



WPSA Operations – Integrated Commissioning Preparations

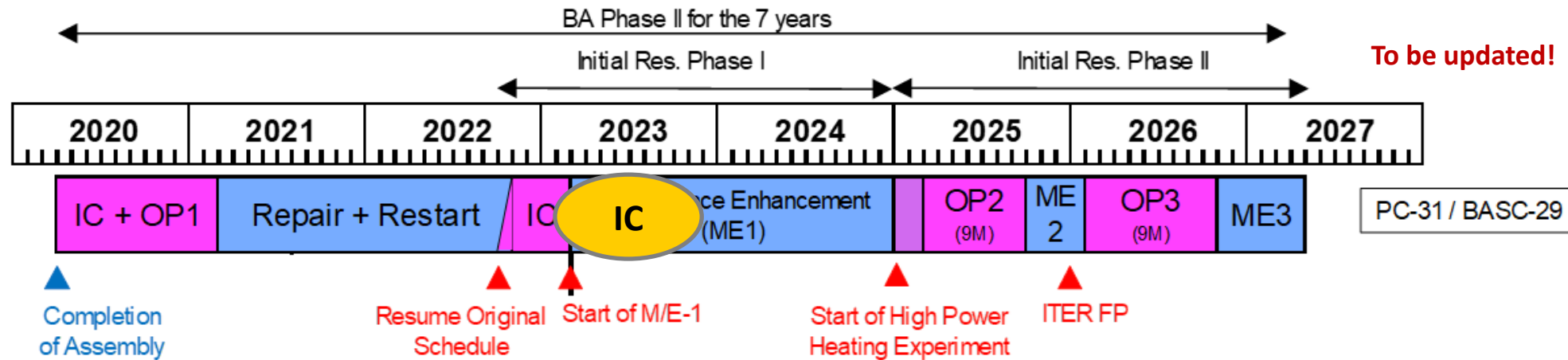
WPSA General Meeting, 6-9 September 2022

Eva Belonohy

WPSA Operations Area Coordinator



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Integrated Commissioning Phase 2 expected to start early 2023

- Joint F4E-QST position following the Global Paschen test (see talk by S. Davis)
- Meeting with governments (MEXT and European Commission) at the end of September 2022

Japan's borders been opening up step by step.

- Quarantine is not required in most cases.
- Strict vaccination history requirements.

Administrative process:

- List of IC experts travelling to Japan was updated in 2022
- Information required to prepare host agreement and assignment form have been confirmed for all travelling experts

List did not change significantly compared to the original 2019 call for participation and subsequent 2021 travelling plan.

- 3 WPSA expert moved/moving to ITER
- Camera tomography and plasma operations experts joined

Current plan includes E. Belonohy for 6 months + 28 IC experts travelling for 0.5 - 4 months with < 3 months trips (standard FP9 mission rules apply)

Still possible to join the IC team with clear task/contribution, please note that office space limits participation to 10-11 EUROfusion experts on site.



FP9 WPSA Operations (E. Belonohy)

[Visa Application Process](#) and administrative requirement of the host agreement and arrangement form

[Visitors' Handbook](#) providing useful information on the required European preparations, arrangement for Japan and living in Japan.

Updates on travel is included in the EU IC team meetings available at [FP9 Integrated Commissioning](#) page.

IC experts travelling to Japan

Surname	First Name	Topic
Belonohy	Eva	IC coordination
Szepesi	Tamas	EDICAM
Kocsis	Gabor	EDICAM
Kovacsik	Akos	EDICAM
Szabolics	Tamas	EDICAM
Hungarian expert 1		EDICAM
Hungarian expert 2		EDICAM
Cavalier	Jordan	Camera Tomography
Svoboda	Jakub	Camera Tomography
Iafrati	Matteo	Plasma Operations
Moreau	Philippe	Plasma Operations
Gallo	Alberto	Plasma Operations
Reux	Cedric	Plasma Operations
Louzguiti	Alexandre	Magnets
Michel	Frederic	Cryo
Bonne	Francois	Cryo
Ricci	Daria	Breakdown
Bin	William	Breakdown
Mattei	Maximilian	Breakdown
Sozzi	Carlo	Breakdown
Lunt	Tilman	Breakdown
Hall	Stephanie	Plasma Operations
Pigatto	Leonardo	Magnetics
Bonotto	Matteo	Magnetics
Bolzonella	Tommaso	Magnetics
Magnetics expert		Magnetics
de Tommasi	Gianmaria	Equilibrium Control
Pironti	Alfredo	Equilibrium Control
Abate	Domenico	Equilibrium Control



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	F4E project leader	Deputy Project Leader and Naka-site representative
F4E JT-60SA project	E. Di Pietro	S. Davis
Topic	EUROfusion contact	Japan contact
Plasma Operation Team	E. Belonohy (G. Falchetto)	M. Yoshida (H. Urano)
Plasma discharge development	E. Belonohy	M. Yoshida (H. Urano)
Plasma breakdown	E. Belonohy, G. Falchetto	H. Urano (T. Wakatsuki)
Plasma control and equilibrium	E. Belonohy	S. Inoue (T. Wakatsuki)
ECWC and gas analysis	E. Belonohy, G. Falchetto	T. Nakano (M. Fukumoto)
MHD and disruption	E. Belonohy, G. Falchetto	M. Takechi (H. Tojo)
EDICAM	E. Belonohy, G. Falchetto	K. Kamiya [diagnostics: Nakano]
Cryogenics and magnets [strong F4E involvement]	E. Belonohy	K. Hamada
Remote data access	G. De Tommasi	

Organised into 7 IC topics with dedicated QST contact people

- QST contacts remain the same except Oyama-san-> Nakano-san
- EU Naka-site coordination team -> OP and CM area coordinators
- **2 Japanese ETLs and 2 TGLs are also QST IC contacts**

Regular meetings

Management:

- QST/F4E Project Coordination Meeting with EUROfusion participation (every 3 weeks)
- Monthly Plasma Team Coordination with M. Yoshida & E. Belonohy + G. Falchetto & H. Urano
- Regular F4E-EUROfusion management catch-up with S. Davis

With IC team:

- Monday JT-60SA IC status meeting with IO experts (every 1-2 weeks) – EU experts invited dependent on IC phase
- EU IC team meeting to update the whole team on the progress

Organised into 7 IC topics with dedicated QST contact people

During IC activities and their preparation

- Regular EU and EU/QST topical group meetings
- Regular QST/EU Plasma Team meetings (except cryo/magnet, 1 EDICAM representative only) chaired by M. Yoshida

-> will restart around pump down (start of IC)



During active phase:

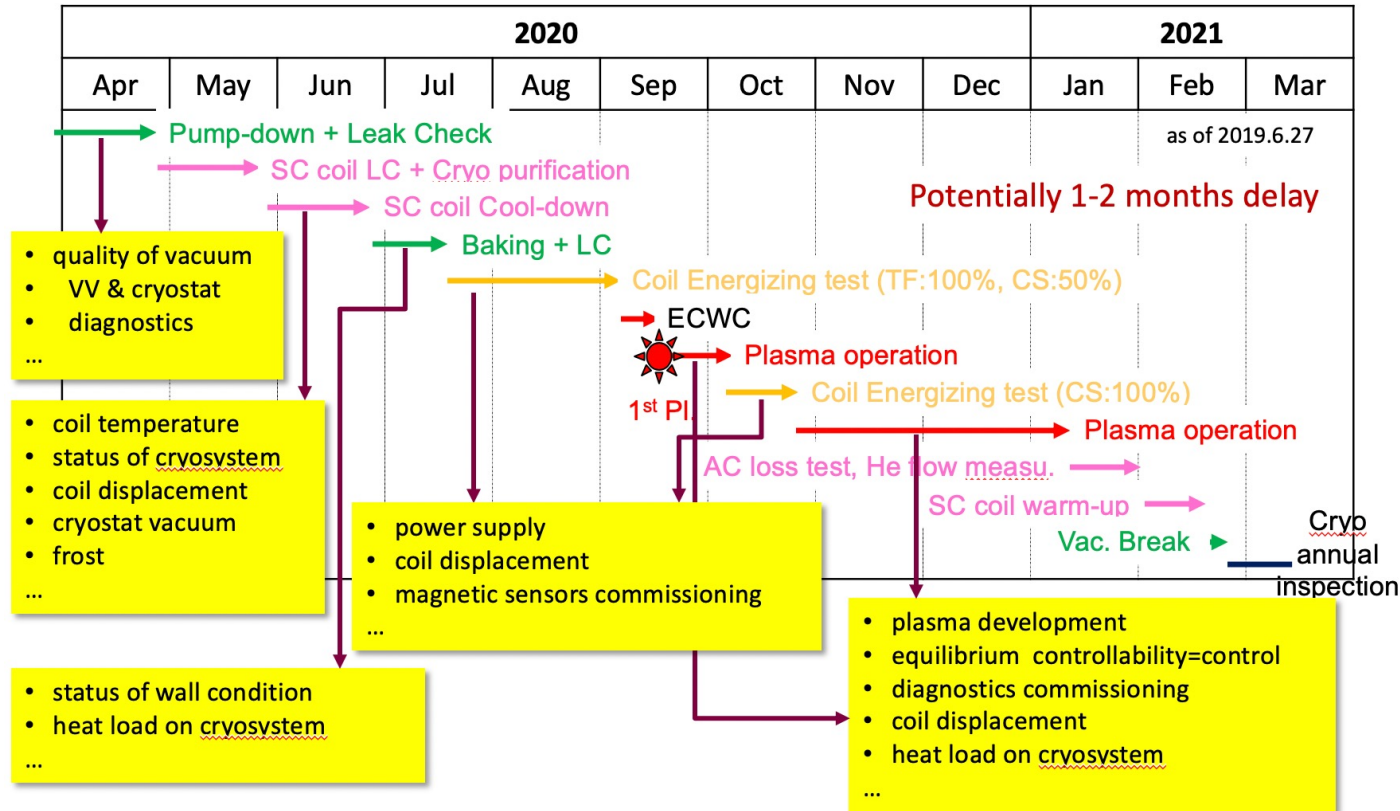
- daily F4E/Europe (@7.30 CET) + EUROfusion catch-up meeting (@ 8.30 CET)
- **Daily control room meeting with QST topic when task is active (@9.00 CET)**
vacuum conditioning -> extend to all topics

Use of Microsoft Teams to communicate –
allocated QST/EUROfusion expert to monitor channels

Integrated Commissioning Timelines



To be updated!



1st integrated commissioning phase reference

- 1st pump down: Early December 2020
- 1st plasma was planned in March 2021

FP9 WPSA Operations (E. Belonohy)
FP8 Integrated Commissioning page
Plasma team folder on the JT-60SA DMS (restricted access to Plasma Team members)
Integrated Commissioning Procedure and IC summary on the JT-60SA DMS (restricted to IPT members)

We expect about 4 months between pumpdown and first plasma attempt.

Plan to be updated based on current availabilities and priorities.

Regular EU IC team meetings and QST/EU Plasma Team meetings to keep you up to date.



Discussion points:

- Risk of runaway electron generation (EU experience collection, simulation to assess risk and prepare mitigation/avoidance strategy, develop detection)
- Limited set of diagnostic -> potential runaway and EC stray detection, MHD analysis
- Priorities from IC targets for 2023 for Europe
- Breakdown in the post-Paschen test conditions (reduced voltages, w/o booster)
- Improvement of the (active) coil protection systems (F4E plant simulator, CEA cryo and magnet modelling as operational tools)
- Preparation of IC activities (equilibrium control, magnetics, vacuum conditioning)
- Identify interest and push for EUROfusion Operations Network events (vacuum conditioning, first plasma, runaway generation)

Session Agenda:

- Cryo and magnets (S. Nicollet)
- ECWC (J. Buermans)
- Equilibrium control (G. de Tommasi)
- Magnetics (L. Pigatto)

FP9 WPSA Operations (E. Belonohy)

[Plasma Operations](#) (incl. vacuum conditioning and breakdown)

[Equilibrium control](#)

[Magnetics](#) and the disruptions database

[Cryo and Magnets](#)

[EDICAM](#) operation Thu session 3

[Camera tomography](#) implementation N/A

FP9 WPSA Code Management (G. Falchetto)

[ECWC](#) simulations

[EDICAM](#) software tools Thu session 3

[Camera tomography](#) software tool N/A

[Breakdown](#) simulations

[Disruption](#) modelling Thu session 4



Cryo & Magnet: evaluate the potential use during integrated commissioning to support coil protection

- CEA support from Europe in case of issues, focus more on plant modelling -> meeting with F4E at the end of September

Wall conditioning: baking + GDC (without TF) + ECWC (with TF) – essential for breakdown and reducing risk of runaways

- Check ECWC shape against planned coil limits
- ECWC experiments could be used to test REC in Cadarache

Equilibrium control: CREATE tool suitable for control room support vs. slower MECS code + parameter scans

- QST code only in compiled version, lack of QST involvement on the topic, CREATE part of the ITER system development
- Plan: ENEA experts in Naka during IC, see how the CREATE tools could support IC.
- Future campaigns: use of CREATE tools in case of 3D perturbations -> advanced controllers eg. with resistive wall modes,
- Post-disruption runaway control?

Magnetics:

- Understand what tools QST plans to use for MHD analysis in IC, potentially use the ENEA one to be used on ITER
- Develop locked mode signal and check availability of 1MHz planned signals in IC
- What modes are expected during IC plasmas (tearing modes, ..). Can we map the operational space with modelling tools?
- Machine protection aspects relevant also for disruptions -> deformation of the vessel, F4E gauges too slow? Check with V. Tomarchio
- Drift calculation of magnetics during ramp up -> not to be confused with slow modes early in the pulse



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Session Agenda:

- Breakdown modelling w/o booster (M. Mattei)
- Feasibility of the EDICAM camera for runaway electron detection in JT-60SA disruptions (G. Pokol)
- Runaway experience at start up from FTU (G. Pucella)
- Discussion of runaway detection and analysis for 2023
- Discussion on plasma operations support

FP9 WPSA Operations (E. Belonohy)

[Plasma Operations](#) (incl. vacuum conditioning and breakdown)

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Breakdown modelling:

- Impurities to be included following discussion/agreement with the F4E/EF working group – few reruns
- Tilmann suggested to apply modelling to AUG
- Question on differences between EU modelling without booster and QST modelling with the booster

Runaway detection feasibility using the EDICAM camera:

- Introduced DREAM and SOFT codes. Another code: STREAM (= DREAM + DYON)
- It should be possible to see synchrotron radiation of stronger runaway electron beams. Could benefit from a second camera view -> check the QST visible cameras
- Could use the IC scenario for the feasibility. Current scenario was a 5.5 MA OP2 plasma disruption with 3 MA RE plateau.
- To use STREAM for synchrotron simulations, extension with kinetic calculation is needed (rough estimate or self consistently).

FTU experience on runaways: experience, useful diagnostics for the future, control to mitigate runaways

- Explore the two options to detect runaways in IC using EDICAM: snow-like effect caused by hard X-rays, synchrotron radiation
- Develop strategy what to do if runaways are detected in IC: equilibrium control, gas valves, ramp down TF?
- Collect multi-machine experience, e.g. JET sustained post-pulse sustained runaway beam
- Difficulty to break down post-runaways and post-disruptions (carbon machine)
- Potential runaway damage

Follow up meeting(s) to gather EUROfusion experience and discuss JT-60SA plans including tasks for 2023.



Discharge simulator:

- Planning to offer discharge simulator training for the IC plasma ops team
- Can the IC scenario be included in the discharge simulator -> demonstrate its use in the control room during IC.
- Need for EU JT-60SA session leaders to support scenario and experiment design and preparation
- Tool for EU scenario development vs. pre-pulse check and pulse optimisation tool -> high current, long pulse
- Experiment Team looking into phasing of experiments during OP2 and OP3
 - Define scenarios with stepwise heating availability for the phasing
 - Would need to including commissioning considerations of systems, plants and enhancements.



Integrated commissioning - IC (December 2020 – March 2021)

Close collaboration with QST and F4E on 7 IC topics

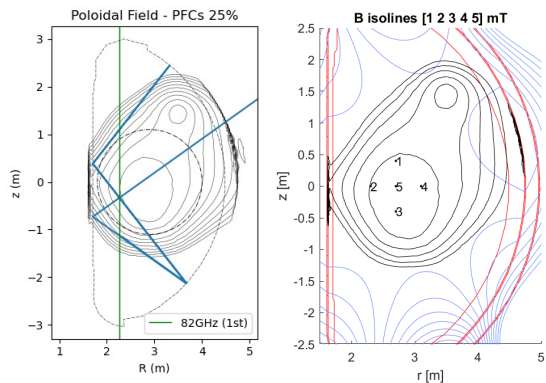
1. Cryo and magnet system: supported coil cool down, energization and repair plan.
2. EDICAM: commissioned the camera remotely. Ready for first plasma.
3. Scenario development: shared first IC experience of MAST-U and WEST. Discussed plasma operation plan.
4. Equilibrium control: prepared CREATE tools for JT-60SA. First steps to learn MECS.
5. Plasma Breakdown: simulated JT-60SA plasma breakdown incl. at various coil currents.
6. Magnetics, MHD, disruptions: Supported calibration of magnetics. Prepared tools for a disruption database.
7. Wall conditioning: direct input into GDC commissioning, ECWC simulation parameter scans.



Magnets: A. Louizguiti with the QST team and S. Davis

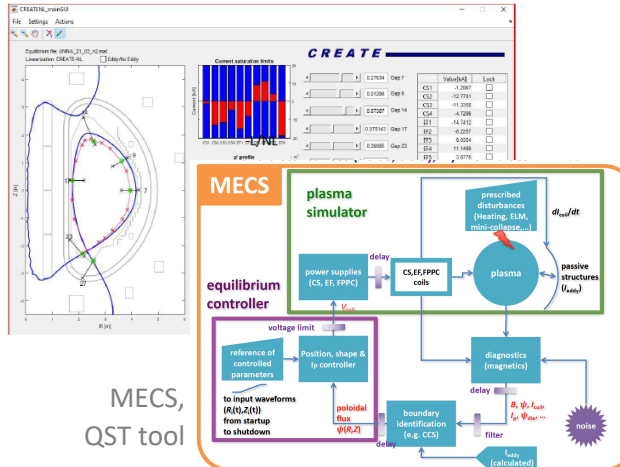


Scenario development: M. Iafrafi in the Naka control room

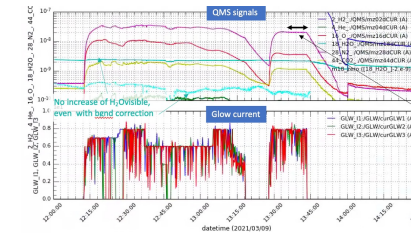


Plasma breakdown with 25% PF coils

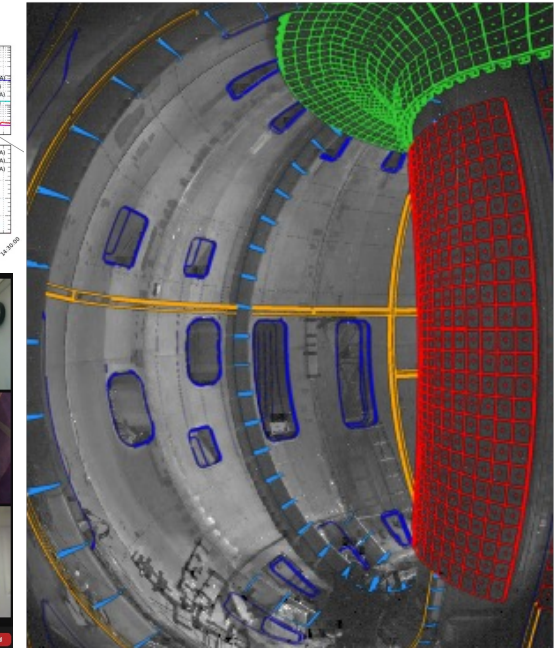
CREATE equilibrium control tools



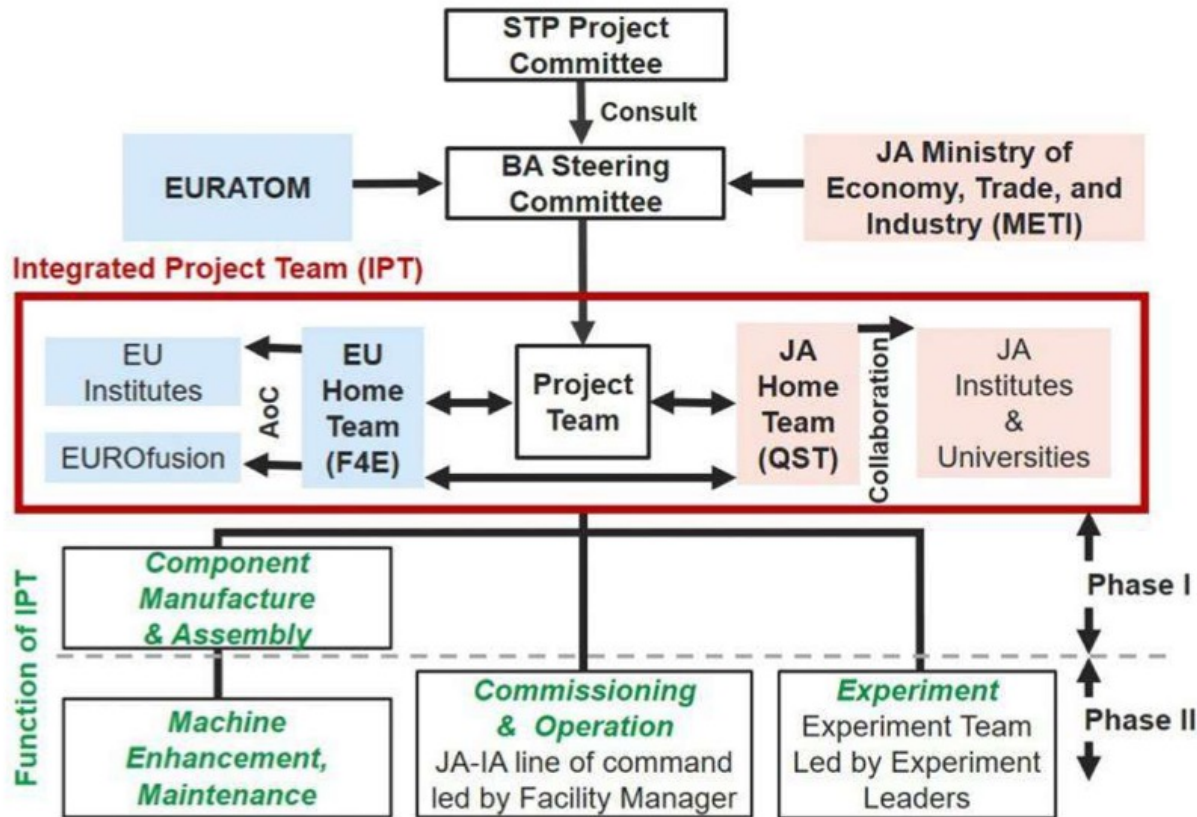
MECS, QST tool



Glow Discharge Cleaning (GDC) commissioning and ECWC preparations with simulations



First EDICAM photo with the camera tomography calibration



Phase 1: Integrated Commissioning is QST's responsibility

- Strong F4E involvement on some plant systems as well as protection systems, timeline and risks.
- EUROfusion support on the 7 IC topic areas with a QST contact and deputy contact for each.
- Both scientific exploitation and operations under the IC team (including named EUROfusion experts)

Phase 2: Operational Phase

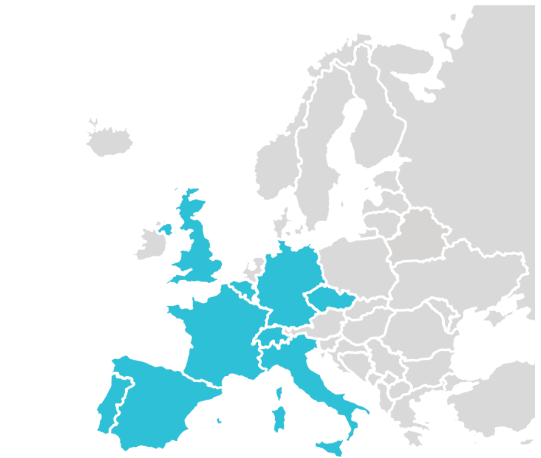
- Scientific exploitation moves to the joint Experiment Team
- How the operational areas will be joint, will only be discussed post-IC with F4E and QST
- We will review the operational experience from IC within WPSA-OP and jointly with F4E and QST.

EUROfusion Operations Network

Established in 2021, EON is a network of 18 experts across 9 associations to:

- facilitate stronger connection between the operational groups of EUROfusion facilities to share operational experience, improve operational reliability and performance,
- support development and training of operators, creation of a joint knowledge base
- contribute to the EUROfusion preparation for the (integrated) commissioning and operation of ITER.

Starting 2022 [EON organizes events, training and seminars](#) on dedicated operational topics open to all EUROfusion experts.



EUROfusion Operations Network members

EON NBI members

2022 activities:

- Review of the operational roles and training on EUROfusion devices
- [Monthly EON seminars on NBI operations](#) started in May 2022
 - Next NBI seminar is on JT-60SA on 15th September 2022

Potential events in 2023 relevant to JT-60SA:

- Vacuum conditioning, first plasma operation including runaway generation
- Commissioning of superconducting coils
- Real-time controllers, hardware and software platforms
- Foundation course on session leading

Positive NBI Teams involved
JET, MAST-U, ASDEX Upgrade, Wendelstein 7-X, TCV, TJ-II, COMPASS-U, JT-60SA
Negative NBI Teams involved
ELISE, BATMAN-Upgrade, SPIDER, MITICA, JT-60SA
Guests
ITER, LHD, (DIII-D)

► Looking for important topics to dedicate EON events relevant for JT-60SA

ITER Operations Network (2017 -)

- Biyearly meetings restarting in 2022 to support ITER's integrated commissioning and operation.
- Participants: representatives of the international labs.

ITER-F4E-QST Trilateral Agreement

- Sharing experience in topics of manufacturing/installation, integrated commissioning and scientific exploitation.
- IO expert participation in integrated commissioning.

Publications

- Integrated commissioning is QST responsibility
- Encourage publications in collaboration with QST and F4E on the commissioning and operational experience, strategy and lessons learned during IC
- [PPCF Special Issue on Operations](#) (QST special editor: Y. Kamada) (dedicated operations papers, published once accepted)



PPCF Special Issue on Operations

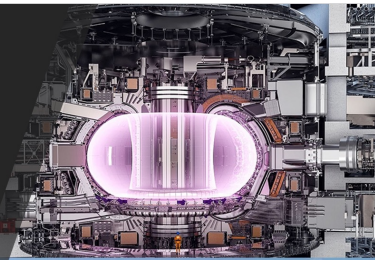
Establish a new field on the operation of fusion devices (commissioning, operation and maintenance of tokamaks, spherical tokamaks and stellarators).

Capture the know-how, expertise and experience of current fusion facilities and commissioning of new fusion facilities.

Share the operational experience, best practices between facilities to improve their operational availability and performance.

Research the operational practices and experiences in multi-machine studies to improve our understanding and increase public acceptance.

Train the future ITER generation by providing reference training material for them.



Reference: 2022 deliverables of the WPSA Operations Area



FP9 Management tasks	Deliverable owner	Beneficiaries
Coordination of the integrated commissioning activities in 2022 in relation to plasma operations (including wall conditioning and breakdown), EDICAM operation and camera tomography, equilibrium control and magnetics, cryogenic systems and superconducting coils).	E. Belonohy	UKAEA
FP9 2022 integrated commissioning activity tasks		
Ensure that the EDICAM camera is ready for wall conditioning and first plasma operation of JT-60SA. Operate and optimise the camera during the integrated commissioning phase.	T. Szepesi	EK-CER
Interface with the EDICAM system and provide timely camera tomography analysis to support ECWC modelling, breakdown studies during the integrated commissioning phase.	J. Cavalier	IPP.CR
Participate in the integrated commissioning of JT-60SA and support the QST team related to plasma operations	M. Iafrati	ENEA
Participate in the integrated commissioning of JT-60SA and support the QST team related to plasma operations	P. Moreau	CEA
Participate in the integrated commissioning of JT-60SA and support the QST team related to plasma operations	E. Belonohy	UKAEA
Support the achievement and optimisation of the plasma breakdown for the first plasma operation of JT-60SA.	D. Ricci	ENEA, MPG
Validate control-oriented plasma linear models against experiment data. This validation will include the implementation of the control algorithms adopted during the Integrated Commissioning within the CREATE tools.	G. de Tommasi	ENEA
Participation of ENEA experts to MECS training provided by QST and/or EU experts.	G. de Tommasi	ENEA
FP8 2022 integrated commissioning tasks		
CREATE personnel to support QST onsite in the commissioning of the plasma equilibrium control system.	G. de Tommasi	ENEA
Support the commissioning of the magnetic diagnostics and perform MHD analysis during the integrated commissioning.	L. Pigatto	ENEA
Support the commissioning activities related to the JT-60SA cryogenic and magnet systems.	F. Michel	CEA

Reference: 2022 deliverables of the WPSA Operations Area



FP9 Management tasks	Deliverable Woner	Beneficiary
Coordination of the activities related to machine and plasma operations. Coordination and training of control room experts Coordination of Remote Access and Participation Coordination of the activities related to the commissioning of the EU-led Enhancements	E. Belonohy	UKAEA
FP9 Preparation of future campaigns tasks		
Review and summarise currently available scientific real-time networks used on EUROfusion facilities as input for consideration by the JT-60SA Experimental Team.	S. Hall	UKAEA
Review and summarise currently available scientific real-time networks used on EUROfusion facilities as input for consideration by the JT-60SA Experimental Team.	O. Ficker	IPP.CR
FP9 Preparation of commissioning of EU enhancement tasks		
Inspection of the Massive Gas Injection system with an onsite visit upon delivery of the system to the Naka site.	M. Dibon	MPG
Preparation activities related to the commissioning and operation of the JT-60SA divertor cryopump system including consideration of experience from European devices.	C. Day	KIT
FP8 Preparation of commissioning of EU enhancement tasks		
Preparation and commissioning of the VUV diagnostic in ENEA prior to delivery to Japan	S. Scully	UKAEA