WPAC Status Report

Physics Project Board |October 27-28th , 2025

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Thanks to contributions by the E-TASC SB

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Organisation of activities

WP AC: Advanced Computing

Infrastructure

- HPC: High Performance Computer
  - HW: Hardware
    - ENEA (2023)
    - ENEA (2024 - 2029)
- LTDSF: Long-Term Data Storage Facility
  - HW: Hardware
    - IPPLM

Support

- ACH: Advanced Computing Hubs
  - 01: High Performance Computing
    - CIEMAT
    - EPFL
    - MPG
  - 02: Integrated Modelling and Control
    - IPPLM
  - 03: Data management
    - VTT
- DATA: Data maintenance and management activities
  - JDC: JET Data Center
    - UKAEA
  - DMP: Data Management Plan
    - CEA
    - EPFL
    - IPPLM
    - MPG
    - VR

Software development

- TSVV: Theory, Simulation, Validation and Verification
  - 01: Physics of the L-H Transition and Pedestals
    - MPG
  - 02: Physics Properties of Strongly Shaped Configurations
    - EPFL
  - 03: Plasma Particle/Heat Exhaust: Fluid/Gyrofluid Edge Codes
    - CEA
  - 04: Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes
    - MPG
  - 05: Neutral Gas Dynamics in the Edge
    - FZJ
  - 06: Impurity Sources, Transport, and Screening
    - CEA
  - 07: Plasma-Wall Interaction in DEMO
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  - 08: Integrated Modelling of MHD Events
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  - 09: Dynamics of Runaway Electrons in Tokamak Disruptions and Start-Up
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  - 10: Physics of Burning Plasmas
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  - 11: Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks
    - MPG
  - 12: Stellarator Optimization
    - MPG
  - 13: Stellarator Turbulence Simulation
    - CIEMAT
  - 14: Multi-Fidelity Systems Code for DEMO
    - UKAEA
  - 15: Pulse Design Tool
    - CEA
- DTE: Digital Twin Enviroment
  - DT: PoC projects
    - CEA
    - CIEMAT
    - ENEA-01
    - ENEA-02
    - EPFL
    - DIFFER
    - UKAEA

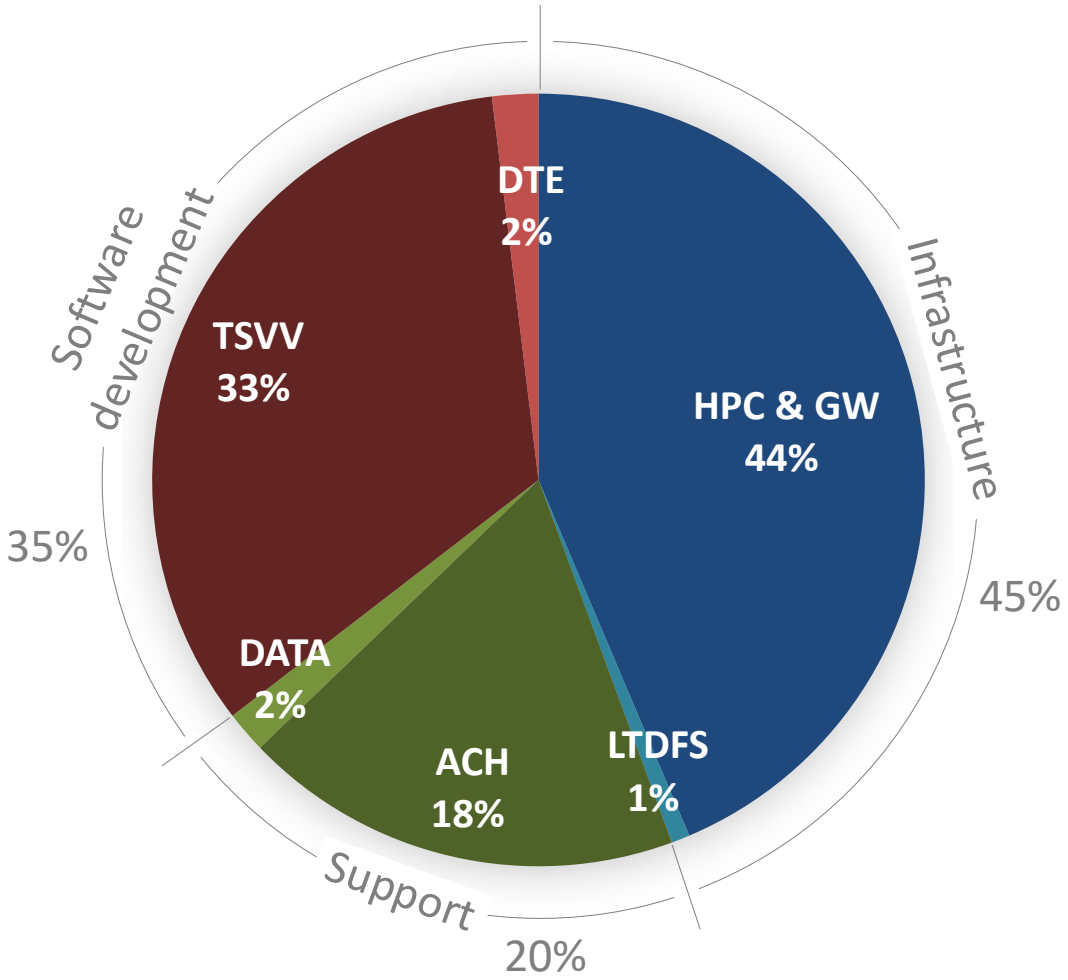
Specifics of the WP:

Majority of activities
are pre-approved by the GA

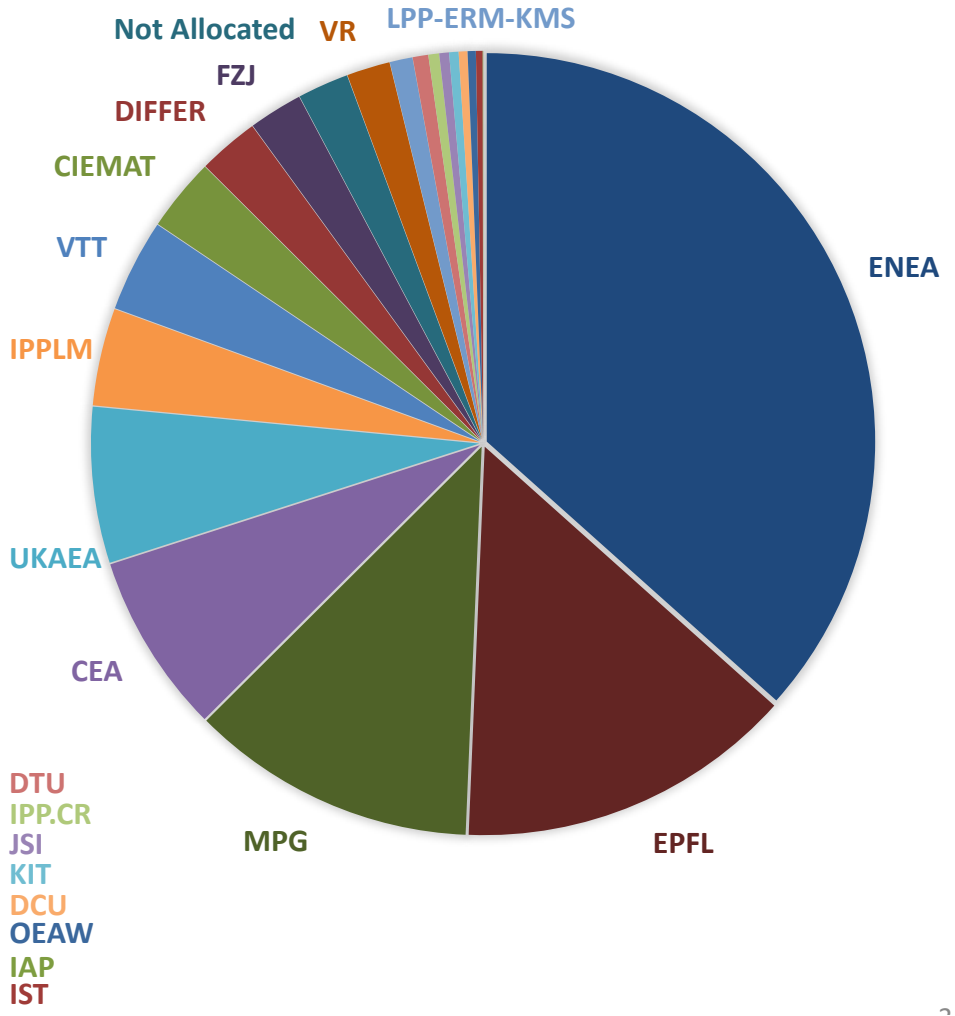
Monitoring of activities
is by the E-TASC SB and the PMU

WPAC resources distribution 2025

Shares of activities based on Consortium Contribution



Contributions by beneficiaries based on Total Resources



Infrastructure

HPC resources

LEONARDO

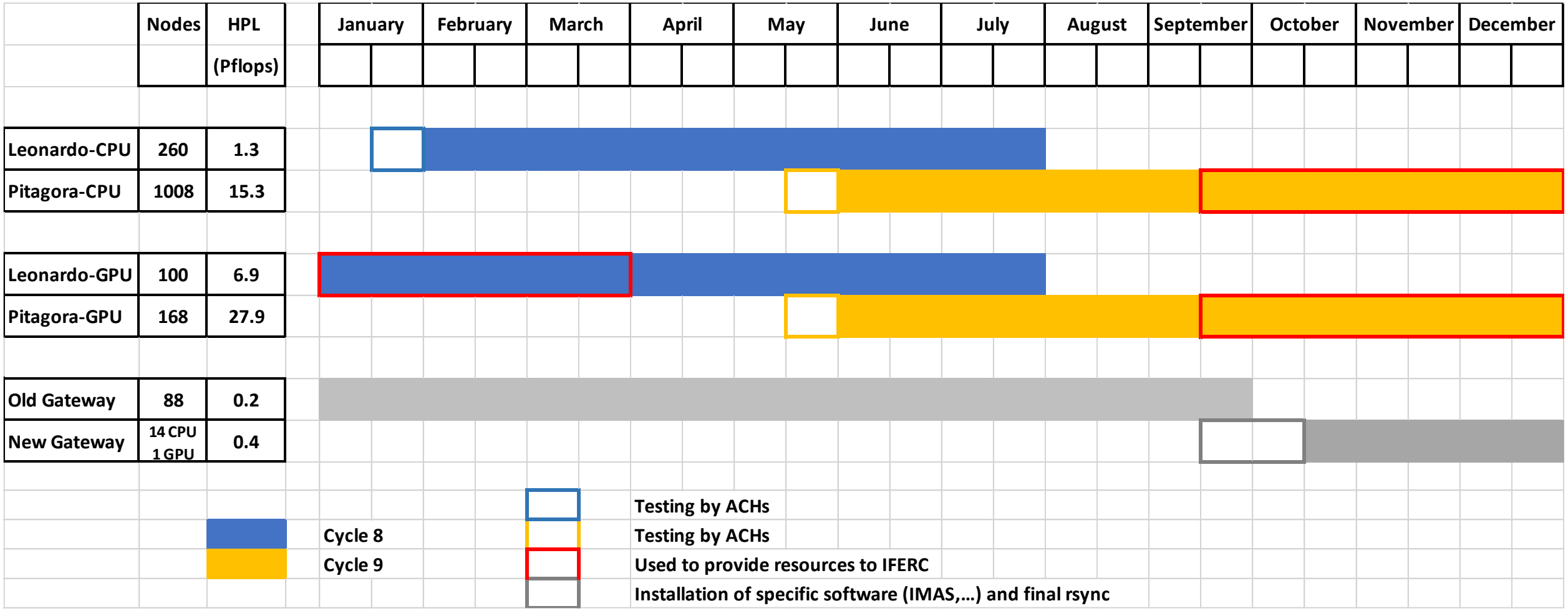
- End of availability to EUROfusion users on July 31 – as agreed during the last PC meeting
- End of cycle 8 at this date
- Very good availability until the end of the cycle
- Data produced will be kept at least for 3 months / more if requested

PITAGORA

- Open to cycle 9 projects
- Full production environment in place since August 13 (Slurm and accounting)
- First reporting to Operations Committee
- Inauguration ceremony scheduled to November 3 with the participation of 2 Italian Ministers
- A number of critical issues remain to be solved – for some of them (not all) work-around provided and documented but this should be considered as a temporary solution
- Call for proposals for the use of the EUROfusion High Performance Computer (10th cycle)

Use of HPC resources

	Nodes	HPL (Pflops)
Leonardo-CPU	260	1.3
Pitagora-CPU	1008	15.3
Leonardo-GPU	100	6.9
Pitagora-GPU	168	27.9
Old Gateway	88	0.2
New Gateway	14 CPU 1 GPU	0.4



Main KPIs (final deliverable is accepted by HPC PC#33)

LEONARDO-DCGP (A5)	Feb. 2025	March 2025	April 2025	May 2025	June 2025	July 2025
Availability	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
SLA	*none*	*none*	*none*	*none*	*none*	*none*
Usage	84.8%	91.9%	81.1%	85.1%	83.7%	85.0%
SLA	*85.0%*	*85.0%*	*85.0%*	*85.0%*	*85.0%*	*85.0%*

LEONARDO Booster (C2)	Feb. 2025	March 2025	April 2025	May 2025	June 2025	July 2025
Availability	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
SLA	*97.0%*	*97.0%*	*97.0%*	*97.0%*	*97.0%*	*97.0%*
Usage	91.2%	81.7%	86.5%	85.1%	77.2%	79.1%
SLA	*none*	*none*	*none*	*none*	*none*	*none*

	Feb. 2025	March 2025	April 2025	May 2025	June 2025	July 2025
Major incidents	2	0	0	0	0	0

	Feb. 2025	March 2025	April 2025	May 2025	June 2025	July 2025
Maintenance A3						
Maintenance A5	0.0	61.5	251.5	13.0	0.0	31.0
Maintenance C2	0.0	61.5	251.5	13.0	0.0	34.0
Remaining time A3						
Remaining time A5	168.0	114.5	-129.0	-134.0	-134.0	-157.0
Remaining time C2	168.0	114.5	-129.0	-134.0	-134.0	-160.0

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Availability

- Very good availability of the C2 partition (Leonardo-GPU) and of the A5 partition (Leonardo-CPU)
- Time allowed for maintenance exceeded for both Leonardo partitions

Usage

- Very good for both partitions

Incidents

- Few incidents – no impact on EUROfusion resources due to the way the nodes are allocated

Collaboration with Japan (BA-Phase 2)

- The PA covering the period of time FY2020 to FY2024 is completed – under this PA, QST made available to IFERC half of the JFRS-1 machine (1.4 Pflops HPL) for EU, JA and joint Project
  - 58% of the resources made available were used by EU projects and EU part of joints project (50%)
  - Equivalent to 300 nodes on average

- A new PA covering the period of time FY2025 to FY2026 is starting with the provision of computing resources (more GPU resources, less conventional resources) and reduced activities
  - This activity will likely end at the end of FY2026 (March 2027)
  - New cycle starting mid-September 2025 until end of March 2026: 10 EU projects, 1 JA projects, 5 Joint projects

		PA IFERC2-CSCPA01-JA.EU Sept. 2020-March 2025		PA IFERC2-CSCPA01-JA.EU Sept. 2025-March 2027	
		#Nodes	**Pflops-HPL**	**#Nodes**	**Pflops-HPL**
EU	CPU	0	0.00	15	0.23
EU	GPU	10 (*)	0.22	5	0.20
JA	CPU	682	1.40	15	0.83
JA	GPU	0	0.00	5	0.88
Total	**CPU**		**1.40**		**1.06**
Total	**GPU**		**0.22**		**1.08**

(*) Marconi100 nodes or equivalent

Gateway and LTDSF

- **New Gateway**
  - Open to users on **Oct 14th**

    https://docs.hpc.cineca.it/specific_users/gateway.html
  - Webinar (introduction to the new Gateway) to be organized in October

EUROFUSION GATEWAY: NEW GATEWAY start of production

Dear Gateway Users,

the NEW GATEWAY is now open to production. Tomorrow morning you will receive an email with subject

"EFGW Single Sign On: mandatory actions required on your account"

with the link to CINECA Keycloak site by which you can:

- verify your email address
- set up your password
- configure the Two Factor Authentication (2FA) access and your personal One Time Password (OTP) device

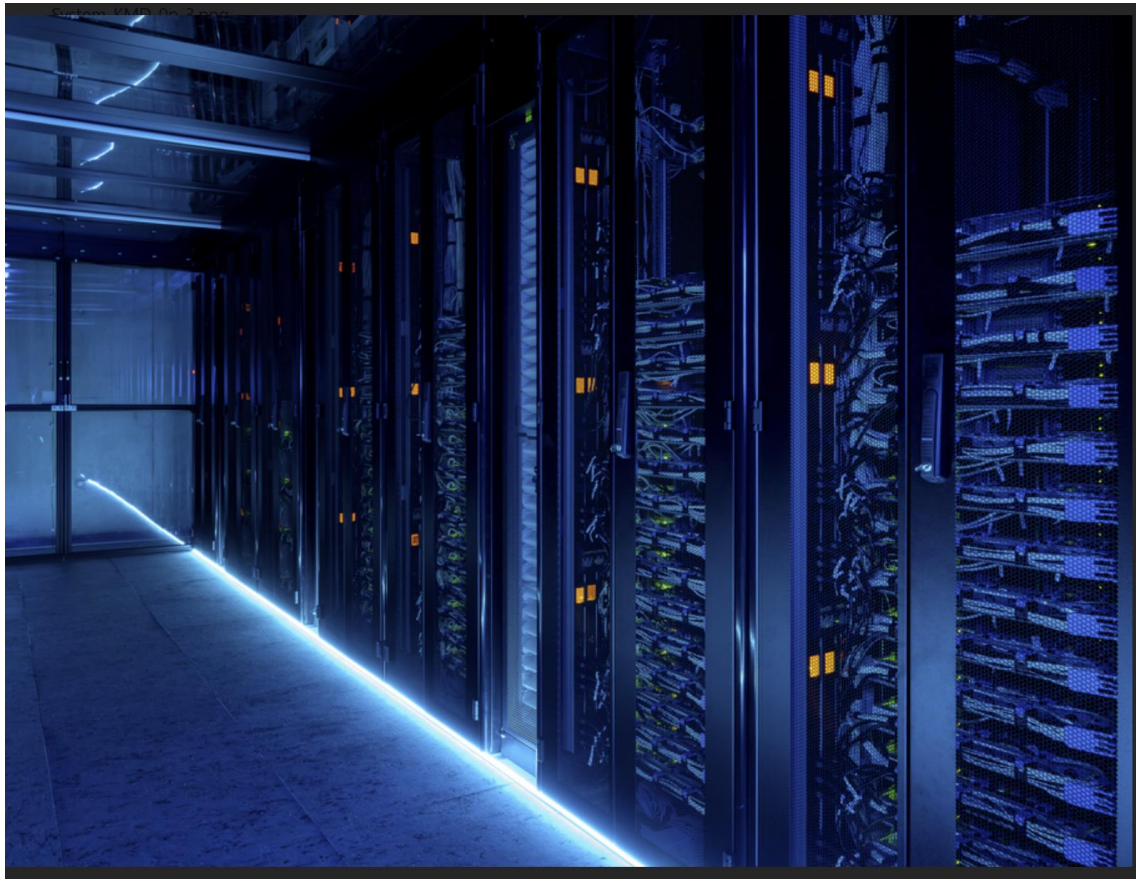
The link expires in 12 hours. If you can't register within this period, once expired please request a new link to superc@cineca.it specifying "EFGW" in the Subject.
The 2FA is mandatory to access the NEW GATEWAY, please refer to the EFGW Gateway documentation.
We remind you that the userid (username) in the NEW GATEWAY is the same of OLD GATEWAY.

- **Long-Term Data Storage Facility (LTDSF)**
  - Storage at PSNC (8 PB disks+8 PB tapes) expected to be made available to users soon
  - Fast (SSD) buffer at CINECA will be install in two phases (0.3 PB / 1 PB)
  - Webinar (introduction to the LTDSF) to be organized in October

- **Integrated LTDSF (Poznań, PL) with the HPC Pitagora system (Bolonia, IT)**
  - **Fast data transfer via fibre optic networks**

- **Phase I** – Long Term Storage – available in Poznan Supercomputing and Networking Center PCSS (Poznań, PL) – August 2025

- **Phase II – Additional data cache (data buffer) in Bolonia between LTDSF in Poznan and HPC Pitagora in Bolonia– October 2025 (installed) – fully operational**



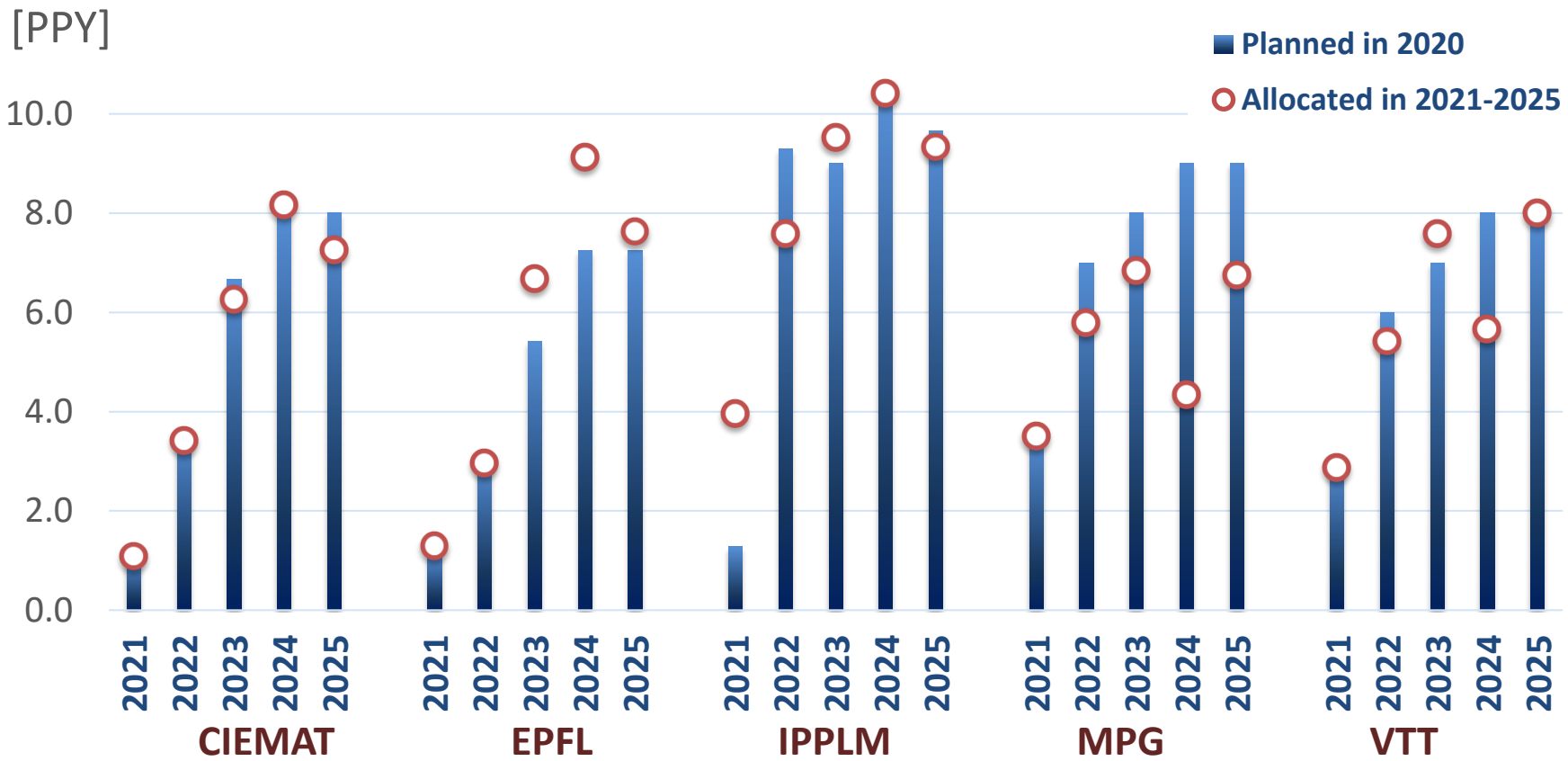
Fast data caches at PCSS

- **Phase III – will increase the capacity of data buffer (Jan 2026), to be used for storing data from many other locations**

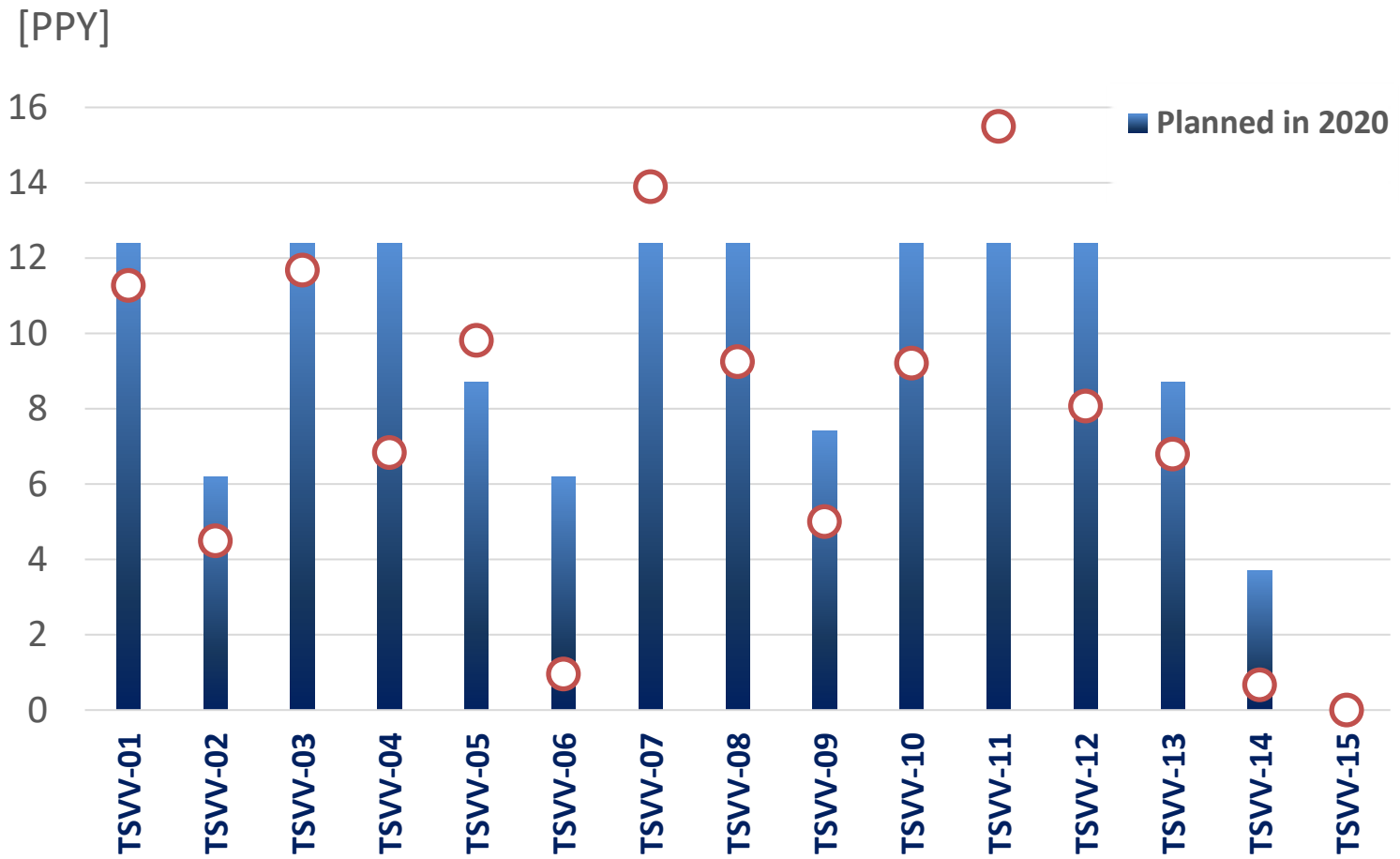
Support

Advanced Computing Hubs

The ACH is considered one of the **most important improvements to EUROfusion software development programme introduced in the current framework**. It has significantly accelerated progress and is highly appreciated and valued by code developers.



Utilization of ACH resources in EUROfusion programme



TSVVs

- All TSVVs are provided with the adequate level of support

Other WPs

- Received overall support
  > 25 PPYs

HPC&GW

- Support level increases annually
  5 PPYs

Transition to 2026-2027

Overall reduction of funds by ~30% compared to 2021-2025 level.

Call for Advanced Computing Hubs 2026-27, issued **9 May 2025** (Ref: GF/DK-25-43); deadline **20 June 2025**

Evaluation by **E-TASC Scientific Board**, appointed per GA24 (Apr 2019) concluded (*EUROfusion GA (25) 52 - 5.5*):

- All proposals were evaluated positively
- **4 ACHs** recommended for 2026–2027 aiming at broad competence coverage within available resources, Cat1 (HPC): **CIEMAT**, **EPFL**, **MPG**, and Cat2 (MFSW): **IPPLM**
- **VTT (AI/ML focus):** not funded as standalone due to budget limits, but competences to be integrated under **ACH-MPG**

Call for tasks to be carried by Advanced Computing Hubs in 2026 (Ref: GF/DK-25-98); deadline **21 November 2025**

E-TASC SB (Approval ACH AWP26): 4-5 December 2025

Category 1: High-Performance Computing (HPC)	Category 2: Modelling Frameworks and Standardized Workflows (MFSW)
Tasks under the category include:	
• Enabling effective GPU usage of a selected set of codes on EUROfusion's HPC platforms with expanded GPU partitions • Selecting and implementing scalable algorithms • Assisting with code parallelization and performance optimization • Optimizing communication patterns and memory usage • Supporting code refactoring efforts • Providing targeted support and training for code developers • Promoting best practices in software engineering and efficient HPC resource utilization • Providing support for the development of AI/ML surrogates for physics models • Supporting large-scale model training and inference on EUROfusion infrastructure • Supporting the development and application of advanced visualization tools	• Supporting the development and maintenance of the Integrated Modelling and Analysis Suite (IMAS) framework to ensure extensibility, maintainability, and usability • Offering technical support to code developers in adapting their codes to the IMAS data model to enable integration and validation • Assisting with code integration and workflow optimization • Contributing to the development of a unified, scalable, and interoperable modelling ecosystem aligned with EUROfusion's long-term objectives • Advancing database infrastructure and evaluating/implementing software solutions for data storage, management, and analysis, as well as authenticated/authorized access control

Data Management Plan (DMP)

Goal is to provide FAIR based data for EUROfusion (related to Grant deliverable). Charge for 2025 is to

- **Provide a searchable catalogue/**database of metadata (waveforms) from the participating sites. (Scenario A)
- **Demonstrate direct data access** of a subset of experimental data for user applications to run on. (Prototyping Scenario B).
- **Investigate** (and pending available resources) develop the technology to integrate

  modelling/simulation data as a ”facility” of its own

Activity is divided into Core services (PSNC) providing infrastructure and Sites (AUG, COMPASS/-U, JET, MAST/-U, TCV and WEST) providing data mappings and remote data access.

With the long-term data storage facility (LTDSF) and the ability to mint PID’s we have the tools to support the longer-term vision towards a one stop facility for researching, accessing, processing, analysing, and sharing experimental and modelling data.

Data Management Plan (DMP)

Infrastructure is in place!

- A UDA (UKAEA) based client/server installation is available and tested on all sites.
- Data ingestion and curation procedures and protocols have been tested for Scenario A data (metadata services) for all devices
- UDA has been updated and is being tested with new security enhancements to allow for Authentication and Authorisation (needed for Scenario B data releases)
- Performance issues with large data volumes has been resolved
- Future work is related to adaptation to user needs and further performance improvements.

Metadata - Waveforms, etc (Scenario A) is ready for production services

- Ready for production services: Will be launched on the new gateway (faster access to HW is being explored).
- EUROfusion users will initial have access to: AUG: (11,500 discharges), WEST (~1,200) , TCV: ("full catalogue"), JET (TBD: on request mapping tool), MAST-/U &Compass/-U (pending release agreement)
    - Some embargos and data restrictions may apply

Direct data access has been demonstrated for a number of use cases (scenario B):

- Remote access tools are available using UDA/IMAS
- A set of user needs representing different TSVVs needs have been defined and tested.
- Relevant data mappings are being developed and have been demonstrated for select devices.

Initial testing of integration with modelling/simulation data has started.

- Strategy is to use SimDB and integrate with UDA/IMAS access
- Allow users to log/share simulation results through the catalogue
- The availability of the long term data storage facility (LTDSF) is of key importance to this

Software development

Included Activities

Theory, Simulation, Verification and Validation (TSVV) - 2021-2025 are aimed to advance our understanding and predictive capabilities. They will underpin **the production of a high-quality suite of "EUROfusion-standard" software** (building on the research software) to model data from EUROfusion facilities and to reliably extrapolate to future devices.

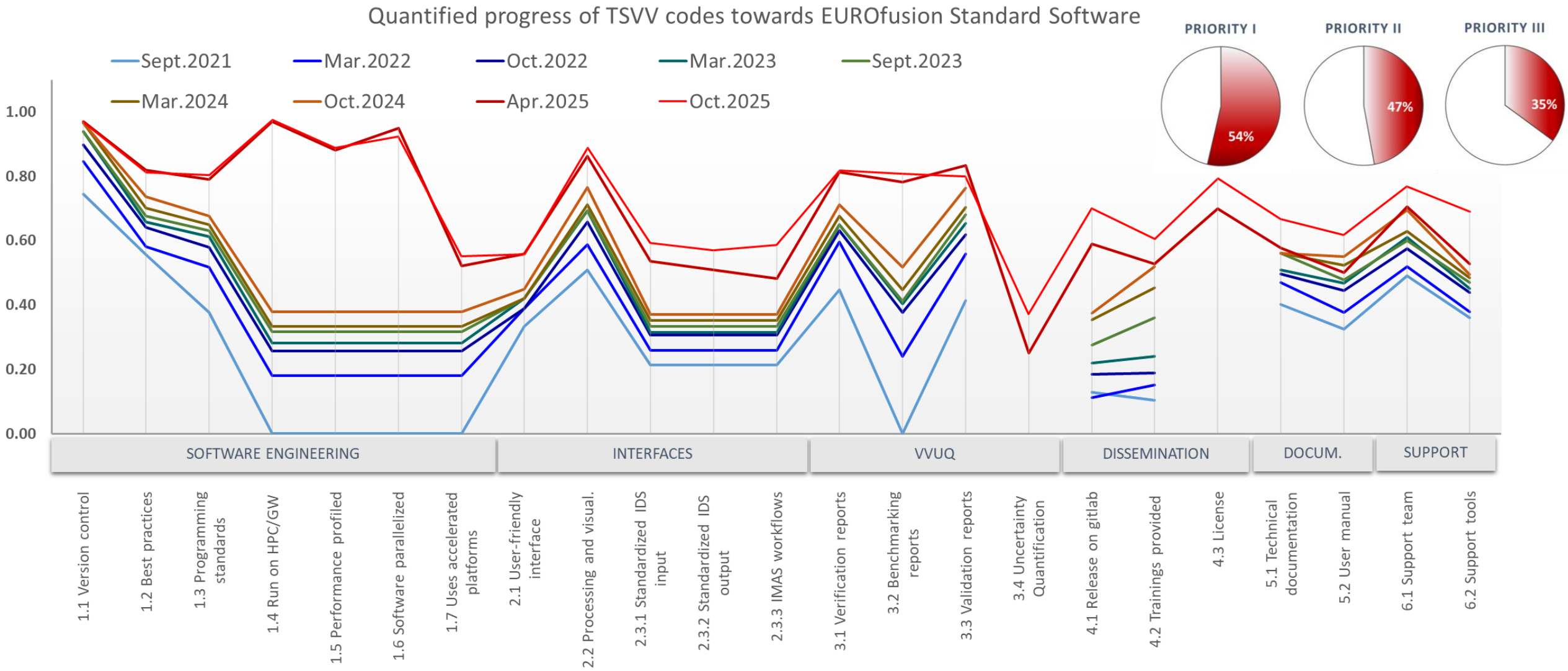
TSVV #	Title
TSVV 01	Physics of the L-H Transition and Pedestals
TSVV 02	Physics Properties of Strongly Shaped Configurations
TSVV 03	Plasma Particle/Heat Exhaust: Fluid/Gyrofluid Edge Codes
TSVV 04	Plasma Particle/Heat Exhaust: Gyrokinetic/Kinetic Edge Codes
TSVV 05	Neutral Gas Dynamics in the Edge
TSVV 06	Impurity Sources, Transport, and Screening
TSVV 07	Plasma-Wall Interaction in DEMO
TSVV 08	Integrated Modelling of Transient MHD Events
TSVV 09	Dynamics of Runaway Electrons in Tokamak Disruptions
TSVV 10	Physics of Burning Plasmas
TSVV 11	Validated Frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks
TSVV 12	Stellarator Optimization
TSVV 13	Stellarator Turbulence Simulation
TSVV 14	Multi-Fidelity Systems Code for DEMO
TSVV 15	Pulse Design Tool

DTE Proof of Concept (PoC) - 2025 (9 months)

The aim is to address identified **gaps and opportunities** through targeted projects. **These projects shall link data from science and engineering** to build integrated solutions that meet current needs and advance future capabilities.

Reference	Title
CEA-02	Integrated Multi-Physics Analysis and Coupled Tools for fusion
CIEMAT-02	Digital Twin Proof of Concept for the Breeding Blanket System
ENEA-01	Digital Twin platform for integrated design of tokamak components – pilot project on EU-DEMO divertor
ENEA-02	Integrated Digital Twin Framework for Disruption Analysis, Tokamak Structural and Activation Product Transport
EPFL-01	Prototyping and assessment of a highly flexible infinitely scalable digital twin of fusion power plants using existing and commercial technologies
DIFFER-02	Divertor digital twin for materials lifetime optimisation
UKAEA	MOOSE platform

TSVV progress towards EUROfusion Standard Software



The quality assurance framework for EUROfusion Standard Software (endorsed by the E-TASC SB on 12.03.2025)
https://idm.euro-fusion.org/?uid=2Q72WQ&version=v2.2

Transition to 2026-2027 - Work Package: Theory and Modelling (WPTM)

Continuation of TSVV programme aimed in establishments of a strong scientific foundation for future fusion experiments through validated predictive simulation tools, enabling reliable extrapolations beyond current machines.

Topical Areas (2026–2027)

Each project (~5–6 FTEs/year) will focus on one of the following areas:

Short Ref.	Focus Area	Core Objectives
TSVV-A	H-Mode & Small/No-ELM Pedestals	Gyrokinetic simulations of L–H transitions and pedestal profiles
TSVV-B	Plasma Exhaust – Fluid Simulations	Validated fluid/gyrofluid edge-SOL transport modelling including neutrals & impurities
TSVV-C	Plasma Exhaust – Gyrokinetic Simulations	Gyrokinetic prediction of plasma exhaust under semi-collisional edge conditions
TSVV-D	Plasma–Wall Interactions	Integrated modelling of steady-state plasma–wall interactions and transient events
TSVV-E	Impurity Sources & Transport	Integrated modelling of W impurity sources, transport, and screening in metallic devices
TSVV-F	Tokamak Disruptions & Runaway Electrons	Self-consistent, validated models for disruption and runaway electron dynamics
TSVV-G	Physics of Burning Plasmas	Simulation tools for energetic particle–MHD–turbulence interactions in tokamaks & stellarators
TSVV-H	Prediction of Plasma Performance	Integrated core–edge modelling for scenario prediction and validation in ITER-like devices
TSVV-I	Stellarator Optimization	Development of optimized stellarator configurations and modules for optimization codes
TSVV-J	Stellarator Core Turbulence	Validation and application of gyrokinetic turbulence codes in 3D magnetic configurations
TSVV-K	Neutral Particle Models	Multi-fidelity neutral physics models integrated into edge turbulence simulations

Transition to 2026-2027 – Digital Twin Environment

Data Infrastructure: *all kind high-quality data, (plasma, materials, machine components and actuators); standardized data formats and interfaces; FAIR data management; uncertainty quantification). High-quality data (plasma, materials, and machine systems), with standardized formats, FAIR-compliant management, and uncertainty quantification.*

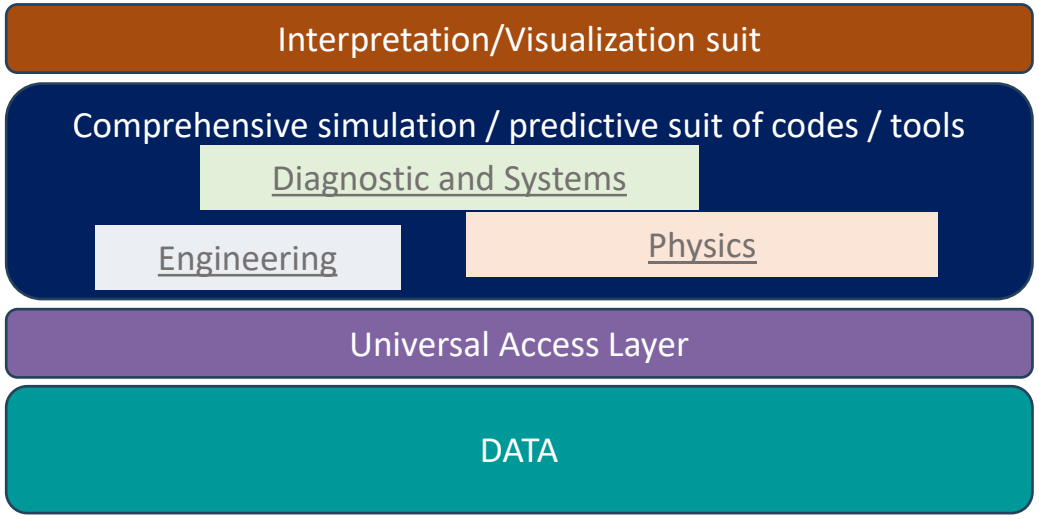
Predictive and Simulation Codes: *Physics-Based models; AI/ML models; HPC Compatibility; frameworks to couple multiple simulation domains.*

Real-Time Feedback Systems: *Control algorithms; integration with real tokamak.*

Visualization Tools: *Friendly UIs, 3D visualization, tools for evaluation of DTE predictions vs experiment.*

Benchmarking and Validation: *Accuracy and reliability of DTE.*

Computing and storage resources



Many of DTE key components are already being developed within existing activities. The 2026-27 programme aims to integrate these individual elements into a unified Digital Twin **Environment**, ensuring full compatibility and seamless communication between them.

Transition to 2026-2027 – WPAC-DTE

Integration of activities into a unified Digital Twin **Environment**

Ref.	Area Title	Objectives	Link to 2021-2025 programme
PDT	**Pulse Design Tool Extension**	Expand PDT for real-time, high-fidelity plasma forecasting and virtual control testing	TSVV-15
DDM	**Data-Driven Predictive Modelling**	Apply AI/ML for faster, validated simulations and real-time analysis/control	AI/ML – pilot projects
ENG	**Integrated Physics/Engineering Framework**	Develop coupled physics-engineering tools (e.g., breeding blanket, divertor models) and synthetic diagnostics	DTE PoC projects
VIS	**Advanced Visualisation Tools**	Create intuitive, interactive visualization for model validation and decision support	ACHs
+			
DMP	**Data Management Plan**	Develop coupled physics-engineering tools (e.g., breeding blanket, divertor models) and synthetic diagnostics	DMP
+			
Active collaboration and liaison with ITER on the IMAS development and F4E on utilization of AI/ML techniques			ACH-IPPLM

Materials & Links

- **EUROfusion Science meeting – Final Report of TSVV projects, 4-2 Nov. 2025**
  https://indico.euro-fusion.org/e/TSVV_Final_Report
- **Summary from 1st E-TASC General Meeting (11-15 Nov. 2024, Garching):**
  https://idm.euro-fusion.org/?uid=2S53YT&action=get_document
- **Materials from the 1st E-TASC General Meeting:**
  https://indico.euro-fusion.org/event/3034/
- **EUROfusion Standard Software:**
  https://idm.euro-fusion.org/?uid=2Q72WQ&version=v2.2
- **Review of Advanced Computing Hubs (ACHs) – 2024:**
  https://idm.euro-fusion.org/Portal/Pages/ContentView.aspx?uid=2RHUC2
- **Mid-Term Review of TSVV projects (2023):**
  https://idm.euro-fusion.org/Portal/Pages/ContentView.aspx?uid=2P9MS8
- **WPAC reporting:**
  https://idm.euro-fusion.org/default.aspx?uid=2PMTS8
- **WPAC Presentation at the last Physics Project Board:**
  https://indico.euro-fusion.org/event/3435/contributions/14169/attachments/6807/12022/WPAC_PB6_Kalupin.pdf