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V0.2	It incorporates feedback from the internal review.
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V1.1	Revised version following the feedback from the project monitors (information added in sections: HPC in European Policy; Argentina; Chile; Costa Rica)

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Executive Summary

High-Performance Computing (HPC) used to be promoted mainly by the big science and defence communities. Nowadays, with the advent of Artificial Intelligence, Machine Learning and Big Data, the broader use of HPC is bearing fruit in industry, commerce, healthcare, and the economy in general. Several countries consider investments in HPC as the key to competing globally.

In this context, coordination and capacity sharing between allied regions are crucial. The RISC2 project gathers eight key European HPC actors and the main HPC actors from Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Uruguay to encourage more robust cooperation between their research and industrial communities on HPC applications and infrastructure deployment.

RISC2 promotes exchanging best practices through meetings, workshops and training events. It builds on the already strong relationships of the consortium partners, the results of the previous bi-regional project (RISC), and the possibilities enabled by the new Ella Link submarine cable, which offers secure high capacity connectivity on a unique and low latency diverse transatlantic route. The main project deliverable will be a cooperation roadmap targeting policymakers, the scientific and industrial communities, identifying key application areas, HPC infrastructure and policy requirements, and exploring ways for the activities established during the project to last beyond its lifetime.

This White Paper on HPC Research, Development and Innovation (RDI) in Latin America sets the basis for the road-mapping activity carried out by the RISC2 project.

The white paper is organised as follows:

- **Section 1** introduces this report, describing its precedents, objectives and methodological approach, and shares an overview of the strategic importance of HPC, computational and data sciences.
- **Section 2** addresses the Latin American HPC landscape by presenting an overview of the HPC activity in the region and then focuses on the targeted country through seven national reports.
- **Section 3** advances on recommendations for Latin America to encourage sustainability in RDI in HPC and strengthen bi-regional collaborations.

Section 1. Introduction

Almost ten years ago, the European Commission (EU) funded the RISC project to deepen strategic research cooperation between the EU and Latin America (LATAM) in High-Performance Computing (HPC). The project focused on building an international and multi-stakeholder community with researchers, policymakers, and users representatives of relevant European and Latin American HPC RDI actors. The RISC project identified common needs, research issues and opportunities for bi-regional cooperation in HPC RDI.

RISC2 leverages the work initiated by the original RISC project to build a stronger bridge between European and Latin American HPC communities with researchers and innovators in all areas of society with access to expertise, knowledge, algorithms and tools for developing, deploying HPC-based services to tackle societal, industrial and environmental challenges.

RISC2 will achieve this overall goal RISC2 via a range of activities:

1) Assess the EU and Latin American collaboration potential in the High-Performance Computing, Artificial Intelligence and Computational Science areas.

2) Raise policymakers' awareness in the EU and LATAM about HPC research cooperation and results, and facilitate dialogue among policymakers, companies, civil society and the research community.

3) Establish strong links with Latin American HPC networks to co-organise awareness-raising events about the EC's ICT Research and Innovation programmes.

4) Provide advanced support services to many prominent Latin American HPC actors to build long-term relationships with key EU counterparts.

Methodological Approach

Based on the previous RISC reports (the *Green Paper on High-Performance Computing and Supercomputing Drivers and Needs in Latin America* and the *Roadmap for High-Performance Computing and Supercomputing strategic R&I in Latin America*), the Consortium has built an updated 'White Paper' in the form of seven National Reports (section 2.2).

The Consortium agreed on a standard template to present the relevant information per country. The template draws from the "Green Paper on High-Performance Computing and Supercomputing Drivers and Needs in Latin America", Section 4 (RISC, 2014), "The EuroHPC JU Supercomputers: Analysis of the Petascale and Pre-exascale systems" (September 2021), and "ETP4HPC's SRA 4 2020: Strategic Research Agenda for High-Performance Computing in Europe" (March 2020).

The partners from RISC2 representing Latin American institutions gathered the necessary information to produce the national reports. The approach to performing the research focused on secondary sources such as international and national studies, project reports and articles. The References section lists the specific sources per country. In addition, this exercise leveraged the central role that these institutions play within their national research ecosystems and their contacts with key stakeholders in each targeted country.

This research is the primary input for D2.5 “Roadmap for HPC R&I between Europe and the LATAM”, focusing on the aspects below. It will also serve as a source of information for D4.1 “Survey and analysis of S&T bilateral agreements” and D4.3 “Analysis of the national HPC policies”.

The overview of the HPC activity in Latin America and the national report consider the following aspects:

- Strengths and weaknesses of the ICT sectors and HPC RDI competencies in Latin America.
- Significant socio-economic factors and trends that influence and impact HPC needs and HPC policy priorities in Latin America.
- Comparison of the key Latin American HPC research areas with the respective EU research priorities, identifying research opportunities to strengthen bi-regional cooperation.
- Analysis of existing and potential commonalities and differences in HPC RDI policy between Latin America and the EU based on a review of policy-focused reports and studies and an exploration of the current bi-regional cooperation in HPC research and infrastructure.
- Recommendations aimed to strengthen and increase bi-regional cooperation in HPC RDI.

Moreover, the RISC2 Consortium will present this White Paper during the awareness-raising events. In addition, it will be a relevant source of information to drive the discussions during the policymakers event.

The strategic importance of HPC and Computational Sciences

This section underlines the importance of Computational Sciences and HPC as fundamental instruments to enhance benefits for citizens, industry and science. In addition, it presents a brief introduction to the HPC landscape in the European Union.

HPC: an essential interdisciplinary field

Computational Science and HPC are vital strategic assets for science, industry and society. Large-scale computing has become an indispensable way to tackle societal and scientific grand challenges and address the industry's need to innovate.

HPC is starting to play a crucial role in medicine. It is a vital tool for discovering new drugs and developing personalised medical therapies. Supercomputing is also critical to understanding the generation and evolution of epidemics and diseases.

Supercomputing contributes to anticipating extreme weather conditions. It can provide accurate simulations predicting the evolution of weather patterns and the size and paths of storms and floods.

Supercomputers are also vital for monitoring the effects of climate change. They do so by improving our knowledge of geophysical processes, monitoring Earth resource evolution, and reducing the environmental footprint of industry and society.

HPC is an essential tool for national security, defence and sovereignty. It enhances innovation in several industrial fields, from health to automotive, agriculture and clean energy production.

The interdisciplinary field stemming from basic sciences, mathematical modelling, quantitative analysis techniques and HPC techniques is integral in addressing the big problems in science, industry and society. New scientific instruments generate data faster than our current capacity to analyse it. In this context, current strategic plans in HPC research and innovation focus on the way forward to reach exascale performance[1] and to increase collaboration between the fields of HPC, AI, Machine Learning and Big Data[2].

In this context, "the entire HPC ecosystem from the processors, communication and all the way up through the various software layers needs to be based on technology that is readily available, not subject to foreign export licencing, and completely trustworthy. For all these reasons, as early as the beginning of the decade, all major developed regions have started to invest heavily in HPC technology. Particularly remarkable is the case of China, which started from scratch and, in a few years, has managed to become a major player in HPC and operates some of the top systems in the world. More traditional HPC players, such as Japan and the US, have also continued to invest and launch programmes such as the Post-K in Japan and the Exascale Computing Project (ECP) from the Department of Energy (DoE) in the US. Finally, the European Commission recently announced the EuroHPC initiative to reach Exascale performance with European technology in the upcoming years"[3].

Toward Exascale Computing

New computational models leverage the traditional distributed and shared memory systems, implementing CPU-GPUs and many-core architectures (such as XEON Phi). New software models use clouds and highly virtualised infrastructures to address new problems. Post-petascale systems and future exascale computers are expected to have an ultra-large-scale and highly hierarchical and heterogeneous architecture with nodes of many-core processors, accelerators and specialised cores. That implies that existing systems, language, programming paradigms and parallel algorithms would have, at best, to be adapted and often become obsolete. New adaptive runtime systems will become necessary to operate these ultra-large-scale parallel systems. These systems will manage massive

[1] Infrastructure Advisory Group (INFRAG). "Multiannual strategic Agenda for the Acquisition of Supercomputers". Retrieved from https://eurohpc-ju.europa.eu/sites/default/files/2020-05/EuroHPC_INFRAG_Multiannual_Strategic_Agenda_2019.pdf on 5 April 2022.
[2] Research and Innovation Advisory Group (RIAG). "Strategic Research and Innovation Agenda 2019". Retrieved from https://eurohpc-ju.europa.eu/sites/default/files/2020-05/EuroHPC_RIAG_Strategic_Agenda_2019_0.pdf on 5 April 2022.
[3] Gagliardi, F., Moreto, M., Olivieri, M. *et al.* The international race towards Exascale in Europe. *CCF Trans. HPC* 1, 3–13 (2019). https://doi.org/10.1007/s42514-019-00002-y

amounts of distributed data and huge distributed load balanced tasks while minimising the energy consumption with fault-resilient properties.

Computational Science is undergoing rapid change. Hardware designers, supported by large public funding, are in a global race to create supercomputers capable of exascale performance: 10^{18} floating-point operations per second (flop/s). Fugaku in Japan until recently was the first supercomputer introduced as the "Exascale generation" supercomputer[4]. In May 2022 the US Department of Energy released the performance of the Oak Ridge Frontier supercomputer breaking the limit of 1 Exascale sustained speed[5].

Meeting the exascale computing challenge requires a sustained effort in key areas of computational science ranging from the development of novel multi-and many-core architectures to new programming models, scalable algorithms, and new modelling techniques and paradigms.

The global race is increasingly competitive, with Japan, the United States and China holding the top places in the TOP500 ranking[6] as of June 2022. The European Union is represented by the LUMI system in Finland and the Adastra system in France in the 3rd and 10th places, respectively. It is worth noticing that both systems have been built and delivered by a US manufactuer.

Specific European policy has been developed to promote several initiatives on the way towards exascale.

HPC in European policy

In 2012, the EU recognised the importance of HPC with the Communication "High-Performance Computing: Europe's place in a Global Race"[7]. The Communication highlighted the strategic nature of HPC as a crucial asset for the EU's innovation capacity. It outlined a strategy to ensure European leadership in supplying and using HPC systems and services by 2020. This Communication drew from the 2009 Communication "ICT Infrastructures for e-Science"[8] .

[4] "Still waiting for Exascale: Japan's Fugaku outperforms all competition once again". Retrieved from https://www.top500.org/news/still-waiting-exascale-japans-fugaku-outperforms-all-competition-once-again/ on 5 April 2022.

[5] Oak Ridge National Laboratory.2022. May, 30. Frontier supercomputer debuts as world's fastest, breaking exascale barrier . https://www.ornl.gov/news/frontier-supercomputer-debuts-worlds-fastest-breaking-exascale-barrier

[6] Top 500 list. June 2022. Retrieved fromhttps://www.top500.org/lists/top500/2022/16/ on 11 August 2022.

[7] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. High-Performance Computing: Europe's place in a Global Race (2012). Retrieved from https://eur-lex.europa.eu/legal-content/GA/TXT/?uri=CELEX:52012DC0045 on 5 April 2022.

[8] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. ICT Infrastructures for e-Science. (2009). Retrieved from https://ec.europa.eu/eurostat/cros/system/files/COM%20%282009%29%20ICT%20INFRASTRUCTURES%20FOR%20e-SCIENCE.pdf on 5 April 2022.

In 2013, the Competitiveness Council adopted the conclusions on the HPC Communication, highlighting the role of HPC in the EU's innovation capacity and stressing its strategic importance to the EU's industrial and scientific capabilities and its citizens[9].

The European Union invested significant funding in developing cutting-edge HPC technology based on these precedents. Among the initiatives to position Europe as a world leader in HPC, it is worth mentioning:

- The Centres of Excellence for HPC,
- The strategic research agendas developed by the ETP4HPC think tank,
- The access to world-class supercomputers in PRACE (Partnership for Advanced Computing in Europe)
- Multiple European projects
- The Exascale EuroHPC Joint Undertaking initiative.

During the last few years, the EU funded many research projects related to HPC. The 2021 edition of the ETP4HPC Handbook of European HPC projects[10] listed 68 ongoing projects (and 34 finalised projects). The exponential growth of the HPC research arena in the EU is explained by the increasing interaction between HPC and many related domains such as Big Data, Artificial Intelligence, the Internet of Things and other technologies. However, "there are no local European vendors capable of supplying EU customers with HPC hardware based on domestic supercomputing technology"[11].

Semiconductors are crucial elements for the modern industry. During 2020 and 2021, the effects of the CoViD-19 pandemic and delays in logistics and transportation, among other factors, contributed to unprecedented disruptions in the supply of microprocessors, negatively impacting RDI industries worldwide.

Moreover, the shortage crisis raised awareness among policymakers about the global dependence from the few companies where first-class modern chips are manufactured[12]. Other indispensable resources for semiconductors manufacturing, such as coolants, are also heavily centralized[13]. The share of Europe in global fabrication capacity is very low. In the case of advanced technologies (the 7- and 5-nm node semiconductors), "100 % of global capacity is based in East Asia (Taiwan and South Korea). Only

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[9] Commission Staff Working Document. Implementation of the Action Plan for the European High-Performance Computing strategy (2016)
Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016SC0106&from=PL on 5 April 2022.
[10] ETP4HPC (2021). European High-Performance Computing projects. Handbook 2021. Retrieved from https://www.etp4hpc.eu/pujades/files/European%20HPC%20Handbook%202021%20final.pdf on 5 April 2022.
[11] Gagliardi, F., Moreto, M., Olivieri, M. *et al.* The international race towards Exascale in Europe. *CCF Trans. HPC* 1, 3–13 (2019). https://doi.org/10.1007/s42514-019-00002-y
[12] Statista. Leading semiconductors foundries revenue share worldwide from 2019 to 2022, by quarter. Retrieved from https://www.statista.com/statistics/867223/worldwide-semiconductor-foundries-by-market-share/#:~:text=Leading%20semiconductor%20foundries%20revenue%20share%20worldwide%202019%2D2022%2C%20by%20quarter&text=In%20the%20first%20quarter%20of,16.3%20percent%20of%20the%20market.
[13] HPCWire. 2022. July, 11. Not cool: Semiconductor Industry to face Coolant shortage. https://www.hpcwire.com/2022/07/11/not-cool-semiconductor-industry-to-face-coolant-shortage/

TSMC (Taiwan) and Samsung (South Korea) are able to manufacture chips at 5nm, and the global economy relies on Taiwan for 92 % of the production of these chips"[14].

A wide range of economic sectors suffer the semiconductor shortage crisis, including, but not limited to, the HPC industry. This context may hinder RDI initiatives in HPC in Europe and elsewhere, negatively affecting the effectiveness of ongoing HPC policies.

Against this background, the US, China and the EU are addressing the semiconductors shortage by establishing a framework of measures for strengthening their domestic semiconductor ecosystems. The Chinese semiconductor industry experienced an unprecedented growth in 2020[15]. In August 2022, the US signed into law the CHIPs and Science Act[16] to boost semiconductor research, development and manufacturing through strong public-private investment. The European Commission adopted the European Chips Act in February 2022. The Commission's proposal for a Regulation on the European Chips Act is expected to be discussed by the European Parliament and Member States in the ordinary legislative procedure.

Through the EU Chips Act, the EU seeks to reinforce its capacity to innovate in the design, manufacturing and packaging of advanced chips, increase substantially its production capacity by 2030, achieving a 20% semiconductor global market share, and develop an in-depth understanding of the semiconductor supply chain, closely monitoring potential shortages.

The European Joint Undertakings KDT JU (successor of the ECSEL JU) and the EuroHPC JU are key instruments to achieve these goals.

The Key Digital Technologies Joint Undertaking (KDT JU)[17] is a Public-Private Partnership for research, development and innovation that funds projects for assuring world-class expertise in key enabling technologies, essential for Europe's competitive leadership in the era of the digital economy. The European Chips Act gives a legal framework for a new public-private partnership – the "Chips Joint Undertaking" - building on the existing KDT JU and with an even more ambitious scope and a much more significant budget: the EU contribution is proposed to be increased from € 1.8 billion up to € 4.175 billion[18].

The EuroHPC JU, implemented in November 2018, is a joint initiative of the EU and European countries to develop a "World-Class Supercomputing Ecosystem in Europe". The EuroHPC JU allows the European Union and the EuroHPC JU participating countries to coordinate their efforts and pool

[14] European Parliament (2022). Briefing document. The EU Chips Act. https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733596/EPRS_BRI(2022)733596_EN.pdf

[15] Semiconductor Industry Association. China's Share of Global Chip Sales Now Surpasses Taiwan's, Closing in on Europe's and Japan's. 2022. January, 10. https://www.semiconductors.org/chinas-share-of-global-chip-sales-now-surpasses-taiwan-closing-in-on-europe-and-japan/

[16] The White House. FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China. 2022. August, 9. https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/fact-sheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chains-and-counter-china/

[17] The Key Digital Technologies Joint Undertaking. https://www.kdt-ju.europa.eu/

[18] KDT. Press Release. KDT to become EU Chips Joint Undertaking. 2022. February, 8. https://www.kdt-ju.europa.eu/sites/default/files/2022-02/KDT%20JU%20and%20the%20Chips%20Act%20_0.pdf

their resources. The main goal is to “boost Europe's scientific excellence and industrial strength, support the digital transformation of its economy while ensuring its technological sovereignty”[19].

As its first action, a specific funding grant of 150 million euros has been allocated to a consortium to develop a European processor, the “European Processor Initiative (EPI)”[20].

The EuroHPC JU has appointed two advisory boards that contribute to elaborating strategic agendas and plans.

- The Research and Innovation Advisory Group (RIAG)[21]
- The Infrastructure Advisory Group (INFRAG)[22]

The EuroHPC JU has procured seven supercomputers located across Europe: LUMI in Finland, Leonardo in Italy, MeluXina in Luxembourg, Vega in Slovenia, Karolina in the Czech Republic, Discoverer in Bulgaria and Deucalion in Portugal. An additional top pre-exascale system is being procured in Spain at the Barcelona Supercomputing Center.

The objectives of the EuroHPC JU are the following[23]:

- “Develop, deploy, extend, and maintain a world-leading supercomputing and data infrastructure in Europe. The objective is to reach exascale capabilities by 2022/2024. Exascale supercomputers are capable of more than a billion billion operations per second (compared to ten billion operations per second of an ordinary laptop device). Another objective is to build 'hybrid' machines that blend the best of quantum and classical HPC technologies with the first state-of-the-art pilot quantum computers by 2025.

- Support the development and uptake of innovative and competitive supercomputing technologies and applications based on a supply chain that will reduce Europe's dependency on foreign computing technology. A specific focus will be given to greener and energy-efficient HPC technologies. Synergies with broader technology sectors and markets, such as autonomous vehicles, extreme-scale, big data, and applications based on edge computing or artificial intelligence will be encouraged.

- Widen the use of HPC infrastructures to a large number of public and private users wherever they are located in Europe and support the development of key HPC skills, education and training for European science and industry. One of the objectives is to create a network of national HPC Competence Centres to ease access to European HPC opportunities in different industrial sectors and deliver tailored solutions. Another iconic objective will be to set up the first pan-European Master of Science programme for HPC to develop HPC talents in Europe”.

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[19] EuroHPC Join Undertaking. Retrieved from https://eurohpc-ju.europa.eu/ on 5 April 2022.
[20] The European Processor Initiative. Retrieved from https://www.european-processor-initiative.eu/ on 6 April 2022.
[21] The Research and Innovation Advisory Group (RIAG). Retrieved from https://eurohpc-ju.europa.eu/research-and-innovation-advisory-group-riag-0 on 5 April 2022.
[22] The Infrastructure Advisory Group (INFRAG). Retrieved from https://eurohpc-ju.europa.eu/infrastructure-advisory-group-infrag on 5 April 2022.
[23] “Discover EuroHPC JU”. Retrieved from https://eurohpc-ju.europa.eu/ on 5 April 2022.

In this context, the EU launched "the first pan-European Master of Science (MSc) programme in High-Performance Computing (HPC). Funded by the EuroHPC Joint Undertaking, the MSc programme will link academic excellence to the current and future challenges of European businesses, industry and the public sector in the multidisciplinary field of HPC. The modular curriculum and partnership with the European HPC industry will provide students with distinct qualifications and outstanding career prospects in the rapidly expanding field of HPC"[24].

HPC domestic initiatives are getting traction in other regions beyond the European Union. China, Japan and the United States are also working toward sovereign technology development in the HPC arena. However, the HPC community is increasingly global, and significant research projects imply international collaboration, from climate modelling to public health issues. In this context, initiatives to foster researchers' access to HPC resources were launched. For example, the EuroHPC JU has funded the EuroCC programme as a central point for the HPC National Competence Centers of 33 countries in Europe. The programme aims to become a gateway for industry and academia to HPC providers, collect HPC-related training offers and foster the industrial uptake of HPC[25].

[24] "EUMaster4HPC : Applications are now open". Retrieved from https://eurohpc-ju.europa.eu/press-release/eumaster4hpc-applications-are-now-open on 5 April 2022.
[25] EuroCC. Retrieved from https://www.eurocc-access.eu/ on 6 April 2022.

Section 2. The HPC ecosystem in Latin America

Overview of the HPC activity in Latin America

As part of the European Union (EU) – Latin America & the Caribbean (LAC) ResInfra project[26], the Red Iberoamericana de Computación de Altas Prestaciones (RICAP) identified and described the best practices in HPC in the EU-Latin American region as critical factors for achieving a sustainable effort in the field. According to the RICAP report *Identification of best practices on HPC for LAC*[27],

> "if Europe wants to play a leading role in setting the priorities for HPC technology research and development on a global scale, it needs to establish strong and sustainable links with all regions of the world already based on the real needs and interests of all involved stakeholders. Furthermore, to contribute to the social inclusion of these emerging economies, a substantial dialogue between the technology research communities working in Europe and these regions must be started, based on the real needs of these local economies and addressing at the same time development opportunities and efficiency growth".

However, the Latin American context shows factors that might hinder HPC research and development. The main concern is the unstructured nature of the research space, which hampers access to resources. The lack of financial capacities and the lack of Science, Technology and Innovation policy prioritisation, together with political instability, were identified as the main challenges for international cooperation, according to the surveys conducted by the EULAC Focus project[28].

The EU-CELAC 2021-2023 Strategic Roadmap[29] identified three pillars to unlock the potential for bi-regional cooperation.

- Pillar 1. Research Infrastructures (RIs)
- Pillar 2. Researcher mobility
- Pillar 3. Global challenges: Health, Sustainable development, Digitalization.
- Innovation

The strategic roadmap recognised the central role played by the EU-LAC Working Group (WG)[30]. The WG organised policy dialogues and workshops, encouraged researchers' exchanges and focused on the prioritisation of thematic areas for cooperation, namely: energy, biodiversity and climate change, food security, health and emerging technologies.

The situation of HPC in Latin America is promising for developing new initiatives and strengthening existing ones. The most salient aspects are related to:

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[26] ResInfra. Retrieved from https://resinfra-eulac.eu/ on 7 April 2022.
[27] RICAP (2020). *Identification of best practices on HPC for LAC.* Retrieved from https://www.eucelac-platform.eu/sites/default/files/list_of_eu-lac_hpc_research_infrastructures.pdf on 7 April 2022.
[28] EULAC Focus Retrieved from https://eulac-focus.net/ on 7 April 2022.
[29] The EU-CELAC 2021-2023 Strategic Roadmap for the implementation of the Brussels Declaration and EU-CELAC Action Plan on Science, Technology and Innovation. Retrieved from https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/documents/eu-celac_strategic-roadmap-2021-2023.pdf on 7 April 2022.
[30] EU-LAC Working Group on Research Infrastructures. Retrieved from https://www.eucelac-platform.eu/research-infrastructures on 7 April 2022.

- Infrastructure development to enhance the interconnection of HPC resources.
- The increasing number of bi-regional cooperation projects centred on (or leveraging) HPC resources.
- The support of international coordination and support initiatives that contribute to a sustainable HPC RDI in the region.

Infrastructure

In terms of infrastructure, several platforms and centres provide computing power and related services. There is steady progress toward the interconnection of centres in the continent and other platforms in Europe and the U.S.

In 2017, the sixth meeting of Senior Officials on Science and Technology of the joint EU-CELAC initiative on Research and Innovation (JIRI) confirmed the need to guarantee a strategic regional partnership in research and innovation through the development of the EU-CELAC Joint Research Area. Research infrastructures are one of the strategic pillars of this Common Research Area (CRA)[31]. 13 research institutions were identified as potential EU and Latin American entities for the sustainability of the RICAP pilot[32], leveraging their engagement with HPC-related activities and their experience with Horizon2020 projects.

Nowadays, the possibilities to improve collaboration initiatives have grown exponentially thanks to the infrastructure resources enabled by the Ella Link submarine cable, with the support of the Bella Programme. Ella Link connects Europe directly to Latin America at 2Tb/s. This submarine cable will foster collaboration and allow the development of new capabilities and the access of National Research and Education Networks (NRENs) to additional HPC resources using services provided by RedCLARA.

The big picture also shows a promising future, with exascale computational capabilities as the goal and an increasing interest in the convergence of HPC, AI, and data analytics. HPC centres in Latin America, such as the Laboratório Nacional de Computação Científica (LNCC) in Brazil and Centro de Investigación y de Estudios Avanzados (CINVESTAV), in Mexico, have recently expanded their infrastructures to provide better support for AI-oriented research.

[31] Mapeo de Infraestructuras de la Investigación en los países de la CELAC. Retrieved from https://celac.d2c2.gub.uy/ on 7 April 2022.
[32] RICAP (2020). Identification of potential EU and LA partners for sustainability of the RICAP pilot. Retrieved from https://www.eucelac-platform.eu/sites/default/files/list_of_eu-lac_hpc_research_infrastructures.pdf on 7 April 2022.

Cooperation projects

For the last three decades, international collaboration in HPC between Europe and Latin America has grown in joint projects' number, size, and impact.

Several projects have been developed in Latin America to build advanced computing platforms with the support of European institutions. EU co-funded projects (EELA, EELA-2, GISELA, CHAIN, CHAIN-REDS, RISC, EUBra-BIGSEA, ENERXICO, and HPC4E) constituted comprehensive initiatives of collaboration in HPC among partners in Europe and Latin American countries. They proved to play a crucial role in fostering academic and industrial development.

The 'Red Iberoamericana de Computación de Altas Prestaciones' (RICAP, Ibero American High-Performance Computing Network)[33] is an initiative born from ResInfra EU-LAC. It aims to integrate Latin American e-Infrastructures (HPC and federated clouds) into a sustainable network. The RICAP project coordinates its activities with SCALAC, agreeing to deploy HPC calls for accessing computing resources via RedCLARA as one of their thematic services. During the COVID-19 pandemic, SINAPAD and SCALAC enabled access to HPC and AI resources for researchers working on pandemic-related projects.

RICAP has stressed that "the ongoing initiatives are working on growing public awareness about HPC and AI research and Environmental issues to put pressure on the governments and academia to act and solve them"[34]. This awareness-raising potential is one of the strengths of the HPC community in Latin America.

Coordination and support initiatives

Several initiatives and organizations foster coordination between Latin American key players in HPC and their counterparts in the European Union, such as RedCLARA and SCALAC. These initiatives are vital factors in building a sustainable HPC ecosystem in the region.

RedCLARA develops and operates the only Latin-American advanced Internet network. Established for regional interconnection and linked to GÉANT2 (pan European advanced network) in 2004 via the ALICE Project. 13 Latin American countries are members of RedCLARA, and its Assembly –where each country has a representative- defines courses of action and the policies to be implemented.

In 2013, with the support of RedCLARA, BSC-CSN (Barcelona Supercomputing Center) and CIEMAT (Energy, Environmental and Technological Research Center), the consortium SCALAC was launched. SCALAC gathers high performance and scientific computing centres and researchers from several Latin American countries and provides services in infrastructure, platforms, applications, training and consulting for research, development and innovation using advanced information technologies.

[33] RICAP. Retrieved from http://www.red-ricap.org/ on 7 April 2022.
[34] RICAP (2020). *Identification of best practices on HPC for LAC*. Retrieved from https://www.eucelac-platform.eu/sites/default/files/list_of_eu-lac_hpc_research_infrastructures.pdf on 7 April 2022.

The EU-CELAC Interest Group, composed of 28 funding agencies from Latin America, the Caribbean and Europe, enhances bi-regional science, technology and innovation through joint actions. In addition, these joint initiatives indicate an increasing interest in bi-regional collaboration at the policy level.

Many Latin American countries have their local computer societies, which are in charge also of HPC topics, as the Sociedade Brasileira de Computação (SBC), Sociedad Chilena de Ciencia de la Computación (SCCC), Sociedad Argentina de Informática (SADIO). The multinational organization Centro Latino Americano de Estudios en Informática (CLEI) counts members from 17 nations.

These societies organised conferences, workshops and seminars during the last decade, such as:

- **The Latin American Computing Conference**, organised by CLEI. The last edition was held in San José de Costa Rica in 2021.
- **ISUM**, organized by the Mexican societies Sociedad Mexicana de Supercomputo (SOMEXSU A.C), Red Mexicana de Supercómputo (REDMEXSU) and Corporación Universitaria para el desarrollo de Internet (CUDI). The 10th edition took place in Mérida in 2019.
- **Jornadas Argentinas de Informática** (JAIIO). Its 50th edition, in 2021, was held online.
- **CARLA** - The Latin American High-Performance Computing Conference 8th edition was hosted by the University of Guadalajara, in Mexico, in 2021. Its 9th edition will be in Porto Alegre, Brazil, in 2022.
- **SBAC-PAD**, organised by the Brazilian society of computing (SBC), takes place in Brazil on odd years and elsewhere on even years. Its 24th edition, in 2022, will be held in Bordeaux, France.

Furthermore, Latin American researchers and academics focused on HPC have organised events dedicated to fostering bi-regional cooperation within European events, such as the Workshop on HPC Collaboration between Europe and Latin America, held during ISC 2015 and ISC 2018 in Frankfurt, Germany.

National reports

The following section presents the HPC ecosystem at the national level, focusing on the seven Latin American countries participating in the RISC2 project: Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Uruguay. Each sub-section addresses the following aspects per targeted country:

- A high-level introduction to the country.
- The strategic goals for the next few years, both in science policy in general and in HPC RDI in particular.
- The HPC infrastructure available in each country.
- Goals and opportunities for bi-regional collaboration with the EU.

Argentina

Argentina covers an area of 2,780,400 km2 (9th in the world, 2nd in LA), and it had an estimated population of 45.864.941 inhabitants in 2021. The Gross Domestic Product (GDP) per capita is 8,579.0 USD (90th in the world), and the Human Development Index is 0.845, among the 66 countries with very high human development. Argentina is an upper-middle-income economy[35].

Despite its rich natural resources, a highly literate population, a robust agricultural sector, and a diversified industrial base, Argentina has suffered from recurring economic crises for the last century. In the previous decades, fiscal account deficits, high inflation, and increasing external debt have become the most salient financial problems in the country. The impact of COVID-19 has been significant in Argentina. In 2020, the country's GDP lost 9.9 percentage points, the most considerable retraction since 2002[36].

Strategic Goals and plans for the next 3-5 years

Argentina has published several long-term plans focusing on periods of ten years in Science and Technology development. The idea of these plans is to align the different short-term projects and initiatives with the proposed objectives.

There is a draft of the National Plan for Science, Technology and Innovation 2020-2030[37]. The local and international context that impacts the plan's formulation is a scenario of high poverty and precariousness in Argentina. This situation is strengthened by the emergence of SARS-CoV-2, which created a new dimension of uncertainty to the global environmental and financial crisis, adding more social and economic vulnerability in developing countries like Argentina.

The strategic goals included in the 2020-2030 plan are based on identifying and characterising significant national challenges with an impact on society, the productive sector and the environment. These challenges require new ways of scientific and technological research jointly with the intervention of the Government to drive the development. The nature of this proposal is inherently interdisciplinary, requiring the coordination of academic, industrial and social stakeholders. The plan aims to generate new scientific and technological knowledge and foster specialized training.

The scientific landscape in Argentina is not homogeneous. There are significant differences in the country due to historical reasons. The 2020-2030 plan will try to bridge these gaps by proposing lines of action targeting specific regions.

The general objectives for the development of the country are:

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35 The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

36 The World Bank. Argentina overview. https://www.worldbank.org/en/country/argentina/overview#1

37 Plan Nacional de Ciencia, Tecnología e Innovación 2030. Retrieved from https://www.argentina.gob.ar/sites/default/files/plan_cti_2030_-_documento_preliminar_septiembre_2020.pdf on 7 April 2022.

- Create a shared vision for the national development project, where agro-industry, manufacturing industry, knowledge-based services, SMEs, and local economies boost incremental added-value processes, strengthen the internal market and increase international trade.
- Reach a balanced regional development, including infrastructure and sustainable economic activities and services.
- Develop an economy characterised by the transformation of technological processes, improving autonomy and jobs creation reaching new markets.
- Foster an integral and sustainable development that takes care of the most vulnerable citizens and makes a responsible usage of natural resources.
- Strengthen the development of productive activities currently marginalized in the informal economy guaranteeing the workers' income and enforcing labour rights.
- Design a development policy that prioritises the increase of exports and local production.
- Promote the growing incorporation of 4.0 technologies into the industry.

The scientific computing community states that its primary concern is to improve HPC capacities to support academic research, including traditional computing research and Artificial Intelligence. After joining the different visions of the next 3-4 years, the responsible directors of all centres said the necessity to get a supercomputer of at least 1 PFLOPS and 1 PB storage. Argentina is the only country in the G20 that has not been part of the TOP500.

Continue building the HPC community and help the outstanding scientists in Argentina catch up with HPC. Many of them are underpowered, and they do not even know that. Persuade the politics that we need continuous HPC investment, as suggested in the CFAS Project report[38].

The country has a Sistema Nacional de Supercómputo (SNCAD)[39] that gives some money (50K USD) to each center every year. They also try to encourage via IPAC[40] the use of the HPC facilities that are associated with them. There are efforts to buy a PFLOP cluster[41], but it has not yet been materialised. Each new administration erases all previous plans and builds new ones. There is no state policy for continuous HPC investment to grow.

[38] Russo, A. (2016) Computación de alto desempeño. Estado del arte en Argentina y en los países del G20. Retrieved from https://ccad.unc.edu.ar/files/estado-del-hpc.pdf on 7 April 2022.
[39] Sistema Nacional de Computación de Alto Desempeño (SNCAD). Retrieved from https://www.argentina.gob.ar/ciencia/sistemasnacionales/computacion-de-alto-desempeno on 7 April 2022.
[40] Iniciativa de Proyectos Acelerados de Cálculo (IPAC). Retrieved from https://www.argentina.gob.ar/ciencia/sistemasnacionales/computacion-de-alto-desempeno/ipac on 7 April 2022.
[41] "Se anunció la creación de un Centro Nacional de Supercómputo". 6 October 2021. Retrieved from https://ccad.unc.edu.ar/2021/10/06/se-anuncio-la-creacion-del-centro-nacional-de-supercomputo/ on 7 April 2022.

Strategic aims in Science and Research

The scientific sector was subject to successive cuts in 2016-2019, suffering the effects of the social and economic crisis and then the impact of the pandemic. Similarly to what happened to the rest of the country, the budget assigned to the sector decreased almost to the level of the year 2007 (in terms of constant money). The investment of the whole country reduced to the level of 2008 (0.49% of GDP). There was also a substantial migration of highly specialised human resources, which is reflected in a decrease in the relation of researchers per thousand persons. Many projects and technological initiatives were paralysed or shut down in this context.

The general guidelines for scientific development are:

- To promote the creation, linking, and transference of knowledge and technologies to contribute to the development of a fairer democracy.
- To strengthen the capacity to perform high-quality scientific research guided by a plan focused on Argentina's social and productive reality and neighbouring countries.
- To intensify the development of the technological capacity to provide responses generated by the regional economies and industrial sectors with exporting potential. It is necessary to invest the efforts in pursuing a robust technical upgrade to overcome our historical underdevelopment, which can be tracked in several unfinished technological projects and the unbalanced productive structure.
- To fortify the productive capacity of companies and cooperatives through the improvement of processes and the increase of technological adoption.
- To coordinate different stakeholders in improving the distribution of activities in the country.
- To work in the generation of plans aligned with different transversal policies: social development, health, education, industry, infrastructure, transport, agro, and defence. In brief, to produce knowledge and technology needed by public policies compatibles with the social and productive reality of Argentina and Latin America.

Strategic Aims in HPC

Argentina has a system of shared research facilities grouped under the “National Systems” initiative. Its objective is to promote the access and efficient usage of research resources for scientific and technological communities, the productive sector, and other interested actors in society.

The Sistema Nacional de Computación de Alto Desempeño (High-Performance Computing National System, SNCAD) aims to consolidate a national network of HPC data centres installed in distributed research institutions throughout the country. This interconnected system aims to fulfil the growing demand for computing, storage, visualisation, and other emergent technologies.

The main objectives are:

- To promote policies that contribute to maximising the usage of the computational resources.

- Support the acquisition of new equipment and the improvement of the existing one.
- To promote the specialisation of human resources through the design and diffusion of courses and schools.
- To promote the integration of the HPC centre into the international research communities.
- To increase the number of HPC users, especially those limited by the need for large computational resources in their research work. An initiative was launched six years ago: Iniciativa de Proyectos Acelerados de Cálculo (Initiative for Accelerated Computational Projects, IPAC), which is a call for projects with a high need for HPC resources. A country-wide call was sent using the diffusion network of the national scientific system. This call is repeated yearly and constitutes a way to bring closer potential users with existing resources.

High Performance and Advanced Computing activities follow national policies articulated with universities and research centers. In this case, it is possible to list seven (7) independent centers:

- National System of High Performance Computing at Physics Department of the Universidad de Buenos Aires (Sistema Nacional de Computación de Alto Desempeño – SNCAD-UBA[42])
- High Performance Computing Center CCT-ROSARIO CONICET at Universidad del Rosario (Centro de Cómputo de Alto Rendimiento CCT-Rosario[43]),
- National Centre of Atomic Energy Research at Bariloche (Centro Nacional de Energía Atómica de Bariloche, CNEA-Bariloche[44]),
- National Center of Computing Simulation and Technology Aplications (Centro de Simulación Computacional para Aplicaciones Tecnológicas - Consejo Nacional de Investigaciones Científicas y Técnicas, CSC-CONICET[45]),
- National Center of Research in Computational Methods (Centro Nacional de Métodos Computacionales – CIMET[46]),
- National Meterological Service (Servicio Meterologico Nacional – SMN[47]),
- Center of High Performance Computing at Universidad Nacional de Cordoba (Centro de Cómputo de Alto Rendimiento de la Universidad Nacional de Cordoba – CCAD-UNC[48]).

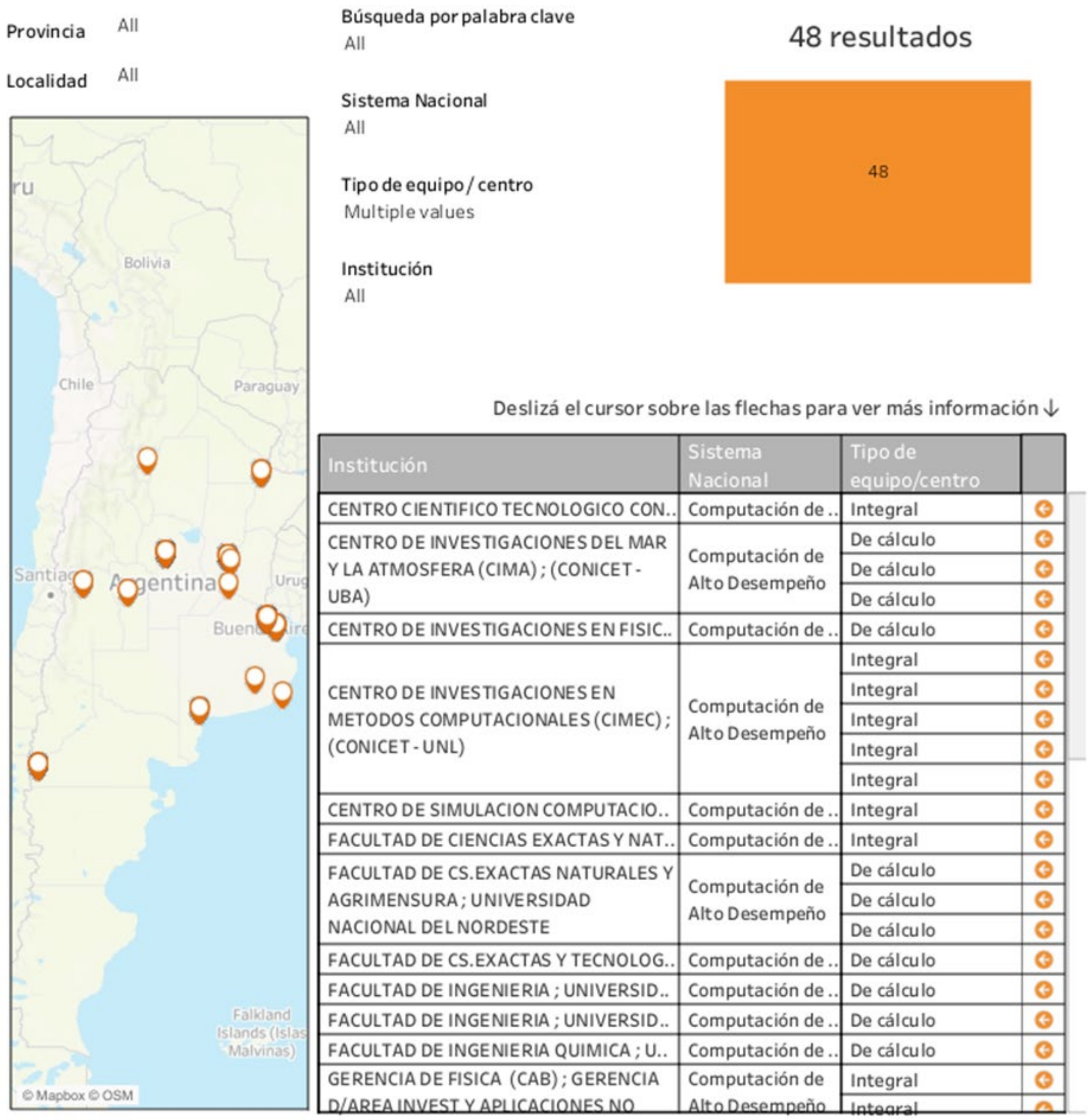
Priority HPC research areas

When writing this document, Argentina does not have specific priority HPC research areas. Despite it being recognized by the local authorities that HPC brings innovation and its use should be encouraged, there is a lack of policies to strengthen its usage and adoption. Some of the priority research areas can obtain advantages from adopting HPC, but this fact is not directly encouraged by the public policies; it is expected to happen *naturally*.

[42] http://dirac.df.uba.ar/
[43] https://www.rosario-conicet.gov.ar/equipamiento/centrodecomputosdealtorendimiento
[44] https://fisica.cab.cnea.gov.ar
[45] https://csc.conicet.gov.ar/
[46] https://cimec.org.ar/
[47] https://www.smn.gob.ar/
[48] https://ccad.unc.edu.ar/

HPC Infrastructure

The following figure shows the current distribution of HPC centres associated with SNCAD.



Institución	Sistema Nacional	Tipo de equipo/centro
CENTRO CIENTIFICO TECNOLOGICO CON..	Computación de ..	Integral
CENTRO DE INVESTIGACIONES DEL MAR Y LA ATMOSFERA (CIMA) ; (CONICET - UBA)	Computación de Alto Desempeño	De cálculo
		De cálculo
		De cálculo
CENTRO DE INVESTIGACIONES EN FISIC..	Computación de ..	De cálculo
CENTRO DE INVESTIGACIONES EN METODOS COMPUTACIONALES (CIMEC) ; (CONICET - UNL)	Computación de Alto Desempeño	Integral
		Integral
		Integral
		Integral
		Integral
CENTRO DE SIMULACION COMPUTACIO..	Computación de ..	Integral
FACULTAD DE CIENCIAS EXACTAS Y NAT..	Computación de ..	Integral
FACULTAD DE CS.EXACTAS NATURALES Y AGRIMENSURA ; UNIVERSIDAD NACIONAL DEL NORDESTE	Computación de Alto Desempeño	De cálculo
		De cálculo
		De cálculo
FACULTAD DE CS.EXACTAS Y TECNOLOG..	Computación de ..	De cálculo
FACULTAD DE INGENIERIA ; UNIVERSID..	Computación de ..	De cálculo
FACULTAD DE INGENIERIA ; UNIVERSID..	Computación de ..	De cálculo
FACULTAD DE INGENIERIA QUIMICA ; U..	Computación de ..	De cálculo
GERENCIA DE FISICA (CAB) ; GERENCIA D/AREA INVEST Y APLICACIONES NO	Computación de Alto Desempeño	Integral
		Integral

Figure 1. Sistema Nacional de Computación de Alto Rendimiento (SNCAD) Argentina's HPC Infrastructure. The map shows the current distribution of the main HPC centres associated with SNCAD. These centers are the backbone of the HPC system and host different clusters (each row represents one single cluster). Retrieved from: https://www.argentina.gob.ar/ciencia/sistemasnacionales/buscador-equipos/buscador-equipos-adheridos

There is no official information about the state and characteristics of HPC systems in Argentina. However, one of the centres (CCAD depending on Universidad Nacional de Córdoba) has gathered information[49] about HPC systems. The table below includes technical details of the main HPC clusters in Argentina.

[49] https://ccad.unc.edu.ar/clustersarg/

System name	Eulogia	Mulatona	Pirayú	Seshat	Coyote	TUPAC	CECAR	Dirac
Location	CCAD-UNC, Córdoba	IATE/CCAD-UNC, Córdoba	CIMEC, Santa Fe	CIMEC, Santa Fe	CIMEC, Santa Fe	CSC-CONICET, Buenos Aires	FCEyN, UBA, CABA	DF, UBA, CABA
Web	https://ccad.unc.edu.ar/equipamiento/cluster-eulogia/	https://ccad.unc.edu.ar/equipamiento/cluster-mulatona/	https://cimec.org.ar/c3/pirayu/equipos.php	https://cimec.org.ar/c3/seshat/equipos.php	https://cimec.org.ar/c3/coyote/equipos.php	https://www.tupac.gob.ar/stories/home/	https://cecar.fcen.uba.ar/	http://dirac.df.uba.ar/
Processor architecture	12*(Xeon Phi 7210 + 96 GiB + IB QDR) + 8*(Xeon Phi 7250 + 96 GiB + IB QDR), Total cores 1312 (5248 en SMT-4).	7*(2*E5-2683v4 + 128 GiB + IB QDR), Total cores 224.	5*(2*E5-2650v4 + 128 GiB + IB FDR) + 30*(2*E5-2650v3 + 128 GiB + IB FDR) + 5*K40 + 1*7120P. Total cores 720.	: 69*(E5-1620v2 + 16 GiB + IB QDR). Total cores 276.	. 6*(2*E5420 + 16GB) + 17*(W3690 + 16 GB) + 9*(E5-1660 + 16 GB). 2*C1060 + 2*GTX 580 + C2050. Rpeak_cpu 3.316 TFLOPS, Total cores 204	58*(4*Opteron 6276 + 128 GiB + IB QDR). 32*M2090. Rpeak_cpu 33.1 TFLOPS, Total cores 3712	30*(2*Opteron 6320 + 64 GiB + IB QDR) + 8*(2*Xeon E5-2620v4 + 64 GiB) 24*K20c Rpeak_cpu 16.128 TFLOPS, Total cores 640.	19*(2*E5-2670v1 + 64 GiB + 2*GigE) + 6*(2*E5-2670v1 + 128 GiB + 2*GigE). Cores total 400.
Peak performance	R_peak 56.32 TFlops R_max (estimated) 22 TFlops	R_peak 6.09 TFlops	Rpeak 26.304 TFlops CPU 7.15 TFlops GPU 1.20 TFlops accel.	Rpeak 8.196 TFlops Rmax 6.927 TFlops	Rpeak_all 5.568 TFlops	Rpeak_all 54.418 TFlops	Rpeak_all 44.208 TFlops	R_peak 8.32 TFlops
Access policy	https://ccad.unc.edu.ar/servicios/pedido-de-cuentas/	https://ccad.unc.edu.ar/servicios/pedido-de-cuentas/	https://cimec.org.ar/c3/pirayu/cuenta.php	https://cimec.org.ar/c3/seshat/cuenta.php	https://cimec.org.ar/c3/coyote/cuenta.php	https://www.tupac.gob.ar/stories/reglamento/	https://cecar.fcen.uba.ar/uso/	http://dirac.df.uba.ar/reglamento

Table 1. HPC infrastructure in Argentina (main clusters)

As can be noted, most of the HPC centres are located in Córdoba, Buenos Aires, and Santa Fe, which are also the places with the most robust scientific tradition in Argentina.

There is no investment policy to acquire and replace new HPC systems. The initiatives are based on the effort of some research groups or institutions or the small funding provided by SNCAD (which can be used to acquire a reduced number of nodes). This is the main point that Argentina has to improve to offer enough state-of-the-art computational resources to scientific and technological communities.

Strategic goals for collaboration with the EU

The cooperation in science, technology, and innovation between Argentina and Europe follows two possible paths: The generation of bilateral actions and programs and the negotiation and participation of the initiatives of Europe as a third country.

There is a local linking office to promote the different actions and support the matchmaking between groups in Europe and Argentina in the Horizon 2020 program. There is also support for Marie Sklodowska-Curie's actions by offering institutions and research laboratories for interested students.

The goals for cooperation are to strengthen the collaborations of research partners in Argentina, but, at the moment of writing this document, Argentina is not ready to advance to the level of cooperation reached by Mexico and Brasil, remaining as a third country for the next future.

Brazil

Brazil has a territorial area of 8,514,866 km^2 (5th in the world, 1st in LA). As of 2019, according to the World Bank, Brazil had an estimated population of 211,049,520 inhabitants (6th in the world, 1st in LA) and a Gross Domestic Product of USD 1,877,824.27 million (9th in the world, 1st in Latin America). Despite those numbers, only 8 Brazilian companies appeared in Fortune's 2019 edition of the Global 500 list: half of them are financial institutions. The remaining ones are related to the commodities markets (oil and gas, minerals, and animal protein). Brazil is an upper-middle-income economy[50].

The impact of COVID-19 is expected to reverse a decade-long steady improvement in the Human Capital Index (which had increased from 0.52 to 0.58 between 2007 and 2019) and calls for strong remedial acceleration policies. In addition, supporting the transition to a greener and more resilient growth model also remains a key challenge. Brazil is home to more than 60 per cent of the Amazon rainforest, the largest tropical forest in the world and has a high share of renewables in its energy matrix, but high exposure to climate risks and deforestation call for a robust reform plan to address these challenges[51].

Strategic goals and plans for the next 3-5 years

The Brazilian electronics market has a history of negative trade balance, with the IT sector corresponding to 41.1% of this market in 2019, according to the Brazilian Association of Electrical and Electronics Industry (Associação Brasileira da Indústria Elétrica e Eletrônica – ABINEE). Even so, Brazil is part of the small group of countries with national companies capable of building HPC systems: the Brazilian IT company Itautec appeared in the June 2012 edition of the Top 500 list for building a supercomputer for Petrobras, the Brazilian oil and gas company (the 68th machine in that list edition).

Indeed, Brazilian HPC technological achievements go back to the late 1980s, when the scientific community showcased significant results like building the NCP1 parallel machine with eight nodes in a hypercube architecture at COPPE/UFRJ. This was news in the New York Times (NYT, August 21, 1990) due to the threat this advanced knowledge could bring to building weapons. The annual Brazilian HPC Conference (SBAC-PAD) goes back to 1988. This active community has influenced incentive policies for funding HPC research and providing HPC services to the Brazilian research community. As a result, two important legal frameworks were established between 2004 and 2006: (i) the presidential decree that created the National System for High-Performance Computing (Sistema Nacional de Processamento de Alto Desempenho – SINAPAD), a network of HPC centres distributed throughout Brazil and coordinated by LNCC; and (ii) the Innovation Incentive Law ("Lei do Bem"), which allowed Brazilian IT companies such as Itautec to invest in RD&I and improve their competitiveness through various tax incentives.

The aforementioned legal frameworks were accompanied by a series of pluriannual strategic RD&I programs starting in 2007, the so-called RD&I National Strategies (Estratégias Nacionais de Ciência,

[50] The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
[51] The World Bank. Brazil Overview. https://www.worldbank.org/en/country/brazil/overview#1

Tecnologia e Inovação – ENCTI). The Brazilian Ministry of Science, Technology, and Innovation (Ministério da Ciência, Tecnologia e Inovações – MCTI) is the key responsible for the Brazilian policy in RD&I and the design of these programs. The enactment of these programs at the federal level occurs primarily using two funding agencies: the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq) and the Innovation and Research Agency (Agência de Inovação e Pesquisa – FINEP). The mission of CNPq is to support research at large, by funding, on a competitive basis, students, research, and national and international projects. The mission of FINEP is to foster industrial innovation and the research infrastructure evolution. A short history of the two most recent pluriannual strategic RD&I programs and their reflection on science and research in general—and HPC in particular—is depicted below:

- The ENCTI 2012-2015 program identified six priority sectors for strategic investments: IT, drug design, oil and gas, defence, aerospatial, and nuclear. Within the IT sector, the program identified the need for the development of a project to expand the country's installed HPC capacity and expand the use of technologies related to various sectors of scientific research and advanced industrial applications. A key result of this strategy was the development of a joint project between Brazil and France, which led to the acquisition and deployment at LNCC of the first generation of the Santos Dumont (SDumont) supercomputer from the French company Bull (now ATOS/Bull), and the deployment of an HPC RD&I centre from this same company near the LNCC campus, in the city of Petrópolis, State of Rio de Janeiro. SDumont was the first petaflop HPC facility deployed in Latin America, according to the Top 500 list;

- The ENCTI 2016-2022 program identified eleven priority sectors for strategic investments: aerospatial / defence, water, food, biomes and bioeconomy, social sciences and technologies, climate, digital society, energy, strategic minerals, nuclear, and health. Within the digital society sector, the program again identified the need for expanding the country's supercomputing power, now referring specifically to the activities of the SINAPAD network. Despite this, the only relevant investments in HPC in Brazil came from the industry, with acquisitions from Petrobras in partnership with other oil companies (including a second generation of the SDumont supercomputer) and Samsung in collaboration with the SiDi institute (this one, the IARA supercomputer, focusing on AI applications).

None of these past ENCTI programs considered the recent developments in the AI area.

Since 2021, the Brazilian government has worked to establish a new, multi-ministerial strategy for RD&I: the National Innovation Strategy (Estratégia Nacional de Inovação – ENI), aiming at the 2021-2024 period. The ENI 2021-2024 program proposes the following goals:

- Increase the volume of business investment in innovation concerning revenue;
- Increase public investment in RD&I;
- Increase the rate of innovation of Brazilian companies;
- Increase the number of companies that use the tax benefits of the Innovation Incentive Law;
- Increase the number of professionals working with innovation in companies.

Strategic aims in Science and Research

The ENI 2021-2024 program has proposed several actions to achieve the goals above. Among them, the ones more directly related to science and research are to be implemented to foster:

- Technological developments and innovation in structuring and strategic sectors of the economy, including aerospatial, nuclear, renewable energy, health, avionics, water, agriculture, strategic minerals, and assistive technologies.
- Technologies that have a transversal impact on the innovation ecosystem include photonics, IoT, and nanotechnology.
- The continuous updating and management of research and development infrastructures and innovation environments to allow their shared use, optimize resource allocation, and promote their integration with international infrastructures.
- The formation of international partnerships by the priorities established by the country.
- The strengthening of the national RD&I system aims to establish, consolidate, and disseminate cooperation networks in diverse areas such as digital transformation, graphene innovation, and AI.

Strategic Aims in HPC

Contrary to the previous ENCTI 2012-2015 and 2016-2022 programs, the ENI 2021-2024 program does not specifically state aims related to HPC. There is nevertheless a clear indication of action plans for continuously updating the research and development infrastructures in the country.

There is also the mentioning of the goal to increase the number of companies benefiting from the Innovation Incentive Law. The acquisitions of the second generation of the SDumont supercomputer for LNCC and of the IARA supercomputer for SiDi are essential examples of the use of such benefits.

Finally, bear in mind the explicit mention of AI as one of the chief targets for establishing cooperation networks in the ENI 2021-2024 program. In this respect, the MCTI developed a specific strategic plan for this area: the Brazilian AI Strategy (Estratégia Brasileira de IA – EBIA). As part of the EBIA, the MCTI, together with the São Paulo State Funding Agency (Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP) and the Brazilian Internet Steering Committee (Comitê Gestor da Internet no Brasil – CGI-BR) have opened calls in 2020 and 2021 for funding the creation of eight Centers for Applied Research in AI. Six of these centres are currently in operation in cybersecurity, health, agriculture, industry 4.0, and IoT; two others are to be implemented in 2022. The Rio de Janeiro State Funding Agency (Fundação Carlos Chagas de Amparo à Pesquisa do Estado do Rio de Janeiro – FAPERJ) has made a similar movement by funding the creation of three AI Thematic Networks. One of the funded networks is coordinated by COPPE/UFRJ with the participation of LNCC in the area of renewable energy and climate change. European energy companies (Repsol, Totalenergies) support this network.

Priority HPC research areas

The convergence of HPC and AI in the scientific realm is a crucial area for exploration in Brazil. Whereas large-scale, high-fidelity simulations employ parallel-enabled numerical methods for model-driven computations, big data analyses use machine learning techniques for data-driven calculations. Their integration may benefit both worlds:

- Machine learning techniques initially relied only on learning from a lot of data; incorporating knowledge about physical laws within these techniques requires less training data and accelerates training.
- Numerical methods are as good as the accuracy of the problem model; incorporating machine learning techniques within these methods leverages the underlying physical laws through sophisticated pattern extraction.

The application research areas expected to benefit from this convergence between HPC and AI include agriculture, aerospatial, climate, energy, health, and material sciences.

HPC Infrastructure

The list below refers to all Brazilian HPC systems with petaflop capability that have appeared in one of the editions of the Top 500 list. Of these systems, only SDumont (1st and 2nd generations) is for "Open Science", being part of the SINAPAD network. Three other HPC systems that are part of the SINAPAD network with capabilities of hundreds of TFlops are included in the table below, marked with an asterisk.

System name	Dragão	Atlas	IARA	Fênix	SDumont (2nd gen)	Ogbon	SDumont (1st gen)	Yemoja*	Lovelace*	Lobo Carneiro*
Location	Petrobras	Petrobras	SiDi	Petrobras	LNCC	SENAI CIMATEC – Petrobras	LNCC	SENAI CIMATEC	CENAPAD-SP	NACAD-COPPE/UFRJ
Web	https://petrobras.com.br/en/	https://petrobras.com.br/en/	https://www.sidi.org.br/en/	https://petrobras.com.br/en/	https://sdumont.lncc.br/	http://www.senaicimatec.com.br/en/infrastrutura/#/centro-de-supercomputacao-para-inovacao-industrial	https://sdumont.lncc.br/	http://www.senaicimatec.com.br/en/infrastrutura/#/centro-de-supercomputacao-para-inovacao-industrial	https://www.cenapad.unicamp.br/parque-computacional/equipamentos/ambiente-dell-lovelace	http://www.nacad.ufrj.br/pt/recursos/sgiicex
Processor architecture	Bull 4029GP-TVRT, Xeon Gold 6230R 26C 2.1GHz, NVIDIA V100, IB EDR Cores: 188,224	Bull 4029GP-TVRT, Xeon Gold 6240 18C 2.6GHz, NVIDIA V100, IB EDR Cores: 91,936	NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100 SXM4 40 GB, IB EDR Cores: 24,800	Bull 4029GP-TVRT, Xeon Gold 5122 4C 3.6GHz, NVIDIA V100, IB EDR Cores: 60,480	Bull Sequana X1000, Xeon Gold 6252 24C 2.1GHz, NVIDIA V100 SXM2, IB EDR Cores: 33,856 + 11,808 + 1,728	Bull Sequana X1000, Xeon Gold 6240 18C 2.6GHz, NVIDIA V100 SXM2, IB EDR Cores: 27,768	Bull B710, Xeon E5-2695v2 12C 2.4GHz, Nvidia K40 + Xeon Phi 7120P, IB FDR Cores: 10,692 + 24,723 + 18,144	SGI ICE X, Intel Xeon E5-2690v2 10C 3GHz, IB FDR Cores: 17,200	Dell AMD Epyc 7662, nVIDIA A100, IB EDR Cores: 7,424 + 896	SGI ICE-X, Xeon E5-2670v3 24C, IB FDR Cores: 6,048
Vendor	Atos	Atos	Nvidia	Atos	Atos	Atos	Atos	HPE	Dell	HPE

Peak performance	TFlops (Linpack): 8,983.0	TFlops (Linpack): 4,376.0	TFlops (Linpack): 3,657.0	TFlops (Linpack): 3,161.0	TFlops (Linpack): 1,849 + 785 + 115	TFlops (Linpack): 1,605	TFlops (Linpack): 456.8 + 363.2 + 321.2	TFlops (Theoretical): 412.8	TFlops (Theoretical): 365.0	TFlops (Theoretical): 226.0
Access policy	N/A	N/A	N/A	N/A	https://sdumont.lncc.br/alloc.php?pg=alloc#	N/D	https://sdumont.lncc.br/alloc.php?pg=alloc#	N/D	https://www.cenapad.unicamp.br/abertura-de-contas/	http://www.nacad.ufrj.br/pt/informacoes/politica-de-uso

Table 2. HPC infrastructure in Brazil

Strategic goals for collaboration with the EU

In November 2021, the European Commission and three Brazilian funding agencies; the National Council for Scientific and Technological Development (CNPq), the Funding Agency for Studies and Projects (FINEP) and the Brazilian National Council of State Funding Agencies (CONFAP), signed an Administrative Arrangement on the mechanisms to support Brazilian participation in Horizon Europe (2021-2027) collaborative projects, Partnerships and Missions[52]. The Administrative Arrangement aims to facilitate the co-funding of Horizon Europe joint activities set up by the three Brazilian funding agencies. It establishes the operational steps necessary to support other collaborative activities, such as the twinning of projects and the launch of coordinated calls. International collaboration is considered especially important in fields that require substantial funding.

HPC is a field that requires high investments. Consequently, collaboration from the global scientific community is necessary to keep up with the advancements in the area. We envision the convergence between HPC, data science (including machine learning) and large-scale scientific computing as the primary strategic goal for collaboration between Brazil and the EU. This convergence is already at the heart of ongoing research and development activities between Brazilian and French partners in the framework of the Inria-Brazil partnership[53]

- HPCProSol (Next-generation HPC PROblems and SOLutions) started in 2021 and is coordinated by Carla Osthoff from LNCC and Francieli Zanon-Boito from the Inria TADAAM team. In the context of the convergence of HPC and big data, the project proposes monitoring and profiling techniques for applications and the design of new coordination mechanisms to arbitrate resources in HPC environments;
- SusAIN (Towards a Sustainable Artificial Intelligence) started in 2021 and gathered Mariza Ferro and Bruno Schulze from LNCC, Inria project- team SPIRALS with Romain Rouvoy as PI and Nayat Sanchez-Pi and Luis Marti from Inria Chile. The project addresses the challenge of reducing the power consumption of AI algorithms deployed in the context of HPC;
- HPDaSC (High-performance Data Science) gathers four research teams from the state of Rio de Janeiro (LNCC, COPPE/UFRJ, UFF and CEFET) and the Inria ZENITH Team. The project began in 2020 and is headed by Patrick Valduriez (Inria) for the French part and by Fabio Porto (LNCC) for the Brazilian side. This project addresses the grand challenge of High-Performance Data Science (HPDaSc) by developing architectures and methods to combine simulation, machine learning and data analytics for applications in life sciences, agronomy, and geoscience (oil & gas);
- EOLIS (Efficient Off-LIne numerical Strategies for multi-query problems) gathers researchers from Brazil (LNCC), Chile (UDEC and UCSC) and France (Inria ATLANTIS Team). Starting

[52] European Commission. "Brazilian Funding agencies end EC sign an administrative agreement to steo up cooperation in research and innovation". 19 November 2021. Retrieved from: https://ec.europa.eu/info/news/brazilian-funding-agencies-and-ec-sign-administrative-arrangement-step-cooperation-research-and-innovation-2021-nov-19_en

[53] https://project.inria.fr/inriabrasil/

in 2021, the project proposes designing, implementing, and analysing novel preprocessing and postprocessing strategies for solving multi-query partial differential equation problems with finite element methods. Applications are in the design of nanostructures for light manipulation and quantification of uncertainties associated with media fields on fluid flows.

The recently launched Center of Excellence in Digital Transformation and Artificial Intelligence of the State of Rio de Janeiro (Hub-Rio) is also worth mentioning. COPPE/UFRJ and LNCC are founding partners.

Some of the key scientific challenges related to the combination of machine learning with a simulation that the Brazilian partners of RISC2 envision tackling in future collaborations include:

- dealing with uncertainty in the data and the models when tackling problems such as exploring stochastic spaces or doing complex multi-objective optimizations;
- developing fundamental numerical methodologies and effective parallel implementations combining machine learning and simulation on large parallel platforms;
- monitoring the lifecycle of data and model combinations through scientific runtime data analyses.

Chile

Chile covers an area of 756.102 km^{2}, and it had an estimated population of 18.307.925 inhabitants in 2021. The Gross Domestic Product (GDP) per capita is 13.232 (67th in the world), and the Human Development Index is 0.851, among the 66 countries with very high human development. Chile is a high-income economy[54].

Chile has a market-oriented economy focused on foreign trade, with commodities making up approximately 60% of total exports. Copper is Chile's top export and provides 20% of revenue. Over the last two decades, Chile has reduced its poverty rate, now lower than most Latin American countries. However, the country still suffers from severe income and education inequality. The stagnation of growth and productivity in the last decade has raised questions over the sustainability of the country's growth trajectory and the type of reforms needed[55].

Strategic aims in Science and Research

Chile needs public policies on Digital Transformation that must be addressed by identifying and measuring the gaps that must be closed to enable the potential that digital can bring to the country's development.

Thus, in the coming years, work must be done to mitigate the following gaps identified by the Commission that the Senate created to promote Chile as a relevant player in the installation of data centres. The gaps to be closed are:

- The competitive gap in digital transformation.
- The technological gap in infrastructure.
- Gaps in the strategic management of companies.
- Gaps in human capital for the digital economy.
- Gaps in cybersecurity.
- Gaps in the modernization of the State.

The vision set forth by the Commission for the Development of Science and Technology is to transform Chile into a world-class scientific and technological centre, diversifying exports towards higher value sectors, including knowledge exports and increasing the level of productive complexity in all sectors, contributing to improving productivity, income equality and growth.

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[54] The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[55] The World Bank. Chile Overview. https://www.worldbank.org/en/country/chile/overview#1

For its part, the recent Ministry of Science, Technology, Knowledge and Innovation (STKI) has defined four major lines of action, which represent new ways of facing the opportunities and challenges of our time:

- Linkage with society by strengthening the social appropriation of knowledge through new institutional capacities with the creation and consolidation of the new "Science and Society Division" and its two focuses of action: "Public Science" to link Science, Technology, Knowledge and Innovation with citizens, including a new portal with educational and scientific material; and "Explora" to have a more effective impact on the educational system.
- Future. Develop capabilities in the public sector to understand and anticipate the challenges of the future with the creation and consolidation of the "Future" pilot office and the launch, together with the Ministry of Economy, Development and Tourism, of the "Data Observatory" for the management of astronomical data; as well as the elaboration of the National Policy and Action Plan for Artificial Intelligence and the design and initial launch of the "Climate Change Observatory".
- Strengthening the STKI ecosystem. Strengthen and enhance the STKI capabilities that support an ecosystem that contributes to charting our development path through the implementation of a National Plan of Centers of Excellence; the implementation of a Talent Development Plan; the development of regional R&D&I capabilities; the execution of the Science and Technology-based Innovation and Entrepreneurship Agenda; the design of the National Technology Services Laboratories; the consolidation of the Technological Innovation Centers; and the implementation of the Committee of Technological and Public Research Institutes.
- Institutional capacities. Provide the institutional powers that generate the best conditions to strengthen the ecosystem and enhance its contribution to the country through the modernization of the new National Agency for Research and Development (ANID); the creation and consolidation of the "Public Policy Division", and the "Office of Studies and Statistics" that will launch a new "Observatory STKI System" and reformulate the R&D survey; and the implementation of the Gender Agenda in STKI.

Chile has the potential to innovate in fields in which the country already has competitive advantages, such as astronomy, sustainable mining, non-conventional renewable energies, agri-food, and fisheries.

Strategic Aims in HPC

Chile is the Latin American country that invests the most in information technologies per capita. During this year alone, investments in cybersecurity are expected to exceed USD 290 million, accessing a global market of more than US $150 billion per year. The measurement of digital development in Chile indicated that the digital economy represents 22% of the country's GDP, placing it in first place in Latin America in the Digital Economic Value Index and with almost 113 thousand people employed in the area. As an example of this multiplier effect, Microsoft is expected to install a data centre that could generate 13 billion dollars in revenue and 51.000 new jobs[56]. Complementing this information, the Secretary of Telecommunications indicates that 5G has the potential to boost the GDP in the coming years[57]. On the other hand, the Ministry of Transport and Communications suggests that the transoceanic cable, which will connect the region with Oceania and finally with Asia, will open enormous possibilities to transform Chile into the digital hub of South America on the Pacific side.

Chile has connectivity conditions and a geopolitical position towards the Pacific, making it an ideal country to invest in data centres. In addition, the climate and sustainability (despite the climate change that has raised temperatures in the country) make Chile a place with lower operational costs by having colder weather for the required cooling. That means lower energy use, as well as greater environmental sustainability. New renewable energy sources add to this advantage. Especially the north of the country and the far south have different advantages in this respect. Another critical aspect is economic stability, which remains attractive despite the country's changes.

The Ministry of Economy reports that we are facing the creation of a completely digital economy ecosystem, which as of September 2021 showed a total of 173 projects with an investment value of US $4.3 billion projected for four years, estimating that by the end of the year it could reach a total of US $5 billion. These projects include announcements from Microsoft, Huawei, Google, Oracle, Grade, Ascenty, Odata, Globant, Accenture, Edge-ConneX, StarLink, Terminal.io, K+S and Becton Dickinson, Equifax, IPNet, ZeroFox, Ubiquity, ThoughtWorks, Nisum, Arkano. Of these projects, investments of $1.491 billion were in the installation phase[58].

This environment is favourable to strengthening the Chilean government's involvement in HPC.

The Chilean government decided in 2010 the creation of national facilities for shared equipment. CMM (Centre for Mathematical Modeling, University of Chile) created the National Laboratory for High-Performance Computing (NLHPC) among the earned facilities. Today, more than 25 partners[59] give scientific support to this initiative and scientists from 49 institutions have access to this computing capacity, based on an open associative model, ensuring equal access to every researcher in the country, with significant support for PhD students and young researchers, regardless of their affiliation or research area. In this way, the NLHPC has become the largest national scientific network that shares critical infrastructure to do science. At the end of 2021, NLHPC was awarded funds to continue its operation for another ten years and will invest approximately USD 1.5 million in 2023 to renew its computing infrastructure.

The NLHPC operates within the University of Chile and makes funding requests to the State. This process could be improved. For almost a year, the NLHPC has been working on creating a consortium (in fact, a non-profit corporation) open to all Chilean universities and research centres, with equal rights and duties, to promote growth and sustainability in the long term. One of the main objectives of the

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[56] https://news.microsoft.com/es-xl/microsoft-announces-transforma-chile-to-accelerate-growth-and-business-transformation-including-a-new-datacenter-region-skilling-commitment-for-up-to-180000-citizens-and-advisory/

[57] https://www.subtel.gob.cl/subsecretario-francisco-moreno-el-despliegue-de-5g-permitira-a-chile-mantener-su-posicion-de-liderazgo-en-la-region/

[58] https://www.accenture.com/t00010101T000000Z__w__/cl-es/_acnmedia/PDF-71/Accenture-Digital-Index-Chile.pdf

[59] https://www.nlhpc.cl/acerca/socios/

consortium is to present the government with a long-term plan for the maintenance and frequent updating of the NLHPC infrastructure. The NLHPC authorities made a formal presentation to the national university community to formalize this consortium. The support of the Chilean university presidents was unanimous, enabling the creation of the consortium within two years. While the consortium is being formalized, the NLHPC will establish contact with the new government, which is fortunately already familiar with the laboratory.

HPC Infrastructure

System name	GUACOLDA - LEFTRARU	CHILEAN AIR FORCE
Location	NLHPC	In 2020 the Chilean Air Force announced that it would acquire a supercomputer. Its specifications are not public.
Web	https://www.nlhpc.cl/infraestructura/	
OS	Linux	
Processor architecture	Cluster Leftraru: 132 nodes, 2*E5-2660v2+48GiB+IB-FDR Cluster Guacolda: 59 nodes, 2*Gold-6152+192/768GiB+IB-FDR,4 V100 Storage: ESS: 3.391TiB IBM Spectrum Scale, via IB-HDR/EDR Tapes: 1.170TiB LTO8, via IB-FDR	
Vendor	Leftraru: HP Guacolda: DELL	
Processing capacity	266 Tflops	
Access policy	https://www.nlhpc.cl/servicios/	

Table 3. HPC infrastructure in Chile

Priority HPC research areas

The research areas in Chile using the HPC are pretty varied[60], including, among others: climatology, oceanography, bioinformatics, chemistry, physics, astronomy, engineering, ecology, economics and education. In astronomy, several research groups have entered astroinformatics to perform large simulations and handle the avalanche of data coming from the large astronomical centres, several installed in Chile. An iconic example of this is ALeRCE[61], an astronomical broker developed in Chile, substantially using the NLHPC infrastructure. In another example, Chilean climate science has also had a spectacular HPC-based breakthrough. A research group was able to simulate 30 years of the climate of the Antarctic Peninsula (several million hours of computation), allowing them to understand and simulate the weather fluctuations of the southern cone of the American continent will have, with the consequent impact on our country, the safety of its citizens, and our economy; and to propose mitigation actions that will have to be taken with years in advance. In quantum chemistry, new research areas are possible thanks to NLHPC: tunnelling magnetoresistance, computer-assisted materials discovery, flexible materials, the study of metabolism for drug discovery and prediction of new stable compounds. The advances in bioinformatics have also used the NLHPC in a critical way, for example, the 1000 Chilean Genomes Project[62], the single-cell sequencing and the TARA Ocean initiative, an oceanographic expedition on a global scale, which is collecting a massive quantity of information that will require HPC capabilities for our national associates (CMM-TARA)[63]. We emphasize the role that NLHPC has played in providing computing and storage capacity for several national projects related to COVID-19, where 14 research groups throughout Chile have used our infrastructure. Their research has advanced our understanding of this pandemic and has enabled them to propose public health strategies to control/mitigate its effects.

Strategic goals for collaboration with the EU

The relationship between Chile and the EU in terms of cooperation is longstanding. Currently, it goes beyond the transfer of resources, prioritizing an exchange of experiences and good practices to face common global challenges through multilateralism.

It should be noted that this relationship has been adapting to the new context of International Cooperation for Development, particularly concerning the challenges faced by Chile as a "Developing Country in Transition". Within this framework, on 25 November 2019, the "Bilateral Fund for Development in Transition Chile-European Union" was signed to establish a strategic dialogue on cooperation for development and respond to the collaboration scenario[64].

The EU actively cooperates with Chile through its regional programmes with Latin America, providing contributions to innovative programmes and international instruments. Cooperation is developed with

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60 https://www.nlhpc.cl/acerca/

61 http://alerce.science/

62 https://www.uchile.cl/noticias/146396/autoridades-participaron-en-el-lanzamiento-del-proyecto-1000-genomas

63 https://www.cmm.uchile.cl/?p=40222

64 https://chile.gob.cl/ue/en/bilateral-relation/international-cooperation/cooperacion-internacional

different actors at the national level, including the executive power, different state bodies, the public and private sector, and the academic area, among others.

This cooperation includes projects such as the link between security and development, good governance, accountability and social capital; inclusive and sustainable growth for human development; higher education and research and development; environmental sustainability and climate change; triangular cooperation and development in transition. The EU's contribution to Chile's Presidency of the United Nations Climate Change Conference (COP25) of EUR 7.5 million through the Euroclima+ programme should be highlighted[65]. Another example is Copernicus. During the first semester of 2018, the Chilean, Brazilian and Colombian governments signed a collaboration agreement with the Copernicus satellite program of the European Union[66]. In this context, the University of Chile, on behalf of Chile, has implemented a repository, in which lhe NLHPC plays an important role, since it is in its facilities that the data provided by Copernicus is handled. The target of this repository is to allow local free access to the Copernicus data covering Chile.

[65] https://www.euroclima.org/chile

[66] Call for Media. Space: European Commission to sign landmark Cooperation Arrangements with three Latin American partners. 5 March 2018. https://www.copernicus.eu/sites/default/files/EN%20-%20Call%20for%20media%20-%20European%20Commission.pdf

Colombia

Colombia covers an area of 1,138,910 km2, and it had an estimated population of 50,355,650 inhabitants in 2021. Despite being the 4th largest economy in Latin America, Colombia's Gross Domestic Product (GDP) per capita is 5.333 USD (115th worldwide). Colombia is an upper-middle-income economy[67].

Colombia´s economy heavily depends on energy and mining exports, increasing its vulnerability to international commodities prices. The economy slowed in 2017 because of falling world market prices for oil. The COVID-19 pandemic hit Colombia hard. However, economic activity has been recovering fast and, by June 2021, reached almost the same level as at the end-2019[68].

Strategic Goals and plans for the next 3-5 years

Since 2010, the information technology and communication ministry (MinTIC) has established national politics related to advanced computing and large-scale data exploitation for national interests for development. In the Peace Process between the Colombian Government and the FARC-EP Guerrilla, different proposals appear and follow the recommendations of international partners and studies from universities in Colombia to improve computing and connectivity capabilities, human resources skills, and competitivity. Different HPC initiatives born from universities and regions (condensed in the RISC-1 report) and the first document of economic and social politics inside the government, including High-Performance Computing, Big Data, and Artificial Intelligence, were presented in 2018, the "CONPES 3920"[69].

Another important aspect, also because of the support of different countries for the Peace Process, was the International Wise Mission (Misión de Sabios)[70] in 2019. The International Mission of Wise Men for the advancement of science, technology and innovation is made up of a group of 47 national and international experts whose objective is to contribute to the construction and implementation of public policy on Education, Science, Technology, and Innovation, as well as the strategies that Colombia must build in the long term, to respond to the productive and social challenges in a scalable, replicable and sustainable manner. One of the crucial proposals was creating the Science, Technology, and Innovation Ministery (MinCiencias).

The International Wise Mission defines eight main focuses: Biotechnology, Bioeconomy and Environment, Basic and Space Sciences, Life and Health Sciences, Social Sciences, Human Development and Equity, Sustainable energy, Creative and Cultural Industries, Ocean and

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[67] The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[68] The World Bank. Colombia overview. https://www.worldbank.org/en/country/colombia/overview#1

[69] CONPES is the Consejo Nacional de Politica Economica y Social from Planning Department, the entity responsible in Colombia to perform political documents as national development in Colombia. Retrieved from https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3920.pdf on 7 April 2022.

[70] Misión de Sabios. Colombia - 19. Retrieved from https://minciencias.gov.co/mision_sabios on 7 April 2022.

Hydrobiological Resources and Converging Technologies –Nano, Info and Cogno- Industries. All of them with the transversal support of advanced computing.

Due to the government changes in 2017, the peace process was perturbed, impacting policies. However, due to the national interest and different regional actions performed by universities and regional centres, it is possible to identify, by regions, two consortiums on HPC and Advanced Computing, one for non-profit and academic research, the Colombian Network of Advanced Computing, leading by the High Performance and Scientific Computing at Universidad Industrial de Santander (SC3UIS) with the Universidad de los Andes and the support of the National RNE RENATA for all academic and research institutions in Colombia, and the other, for-profit and general information technology support, led by the Colombian Bioinformatics Center (BIOS) and with the participation of the Universidad del Rosario and the MinTIC. The first consortium is named LaRedCCA, and a significant impact was observed during the COVID pandemic.

However, another HPC Center collaborates with the SC3UIS centre in a peer-to-peer relationship, the Apollo EAFIT Center, a private university centre to support research and HPC needs in the EAFIT University at Medellin, Colombia.

The main strategic goals and plans for the next 3-5 years are in three axes: robust infrastructure, collaboration, and impact. The first one is addressed to recover the initiative of the National Advanced Computer Center, from the experience and interaction between the SC3UIS and the Universidad de los Andes, with the support of Minciencias as the most important centres to provide HPC and HPC/AI support in Colombia for research and development. The second axe is to improve collaboration with the national institutions via LaRedCCA and with the international consortiums via SCALAC. The third one is to enhance the support of industrial and social projects with the other for-profit networks and enterprises, mainly the medium enterprises, with the help of the Industry, Tourism and Commerce Ministry and unions in Colombia.

Strategic aims in Science and Research

For Colombia, the strategic aims coincide with the ones proposed by the international "Wise Mission" in 2019 and the UN Sustainable Development Goals (SDGs). The Science, Technology, and Innovation Ministry (MinCiencias) takes these 17 goals as the basis for all calls for projects. For the Colombian government, all the goals support the country's development, and all the proposed projects will be inside the action of one of these goals.

Strategic Aims in HPC

Strategic aims in HPC are aligned with the international "Wise mission" and the SDG-related projects developed in Colombia. The current CONPES 3920 considers the SDGs and the International Wise Mission to provide a legal framework for the different calls for projects in science and technology. In the case of HPC and Artificial Intelligence, it is possible to summarize the specific aims of HPC as follows:

- Guarantee autonomy in large-capability infrastructure for AI support and Big Data.
- Improve human skills in HPC, AI, and Big Data knowledge and competitiveness.
- Increase the use of HPC in productive projects in industry and medium enterprises.

On the other hand, the academic community follows the initiative to create the Colombian Advanced Computing Center from the SC3UIS centre to leverage the support for the country's different regional projects and support the development of new centres more directly. A concern in the academic community is the high technological dependency motived by the actual government, despite the legal framework—the use of cloud platforms to support research or research projects.

Priority HPC research areas

- Hybrid/Accelerated Computing
- Large Scale Data
- HPC/AI Convergence
- Quantum Computing and Non-Von Newmann architectures
- HPC Ultrascale architectures

HPC Infrastructure

System name	GUANE	YAJE	FELIX	THOR	APOLO	BIOS - Centro de Bioinformática y Biología Computacional de Colombia	Laboratorio de Computación Avanzada para Investigación	ROSMME by DELL EMC
Location	SC3UIS (Bucaramanga)				Apolo EAFIT Center (Medellin)	BIOS (Manizales)	Universidad del Rosario (Bogotá)	Universidad de Cartagena (Cartagena de Indias)
Web	https://www.sc3.uis.edu.co/				https://www.eafit.edu.co/apolo#specifications	https://bios.co/infra/clusterhpc/	https://www.urosario.edu.co/Laboratorio-Computacion-Avanzada-Investigacion/Infraestructura/	
Processor architecture	**GUANE Frontend** ProLiant DL380 G7 Processor: 2 Intel(R) Xeon(R) CPU E5640 @ 2.67GHz - 16 Cores MemTotal: 94GB **GUANE 5 NODES Class 1**	ProLiant ML350 Gen9 Processor: 1 Intel(R) Xeon(R) CPU E5-2609 v3 @ 1.90GHz - 6 Cores MemTotal: 48GB	ProLiant DL580 G7 Processor: 4 Intel(R) Xeon(R) CPU X7560 @ 2.27GHz - 64 Cores MemTotal: 128GB	ProLiant DL580 Gen9 Processor: 4 Intel(R) Xeon(R) CPU E7-8867 v3 @ 2.50GHz - 128 Cores MemTotal: 1.2 TB	Master Node: 1 Server DELL PowerEdge R730: Intel Xeon E5-2683v4@2.10GHz (32 Cores) 32 GB RAM DDR4@2400 MHz. HDD: 480 GB SAS-3@12 Gbps. High-Speed Network Adapter:	**Cluster HPE** 7 ProLiant SL230s Gen8 32 Cores 256 GB RAM 2 ProLiant SL250s Gen8 32 Cores 256 GB RAM 2 Tesla K20m	**8 Nodes Lenovo** - Class 1 Node de 32 CPU cores and 4 Nvidia P100 by node - Class 2 Nodo de 32 CPU cores and 4 NVIDIA amper A30 by node	1 PowerEdge R330 4 Cores Intel(R) Xeon(R) CPU E3-1225 16GB RAM 5 PowerEdge R730 40 Cores 2 Intel(R) Xeon(R) CPU E5-2640 128GB RAM

	ProLiant SL390s G7 Processor: 2 Intel(R) Xeon(R) CPU E5645 @ 2.40GHz - 24 Cores MemTotal: 102GB Device: 8 NVIDIA Tesla M2050 3GB by node **GUANE - 3 NODES Class 2** ProLiant SL390s G7 Processor: 2 Intel(R) Xeon(R) CPU E5640 @ 2.67GHz - 16 Cores MemTotal: 102GB Device: 8 NVIDIA Tesla M2050 3GB by node **GUANE - 8 NODES Class 3** ProLiant SL390s G7 Processor: 2 Intel(R) Xeon(R) CPU E5645 @ 2.40GHz - 24 Cores	Device: 1 NVIDIA GeForce GTX Titan X 12 GB	Device: 2 NVIDIA GeForce GTX Titan X 12 GB by node		ConnectX-3 Dual Port. Coprocessing: 1 Server Dell PowerEdge R730: Intel Xeon E5-2683v4@2.10GHz (32 Cores) 64 GB RAM DDR4@2400 MHz. Coprocessor: nVidia Tesla K80 GPU: 2x Kepler GK210 Memory size (GDDR5) : 24GB (12GB per GPU). CUDA cores: 4992 (2496 per GPU). HDD: 1 TB SAS-3@12 Gbps. High Speed Network Adapter: ConnectX-3 Dual Port. Processing: 5 Servers DELL PowerEdge M630: Intel Xeon E5-2683v4@2.10GHz (32 Cores) 64 GB RAM DDR4@2400 MHz. HDD: 1 TB SATA III@12	2 ProLiant SL250s Gen8 32 Cores 256 GB RAM 2 Xeon Phi coprocessor 5100 1 ProLiant DL560 Gen8 64 Cores 1 TB RAM 1 Storage MSA P2000 G3 240 TB **Cluster INSPUR** 2 Administrator login node Inspur rack server NF5280M5 2 Intel Xeon 6126 128 GB RAM 1 MIC computing node Inspur NF6248 Fusion supercomputing server 4 Intel Xeon PHI 7210 192 GB RAM 20 Common node Inspur high-density serverNS5162M5 2 Intel Xeon 6132 192 GB RAM	180 TB shared storage	1 PowerEdge R640 88 Cores 4 Intel(R) Xeon(R) Gold 6152 320GB RAM

	MemTotal: 102GB Device: 8 NVIDIA Tesla M2075 5GB by node				Gbps. High-Speed Network Adapter: ConnectX-3 Dual Port. Big Memory: 1 Server HPE DL360 G9: Intel Xeon E5-2670@2.30Ghz (24 Cores) 388 GB RAM DDR4@2133 MHz. HDD: 1 TB SATA III. High-Speed Network Adapter: Connect-IB MT27600 Q SFP@56 Gbps Dual Port.	2 Fat node Inspur eigth-channel server TS860G3 8 Intel Xeon E7-8880v4 2048 GB RAM 3 GPU computing node Inspur rack server NF5280M5 2 Intel Xeon 6132 192 GB RAM 4 NVIDIA P100 1 Masive computing node Inspur K1-910 8 Itanium 9540 256 GB RAM 4 IO node Inspur rack server NF5280M5 2 Intel Xeon 6126 256 GB RAM 1 Inspur AS5300G2 mass storage 240 TB		
Vendor	HP						DELL	
Peak performance							40 TFlops	

Access policy	http://wiki.sc3.uis.edu.co/index.php/%C2%BFC%C3%B3mo_Acceder_a_los_Recursos%3F	https://apolo-docs.readthedocs.io/en/latest/gettingstarted/index.html#how-to-apply-for-computing-time-on-apolo		https://www.urosario.edu.co/Documentos/Administrativos/Tecnologia/Centauro/Reglamento-y-Politica-de-Uso.pdf	

Table 4. HPC infrastructure in Colombia

Strategic goals for collaboration with the EU

The EU support Colombia's efforts in developing regional policies, for which EU experience is highly regarded, in particular in the fields of cross-border cooperation, sustainable urban development and regional innovation strategies and policies, including policies and practices aiming at the successful inclusion and integration of migrants and refugees, in particular in border areas.

The meeting was preceded by the signature by Commissioner Ferreira and Vice President Ramirez of the new action plan on EU-Colombia Regional Policy Cooperation (2021-2025) to strengthen cooperation and exchange experience and good practices on regional development issues around four main areas: economic, social and territorial cohesion for stabilization and consolidation; border development and integration; economic development and economic recovery; and migration as a factor of development, including integration of migrants as part of migration policy.

The action plan is one of the first concrete instruments to advance sectoral dialogue and cooperation and take forward the "EU-Colombia Memorandum of Understanding on an Agenda of enhanced political and sectoral dialogue and cooperation for the next decade" adopted by the EU Commission.

In Science and Technology, the EU commission supports the participation of universities and centres in EU calls inside the different frameworks, mainly the calls addressed to postgraduate studies, removable energies, and environment preservation. Also, as a decentralized collaboration among the other EU countries and Colombia, bi-national programs exist, highlighting the special academic cooperation between France, Spain, Germany, and Italy. France is the first science and technology European partner in Colombia, followed by Spain, Germany, and Italy. France is the first destination for science and technology postgraduate formation in Europe.

Costa Rica

Costa Rica covers an area of 51.100 km2, and it had an estimated population of 5.151.140 inhabitants in 2021. The Gross Domestic Product (GDP) per capita is 12.141 (82nd in the world), and the Human Development Index is 0.810, among the 66 countries with very high human development. Costa Rica is an upper-middle-income economy[71].

Although the backbone of the Costa Rican economy is the agricultural sector, it includes powerful technology and tourism industries. The standard of living is relatively high, and Costa Rica has experienced steady progress toward universal access to healthcare, education, electricity and clean water supply.

Despite Costa Rica's robust health system and timely crisis response, the pandemic had a heavy toll on its economy. Gross Domestic Product (GDP) contracted 4.1 per cent in 2020, the most significant drop in four decades, driven by sharp declines in investment and private consumption[72].

Strategic Goals and plans for the next 3-5 years

According to the current National Plan for Development and Public Investment of Costa Rica[73], the overarching national goal is to generate inclusive economic growth at the regional and national levels, aware of the environment that produces high-quality employment and reduces poverty and inequality. National strategic goals are:

- Increase competitiveness, national productivity and the generation of formal employment in Costa Rica by promoting innovation, entrepreneurship, human resources training, insertion into the international market and compliance with labour rights.
- Generate conditions for urban planning, land use, infrastructure and mobility to achieve resilient, sustainable and inclusive urban and rural spaces.
- Guarantee the rights of people to live with dignity in their homes, in safe, protective and inclusive environments, satisfying the fundamental needs that favour their human development.
- Improve the population's health conditions to live more years free of diseases and without disabilities by promoting healthy lifestyles and expanding the Sickness and Maternity Insurance (SEM) and the Disability, Old Age and Death Insurance (IVM).
- Develop skills in people by increasing the coverage and quality of the educational system, contributing to the country's progress.

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[71] The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

[72] The World Bank. Costa Rica overview. https://www.worldbank.org/en/country/costarica/overview#1

[73] Plan Nacional de Desarrollo y de Inversión Pública del Bicentenario 2019-2022. Retrieved from https://sites.google.com/expedientesmideplan.go.cr/pndip-2019-2022/

- Keep inflation close to that of the country's main trading partners and promote the consolidation of public finances, facilitating the reduction of the cost of living, attenuating the trajectory of public debt and decision-making by the national productive sector.
- Improve the efficiency and stability of the financial system and the inclusion of segments with difficult access to financial services, contributing to the country's economic growth.
- Increase employment in peripheral regions through a participatory management model that promotes development.

Strategic aims in Science and Research

The current National Plan for Science, Technology and Innovation of Costa Rica[74] is based on the following principles: respect for human dignity, universality, human development, collaborative creation, ethics, and gender equality. The plan relies heavily on the National Information System on Science, Technology and Innovation (SNCTI). The plan establishes these strategic areas:

- Human talent:
    - Promote training of STEAM teaching faculty.
    - Increase the number of people who graduated from STEAM programs.
    - Increase the advanced human capital.
- Knowledge generation:
    - Articulate efforts of SNCTI members to increase scientific production.
    - Improve practices to regulate R&D activities.
    - Provide optimal conditions for knowledge generation.
- Transforming innovation:
    - Foster interaction of SNCTI members to accelerate innovation.
    - Develop competencies for technology transfer and innovation.
    - Develop and move forward with funding mechanisms.

The plan includes transversal and emergent topics: human health and life sciences research, bioeconomy, digital technologies, artificial intelligence, and aerospace development.

[74] https://www.micitt.go.cr/sites/default/files/pncti_2022-2027_30112021.pdf

Strategic Aims in HPC

- Consolidate a handful of leadership HPC centres across the country capable of offering high-quality computing services in simulation, artificial intelligence, and data science.
- Integrate more research laboratories by adding advanced computing into their scientific workflows, either automating some stages or adding additional stages with data analytics, simulation or pattern recognition.
- Increase the sophistication of the community of users of HPC services with training in high-level technologies with a lower learning curve for interacting with HPC tools and infrastructure.
- Enrich the HPC ecosystem with alliances with research centres and industry partners to promote a healthier exchange of experiences, talent and resources.
- Consolidate international collaboration and networking with scientific programs with leading institutions in the Americas and Europe.
- Secure government funding for sustaining the infrastructure and research programs in HPC.

Priority HPC research areas

- Computational Earth Sciences. Considering that Costa Rica sits on the Pacific Rim of Fire (a region with high seismic and volcanic activity globally), both seismology and volcanology will require simulation, data analysis and machine learning to push the envelope in their respective fields. Costa Rica is also an oceanic country (most of its territory is in its patrimonial sea), and marine modelling is fundamental for boosting economic activities. Additionally, climate change will force the use of more complex climate modelling and simulation.
- Bioinformatics. Since Costa Rica enjoys significant biodiversity developing sophisticated bioinformatics pipelines for genomic sequence analysis will be crucial. Furthermore, protein folding algorithms and molecular dynamics simulations will be fundamental for drug discovery and other pharmaceutical applications.
- Computational Physics. As Costa Rica is committed to maintaining more than 99% of its electricity production from renewable sources, developing more plasma physics reactors is imperative. A country with substantial water resources begs for precise computational fluid dynamics models for understanding the dynamics of all rivers. Also, as the National Development Plan points out, space exploration in astrophysics and space engineering will play a significant role in the country's future. Both will demand a massive amount of computation. Finally, health physics will be increasingly crucial for reaching better health services.
- Big Data Analytics. As data sources become more prevalent and productive, developing a solid platform for data exploration and understanding will be essential. Massive datasets are available from vehicle traffic, health records, and social welfare institutions. Those databases require the best techniques for data analysis and pattern recognition. In addition, bioacoustic analysis from marine mammals and birds will need that platform.

HPC Infrastructure

System name	Kabré Supercomputer	University of Costa Rica (UCR)	National University (UNA)
Location	National High Technology Center (CeNAT)	Materials Science and Engineering Research Center (CICIMA)	National University (UNA) - School of Physics
Web	https://kabre.cenat.ac.cr/	http://www.cicima.ucr.ac.cr/index.php/en/	https://www.una.ac.cr/
OS	Linux CentOS 7.2	Ubuntu 20.04 LTS	Linux CentOS 6.7
Processor architecture	Simulation nodes (32 nodes): Intel Xeon Phi KNL, 64 physical cores, 96 GB of main memory Data science nodes (5 nodes): Intel Xeon, 24 physical cores, 16-128 GB main memory Machine learning nodes (8 nodes): Intel Xeon, 16 physical cores, 16-32 GB main memory, half the nodes with NVIDIA K40 GPU, half with NVIDIA V100 GPU Bioinformatics nodes (7 nodes): Intel Xeon, 24 physical cores, 512-1024 GB main memory Storage capacity: 120 TB	Head nodes (1 node): Intel Xeon, 20 physical cores, 64 GB main memory Computing nodes (14 nodes): Intel Xeon, 20 physical cores, 64 GB of main memory Storage capacity: 65 TB	Head nodes (1 node): Intel Xeon, 20 physical cores, 64 GB main memory. Computing nodes (11 nodes): Intel Xeon, 20 physical cores, 64 GB main memory. Storage capacity: 12 TB
Access policy	Restricted to students and staff of all public universities in Costa Rica	Restricted to students and staff of the University of Costa Rica	Restricted to students and staff of the National University

Main research domains	Full computational science spectrum, big data, artificial intelligence, bioinformatics	Astrophysics, particle physics, nuclear physics, quantum mechanics, molecular dynamics, plasma physics, bioinformatics, criminology	Computational physics, bioinformatics

Table 5. . HPC infrastructure in Costa Rica

Strategic goals for collaboration with the EU

Costa Rica and Europe have a long-standing tradition in cooperation. The Delegation of the European Union in the country was established in 1984, having reached political maturity. Two mechanisms help implementing that relationship. First, the Political Dialogue and Cooperation Agreement (PDCA) between the European Union and Central America of 2014[75] has intensified political dialogue and cooperation on issues of regional integration and plans for social cohesion, environment, education, science, and technology. Second, the EU-Central America Association Agreement[76] strengthens the pillars of policy, cooperation, and trade.

The National Council of Rectors (CONARE), an association of all public universities in the country, has lately signed cooperation agreements with European institutions. For instance, there is an agreement with the Max Planck Society[77], the German Research Foundation (DFG)[78], and LHCb at CERN. Those agreements are specific for research, education, and technology transfer projects. They include all campuses of all five public universities. In addition, specific agreements have been signed by individual universities with European institutions.

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75 "EU-Central America political dialogue and cooperation agreement". https://eur-lex.europa.eu/EN/legal-content/summary/eu-central-america-political-dialogue-and-cooperation-agreement.html

76 "EU-Central America Association Agreement". https://trade.ec.europa.eu/access-to-markets/en/content/eu-central-america-association-agreement

77 https://www.conare.ac.cr/transparencia/servicios-y-tramites/fondos-del-sistema/category/48-max-planck

78 https://www.conare.ac.cr/transparencia/servicios-y-tramites/fondos-del-sistema/category/49-dfg

Mexico

Mexico covers an area of 1.964.375 km2, and it had an estimated population of 130.207.371 inhabitants in 2021 (10th in the world)[79]. The Gross Domestic Product (GDP) per capita is USD 8.329 (89th globally)[80]. Despite being the 11th largest globally, Mexico's income distribution remains highly unequal[81]. Mexico is an upper-middle-income economy[82].

In 2020, with the onset of the COVID-19 crisis, Mexico's GDP contracted by 8.3%, its lowest level since the Great Depression[83]. Over the last three decades, Mexico has underperformed in growth, inclusion, and poverty reduction compared to similar countries. Its economic growth averaged just above 2 per cent a year between 1980 and 2018, limiting progress in convergence relative to high-income economies[84].

Strategic Goals and Plans for the next 3-5 years

The Mexican National Development Plan 2019-2024[85] introduces the National Plan for Innovation among the responsibilities of the National Council of Science and Technology (Conacyt). The National Plan for Innovation (PNi) aims to articulate national innovation efforts to benefit society and national development with the participation of universities, towns, scientists, private companies and public bodies. In December 2020, as part of generating the PNi, the General Council for Scientific Research, Technological Development, and Innovation established the priorities for the Humanities, Sciences, Technologies and Innovation system (HCTI): Health, Energy and Human Security.

One of the main priorities under development is the national innovation agendas, with their corresponding roadmaps for the short (2021), medium (2022) and long term (2024), as well as the investment needed to secure them.

Within the cross-cutting strategies, HCTI efforts have been established in coordination with different actors, using key tools such as Artificial Intelligence, Industry 4.0, robotics, and digital strategy, among others, for the diagnosis, treatment and prevention of priority challenges to contribute to social welfare.

The National Digital Strategy 2021-2024 (DOF - Official Gazette of the Federation, 2021) is a set of actions that the Government of Mexico carries out to promote the use and development of Information

[79] CIA. The World Factbook. Mexico. Retrieved from https://www.cia.gov/the-world-factbook/countries/mexico/ on 1 April 2022.
[80] World Bank. GDP per capita in US$. Retrieved from https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?most_recent_value_desc=true on 1 April 2022.
[81] World Bank. Gini index (World Bank estimate) Retrieved from https://data.worldbank.org/indicator/SI.POV.GINI on 1 April 2022.
[82] The World Bank. World Bank Country and Lending Groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
[83] CIA. The World Factbook. Mexico. Retrieved from https://www.cia.gov/the-world-factbook/countries/mexico/ on 1 April 2022.
[84] The World Bank. Mexico overview. https://www.worldbank.org/en/country/mexico/overview#1
[85] Conacyt. Dirección Adjunta de Desarrollo Tecnológico, Vinculación e Innovación. Retrieved from https://conacyt.mx/conacyt/areas-del-conacyt/desarrollo-tecnologico-e-innovacion/ on 1 April 2022.

and Communication Technologies (ICT), especially connectivity to the Internet. The strategy's mission is to promote and encourage Mexicans to enjoy and benefit from access to information and communication technologies and broadband and Internet services and their potential. This strategy has two lines of action: (1) Digital Policy. Transform the Federal Public Administration through the use and exploitation of ICTs to improve and make transparent government services provided to citizens. (2) Digital Social Policy. Increase Internet coverage throughout the country to combat marginalization and connect the poorest and most remote areas, facilitating their integration into productive activities. With this axis, it is sought that health centres and hospitals have wireless internet and other spaces such as schools, public squares, or highways.

In the article (Toche, 2022) (Government of Mexico & Conacyt, 2020), advances in the new Science and Technology Law are presented, which is still pending definition in the chambers of deputies and senators. This law initiative establishes the need to create a National Information System that will constitute, manage, and keep the National Information System up to date to guarantee the implementation of a comprehensive open science policy. The National Information System will also include data related to technical services for technological modernization, standardization, industrial property, technological development and innovation. The details of this system are described in the seventh title entitled "On Information" in Chapter I, "On the National Information System". Chapter II, "Of the repositories" describes "a national strategy for access to information in the field of humanities, sciences, technologies and innovation, to guarantee that universal and cutting-edge knowledge is available to the people of Mexico, in particular, for students, academics, researchers, humanists, scientists, technologists and innovators.

In 2021, the Federal Telecommunications and Broadcasting Law (DOF - Official Gazette of the Federation, 2021) was published. Chapter I, "From the National Registry of Mobile Telephony Users", mentions the need to manage and process large volumes of data. Considerable computing power will be required to deal with the processing of this data. This pattern could reach more than 88 million users when in 2019, it was 86.5 million users. This information is obtained from the National Survey on Availability and Use of Information Technologies in Households (ENDUTIH) 2020 (INEGI, 2021).

This survey also shows the growth of internet users in Mexico, which has already reached 84.1 million internet users, representing 72.0% of the population aged six or older. This figure reveals an increase of 1.9 percentage points compared to that registered in 2019 (70.1%).

Similarly, the survey estimates that 78.3% of the population located in urban areas are users, while mobile telephony in rural areas is 50.4%. In 2019 users in urban areas were estimated at 76.6%, and in rural areas, the estimate was 47.7%.

The three principal means for connecting users to the Internet in 2020 were: smartphones with 96.0%, laptops with 33.7% and televisions with Internet access with 22.2 %.

This increase in mobile telephony confirms the increase in access to services of the different levels of government, which must be implemented in the coming years. The main activities carried out by Internet users in 2020 are communicating (93.8%), searching for information (91.0%) and accessing social networks (89.0%).

Finally, an exciting fact extracted from the ENDUTIH is that there is an increase of almost ten percentage points in the use of the computer at home compared to 2019, when it is used for: school work (54.9%), work activities (42.8%) and as a means of training (30.6%).

Undoubtedly, this increase in Internet use will demand greater consumption of government technology services and access to public information in the coming years.

In the health sector, the need for supercomputing policies is also evident. An example is the General Health Law (Chamber of Deputies of the H. Congress of the Union, 2022). Article 53 Bis instructs health service providers to register biometric data, and other electronic identification means. This suggests the processing of millions of data to access health services. Similarly, article 109 Bis of the same law establishes the need to guarantee the interoperability, processing, interpretation and security of the information contained in electronic clinical records. This requirement suggests the need for high-performance computing technology to maintain the quality of service to Mexican health centres.

In this same sense, the Health Sector Program (DOF - Official Gazette of the Federation, 2020), derived from the National Development Plan 2019-2024 in its chapter I entitled "Common Provisions" in the sixth article, defines the objectives of the National System of Health as a promoter of the development of health services. This development must be based on the integration of Information and Communication Technologies. Similarly, in the seventh article, the system is defined as a promoter of the incorporation, use and exploitation of Information and Communication Technologies in Health services;

In the oil sector, there is a similar vision in the Oil Law (DOF - Official Gazette of the Federation, 2014) in the third chapter, "Of the information obtained from Reconnaissance Superficial Exploration, Exploration and Extraction of Oil". Article 33 establishes that the information obtained from Surface Reconnaissance and Exploration activities must be delivered to the National Oil Commission. The report includes Acquisition, processing, reprocessing, interpretation and geological control of the seismic pre-processing, interpretation of seismic data, velocity and migration model, in time and in-depth, among other data.

In this same law, article 35 defines a National Oil Information Center, made up of a system to collect, store, safeguard, administer, use, analyze, keep updated and publish the information and statistics related to various data related to oil.

In this sense, the National Oil Information System (DOF - Official Gazette of the Federation, 2010) in its Chapter I, "General Provisions", article 4, establishes that it must receive various data related to the sector.

The energy sector is no exception since Chapter II, "On the Energy Transition Information System", defines the Energy Information System within the National Statistical and Geographic Information System (SENER | Energy Information System, 2022). Article 98 establishes that the system aims to record, organize, update and disseminate information on the sustainable use of energy. The Law of Energy Transition (DOF - Official Gazette of the Federation, 2015) in chapter six, "Of the Intelligent Electrical Networks Program", article 37, proposes the "Intelligent Electrical Networks Program" to support the modernization of the National Transmission Network and the General Distribution Networks, to maintain a reliable and safe infrastructure that meets the electricity demand in an economically efficient and sustainable manner, and that facilitates the incorporation of new technologies that promote cost reduction in the electricity sector.

Article 38 defines that the Smart Electricity Grids Program must identify, evaluate, design, establish and implement strategies, actions and projects regarding electricity grids, among which the following may be considered: (a). The use of digital information and control technologies to improve the reliability, stability, security and efficiency of the National Transmission Network and the General Distribution Networks; (b). The dynamic optimization of the operation of the National Transmission Network and the General Distribution Networks and their resources; (c). The development and integration of distributed generation projects, including those for generation from Renewable Energies;

On the other hand, in the Energy Sector Program (DOF - Official Gazette of the Federation, 2020) derived from the National Development Plan 2019-2024, priority objective six establishes that guidelines, quality standards, validation mechanisms must be determined, processing, updating, safeguarding, publication and access to the information of the sector with the corresponding participation of the Secretariat and other actors of the industry.

In terms of massive data management, the Law of the National Statistical and Geographic Information System (DOF - Official Gazette of the Federation, 2018), in the section "Of the National Subsystem of Government, Public Security and Delivery of Justice", article 28 Bis, establishes that the subsystem

> "will have the objective of institutionalizing and operating a coordinated scheme for the production, integration, conservation and dissemination of statistical and geographic information of national interest, of quality, pertinent, truthful and timely that allows knowing the situation of the management and performance of the public institutions that make up the State and their respective powers in the functions of government, public security and administration of justice, to support the processes of design, implementation, monitoring and evaluation of public policies in these matters."

Strategic Aims in Science

The key objectives of the Conacyt Institutional Program for 2020-2024[86] are the following:

a) Strengthen the Science, Technology and Innovation community through training, consolidation and linkage with different sectors of society to face national priority problems from an inclusion-focused approach.

b) Articulate an innovation ecosystem that integrates scientific, technological and innovation development stakeholders in the country to meet national priorities, respectful of the environment, the biocultural wealth and society.

c) Increase the impact of humanistic, scientific, and technological knowledge in solving the country's top problems through the Strategic National Programs and society's benefit.

[86] Diario Oficial de la Federación. PROGRAMA INSTITUCIONAL 2020-2024 DEL CONSEJO NACIONAL DE CIENCIA Y TECNOLOGÍA. Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5595309&fecha=23/06/2020 on 1 April 2022.

d) Strengthen and consolidate the capacities of the country's scientific community to generate cutting-edge scientific knowledge to impact the well-being of the population and the environment positively.

e) Articulate and strengthen the country's scientific, humanistic, and technological capacities by linking with regional actors to influence national strategic problems favouring social benefit, environmental care, biocultural wealth, and common goods.

f) Expand the impact of sciences, humanities, and technologies by articulating, collaborating, and defining standards between universities, research centres, and government agencies, improving national science-based public policies for social welfare.

Strategic Aims in HPC

Mexico has significant experience using supercomputers, which began in 1991 when Universidad Nacional Autónoma de México (UNAM) installed a Cray YMP. Afterwards, Mexico appeared in the Top 500 supercomputing list several times: for example, the case of the oil industry (Top 83, Top 84, and Top 85 in the list of November 2003). A few years later, UNAM and Universidad Autónoma Metropolitana (UAM) placed computers in slots 126 (2006) and 225 (2008).

Other outstanding projects in Mexico were the National Laboratory for High-Performance Computing in Mexico City (UNAM-UAM-CINVESTAV), the National Supercomputing Center of San Luis Potosi within the Instituto Potosino de Investigación Científica y Tecnológica (IPICYT), the Grids National Laboratory, the National Supercomputing Laboratory of the Southeast (LNS) from the Benemérita Universidad Autónoma de Puebla, and ABACUS-CINVESTAV, which placed its supercomputer ABACUS-I in the 255 slot of the top 500 list of June 2015. In addition to these laboratories, there are new supercomputer centres in development by the University of Guadalajara (Leo Atrox) and the University Autonomous of the State of México (UAEMEX).

Although Mexico counts with a platform and solid experience in supercomputing, these supercomputing resources are not enough to conduct research and development.

The continuous joint effort by national institutions, organizations, and government should positively impact the need for computer power in academia, government, society, and industry to further advance research and development.

Since the beginning of the current federal administration, Mexico has been in the process of political-economic transformation that has impacted all the productive sectors of the country. During this period, several changes have been made to laws that govern the strategic dependencies of the federal government. Dependencies such as Health, Energy, Hydrocarbons, Education, Citizen Attention, Geography and Statistics, among others, have made modifications to their legal environment to initiate the capture, processing, and administration of large volumes of data. These laws are oriented to the General Law of "Protection of Personal Data in Possession of Obligated Subjects" in force since 2017 by the Mexican government (DOF - Official Gazette of the Federation, 2017). These laws have made the federal government aware of the need to establish a technological infrastructure that supports the capture, transmission and administration of large volumes of data.

Consequently, HPC activity in Mexico has focused on strengthening installed hardware and software capacities in educational institutions and research centres under the CONACYT National Laboratory Program (PLN-CONACYT, March 2021). Within this program, it is expected that the country's humanistic, scientific, technological and innovation infrastructure will be generated, developed, consolidated and strengthened. In this way, the laboratories are expected to promote universal access to knowledge and its benefits while contributing to fulfilling the objectives of the National Development Plan and the Special Program for Science, Technology and Innovation.

In this same sense, state governments have made efforts to support science and technology with a particular interest in data science, robotization in the software of administrative processes, industry 4.0 and artificial intelligence applied to topics of interest to the state. There are successful examples, such as the governments of Baja California, Nuevo León, Guanajuato, Jalisco, and Veracruz, among others. Training programs have been applied in the definition, use, and evaluation of technological tools that require advanced computing in these states.

In industry, HPC application areas are being promoted in topics such as industry 4.0, distribution logistics and production forecasting systems based on artificial intelligence. For example, CANIETI reports the existence of 38 high-tech clusters involving more than 2,100 companies in 28 entities in the country (CANIETI, 2012). Its report indicates more than 900,000 jobs in Mexico related to the ICT industry, of which 600,000 are professionals in information technology and 400,000 are professionals specialized in software. In (CANIETI Noreste, 2020), it is reported that the organization perceives an increase in areas such as RPA's (Robotic Process Automation) to automate repetitive and routine tasks, data use strategy, artificial intelligence, the Internet of things (IoT) and cybersecurity among others.

On the other hand, the National Chamber of the Transformation Industry (CANACINTRA) presented, in 2021, the program of the National Network of Innovation Nodes in which 14 states of the Republic participate (Ávila A., 2021). These nodes will support joint projects on mathematics, simulation, data science and artificial intelligence. Among the participating sectors are the aeronautical, automotive, chemical, and pharmaceutical sectors.

In this same sense, the National Chamber of Commerce, Services and Tourism (CANACO Servytur) promotes the introduction of new technologies, especially data science and artificial intelligence applied to business, in affiliated companies through its annual event “Tech Summit” (CANACO Monterrey, 2021).

In March 2022, the federal government, through CONACYT, has published the call for the granting of a "Fiscal Stimulus for Technology Research and Development" (Conacyt, 2022; Official Gazette of the Federation, 2022), where Mexican organizations can increase private investment in scientific research and technological development in the country. This incentive is granted through a tax credit to the taxpayer who spends and invests in research and technological development, creditable against the taxpayers' income tax and can be exercised over ten years until exhausted.

Priority HPC Research Areas

In Mexico[87], ABACUS, the Laboratory for Applied Mathematics and HPC at the Centro de Investigación y de Estudios Avanzados (CINVESTAV), exemplifies the diverse HPC initiatives grouped in the Mexican Network in HPC (REDMEXSU).

CINVESTAV is a public institution ranked within the top Mexican National Research Centers and Postgraduate Education Institutions. Through ABACUS and LANCAD, a prime provider of HPC resources to Mexico's scientific and technological communities, CINVESTAV has an outstanding record regarding initiatives to foster interaction between academia, government, industry, and society successful track of worldwide collaboration. ABACUS houses one of the top Latin American research supercomputers, placed 255th in the TOP500 list of July 2015, with an updated total performance of ~0.5 petaflops and a storage capacity of 1 petabyte.

Since 2016, ABACUS has supported scientific efforts to solve complex problems through collaborative work between different research communities spread throughout Mexico. ABACUS has assisted more than 140 research projects and over 250 academic articles.

Examples of research areas are:

- numerical simulation of vascular malformations in the brain;
- studies of racemization of molecular helices;
- numerical simulation of environmental hazards;
- sandpile simulations and applications;
- covering arrays and software testing;
- cryptographic algorithms;
- simulation of subatomic processes;
- simulation of astrophysical phenomena;
- Energy: the ENERXICO Project[88].

HPC Infrastructure

According to specific regional research and technological needs, Mexico has funded different HPC public infrastructures. Consequently, at least ten HPC centres are housed in state universities, federal research centres, and National Council for Science and Technology (Conacyt) centres. These

[87] Gitler, Gomes, Nesmachnow. "The Latin American Supercomputing Ecosystem for Science" in Communications of the ACM (CACM). November 2020. Vol. 63. N. 11.

[88] ENERXICO Project. Retrieved from https://enerxico-project.eu/ on 1 April 2022.

supercomputing centres are members of the Mexican Network of HPC (REDMEXSU)[89], which offers coordinated HPC resources and training to research communities in the country.

[89] Red Mexicana de Supercómputo (REDMEXSU). Retrieved from http://www.redmexsu.mx/ on 1 April 2022.

System name	LEO ATROX	ABACUS I	XIUHCOATL	THUBAT KAAL II	CUETLAXCOAPAN	YOLTLA	MIZTLI
Location	Center for Data Analysis and Supercomputing (CADS) - University of Guadalajara	Laboratory for Applied Mathematics and HPC (ABACUS - CINVESTAV)	CGSTIC - CINVESTAV	Centro Nacional de Supercómputo (CNS)	Laboratorio Nacional de Supercómputo del Sureste de México (LNS)	Laboratorio de Supercómputo y Visualización en Paralelo (LSVP) UAM–Unidad Iztapalapa- Laboratorio Nacional de Cómputo de Alto Desempeño (LANCAD)	Dirección de Cómputo y de Tecnologías de Información y Comunicación (DGTIC) - Laboratorio Nacional de Cómputo de Alto Desempeño (LANCAD)
Web	https://cgsait.udg.mx/cads	https://www.abacus.cinvestav.mx/	http://www.lancad.mx/?p=1182	https://cns.ipicyt.edu.mx/	https://lns.buap.mx/	http://www.lancad.mx/?page_id=96	http://www.lancad.mx/?p=59
OS	N/D	Linux	Linux CentOS 6.X	RedHat 7.3	N/D	Linux CentOS	RedHat Enterprise Linux, Scientific Linux RedHat Enterprise.
Processor architecture	150 nodes in total: - 140 nodes XEON Gold. - 4 nodes Fat. - 2 nodes NVIDIA Tesla P100. - 4 nodes XEON PHI.	Two sub-systems: SGI ICE-XA (CPU nodes) and SGI ICE-X (GPU nodes)	CPU x86 in 213 nodes: - 67 nodes AMD Interlagos 6274. - 84 nodes Intel X5675. - 62 nodes Intel E5-V4. GPU/Co-processors in 40 nodes: - 5 Nodes GPUs NVIDIA 2070/2075 & Intel X5675. - 12 Nodes GPUs NVIDIA K40 & Intel E5-2650L v3.	- 86 nodes: 82 INTEL XEON X86 BITS SKYLAKE & 4 nodes with 4 cards NVIDIA p100 each - Workload manager: SLURM - Storage system: Lustre High availability 1.7 PB. - Network: Infiniband EDR	228 nodes Thin (5472 cores). 2 CPU of 12 cores and 128 GB RAM. 20 nodes Fat (480 núcleos). 2 CPU of 12 cores and 512 GB RAM. 20 nodes semi Fat (480 núcleos). 2 CPU of 12 cores and 256 GB RAM.	Management nodes (1 master node, 2 service nodes): 2 processors Intel Intel(R) Xeon(R) CPU E5-2695 v2 @ 2.40GHz. 188 nodes : 2 processors Intel(R) Xeon(R) CPU E5-2670 v2 @ 2.50GHz. 58 nodes : 2 processors Intel(R) Xeon(R) CPU	X86 processor: - 332 nodes HP Proliant SL230 y SL250. - 2 processors Intel Xeon per node. - 5312 cores. GPU processor: 16 GPUs NVIDIA M2090.

System name	LEO ATROX	ABACUS I	XIUHCOATL	THUBAT KAAL II	CUETLAXCOAPAN	YOLTLA	MIZTLI
			- 4 Nodes Xeon-Phi 7120P. - 19 Nodes GPUs NVIDIA K80 Intel E5-2660 v3.	100GBPS - All to All topology	2 nodes Big Fat (120 núcleos). 2 CPU of 30 cores and 1024 GB RAM (1TB). 2 nodes with GPU with 2 cards K40 Nvidia (11520 cores CUDA). 2 CPU of 12 cores and 128 GB RAM. 2 nodes with MIC with 2 cards 7120P Intel (244 cores MIC). 2 CPU of 12 cores and 128 GB RAM.	E5-2660 v3 @ 2.60GHz 46 nodes : 2 processors Intel(R) Xeon(R) CPU E5-2683 v4 @ 2.10GHz	
Manufacturer	Fujitsu	SGI	Hybrid cluster (INTEL, AMD, NVIDIA-GPU and INTEL co-processors)	ATOS Bull	Fujitsu	DELL	HP
Peak performance	504 Tflops	429 Tflops (284 Tflops Linpack CPUs + 145 Tflops Linpack GPUs)	313 Tflops	257 Tflops	250 Tflops	152 Tflops	118 Tflops
Access policy	N/D	N/D	http://www.lancad.mx/?page_id=236	http://cns.ipicyt.edu.mx/index.php/2021/0	https://lns.buap.mx/?q=file/politicasdeuso2021-v11	http://www.lancad.mx/?page_id=236	http://www.lancad.mx/?page_id=236

System name	LEO ATROX	ABACUS I	XIUHCOATL	THUBAT KAAL II	CUETLAXCOAPAN	YOLTLA	MIZTLI
				3/13/politicas-de-uso-thubat-kaal-2-0/			

Table 6. HPC infrastructure in Mexico

Strategic Goals for Collaboration with the EU

The Mexican National Council of Science and Technology (Conacyt) announced in March 2022[90] the new co-funding scheme "Puerta Horizonte Europa", which will provide financial support for Mexican partners in successful Horizon Europe projects. Following the co-funding scheme started in 2014, this new strategy aims to encourage the participation of Mexican entities in Horizon Europe calls and strengthen bilateral relations in science, technology and innovation. The strategic areas are health, energy and human security.

These funding schemes continue with the interest stated by the EU and Mexico at the 9th Joint EU-Mexico Steering Committee meeting[91] hosted by Conacyt in March 2018, when both sides emphasised the need to deepen, scale up and open cooperation in selected thematic areas:

- Information and Communication Technologies: Building on the successful activities of the last years, both parties have intensified the collaboration on FIWARE technologies. A flagship EUMexico joint call on High-Performance Computing (HPC) will develop a strategic partnership in HPC that enables advancing the work on HPC applications in domains of common interest such as energy, including oil, and life sciences, earth sciences, climate change and air pollution, and natural disasters. Mexican partners are developing exascale-ready application code, such as the first Smoothed Particle Hydrodynamics-based code for the numerical simulation of oil reservoirs. Furthermore, novel applications of AI are being implemented to mimic the insight and experience of the experts who need to make inferences based on-field characteristics.

- Energy research is exemplified in projects such as GEMex and ENERXICO. The ENERXICO project built upon the expertise of a consortium of 15 institutions from Mexico and the EU to deliver groundbreaking new energy solutions, including wind turbine simulations to improve the efficiency of wind farms and make wind energy more competitive, geophysics exploration and oil reservoir modelling, and thermo- and fluid-dynamic processes of biofuel combustion for transportation.

- Health research encourages cooperation through the flagships of cancer research and personalized medicine.

- Both sides pledged to encourage cooperation between European and Mexican research centres under the Climate and Resource Efficiency challenge and ensure participation in the flagships on nature-based solutions and sustainable urbanisation and climate change impacts on biodiversity and ecosystem services. Further increased cooperation through multilateral platforms is also encouraged, such as the Belmont Forum and the Group on Earth Observations (GEO).

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[90] European Commission, 24 March 2022. "CONACYT announces its commitment to finance Mexican institutions and researchers participating in Horizon Europe calls". Retrieved from https://ec.europa.eu/info/news/conacyt-announces-its-commitment-finance-mexican-institutions-and-researchers-participating-horizon-europe-calls-2022-mar-24_en on 1 April 2022.

[91] "Roadmap for EU - Mexico S&T cooperation" (October 2018). Retrieved from https://ec.europa.eu/info/sites/default/files/research_and_innovation/strategy_on_research_and_innovation/documents/ec_rtd_mx_roadmap_2018.pdf on 1 April 2022.

- Both parties also recognized the consolidation of the EU-LAC partnership in R&I under the Common Research Area. They ensured greater access for Mexico to pan-European research infrastructures of global nature. They consolidated Mexico's leading role in helping to define the scope of the Research Infrastructures working group and the sustainable urbanisation task force.

Uruguay

Uruguay has an extension of 176.000 km^2 and 138.000 km^2 of jurisdictional waters. Uruguay has an estimated population of 3.51 million, of whom 2 million live in the metropolitan area of Montevideo, its capital.

The level of security, high literacy rate, and high levels of health confirm that the quality of life is one of the principal characteristics of the country. It is the most reliable country in Latin America and the Caribbean, ranking number one in the Democracy Index[92], Low Corruption[93], Civil Liberties[94], Rule of Law Index[95], Social Mobility[96], and E-Government Development Index[97].

Uruguay is a leader in the generation of clean energies, ranking #2 in the world according to the 2019 report from REN21, with 97% of renewable energy generation in its energy generation matrix (i.e. 44% hydraulic, 32% wind, 18% biomass, 3% thermal, 3% photovoltaic)[98]. It ranks number one globally on Energy Transition Index[99] and Green Future Index[100].

Finally, Uruguay ranks number one in Internet connectivity in LAC with the most remarkable Internet penetration of fixed broadband and the most significant percentage of homes and companies connected by optical fibre in LAC, according to the World Economic Forum (2019), and the United Nations (2020).

Strategic Goals and plans for the next 3-5 years

Uruguay has committed to advance in technology and sustainability in both the short and long terms. The national government, working transversally with ministries, autonomous entities, and decentralized services, has taken on the responsibility of leading public policies around developing smart technological solutions and complying with sustainable development goals. Global commitments have been translated into specific national and local plans to adapt them to the realities of each territory, building upon institutional and intersectoral cooperation and coordination, as well as collaboration with the public and private sectors, civil society, academia, media, and research centres.

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92 Economist Intelligence. Democracy Index 2020. https://www.eiu.com/n/campaigns/democracy-index-2020/

93 Transparency International. Uruguay. https://www.transparency.org/en/countries/uruguay

94 Freedom House. Uruguay. https://freedomhouse.org/country/uruguay/freedom-world/2021

95 World Justice Index. Uruguay. https://worldjusticeproject.org/rule-of-law-index/country/2021/Uruguay/

96 World Economic Forum (2020). The Global Social Mobility Report 2020. https://www3.weforum.org/docs/Global_Social_Mobility_Report.pdf

97 United Nations. e-Governement Knowledgebase. https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/185-Uruguay

98 REN21. Renewables Global Status Report. https://www.ren21.net/reports/global-status-report/?gclid=CjwKCAjwur-SBhB6EiwA5sKtjpsQbh50ltKxO9sUnPJEVMRZhRPKuJdlg0zwddIKYxKXb30vLLeUKxoC4LwQAvD_BwE

99 World Economic Forum (2021). Energy Transition Index Report. https://www.weforum.org/reports/fostering-effective-energy-transition-2021

100 MIT Technology Review (2021). The Green Future Index. https://www.technologyreview.com/2021/01/25/1016648/green-future-index/

The national government has promoted a diversity of public policy actions in the area of Science, Technology and Innovation (Ciencia, Tecnología e Innovación, CTI) to take advantage of the opportunities emerging from these fields to foster economic and social development. The National Strategic Plan for Science, Technology and Innovation (PENCTI)[101] has defined a set of processes of programmatic-strategic elaboration aimed at concretizing the advances in science and technology, consolidating the financial support that provides incremental and permanent support to said public policies. Overall, the development of science, technology and innovation in Uruguay is part of a current techno-economic paradigm in the world, which will deepen in the coming years. This paradigm considers knowledge and innovation as the main engines for development.

Based on a systemic approach, PENCTI has defined the main lines of action for several research-based initiatives, including:

- Promoting national education, research and development programs to generate scientific capacities in strategic areas.
- Strengthening the relationship between universities and society.
- Promoting innovation incubators to enable synergies between the industry and the academy.
- Focusing on developing innovative knowledge generation and its application to production processes in the country.

Strategic aims in Science and Research

Science and research planning is driven by National Council for Innovation, Science and Technology (Consejo Nacional de Innovación, Ciencia y Tecnología, CONICYT). According to CONICYT strategic plan 2010-2030, the main goals for the Uruguayan government are the following:

- Consolidate the scientific-technological system and its link with the productive and social reality:
    - Form or consolidate critical masses for scientific and technological research in the areas of the most significant relevance for the country's development with a short, medium and long term approach.
    - Dynamize the interaction between R&D institutions and other agents in fields related to Science, Technology and Innovation (STI), linking the supply with the demand for knowledge.
    - Increase Uruguay's participation in regional and international research networks.
    - Build workspaces for young researchers and the insertion of researchers based abroad.
    - Contribute to the environmental sustainability of production systems.

[101] CONICYT. Plan Estratégico en Ciencia y Tecnología. https://www.conicyt.gub.uy/pencti

- Increase the competitiveness of the productive sectors in the globalization scenario:
    - Contribute to transforming the productive structure via diversification and value addition.
    - Stimulate innovation in SMEs inserted in dynamic "clusters" based, in particular, on regional specializations.
- Develop capacities and opportunities for the social appropriation of knowledge and inclusive innovation:
    - Generate and apply knowledge to solve social problems and social inclusion.
    - Disseminate scientific-technological advances in terms that make them understandable to all citizens and favour the social appropriation of knowledge.
    - Foster the scientific, technological and entrepreneurial spirit of children and young people through programs to popularize science and technology.
- Educate and train the human resources required to meet the demands of building a knowledge society.
- Develop a system of prospection, surveillance and technological evaluation as support for the achievement of the other proposed objectives and evaluation of public policies and STI instruments.

Strategic Aims in HPC

The strategic goals regarding HPC in Uruguay are related to disseminating and consolidating actions developed by the National Supercomputing Center (Centro Nacional de Supercomputación, ClusterUY)[102] to bring support for research and technology in the country. In this regard, several vital goals are being undertaken, including:

- The training of scientists, techniques, and postgraduate students on methods and techniques related to high-performance scientific computing, distributed computing, high-performance numerical models, high-performance computing for computational and artificial intelligence and high-performance computing for processing large volumes of data.
- Consolidate the operation of the National Supercomputing Center initiative by expanding the base of users and broadening the areas of application through specific agreements with relevant actors of the Uruguayan research and industry ecosystem. New users and deals will help with the self-managed and self-supported paradigm for economic support that the Center applies.
- Increase the application of high-performance computing for solving relevant problems for the country, including those related to energy and renewable energy (involving the national

[102] Cluster UY. Centro Nacional de Supercomputación. www.cluster.uy

electricity company, UTE)[103], biotechnology and genomics (with the participation of Institut Pasteur Montevideo)[104], and agroinformatics (with the involvement of the National Institute of Agricultural Research)[105], among others.

- Expand and update the available infrastructure by acquiring new cutting-edge computing equipment, taking advantage of the most recent GPU and multicore technologies developments.

Priority HPC research areas

The priority research areas for the application of high-performance computing are in line with those defined as strategic for the country in the PENCTI program. They are all focused on fostering and improving social and sustainable development, advancing toward a better quality of life for citizens. The most relevant research areas include:

- Chemistry, biology and bioinformatics, a research area where both Universidad de la República[106] and Institute Pasteur Montevideo have developed significant contributions, particularly in protein chemistry, molecular biology, structural biology, and genomics. Important scientific projects are using HPC techniques in this regard. Many others could benefit from proper training of local human resources in HPC and scientific computing to expand the horizon of the proposed research.

- Agricultural and agro-industrial production, a field where the National Institute for Agricultural Research (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, INIA) generates and adapts knowledge and technologies to contribute to the sustainable development of the agricultural sector in Uruguay, taking into account state policies, social inclusion, and demands from the market and consumers.

- Energy, with the primary goal of strengthening the current leadership of Uruguay in renewable energy, with a strong focus on wind and solar energy generation. The National Electricity Company (UTE) plays a significant role in research and innovation in this regard, and it is a key partner of the National Supercomputing Center initiative. Both academia and private companies are also developing sophisticated projects, models, and big data applications that will undoubtedly benefit from high-performance computing capabilities.

- Biotechnology, a research area for which the National Biotechnology Plan proposes key developments related to the training of human resources, the creation of an adequate regulatory framework for biotechnology, and a better coupling of industry and academia as the main goals for developing this research area in the 2020's decade. Despite having a less significant human capital pool and a more reduced internal market (compared to neighbouring countries), Uruguay

[103] UTE. https://portal.ute.com.uy/
[104] Institut Pasteur Montevideo. http://pasteur.uy/en/home/
[105] Instituto Nacional de Investigación Agropecuaria. http://www.inia.uy/
[106] Universidad de la República. https://udelar.edu.uy/portal/

has introduced biotechnology research, services and products through small and medium-sized enterprises and the knowledge generated in academia.

- Technology research and development, where the Uruguayan Technology Laboratory (Laboratorio Tecnológico del Uruguay, LATU)[107] is a national reference in innovation, technology transfer, and value solutions in analytical services, conformity assessment, metrology and technological services. LATU promotes scientific research and entrepreneurial culture and the development of technological platforms. HPC services can play a significant role in fostering new initiatives related to developing technical solutions for the industry, the agro-industrial chains and national manufacturing and production initiatives.

- Software development and services are vital because more than 1000 active software companies, combined with high technology, education, and government policies, are making Uruguay a true digital hub in the region. Software development companies generate more than one billion USD in exports, mainly to the US, making Uruguay one of the world's leading software exporters per capita. In turn, software development generates more than 20% of the new job opportunities in the Uruguayan market. The Uruguayan government has declared Information Technology an official area of interest, working to promote its industry with programs and tax incentives. Critical elements for promotion are Uruguay's 2020 Digital Agenda[108]; the Digital Government Artificial Intelligence Strategy[109] launched to promote the responsible use of AI in the public sector; the first commercial 5G network deployed in Latin America by the national telecommunication company Antel[110] (in 2019); and specific plans for the development of digital competencies; the national Fiber to the Premises coverage, planned by 2022, and the Proyecta Uruguay program[111], launched by National Research and Innovation Agency to make the country more attractive to innovative start-ups and entrepreneurs.

- Other areas, such as human and animal health, environment and environmental services, logistics and transportation, can also benefit from HPC's advanced to develop more robust initiatives and products.

HPC Infrastructure

The main HPC centre in Uruguay is the National Supercomputing Center (ClusterUY)[112], a joint initiative of Universidad de la República (UdelaR) with relevant partners such as the national energy company (UTE), the national telecommunications company (ANTEL) and other Uruguayan research centres. The computational infrastructure was funded by the Scientific Equipment Program of the National Agency for Research and Innovation (ANII) in 2017. ClusterUY operates a cluster

[107] Laboratorio Tecnológico de Uruguay. https://www.latu.org.uy/

[108] Agenda Uruguay Digital. https://www.gub.uy/agencia-gobierno-electronico-sociedad-informacion-conocimiento/politicas-y-gestion/programas/agenda-digital-del-uruguay

[109] Estrategia de Inteligencia Artificial (2021). https://www.gub.uy/agencia-gobierno-electronico-sociedad-informacion-conocimiento/comunicacion/publicaciones/estrategia-inteligencia-artificial

[110] Antel. https://www.antel.com.uy/

[111] Proyecta Uruguay. https://proyectauruguay.uy/

[112] Cluster UY. Centro Nacional de Supercomputación. www.cluster.uy

infrastructure, having 1216 CPU computing cores (1120 Intel Xeon-Gold 6138 2.00GHz cores and 96 AMD EPYC 7642 2.30GHz cores). It also has 3.8 TB of RAM and 28 Nvidia Tesla P100 GPU cards with 12Gb of memory (a total number of 100352 GPU cores). The servers are interconnected through a high-speed 10 Gbps Ethernet network. The Center provides the highest computing power available in the country, with a theoretical performance peak of 327 TFLOPS.

ClusterUY provides services to all national research, scientific, and technological initiatives developed in the country, and it also provides support to international researchers through specific agreements and collaborations. In March 2022, ClusterUY had more than 350 users from 23 institutions. In the lifespan of the Center (2018-2021), it has given support to more than 50 scientific and technology projects. The National Supercomputing Center is linked to other high-performance computing infrastructures in the region via networks and regional initiatives such as Advanced Computing System for Latin America and the Caribbean (SCALAC), Latin American Cooperation of Advanced Networks (RedCLARA), and Ibero-American Network of High-Performance Computing (RICAP).

ClusterUY has directly impacted science and innovation, significantly increasing the country's goals and horizons of research activities. The list of application areas includes Astronomy, Bioinformatics, Biology, Computer graphics, Computer Sciences, Data analysis, Energy, Engineering, Geoinformatics, Mathematics, Optimization, Physics, Social Sciences, Statistics, and others.

Industry and public organizations are also using ClusterUY. The National Electricity Company UTE is developing research related to the analysis of domestic power consumption patterns, load curve classification, energy efficiency, and other subjects. The National Telecommunications Administration Antel is developing research on big data analysis, data centre performance analysis, mobility of users, and other topics. Other organizations and administrations using ClusterUY include the National Administration for the Electricity Market, supporting the power generation investment and energy export planning for Uruguay, the Ministry of Industry and Mining for energy-related research, and the Pasteur Institute for research on bioinformatics and biotechnology.

System name	**CLUSTER UY**
Location	National Supercomputing Center – Datacenter Ing. José Luis Massera - Antel
Web	https://www.cluster.uy/
OS	Linux CentOS 7
Processor architecture	1216 CPU computing cores (1120 Intel Xeon-Gold 6138 2.00GHz cores and 96 AMD EPYC 7642 2.30GHz cores). 3.8 TB of RAM 28 Nvidia Tesla P100 GPU cards with 12Gb of memory (a total number of 100352 GPU cores).
Vendor	N/D
Peak performance	327 TFlops
Access policy	http://cluster.uy/registro

Main research domains	Astronomy, Bioinformatics, Biology, Computer graphics, Computer Sciences, Data analysis, Energy, Engineering, Geoinformatics, Mathematics, Optimization, Physics, Social Sciences, Statistics

Table 7. HPC infrastructure in Uruguay

Strategic goals for collaboration with the EU

The national cooperation framework 2021-2025[113] has been oriented to prioritize those areas for generating the conditions that allow Uruguay to develop and enhance sustainable development and significantly reduce poverty in its different dimensions (moving consumption needs, capacity building, access to health and healthy habitat, exercise of rights, etc.). Due to the comprehensive nature of this guiding principle, several simultaneous programmatic actions have been proposed in the field of economic, productive and employment policies, in the area of environmental policies (sustainable management of natural resources, promotion of renewable energies, adaptation and mitigation of the effects of climate change, etc.) and the main areas of social policy (education, health, social security, protection, etc.). In addition, this principle implies promoting, when necessary, legal and institutional transformations to combat processes of social exclusion and manifestations of discrimination, as well as developing actions (sensitization and awareness strategies) that allow the banishing of cultural norms, values and patterns that reproduce prejudices and discriminatory behaviour towards the most relegated population groups.

Some relevant projects currently under development with bilateral collaboration between Uruguay and the European Union are:

- Development of the information technology sector to promote labour insertion (and the participation of women) in this sector (project developed by Ministry of Labor and Social Security).
- Promotion of circular economy: Innovation and Sustainable Development of the mechanical wood transformation industry to stimulate sustainable production and consumption. (project developed by Ministry of Industry, Energy and Mining).
- Training young Innovators to stimulate the training of qualified human resources in science, technology and innovation.

These initiatives contribute to Uruguayan advancements in the Sustainable Development Agenda and the Sustainable Development Goals (SDG[114]) by executing specific tasks under SDG 4 "quality education", SDG 5 "gender equality", SDG 8 "decent work and economic growth", SDG 9 "industry, innovation and infrastructure", SDG 10 "reduced inequalities", SDG 12 "responsible consumption and production", SDG 16 "strong institutions" and SDG 17 "partnerships to achieve the goals".

[113] Marco Estratégico de Cooperación de las Naciones Unidades en Uruguay 2021-2025. https://www.gub.uy/agencia-uruguaya-cooperacion-internacional/politicas-y-gestion/convenios/marco-estrategico-cooperacion-naciones-unidas-uruguay-2021-2025

[114] United Nations. Sustainable Development Goals. Retrieved from https://www.un.org/sustainabledevelopment/development-agenda/ on 7 April 2022.

Other exciting approaches for collaboration are Triangular Cooperation programs, which have become increasingly relevant to mobilize and increase cooperation capacities outside the traditional models of bilateral cooperation. This modality empowers local capabilities, promotes cooperation and exchanges, fills knowledge gaps, and better mobilises the technical and policy levels. The European Union has pointed to the need to contribute to the 2030 Agenda through different modalities. Several programs have developed between Uruguay, the European Union and other Latinoamerican countries, e.g. through ADELANTE[115], the emblematic programme of the European Union for regional cooperation between Latin America and the Caribbean. Relevant social project developed within this program is Citizen View (Mirada ciudadana)[116], aimed at improving governance and implementing quality public policies to reduce inequalities in the region, and Street Network (Red Calle)[117], aimed at developing policies to support the homeless, influencing public authorities, and sensitizing civil society to the cause of the homeless through a more effective people care policy aimed at improving their living conditions.

Finally, several actions have been developed to promote the cooperation between Uruguay, the region, and the EU at different levels and to adequately disseminate relevant information about collaboration, education, and research and development opportunities to be developed with European partners.

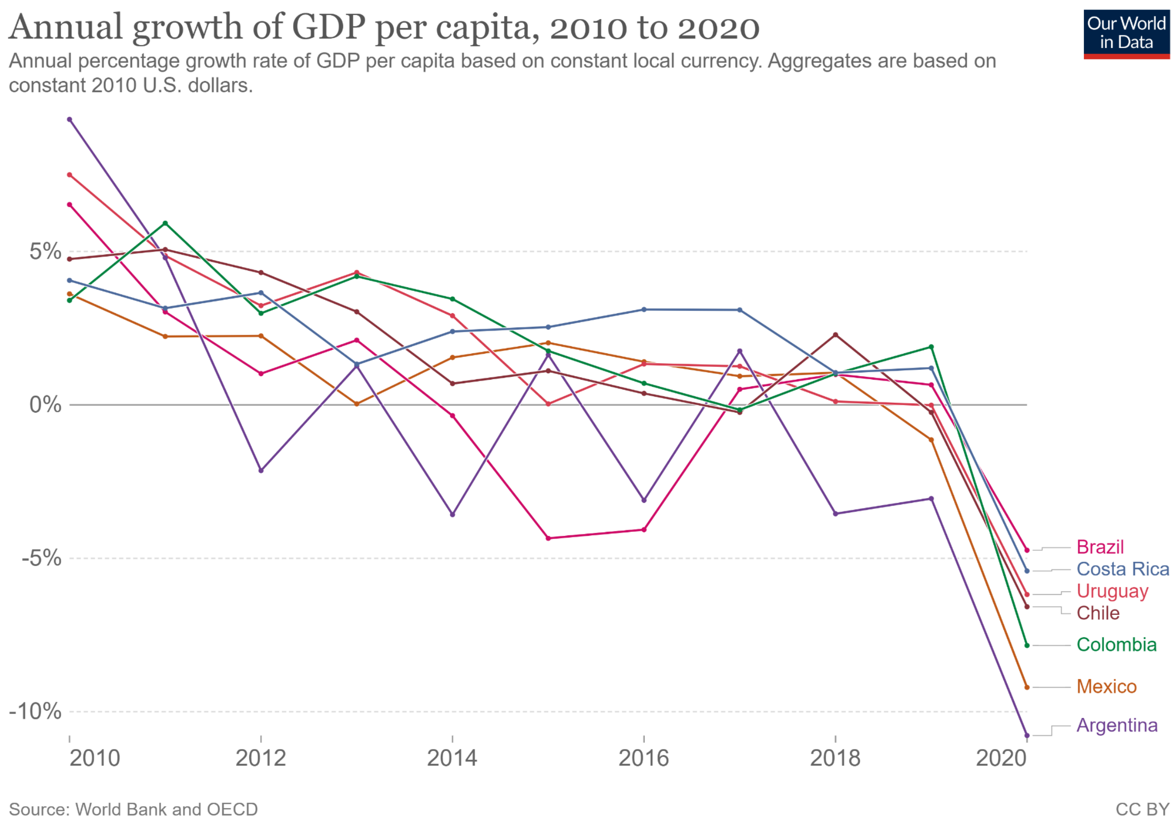
[115] Programa Adelante. https://www.adelante-i.eu/

[116] Mirada Ciudadana. https://www.adelante-i.eu/en/mirada-ciudadana

[117] Red Calle. https://www.adelante-i.eu/red-calle

Conclusions

Almost ten years have passed since the original RISC project issued recommendations to strengthen the HPC ecosystem in LATAM. During the last few years, the world has witnessed extraordinary threats, such as the global COVID-19 pandemic, climate change and environmental degradation and an increase in political instability. These factors have hit hard in Latin America.



Annual growth of GDP per capita 2010-2020 for the targeted countries. Retrieved from https://ourworldindata.org/grapher/gdp-per-capita-growth

At the same time, the pandemic and the extreme weather events pushed forward the need to enhance international scientific collaboration. In addition, the unstable geopolitical situation and the rising commodities prices are encouraging sovereign domestic initiatives in technology development.

This section presents recommendations for Latin America to encourage sustainability in RDI in HPC and strengthen bi-regional collaboration, based on the description of the HPC ecosystem in Europe and the targeted countries. These recommendations will be further developed in D2.5, "Roadmap for HPC R&I between Europe and the LATAM".

The sections below focus on the aspects addressed in the national reports: HPC research areas, HPC infrastructure and strategic goals for collaboration, setting the ground for the road mapping activity to be carried out in the following months.

Priority HPC Research Areas

Recommendation 1. The priority HPC research areas per country, identified in each national report, should be mapped with policy documents, action plans and calls. These mapping should be considered in other deliverables in this project, especially D2.5 Roadmap for HPC R&I between Europe and the LATAM, D2.6 Joint Action Plans, D4.1 Survey and analysis of S&T bilateral agreements and D4.3 Analysis of the national HPC policies.

Recommendation 2. It is recommended to establish Centres of Excellence in Latin America to support scientific applications, introducing new computational methods and techniques to enhance the research and innovation in these essential application domains. These Centres of Excellence could build upon the experience of the European Centres of Excellence (CoEs) for High-Performance Computing. The CoEs "promote the use of upcoming exascale and extreme performance computing capabilities and scale-up existing parallel codes towards exascale scaling performance. Furthermore, they address the skills gap in computational science in the targeted domains by specialised training for increased adoption of advanced HPC in industry and academia. They bring together the European world-class knowledge and expertise in applying established mechanisms, user-driven development, performance tools and programming models for HPC, and co-design activities for real systems based on leading-edge technologies".

Recommendation 3. Since most of HPC's value comes from its application to real scientific, engineering and societal problems, policymakers must dedicate effort to supporting application users and developers. These efforts will create the conditions for developing scalable, performing and competitive applications through a pool of highly-trained specialists, new software tools and methodologies, effective dissemination and sharing of knowledge.

HPC infrastructure

Recommendation 1. HPC systems reveal a considerable gap between Latin American countries and the other geographical regions globally. The presence of Latin American supercomputers in the Top500 list (November 2021)[118] shows only five systems (all of them in Brazil). Only SDumont (388º place) is located in a public research institution, the Brazilian National Laboratory of Scientific Computing (LNCC). As described in the national reports, there are less powerful supercomputers in all targeted countries. Improving and coordinating the HPC infrastructures in LATAM would provide better services for public and private research institutions.

Recommendation 2. The different national HPC centres in Latin America should federate together and cooperate in creating a solid HPC Ecosystem in Latin America, providing joint programmes in terms of support, research, cooperation and education. This ecosystem should cooperate and make synergies at the European level as well. The EU HPC JU flagship is an excellent example of procurements of large HPC systems in a coordinated and centralized way and at the same time using them for creating a federated international HPC structure also capable of delivering services in a Cloud distributed

[118] Top500. November 2021. Retrieved from https://www.top500.org/lists/top500/2021/11/ on 7 April 2022.

approach. The existence of an EU central funding agency makes this plan easier. The RedCLARA Latin American national research and education networks and the Bella Programme could act as solid instruments to integrate the different HPC national facilities with high-speed networks and cloud infrastructure services.

Recommendation 3. Deploying a production-quality HPC infrastructure widely spread in Latin America, compared to similar initiatives in the rest of the world, will face different economic and political issues, essentially due to the absence of an international common funding mechanism. Therefore, a very well defined strategy and plan will be required. This plan should be supported and implemented by national agencies through specific funds in a long-term vision. Possibly in collaboration with international agencies in other regions of the world, like the EU, where a long tradition of cooperation with LATAM in HPC exists.

Strategic Goals for Collaboration

Recommendation 1. The development of new computational applications and numerical methods to advance science cannot remain isolated. Coordination in scientific disciplines and development of new applications, computational methods and tools must be effectively encouraged and supported in an integrated plan, pushing the international collaboration. In this vein, association with EuroHPC Joint Undertaking at the European level could be established for joint HPC initiatives, establishing a partnership so that Latin American researchers could access the more prominent European HPC infrastructure.

Recommendation 2. Encourage the development of Open Source solutions to foster international collaboration and the emergence of international de facto standards, enabling commercial exploitation.

Recommendation 3. Specialised degrees in HPC at the higher education level should be encouraged and organised in cooperation between LATAM and EU academic partners, designing standard curricula and activating joint degrees at MSc and PhD levels. The LATAM students could spend part of their educational activity in one of the European partner institutions. The funds to organise the mobility of these students could be identified via common EU-LATAM programmes. PhD level training could involve research activities linked to specific computational projects in cooperation between LA and the EU. Tools and curricula produced by the recent EUmaster4HPC, as an initiative of the EuroHPC JU, could be made available to LATAM partners.

Acronyms and abbreviations

AI	Artificial Intelligence
BSC-CSN	Barcelona Supercomputing Center – Centro Nacional de Supercomputación
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
CINVESTAV	Centro de Investigación y de Estudios Avanzados
CLEI	Centro Latino Americano de Estudios en Informática
CoEs	Centres of Excellence
COVID	Coronavirus Disease
CPU-GPUs	Central Processing Unit – Graphics Processing Unit
CRA	Common Research Area
CUDI	Corporación Universitaria para el desarrollo de Internet
DoE	Department of Energy
ECP	Exascale Computing Project
EPI	European Processor Initiative
ETP4HPC	European Technology Platform for High-Performance Computing
EuroHPC JU	Europe HPC Joint Undertaking
EU	European Commission
Flop/s	Floating-point operations per second
G20	Group of Twenty

GDP	Gross Domestic Product
HPC	High-Performance Computing
ICT	Information and Communication Technology
INFRAG	Infrastructure Advisory Group
JAIIO	Jornadas Argentinas de Informática
JIRI	Joint Initiative on Research and Innovation
LATAM	Latin America
LNCC	Laboratório Nacional de Computação Científica
MSc	Master of Science
NRENs	National Research and Education Networks
PhD	Doctor of Philosophy
PRACE	Partnership for Advanced Computing in Europe
R&I	Research and Innovation
RDI	Research, Development and Innovation
REDMEXSU	Red Mexicana de Supercómputo
RIAG	Research and Innovation Advisory Group
RICAP	Red Iberoamericana de Computación de Altas Prestaciones
RIs	Research Infrastructures
S&T	Science & Technology

SADIO	Sociedad Argentina de Informática
SBC	Sociedade Brasileira de Computação
SCALAC	Advanced Computing System for Latin America and the Caribbean
SCCC	Sociedad Chilena de Ciencia de la Computación
SINAPAD	Sistema Nacional de Processamento de Alto Desempenho
SMEs	Small & Medium Entreprises
SOMEXSU	Sociedad Mexicana de Supercómputo
SRA	Strategic Research Agenda
UAM	Universidad Autónoma Metropolitana
UNAM	Universidad Nacional Autónoma de México
WG	Working Group
WP	Work Package

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