

Enhancements of the central Safety System for Wendelstein 7-X operational phase OP2.4

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ABSTRACT

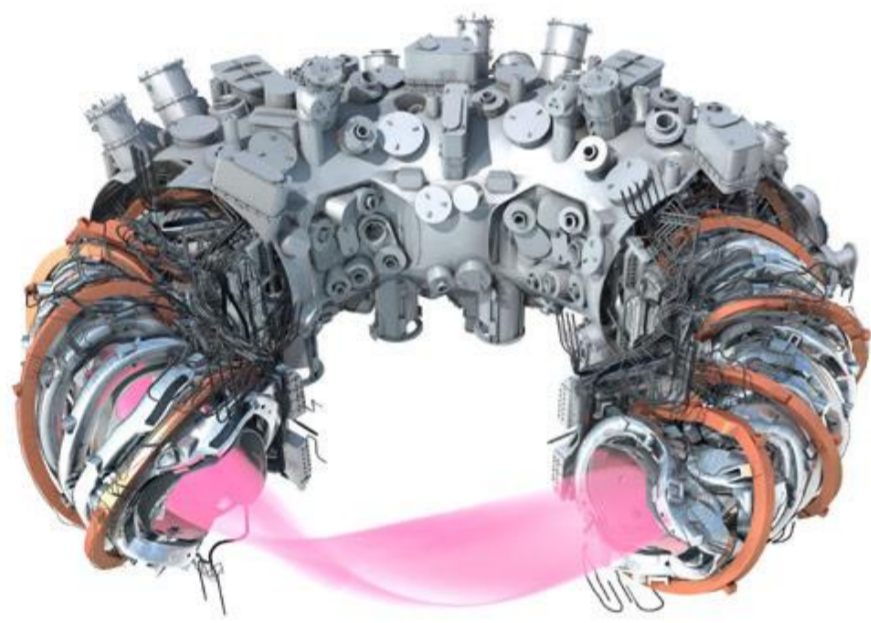
Ensuring the safety of personnel, the environment, and equipment during operation of the Wendelstein 7-X (W7-X) superconducting fusion experiment is a fundamental legal requirement. A central objective of the W7-X development is therefore to reduce the inherent hazard potential through technical, organizational measures and personal safety measures to a level at which the remaining residual risk is acceptable.

The safety control systems of W7-X are designed in accordance with IEC 61511 (functional safety for the process industry).

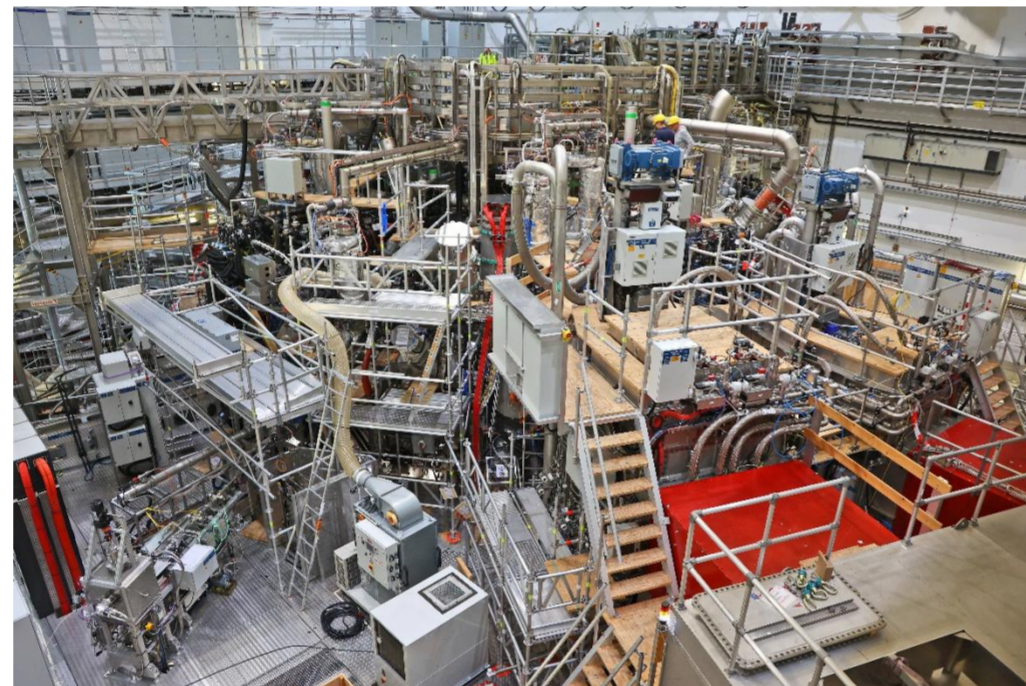
Since the start of W7-X operation in December 2015, the cSS has been continuously adapted to meet increasing safety requirements, mainly driven by the integration of new technical systems and diagnostics. During previous conversion phases, however, the cSS was shut down. To reduce or largely eliminate extensive organizational measures, the cSS is being modified for operational phase OP2.4 to enable safety-relevant operation also during conversion and assembly phases by implementing appropriate safety functions.

This paper presents the architecture and core functions of the cSS, followed by a detailed description of the modifications introduced to support safety operation during assembly phases. Newly implemented safety functions, special operating modes, and modifications to the interface cabinets of the cSS for OP2.4 are described. Finally, first results from the commissioning of the enhanced cSS are discussed.

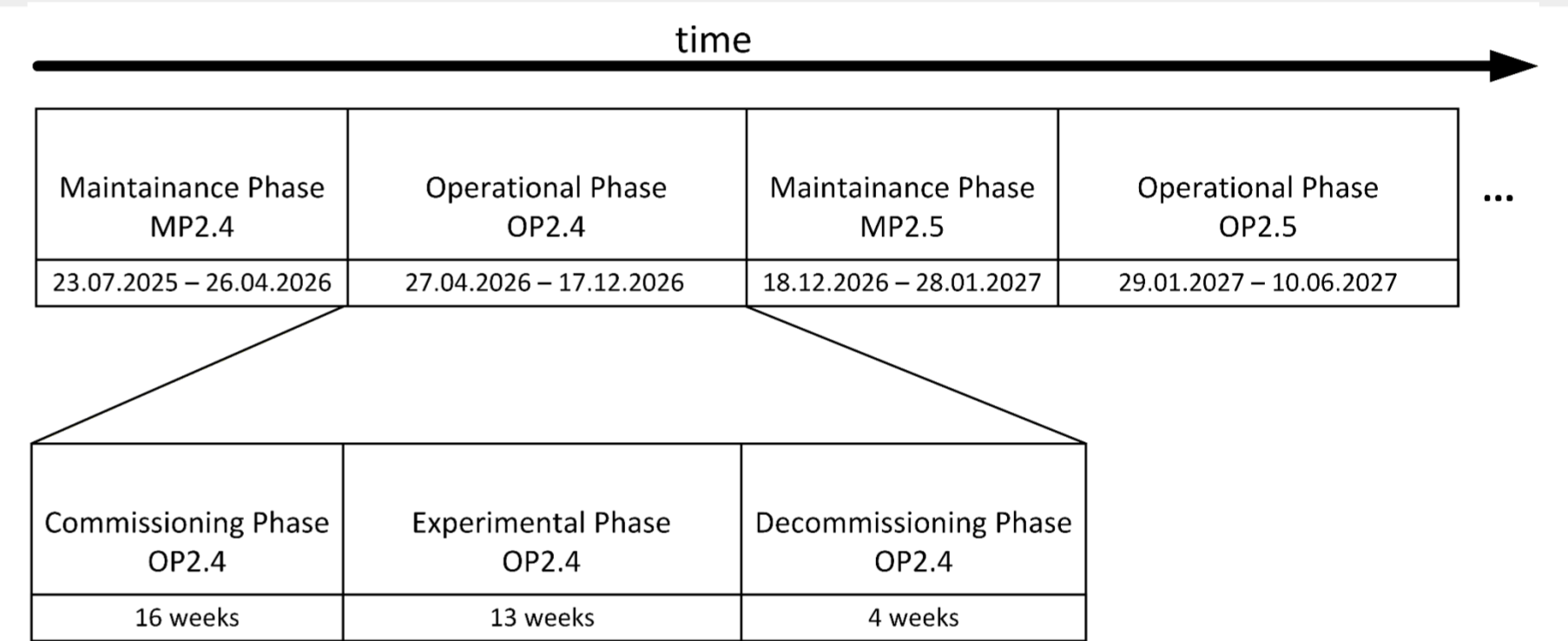
OPERATION OF W7-X



CAD model of W7-X



View on W7-X in the torus hall



Operational phases of W7-X

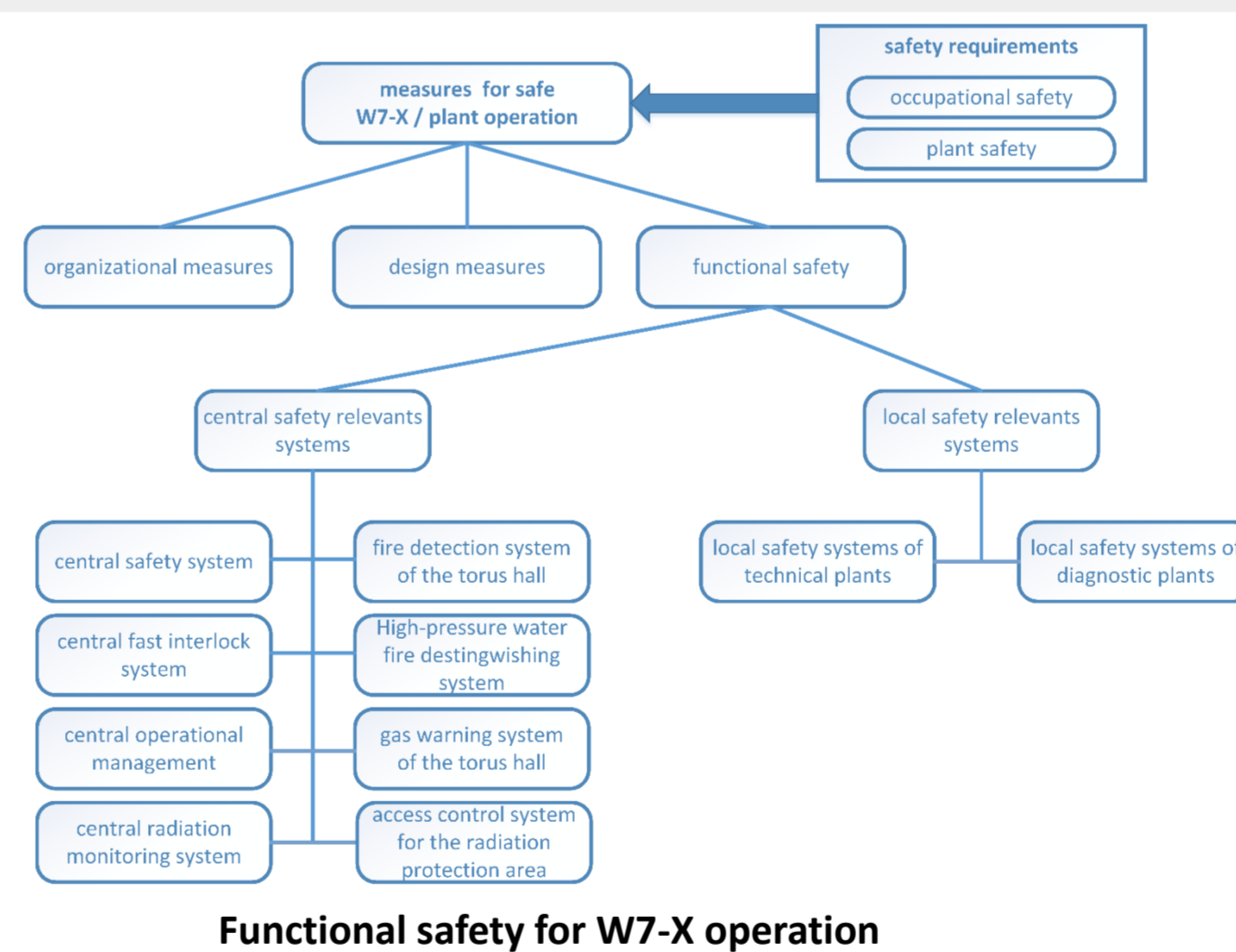
FUNCTIONAL SAFETY FOR W7-X

Measures for a safe operation:

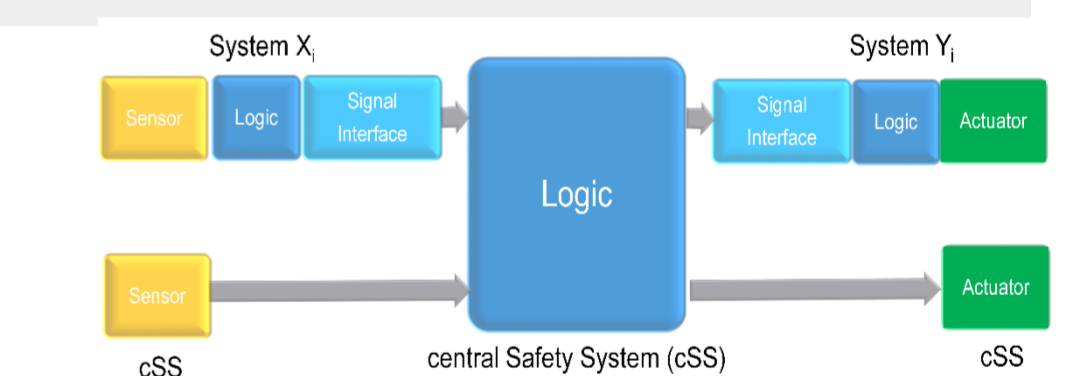
- Organizational measures,
- Design measures,
- Functional safety for diagnostics and technical plants,

Important safety concepts

- Concept of Safety Levels
- Safety Instrumented Functions (SIF)
- Emergency Stop logic (ES),
- Access Control for the Radiation Protection Area,
- Special Operating Functions (SOF)



Functional safety for W7-X operation



Structures of a Safety Instrumented Function (SIF):

Safety Level	W7-X	Emergency Stop	Standby	Experiment
Vacuum systems	Red	Red	Green	Green
Cooling circuits	Red	Red	Green	Green
Cryo plant	Red	Red	Green	Green
Magnetic system	Red	Red	Green	Green
Plasma heatings	Red	Red	Green	Green
Diagnostics	Red	Red	Green	Green
Entry to RPA ¹	Red	Red	Green	Green

¹ RPA: Radiation protected area

CHANGES OF SAFETY SYSTEM FOR OP2.4

Changes of safety system hardware: ✓

- Exchange of PLC HW ET200M modules with ET200SP modules,
 - Modification of 14 cSS interfaces and 3 PLC cabinets was necessary
- **Replacement of Pilz safety relays** ✓
 - 100 of 258 Pilz Type 7.1 safety relays were replaced (defect or end of live time)
- **Changes to the interfaces** ✓
 - Modification of 5 existing cSS interfaces,
 - Implementation of 2 new interfaces (Powder Dropper, Heavy Ion Beam Probe),
 - New Fast Interlock System interface for Powder dropper,

Changes of safety system software: ✓

- Implementation of a new Safety Level: SL Assembly,
- Adjustment of the release signal matrix for the SL Assembly,
- 11 new Special Operation Functions (for SL Assembly),
- Upgrade PLC software from version PCS7 V9.3 to PCS7 V10,
- Modification of certain existing safety functions,
- Expansion of the access control logic for the radiation protection area through the integration of 3 door sensors from the pre-assembly hall,
- Expansion of the cSS simulation system SIMIT for OP2.4,