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VALIDATION TESTS AND ACCEPTANCE OF TIER-1 SYSTEM

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Executive Summary

This document updates the previous deliverable D3.2.4 which outlined the procedures for the validation and acceptance of the PRACE-Italy Tier-1 HPC system (GAIA). The present report is focused to overview the sustainability plan of the PRACE-Italy Tier-1 HPC system. The final value of the KPI “n. of racks delivered” is also reported.

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1. OVERVIEW OF THE SUSTAINABILITY PLAN

1.1. Introduction

The PRACE-Italy Tier-1 HPC system, GAIA, has now reached the phase of pre-production. We plan to move to users' access and full production in the first quarter of 2026, aligning with the conclusion of the TeRABIT project. An exhaustive description of the technical characteristics of GAIA was provided in the recent documents delivered in WP3, therefore in this report we focus on tracking an overview on how to assure sustainability after the project conclusion, e.g. covering a horizon until 2030.

In the following sections, we will briefly discuss the placement of GAIA within the national and European context, the added value in the TeRABIT vision and the institutional efforts in place of OGS and Cineca to sustain the infrastructure in the next 5 years.

1.2. PRACE-Italy Tier-1 system placement in national and European context

The upgrade of the PRACE-Italy Tier-1 system is aimed to maintain and reinforce its support to cutting-edge research across disciplines and borders, strengthening national and European scientific excellence and digital capabilities by providing access to advanced HPC services within the broader European research infrastructure landscape. This fully aligns with the European Strategy on Research and Technology Infrastructures¹, which aims to reinforce world-class facilities, enhance accessibility for researchers and innovators, and integrate digital and computing resources across Member States to boost competitiveness and scientific leadership.

Moreover, the augmented capability of the PRACE-Italy Tier-1 system reached within the TeRABIT action, further strengthens PRACE's long-standing user-oriented strategy, which places scientific communities at the centre of HPC service design and delivery. By enhancing computational performance, data throughput, and workflow efficiency, the upgraded infrastructure responds directly to the evolving needs of users working on data-intensive and computationally demanding applications. In line with PRACE principles, the access to GAIA resources is planned to be accompanied by dedicated user support, training activities, and optimisation services, ensuring that researchers can fully exploit advanced architectures. This user-driven approach maximises scientific impact, lowers entry barriers to HPC, and fosters a sustainable and inclusive European HPC ecosystem.

Through TeRABIT, PRACE-Italy's capabilities are now integrated with high-capacity network and cloud-edge computing infrastructures, improving connectivity, data handling and HPC performance for the Italian and European research communities. This constitutes a first important step in view

¹ https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-strategy-research-and-technology-infrastructures_en

of the next phase of the national plan of research infrastructures ("Piano Nazionale Infrastrutture di Ricerca – PNIR 2021-2027"²).

On the specific plan concerning the exploitation of the TeRABIT infrastructure services in collaboration with industry actors, we mention the participation of INFN and OGS to the "post-PNRR" calls open under the National Research, Innovation and Competitiveness Program for the Green and Digital Transition 2021-2027³, with the proposal "Computing Research infrastructure for Engineering, Science and Technology" (CREST), submitted in July 2025. The proposal consortium includes also the Universities of Naples and Bari, CNR, and INGV. CREST aims at enhancing the

A further action in view of the next phase of PNIR is the agreement between OGS and Cineca, outlined in Section 1.3.

1.3. OGS – Cineca agreement 2026-2030

OGS and Cineca are already working on the agreement that will cover the next 5 years. Since 2015, the two institutions have collaborated to maintain and upgrade the PRACE-Italy Tier-1 infrastructure and related services, also through the MUR fundings dedicated to PRACE-Italy strategic research infrastructure. Through the last 10 years, five consecutive bi-annual agreements have contributed 1) to support the Cineca HPC ecosystem cutting-edge capability to national and international users, and 2) to reinforce the OGS usage of HPC services, with a continuous increase of the users (Tab. 1) and the core-hours (Tab.2).

For the first time, the ongoing agreement is intended to last 5 years, motivated by the fact that OGS is co-owner of GAIA co-participating in the tender procedure through the TeRABIT project. The agreement will include the following services (others are currently under discussion):

- Professional support for the OGS research lines described in the HPC-TRES scientific plan⁴ and other innovative applications (including profiling, optimization, porting of existing codes, or development of new, innovative codes), including on cutting-edge hybrid/accelerated HPC architectures (with an exascale perspective).
- Resources for up to 12 million CPU hours per year for computation, plus storage for data analysis/visualization.
- Long-term archive (5 TB on a tape library until December 31, 2030)
- Technical and professional support in preparing IS CRA/PRACE/EUDAT/EuroHPC proposals for production applications and projects to be submitted for national or international calls (e.g., Horizon Europe, tenders for specific services), with updates and information on national and international funding initiatives involving HPC applications related to OGS activities (e.g., proof of concept for "ocean IoT").
- Technical support for the implementation and use of virtual systems on Cineca resources (e.g., virtual machines for application/workflow monitoring, OGS-specific web pages), as

² <https://www.mur.gov.it/sites/default/files/2021-10/Decreto%20Ministeriale%20n.1082%20del%2010-09-2021%20-%20PNIR%202021%20-%202027.pdf>

³ "Programma Nazionale Ricerca, Innovazione e Competitività per la transizione verde e digitale 2021-2027; Azione 1.1.1 – Potenziamento delle Infrastrutture di Ricerca (IR) pubbliche che operano in ambito S3 finalizzato all'avanzamento tecnologico delle imprese, D.D. n. 310 del 18-03-2025"

⁴ <https://www.ogs.it/en/content/hpc-training-and-research-earth-sciences-hpc-tres>

well as light-virtualization solutions such as containers, to simplify the construction of software stacks and increase the flexibility of the computing environment.

- Numerical simulation data management, conceived as an evolution towards database or other high-level storage systems, with metadata linked to model outputs and easy-to-use interfaces, similar to cloud services like Dropbox, with the ability to directly link external data (a very important aspect since data is increasingly becoming a publication asset that can be cited and significantly increase the visibility and impact of a research group or institute).
- Technical support for the development of advanced scientific visualization facilities, both at CINECA and at OGS.
- 1 PB dedicated to data exchange and repository of the outputs of the regional climate models produced during the Horizon Europe RIVIERADE project (1/1/2026 – 31/12/2029)⁵.

This agreement will place the basis to support the valorization of PRACE-Italy research infrastructure in the framework of the PNIR next phase, but also up-scaling towards the PRACE European framework or other analogous European initiatives, for which OGS plans to become an associate member.

Moreover, through this agreement, OGS becomes qualified to promote a federation among TeRABIT and several research infrastructures in the Earth science and natural hazards domain that have been strengthened under the PNRR framework (e.g. ITINERIS, ECCSELLENT, MEET, NBFC data hubs, among others). This initiative aims to reinforce OGS's role as a national actor, fostering the full exploitation of major European research infrastructures in that domain (such as DANUBIUS, JERICO, EMSO, EPOS) and broadening user access. The approach is oriented towards capitalising on already operational resources and further integrating them with the digital domain, by providing advanced HPC and AI capabilities to extract knowledge from the large volumes of data generated by these infrastructures.

1.4. Added value of PRACE-Italy Tier-1 system after TeRABIT

GAIA was designed as a hybrid system offering both HPC and Cloud services covering the whole data workflow, integrated with state-of-the-art computing capacities and AI heterogeneous approach, and being flexible for a broad spectrum of users. This kind of architecture appears optimally consistent with the development of environmental digital twins, which do integrate a data lake, sensors to monitor the environment which produce continuous data streams, numerical models and AI/ML algorithms for prediction and what-if scenarios, an interactive user interface.

GAIA availability to users is guaranteed for at least 5 years. Due to the ongoing deceleration of CPU performance improvements across generations, the authors anticipate that the system will retain its relevance within the HPC and cloud computing landscape for more than five years. An extension from five to eight years of service life is achievable and will provide sustained support for long-term operations, particularly those tailored to cloud-based environments.

The evolution of PRACE-Italy within TeRABIT extends the current research infrastructure including the HPC-Bubbles managed by INFN, offering an alternative for users to the centralized HPC resources and putting the basis for reinforce the national HPC strategy, which obviously has ICSC

⁵ <https://cordis.europa.eu/project/id/101181983>

as the main pillar. The expansion of the offer in terms of HPC, covering a range of services much wider than in the past, requires the empowerment of users to efficiently exploit them, and therefore a possibility to further collaboration in the training activities. Skills and competences of the Cineca and INFN technologists and HPC professionals of will be therefore further valorised in the framework of the sustainability plan.

Another important component that is oriented to enforce the added value of GAIA in the sustainability plan is its role in offering a platform for climate data, thus strengthening the research network that was built during the PNRR in the domain of climate sciences, with a special focus to the experience in the “Diagonal Spoke 8” (Science underpinning climate services for risk mitigation and adaptation⁶) of RETURN and in the Spoke 4 (Earth and Climate⁷) of ICSC. The initiative “ClimateDataIT” which stemmed out from the activities carried out within Spoke 4 aims at creating an entry access point for climate data produced by the national climate community following agreed standards and protocols, with the ambitious goal to develop and put in place an Italian node for the Earth System Grid Federation (ESGF⁸). In perspective, this strategic action will be able to offer both to the national climate research community and to all the possible stakeholders (public and private) a qualified platform where to develop climate services for the benefit of society, contributing to the growth of the community interested in access the services offered by the TeRABIT infrastructure.

In a similar view, the development of the Pilot Use Case “UrgentShake” represents an innovative system that acts as a prototype that can inspire similar workflows targeted to exploit the urgent computing and the TeRABIT infrastructure for earthquake monitoring and define best practices for their efficient use.

Year	PICO	GALILEO	MARCONI-A1	MARCONI-A2	MARCONI-A3	GALILE2	G100	M100	BOOSTER	DCGP	All servers
2015	3	2									5
2016	12	3									12
2017	16	11	10	1							22
2018		2	18	11		6					20
2019				11		22					25
2020						31		3			25
2021						22	18	11			28
2022							30	6			32
2023					1		38	4	4		41
2024					1		52		11	2	56
2025							124		106	123	130

Table 1 - OGS users per year from 2015 to 2025 over different computing platforms. Table taken from the Cineca Annual Report “Relazione sull’attività svolta da CINECA nell’ambito della convenzione con OGS (anno 2025)”.

⁶ <https://www.fondazionereturn.it/spoke8/en/>

⁷ <https://www.supercomputing-icsc.it/en/spoke-4-earth-climate-en/>

⁸ <https://esgf.github.io/>

Core hours consumed by OGS projects from 1-1-2015 to 31-12-2025												
Acco unt	Year	PICO	GALILEO	GALILE2	MARCON I-A1	MARCON I-A2	MARCON I-A3	G100	M100	BOOSTER	DCGP	All servers
start		12/01/2015	09/02/2015	04/03/2018	04/07/2016	02/01/2017	01/01/2018	11/08/2021	04/05/2020	08/03/2023	25/01/2024	
end		02/04/2018	30/06/2018	31/07/2021	26/09/2018	30/09/2020	21/10/2024		19/07/2023			
OGS	2015	54.106	167									54.273
OGS	2016	138.205	13.373									151.578
OGS 16	2016	9.883										9.883
OGS	2017	250.286	55.047		151.234	1.346						457.913
OGS 16	2017	45.141	14.623		30.649							90.413
OGS	2018		10.016	99.113	289.133	2						398.264
OGS 16	2018				42.562	26.342						68.904
OGS 18	2018			40.578		298.335						338.913
OGS	2019			923.236		52.359						975.595
OGS 18	2019			149.325		420.378						569.703
OGS 20	2019			335.031								335.031
OGS	2020			2.885.970								2.885.970
OGS 20	2020			1.803.451		60.081			2.286			1.865.818
OGS	2021			993.602				87.530				1.081.133
OGS 20	2021			194.924				7.960	49.106			251.990
OGS 21	2021							623.438	44.186			667.624
OGS	2022							1.471.964				1.471.964
OGS 21	2022							1.971.122	7.722			1.978.844
OGS	2023						115.970	1.327.353				1.443.322
OGS 21	2023							1.160.010	192.883			1.352.893
OGS 23	2023							2.710.554		16.962	16.962	2.744.479
OGS	2024						197.976	1.283.314				1.481.290
OGS 23	2024							4.735.855		22.520	34.503	4.792.878
OGS	2025							2.559.268			1.286.018	3.845.286
OGS 23	2025							3.862.845		127.689	1.154.480	5.145.014
PNRR	2025							3.133			898.279	901.412
Totali		497.621	93.226	7.425.231	513.578	858.843	313.946	21.804.346	296.183	167.171	4.544.722	35.357.254

Table 2 - OGS core-hours per year from 2015 to 2025 over different computing platforms. Table taken from the Cineca Annual Report "Relazione sull'attività svolta da CINECA nell'ambito della convenzione con OGS (anno 2025)".

2. CONCLUSION

The upgrade of the PRACE-Italy Tier-1 system represents a strategic investment aligned with PRACE's user-oriented and impact-driven vision, aimed at strengthening Europe's research and innovation capacity. By improving accessibility, scalability, and service reliability, GAIA will support diverse scientific communities and will promote efficient use of public HPC resources. This evolution is strategic in terms of the sustainability plan of the TeRABIT infrastructure, is in line with the EU strategy on research and technology infrastructures, and reinforces PRACE's role as an enabling infrastructure, bridging national and European priorities, fostering inclusiveness, and ensuring that advanced computing capabilities effectively translate into scientific excellence, technological innovation, and societal benefits.

In terms of KPI "final n. of racks delivered", we can confirm the previous value of 24 (see deliverable D3.2.4).