

Objectives per WP for extension of CWP for 2026/2027 , 10 Dec. 2024

## **WPPrIO: Preparation of ITER Operation**

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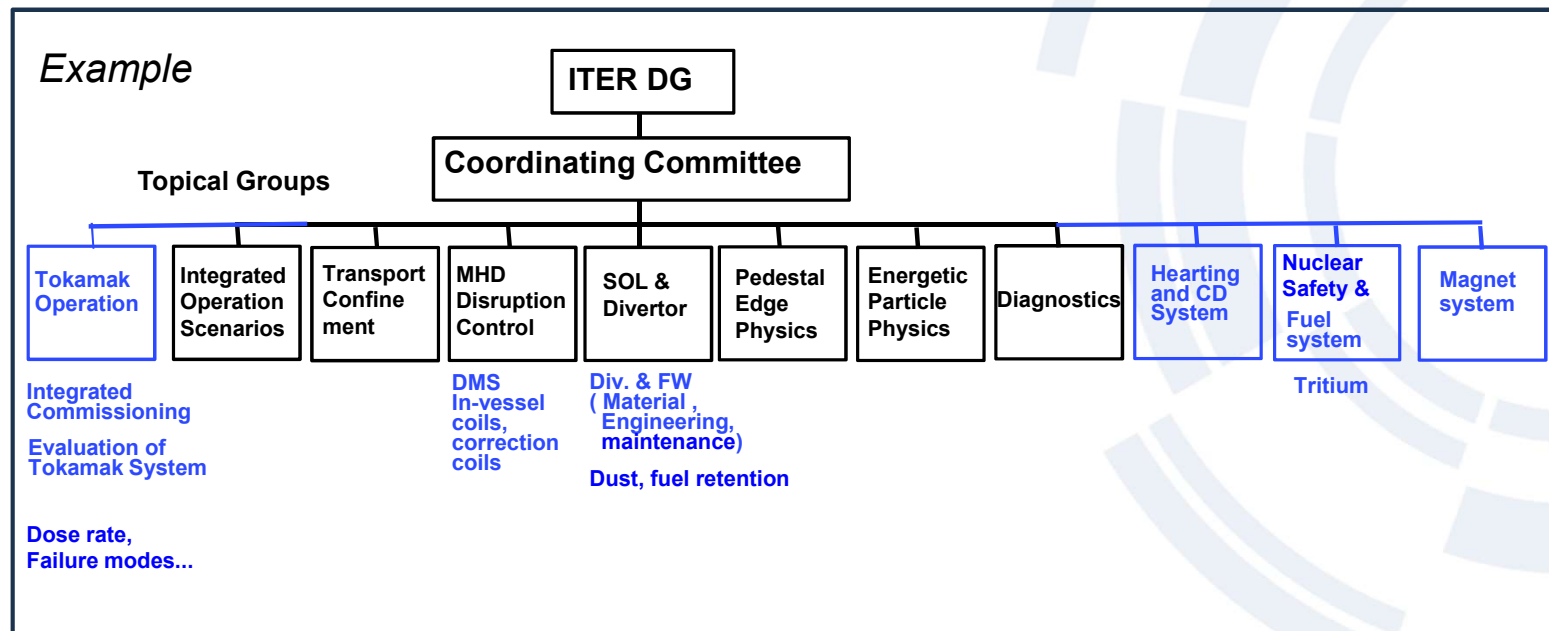
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## Updates from ITER-IO, ITPA-CC – slide from Yutaka KAMADA

### The ‘new fusion era for DEMO’ needs reliable and efficient integration of physics and engineering

- Reinforcement of ITPA with Integration of Physics & Engineering => ‘ITP**EA**’
- **ITER Construction / Commissioning / SRO & DT-1 Operation / evaluation of nuclear safety** (incl. NBTF, TF Cold Test )



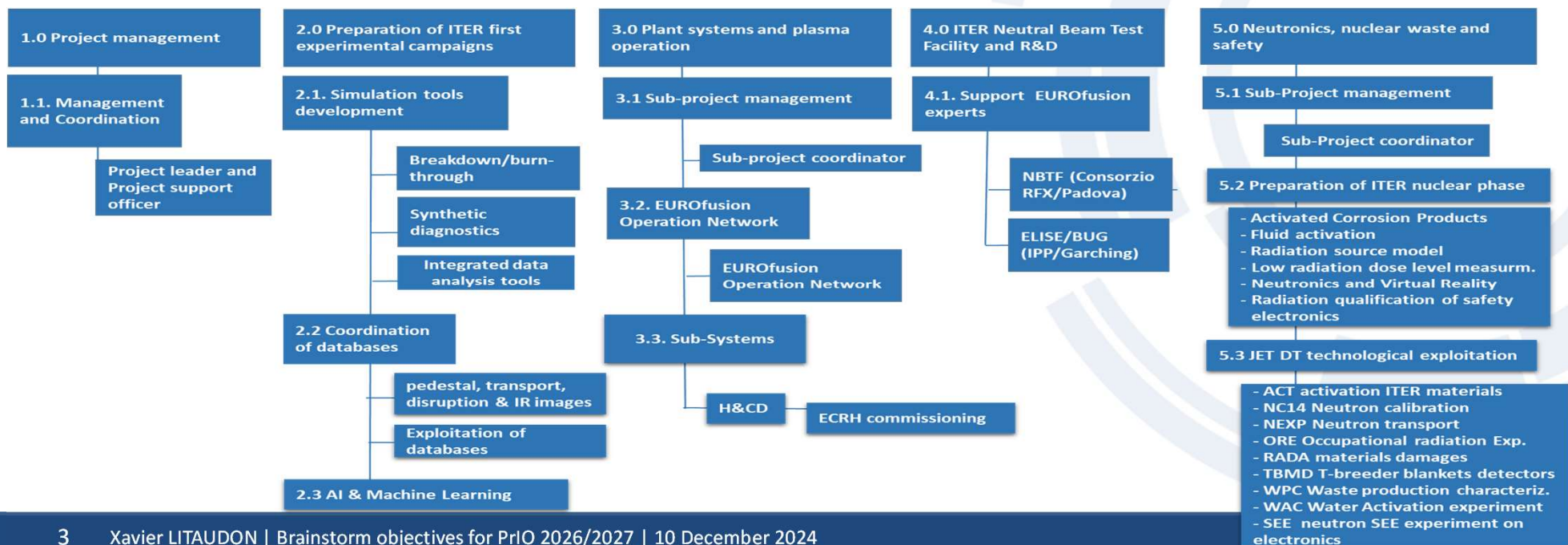
**Proposal => for agreement at mid 2025 => start from Dec. 2025**



# First set of proposals based on the existing PrIO structure (WBS)

- 5 Sub-Projects with delegation and gender equality

- SP-1 Project management (G. Falchetto)
- SP-2 Preparation of ITER first experimental campaigns (X. Litaudon)
- SP-3 Plant systems and plasma operation (E. Belohony)
- SP-4 ITER Neutral Beam Test Facility and R&D (U. Fantz, D. Marcuzzi)
- SP-5 Neutronics, Nuclear waste and Safety (S. Villari)





## SP-2 Preparation of ITER first experimental campaigns

With TE, SA, PWIE, DC

- **Development and validation of operational tools**, broadly defined to include methods, codes and procedures **ready before ITER application (tested, validated and reliable)**
- Database, Operational tools including AI based fast tools, synthetic diagnostics and Integrated data analysis (**in collaboration with GA/USA**)
  - Stronger focus on fully compatible with IMAS as a « MUST » and multi-machine verification and validation
  - “ To enable IMAS to become a world-wide standard for fusion research and to lower the barriers to developing, validating, applying and contributing to this software, the ITER Organization Director General has approved the release of IMAS software under Open-Source licenses (CC BY-ND 4.0 and LGPL 3.0) on 22/11/2024” (sic ITPA-CC )
- Expand on existing synthetic diagnostics and Integrated data analysis: IR, FILD, Magnetic, Bolometry, Neutronic and gamma ray spectrometer, FOCS and initiate new activities on synthetic diagnostics and Integrated data analysis, e.g.:
  - Ti and D-T fuel ratio determination from neutron camera
  - Integrated data analysis with kinetic and magnetic data (equilibrium)
  - Synthetic diagnostic for W lines identification and influx measurement
- **IR synthetic diagnostic & wall protection monitoring:**
  - accelerating the entire IR simulation to obtain a representative synthetic database for machine learning development for temperature inversion with application to real experimental data & control
  - effect of boronisation on optical materials properties (emissivity and reflectivity)

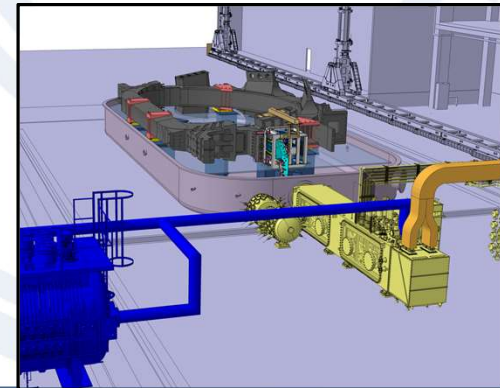


## SP-3 Plant systems and operation

With TRED, SA, DCT, HCD, MAG

“Operation” encompassing integrated commissioning, plasma & machine/sub-systems operation including scientific exploitation to be carried out in advance of the start of ITER plasma operation

- Coordination of the EUROfusion Operation Network and liaise with new ITER initiatives (ITPEA, ION) : ECRH, NBI sub-network
  - Strong value of ITER before “Plasma Operation”: Manufacturing, Assembly, construction, **commissioning and Integrated commissioning**
  - IO will focus effort on ITER construction and IO will request DA to be more involved in commissioning and Integrated commissioning
  - Address long pulse operation: procedure, availability & reliability ( in collaboration with IEA CICLOP) for ITER & VNS
- Support tokamak operation with conversational AI Interface Multimodal Large Language Models
  - multi-machine application
  - integrate diverse datasets types ( text , images, etc ) to address a wider range of operational
- Increase ECRH EUROfusion effort in support to ITER revised baseline
  - ITER Significant transition from 24 Gyrotron procurements to 80 in the revised baseline
  - commissioning on test beds is on the critical path of the timeline
  - EUROfusion Participation in the ITER ECRH commissioning
- Participation in the TF/PF superconducting magnet cold tests
  - “All members and DA welcomed “
  - Connection to ITER’s Cryogenic plant : 1 of 3 Helium refrigerators to cool the coils at 4 Kelvin.
  - Cryostat to accommodate TF coils and PF1 coil,
  - A complete unit of energization (up to 67kA for TFs) and fast discharge unit.







## SP-4 ITER Neutral Beam Test Facility and R&D

With SA, DES, DCT-VNS

- Coordinated strategy and planning under finalisation (ITER–STAC questions)
- EUROfusion participation in the NBTF (SPIDER and MITICA), **Extend agreement with IO**
  - “Operation at the NBTF should be considered comparable to ITER operation based on their commonalities in terms of technology testing, system integration, and procedure development.” Yutaka KAMADA
  - SPIDER: Inputs to MITICA, operation in full configuration and beam uniformity studies ( >75kW/driver, 270A/m<sup>2</sup>, 50s), Assessment of beam divergence for diagnostic beam
  - MITICA: integrated test up to (700kV, 240A/m<sup>2</sup>, <1s) with simultaneous achievement of current, uniformity, co-extracted electron, divergence: first operation end of 2026, 2027 for the first campaign **focusing on H**
- Expand the R&D activities with BUG and ELISE to contribute to NBTF/ITER
  - High performance one hour **deuterium beam** (**new solid-state RF generators are required**)
  - Beam optics studies, new caesiation concept, reduction of co-extracted electrons (electron fence), RF coupling efficiency
- Optimisation negative ion RF source without plasma asymmetry (Beam divergence)
  - Test of RF source with radial magnetic field to cancel the electron diamagnetic Hall current and improve beam divergence as in the plasma source for space propulsion (Hall Thrusters)
- Integrated injector simulation from source to plasma deposition (inc. AI surrogate models)
- Positive NBI system for a volumetric neutron source
  - Design of reliable positive NBI system and experiments for a steady state ion source with a new facility for testing of continuous operating NBI sources and beamline components
- **International collaboration with QST**: pos and neg. ions for JT-60SA and neg. ions for ITER
  - test the electron fence with a JT-60SA-like plasma grid at BUG (grid provided by QST and/or F4E)



## SP-5 Neutronic

With BB, DES, DCT, MAT, ENS

- Validation of nuclear codes during the JET decommissioning (**pending agreement with UKAEA**)
  - Reduce the uncertainties in Occupational Radiation exposure predictions
  - Improve the nuclear techniques for analysis of irradiated materials and waste characterisation
- Preparation of Neutronics experiments in ITER (SRO, ST1) in support to DT2 licensing based on JET expertise (**Int. Coll with CN/BEST**)
- Fluid-activation experiments & model validation of water activation prediction
  - Validation of fluid activation multi-physics tools
- Activated Corrosion Products experiments & model validation in fusion relevant conditions
  - reduce uncertainties in ACP predictions (OSCAR-Fusion) in ITER conditions (water chemistry, thermal hydraulic regimes and radioisotopes...)
  - Developments of new models for erosion/corrosion laws for ITER materials and conditions (magnetic field, Radiolysis)
- Integrated plasma physics and neutronic simulation in support to new ITER baseline
  - Accurate radiation sources calculation in the various ITER phases, including Neutron synthetic diagnostics & AI surrogate models
- Diagnostics & electronics components test under irradiation & temperature gradients
  - simultaneous fusion neutrons irradiation and ITER temperature conditions (“Oven” at FNG and GENeUSIS , General Experimental Neutron Systems Irradiation Station)
- Open-source Neutronics codes development Verification and validation (**international with USA**)
  - Various geometry representations and exascale computing (GPU usage) with no restrictions for deployment on cloud and cluster environments (International collaboration) for nuclear analysis