CN-next (CN_post PNRR) Agenda Strategica

1 Vision

The rapid increase in data generation is drastically transforming all the sectors in business and science, facilitated by advancements in scientific methods and technologies, such as Artificial Intelligence (AI), High Performance Computing (HPC) and Quantum Computing (QC).

The increase in data produced by internet-connected devices is also essential for productive sectors such as retail, which uses consumer behaviour analytics to refine marketing strategies, or manufacturing, where real-time monitoring systems improve efficiency and maintenance.

Important scientific research disciplines, such as environmental monitoring, genomics, medicine and fundamental physics, are generating huge data volumes from both terrestrial and space-based instruments; Italy is a stakeholder in a large fraction of the initiatives, and is expected to provide computing resources and support.

On the other hand, numerical modelling is essential in both scientific research and industrial applications. Studying theoretical frameworks and comparing them with empirical data is essential for enhancing our understanding of the processes under investigation. Numerical modelling also facilitates the development of digital twins that simulate physical systems or processes in real-time. This capability enables optimisation and outcome prediction across diverse applications, ranging from fundamental research to applied domains like engineering, healthcare, and urban planning.

The distribution of data, expertise, and personnel across multiple locations requires enhanced networking and collaboration, particularly within scientific and industrial sectors in the EU and Italy, to be secured via specific funding initiatives. This networking is crucial for resource and data sharing, as well as for promoting collaborative projects that extend across national and international borders.

The convergence of computational and analysis methodologies from all the domains underscores the pivotal role of data as the foundation for scientific and industrial progress. The rapid expansion of data generation necessitates the development of advanced computational infrastructures, as well as innovative algorithms, skills, expertise, tools, and services. **These elements collectively lead to the establishment of computational laboratories that foster significant synergies between scientific and industry-oriented research, facilitating the identification of common interests and strategies for the development of effective and innovative R&D solutions.**

1.1 The European and National Landscape

The European Digital Strategy, published in 2020, sets out the EU's vision for a data-driven society and outlines a number of actions that the EU will take to promote the development and use of big data and the data economy. The Strategy focuses on four key areas: building a fair and open data market, increasing the availability of data, supporting the development of data skills and technologies, and ensuring that data is used in a trustworthy and ethical manner.

This vision is directly supported and further enabled by initiatives aimed at strengthening Europe's digital capabilities, including its leadership in high-performance computing (HPC), artificial intelligence (AI), and the data economy, which is supported by numerous supportive EU initiatives and policies.

In the last decade, Europe has recognized the importance of integrating HPC (High-Performance Computing) and cloud computing. Traditionally, HPC has been focusing on numerical experiments and theoretical computations, while cloud-based data analysis prioritized user experience and scalability. These independent evolutionary paths have resulted in distinct developments in software, virtualization, and system efficiencies. However, there is a growing acknowledgment of the benefits of converging these infrastructures, particularly for tackling complex problems in research and industry.

Central to these efforts is the deployment of the infrastructure via the EuroHPC Joint Undertaking (JU), instrumental in setting up exascale and advancing toward post-exascale supercomputers, crucial steps in maintaining a competitive edge in global technology sectors. ~~Complementing this is the European Cloud Initiative, which aims to establish Europe as a leader in cloud computing~~. This initiative supports the development of European cloud service providers and enhances access to cloud services, integrating seamlessly with broader EU digital strategies.

The European Open Science Cloud (EOSC) plays a pivotal role in this ecosystem by offering a virtual environment with open and seamless services for storage, management, analysis, and re-use of research data, across borders and scientific disciplines. This initiative underscores the EU’s commitment to fostering an open science community where data from publicly funded research is accessible to all, enhancing scientific collaboration and innovation. The European Data Strategy and the forthcoming European Data Act of 2022 aim to unify the data market, enhance data availability, and protect data usage standards across the EU. Initiatives like GAIA-X and the European Data Space Alliance facilitate a cohesive data-sharing ecosystem, crucial for fostering an inclusive data economy.

Complementing these infrastructural developments, the FF4EuroHPC project, as part of the Horizon 2020 programme, plays a vital role by empowering Small and Medium-sized Enterprises (SMEs) to harness HPC technologies. This initiative

enables SMEs to explore and implement HPC solutions to enhance their innovation capabilities, thereby improving their products, services, and competitiveness in the global market.

Further enhancing the HPC landscape, initiatives like the Quantum Flagship aim to pioneer quantum computing technologies, which are expected to surpass existing computational capabilities by significant orders of magnitude. National efforts, such as France's Plan 2030 and Germany's national HPC strategy, complement European endeavors, enriching the continent's overall technological capabilities.

In AI, Europe strives for global leadership through regulatory frameworks and strategic planning. The European AI Act categorizes AI systems by risk, ensuring that high-risk applications meet stringent guidelines while promoting transparency in lower-risk applications. The comprehensive European AI Strategy, alongside the European AI Alliance, promotes the development and ethical use of AI, with the European AI Research Initiative supporting applications across diverse sectors like healthcare and manufacturing. In Italy the "AI Factory IT4LIA", selected by the EuroHPC Joint Undertaking, is a pioneering project aimed at boosting Italian AI development and competitiveness. It is focused on creating a top-tier AI-optimized supercomputer. This facility is designed to bridge the gap between AI service providers and users, fostering collaboration across multiple sectors in science and industry.

1.2 Role and ambition of the CN-Next

The CN-Next plays a crucial role in advancing Italy's capabilities in High-Performance Computing, Big Data, and Quantum Computing. The CN-Next tackles urgent and growing scientific and social challenges by offering cutting-edge infrastructure and promoting collaboration among academics, industry, and international partners. As technology advances, The CN-Next seeks to expand its scope by continuously upgrading its technological resources, intensifying participation in global research initiatives, and improving its educational programs to cultivate a computing culture and awareness at the national level, thereby fostering the next generation of Computing and Data Scientists capable of contributing to academia and industry.

The CN-Next's strategy involves both enhancing and substantially broadening its capabilities and resources. The enhancement will grant researchers from academia and enterprises, including SMEs, access to advanced computing technologies encompassing infrastructure, services, software, algorithms, and tools and support and counseling by highly qualified experts. These resources will enable the development of innovative solutions to complex issues in critical domains such as healthcare, environmental science, fundamental science, material science, and advanced manufacturing, among the others. The CN-Next aims to foster a

collaborative ecosystem that promotes innovation, thereby contributing significantly to societal and economic advancement.

The CN-Next seeks to accelerate the adoption of transformative technologies in multiple sectors, facilitating the creation of innovative products and services that enhance technological progress and economic development. The Centers' initiatives, stem from the National Recovery and Resilience Plan (NRRP), will play a crucial role in fostering Italy's economic growth and technological advancement, thereby positioning the country as a leader in global scientific research and industry.

The CN-Next will focus on several key areas:

- **Updating National strategic computing infrastructures**: the CN-Next will have a central role in the integration of HPC and cloud environments, providing a framework for science and industry based on novel Exascale HPC platforms, Cloud and Data lakes. This involves maintaining and upgrading the current Italian infrastructures and developing novel solutions (software and hardware).
- **Advisory for Policy Making:** the CN-Next will be the recognized partner in Italy for policy makers (at national, continental and global level), when defining medium-long term strategies related to large scale computing, quantum computing and AI.
- **Fostering Scientific Research**: the CN-Next will intensify its efforts to foster scientific research by providing researchers with advanced computational tools and environments. This will enhance their ability to conduct high-level research across various scientific disciplines, contributing to breakthroughs that can address complex global challenges.
- **Capacity Building:** the CN-Next will be the recognized go-to partner whenever a project (public, private) needs consulting, partnership and test of solutions in the fields of large scale scientific computing, Big Data, HPC and Quantum Computing.
- **Promoting Industry and Science collaborations and synergies**: by enhancing networking between science and industry and promoting knowledge exchange, the CN-Next aims to drive innovation and practical applications of research findings. Synergies between research institutions and academia are essential for fostering collaboration and enhancing knowledge exchange, which are critical for advancing scientific and educational endeavors.
- **Fostering Educational Initiatives**: the centre will enhance its educational and dissemination efforts, focussing on increasing public and academic awareness regarding the capabilities of advanced computing.
- **Promoting High level Education and Training:** The primary focus will be on training existing professionals and future experts, providing them with essential skills to succeed in the domains of HPC, Big Data, and Quantum Computing.
- **Coordinating engagement in Projects:** The center will participate and support the participation of its affiliates in regional, national, European and international projects, leveraging collaborations to foster advancements in computing and data sciences.

- **Fostering International Agreements:** the CN-Next will strengthen its international partnerships, facilitating global knowledge exchange and cooperation in scientific and technological endeavors.

2. Mission

Italy aims to establish a leading digital infrastructure in HPC, Big Data, Quantum Computing, and new information technologies. The CN-Next is instrumental to this objective by positioning itself as a national reference point that is distinguished by advanced computing/network technologies and expert human resources. The CN-Next will address the future computing, data management, and analysis needs of both the scientific and industrial communities. By enhancing collaboration and facilitating the exchange of skills and knowledge between these sectors, the CN-Next seeks to foster the development of a distributed Italian research and development infrastructure that integrates both public and private research centers.

To achieve this outstanding mission, 4 strategic goals can be identified that concretely represent the described challenging objectives of the CN-Next. The following picture represents a global coherent view of the identified SGs.

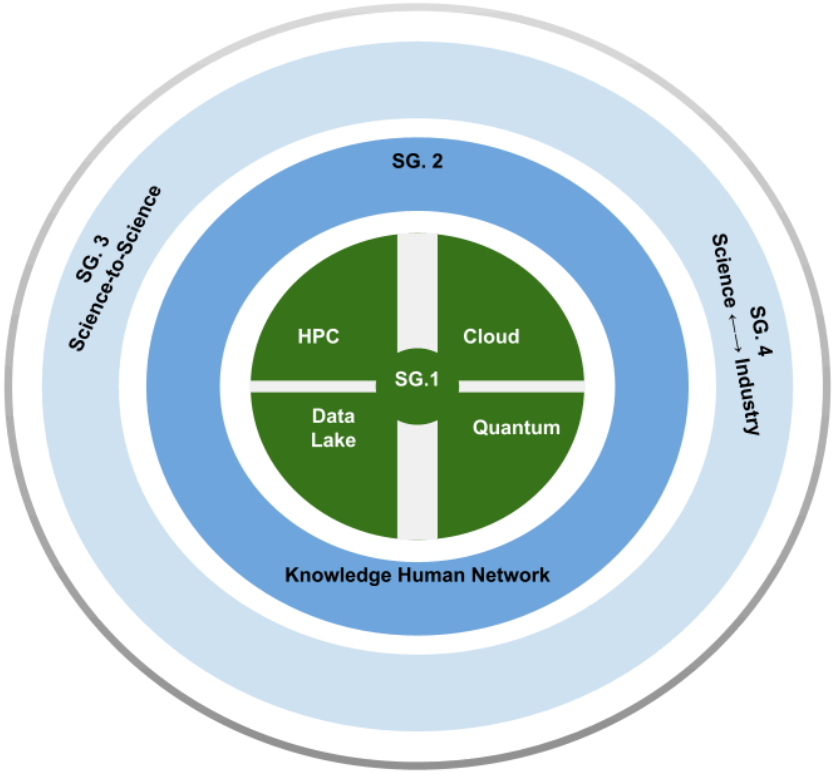

Fig. 1 - Strategic objectives and concrete actions to implement the CN-Next's vision and fulfill its mission.

2.1 Strategic Goals

SG.1 - Building and sustaining the permanent Italian National Computing, Data and Quantum Infrastructure, by developing, deploying, maintaining and extending the CN-Next infrastructure to support diverse scientific and industrial applications.

SG.2 – Establishing and maintaining a knowledge network of specialists to promote progress in HPC, Big Data, and Quantum Computing through robust collaboration and effective educational programs.

SG.3.1 – Facilitating collaboration among diverse scientific communities to address shared challenges in HPC, Big data, and Quantum Computing by creating a platform for experts and domain scientists to exchange ideas, share resources, and engage in collaborative research. This environment will facilitate cross-disciplinary collaborations essential for significant innovations.

SG.3.2 – Fostering collaboration between scientific and industrial sectors on common challenges related to HPC and Big Data management and processing. This will bridge the research-to-market gap by implementing medium- and long-term projects that have substantial industrial implications. Strategic initiatives are crucial for aligning Italy with leading nations in applied research.

SG.3.3 – Fostering collaboration between industrial sectors on common challenges related to HPC and Big Data management and processing.

SG.4 – Impact on policies: The CN-Next will be the reference ecosystem used by policy makers when defining medium-long term strategies related to large scale computing.

3. How to achieve the strategic goals

SG.1 - Building and sustaining the permanent Italian National Computing, Data and Quantum Infrastructure

- Implement, maintain and expand **top class exascale and post-exascale HPC and Cloud** platforms for Science and Industry.
- Promote the **extensive adoption of Data Lake solutions** that connect existing resources and integrate new data streams, preserving their distinct characteristics while improving Findability, Accessibility, Interoperability and Reusability **(FAIR principle)**. Do so by developing, maintaining and supporting core services via middleware layers to be deployed on all the partners' resource installations.
- Outline strategies to **incorporate and expand cutting-edge network technologies** that support connectivity at national and international levels, ensuring fast, secure data transfer.
- Emphasize the **integration of top-tier supercomputing and cloud infrastructures,** combining advanced hardware, software platforms, algorithms and technologies to support diverse scientific and industrial applications.
- Focus on the deployment and the regular maintenance of essential functionalities and services that **optimize the usability and performance of the infrastructure**.
- Detail efforts to **develop and promote interoperability standards** that allow seamless integration and operation across different HPC and cloud platforms. This should facilitate more efficient data sharing and processing across various technological environments.
- **Carry out groundbreaking applied research** to advance the understanding and development of HPC, Big Data, and Quantum Computing.
- **Identify and analyze emerging trends, potential growth areas, and untapped opportunities in HPC, Big Data, and Quantum Computing for Academy and Industry**. This involves reviewing current research, and analyzing market reports to understand how these technologies are evolving and being adopted. This strategic approach will help pinpoint areas where these technologies can create significant value and drive innovation.

SG.2 – Sustaining and maintaining a knowledge network of experts

- Emphasize the **role of individuals in driving innovation** through their ability to solve complex problems. Highlight the importance of nurturing talent and expertise within the network.
- Continue to **expand on higher education** offerings, particularly by introducing PhD programs tailored also to industry needs. These programs should not only focus on theoretical knowledge but also offer practical training

and problem-solving experiences, co-funded by industry leaders, the CN-Next and collaborating research centers.
- Strengthen the integration of diverse disciplines by **organizing events (workshops, conferences, seminars) or preparing reports (white papers, blueprints, technical roadmaps) that encourage the sharing of knowledge and foster potential collaborations** between scientific and industrial communities. Focus these on emerging trends and recent discoveries.
- Initiate research and explorations in HPC, Big Data, and Quantum Computing that **anticipate future technological needs and challenges,** ensuring the network remains at the cutting edge.
- Develop a vibrant and supportive environment that encourages the generation of **innovative ideas and technological breakthroughs,** positioning the network as a leading incubator of talent and creativity.

SG.3.1 – Coordinating efforts across various scientific communities, focusing on common challenges in HPC and Big Data

- Establish a platform where **experts from diverse scientific fields can converge to exchange ideas, combine resources, and participate in collaborative research.** This environment will support cross-disciplinary partnerships that are vital for breakthrough innovations.
- Foster the mapping of the different communities and develop methodologies to **streamline the use of computational resources, minimizing overlap and waste.** This includes sharing algorithms, tools, and computational power across projects to maximize efficiency and output.
- Encourage a culture that thrives on creativity and problem-solving, where innovative solutions to complex scientific and industrial challenges are pursued. Foster an environment that **supports experimentation**.

SG.3.2 – Fostering scientific and industrial collaboration on HPC and Big Data handling common topics.

- **Enhanced Scientific-Industrial Collaboration** to bridge the gap between research and market applications, the CN-Next will implement strategies to enhance interaction between the scientific community and the industrial sector. This includes setting up **joint innovation labs, technology transfer offices, and regular networking events** aimed at translating scientific discoveries into commercial products and services.
- Academia will **form new generations of specialists** who can be **employed** by industry and enterprises to boost R&D programs.
- The CN-Next will establish mechanisms to **facilitate the flow of knowledge across sectors.** This includes creating digital platforms for data sharing, organizing thematic workshops, and offering training sessions that help

researchers and industry professionals stay updated on the latest technologies and methodologies in HPC and Big Data.
- Launch collaborative research programs that pool expertise and resources from both sectors to innovate and develop solutions.
- Collaborate with funding bodies to create **Joint Funding Opportunities** specifically for joint projects in HPC and Big Data.
- The CN-Next will create incentives for universities and research institutes to direct their **applied research efforts towards addressing industrial challenges.** This could involve providing funding for applied research projects, setting up industrial PhD programs, and establishing partnerships with private companies to ensure that academic research is aligned with real-world industrial needs and can be seamlessly transitioned into market-ready technologies.

SG.3.3 - **Fostering industry-industry collaboration on HPC and Big Data handling common topics**

Brokering è uno dei modi di implementare i goal strategici SG 3.1, 3.2, 3.3

SG.4 - Impact on policies

- The CN-Next will support the bottom-up process of collecting and defining community-level proposals for policies on technical, ethical, political decisions.
- The CN-Next will serve as expert consultant for national, continental and global policies, towards government bodies, associations and initiatives.

3.3 Recommendations

1. **Research and technological development,** central to the CN-Next's mission, should not be confined solely to the academic community but **must involve both the industrial sector and research institutions,** each contributing equitably in terms of financial and resource investments.
2. **The CN-Next is not a funding agency** but it plays a crucial role in supporting and sustaining technological research by **co-financing participation in projects**.
3. Guide the creation and implementation of **cutting-edge AI technologies and HPC algorithms** that optimize resource use across platforms, via the interplay between domain experts and AI experts.
4. The CN-Next will promote **responsible innovation practices** that align with the values of integrity, inclusivity, and sustainability.

5. The CN-Next will provide crucial **support to SMEs to advance the Technology Readiness Level (TRL) of their solutions,** empowering them to meet market demands effectively. Though, the CN-Next is not expected to be the platform to support production activities, but to demonstrate their viability.
6. The CN-Next will foster conditions that **support significant technological progress within industries and research**.
7. The CN-Next will **improve market visibility** and ensure the viability of innovations through strategic marketing and robust business models.
8. The CN-Next will **connect businesses** with top-tier expertise to refine product development and business strategies.
9. The CN-Next will **encourage collaborations** and partnerships that leverage global networks and local strengths.
10. The CN-Next will **stimulate transformative approaches** in public administration to **enhance efficiency and service delivery**.
11. The CN-Next will **energize and support the creation of spin-off ventures** to exploit new market opportunities and encourage entrepreneurial activity.
12. The CN-Next will **promote the absorption of the new generations of qualified people** by industries and enterprises.

3.4 Liaison with relevant EU Initiatives and Programs

The main objective of the CN-Next is to become the national reference institution for projects dealing with HPC, Big Data, Quantum Computing and new information technologies. In particular, we expect the CN-Next to interact with

- the EuroHPC JU
- the EOSC
- the Quantum Flagship initiative
- GAIA-X

On top of these, top tier EU initiatives on computing, the CN-Next will interact with all the initiatives (domain specific or generic) listed below (and more)

- European AI Alliance
- The European AI Research Initiative
- European Data Space Alliance (EDSA)
- Data, AI and Robotics (DAIRO) Association
- International Data Spaces Association (IDSA)
- European Cloud Initiative
- Relevant R&I projects funded under
- the Digital Europe Programme
- the Horizon Europe Programme
- the European Innovation Council (EIC) initiative

3.6 Sustainability and Governance

Sustainability:

The CN-Next is a partnership between private and public institutions that engage in a project where each institution must find a direct advantage in its core / institutional activities.

The Centre aims at supporting the specified goals (SG1-SG4), summarized in the following list:

- infrastructure and human maintenance and development
- promote collaboration and synergy in science
- promote knowledge and technology transfer between science and industry
- promote the birth and growth of innovative enterprises (spin-off, start-up)

The CN-Next must secure funding to **sustain** these objectives. These shall be granted both by institutional contributions and by the payment of the specific offered deployed by the Center.

Membership fee:

Fee that each partner must pay to join the Center. This is intended to be used for all the administrative and core tasks of the CN-Next, and to support innovative initiatives. It also guarantees a free share of the services to the partners. Alternatively to a “money fee”, in-kind contributions (personnel, resources) are possible.

Public fundings:

A part of the CN-Next budget must be guaranteed as annual public funding. This part of the budget has the primary objective of covering the salaries of technical staff, promoting synergies and collaborations, educational and awareness-raising activities, high-level education and for the maintenance and development of infrastructure.

Pay per Service:

The CN-Next should offer two levels of services, the fees for which are used for maintenance and development of the infrastructure:

- Core services: a small and well defined set of services (Authorization and Authentication Infrastructure, computing, data management, networking) to be made available by the CN-Next itself, paid for through fees or in-kind contributions from affiliates. By paying an annual fee, participants should be able to access fee-based services, including HPC and Cloud computing hours, storage, etc.
- Higher level services: services, counselling, support, and resources provided to any interested party by CN-Next affiliates, via a marketplace-like

mechanism mediated by the CN-Next. In this respect, the CN-Next will provide a marketplace-like structure, where the CN will serve

- As the manager of portal which lists / broadcasts / manages request and offer
- As a facilitator between request and offer
- As a counselor/validator for implementation solutions
- As a guarantor for a fair price / cost

Governance:
CN-Next governance should remain as lean as possible. Based on the present ICSC governance organization, the CN-Next governance should include the following bodies:

- a CdA, with qualified membership
- A Director General
- An assembly of the affiliates
- A Scientific Advisory Board
- An Industrial Advisory Board
- Advisory Ethics Board

Finally, the CN-Next should provide a specific office aimed at ensuring the promotion and dissemination of all CN-Next initiatives (Observatory). This will allow the creation of a consolidated network at national and international level between research institutions, SMEs and industries, necessary to adequately address new opportunities in the fields of artificial intelligence, Big Data analysis, and QC. The network will also play a key role in applying for new funding by taking advantage of EU opportunities.

The current Spoke structure denotes a dichotomy between academic and industrial partners, with the former organized per domain, and the latter added a posteriori the the Spokes.
The CN-Next should solve this by moving to a structure in which initiatives are framed in a 2-D matrix structure, in which the interests of the affiliates is towards technology Competence Centers (CCs). As a mere example, we imagine a structure as the one sketched below

	CoC Quantum	CoC HPC	CoC AI	CoC Data Intensive	…
Affiliate # 1 (pub/ind)	X		X		
Affiliate # 2 (pub/ind)		X	X		
…					

Each Competence Center (from a list decided in the CdA after having consulted the Industrial and Scientific Advisory Boards) will be organized with a Lead and a Co-Lead, chosen among the interested institutes, possibly rotating with time.
The main task of the CCs will be to:

- Gather the interests on a specific broad technology domain
- Foster an active communication and transfer of knowledge between the various initiatives
- Advice on standard solutions already proven successful
- Collect and manage a knowledge basis on the specific domain

SC sustainability: KPIs

Consistently with what discussed during the ICSC activity, the Key Performance Indicators for the CN-Next can be identified as:

- **Reliability**: Demonstrated ability to coordinate, manage and carry out complex projects.
- **Economic Impact and Sustainability**: Capacity to draw external resources to ensure the activity's sustainability.
- **Impact on society:** Ability to have an impact on the scientific community and the relevant socio-economic communities, also thanks to the involvement of public and private actors, also beyond the initial ICSC core.
- **Networking and Innovation:** activities of education and training, international collaborations and projects, publications, conferences, dissemination and public outreach activities, patents.
- **Impact on Policies**: Ability to provide guidance on reference policies by means of, e.g., white papers, policy proposals taking into account their political sustainability, commitment from other Ministries.
- **Building capacity**: The ability to create facilities (infrastructure, laboratories, services) for applied research in a "participatory" mode, to recruit new skills (PhDs and researchers), also in synergy with businesses, and to create value through innovation and intellectual property (patents and business creation).
- **International Visibility**: The capacity to be a qualified partner in international projects, representing the computing ecosystem and promoting its participation and the participation of the affiliated to EU funding opportunities.