Reflections about the 2025 AWP for WP TE

WP TE – Work Package Tokamak Exploitation

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On behalf of WP TE TFLs

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Continuation: 9 Research Topics + DTE2/He A&M + JET data validation

RTCs are appointed until end of 2025

ITER

RT01: Core-Edge-SOL integrated H-mode

DEMO

RT02: Alternative to type-I ELM regimes

Physics & Control integration

RT03: Disruption & RE mitigation strategies

RT04: Machine generic integrated control

RT05: Physics of divertor detachment

RT08: Physics of high β long pulse scenario

RT09: Physics of energetic particles

RT06: preparation of efficient PFC operation

RT07: Alternative divertor configuration

PEX Upgrades on WEST/AUG/MAST-U/TCV

Mission 1 **Mission 2**

2023 – Overall progress monitoring by Subjective Scientific Readiness Levels based on level 3 reports that inform the technical report

Level	Criteria
Emerging	Little or no understanding yet on WP TE devices
Exploratory	Physical process is assessed on WP TE devices, transposing to ITER or DEMO is uncertain
Judgemental	Controlling physical processes has been assessed on WP TE devices, but extrapolation to ITER/DEMO requires scalable parameters and further investigation
Mature - needs underpinning	Good understanding of controlling physical processes on WP TE devices, but major uncertainty in view of transposing ITER/DEMO
Mature - needs support	A good understanding has been achieved on WP TE devices, further research exploring ITER or DEMO relevant parameters
Established	Understanding is well developed and can be applied to ITER or DEMO

Definition established within WP TE in 2021 and monitored since then

2023 – Changes in SSRLs for 2023

Level	Emerging	Exploratory	Judgemental	Mature-needs underpinning	Mature-needs support	Established

RT	Title	D1	D2	D3	D4	D5	D6	D7
RT22-01	Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER	X		X		X	X	X
RT22-02	Physics understanding of alternatives to Type-I ELM regime			X			X	
RT22_03	Strategies for disruption and run-away mitigation		X				X	
RT22_04	Physics-based machine generic systems for an integrated control of plasma discharge	X		X		X		
RT22-05	Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation		X				X	
RT22-06	Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS		X		X	X		
RT22-07	Physics understanding of alternative divertor configurations as risk mitigation for DEMO	X			X			
RT22-08	Physics and operational basis for high beta long pulse scenarios							
RT22-09	Physics understanding of energetics particles confinement and their interplay with thermal plasma					X		

DX: Numerator of deliverable or scientific objective

"X" marks a scientific objective of an RT with a change of the SSRL in 2023 compared to 2022 based on the level 3 reporting

Grant Deliverables until end 2025

"Title" in Sygma	Title in CWP	Due Date	Expected deliverable date	Status	Comments/Reason for delay
TE.D.08	Balance between gross and net erosion of W under different operational conditions in full-metallic toroidal devices	31/12/2023	31/12/2024	delayed	Laboratory results & interpretative modelling
TE.D.09	Establishment and comparison of N and Ne-seeded partially-detached divertor in high-power operations in view of ITER radiative scenario.	31/12/2023	31/12/2024	delayed	Data acquired, data validation & interpretative modelling ongoing
TE.D.12	The physics basis for the decision for an alternative divertor configuration for DEMO.	Dec. 2024	12/2025		Upper divertor of ASDEX Upgrade delayed and considered important
TE.D.13	Recommendation on the seeding impurity mix in view of a future reactor.	Dec. 2024	12/2024 or 12/2025		Data exists – but analysis progress by end of year unclear

Topics in 2025 with a likely stronger bias than 2024

- ITER re-baselining related activities on metallic devices (AUG & WEST)
- Encouragement to propose and implement recommendations from ITPA meetings
- Elements related to boronization
- Likely will add in RT-06 a more specific deliverable for boronization
- TFLs to discuss outcome of spring ITPA meetings before summer break in view of preparation of call for 2025
- Possible input to JT-60SA through experimental proposals to WP TE devices – tbd (if for 2025 or 2026 and to which extent – discussion started)
- Increase SSRL in RT08 and RT09 (of the basic elements that are required for the more integration oriented scientific objectives)
- 1st half of 2025 on AUG will still likely have a significant element related to the PEX Upgrade (upper divertor)
  - RT-07 D2 might be reformulated also in view of CRD emerging

JET analysis

- We’re expecting to continue with the present analysis in view of the FEC IAEA 2025 to allow the best possible anlysis
- ➔ no changes
- In 2024 ~1/3 of WP TE financial resources went into JET specific activities → we will try to keep this commitment up with a slight reduction as the forecasted data validation effort is lower for 2025 than for 2024
- Expect an analysis week in 09/24 and likely an additional one in late spring 2025

Interpretative modelling and extrapolations to ITER and DEMO

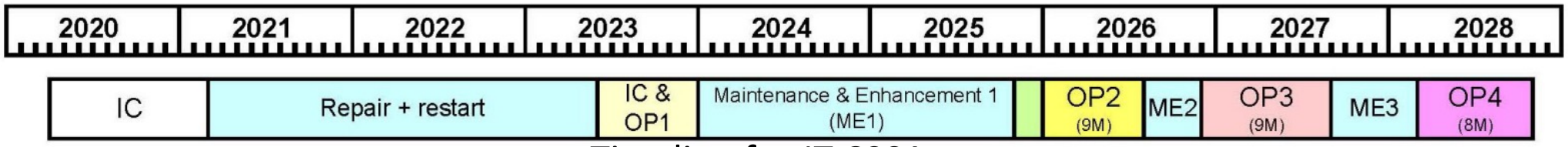
- As a reminder already in the 2024 call for participation:
  - “Proposals for participation addressing issues raised by the ITER new baseline (see for instance the document listing R&D issues to be investigated here), as well as for extrapolating findings from present WP TE devices to next step fusion devices, such as ITER and DEMO, are encouraged”
- For extrapolations in the initial funding scheme funding was lacking and it was expected to receive funds in the course of 2024 – enable by GA April 2024 – WPTE now implementing additional resources, however main focus is interpretative modelling
- Motivating, driving and identifying human resources for extrapolations to ITER / DEMO is difficult – might require more advertisement – the present effort in increasing these resources might be a first step
- Need to have the appropriate resources right from the start of 2025 to secure the participation → but requesting additional funds will depend on the success of allocating those additional granted to WP TE in 04/24
- Issue of training participants in code usage? Human resources? Problem is EUROfusion has a lot of accumulated data – Attention U.S. is eager to provide interpretative modelling (e.g. RT02) and we have a EUROfusion – U.S. collaboration agreement signed at IAEA 2023 on no ELM scenarios…

Changes to AWP 2024 – Integration of JT-60SA scientific exploitation into WP TE

- Scientific exploitation and preparation, including modelling, of future JT-60SA experimental campaigns has been moved from WP SA to WP TE
- Jeronimo Garcia is 1 (3) (1 EU, 2 JA) Experimental Team Leaders of the JT-60SA Experiment Team and has additionally become a DTFL for JT-60SA inside WP TE
- Initial definition of members of Experimental Team through WP TE wiki entries
- Resource loaded call for participation has been analysed, next step is implementation into IMS and notification of participants

Proposed path for integration – ***details presently under discussion – initiating better exchange with RT08/09***

I. Step wise facilitate the communication across the various devices and integrate the research of the 9 RTs and the 6 JT-60SA Topical Groups with the EUROfusion TG leaders possibly becoming an equivalent to the RTCs
II. Define and provide access for the JT-60SA Experiment Team (including QST) to TFMs and RT team discussions
III. Prepare a common call across all WP TE devices for 2025 to serve as a dry run and identify required adjustments
IV. Possibly a common call for proposals followed by common call for participation across all devices for 2026



Timeline for JT-60SA

Call Structures

- Timeline not defined yet, but similar timeline as for 2024 expected
- Aim at call for proposals across WP TE operating devices (4)
- Potentially pre-allocate 90% of the device time to RTs before the call as last time this was done before the programme meeting anyways and then allow some margin to adjust based on programmatic discussion
- Aim at joint call for participation including JET analysis, JET data validation and activities for scientific exploitation of JT-60SA
  - Modelling proposal will as for 2024 be part of proposed work plans to achieve the scientific objectives – they are not part of the call for proposals that precedes the call for participation
  - These modelling proposals can/shall include extrapolations to ITER and DEMO – where especially those towards ITER are missing, while some for DEMO are housed in the DCT under FTD (how will this work after the restructuring tbd)

Extended strategy beyond 2025 – initiated…identification of machine capabilities

Example for RT01 and RT02

Research Topic	Scientific objectives	Level 3 report 2022	Level 3 report 2023	JET Analysis 2025	JET Analysis 2026	JET Analysis 2027	JT-60SA-C	JT-60-SA-W	ASDEX-U 2024	ASDEX-U 2025	ASDEX-U 2026	ASDEX-U 2027	TCV 2024	TCV 2025	TCV 2026	TCV 2027	MAST-U 2024	MAST-U 2025	MAST-U 2026	MAST-U 2027	WEST 2024	WEST 2025	WEST 2026	WEST 2027
RT22-01: Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER	**D1:** Develop and understand stationary H-mode scenario at low collisionality and with dominant electron heating	Judgemental	Mature																					
	D2: Provide physics-based cross-field transport coefficients to TSVVs (1, 3, 4 and 11) for turbulence modelling	Exploratory	Exploratory																					
	D3: Determine the impact of different impurity mixes for partially detached divertors in high power operations in view of ITER radiative scenarios	Judgemental	Mature																					
	D4: Assess pedestal performances in condition closer to future devices including large SOL opacity, low pedestal collisionality, peeling limited plasma	Judgemental	Judgemental																					
	D5: Quantify impurity screening for high temperature pedestals	Exploratory	Judgemental																					
RT22-02: Physics understanding of alternatives to Type-I ELM regime	**D1:** Quantify turbulent and MHD driven transport in the vicinity of the separatrix and implications for predictions for ITER and DEMO	Exploratory	Exploratory																					
	D2: Quantify first wall load in no-ELM scenarios and provide model for SOL transport extrapolation	Judgemental	Judgemental																					
	D3: Extend the parameters space of no-ELM scenarios to large Psep/R and/or pedestal top collisionallities relevant for ITER and DEMO	Exploratory	Judgemental																					
	D4: Determine the key physics mechanisms regulating edge transport in order to access no-ELM regimes	Exploratory	Exploratory																					
	D5: Determine access window and physics understanding for RMP ELM suppression and its compatibility with ITER FPO scenarios	Judgemental	Judgemental																					
	D6: Quantify the overall performance of negative triangularity plasmas in view of DEMO	Exploratory	Judgemental																					