



WPSA Code Management and Simulation Area overview & 2023 main objectives

WPSA Project Planning Meeting, 6-9 September 2022

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WPSA Code Management and Simulation area strategy



- Establish **reliable modelling codes, workflows and operation related tools** for routine use in JT-60SA scientific exploitation
- **Modelling support to the enhancements and diagnostics** procured by EU
- Specific focus on **modelling the Initial Research Phase** + **contribute to Integrated Research Phase wall diagnostics design (F4E/WPDIV)**

	Phase	Expected operation schedule	Annual Neutron Limit	Remote Handling	Lower Divertor (wall material)	P-NB Perp.	P-NB Tang.	N-NB	NB Energy Limit	ECRF 110 GHz & 138 GHz	Max Power
Initial Research Phase	phase I	2020-2023	-		-	0	0	0	0	1.5MW x 5s	1.5MW
		2025	(N2)			3MW	3MW				19MW
	phase II	2025	3.2E19 (N2)	R&D	Carbon Div. Pumping (Carbon)	6.5MW			23MW x 14s duty = 1/30	1.5MW x 100s + 1.5MW x 5s	26.5MW*
		2026									
phase III	2027									33MW*	
Integrated Research Phase	phase I	2029 - 2032	4E20 (water)		Actively cooled Carbon Div. Pumping (10MW/m ² ss, 15MW/m ² x 5s) (Carbon)	13MW	7MW		20MW x 100s 30MW x 60s duty = 1/30	7MW x 100s	37MW
	phase II	2033 -	1E21 (water)		Actively cooled Tungsten Div. Pumping (Tungsten)			10MW			
Extended Research Phase		>5y	1.5E21 (Boron)	Use	Actively cooled Tungsten Advanced Structure (U. Div. to be considered) (Tungsten)	16MW	8MW		34MW x 100s		41MW

(filler in the VV double wall) Upper Open Carbon Divertor (very limited heat handling capability) is always ready *Real Injection: ~26MW x 2-3 sec limited by divertor cooling

Updated Project Phases
BA SC 29



❖ Operation oriented tools and synthetic diagnostics :

- Discharge simulator development
- Breakdown simulator development & optimization of BD scenarios
- **Electron Cyclotron Wall Conditioning ECWC simulation tools ready for validation**
- **Integrated Data Analysis** tools requirement capture
- Proposal for **disruption mitigation/avoidance** trigger
- **Visible imaging analysis tools provision (camera tomography, EDICAM)**
- Assessment of PCI measurement
- FIELD synthetic diagnostics **new**

❖ Modelling for JT-60SA Initial Research Phase scenarios

- **Scenario** modelling with operationally oriented integrated modelling **transport** codes
- **Edge and divertor modelling** (C scenarios + **wall diagnostics design support**) **new**
- **Energetic Particle** stability analysis
- **MHD** stability analysis
- RWM **control**
- Non-linear MHD modelling of pellet triggered **ELMs**
- **Runaway** electron heat loads on PFC
- **Disruption modelling tools ready for validation**

Relevant EUROfusion wiki page

[WPSA.CM Area](#)

Indico:

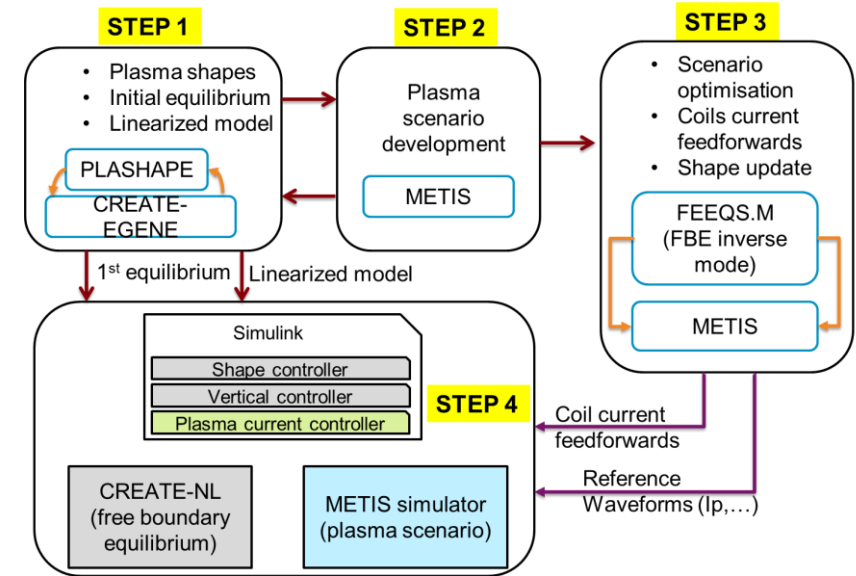
[WPSA General Meeting May 2022](#)

WPSA.CM Operation related Tasks 2022



TOPIC	Deliverable 2022	Del Owner / Team
	Plasma operation oriented tools	
Plasma discharge simulator	Verified JT-60SA pulse simulator including implementation of current, gaps and vertical stabilization controllers	E. Joffrin JF Artaud C Boulbe B Faugeras (CEA, Univ Nice) M Mattei D Frattolillo et al (ENEA CREATE)
	Provision of discharge simulator select test cases	W Bin (ENEA CNR Mi) G Giruzzi (CEA)
ECWC modelling	Report on the validation of ECWC code (TOMATOR-1D) on the first data from JT-60SA Integrated Commissioning !pending IC - postponed to 2023	J Buermans (LPP-ERM-KMS)
Breakdown modelling	Documentation on runs on JT-60SA breakdown using a nonlinear optimization technique. Extended scope in support of IC – simulating limit conditions tbd after Paschen test	Daria Ricci L Figini M Mattei (CNR Mi, ENEA CREATE)
Integrated Data Analysis	Plan for the implementation of IDAV for JT-60SA scientific exploitation – on standby pending dedicated ET meeting with QST	R Fischer D Stieglitz (IPP Garching)
Disruption trigger	Proposal for building parsimonious disruption mitigation/avoidance triggers	Jesùs Vega (CIEMAT) M Gelfusa A Murari R Rossi (ENEA) T Cracinescu (IAP) F Bairaktaris A Papadopoulos (NCSR)

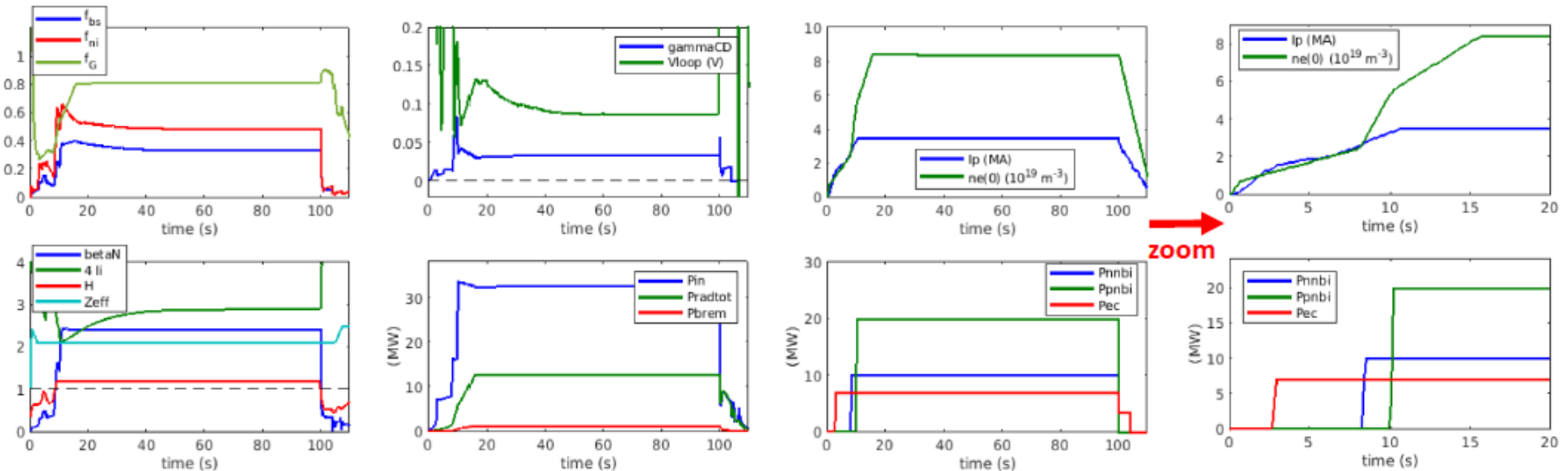
- ✓ Discharge Simulator & user group on the EUROfusion Gateway
- ✓ EGENE, METIS and FEEQS have been installed on the Gateway
- ✓ Calculations for scenario 2 and 4.2 (priorly done with METIS NICE - local platform)
- “Strong coupling” development for better description of the Ip, recent work for implementation of controllers CREATE/CEA



! Feasibility of the scenarios in the PID to be revised

(in interaction with QST)

Scenario 4.2, issues with Ip ramps and EF4 saturation => more realistic tuning of the scenario is necessary

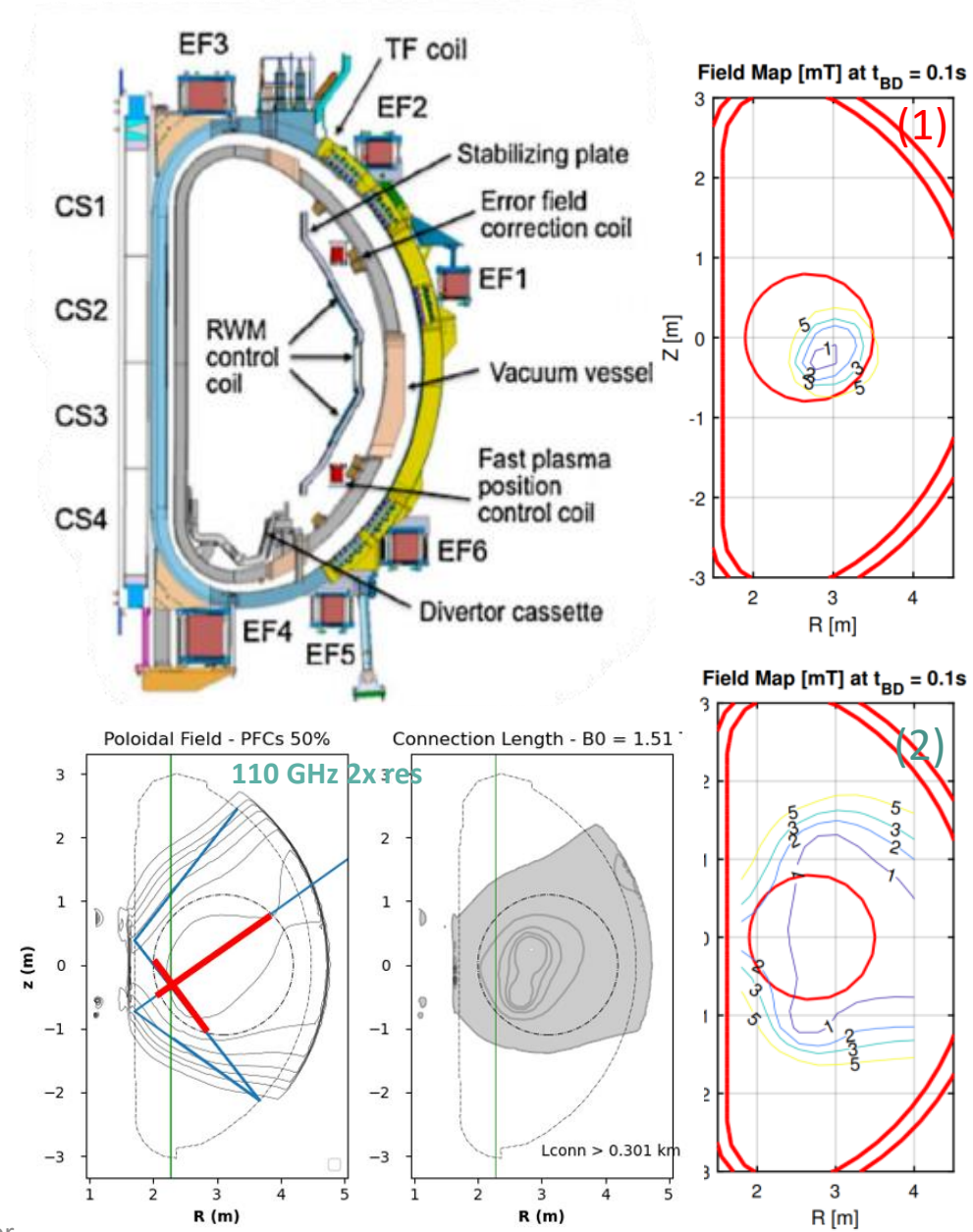




Investigations of BD scenarios in the presence of degraded performance of the CS coils (electromagnetic analysis)

Recent activity promoted by F4E / CM BD task extended / reoriented by-weekly meeting during this summer

- Scenario JT60SA_BD_HC_noCS1: Half current in the central solenoid but zero current in CS1 module, full maximum total voltage on coils (5kV).
=> electric field can be 0.6 V/m but the null region becomes very small and is shifted outwards. Plasma formation maybe possible but the ramp up would be quite difficult to achieve (1)
- Scenario JT60SA_BD_HC_0d3_Vtot2kv: Half current in the central solenoid, reduced total voltage on coils (2kV).
=> The electric field can be max 0.3 V/m. The null region is ok and the plasma current ramp up seems doable (2)
 - EC absorption very low (3%@82 GHz, 1%@110 GHz) with the IC waveguide launcher
- Other breakdown scenarios being explored (might introduce a decision point after the Global Paschen Test)
 - with and w/o Switching Network Unit, various EF settings, $E_{//} \sim 0.4\text{V/m}$
 - with and w/o Booster PS (level of ripple in the present configuration harmful for coil insulation)



WPSA.CM Modelling Tasks 2022 (1)



TOPIC	Deliverable 2022	Del Owner
Scenario development transport analysis	Integrated modelling of ramp-up of initial research phase scenarios with first principles transport models	L Garzotti D Taylor (UKAEA) P Strand D Yadikin E Fransson (VR) P Huynh (CEA)
MHD and control	MHD stability chain deployed to users	R Coelho (IST)
	Application of CarMa-D model in state-space representation for developing RWM control time simulation and test controller concepts	L Pigatto et al (ENEA RXF)
	Validation of disruption modelling tools (CarMa0NL-CARIDDI) on first JT-60SA mechanical data ! Pending IC postponed to 2023	F Villone et al (ENEA CREATE)
	Estimate of heat load levels and distributions caused by REs via a workflow coupling particle tracing codes to FLUKA.	J Caloud A Casolari E Macusova (IPP.CR)
Pedestal and edge	Report/publication on (JOEKK) modelling of multiple pellet injection in self-consistently evolving pedestal profile	S Futatani (CIEMAT UPC)
Energetic Particle modelling	Demonstration of automated application of the EP workflow to the assessment of EP-stability in ramp-up and steady state plasmas.	Ph Lauber (IPP-Garching)
	Provide ASCOT distribution function for beam ions	A Snicker (VTT)
	Analysis of linear AE stability of initial research phase (H,D) scenarios	R Coelho (IST)

Wed 7th 14h-18h Topic session: Discharge simulator and scenario modelling: core transport, MHD & Fast particles stability, RWM control, ELMs



TOPIC	Deliverable 2022	Del Owner
Edge and divertor modeling	Sensitivity study of low n /current drive scenarios with C divertor, with SOLEDGE3X edge transport code, including impurity seeding impact	G Falchetto K Galazka (CEA)
	Assessment of JT-60SA Initial research phase II scenario 2 via edge/divertor modelling integrated with core conditions (SOLEDGE)	L Balbinot (ENEA)
	Modelling of C wall Scenario 2 with SOLPS-ITER.	P Chmielewski (IPPLM)
	Report on the benchmark of SOLPS_ITER to SONIC.	G Rubino D Coster (ENEA, IPP)

- ✓ Modelling support to Langmuir probe design assessment for Integrated Research Phase (WPDIV need)
- ✓ 26/07 Dedicated meeting WPSA CM ENH reporting to WPDIV F4E

Thu 8th 14h30-16h Parallel session: Edge/divertor modelling

WPSA.CM Synthetic diagnostics Tasks 2022



TOPIC	Deliverable 2022	Del Owner / Team
	Synthetic diagnostics development	
Turbulent transport	Assessment of the JT-60SA PCI diagnostics measurement, on relevant high-beta gyrokinetic turbulence including fast ions	A Iantchenko (EPFL)
Visible imaging	Feasibility study of tomographic inversion for characterizing runaways in plasma conditions relevant for JT-60SA	J Cavalier J Svoboda (IPP.CR)
	Improved EDICAM visualization tools	T Szepesi et al (EK)
FILD	Optimization of FILD detector head geometry using synthetic diagnostics new	M Garcia-Munoz et al (CIEMAT Univ Sevilla)

Thu 8th 10h30
Topic session: FP9
Enhancements

Thu 8th 14h
Parallel session:
Preparation of
the FP8
enhancements
commissioning



- No significant impact of the delayed IC on the development of tools for scientific analysis and in simulation activities in preparation of the experimental campaign.
- The activities related to **validation of modelling tools on IC data** are postponed to 2023.

Progress towards the deployment of validated analysis and modelling tools for operation and scientific exploitation

- **Trainings on the Discharge Simulator** as well as **on the released modelling tools** in support to the scientific exploitation shall be planned respectively ahead of the IC and experimental campaigns.
- Contribute to the analysis of the IC data in liaison with the Experiment Team.
- Provide support for Diagnostics R&D

Modelling to be defined in coordination with Experiment Team

Extend modelling using developments from TSVV ?



TSVV	Objective/topic	When
1. Physics of the L-H Transition and Pedestals	Interpretative and predictive capability of L-H transitions	Before/after first H mode plasma (2025?)
3. Boundary plasma modelling	neutrals/recycling modelling, impurities in edge turbulent codes	~2025
8. MHD Transients	Disruption modeling, SPI and MGI mitigation, ELM triggering and pacing	Possibly from 2023
9. Dynamics of Runaway Electrons in Tokamak Disruptions	Validation of RE generation model	Possibly from 2023
10. Physics of Burning Plasmas	Energetic Particle stability and transport, N-NBI distribution function modeling, ramp-up scenario with NBI	Ongoing, data ~2025

- Proposals of EUROfusion Research Grants (ERG) welcome

**Modelling aims and needs to be defined
in coordination with Experiment Team**

This meeting CM sessions – 2023 activity planning



- **IC related topics:**

ECWC, breakdown modelling, startup runaway detection

Wed 7th @11h

Topic session: IC 2023 preparation - First plasma

- **Scenario modelling** - all aspects: discharge simulator, core transport/turbulence, MHD and fast particles stability

- discussion shall focus on scenario revision to identify feasibility, limits and needs for advanced modelling
- definition of use cases for trainings

Wed 7th 14h-18h

Topic session: Discharge simulator and scenario modelling

- **Edge/SOL divertor modelling** (including **Langmuir probes** design) interface to equilibrium

Thu 8th 14h30-16h Room 2

Parallel session: Edge/divertor modelling

- **Disruption** trigger alarm / disruption modelling

Thu 8th 16h30 Room 2

Parallel session: Disruption avoidance techniques

- **EDICAM & synthetic diagnostics (TPCI, FILD)** will be discussed during the respective enhancement sessions

Thu 8th 10h30 & 14h Room 1 ENH sessions



BACKUP



*Please keep your Task
wikipage up-to-date*

- <https://wiki.euro-fusion.org/wiki/WPSA: Code Management and Simulation>
- The **EUROfusion Gateway** cluster is the home of WPSA code development work and shared simulation tools
 - **Gateway access request** please follow the procedure on: <https://wiki.eufus.eu/doku.php>
 - Gateway login (X2Go, NoMachine, ssh) g2username@login.eufus.eu
 - A training on the Gateway setup and use (as well as on IMAS) provided by ACH is available, links on: <https://wiki.euro-fusion.org/wiki/ACH-04>
- A **gitlab** has been setup: <https://gitlab.eufus.eu/>
- A repository for WPSA Gateway users has been created : </afs/eufus.eu/gw/wpsa>
you can request access to **admins**: mail to rcoelho@ipfn.ist.utl.pt; CC gloria.falchetto@cea.fr
- Previous JT-60SA modelling data is stored here:
</afs/gw/wpsa/groupoffice/users/MODELING>
- Documentation tutorials on discharge simulator METIS / CREATE_EGENE
 - https://wiki.euro-fusion.org/wiki/WPSA_CM: Discharge simulator
- Gateway repository : </afs/gw/wpsa/applications/>

Reference CM deliverables 2022 - modelling (1)



Deliverable ID	Deliverable title	Deliverable Owner	Beneficiaries
SA-SE.CM.M.01-T003-D001	MHD stability chain deployed to users	R Coelho	IST
SA-SE.CM.M.01-T004-D001	Application of CarMa-D model in state-space representation for developing RWM control time simulation and test controller concepts	L Pigatto	ENEA
SA-SE.CM.M.01-T005-D001	Report/publication on the modelling of multiple pellet injection in self-consistently evolving pedestal profile	S Futatani	CIEMAT
SA-SE.CM.M.02-T003-D001	Report/publication on integrated modelling of ramp up of initial phase Scenario 2 with first principles transport models	L Garzotti	UKAEA
T003-D002		P Strand	VR CEA
SA-SE.CM.M.02-T004-D001	Assessment of the JT-60SA PCI diagnostics measurement, on relevant high-beta turbulence including fast ions.	A Iantchenko	EPFL
SA-SE.CM.M.03-T003-D001	Final report on the modelling of initial research phase II scenarios with edge/SOL transport code	G Falchetto	CEA
SA-SE.CM.M.03-T003-D002	Assessment of JT-60SA Initial research phase II scenario 2 via edge modelling integrated with core conditions.	L Balbinot	ENEA
SA-SE.CM.M.03-T003-D003	Final report on the modelling of C wall Scenario 2 with SOLPS-ITER.	P Chmielewski	IPPLM
SA-SE.CM.M.03-T004-D001	Report/publication on the benchmark of SOLPS_ITER to SONIC.	G Rubino	ENEA MPG

Reference CM deliverables 2022 - modelling (2)



Deliverable ID	Deliverable title	Deliverable Owner	Beneficiaries
SA-SE.CM.M.04-T002-D001	Demonstration of automated application of the EP workflow to the assessment of EP-stability in ramp-up and steady state plasmas.	Ph Lauber	MPG
SA-SE.CM.M.04-T002-D002	Report/publication on linear AE stability of JT-60SA initial research phase H and D scenarios	R Coelho	IST
SA-SE.CM.M.04-T002-D003	Provide ASCOT distribution function for beam ions	Antti Snicker	VTT
SA-SE.CM.M.05-T004-D001	Estimate of heat load levels and distributions caused by REs at JT-60SA via a workflow coupling particle tracing codes to FLUKA.	J Caloud	IPP.CR

Reference CM deliverables 2022 : Operation and synthetic diagnostics (3)



Deliverable ID	Deliverable title	Deliverable Owner	Beneficiary
SA-SE.CM.OP.01-T002-D001	Verified JT-60SA pulse simulator including implementation of current, gaps and vertical stabilization controllers	Joffrin (CEA)	CEA
SA-SE.CM.OP.01-T003-D001	Provision of discharge simulator select test cases	William Bin	ENEA
SA-SE.CM.OP.03-T002-D001	Documentation on runs on JT60-SA breakdown using a nonlinear optimization technique.	Daria Ricci (ENEA-CNR)	ENEA
SA-SE.CM.OP.04-T002-D001	Plan for the implementation of IDAV for JT-60SA scientific exploitation	Rainer Fischer (IPP-Garching)	MPG
SA-SE.CM.OP.05-T002-D001	Proposal for building parsimonious disruption mitigation/avoidance triggers_CIEMAT	Jesus Vega	CIEMAT
SA-SE.CM.OP.05-T002-D002	Proposal for building parsimonious disruption mitigation/avoidance trigger_ENEA_IAP	M Gelfusa	ENEA IAP
SA-SE.CM.OP.05-T002-D003	Proposal for building parsimonious disruption mitigation/avoidance triggers_NCSR	Fotis Bairaktaris	NCSR
SA-SE.CM.SD.01-T003-D001	Feasibility study of tomographic inversion for characterizing runaways in plasma conditions relevant for JT-60SA	Cavalier (IPP.CR)	IPP.CR
SA-SE.CM.SD.01-T004-D001	Improved EDICAM visualization tools	Szepesi (EK)	EK-CER
SA-SE.CM.SD.02-T001-D001	Optimization of FILD detector head geometry using synthetic diagnostics	Manuel Garcia-Munoz	CIEMAT

Changes in CM tasks



Deliverable ID	Deliverable title	Deliverable Description	Deliverable Owner	Resources Beneficiary	PM	Comments(issues, goals, any relevant update, risk of delay, staff difficulties)
SA-SE.CM.M.05-T003-D001	Preliminary report on the validation of disruption modelling tools (CarMa0NL-CARIDDI) on first JT-60SA mechanical data	Validation of disruption modelling tools (CarMa0NL-CARIDDI) using JT-60SA halo current and strain gauges measurements	Villone (CREATE)	ENEA	2	Move task to 2023. Move resources to SA-SE.CM.OP.03-T002-D001
SA-SE.CM.OP.02-T001-D001	Report on the validation of TOMATOR-1D code on the first data from JT-60SA Integrated Commissioning	Validate TOMATOR-1D code on the first data from commissioning.	Johan Buermans	LPP-ERM-KMS	2	Move task to 2023
SA-SE.CM.OP.03-T002-D001	Documentation on runs on JT60-SA breakdown using a nonlinear optimization technique.	Optimization and Simulation of 4 BD scenarios for JT60-SA (full and half CS current combined with full and half toroidal field) using a nonlinear optimization technique.	Daria Ricci (ENEA-CNR)	ENEA	4	Extend scope in support of modelling for IC after Paschen test - use FP8 funding from SA-O.A06-T003-D002 (2 PMs)