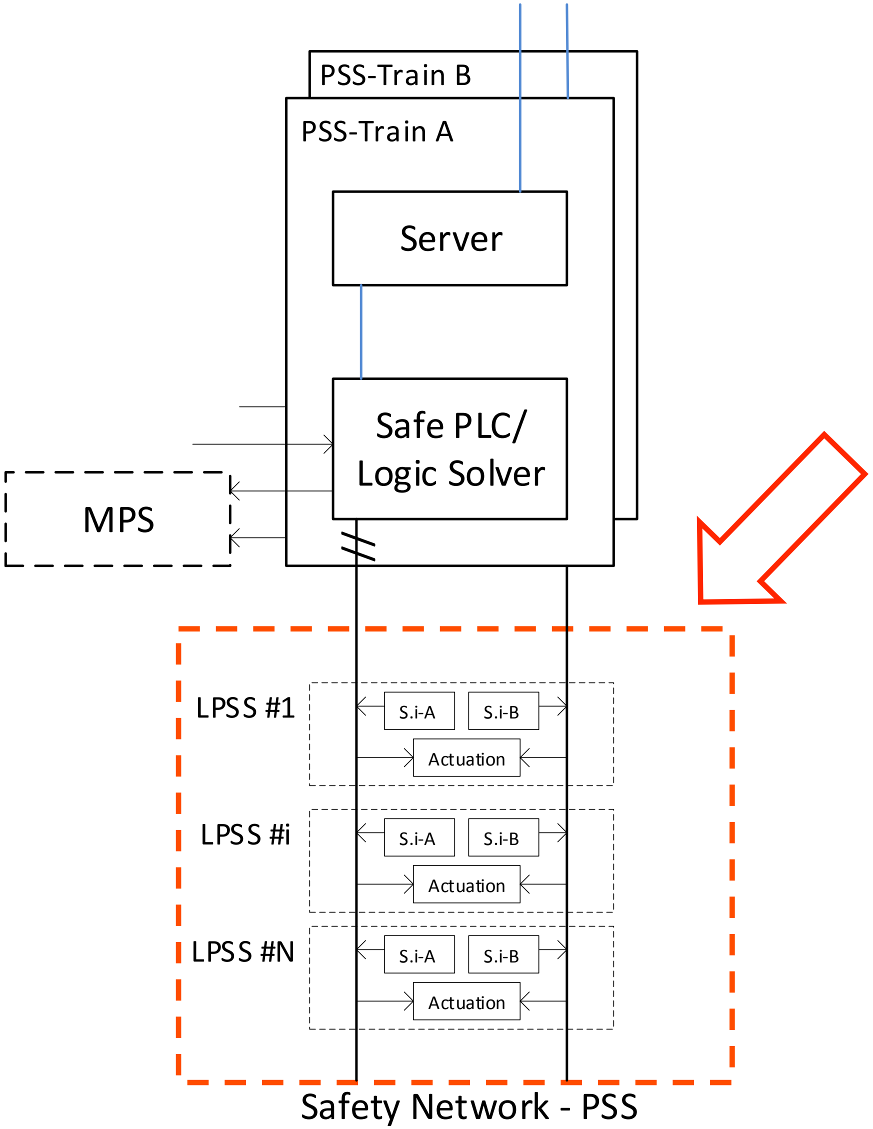
The **PSS** implements the safety functions: **two identical trains** collecting the inputs from the plant sensors (installed in different parts of the plant).

Input data also include signal coming from the other SCS sub-systems **(OSS, PASS, RAMSES)**, as well as the signals generated from the **operator hardwired HMI.**

Each controller perform the safety logics in **independent** way and **a double voting** mechanism checks the elaboration results for discrepancies.

The design of the SN-PSS is strongly related to the assigned **SIC level**.

In this preliminary definition, it is assumed to use a direct cabling of the field devices.



# Conclusions

- Design of the **Central** Instrumentation and Control Systems with its relationship with **Local** Instrumentation and Control Systems has been presented
- Status of the project is at a **preliminary phase** (the overall plant design is still ongoing)
- **Main components and networks** have been characterized
- No specific attention to **software/hardware solutions** at this stage

## Some future work…

- Control **logics** in operational and emergency conditions (integration)
- **Safety** signals identification and **SIC** components design
- **Timing network** based on IEEE-1588 with three levels of accuracy
- Specific Safety Control System subsystems detailed design:
  - **Occupational Safety (OSS)**
  - **Personnel Access (PASS)**
  - **Environment Radiation Monitoring System (RAMSES)**