DEMO Activities in the Broader Approach Programme BA Phase II

Presented by S. Clement

With the contributions of the IFERC Integrated Project Team

Content

- The Broader Approach Agreement (BA)
- Organisation of activities in BA
- DEMO activities in BA Phase I:
  - Organisation
  - DEMO Design Activities (DDA)
  - DEMO R&D (materials for DEMO activities)
- DEMO activities in BA Phase II
  - Objectives for BA Phase II
  - DEMO Design: 8 collaborative tasks
  - DEMO R&D: 4 collaborative tasks
  - Results and Planning
- Conclusions

IFERC

The Broader Approach Agreement

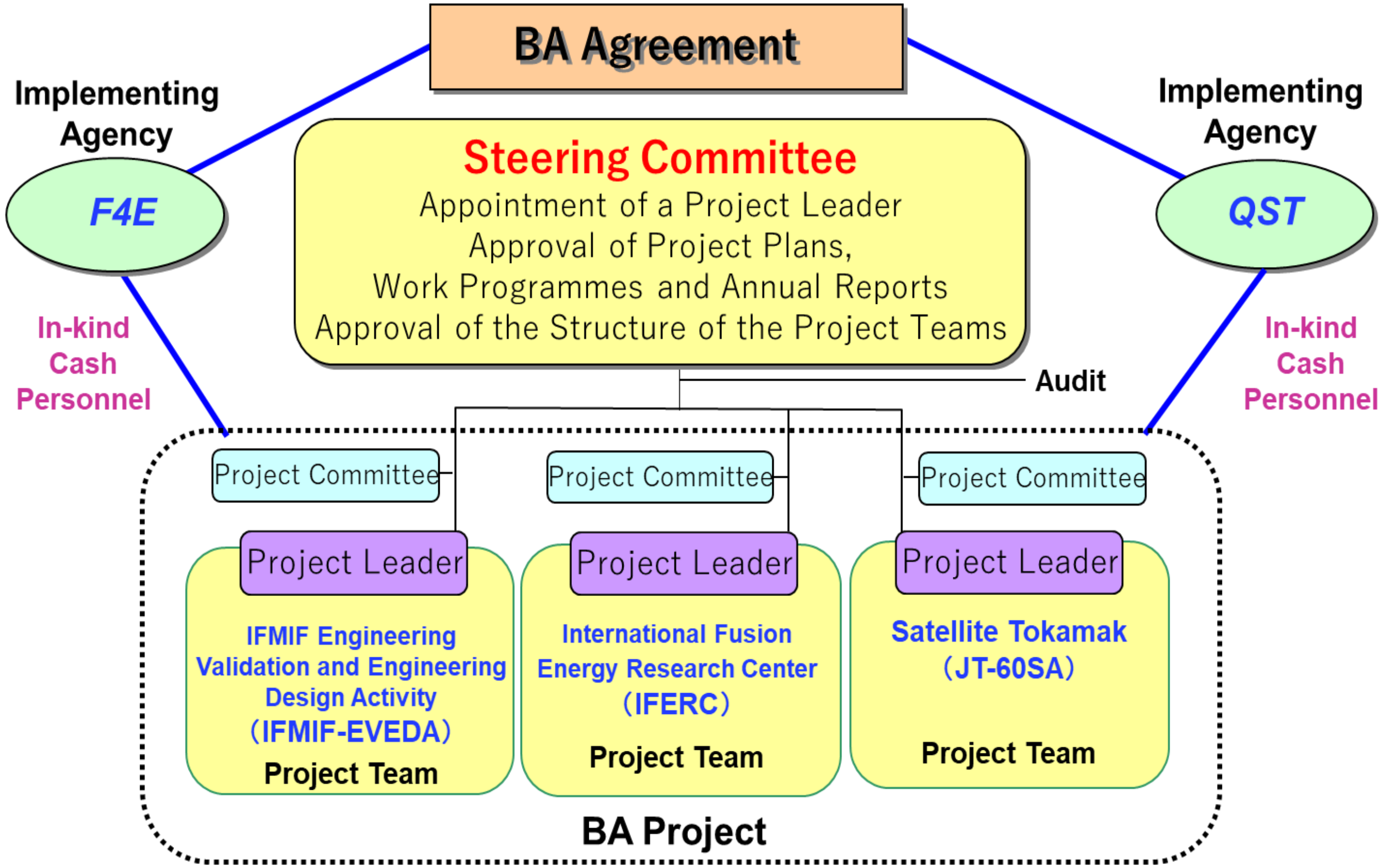
The Broader Approach Agreement started in June 2007, initially for 10 years and then was extended until March 2020 (BA Phase I)

- **Collaboration between EU (Euratom) and Japan implemented by F4E and QST**
- **Three projects: JT60-SA (Naka), IFMIF/EVEDA and IFERC (Rokkasho)**
- **DEMO activities are part of the IFERC Programme**

In March 2020, the BA Agreement was extended, without end date

- In BA phase I, all the resources contributed by both parties were agreed upfront
- In BA phase II, the long term planning of resources is done in the Project Plan by proposing the resources for the next 5 years
- The annual resources are approved by the BA Steering Committee in April of the same year, and ad referendum for the following years

How are the BA activities organized?



Reporting to governance:
- Project Plan for long term planning including resources
- Annual planning of resources is proposed in the Work Programme,
- General reporting: an Annual Report

Organisation and share of activities:
- The "commitment" of resources is done by multi-year Procurement Arrangements (PA) between the two Implementing Agencies
- When a PA is signed, deliverables are defined with a due date
- When the deliverable is formally approved by both IAs and PL in the DMS (Document Management System), the PL allocates the credit associated

Implementation of the activities for IFERC
- Small Project Team in Rokkasho, coordinating the contributions of a larger Integrated Project Team in EU and JA
- IFERC has three sub-projects (Computational Simulation Centre, DEMO activities and Remote Experimentation Centre
- DEMO Design Activities has its own DDA Leader (Aiba-san, recently nominated)

IFERC

FUSION FOR ENERGY

QST

BA Phase I

IFERC

DEMO Activities in BA Phase I

In BA phase I, the DEMO activities were divided in

- DDA (DEMO Design Activities) implemented on the EU side as part of the EFDA/EUROfusion DEMO Design activities, and in Japan by JAEA/QST and collaborating institutions
- DEMO R&D, activities in research in blanket materials, implemented in EU through the voluntary contributions of some countries (France, Italy, Spain, Germany, Switzerland and Belgium), and in Japan by JAEA/QST and collaborating universities

DDA

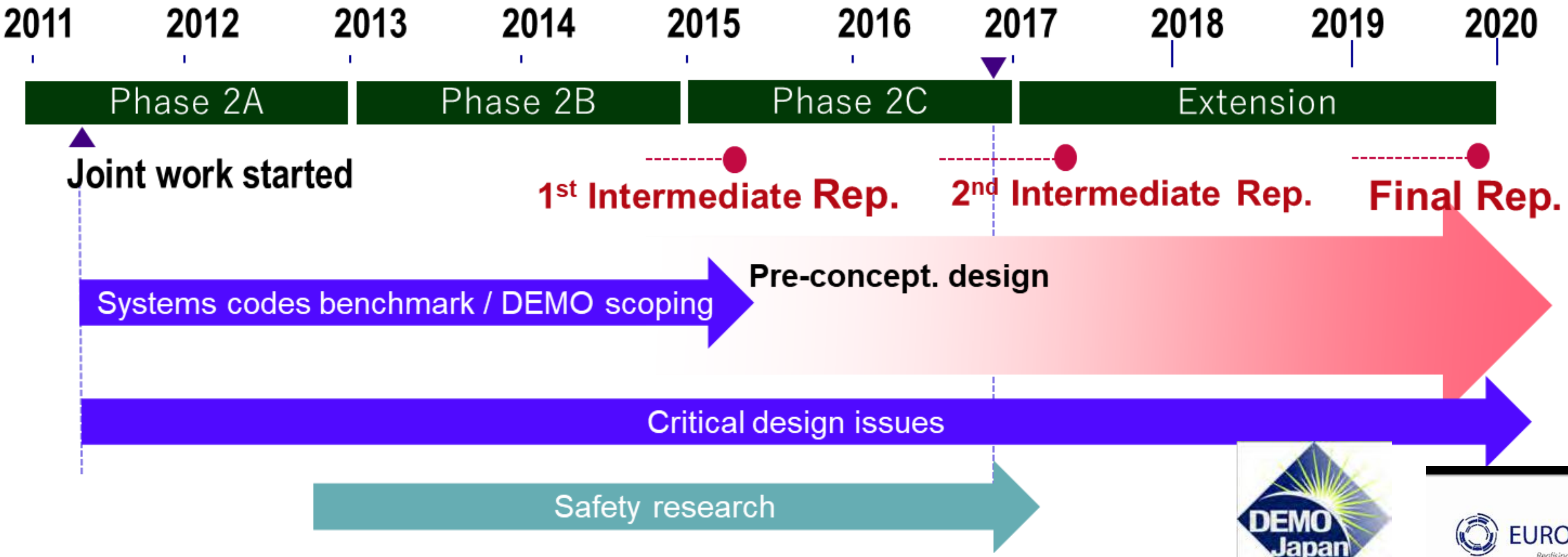
- Main objective of DDA: the development of a pre-conceptual design of a Demonstration Fusion Power Reactor (DEMO), integrating the technology and physics aspects for optimal performance, i.e. availability and efficiency, by addressing the key issues in physics, technology and system engineering
- Taking account of the variability of the DEMO concepts at the onset of the BA Agreement, the DEMO Design Activities were organized in two phases:
  - Phase One: Analyse common elements for DEMO (2007-2010)
  - Phase Two: Develop potential Conceptual DEMO Designs (2011-2020)

DEMO R&D

- Activities in research in blanket materials: functional materials (SiC/SiC, advanced neutron multipliers, advanced tritium breeders), structural materials (RAFM steels: EUROFER97 and F82H), tritium behaviour in materials. These activities started in 2008, together with the construction of a materials laboratory in Rokkasho.

DDA in BA Phase I

- Technical ROs designed on each side for each topic of interest
- Regular topic meetings and DDA management meetings (monthly)
- Twice a year, Technical Coordination Meetings jointly with DEMO R&D
- Two peer reviews (2012 and 2017) by external reviewers to advise on the conduct of the programme




Intermediate Report of BA DEMO Design Activity

Japan Home Team
EU Home Team
DDA Unit of the IFERC Project Team

26 February 2015

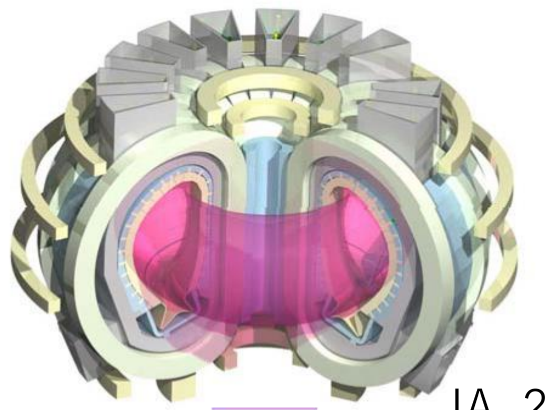
DEMO Japan

EUROfusion
Realising Fusion Electricity

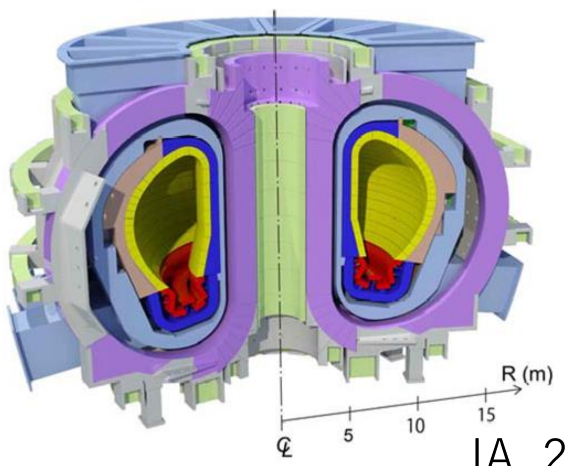
IFERC

DEMO Design Activities Phase I

Convergence of designs



JA, 2014



JA, 2017

Pre-conceptual design

- Initially, each side pursued its own DEMO programme and shared results, but a convergence of designs has evolved
  EU: DEMO1 (pulsed) – R_p = 9.1 m, B_{max} = 12.3 T, κ_{95} = 1.6 and P_{net} ~ 0.5 GW (P_{fus} = 2 GW)
  JA: DEMO-2014 (SS) – R_p = 8.5 m, B_{max} = 12.1 T, κ_{95} = 1.65-1.7 and P_{net} ~ 0.2-0.3 GW (P_{fus} ~ 1.5 GW)

Code benchmarking

Example: benchmarking of divertor codes

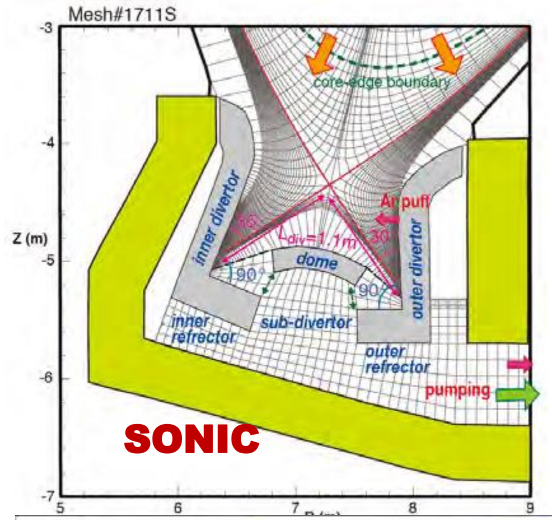
Critical design issues

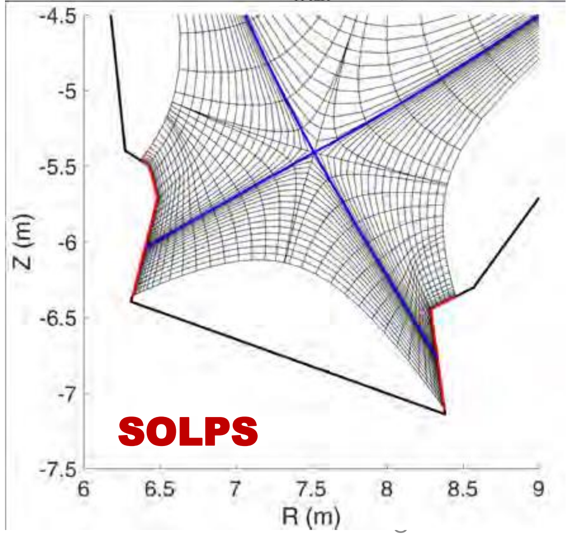
- Large technology gaps between ITER and DEMO identified: divertor heat exhaust, remote maintenance, in-vessel components (blanket and divertor, including **materials**' issues).

Based on results, definition on further areas for joint work:

- (1) Divertor model in system code (PROCESS),
- (2) DEMO physics: ELM mitigation strategy
- (3) SONIC and SOLPS simulations for EU divertor level (Psep~150MW),
- (4) Study on shielding and water activation for Breeding Blanket design,
- (5) SC magnet design,
- (6) BoP: Tritium permeation.

Benchmarking design tools





IFERC

DEMO R&D in BA Phase I

Based on common interests of EU and JA, **5 generic DEMO R&D tasks for the blanket system** were defined at the beginning of the BA:

T1) SiC/SiC Composites

T2) Tritium Technology

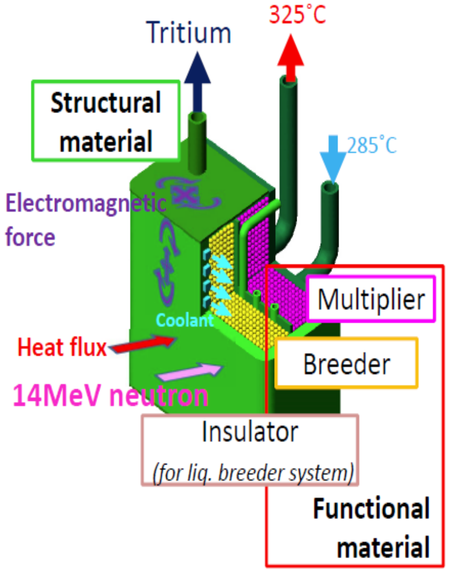
T3) Materials Engineering

T4) Advanced Neutron Multiplier

T5) Advanced Tritium Breeders.

QST

Requirement for the blanket system



- Required function
  - Shield the high energy fusion neutron
  - Breed Tritium (TBR > 1.05)
  - Convert neutron energy into heat
- Expected performance
  - Assure safety and reliability throughout the assumed service period under the assumed operation mode.
  - Reduce radioactive level which is consistent with waste management and recycle strategy.
  - Ensure maintenance and inspection service are feasible.

★ Material development for blanket system is expected to provide sound engineering bases for

✓ *Safety, reliability and realizability of blanket designs*

✓ *waste management, recycle, maintenance and inspection scenarios*

DEMO R&D Results in Phase I

T1: SiCf/SiC composites

- Creation of a fundamental database of mechanical /physical/chemical properties of SiC/SiC composites for their use as functional material in the Dual Coolant Breeding Blanket concept.
- Characterisation of SiC/SiC composites under irradiation and of the interaction of SiC/SiC with liquid metal coolant

T4: Advanced neutron multiplier

- Development of in-house techniques for the fabrication of beryllide pebbles and bars ($Be_{12}V$ in JA, $Be_{12}Ti$ in EU).
- The techniques have been optimised and the pebbles have been extensively characterised.
  - To prevent increase of H_2 generation various beryllides have been surveyed.
  - Hydrogen generation tests
  - Tritium retention tests

T5: Advanced tritium breeder

- EU and JA: in-house techniques to produce lithium based composite pebbles including the reprocessing stage.
- Several materials tested and characterised, including tritium release properties,
- Optimisation of fabrication techniques
- Pebble of super advanced tritium breeder **LTZO20** developed by emulsion method.

T2: Tritium technology

- **In Rokkasho**: licensing of the DEMO R&D Building in 2011, initial storage capacity: **7.4TBq for tritium, 500MBq for P-32 and 916MBq for Fe-59.**
- Tritium analysis methods developed,
- basic studies on tritium behaviour (gas, liquid, and vapour) in materials, such as diffusion, sorption, and corrosion

T2: EU and JA analysis of tritium retention in JET ITER Like Wall (ILW) dust and tiles

- To characterise dust and divertor samples taken from the JET divertor, of high interest for ITER as it provides the only experimental evidence in a tokamak of tritium retention with different first wall materials

T3: Structural Materials

Collaboration on RAFM steels, F82H in Japan and EUROFER97 in EU

- JA: optimisation of the fabrication techniques such as ESR (Electro Slag Remelting)
- EU and JA: optimisation of joining techniques
  - JA characterised HIPped joints (Hot Isotropic Pressure) in function of the thickness of welding: torsion test identified as an effective destructive testing method
  - EU produced and characterised welding samples by electron beam (EB) and Tungsten Inert Gas (TIG) welding
  - A number of samples sent to Rokkasho for further analysis;
- EU and JA: study of neutron irradiation effects, including the development of models and the compilation of a database;
- JA: reactor relevant safety studies, such as studying the response of the blanket structure to a loss of coolant accident (LOCA).
- EU: studies on small specimen techniques, relevant for future testing in IFMIF-like facilities.

DEMO Activities in BA Phase I Summary

Final reports [issue date]	# of papers	Achievements
DEMO Design [Feb. 2020]	557 (EU&JA:EU:JA) (3%:86%:11%)	Pre-conceptual designs including device parameters were developed. Critical design issues were identified and R&D tasks to find feasible solutions were specified.
DEMO R&D: for blanket [Dec. 2017]	291 (EU&JA:EU:JA) = (7%:15%:78%)	Tritium technology: Various techniques were developed by using the world-class unique facility in Rokkasho. Structural materials: F82H in JA and EUROFER97 in EU were characterized and optimized, which leads to MPH. Functional materials: In-house fabrication techniques of advanced neutron multiplier and advanced T-breeders are established, and the characterization was implemented. SiC_f/SiC composites: R&D results in Fundamental database of mechanical/physical/chemical properties.
DEMO R&D: for JET-ILW [Dec. 2019]	13 (all as EU&JA)	Characterization of dust and tile samples of JET-ILW, as an important input for ITER as only experimental instance of Tritium production and retention in a tokamak with similar materials as PFC

BA Phase II

DEMO Activities in BA Phase II

In the negotiations for the extension of the BA Agreement, the objectives for DEMO activities were reviewed in the context of providing general support for future reactor construction:

Objectives:

- to consolidate and further the know-how on analysis/design of fusion reactors (e.g. DEMO) in strong collaboration with JT-60SA and ITER
- to provide support to the IFMIF validation and design projects, both those taking place in the Rokkasho site (LIPAc) and the projected DONES and Advanced Fusion Neutron Source (A-FNS), including making use of the licensed materials laboratory

Following the recommendations of the latest Peer Review of the BA DEMO programme, the specific objectives for the BA DEMO activities were

- to consolidate the knowledge base so far achieved and needed for the design of DEMO;
- to define design requirements, existing standards, design inputs, design rules including the physics basis for DEMO Design;
- to provide input to parallel and future R&D activities needed for DEMO;
- to address more in detail some design and physics issues;
- to develop pre-conceptual design options for DEMO.

DEMO Activities in BA Phase II

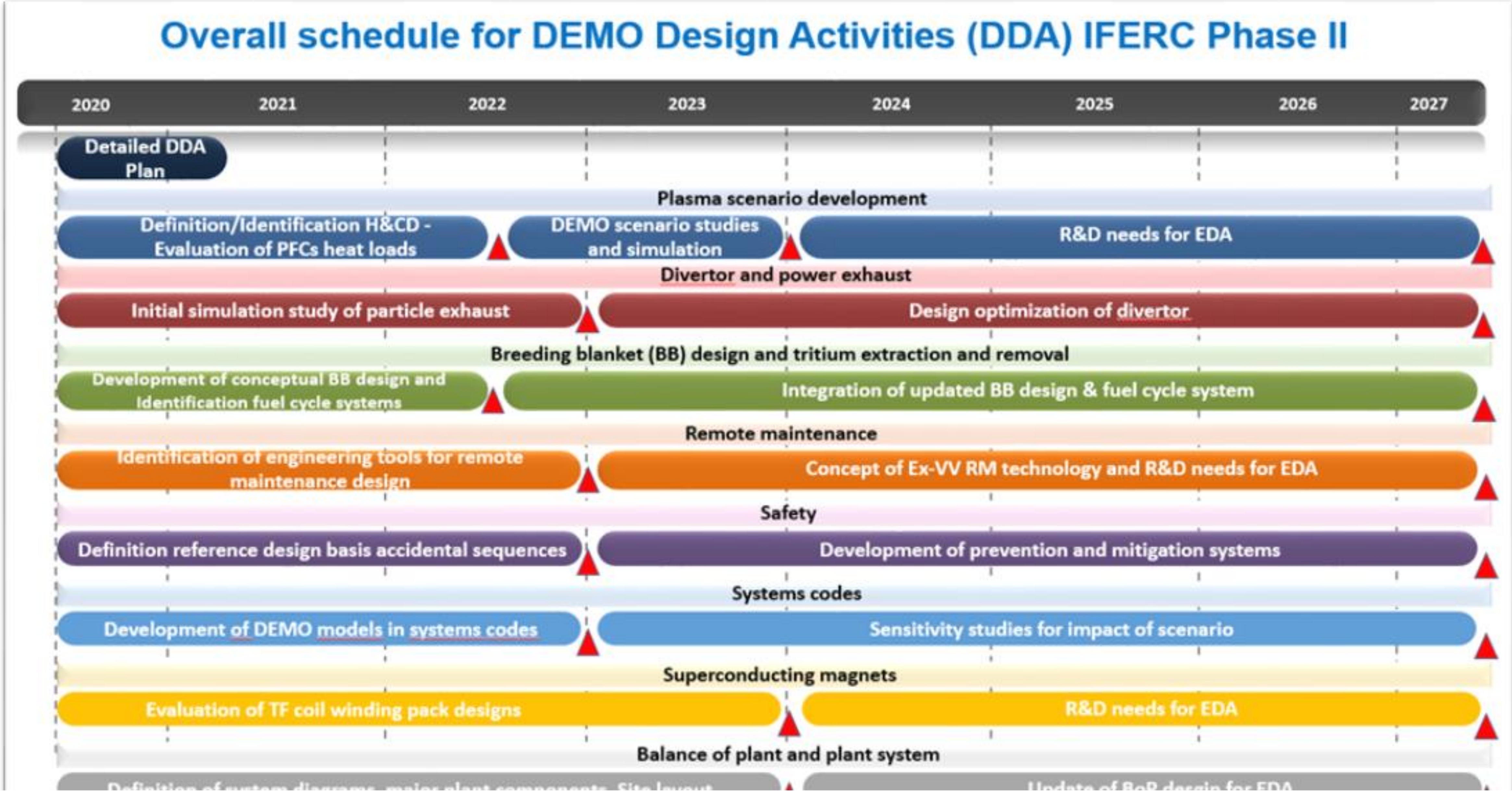
- **DEMO Design**: reorganization of activities according to priorities; collaboration with ITER to be explored
- 5 subjects identified for contributions to BA joint work:
  (1) Plasma scenario development
  (2) Divertor and power exhaust
  (3) Breeding blanket design, and tritium extraction and removal
  (4) Remote maintenance
  (5) Safety

In addition, JA contributes to BA with activities on
  (6) Systems codes
  (7) Superconducting magnets
  (8) Balance of plant (BoP) and plant system

- **DEMO R&D**: 4 main activities dedicated to production of databases, inputs to engineering handbooks, preparation of IFMIF exploitation with materials analysis techniques, and review of lessons learned in the existing fusion projects

IFERC

DEMO Activities in BA Phase II



IFERC

DDA in BA Phase II: Task 1

(1) Plasma scenario development

Scope: Although JA and EU DEMOs consider different plasma operation scenarios, common physics issues have been identified:
(a) the assessment of the ramp-up scenario for highly elongated plasma by means of plasma equilibrium simulators,
(b) the assessment of plasma heat loads on the first wall
(c) the study of plasma scenarios (to be developed) with no/small ELM.

Objectives:

- Task 1.1: identification of heating and current drive (H&CD) requirements for all the relevant discharge phases, namely flat-top, ramp-up and ramp-down, by considering all the functions: current drive, radiative instability control, burn control, MHD instabilities control, access to H-mode. In particular, it is important to assess whether two or more functions (e.g. current drive and MHD instabilities control) can be performed by the same actuator at the same time, or not. Also, an indication on the most adequate technology (EC, NB) for each of the indicated functions shall be provided.
- Task 1.2: Evaluation of PFC heat loads during transients: The objectives are to determine the heat load, the load specification; to characterize the foreseeable (e.g. plasma limiter phase during ramp-up/ramp-down) and unforeseeable plasma transients (e.g. disruptions, mitigated and unmitigated, including TQ/CQ, VDE, H-L transitions) leading to plasma – PFC interaction; and to analyse the loads due to charged particles, radiation, and runaway electrons (RE).

Results

- T1.1: JA: The amount of heating power required for L-H transition in JA DEMO was evaluated with an integrated modeling code suite TOPICS. EU: The optimization of ramp-up trajectories is progressing, employing ASTRA and ASTRA/Simulink
- T1.2: A joint activity has continued for the development of workflow to evaluate the energy deposition due to runaway electron impact during in disruption events. A benchmark test between INDEX (JA) and GO (EU) has been performed by simulating a major disruption scenario in EU DEMO.

DDA in BA Phase II: Task 2

(2) Divertor and Power Exhaust

Main scope: (i) Identification of common modelling issues on detachment simulations of SOLPS-ITER and SONIC codes, in the same divertor geometry of EU DEMO, (ii) Simulation and parameter study of He exhaust in the detached divertor of JA and EU DEMOs, and (iii) Common definition of engineering design criteria, assumptions and material data for EU and JA divertors.

Concerning (i), the milestones defined for 2022 have been:

- Continuation of the comparative work for EU DEMO standard scenarios between SOLPS-ITER and SONIC: SONIC simulations for EU DEMO divertor have been carried out successfully with similar power exhaust parameters as EU SOLPS used.
- Scans of divertor neutral pressure and Argon impurity concentration to assess operational window of EU DEMO.

Concerning (ii), the milestones defined for 2022 have been:

- JA continuing SONIC assessment for the He and particle exhaust in the JA DEMO divertor (edge parameters and dome geometry). Neutral and gas collision model are introduced to investigate influences on the pumping and detachment.
- EU continuing SOLPS-ITER assessment for the divertor liner of the EU DEMO divertor: review of divertor structure and its impact on plasma, e.g. heat loads, erosion pattern, and identification of key design parameters for the divertor shape optimisation.

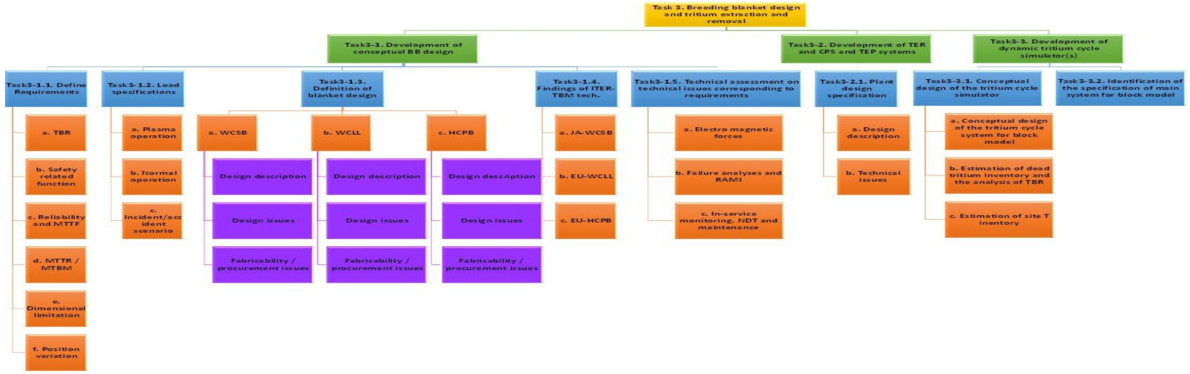
Concerning (iii), the milestones defined for 2022 have been:

- Selection of common material and design database for the divertor (including properties in the operational range wrt the temperature and irradiation conditions, including the dome/liner).

DDA in BA Phase II: Task 3

(3) Breeding blanket design, and tritium extraction and removal

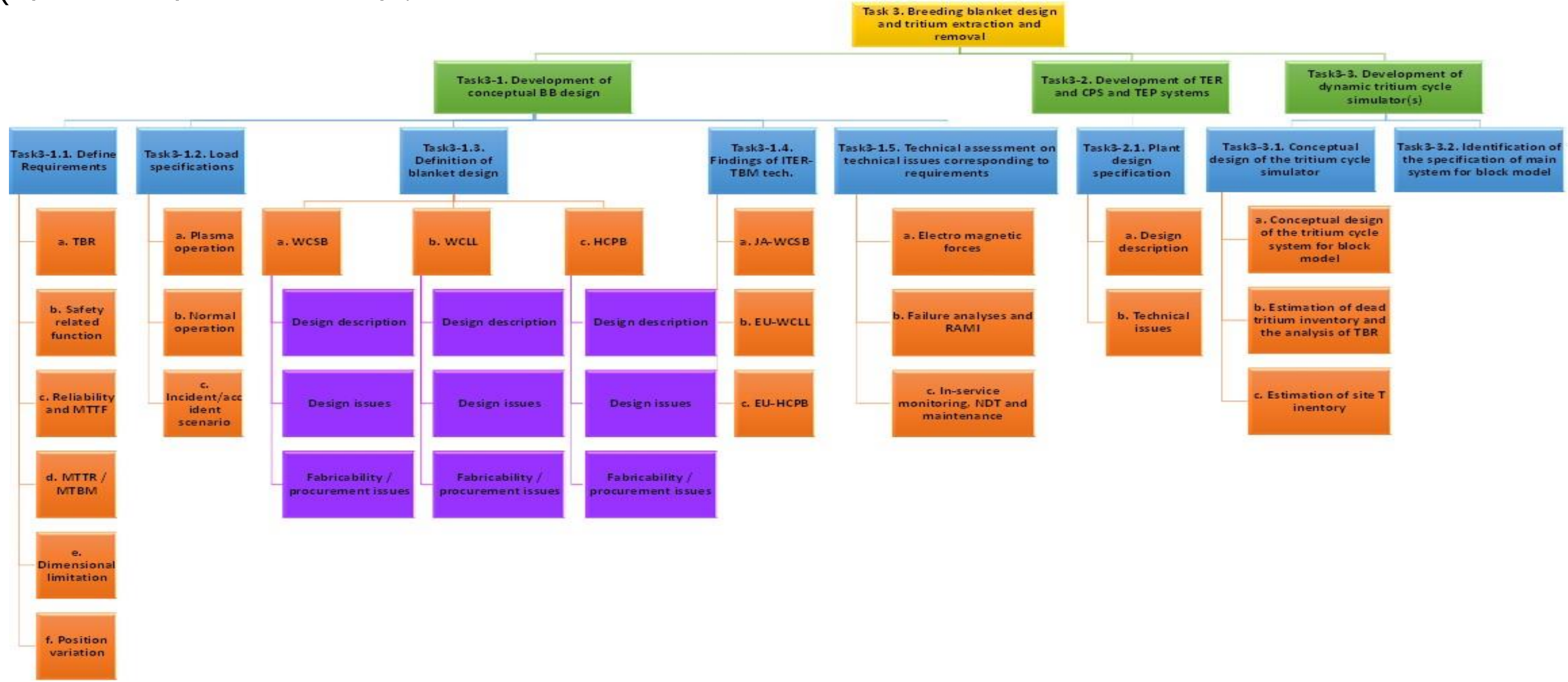
Task 3 of the DDA has been focused on three main activities: (i) the development of the conceptual design of the BB with particular focus on the three variants, namely Water Cooled Lithium Lead (WCLL), Helium Cooled Pebble Bed (HCPB) and Water Cooled Solid Breeder (WCSB), (ii) development of Tritium Extraction and Removal (TER) and Coolant Purification Systems (CPS) and Tokamak Exhaust Processing (TEP) systems and (iii) the development of the fuel cycle system design. At the beginning of 2021, the Work Breakdown Structure (WBS) was agreed upon and finalized between JA and the EU. The WBS is organized into 5 levels (from 0 to level 4) highlighted in different colours (see Figure). At level 1, the three above-mentioned activities are reported. Concerning the development of conceptual BB design, 5 sub-activities have been identified at level 2.



IFERC

DDA in BA Phase II: Task 3

(3) Breeding blanket design, and tritium extraction and removal



DDA in BA Phase II: Task 4

(4) Remote maintenance

The purpose of this task is to produce a review document that highlights and selects emerging technologies that have the potential to solve maintenance strategy challenges for the ex-vessel and active maintenance facilities of EU DEMO and JA DEMO. This will require a review of current ex-vessel and active maintenance facility strategies of both future devices, a capturing of risks and technology gaps followed by an investigation into current industrial or emerging technologies that should be the focus of future concept design research programs to bridge the technology gaps. Engineering tools should also be identified.

In this area, no joint work is defined for the moment. The EU and JA share the results of their domestic activities

JA programme 2021-22:
To identify and study solutions that have the potential to solve maintenance strategy challenges for ex-vessel/in-vessel and active maintenance facilities (AMF), the work in this area in 2021 is broken down into the following tasks;

(i) Studies of design requirements for DEMO AMF: Functions for maintenance cell, transfer cask and AMF, Divertor maintenance for in-vessel and AMF, Interface structure (support, cooling pipe configuration) between back plate and breeding blanket (BB) for maintenance in AMF

(ii) Cooling pipe welding & cutting tools for blanket in VV upper port

EU Programme
Several Remote Maintenance tasks (Study-Sprint) and new activities for the Maintenance Transversal function have been launched within the DEMO Central Team on the EU side during 2021

DDA in BA Phase II: Task 5

(5) Safety
The purpose is to develop DEMO safety concepts relevant to the current DEMO designs for reinforcing substantial environmental and safety advantages of fusion. In order to develop DEMO-relevant prevention and impact mitigation systems, safety studies include i) definition of initial events and accident sequences, ii) assessment of mitigation systems for reference accident sequences, iii) development of waste characterization and management strategy, and iv) assessment of licensing constraints.

The four activity of common JA and EU interest have progressed from EU side as below

i) The identification of the source terms

EU: Further data have been obtained for the tritium inventories in the Fuel Cycle thanks to the progress of the relevant design.

JA: development of a coupled analysis code for nuclear, thermal, and tritium diffusion to evaluate tritium retention for a two-dimensional model of in-furnace equipment .

ii) The completion of the first set of dominant accident sequences or postulated initiating event (PIE): identification and analysis

EU: Further PIE have been identified as results of new FMEA analyses. Further deterministic DBA and BDBA have been performed, as, e.g. the tritium accident analysis inside the tokamak building and a fire accident analysis in the Li-Pb vault.

JA: Benchmarking of safety codes MELCOR and TRAC-PF1, and design study of the pressure suppression pool.

iii) Radioactive waste management

EU: Sensitivity analyses of the impurity reduction on the impact on radioactive waste amount have been performed.

JA: Studies to reduce Intermediate Level Waste, concentrating on C-14

iv) Promote development of standards for Fusion plants

Collection of EU standards for fusion application and review of licensing regulation in Japan.

DDA in BA Phase II: Tasks 6,7,8 (JA contribution, common discussions)

(6) Systems codes:
The main objectives are:
- Improvement of physical model and cross-check with more detail codes
- Extension and revision of costing model in systems code
- Assessment of magnet modelling in systems code
- Wide-range benchmarking about robustness of plasma design, uncertainty, cost estimation etc.

(7) Superconducting magnets
- The purpose of the magnet design is to develop the most feasible Winding Packs concepts based on the shared comparisons and benchmarking of designs on both EU and JA.

(8) Balance of plant (BoP) and plant system
The objective of the balance of plant (BoP) and Plant system activities is to develop the overall plant concept of DEMO considering the following work items:
- Development of power conversion system
- Development of plant electrical system
- Development of cryo-plant system
- Delineation of layout of plant site and tokamak complex
- Assessment of Tritium permeation in the primary cooling system

IFERC

DEMO Design Activities summary

- The first intermediate Check and Review of DEMO programme (similar to G1 Gate Review for EU in 2020) was successfully completed in Japan.
- We are recovering from the problems caused by COVID of lack of interaction and coordination
- TCM to take place possibly in October/November in person
- On that occasion, some ITER experts will be invited to discuss possible areas of common interest under the Cooperation Arrangement between BA and ITER
- Progress meeting in April 2022 place in order to
1. report on progress on design studies if any in Europe and Japan, to review/ change the DEMO design space (i.e., main design parameters).
2. present for each of the areas of collaboration the work to be done in the next 6-month in view of a possible TCM meeting in person in November 2022
- **DDA Tasks: 54 publications, 1 joint paper**
- In addition, a special issue of Fusion Engineering and Design was dedicated to the EU Gate review (25 publications)
- Collaboration with DEMO R&D activities gaining importance: studies in tritium extraction and removal

35th Task Meeting @2021.7.20 - 21

DEMO R&D in BA Phase II

Four tasks were agreed

Task 1 (T1): R&D on Tritium Technology

Task 2 (T2): Development of Structural Material for Fusion DEMO In-Vessel Components:

Task 3 (T3): Neutron irradiation experiments of Breeding Functional Materials (BFMs)

Task 4 (T4): Development of material corrosion database

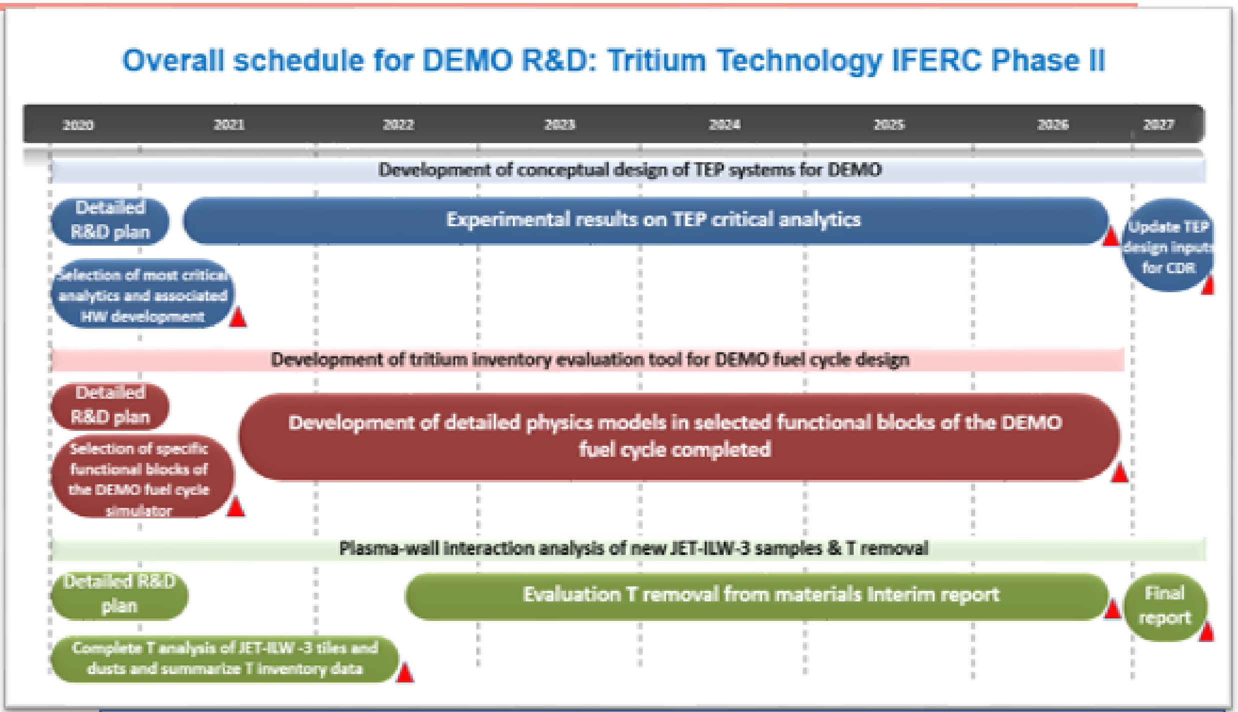
These tasks are executed under 4 Procurement Arrangements covering 4 years (2021-2024) so detailed deliverables are defined for this period. The planning of activities in the Project Plan extends to 2027.

IFERC

DEMO R&D Task 1: Tritium

Background:
For DEMO design, it is extremely important to develop and validate the technology for the tritium continuous processing and accountancy. TEP system shall handle the tokamak exhaust and the flow of tritium extracted from the breeding blanket.

The fruitful collaboration on the analysis of tritium retention in tiles and dust from JET is continuing



Main Objectives

- Complete T analysis of JET-ILW-3 tiles and dusts, and summarize as the T inventory data
- Determine the T balance and the T removal efficiency
- Develop the conceptual design of TEP system
- Develop an analysis system of T flows with negligible memory effect and capability of in–situ continuous measurement
- Select specific functional blocks of the DEMO fuel cycle and develop detailed physics models.

Key activities:

Subtask1-1: Analysis of plasma wall interaction using JET DT samples for evaluation of T inventory and T recovery

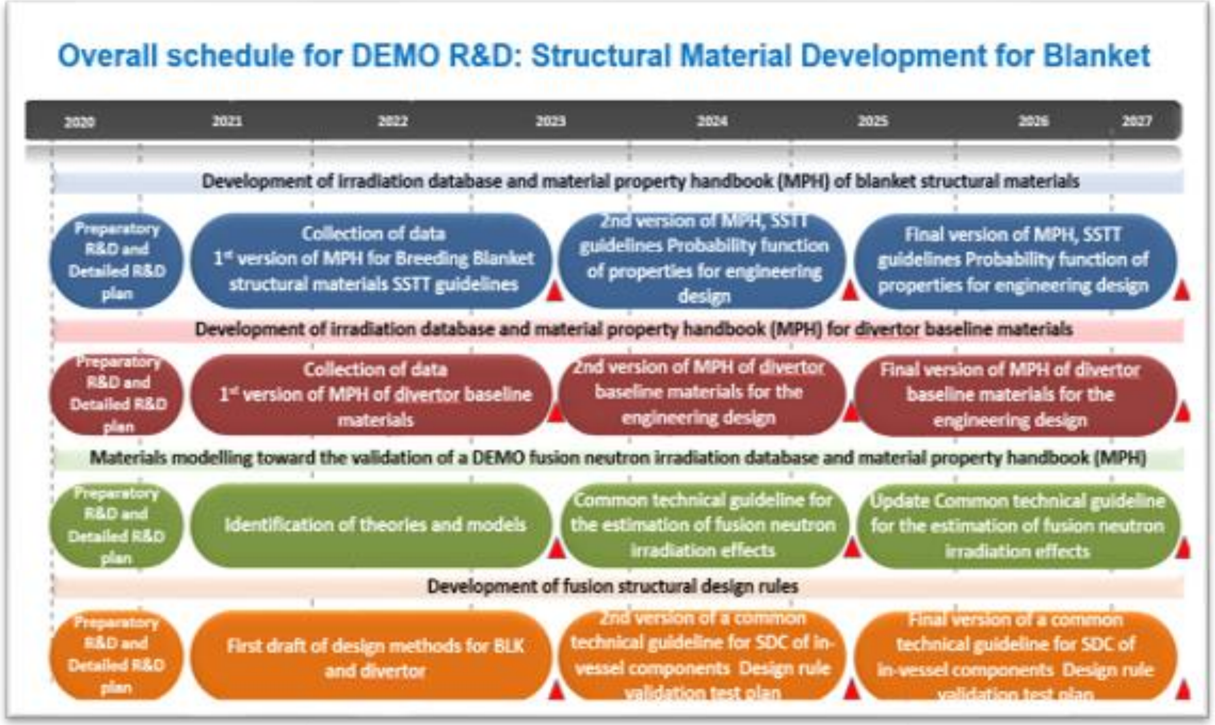
Subtask1-2: Development of conceptual design of TEP systems for DEMO

Subtask1-3: Development of T Inventory evaluation tool for DEMO fuel cycle design

IFERC

DEMO R&D Task 2: Structural materials

Background: The most significant issues for developing structural design code (SDC) for fusion DEMO in-vessel components regard the problem that existing design codes have to be extended to be applicable for highly irradiated structures under fusion neutron spectra. Existing code frameworks are based on long-term experience in fission as well as for different classes of materials. As fusion DEMO SDC for in-vessel components have to be developed (nearly) without any experience and feedback from facilities under similar operating conditions a clear strategy and a strong international collaborative effort are mandatory



Final objectives:

• Development of the technical bases for DEMO Structural Design Criteria for in-vessel components and respective material Annexes for RAFM steels, Cu-alloys and W-based materials.

• Probability-based design methodologies to complement the conventional deterministic design method.

• Irradiation database and respective methodologies to best estimate the fusion neutron irradiation effects including collaborative neutron irradiation in order to qualify and validate the whole set of data, design methodologies, and the structural design rules developed

IFERC

DEMO R&D Task 2: Structural materials

Subtask 2-1 - Development of irradiation database and material property handbook (MPH) of blanket structural materials:

- RAFM MPH (reference material specification, physical & mechanical props., weld & joints, etc.),
- Statistical analyses of RAFM DB by Bayesian approach/MCMC method and bootstrap method, as well as conventional statistical analyses.

Subtask 2-2 - Development of irradiation database and material property handbook for divertor baseline materials: W MPH, Cu-alloy MPH (reference material specification, microstructure, physical & mechanical props., etc.)

Common issues in subtasks 2-1 & 2-2 - SSTT development and neutron irradiation:

- SSTT guideline
- Irradiation experiments

Subtask 2-3 - Materials modelling toward the validation of a DEMO fusion neutron irradiation database and material property handbook:

- Quantitative assessment of generation of irradiation damage
- Correlation of irradiation effects between fusion neutron environment and other irradiation environments (e.g., fission neutron and ion beam)
- Synergistic effect of He and H
- Swelling estimation

• **Subtask 2-4** - Development of fusion structural design rules:

- Analytical methodologies and structural design rules required for in-vessel components
- Experimental based verification strategy of the design rule

IFERC

DEMO R&D Task 3: Neutron irradiation experiments of Breeding Functional Materials (BFMs)

Objective:

- Building on the advanced T breeders and advanced neutron multipliers developed in BA phase I, the main objective in BA Phase II is to perform new neutron irradiation experiments of these breeding functional materials for the establishment of the DEMO design database. This must be done by evaluating initial neutron irradiation behaviour via in-situ tritium release experiments and post-irradiation experiments (hereinafter denoted as PIEs) of irradiated BFMs

The initial irradiation facility was IVV-2M at the INM

Need revision on Work Plans in 2022 - 2023

- Re-identification of irradiation facility

Work Plans in 2022 -> 2024

- The neutron irradiation for PIEs using JA and EU samples
- Samples preparation and shipping

Work Plans in 2023 -> 2025

- The neutron irradiation for PIEs using JA and EU samples
- The neutron irradiation for in-situ tritium release experiment using EU samples
- The neutron irradiation for in-situ tritium release experiment using JA samples
- PIEs preparation

Work Plans in 2024 -> 2026

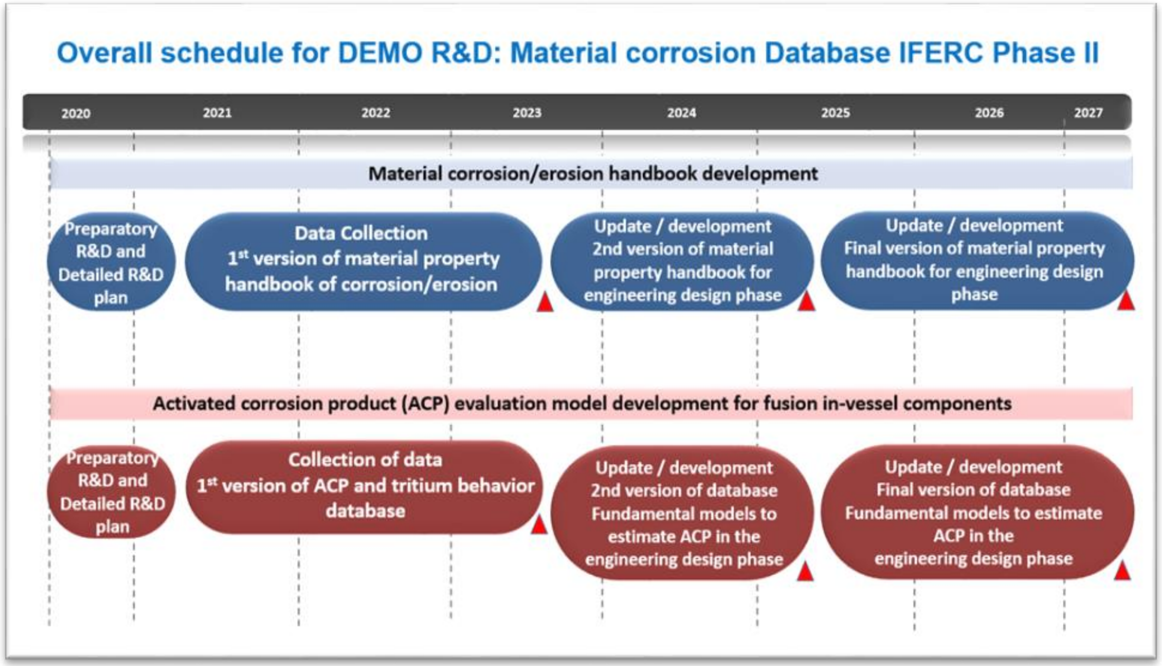
- The neutron irradiation for in-situ tritium release experiment using JA samples
- Execution of PIEs in a KIT hot cell

IFERC

DEMO R&D Task 4: material corrosion database

Background:

- In Japan:
  - The water-cooling ceramic breeding (WCCB) blanket system is the primary option of the Japanese DEMO; liquid metal system (Pb-Li) is regarded as one of the promising options to demonstrate more enhanced features and to expand attractiveness for commercialization
- In EU:
  - High temperature and high-pressure water is a candidate as a coolant in blanket and divertor; PbLi is the breeder of the European Water Cooled Lithium-Lead Breeding Blanket (WCLL BB)



Final objectives:

- Development of the core technologies about the water and the liquid metal Pb-Li systems and understanding compatibility of DEMO materials with high temperature and high-pressure water and/or liquid Pb-Li metal.
- Understanding the synergetic effects of the DEMO relevant environments
- Characterization of corrosion products and their behavior in cooling circuits for safety assessment.

Subtask 4-1 - Material corrosion/erosion handbook development

✓ Effect of fusion DEMO relevant environments (magnetic field and irradiation) on corrosion behavior
✓ Effect of flow regime on corrosion behavior
✓ Effect of chemistry on corrosion behavior
✓ Assessment of post corrosion property

- **Subtask 4-2** - Activated corrosion product (ACP) evaluation model development for fusion in-vessel components

DEMO R&D summary

In 2021, good progress in the implementation of 4 new joint PAs (2021 to 2024)

Task 1 (T1): R&D on Tritium Technology: **4 papers of which 3 joint JA EU**
Task 2 (T2): Dev. of Structural Material for Fusion DEMO In-Vessel Components: **26 papers, 1 joint**
Task 3 (T3): Neutron irradiation experiments of Breeding Functional Materials (BFMs) **7 papers, 1 joint**
Task 4 (T4): Development of material corrosion database **4 papers**

For each task, final objectives, key activities and key deliverables have been defined

- steady progress in the four main tasks:
- the preparation of hardware, experimental procedures, transportation of samples to be irradiated is underway, as well as modelling activities
- the population of engineering databases had started.

Issues: The recent international situation has caused a delay in the activities in Task 3

Conclusions

- The Broader Approach Agreement provides a framework for sharing the DEMO activities in EU and Japan in an organized way, finding synergies and helping to make a better usage of resources.
- BA promotes the joint production of engineering handbooks, reliable material databases, design rules, with a strong emphasis in safety and licensing
- In BA phase II, IFERC is mandated to support the existing fusion construction projects (ITER, JT60-SA), the IFMIF/EVEDA programme in Rokkasho as well as the future DONES and A-FNS devices

Acknowledgments

Many thanks to all members of the DDA and DEMO R&D integrated project team, and in particular to

- the DDA Technical Coordinators
 G. Federici and Y. Sakamoto
- the DEMO R&D Technical Coordinators
H. Tanigawa, A. Spagnuolo and G. Aiello
- All the TROs

IFERC

FUSION FOR ENERGY

QST

THANK YOU FOR YOUR ATTENTION !

http://www.iferc.org