FINAL DESIGN OF CONTROL AND DATA ACQUISITION SYSTEM FOR THE ITER HEATING NEUTRAL BEAM INJECTOR TEST BED

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1. ABSTRACT

Tokamaks use **heating neutral beam** (**HNB**) injectors to reach fusion conditions and drive plasma current. ITER, the large international tokamak, will have three high-energy, high-power (1MeV, 16.5MW) HNBs. MITICA, the **ITER HNB test bed**, is being built at the ITER Neutral Beam Test Facility [1], Italy, to develop and test the ITER HNB [2], whose requirements are far beyond the current HNB technology. MITICA [3] operates in a pulsed way with **pulse duration** up to **3600s** and 25% duty cycle. It requires a complex **control and data acquisition system (CODAS)** to provide supervisory and plant control, monitoring, fast real-time control, data acquisition and archiving, data access, and operator interface. The control infrastructure consists of two parts: central and plant system CODAS. The former provides high-level resources such as servers and a central archive for experimental data. The latter manages the MITICA plant units, i.e., components that generally execute a specific function, such as power supply, vacuum pumping, or scientific parameter measurements. CODAS integrates various technologies to implement the required functions and meet the associated requirements. Our paper presents the CODAS requirements and architecture based on the experience gained with SPIDER, the **ITER full-size beam synchronization**, **fast real-time control**, **software development** for long-lasting experiments, **system commissioning** and **integration**.

2. MITICA CODAS ARCHITECTURE

Two main CODAS infrastructures:

- ❑ Central CODAS
- ❑ Plan System CODAS

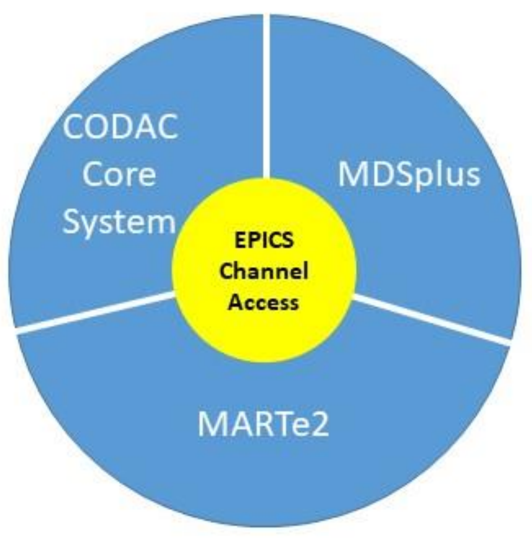
	Unit	Figure
Plant Units	No.	20
Process Variables	No.	20000
Real-time cycle time	ms	1
Diagnostics	No.	1000
Max Sampling Frequency	MS/s	2
Data throughput	MB/s	200
Expected annual data amount	TB	30

3. SOFTWARE ENVIRONMENT

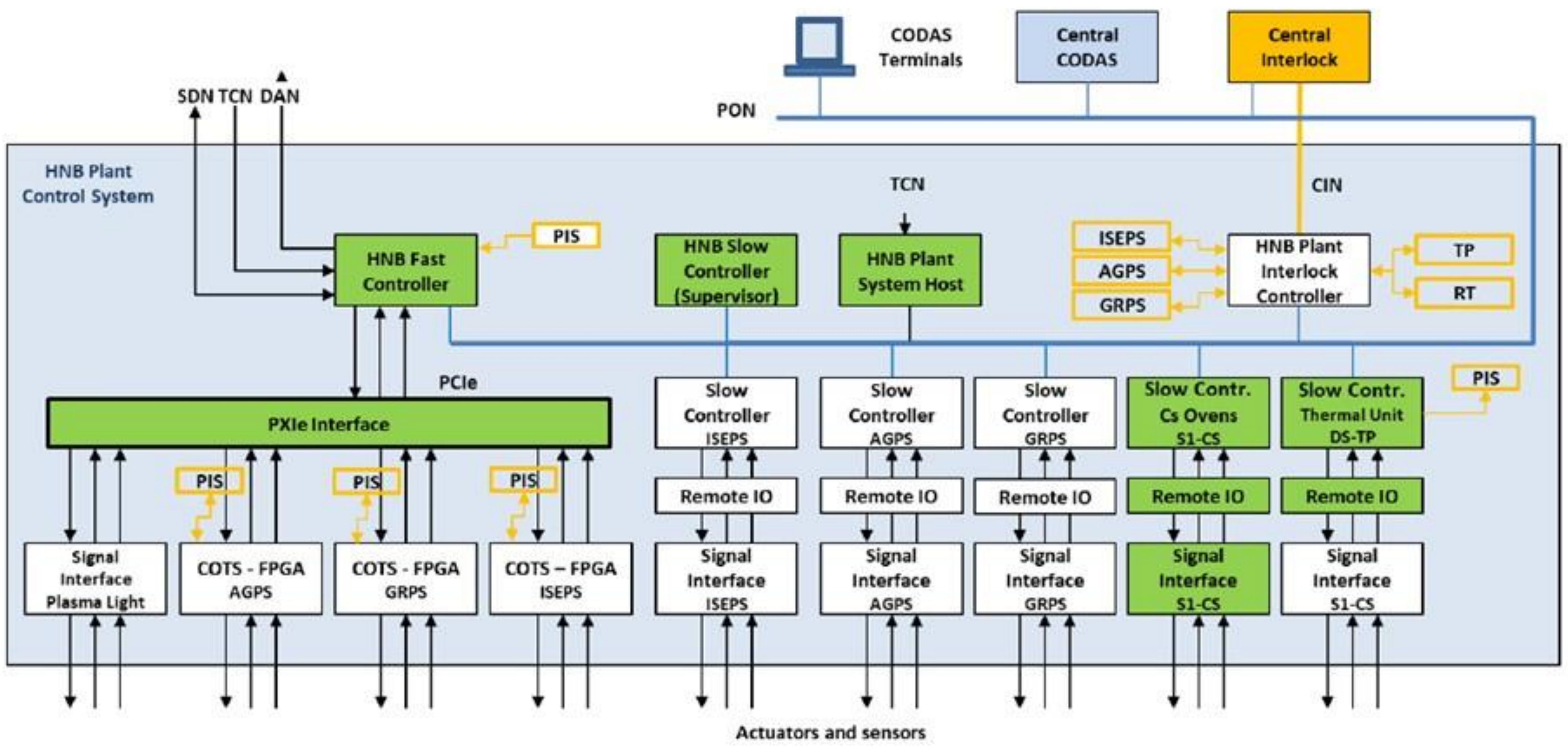
MITICA CODAS is built on three software frameworks [4]:

- ❑ ITER CODAC Core System (CCS) for monitoring, supervisory functions, and timing synchronization;
- ❑ MDSplus for data management (data acquisition, storage, and access);
- ❑ MARTe2 for real-time operations;

MITICA software frameworks



MITICA Plant Units scheme



4. MITICA SYNCHRONIZATION

In the long lasting experiments scenario the absence of a good synchronization among the plant systems can potentially result in data loss or even in critical situations. ITER defines its **Time Communication Network (TCN)** [5] to solve this issue.

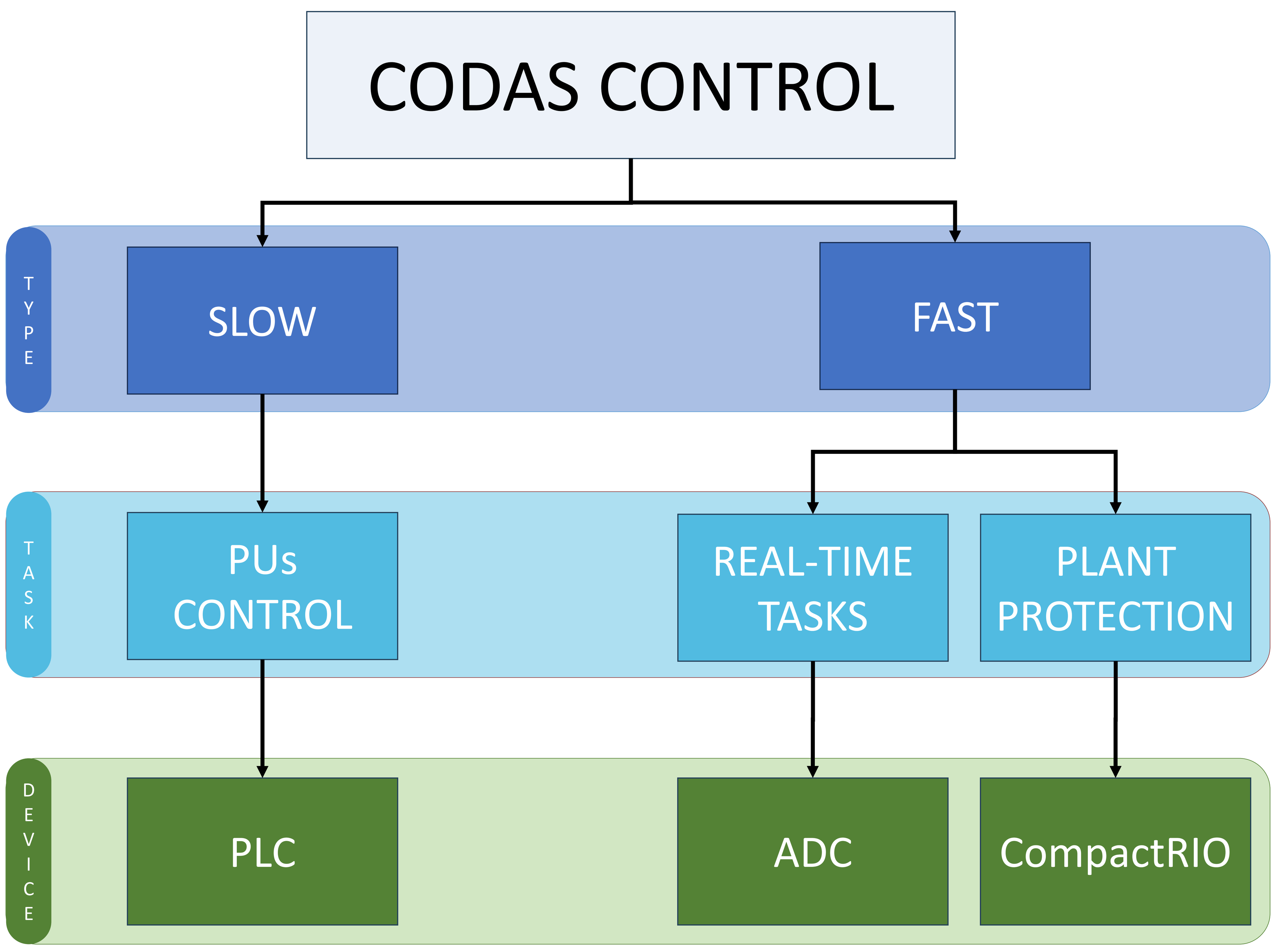
TCN characteristics:

- ❑ Synchronization delay < 50ns;
- ❑ Based on the IEEE1588 synchronization protocol;
- ❑ Supported by APIs developed by ITER installed in every CODAC system natively (after CODAC 6.0);
- ❑ Supported by two different National Instruments devices (proposed in the ITER catalogue);
- ❑ Hierarchical topology based on the different network tasks.

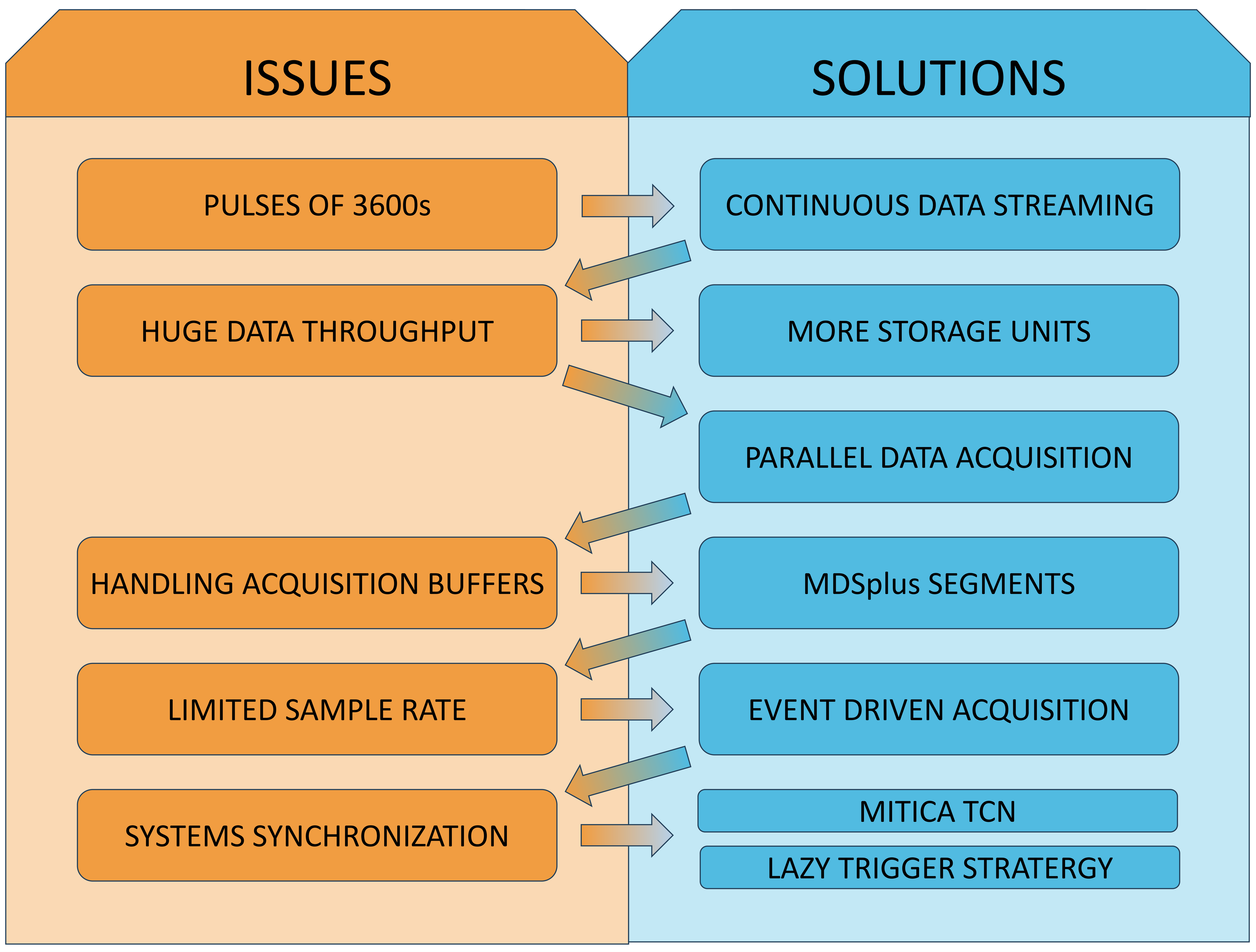
MITICA TCN:

- ❑ Validated by Omnet++ simulations;
- ❑ Fully implemented;
- ❑ Successful test campaigns;
- ❑ In line with the ITER requirements;
- ❑ Copper cables and fiber optics based topology;
- ❑ Already adopted in the last MITICA commissionings.

5. CONTROL AND DATA ACQUISITION



7. DATA ACQUISITION IN LONG LASTING EXPERIMENTS



6. SYSTEM ACCEPTANCE AND INTEGRATION

The approval process for plant supplies consists of multiple sequential phases:

- ❑ **Factory Acceptance Test (FAT):**
  - ❑ Main system functions verification;
  - ❑ Only some of the Plant Unit parts can be tested;
- ❑ **Site Acceptance Tests (SAT):**
  - ❑ Installation of the Plant Unit at NBTF;
  - ❑ HMI-based test campaigns;
  - ❑ CODAS communication tests;
- ❑ **Installation tests:**
  - ❑ CODAS has the control of the whole Plant Unit;
  - ❑ Ignored commands from HMI;
  - ❑ The system logic is accurately tested (alarms, warnings, feedbacks, etc.);
- ❑ **Integration:**
  - ❑ The Plant Unit is integrated and tested with the other already present systems

8. ACKOWLEDGEMENT

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9. MAIN REFERENCES

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