ANNUAL WORK PLAN 2015

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1 Coherence with the Work Plan (Annex 1 to the Grant Agreement)

1.1 Introduction and summary

This document presents the activities to be implemented in 2015 by the EUROfusion Consortium for the realization of the Roadmap. The 2015 Work Programme remains strongly focused on delivering the high-level work packages defined in the EU roadmap for developing fusion energy. Section 1 presents a summary of the activities, their expected impact and the relation with the full proposal described in Annex 1 of the grant agreement. Section 2 presents the detailed description of the activities in each Work Package and the associated resources broken down by Work Package and Consortium member.

ITER Physics. (NB: JET work is now included under ITER Physics, see Sec 1.3) Out of the 8 Missions defined in the roadmap, the ITER Physics (IPH) work primarily deals with Mission 1 “Plasma Regimes of Operation”, Mission 2 “Heat Exhaust System” and Mission 8 “Stellarator” and the corresponding headlines defined in Annex 1. The central activity of the 2015 Programme will be the exploitation of JET, ASDEX Upgrade (AUG), TCV and PFC test facilities in support of Missions 1 and 2 and the start of operation of W7-X in support of Mission 8. This will include preparation for future JET DT experiments. PFC studies will include preparation for exploitation of the WEST facility, due to begin operation in 2016. Studies of alternative divertor concepts will continue, with a report on the technical requirements for a possible Divertor Test Tokamak due at the end of 2015. Preparation for the European exploitation of JT-60SA and stellarator reactor studies will continue. All of the work will be supported by code development, with a focus on providing integrated modelling, and infrastructure support activities.

Power Plant Physics and Technology. An important objective of the roadmap Horizon 2020 is to lay the foundation of a Demonstration Fusion Power Reactor (DEMO) to follow ITER, confirming the capability of generating several hundred MW of net electricity and operating with a closed fuel-cycle by 2050. Achieving this ambitious (but realistic) goal requires establishing a coherent and vigorous design and R&D effort to conduct all the technical activities identified in the roadmap and outlined in the Work Plan. The Work Plan sets out the objectives, requirements and scope of the foreseen work; defines the expected deliverables and output from the project activities and defines the expected timeline and overall milestones. It also identifies areas where early involvement of industry is desirable; areas where international collaboration would offer benefits and finally areas where training could be an important element for consideration.

Socio Economic Studies. The objective of the Socio-Economic Studies Project is to assess the social and economic viability of fusion energy. Research in fusion economics will be carried out to understand the internal and external costs of fusion energy. The possible role of fusion power on the future energy markets and its competitiveness under different conditions will be analysed with the employment of the global energy system’s model generators such as EFDA TIMES and TIAM. The level and the conditions of the social acceptance of fusion energy will be studied periodically, including the public and stakeholders' reasoning on the power plant safety. Understanding these elements is crucial for fusion technologies successful integration into the global and European electricity system, especially in the situation in which the nuclear energy image suffers from the Fukushima accident's consequences and in the consideration of the fact that fusion energy market chances depend strongly on fusion power plant costs.

Communications[1]. Communications are a strategic support office to the Programme Manager and Consortium Members. The broad dissemination of news is done on three main levels: communicating to the public in all its diversity, to the fusion community and to colleagues of the Programme Management Unit. With the establishment of EUROfusion the last two levels have become more important which is why time will be spent in 2015 to develop these information channels further.

The Head of Communications chairs and coordinates the European Public Information Network (PIN) for fusion research. In 2015 the PIN Board will finish the 'Fusion Presentation Kit'. The remaining time will be used to complete unfinished tasks from the former Working Groups.

Additionally it is planned to scrutinise all EFDA on- and offline media step by step for content, relevance, usage and usability respectively and appropriately renew the material.

Education and Training. The proposed Education Programme under the EUROfusion Consortium for H2020 (2014-2020) is aiming at the support of PhD programmes in the fusion institutions or of university student programmes across Europe, building on the FuseNet experience. In this context, the specific role of FuseNet will be to assist the Consortium in the implementation of the peer review of the proposals on education by the different Consortium members, on the basis of which a significant fraction of the education funds (35%) will be allocated, and in the subsequent monitoring of these educational activities.

The activities previously foreseen as EUROfusion Researcher Fellowship will be implemented as planned; however, since they foresee the promotion of excellence, and do require a proposal from a researcher, they shall in future be considered as EUROfusion Researcher Grants. A similar approach is envisaged for the Engineering activities.

Enabling Research. In addition to the mission-oriented work, the programme aimed at promoting fundamental understanding and longer perspective research will be continued. Enabling research involving devices funded under the common programme is incorporated into the respective Work Package. Although the Enabling Research programme promotes fundamental understanding and is judged for its excellence, only topics with relevance for fusion research are eligible for joint programme funding. With this respect, the Keep-in-Touch activities to the complementary approach of the Inertial Fusion Energy (IFE) are of significance and will be eligible with a maximum percentage of about 10% of the total funding available during the five years of the grant.

[1] Previously named "Public Information" in Grant Proposal

1.2 Expected impact

Contribution to the success of ITER. JET experimental campaigns in 2015 will concentrate on preparation of ITER operating scenarios and, in particular, on the compatibility of high performance operation with the ITER first wall material mix. The development of operational scenarios based on the conventional and hybrid ELMy H-mode should provide maximum fusion energy in the 2017 JET DT experiment. The high priority physics studies, such as disruption mitigation (including studies of run-away electrons) taking benefit of the installation of third disruption mitigation valve, L to H mode threshold scaling, core plasma and pedestal confinement with different isotopes and fuels, highly radiative plasmas with extrinsic seeding impurities, pellet ELM pacing with the new vertical high field side track. To address key questions of the ITER research plan and to cover the entire range of working gases foreseen for ITER, a short He campaign (1 month) will be carried out. According to ITER-IO, access to Type I ELMy H-mode operation in the non-active phase is an important milestone in the ITER Research Plan both to demonstrate H-mode access and to develop ELM control schemes, and to ensure a fast and risk-controlled path to early DT operation in ITER.

DEMO preparation. To support the definition of the top level requirements for the DEMO Fusion Power Plant the EUROfusion Work Programme 2014 originally foresaw the establishment of a DEMO Stakeholder Group (SHG) consisting of individuals that represent a wide cross section of interests in the future DEMO Fusion Power Plant on the path to commercial fusion electricity. However, because of the potential sensitivity of some of the issues involved in the discussion, and especially the need to focus the discussions at the beginning on the definition of the Top Level Requirements, a proposal has been to study the process followed in other fields, especially fission, and draw lessons from the approach used. After this initial step, a proposal will be made to form the DEMO Stakeholders Group and to agree on the ToR. In 2015 it is foreseen that an agreement will be reached on the expected uses (i.e. missions), users and postulated operational scenarios for the DEMO plant. Furthermore, the SHG will agree the top-level plant key performance indicators (KPIs) in terms of minimum acceptable thresholds and also agree the relative value attributed to increases in performance from the minimum requirements i.e. value modelling.

Train Generation ITER. During late 2014 and early 2015 an update of the human resource survey carried out in 2006 will be launched within EUROfusion. In parallel, a prospective exercise taking into account the foreseen needs during ITER operation as well as those related to the preparation and construction of DEMO will be started in close collaboration with F4E and possibly also FuseNet to establish future requirements. On the basis of these two studies, an appropriate strategy will be defined and discussed with the Commission. The outcome of the study is expected to be available in the first half of 2015.

Technology Transfer. Following the completion of the FUTTA project that was launched in 2013 under EFDA, but kicked off in 2014, the results will be evaluated and the possibilities to set up a Technology Transfer Project Office (TTPO) will be investigated. A dedicated event to inform European industrial partners about opportunities will be organized in collaboration with the F4E ILO network and FIIF.

1.3 Correspondence with the description of work – Annex 1

ITER Physics. The conclusion of the old JET Operating Contract in 2014 has enabled the logical combination of the JET activities into ITER Physics Department. Thus, from 2015 onward all of these Work Packages will be treated together. For clarity, these are Work Packages 1-14 listed in Table 3.1b of Annex 1, namely:

1. WPJET1: JET Campaigns
2. WPJET2: Plasma-Facing Components
3. WPJET3: Technological Exploitation of DT operation
4. WPJET4: JET Enhancements
5. WPMST1: Medium-Size Tokamak Campaigns
6. WPMST2: Preparation of exploitation of Medium-Size Tokamaks
7. WPPFC: Preparation of efficient PFC operation for ITER and DEMO
8. WPDTT1: Assessment of alternative divertor geometries and liquid metals PFCs
9. WPDTT2: Definition and design of the DTT
10. WPSA: Preparation of exploitation of JT-60SA
11. WPS1: Preparation and Exploitation of W7-X Campaigns
12. WPS2: Stellarator Theory Development and Modelling
13. WPCD: Code development for Integrated Modelling
14. WPISA: Infrastructure support activities

As in 2014, the Annual Work Plan 2015 is organised along these Work Packages with, in each case, the objectives and description of work outlined. The description of work is listed against the 5 year technical “key” deliverables which are the same as those given in Section 3.1 of Annex 1. For ease of reference and monitoring, these have now been numbered and entered into a database which is used to produce the relevant text in this document. This has the additional benefit that the same information can be produced against the programmatic goals, Section 4.

PPPT. The arrangement of the work in distributed Projects is proposed and viewed as a major step forward to perform the required design and development in an efficient way. In this context, a number of Projects has been defined, with well-defined deliverables, milestones and time schedule, and resource allocation. They include:

- **WPMAG:** Magnets system project
- **WPCS:** Containment structures project
- **WPBB:** Breeding blanket project
- **WPDIV:** Divertor project
- **WPHCD:** Heating and current drive systems project
- **WPTFV:** Tritium, fuelling & vacuum systems project
- **WPBOP:** Heat transfer, Balance-of-Plant and site project
- **WPDC:** Diagnostic and control project
- **WPRM:** Remote maintenance system project
- **WPMAT:** Materials project
- **WPENS:** Early neutron source project
- **WPSAE:** Safety and Environment project

In addition, work on Plant Systems Engineering and Design Integration and DEMO Physics Integration will be managed by the Programme Management Unit to ensure that a consistent and integrated DEMO concept design is delivered taking into account the overall DEMO plant requirements and the findings that will emerge through the execution of the projects. It consists of activities to be executed by Design Teams within member laboratories or Industry through specific Tasks (e.g., Requirements Analysis; Plant System Modelling; CAD Configuration, System Level Analysis & Simulations, Definition of Systems Engineering Framework and Technical Processes, Physics Integration). The scope of the activities to be carried out in each of the projects in WP2015 is described below together with the main deliverables. The activities in the WPCS will be put on hold until the definition of the safety boundary requirements, foreseen to be available by the middle of 2015. The scope of the activities to be conducted in the Project WPENS has been modified taking into account comments and suggestions from F4E. The process of selecting a Project Leader is expected to start soon (if possible already before the end of 2014). The Project Leader will then prepare a proposal for activities to be implemented if possible; already in the second half of 2015 (amendment of AWP15 would be required in this case). The PL should then launch a call for participation, evaluating and selecting bids, forming a Project team, define and submit a Project Management Plan to be approved by a (to be established) Project Board and a Work Programme Proposal (consistent with resources available in 2015) to be approved by the General Assembly.

Socio Economic studies. Socio Economic studies will be carried out within the Work Package WPSES.

Communications. Communications activities will be carried out within the Work Package WPPI.

Education and Training. Continuance in Education and Training activities is foreseen. Modifications are foreseen with regard to Training activities.

Enabling Research. The activities in Enabling Research will be carried out within the Work Package WPENR.

2 Annual Work Plan activities

2.1 Annual Work Plan

In the following a short summary of the Annual Work Plan is presented.

2.1.1 ITER Physics

The ITER Physics (IPH) 2015 Work Plan is strongly focused on achieving the milestones defined in the EU roadmap for developing fusion energy. Out of the 8 Missions defined in the roadmap, IPH primarily deals with Missions 1, 2 and 8 which aim to resolve a series of key issues for ITER and DEMO divided into Headlines for convenience, see Table 1 and, for the definitions, Sec 1.2 of Annex 1. The work is implemented through 14 Work Packages, listed in Table 2 and Table 3.1b of Annex 1 (Work Packages 1-14). The ITER Physics work is developed and presented by following both

- a **Work Package structure** (Section 2.1) where the technical "key" 2015 deliverables (when relevant) have been highlighted, and,
- a **programmatic structure** (Section 4) where the contributions of the relevant Work Packages have been regrouped along the missions and headlines structure.

Table 1: IPH related Missions and Headlines

Mission 1:	Plasma Regimes of Operation
	Headline 1.1: Increase the margin to achieve high fusion gain on ITER
	Headline 1.2: Operation with reduced or suppressed ELMs
	Headline 1.3: Avoidance and mitigation of disruption and runaways electrons
	Headline 1.4: Integration of MHD control into plasma scenarios
	Headline 1.5: Control of core contamination and dilution from W PFCs
	Headline 1.6: Determine optimum particle throughput for reactor scenarios
	Headline 1.7: Optimise fast ion confinement and current drive
	Headline 1.8: Develop integrated scenarios with controllers
	Headline 1.9: Qualification of Advanced Tokamak scenarios
Mission 2:	Heat Exhaust System
	Headline 2.1: Detachment control for the ITER and DEMO baseline strategy
	Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
	Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
	Headline 2.4: Investigate alternative power exhaust solutions for DEMO
Mission 8:	Stellarator
	Headline 8.1: Qualification of Helias optimised stellarator operation
	Headline 8.2: Theory development and modelling / stellarator optimisation

Table 2: IPH Work Packages

1. WPJET1:	JET Campaigns
2. WPJET2:	JET Plasma-Facing Components
3. WPJET3:	Technological Exploitation of JET DT Operation for the ITER preparation
4. WPJET4:	JET Enhancements
5. WPMST1:	Medium-Size Tokamak campaigns
6. WPMST2:	Preparation of Exploitation of Medium-Size Tokamaks
7. WPPFC:	PFC test facility work
8. WPDTT1:	Assessment of alternative divertor geometries and liquid metals PFCs
9. WPDTT2:	Definition and design of the Divertor Tokamak Test facility
10. WPSA:	Preparation of exploitation of JT-60SA
11. WPS1:	Preparation and Exploitation of W7-X Campaigns
12. WPS2:	Stellarator optimisation: Theory Development, Modelling and Engineering
13. WPCD:	Code Development for Integrated Modelling
14. WPISA:	Infrastructure Support Activities

The central activity of the 2015 Programme will be the exploitation of JET, ASDEX Upgrade (AUG), TCV and PFC test facilities in support of Missions 1 and 2 and the start of operation of Wendelstein 7-X (W7-X) in support of Mission 8. The overview of the planning of the 2015 experiments on JET, ASDEX Upgrade and TCV is given in Figure 1 which highlights a significant overlap in the experimental campaigns that will require a tight coordination among the experimental teams. The JET and MST TFLs will draft an experimental programme to implement on each device which will be discussed during a common General Planning Meeting that will take place early 2015 in Lausanne. The experimental activity is supported by coherent and integrated research programme addressing code development, diagnostics and hardware enhancements as well as theory with first principle modelling (validation on experiments), integrated modelling for the preparation, analysis of the experiments, and finally, the extrapolation towards JT-60SA, ITER and reactor conditions (including the modelling of alternative power exhaust solutions for DEMO). Key scientific issues for ITER and reactor (e.g. runaways and disruption physics, heat and particle exhaust physics, fast particle physics, Tungsten and impurity transport etc.) will be developed in an integrated vision and in synergy with the progress made in the Enabling Research activities. The comparative studies of different magnetic confinement concepts or configuration is a challenge for the validation of the model and should enhance the reliability of our prediction in the long term. In some specific scientific topics (e.g. physics of L to H transition, disruption physics, plasma exhaust, confinement), the use of multi-machine database will be encouraged for validating the models.

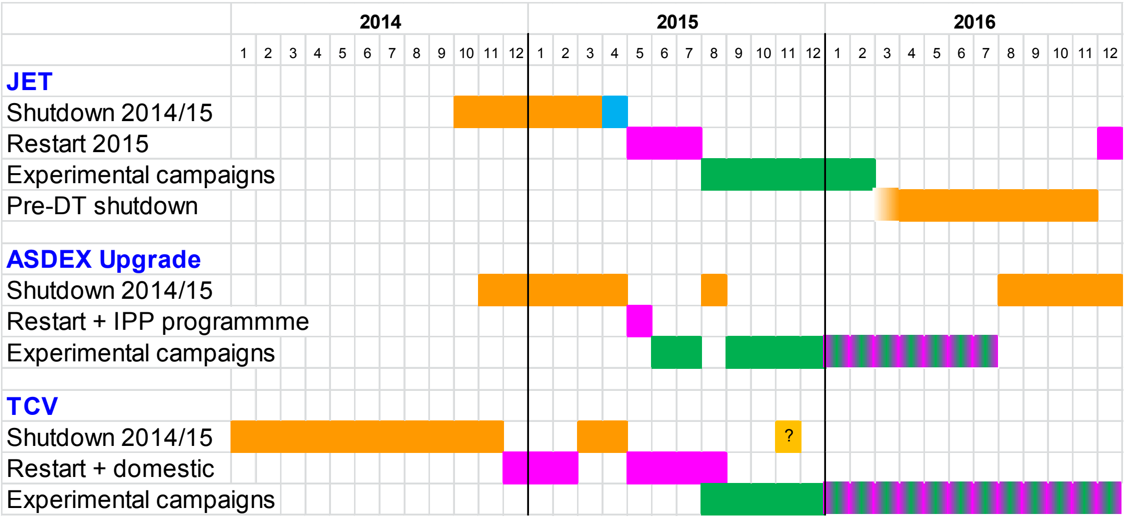

Fig. 1: Overview of the planning of the 2015 experiments on JET, ASDEX Upgrade and TCV

The Consortium Work Plan foresees that a DT Campaign will be carried out in 2017 on JET and that the Campaigns in 2015 and 2016 will be devoted to the optimisation of ITER regimes of operation in the presence of the ITER-like Wall and to the optimal preparation of the DT Campaign. A shutdown is planned until April 2015 to remove tile samples (including tungsten lamellae from the melt experiments), to re-instate the ITER-like antenna to increase the ICRH power and to optimise the pellet injection track with the aim to deliver pacing pellets reliably to the plasma. Post mortem analysis of tiles removed from JET will be used to quantify the rate of material erosion, transport and deposition and thus to validate models of these processes. In 2015-2016, Deuterium operation will focus on ITER scenario development with the ITER-like Wall with up to 34 MW of NBI power and 12 MW ICRH available with seven month of experimental campaign (from August 2015 up to February 2016). The development of operational scenarios based on the conventional and hybrid ELMy H-mode should provide maximum fusion power in a JET DT experiment (above ≈15 MW of fusion power) of fusion power in stationary conditions (≈5 s). Together with the scenario development, a strong focus and emphasis on JET utilization will be pursue for addressing urgent ITER needs as highlighted in the ITER research plan, and developing a sound physics basis for the extrapolation through first principle and integrated modelling of JET results to ITER. The high priority physics studies, such as disruption mitigation (including studies of run-away electrons) taking benefit of the installation of a third disruption mitigation valve, L to H mode threshold scaling, core plasma and pedestal confinement with different isotopes and fuels, highly radiative plasmas with extrinsic seeding impurities, pellet-ELM pacing with the new vertical high field side pellet track, fast particle physics (upgraded TAE system). To cover the entire range of working gases foreseen for ITER, it is foreseen that a He campaign (1 month) will be carried out during the start of the 2015 JET experimental campaign. The final decision should be taken after the completion of the Hydrogen campaign in 2014. In this context, during the period 2014-18 on JET, a series of experimental campaigns and shutdowns are planned that include experiments covering the entire range of working gases foreseen for ITER (H, D, T and He), culminating in an extensive DT campaign. The prime objective of the JET He campaign is to characterize the L-H threshold power scaling and the performance of the type I ELMy H mode in He with the ITER first wall materials. To implement this programme and to coordinate the subsequent analysis the JET Task Force structure consists of two Task Forces: (i) Integrated operational scenarios and (ii) Physics and technology for ITER. In 2015, the preparation of the technological exploitation of DT operations at JET with the objective to bring the necessary preparations for maximising the scientific and technological return of DT operations will consist in : (i) Calibration and characterization of the 14 MeV neutron generator to be used in the in-vessel calibration of the JET neutron detectors at 14 MeV neutron energy; (ii) Design of neutronics, activation and radiation damage experiments to be carried out at JET during DT operations; (iii) experimental plans for the measurements of tritium retention in ILW materials, and for the data collection on occupational dose and on waste generation and characterization, (iv) Installation and commissioning of the vertical neutron spectrometer diagnostic.

The exploitation of ASDEX Upgrade (AUG) on issues connected with Missions 1 and 2 (WPMST1) will complement the work at JET (WPJET1) to provide a step-ladder approach for extrapolations to ITER and DEMO and in areas, where AUG has unique experimental capabilities and flexibility. In 2015, AUG experiment will benefit of the installation of two new three straps ICRH antenna to increase the power (generator power 7MW) while minimizing the source of W through the reduction of the rectified RF sheath. The European exploitation of ASDEX Upgrade will continue in June 2015 and last until the end of the year and will comprise about ≈30 operational days (figure to be confirmed with the exact 2015 budget, cost of operation and scientific priorities). The main focus of the MST1 campaign will be on the demonstration of ELM mitigation / suppression (magnetic coils and pellets) and divertor heat load control with high radiation power fraction (>80%) in ITER and reactor relevant scenarios. This work will complement the JET experiment (i) on the development of relevant divertor power handling with stationary conditions and (ii) on the ELMs mitigation techniques in Helium plasmas if Helium campaigns are decided for, both at JET and ASDEX-U.

Whereas MAST-U will still be in shut-down most of 2015, TCV will become available in the second half of 2015 from September to December 2015 for the physics campaign with a possible one-month break to install a replacement X2-X3 gyrotron. During 2014 and early 2015, TCV is undergoing a major upgrade in heating power (ECRH and NBI), which will allow from 2015 on amongst other issues proof of principle investigations on snowflake divertor configurations. From September 2015, the ECRH power is 1.2 MW X2 and 1.35 MW X3, together with 1 MW NBI power. It is foreseen to initiate a campaign at TCV in 2015 comprising approximately ≈15 days of operation (figure to be confirmed with the exact 2015 budget, cost of operation and scientific priorities). The main focus will be on the exploitation of the shaping flexibility and new heating source upgrade in TCV for alternative divertor geometry and ELMy H-mode studies. The super-X divertor can be investigated in MAST-U from 2016 on after about 2 years of shut down and initial commissioning.

Another important challenge in 2015 will be the implementation of the European task force for the initial exploitation of W7-X (WPS1), which will have its first campaign in 2015 (starting around the middle of 2015). In view of later campaigns, diagnostics and components will be prepared for the European exploitation of W7-X. In view of key elements in the development of the HELIAS line, discharge scenarios will be pursed to be qualified experimentally. For a theory driven, efficient exploitation, predictive modelling of specific W7-X scenarios will be conducted in 2015. During these first campaigns (until 2017), W7-X will operate without the actively cooled steady state divertor, so the pulse length will be limited to 10 seconds at full power available during this phase. Longer pulses (≈ 1 minute) will be possible but at reduced power. Nevertheless, first important results are expected on plasma initiation with ECRH, scenario development, confinement, impurity transport, power and particle exhaust in this first phase. The very first operational phase is to verify the quality of magnetic flux surfaces and to demonstrate plasma generation with ECR heating. Diagnostics for the characterization of these first HELIAS plasmas and safety relevant diagnostics will be operated by EUROfusion contributors as a part of the W7-X Team. On the longer perspective for mission 8, the work package WPS2 (Stellarator optimisation: theory development and modelling) deals with the optimization of the stellarator concept in view of a future reactor. In 2015, it is proposed to include the stellarator module into a system code in view of addressing tokamaks and stellarator reactors design using similar tools and approach. WPS2 also supports the preparation of the theory driven exploitation of W7-X.

The preparation of future campaigns on the MST as well as supportive investigations on other European devices and test beds are tackled with the Work Package WPMST2. These projects includes development of diagnostics (e.g. super-X Divertor Thomson Scattering diagnostic on MAST-U, snowflake IR Imaging diagnostic on TCV) and control tools, activities to develop efficiency of heating systems, complementary work on small size devices for scaling laws, as well as the development and validation of SOL modelling and activities on disruption and runaway electrons mitigation and MHD stability control..

The preparation of the European participation to the exploitation of JT-60SA is dealt with in WPSA. This work package will support the preparation of a European exploitation of JT-60SA. Since the operation of JT-60SA will only start in 2019/2020, the activity will mainly comprise modelling work in support of the scenario development (Roadmap Mission 1). In addition WPSA should provide the platform for the potential update of the JT-60SA research plan and for the elaboration of efficient tools for data access and evaluation procedures. In 2015 the key deliverables are the complete core-equilibrium modelling of flat-top phases of the proposed JT-60SA scenarios, Divertor pumping modelling (including elements for a technical design of the cryopumping systems) and definition and prioritization of the ECRH system functionalities (NTM, sawtooth control, current profile tailoring, impurities control) and in low absorption scenarios (start-up assist, wall cleaning). In addition, the studies for the development of W divertor on JT-60SA will be initiated including the first assessment of the start-up / ramp down strategy and expected main chamber power loads, assessment of the relevant scenarios for all metal PFCs.

The work package WPPFC, WPDTT1 and WPDTT2 are mainly related to mission 2 of the European roadmap addressing issues relevant for ITER and DEMO The work package WPPFC comprises projects in support of the headlines 1.6 Determine optimum particle throughput for reactor scenarios, 2.2 Prepare efficient PFC operation for ITER and DEMO, and 2.4 Investigate alternative power exhaust solutions for DEMO. Specifically, experiments on linear devices (PSI-2, Pilot-PSI, Magnum, Magnum-PS) for simulation of ITER/DEMO-like particle/power loads, laboratory work on plasma material interaction (power handling, erosion, H-retention) necessary for extrapolation to ITER and DEMO, the testing of improved DEMO relevant armour materials (W alloys, EUROFER,...) and advanced DEMO relevant armour materials (liquid metals) will fall within this project. The international panel[2] in charge of the evaluation of WEST as a EUROfusion facility has strongly recommended that it is located within the WPPFC project with existing high heat flux facilities and linear machines for the first period 2015-2017 of WEST exploitation. If there is a positive vote by the EUROfusion General Assembly on WEST as a EUROfusion common facility a new call for the

[2] For a new facility such as WEST, the General Assembly has appointed a Panel in charge of evaluating "the potential contribution of WEST to the European Fusion Roadmap, the added value and the cost/benefit ratio of WEST compared to the already existing or upcoming EU facilities". On July 1st, the Panel has provided EUROfusion with written recommendations. Following the Terms of Reference of the Panel, the implementation of such recommendations has to be discussed and voted on at the General Assembly of September 2014.

WPPFC project will be made. Within mission 2, the WEST project will focus on actively cooled ITER mono-block testing in a plasma environment and will fill an important gap in current capabilities. Preparatory activities (e.g. bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines, Divertor modelling for the preparation of ITER monoblocks testing, etc) directly aligned with the recommendations from the panel in charge of the evaluation of WEST will start already in 2015 for an efficient WEST exploitation in 2016. WPDTT1 aims at providing an assessment of alternative divertor geometries and liquid metals PFCs and will provide sufficient information for the decision on the parameters of a possible Divertor Tokamak Test (DTT). In 2015, the WPDTT1 project will report on alternative power exhaust solutions for DEMO. The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations (e.g. Super X divertor, snowflake divertor) as well as the most promising liquid metal PFC solutions. The WPDTT2 project deals with the definition and the conceptual design of Divertor Tokamak Test. Before the finalisation of the conceptual design of a DTT, integration issues and DEMO compatibility must be assessed taking into account the results from WPPFC. By the end of 2015, WPDTT2 will report on the DTT technical requirements with inputs from WPDTT1, WPPFC and experimental results from international collaborations.

Code development for integrated modelling is performed within WPCD. This Work package will focus on “customer oriented” code architecture development as for example the set-up of a core transport simulator including various equilibrium and transport as well as heating and current drive modules. In 2015, the key deliverables are (i) Suite of robust codes for modelling IC, NBI, EC and alpha sources verified according to a WPCD verification procedure; (ii) Robustly running ETS core transport workflows (fixed and free boundary) with full hierarchy of transport models and full integration of H&CD, including synergies (between NBI, alpha sources and IC), (iii) Coupling FBE - Transport - Controller (finalized version). By the end of 2015, the European Transport Solver (ETS) will be deployed on the JET analysis cluster for exploitation on interpretive analysis of JET experiments.

As in previous years, the work plan foresees central support for high performance computing and the Gateway computer. In addition to this activity the functional maintenance of the Integrated Modelling platform the implementation of new functionalities and new modules as well as user training will be provided in the framework of infrastructure support activities (WPISA).

2.1.2 Power Plant Physics and Technology Department

WPPMI

The activities foreseen in 2015 are divided into the following areas:

(i) requirements analysis (i.e., Stakeholder requirements definition / plant requirements analysis); (ii) plant design definition and optimisation (e.g., an independently moderated TRL assessment; parameter trade off assessment and prioritisation exercise such as an aspect ratio scans, etc.) ; (iii) system level analysis & plant engineering studies; (iv) definition of a systems engineering framework and technical processes (e.g., CAD configuration management); (v) project management activities (e.g, definition of deliverables for the CDA, formation and maintenance of the Master Schedule; interface management); and (vi) DEMO Physics Integration (i.e., System code analysis and development of point design options; DEMO physics basis development; DEMO physics design integration).

WPMAG

The work package WPMAG is divided in four activity areas, namely winding pack & interfaces, structures and fabrications, R&D and qualification and advanced magnet technologies (HTS). priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): update as required the magnet system requirement (SRD) and load specification (LS) documents; magnet system CAD configuration model (inc. TF, PF & CS coils); magnet system design document; candidate TF, PF & CS design specifications and engineering analysis reports; reference document on DEMO TF conductor prototype samples; reference documents on HTS samples fabrication / tests.

WPBB

The work package WPBB is divided in nine activity areas (sub-projects) namely Management and Support Team, HCPB Design and R&D, HCLL Design and R&D, WCLL Design and R&D, DCLL Design and R&D, LiPb Technology Development, Blanket Tritium Technology Development, Blanket Tritium Technology Development, Blanket Manufacturing, and FW/limiter design and R&D. Priority activities foreseen in 2015 include (see full details in Sect. 2.2): (i) update as required the PMP, SRD, LS documents and CAD Configuration (CCD) model with the aim to consolidate the basis for the foreseen first design development phase (in 2015-2017); (ii) start integrated and self-consistent design work for all the blanket options ensuring that from the very beginning they meet the requirements. (iii) cContinue the implementation of R&D activities as planned in the WPBB PMP that will build on the outcome of the 2014 R&D results.

WPDIV

The work package WPDIV is divided in two activity areas, namely Cassette design and integration and divertor target technology.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2):: : update as required PMP, System Requirements (SRD) and Load Specification (LS) documents; design-to-code reports for all target concepts; fabricated mock-ups of most concepts foreseen for HHF test campaign in 2016; report on qualified fabrication technology for flat tile/saddle concept; helium-cooled target: 1st phase development report

WPHCD

The work package WPHCD is divided in eight activity areas, namely: H&CD System Engineering, EC Conceptual Design, EC R&D, EC Advanced technologies, NB Conceptual design, NB advanced concept, ICRF Conceptual design, Management Support.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): *System Engineering:* (i) update as required System Requirement Document (SRD) for the H&CD system and Load Specifications (LS) of specific systems; (ii) status design report for EC and NB

EC Conceptual Design: (i) Final report on gyrotron requirements; (ii) report on ECW system components (transmission line, launchers, RF loads) selection and the corresponding intermediate design reports; (iii) first conceptual design of the ECW system.

EC R&D and Advanced concept: (i) status report on the 170 GHz components procurement; (ii) report on the 240 GHz step tuneable gyrotron design and its ancillary system (10 T magnet), including contact with industry; (iii) report on R&D for fabrication of large size window and on characterisation dielectric properties; (iv) reports on code developments necessary for and applications to the design of gyrotrons; (iv) report on preliminary calculations for a multi stage depressed collector

Neutral Beam Conceptual Design and Advanced Concept: (i) initial development of large scale studies of alternative/optimized negative ion sources and consolidation of small scale studies and experiments; (ii) energy recovery: scale analysis and preparation of small-scale tests on available facilities; (iii) progress of conceptual design studies, layout and CAD integration; (iv) progress on tests of photo-neutralisation; (v) completion of parallelization of codes and simulation of a single source-accelerator

IC Conceptual Design: (i) report on the functional definition of the ICRF system; (ii) progress report on preliminary specifications for an IC antenna

WPTFV

The work package TFV is divided in four activity areas, namely tritium systems development, matter injection systems development, vacuum systems development, and integration and management. The latter includes a continuous activity on the development of a fuel cycle simulator tool. In line with the Project Management Plan of WPTFV.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): update as required PMP; SRD and LS documents; update CAD Models for system engineering analysis and integration studies; revised / update list of interfaces; conduct a survey on gas injection technology methods; report on the THESEUS mercury monitoring systems; sticking coefficient results of the TIMO open panel experiment; report on the numerical treatment of the gas adsorption problem in cryogenic pumping; report on materials characterization at industry.

WPBOP

This work package is divided in four activity areas: Project Management; Primary Heat Transfer System (PHTS) & BoP System Engineering; PHTS & BoP Modelling and Analysis; LiPb Heat Exchanger and Fluid Technology.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): / deliverables: update as required Project Management Plan (PMP) Document; update as required System & Safety Requirements Documents; update as required CAD Models for system engineering analysis and integration studies and interface compilation; refine PHTS & BoP System Analysis models; continue PHTS & BOP thermodynamic modelling activities with APROS code for both He and water as primary coolants.

WPDC

This work package is divided in four activity areas: Project Management; D&C System engineering and Design Integration, Plasma Control R&D and Diagnostics R&D.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): preparation of Project Management Plan; preliminary D&C SRD; preliminary DEMO control requirements document; preliminary candidate diagnostic systems document; preliminary actuator properties document; CAD models for implementation of the front-end components into the DEMO tokamak for a number of relevant diagnostic systems. In addition, preparation of a preliminary reports on control simulations for core plasma density and radiation, for plasma shape and position, and for the control of MHD instabilities. Preliminary reports on pre-conceptual studies expected performance (accuracy, time resolution, reliability and lifetime, etc.) and maintainability of candidate diagnostic systems under DEMO conditions.

WPRM

This work package is divided in six activity areas: (i) Maintenance System Engineering, (ii) In-vessel Remote Maintenance Systems, (iii) Ex-vessel Remote Maintenance Systems, (iv) Services Joining Technology, (v) DEMO Remote Maintenance Test Facility, and (vi) Management

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): update as required Project Management Plan (PMP) Document; system requirements and Load Specification Documents and CAD models for system engineering analysis and integration studies. Design description document for both the “proof of principle” blanket maintenance system and associated mock-up; concept design description for both the “proof of principle” vertical port/blanket pipe handling systems (i.e. tools and end-effectors) and the associated mock-up; placement of manufacturing contracts for the tooling/end-effectors and mock-ups for testing the remote handling compatibility of blanket attachment concepts; design assessment report on concept divertor cassette maintenance systems; Design Description for both the “proof of principle” divertor cassette in-vessel attachment maintenance system (i.e. tools and end-effectors) and associated mock-up; manufacture of tooling/end-effectors and mock-ups for testing the remote handling compatibility of divertor attachment concepts; design assessment report on concepts for in-vessel transporters/manipulators and on concepts for transfer casks for blanket modules, divertor cassettes, etc. Design assessment report on concepts for the Active Maintenance Facility; Prepare definition and procurement contracts for mock-ups for testing the remote handling compatibility of service joining technologies

WPMAT

This work package is divided in six activity areas: (i) Engineering Data & Design Integration; (ii) Advanced Steels; (iii) High Heat Flux Materials; (v) Integrated Radiation Effects Modelling and Experimental Validation; and (vi) Management

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2):

- *Engineering Data and Design Integration*: development of an Interface Management Plan and Materials Management Framework (outline proposals presented in 2014). Development of the material data infrastructure necessary for PPPT, identify main gaps in the material database and interact with the testing community to plan experimental campaigns to fulfil those gaps at due time. Propose a Materials Handbook architecture, provide design allowables for the baseline structural materials for application by designers
- *Advanced Steels*: Development of advanced 9Cr FM steels for water cooled application or with improved high temperature mechanical properties; microstructural and mechanical characterization of Eurofer after special heat treatments or thermomechanical treatments. Fabrication of new 9Cr steel batches with optimized chemical compositions selected using thermodynamics calculations. First down-selection of chemical compositions and thermomechanical treatments.
- *High-Heat-Flux-Components:* Set up of a manufacturing route for W-based matrix materials and SiC-fiber reinforced W-composites in collaboration with industry; characterization of lab scale and in collaboration with industry produced self – passivating W alloys; Manufacturing and characterization of laminate structures in collaboration with industry; optimization of Cu-interlayer materials, basic characterization of high temperature interlayer materials and assessment of multi-metal laminates. Fabrication and characterization of tungsten-fiber W-composites. Improvement of fabrication processes for structural joints (W-EUROFER and tungsten-tungsten) and functional interlayers (e.g. W/Cu FGM). Component manufacturing using HRP for water and helium cooling concept designs
- *Integrated Radiation Effects Modelling and Experimental Validation:* development ad validation of models for (i) defect production and transmutation in pure metals and alloys; (ii) microstructural evolution of dislocation and vacancy cluster microstructure; (iii) interaction of radiation defects and radiation-induced precipitates with dislocations; (iv) changes in mechanical and physical properties under irradiation, in particular embrittlement and swelling; (v) experimental validation of models through observation of microstructural changes due to irradiation.
- *Functional Materials:* First characterization test of available candidate materials for optical and dielectric applications; identification of new materials with improved properties. Analysis of data for available candidate materials and development of a program devoted to their improvement and the assessment of the effects of radiation. Preparation of the first set of both dielectric and optical ceramics. Development of a

computer code for the kinetics of radiation damage accumulation taking into account defect formation, migration, and interaction. Assessment of the level of radiation for control, safety and H&CD in the machine: data incoming from DEMO design groups.

WPENS

The activities on the design and R&D of IFMIF are with the management of Fusion for Energy under the Broader Approach activities with Japan. The BA agreement comes to an end in 2017 and discussion has been started by F4E on the definition of Post BA activities including the possibility of the realization of the ENS. A technical assessment on Options towards IFMIF is being conducted. In this context, the content of the WPENS in the Work Plan has been modified taking into account comments and suggestions from F4E. The scope of the activities to be conducted in the Project WPENS has been modified taking into account comments and suggestions from F4E. The process of selecting a Project Leader is expected to start soon (if possible already before the end of 2014). The Project Leader will then prepare a proposal for activities to be implemented if possible; already in the second half of 2015 (amendment of AWP15 would be required in this case). The PL should then launch a call for participation, evaluating and selecting bids, forming a Project team, define and submit a Project Management Plan to be approved by a (to be established) Project Board and a Work Programme Proposal (consistent with resources available in 2015) to be approved by the General Assembly.

WPSAE

This work package is divided in three activity areas: (i) Design and Licencing Requirements; (ii) Integrated Safety Analyses / Source Terms / Models & Codes; (iii) Radioactive Waste Management; and (iv) Management of the Project Team.

Priority activities/ deliverables foreseen in 2015 include (see full details in Sect. 2.2): update as required of the Project Management Plan (PMP) Document; preliminary Safety Guidelines report by incorporating feedback from system designers; General Safety Principles document; FFMEA and accident sequences; Fusion-specific clearance limits; Feasibility report of waste recycling.

2.1.3 Socio Economic Studies

Work package WPSES contains a number of activities: (i) assessing the internal and external costs of fusion electricity; (ii) developing future energy scenarios that integrate the results of the cost assessment and also the social science activities; (iii) mapping the stakeholder engagement and public opinion; (iv) interpret the results of these activities in such a way that they can be used for wider dissemination.

The priority activities/deliverables foreseen in 2015 are the update to the fusion cost database and the commissioning of the work on stakeholder engagement and public opinion.

2.1.4 Communications

The overall communication tasks remain the same as in 2014. That includes the activities in the 'Public Information Network' (PIN) as they proved to increase the interactivity among its members.

In 2015 both EUROfusion and PMU's internal website will be further developed to provide relevant information for the working level.

Due to the overall delay with the establishment of EUROfusion the review process of EFDA media was postponed to 2015.

The design and opening of a new Fusion Expo originally scheduled for 2014/15, is delayed because a decision on how to proceed was not taken. Assuming that the Fusion community will take a decision on how to run the Fusion Expo towards the end of 2014 design could be made during 2015. The opening of the new exhibition can then be envisaged in 2016.

2.1.5 Education and Training

Funds in support of PhD programmes are allocated based on the evaluation of the programmes and how the programmes will be developed in the period to 2018, building on existing strengths and improving weaker aspects. EUROfusion Researcher Fellowships will be implemented as planned, and in future will be considered as EUROfusion Researcher Grants (ERG). A similar approach is envisaged for the Engineering activities, to replace the former Goal Oriented Training scheme.

2.1.6 Enabling Research

In addition to the mission-oriented work, the Enabling Research Programme aimed at promoting fundamental understanding and longer perspective research will be continued. Whereas in 2014 only Enabling Research projects with a run time of one year were granted, the call for 2015 (launched in 2014) is also open for Enabling Research Projects of up to three years.

2.2 Detailed work description

2.2.1 WPJET1: JET Campaigns

Set of Activities Number	01	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	JET Campaigns (WPJET1)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 14,776 k€ (10,526k€ EUROfusion contribution) including 130 ppy (including 27 ppy NJOC secondees) for execution of tasks, 9.00 ppy for TFL and 2,465.761 k€ for missions.

Objective

The Consortium Work Plan foresees that a DT Campaign will be carried out in 2017 on JET and that the Campaigns in 2015 and 2016 will be devoted to the optimisation of ITER regimes of operation in the presence of the ITER-like Wall and to the optimal preparation of the DT Campaign. The work programme 2015 is written on the assumption of the reference scenario as shown in Fig. 2. A shutdown is planned until April 2015 to remove tile samples (including tungsten lamellae from the melt experiments), to re-instate the ITER-like antenna to increase the ICRH power and to optimise the pellet injection track with the aim to deliver pacing pellets reliably to the plasma. According to the newly implemented EU fusion research structure, the Culham Centre for Fusion Energy (CCFE) will operate the JET facility under contract from the European Commission. JET operation will be provided as an in-kind contribution to the EUROfusion Consortium, which is responsible for implementing the coordinated programme under a separate grant agreement with the Commission.

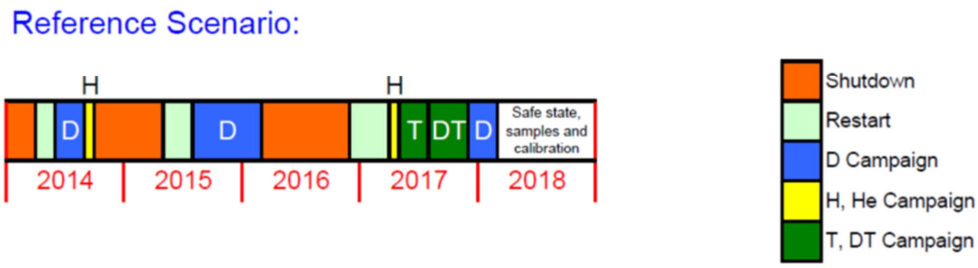

Fig. 2: JET operation 2014 – 2018 – Reference Planning scenario

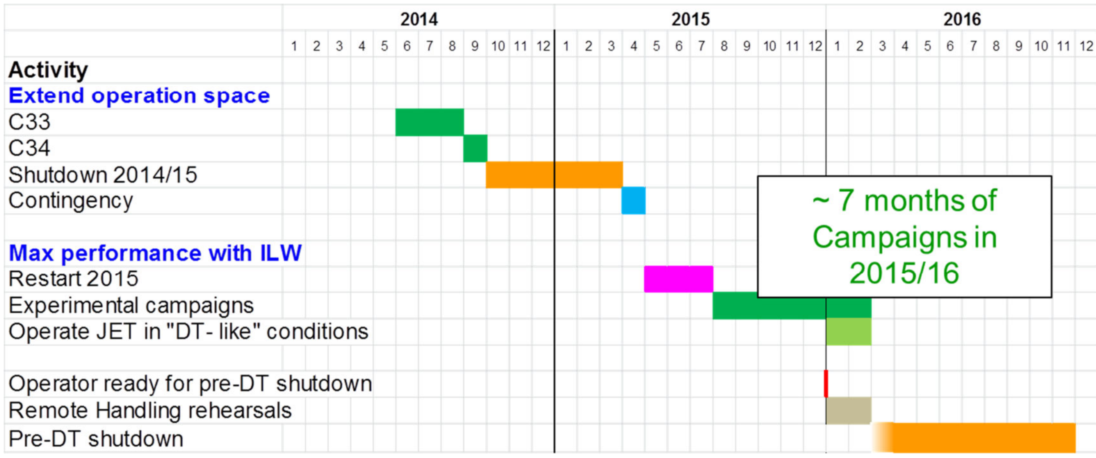

Fig. 3: 2015-2016 JET Campaigns

In 2015-2016, Deuterium operation will focus on ITER scenario development with the ITER-like Wall with up to 34 MW of NBI power (in Deuterium) and 12 MW ICRH available with seven month of experimental campaign (from August 2015 up to February 2016). January and February 2016 will be mainly devoted to operate JET in 'DT-like' conditions to check the reliability of the developed scenario. The development of operational scenarios based on the conventional and hybrid ELMy H-mode should provide maximum fusion power in a JET DT experiment (above ≈15 MW of fusion power) of fusion power in stationary conditions (≈5 s). To reach high performance regimes the 2015/2016 additional power capabilities are summarised as follow:

- Neutral Beam Heating Power capabilities depending on the gas species

Parameter	Gas species			
	H_2	**D_2**	**T_2**	**^{4}He**
Maximum beam energy (keV)	90	125	118	120
Maximum power per PINI (MW)	1.0	2.16	2.2	1.56
Maximum total power (MW)	**16.0**	**34.6**	**35.2**	**25.0**

- ICRH and LHCD capabilities

System	Power in H-mode		
	33 MHz	**42 MHz**	**51 MHz**
Four A2 Antennas (MW)	4-6	6-8	4-6
Re-instated: ITER-like Antenna (MW)	2-3	≈ 4	-
Maximum ICRH power (MW)	**9**	**12**	**6**
LHCD	**1-3MW**		

Pellets: New vertical (High Field Side) track optimising pellets for pacing and fuelling

Disruption mitigation: a third mitigation valve to the JET system (DMV3) using the port currently occupied by the Octant 5 reciprocating probe drive. It is an open question as to what extent a distributed system of DMVs can reduce the radiation asymmetry.

In detail, operations at JET will have to maximize the scientific output in 2015-2016 with constraints, mainly set by the limits for the Be and W tiles. These are:

- The use of the bulk tungsten tiles in terms of energy load, which will be limited to ≈60 MJ per stack;
- Limits for the surface temperature of the wall components: Currently at <950°C for Be, at <1200°C for the W-coated CFC tiles and <1000°C for the bulk-W tiles, but with the option for a limited number of discharges above this limit up to 2200°C;

There will be a need to coordinate and monitor the operational performance of the Operator, and especially the plasma restart targets to be in line with programme requirements. This will also include the training of control staff, in particular Session Leaders.

Together with the scenario development, a strong focus and emphasis on JET utilization will be pursued for addressing urgent ITER needs as highlighted in the ITER research plan, and developing a sound physics basis for the extrapolation through first principle and integrated modelling of JET results to ITER. The high priority physics studies, such as disruption mitigation (including studies of run-away electrons) taking benefit of the installation of third disruption mitigation valve, L to H mode threshold scaling, core plasma and pedestal confinement with different isotopes and fuels, highly radiative plasmas with extrinsic seeding impurities, pellet ELM pacing with the new vertical high field side track. To cover the entire range of working gases foreseen for ITER, it is foreseen that (decision to be taken after the completion of the Hydrogen campaign in 2014) a He campaign (1 month) will be carried out at the start of the 2015 JET experimental campaign. In this context, during the period 2014-18 on JET, a series of experimental campaigns and shutdowns are planned that include experiments covering the entire range of working gases foreseen for ITER (H, D, T and He), culminating in an extensive DT campaign. The prime objective of the JET He campaign is to characterize the L-H threshold power scaling and the performance of the type I ELMy H mode in He with the ITER first wall materials and He pumping conditions (Argon frosting available). According to ITER-IO, access to Type I ELMy H-mode operation in the non-active phase is an important milestone in the ITER Research Plan both to demonstrate H-mode access and to develop ELM control schemes, and to ensure a fast and risk-controlled path to early DT operation in ITER. The most viable path for ITER to access the Type I ELMy H-mode during the non-active phase is in helium plasmas. Following ITER-IO recommendation, it is necessary that the fusion community assesses whether the present ITER Research Plan strategy based on ELMy H-mode operation in helium is sound or not. This requires experimental confirmation of the key open issues that affect the operability of ITER in helium H-modes with a W-divertor. In addition, the comparison of Type I ELMy H-mode behaviour and ELM control between deuterium and helium plasmas will provide advances in the physics understanding (dependence of turbulent core plasma transport on main ion species, role of particle transport on ELM control, role of sources and pinches in the pedestal to plasma fuelling in H-modes, edge and core high-Z impurity transport in H-modes, edge MHD stability in Type I ELMy H-mode and the physics mechanism determining the pedestal width, etc..). In this document, it is assumed that a one month He campaign (two –three weeks in pure He and two weeks to reduce He concentration < 2%) will take place at the beginning of the experimental campaign in August 2015, leaving September-Dec. 2015 in D for high performance scenario development. The final decision to maintain or not the He campaign will depend on the output of the 2014 H campaign and the finding on the L-H power threshold with H.

Management

Two task forces will be responsible for the execution of the JET experimental programme, called as follows:

- Integrated operational scenarios; This TF is in charge of the scenario development of the ELMy H-mode and the Hybrid mode that requires similar expertise (on core-edge integration, optimization of the edge pedestal stability and core MHD stability).
- Physics and technology for ITER. This TF is in charge of addressing urgent ITER needs as highlighted in the ITER research plan, and developing a sound physics basis for the extrapolation through first principle and integrated modelling of JET results to ITER.

Modelling for preparation, interpretation will be an integral part of the work package to ensure an efficient exploitation of the experiments and extrapolation towards ITER.

Following a call for participation, the experimental proposals will be screened by the JET TFLs (and MST TFLs for the joint JET–MST experiments) who will foster discussions amongst the proponents to consolidate the set of proposals and to fill obvious gaps. Out of this set the TFLs will draft an experimental program which will be discussed at the common (JET, ASDEX Upgrade and TCV) General Planning Meeting (January 2015 in Lausanne). Shortly after the GPM a rough draft timeline for the implementation of the European exploitation of JET, ASDEX Upgrade, and TCV will be issued to allow for a call for manning.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Develop high performance scenario with H>0.9, W_{th}≈10-12MJ stationary (>5s) on JET towards low ρ^*, ν^*. • Quantify disruption mitigation efficiency in high energy plasmas and extrapolate to ITER • Demonstrate ITER relevant divertor power handling at P_{sep}/R≈10MW/m. Model and extrapolate towards ITER conditions.

Description of work

WPJET1
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D01: Study heat, particle and momentum confinement in conventional and improved H-modes and hybrids and the dimensionless scaling towards ITER (2015)
- Collaboration WPJET1 / WPMST1: Pedestal model validation with H and D plasmas.
- Explore operation with reduced torque injection by exploiting the full capability of the ICRH ITER Like Antenna (total ICRH power 12MW). *- Collect data for multi-machine scaling (β_N, ρ* and ν*) for both scenarios and assess importance of additional parameters (gas type) for confinement scaling.*
H1.1-D02: Demonstrate compatibility of conventional and improved H-mode with ITER wall materials (2015)
- Develop high performance scenario with H>0.9, W_{th}>10-12MJ stationary (>5s) on JET both for the conventional and hybrid at lowest possible ρ, ν*. Heat load control integrated in the development. Integrated modelling in support for scenario preparation.*
H1.1-D03: Qualification of improved H-mode confinement at large machine size and at full machine performance (2015)
- Collaboration WPJET1 / WPMST1: Extend high performance phase (H>1.3) to 5s for stationary high performance DT scenario. Use ASDEX-U and JET similarity experiments to extrapolate to next step devices.
H1.1-D04: Characterise L-H threshold power and access to H98(y,2)≈1 (e.g. power) in ITER-relevant conditions (2015; T&DT 2017)
- Assess L-H threshold and H=1 access in He (if He campaign for JET approved), compared to H scaling. *- Access to H≈1 scenarios at P/P_{LH}≈1-1.2.* *- Identify the link between SOL conditions and L-H threshold and perform turbulence measurements.* *- Compare with basic understanding of the L-H power threshold and role of isotope mass (link with the Enabling Research Programme)*
- Collaboration WPJET1 / WPMST1: collect data for the L-H scaling law including the effect of seeding gases and comparison with JET/AUG.
H1.1-D05: Test isotope scaling of the improved H-mode in H, D, DT and T (includes L-H for MST1) (2015)
- Explore improved H-mode in He (If He campaign approved in 2015).
H1.1-D06: H-mode and hybrid confinement scaling in regimes with high radiated power fractions (2018)
- Experiments with high radiated power fractions started in 2014 to be completed in 2015.
H1.1-D09: Develop physics models for the density limit (2018)
- Collaboration WJET1 / WPMST1: Perform TCV density limit studies and compare with AUG and JET results.

H1.1-D11: Develop gas puff technique and related modelling to maximise ICRF power in H-mode independently of the edge conditions (2017)
- Study of gas fuelling and modelling of ICRH power coupling in H mode. Comparison between ITER Like antenna and A2 antenna in terms of coupling, RF sheath rectification and W production.
H1.1-D13: Core transport simulator including: - various equilibrium and transport modules; - turbulence modules; - impurities; - pellets; - neutrals; - sawteeth, NTM; - heating and current drive modules (extended to synergies, EC, NBI, IC, LH and fast-ions) with improved physics (2017)
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure.
- Collaboration WPCD / WPJET1: Interpretative analysis and modelling of JET selected discharges with ETS.
Headline 1.2: Operation with reduced or suppressed ELMs
H1.2-D01: Quantify difference of ELMs, edge pedestal and L-H transition in H, D, T and He plasmas (2017)
- To be completed with He data if campaign is approved for 2015.
H1.2-D02: Demonstrate high dynamic range ELM pacing and low accompanying fuelling thus minimising the impact on confinement (2015)
- Pellet ELM pacing with the new pellet vertical track in high performance scenarios.
H1.2-D05: Establish scaling of small/no ELM regimes with high mantle radiation close to the density limit) and extrapolate to low collisionality (2015 (D), 2017 (T&DT); Extrapolation: 2019)
- Perform scenario development close to density limit.
H1.2-D07: (a) Develop and validate ELM model (for small ELMs) particularly with respect to: 1. Reproducing observed expansion of wetted surface during ELMs; 2. Explain the difference between inner/outer target and main wall; 3. Explain the fractional loss dependence of collisionality and on plasma impurity content; 4. Prediction of the dependence on ρ^*; 5. Validation of models for pellets pacing (b) Validate pedestal models (2018)
- Collaboration WPJET1 / WPMST1: Simulate one JET and one AUG discharge with first principle code.
- Collaboration WPJET1 / WPMST1: Test non-linear ELM model on AUG and JET plasmas.

Headline 1.3: Avoidance and mitigation of disruption and runaways electrons
H1.3-D01: Develop robust operation of ITER scenarios and their safe termination (2015)
- Experiments in JET using exploiting three Disruption Mitigation Valves and study impact of multiple valves on radiation asymmetry (integrated in scenario development H-1.1-D02).
H1.3-D02: Quantify the efficiency of massive gas injection for disruption mitigation to high current (4 MA) (2015)
- Experiments at high total energy E_{tot} will be performed in 2015 (data for low E_{tot} is available from 2014).
H1.3-D03: Extend studies of disruption avoidance and mitigation to conditions mimicking the hardware constraints expected on ITER (vertical stability capability, internal inductance, fast β changes) (2015)
- Experiments in JET exploiting three Disruption Mitigation Valves and study impact of multiple valves on radiation asymmetry. Quantify efficiency of mitigation with three Disruption Mitigation Valves in different toroidal and poloidal location. *- Characterise halo current and heat load distribution.* *- Develop and test disruption predictors. Compare with different predictors*
H1.3-D06: Document conditions for run-away electron generation and mitigation (2015)
- If necessary complete experiments from 2014. Investigate alternative methods to control run-away beams in 2015.
H1.3-D08: Validation of runaway generation model : determine runaway heat loads and forces in case of loss of control (2018)
- Describe the run-away existence domain with model developed in the Enabling Research programme and validate the full kinetic models.
H1.3-D09: Develop disruption prediction methods that minimise the requirements for model training on ITER and real-time predictors methods optimised in term of model training, success rate, anticipation time, differentiation among different types of disruptions (2018)
- Study, develop and test a locked mode predictor.
H1.3-D11: Qualification of Massive Gas Injection as a mitigation method for heat loads and forces (fuelling efficiency, local peaking of radiation load as function of MGI parameters and plasma conditions) (2015)
- cf H1.3-D03.
H1.3-D12: Develop Disruption workflow – including ELM module/RMP (2017)
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium.
Headline 1.4: Integration of MHD control into plasma scenarios
H1.4-D01: Demonstrate integrated and routine sawtooth control in high performance, inductive scenarios (2016)
- Sawtooth control and avoidance in combined scenario with NTM control. Full use of the extra ICRH power capability (ITER Like Antenna).
H1.4-D06: Clarify role of low rotation in mode stability (2016)
- Explore operation with reduced torque injection by exploiting the full capability of the ICRH ITER Like Antenna (total ICRH power 12MW).

Headline 1.5: Control of core contamination and dilution from W PFCs
H1.5-D01: Demonstrate acceptable W concentration in the foreseen reactor regimes (H-mode, hybrid and non-inductive) ITER wall materials and inductive operation: 1. Investigate the effect of ELM suppression and mitigation on high-Z peaking; 2. Develop high-Z accumulation avoidance by means of central electron heating, eventually also alpha heating; 3. Minimise heavy impurity sputtering and local heat loads by optimisation of plasma edge and reduction of ICRF sheaths. (2015 (2017 for DT) for standard H-mode, 2018 for improved H-mode (hybrid), 2020 for non-inductive scenarios)
- Integrated in the scenario deliverable with stationary conditions (≈5s). Optimise ICRF power level, gas injection, seeding gas. Obtain stationary good confinement scenario. *- Comparison of W production between ILA versus A2 ICRH antenna.*
H1.5-D02: Develop and validate models for impurity transport in the foreseen reactor regimes. Link to the model development in Headline 1.6. (2020)
- Validation and exploitation of the ETS impurity transport module on JET experiments. Validate first principle impurity transport model.
H1.5-D03: Develop and validate models for RF sheaths in order to minimise heavy impurity sputtering and local heat loads - includes test of RF sheaths models (work on test stands, modelling and antennas design) (2018)
- Test RF sheath models by comparing the W production from the ITER-Like vs. A2 ICRH antennas.
Headline 1.6: Determine optimum particle throughput for rector scenarios
H1.6-D02: Validation of models for core particle convective transport, pellet ablation and drifts. Link to the model development in Headline 1.5 (2015)
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
H1.6-D03: Demonstration of core particle fuelling in conditions of low neutral penetration (2015)
- Explore core particle fuelling (pellet) in scenario matching ITER pedestal conditions, high temperature, high density and compare with gas puff. *- Demonstrate fuelling capabilities in He.* *- Test results with models used for ITER prediction.*
H1.6-D04: Optimisation of DT fuel mixture control and use of tritium (2017)
- Collaboration WPJET1 / WPCD: Simulate fuelling conditions that will be available in a DT campaign; ETS scenario modelling for DT campaign fuelling.
H1.6-D08: Assessment of impact of particle throughput on fuel retention (2015)
- Complement existing data in D and H with He data if He campaign is decided.
H1.6-D09: Assess the impact of the metallic wall on the wall pumping Compare tokamaks of different size (2015)
- JET has done some experiments before 2014. Data mining on-going.
H1.6-D10: Determine effect of pumping-/ divertor-geometries on He-pumping, including fuelling, pellets injection etc (2017)
- If He campaign is decided for, document He pumping by Argon frosting in the pumps and density control in He.

Headline 1.7: Optimise fast ion confinement and current drive
H1.7-D02: Investigation of fast ion losses and their power scaling for various scenarios (2017)
- Work on-going on fast ion losses and scaling. Upgrade of the TAE system (see WPJET4). During 2015 a new digital control system including the capability to control relative phase between the antennas will be implemented to measure at the same time drive and damping of the modes, i.e. the whole set of parameters determining their linear stability. Compare with theoretical prediction.
H1.7-D04: Benchmark codes and validate non-linear models for fast ion-MHD interaction (2017)
- Report on benchmarking of non-linear MHD codes for fast ion MHD interaction on identified test cases (task will continue in 2016). *- Integration of synthetic diagnostics (including fast-ion) diagnostics in Integrated Modelling framework for comparison to experiment (also in support to H8.2- new task).*
H1.7-D05: Systematically vary the plasma fast ion content to separate the dependence of confinement, stability and bootstrap current on thermal and fast ion pressure (2020)
- Quantify the effect of the fast particle density and distribution on thermal plasma transport, MHD stability and bootstrap current - Compare to theoretical and first principle prediction to assess how plasma turbulence is controlled by fast particles (link with Enabling Research programme) - Use extra ICRH power capability provided by the ILA- Parasitic activity to the scenario development.
Headline 1.8: Develop integrated scenarios with controllers
H1.8-D01: Demonstrate combination of individual control algorithms into integrated control scenarios: Combine avoidance of NTMs, possibly via sawtooth control, with control of ELMs, disruptions, core contamination, divertor detachment, fuel species mixture and simulated burn (2018)
- Develop real-time control algorithm: sawtooth control, ELM control and W control using P_{rad}*, divertor detachment (under Mission 2). Explore burn control with extra-ICRH power.*
H1.8-D02: Demonstrate combination of individual control algorithms into integrated control scenarios: Use first principle simulation and modelling of individual control requirements to develop simplified plant dynamical models and observers for use in control algorithms (2018)
- Develop ad-hoc models for routine controllers used in the high performance scenarios.
H1.8-D03: Test of minimum diagnostic and actuator set for control: Develop and test measurement techniques for ITER and DEMO (2015, DT-related 2017)
- cf H1.8-D01.
Headline 1.9: Qualification of Advanced Tokamak scenarios
H1.9-D04: Integrated model validation so as to define, in as much as possible without definitive large machine results, the current drive requirements for non-inductive operation in JT-60SA (decision ≈2023) and ITER (≈2024) (2018)
- Collaboration WPJET1 / WPSA: Development of advanced scenario for the preparation of JT-60SA non-inductive regimes. Investigate similarity experiments JET – JT-60SA experiments.

Headline 2.1: Detachment control for the ITER and DEMO baseline strategy
H2.1-D01: Develop and test relevant sensors and actuators for detachment detection and control (2015)
- Develop real time control algorithm for detachment control with different fuelling methods at high P_{sep}/R (≈10 MW/m).
H2.1-D02: Investigate/document confinement at detachment for different fuelling methods / locations (2015)
- Experiments on detachment with different fuelling methods at high P_{sep}/R (≈10 MW/m)
H2.1-D03: Document H-L threshold scaling up to Greenwald density limit at high auxiliary heating power (2015)
- Data should be available from 2014 including the Hydrogen phase. Continue in 2015 if He campaign is decided.
H2.1-D04: Document influence of shaping on heat loads (steady state, ELMs) in the divertor (2015)
- Analysis of existing database
H2.1-D05: Optimise impurity mix for divertor and mantle radiation (2015)
- Experiment to be considered in 2015
H2.1-D06: Benchmark codes to predict detachment, particle and power loads in ITER and DEMO (linked to Headline 2.3) (2017)
- On-going predictive modelling for several gases, proposed move to H2.3
H2.1-D07: Document detailed conditions to reach detachment at highest available P_{se}p/R and close to Greenwald density limit and quantify particle and power loads to the main chamber (2015)
- Experiments on detachment with different fuelling methods at high P_{sep}/R (≈10 MW/m).
H2.1-D08: Investigate the compatibility of W with extrinsic impurity seeding / optimize impurity mix for divertor and main chamber radiation (linked to Headline 2.2) (2018)
- Investigation of N_2 and Ne compatibility done in 2014. Ne will continue in 2015 but other gases such as Ar are being considered
H2.1-D09: Compare influence of different divertor geometry on heat loads (2018)
- Experiment pending ongoing analysis and associated SOL modelling
H2.1-D10: Demonstrate low W sources and W core penetration for (partially) detached divertor conditions and relevant P_{sep}/R (2018)
- Data collected from detachment studies (see H2.1-D09)
H2.1-D11: Demonstrate compatibility of detachment with ELM mitigation methods / ELM-free / 'small' ELM scenarios (2016)
- Use pellets mitigation scheme on detached plasmas
Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
H2.2-D03: Develop Ion Cyclotron Wall Conditioning techniques (2015 ; DT 2017)
- Completed in 2014 (D and H), on-going data analysis. Possible additional experiments if He campaign is approved
H2.2-D05: Validate codes on plasma wall interactions (erosion, re-deposition and migration) (2016)
- Collaboration WPJET1 / WPMST1 / WPPFC: Test codes on expanded database

H2.2-D01: Investigate evolution of melt layers of metallic surfaces, and their influence on the plasma behaviour (2015)
- Collaboration WPJET1 / WPJET2: Study completed in 2014. Modelling is ongoing. A new lamella will be installed in the 2014 shutdown for experiments in 2015. The objective is to resolve an anomalously low heat flux on the exposed tungsten edge compared to what is expected from geometric projection of the heat flux seen on normal lamellas. This problem is compounded by the fact that IR camera had a side view of the edge and cannot resolve the peak temperature.
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.3-D06: Optimise predictive models for ITER and DEMO divertor/SOL: Self-consistent coupling between core and edge transport codes (2015)
- Verification and validation of codes on JET and MST through edge modelling tasks (e.g. SOL conditions & detachment, radiation and fluxes, SOL drifts, SOL currents, Be erosion/yields, Material migration, Core/edge integrated mod., Edge turbulence) and extrapolations towards ITER and DEMO.
H2.3-D03: Validation and exploitation of turbulence and synthetic probe workflow for experiment analysis (NEW) (2015)
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis (TCV, JET if probes / probe data available)

Use of EU facilities

JET

International Collaborations

International collaborations for Provision of hardware and/or its exploitation

- Japan: Investigation of alignment system of collection optics and calibration system for Thomson scattering system
- Russia: Study of fast ions with gamma-ray diagnostics and the study of runaways; Spectroscopy methods to overcome the divertor stray light problem; JET study of fast ions with gamma-ray diagnostics and the study of runaways; Commissioning of neutron flux monitor based on CVD diamond detector and measurements of neutron spectra during JET Experimental Campaign
- Brazil and USA: TAE amplifier and control upgrade enhancement project
- India: Calibration of Neutron Detectors system at JET; Imaging Spectroscopy diagnostics at JET; Participation in the conceptual design of the JET ELM Control Coils Resources

Participation in multi-machine coordinated Experiments: ITER-IO, Japan, US and China (collaboration under discussion)

2.2.2 WPJET2: Plasma Facing Components

Set of Activities Number	02	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Investigation of Plasma-Facing Components for ITER (WPJET2)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 1,801.931 k€ (946 k€ EUROfusion contribution) including 15.75 ppy, hardware and use of Facilities.

Objective

WPJET2 programme aims at a comprehensive post mortem analyses of materials retrieved from JET after experimental campaigns: plasma-facing components (PFCs), long-term probes and dust. The general work plan and work programme (2014-2018) are coherent with the Reference Scenario of JET operation. This implies that materials retrieved during three shutdowns in 2012, 2014 and 2016 after D-D campaigns and, possibly (decision to be taken later) after D-T shutdown are to be studied. As specified in the Work Programme of the EUROfusion Consortium, WPJET2 aims at the efficient use of PFC in view of ITER and DEMO requirements. The JET2 programme focuses on laboratory examination of wall components, in-vessel erosion-deposition probes (EDP) including test mirrors (Headline 2.2 and 6.8) and dust (Headline 2.2 and 5.2). This also includes collaboration on modelling within the framework of the WPJET1 Edge and SOL modelling. The overall goals of JET2 are listed below.

- Determine material migration patterns;
- Determine the distribution and to quantify fuel accumulation in order to provide best possible predictions regarding tritium inventory in ITER;
- Prepare grounds for the material studies following the planned DT Campaign.

There are three main strands identified in the Work Plan: material erosion and deposition in the ITER-like Wall, Dust and First Mirrors. Activities in 2015 will be focused on: (i) the completion of analyses for materials retrieved in 2012 after 2011-2012 campaigns, (ii) work related to the 2014-2015 shut-down and (iii) first results for materials retrieved in that shut-down. The key objectives comprise the determination erosion-deposition pattern, quantification of fuel inventory and provision of data for modelling; the modelling work will be carried out under WPJET1 coordination.

Management

Project Leader. Sub-Project Leaders have been nominated to coordinate activities in three areas where several Associations contribute the programme: (i) Total Fuel Retention with Thermal Desorption Spectrometry (TDS), (ii) Modelling Co-ordination with WPJET1, (iii) Material Migration and Fuel Retention with Ion Beam Analysis (IBA)

Main Objectives

TOP THREE 2015 OBJECTIVES
• Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust. • Completion of analysis of materials retrieved in 2012 and integrated material migration picture based on complete set of results after 2011-2012 operation. • First results from the analyses of PFC and probes retrieved after 2013-2014 operation.

Description of work

WPJET2
Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
H2.2-D06: Dust: Qualify production mechanisms (2015)
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● The dust samples collected will be subsequently analysed for composition, size and fuel content.* *● These data will be used to calculate conversion factors from layers to dust and to validate models for dust production.*
H2.2-D07: Dust: Quantify dust production (2017)
- Quantify Be dust production and composition (ITER-IO expecting answers from JET2)
H2.2-D11: Erosion of ITER/DEMO relevant armour materials (2016)
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● First results from the analyses of PFC and probes retrieved after 2013-2014 operation* *- Completion of analysis of materials retrieved in 2012 and integrated material migration picture based on complete set of results after 2011-2012 operation.* *Post mortem analysis of tiles removed from JET will be used to quantify the rate of material erosion, transport and deposition and thus to validate models of these processes. In-situ measurements (quartz microbalance device, QMB) and shot-resolved observations (spectroscopy) shall be addressed. In addition, the elemental and chemical composition of deposited layers will be studied*

H2.2-D20: Post mortem analysis of mirrors exposed to JET plasmas (2015 and 2018)
- Post mortem analysis of mirrors exposed to JET plasmas provides unique information on the expected lifetime of first mirrors in ITER: *● The programme will investigate the change of the optical performance of test mirrors placed in various locations in JET (main chamber and divertor).* *● Analyses will be carried out to determine the impact of erosion-deposition processes on optical properties.*
H2.2-D01: Investigate evolution of melt layers of metallic surfaces, and their influence on the plasma behaviour (2015)
- Collaboration WPJET1 / WPJET2: Study completed in 2014. Modelling is ongoing. A new lamella will be installed in the 2014 shutdown for experiments in 2015. The objective is to resolve an anomalously low heat flux on the exposed tungsten edge compared to what is expected from geometric projection of the heat flux seen on normal lamellas. This problem is compounded by the fact that IR camera had a side view of the edge and cannot resolve the peak temperature.
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.2-D07: Dust: Quantify dust production (2017)
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● The dust samples collected will be subsequently analysed for composition, size and fuel content.* *● These data will be used to calculate conversion factors from layers to dust and to validate models for dust production.*

Use of EU facilities

JET

International Collaborations

IFERC-Rokkasho: Studies of dust retrieved after the 2011-2012 operation will be carried at IFERC-Rokkasho. After a long procedure the sample was shipped to Japan mid 2014.

UCSD: Marker layers on some wall probes (inserts in the inner wall cladding) were prepared by UCSD and the probes were exposed in 2011-2012.

2.2.3 WPJET3: Technological Exploitation of DT Operation

Set of Activities Number	03	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Technological Exploitation of DT Operation for the ITER preparation (WPJET3)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total EUROfusion resources 1,676.856 k€ (1,052 k€ EUROfusion contribution) including 15.53 ppy, Missions hardware and use of EU Facilities.

Objective

WPJET3 is a work-package of technology projects in conjunction with a DT experiment on JET, in the areas of neutronics, neutron induced activation and damage in materials, nuclear safety, tritium retention, waste production. The Work Package on the Technological Exploitation of DT operation (WPJET3) has therefore been launched with the objective to bring the necessary preparations for maximising the scientific and technological return of DT operations at JET. The JET3 Project objectives and scope are defined assuming that the Reference DTE2 scenario will be performed. The present Reference option is to perform a full DT campaign (DTE2) using the remaining 14 MeV neutron budget of 1.7×10^{21}, with operational phases in hydrogen, 100% tritium, extensive operation with 50:50 D:T mixtures and a tritium removal phase in deuterium. With this proposed budget, the achievable neutron fluence on the first wall of JET will be up to 10^{20} n/m^2, comparable to that occurring in ITER at the end of life in the rear part of the port plug, where several diagnostic components are located. The unique 14 MeV neutron yields produced in DTE2 will be exploited as much as possible to validate codes, models, assumptions, procedures and data currently used in ITER design thus reducing the related uncertainties and the associated risks in the machine operation. In order to fully exploit the nominal neutron budget available, and to obtain a full scientific return for the investment into the DT campaign, an accurate calibration of JET neutron detectors (235U fission chambers and the in-vessel activation system) at 14 MeV neutron energy must be performed using a DT neutron generator deployed inside the vessel by remote handling. The 14 MeV neutron flux/fluence will be used to irradiate samples of real ITER materials used in the manufacturing of the main in vessel components, such as W, Be, CuCrZr, 316L(N)-IG. The measured neutron induced activities will be used to validate the calculation predictions. The proposed DT campaign will require using 60 g of T in the AGHS plant, while the total releasable T inventory allowed outside the T plant is limited to 11 g T on the various cryo-panels and to 4 g on the mobile in-vessel inventory. The DTE2 campaign would provide accurate information on tritium retention in ITER wall materials. Also, other important ITER issues will be addressed such as the generation and characterization of waste, and the Occupational Radiation Exposure

(ORE) associated with specific tasks, which will be used to validate assumptions made and models used by IO.

The project will contribute to a variety of programmatic headlines of the Work Plan for the Implementation of the Fusion Roadmap in 2014-2018 : Headline 1.8: Develop integrated scenarios with controllers , Headline 2.2: Prepare efficient PFC operation for ITER and DEMO , Headline 4.1: Design and R&D of HCLL/HCPB et concepts , Headline 5.2: Integrated safety analyses and demonstration of safety margins in the design , Headline 5.3: Radioactive waste management , Headline 6.5: Heating & current drive systems , Headline 6.6: Tritium, fuelling vacuum systems , Headline 6.8: Diagnostics and control systems

Management

Project leader. The project comprises ten Sub-projects: Neutron detector calibration at 14-MeV neutron energy - NC14, Experiments for neutron transport & activation code validation – NEXP , Activation measurements for ITER material & data validation – ACT, Test of detectors for tritium breeder ets – TBMD, Functional material damage studies – RADA, Operational experience on occupational dose – NSAF, Measurement of T permeation, retention, outgassing and of airborne T – TRI, Waste production and characterization – WPC, DEMO-relevant studies, including Fuel cycle – DFC. In addition, there is a transverse area of activity on numerical analyses in support of all sub-projects for the characterisation of neutron field, activation and dose rates – NCAL- to provide the calculation of the neutron and γ-ray spectra and of other nuclear quantities needed for the activities in the sub-projects.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Calibration and characterization of the 14 MeV neutron generators to be used in the in-vessel calibration of the JET neutron detectors • Design of neutronics, activation and radiation damage experiments to be carried out at JET during DT operations. • Experimental plans for the measurements of tritium retention in ILW materials, and for the data collection on occupational dose and on waste generation and characterization.

Description of work

A detailed list of deliverables is in the WPJET3 Project Management Plan available under IDM https://user.efda.org/?uid=2KZHDK

Use of EU facilities

JET

International Collaborations

Collaboration is being established with US DOE on neutronics analyses of experiments carried out at JET with the objective to provide experimental validation of neutronics codes under development for ITER nuclear analyses

2.2.4 WPJET4: Enhancements

Set of Activities Number	04	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	JET Enhancements (WPJET4)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 2,326.355 k€ (1,817 k€ EUROfusion contribution) including 14.28 ppy, Missions, hardware.

Objective

In order to complete the exploitation of the JET ITER-like Wall and to take full benefit from deuterium-tritium experiments on JET, it is necessary to carry out a small number of system refurbishments or upgrades. First priority has been given to completion of projects funded by existing EFDA contracts.

Management

Main Objectives

TOP THREE 2015 OBJECTIVES
• Installation and commissioning during 2015 operations of the JET ITER-Like Antenna • Installation and plasma commissioning of the upgraded TAE system • Installation and commissioning of the vertical neutron spectrometer diagnostic

Description of work

The following table describes the work to be done in 2015 for each refurbishment or upgrade.

WPJET4
Support work PMP deliverables:
JET4-1: Re-installation of the JET ITER-like Antenna (2015)
The JET ITER-like antenna will provide increased central electron heating and allow more complete tests of tungsten control under Headline 1.5. The system will be re-installed during the shutdown to begin at the end of in 2014 and re-commissioned and exploited in deuterium plasmas in 2015 and in DT plasmas in 2017. Demonstration of reliable operation of the ILA is also viewed positively by the ITER IO as preparation for operation of their ion cyclotron heating system.
JET4-10: Correlation Reflectometer (2017)
The new correlation reflectometer started producing very interesting results during last campaigns. The effects of the different isotopic composition on the plasma turbulence and related effects (such as the modifications in the ELM behaviour) will be one of the main topics of the D-T campaigns. Unfortunately, the present diagnostic operates only in the W band. The installation of a 96-144 GHz band would allow improving the coverage, an essential ingredient during D-T operation when the number of pulses will be very limited and the maximum of information will have to be obtained from each of them. A new design of the front-end mirror will provide the Doppler shift measurement capability. This and further hardware procurement, installation and commissioning are planned for 2015.
JET4-11: Neutron Camera (2017)
The Neutron Camera is a JET diagnostic with the main function of measuring the neutron emissivity profile due to 2.5 MeV (DD) and 14 MEV (DT) neutrons over a poloidal plasma cross-section using line-integrated measurements along a number of collimated channels (lines-of-sight, LOS). The goals of the project are to increase of the performances and reliability of the 14 MeV neutron measurements performed by BC418 detectors and to assess the possibility of increasing the counting rate capabilities of the detection system based on NE213 detectors. In 2015 the data acquisition system for the BC418 detectors will be procured and initial related firmware version developed. Preliminary laboratory tests will also be performed.
JET4-3: Vertical neutron spectrometer (2015)
The vertical neutron spectrometer gives the best separation of neutron spectra from RF-driven and thermal sources, due to the RF-driven ion motion being mainly in the vertical poloidal plane. This also applies for neutron spectra from synergetic NBI plus RF-driven sources. This view complements the existing horizontal view, which gives the best separation of neutron spectra from NBI and thermal sources, as the NBI injection is pseudo tangential in the toroidal plane and gives rise to co- or counter streaming ion populations. The resulting information will be used to study and optimise fast ion confinement (Headline 1.7). This project was agreed as part of the 2012 Work Programme. Delays in launching the project and the need to commission the system on plasma mean that completion is now expected in 2015.
JET4-4: Refurbish the low energy neutral particle analyser (2017)
The refurbished low energy neutral particle analyser will allow measuring the plasma isotope mix in hydrogen, deuterium and tritium, important for Headline 1.6. This system requires a new generation of neutron-insensitive detectors and refurbishment of its data collection and control hardware. The upgrade system is only likely to operational in time for the DT campaigns in 2017.

JET4-5: Upgrade of the TAE system (2015)
The present amplifiers will be replaced with a new generation of independent amplifiers, one for each in-vessel antenna. During 2015 a new digital control system including the capability to control relative phase between the antennas will also be implemented with plasma commissioning foreseen.
JET4-6: Gamma Ray Spectrometer (2017)
KM6T and KM6S provide horizontal and vertical measurements, respectively, of the alpha particles via gamma ray emission spectroscopy of the nuclear reaction $^{9}Be(\alpha, n\gamma)^{12}C$. These views therefore allow obtaining information from two moments of the alpha velocity distribution. In order to provide good quality measurements in a full D-T campaign, KM6T should be upgraded to cope with the more challenging radiation environment. It is also worth pointing out that the enhancement of this diagnostic would be the continuation of a successful EP2 project (TCS). The proposed enhancement would consist of: installation of additional neutron shielding the torus hall; replacement of the polyethylene neutron attenuator with LiH; replacement of the BGO-detector with LaBr3; and replacement of the Silena ADC with digital DAQ. To maintain the capability of KM6S in D-T, it is necessary to reduce the flux of 14 MeV neutrons reaching the detectors. It is proposed to achieve this by the installation of a 2nd LiH neutron attenuator in the existing collimator. This technology has already been tested in previous campaigns with very positive results. In 2015 design, procurement and manufacturing activities are foreseen. Furthermore the work on both data acquisition system and on modelling tasks will be progressed.
JET4-7: Gamma Ray Camera (2017)
The gamma ray cameras provide information about the spatial localisation of the alpha particles by profile and tomographic reconstruction of the gamma-ray emission from the nuclear reaction $^{9}Be(\alpha, n\gamma)^{12}C$. At the expected high count rates of D-T campaigns, the replacement of CsI-detectors by compact LaBr3 is required to obtain acceptable measurements. Moreover, these new detectors would allow the full exploitation of the new digital electronics, successfully developed in the framework of an EP2 project (DNGG). Simulation calculation and detector development activities will be pursued in 2015.
JET4-8: Scintillator Probe (2017)
The scintillator probe measures the fast ion loss distribution as a function of time, energy and pitch angle. It is complementary to the Faraday cup system. The main physics focus of the diagnostic is the study of the mechanisms of loss of ICH tail ions and fusion alphas during MHD activity. To optimise its use during DT, a small upgrade is required: an upgrade of the DAQ electronics to match the response time of the scintillator and to allow measurements of fast ion losses due to fast MHD; and installation of a heated fibre jacket for compatibility with high neutron yield (DT) discharges. During 2015 the system requirements will be reviewed followed by scintillator screen characterisation and initial electronics tests.
JET4-2: Upgrade of the JET viewing system (2015)
The upgraded of the JET viewing system will allow safe operation of ITER scenarios with the ITER like wall for hydrogen, deuterium and tritium, deuterium-tritium with a high 14 MeV neutron flux. This upgrade is essential for addressing Headline 1.1. Three of the JET visible and infrared views will be upgraded for compatibility with deuterium-tritium operation. During 2015 conceptual, schematic and detailed design tasks will be pursued. The procurement process will also be initiated.

JET4-9: Lost alpha Gamma-ray monitor (2017)
This new diagnostic based on the detection of gamma-rays emitted by the Be-wall from the nuclear reactions $^{9}Be(\alpha, n\gamma)^{12}C$ was originally proposed for ITER (1991). However, such a diagnostic has never been deployed on a tokamak. On the other hand, lost alpha particles can be easily monitored in JET with the gamma-ray camera detectors that have a peripheral field of view. To make these measurements possible, a thick Be-target should be installed in the vessel below the equatorial plane in the field of view of the detectors. In this case the confined and lost alphas would be measured simultaneously using the same nuclear reaction and detectors. Currently this project is undergoing a strategy review.

Use of EU facilities

JET

International Collaborations

See section on WPJET1.

Participation of MIT (Massachusetts Institute of Technology) and IFUSP (Institute of Physics, University of São Paulo) as members of the TAE system upgrade project team through the framework of bilateral agreements.

2.2.5 WPMST1: Medium-Size Tokamak Campaigns

Set of Activities Number	05	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Medium-Size Tokamak Campaigns (WPMST1)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 16,576.934 k€ (12,720.105 k€ EUROfusion contribution) including 56.37 ppy, Missions, Use of EUROfusion facilities (9,844.800 k€).

Objective

Experiments on medium-size tokamaks complement the work at JET (WPJET1) to provide a step-ladder approach for extrapolations to ITER and DEMO. It will also cover areas and regimes, where MSTs have unique experimental capabilities and flexibility. Modelling for preparation, interpretation will be an integral part of the MST and JET work packages to ensure an efficient exploitation of the experiments and extrapolation towards ITER.

During the period 2014-18, a series of experimental campaigns and shutdowns are planned at the European divertor tokamaks. ASDEX Upgrade with its all tungsten plasma facing components will play an important role as a medium sized counterpart to JET specifically for experimental investigation which relies on all metal plasma facing components. In 2015, AUG experiment will benefit of the installation of two new three straps ICRH antenna to increase the power (generator power 7MW) while minimizing the source of W through the reduction of the rectified RF sheath. The European exploitation of ASDEX Upgrade, done in parallel with the IPP internal program, will start in June 2015 and up to the end of the year (no operation in August until mid-September).

During 2014, TCV is undergoing a major upgrade in heating power, which will allow from 2015 on amongst other issues proof of principle investigations on snowflake divertor configurations.

The super-X divertor will be investigated in MAST-U from 2016 on after about 2 years of shut down and initial commissioning. The detailed distribution of resources during 2016 has to be decided late 2014 or early 2015.

Machine capabilities of contributing MST devices in 2015

- ASDEX Upgrade capabilities:

  - $R = 1.65$ m, $a = 0.5$ m, $B_t = 3.1$ T, $I_p = 1.4$ MA, all W PFCs.
  - Additional power (Power supplies allow up to 25 MW heating simultaneously):

    - NBI ≈20 MW
    - ICRH ≈ 7 MW (30, 36 MHz) with 2015: two new three straps ICRH antenna for reduced W source
    - ECRH I ≈ 4x0.5 MW (140 GHz) and ECRH II ≈ 4x1(0.8) MW (140, (105) GHz) with mirrors steerable in poloidal and toroidal direction for CD.

  - Fueling and pumping: Highly flexible gas injection system (new in 2014), highly flexible pellet injection system, Cryo-pump with full and 1/3 pumping capacity (new in 2014, for high recycling scenarios)
  - Magnetic perturbations: rotating magnetic perturbations with 2x B-coils by new BUSSARD power supply at $f < 500$ Hz

- TCV capabilities :

  - $R = 0.88$ m, $a = 0.25$ m, $I_p < 1$ MA, $B_t < 1.54$ T, $\kappa < 2.8$, $-0.6 < \delta < 0.9$
  - Duration 2 s (4 s max) discharge
  - Auxiliary heating in 2015 and foreseen in 2016 -2018:

    - until Aug 2015: 1.2 MW X2 ECRH, 1.35 MW X3 ECRH
    - Sep-Dec 2015: 1.2 MW X2, 1.35 MW X3, 1 MW NBI
    - Jan-Jun 2016: 2 MW X2, 1.35 MW X3, 1 MW NBI
    - from Jun 2016: 2.7 MW X2, 1.35 MW X3, 1 MW NBI
    - from late 2017: additional 1 MW switchable X2/X3
    - from late 2018: additional 1 MW switchable X2/X3

Experimental planning

Fig. 1 shows the overview of the planning of the 2015 experiments on ASDEX Upgrade and TCV. The draft timeline for the experiment execution will be continuously updated and detailed to allow an efficient planning of the necessary travel arrangements.

- Campaign on ASDEX-Upgrade

The European exploitation of ASDEX Upgrade done in parallel with the IPP internal program, will start in June 2015 and up to the end of the year (no operation in August until mid-September) and will comprise about ≈30 operational days (figure to be confirmed with the exact 2015 budget, cost of operation and scientific priority). The foreseen ASDEX Upgrade operation in 2015 is as follows

  - Nov 2014-April 2015 shutdown fort the installation of two 3-strap ICRF antennas and steel heat-shield
  - mid May 2015: Restart and IPP internal programme
  - mid June - end July 2015: Experimental EUROfusion operation and IPP internal programme
  - mid Sept – Dec 2015: Experimental EUROfusion operation and IPP internal programme

- Campaign on TCV

The European exploitation of TCV done in parallel with the CRPP internal programme will start in August 2015 and up to the end of the year and will comprise about ≈15 operational days (figure to be confirmed with the exact 2015 budget, cost of operation and scientific priority). The foreseen TCV Upgrade operation in 2015 is as follow

  - until Nov 2014: shutdown for vessel modifications in preparation for NBI
  - Dec 2014-Feb 2015: technical commissioning and initial physics domestic campaign
  - Mar-Apr 2015: shutdown for NBI installation
  - May-Aug 2015: NBI commissioning and first physics campaign (possibility to include EUROfusion experiments with ECRH only since NBI is not guaranteed)
  - Sep-Dec 2015: Second physics campaign - Experimental EUROfusion operation (with NBI and ECRH) and CRPP internal programme. Possibility of one-month break to install a replacement X2-X3 gyrotron

- Code development and modelling

Modelling for preparation and interpretation will be an integral part of the work package to ensure an efficient exploitation of the MST and JET experiments.

Management

Five MST1 task force leaders have been selected in September 2013. The Task Force Leaders ensure the execution of the programme in line with the priorities approved and bring together communities dedicated specialists from all over Europe. The task force provides the diversity of scientific competence and capabilities needed for the execution of the programme and they ensure an integrated approach to the key elements in Mission 1 & 2 of the European Roadmap. In addition they provide the link to the JET TFLs and the basis for international collaborations, particularly for ITER high-priority multi-machine co-ordinated experiments. The TFLs are assisted in their tasks by members of the Programme Unit. Following a call for participation, the experimental proposals will be screened by the MST TFLs (and JET TFL for the joint experiment) who will foster discussions amongst the proponents to consolidate the set of proposals and to fill obvious gaps. Out of this set the TFLs will draft an experimental program which will be discussed at the common (JET, ASDEX Upgrade and TCV) General Planning Meeting (January 2015 in Lausanne). Shortly after the GPM a rough draft timeline for the implementation of the European exploitation of ASDEX Upgrade, TCV and JET will be issued to allow for a call for manning.

For the 2015 MST experimental campaign the same topical block structure as in 2014 will remain with three scientific blocks: 1) scenario and confinement, 2) MHD and control, 3) Plasma Wall Interaction and edge. In 2015 it is proposed that, within this structure of three blocks, the experiments will be divided in two main categories: (a) 'flagship' experiments and (b) 'proof of principle' experiments. Flagship experiments will address high priority topics and will have a significant number of discharges, with a sufficient number of contingency shots to ensure the highest probability of success. It is planned to set up important scientific teams, assembling all relevant skills, to run them in an integrated manner. When possible and relevant they will be in a coordinated manner with JET experiments, sharing scientific team members and expertise. Proof of principle experiments will be dedicated to new ideas with future high potential.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Understand the effect of density versus collisionality and operation with an all metal wall for ELM mitigation/suppression with pellets and resonant magnetic perturbations. • Increase efficiency and understanding of methods for disruption mitigation or avoidance and runaway electrons control • Increase the operational margin for ITER and DEMO relevant scenarios with high PSOL/R and tolerable target heat loads.

Description of Work

The following table summarises the key deliverables for WPMST1 in 2015 for each relevant headline.

WPMST1
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D01: Study heat, particle and momentum confinement in conventional and improved H-modes and hybrids and the dimensionless scaling towards ITER (2015)
- Collaboration WPJET1 / WPMST1: Pedestal model validation with H and D plasmas.
- Study the impact of Helium as minority impurity (fusion product leading to 10-20% He concentration) on H-mode confinement in TCV and AUG– approximatively 10-30% He. *- Complete study of scaling of intrinsic rotation and impact of sawteeth on momentum transport (AUG and TCV).*
H1.1-D03: Qualification of improved H-mode confinement at large machine size and at full machine performance (2015)
- Collaboration WPJET1 / WPMST1: Extend high performance phase (H>1.3) to 5s for stationary high performance DT scenario. Use ASDEX-U and JET similarity experiments to extrapolate to next step devices.
H1.1-D04: Characterise L-H threshold power and access to H98(y,2)≈1 (e.g. power) in ITER-relevant conditions (2015; T&DT 2017)
- Collaboration WPJET1 / WPMST1: collect data for the L-H scaling law including the effect of seeding gases and comparison with JET/AUG.
- Study L-H transitions and access to type-I ELMy H-mode with impurity seeding towards high mantle radiation and high density on AUG and TCV. *- Improve scaling of the L-H transition power at low density where the conventional scaling does not work.*
H1.1-D06: H-mode and hybrid confinement scaling in regimes with high radiated power fractions (2018)
- Develop an integrated ITER baseline scenario (at low β_N*≈1.5-1.8) with impurity seeding in AUG.* *- Develop high radiative power fraction scenarios with good confinement for both low and high triangularity plasmas at high* β_N*=2.5-3 (ITER improved H-mode and DEMO relevant).* *- Also part of H1.2 deliverable H1.2-D05 "Establish scaling of small/no ELM regimes with high mantle radiation close to the density limit".*

H1.1-D07: H-mode and hybrid confinement scaling near the density limit (2015; 2017 with isotope dependence)
- Develop operational conventional and hybrid scenarios at low and high triangularity and study their confinement near the density limit.
H1.1-D09: Develop physics models for the density limit (2018)
- Collaboration WJET1 / WPMST1: Perform TCV density limit studies and compare with AUG and JET results.
H1.1-D11: Develop gas puff technique and related modelling to maximise ICRF power in H-mode independently of the edge conditions (2017)
- Study and optimise use of gas puff for ICRH coupling in AUG.
Headline 1.2: Operation with reduced or suppressed ELMs
H1.2-D01: Quantify difference of ELMs, edge pedestal and L-H transition in H, D, T and He plasmas (2017)
- Subject to WPMST1-AUG He campaign: *● Test the transferability of RMP ELM mitigation techniques to Helium in particular with respect to impurity influx.* *● Measure the inter ELM evolution and ELM energy losses in Helium.* *● Quantify the effect of impurity seeding in Helium with respect to ELM mitigation and impurity control.*
H1.2-D04: Develop small / no ELM regimes scenarios and extrapolate towards low collisionality-high density (2015; Extrapolation: 2020)
- Type III collisionality stepladder study with JET.
H1.2-D05: Establish scaling of small/no ELM regimes with high mantle radiation close to the density limit) and extrapolate to low collisionality (2015 (D), 2017 (T&DT); Extrapolation: 2019)
- Establish the operational range of small ELMs in discharges close to the density limit and with high mantle radiation on AUG and develop similar regimes on TCV (linked to HL-1.1).
H1.2-D06: Construct empirical confinement scaling laws, as for the ELMy H-mode, for small/no ELM regimes (2018)
- Data to be collected under other H1.2 deliverables.
H1.2-D07: (a) Develop and validate ELM model (for small ELMs) particularly with respect to: 1. Reproducing observed expansion of wetted surface during ELMs; 2. Explain the difference between inner/outer target and main wall; 3. Explain the fractional loss dependence of collisionality and on plasma impurity content; 4. Prediction of the dependence on ρ^*; 5. Validation of models for pellets pacing (b) Validate pedestal models (2018)
- Collaboration WPJET1 / WPMST1: Test non-linear ELM model on AUG and JET plasmas.
- Model AUG discharges with mitigated ELMs using 3D stability and equilibrium codes.
-Collaboration WPJET1 / WPMST1: Simulate one JET and one AUG discharge with first principle code.

H1.2-D08: Extrapolate ELM avoidance/mitigation techniques to low collisionality but high density and assess the impact on confinement and the L-H transition (2018)
- Extend studies of ELM mitigation with RMPs to n=4 and compare to existing MAST data (task) including the effect on the L-H transition. *- Study RMP and pellet ELM mitigation with impurity seeding at low density to disentangle the effect of density and collisionality.* *- Demonstrate ELM mitigation/ suppression (magnetic coils and pellets) scenarios in ITER baseline plasmas as well as in high β_N high radiative fraction scenarios (AUG).*
H1.2-D09: Test compatibility of shallow pellet fuelling with ELM avoidance/mitigation (2017)
- Quantify the effect of refuelling of RMP ELM mitigated n=2 and if available n=4 using shallow pellets.
H1.2-D10: Establish a scaling of the H-mode power threshold at low density and assess the role of SOL / divertor and ELM mitigation technique (2017)
- Continue studies on divertor geometry on the L-H transition including snow flake configurations on TCV and AUG (overlap with HL 2.4). *- Establish scaling of the low density branch of the L-H transition with density, plasma current and toroidal field on TCV and AUG.* *- Continue studies of the effect of RMP ELM mitigation on L-H transition on AUG and on plasma turbulence.*
Headline 1.3: Avoidance and mitigation of disruption and runaways electrons
H1.3-D01: Develop robust operation of ITER scenarios and their safe termination (2015)
- Experiments in AUG exploiting 2 (or 3 if available) fast DMVs. Explore current quench dynamics. *- Continue experiments on disruption avoidance via ECRH/ECCD.* *- Explore disruption mitigation in high β scenario.*
H1.3-D06: Document conditions for run-away electron generation and mitigation (2015)
- Continue studies of runaway generation in AUG and TCV, supported by high resolution run-away electron diagnostics. *- Study run-away electron mitigation with MGI in AUG.* *- Additional data from WPMST2 project (MST2-9).*
H1.3-D07: Test control of runaway electrons by alternative methods (non-axisymmetric fields) (2015)
- Explore possibility of RE beam decorrelation via magnetic perturbation *- Additional data from WPMST2 project (MST2-9).*
H1.3-D09: Develop disruption prediction methods that minimise the requirements for model training on ITER and real-time predictors methods optimised in term of model training, success rate, anticipation time, differentiation among different types of disruptions (2018)
- Application of JET predictor at AUG
H1.3-D10: Develop full 3D codes (plasma + vessel) to describe halo current formation and asymmetries (2020)
- Collaboration WPMST1 / WPCD: Benchmark codes against AUG data.

H1.3-D11: Qualification of Massive Gas Injection as a mitigation method for heat loads and forces (fuelling efficiency, local peaking of radiation load as function of MGI parameters and plasma conditions) (2015)
- Investigate the effect of toroidal and poloidal asymmetries on disruption mitigation with MGI. *- Assess the ratio of radiated power to divertor power during MGI, with high resolution diagnostic and in a broad database.* *- Assess the fast dynamics of injected impurities by means of high resolution diagnostics.* *- Test transferability of disruption mitigation methods in He (experiment and numerical simulation).*
H1.3-D12: Develop Disruption workflow – including ELM module/RMP (2017)
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium
Headline 1.4: Integration of MHD control into plasma scenarios
H1.4-D01: Demonstrate integrated and routine sawtooth control in high performance, inductive scenarios (2016)
- Sawtooth control experiments on TCV and AUG up to high β, with various tools (ECCD/ECRH, magnetic perturbation,..) ($\beta_N \lesssim 3$).
H1.4-D03: Define system requirements / control algorithms for non-inductive scenarios (2020)
- Continue experiments to improve understanding of the interaction of magnetic perturbations with the plasma towards high β, also testing control algorithms (synergy with MST2 project MST2-9)
H1.4-D04: Improve modelling of mode dynamics to take into account realistic wall geometries (RWM) and actuators (NTM and RWM) (2018)
- Collaboration WPCD /WPMST1: RWM workflow validated on multiple devices (benchmark codes against AUG data).
H1.4-D05: Develop first principles understanding and simulation capability for NTM dynamics including wave-particle absorption in magnetic island. Validate such models (2020)
- Continue 2014 experiments *- NTM control experiments: Active stabilisation of (2,1) mode. Pre-emptive stabilisation using RAPTOR feedback model.*
H1.4-D06: Clarify role of low rotation in mode stability (2016)
- Explorative experiments.

Headline 1.5: Control of core contamination and dilution from W PFCs
H1.5-D01: Demonstrate acceptable W concentration in the foreseen reactor regimes (H-mode, hybrid and non-inductive) ITER wall materials and inductive operation: 1. Investigate the effect of ELM suppression and mitigation on high-Z peaking; 2. Develop high-Z accumulation avoidance by means of central electron heating, eventually also alpha heating; 3. Minimise heavy impurity sputtering and local heat loads by optimisation of plasma edge and reduction of ICRF sheaths. (2015 (2017 for DT) for standard H-mode, 2018 for improved H-mode (hybrid), 2020 for non-inductive scenarios)
- Study high Z transport in ELM mitigated low collisionality plasmas. *- Use new ICRH antenna to develop high density scenarios (when EC does not go to the core)*
H1.5-D02: Develop and validate models for impurity transport in the foreseen reactor regimes. Link to the model development in Headline 1.6. (2020)
- Testing of models with 2014 AUG results
H1.5-D03: Develop and validate models for RF sheaths in order to minimise heavy impurity sputtering and local heat loads - includes test of RF sheaths models (work on test stands, modelling and antennas design) (2018)
- Characterisation of new 3 straps ICRH antenna. *- Synergy with MST2 project MST2-10 and MST2-11.*
Headline 1.6: Determine optimum particle throughput for rector scenarios
H1.6-D02: Validation of models for core particle convective transport, pellet ablation and drifts. Link to the model development in Headline 1.5 (2015)
- AUG experiments to compare shallow pellet fuelling with gas fuelling.
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
H1.6-D06: Test of particle throughput in conditions matching the foreseen ITER pumping capabilities (2015)
- AUG experiments without cryo or with reduced cryo (only 1/3 of segments cooled).
H1.6-D10: Determine effect of pumping-/ divertor-geometries on He-pumping, including fuelling, pellets injection etc (2017)
- As part of H1.1-D01 "Study heat, particle and momentum confinement in conventional H-mode and improved H-modes (hybrid) and the dimensionless scaling towards ITER (2015).
H1.6-D11: Determine technological and physics limits on density peaking (2016)
- Continue AUG core fuelling experiments: extension to stationary conditions, use of shallow pellet.
Headline 1.7: Optimise fast ion confinement and current drive
H1.7-D02: Investigation of fast ion losses and their power scaling for various scenarios (2017)
- Study effect of ECRH/ECCD on Alfvén instabilities; determine viability as a control technique. *- Quantify and characterise effect of sawteeth on fast ion redistribution (completing preliminary 2014 experiments)*
H1.7-D03: Study the slowing down and losses of fusion alpha particles in JET during the 'after-glow' phase of high performance DT discharges (2017)
- Quantify the slowing-down and confinement of energetic He from He-doped beams.

H1.7-D07: Investigate the effect of fast ion confinement on current drive (2015)
- Extend 2014 experiments with AUG power scan.
H1.7-D08: Assess and document off axis current drive performance (2018)
- Document NBCD and determine on- vs off-axis efficiency; and document fast ion population, dynamics and losses as functions of plasma parameters (power, density, current). *- Determine dependence of anomalous fast-ion transport on E/T_e, on beam isotope, on Z_{eff}.*
H1.7-D10: Improving fast ion diagnosis on the current devices (2016)
- Exploitation of the new detector for poloidal detection (FILD4 & FILD5) for AUG *- Synergy with WPMST2 project MST2-3*
Headline 1.8: Develop integrated scenarios with controllers
H1.8-D01: Demonstrate combination of individual control algorithms into integrated control scenarios: Combine avoidance of NTMs, possibly via sawtooth control, with control of ELMs, disruptions, core contamination, divertor detachment, fuel species mixture and simulated burn (2018)
- Demonstrate integrated control of three or more among NTMs, sawteeth, ELMs, disruption mitigation and divertor detachment, using diagnostic observers + real-time modelling and assessing minimal necessary observer set. Coordinate jointly on AUG and TCV.
H1.8-D03: Test of minimum diagnostic and actuator set for control: Develop and test measurement techniques for ITER and DEMO (2015, DT-related 2017)
- cf H1.8-D01.
Headline 2.1: Detachment control for the ITER and DEMO baseline strategy
H2.1-D01: Develop and test relevant sensors and actuators for detachment detection and control (2015)
- Investigate substituting machine specific sensors with more general measurements.
H2.1-D02: Investigate/document confinement at detachment for different fuelling methods / locations (2015)
- Analysis of existing database, although a dedicated experiment is desirable.
H2.1-D03: Document H-L threshold scaling up to Greenwald density limit at high auxiliary heating power (2015)
- Part of studies for H1.1-D04 "Characterise L-H threshold power and access to H98(y,2)≈1 (e.g. power) in ITER-relevant conditions (2015; T & DT 2017)".
H2.1-D04: Document influence of shaping on heat loads (steady state, ELMs) in the divertor (2015)
- Analysis of existing database.
H2.1-D05: Optimise impurity mix for divertor and mantle radiation (2015)
- Extend experience with high Z core radiation and high SOL radiation.
H2.1-D06: Benchmark codes to predict detachment, particle and power loads in ITER and DEMO (linked to Headline 2.3) (2017)
- On-going. Continue analysis.
H2.1-D07: Document detailed conditions to reach detachment at highest available P_{sep}/R and close to Greenwald density limit and quantify particle and power loads to the main chamber (2015)
- Document detachment conditions on TCV.

H2.1-D08: Investigate the compatibility of W with extrinsic impurity seeding / optimize impurity mix for divertor and main chamber radiation (linked to Headline 2.2) (2018)
- Open call for physics studies on AUG.
H2.1-D09: Compare influence of different divertor geometry on heat loads (2018)
- AUG experiments may follow analysis of 2014 studies for open and closed divertor. *- First WPMST1-TCV experiments will concentrate on divertor leg length.*
H2.1-D10: Demonstrate low W sources and W core penetration for (partially) detached divertor conditions and relevant P_{sep}/R (2018)
- Scan of radiation fraction on AUG.
H2.1-D11: Demonstrate compatibility of detachment with ELM mitigation methods / ELM-free / 'small' ELM scenarios (2016)
- Study effect of RMPs on access to detachment on AUG.
Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
H2.2-D04: Minimisation of divertor and main chamber erosion, quantify (and try to extrapolate) main chamber filamentary transport (expected particle flux and energy) (2015)
- Dedicated studies for first wall particle and heat load transport by comparing divertor (IR and probes) and first wall (IR and probes) in AUG and TCV
H2.2-D05: Validate codes on plasma wall interactions (erosion, re-deposition and migration) (2016)
- Study effect of divertor target shape on plasma surface interactions.
- Collaboration WPJET1 / WPMST1 / WPPFC: Test codes on expanded database
H2.2-D06: Dust: Qualify production mechanisms (2015)
- Supported through piggyback studies
H2.2-D07: Dust: Quantify dust production (2017)
- Supported through piggyback studies
H2.2-D01: Investigate evolution of melt layers of metallic surfaces, and their influence on the plasma behaviour (2015)
- Complement studies performed at JET with AUG studies using the divertor manipulator.
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.3-D04: Optimise predictive models for ITER and DEMO divertor/SOL: Development of computational tools for edge transport extending up to PFC (2018)
Application of SOLPS to TCV SOL geometry studies. Interpret simple attached cases based on AUG 2014 L-mode plasmas.
H2.3-D03: Validation and exploitation of turbulence and synthetic probe workflow for experiment analysis (NEW) (2015)
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis (TCV, JET if probes / probe data available)

Headline 2.4: Investigate alternative power exhaust solutions for DEMO
H2.4-D01: Proof of Principle of detachment control in alternative divertor geometries: document detailed conditions to reach detachment at highest available PSOL/R and close to Greenwald density limit (2016)
- Characterisations of plasmas in snowflake configuration with respect to high density operation. Characterisations of plasmas in snowflake configuration with respect to seeded operation. Study of L-H and H-L transition with divertor geometry on AUG and TCV, including snowflake configuration.
H2.4-D02: Proof of Principle of detachment control in alternative divertor geometries: Demonstrate removal of peak load (2016)
- Study of power deposition profiles during snowflake operation under attached conditions.
H2.4-D03: Proof of Principle of detachment control in alternative divertor geometries: Assess effect of transients (β, li) on control of divertor geometry (2016)
- Characterise stability of snowflake configuration during ELMs and sawteeth.

Use of EU facilities

AUG, TCV

International Collaborations

MST1 TFLs and scientists will collaborate with those on tokamaks outside of Europe.

2.2.6 WPMST2: Preparation of Exploitation of Medium-Size Tokamaks

Set of Activities Number	06	Start Date or Starting Event	01-Jan-15
Set of Activities Title	Preparation of Exploitation of Medium-Size Tokamaks (WPMST2)		
Participant Number	Short name of Participant	Person-months per Participant:	

Resources: Foreseen total resources of 2,829.175 k€ (1,344 k€ EUROfusion contribution) including 20 ppy, missions and hardware.

Objective

This work package comprises Projects which are necessary for a successful exploitation of the MSTs. They are either directly linked to a headline specific deliverable or provide a more general support to one or several headlines. It is expected that during the execution of the Work Plan further Tasks will have to be defined. These Projects include diagnostic development, work on test stands and modelling activities to develop efficiency of heating systems, complementary work on small size devices necessary for scaling laws, preparatory work on small size devices when the extrapolation of the result to MSTs is relevant (for example for safety reasons), off-line development of control algorithms and control tools before final real-time optimisation and validation.

Management

Programme Management Unit through individual Project Leaders

Description of work

The full detailed lists of deliverables are in the WPMST2 Project Management Plans. The table below describes the current 2014 MST2 project which is likely to continue at least part of 2015. The addition of the following additional projects for MST2 in 2015 was discussed between the MST1 TFLs and the PMU.

- Gold foil bolometers on MST for runaway and disruptions studies. Upgrade, new systems for tomography etc.
- Imaging of runway electron beam on MST
- Developing the adaptor to facilitate interchangeable probes between MST devices
- Improving special and spectral resolution of TCV TS system
- Pedestal reflectometer on TCV

– New infrared periscope system on AUG

WPMST2
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D11: Develop gas puff technique and related modelling to maximise ICRF power in H-mode independently of the edge conditions (2017)
- WPMST2 PMP number MST2-10: Implementation of multichannel edge density profile reflectometer for ICRF antenna on AUG (completion date April 2015). 2015 deliverables: *● Electronic installation report* *● Elaboration of a software for density reconstruction* *● Final report after commissioning*
H1.1-D12: Improve arc detection systems during ELMs (work on test stands and RF systems) (2017)
Specific MST2 call for the arc detection system during ELMs is planned for WP15 under WPMST2 umbrella
Headline 1.3: Avoidance and mitigation of disruption and runaways electrons
H1.3-D06: Document conditions for run-away electron generation and mitigation (2015)
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (ongoing project)
H1.3-D07: Test control of runaway electrons by alternative methods (non-axisymmetric fields) (2015)
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (ongoing project)
H1.3-D08: Validation of runaway generation model : determine runaway heat loads and forces in case of loss of control (2018)
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (ongoing project). H1.3-D06,D07,D08 in MST2 will be jointly addressed in collaborative efforts on FTU and COMPASS tokamaks (in support of MST and JET activities): *Highlights of FTU contribution(experiments and supporting activities) in WP15 include :* *• determination of critical field by investigation of runaway suppression (as in DIII-D)* *• extension of parameter range for runaway generation* *• runaway control, also in X-point configuration* *• development of a new RE controller based on the linearized current and position model* *Work on COMPASS will concentrate on two main campaigns:* *• benchmarking of the GO and LUKE models* *• the role of plasma shaping and plasma limited or diverted configurations in runaway generation* *• In addition, project relevant hardware enhancements, including two more HXR detectors (for poloidal studies) and further development of Cherenkov detectors, are also planed*

Headline 1.5: Control of core contamination and dilution from W PFCs
H1.5-D03: Develop and validate models for RF sheaths in order to minimise heavy impurity sputtering and local heat loads - includes test of RF sheaths models (work on test stands, modelling and antennas design) (2018)
- WPMST2 PMP number MST2-10: Implementation of multichannel edge density profile reflectometer for ICRH antenna on AUG. Completion April 2015. *- WPMST2 PMP number MST2-11: Studies of RF sheaths and diagnostics on IShTAR. 2015 work:* *● IShTAR hardware and experiments: Find the best operating conditions in order to reach the highest plasma density and largest plasma volume, and start operation with other gases* *● Antennas: Finalise the design (foreseen for 2014), construct and install the single strap antenna.* *● Diagnostics: construct a probe array and/or movable probe for measuring density profiles in 2D or 3D & Installation of a spectrometer*
Headline 1.7: Optimise fast ion confinement and current drive
H1.7-D10: Improving fast ion diagnosis on the current devices (2016)
- WPMST2 PMP number MST2-3: Implementation of the scintillator-based fast ion loss detectors (FILD) on MAST and AUG (completion date Dec. 2015). 2015 deliverables *● Installation of new detector for poloidal detection (FILD4 & FILD5) for AUG* *● Installation of out-vessel components including reciprocating and light acquisition systems* *● Dedicated experiments to validate first experimental data* *- WPMST2 PMP number MST2-4: Development study of the upgrade for Neutron Calibration on MAST-U (completion date Dec. 2014)* *● 2015: construction of the neutron camera upgrade pending on cost request*
Headline 2.1: Detachment control for the ITER and DEMO baseline strategy
H2.1-D12: Improve divertor and SOL diagnostics to allow new insight in underlying physics (n_e, T_e, T_i, flows, impurities) (2016)
- WPMST2 PMP number MST2-1: Implementation of the super-X Divertor TS diagnostic on MAST-U tokamak (completion date Dec. 2015). 2015 deliverables: *● Completion of collection optics;* *● Installation of LASER beam in MAST-U area.* *- WPMST2 PMP number MST2-2: Implementation of snow flake IR Imaging diagnostic on TCV tokamak (completion date March 2015). 2015 deliverables:* *● Commissioning of improved snow flake IR imaging diagnostic*
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.3-D06: Optimise predictive models for ITER and DEMO divertor/SOL: Self-consistent coupling between core and edge transport codes (2015)
- ITER modelling effort on COMPASS with SOL1D: to be considered under WPMST2.

Support work PMP deliverables:
MST2-12: Support work for Headline 1.1: Power decay-length scaling and pedestal scaling studies and related diagnostics in support of MST and JET (2016)
2015 deliverables: *– Populate the database for pedestal scaling* *– Routinely operating Li-beam emission spectroscopy* *– Scaling of SOL power decay length for various plasma conditions in limited circular plasmas* *– Divertor power decay length scaling for various plasma conditions in diverted L-mode and H-mode* *plasmas*
MST2-5: Diagnostics upgrade for Headline 1.4 and Headline 1.8 studies: Implementation of imaging MSE on AUG (2015)
Completion Dec. 2015. 2015 deliverables: *- Install the in-vessel optical relay system on site* *- Perform measurements using the new in-vessel optical relay system and the existing ex-vessel IMSE prototype* *- Design, build and commission the new optimised IMSE system*
MST2-6: Diagnostics upgrade for Headline 1.4 and Headline 1.8 studies: Implementation of the high accuracy Thomson scattering pedestal diagnostics for bootstrap current measurements on AUG (2015)
Completion Dec. 2015. 2015 deliverables: *- software development* *- complete installation and calibration* *- commissioning*
MST2-7: Support work for Headline 1.4 and Headline 1.8: Real time control of error field and MHD modes on MAST and AUG (2017)
2015 deliverables: *- report on design and installation of MAST-U real-time control*
MST2-8: Support work for Headline 1.4 and Headline 1.8: Implementation of real-time plasma prediction and feedback control using RAPTOR on TCV and AUG (2016)
2015 deliverables: *- Implementation of an integrated controller on TCV and/or AUG*

Use of facilities

To be defined within each specific project

International Collaborations

None foreseen.

2.2.7 WPPFC: Preparation of efficient PFC operation for ITER and DEMO

Set of Activities Number	07	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Preparation of efficient PFC operation for ITER and DEMO (WPPFC)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 3,589.717 k€ (1,806.582 k€ EUROfusion contribution) including 36.52 ppy, missions and hardware.

The consequence of WEST inclusion on the work plan 2015 -2017 is detailed in a separate document. EUROfusion will only finance activity in line with the panel recommendation. For 2015 the estimated total resources are 3,296 k€ (1,497 k€ EUROfusion contribution) including 13 ppy, 20 days of heat load/post mortem facilities, and 20 days of operation of EUROfusion linear facilities. It is proposed to fund the activities by bringing forward resources that are reserved for mission 2 activities in 2018, so basically this boils down to transferring budget from one to another work package within mission 2.

Objective

WPPFC represents a central part of the EUROfusion contributions to mission 2 within 3 headlines. WPPFC is structurally divided into two parts:

(a) the first one deals with conventional metallic plasma-facing materials, thus ITER-like materials (Beryllium and Tungsten) as well as advanced materials like Wf/W (fibre-enforced tungsten) or EUROFER foreseen for DEMO and, potentially useful as PFCs

(b) The second one addresses the issue of advanced plasma-facing materials components employing liquid metals like Li, Sn or corresponding alloys as base material.

Activity (a) is more advanced than (b) and indeed more detailed studies under steady-state and transient loads are goal of (a) whereas (b) is addressing basic plasma-surface interaction studies. However, the focus of both lays in the full characterisation, exploitation, and qualification of the plasma-facing materials and components in view of ITER and DEMO needs and provision of enough conclusive information to qualify liquid PFCs for a potential use in the DTT within the next 3 years.

Part (a) activity is addressing the three key areas which ensure a safe and efficient use of PFCs for ITER and DEMO: the lifetime aspect (e.g. by transients and steady-state operation, material, erosion, surface damage etc.), the safety aspect (fuel retention, neutron damage and its impact on retention, seeding...), and the predictive modelling (code validation for

ITER and DEMO). Five subprojects have been created to cover these areas in detail and to bridge the tests and development in linear devices to the operation and tests in tokamaks:

- Power and particle load studies and qualification (SP1);
- PWI Processes I: erosion, deposition and mixing (SP2);
- PWI Processes II: fuel retention, fuel removal and material damage (SP3);
- Plasma-characterisation and modelling (SP4);
- Post-mortem analysis and material migration (SP5)

The bridge between linear device and tokamak test is insured via the application of theoretical interpretation and numerical modelling which covers plasma edge modelling with the main plasma modelling codes (SOLPS, EIRENE etc.) combined with surface interaction codes (ERO, WallDyn etc…). Additional information is obtained by dedicated laboratory experiments addressing the physics behind the different plasma-wall interaction processes, addressing the power handling capability as well as post-mortem analysis with various techniques required to get an inside e.g. in the structural changes caused by neutron or self-damage. WPPFC covers here the full cycle of material migration: erosion, transport, deposition associated with material mixing and fuel retention, finally ending in dust production. Not only the integral process in tokamaks is covered by analysis of post-mortem analysis of components, also the detailed physics processes on atomistic level is studied, modelled and transferred to larger scale models used finally for predictions of material migration, fuel retention and dust production in ITER and DEMO. These detailed studies allow also the optimisation of materials as well as allows the development for solutions for critical processes like fuel retention via fuel release techniques. The subprojects address different aspects of the process, but also are complementary and feed each other to provide the full answer to questions of plasma-surface interaction with ITER grade materials and advanced materials for DEMO. Analysis methods include the full set of post-mortem analysis techniques in the different European laboratories which are working together ensuring with complementary techniques answers to specific questions. In order to be able to compare different studies and exposures standard grades of plasma-facing material and preparation are provided in order to compare the experimental and modelling results.

The power handling studies are focused on transient simulations in test components with loading by electron beams, ion beams, LASER or by pulsed or steady-state plasma impact. Synergistic effects of power load and plasma load as well as the impact of intrinsic (C, O, He) and extrinsic impurities (Ar, Ne, N_2) and the role of neutron damage on PFC performance and surface properties are the main variants in the investigations. The studies finally end in ITER mock-up testing under divertor or main chamber conditions in linear plasma devices and, if appropriate, in beam devices for certain aspects which can be used as references for advanced materials. Comparison of the different loading techniques with respect to physical impact and material damage in transients is studied in 2014 allowing a direct comparison and potential exchange of results from the different techniques.

The international panel in charge of the evaluation of WEST as a EUROfusion facility has recommended that it is located within the WPFC project with existing high heat flux facilities and linear machines for the first period 2015-2017 of WEST (phase 1). If there is a positive vote by the EUROfusion General Assembly on WEST as a EUROfusion common facility a new call for the WPPFC project will be made. Within mission 2, the WEST project will focus on actively cooled ITER mono-block testing in a plasma environment and will fill an important gap in current capabilities. The following studies to be performed during the operational phase 1 would complement various ongoing WPPFC ones: Test under relevant peak plasma heat fluxes (10 MW/m²), Impact of leading edges due to misalignments, tile shaping, Tokamak operation with damaged W components, Performance of components « out of » acceptance criteria, In-situ monitoring of actively cooled W components. Preparatory activities, directly aligned with the recommendations from the panel in charge of the evaluation of WEST, start in 2015 for an efficient start of the WEST exploitation in 2016. These 2015 activities are as follow : bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines, divertor modelling for the preparation of ITER monoblocks testing**,** development of high resolution IR system for monitoring PFC surface temperature, development of visible spectroscopic diagnostics for monitoring PFC tungsten sources and D recycling, development of actively cooled Langmuir probes embedded in divertor ITER-like targets to measure edge plasma parameters.

Part (b) is following the same scheme as part (a), but on a smaller scale related to the lower initial level of studies performed in previous EFDA schemes. Addressing fundamental questions of plasma-wall interaction with liquid metals such as erosion, retention, dust production as well as developing at the same time with the best suitable liquid metal or alloy a full representative plasma-facing component mock-up which is able to sustain steady-state power loads similar or superior to conventional components. The following sub-project "Power and particle load studies and PWI processes in liquids (SP6)" deals under the WPPFC with those issues. Certainly, the liquid metal studies need to be accompanied by detailed tokamak studies executed under WPDTT1. Both WPDTT1 and WPPFC are contributing finally to the decision of the divertor to be built under WPDTT2

Overall, the studies in WPPFC are essential to ensure a safe and reliable ITER operation with the current set of materials and components Beryllium and Tungsten. The WPPFC work is strongly linked in view of ITER needs with the work packages WPJET1, WPJET2, WPMST1, and WPCD. In the view of DEMO, the link is strongest with WPDTT1, WPMAT and WPDIV.

Management

This project is managed by a project leader and 6 coordinators for the following subprojects:

- Power and particle load studies and qualification (SP1);
- PWI Processes I: erosion, deposition and mixing (SP2);
- PWI Processes II: fuel retention, fuel removal and material damage (SP3);
- Plasma-characterisation and modelling (SP4);
- Post-mortem analysis and material migration (SP5);
- Power and particle load studies and PWI processes in liquids (SP6)

Main Objectives

TOP THREE 2015 OBJECTIVES
• Determination of the impact of He exposure (He vs. He + D vs. D) on the power-load handling and crack-behaviour of bulk tungsten plasma-facing components under different transient heat loads. This study includes the identification of main physics mechanisms responsible for the surface morphology changes, the discrimination of damage thresholds as function of the changes, and the erosion properties of ITER-grade tungsten. Its impact on the power handling capabilities and the lifetime of the all-W divertor in ITER will be assessed (done under SP1) • Clarify the impact of neutron damage on fuel retention mechanisms and its strength in tungsten and beryllium plasma-facing material. These studies include a comparison of real neutron damage to self-damage by the plasma-facing material, the dependence of the retention rate on the damage rate, and associated modelling of the defect type and its concentration evolution as function of DPA and material temperature (SP3) • Production and qualification of Li-Sn alloys as plasma-facing material with respect to fuel retention and material erosion under deuterium impact. Exposure of liquid plasma-facing components made of Li-Sn will be executed in pilot-PSI at high particle flux and fluence. The results will have impact on the decision of the liquid metal/alloy used in DTT1 (SP6).

Description of work

The full detailed list of deliverables is in the WPPFC Project Management Plan. The following table describes the work to be done in under each relevant headline.

WPPFC
Headline 2.1: Detachment control for the ITER and DEMO baseline strategy
H2.1-D08: Investigate the compatibility of W with extrinsic impurity seeding / optimize impurity mix for divertor and main chamber radiation (linked to Headline 2.2) (2018)
- Qualification of the impact mechanisms of seeding gases (Ar and N) on fuel retention and fuel release in W PFCs (WPPFC PMP deliverables PFC.TD10) and Assessment of the impact of nitrogen as seeding gas on W PFCs and characterisation of WN layers (WPPFC PMP deliverables PFC.TD06): *● Role of seeding impurities on fuel retention and removal techniques* *● WN formation, erosion and characterisation* *● BeN formation, erosion and characterisation* *- Development and characterisation of ITER-like mixed layers (WPPFC PMP deliverable PFC.TD19)*
Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
H2.2-D02: Quantify isotope-exchange on ITER and DEMO relevant materials (2016)
Quantification of the isotope exchange capability in EUROFER and in W as reference (WPPFC PMP deliverable number: PFC.TD12). 2014 ==> Exchange and de-trapping in W and n-damaged W. 2015 ==> Expand to synthetic Be/D-layers and higher temperatures in W

H2.2-D05: Validate codes on plasma wall interactions (erosion, re-deposition and migration) (2016)
- Collaboration WPJET1 / WPMST1 / WPPFC: Execution of edge modelling codes related to experiments within WPPFC and benchmark of ERO, WALLDYN and MD (PMP WPPFC deliverable number PFC.TD14) *● Plasma-background and plasma-sheath modelling (Codes: SOLPS, SOLEDGE, PIC, 3DMHD)* *● Plasma-surface interaction and transport modelling (Codes: ERO, WALLDYN, ASCOT, MD,...)* *● Material migration in tokamaks (post-mortem analysis)*
H2.2-D11: Erosion of ITER/DEMO relevant armour materials (2016)
- Qualification of EUROFER as plasma-facing material (WPPFC PMP deliverable PFC.TD05) *- Assessment of the impact of nitrogen as seeding gas on W PFCs and characterisation of WN layers (WPPFC PMP deliverable PFC.TD06)* *- Quantification of differences in power load damage thresholds and W structure modification by different loading techniques. Synergetic impact of fuel flux (D and/or He) and fluence (WPPFC PMP deliverable PFC.TD01 and WPPFC PMP deliverable PFC.TD03)* *- BeN and WN formation, erosion and characterisation : 2015 ==> film formation / erosion / characterisation in connection with PISCES B experiments*
H2.2-D13: Cross-check retention properties in heavy-ion (HI) damaged materials with that of neutron damaged material (2016)
- Quantification of the impact of neutron damage on the thermo-mechanical properties of W and comparison with W self-damaged W (WPPFC PMP deliverable PFC.TD03) *● Synergistic loading and its effects on W surfaces and its properties* *● Thermo-mechanical properties of damaged W surfaces* *● Post mortem analysis*
H2.2-D14: Retention in neutron/HI damaged PFM as a function of irradiation temperature, preferentially for simultaneous (HI) and plasma irradiation (2017)
- Quantification of the impact of neutron damage on fuel retention in Be and W (WPPFC PMP deliverable PFC.TD08): *● Thermo-mechanical properties of damaged W surfaces* *● Role of neutron damage on retention mechanism and "strength" in Be/W* *- WEST Bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines. Associated analysis and modelling*
H2.2-D18: Reproduction and study of ILW material mixture (NEW) (2016)
- Development and characterisation of ITER-like mixed layers (WPPFC PMP deliverable PFC.TD19) *- Quantify outgassing of super-saturated Be and W surfaces (WPPFC PMP deliverable PFC.TD09)*
H2.2-D19: Effects of Helium nanostructured Tungsten on transient loading (NEW) (2016)
- Effects of He nano-structured W on transient power loading (included in WPPFC PMP deliverable PFC.TD02)
H2.2-D15: Characterise sputtering and power handling of damaged PFC (NEW) (2018)
- Quantification of the impact of neutron damage on the thermo-mechanical properties of W and comparison with W self-damaged W (WPPFC PMP deliverable PFC.TD03): *● Thermo-mechanical properties of damaged W surfaces* *● Synergistic loading and its effects on W surfaces and its properties* *● Post mortem analysis*

- WEST Bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines. Associated analysis and modelling.
H2.2-D17: Qualification of plasma surface interaction diagnostics (NEW) (2015)
- Qualification of LIBS as in-situ fuel retention and material composition techniques (WPPFC PMP deliverable PFC.TD17) *- Development of high resolution IR system for monitoring PFC surface temperature (WEST)* *- Development of visible spectroscopic diagnostics for monitoring PFC tungsten sources and D recycling (WEST)* *- Development of actively cooled Langmuir probes embedded in divertor ITER-like targets to measure plasma parameters around the divertor strike points. Focus on technology transferable to ITER divertor targets (WEST)*
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.3-D04: Optimise predictive models for ITER and DEMO divertor/SOL: Development of computational tools for edge transport extending up to PFC (2018)
- WEST Divertor modelling for the preparation of ITER monoblocks testing (as defined by F4E) in tokamak environment. Impact of Divertor topology (compact Divertor, pumping baffle) on density regimes and on the W screening capability
Headline 2.4: Investigate alternative power exhaust solutions for DEMO
H2.4-D10: Proof of Principle of liquid PFC solutions: Demonstrate substantial power load capability of liquid metal PFCs ($\geq$ 10 MW/m^2) (2015)
- Qualification of the power handling capabilities of actively cooled CPS structures with Sn (WPPFC PMP deliverable PFC.TD22)
H2.4-D12: Proof of Principle of liquid PFC solutions: Demonstrate ‘integrity’ of liquid surface during plasma instabilities and during substantial transient power loads. Characterize possible mixed material effects (main chamber PFCs/cooling structure) (2015)
- Gross and net erosion yields of liquid metals: Sn, Li, corresponding alloys (WPPFC PMP deliverable PFC.TD20) *- Mixing of Sn, Li, alloys with W (WPPFC PMP deliverable PFC.TD20)*
H2.4-D13: Proof of Principle of liquid PFC solutions: Quantify H retention and outgassing of liquid metal PFCs (2015)
- Quantification of fuel retention in Li, Sn and corresponding alloys (WPPFC PMP deliverable PFC.TD21)
Support work PMP deliverables:
PFC.TD04: Assessment of plasma pinches to simulate disruption heat loads on W material and comparison with other loading techniques (2016)
2015 ==> extend database on He damaged and W-fuzz samples
PFC.TD13: Provision of plasma backgrounds for linear plasmas, dedicated MST1 experiments and ITER referenced used for PWI studies (2016)
- Plasma-background and plasma-sheath modelling (Codes: SOLPS, SOLEDGE, PIC, 3DMHD): 2015 ==> Expand to specific linear plasmas with seeding and AUG plasmas *- Plasma-surface interaction and transport modelling (Codes: ERO, WALLDYN, ASCOT, MD,...): 2015 ==> Expand to specific linear plasmas with seeding and AUG plasmas* *- Plasma characterisation: 2015 ==> Characterisation continues in seeded plasmas*

PFC.TD15: Plasma characterisation of linear plasma devices at low T_e as required for plasma background modelling (i.e. neutral distribution) (2016)
- Plasma-background and plasma-sheath modelling (Codes: SOLPS, SOLEDGE, PIC, 3DMHD): 2015 ==> Expand to specific linear plasmas with seeding and AUG plasmas *- Plasma characterisation: 2015 ==> Characterisation continues in seeded plasmas*
PFC.TD16: Determination of material migration paths in AUG by tracer techniques (i.e. 15N2) and post-mortem analysis (2016)
- Clarify the role of prompt re-deposition and surface morphology of tungsten in the local material migration in ASDEX Upgrade. This includes plasma diagnosis; post-mortem analysis of dedicated components exposed in ASDEX Upgrade and associated modelling of the local transport. Benchmark of predictive PIC modelling of prompt re-deposition.
PFC.TD18: Provision of post-mortem analysis for WPPFC programmatic deliverables (2015)
PFC.TD23: Preparation, development and execution of the PFC work package for 2014 (2015)
PFC.TD24: Preparation of reference samples of Be and W and reference mixed layers samples (2015)
PFC.TD25: Provision of 3He to different RU with accelerator system for post-mortem analysis (2015)

Use of facilities

Operational days of the following linear plasma facilities: PSI-2 (FZJ), Pilot-PSI (FOM), Magnum-PSI (FOM) will be financed by EUROfusion and utilised to carry out activities within the project. Note that in 2015, Magnum-PSI will not be available due to its relocation.

Several other European facilities will be utilised for heat load studies and post-mortem analysis.

International Collaborations

The use of the US linear plasma facility PISCES-B (UCSD) is also foreseen in the frame of the EUROfusion international collaboration.

2.2.8 WPDTT1: Assessment of Alternative Divertor Geometries and Liquid Metals PFCs

Set of Activities Number	08	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Assessment of alternative divertor geometries and liquid metals PFCs (WPDTT1)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 1,440.118 k€ (652k€ EUROfusion contribution) including 4.65 ppy, missions and hardware. Note that the provisional tables in the PMP states 6.25 ppy and 870 k€ of total hardware resources for 2015.

Objective

This work package examines the feasibility for DEMO of different solutions for the divertor (alternative divertor geometries and liquid metals PFCs) and the gaps in parameter space in view of the definition of a Divertor Tokamak Test. DTT1 project is entirely in support of Headline 2.4 “Alternative power exhaust solutions for DEMO”. Specifically, coil configurations for alternative divertor geometries, particle transport and power exhaust will be investigated by modelling at different level of sophistication and the exhaust capability of liquid PFC solutions will be assessed by modelling and by experiments in fusion devices. The experiments should focus on the power load capabilities of the liquid metal solution. Before the eventual start of the conceptual design of a DTT integration issues and DEMO compatibility must be assessed within this work package.

The primary objective of the project are to : (i) assess requirements for physics model development; (ii) assess the DEMO compatibility of alternative divertor designs including the “Super-X divertor” and the “Snow Flake Divertor”; (iii) assess the DEMO compatibility of liquid metal PFCs solutions and select the best liquid metal solution, if viable.

Management

Project Leader. The DTT1 project is organized in an "Alternative divertor configurations" (AC) area and "Liquid metal PFC" (LM) area. The AC subproject includes activities on: AC physics assessment, equilibrium generation, power exhaust modelling and experimental test of models. The LM subproject includes activities: LM physics assessment, experimental test of LM PFC solutions, PFC properties of LMs and power exhaust modelling.

Main Objectives

TOP 2015 OBJECTIVES
• Report on alternative power exhaust solutions for DEMO (Super X, snowflake, liquid metal).The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations as well as the most promising liquid metal PFC solutions. The DEMO compatibility will be quantified in terms of benefits and costs of the alternative solutions compared to conventional power exhaust solutions. The assessment also includes the identification of the uncertainties (WPDTT1 PMP deliverable PD05/CD03)

Description of work

The full detailed list of deliverables is in the WPDTT1 Project Management Plan. The following table describes the work to be done in 2015 under each relevant headline.

WPDTT1
Headline 2.4: Investigate alternative power exhaust solutions for DEMO
H2.4-D10: Proof of Principle of liquid PFC solutions: Demonstrate substantial power load capability of liquid metal PFCs (≥ 10 MW/m²) (2015)
- Provide input for H2.4-D15 and H2.4-D17: *● Test of a cooled liquid Li CPS limiter in FTU (2014-2015)* *● Test of a cooled liquid Sn CPS limiter in FTU (starting in 2015)* *● Model the stationary power load capability of a CPS based LM solution (2014)*
H2.4-D11: Proof of Principle of liquid PFC solutions: Investigate conditions for acceptable plasma dilution/impurity content at high power loads (dominant PFC, 'divertor impurity screening') (2015)
- Provide input for H2.4-D17 *• Evaluate compatibility of LM PFC with core performance in FTU (2014-2015)* *• Model DEMO SOL with LM boundary condition (2015)*
H2.4-D12: Proof of Principle of liquid PFC solutions: Demonstrate 'integrity' of liquid surface during plasma instabilities and during substantial transient power loads. Characterize possible mixed material effects (main chamber PFCs/cooling structure) (2015)
- Provide input for H2.4-D17: *• Model CPS behaviour under transient conditions*
H2.4-D13: Proof of Principle of liquid PFC solutions: Quantify H retention and outgassing of liquid metal PFCs (2015)
- Provide input for H2.4-D17 *• Improve and complete measurements of hydrogenic retention in Li, Sn and LiSn alloys (through experiments in FTU, TJ-II and ISTTOK).*
H2.4-D15: Assess requirements for physics model development (2014)
- WPDTT1 PMP deliverable PD04 (to be completed in 2014)

H2.4-D16: DEMO compatibility of alternative divertor designs: 1. assess Super-X divertor; 2. assess Snow Flake Divertor; 3. assess further geometries/techniques (2015)
- WPDTT1 PMP deliverable PD05/CD03: Report on alternative power exhaust solutions for DEMO (Super X, snowflake, liquid metal). *● The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations as well as the most promising liquid metal PFC solutions.* *● The DEMO compatibility will be quantified in terms of benefits and costs of the alternative solutions compared to conventional power exhaust solutions. The assessment also includes the identification of the uncertainties.*
H2.4-D17: DEMO compatibility of liquid metal PFCs: 1. assess liquid PFC solution; 2. select best liquid metal, if viable (2015)
- WPDTT1 PMP deliverable PD05/CD03: Report on alternative power exhaust solutions for DEMO (Super X, snowflake, liquid metal). *● The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations as well as the most promising liquid metal PFC solutions.* *● The DEMO compatibility will be quantified in terms of benefits and costs of the alternative solutions compared to conventional power exhaust solutions. The assessment also includes the identification of the uncertainties.*
Support work PMP deliverables:
PD09: Report on annual progress in project (2016)
PD05: Revised DEMO configurations. Generate a set of DEMO AC equilibria with optimised coil configuration taking into account electro-mechanical constraints (2015)
PD08: Report on annual progress for each activity defined in the PMP (2015)

Use of EU facilities

Alternative divertor configurations will require analysis experiments on TCV (**MST1**), + international collaboration (c.f. below on DIII-D, EAST, HL-2A)

In the liquid metal PFC area, experiments are foreseen in FTU, TJ-II, ISTTOK and on linear devices Magnum-PSI, Pilot-PSI, Gym (PFC) and international collaboration (c.f. below)

International Collaborations

In the alternative divertor configurations area international collaborations are part of activity AC-5 "Experimental test of models" and are summarised as follow:

- **Collaboration with EAST on the study of the snowflake (SF) divertor in long-pulse, high power discharges** EAST has the potential to investigate the exhaust performance of the SF divertor in long-pulse discharges and using an actively cooled W divertor.
- **Collaboration with DIII-D on the study of the radiative snowflake (SF) divertor in high power discharges** DIII-D offers the unique opportunity of investigating the performance and stability of a radiative SF divertor at high power in an exceptionally

well diagnosed environment. It can also complement TCV experiments with a lower normalised SOL width λ_q/a.

- **Collaboration with HL-2A on the study of the X divertor (XD) configuration** The HL-2A divertor offers a unique possibility to investigate the behaviour of the X divertor configuration (strong poloidal flux expansion after an initial constriction) together with a strong baffling, in particular with respect to the stability of detachment.

In the "Liquid metal PFC" area international collaborations are carried out within the activity LM-3 "Experimental test of LM PFC solutions" and within the activity LM-4 "PFC properties of LMs" and are summarised as follow:

- **Collaboration with EAST on liquid Li CPS.** It is planned to test various LM delivery system (free flowing liquid Li (FLiLi), liquid metal in trenches (LiMIT) as limiters.
- **Collaboration with University of Illinois in Urbana on Li/Sn alloys.** Investigate the wetting properties and chemical activity of Li/Sn alloys in preparation of plasma exposure experiments in CIEMAT and IST.
- **Collaboration with NSTX-U on liquid Li.** The assessment of liquid Li as part of a high-duty-factor integrated PMI solution for next steps is part of a high level goal for the NSTX-U 5 year plan.
- **Collaboration with KTM on liquid Li CPS divertor.** KTM will offer the opportunity to test an actively cooled CPS liquid Li divertor module (1/24th of the toroidal circumference) in a tokamak environment.

2.2.9 WPDTT2: Definition and Design of the Divertor Tokamak Test Facility

Set of Activities Number	09	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Definition and design of the Divertor Tokamak Test facility (WPDTT2)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 1,008.651 k€ (537.568 k€ EUROfusion contribution) including 10.25 ppy and mission costs.

Re-allocation of the resources has been required, taking into account the contractual deadlines of deliverables CD02 "Report on a Divertor Test Tokamak technical requirements" (December 2015) and CD03 "DTT conceptual design" (December 2016). The heavy work load due to Task 4 Definition of DTT technical requirements (related to CD02) and Task 5 DTT conceptual design (linked to CD03) suggests an increase in the resources in terms of ppy in 2015-2017. The requested 2015 resources are 10.25ppy and a new call for participation is under preparation if approved by the GA. It is proposed to have a go / no go decision on DTT around the end of 2015.

Objective

This work package comprises subprojects which deal with the definition and the conceptual design of Divertor Tokamak Test. The conceptual design will be started after review of the remaining gaps and the possible solutions taking into account the results of the work packages WPPFC and WPDTT1 and the recommendations of the expert panel initiated by the EFDA SC in 2013. It must provide enough positive evidence that the investigated solutions could be integrated in a DEMO device in case the conventional divertor solution does not yield the necessary capabilities for power exhaust. The eventual DTT conceptual design activity should be performed in close coordination with the DEMO design integration project (WPPMI). Depending on the outcome of the review, the Project will provide the design of a new machine or the upgrade of an existing device. The project will contribute to Headline 2.4: Investigate alternative power exhaust solutions for DEMO of the Work Plan for the Implementation of the Fusion Roadmap in 2014-2018.

The specific objectives of the WPDTT2 (Definition and Design of the Divertor Tokamak Test Facility) are to: (i) Demonstrate a heat exhaust system capable of withstanding the large load of DEMO in case of inadequate radiated power fraction; (ii) Close the gaps in the exhaust area that cannot be addressed by present devices; (iii) Demonstrate that the possible (alternative or complementary) solutions (liquid metals or advanced divertor configurations) can be integrated in a DEMO device. In order to mitigate the risk that a conventional divertor might not be suitable for DEMO, the project will: i) define the DTT technical requirements; ii) provide a DTT conceptual design. Two possible solutions are considered: advanced divertor configurations and/or liquid metals. Two alternative platforms are considered: upgrade of an existing device or a new tokamak.

Management

Project Leader. The project is divided in 6 technical tasks: Assessment of advanced configurations; Assessment of liquid metals, Definition of DTT technical requirements, DTT conceptual design, DTT engineering design, DTT construction.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Report on activities in support to WPDTT1 on advanced magnetic configurations, liquid metals and alternative solutions • Report on activities aimed at a pre-conceptual "baseline" DTT design (feasibility study) • Report on a Divertor Tokamak Test technical requirements

Description of Work

The full detailed list of deliverables is in the WPDTT2 Project Management Plan. The following table describes the work to be done in 2015 under each relevant headline.

WPDTT2
Headline 2.4: Investigate alternative power exhaust solutions for DEMO
H2.4-D18: Definition of DTT technical requirements (2015)
- WPDTT2 PMP deliverable T03: Progress Report 2015 Part 1 - activities in support to WPDTT1 on advanced magnetic configurations, liquid metals and alternative solutions. *- WPDTT2 PMP deliverable TD04 (CD02): Report on Divertor Tokamak Test technical requirements.*
H2.4-D19: DTT conceptual design (new machine or upgrade of existing device) (2016, depending on outcome of the review) (2016)
- WPDTT2 PMP deliverable T03: Progress Report 2015 Part 2 - activities aimed at a pre-conceptual "baseline" DTT design (feasibility study)

Use of EU facilities

WPDTT2 shall maintain a close link to the facilities through the work done in WPDTT1.

International Collaborations

The WPDTT2 project follows with interest all the international collaborations established by WPDTT1 and is directly involved in a collaboration with **EAST on the study of the snowflake (SF) divertor in long-pulse, high power discharges.** EAST has the potential to investigate the exhaust performance of the SF divertor in long-pulse discharges and using an actively cooled W divertor. The main role of WPDTT2 in this collaboration is in the optimization and the control of SF equilibria in EAST.

2.2.10 WPSA: Preparation of Exploitation of JT-60SA

Set of Activities Number	10	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Preparation of exploitation of JT-60SA (WPSA)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resource of 580.527 k€ (316.953 k€ EUROfusion contribution) including 6.25 ppy and missions costs (including missions to Japan).

Objective

This work package is in support of a European exploitation of JT-60SA within the broader approach and possibly beyond. The activities will run throughout the period 2014-2018. The main Objective is to prepare for a high level EU participation in JT-60SA scientific exploitation, fully integrated in the EU fusion programme. In addition , the project will (i) diffuse knowledge on JT-60SA characteristics, scientific goals, operation tools within the EU fusion physics community; (ii) Prepare the EU-JA research plan for the JT-60SA campaigns; (iii) Prepare a full and efficient access to data and analysis tools; (iv) Prepare to play an active role in operation and campaigns management.

Management

Project leader. The implementation of this programme is organised in three main areas:

- **Modelling.** Integrated modelling of the JT-60SA reference scenarios is an essential step for the preparation of experiments. Furthermore, various specific physics aspects are being investigated and clarified in the areas of MHD, transport and confinement, fast particle physics.
- **Sub-systems.** Specific studies are carried out in order to complete or improve the design of specific sub-systems of the machine, or to prepare their use. Examples of on-going investigations are: ECRH antenna, divertor pumping system, polarimetry diagnostic. Further studies on other diagnostics, pellet injection and metallic divertor are envisaged, following the main needs expressed by the Project Team.
- **Operation.** These activities include the study of the main requirements of the JT-60SA data system, validation and analysis tools; the preparation of the methods and procedures of tokamak operation; the elaboration of the structures and methods of campaign management.

Normal management activities are foreseen including the organisation of the annual Project Team Meeting, production of the annual report, and preparation of the SA parts of the 2016 Work Plan.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Core-equilibrium modelling of flat-top phases of JT-60SA scenarios. Use of CRONOS code, progressive extension to JINTRAC and ASTRA (SA.M.D04): • Divertor pumping modelling: Validation of the neutral code. Elements for a technical design of the cryopumping systems (SA. S.D06) • ECRF system: Definition and prioritization of the system functionalities (NTM, sawtooth control, current profile tailoring, impurities control) and in low absorption scenarios (start-up assist, wall cleaning). Comparison of the antenna model with the result of the optical tests. Input for antenna performances optimization. Requirements for real time control of the antenna and conceptual design of the control loop. Stray radiation probes conceptual design (SA.S.D04)

Description of work

The full detailed list of deliverables is in the WPSA Project Management Plan. Some tasks are multi-year with the final delivery date beyond 2015.

WPSA
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D14: Coupled core-edge simulations for JT-60SA with the COREDIV code for Carbon PFC (NEW) (2015)
WPSA PMP deliverable number SA.M.D03 (linked also to H1.9 and H2.3)
H1.1-D15: Core-equilibrium modelling of flat-top phases of JT-60SA scenarios. Use of CRONOS code, progressive extension to JINTRAC and ASTRA (NEW) (2015)
WPSA PMP deliverable number SA.M.D04 (also linked to H1.7, H1.9 and H2.3)
Headline 1.4: Integration of MHD control into plasma scenarios
H1.4-D08: MHD analysis of kinetic profiles of the JT-60SA operational scenarios, including study of pedestal stability conditions (NEW) (2018)
WPSA PMP deliverable number SA.M.D02
H1.4-D09: Study of RWM evolution in JT-60SA and requirements for stabilization (NEW) (2015)
WPSA PMP deliverable number SA.M.D07
H1.4-D10: Study of NTM control and stabilization for JT-60SA (NEW) (2015)
WPSA PMP deliverable number SA.M.D11
H1.4-D11: Report on the JT-60SA diagnostic systems: diagnostics for pedestal physics. Feasibility studies for BES, video pellet and other video diagnostics applications, polarimetry (NEW) (2015)
WPSA PMP deliverable number SA.S.D05 (also linked H1.8)

Headline 1.5: Control of core contamination and dilution from W PFCs
H1.5-D04: WPSA PMP deliverable number SA.S.D07: Report on the development of W divertor for JT-60SA: Assessment of the start-up / ramp down strategy and expected main chamber power loads. Assessment of the relevant scenarios for all metal PFCs (also linked to H2.2) (2018)
- *WPSA PMP deliverable number SA.S.D07* - *Assessment of the start-up / ramp down strategy and expected main chamber power loads.* - *Assessment of the relevant scenarios for all metal PFCs.*
Headline 1.6: Determine optimum particle throughput for rector scenarios
H1.6-D12: JT-60SA divertor pumping modelling: Validation of the neutral code. Elements for a technical design of the cryopumping systems (NEW) (2015)
- *'WPSA PMP deliverable number SA.S.D06 (also linked to H1.8).*
H1.6-D13: Preliminary studies of the JT-60SA pellet injection system concept (NEW) (2017)
- *WPSA PMP deliverable number SA.S.D07*
Headline 1.7: Optimise fast ion confinement and current drive
H1.7-D11: Assessment of fuelling and current control requirements to maintain steady state in the JT-60SA operational scenarios (NEW) (2016)
- *WPSA PMP deliverable number SA.M.D05.*
Headline 1.8: Develop integrated scenarios with controllers
H1.8-D08: Definition and prioritization of the ECRF JT-60SA system functionalities (NEW) (2017)
- *WPSA PMP deliverable number SA.S.D04:* ● *functionalities for NTM, sawtooth control, current profile tailoring, impurities control and low absorption scenarios (start-up assist, wall cleaning).* ● *Comparison of the antenna model with the result of the optical tests.* ● *Input for antenna performances optimization.* ● *Requirements for real time control of the antenna and conceptual design of the control loop.* ● *Stray radiation probes conceptual design*
H1.8-D09: Calculation of the magnetic flux map at breakdown for JT-60SA. Modelling of breakdown with and without ECCD assist (NEW) (2016)
- *WPSA PMP deliverable number SA.O.D07.*
Headline 1.9: Qualification of Advanced Tokamak scenarios
H1.9-D04: Integrated model validation so as to define, in as much as possible without definitive large machine results, the current drive requirements for non-inductive operation in JT-60SA (decision ≈2023) and ITER (≈2024) (2018)
- *Collaboration WPJET1 / WPSA: Development of advanced scenario for the preparation of JT-60SA non-inductive regimes. Investigate similarity experiments JET – JT-60SA experiments.*
Headline 2.2: Prepare efficient PFC operation for ITER and DEMO
H2.2-D21: Establish the conditioning procedure with EC wall conditioning in JT-60SA. Validate EC wall conditioning by experiments in EU machine relevant for JT-60SA (NEW) (2017)
- *WPSA PMP deliverable number SA.O.D06.*

Use of EU facilities

Indirect use to provide validation of physics and engineering for JT-60SA.

International Collaborations

JAEA and the Japanese universities.

2.2.11 WPS1: Preparation and Exploitation of W7-X Campaigns

Set of Activities Number	11	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Preparation and Exploitation of W7-X Campaigns (WPS1)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 14,064.454 k€ (3,554 k€ EUROfusion contribution) including 23.49 ppy, missions and use of W7-X facility.

Objective

This work package will manage and coordinate the European exploitation of W7-X (Headline 8.1) which will have its first campaign in 2015. The main task/deliverable in 2015 will be the preparation and the execution of the first operational phase of W7-X. The key objectives are to (i) implement the TF and develop a consistent programme for the initial European exploitation of W7-X; (ii) support the initial operation of W7-X by scenario development, diagnostics and components and develop a Stellarator Fusion Power Plant Physics Basis; (iii) predictive modelling for heat and impurity transport and fast particles (2016 cont.). During the first campaigns (until 2017), W7-X will operate without the actively cooled steady state divertor, so the pulse length will be limited to 10 seconds at full power available during this phase. Longer pulses (≈ 1 minute) will be possible at reduced power. Nevertheless first important results are expected on scenario development, on confinement and power and particle exhaust in this first phase.

Management

Project/Task-Force Leader. The project is organised in three activity areas: (i) Area A: Experimental Scenario Development for W7-X Exploitation, (ii) Area B: Diagnostics and Components, (iii) Area C: Predictive modelling for W7-X.

Main Objectives

TOP THREE 2015 OBJECTIVES

- Achieve first plasma (OP1.1 goals: E< 2MJ, e.g. 2MW <1s), implement a European task force to exploit the first experimental campaign on W7-X
- Develop and assess detection methods for safe ECRH operation (also in view of ITER)
- Edge and core modelling of consistent scenarios, with respect to core and edge. Calculation of particle sources

Description of work

The full list of deliverables is in the WPS1 Project Management Plan. The following table describe the work to be done in 2015 under each relevant headline.

WPS1
Headline 8.1: Qualification of Helias optimised stellarator operation
H8.1-D01: Scenario development: demonstrate pulsed operation (8 MW / 10 s to 1 MW / 1 minute) (2018)
- Achieve first plasma (OP1.1 goals: E< 2MJ, e.g. 2MW <1s), implement a European task force and participate in the first experiment campaign on W7-X. *- Support work on diagnostics and components: reflectometry, video diagnostics and imaging software, impurity diagnostics, fast particle diagnostics (new task TBD), probes, ICRH and support actions.* *- Supporting physics studies in view of developments of experimental approaches on W7-X and model validation to develop a physics base for the HELIAS line (also within international cooperation): optimization(impact of neoclassical effects on turbulent transport , H8.1-D07), particle transport and fuelling and divertor physics (exhaust, H8.1-D09), impurity transport (impact of potential asymmetry on flux surfaces, H8.1-D05), fast ion.* *- Develop and assess detection methods for safe ECRH operation (also in view of ITER) (new task TBD).*
H8.1-D02: Scenario development: development of credible scenarios for steady state operation (2018)
- Covered in edge modelling (H8.1-D09).
H8.1-D03: Scenario development: qualification of heating schemes up to very high densities (2017)
- Pursue the study of the transition from X- to O-mode.
H8.1-D05: Confinement studies: predictive modelling for heat and impurity transport using existing physics basis (2016, cont.)
- Modelling of heat (impact of scenario) and impurity transport and fast particles (study of fast ion losses).
H8.1-D06: Confinement studies: verification of neoclassical confinement optimization (2016, cont.)
- Pursue the core scenario predictive modelling in the W7-X magnetic configuration space.
H8.1-D07: Confinement studies: study of impact of neoclassical optimization on turbulent transport (2017, cont.)
- Diagnostic (reflectometer) and modelling activities. *- Development of experimental approaches for W7-X: impact of neoclassical effects on turbulent transport.*
H8.1-D09: Power and particles exhaust: Qualification of safe divertor operation (2018)
- Edge and core modelling: develop consistent scenarios with respect to core and edge. Calculation of particles sources.

Headline 8.2: Theory development and modelling / stellarator optimisation
H8.2-D04: Develop new stellarator configurations close to HELIAS, giving higher priority to fast ion confinement and less weight to aspects now deemed less crucial such as MHD stability. (2018)
- Collaboration WPCD / WPS1 / WPS2 : fast ion losses synthetic diagnostics integration (New task TDB).

Use of EU facilities

W7-X, TJ-II

International Collaborations

NIFS, PPPL: conduct experimental transport validation studies

NIFS: qualify stellarator specific fuelling schemes

NIFS, U-Kyoto: ongoing work on the International Stellarator Profile Database, ECH/Non-inductive start-up studies, ICH modelling
U-Wisconsin: divertor physics

2.2.12 WPS2: Stellarator Optimisation: Theory Development, Modelling and Engineering

Set of Activities Number	12	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Stellarator optimisation: Theory Development, Modelling and Engineering (WPS2)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen resources of 365.680 k€ (200 k€ EUROfusion contribution) including 4.4 ppy and missions cost.

Objective

This work package concerns the optimisation of the stellarator concept in view of a future reactor. The investigations are fully theory/modelling based and should put a strong emphasis on the integration of technical boundary conditions and limits. Reactor engineering studies should be performed with the same methodology as those for DEMO performed under WPPMI. The activities will run throughout the whole period 2014-2018 and shall incorporate the experimental results provided by WPS1 from 2015 onwards. The general project objectives are summarised as follow

- Contribute to bring stellarator to maturity.
- Give support to W7-X Exploitation.
- Optimization of W7-X-like (Helias) Configuration and looking for advantages and disadvantages of other possible configurations.
- Inclusion of engineering in the optimization process: Coil design and room for the Breeding Blankets

Management

Project Leader. The S2 Work Package is divided into four areas: management, integrated optimisation tools, stellarator theory, and stellarator engineering. Normal management activities are foreseen including production of the annual report and preparation of the S2 parts of the 2016 Work Plan.

Main Objectives

TOP THREE 2015 OBJECTIVES
• Comparison of tokamaks and stellarator modules in a single system code (e.g. PROCESS). The stellarator module has been added to this system code. Now, it will be possible to compare both types of reactors using this code. • Operational scenarios of ECRH and ECCD in W7-X. The ECRH system in W7-X is the most advanced of its kind and is similar to the one that will be used in ITER. • 3D optimised configurations for alpha-particle confinement and minimization of bootstrap current. Some lessons can be learned on how to tailor 3D configurations in order to improve alpha particle confinement and control bootstrap current.

Description of work

A detailed list of deliverables is in the WPS2 Project Management Plan. The following table describes the work to be done in 2015 under each relevant headline.

WPS2
Headline 8.2: Theory development and modelling / stellarator optimisation
H8.2-D01: Include engineering constraints in stellarator optimization together with advances in physics understanding and computational capabilities (2018)
- WPS2 PMP deliverable D10: Comparison of tokamaks and stellarator modules in system code (e.g. PROCESS). The stellarator module has been added to this system code. Now, it will be possible to compare both types of reactors using this code.
H8.2-D02: Improve tools for predictive edge modelling for 3D geometries of stellarators (2018)
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium (VMEC) codes into Integrated Modelling Framework (new task t.b.d.).
- WPS2 PMP deliverable D8: *● Test the EXTENDER code.* *● Apply FINDF code to the edge transport in W7-X. Start the benchmark of FINDF.*
H8.2-D03: Include turbulent transport models in stellarator optimization, in addition to the neoclassical optimisation (2018)
- WPS2 PMP deliverable D5, D9: *● Identify proxies for optimising stellarator configurations taking into account minimisation of Zonal Flow damping and stabilisation of Trapped Electron Modes.*
H8.2-D04: Develop new stellarator configurations close to HELIAS, giving higher priority to fast ion confinement and less weight to aspects now deemed less crucial such as MHD stability. (2018)
- Collaboration WPCD / WPS1 / WPS2: fast ion losses synthetic diagnostics integration (new task t.b.d.).

- WPS2 PMP deliverables D1, D6 and D7: *● Study low order resonances in the plasma centre regarding the effect of magnetic well and current drive.* *● Neoclassical optimisation to minimise bootstrap current and improve α-particle confinement. Develop coils able to create such optimised configurations.* *● Modelling of deviation from omnigeneity and its impact on the multiplication of possible optimization strategies to get good Neoclassical particle confinement, including fast particles.*
H8.2-D05: Stellarator reactor engineering and technology studies, including systems code design optimisation and costing studies, requirements analyses for Breeding Blanket / shield, coil spacing, bend radius, superconductor type and properties; space requirements etc., diagnostic and heating system port and space requirements, RH requirements, remote handling space needs, etc. (2018)
- Collaboration WPCD / WPS2: Adaptation of ICRH/ECCD codes for stellarators to Integrated Modelling framework (new task t.b.d.)
- WPS2 PMP deliverables D2, D3, D4 and D11: *● Addition of 3D curvature to coil design codes* *● Simulations of minority heating with relevant strap antenna description at 2.5 T.* *● ECCD and ECRH modelling with transport and passing/trapped electrons* *● Define operational scenarios of ECRH and ECCD in W7-X. Analyse the effect of ECRH on magnetic configuration. The ECRH system in W7-X is the most advanced of its kind and is similar to the one that will be used in ITER.* *● Study of 3D Breeding Blanket development with 3D neutron flux estimates*

Use of EU facilities

W7-X, TJ-II, HPC-FF, Gateway

International Collaborations

ORNL, University of Princeton (USA): Use of STELLOP code for Optimization.

NIFS: Work on island dynamics

2.2.13 WPCD: Code Development for Integrated Modelling

Set of Activities Number	13	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Code Development for Integrated Modelling (WPCD)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 1,794.24 k€ (1,018.087 k€ EUROfusion contribution) including 18.67 ppy and missions cost. This includes the work related to 'Extension of STARWALL to halo currents' with ITER-IO (about 30 k€ contribution for 0.8 ppy and mission costs).

Objective

The Code Development for Integrated Modelling project supports the achievement of Mission 1 and 2 goals via the development of existing modelling codes with a particular focus on integrated modelling. Extensions to integrated modelling related to Mission 8 – "Stellarators" are foreseen for 2015-2018 and should be planned in collaboration with the related work packages. The primary objectives of the Code Development for Integrated Modelling are:

1. Provide a suite of codes that can be validated on existing machines and used for ITER and DEMO predictions (i) build on existing modelling codes developed by the EFDA Associates including the infrastructure, toolset and codes developed under the EFDA ITM Taskforce, ii) add new physics to the existing models, iii) couple codes into integrated workflows, iv) code optimization).
2. Specific ITER simulation work in support of ITER IO and F4E with specified deliverables.

Management

The project is divided into 8 sub-projects, each tackling the development of a specific physics oriented complete workflow the validation of which is planned in collaboration with experiments, through JET and MST work packages. Each of the subprojects or activities, here below ACT, comprehends integrated modelling developments needed to specifically support Mission 1 "Plasma regimes of Operation" and Mission 2 "Heat Exhaust systems" Headlines:

- ACT1-"Equilibrium and stability chain development and exploitation" successively builds elements to provide the modelling capability allowing to tackle "MHD control in plasma scenarios" , related to H1.4 "Integration of MHD control into plasma scenarios" (in support to MST1 deliverables).

- ACT3 on the development of a "Core transport simulator with extended capabilities" together with ACT2-"Free boundary equilibrium and control" and ACT5 – "Heating and Current Drive", supplying the required sources, build the needed elements to provide the modelling capability to study integrated scenario with controllers, related to H 1.8 "Develop integrated scenarios with controllers" (in support to 2016 deliverables of MST1, JET1, MST2 in order to prequalify ITER scenarios).
- ACT4 on the development of "Turbulence workflows with synthetic diagnostics" is strictly related to H2.3 "Optimise predictive models for ITER and DEMO divertor/SOL", addressing validation of turbulence codes of increased complexity and dimensionality, putting the foundation to the development of 3D turbulence models for the SOL.
- ACT6-"Benchmarking of non-linear codes for fast-ion and MHD interaction" specifically addresses developments related to H 1.7 "Optimise fast ion confinement and current drive", specifically "Benchmark codes and validate non-linear models for fast ion MHD interaction" (in support to MST1,2 2015 deliverables)
- ACT7-"Edge/SOL code and workflow development" (including 7.1 SOLPS technical optimization 7.2 AMNS data and interfaces, 7.3 Pedestal/SOL code development and core-edge workflow development, 7.4 core/edge and edge code adaptation) specifically addresses H 2.3 "Optimise predictive models for ITER and DEMO divertor/SOL". Following developments up to 2018, tackling core-edge coupling and coupling to PFCs will further support H1.5, H1.9 and the other Mission 2 Headlines.
- ACT8- Support activities (8.1 portal /webpage maintenance, 8.2 visualization tools development, 8.3 experimental data interface, 8.4 local IM platform installation contacts). ACT8.3 includes contact persons for experimental data that should ensure the data provision for the validation on experimental devices.

Main Objectives

TOP THREE 2015 OBJECTIVES

• WP15-CD.D03: **Core transport simulator with heating synergies**.
  o ETS core simulator (fixed and free boundary) with full hierarchy of transport models and full integration of H&CD, including synergies.
  o Simulator release + regression test).
  o Implementation of the released ETS workflow into JEC2020 modelling infrastructure
• WP15-CD.D04: **Controlled Free boundary ETS**.
  o Feedback controlled free boundary ETS (finalized version)
  o Simulator release + regression test
• WP15-CD.D01: **RWM chain**.
  o RWM workflow.
  o Chain release + regression test

Description of work

A detailed list of deliverables is in the WPCD Project Management Plan. The following table describe the work to be done in 2015 under each relevant headline. Some tasks are multi-years with the final delivery date beyond 2015.

WPCD
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D13: Core transport simulator including: - various equilibrium and transport modules; - turbulence modules; - impurities; - pellets; - neutrals; - sawteeth, NTM; - heating and current drive modules (extended to synergies, EC, NBI, IC, LH and fast-ions) with improved physics (2017)
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure
- Collaboration WPCD / WPJET1: Interpretative analysis and modelling of JET selected discharges with ETS
- ETS core simulator (fixed and free boundary) with full hierarchy of transport models and full integration of H&CD, including synergies (without LH and fast particles). Simulator release and regression test (WPCD PMP deliverable number WP15-CD.D03)
Headline 1.2: Operation with reduced or suppressed ELMs
H1.2-D11: ELM control workflow – including ELM module/3D MHD non-linear code (in support of other deliverables from H1.2) (2017)
- Integration of a simple ELM module in the ETS
Headline 1.3: Avoidance and mitigation of disruption and runaways electrons
H1.3-D10: Develop full 3D codes (plasma + vessel) to describe halo current formation and asymmetries (2020)
- Upgrade of JOREK to include vessel halo currents for disruption modelling and benchmark codes against AUG data (collaboration WPMST1/WPCD) *- Verified JOREK - extended STARWALL coupled code, adaptation to Integrated modelling standards (collaboration ITER-IO)*
H1.3-D12: Develop Disruption workflow – including ELM module/RMP (2017)
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium
Headline 1.4: Integration of MHD control into plasma scenarios
H1.4-D04: Improve modelling of mode dynamics to take into account realistic wall geometries (RWM) and actuators (NTM and RWM) (2018)
- 3-D ASDEX-U wall implemented in integrated Modelling infrastructure for use of RWM codes.
- Collaboration WPCD /WPMST1: RWM workflow validated on multiple devices (benchmark codes against AUG data).
H1.4-D07: Extended linear stability chain (equilibrium coupled to MHD stability, edge instabilities, fast particle driven instabilities, RWM, ELMs) (2016)
- RWM workflow release and regression test (WPCD PMP deliverable number WP15-CD.D01) *- MHD linear stability chain including new physics (rotation or peeling-ballooning type instabilities that are observed on the onset/linear drive of the ELM). Linear MHD stability chain documentation and tutorial (WPCD PMP deliverable number WP15-CD.D02)*

Headline 1.6: Determine optimum particle throughput for rector scenarios
H1.6-D02: Validation of models for core particle convective transport, pellet ablation and drifts. Link to the model development in Headline 1.5 (2015)
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
H1.6-D04: Optimisation of DT fuel mixture control and use of tritium (2017)
- Collaboration WPJET1 / WPCD: Simulate fuelling conditions that will be available in a DT campaign; ETS scenario modelling for DT campaign fuelling.
Headline 1.8: Develop integrated scenarios with controllers
H1.8-D01: Demonstrate combination of individual control algorithms into integrated control scenarios: Combine avoidance of NTMs, possibly via sawtooth control, with control of ELMs, disruptions, core contamination, divertor detachment, fuel species mixture and simulated burn (2018)
- Coupled feedback controlled free boundary plasma simulator and transport solver – finalised version of the Feedback controlled free boundary ETS Simulator release + regression test (PMP WPCD deliverable number: WP15-CD.D04) *- Integration of synthetic diagnostic*
Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL
H2.3-D06: Optimise predictive models for ITER and DEMO divertor/SOL: Self-consistent coupling between core and edge transport codes (2015)
- Benchmark ETS core-edge workflow versus JINTRAC-COCONUT (new task)
H2.3-D04: Optimise predictive models for ITER and DEMO divertor/SOL: Development of computational tools for edge transport extending up to PFC (2018)
- Application of SOLPS to TCV SOL geometry studies.
- Finalized SOLPS speed-up studies *- Prototype edge workflow modelling SOL and interaction with PFCs (2015 milestone from PMP) (also in support to H1.5, H2.2)*
H2.3-D03: Validation and exploitation of turbulence and synthetic probe workflow for experiment analysis (NEW) (2015)
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis of MST and JET if probes / probe data available.
Headline 8.2: Theory development and modelling / stellarator optimisation
H8.2-D02: Improve tools for predictive edge modelling for 3D geometries of stellarators (2018)
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium codes into Integrated Modelling Framework (new task t.b.d.)
H8.2-D04: Develop new stellarator configurations close to HELIAS, giving higher priority to fast ion confinement and less weight to aspects now deemed less crucial such as MHD stability. (2018)
- Collaboration WPCD / WPS1 / WPS2 : fast ion losses synthetic diagnostics integration (new task t.b.d.)

H8.2-D05: Stellarator reactor engineering and technology studies, including systems code design optimisation and costing studies, requirements analyses for blanket / shield, coil spacing, bend radius, superconductor type and properties; space requirements etc., diagnostic and heating system port and space requirements, RH requirements, remote handling space needs, etc. (2018)
- Collaboration WPCD / WPS2: Adaptation of ICRH/ECCD codes for stellarators to Integrated Modelling Framework frame work (new task t.b.d.)

Use of EU facilities

- Gateway Computing Cluster: Repository of CD IM infrastructure and data and computing resources.
- JET and MST: Code and workflow validation, Shots database for modelling, Data mapping for selected data.

Specifically, the following inputs are required:

1. Data structure update (WPISA CPT);
2. Data mapping for AUG (WPMST1) including: MSE, ECE, Thomson Scattering and CX;
3. Machine Description for AUG IC antenna;
4. Data mapping for JET;
5. Wall, equilibrium data for full-vessel grid development (MST, JET, JT-60SA, ITER, DEMO)

International Collaborations

ITER-IO: i) for the platform development and adaptation of integrated modelling tools to ITER Data Structure (IDS); ii) for the SOLPS technical optimization; iii) for disruption modelling with JOREK (upgrade of JOREK to include vessel halo currents).

US (UC San Diego) for the Kepler development (together with WPISA).

2.2.14 WPISA: Infrastructure Support Activities

Set of Activities Number	14	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Infrastructure support activities (WPISA)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Foreseen total resources of 1,108.855 k€ (1,108.855 k€ EUROfusion contribution) including 9.6 ppy and missions cost.

Objective

Managing and supporting the codes and workflows requires dedicated hardware and small teams of software developers and computational physicists. Under this work package the core programming team (CPT), the gateway (GW) and the high level support team (HLST) are coordinated.

Management

Overall coordination of WPISA activities is done by Programme Management Unit (WPISA Responsible Officer). Each team in WPISA (CPT, GW and HLST) is led by the Team Leader, who is reporting to the PMU RO.

Description of work

WPISA
Headline 1.1: Increase the margin to achieve high fusion gain on ITER
H1.1-D13: Core transport simulator including: - various equilibrium and transport modules; - turbulence modules; - impurities; - pellets; - neutrals; - sawteeth, NTM; - heating and current drive modules (extended to synergies, EC, NBI, IC, LH and fast-ions) with improved physics (2017)
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure

Headline 8.2: Theory development and modelling / stellarator optimisation
H8.2-D02: Improve tools for predictive edge modelling for 3D geometries of stellarators (2018)
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium (VMEC) codes into Integrated Modelling Framework (New task t.b.d)
Support work PMP deliverables:
ISA-1: Core programming team (CPT)
• Functional maintenance of the Integrated Modelling platform and tools; • Implement the new functionalities to the infrastructure; • Support to the integration of modules into workflows; • Provision of trainings on the Integrated Modelling infrastructure and workflows
ISA-2: Gateway (GW)
• Maintain the hardware of gateway computer, support users on technical issues
ISA-3: High level support team (HLST)
• Parallelise codes using e.g. Open MP and/or MPI standards for massively parallel computers; • Improve the performance of existing parallel codes both at the single node and inter node levels; • Support the transfer of codes to new multiprocessors architectures; • Choose and if necessary adapt algorithms and/or mathematical library routines to improve applications for the targeted computer architectures; • Give feedback to the community based on experience gained from specific project work; • Provide guidance for young scientists on available training activities in HPC and towards upcoming new computer architectures; • Provide consultancy to scientists within the Associates working on HPC; • Exploit developments made by the ITM Task Force, especially in the fields of standards, graphical user interfaces, common data bases and parallel visualization, for the benefit of the IFERC-CSC users.

Use of EU facilities

Gateway computing cluster, located in IPP Garching

International Collaborations

US (UC San Diego) for the Kepler development (together with WPCD)

Japan for the exploitation of HPC

2.2.15 WPPMI: Plant Level System Engineering, Design Integration and Physics Integration

Set of Activities Number	15	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Plant Level System Engineering, Design Integration and Physics Integration (WPPMI)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: Resources foreseen in 2015 include 24.7 ppy from labs + 1.7 ppy from industry.

Objective

The Work Package WPPMI consists of activities to be executed by Design Teams within member laboratories or Industry through specific Tasks. The activities foreseen in 2015 can be divided into the following main areas:

- Requirements analysis
- Plant Design Definition and Evaluation
- System Level Analysis
- System Engineering Framework and Technical Processes
- Integration Management
- DEMO Physics Design Integration

The WPPMI activities will be managed directly by the Programme Management Unit. In order to ensure the necessary link with the Consortium members, a PPPT Advisory Board will be established to review the priorities in the areas of physics and system integration and advise on the strategy to be taken at each stage of the process.

Description of work

A brief description of the activities foreseen in 2015 is provided below together with a description or list of the main deliverables. Tasks where involvement of industry is expected are also indicated.

Requirements Analysis

Stakeholder Requirements Definition

To support the definition of the top level requirements for the DEMO Fusion Power Plant, the EUROfusion Work Programme 2014 originally foresaw the establishment of a DEMO Stakeholder Group consisting of individuals that represent a wide cross section of interests in the future DEMO Fusion Power Plant on the path to commercial fusion electricity. However, because of the potential sensitivity of some of the issues involved in the discussion, and especially the need to focus the discussions at the beginning on the definition of the Top Level Requirements, a proposal has been to study the process followed in other fields, especially fission, and draw lessons from the approach used.

EUROfusion will develop for this first step:-

- A proposal of DEMO principal missions, forming the main objectives of the project
- A supporting Operational Concept Description, being a precursor to an Operational Concept Document
- A rationale of constraints, both technical and non-technical, which bound the available DEMO principal parameter space, within which, the plant conceptual configuration can then be derived.

After this initial step, a proposal will be made to form the DEMO Stakeholders Group (SHG). In 2015, it is foreseen that the SHG will agree on the expected uses (i.e. missions), users and postulated operational scenarios for the DEMO plant. Furthermore, the SWG will agree the top-level plant key performance indicators (KPIs) in terms of minimum acceptable thresholds and also agree the relative value attributed to increases in performance from the minimum requirement thresholds i.e. value modelling.

Deliverables

- A Stakeholder requirements document (SHRD) including KPIs and value model. Stakeholder requirements will also have been written in requirements language and syntax and held in a format compatible with database upload.

Plant Requirements Analysis

The work foreseen in 2015 should continue work started in 2014, however emphasis needs to move towards ensuring that a consistent approach is also being applied across the PPPT projects and that traceability starts to be established between plant requirements and lower-level systems. By the end of 2015, this task should have completed an OCD and PRD fully developed from the SHRD, and developed plant functions to the point that individual projects agree the basic architecture they intend to employ to satisfy those functions (for all states and modes). More specifically the intention is to:

- Develop an Operational Concept Document (OCD) that sets out the expected uses (i.e. missions), users and operational scenarios for the DEMO plant. This document will be in an early draft as an input into the stakeholder engagement process, which will then be fully developed in parallel with the DEMO Stakeholder Group (SHG).
- Identify relevant requirements sources e.g. stakeholders, codes & standards, regulations, etc.
- Plan Requirements Analysis, and review the Requirements Management Plan developed in 2014, further develop the Plant Requirements Document drafted in 2014
- Read already documented requirements and measure requirements quality. Define validation expectations for design requirements already captured.
- Establish DEMO Plant system context and boundary. Perform a context analysis to identify what falls within the DEMO Plant System boundary and what systems are external interfaces, with SHG guidance.

- Identify required states and modes of the DEMO Plant System. Propose and model top-level plant states and modes to assist in describing required behaviour and functions
- Further develop the Functional Flow Block Diagrams (FFBDs) completed in 2014, consequently developing Physical Architecture Allocation Models (PAAMs) in collaboration with the projects
- Start to assign and flow-down performance requirements from top-level plant KPIs down to lower-level functions

Deliverables

Main expected deliverables are:

- Plant-level and System-level Functional Models i.e. FFBDs (reviewed and agreed with all PLs)
- Functions to System-Level PAAMs (reviewed and agreed with all PLs)
- Traceability between Plant-level and System-level requirements documented according to the requirements management plan
- DEMO Operational Concept Description (OCD) – updated release
- DEMO Plant Requirement Document (PRD) – updated release

Plant Design Definition and Optimisation

Plant Design Definition

The work in 2015 will build on that already started in 2014 in order to further develop an appropriate set of architectural diagrams/models. These diagrams/models capture the overall functional, operational and physical plant design perspectives needed to fully communicate the design at the CDA in a fully integrated manner. Diagrams to this effect are:

- Piping & Instrumentation Diagrams (P&ID)
- Process Flow Diagrams
- Plant Breakdown Structure (PBS)
- Functional Breakdown Structure (FBS)
- Operational Sequence Diagrams
- Plant Control Diagrams
- Power Flow Diagrams i.e. Sankey diagrams
- Physical representation in 3D space models e.g. CATIA

For the purposes of developing the System Engineering framework, it must be established how “objects” within such diagrams/models will be related to one another and other data classes i.e. requirements, etc. through the Systems Engineering framework tool (see para. 0). This is most likely to be by utilising the PBS and FBS as key metadata items.

The Plant Design Description (PDD) document should then be updated and reflect a textual description of the plant design for each project area. It should within the text, refer to any documents or diagrams that have helped shape the design as described in the document such as:

- Key technical decisions
- Principal requirements by relevant PBS / FBS
- Any of the diagrams in the above list relevant to the plant being described
- Open questions and future challenges

At the end of 2015, first revisions of the diagrams needed to define the plant for each project area should exist. How objects within the diagrams will be searchable for every occurrence of them must be established and worked into the requirements document for the Systems Engineering Framework. The PDD is to be completed and act as the reference for related design definition diagrams. It is not the job of the PDD to replicate the functionality of the SE Framework, but at least provide a condensed description of the plant at this conceptual stage of plant definition and how it was arrived at.

Plant Design Optimisation Studies

For the DEMO design to have the maximum chance of meeting performance requirements, it must be extremely optimised across all design elements. This requires a thorough understanding of the current reference technology and its relative maturity, resolution of the maximum performance envelope through the observed variance of key parameters relative to each other, and the development of a decision making process sequence able to capitalise on perceived optimisations, such that they can be fully integrated in the correct order to secure the performance benefit and minimise technical risk. To this end, the following activities are proposed for 2015:-

- **An Independently moderated TRL Assessment**. Technologies across the project need to be assessed against a common set of technology readiness criteria in order to better understand the relative challenges each technology option presents. This is needed so that a clear performance advantage / technical risk assessment can be made and fed into later technical decision making processes. In order to maximise the effectiveness and fairness of the decisions, external moderation of the TRL assessment is needed as a minimum.
- **A Parameter trade off assessment and prioritisation exercise**. The DEMO project must ensure an intelligent selection of trade off studies are performed, that will shed light on the sweet spots, cardinal parameters and interfaces need to be pushed towards to afford the most arguable plant design. This should be conducted by a number of workshops to brainstorm, join-up, rationalise and rank such parameters and/or key design interfaces. The result of this exercise will be to add or modify the following list of already identified studies for 2015:

    - **Aspect Ratio Scan**: started in 2014, this trade-off study will investigate a range of aspect ratio design points produced using the PROCESS systems code and then assess the impact on a number of important design drivers such as: (i) vertical Plasma Stability and Control; (ii) foreseen Disruption Forces; (iii) impact on Magnet System; (iv) impact on Tritium Breeding; (v) Maintainability of in-vessel components; (vi) Impact on Overall Availability; (vii) Impact on Cost; (viii) Impact on Technological Risk; (ix) Attractiveness of integrating HCD systems.
    - **Development of a blanket attachment system:** the blanket segmentation and supports have significant impact on the activities carried out in WPBB, WPRM, WPSAE, WPBOP, and WPCS projects. This study, building on 2013 and 2014 work will analyze the main requirements from these interfacing systems and reconcile design integration issues in an objective manner.
    - **Recirculating Electrical Power Requirements:** the dynamic recirculating electrical power requirements of the major power consumers e.g. magnets, cyroplant, T-plant, HCD systems, primary cooling pumps, etc., are influenced by a number of factors such as the architectural design and operational concept of the DEMO plant. This trade-off study to be started in 2015 will

analyze the range and dynamic nature of the recirculating electrical power requirements for different operational scenarios and design configurations and explore the impact of BoP, grid and energy storage needs.

- **Sweeping of Divertor Strike Points:** the expected level of heat flux on the Divertor is one of the main design drivers for DEMO and will push the technology and materials to their limits. One idea to mitigate this risk is to electromagnetically induce a low-frequency sweep of the divertor strike points in order to distribute the incident heat over a larger area and hence lower the instantaneous heat flux. A design study will be performed in 2015 to investigate the feasibility of achieving a sweeping function and explore the related pros and cons at Plant level.

- **A Critical Decision Making Process:** A task is needed to resolve a) what are the critical technical decisions to be made in this project phase, b) when and in which order should they be made, and c) what is the process by which they should be made in order to obtain a clear result that will stand up to future scrutiny and be understandable in 10 year's time. Part a) can be conducted in a review meeting with further opinion canvassing to gather a master list. Part b) will be resolved partly through a basic logic sequence showing series and parallel decisions, and partly in alignment with the output from a fully integrated plan (0), and c) will involve using critical decision matrices with agreed assessment criteria. This activity in particular requires close support and monitoring from the PMIAB.

System Level Analysis & Plant Engineering Studies

The activities on System Level Analysis and Plant Engineering Studies support the development of a coherent DEMO design basis, ensuring that the proposed technical solutions for the components (to be developed within the Projects) are properly integrated, the plant requirements are met and interfaces are defined and satisfied. Specific engineering assessments will be carried out in support of the studies foreseen in 2.3.2. Such assessments were conducted also in 2014: (i) a design of the TF coil casings study conducted as part of a machine aspect ratio scan and an assessment of the limitations for the integration of an NB with the TF coils; (ii) design requirements for a shielding plug in the upper vertical port; and (iii) and a study based on EM and structural assessments to determine whether the upper port structure could be single-walled to increase the port-internal space.

Work Planned for 2015 Includes:

- Neutronic analysis (global tokamak assessments following the definition of the aspect ratio, supporting assessments for integration studies, continuation of the development of the DEMO nuclear analysis report).
- Global electromagnetic assessments following the definition of the aspect ratio to further develop the DEMO tokamak load specification.
- Structural design development of vessel, cryostat, and tokamak supporting structures building on 2014 results.
- Structural assessments in support of design studies and to define major tokamak interfaces.
- Global plant thermal analysis (for thermal expansion / cryoplant power control). Continuation of the 2014 study based on the updated DEMO aspect ratio.

- Global thermo-hydraulic assessment for the different operating states (for global coolant pressure / temperature control and to assess different cooling scheme variants.)
- RAMI studies shall be carried out as a continuation of 2014 works to support the ongoing definition of the overall plant architecture and the various blanket concepts through (i) investigating the impact in terms of RAMI of the choice of water-cooled and helium-cooled blanket concepts; (ii) integrate RAMI relevant information / findings from other project areas i.e. impact of pulsed operation on turbines (BoP), mean down time for blanket segment replacement (RM), impact of number of cooling circuits and vessel feed-throughs (BB), (iii) repeating the availability goal setting exercise, (iv) Determining where single point failures will cause unacceptable plant downtime and suggest installed stand-by equipment in these areas.

Deliverables

Main expected deliverables are:

- Analysis reports (RAMI, neutronics, electromagnetics, structural, thermohydraulic)
- Design of vessel and cryostat
- Plant and tokamak models providing the parameters required for various system interface specifications
- DEMO neutronics model (update 2015)
- Design studies assessment reports in support of the studies foreseen in 2.3.2

Systems Engineering Framework and Technical Processes

Definition of a Systems Engineering Framework

The ability to structure, manage, control and provide access to technical data is seen as a key element in the success of complex and highly integrated technical programmes such as the DEMO conceptual design activity (CDA). The purpose of this activity, which was started in 2014, is to realise the implementation of a model-based technical management system in the context of an overall Systems Engineering Framework. In 2014, an Official Journal of the European Union (OJEU) call for tender has been initiated in order to select and engage an industrial partner to develop the Systems Engineering Framework. This partner is due to be selected in November 2014.

Work foreseen in 2015 includes:

- Perform an initial requirements capture exercise for the Systems Engineering Framework tool involving PMU, PLs and project team users
- Explore and define interoperability requirements with other IT systems
- Develop a core Engineering Data Model through the definition of data classes, relationships and metadata attributes. Such data cases in the core model will initially include: Requirement; Plant Component (i.e. PBS element); Interface; Function; Design (subset functional, physical, etc.); Design Change
- Explore usability requirements i.e. GUI, ease of access/use, visibility, acceptance in fusion community
- Review, recommend and implement a suitable physical architecture / implementation for the Systems Engineering Framework

- Using the selected tool implementation, develop a core function for Interface Management to include data model and workflow
- Formation of Systems Engineering Framework tool with a small amount of data instances (i.e. <500) in a few data classes (i.e. 6 to 10) User evaluation / testing leading to requirements and design refinement.

Deliverables

Main expected deliverables are:

- Interface Management Tool
- Systems Engineering Framework tool (alpha release, i.e. functional demonstration to small set of users)

CAD configuration management

A technical management process will be established to support the execution of the Projects and ensure that the required level of consistency and control is exercised. Many of these technical processes (e.g. Interface Management, Risk Management, Change Management, etc.) will be initially developed by the PMU and reviewed with the PPPT Project Leaders. However, it is currently foreseen that CAD Configuration Management processes will be developed under tasks in 2015 in strong collaboration with the Systems Engineering Framework activity. The scope of this work will consider the 2014 achievements and develop a Configuration Management Plan (CMP) for Design Management in accordance with ISO 10007.

The activities to be defined within the CMP are as follows:

- *Configuration Management Planning* – Identification of tool sets and software e.g. CAD, PLM, DMU. Establish CAD design data lifecycle management and release processes for managing baselines and consideration of the authorities and responsibilities necessary for implementing.
- *Configuration Identification* – Methods for structuring master geometry, design CAD data and interface controls between design CAD data.
- *Change Control* – Management of change to design CAD data within baselines and version control.
- *Configuration Status Accounting* – Reporting on CAD design data e.g. lifecycle status/maturity, status of change, configuration baseline status, version status.
- *Configuration Audit* – Verification strategies of Design Solutions against Requirements.

On-site and remote support along with possibly training provided to the PMU in the following areas:

- The implementation and customization of the CAD management system of the choice (outcome of task in 2014).
- The implementation and customization of the CAD model data preparation and handling as proposed in 2014.

Deliverables

Main expected deliverables are:

- Design Configuration Management Plan (DCMP)
- Implementation and customization report on the CAD management system
- Implementation and customization report on the CAD model data preparation and handling

Project Management Activities

Definition of Deliverables for the CDA

The EUROfusion Consortium does not have a clear and agreed set of deliverables required for the Conceptual Design Assessment. An activity is required to resolve these deliverables to understand the master list, the form and context of the information required for each listed deliverable, its completeness and quality targets. A proposal for the deliverables can be made by the PMU, but this must be approved by the appropriate core stakeholders, such as the Project Sponsor and the PMIAB. A programme of deliverable definition, presentation, iteration and approval must be conducted in 2015 in order to define the outputs of the individual projects in a coordinated fashion as dictated by the master schedule.

Formation and Maintenance of the Master Schedule

Currently, within PPPT, we have developed plans for the individual projects, however they are not fully harmonised with appropriate interlinking across projects. It is important these links are identified, since unoptimised sequencing in one project may lead to significant delay in another. To this end, it is intended to acquire dedicated resource to pull together the individual project plans and undertake a linking and sequencing exercise to ensure an optimum flow of design outcomes and decisions across the projects. This is essential in meeting deadlines for deliverables, avoiding re-work and minimizing uncertainty with the projects. This exercise is strongly linked to the Decision making process in 0. By the end of 2015, a harmonised plan with rolled up activities from the individual plans should be complete, with defined CDA deliverables as key outputs. A cycle of update window, resource profile adjustment and re-baselined publication needs establishing for future years, perhaps on a bi-monthly basis.

Interface Management

Interface management needs a higher profile within PPPT activities in 2015 compared to previous years. A master interface list exists, but it is not being actively pursued by the individual projects without PMI encouragement. The way interfaces are catalogued, displayed, searched and managed must be improved in 2015, so that persons within individual projects can quickly access their critical interfaces and initiate a process if they want to update or create interfaces. It is currently targeted to undertake this improvement within the Systems Engineering Framework in 2015, either way, a useable system must be in place by year end.

DEMO Physics Integration

During the DEMO concept definition and conceptual design work, extensive design and engineering efforts combined with appropriate physics basis guidelines are foreseen. The relevant physics knowledge – referred to as DEMO Physics Basis – and the activities requiring physics expertise are gathered in DEMO Physics Integration.

The main areas foreseen in 2015 are:

- Systems Code analyses
- DEMO Physics Basis Development

- DEMO Physics Design Integration

Also a number of additional studies is anticipated, which come up on a relatively short notice.

System Code Analysis and Development of Point Design Options

System codes incorporate a comprehensive and relatively simplified model of an entire power plant. They are used to develop DEMO design points, which are consistent with respect to all relevant physics and engineering constraints.

The activities related to system codes can be grouped in the following areas:

- System code physics model improvements
- System code engineering model improvements
- System code development and documentation
- Design point analysis including parameter scans and sensitivity studies
- System code benchmarks

DEMO Physics Basis Development

A key activity is the predictions of all relevant aspects of the physics of DEMO. This information is used for the development of the DEMO design points and also by the projects developing the concept design for DEMO components.

The activities in the DEMO Physics Basis Development envisaged for 2015 can be grouped in the following areas:

- Plasma Scenario Modelling
    - Further refinement of ramp-up and ramp-down scenarios – especially with more detailed descriptions of the heating systems
    - Simulation of pellet fuelling and related effects
    - Simulation of the effect of planned and unplanned perturbations (e.g. actuator failure)
    - Investigation and optimisation of DEMO impurity seeding scenarios
    - Simulation of the DEMO breakdown phase
- Transport
    - Confinement time prediction for DEMO
    - Gyro-kinetic simulations of core transport in DEMO
    - Core and edge impurity transport in DEMO
    - Prediction of the edge density limit for DEMO
    - Prediction of rotation in DEMO with and without neutral beam heating
- MHD
    - Prediction of the DEMO pedestal
    - Analysis of the global stability of DEMO scenarios
    - Study of DEMO triangularity effects
    - Investigation towards DEMO operation with mitigated or suppressed ELMs
- H&CD
    - New assessment of current drive efficiency

- Fast particles
    - Simulations of fast particle losses with a Monte Carlo guiding-centre orbit-following code – investigate ripple effects
    - Stability of alpha-driven modes (linear and non-linear kinetic stability calculations)
- Specification of Wall Loads
    - Steady state thermal loads at the main chamber wall of various types (e.g. due to thermal electrons/ions)
    - Transient thermal loads at the main chamber wall (e.g. due to confinement transients and plasma disruptions)
    - Divertor thermal loads (high and low heat flux regions)
- Plasma Edge and Plasma Wall Interactions
    - Simulation of the DEMO divertor with integrated divertor modelling tools
    - Erosion lifetime estimates (e.g., divertor strike points and wall)
    - Effects of divertor sweeping
- Optimisation of a conventional divertor layout for DEMO (recommended by the gap assessment report 2012)

DEMO Physics Design Integration

This area includes activities aiming at a specification of the DEMO plasma conditions or of DEMO components, which imply particularly strong interfaces between physics and engineering.

In DEMO Physics Basis Design Integration, activities in following areas are envisaged:

- Vertical Stability Analysis
- Plasma Disruption Analysis
- Evaluation of the Toroidal Field Ripple

Deliverables

Main expected deliverables are:

- Report on DEMO Design Points Studies
- DEMO Physics Basis Document (preliminary version)
- DEMO Wall Load Specification (preliminary version)

2.2.16 WPMAG: Magnets system

Set of Activities Number	16	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Magnet system (WPMAG)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 7.3 ppy are foreseen in 2015 for the execution (including 0.2 ppy for industry), plus an additional 0.7 ppy for the management function of the Project Leader. 705 k€ expenditure is foreseen on hardware.

Objective

The work package WPMAG is divided into four activity areas, namely Winding Pack & Interfaces; Structures and Fabrications; R&D and Qualification; and Advanced Magnet Technologies (HTS)[3].

Winding Pack & Interfaces

This includes detailed analyses of the TF Winding Pack design ensuring compliance with design criteria both in operation and in quench conditions (T margin, hotspot temperature…). The optimization should:

- be based on the technical baseline defined during 2014 activities, maintaining if appropriate, multi-options design proposals;
- be derived from the outcomes of 2014 thermo hydraulic studies regarding temperature margin and from mechanical studies considering realistic pack composition (steel, insulation);
- include considerations arising from feasibility assessments led by labs and industry in 2014.

The technical evaluation of DEMO machine operating point options (being generated by using system codes (see WPPMI) will be performed, selecting whenever possible the most promising TF Winding Pack baseline options, by using agreed methods and tools.

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[3] It should be noted that the notation used to identify the work packages differs from that used in 2014 and reflects the WBS approved in the PMPs by the Project Boards.

In addition: 1) analyze the requirements of the Central Solenoid (CS) and Poloidal Field (PF) coil system CAD configuration and current scenarios in DEMO baseline operation (coming from System Codes and plasma equilibria and vertical stability calculations); 2) identify the most demanding conditions arising from the scenario for out-of-plane forces and conduct the appropriate EM analyses. Assess the load conditions on CS & PF systems and build a first design of coils and conductors for both systems. The designs should be consolidated through EM and thermohydraulic analysis under expected operation conditions (steady-state, transients).

Structures and Fabrication

Perform global 3D structural analyses on updated TF magnet system under the most demanding load cases (to be defined, but at least including cool-down + TF load + CS load + PF load) and check TF design compliance with acceptance criteria and with system integration (components clearance). If applicable, a parametric analysis will be performed on local contact elements (i.e. shear keys, OIS bolts…) to investigate the most suitable design regarding these structural parts. Conduct various 2D local analyses where mechanical issues are identified by 3D (insulation shear stress, etc…). Apply interfacing tools developed in 2014 (e.g. interpolator…) and together with detailed 2D studies, assess the tool ability to integrate all elements in a multi-physics platform.

Conduct first mechanical studies of CS and PF systems to assess the coils design, as integrated in the overall magnet system. In particular, determine the limit forces to keep CS integrity during discharge, conduct first fatigue analysis to ensure proper CS structures dimensioning. A preliminary assessment leading to first recommendations on structures regarding assembly in the tokamak and assess their impact on any magnet system design from the start is foreseen in 2015.

As for thermal calculations, perform refined simulations of TF coil behaviour to account for the neutron heat load transport through structures. Parametric analyses considering different contact conditions or insulation material shall be carried out. The outcome would be transmitted as input, liaising with thermo-hydraulic analysts. At the same time, continue to develop a standalone program for He temperature simulation, to serve as efficient tool for parametric analyses.

As for feasibility studies, use labs and industry expertise to judge feasibility, development costs and manufacturability of main design options being considered. The field of application should now cover not only the winding pack but also the structures, the magnet acceptance tests, magnets transportation and assembly in the tokamak.

R&D and Qualification

Complete the manufacture of the two TF conductor samples, either RW1 or WR1. This includes the acceptance tests of short lengths manufactured in 2014 and their assembly into SULTAN (or EDIPO) samples. The samples' designs should be defined to be able to provide as much information as possible during the test campaigns. For example, appropriate investigations on instrumentation or bottom joint design would ensure experimental data to be optimally instructive for further TF design work. For the RW1 particular case, the geometry in which heat treatment will be applied is of importance to ensure the best relevance in tests.

SULTAN (or EDIPO) test programs for RW1 & WR1 should be defined to maximize the output and check response either in DC (operation, cycling) or in AC (losses, stability) regimes to provide a robust reference for future choices on TF conductor design.

As for sample tests, at least one of the two samples is expected to be tested in SULTAN (or EDIPO), or both according to the facility availability and the degree of advancement of sample manufacture. The test data would be post-treated and interpreted according to the various models developed in the community. The outcomes and especially their comparison with hypotheses considered for WP design (e.g. effective strain) should be discussed and associated conclusions/ recommendations drawn.

Advanced Magnet Technologies (HTS)

Investigations of commercial tapes through dedicated tests are continued, focusing on the fabrication routes that appeared the most promising in 2014. Generic studies on those materials are still conducted consistently with outcomes and strategy from 2014 work.

The fabrication of experimental cables (Roebel, CORC, etc…) and the associated quality controls will be continued and tentatively achieved for those started in 2014.

Electromechanical modelling will focus on the simulations of the conditions relevant to the tests of the manufactured cables. When applicable, feedback will be drawn between tests results and modelling outcomes and the gaps, if any, will tentatively explained for next model upgrades. Generic models are also investigated following work started in 2014.

Continue work on a HTS DEMO coil, identifying the strength of the configurations presently exposed. An overview of the outcomes is provided together with recommendations for future activities orientations in this domain.

High current facility preparation advancement is checked in view of future HTS cable samples tests.

Management

Following the approval of the Project Management Plan (PMP) in 2014, a revision will be issued to reflect any detailed adjustments to the planning of the activities. The key management activities shall aim at consolidating the integrated team e.g. routinely uses of meetings, collective documents and IDM tool.

Description of work

Main Deliverables (Status)

- Magnet System Load Specification (LS) - (Advanced draft)
- Magnet System CAD Configuration model (inc. TF, PF & CS coils) - (Draft)
- Magnet System Design Document - (Draft)
- Candidate TF, PF & CS Conductor Engineering Analysis Reports - (Final)
- Candidate TF, PF & CS Conductor Design Specifications - (Final)
- Reference document on DEMO TF conductor prototype samples - (Final)
- Reference documents on HTS samples fabrication / tests - (Final / draft)

Use of facilities

The use of a number of EU facilities is foreseen in 2015. These include superconducting magnet facilities such as SULTAN, EDIPO (CRPP, CH) or FBI (KIT, DE) where full-size conductor samples can be tested under representative field, current and temperature. Furthermore, facilities for the mechanical testing of conductors under various strain regimes is also foreseen (such as those at the University of Twente). In the HTS area, the aforementioned facilities would also be used and those for the investigation of the effects of neutron irradiation (e.g. TRIGA at ATI) on superconducting properties will also be utilized.

Expected Role of Industry

Industrial involvement in 2015 is mainly foreseen in:

- Providing feasibility studies on DEMO TF magnet system, namely in complement to the ones provided in 2014 and investigating new fields (CS & PF systems, magnets acceptance tests, magnets assembly…)
- Manufacturing of TF conductor samples for R&D on DEMO TF system
- Providing HTS tapes and possibly manufacturing HTS cable samples.

2.2.17 WPBB: Breeding blanket

Set of Activities Number	17	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Breeding Blanket (WPBB)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 43.98 ppy in labs are foreseen in 2015, in addition to 5.2 ppy for the Project Leader and Group Leaders and 2.3 ppy from Industry. 2712.5 k€ expenditure is foreseen on hardware.

Objective

The work package WPBB is divided into nine activity areas (sub-projects) namely Management and Support Team, HCPB Design and R&D, HCLL Design and R&D, WCLL Design and R&D, DCLL Design and R&D, LiPb Technology Development, Blanket Tritium Technology Development, Blanket Tritium Technology Development, Blanket Manufacturing, and FW/limiter design and R&D.

Activities foreseen in 2015 include:

a) Revision of the System Requirement Document (SRD) and CAD Configuration Document (CCD) involving PMU and other PLs with the aim to consolidate the basis for the foreseen first design development phase (in 2015-2017);
b) Start integrated and self-consistent design work for all the blanket options ensuring that from the very beginning they meet the requirements.
c) Continue the implementation of R&D activities as planned in the WPBB PMP that will build on the outcome of the 2014 R&D results.

The activities planned in 2015 are described in detail below:

Management and Support Team

The key activities foreseen in 2015 include the coordination of the revision of the blanket specifications and interfaces that will be collected in two main documents, SRD and CCD, at the end of the year. The part of the work related to the “external interfaces” will be performed in strong co-operation with PMU and PLs of the other projects. The “internal interfaces” will be strictly monitored to keep coherence and control of the BB Project. The general coordination role of this team includes also the coordination of the neutronic analyses in the WPBB: in particular in 2015, specific DEMO models to be used in nuclear analyses will be recommended.

The process of exchange of information among the different Projects will be continued in 2015 with specific deliverables; e.g. an assessment of the remote handling system proposed in RMS.

Also, work includes Project and Quality management, Schedule, Risk Register, Action Register control, together with management of CAD exchange with PMU and BB participant RUs.

The following analysis activities are foreseen in 2015:

- EM Analyses of DEMO Blanket System: on the basis of the DEMO configuration model, the EM model for the HCPB DEMO configuration will be developed in Maxwell code (the ANSYS module that will substitute the present EMAG module for EM analysis).
- The McCad conversion software for neutronics analyses will be further developed with improved decomposition algorithms and extended conversion functions for the TRIPOLI code. This will include a description of the interface between TRIPOLI and McCad.
- The functionalities implemented in both TRIPOLI-4 and MENDEL and their verification through a test case will be described.
- Development of the system code module simulating the blanket system in the PROCESS code.

HCPB Design and R&D

Work is foreseen in the following areas:

- System specifications and integration;
- Design and analyses;
- Breeding materials R&D.

Following the completion of the preliminary design description document in 2014, the HCPB design team will perform design studies in 2015 to meet the specifications included in the SRD 2014 and support the revision process that will lead to the SRD version 2015. Design activities for the HCPB blanket foreseen in 2015 include:

- Adaptation of the blanket geometry to the modified plasma shape (CAD model to be provided by PMU) and the proposed maintenance scheme.
- Development of more representative FE models for thermo-hydraulic analyses.
- Optimization of the blanket design aiming at maximizing the TBR.

The following activities are foreseen in 2015 on breeding materials R&D:.

- Ceramic Breeder Production & Characterization: out-of-pile hydrogen isotope absorption/release experiments, procurement and set-up of equipment, temperature and load dependent measurements of the thermal conductivity of lithium orthosilicate based pebble beds,
- Ceramic Breeder Pilot Plant Development: design of pilot plant (intermediate report)
- Ceramic Breeder Characterization: chemical compatibility corrosion tests in Li_2TiO_3 and Titanate/Silicate mixtures at 550°C and He/H_2. Characterization of the corrosion layer.
- Ceramic breeder characterization under irradiation: evaluation of the ionizing radiation effects on the materials properties.

- Beryllium multiplier R&D: Results on compatibility of Be/$Be_{12}Ti$ with air and steam and with structural materials (e.g. EUROFER) and results of out-of-pile T absorption/release test.

HCLL Design and R&D:

Work is foreseen in the following areas:

- System specifications and integration;
- Design and analyses.

Following the completion of the preliminary design description document in 2014, the HCLL design team will perform design studies in 2015 to meet the specifications included in the SRD 2014 and support the revision process that will lead to the SRD version 2015. Design activities for the HCLL blanket foreseen in 2015 include:

- Adaptation of the blanket geometry to the modified plasma shape (CAD model to be provided by PMU) and the proposed maintenance scheme.
- Development of more representative FE models for thermo-hydraulic analyses.
- CFD analyses of the manifold system.
- Finalization on the back supporting structure geometry, including analysis of different options.
- Development of models for the Monte Carlo neutronic analyses performed with Tripoli-4.

WCLL Design and R&D

Work is foreseen in the following areas:

- System specifications and integration
- Design and analyses
- Water cooling technology

Following the completion of the preliminary design description document in 2014, the WCLL design team will perform design studies in 2015 to meet the specifications included in the SRD 2014 and support the revision process that will lead to the SRD version 2015. Design activities for the WCLL blanket foreseen in 2015 include:

- further develop WCLL blanket layout in terms of module size, breeder region thickness, and manifold integration, based on the result of the review studies done in WP 2014.
- further optimize the layout of the coolant pipes and the manifold scheme. Alternative configurations will be considered in view of further development of the blanket design.

Work on water cooling technology in 2015 includes studies of corrosion, water radiolysis and water chemistry.

DCLL Design and R&D

Work is foreseen in the following areas:

- System specifications and integration;
- Design and analyses, and
- Flow Channels Insert (FCI) R&D

Following-up on the completion of the preliminary design description document in 2014, the WCLL design team will perform design studies in 2015 to meet the specifications included in the SRD 2014 and support the revision process that will lead to the SRD version 2015. Design activities for the DCLL blanket foreseen in 2015 include:

- Adaptation of the main blanket performances to the new DEMO specifications and CAD model of DEMO (expected for the end of 2014), to be delivered by PMU.
- Upgrading of the DCLL CAD model with the information obtained during 2014. In particular, the manifold pipes will be integrated in the design and the shielding will be reviewed. Guidelines on remote maintenance will be applied to the entire MMS (parallel walls already included in the 2014 DCLL CAD model).
- Conduct neutronics, thermohydraulics (including MHD phenomena –see below) and thermomechanical calculations for the new geometry.
- Preliminary detailed design of an inboard equatorial module.

R&D on Flow Channels Insert (FCI) includes the development of the DCLL specific technology of the Flow Channels Insert (FCI) to mitigate the MHD effects on the PbLi flow. The following tasks are foreseen in 2015:

- Characterization and construction of FCI mock-up based on previous designs
- Technological study of the fabrication of FCI made of SiC (or SiC_f/SiC) material.
- First experimental campaign on Radiation Induced Conductivity measurements (on sandwich FCI).

LiPb Technology Development

Work is foreseen in the following areas:

- Design of the PbLi loop, integration and assessment of related components;
- MHD calculation and experimental validation for design related geometry of DCLL, HCLL and WCLL;
- Development of coating in PbLi, test and characterization under low and high velocity conditions, and
- PbLi purification and chemical interactions.

In 2015 activities will focus on the following aspects:

- Development of preliminary functional analysis of $Pb_{16}Li$ loops and their integration with other systems
- Preliminary 3D CAD modeling of PbLi loops based on the first available PFD.
- Identification of the operative conditions of each equipment present in the PbLi Loops, including the identification and assessment of the commercial component availability and reliability.
- Calculation of 3D MHD flows related to liquid metal blankets: comparison with experimental data, asymptotic solution and other codes for 3D MHD flows, identification of code limits and simulation requirements, and optimization of design solutions.
- MHD experiments: completion of experiments in modified HCLL blanket mock-up and fabrication of test section for DCLL tests.
- Development of anticorrosion barriers: screening test of the first coating production and samples characterization.
- Coatings qualification under ionizing irradiation: first series of samples will be irradiated and gas permeation tests will be performed.

- Neutron irradiation of coatings: work plan including preliminary thermo-hydraulic calculations to support conceptual design of experimental rigs.
- Compatibility tests of high velocity LiPb channels: Perform qualification tests with preliminary coating developed (1000h/2000h at relevant DCLL conditions) and characterization of the test samples prior and after the PbLi exposure.
- PbLi Control and Purification: completion of experimental set-up and performance of small experiments to calibrate the measurement procedures and to assess the deposition of PbLi corrosion products on cold surfaces.
- Water-PbLi Reaction: designing, implementing and executing Separate Effect Test facility experiments for code validation purposes and execution of a first campaign of validation experiments.

Blanket Tritium Technology Development

Work is foreseen in the following areas:

- Design of Tritium Extraction Systems for the four blankets,
- Tritium transport modeling in the complete Blanket System including relevant auxiliary,
- Development of Tritium extraction processes
- Tritium permeation barrier development.

In 2015 the activities will focus on the following aspects:

- Completion of the Tritium Extraction System Preliminary Design including flow diagrams and operational points. Definition of reference concepts and possible advanced alternatives to be investigated up to 2017.
- Modeling of the T transport in HCLL and DCLL blanket systems based on the preliminary design of the two systems. Determination of operational points for T systems.
- Detailed analysis of T transport in the breeder zone: requirements, single models implementations and first series of calculations for HCPB, HCLL and WCLL
- Experiments on Tritium Extraction from helium purge gas in HCPB with advanced membranes at small scale with tritium: conceptual design of the experimental set-up and test plan.
- Experiments on Tritium Extraction from helium purge gas in HCPB with catalytic membrane reactor at medium small scale without tritium, study for optimizing catalyst and membranes.
- Experiments on Tritium Extraction from PbLi at low velocity for HCLL and WCLL at small scale with tritium using a Vacuum Sieve Tray (VST): design and manufacture prototype tritium compatible VST.
- Experiments on Tritium Extraction from PbLi at low velocity for HCLL and WCLL at medium scale without tritium: Preliminary design of the test matrix and design of experimental ring.
- Experiments on Tritium Extraction from PbLi at high velocity for DCLL at small scale without tritium using a permeator under vacuum (PAV): Fabrication, purchases and installation of the experimental PbLi loop, detailed design of PAV, purchase of materials and fabrication.
- Permeation Test on coating (for PbLi) under Irradiation: final design of the experimental facility.
- Permeation Test on natural oxide layers promoted using helium chemistry control (with tritium) for HCPB: final detailed design of the experiments.

Blanket Manufacturing

Work is foreseen in the following areas:

- Assessment of Blanket Manufacturing technologies:
- Manufacturing tests, and
- Aqueous Corrosion tests for WCLL.

In 2015 the activities will focus on the following aspects:

- Definition of consolidated fabrication and assembly strategy for the four blanket concepts including definition of experiments for demonstration.
- Summary of development need for welding equipment and strategy for realization of needed equipment
- Test in water facility at PWR conditions: 2 month test consisting in exposure of specimens without load and under load at the RVS-3 facility including post-test evaluation
- Corrosion test of EUROFER in water at PWR conditions: initial tests consisting in pressurized water exposure of coupon samples & 2 month test at the RVS-3 facility, comparison of oxide layer development under and without irradiation

FW/limiter design and R&D

This activity area comprises the design development and integration of the DEMO First Wall (FW) and plasma limiters and the qualification of the related fabrication technology. Hence, foreseen activities in 2015 include:

- The definition of the FW and Limiter System Requirements and Load Specification.
- Design of FW and limiter system in compliance with the requirements.
- Assessment of technology limits of a helium-cooled FW.
- Assessment of the technology limits of a water-cooled FW.

In 2015 the activities will focus on the following aspects:

- Develop a comparative analysis procedure to be used for conceptual design of FW. This shall ensure consistent engineering analyses and integrate inputs from physics models and design codes.
- Define the initial FW/Limiter SRD and LSD, with input from "top-down" requirements led by physics studies and "bottom-up" requirements informed by engineering analyses.
- A Stage 1 Design Report will be issued describing conceptual studies of FW and limiter concepts, with the aim of informing a decision on whether Limiter-based configurations need to be pursued for DEMO.
- Study of enhanced helium-cooled FW channel geometries using experimental validation. This includes finalizing the manufacturing of test sections for comparative test of channels, loop manufacturing and instrumentation selection.
- Design report on WCLL FW channel design and analyses. Following on from the design release 2014, the design of test sections for comparative heat transfer studies will be completed.

Description of work

Main Deliverables (Status)

Management and Support Team

- BB SRD 2015, result of a major revision with PMU and other PLs .
- BB Configuration Control Documents 2015, result of a major revision with PMU and other PLs.
- Assessment report on RMS 2015, Assessment report reporting feedback on the proposed RH system issued.

HCPB Design and R&D:

- CAD, Neutronic, Thermo-hydraulics and Thermo-mechanical analysis
- Report on compatibility studies between structural materials and ceramic breeders.
- Report on out-of-pile hydrogen isotope absorption/release experiments in ceramics breeders.
- Report on compatibility studies between Be and structural material, steam and air.

HCLL Design and R&D:

- CAD, Neutronic, Thermo-hydraulics and Thermo-mechanical analysis

WCLL Design and R&D:

- CAD, Neutronic, Thermo-hydraulics and Thermo-mechanical analysis.
- Report on studies of corrosion, water radiolysis and water chemistry.

DCLL Design and R&D:

- CAD, Neutronic, Thermo-hydraulics and Thermo-mechanical analysis contribution to DCLL DDD2017 (2015 improvements)
- Construction and characterization of FCI mock-up based on previous designs and experimental campaign on RIC
- Technological study on fabrication of FCI made of SiC (or SiC/SiC) material

LiPb Technology Development:

- Preliminary 3D CAD modeling of PbLi loops.
- MHD experiments in modified HCLL blanket mock-up.

Blanket Tritium Technology Development:

- Tritium Extraction System Preliminary Design.
- Modeling of the T transport in HCLL and DCLL blanket systems.
- Set up of the main experiments.

Blanket Manufacturing:

- Consolidated fabrication and assembly strategy for the four blanket concepts.

FW/limiter design and R&D:

- Preliminary SRD and LSD for the FW and Limiter.
- Stage 1 Design Report including selection of candidate FW/limiter configuration(s).
- Manufacturing, instrumentation and taking into service of test sections (Ph2), measurement of heat transfer and pressure drop at Reynolds number relevant for FW.

Use of facilities

The use of a number of EU-based facilities is foreseen in 2015. Namely, LIFUS-5 or RELA III (ENEA) to study the reaction of LiPb and water in WCLL relevant condition, RVS-3 facility (IPP-CR) for the study of EUROFER aqueous corrosion, HELOKA low pressure (KIT) to study the performance of advanced helium-cooled FW channels, KALOS for the fabrication of ceramic pebbles (KIT), VdG electron accelerator (CIEMAT) for RIC measurements on FCI, NAYADE Co-irradiation facility (CIEMAT) for irradiation of Li-ceramics BB and corroded specimens, SIMS (CIEMAT) to analyze the light ions implanted or irradiated in such environment, Dual Beam Microscopy (FIB/SEM) (CIEMAT) for microstructural characterization. FTIR Spectrophotometer (CIEMAT) for water evaluation in ceramics pebbles.

Expected Role of Industry

None foreseen in 2015.

2.2.18 WPCS: Containment structures

Set of Activities Number	18	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Containment structures (WPCS)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

This project is expected to be launched in 2015.

2.2.19 WPDIV: Divertor

Set of Activities Number	19	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Divertor (WPDIV)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 10.18 ppy in labs, 0.7 ppy for the Project Leader and 0.38 ppy in industry are foreseen in 2015. 818 k€ expenditure is foreseen on hardware.

Objective

The work package WPDIV is divided into two activity areas, namely Cassette design and integration; and divertor target technology. The activities foreseen in 2015 are described below.

Cassette Design and Integration:

Main activities foreseen in 2015 include:

- Advance the preparation of the Loads Specification Document (LSD) on the basis of the preliminary draft which is to be released by the end of 2014. The LSD shall cover the electromagnetic, neutronic, thermal and structural loads of the Cassette body system. Preliminary neutronics analyses were started in 2014, but more comprehensive computational analyses required for the load specifications will be performed in 2015.
- Advance the preparation of the System Requirements Document (SRD) for the Cassette Body. The SRD shall list the technical requirements of the Cassette body and shall be consistent with the DEMO Project Requirements Document (PRD). The SRD shall contain all top level system requirements including functional, design, safety, operational, maintenance and quality aspects.
- Preparation of a Divertor Interface Control Document (ICD). The aim is to define the functional and physical interfaces between the Divertor and other systems of the DEMO Tokamak and to solve potential interface issues. Examples are Vacuum Vessel, Blanket, assembly, remote handling, cooling water system, vacuum pumping, plasma control system and diagnostics, buildings and waste treatment.
- Preparation of a Functional Requirements Verification Report. This should demonstrate that the Divertor Cassette system is capable of satisfying the essential functions (i.e., power handling and heat exhaust, shielding, etc.). The first version shall be updated later during project.

- Development of a 3D CAD model of the Cassette system. The major components to be modelled are Cassette body, supporting structures of inner & outer vertical target, and (if existing) a central dome.
- Selection of the most promising cooling scheme (e.g., parallel cooling vs in-series cooling of the PFCs) considering the impact of different structural materials choices and related cassette coolant temperature, geometry layout, thermo-hydraulics and RH aspects.

Divertor Target Technology

Six different concepts of water-cooled target are developed and one for a helium-cooled target (i.e., 1) ITER-like monoblock, 2) thermal break monoblock, 3) composite tube monoblock, 4) chromium heat sink, 5) functionally graded heat sink, 6) flat tile/saddle and 7) helium-cooled composite tube heat sink). Preliminary works for Target concept development have been commenced in 2014 to prepare materials procurement and mock-up fabrication. Following preliminary work conducted in 2014 (e.g., on materials specification, joining technique specification for mock-up fabrication, HHF test guidelines, FEM analysis guidelines and standard materials database/design criteria (in close collaboration with WPMAT-EDDI); metallurgical development of composite materials (in close collaboration with WPMAT-HHFM)), main activities foreseen in 2015 include:

- design-to-code study (initially considering only elastic criteria), materials procurement, characterization of advanced materials, joining technology development and fabrication of most 1st phase mock-ups to be qualified and tested in 2016.
- For helium-cooled Target, the major goal of work program in 2015 is to verify by analysis the power handling requirements and to demonstrate the technical feasibility of large-scale production of a 1000 mm long W composite laminate pipe joined on both ends to steel. The basic form of the small scale mock-up shall be tested at the HHF test facilities (KATHELO, HELOKA) for the qualification of W composite laminate pipe using pressurized helium gas at about 600 °C.

Management

- Coordination activity: High-heat-flux test
  The first version of the standard guidelines for HHF test shall be finished by end 2014. The guidelines shall then be implemented into the mock-up test programs planned in 2016. In 2015 there will be further updating and supplement in accordance with the progress of diagnostic instrumentation and installation of new equipment at the HHF test facilities. In 2015 a calibration test shall be conducted on ad-hoc produced reference material samples to specify the optimal calibration parameters for the diagnostic devices and measurement processes.
- Coordination activity: Analysis
  Following the previous work in 2014 to prepare initial guidelines for elastic FEM analysis and design rules, the refinement of the guidelines shall be continued in 2015. The iterative cooperation with WPMAT-EDDI on materials data collation and design criteria definition will support the design study activities for the Target concepts. The guidelines for inelastic analysis and inelastic code applications shall be launched as well in close collaboration with WPMAT-EDDI.

Description of work

Main Deliverables (Status)

- Load specification for Divertor(1st version)
- System Requirements Document (SRD) for the Cassette Body (1st version)
- Design-to-code reports for all target concepts
- Fabricated mock-ups of most concepts foreseen for HHF test campaign in 2016
- Report on qualified fabrication technology for flat tile/saddle concept
- Helium-cooled target: 1st phase development report

Use of facilities

It is expected that a number of EU-based facilities will be employed in 2015, namely, the SATIR (CEA) facility for thermography qualification of mock-ups, possibly HHF testing of some water-cooled mock-ups fabricated before schedule at FE200 (CEA) and GLADIS (IPP), and the KATHELO (KIT) for the HHF testing of the helium-cooled target concept.

Expected Role of Industry

None foreseen in 2015.

2.2.20 WPHCD: H&CD systems

Set of Activities Number	20	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Heating and Current Drive systems (WPHCD)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 14.2 ppy for the execution of the Workprogramme (including 0.3 ppy for industry) are allocated in 2015, plus an additional 0.5 ppy for the management function of the Project Leader.

615 k€ total expenditure on hardware is foreseen.

Objective

The work package WPHCD is divided into eight activity areas, namely: H&CD System Engineering, EC Conceptual Design, EC R&D, EC Advanced technologies, NB Conceptual design, NB advanced concept, ICRF Conceptual design, Management Support..

H&CD System Engineering

The deliverables will consist of various updates to the different heating systems linked with the selection of DEMO parameters (e.g. aspect ratio scan being carried out in WPPMI). This will lead to load definitions, preliminary CAD models and design descriptions.

EC Conceptual Design

The elements foreseen in the PMP will be implemented during 2015. They include the conceptual design of many elements of the system: transmission line, launchers and system integration. Selection of transmission line and launcher types is one of the expected outcomes of the activities. After the selection of the gyrotron frequency, the design activity on RF load will start. In parallel, the activity on broadband RF selection windows will move to the concept development phase. This activity is foreseen to continue beyond 2015.

EC R&D

The EC R&D objective is the development of a gyrotron with performance compatible with EC use on DEMO. In this respect the selection of the main parameters of DEMO (in particular the toroidal magnetic field and the plasma parameters for operation scenarios) will determine the frequency and conditions for the rest of the development. It is expected that some definition of the field and of the required ECCD frequency will be provided already in 2014/beginning of 2015 so that actual development could be launched in 2015.

The activities planned for 2015 are: Continuation of the upgrade of the 170 GHz coaxial-cavity pre-prototype for longer pulses (100 ms) as base for future developments; continuation of the design work for a pre-prototype step-tuneable high frequency (240 GHz) gyrotron; continuation of analysis and development of a candidate for high power broadband window solution; detailing of the 10 T superconducting magnet specification (in collaboration with industry); continuation of the work for tools improvements including design tools for double corrugation concepts; continuation of the development of dielectric characterisation procedures.

EC Advanced Technologies

As far as Advanced EC systems are concerned, work to be carried out in 2015 includes: continuation of preliminary design studies, calculations and simulations for high power multi stage depressed collector gyrotrons.

NB Conceptual Design

The activities encompass: the confirmation of the system requirements after the conclusions of the aspect ratio scoping studies and the PMI definition of the requirements of various DEMO scenarios.

In parallel with progress of the high level DEMO requirements, the conclusion of aspect ratio studies and the definition of the toroidal field coils numbers, the concept of the injector will continue to be developed. It will take into account all the input that can arise from the activities concerning the study of the safety issues, the needs for the Remote installation and maintenance, and all the other boundary conditions set by the interfacing components and plant systems.

The conceptual design will include all components of the injectors and all components up to the plasma boundary inside the vessel ports.

The first exploratory studies of an optimised accelerator initiated on 2014 will be more finalised in 2015 with the scope to identify some reference configurations that could be analyzed in greater detail with the available codes or with more advanced tools when they are available.

Regarding the development of R&D activities, these will continue the work developed in 2014 in the areas of:

- Development and performance characterization of plasma source with different RF configurations or with optimised inductively coupled RF sources.
- Development of alternative and/or optimized negative ion production systems based both on surface production and volume production and with or without Cs coated or implanted into the Plasma Grid wall material. From the conceptual, small case studies and specific laboratory characterization of negative ion production in different materials, a large scale study will be initiated and proposed for possible experimental validation in following steps.
- Development of the energy recovery systems to be tested in existing test beds at CCFE and RFX.

NB Advanced concept

The goal of this activity is efficiency optimisation of the NB system, which will be performed both through 3D numerical modelling (Advanced modelling) of the injector components and a feasibility study of beam photoneutralization. These developments aim to achieve a drastic reduction in the gas injected along the beam-line (source and neutralizer), which leads to significant beam losses and thermal loads on electrodes resulting in poor injector wall-plug efficiency.

The "Advanced modelling" aims to develop 3D massively parallel models of the injector components; these numerical tools will be validated by dedicated experiments on test beds; they will help in future injector optimization or the development of innovative concepts.

Photoneutralization is challenging and requires a feasibility study before considering its implementation on a NBI system. This study involves the development of a high power Fabry-Perot cavity (in the MW range), the development of associated optical components (mirrors, high power CW fiber Laser) and their tests on dedicated test-beds. Note that these efforts are multi-annual ones to be pursued at least until 2018.

ICRF Conceptual design

The requirements on Physics & Engineering design will be further elaborated, adapted to the still changing boundary conditions of the machine design and hopefully finalized. Scoping studies, in particular on the effect of an in-blanket distributed antenna on the tritium breeding ratio will be performed.

Based on these studies, the functional definition of the ICRF system (with emphasis on the antenna) will be addressed.

First steps will be taken on the conceptual design of the antenna, which may include proposals for tests of such an antenna on existing experimental facilities and investigations of specific aspects in test stands.

Management

In line with PMP, the Project Leader will establish the Technical Specifications for activities to be performed by the participating Institutions (Annex I of PMP). Reporting activities as well as other managerial activities according to the PMP will be performed.

Description of work

Main Deliverables

System Engineering

- Update as required System Requirement Document (SRD) for the H&CD system and Load Specifications (LS) of specific systems
- Status design report for EC and NB

EC Conceptual design

- Final report on gyrotron requirements
- Report on ECW system components (transmission line, launchers, RF loads) selection and the corresponding intermediate design reports
- First conceptual design of the ECW system

EC R&D and Advanced concept

- Status report on the 170 GHz components procurement

- Report on the 240 GHz step tuneable gyrotron design and its ancillary system (10 T magnet), including contact with industry
- Report on R&D for fabrication of large size window and on characterisation dielectric properties
- Reports on code developments necessary for and applications to the design of gyrotrons
- Report on preliminary calculations for a multi stage depressed collector

Neutral Beam Conceptual Design and Advanced Concept:

- Initial development of large scale studies of alternative/optimized negative ion sources and consolidation of small scale studies and experiments
- Energy recovery: scale analysis and preparation of small-scale tests on available facilities
- Progress of conceptual design studies, layout and CAD integration
- Progress on tests of photoneutralisation
- Completion of parallelization of codes and simulation of a single source-accelerator

IC Conceptual Design

- Report on the functional definition of the ICRF system
- Progress report on preliminary specifications for an IC antenna

Use of facilities

It is foreseen to use the Facilities described in the PMP.

Expected role of industry

To be determined.

2.2.21 WPTFV: Tritium, Fuelling & Vacuum Systems

Set of Activities Number	21	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Tritium, fuelling & vacuum systems (WPTFV)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources foreseen in 2015 include, 6.17 ppy for execution (plus 0.4 ppy for the project lead), 0.45 ppy industry, and 0.387 M€ for hardware.

Objective

The work package TFV is divided into four activity areas, namely tritium systems development, matter injection systems development, vacuum systems development, and integration and management. The latter includes a continuous activity on the development of a fuel cycle simulator tool in line with the Project Management Plan of WPTFV.

Tritium systems concept development and simulation

The tritium systems comprise the purification system of the breeding blanket cooling loop as well as the inner tritium plant systems with the functions of exhaust detritiation, isotope separation and recovery, storage and delivery, and accountancy. Main activities in 2014 included the compilation of system requirements, concept and technology reviews. The work in 2015 will focus on the following main activities:

- Develop a concept design for a coolant purification system based on the activity levels, chemical composition and purity levels. This will be done for both water and helium coolants (to match the various breeder blanket concepts). Waste by-products from any processing stage will be assessed for their ease of subsequent disposal. Simulations will also be performed to predict system performance and to support the design development.
- Study and develop methods of recovery tritium from helium and other impurity gases, by chemical or physical methods.
- Start a conceptual design of a DEMO tritium plant isotope separation system. This will have a strong impact on overall DEMO safety case so minimising any releasable source term will be part of the design aim.
- Start the development of reliable tritium accountancy methods, including a robust real time in vessel monitoring/detection method and a global fuel cycle accountancy methodology. Simulations will also be performed to predict system performance and to support the design development.

Matter injection systems concept development and simulation

Matter injection technologies are being assessed in 2014 and DEMO matter injection requirements compiled. Based on these results, the most mature and/or promising concept will be chosen, and the focus is on core fuelling. The work in 2015 will focus on the following main activities:

- Completion of the core pellet fuelling physics modelling in an open loop configuration that yields ablation and deposition profiles (calculations with no feedback on the plasma) for characteristic pellet parameters for DEMO scenario, post-pellet transport effects and averaged particle sustainment time. It will also provide a first estimate of the required particle flux to fulfil fuelling requirements.
- Based on the results found in the activity above, full modelling of pellet fuelling will be started, including pellet ablation, drift and post-pellet transport (closed loop modelling). The pellet values as found in stage 1 of the modelling activity above will be refined. This activity will be continued in the following years, and will, in its final stage, also include a comparison with gas fuelling.
- Start of the conceptual design development of the gas injection system that supplies fuelling gases and non hydrogenic gases for other functions. It has to be described and its components will be defined.

Vacuum systems concept development and simulation

Main activities will focus on the development and staged testing of alternative pumps to implement the Direct Internal Recycling concept. Activities foreseen in 2015 include:

- Development of a mercury liquid ring pump: demonstrate the avoidance / control of mercury propagation by using cooled baffles, a vapour monitoring system will be installed and commissioned in the test facility THESEUS. In addition, a gas analysing system based on a RGA will be installed for measuring the gas composition and the mercury content in the dosing dome.
- Furthermore, the fully tritium compatible liquid ring pump for JET (to be installed in the JET Active Gas Handling System and to be operated in the course of the JET DT campaign in 2017) will be manufactured, based on the design that is being elaborated in 2014, and the components of the complete test stand will be procured.
- Development of a mercury diffusion pump: continue the design development of a prototype linear diffusion pump, involving vacuum flow, mechanical and thermo-hydraulic analyses. This activity will not be ready before 2016.
- Development of a metal foil pumps: perform further extensive parametric experimental campaigns in the HERMES metal foil characterization facility to reveal the metal foil dependency on different operational parameters like temperature, thickness, material etc.
- Development of multi-stage cryopumps: complete the open panel test experiments in the TIMO facility and analyse the data with different numerical modelling approaches so as to reveal the relevant sticking coefficient information.
- Development of an alternative NBI vacuum pumping system: characterize the candidate getter materials in a complementary programme executed in parallel at industry and at KIT.

TF&V Integration and Management

This comprises all managerial aspects to integrate the systems by compiling requirements, managing interfaces, defining analysis strategies and providing a coherent project management framework. Furthermore, the PMP will be updated and the performance of the different activities regularly monitored. This activity also includes the development of a fuel cycle simulator. Here, following the system identification that is taking place in 2014, the TFV systems are being built up and first real simulation activities will start in 2015, based on the commercial tool EcosimPro including its fusion specific libraries.

Management

Update if required the Project Management Plan (PMP), manage implementation of the work programme according to scope, timeline and resources described in the PMP; ensure timely and cost-effective achievement of deliverables in the Project Team.

Description of work

Main Deliverables

- Matter injection Technology Survey
- Report on the THESEUS mercury monitoring systems
- Sticking coefficient results of the TIMO open panel experiment
- Report on the numerical treatment of the gas adsorption problem in cryogenic pumping
- Report on materials characterization at industry
- Report on material characterization at KIT

Use of facilities

The following facilities are used in the execution of AWP15:

- THESEUS (KIT) – for testing and integration of an alternative set of vacuum pumps in DEMO relevant conditions (except tritium)
- HERMES (KIT) - to characterize metal foil pumps for ion driven permeation pumping performance
- TIMO (KIT) – for testing the cryopump with hydrogen separation (backup solution)
- Tritium laboratory TLK (KIT) – testing tritium measurement techniques
- Active Gas Handling System (JET) – specific testing of tritium process technology
- Facilities to characterize getter materials (industry, KIT)

Expected Role of Industry

Industrial involvement in AWP15 is foreseen in the characterization of novel getter materials for potential use in an alternative vacuum pump concept, and in the design of a tritium-compatible mercury liquid ring pump. In both areas, the candidate companies have been already chosen in 2014 and it is envisaged to continue the collaboration.

2.2.22 WPBOP: Heat Transfer, Balance-of-Plant and Site

Set of Activities Number	22	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Heat transfer, balance-of-plant and site (WPBOP)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 2.2 ppy from labs and 0.8 ppy from industry are foreseen in 2015, plus an additional 0.5 ppy for the management function of the Project Leader. No expenditure on hardware is foreseen.

Objective

This work package is divided into four activity areas: Project Management; Primary Heat Transfer System (PHTS) & BoP System Engineering; PHTS & BoP Modelling and Analysis; LiPb Heat Exchanger and Fluid Technology.

A priority for 2015 is the finalization of a conceptual design of an intermediate cooling loop with the goal to provide independency from the grid during the Plasma Operation State (POS) and Standby State (STS); modelling activities with APROS code should support the evaluation of cost and benefit of the PHTS & BoP reference proposed configurations taking into account the update of input data provided by the 2014 activities on Breeding Blanket, Divertor and Vacuum Vessel. All activities related to LiPb Heat Exchanger and Fluid Technology are postponed to the 2016 work program.

Primary Heat Transfer System (PHTS) & BoP System Engineering

The key activities within this work package in 2015 are: (i) finalize the PHTS and BoP configurations comprehensive of an intermediate cooling loop to satisfy the draft System Requirement Document (SRD) and System Safety Requirement Document; (ii) analysis of the proposed systems configuration in all plant scenarios defined in DEMO SRD with the purpose to identify the components design sizing condition; (iii) analysis of the draft Electrical Power Requirements generated during WP14 to evaluate a credible range of net electrical power deliverable to the grid and (iv) update (from WP14) of PHTS and BoP system analysis models.

Modelling, analysis and concept design of PHTS & BoP

From the activities developed in 2014 for the four considered blanket concepts (HCLL, HCPB, WCLL & DCLL) continue the modelling and analysis of the primary heat transfer system. This activity shall consider the possible need to control individual blanket module temperature within acceptable limits during operation. Modelling of an intermediate cooling loop as part of PHTS based on a preliminary sizing provided by the WP2014 activities is foreseen.

Evaluation of options for BoP technology and design shall be modelled and analysed considering possible combinations of primary/secondary coolants. Continuation of studies into DEMO-specific issues such as tritium transport from primary to secondary loops etc. is foreseen.

LiPb Heat Exchanger and Fluid technology

The start of these activities is postponed to 2016.

Management

Update of the Project Management Plan (PMP) and development of a detailed program schedule.

Description of work

Main Deliverables (Status)

- System Requirements Document (SRD) – (Intermediate)
- Safety Requirements Document – (Intermediate)
- PHTS & BoP System Analysis models – (Intermediate)

The update of the documents is required by the outcomes of BB and VV activities developed in 2014 and the update/issue of DEMO SRD and Safety Requirements Document.

Use of facilities

None foreseen for 2015.

Expected Role of Industry

European industry involvement is foreseen contributing in particular to support the design of the systems into areas where technologies are very mature and it is possible to take advantage of their knowledge on system elements such as heat exchangers and turbo-machinery and to evaluate the opportunities to leverage developments foreseen from the Generation IV fission power plant programme.

The in-depth use of proprietary thermodynamic modelling and analysis is provided by industrial partner as VTT through the availability of the APROS code.

2.2.23 WPDC: Diagnostic and Control Systems

Set of Activities Number	23	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Diagnostic and Control Systems (WPDC)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources foreseen in 2015 are 5 ppy in Labs + 0.4 ppy for the Project Leader. No expenditure on hardware is foreseen in 2015.

Objective

This work package is divided into four activity areas: Project Management; D&C System engineering and Design Integration, Plasma Control R&D and Diagnostics R&D.

D&C System Engineering and Design Integration

The activities planned for 2015 include:

- Preparation of a Draft System Requirements Document (SRD) of the DEMO D&C system, including an initial DEMO control requirements table.
- Assessment of candidate diagnostic systems on their applicability for DEMO, and preparation of a preliminary list of DEMO diagnostics, including justification.
- Review of information on the relevant properties of actuators for the DEMO control: (i) plasma shaping system (coil system), (ii) fuelling and pumping systems (including pellet injection system) and (iii) H&CD systems.
- Assessment / justification on various options for the integration of diagnostic front end components in DEMO, specifically: (i) straight viewing tubes located in the corners of blanket modules and divertor tiles; (ii) modifications to blanket modules and divertor tiles; (iii) replacement of a number of blanket modules by diagnostic modules.
- Initial CAD studies on selected options to integrate diagnostic front end components into DEMO by DCR proposal.
- Development of a project management plan (PMP) including organizational structure of the project, budget planning, project schedule and work-package description.

Control R&D

Within 2015, a first version of a complete list of detailed DEMO control functions, modules and strategies, and a control system layout, shall be developed. Furthermore, an initial quantitative understanding of the dynamic behaviour of the DEMO plasma control system shall be derived for a number of key control parameters. To this purpose, control oriented models for various aspects of the plasma behaviour shall be developed and applied. The aim is first to develop and demonstrate the controllability of the DEMO plasma based on the measurements and actuators which are available, and second to obtain quantitative information on the achievable control accuracy and reliability. The latter ones shall be used to determine the typical size of necessary margins against relevant operational limits, which should be taken into account in the definition of the plasma scenario in order to reliably avoid disruptions. Specifically, the following issues should be addressed:

- Density and radiation in the core plasma
- Plasma shape and position
- Core plasma MHD instabilities

Diagnostic R&D

The activities planned for 2015 shall contribute to develop a consolidated list of candidate diagnostic systems for DEMO control, and to start assessing their implementation and the resulting expected performance (accuracy, reliability, lifetime) under DEMO conditions. The main selection criteria are: (i) diagnostic applicability under relevant DEMO plasma conditions (control of flat-top phase, start-up and ramp-down; emergency ramp-down); (ii) robustness and high reliability (diagnostic lifetime several full power years under DEMO conditions); (iii) completeness of the diagnostic suite to cover all those measurements needed for control; (iv) low space occupation (low impact on TBR; first wall and divertor integrity); (v) maintainability. Specifically, the following list of diagnostic methods shall be addressed in detail:

- Microwave diagnostics (reflectometry and ECE)
- IR interferometry/polarimetry
- Passive spectroscopy from IR to SXR
- Neutron and gamma spectroscopy
- Magnetic diagnostics (coils and Hall sensors)
- Thermo-currents at divertor target plates (detachment control)
- FW and divertor coolant temperature, flow and pressure
- Measurements related to gas/beam/pellet fuelling and gas exhaust

In addition, an assessment of other potential diagnostic methods on their usability under DEMO conditions shall be performed, in particular with respect to new developments. As a part of this, the needs and possibilities for diagnostics related to safety and licensing issues will be investigated, specifically with a view on disruption mitigation, dust and Tritium retention.

Management

Following the selection of the Project Leader in 2014, the key activity within the work package is the development of a Project Management Plan (PMP), the preparation of a CfP, evaluation of the bids and allocation of resources to participating EUROfusion Consortium members to establish a Project Team.

Description of work

Main Deliverables

- Project Management Plan (PMP) Document - (Final)

- D&C System Requirements Document (SRD) - (Draft)
- DEMO Control Requirements Document (Draft)
- Candidate Diagnostic Systems Document (Draft)
- Actuator Properties Document (Draft)
- CAD models for implementation of the front-end components into the DEMO tokamak for a number of relevant diagnostic systems (Draft)
- Report on the development of a list of detailed DEMO control functions, modules and strategies, and a control system layout (Draft)
- Report on control simulations for core plasma density and radiation, including recommendations for the plasma scenario definition related to the maximum numbers for the relative density ndl/nGW and the maximum radiation level Prad/Pheat (Draft)
- Report on control simulations for plasma shape and position, including recommendations for the maximum controllable elongation and triangularity, and the minimum gap needed between separatrix and first wall on inboard side, outboard side and upper side of the vessel (Draft)
- Report on simulations on the control of MHD instabilities, including recommendations for the definition of the plasma scenario (avoidance of instabilities), diagnostics and actuator properties (instability control) (Draft)
- Reports on pre-conceptual studies on the implementation, expected performance (accuracy, time resolution, reliability and lifetime, etc.) and maintainability of each of the following candidate diagnostic systems under DEMO conditions:

  - Microwave diagnostics (reflectometry and ECE) (Draft)
  - IR interferometry/polarimetry (Draft)
  - Passive spectroscopy from IR to SXR (Draft)
  - Neutron and gamma spectroscopy (Draft)
  - Magnetic diagnostics (coils and Hall sensors) (Draft)
  - Thermo-currents at divertor target plates (detachment control) (Draft)
  - FW and divertor coolant temperature, flow and pressure (Draft)
  - Measurements related to gas/beam/pellet fuelling and gas exhaust (Draft)

- Report on the assessment of other potential diagnostic methods on their usability under DEMO conditions, addressing implementation issues and the expected performance (accuracy, time resolution, reliability and lifetime) and maintainability under DEMO conditions (Draft)
- Report on the assessment of diagnostic needs and possibilities related to safety and licensing, in particular concerning disruption mitigation, dust and Tritium retention (Draft)

For all activities apart from the development of the PMP, a continuation is foreseen after 2015 (therefore the reports to be delivered are labelled as “draft”). While the WPDC activities in 2015 are primarily addressing the needs of the current conceptual studies on a DEMO tokamak, stellarator specific diagnostic and control issues will be taken up at a later stage, as appropriate.

Use of facilities

In 2015, no work on facilities is foreseen.

Expected Role of Industry

In 2015, no involvement of industry is foreseen.

2.2.24 WPRM: Remote Maintenance Systems

Set of Activities Number	24	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Remote Maintenance Systems (WPRM)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 17.8 ppy for execution (incl. 0.7ppy for industry) plus 0.7 ppy for the Project Leader and 375k€ of hardware are foreseen. .

Objective

This work package is divided into six activity areas: (i) Maintenance System Engineering, (ii) In-vessel Remote Maintenance Systems, (iii) Ex-vessel Remote Maintenance Systems, (iv) Services Joining Technology, (v) DEMO Remote Maintenance Test Facility, and (vi) Management

Remote Maintenance System Engineering

The key activities within this work package will be a continuation and substantiation of the WP14 which are: (i) capture, analysis and definition of Remote Maintenance System requirements; (ii) review of a draft System Requirement Document (SRD); (iii) assessment of plant architectural options (i.e. blanket concepts, service pipes, ex-vessel systems etc.) and impact on RM System integration; (iv) analysis of ex-vessel radiation environmental conditions and application of RH equipment, (v) further develop an integrated Remote Maintenance CAD model, (vi) assessment of the control and operating system architecture.

In-vessel Remote Maintenance Systems

A strong interaction with projects WPBB and WPDIV is required to develop concepts for the transport systems/manipulators, mechanical attachment of in-vessel components, pipe layouts and the handling for each of the blanket variants/types. Proof of principle engineering designs of the blanket maintenance systems along with supporting mock-up designs will be developed for testing the remote handling compatibility of blanket components. Concepts for in-vessel transporters/manipulators will be further developed for the divertor maintenance along with the design of "proof of principle" tooling/end/effectors for remote handling compatibility testing of mechanical attachment of the divertor components. Also, substantiate the need for a Multipurpose Deployer and further develop the remote maintenance systems recovery along with the tokamak maintenance concepts (i.e. inspection, dust collection, local repairs, etc.).

Ex-vessel Remote Maintenance Systems

Within this work package the further development of transfer casks for blanket modules and divertor cassettes is foreseen along with the requirements analysis and strategy development for the maintenance of H&CD, Diagnostics, Vacuum, and other ex-vessel systems. Prepare the engineering design of a "proof of principle" cask contamination control door in preparation for the manufacture of a mock-up. Further develop the logistic tools used to provide qualitative plant down time assessments. Development of the concept for the Active Maintenance Facility to include support for all ex-vessel maintenance functions.

Services Joining Technology

Interaction with Projects WPBB and WPDIV to provide further definition of options for coolant / breeder circuit pipe work for in-vessel components and an application assessment for the various service joining technologies under consideration. Development of concept tool designs along with design of "proof of principle" tools and their test rigs. Industrial involvement to provide bench testing and evaluation of remote pipe cutting/joining technologies is foreseen.

DEMO Remote Maintenance Test Facility

No activity is foreseen in 2015.

Management

Update if required the Project Management Plan (PMP), manage implementation of the work programme according to scope, timeline and resources described in the PMP; ensure timely and cost-effective achievement of deliverables in the Project Team.

Description of work

Main Deliverables (status)

- Project Management Plan (PMP) - (Updated as required)
- System Requirements Document (SRD) - (Final v1)
- Design Assessment Report on plant architecture following the integration of in-vessel and ex-vessel maintenance systems (Final v1)
- RMS CAD Configuration model - (Final v1)
- Load Specification (LS) including update of shut-down radiation levels, decay heating and other expected environmental conditions - (Final v1)
- Engineering Design Description for both the "proof of principle" blanket maintenance system and associated mock-up (Final)
- Concept Design Description for the vertical port maintenance (Final v1)
- Concept Design Description for both the "proof of principle" vertical port/blanket pipe handling systems (i.e. tools and end-effectors) and the associated mock-up (Final)
- Engineering Design Description for both the "proof of principle" blanket in-vessel attachment maintenance system (i.e. tools and end-effectors) and associated mock-up (Final)
- Placement of manufacturing contracts for the tooling/end-effectors and mock-ups for testing the remote handling compatibility of blanket attachment concepts
- Design Assessment Report on concept divertor cassette maintenance systems (Draft)
- Concept Design Description for the divertor port maintenance (Draft)

- Engineering Design Description for both the “proof of principle” divertor cassette in-vessel attachment maintenance system (i.e. tools and end-effectors) and associated mock-up (Final)
- Manufacture of tooling/end-effectors and mock-ups for testing the remote handling compatibility of divertor attachment concepts
- Design Assessment Report on concepts for in-vessel transporters/manipulators inc. Multi-Purpose Deployer - (Final v1)
- Design Assessment Report on concepts for transfer casks for blanket modules, divertor cassettes, etc. - (Final v1)
- Design Assessment Report on concepts for the maintenance of H&CD, Diagnostics Vacuum and other ex-vessel systems - (Draft)
- Design Assessment Report on concepts for the Active Maintenance Facility - (Draft)
- Prepare definition and procurement contracts for mock-ups for testing the remote handling compatibility of service joining technologies

Use of facilities

To support the R&D programme, it is foreseen in WP15 that preparation of mock-up facilities equipped remote handling systems will be started; in particular, to support the testing of mock-ups for in-vessel component attachments and remote pipe connections.

Expected Role of Industry

In WP15, industrial involvement is mainly foreseen in terms of manufacturing mock-ups for in-vessel component attachments and remote pipe connection R&D i.e. in-bore welding, brazing, mechanical connections, etc. Industry will also be used to substantiate the maintenance strategies for both the blanket and divertor maintenance.

2.2.25 WPMAT: Materials

Set of Activities Number	25	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Materials (WPMAT)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 52.28 ppy for the execution plus 5.80 ppy for industry are foreseen in 2015, plus an additional 1 ppy for the management function of the Project Leader and 2.50 ppy for Group Leaders. 3849 k€ expenditure on hardware is foreseen.

Objective

This work package is divided into six activity areas: (i) Engineering Data & Design Integration; (ii) Advanced Steels; (iii) High Heat Flux Materials; (v) Integrated Radiation Effects Modelling and Experimental Validation; and (vi) Management

Engineering Data & Design Integration

In 2015 this area will further develop existing activities and progress new activities within the following four work streams:

- Co-ordination & Interface Activities
  EDDI will continue to implement, seek feedback and further develop its Interface Management Plan and the planned Materials Management Framework (outline proposals presented in 2014). Effectively these activities will present a traceable, controlled framework to exchange information related to the material mission, plus a mechanism to interrogate and progress the maturity of each material solution.
  In particular, the Material Management Framework for PPPT will be rolled out and applied for the first time in 2015. This will include interaction with component designers, other transverse projects and the other material subprojects. These interactions will seek to understand evolving high priority design needs for material data and performance, identifying new work streams or focus areas for the other material projects, and elevate new material solutions for consideration within design.
- Material Database & Handbook
  This work area will continue to develop the material data infrastructure necessary for PPPT, identify the main gaps in the material database and interact with the testing community to plan experimental campaigns to fulfil those gaps at due time.

Within 2015, the baseline Materials Handbook architecture will be proposed, design allowables for the baseline structural materials will be calculated and activities will culminate in the initial release of the PPPT Materials Handbook for application by designers.
Considering the individual databases, joint efforts with the other WPMAT sub-projects will seek to address the following areas:

- The baseline structural material databases (CuCrZr, EUROFER97) established in 2014 will be further populated
- Infrastructure for the baseline armour material (tungsten) database will be implemented
- A Functional Material Qualification procedure will be pursued including efforts to harmonise/develop standardised testing procedures and practices
- Develop infrastructure and initial population of database for advanced structural and armour materials
- Take initial steps towards a jointed material database (with an initial focus on the blanket to be confirmed)

- Structural Design Criteria
  This work stream will continue to address the design validation needs of the DEMO in-vessel components by identifying existing codes & standards and the required improvements/extensions to fulfil the needs of the overall DEMO plant design, in particular for structural. Crucially, this will seek in the long-term to work towards a complete, consistent set of DEMO Structural Design Criteria for In-Vessel Components. Within 2015, four strands of effort are as follows:

  - Addressing priority gaps including: (i) extension of non-ductile rules to address the challenges of blanket design validation, building on similar work in 2014 focused on the divertor; (ii) initial effort to develop structural design criteria for joints, based on the recommendations of the gap analysis undertaken in this area in 2014
  - Enhancing the content of the existing structural design criteria by further work on creep-fatigue and fatigue rules with accompanying tools for implementation by designers
  - Finally, Interim SDC-IC Guidance will be issued to PPPT Design Projects to steer ongoing design validation. A formal first release of the DEMO SDC-IC will in turn follow in 2016
  - Interaction with the community to plan experimental campaigns to validate existing and newly developed design criteria as

- Testing
  This stream will, as in 2014, seek to produce, distribute and implement experimental campaign plans to meet the prioritised needs of the design, database and design criteria development, as identified in other parts of the project. Also, further progress and possible roll-out of a formal PPPT Material Archiving and Specimen Tracking Scheme is expected in 2015.

Advanced Steels

The main activities foreseen in 2015 include:

- Development of advanced 9Cr FM steels for water cooled application or with improved high temperature mechanical properties: microstructural and mechanical characterization of Eurofer after special heat treatments or thermomechanical treatments. Fabrication of new 9Cr steel batches with optimized chemical compositions selected using thermodynamics calculations. First down-selection of chemical compositions and thermomechanical treatments.

- Preparation for the production of a large batch of 14%Cr ferritic ODS alloy (50-100 kg): Mechanical alloying (MA), consolidation by HIP of the pre-alloyed powders produced in 2014 and studies to select hot-rolling conditions for the production of thin plates.
- 14%Cr ODS production by alternative route (without MA): improvement of the atomization process to increase yield and powder quality. Transfer of know-how to industry and fabrication of a ≈ 40 kg batch. Microstructural characterization of atomized/consolidated powders and first trials of plate fabrication.
- Industry will be highly involved in the 2015 activities: production of steel batches, steel processing (TMT), fabrication of powders and MA.

High Heat Flux Materials

The main activities foreseen in 2015 include:

- Production of W alloys via the PIM/MIM manufacturing route for characterization and as armour parts, using the newly installed tool in 2014.
- Set up of a manufacturing route for W-based matrix materials (with SiC, TiC, WC) and SiC-fiber reinforced W-composites in collaboration with industry
- Characterization of lab scale and in collaboration with industry produced self – passivating W alloys
- Intensive qualification and characterization: standard mechanical and thermo-physical properties (tensile, LCF, thermal conductivity, CTE, etc…) and testing with respect to application limits by thermal shock (e-beam) and thermal fatigue (e-beam, ion-beam),
- Based on the selected fabrication route first production and characterization of Cu-composite materials (particle and fibre reinforced)
- Manufacturing and characterization of laminate structures in collaboration with industry; optimization of Cu-interlayer materials, basic characterization of high temperature interlayer materials and assessment of multi-metal laminates
- Extension of the database, mainly fracture-toughness and long term grain stability of thin W-plates and foils
- Fabrication and characterization of tungsten-fibre W-composites using PM (multi-fibre components) and CVI (advanced fibre engineering) manufacturing routes
- Improvement of fabrication processes for structural joints (W-EUROFER and tungsten-tungsten) and functional interlayers (e.g. W/Cu FGM)
- Component manufacturing using HRP for water and helium cooling concept designs

Integrated Radiation Effects Modelling and Experimental Validation

The work to be carried out within this work package is devoted to the study of (i) Defect production and transmutation in pure metals and alloys; (ii) Microstructural evolution of dislocation and vacancy cluster microstructure; (iii) Interaction of radiation defects and radiation-induced precipitates with dislocations; (iv) Changes in mechanical and physical properties under irradiation, in particular embrittlement and swelling; (v) Experimental validation of models through observation of microstructural changes due to irradiation.

The main milestones for 2015 are the following:

- DFT based models for the high temperature configurations of radiation defects, including models for solute segregation to defects and dislocations
- Models for evolution of defect configurations in Fe, W and similar metals and alloys. Monte Carlo models for reactions, recombination and clustering of radiation defects
- DFT and atomistic models for screw and edge dislocations in bcc metals and alloys, models for dislocation transition pathways, kinks and screw-edge dislocation configurations
- Assessment of defect production in high energy cascades, the effect of helium on defect production and microstructural evolution. Production of defects by nuclides produced by transmutation at high neutron energies.
- Development of a model for microstructural evolution on the mesoscale, relating operating temperature ranges and microstructure.
- Assessment of models for dislocation dynamics in radiation microstructures, describing temperature dependent swelling and embrittlement
- Assessment of the effect of synergetic accumulation of helium and hydrogen in the microstructure, identification of the origin of the synergetic enhancement of swelling

Functional Materials

The main activities foreseen in 2015 include:

- First characterization test of available candidate materials for optical and dielectric applications, including some new developed self-doped nano-aluminas. Use of accelerators and dedicated systems for in-beam characterization and large SPS production equipment.
- Identification of new materials with improved properties for optical and dielectric applications (Low RIA and RL, Low loss tangent). Comparison of radiation damage in MgO, Al2O3, Lu3Al5O12, both pure and doped with different impurities.
- Analysis of the data for available candidate materials for optical and dielectric applications and development of a program devoted to the improvement of the materials and the assessment of the effects of radiation. Preparation of the first set of both dielectric and optical ceramics prepared by SPS, [pure alumina, mullite (2Al2O3:SiO2) and Ca3Al2O6]. Here industrial partner from Ciemat plays an important role.
- First steps on modeling activities for Al2O3 samples from first principles, including Frenkel defects. Development of the computer code for the kinetics of radiation damage accumulation taking into account defect formation, migration, and interaction.
- To determine the impact of ion-radiation damage on the reflectivity of Mo pc mirrors in order to assess: (i) the mirror lifetime and (ii) damage mitigation methods. Use of accelerator for ion irradiation.
- Assessment of the level of radiation for control, safety and H&CD in the machine: data incoming from DEMO design groups.

Management

The key activities envisaged for WP15 will be to manage the development and integration of the activities developed in the various Activity Areas in line with deliverables identified in Project Management Plan (PMP).

Description of work

Use of facilities

For the achievement of the goals mentioned of the Materials Project 2015 different facilities located in Europe must be used:

- Materials Test Reactors (tbd)
- Ion and electron beam irradiation facilities
- Microstructural characterisation equipment
- Characterisation equipment for Physical and Mechanical properties
- Thermal shock facilities
- H/He beam loads facilities

Expected Role of Industry

Industry plays an active role in the Materials project 2015. Industry involvement is needed from the very first steps in some areas. This collaboration should play a major role in the case of the steels, and also the case of coatings and insulators.

In the case of the development of high performance steels like ODS steels and Thermomechanical treatment (TMT) steels the following action should be taken:

- Involvement of well consolidated industrial partners as ArcelorMittal, to explore production routes and production at industrial level
- Benefit of existing funds for the development of improved/new steels like Research Fund for Coal & Steel if the proposal submitted in September 2014 is accepted.
- Creation of framework for continuous transfer of knowledge between research institutes and industry

In the case of the development of W and W alloys for armour and structural applications the following action should be taken:

- Increase the already existing involvement with the industry. Mainly collaboration in the development of W alloys with Plansee.
- Creation of framework for continuous transfer of knowledge between research institutes and industry

In the case of the development of Cu and Cu- alloys for cooling substructures (pipes) the following action should be taken:

- Collaboration with industrial partners to develop improved Cu – alloys with respect to those already produced for ITER. Involvement of industrial partner with experience in production of these materials for ITER should be a priority.
- Creation of framework for continuous transfer of knowledge between research institutes and industry

In the case of the development of insulators (functional materials) the following action should be taken:

- Collaboration with the industrial partners (Nanoker Research) to develop improved/new insulators respect to the already produced for ITER.
- Creation of framework for continuous transfer of knowledge between research institutes and industry

Opportunities for International collaboration

Collaborations and possible joint use of the Materials Research Laboratory built in the International Fusion Energy Research Centre (IFERC), Rokkasho, within the Broader Approach Activities have been proposed for 2015. Opportunities for irradiation testing in US (HFIR/ ORNL) and Russian fission reactors (BOR60) are being explored and testing specifications for meaningful testing programme defined.

2.2.26 WPENS: Early Neutron Source Definition and Design

Set of Activities Number	26	Start Date or Starting Event	01-Jan-15
Set of Activities Title	Early Neutron Source Definition and Design (WPENS)		
Participant Number	Short name of Participant	Person-months per Participant:	

Objective

The scope of the activities to be conducted in the Project WPENS has been modified taking into account comments and suggestions from F4E. The process of selecting a Project Leader is expected to start soon (if possible already before the end of 2014). The Project Leader will then prepare a proposal for activities to be implemented if possible; already in the second half of 2015 (amendment of AWP15 would be required in this case). The PL should then launch a call for participation, evaluating and selecting bids, forming a Project team, define and submit a Project Management Plan to be approved by a (to be established) Project Board and a Work Programme Proposal (consistent with resources available in 2015) to be approved by the General Assembly.

2.2.27 WPSAE: Safety and Environment

Set of Activities Number	27	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Safety and Environment (WPSAE)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: 10.20 ppy are foreseen in 2015 for the execution (including 0.2 ppy for industry), plus an additional 0.7 ppy for the management function of the Project Leader. 600 k€ expenditure on hardware is foreseen.

Objective

This work package is divided into three activity areas: (i) Design and Licencing Requirements; (ii) Integrated Safety Analyses / Source Terms / Models & Codes; (iii) Radioactive Waste Management; and (iv) Management of the Project Team.

Design and Licensing Requirements

Key activities are to implement the safety approach in the evolving design, ensuring that all required safety functions are identified, specified, and provided for in the design of systems, structures and components. The main aspects of the safety approach will be set out in the General Safety Principles document, a draft of which has been prepared in 2014. The Plant Safety Requirements Document (PSRD), also drafted in 2014, will be further elaborated in response to the findings of safety analyses and the evolving design concepts. A review of the possible licensing regimes for DEMO, started in 2014, will be continued.

Integrated Safety Analyses / Source Terms / Models & Codes

Development of computer codes for safety analysis will be carried out following a survey of needs during 2014, including the start of experimental work to improve code validation, such as tests on water-LiPb reactions. Code development will include continuation of ongoing work on a unified system for shut-down gamma dose rate computation.

Functional Failure Modes and Effects Analysis (FFMEA) of key systems, begun in 2014, will be continued and will lead to a determination of the representative accident sequences that will be the subject of detailed safety analyses in future years. For input to these analyses, computation of materials activation, decay heat, and related quantities will be started, as well as an initial evaluation of activated corrosion and sputtering products in coolants. Quantification of source terms for these accident analyses will also be started.

Following an initial assessment of potential sources of tritium release in 2014, an evaluation of environmental releases of tritium in normal operation and maintenance will commence.

As with many of the above-mentioned analyses and assessments, this work is due to be carried out over several years and will both follow the evolution of the design as well as seeking to influence it.

Radioactive Waste Management

A review of clearance indices for radioactive material, started in 2014, will be concluded with a proposed definition of a new fusion-specific set of limits. A related study of composition limits for DEMO materials will also continue.

Following a review during 2014 of detritiation systems for solid waste materials, the most promising candidates will be identified and a programme of R&D on these will be elaborated. Preparation for the execution of this R&D will commence.

A feasibility study of waste recycling, to establish if viable and economic recycling processes are possible, will be completed with the proposal of criteria to classify waste for its recycling potential. Studies aimed at reducing the quantity of radioactive waste will continue, in parallel with the development of design concepts.

Management

Following the approval of the Project Management Plan (PMP) in 2014, a revision will be issued to reflect any detailed adjustments to the planning of the activities.

Description of work

Deliverables

- General Safety Principles document - (final)
- FFMEA and accident sequences - (final)
- Fusion-specific clearance limits – (final)
- Feasibility report of waste recycling – (final)

Use of facilities

Experimental facilities will be employed for tests related to the improved validation of computer codes and models to be used for safety analyses. In addition, the preparation will start of facilities to test the feasibility of detritiation techniques for solid waste materials. A total hardware expenditure of 600 k€ is foreseen in 2015.

A liaison is maintained with the JET technology tasks programme, in order to exploit any synergies arising.

Expected Role of Industry

Industrial input is needed to determine criteria for clearance and recycling of radioactive material and for the development of viable processes for this recycling.

Opportunities for International Collaboration

Developments in the fusion safety programmes outside of Europe, particularly in the US and Japan, are monitored and a dialogue with those programmes will be maintained with the aim of establishing collaboration in areas of common interest.

2.2.28 WPSES: Socio Economic Studies

Set of Activities Number	28	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Socio Economic Studies (WPSES)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Resources: In the PMP, 3.65 ppy plus an additional 60 k€ on commissioned studies of stakeholder/public opinion are foreseen in 2015, although this has not yet been finalised. In addition, 0.25 ppy is envisaged for the management function of the Project Leader.

Objective

Internal and External Costs

Following 2014 work to identify the key data needed to update the fusion costs, the work in 2015 will concentrate on producing an updated fusion cost database, based on publically available data, including ITER costs and cost assessments from related industries. External cost assessment will be started, particularly integrating work carried out in WPSAE. Interaction with WPPMI is also foreseen throughout the Project.

Future Energy Scenarios

Energy scenario activities will build on existing 2014 activities and integrate the activities going on in both the costing activities and the social science activities, producing energy scenarios which are more closely aligned with the social science activities, particularly the future storylines, and costing activities, as results become available.

Stakeholder Engagement, Public Opinion and Media Framing

The key activity for 2015 is to commission and evaluate work on stakeholder, public, and media attitudes to fusion. The 2014 work will have clarified the options for these studies, including costs of different approaches, and the work will proceed on the basis of making best use of available resources. These studies will provide key inputs for energy scenario modelling and will interact with the WPSAE tasks, providing guidance to ways to optimise design.

Outreach

No activity has been carried out in this area in 2014. In 2015, the activities are foreseen to be restricted to interpreting the results in a way that is most useful for wider dissemination. This activity is expected to concentrate on interpretation of results for outreach activities;

feedback to designers through interaction with WPSAE and WPPMI is covered in the other tasks.

Management

Following the appointment of a Project Leader in April 2014, a draft Project Management Plan now exists. After review and approval, a revision will be issued to reflect detailed adjustments to the planning of the activities, as necessary.

Description of work

Main Deliverables

The main deliverables foreseen in 2015 are the update to the fusion cost database and the commissioning of the work on stakeholder engagement and public opinion.

Use of facilities

None foreseen.

Expected Role of Industry

Assessments of stakeholder views and/or public opinion will be carried out externally, as resources allow.

Opportunities for International Collaboration

The energy scenario modelling will be promoted within the wider energy modelling community. There is an IEA Task on Socio-Economic studies, where the results will be reported, and wider engagement sought. There is an ambition to engage the IEA secretariat in further considering an IEA Roadmap for Fusion and this will be pursued.

2.2.29 WPPI: Communications Activities

Set of Activities Number	29	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Communications (WPPI)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

Objective

Communicating EUROfusion

Besides basic information on fusion research an emphasis will be given on progress on the Roadmap and the exploitation of JET.

The Communications team will continue to encourage Research Units to contribute topics to the **EUROfusion website** (www.euro-fusion.org) and the **newsletter** 'Fusion in Europe'.

To represent the Research Units in these media the EUROfusion Communications team depend crucially on the input from the Research Units communicators'.

The EUROfusion section on the **Users' website** will be further developed to provide relevant information on a working level. Additionally the Programme Manager and his team will continue to update the community via the newly established NEWSbrief.

It is planned to extend the **Programme Management Unit's** (PMU's) **intranet** to display information for the day-to-day business.

Part of the external communication is the distribution of media to the public. In 2015 it is planned to review existing but outdated EFDA media and create new media with the EUROfusion branding.

Public Information Network

The tools introduced in 2012 namely the weekly newsletter, the monthly video conference and the PINtranet intensify the network's interaction. EUROfusion Communications will continue to feed these channels initiating discussions and distributing information of general interest. An annual meeting in person is planned mid-year, for which further details are not available at the time of writing.

The Head of Communications will continue to work with the PIN Board on the 'Fusion presentation kit' – an editable presentation on fusion for the community. It is planned to finalise the kit in 2015. Afterwards the Board will continue to work on unfinished tasks of the former Working Groups. The overall aim of all these activities is to come closer to coherent messages across all labs.

Fusion Expo

Assuming that the decision is made by the end of 2014 on how to proceed with the planned new Fusion Expo a call for participation to initiate the project can be launched in 2015 followed by the official opening in 2016.

Exhibitions are effective vehicles to actively bring the messages to the citizens and to open the dialogue with the public. The fusion community should not miss the chance to re-vitalise the Fusion Expo in a modern way appreciating new developments in outreach and education.

2.2.30 WPEDU: Education

Set of Activities Number	30	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Education (WPEDU)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

The main objective is to develop the EUROfusion members PhD programmes by the allocation of funds aiming at supporting and extending the programmes, and at promoting specific activities such as funding for placements in other countries, attendance to summer schools, support for new lecture courses, etc. The funds are allocated based on the evaluation of the programmes and how the programmes will be developed in the period to 2018, building on existing strengths and improving weaker aspects. The PhD education in each research institution is evaluated from: the number of the ongoing PhD students and the number of PhD thesis in fusion completed in the previous 5 years, in a field relevant to Fusion research in the respective Research Units (Doctorates relevant to Inertial Fusion research are supported if they do not include military applications and there is a cap of 10% in the support per Research Unit); and from an assessment of the Quality of training in EUROfusion members based on a paper describing the doctoral training arrangements for fusion in its country. The allocation of funds is based 65% on student and thesis numbers (approximately 32.5% each), and 35% on the quality assessment of the student training. The allocated funds are adjusted using the correction coefficient used in the remuneration of officials of the European Union *[2013 Work Programme People - European Commission C(2012)4561 of 9 July 2012]*. An amount of 200k€ has been earmarked for the management of the programme through FuseNet. Furthermore, 150k€ will be allocated to support the undergraduate programme. The information above on the number of the ongoing PhD students and the number of PhD thesis in fusion completed in the previous 5 years (2008-2012) was requested by the EFDA Leader to the Heads of Research Unit on 15 May 2013 and the relevance of the Thesis to Fusion was reviewed. The information relative to the number of PhD students will be updated every 3 years.

2.2.31 WPTRA: Training and Grants

Set of Activities Number	31	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Training and Grants (WPTRA)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

The activities previously foreseen as EUROfusion Researcher Fellowships will be implemented as planned; however, since they foresee the promotion of excellence, and do require a proposal from a researcher, they shall in future be considered as EUROfusion Researcher Grants (ERG). It is foreseen that in 2015 a total of about 10 ERGs will be allocated based on a call during summer 2014 and a subsequent evaluation and selection in Oct./Nov. 2014.

A similar approach is envisaged for the Engineering activities, to replace the former GOT scheme, where in 2015 a total of 20 grants are foreseen.

2.2.32 WPENR: Enabling Research

Set of Activities Number	32	**Start Date or Starting Event**	01-Jan-15
Set of Activities Title	Enabling Research (WPENR)		
Participant Number	**Short name of Participant**	**Person-months per Participant:**	

In addition to the mission-oriented work, the Enabling Research Programme aimed at promoting fundamental understanding and longer perspective research will be continued. A call for projects, aiming to address several areas in which fundamental understanding is required to advance fusion research, was issued in June 2014. The proposals are being assessed and selected by STAC in the fall of 2014 following the established evaluation criteria. The list of selected projects will be presented to the General Assembly in November 2014. Whereas in 2014 only Enabling Research projects with a run time of one year were granted, the call for 2015 (launched in 2014) is also open for Enabling Research Projects of up to three years. The total final volume for the proposals to start in AWP2015 amounts to approximately 13 M€.

Table 2.3b: AWP Set of Activities

Indicative allocation of resources as of Sep. 2014. To be replaced by tables in required format Dec. 2014.

The work plan of WPS1 and the corresponding budget are only provisional, as they do not consider the recommendations by the panel reviewing the whole work programme and by STAC. In the next meeting of the General Assembly an adjusted work plan for WPS1 will be presented which takes these recommendations into account. Possible additional work packages within WPS1 will be advertised in calls.

Work Package	**Sum of Total Resources (k€)**	**Sum of Grand Total _EC Contr.**
WPBB	8088.512	4148.198
WPBOP	402.381	271.558
WPCD	1794.240	1018.087
WPCS	354.500	215.875
WPDC	600.001	350.001
WPDIV	2107.895	1029.079
WPDTT1	1440.118	652.011
WPDTT2	1008.651	537.568
WPEDU	15847.624	8097.764
WPENR	9603.910	5000.390
WPENS	818.560	409.280
WPHCD	2222.766	1165.611
WPISA	1108.855	1108.855
WPJET1	14776.310	10526.214
WPJET2	1801.931	946.251
WPJET3	1676.856	1052.189
WPJET4	2326.355	1816.906
WPMAG	1771.919	874.159
WPMAT	11041.032	5574.262
WPMST1	16576.934	12720.105
WPMST2	2829.175	1344.375
WPPFC	6871.637	3294.742
WPPI	200.000	200.000
WPPMI	2650.649	1428.002
WPPMU	9391.790	9391.790
WPRM	2313.301	1214.039
WPS1	14064.454	3554.105
WPS2	365.680	199.931
WPSA	580.527	316.953
WPSAE	1775.243	871.510
WPSES	298.850	151.750
WPTFV	1191.530	592.984
WPTRA	2974.180	2974.180
Grand Total	**140876.3637**	**83048.72258**

2.3 Participation in AWP activities and resources (Table 2.3d and 2.3e)

2.3.1 Information on the participants

To be added at a later date

2.3.2 Resources to be committed

Detail known at a later date

Table 2.3e Other major cost items (travel, equipment, infrastructure, goods and services)

To be added at a later date

[Participant]

[Participant]	Cost (k€)	Justification
Travel		
Equipment Goods and services Other		
Large Research Infrastructure		
Total		

Table 2.3f Purchase of equipment foreseen to be included in the JET facilities

Revisions expected in Dec. version – information on hardware purchases for JET will be updated following foreseen Calls

Beneficiary	Work Package	Equipment 2015
CIEMAT	**WPJET4**	Scintillator screens and PMT amplifiers
IAP	**WPJET4**	Neutron shields, gamma ray shields, LiH neutron attenuators
IAP	**WPJET4**	Monitor target, target carrier
IPPLM	**WPJET4**	Detector including scintillator, magnetic shielding, PMT, voltage divider, high voltage power supply
IPPLM	**WPJET4**	Prototype Detector
IST	**WPJET4**	Electronic components, RF components, Millimeter wave components, Delay line, Acquisition boards, Structural parts
ENEA-CNR	**WPJET4**	Prototype Detector
ENEA-CNR	**WPJET4**	Pulsed light source for C&M, HV, preamp, cables, Detector with Magnetic shield
ENEA-Frascati	**WPJET4**	Data acquisition system for BC148 detectors

3 Timeline for the implementation

Work Programme 2015 preparation

- 31 July 2014 – Table of contents of AWP2015 to STAC
- 31 August 2014 – Draft AWP2015 circulated to STAC AHGs
- 5 September 2014 – Assessment of AWP2015 by STAC AHGs
- 12 September 2014 – Written assessment report of AWP2015 by STAC AHGs
- 19 September 2014 – STAC endorsement of AWP2015
- 23 September 2014 – Presentation of AWP2015 to the GA. Adoption of the general structure and gross breakdown of the budget over the Work Packages
- 30 September 2014 – Draft AWP2015 uploaded to the SYGMA system

Selection of TFL and PLs

- April 2014 – Launch of the selection of JET Task Force Leaders for 2015
- June 2014 – Launch of the Call for the Project Leaders for WPDC
- October 2014 – Launch of the Call for the Project Leader for WPENS

Definition of individual Research Unit contribution

- 6 June 2014 – Launch of the Calls for Proposals for Enabling Research
- 15 July 2014 – Launch of the Calls for EUROfusion Researcher Grants (close 9-Sep)
- 1 October 2014 – Launch of the Calls for EUROfusion Engineering Grants
- 14 October 2014 – Launch of the Calls for Allocation of Resources in a range of Work Packages (JET2, PFC, DTT2, SA, DC, ….)
- 20 October 2014 – Launch of Call for Proposals for JET1 (close 21-Nov)
- 3 November 2014 – Launch of Call for Proposals for MST1 (close 21-Nov)
- 13 November 2014 – Approval of Enabling Research Proposals and EUROfusion Researcher Grants by GA
- 17 – 21 November 2014 – JET Task Force Meeting for 2015 Campaign preparation
- 28 November 2014 – Project Boards to agree on Allocation of Resources
- 10 December 2014 – Proposal of Allocation of Resources to the GA
- 18 December 2014 – GA meeting for the approval of the distribution of activities.
- 19 January 2015 – General Planning Meeting for JET and for MST campaigns
- 9 February 2015 – Call for Manning of MST1 & JET campaigns (close 28-Feb)

Administrative / financial

- 1 January 2015 – Preparation of necessary data for intermediate reporting towards EC within RUs
- 10 February 2015 – Submission of information to Coordinator/PMU
- 15 February 2015 – Assessment of achieved deliverables by PMU
- 21 February 2015 – GA approval of Intermediate Reports
- 1 May 2015 – Assessment of achieved deliverables

- 1 June 2015 – Payment for 2014 by Commission to Coordinator
- 1 July 2015 – Payment for 2014 from Coordinator to Research Units using data from Information Management System

4 Appendix: Programmatic presentation of ITER Physics work

In this section the 2015 ITER Physics work is presented in a programmatic way - i.e. for each headline and deliverable the contribution from relevant Work-Packages is given. The deliverables here are the same as in Sec 2.2, but reordered programmatically.

4.1 Mission 1: Plasma regime of operation

4.1.1 Headline 1.1: Increase the margin to achieve high fusion gain on ITER

Headline 1.1
H1.1-D01: Study heat, particle and momentum confinement in conventional and improved H-modes and hybrids and the dimensionless scaling towards ITER (2015)
WPJET1
- Explore operation with reduced torque injection by exploiting the full capability of the ICRH ITER Like Antenna (total ICRH power 12MW). *- Collect data for multi-machine scaling (β_N, ρ* and ν*) for both scenarios and assess importance of additional parameters (gas type) for confinement scaling.*
- Collaboration WPJET1 / WPMST1: Pedestal model validation with H and D plasmas.
WPMST1
- Study the impact of Helium as minority impurity (fusion product leading to 10-20% He concentration) on H-mode confinement in TCV and AUG– approximatively 10-30% Helium. *- Complete study of scaling of intrinsic rotation and impact of sawteeth on momentum transport (AUG and TCV).*
- Collaboration WPJET1 / WPMST1: Pedestal model validation with H and D plasmas.
H1.1-D02: Demonstrate compatibility of conventional and improved H-mode with ITER wall materials (2015)
WPJET1
- Develop high performance scenario with H>0.9, W_{th}>10-12MJ stationary (>5s) on JET both for the conventional and hybrid at lowest possible ρ and ν*. Heat load control integrated in the development. Integrated modelling in support for scenario preparation.*
H1.1-D03: Qualification of improved H-mode confinement at large machine size and at full machine performance (2015)
WPJET1
- Collaboration WPJET1 / WPMST1: Extend high performance phase (H>1.3) to 5s for stationary high performance DT scenario. Use AUG and JET similarity experiments to extrapolate to next step devices.
WPMST1
- Collaboration WPJET1 / WPMST1: Extend high performance phase (H>1.3) to 5s for stationary high performance DT scenario. Use AUG and JET similarity experiments to extrapolate to next step devices.

H1.1-D04: Characterise L-H threshold power and access to H98(y,2)≈1 (e.g. power) in ITER-relevant conditions (2015; T&DT 2017)
WPJET1
- Collaboration WPJET1 / WPMST1: collect data for the L-H scaling law including the effect of seeding gases and comparison with JET/AUG.
- Assess L-H threshold and H=1 access in He (if He campaign for JET approved), compared to H scaling. *- Access to H≈1 scenarios at P/P_{LH}≈1-1.2 .* *- Identify the link between SOL conditions and L-H threshold and perform turbulence measurements.* *- Compare with basic understanding of the L-H power threshold and role of isotope mass (link with the Enabling Research Programme)*
WPMST1
- Study L-H transitions and access to type-I ELMy H-mode with impurity seeding towards high mantle radiation and high density on AUG and TCV. *- Improve scaling of the L-H transition power at low density where the conventional scaling does not work.*
- Collaboration WPJET1 / WPMST1: collect data for the L-H scaling law including the effect of seeding gases and comparison with JET/AUG.
H1.1-D05: Test isotope scaling of the improved H-mode in H, D, DT and T (includes L-H for MST1) (2015)
WPJET1
- Explore improved H-mode in He (If He campaign approved in 2015).
H1.1-D06: H-mode and hybrid confinement scaling in regimes with high radiated power fractions (2018)
WPJET1
- Experiments with high radiated power fractions started in 2014 to be completed in 2015.
WPMST1
- Develop an integrated ITER baseline scenario (at low β_N≈1.5-1.8) with impurity seeding in AUG. *- Develop high radiative power fraction scenarios with good confinement for both low and high triangularity plasmas at high β_N =2.5-3 (ITER improved H-mode and DEMO relevant).* *- Also part of H1.2 deliverable H1.2-D05 "Establish scaling of small/no ELM regimes with high mantle radiation close to the density limit".*
H1.1-D07: H-mode and hybrid confinement scaling near the density limit (2015; 2017 with isotope dependence)
WPMST1
- Develop operational conventional and hybrid scenarios at low and high triangularity and study their confinement near the density limit.
H1.1-D08: Develop ITER ICR heating schemes (H non-activated phase, DT phase) (2017)
No work in 2015
H1.1-D09: Develop physics models for the density limit (2018)
WPJET1
- Collaboration WJET1 / WPMST1: Perform TCV density limit studies and compare with AUG and JET results.

WPMST1
- Collaboration WJET1 / WPMST1: Perform TCV density limit studies and compare with AUG and JET results.
H1.1-D10: Map density limit in non-inductive regimes of operation (2020)
No work in 2015
H1.1-D11: Develop gas puff technique and related modelling to maximise ICRF power in H-mode independently of the edge conditions (2017)
WPJET1
- Study of gas fuelling and modelling of ICRH power coupling in H mode. Comparison between ITER Like antenna and A2 antenna in terms of coupling, RF sheath rectification and W production.
WPMST1
- Study and optimise use of gas puff for ICRH coupling in AUG.
WPMST2
- WPMST2 PMP number MST2-10: Implementation of multichannel edge density profile reflectometer for ICRF antenna on AUG (completion date April 2015). 2015 deliverables: *● Electronic installation report* *● Elaboration of a software for density reconstruction* *● Final report after commissioning*
H1.1-D12: Improve arc detection systems during ELMs (work on test stands and RF systems) (2017)
WPMST2
Specific MST2 call for the arc detection system during ELMs is planned for WP15 under WPMST2 umbrella
H1.1-D13: Core transport simulator including: **- various equilibrium and transport modules;** **- turbulence modules;** **- impurities;** **- pellets;** **- neutrals;** **- sawteeth, NTM;** **- heating and current drive modules (extended to synergies, EC, NBI, IC, LH and fast-ions) with improved physics** **(2017)**
WPCD
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure
- Collaboration WPCD / WPJET1: Interpretative analysis and modelling of JET selected discharges with ETS
- ETS core simulator (fixed and free boundary) with full hierarchy of transport models and full integration of H&CD, including synergies (without LH and fast particles). Simulator release and regression test (WPCD PMP deliverable number WP15-CD.D03)
WPISA
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure

WPJET1
- Collaboration WPCD / WPISA / WPJET1: Implementation of the released ETS workflow into JEC2020 modelling infrastructure.
- Collaboration WPCD / WPJET1: Interpretative analysis and modelling of JET selected discharges with ETS.
H1.1-D14: Coupled core-edge simulations for JT-60SA with the COREDIV code for Carbon PFC (NEW) (2015)
WPSA
WPSA PMP deliverable number SA.M.D03 (linked also to H1.9 and H2.3)
H1.1-D15: Core-equilibrium modelling of flat-top phases of JT-60SA scenarios. Use of CRONOS code, progressive extension to JINTRAC and ASTRA (NEW) (2015)
WPSA
WPSA PMP deliverable number SA.M.D04 (also linked to H1.7, H1.9 and H2.3)

4.1.2 Headline 1.2: Operation with reduced or suppressed ELMs

Headline 1.2
H1.2-D01: Quantify difference of ELMs, edge pedestal and L-H transition in H, D, T and He plasmas (2017)
WPJET1
- To be completed with He data if campaign is approved for 2015.
WPMST1
- Subject to WPMST1-AUG He campaign: ● *Test the transferability of RMP ELM mitigation techniques to Helium in particular with respect to impurity influx.* ● *Measure the inter ELM evolution and ELM energy losses in Helium.* ● *Quantify the effect of impurity seeding in Helium with respect to ELM mitigation and impurity control.*
H1.2-D02: Demonstrate high dynamic range ELM pacing and low accompanying fuelling thus minimising the impact on confinement (2015)
WPJET1
- Pellet ELM pacing with the new pellet vertical track in high performance scenarios.
H1.2-D03: If agreed in 2013, design, procurement and installation of an ELM Control Coil set in JET , allowing a subsequent test of the size scaling of this method of ELM suppression (2017)
No work in 2015 - Proposal not agreed yet
H1.2-D04: Develop small / no ELM regimes scenarios and extrapolate towards low collisionality-high density (2015; Extrapolation: 2020)
WPMST1
- Type III collisionality stepladder study with JET.

H1.2-D05: Establish scaling of small/no ELM regimes with high mantle radiation close to the density limit) and extrapolate to low collisionality (2015 (D), 2017 (T&DT); Extrapolation: 2019)
WPJET1
- Perform scenario development close to density limit.
WPMST1
- Establish the operational range of small ELMs in discharges close to the density limit and with high mantle radiation on AUG and develop similar regimes on TCV (linked to HL-1.1).
H1.2-D06: Construct empirical confinement scaling laws, as for the ELMy H-mode, for small/no ELM regimes (2018)
WPMST1
- Data to be collected under other H1.2 deliverables.
H1.2-D07: (a) Develop and validate ELM model (for small ELMs) particularly with respect to: 1. Reproducing observed expansion of wetted surface during ELMs; 2. Explain the difference between inner/outer target and main wall; 3. Explain the fractional loss dependence of collisionality and on plasma impurity content; 4. Prediction of the dependence on ρ*; 5. Validation of models for pellets pacing (b) Validate pedestal models (2018)
WPJET1
- Collaboration WPJET1 / WPMST1: Simulate one JET and one AUG discharge with first principle code.
- Collaboration WPJET1 / WPMST1: Test non-linear ELM model on AUG and JET plasmas.
WPMST1
-Collaboration WPJET1 / WPMST1: Simulate one JET and one AUG discharge with first principle code.
- Collaboration WPJET1 / WPMST1: Test non-linear ELM model on AUG and JET plasmas.
- Model AUG discharges with mitigated ELMs using 3D stability and equilibrium codes.
H1.2-D08: Extrapolate ELM avoidance/mitigation techniques to low collisionality but high density and assess the impact on confinement and the L-H transition (2018)
WPMST1
- Extend studies of ELM mitigation with RMPs to n=4 and compare to existing MAST data (task) including the effect on the L-H transition. - Study RMP and pellet ELM mitigation with impurity seeding at low density to disentangle the effect of density and collisionality. - Demonstrate ELM mitigation/ suppression (magnetic coils and pellets) scenarios in ITER baseline plasmas as well as in high β_N high radiative fraction scenarios (AUG).
H1.2-D09: Test compatibility of shallow pellet fuelling with ELM avoidance/mitigation (2017)
WPMST1
- Quantify the effect of refuelling of RMP ELM mitigated n=2 and if available n=4 using shallow pellets.

H1.2-D10: Establish a scaling of the H-mode power threshold at low density and assess the role of SOL / divertor and ELM mitigation technique (2017)
WPMST1
- Continue studies on divertor geometry on the L-H transition including snow flake configurations on TCV and AUG (overlap with HL 2.4). *- Establish scaling of the low density branch of the L-H transition with density, plasma current and toroidal field on TCV and AUG.* *- Continue studies of the effect of RMP ELM mitigation on L-H transition on AUG and on plasma turbulence.*
H1.2-D11: ELM control workflow – including ELM module/3D MHD non-linear code (in support of other deliverables from H1.2) (2017)
WPCD
- Integration of a simple ELM module in the ETS

4.1.3 Headline 1.3: Avoidance and mitigation of disruption and runaways electrons

Headline 1.3
H1.3-D01: Develop robust operation of ITER scenarios and their safe termination (2015)
WPJET1
- Experiments in JET using exploiting three Disruption Mitigation Valves and study impact of multiple valves on radiation asymmetry (integrated in scenario development H-1.1-D02).
WPMST1
- Experiments in AUG exploiting 2 (or 3 if available) fast DMVs. Explore current quench dynamics. *- Continue experiments on disruption avoidance via ECRH/ECCD.* *- Explore disruption mitigation in high β scenario.*
H1.3-D02: Quantify the efficiency of massive gas injection for disruption mitigation to high current (4 MA) (2015)
WPJET1
- Experiments at high total energy E_{tot} will be performed in 2015 (data for low E_{tot} is available from 2014).
H1.3-D03: Extend studies of disruption avoidance and mitigation to conditions mimicking the hardware constraints expected on ITER (vertical stability capability, internal inductance, fast β changes) (2015)
WPJET1
- Experiments in JET exploiting three Disruption Mitigation Valves and study impact of multiple valves on radiation asymmetry. Quantify efficiency of mitigation with three Disruption Mitigation Valves in different toroidal and poloidal location. *- Characterise halo current and heat load distribution.* *- Develop and test disruption predictors. Compare with different predictors*
H1.3-D04: Determine disruption probability in non-inductive regimes of operation (2020)
No work in 2015
H1.3-D05: Scaling of MGI efficiency in non-inductive regimes (2020)
No work in 2015

H1.3-D06: Document conditions for run-away electron generation and mitigation (2015)
WPJET1
- If necessary complete experiments from 2014. Investigate alternative methods to control run-away beams in 2015.
WPMST1
- Continue studies of runaway generation in AUG and TCV, supported by high resolution run-away electron diagnostics. *- Study run-away electron mitigation with MGI in AUG.* *- Additional data from WPMST2 project (MST2-9).*
WPMST2
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (on-going project)
H1.3-D07: Test control of runaway electrons by alternative methods (non-axisymmetric fields) (2015)
WPMST1
- Explore possibility of RE beam decorrelation via magnetic perturbation *- Additional data from WPMST2 project (MST2-9).*
WPMST2
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (on-going project)
H1.3-D08: Validation of runaway generation model : determine runaway heat loads and forces in case of loss of control (2018)
WPJET1
- Describe the run-away existence domain with model developed in the Enabling Research programme and validate the full kinetic models.
WPMST2
- WPMST2 PMP number MST2-9: Mitigation of runaways, validation of runaway generation models studies and related diagnostics in support of MST and JET activities (on-going project). H1.3-D06,D07,D08 in MST2 will be jointly addressed in collaborative efforts on FTU and COMPASS tokamaks (in support of MST and JET activities): *Highlights of FTU contribution(experiments and supporting activities) in WP15 include :* *• determination of critical field by investigation of runaway suppression (as in DIII-D)* *• extension of parameter range for runaway generation* *• runaway control, also in X-point configuration* *• development of a new RE controller based on the linearized current and position model* *Work on COMPASS will concentrate on two main campaigns:* *• benchmarking of the GO and LUKE models* *• the role of plasma shaping and plasma limited or diverted configurations in runaway generation* *• In addition, project relevant hardware enhancements, including two more HXR detectors (for poloidal studies) and further development of Cherenkov detectors, are also planed*

H1.3-D09: Develop disruption prediction methods that minimise the requirements for model training on ITER and real-time predictors methods optimised in term of model training, success rate, anticipation time, differentiation among different types of disruptions (2018)
WPJET1
- Study, develop and test a locked mode predictor.
WPMST1
- Application of JET predictor at AUG
H1.3-D10: Develop full 3D codes (plasma + vessel) to describe halo current formation and asymmetries (2020)
WPCD
- Upgrade of JOREK to include vessel halo currents for disruption modelling and benchmark codes against AUG data (collaboration WPMST1/WPCD) *- Verified JOREK - extended STARWALL coupled code, adaptation to Integrated modelling standards (collaboration ITER-IO)*
WPMST1
- Collaboration WPMST1 / WPCD: Benchmark codes against AUG data.
H1.3-D11: Qualification of Massive Gas Injection as a mitigation method for heat loads and forces (fuelling efficiency, local peaking of radiation load as function of MGI parameters and plasma conditions) (2015)
WPJET1
- cf H1.3-D03.
WPMST1
- Investigate the effect of toroidal and poloidal asymmetries on disruption mitigation with MGI.- Assess the ratio of radiated power to divertor power during MGI, with high resolution diagnostic and in a broad database.- Assess the fast dynamics of injected impurities by means of high resolution diagnostics.- Test transferability of disruption mitigation methods in He (experiment and numerical simulation).
H1.3-D12: Develop Disruption workflow – including ELM module/RMP (2017)
WPCD
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium
WPJET1
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium.
WPMST1
- Collaboration WPCD / WPJET1 /WPMST1: Validation of the ETS with free boundary equilibrium

4.1.4 Headline 1.4: Integration of MHD control into plasma scenarios

Headline 1.4
H1.4-D01: Demonstrate integrated and routine sawtooth control in high performance, inductive scenarios (2016)
WPJET1
- Sawtooth control and avoidance in combined scenario with NTM control. Full use of the extra ICRH power capability (ITER Like Antenna).
WPMST1
- Sawtooth control experiments on TCV and AUG up to high β_N, with various tools (ECCD/ECRH, magnetic perturbation,..) ($\beta_N \lesssim 3$).
H1.4-D02: If agreed in 2014, design, procurement and installation of an ECCD system in JET , allowing a subsequent test of the size scaling of MHD control in inductive regimes (2017)
No work in 2015
H1.4-D03: Define system requirements / control algorithms for non-inductive scenarios (2020)
WPMST1
- Continue experiments to improve understanding of the interaction of magnetic perturbations with the plasma towards high β, also testing control algorithms (synergy with MST2 project MST2-9)
H1.4-D04: Improve modelling of mode dynamics to take into account realistic wall geometries (RWM) and actuators (NTM and RWM) (2018)
WPCD
- 3-D ASDEX-U wall implemented in integrated Modelling infrastructure for use of RWM codes.
- Collaboration WPCD /WPMST1: RWM workflow validated on multiple devices (benchmark codes against AUG data).
WPMST1
- Collaboration WPCD /WPMST1: RWM workflow validated on multiple devices (benchmark codes against AUG data).
H1.4-D05: Develop first principles understanding and simulation capability for NTM dynamics including wave-particle absorption in magnetic island. Validate such models (2020)
WPMST1
- Continue 2014 experiments *- NTM control experiments: Active stabilisation of (2,1) mode. Pre-emptive stabilisation using RAPTOR feedback model.*
H1.4-D06: Clarify role of low rotation in mode stability (2016)
WPJET1
- Explore operation with reduced torque injection by exploiting the full capability of the ICRH ITER Like Antenna (total ICRH power 12MW).
WPMST1
- Explorative experiments.

H1.4-D07: Extended linear stability chain (equilibrium coupled to MHD stability, edge instabilities, fast particle driven instabilities, RWM, ELMs) (2016)
WPCD
- RWM workflow release and regression test (WPCD PMP deliverable number WP15-CD.D01)- MHD linear stability chain including new physics (rotation or peeling-ballooning type instabilities that are observed on the onset/linear drive of the ELM). Linear MHD stability chain documentation and tutorial (WPCD PMP deliverable number WP15-CD.D02)
H1.4-D08: MHD analysis of kinetic profiles of the JT-60SA operational scenarios, including study of pedestal stability conditions (NEW) (2018)
WPSA
WPSA PMP deliverable number SA.M.D02
H1.4-D09: Study of RWM evolution in JT-60SA and requirements for stabilization (NEW) (2015)
WPSA
WPSA PMP deliverable number SA.M.D07
H1.4-D10: Study of NTM control and stabilization for JT-60SA (NEW) (2015)
WPSA
WPSA PMP deliverable number SA.M.D11
H1.4-D11: Report on the JT-60SA diagnostic systems: diagnostics for pedestal physics. Feasibility studies for BES, video pellet and other video diagnostics applications, polarimetry (NEW) (2015)
WPSA
WPSA PMP deliverable number SA.S.D05 (also linked H1.8)

4.1.5 Headline 1.5: Control of core contamination and dilution from W PFCs

Headline 1.5
H1.5-D01: Demonstrate acceptable W concentration in the foreseen reactor regimes (H-mode, hybrid and non-inductive) ITER wall materials and inductive operation: 1. Investigate the effect of ELM suppression and mitigation on high-Z peaking ; 2. Develop high-Z accumulation avoidance by means of central electron heating, eventually also alpha heating; 3. Minimise heavy impurity sputtering and local heat loads by optimisation of plasma edge and reduction of ICRF sheaths. (2015 (2017 for DT) for standard H-mode, 2018 for improved H-mode (hybrid), 2020 for non-inductive scenarios)
WPJET1
- Integrated in the scenario deliverable with stationary conditions (≈5s). Optimise ICRF power level, gas injection, seeding gas. Obtain stationary good confinement scenario. - Comparison of W production between ILA versus A2 ICRH antenna.
WPMST1
- Study high Z transport in ELM mitigated low collisionality plasmas. - Use new ICRH antenna to develop high density scenarios (when EC does not go to the core)

H1.5-D02: Develop and validate models for impurity transport in the foreseen reactor regimes. Link to the model development in Headline 1.6. (2020)
WPJET1
- Validation and exploitation of the ETS impurity transport module on JET experiments. Validate first principle impurity transport model.
WPMST1
- Testing of models with 2014 AUG results
H1.5-D03: Develop and validate models for RF sheaths in order to minimise heavy impurity sputtering and local heat loads - includes test of RF sheaths models (work on test stands, modelling and antennas design) (2018)
WPJET1
- Test RF sheath models by comparing the W production from the ITER-Like vs. A2 ICRH antennas.
WPMST1
- Characterisation of new 3 straps ICRH antenna. *- Synergy with MST2 project MST2-10 and MST2-11.*
WPMST2
- WPMST2 PMP number MST2-10: Implementation of multichannel edge density profile reflectometer for ICRH antenna on AUG. Completion April 2015. *- WPMST2 PMP number MST2-11: Studies of RF sheaths and diagnostics on IShTAR. 2015 work:* ● *IShTAR hardware and experiments: Find the best operating conditions in order to reach the highest plasma density and largest plasma volume, and start operation with other gases* ● *Antennas: Finalise the design (foreseen for 2014), construct and install the single strap antenna.* ● *Diagnostics: construct a probe array and/or movable probe for measuring density profiles in 2D or 3D & Installation of a spectrometer*
H1.5-D04: WPSA PMP deliverable number SA.S.D07: Report on the development of W divertor for JT-60SA: Assessment of the start-up / ramp down strategy and expected main chamber power loads. Assessment of the relevant scenarios for all metal PFCs (also linked to H2.2) (2018)
WPSA
- WPSA PMP deliverable number SA.S.D07 *- Assessment of the start-up / ramp down strategy and expected main chamber power loads.* *- Assessment of the relevant scenarios for all metal PFCs.*

4.1.6 Headline 1.6: Determine optimum particle throughput for reactor scenarios

Headline 1.6
H1.6-D01: Test of the influence of central alpha particle heating on core density peaking (2017)
No work in 2015
H1.6-D02: Validation of models for core particle convective transport, pellet ablation and drifts. Link to the model development in Headline 1.5 (2015)
WPCD
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
WPJET1
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
WPMST1
- Collaboration WPMST1 / WPJET1 / WPCD: ETS particle transport analysis of JET and MST discharges.
- AUG experiments to compare shallow pellet fuelling with gas fuelling.
H1.6-D03: Demonstration of core particle fuelling in conditions of low neutral penetration (2015)
WPJET1
- Explore core particle fuelling (pellet) in scenario matching ITER pedestal conditions, high temperature, high density and compare with gas puff. *- Demonstrate fuelling capabilities in He.* *- Test results with models used for ITER prediction.*
H1.6-D04: Optimisation of DT fuel mixture control and use of tritium (2017)
WPCD
- Collaboration WPJET1 / WPCD: Simulate fuelling conditions that will be available in a DT campaign; ETS scenario modelling for DT campaign fuelling.
WPJET1
- Collaboration WPJET1 / WPCD: Simulate fuelling conditions that will be available in a DT campaign; ETS scenario modelling for DT campaign fuelling.
H1.6-D05: Validation of plasma exhaust models (2018)
No work in 2015
H1.6-D06: Test of particle throughput in conditions matching the foreseen ITER pumping capabilities (2015)
WPMST1
- AUG experiments without cryo or with reduced cryo (only 1/3 of segments cooled).
H1.6-D07: Document He pumping in ITER regimes of operation (2015)
No work in 2015
H1.6-D08: Assessment of impact of particle throughput on fuel retention (2015)
WPJET1
- Complement existing data in D and H with He data if He campaign is decided.

H1.6-D09: Assess the impact of the metallic wall on the wall pumping Compare tokamaks of different size (2015)
WPJET1
- JET has done some experiments before 2014. Data mining on-going.
H1.6-D10: Determine effect of pumping-/ divertor-geometries on He-pumping, including fuelling, pellets injection etc (2017)
WPJET1
- If He campaign is decide, document He pumping by Argon frosting in the pumps and density control in He.
WPMST1
- As part of H1.1-D01 "Study heat, particle and momentum confinement in conventional H-mode and improved H-modes (hybrid) and the dimensionless scaling towards ITER (2015).
H1.6-D11: Determine technological and physics limits on density peaking (2016)
WPMST1
- Continue AUG core fuelling experiments: extension to stationary conditions, use of shallow pellet.
H1.6-D12: JT-60SA divertor pumping modelling: Validation of the neutral code. Elements for a technical design of the cryopumping systems (NEW) (2015)
WPSA
- WPSA PMP deliverable number SA.S.D06 (also linked to H1.8).
H1.6-D13: Preliminary studies of the JT-60SA pellet injection system concept (NEW) (2017)
WPSA
- WPSA PMP deliverable number SA.S.D07

4.1.7 Headline 1.7: Optimise fast ion confinement and current drive

Headline 1.7
H1.7-D01: Preparation of burning plasma physics on ITER (2020)
No work in 2015
H1.7-D02: Investigation of fast ion losses and their power scaling for various scenarios (2017)
WPJET1
- Work on-going on fast ion losses and scaling. Upgrade of the TAE system (see WPJET4). During 2015 a new digital control system including the capability to control relative phase between the antennas will be implemented to measure at the same time drive and damping of the modes, i.e. the whole set of parameters determining their linear stability. Compare with theoretical prediction.
WPMST1
- Study effect of ECRH/ECCD on Alfvén instabilities; determine viability as a control technique. *- Quantify and characterise effect of sawteeth on fast ion redistribution (completing preliminary 2014 experiments)*

H1.7-D03: Study the slowing down and losses of fusion alpha particles in JET during the 'after-glow' phase of high performance DT discharges (2017)
WPMST1
- Quantify the slowing-down and confinement of energetic He from He-doped beams.
H1.7-D04: Benchmark codes and validate non-linear models for fast ion-MHD interaction (2017)
WPJET1
- Report on benchmarking of non-linear MHD codes for fast ion MHD interaction on identified test cases (task will continue in 2016). *- Integration of synthetic diagnostics (including fast-ion) diagnostics in Integrated Modelling framework for comparison to experiment (also in support to H8.2- new task).*
H1.7-D05: Systematically vary the plasma fast ion content to separate the dependence of confinement, stability and bootstrap current on thermal and fast ion pressure (2020)
WPJET1
- Quantify the effect of the fast particle density and distribution on thermal plasma transport, MHD stability and bootstrap current – Compare to theoretical and first principle prediction to assess how plasma turbulence is controlled by fast particles (link with Enabling Research programme)- Use extra ICRH power capability provided by the ILA- Parasitic activity to the scenario development.
H1.7-D06: Optimise pedestal and core density and temperature to maximise current profile control (e.g. propagation and damping of LH waves) in view of advanced regimes in ITER (2020)
No work in 2015
H1.7-D07: Investigate the effect of fast ion confinement on current drive (2015)
WPMST1
- Extend 2014 experiments with AUG power scan.
H1.7-D08: Assess and document off axis current drive performance (2018)
WPMST1
- Document NBCD and determine on- vs off-axis efficiency; and document fast ion population, dynamics and losses as functions of plasma parameters (power, density, current). *- Determine dependence of anomalous fast-ion transport on E/T_e, on beam isotope, on Z_{eff}.*
H1.7-D09: Development of ITER relevant fast ion diagnostics (2016)
No work in 2015
H1.7-D10: Improving fast ion diagnosis on the current devices (2016)
WPMST1
- Exploitation of the new detector for poloidal detection (FILD4 & FILD5) for AUG *- Synergy with WPMST2 project MST2-3*

WPMST2
- WPMST2 PMP number MST2-3: Implementation of the scintillator-based fast ion loss detectors (FILD) on MAST and AUG (completion date Dec. 2015). 2015 deliverables *● Installation of new detector for poloidal detection (FILD4 & FILD5) for AUG* *● Installation of out-vessel components including reciprocating and light acquisition systems* *● Dedicated experiments to validate first experimental data* *- WPMST2 PMP number MST2-4: Development study of the upgrade for Neutron Calibration on MAST-U (completion date Dec. 2014)* *● 2015: construction of the neutron camera upgrade pending on cost request*
H1.7-D11: Assessment of fuelling and current control requirements to maintain steady state in the JT-60SA operational scenarios (NEW) (2016)
WPSA
- WPSA PMP deliverable number SA.M.D05.

4.1.8 Headline 1.8: Develop integrated scenarios with controllers

Headline 1.8
H1.8-D01: Demonstrate combination of individual control algorithms into integrated control scenarios: Combine avoidance of NTMs, possibly via sawtooth control, with control of ELMs, disruptions, core contamination, divertor detachment, fuel species mixture and simulated burn (2018)
WPCD
- Coupled feedback controlled free boundary plasma simulator and transport solver – finalised version of the Feedback controlled free boundary ETS Simulator release + regression test (PMP WPCD deliverable number: WP15-CD.D04) *- Integration of synthetic diagnostic*
WPJET1
- Develop real-time control algorithm: sawtooth control, ELM control and W control using Prad, divertor detachment (under Mission 2). Explore burn control with extra-ICRH power.
WPMST1
- Demonstrate integrated control of three or more among NTMs, sawteeth, ELMs, disruption mitigation and divertor detachment, using diagnostic observers + real-time modelling and assessing minimal necessary observer set. Coordinate jointly on AUG and TCV.
H1.8-D02: Demonstrate combination of individual control algorithms into integrated control scenarios: Use first principle simulation and modelling of individual control requirements to develop simplified plant dynamical models and observers for use in control algorithms (2018)
WPJET1
- Develop ad-hoc models for routine controllers used in the high performance scenarios.
H1.8-D03: Test of minimum diagnostic and actuator set for control: Develop and test measurement techniques for ITER and DEMO (2015, DT-related 2017)
WPJET1
- cf H1.8-D01.

WPMST1
- cf H1.8-D01.
H1.8-D04: Test of minimum diagnostic and actuator set for control: Optimization of the minimum set of realistic sensor / actuator by means of IM (2015)
No work in 2015
H1.8-D05: Test of minimum diagnostic and actuator set for control: Test of a DEMO-relevant measurement set for scenario control (2018)
No work in 2015
H1.8-D06: Pre-qualify complete ITER scenarios on present machines: Qualification of the candidate plasma scenarios on the existing machines, including scaling with ρ^* and separation of collisionality / Greenwald fraction. The work should be supported by realistic numerical simulations (including controllers/actuators) (2016)
No work in 2015
H1.8-D07: Pre-qualify complete ITER scenarios on present machines: Integration with DT operation (2017)
No work in 2015
H1.8-D08: Definition and prioritization of the ECRF JT-60SA system functionalities (NEW) (2017)
WPSA
- WPSA PMP deliverable number SA.S.D04: ● *functionalities for NTM, sawtooth control, current profile tailoring, impurities control and low absorption scenarios (start-up assist, wall cleaning).* ● *Comparison of the antenna model with the result of the optical tests.* ● *Input for antenna performances optimization.* ● *Requirements for real time control of the antenna and conceptual design of the control loop.* ● *Stray radiation probes conceptual design*
H1.8-D09: Calculation of the magnetic flux map at breakdown for JT-60SA. Modelling of breakdown with and without ECCD assist (NEW) (2016)
WPSA
- WPSA PMP deliverable number SA.O.D07.

4.1.9 Headline 1.9: Qualification of Advanced Tokamak scenarios

Headline 1.9
H1.9-D01: Demonstration of regime existence and of the feasibility of operation above the no-wall stability limit (2020)
No work in 2015
H1.9-D02: Integration of the scenario with acceptable fast particle losses, density and divertor heat load (2020)
No work in 2015
H1.9-D03: If agreed in 2014, design, procurement and installation of an Electron Cyclotron Current Drive system in JET , allowing a subsequent proof-of-principle test of the size scaling of current drive requirements for non-inductive operation (2017)
No work in 2015
H1.9-D04: Integrated model validation so as to define, in as much as possible without definitive large machine results, the current drive requirements for non-inductive operation in JT-60SA (decision ≈2023) and ITER (≈2024) (2018)
WPJET1
- Collaboration WPJET1 / WPSA: Development of advanced scenario for the preparation of JT-60SA non-inductive regimes. Investigate similarity experiments JET – JT-60SA experiments.
WPSA
- Collaboration WPJET1 / WPSA: Development of advanced scenario for the preparation of JT-60SA non-inductive regimes. Investigate similarity experiments JET – JT-60SA experiments.

4.2 Mission 2: Heat-exhaust systems

4.2.1 Headline 2.1: Detachment control for the ITER and DEMO baseline strategy

Headline 2.1
H2.1-D01: Develop and test relevant sensors and actuators for detachment detection and control (2015)
WPJET1
- Develop real time control algorithm for detachment control with different fuelling methods at high P_{sep}/R (≈10 MW/m).
WPMST1
- Investigate substituting machine specific sensors with more general measurements.
H2.1-D02: Investigate/document confinement at detachment for different fuelling methods / locations (2015)
WPJET1
- Experiments on detachment with different fuelling methods at high P_{sep}/R (≈10 MW/m)
WPMST1
- Analysis of existing database, although a dedicated experiment is desirable.
H2.1-D03: Document H-L threshold scaling up to Greenwald density limit at high auxiliary heating power (2015)
WPJET1
- Data should be available from 2014 including the Hydrogen phase. Continue in 2015 if He campaign is decided.
WPMST1
- Part of studies for H1.1-D04 "Characterise L-H threshold power and access to H98(y,2)≈1 (e.g. power) in ITER-relevant conditions (2015; T & DT 2017)".
H2.1-D04: Document influence of shaping on heat loads (steady state, ELMs) in the divertor (2015)
WPJET1
- Analysis of existing database
WPMST1
- Analysis of existing database.
H2.1-D05: Optimise impurity mix for divertor and mantle radiation (2015)
WPJET1
- Experiment to be considered in 2015
WPMST1
- Extend experience with high Z core radiation and high SOL radiation.
H2.1-D06: Benchmark codes to predict detachment, particle and power loads in ITER and DEMO (linked to Headline 2.3) (2017)
WPJET1
- On-going predictive modelling for several gases, proposed move to H2.3
WPMST1
- On-going. Continue analysis.

H2.1-D07: Document detailed conditions to reach detachment at highest available P_{sep}/R and close to Greenwald density limit and quantify particle and power loads to the main chamber (2015)
WPJET1
- Experiments on detachment with different fuelling methods at high P_{sep}/R (≈10 MW/m).
WPMST1
- Document detachment conditions on TCV.
H2.1-D08: Investigate the compatibility of W with extrinsic impurity seeding / optimize impurity mix for divertor and main chamber radiation (linked to Headline 2.2) (2018)
WPJET1
- Investigation of N2 and Ne compatibility done in 2014. Ne will continue in 2015 but other gases such as Ar are being considered
WPMST1
- Open call for physics studies on AUG.
WPPFC
- Qualification of the impact mechanisms of seeding gases (Ar and N) on fuel retention and fuel release in W PFCs (WPPFC PMP deliverables PFC.TD10) and Assessment of the impact of nitrogen as seeding gas on W PFCs and characterisation of WN layers (WPPFC PMP deliverables PFC.TD06): *● Role of seeding impurities on fuel retention and removal techniques* *● WN formation, erosion and characterisation* *● BeN formation, erosion and characterisation* *- Development and characterisation of ITER-like mixed layers (WPPFC PMP deliverable PFC.TD19)*
H2.1-D09: Compare influence of different divertor geometry on heat loads (2018)
WPJET1
- Experiment pending ongoing analysis and associated SOL modelling
WPMST1
- AUG experiments may follow analysis of 2014 studies for open and closed divertor. *- First WPMST1-TCV experiments will concentrate on divertor leg length.*
H2.1-D10: Demonstrate low W sources and W core penetration for (partially) detached divertor conditions and relevant P_{sep}/R (2018)
WPJET1
- Data collected from detachment studies (see H2.1-D09)
WPMST1
- Scan of radiation fraction on AUG.
H2.1-D11: Demonstrate compatibility of detachment with ELM mitigation methods / ELM-free / 'small' ELM scenarios (2016)
WPJET1
- Use pellets mitigation scheme on detached plasmas
WPMST1
- Study effect of RMPs on access to detachment on AUG.

H2.1-D12: Improve divertor and SOL diagnostics to allow new insight in underlying physics (n_e, T_e, T_i, flows, impurities) (2016)
WPMST2
- WPMST2 PMP number MST2-1: Implementation of the super-X Divertor TS diagnostic on MAST-U tokamak (completion date Dec. 2015). 2015 deliverables: *● Completion of collection optics;* *● Installation of LASER beam in MAST-U area.* *- WPMST2 PMP number MST2-2: Implementation of snow flake IR Imaging diagnostic on TCV tokamak (completion date March 2015). 2015 deliverables:* *● Commissioning of improved snow flake IR imaging diagnostic*

4.2.2 Headline 2.2: Prepare efficient PFC operation for ITER and DEMO

Headline 2.2
H2.2-D01: Investigate evolution of melt layers of metallic surfaces, and their influence on the plasma behaviour (2015)
WPJET1
- Collaboration WPJET1 / WPJET2: Study completed in 2014. Modelling is ongoing. A new lamella will be installed in the 2014 shutdown for experiments in 2015. The objective is to resolve an anomalously low heat flux on the exposed tungsten edge compared to what is expected from geometric projection of the heat flux seen on normal lamellas. This problem is compounded by the fact that IR camera had a side view of the edge and cannot resolve the peak temperature.
WPJET2
- Collaboration WPJET1 / WPJET2: Study completed in 2014. Modelling is ongoing. A new lamella will be installed in the 2014 shutdown for experiments in 2015. The objective is to resolve an anomalously low heat flux on the exposed tungsten edge compared to what is expected from geometric projection of the heat flux seen on normal lamellas. This problem is compounded by the fact that IR camera had a side view of the edge and cannot resolve the peak temperature.
WPMST1
- Complement studies performed at JET with AUG studies using the divertor manipulator.
H2.2-D02: Quantify isotope-exchange on ITER and DEMO relevant materials (2016)
WPPFC
- Quantification of the isotope exchange capability in EUROFER and in W as reference (WPPFC PMP deliverable number: PFC.TD12). 2014 ==> Exchange and de-trapping in W and n-damaged W. 2015 ==> Expand to synthetic Be/D-layers and higher temperatures in W
H2.2-D03: Develop Ion Cyclotron Wall Conditioning techniques (2015 ; DT 2017)
WPJET1
- Completed in 2014 (D and H), on-going data analysis. Possible additional experiments if He campaign is approved

H2.2-D04: Minimisation of divertor and main chamber erosion, quantify (and try to extrapolate) main chamber filamentary transport (expected particle flux and energy) (2015)
WPMST1
- Dedicated studies for first wall particle and heat load transport by comparing divertor (IR and probes) and first wall (IR and probes) in AUG and TCV
H2.2-D05: Validate codes on plasma wall interactions (erosion, re-deposition and migration) (2016)
WPJET1
- Collaboration WPJET1 / WPMST1 / WPPFC: Test codes on expanded database
WPMST1
- Collaboration WPJET1 / WPMST1 / WPPFC: Test codes on expanded database
- Study effect of divertor target shape on plasma surface interactions.
WPPFC
- Collaboration WPJET1 / WPMST1 / WPPFC: Execution of edge modelling codes related to experiments within WPPFC and benchmark of ERO, WALLDYN and MD (PMP WPPFC deliverable number PFC.TD14) *● Plasma-background and plasma-sheath modelling (Codes: SOLPS, SOLEDGE, PIC, 3DMHD)* *● Plasma-surface interaction and transport modelling (Codes: ERO, WALLDYN, ASCOT, MD, ...)* *● Material migration in tokamaks (post-mortem analysis)*
H2.2-D06: Dust: Qualify production mechanisms (2015)
WPJET2
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● The dust samples collected will be subsequently analysed for composition, size and fuel content.* *● These data will be used to calculate conversion factors from layers to dust and to validate models for dust production.*
WPMST1
- Supported through piggyback studies
H2.2-D07: Dust: Quantify dust production (2017)
WPJET2
- Quantify Be dust production and composition (ITER-IO expecting answers from JET2)
WPMST1
- Supported through piggyback studies
H2.2-D10: Dust: Develop dust removal techniques (2018)
No work in 2015
H2.2-D11: Erosion of ITER/DEMO relevant armour materials (2016)
WPJET2
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● First results from the analyses of PFC and probes retrieved after 2013-2014 operation* *- Completion of analysis of materials retrieved in 2012 and integrated material migration picture based on complete set of results after 2011-2012 operation.*

Post mortem analysis of tiles removed from JET will be used to quantify the rate of material erosion, transport and deposition and thus to validate models of these processes. In-situ measurements (quartz microbalance device, QMB) and shot-resolved observations (spectroscopy) shall be addressed. In addition, the elemental and chemical composition of deposited layers will be studied

WPPFC

- Qualification of EUROFER as plasma-facing material (WPPFC PMP deliverable PFC.TD05)
- Assessment of the impact of nitrogen as seeding gas on W PFCs and characterisation of WN layers (WPPFC PMP deliverable PFC.TD06)
- Quantification of differences in power load damage thresholds and W structure modification by different loading techniques. Synergetic impact of fuel flux (D and/or He) and fluence (WPPFC PMP deliverable PFC.TD01 and WPPFC PMP deliverable PFC.TD03)
- BeN and WN formation, erosion and characterisation : 2015 ==> film formation / erosion / characterisation in connection with PISCES B experiments

H2.2-D12: Develop barriers for plasma driven permeation (2017)

No work in 2015

H2.2-D13: Cross-check retention properties in heavy-ion (HI) damaged materials with that of neutron damaged material (2016)

WPPFC

- Quantification of the impact of neutron damage on the thermo-mechanical properties of W and comparison with W self-damaged W (WPPFC PMP deliverable PFC.TD03)
- *Synergistic loading and its effects on W surfaces and its properties*
- *Thermo-mechanical properties of damaged W surfaces*
- *Post mortem analysis*

H2.2-D14: Retention in neutron/HI damaged PFM as a function of irradiation temperature, preferentially for simultaneous (HI) and plasma irradiation (2017)

WPPFC

- Quantification of the impact of neutron damage on fuel retention in Be and W (WPPFC PMP deliverable PFC.TD08):
- *Thermo-mechanical properties of damaged W surfaces*
- *Role of neutron damage on retention mechanism and "strength" in Be/W*

- WEST Bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines. Associated analysis and modelling

H2.2-D15: Characterise sputtering and power handling of damaged PFC (NEW) (2018)

WPPFC

- Quantification of the impact of neutron damage on the thermo-mechanical properties of W and comparison with W self-damaged W (WPPFC PMP deliverable PFC.TD03):
- *Thermo-mechanical properties of damaged W surfaces*
- *Synergistic loading and its effects on W surfaces and its properties*
- *Post mortem analysis*

- WEST Bulk and coated tungsten PFC qualification in high heat flux facilities and linear machines. Associated analysis and modelling.

H2.2-D16: Develop T removal techniques from ITER and DEMO relevant materials (2018)
No work in 2015
H2.2-D17: Qualification of plasma surface interaction diagnostics (NEW) (2015)
WPPFC
- Qualification of LIBS as in-situ fuel retention and material composition techniques (WPPFC PMP deliverable PFC.TD17) *- Development of high resolution IR system for monitoring PFC surface temperature (WEST)* *- Development of visible spectroscopic diagnostics for monitoring PFC tungsten sources and D recycling (WEST)* *- Development of actively cooled Langmuir probes embedded in divertor ITER-like targets to measure plasma parameters around the divertor strike points. Focus on technology transferable to ITER divertor targets (WEST)*
H2.2-D18: Reproduction and study of ILW material mixture (NEW) (2016)
WPPFC
- Development and characterisation of ITER-like mixed layers (WPPFC PMP deliverable PFC.TD19) *- Quantify outgassing of super-saturated Be and W surfaces (WPPFC PMP deliverable PFC.TD09)*
H2.2-D19: Effects of Helium nanostructured Tungsten on transient loading (NEW) (2016)
WPPFC
- Effects of He nano-structured W on transient power loading (included in WPPFC PMP deliverable PFC.TD02)
H2.2-D20: Post mortem analysis of mirrors exposed to JET plasmas (2015 and 2018)
WPJET2
- Post mortem analysis of mirrors exposed to JET plasmas provides unique information on the expected lifetime of first mirrors in ITER: *● The programme will investigate the change of the optical performance of test mirrors placed in various locations in JET (main chamber and divertor).* *● Analyses will be carried out to determine the impact of erosion-deposition processes on optical properties.*
H2.2-D21: Establish the conditioning procedure with EC wall conditioning in JT-60SA. Validate EC wall conditioning by experiments in EU machine relevant for JT-60SA (NEW) (2017)
WPSA
- WPSA PMP deliverable number SA.O.D06.

4.2.3 Headline 2.3: Optimise predictive models for ITER and DEMO divertor/SOL

Headline 2.3
H2.2-D07: Dust: Quantify dust production (2017)
WPJET2
- Retrieval of materials from 2013 - 2014 campaigns for ex-situ analyses: PFC, erosion-deposition probes and dust: *● The dust samples collected will be subsequently analysed for composition, size and fuel content.* *● These data will be used to calculate conversion factors from layers to dust and to validate models for dust production.*
H2.2-D09: Dust: Model impact on plasma operation (2018)
No work in 2015
H2.3-D01: Physics extensions, code validation, coupling of material migration code to the plasma code: Coupled material migration - plasma code validation for simple L-Mode cases in all metal (C-free) devices ; extension of validations to high power, high density impurity seeded H-modes (2017)
No work in 2015
H2.3-D02: Physics extensions, code validation, coupling of material migration code to the plasma code: Validation of 3D migration codes (like ERO or ASCOT) and their coupling to plasma codes (like SOLPS) (2017)
No work in 2015
H2.3-D03: Validation and exploitation of turbulence and synthetic probe workflow for experiment analysis (NEW) (2015)
WPCD
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis of MST and JET if probes / probe data available.
WPJET1
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis (TCV, JET if probes / probe data available)
WPMST1
- Collaboration WPCD / WPMST1 / WPJET1: experiment analysis (TCV, JET if probes / probe data available)
H2.3-D04: Optimise predictive models for ITER and DEMO divertor/SOL: Development of computational tools for edge transport extending up to PFC (2018)
WPCD
- Finalized SOLPS speed-up studies *- Prototype edge workflow modelling SOL and interaction with PFCs (2015 milestone from PMP) (also in support to H1.5, H2.2)*
- Application of SOLPS to TCV SOL geometry studies.
WPMST1
- Application of SOLPS to TCV SOL geometry studies. Interpret simple attached cases based on AUG 2014 L-mode plasmas.

WPPFC
- WEST Divertor modelling for the preparation of ITER monoblocks testing (as defined by F4E) in tokamak environment. Impact of divertor topology (compact divertor, pumping baffle) on density regimes and on the W screening capability
H2.3-D05: Optimise predictive models for ITER and DEMO divertor/SOL: Fully develop 3D code(for example EMC-3) for proper treatment of effects of Magnetic Perturbations, benchmark with 2D codes and experiments (2015)
No work in 2015
H2.3-D06: Optimise predictive models for ITER and DEMO divertor/SOL: Self-consistent coupling between core and edge transport codes (2015)
WPCD
- Benchmark ETS core-edge workflow versus JINTRAC-COCONUT (new task)
WPJET1
- Verification and validation of codes on JET and MST through edge modelling tasks (e.g. SOL conditions & detachment, radiation and fluxes, SOL drifts, SOL currents, Be erosion/yields, Material migration, Core/edge integrated mod., Edge turbulence) and extrapolations towards ITER and DEMO .
WPMST2
- ITER modelling effort on COMPASS with SOUL1D: to be considered under WPMST2.

4.2.4 Headline 2.4: Alternative power exhaust solutions for DEMO

Headline 2.4
H2.4-D01: Proof of Principle of detachment control in alternative divertor geometries: document detailed conditions to reach detachment at highest available PSOL/R and close to Greenwald density limit (2016)
WPMST1
- Characterisations of plasmas in snowflake configuration with respect to high density operation. Characterisations of plasmas in snowflake configuration with respect to seeded operation. Study of L-H and H-L transition with divertor geometry on AUG and TCV, including snowflake configuration.
H2.4-D02: Proof of Principle of detachment control in alternative divertor geometries: Demonstrate removal of peak load (2016)
WPMST1
- Study of power deposition profiles during snowflake operation under attached conditions.
H2.4-D03: Proof of Principle of detachment control in alternative divertor geometries: Assess effect of transients (β, li) on control of divertor geometry (2016)
WPMST1
- Characterise stability of snowflake configuration during ELMs and sawteeth.
H2.4-D04: Proof of Principle of detachment control in alternative divertor geometries: Demonstrate divertor retention of eroded divertor material (2016)
No work in 2015

H2.4-D05: Proof of Principle of detachment control in alternative divertor geometries: Investigate He pumping capabilities (2016)
No work in 2015
H2.4-D06: Proof of Principle of detachment control in alternative divertor geometries: Test liquid metal PFCs in a high power divertor tokamak (plasma compatibility, effect of oblique magnetic field and transient power loads) (2016)
No work in 2015
H2.4-D07: Proof of Principle of detachment control in alternative divertor geometries: If possible, use of machines with different size to improve predictive capability to DEMO (2016)
No work in 2015
H2.4-D08: Proof of Principle of detachment control in alternative divertor geometries: Support analysis with modelling effort in view of assessment for DTT/ITER/DEMO (2016)
No work in 2015
H2.4-D09: Proof of Principle of compatibility of detached operation with ELM mitigation/control in alternative divertor geometries: Investigate compatibility of the detachment with ELM mitigation methods / ELM-free / 'small' ELM scenarios (2016)
No work in 2015
H2.4-D10: Proof of Principle of liquid PFC solutions: Demonstrate substantial power load capability of liquid metal PFCs (≥ 10 MW/m²) (2015)
WPDTT1
- Provide input for H2.4-D15 and H2.4-D17: ● *Test of a cooled liquid Li CPS limiter in FTU (2014-2015)* ● *Test of a cooled liquid Sn CPS limiter in FTU (starting in 2015)* ● *Model the stationary power load capability of a CPS based LM solution (2014)*
WPPFC
- Qualification of the power handling capabilities of actively cooled CPS structures with Sn (WPPFC PMP deliverable PFC.TD22)
H2.4-D11: Proof of Principle of liquid PFC solutions: Investigate conditions for acceptable plasma dilution/impurity content at high power loads (dominant PFC, 'divertor impurity screening') (2015)
WPDTT1
- Provide input for H2.4-D17 • *Evaluate compatibility of LM PFC with core performance in FTU (2014-2015)* • *Model DEMO SOL with LM boundary condition (2015)*
H2.4-D12: Proof of Principle of liquid PFC solutions: Demonstrate 'integrity' of liquid surface during plasma instabilities and during substantial transient power loads. Characterize possible mixed material effects (main chamber PFCs/cooling structure) (2015)
WPDTT1
- Provide input for H2.4-D17: • *Model CPS behaviour under transient conditions*
WPPFC
- Gross and net erosion yields of liquid metals: Sn, Li, corresponding alloys (WPPFC PMP deliverable PFC.TD20) *- Mixing of Sn, Li, alloys with W (WPPFC PMP deliverable PFC.TD20)*

H2.4-D13: Proof of Principle of liquid PFC solutions: Quantify H retention and outgassing of liquid metal PFCs (2015)
WPDTT1
- Provide input for H2.4-D17 *• Improve and complete measurements of hydrogenic retention in Li, Sn and LiSn alloys (through experiments in FTU, TJ-II and ISTTOK).*
WPPFC
- Quantification of fuel retention in Li, Sn and corresponding alloys (WPPFC PMP deliverable PFC.TD21)
H2.4-D14: Proof of Principle of liquid PFC solutions: Support analysis with modelling effort in view of assessment for DTT/ITER/DEMO (2015)
WPDTT1
cf. H2.4-D11 & H2.4-D12
H2.4-D15: Assess requirements for physics model development (2014)
WPDTT1
- WPDTT1 PMP deliverable PD04 (to be completed in 2014)
H2.4-D16: DEMO compatibility of alternative divertor designs: **1. assess Super-X divertor;** **2. assess Snow Flake Divertor;** **3. assess further geometries/techniques** **(2015)**
WPDTT1
- WPDTT1 PMP deliverable PD05/CD03: Report on alternative power exhaust solutions for DEMO (Super X, snowflake, liquid metal). *● The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations as well as the most promising liquid metal PFC solutions.* *● The DEMO compatibility will be quantified in terms of benefits and costs of the alternative solutions compared to conventional power exhaust solutions. The assessment also includes the identification of the uncertainties.*
H2.4-D17: DEMO compatibility of liquid metal PFCs: 1. assess liquid PFC solution; 2. select best liquid metal, if viable (2015)
WPDTT1
- WPDTT1 PMP deliverable PD05/CD03: Report on alternative power exhaust solutions for DEMO (Super X, snowflake, liquid metal). *● The deliverable requires an assessment of the DEMO compatibility of the most promising techniques and alternative configurations as well as the most promising liquid metal PFC solutions.* *● The DEMO compatibility will be quantified in terms of benefits and costs of the alternative solutions compared to conventional power exhaust solutions. The assessment also includes the identification of the uncertainties.*
H2.4-D18: Definition of DTT technical requirements (2015)
WPDTT2
- WPDTT2 PMP deliverable T03: Progress Report 2015 Part 1 - activities in support to WPDTT1 on advanced magnetic configurations, liquid metals and alternative solutions. *- WPDTT2 PMP deliverable TD04 (CD02): Report on a Divertor Test Tokamak technical requirements.*

H2.4-D19: DTT conceptual design (new machine or upgrade of existing device) (2016, depending on outcome of the review) (2016)
WPDTT2
- WPDTT2 PMP deliverable T03: Progress Report 2015 Part 2 - activities aimed at a pre-conceptual "baseline" DTT design (feasibility study)

4.3 Mission 8: Stellarator

4.3.1 Headline 8.1: Qualification of Helias optimised stellarator operation

Headline 8.1
H8.1-D01: Scenario development: demonstrate pulsed operation (8 MW / 10 s to 1 MW / 1 minute) (2018)
WPS1
- Achieve first plasma (OP1.1 goals: E< 2MJ, e.g. 2MW <1s), implement a European task force and participate in the first experiment campaign on W7-X. *- Support work on diagnostics and components: reflectometry, video diagnostics and imaging software, impurity diagnostics, fast particle diagnostics (new task TBD), probes, ICRH and support actions.* *- Supporting physics studies in view of developments of experimental approaches on W7-X and model validation to develop a physics base for the HELIAS line (also within international cooperation): optimization(impact of neoclassical effects on turbulent transport , H8.1-D07), particle transport and fuelling and divertor physics (exhaust, H8.1-D09), impurity transport (impact of potential asymmetry on flux surfaces, H8.1-D05), fast ion.* *- Develop and assess detection methods for safe ECRH operation (also in view of ITER) (new task TBD).*
H8.1-D02: Scenario development: development of credible scenarios for steady state operation (2018)
WPS1
- Covered in edge modelling (H8.1-D09).
H8.1-D03: Scenario development: qualification of heating schemes up to very high densities (2017)
WPS1
- Pursue the study of the transition from X- to O-mode.
H8.1-D04: Scenario development: edge-iota control including ECCD (2018)
No work in 2015
H8.1-D05: Confinement studies: predictive modelling for heat and impurity transport using existing physics basis (2016, cont.)
WPS1
- Modelling of heat (impact of scenario) and impurity transport and fast particles (study of fast ion losses).

H8.1-D06: Confinement studies: verification of neoclassical confinement optimization (2016, cont.)
WPS1
- Pursue the core scenario predictive modelling in the W7-X magnetic configuration space.
H8.1-D07: Confinement studies: study of impact of neoclassical optimization on turbulent transport (2017, cont.)
WPS1
- Diagnostic (reflectometer) and modelling activities. *- Development of experimental approaches for W7-X: impact of neoclassical effects on turbulent transport.*
H8.1-D08: Power and particles exhaust: Tailoring of island configuration (2017)
No work in 2015
H8.1-D09: Power and particles exhaust: Qualification of safe divertor operation (2018)
WPS1
- Edge and core modelling: develop consistent scenarios with respect to core and edge. Calculation of particles sources.

4.3.2 Headline 8.2: Theory Development, Modelling and Engineering

Headline 8.2
H8.2-D01: Include engineering constraints in stellarator optimization together with advances in physics understanding and computational capabilities (2018)
WPS2
- WPS2 PMP deliverable D10: Comparison of tokamaks and stellarator modules in system code (e.g. PROCESS). The stellarator module has been added to this system code. Now, it will be possible to compare both types of reactors using this code.
H8.2-D02: Improve tools for predictive edge modelling for 3D geometries of stellarators (2018)
WPCD
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium (VMEC) codes into Integrated Modelling Framework (new task t.b.d.).
WPISA
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium (VMEC) codes into Integrated Modelling Framework (new task t.b.d.).
WPS2
- WPS2 PMP deliverable D8: ● *Test the EXTENDER code.* ● *Apply FINDF code to the edge transport in W7-X. Start the benchmark of FINDF.*
- Collaboration WPS2 / WPCD /WPISA: Porting of 3D equilibrium (VMEC) codes into Integrated Modelling Framework (new task t.b.d.).

H8.2-D03: Include turbulent transport models in stellarator optimization, in addition to the neoclassical optimisation (2018)
WPS2
- WPS2 PMP deliverable D5, D9: *● Identify proxies for optimising stellarator configurations taking into account minimisation of Zonal Flow damping and stabilisation of Trapped Electron Modes.*
H8.2-D04: Develop new stellarator configurations close to HELIAS, giving higher priority to fast ion confinement and less weight to aspects now deemed less crucial such as MHD stability. (2018)
WPCD
- Collaboration WPCD / WPS1 / WPS2: fast ion losses synthetic diagnostics integration (new task t.b.d)
WPS1
- Collaboration WPCD / WPS1 / WPS2: fast ion losses synthetic diagnostics integration (New task t.b.d).
WPS2
- WPS2 PMP deliverables D1, D6 and D7: *● Study low order resonances in the plasma centre regarding the effect of magnetic well and current drive.* *● Neoclassical optimisation to minimise bootstrap current and improve α-particle confinement. Develop coils able to create such optimised configurations.* *● Modelling of deviation from omnigeneity and its impact on the multiplication of possible optimization strategies to get good Neoclassical particle confinement, including fast particles.*
- Collaboration WPCD / WPS1 / WPS2: fast ion losses synthetic diagnostics integration (new task t.b.d).
H8.2-D05: Stellarator reactor engineering and technology studies, including systems code design optimisation and costing studies, requirements analyses for Breeding Blanket / shield, coil spacing, bend radius, superconductor type and properties; space requirements etc., diagnostic and heating system port and space requirements, RH requirements, remote handling space needs, etc. (2018)
WPCD
- Collaboration WPCD / WPS2: Adaptation of ICRH/ECCD codes for stellarators to Integrated Modelling Framework frame work (new task t.b.d.)
WPS2
- WPS2 PMP deliverables D2, D3, D4 and D11: *● Addition of 3D curvature to coil design codes* *● Simulations of minority heating with relevant strap antenna description at 2.5 T.* *● ECCD and ECRH modelling with transport and passing/trapped electrons* *● Define operational scenarios of ECRH and ECCD in W7-X. Analyse the effect of ECRH on magnetic configuration. The ECRH system in W7-X is the most advanced of its kind and is similar to the one that will be used in ITER.* *● Study of 3D Breeding Blanket development with 3D neutron flux estimates*
- Collaboration WPCD / WPS2: Adaptation of ICRH/ECCD codes for stellarators to Integrated Modelling framework (new task t.b.d)