Pre-PSD Project Board

WPTE: FP10 and activities in 26-27 towards the future

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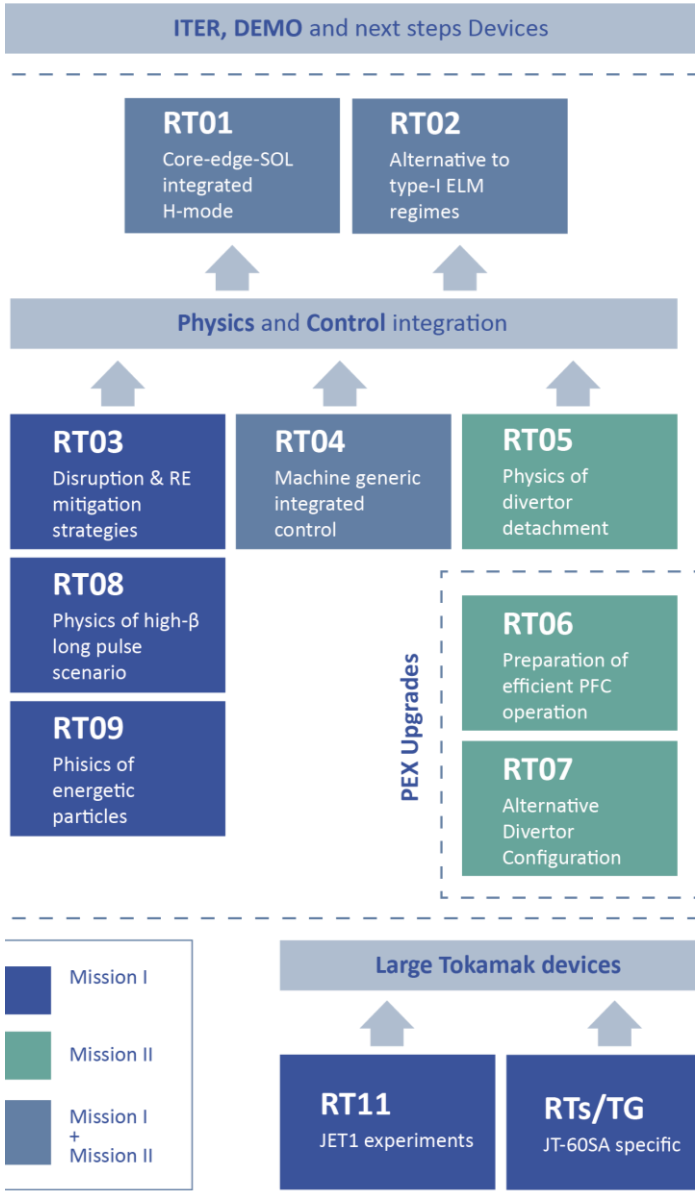
Present structure of WPTE based on EUROfusion Roadmap



WPTE framework Based on EUROfusion Road Map:

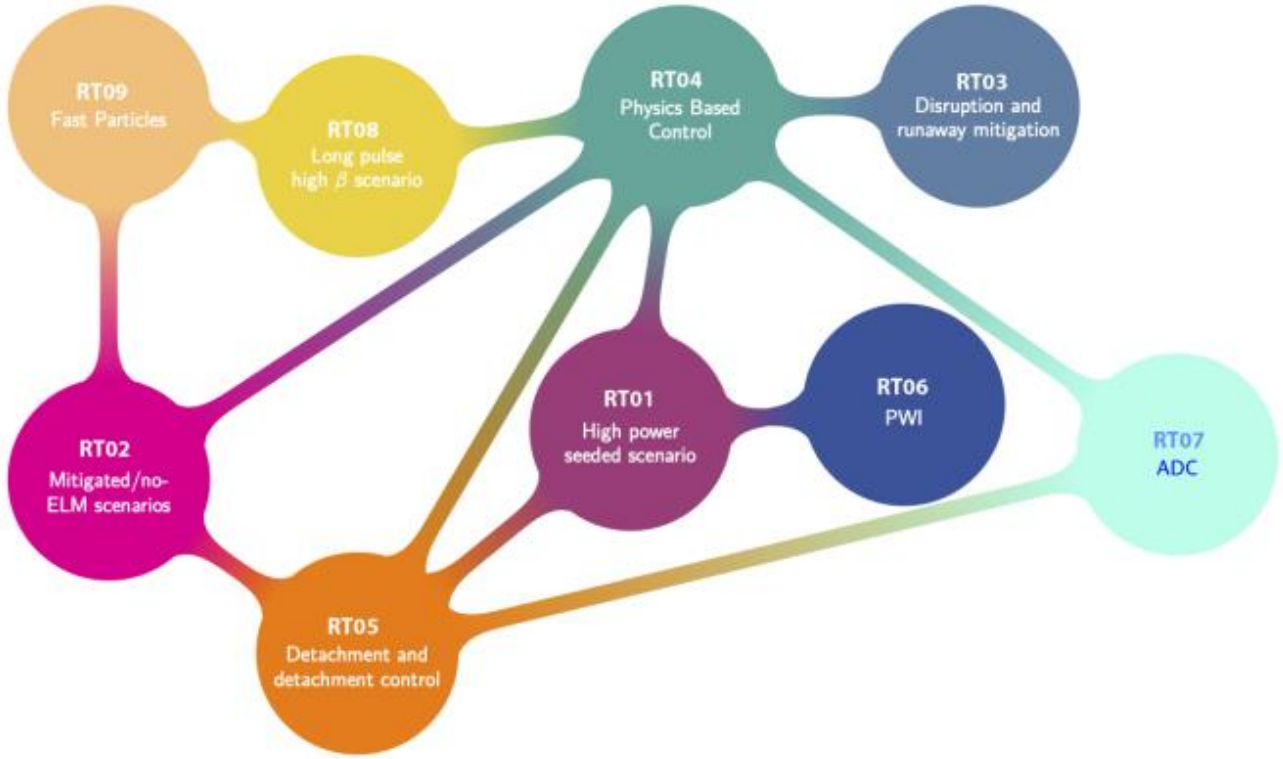
- **Mission I**: Plasma Regimes of Operation (and fusion technology)
- **Mission II**: Heat exhaust solutions

- Use available European tokamaks (**AUG, TCV, WEST, MAST-U**) and past experiments (**JET**) to advance ITER and Pilot Plant design
- Research Topics (01-09) to address specific deliverables with a staged integration and cross-device approach
- RT-11 dedicated to JET analysis from previous research programmes
- RT12-RT18 Mapping/replicating the JT-60SA Topical Groups

Research Topic Scientific Objectives:

- Established in 2022 with minor evolution throughout the years: broad enough to justify long-term endeavour but with limitation
- Strongly based on European device capabilities (e.g. SPI, high-current JET operation etc) ⍰ are they capable to incorporate new devices?
- **Does EUROfusion roadmap MISSION concept still represent the appropriate approach?**

Comments on integration: successful/unsuccessful story



- TE program **not conceived** as hierarchy of research topics (no building blocks!) but since the beginning with strong interactions between research topics
- Successful stories of integration: Detachment control deployment and usage (RT04-RT05), High Fluence Campaign in XPR (RT06-RT05), high-beta pulses with exhaust constraints (RT08-RT07), Runaway PFC damage (RT03-RT06), Multiple X-points control (RT04-RT07), Detachment comparison in LSN/ADC (RT05-RT07)
- Successful integration of JET into WPTE proving robustness of step-ladder approach
- Improvements needed in view of integration of potential new devices in particular JT-60SA

- **Limits:**
  - **Challenging management with multiple simultaneous machine operation. Issue at TFL/RTC levels (adequate numbers or commitment?)**
  - **Bureaucracy and management perceived as excessive from the community → this impact in particular the motivation of potential good RTC candidate**
  - **Call for proposals: needed (can't skip input from the community) but still perceived as "individual proposals" w/o integration**

Scientific objectives and SSRL monitoring

- As presently defined, RT Scientific Objectives are strongly based on:
  - JET inclusion
  - ITER R&D (including re-baseline)
  - JT-60SA preparation (not exploitation)
- Monitored through the SSRL since 2022: presently mostly at SSRL 4-5 only few at lower levels

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

RT	*Title*	*D1*	*D2*	*D3*	*D4*	*D5*	*D6*	*D7*
RT01	Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER	X				X		
RT02	Physics understanding of alternatives to Type-I ELM regime				X		X	
RT03	Strategies for disruption and run-away mitigation		X					X
RT04	Physics-based machine generic systems for an integrated control of plasma discharge		X			X		
RT05	Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation							
RT06	Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS		X					
RT07	Physics understanding of alternative divertor configurations as risk mitigation for DEMO				X			
RT08	Physics and operational basis for high beta long pulse scenarios		X	X				
RT09	Physics understanding of energetics particles confinement and their interplay with thermal plasma				X	X		

Limits:

- **ITER MoU items not yet fully represented MoU items will appear in the RT Work Awareness Table (WAT) in any case**
- **Sc. Objc. ARE NOT a one to one representation of next step gaps TRL.**
- **GAPs can be defined if and only if next steps is identified**
- **For 2026-2027 WPTE Work Program Next Step remains ITER (no foreseen activity towards Pilot A/Pilot B)**

JT-60SA Integration

- A MoU between F4E and EUROfusion exists which includes, among others, a list of scientific priorities:
  1. Development and investigation of high performance scenarios compatible with future W-PFCs,
  2. Avoidance and mitigation of disruptions and runaways,
  3. Fast ion physics,
  4. Development and validation of high-level real-time control strategies.

➢ Further specifications are needed for some of the topics (e.g. fast ions but as well as scenarios) together with a clarification on the boundary conditions: e.g. deployment of control systems potentially require access to low-level plant structure. Is there an agreement with QST about that?

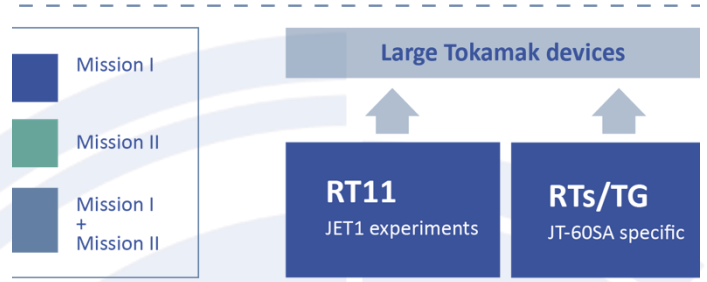
- MoU Document and accompanying implementing document under revision → no involvement of WPTE up to now

JT-60SA contribution to present WPTE program

Essential
Beneficial

		Research Topics	JT-60SA in C
ITER Scenario	RT01	Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER	
ITER Scenario	RT03	Strategies for disruption and run-away mitigation in support of the ITER DMS	Control of run-away & disruption
ITER Scenario	RT04	Physics-based machine generic systems for an integrated control of plasma discharge	Real time control and breakdown
DEMO Scenario	RT08	Physics and operational basis for high beta long pulse scenarios	Target scenario for JT-60SA
DEMO Scenario	RT02	Physics understanding of alternatives to Type-I ELM regime	
Burning plasma	RT09	Physics understanding of energetics particles confinement and their interplay with thermal plasma	Target physics topic for JT-60SA
PEX – Exhaust	RT05	Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation	
PEX – Exhaust	RT07	Physics understanding of alternative divertor configurations as risk mitigation for DEMO	Not applicable
PEX – PFC	RT06	Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS	Not applicable in C environment

Programmatic inclusion of JT-60SA activities



	Research topic	IMS tag	TGL/CP
JT-60SA specific	TG-ORD	RT12	?
	TG- MHD	RT13	G. Pucella
	TG-TC	RT14	L. Garzotti
	TG-EP	RT15	Y. Kazakov
	TG-PED	RT16	Y. Liang
	TG-DSP	RT17	G. Falchetto
	IMAS	RT18	F. Imbeaux

- JT-60SA integrated by mapping Topical Groups into new Research Topics : convey ET priorities into EF **BUT** not the other way around.
- Experiments in JT-60SA not conceived as EF GAP filling activities (although some clear benefits identified) but we need to acknowledge a steep learning-curve on a new machine

How to transfer knowledge gained on JT-60SA into WPTE to allow SSRL progresses?

- TGL naturally acting as Experiment Team TGL: does not feel necessarily the need for coordinating the European effort
- Cross communication with RT01-RT09 limited so far. Not only a communication issue but JT-60SA EU community is limited in number (not in committed amount)
- Possible short-term solution: embedding TG-high level topics as RT01-09 Scientific Objectives (e.g. ORD-baseline into RT01, ORD-high beta into RT08 etc) → but we need to embed TGL as RTC. **Not an easy task might not be feasible within 2027**
- Once OP2 experiments are defined, re-define RT12-18 Scientific Objectives and provide the clear indication on how they should progress the advancement of RT01-RT09 SSRL
- **Clear need of new structure in view of FP10 with stronger recognized role of WPTE (or WPTE successor in FP10)**

Ensuring Full JET Exploitation

- JET exploitation embedded into RT01-09 and as well RT11 for which newly established Scientific Objectives defined
  - D1. Complete analysis of parameter dependence of separatrix properties to support extrapolation to ITER operational scenarios
  - D2. Complete analysis of experiments utilising novel ICRH schemes relevant to ITER and extrapolation to ITER operational scenarios
  - D3. Complete analysis of experiments that provide specific information on isotopic effects relevant to ITER and extrapolate to ITER operational scenarios
  - D4. Complete analysis of L-H transition studies and databases including divertor configurations. Extrapolate results to ITER operational scenarios
- WPTE Priorities presented (https://wiki.euro-fusion.org/images/2/21/JET_priorities_20251117.pdf) but struggling in keep interest in many (not all) RTs
- **In view of FP10 and to appropriate JET scientific exploitation we need**:
  - Ensure data consistency/validation commitment (UKAEA commitment expected to fade away by end of 2027). Expected still backlog (limited) by the end of 2027. Limited interest from non-UKAEA beneficiaries
  - Ensure IMAS (full) data availability and documentation → Not from WPTE resources but needed. Outsourcing outside EF?
  - In view of potential opening of JET data: Ensure monitoring of data usage in publication → ad-hoc group in 2026-2027

Modelling

- Interpretative modelling of WPTE experiments presently funded primarily from WPTE.
- Ensure **prioritization** of Validation in TSV**V** happening via Task Force Inputs

Research Topic	*Scientific Objective*	*TSVV synergy Established*	*TSVV synergy Starting*	*TSVV synergy Strategic*	*Modelling needs*
RT-01	**Core-Edge-SOL integrated H-mode scenario compatible with exhaust constraints in support of ITER:** • Seeded JET-ITER baseline • Low collisionality / peeling limited plasmas • Er and turbulence	**TSVV-H**	TSVV-B	**TSVV-A, TSVV-E** **TSVV-A, TSVV-F** **TSVV-A, TSVV-B**	**JOREK** **GK, GENE-X** **GYSELA, SOLEDGE**
RT-02	**Physics understanding of alternatives to Type-I ELMs:** • QCE • Interpretation of RMP experiments • NT	**TSVV-B** (AUG) **TSVV-B, TSVV-A**	TSVV-B (JET?)	**TSVV-A, TSVV-C** **TSVV-F, TSVV-B**	**GENE, GENE-X, SOLPS** **JOREK**
RT-03	**Strategies for disruption and run-away mitigation**	**TSVV-F**			**JOREK**
RT-04	**Physics-based machine generic systems for an integrated control of plasma discharge**			**TSVV-H (potential)**	
RT-05	**Physics of divertor detachment and its control for ITER, DEMO and HELIAS operation**	**TSVV-B**		**TSVV-A, TSVV-C,** **TSVV-H, TSVV-K**	**GK, JINTRAC,** **GENE-X, SOLPS**
RT-06	**Preparation of efficient Plasma Facing Components (PFC) operation for ITER, DEMO and HELIAS**	**TSVV-D,** TSVV-E, TSVV-K			
RT-07	**Physics understanding of alternative divertor configurations as risk mitigation for DEMO**	**TSVV-B**		**TSVV-D**	**SOLPS, SOLEDGE**
RT-08	**Physics and operational basis for high beta long pulse scenarios**	**TSVV-H**	TSVV-F	**TSVV-A**	**JOREK, GK**
RT-09	**Physics understanding of energetics particles confinement and their interplay with thermal plasma**	**TSVV-G**			

WPTE progress tracking: Experiments, Analysis and Modelling

WPTE actions to improve FP9 documentation

- Current Wiki pages track the Tokamak Scientific Exploitation
- Implementation of new Wikis dedicated to A&M under discussion (to ensure documentation in view of next FP10)

1. Definition of the pulse datasets → **Facilitate modelling-oriented data access**
2. Analysis progress and open questions → **Improve traceability of ongoing work**
3. Modelling activities and validation status → **Enable prioritization of A&M**
4. Links to publications, reports and presentations → **Support cross-RT and TE-TM synergies**
5. Cross-device and cross-RT connection highlighted → **Support knowledge transfer**

Ensuring traceability and reproducibility across experiments, data and modelling

- Need to realize a citable repository for EF publications.
- Strategic action for reproducibility in view of potential broader access to EU machine data
- It needs to be supported by a "legal framework" (e.g. associated to clearance on EF pinboard)
- Ensure that every publication has attached an accessible repository with data/processing/modelling
- Should not fall under WPTE but should be pursued at higher level

Looking ahead worldwide: where EF should engage to fill the gap?

		2026	2027	2028	2029	2030	2031	2032	2033	2034
EU	WEST	Phase II	Phase II		Phase III	Phase III	Phase III	Phase III	Phase III	Phase III
	AUG	Up div	Up div							
	MAST-U		EBW …							
	TCV					?	?	?	?	
	JT-60SA		OP2	OP3	OP4		W OP5			
	DTT								Low power	Low power
	COMPASS-U						Low power			High Twall, metallic liquids
	W7X	OP2.4	OP2.5	OP2.6	OP2.7					
	VNS / FPP									
UK	STEP									
CN	BEST					D-T	D-T			
	EAST									
KO	HL3/HL4		DT							
	KSTAR									
US	DIII-D									
	SPARC				DT					
IO	ITER									

W

C

SRO

Work in preparation to FP10

- Preparation of FP10
  - Define the targeted Device beyond ITER (FPP/FOAK?)
  - GAPs identification (done at department level)
  - TRL and metric for improvement: same metrics throughout FSD department. WP SSRL used in synergy to ensure progresses of FSD TRL
- Methodology as Design Structure Matrices (DSM) used by EUROfusion Working Group, useful but require discussion (at department levels) of the different nodes
- Present EU-devices **are close to the limit of their capabilities** to ensure advancement in TRL or understanding incremental knowledge in specific point feasible. Therefore, it is mandatory to initiate an analysis of potential contribution of different future EU and non-EU devices, together with the nominal capabilities and timeline. Done (to be refined) for JT-60SA but activity should start (at PSD level?) in 2026 for all the devices
- Based on identified GAPS and machine capabilities **drive a strategy for EF engagement**
- Questions and issues:
  - In view of integration a single WP handling with multiple devices desirable for FP10 but **a real challenge from the management point of view. Decoupling Medium-size from large international devices operation/exploitation will make it more agile but with potential risk of reducing cohesion of the program**
  - In EU devices EF success coming from a combination of operation knowledge and science (deep knowledge of machine/plant capabilities) → this paradigm might not be extrapolated to non-EU devices where we will be "customers". Any remedial action to be implemented?