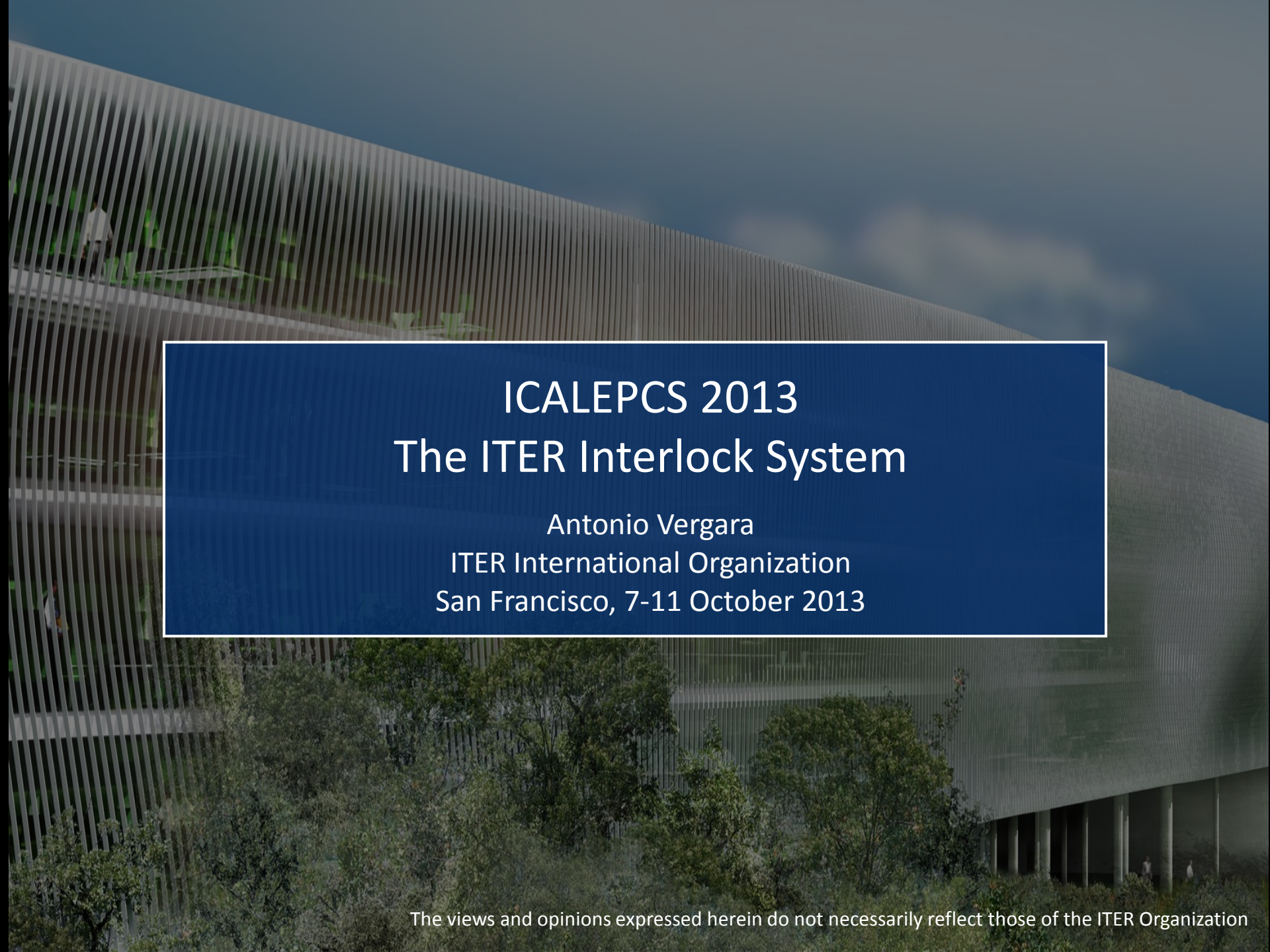
china eu india japan korea russia usa



ICALEPCS 2013
The ITER Interlock System

Antonio Vergara
ITER International Organization
San Francisco, 7-11 October 2013

ITER Project – Summer 2013

Interlocks at ITER

ITER main sources of risk (regarding interlocks):

Interlocks at ITER

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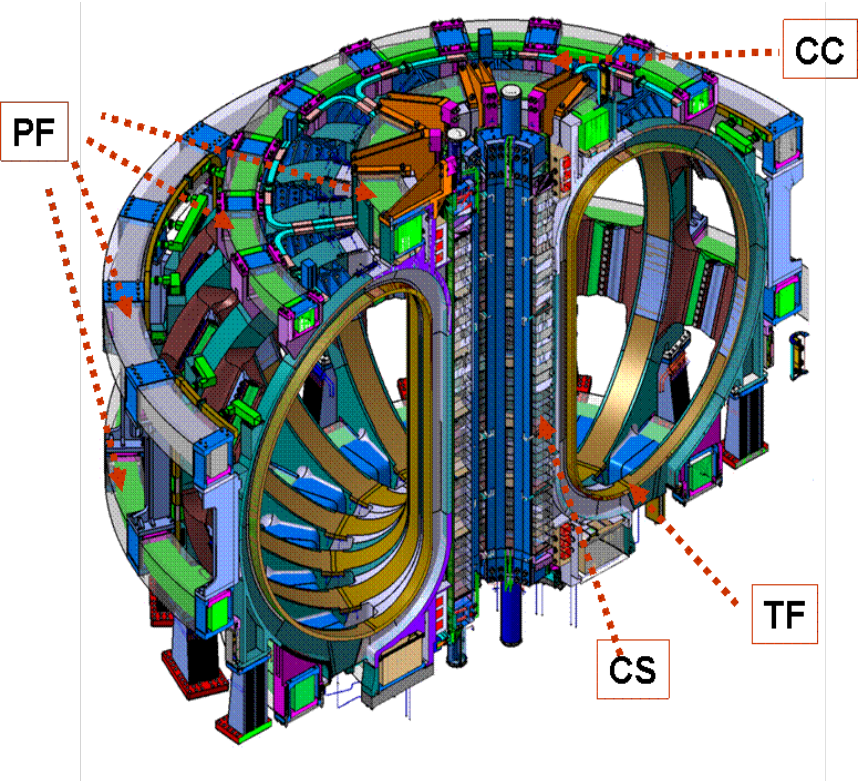
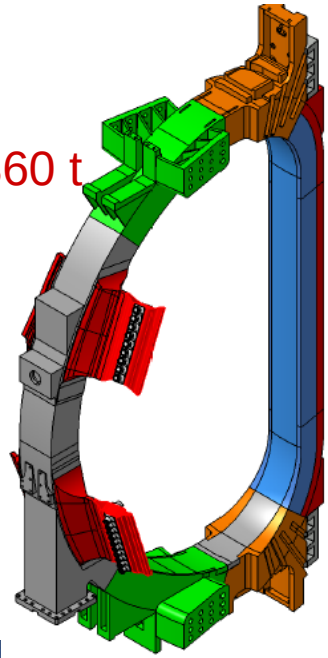
✓ Superconducting magnets



Mass of 1 TF Coil:
16 m Tall x 9 m Wide, ~360 t



Boeing 747-300
(Maximum Takeoff Weight) ~377 t

Total Magnetic Energy ~ 100 GJ

Interlocks at ITER

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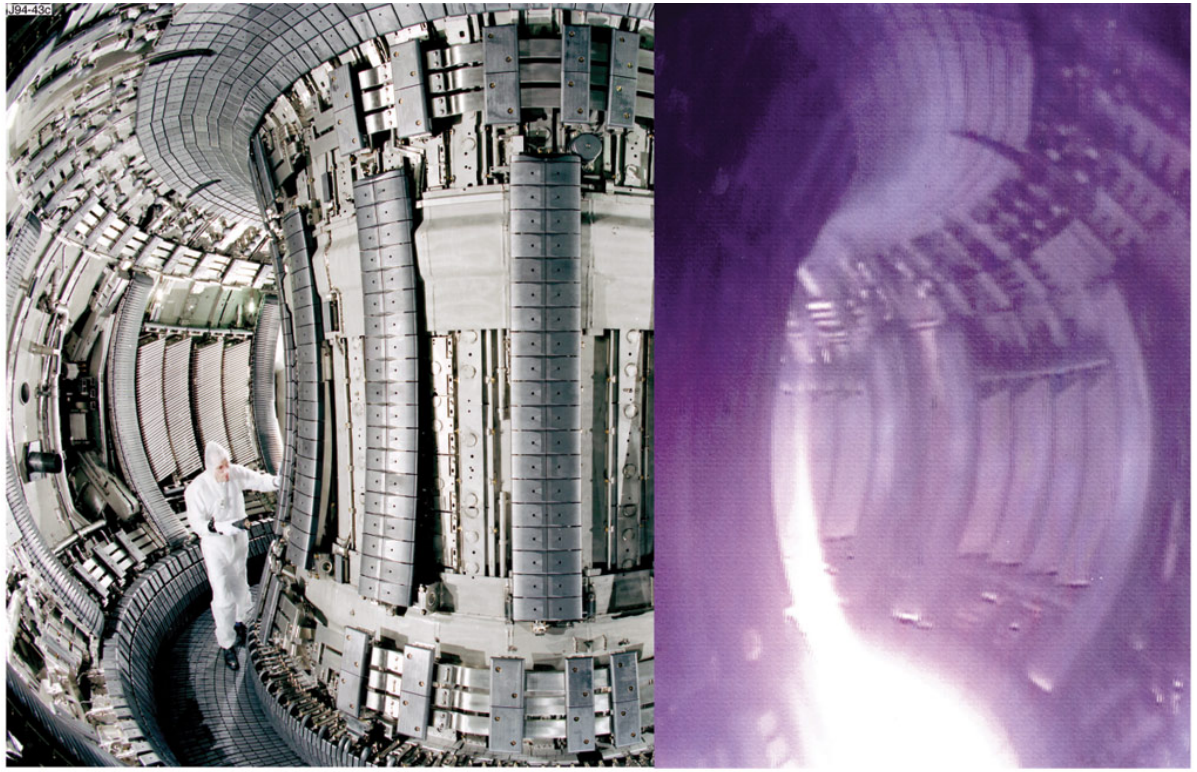
- ✓ Superconducting magnets

- ✓ Plasma:
  - Energy / Temperature / Density → internal damage
  - Current → disruptions



Interlocks at ITER

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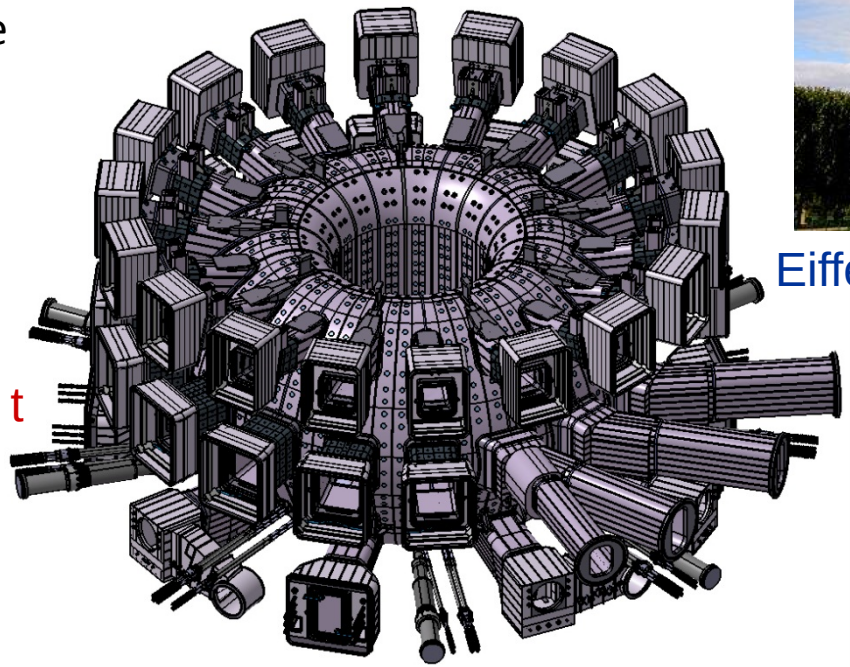
- ✓ Superconducting magnets
- ✓ Plasma:
  - Energy / Temperature → internal damage
  - Current → disruptions
- ✓ Mechanical structure

Eiffel Tower mass: ~7300 t



VV & In-vessel components mass: ~8000 t

Interlocks at ITER

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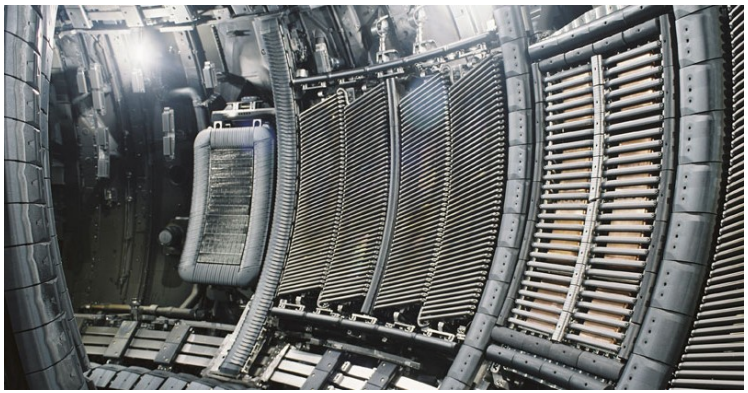
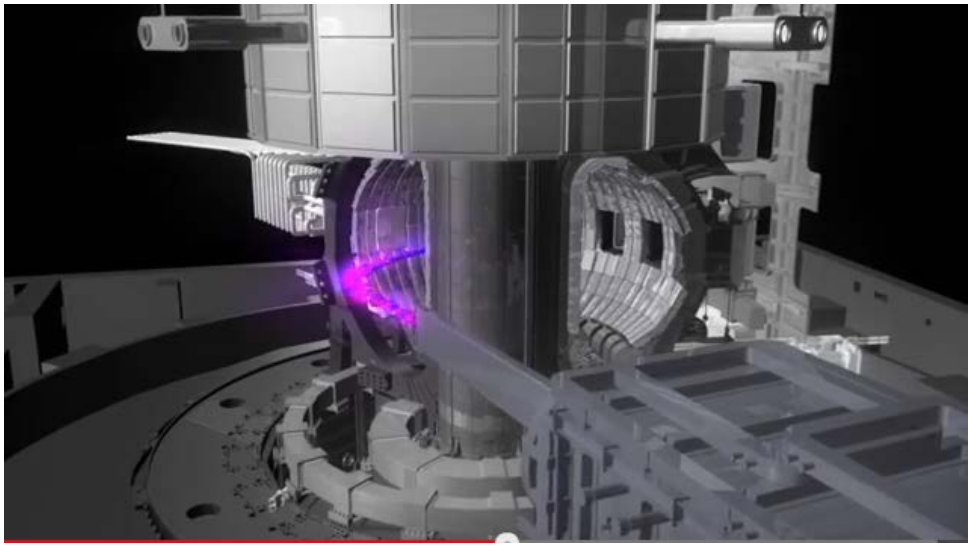
- ✓ Superconducting magnets
- ✓ Plasma:
  - Energy / Temperature → internal damage
  - Current → disruptions
- ✓ Mechanical structure
- ✓ Plasma heating and fuelling systems





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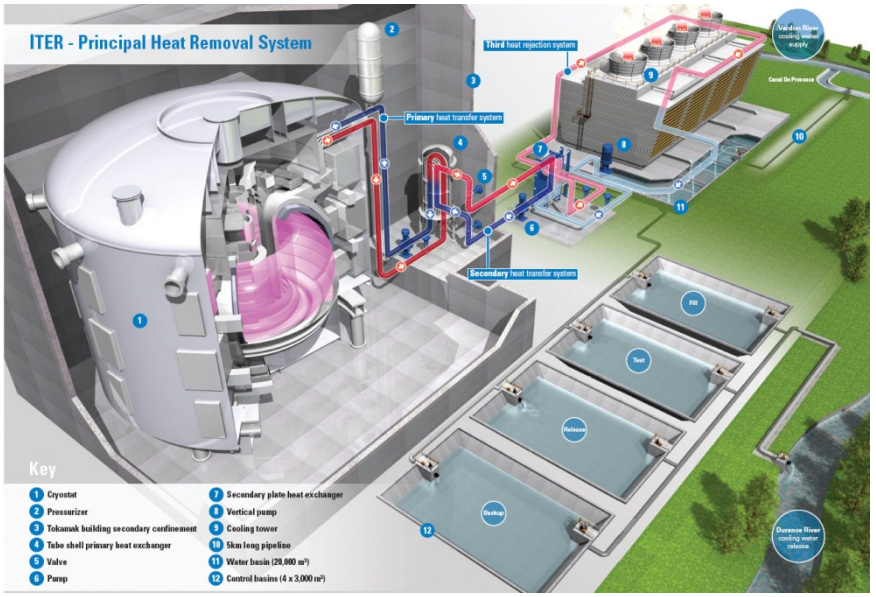
- ✓ Cryogenics, vacuum and cooling systems



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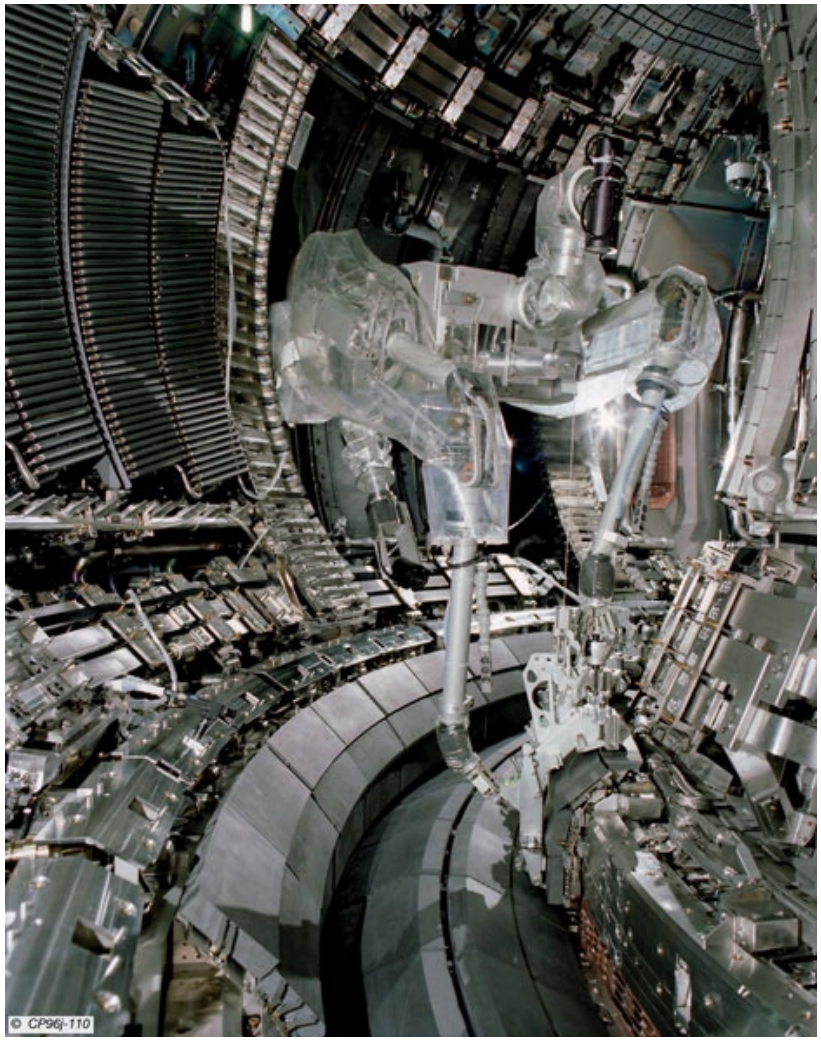
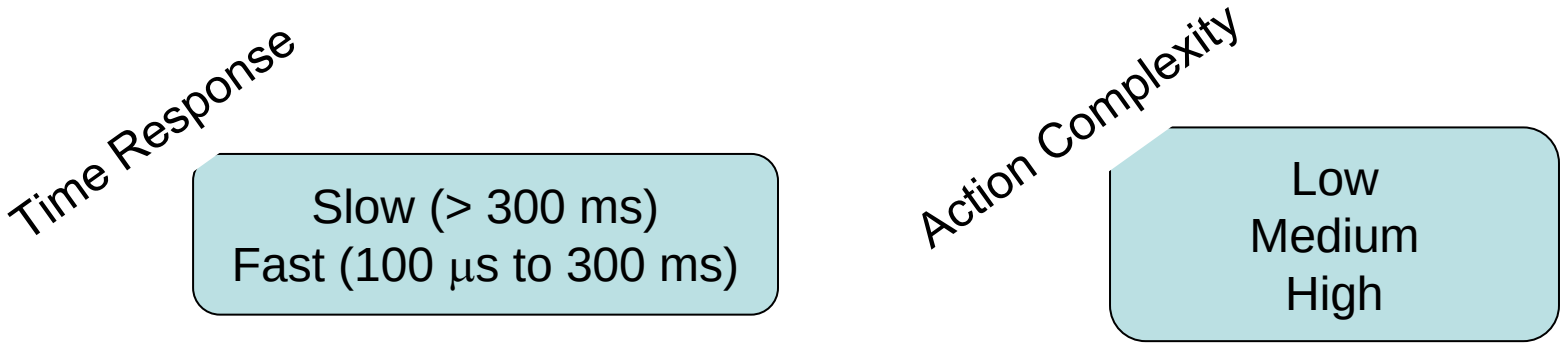
- ✓ Cryogenics, vacuum and cooling systems
- ✓ Remote handling systems



Particularities of ITER interlock systems

1. An eclectic collection of actions



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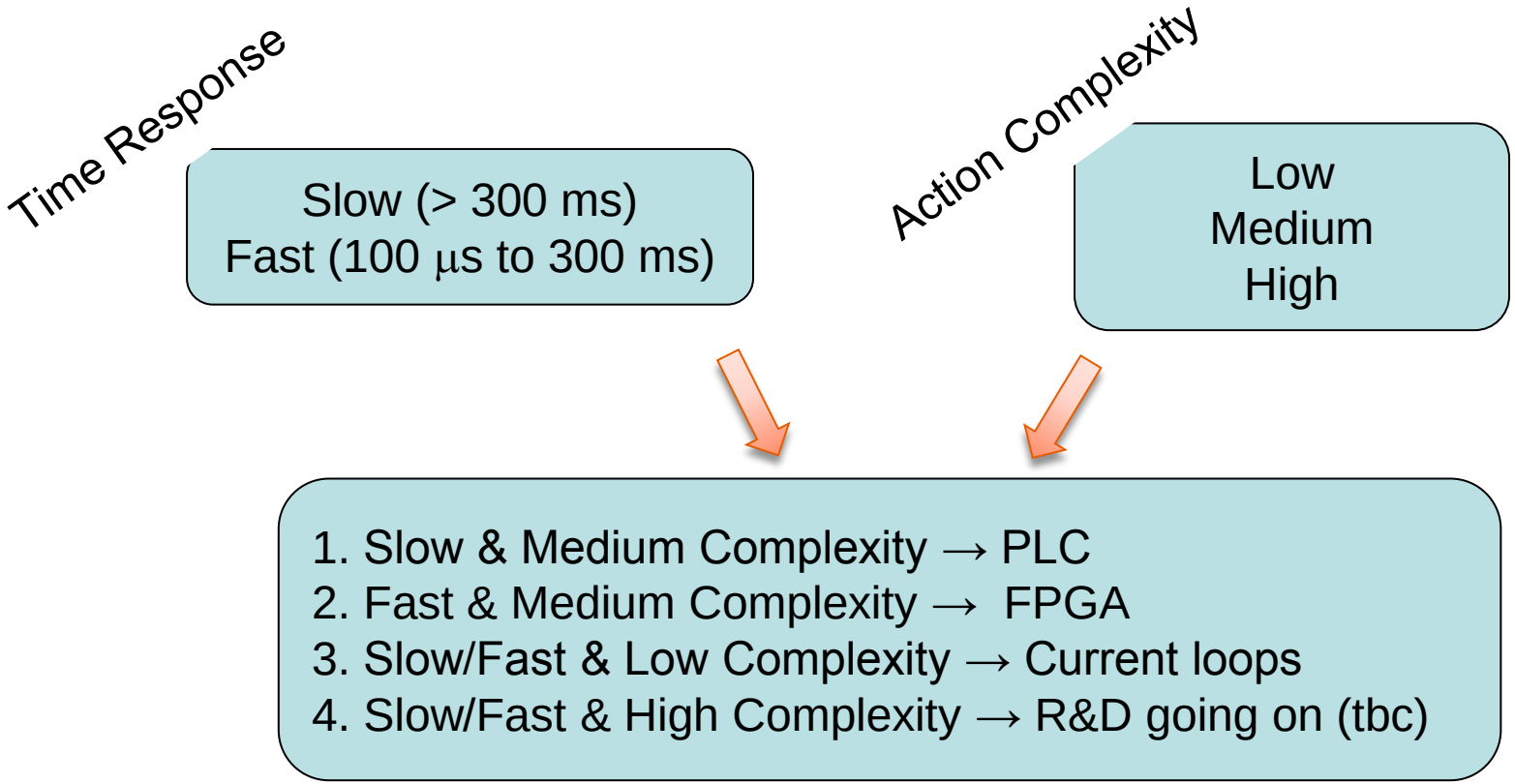

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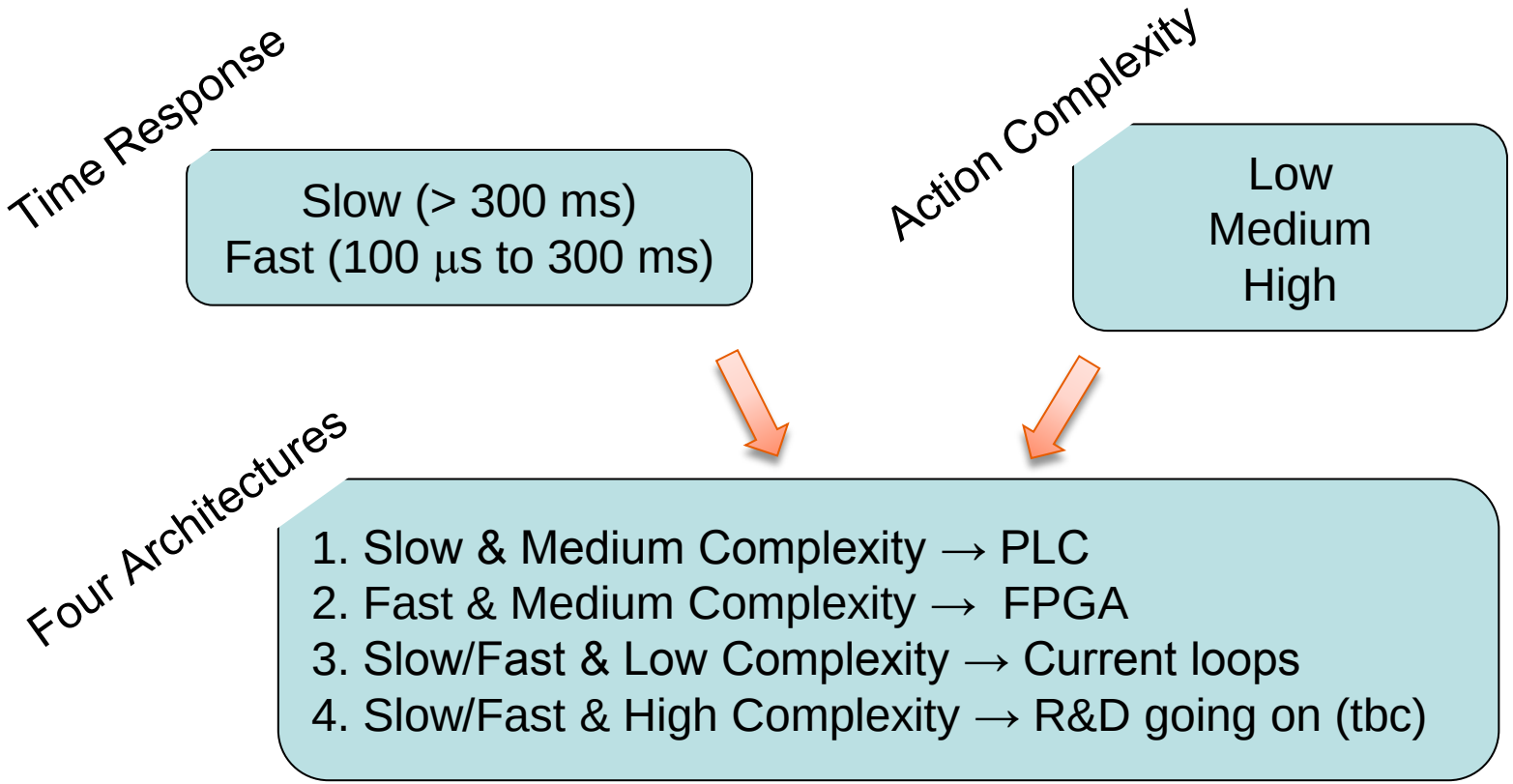


Interlocks at ITER

Particularities of ITER interlock systems

1. An eclectic collection of actions

2. The not-so-safe fail safe states

   → Identification of safe states after a degradation of the interlock components is not always obvious and even impossible sometimes without implying long machine downtimes.

   → Interlocks design shall allow early internal failure detection followed by a controlled sequence of actions

   → Setting the interlock outputs in their fail-safe sates is the last option to be taken

   → Intelligent redundancy + self-diagnostics

Interlocks at ITER

Interlocks at ITER

Particularities of ITER interlock systems

1. An eclectic collection of actions

2. The not-so-safe fail safe states

3. Expensive interlock actions (or when the cure is worse than the disease)

   → Triggering interlocks not only reduces the ITER operation availability but also the tokamak lifetime

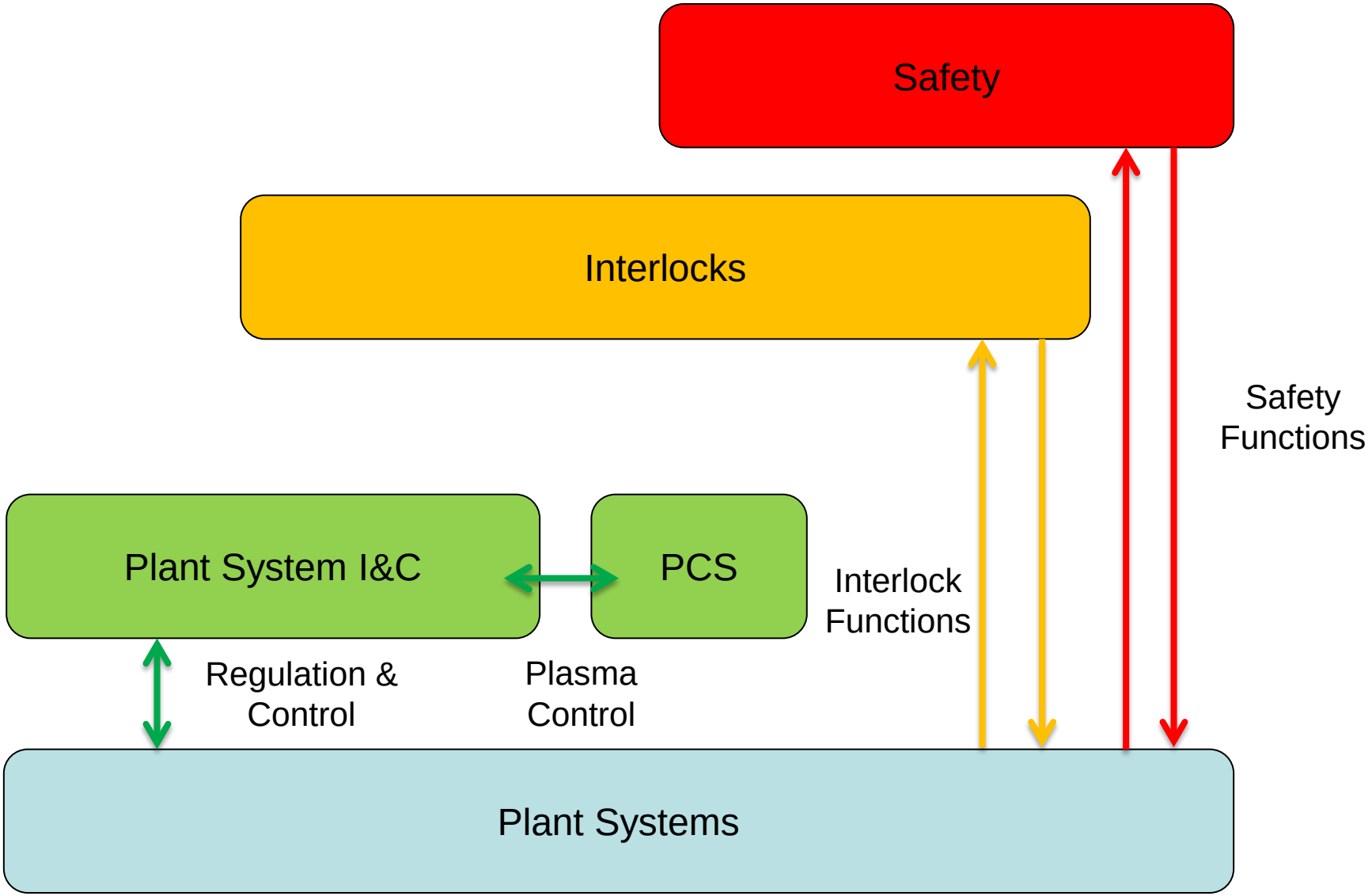
   → Example: limited total number of coil fast discharges or unmitigated disruptions

   → 'Soft' interlock actions performed in collaboration with conventional controls and always backed-up by 'hard' interlocks

Particularities of ITER interlock systems

1. An eclectic collection of actions
2. The not-so-safe fail safe states
3. Expensive interlock actions (or when the cure is worse than the disease)
4. Safety and Interlock Segregation

ITER Defense-in-depth Approach



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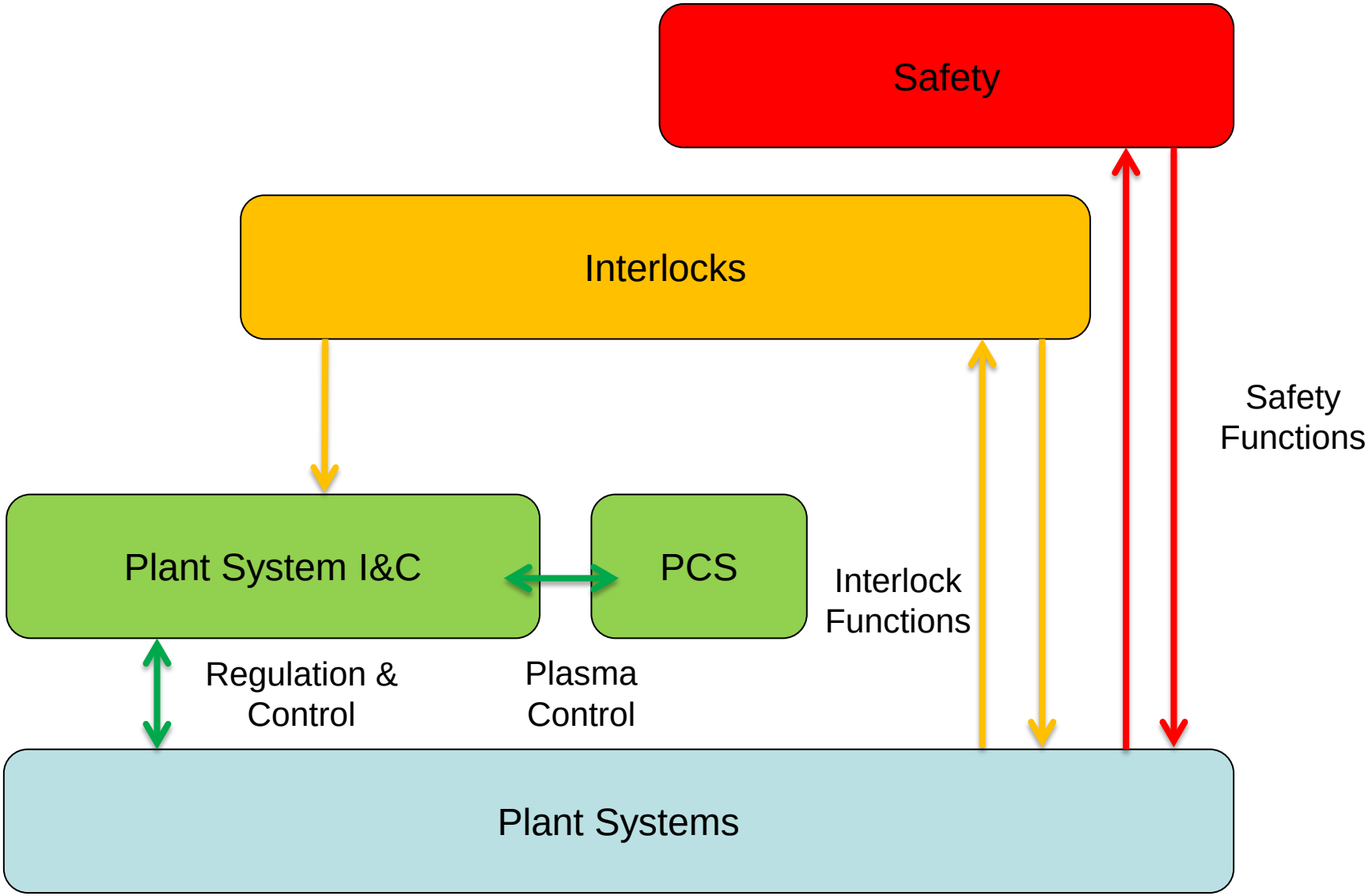

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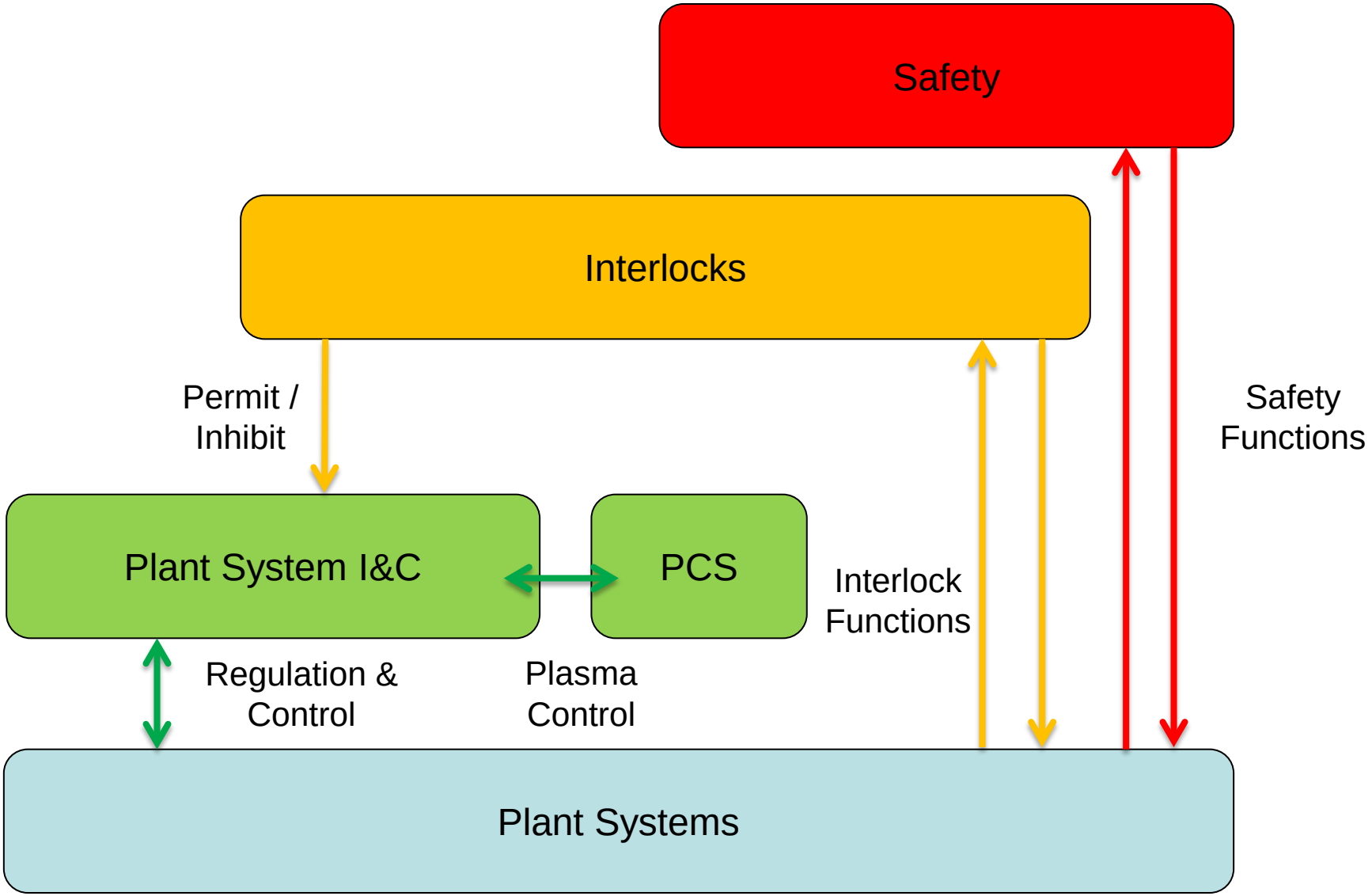

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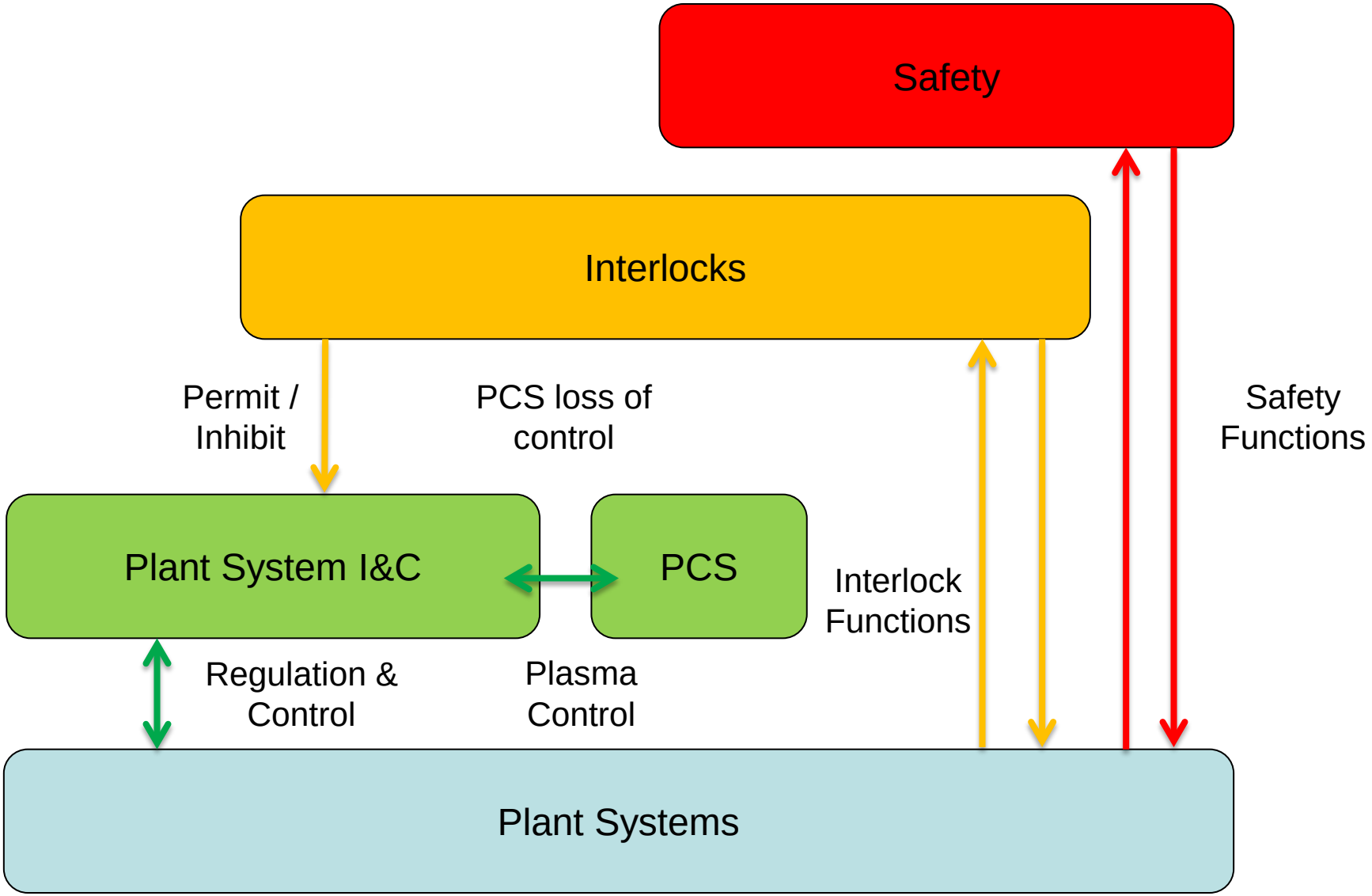

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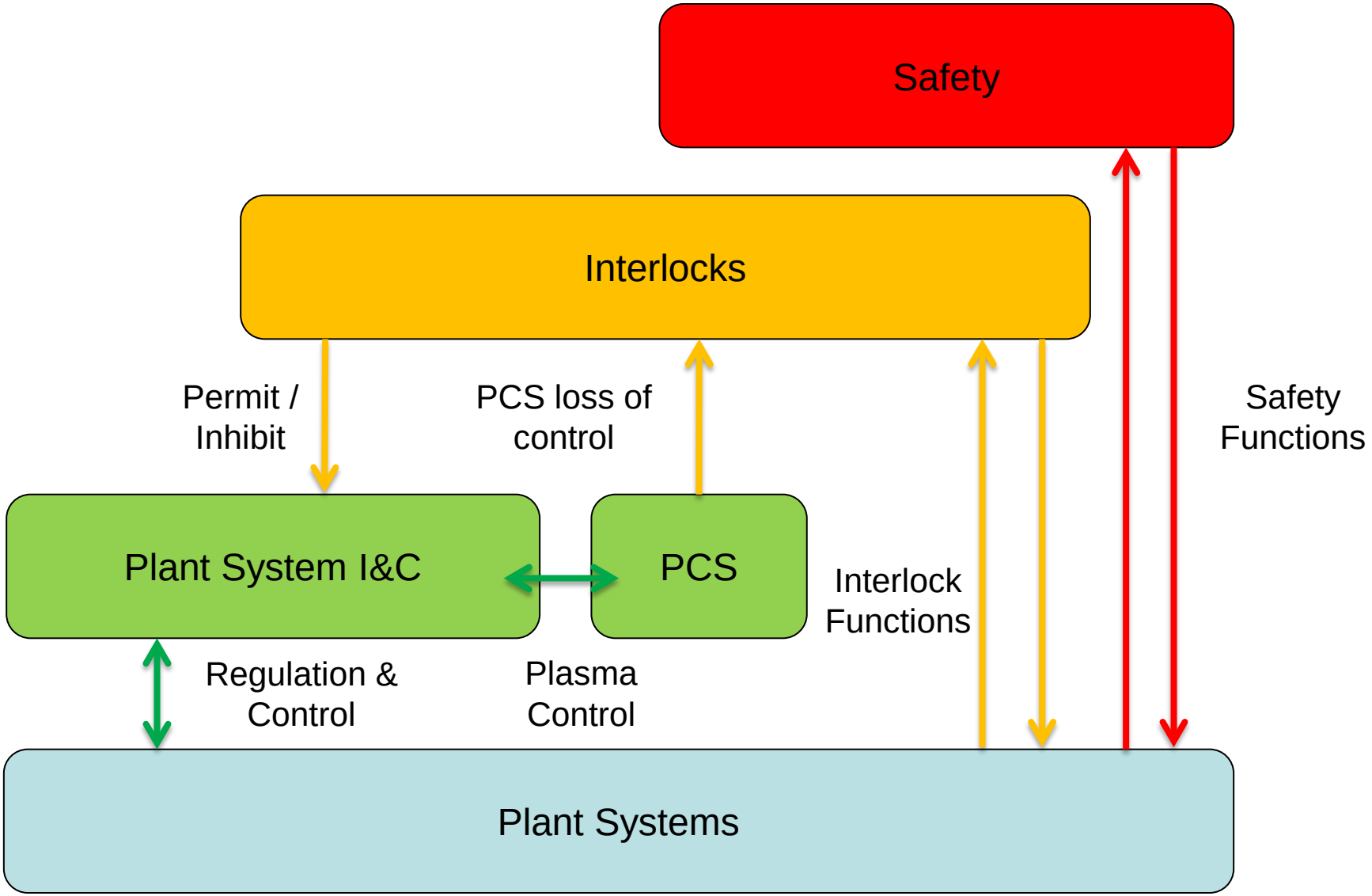

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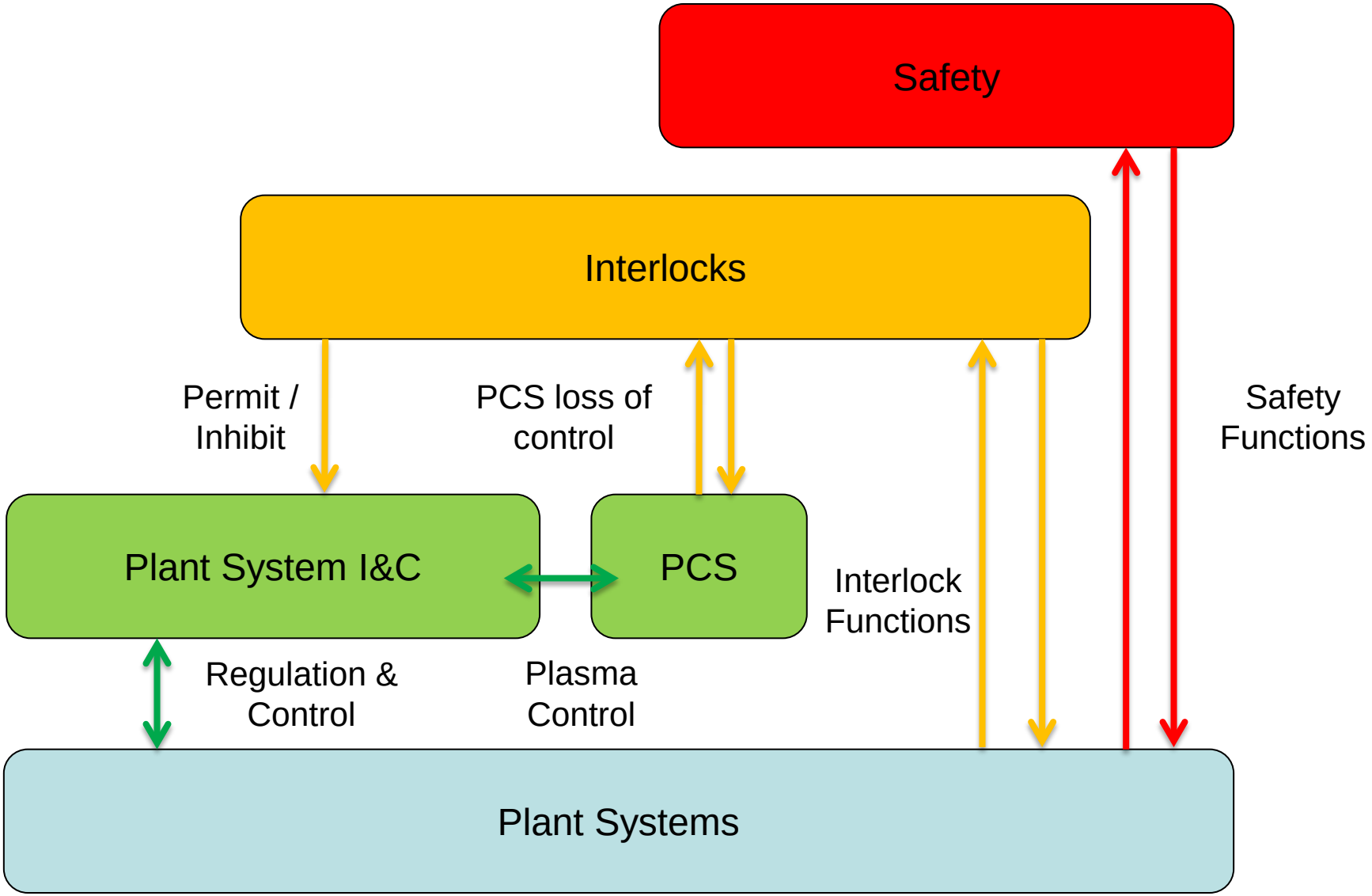

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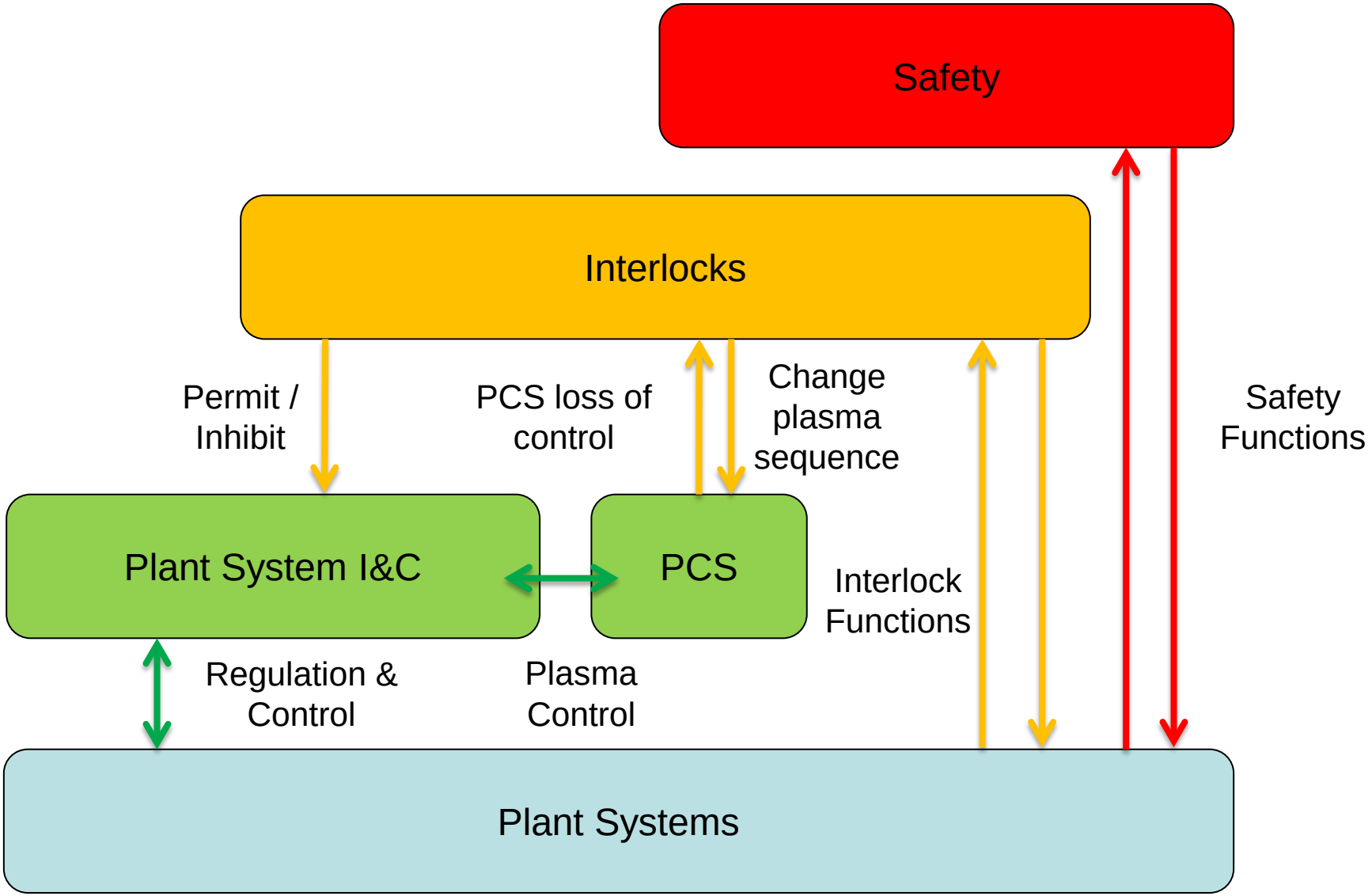


Interlocks at ITER

Interlocks at ITER

Particularities of ITER interlock systems

1. An eclectic collection of actions

2. The not-so-safe fail safe states

3. Expensive interlock actions (or when the cure is worse than the disease)

4. Safety and Interlock Segregation

5. ITER design not yet completely frozen

→ around 130 interlock functions identified and partially developed
→ .. but more will come
→ Open, flexible, scalable and commissionable design solutions

Interlocks at ITER

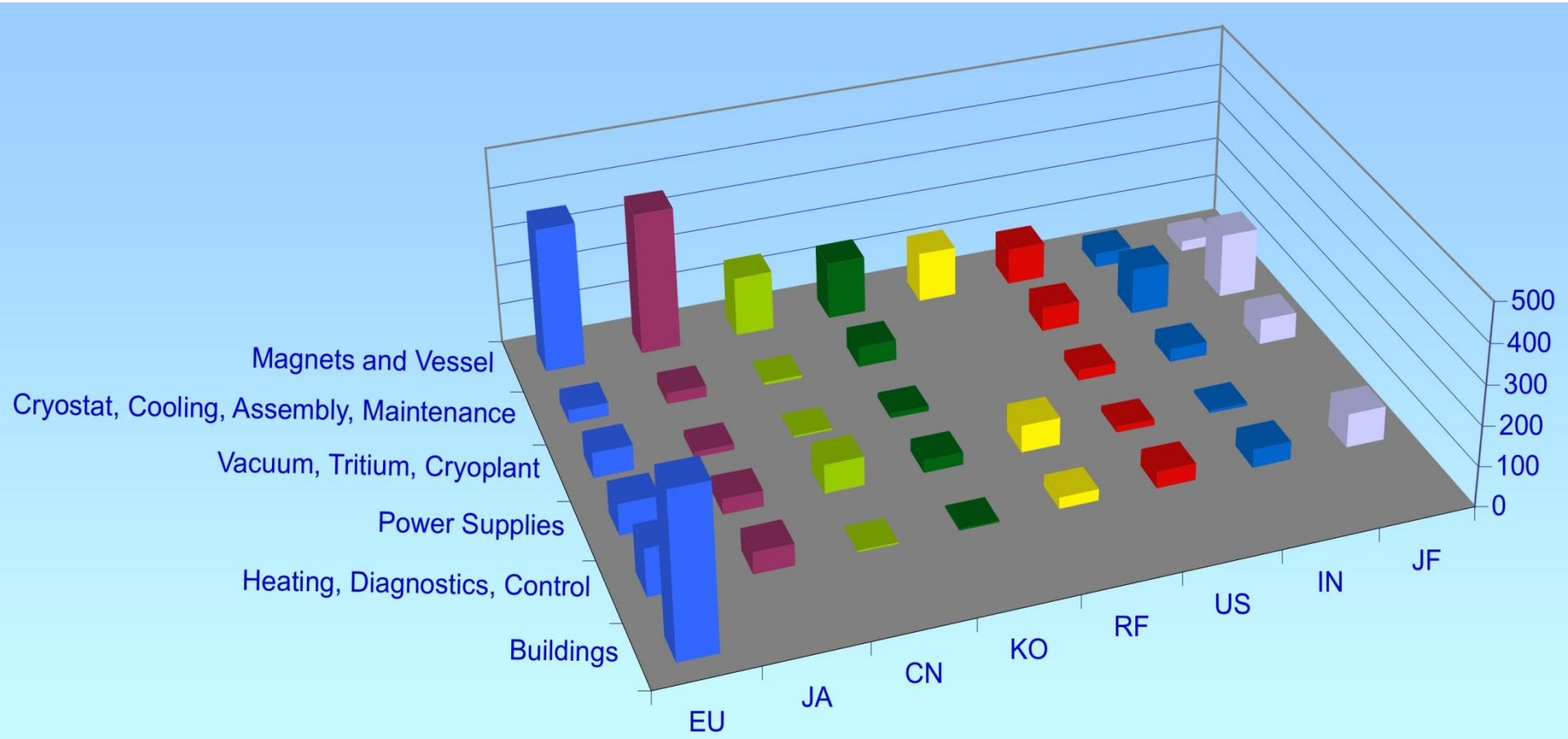
Particularities of ITER interlock systems

1. An eclectic collection of actions
2. The not-so-safe fail safe states
3. Expensive interlock actions (or when the cure is worse than the disease)
4. Safety and Interlock Segregation
5. ITER design not yet completely frozen
6. ITER complex procurement strategy

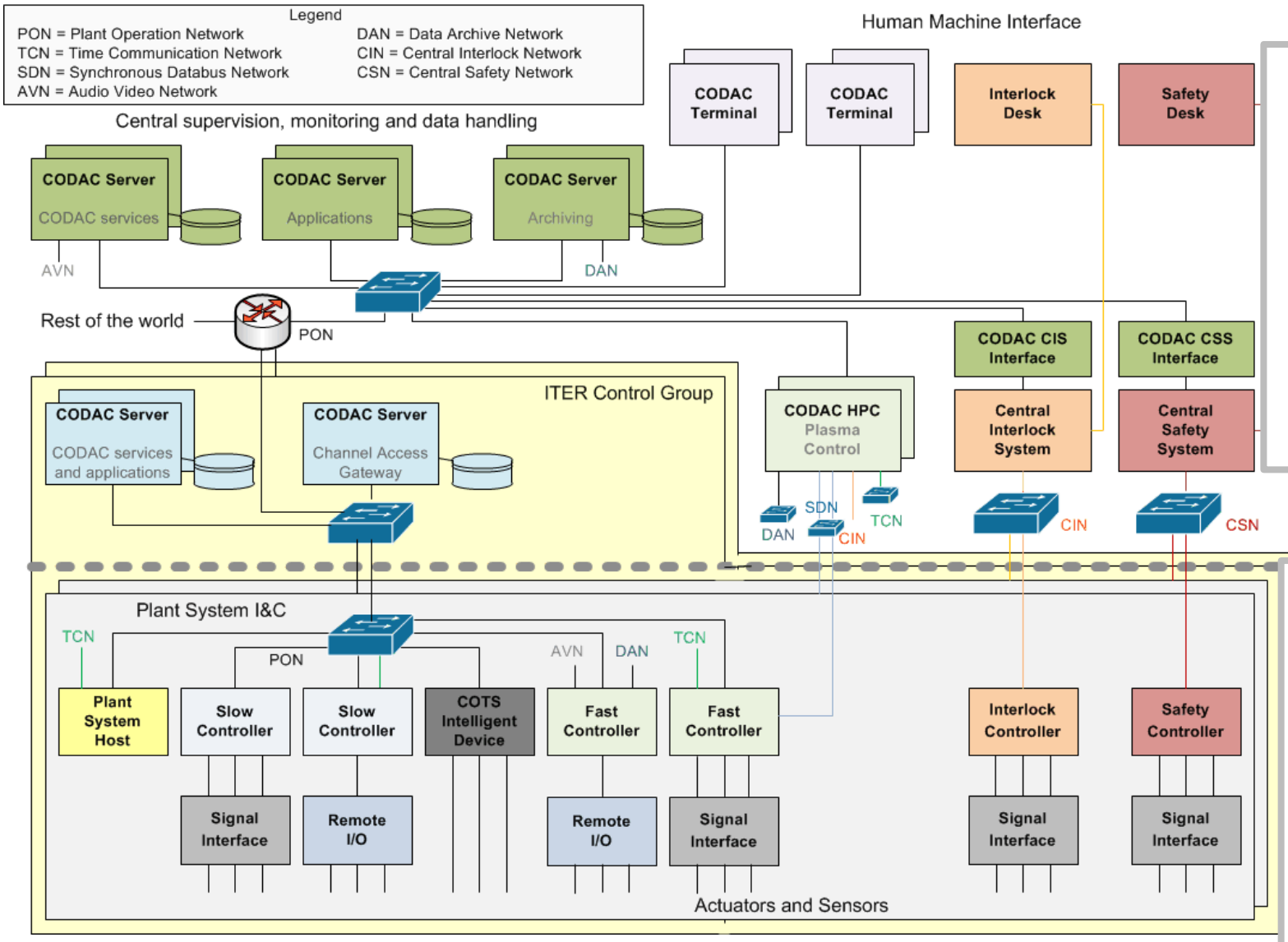
→ One interlock system and 36 countries

ITER Procurement Strategy

A unique feature of ITER is that almost all of the machine will be constructed through *in kind procurement* from the Members



In-fund and in-kind procurement



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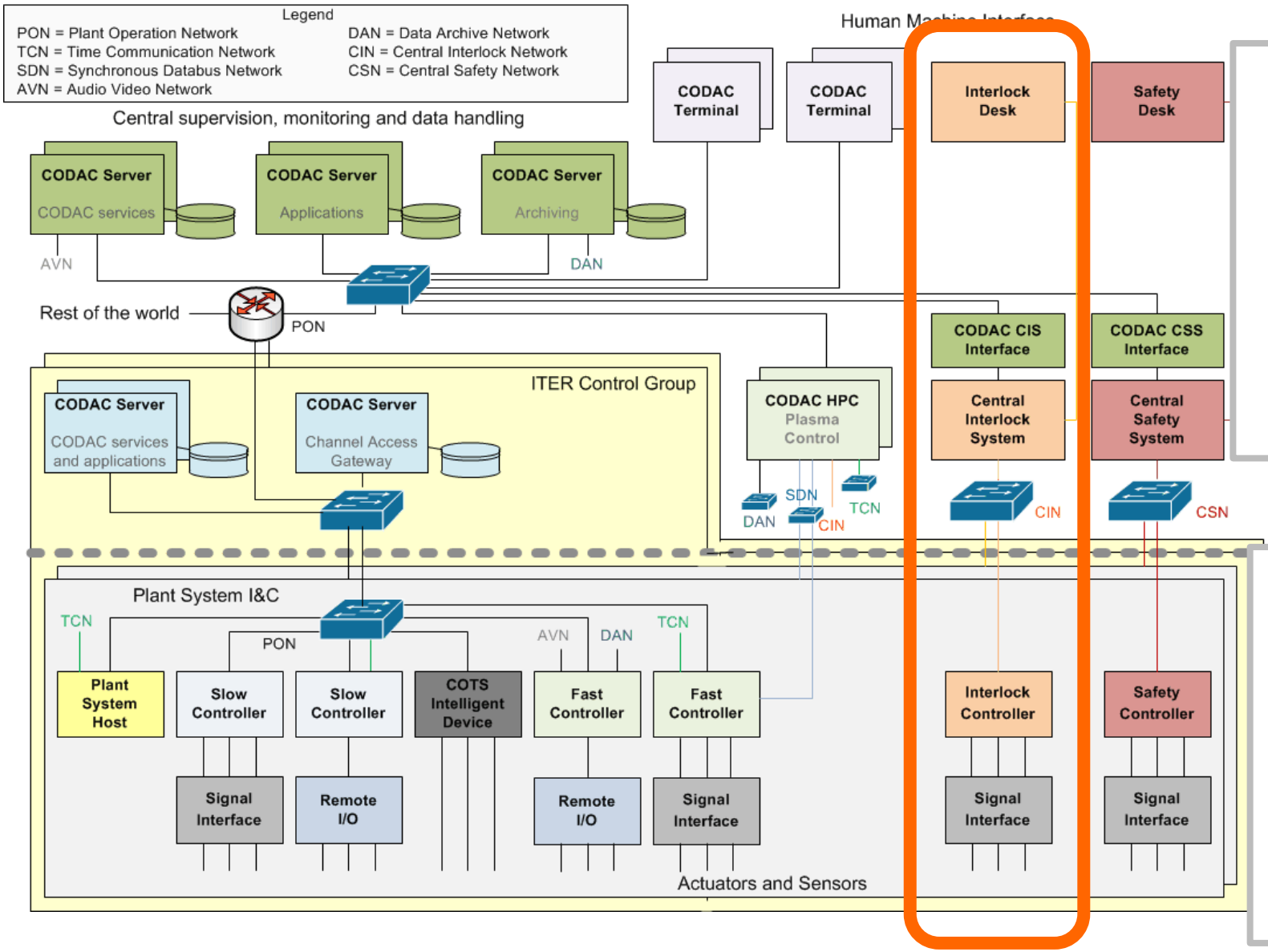

Conclusions

The unprecedented technical and managerial complexity of ITER requires an interlock design where the traditional simplicity of tokamak investment protection systems has been replaced by a **4-architecture solution** with different technological choices

The ITER Interlock System will most likely be the first machine protection system built with most of its components provided **in-kind from up to 36 different countries**

A strong effort is being put in place to ensure that all actors around the globe design, build and configure the parts of the puzzle to be **properly integrated** with the central system

The experience acquired during the design of the **ITER conventional controls** (CODAC) is extremely valuable, specially regarding the establishment of **standard hardware, software and methods**

The ITER interlock system will complete its final design in **December 2015**.

@ITERinterlocks

@ITERinterlocks

Thank you…