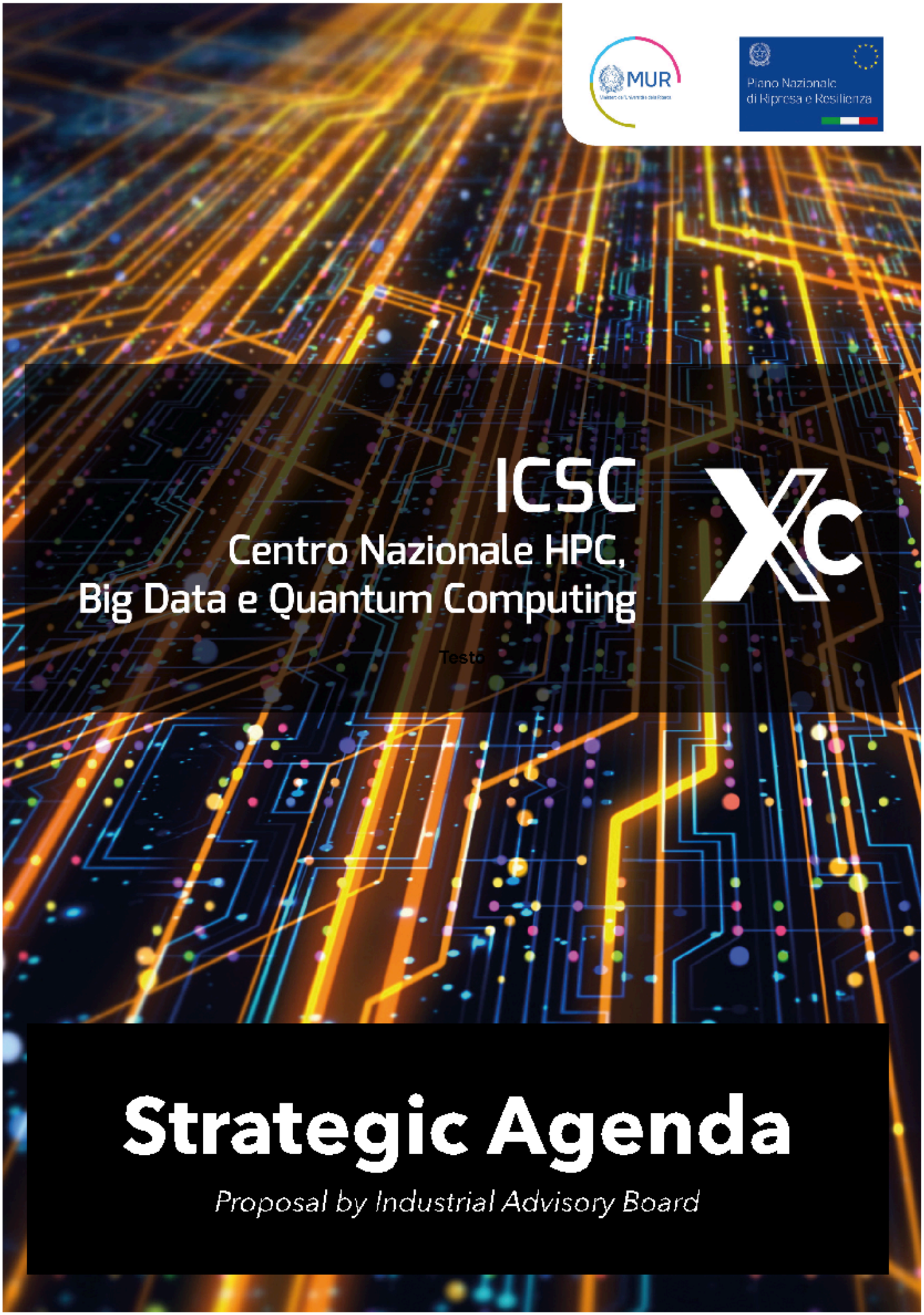
MUR
Piano Nazionale
di Ripresa e Resilienza
ICSC
Centro Nazionale HPC,
Big Data e Quantum Computing
Testo
Strategic Agenda
Proposal by Industrial Advisory Board

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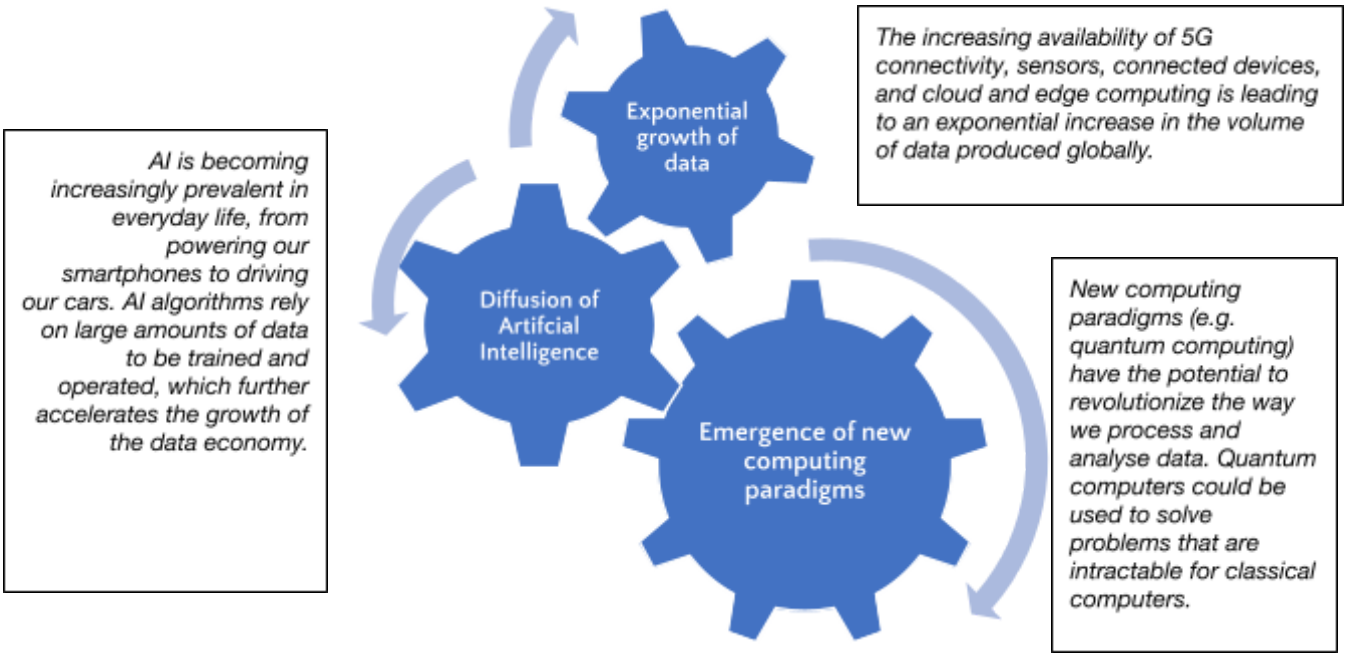
Vision

5G connectivity, sensors everywhere, connected devices, and the shift to cloud and edge computing and digital continuum are among the forces that are leading to the exponential increase of the volume of data produced globally (by humans and machines) in recent years[1]. The diffusion of artificial intelligence (AI) into everyday life, and the development of frontier paradigms such as quantum computing, will further strengthen the role of data in shaping our world.

The exponential growth of data, the diffusion of AI and the emergence of new computing paradigms are having a profound impact on our world, thus becoming increasingly important in all aspects of our lives, from the way we work to the way we interact with each other.



Businesses are using data to improve their operations and decision-making (e.g. to optimize their supply chains, target their customers more effectively, and develop new products and services). Governments are using data to improve public services and make better decisions (e.g. to improve traffic flow, reduce crime, and identify and target social programs). Individuals are using data to improve their lives (e.g. to track their fitness, manage their finances, and make more informed decisions about their health).

The diffusion of AI is also having a major impact on our world. AI is being used to develop new applications and services in a wide range of industries, including healthcare, finance, and transportation. For example, AI is being used to develop new drugs, diagnose diseases, and develop self-driving cars.

The emergence of new computing paradigms such as quantum computing has the potential to further accelerate the growth of the data economy and the diffusion of AI. Quantum computers could be used to solve problems that are intractable for classical computers, such as developing new drugs and materials.

While data is a core component of the digital economy, it is the core product of “data economy”, which involves the generation, collection, storage, processing, distribution, analysis, elaboration, delivery, and exploitation of data enabled by digital technologies, which ensure that data is accessible and usable and extract value from it, by creating a variety of applications with a great potential to improve daily life.

In this data-oriented landscape, digital infrastructures, high performance computing architectures, hyper scale cluster architectures and multi-terabit bandwidth network infrastructures play a crucial role and will require deep and effective innovation in the next few years.

[1] Between 2018 and 2025, from 33 zettabytes to 175, according to the International Data Corporation (IDC).

The European and National Landscape

Europe is at the forefront of high-performance computing (HPC), artificial intelligence (AI), and the data economy. The European Union (EU) is also committed to supporting the development and use of these technologies through a number of initiatives. However, the European landscape on HPC, AI, and the data economy is dynamic and evolving rapidly.

The European **High-Performance Computing (HPC)** landscape is characterized by the *EuroHPC Joint Undertaking (JU)*, a strong public-private partnership between the European Union, European countries, and private partners. The mission of the EuroHPC JU is to develop a world-class HPC infrastructure in Europe. The EuroHPC JU is currently deploying three pre-exascale supercomputers and supporting the development of exascale supercomputers in Europe. The EuroHPC JU is also supporting the development of HPC technologies and applications, such as new programming models, compilers, and runtime systems for HPC systems.

In addition to the EuroHPC JU, in Europe there are a number of other initiatives related to HPC. For example, the European Commission has launched the Quantum Flagship initiative, which aims to develop a quantum computer that is 100 million times more powerful than any existing computer. The Quantum Flagship initiative will also support the development of HPC technologies for quantum computing.

There are also a number of national and regional initiatives on HPC in Europe. For example, the French government has launched the Plan France 2030, which includes a significant investment in HPC. The German government has also launched a national HPC strategy.

Italy is investing in HPC co-funding with EuroHPC Leonardo, a pre-exascale world-class Tier-0 system, which will offer highly competitive HPC services to Italian and European public and private researchers. The ongoing project of Polo Strategico Nazionale (PSN) will collect Italian Public Administration's data assets in a national cloud infrastructure. Italy has a strong HPC research community and a growing HPC industry. Italian HPC systems are used by a wide range of researchers and businesses to solve complex problems in a variety of industries, including science, engineering, and finance.

Europe is a leader in **Artificial Intelligence** research and innovation, with the ambition and aim of developing and using AI in a safe, ethical, and trustworthy manner. The EU has launched a number of initiatives to promote the development and use of AI, including:

- *The European AI Act* is the first comprehensive legal framework for AI in the world. It classifies AI systems into four risk categories, with different requirements for each category. The highest-risk AI systems are prohibited, while lower-risk systems are subject to requirements such as transparency and accountability.
- The *European AI Strategy* sets out the EU's vision for AI and outlines a number of actions that the EU will take to promote the development and use of AI in Europe. The Strategy focuses on three key areas: increasing investment in AI research and development, making AI available to all, and ensuring that AI is used in a trustworthy and ethical manner.
- The *European AI Alliance* is a public-private partnership that was launched in 2019. It brings together stakeholders from across Europe to shape the EU's AI policies and investments. The Alliance is working on a number of initiatives, including developing a code of conduct for AI and supporting the development of AI start-ups.
- The *European AI Research Initiative* is a €1 billion initiative that was launched in 2020. It aims to support research and development in AI in Europe. The Initiative is funding a number of research projects, including projects on AI for healthcare, climate change, and manufacturing.

The European **data economy** is still in its early stages of development, but it is growing rapidly. The EU is committed to supporting the development of the data economy through a number of initiatives, including:

- The *European Data 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.
- The *European Data Act* was proposed by the European Commission in February 2022. It aims to create a single market for data in the EU and to make it easier for businesses and individuals to

share and use data. The Act also sets out new rules on how data can be collected and used, and gives individuals more control over their personal data.

- The *European Data Space Alliance (EDSA)* is a coalition of organizations working to promote the development and use of common European data spaces. The EDSA was founded in 2020 and has over 300 members from industry, academia, and government. The EDSA's mission is to make Europe a leader in the data economy by creating a common European data space where data can be shared and used across sectors and borders.
- *Common European Data Spaces* are digital spaces in which data can be shared and used across different sectors and borders. The EU is currently developing a number of Common European Data Spaces, including in the areas of healthcare, environment, and manufacturing.
- *Data, AI and Robotics (DAIRO) Association*, formerly known as BDVA, the Big Data Value Association, is a leading European association in the field of data, AI, and robotics. It has over 300 members from industry, academia, and government. DAIRO's mission is to promote the development and use of data, AI, and robotics to create economic and social value for Europe. DAIRO is a co-founder of the European Data Space Alliance, a coalition of organizations working to promote the development and use of common European data spaces.
- *GAIA-X* is a European initiative to create a secure and federated data infrastructure that enables the sharing and use of data across sectors and borders. GAIA-X is based on open standards and technologies, and is designed to be trustworthy and compliant with European regulations. GAIA-X plays a key role in the European Data Economy by providing a secure and trusted environment for businesses and individuals to share and use data. This will enable businesses to develop new products and services, and will help individuals to get more value from their data.
- The *International Data Spaces Association (IDSA)* is a non-profit organization that promotes the development and use of International Data Spaces (IDS), which is a standard and reference architecture for a secure and trusted data sharing ecosystem.
- The *European Cloud Initiative* aims to make Europe a leader in the cloud computing market. The Initiative is supporting the development of European cloud computing providers and is making it easier for businesses and individuals to access and use cloud computing services.

There are also a number of national and regional initiatives on big data and the data economy in Europe. Many European countries have launched their own national data strategies and are investing in the development of big data technologies and infrastructure.

In addition to these initiatives, the EU is also supporting HPC, AI, and data economy through a number of other research and innovation programs:

- The Digital Europe Programme is a €7.5 billion program that aims to accelerate the digital transformation of Europe.
- The Horizon Europe is the European Union's research and innovation framework program for 2021-2027. Horizon Europe will support research and development in innovative technologies and applications.
- The European Innovation Council (EIC) is a new initiative that aims to support the development and market entry of innovative products and services. The EIC supports startups and scaleups in Europe.

Role and ambition of the CN

The National Centre (CN) on HPC, Big Data, and Quantum Computing is conceived with the ambitious goal of becoming a **lasting and enduring initiative**. Its primary mission is to provide sustained support to the Italian scientific community and industrial sector, extending its reach well beyond the boundaries of the PNRR project.

The CN is dedicated to addressing both **current and future scientific and societal challenges**, reinforcing and broadening the scope of existing competences, as well as enhancing the availability of critical infrastructural resources. This enduring commitment ensures that the CN remains a cornerstone in advancing the Italian scientific and technological capabilities on HPC, Big Data, data economy, AI, and Quantum Computing.

The CN will not only strengthen but significantly **expand the existing competences and infrastructural resources**. Researchers and businesses will gain unparalleled access to state-of-the-art HPC, big data, and quantum computing technologies. This will empower them to pioneer groundbreaking solutions to intricate challenges across diverse domains, such as healthcare, climate change mitigation, and advanced manufacturing. By fostering a collaborative environment that encourages innovation, the CN is poised to drive remarkable advancements in these critical areas, ultimately benefitting society and the economy at large.

The CN is expected to undertake a pivotal role **in nurturing and mentoring the upcoming wave of experts** in HPC, big data, and quantum computing. This proactive stance on education and skill development is paramount to Italy's sustained leadership in these domains. By equipping the next generation with knowledge, expertise, and hands-on experience, the CN will be able to lay the foundation for Italy to retain its distinguished status as a frontrunner in these cutting-edge fields. Through comprehensive training and mentorship, the CN will not just prepare the experts of tomorrow but also fortify the nation's enduring influence in the global technology landscape.

Moreover, the CN will support the Italian scientific community and industrial system by:

- Facilitating **access to world-class HPC, Big Data, and Quantum Computing resources**, the CN will preside over a suite of HPC and big data systems, complemented by a cutting-edge quantum computer. This comprehensive resource offering provides researchers and businesses with the requisite means to embark on pioneering research initiatives and cultivate innovative solutions.
- Fostering the **advancement of novel applications** in HPC, Big Data, and Quantum Computing. The CN is committed to nurturing the growth of innovative applications in the realms of HPC, Big Data, and Quantum Computing. It endeavors to provide support and comprehensive backing to researchers and businesses actively engaged in the development of pioneering applications within these domains. This proactive approach serves a dual purpose. Firstly, it expedites the widespread adoption of these transformative technologies, amplifying their integration across diverse sectors. Secondly, by boosting the creation of novel applications, this initiative catalyzes the evolution of cutting-edge products and services, strengthening the technological landscape and enhancing the potential for economic growth and advancement.

The CN intends to assume a pivotal and influential role in actively contributing to the realization of the overarching objectives outlined in the National Recovery and Resilience Plan (PNRR). This comprehensive initiative is poised to be a cornerstone in driving economic growth, fostering innovation, and enhancing sustainability, in alignment with the PNRR's core aspirations. Through a dedicated focus on research, technology, and expertise, the CN is well-positioned to accelerate the nation's journey toward economic expansion, leveraging technological innovation as a catalyst. By nurturing innovation and fostering a dynamic environment for groundbreaking research, the CN will serve as a catalyst for driving economic growth, positioning Italy as a leader in advanced technology, and promoting sustainable practices across various sectors. In synergy with the PNRR, the CN will play a crucial role in advancing the nation's socioeconomic and environmental aspirations, shaping a resilient and prosperous future for Italy.

In this scenario, the IAB underlines the importance of *strategically* allocating attention to HPC, Quantum Computing, Big Data, Cloud and as-a-service model in a manner that closely **aligns with prevailing market dynamics and anticipates future trends**. This strategic approach is contingent upon a thorough assessment of the application scenarios and requisites articulated by Italian enterprises. Hence, the IAB advises a **judicious distribution of emphasis on these transformative technologies**, guided by a profound understanding of how they resonate with contemporary market conditions, actual industrial needs, and evolutionary trajectories in the technology landscape. By keeping a keen eye on emerging trends and envisaging evolving demands, this approach ensures that the development of HPC, Quantum Computing, Big Data, and Cloud in the CN will be driven by the imperative to **harmonize technological capabilities with the specific needs and aspirations of Italian businesses**. Thus, the CN will empower Italian businesses to navigate the intricacies of today's rapidly evolving digital landscape while providing them with the tools and services they require to drive innovation and achieve sustained growth.

The PNRR project will undertake the critical task of delineating, designing, and constructing the **foundational elements of the CN**, setting the stage for the kick-off of its operations. Consequently, the

desired outcomes of the PNRR initiative are multifaceted and oriented toward catalyzing significant advancements across various dimensions:

1. **National-level distributed cloud-based supercomputing infrastructure**. At its core, the PNRR project aims to forge a state-of-the-art national-level supercomputing cloud distributed infrastructure. This technological backbone is designed to satisfy to the multifaceted needs of technical-scientific computing and the processing of vast datasets, thereby fostering the development of data-intensive and computational-intensive applications spanning a wide array of societal and industrial domains.
2. **Network of expert teams and communities**. In alignment with its vision, the project will foster the establishment of a network comprising high-quality teams of experts in HPC, Big Data, AI, and Quantum Computing. These teams will be complemented by domain specialists, ensuring a multidisciplinary approach that effectively anchors and leverages cutting-edge computing technologies within real-world use cases.
3. **Knowledge Hub**. The PNRR project is dedicated to setting up and cultivating a knowledge hub with a multifaceted orientation. Within this ecosystem, three vital components will be fostered:
    a. *Observatory*: A vital source of insights, the observatory will monitor the pulse of technological advancements, market trends, and emerging challenges.
    b. *Foresights*: By anticipating future developments, the PNRR initiative seeks to be at the vanguard of technological progress, equipping Italy to lead in the world of advanced computing.
    c. *Recommendations*: In the interest of informed decision-making, the provision of recommendations grounded in empirical knowledge is integral to the knowledge hub.
4. **Data Hub**: To cater to the burgeoning data needs of the digital era, the PNRR project is dedicated to the establishment of a robust data hub. This resource will serve as a distributed repository and data spaces, facilitating efficient data management and accessibility for a wide spectrum of applications.
5. **Digital Services**: An array of digital services will be engendered to augment the value proposition of the CN. These services will empower stakeholders to harness the full potential of advanced computing technologies, thereby driving innovation and progress.
6. **Support Services**: Recognizing the significance of human capital in this endeavor, the PNRR project will deliver a suite of support services. These encompass pivotal functions such as training programs, advisory services, and comprehensive assessments, ensuring that the expertise required to optimize and harness advanced computing technologies is readily available.

These outcomes represent the building blocks and assets on top of which to kick-off the operations of the CN during the PNRR project and support its evolution after its end. In summary, the PNRR project's comprehensive strategy not only aspires to establish a state-of-the-art computing facility but also to create an ecosystem that is aware of market trends, forward-thinking, and equipped to provide invaluable services to both society and industry.

To lay the basis for the future operations of the CN, over the course of the project's implementation, a comprehensive model and a well-thought-out plan for ensuring the sustainability of the CN beyond the scope of the PNRR will be carefully designed. This forward-looking endeavor aims to not only secure the immediate functioning of the CN but also to lay the foundation for its dynamic evolution.

The IAB encourages the governance bodies and the members of the CN to develop such a **sustainability strategy and plan** in terms of *strategic vision* (starting from this document); financial, human and operational *resource needs and allocation*; *operational framework* (organization, governance, procedures, etc.); *evolutionary strategies*; *engagement, collaboration, and partnership*; *financial and economic models* (revenue streams, funding sources, and investment strategies); *policy and regulation compliance* (e.g. to GDPR).

Mission

The CN aims to be the **long lasting (beyond the PNRR) reference national digital infrastructure and excellence Centre in Italy** for research and innovation on HPC, Big Data, Quantum Computing, and new computing technologies. The CN, leveraging on existing and new HPC, Cloud and Big Data infrastructures and relying on a high-level support team, will be accessible by the scientific and industrial communities through flexible and uniform cloud web interfaces.

The CN will contribute to the Italian (and EU) digital sovereignty, leadership, and autonomy in HPC infrastructure, data, and services by fostering innovation across the computing continuum.

The companies participating in the CN and the representing Advisory Industrial Board have jointly identified four Strategic Goals (SGs) that concretely represent the ambition and challenging objectives of the CN and the actual expectations of its industrial members. The following picture represents the holistic view of SGs and the actions to achieve them in the context of the roadmap that the AIB has identified.

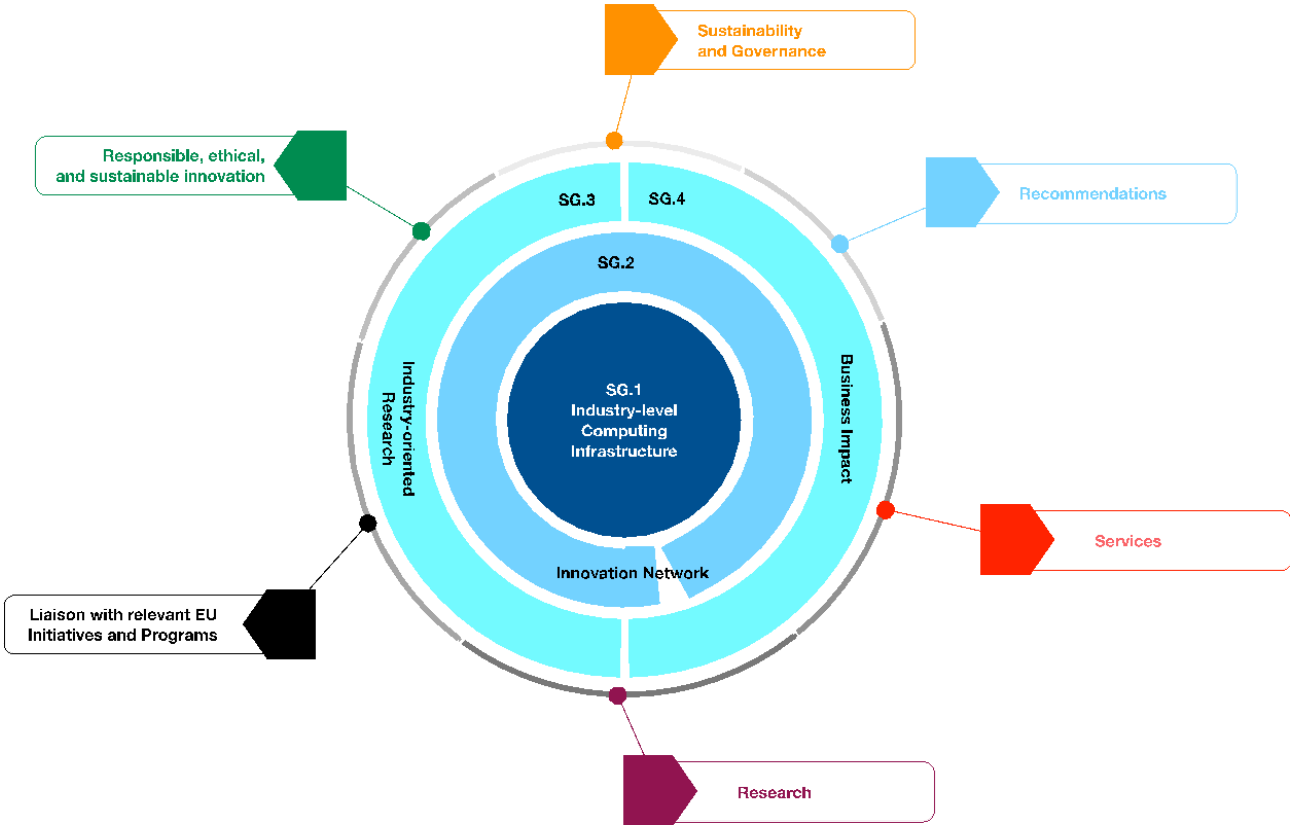


Fig. 1 - Strategic objectives and concrete actions to implement the CN's vision and fulfilling its mission.

Strategic Goals

This section provides a comprehensive listing and detailed description of the strategic goals that form the cornerstone of the CN mission. These strategic goals have been thoughtfully crafted in alignment with the insights and recommendations of the industrial board. They represent the fundamental pillars on which our mission is founded, and they chart the course for our endeavors in the field of advanced technology and innovation.

SG.1 Industry-level Computing Infrastructure

The core strategic goal of the CN is the definition, design, creation, setup, deployment, and operations of a world-class national supercomputing cloud *infrastructure*. The AIB envisions such an infrastructure as an integrated hardware and software (federated) platform, providing essential functionalities and services (to the wide range of potential users), including, but not limited to, (micro-)service management and composition, big

data management and analytics infrastructure, quantum simulators (or computers), DevOps, DataOps, and MLOps capabilities, and AI/ML training dataset management.

The CN computing infrastructure must provide members of the research and scientific community, industry (including SMEs) and the public sector with easy and transparent access to highly flexible and configurable data and computing resources and services, adaptable to a wide range of applications and user needs.

The envisaged capabilities and functionalities should be offered with the proper service level needed by each user, in terms of cost, speed, accessibility, scalability and resiliency, particularly important for high TRL applications and prototypes.

It should be noted that the industrial members and the whole user community envisage and expect an industry-level middleware and application software stack, including secure, production-level, state-of-the-art (open-source) software components, which will allow flexible service composition and a comprehensive set of access policies. This is particularly important on the application and adoption of mature and state of the art cybersecurity measures and standards.

SG.2

Innovation Network

The second key element for making the CN vision a reality and fulfilling the mission is *people* and their capability (and capacity) to (co-)create innovation. Therefore, the CN is envisaged as a unique environment through which competitiveness and innovation can be enforced for the benefit of the entire National system.

The CN should be able to foster, stimulate and empower links, collaboration and cooperation between the scientific community and the industrial system in order to build capacity by sharing expertise within the broader scientific community with the ultimate goal of strengthening the areas where Italy is lagging behind.

The CN is expected to play a pivotal role in cultivating the expertise of the upcoming generation in the realms of HPC, Big Data, and Quantum Computing. In furtherance of this mission, the CN should institute a diverse array of training programs and immersive workshops dedicated to these cutting-edge domains. These educational initiatives serve a twofold purpose. Firstly, they are instrumental in equipping the emerging workforce with the essential knowledge and hands-on experience vital for continued excellence and leadership in these fields. Secondly, they underpin Italy's ability to maintain its position as a frontrunner in HPC, Big Data, and Quantum Computing, ensuring the nation remains at the forefront of global technological innovation and progress.

Researchers and businesses should find within the CN's resources the essential tools to embark on exploratory journeys and undertake forward-looking investigations on HPC, Big Data, and Quantum Computing. These resources serve as the lifeblood of pioneering exploration, enabling experts to test the limits of such technologies in real-world applications.

The CN should be a catalyst for collaboration, fostering a dynamic environment where multidisciplinary experts, at the national level as well as globally, converge to share knowledge, leverage resources, and collectively engage in joint research and innovation endeavors.

At the heart of the CN is the cultivation of innovation. The CN's comprehensive resource ecosystem empowers researchers and businesses to engineer innovative solutions leveraging on HPC, Big Data, and Quantum Computing and tackle complex challenges in fields such as healthcare, climate action, advanced manufacturing, and many more. This culture of innovation will serve as a dynamic incubator, nurturing an environment where the ability to attract and retain exceptional talents thrives. It should encompass a range of practices and attributes that not only stimulate creativity and fresh thinking but also create a magnetic pull for top-tier individuals.

SG.3 Industry-oriented Research

The CN should be firmly dedicated to exploiting the transformative power of advanced technologies such as HPC, Big Data, and Quantum Computing to drive applied research and industry-oriented innovation, solve practical challenges, and empower industries and businesses to thrive in the digital era, bridging the gap between such cutting-edge technology and real-world industrial and societal applications.

Thus, the CN should be dedicated to conducting cutting-edge research that advances the state of knowledge and translate it into practical solutions for industry.

To this aim the IAB envisages strategic collaborations with industry partners to ensure that research is not only academically rigorous but also directly applicable to the challenges and opportunities faced by businesses, thus pursuing the goal of enhancing industry competitiveness and success. Through the foreseen ecosystem (see SG.2), the CN will be able to inspire and support the development of novel applications and technologies that have a tangible impact on the industrial landscape.

The CN should aspire to be a global leader in applied research on HPC, Big Data, and Quantum Computing at the EU level, setting standards for innovation, collaboration, and impact. It should be at the forefront of technological advancements and to contribute to the growth and competitiveness of industries on a national and international scale.

Applied research also involves and requires the investigation of multi-faced disciplines or aspects that turn scientific-oriented only research into industrial-oriented in-depth research, leading to a comprehensive, realistic and effective roadmap for the future:

- *Cutting-edge hardware advancements*: examination of emerging hardware technologies, encompassing processors, memory architectures, storage solutions, and network infrastructure, identifying and harnessing hardware breakthroughs that will fuel the next generation of computing systems.
- *Base software ecosystem evolution*: the investigation should include the evolution of base software and infrastructural frameworks, on which the research on HPC, Big Data, and Quantum Computing foreseen by the CN can leverage.
- *Performance optimization*: ensuring that the next-generation systems foreseen by the CN, not only deliver exceptional computational power, but also operate with maximum efficiency, reducing energy consumption and environmental impact.
- *Scalability and flexibility*: scalability is a fundamental and required feature to be considered by-design, to meet the demands of diverse workloads and applications. Adaptability and flexibility are also vital for accommodating the evolving needs of various industries and research fields.
- *Security and reliability*: robust security measures and dependable operations should also be included by-design in applied research, to deliver outcomes (methodologies, frameworks, prototypes, services, etc.) effectively exploitable for developing the next generation of systems against cyber threats while ensuring uninterrupted, reliable performance.
- *Ethical and responsible computing*: the exploration of these technologies should be aware of the implications of the research on society, and prioritize responsible innovation that benefits humanity.

SG.4 Business and Societal Impact

The industry-oriented applied research on HPC, Big Data, and Quantum Computing envisaged by the IAB (see SG.3) should make a positive and lasting impact on industry, society, and the advancement of these transformative technologies. The mission should be to catalyze and amplify the transformative business impact of such research, foster innovation, stimulate competitiveness, and unlock the full potential of advanced technologies for the benefit of Italian businesses.

To this aim, the IAB envisages the creation of innovation ecosystems where ideas, expertise, and resources converge to drive pioneering business-centric solutions that

translate the cutting-edge technologies into tangible benefits, optimizing operations, and empowering businesses to thrive in a digital-first era.

Hence, the driving force behind the research and application of the cutting-edge HPC, Big Data, and Quantum Computing technologies should be the real-world needs of industries.

Beyond research, the CN's resources have the potential to be an economic driver. By harnessing the power of these technologies, businesses and industries can enhance their competitive edge, improve their operations, and ultimately contribute to national economic growth.

The IAB envisages responsible innovation research on HPC, Big Data, and Quantum Computing, ensuring that its business impact aligns with the values of integrity, inclusivity, and sustainability, thus contributing to a landscape of innovation, competitiveness, and responsible growth in the business world.

The IAB expects that the benefits of research within the CN extend beyond industry, addressing broader societal challenges, such as healthcare, environmental sustainability, and social well-being, using the power of advanced computing.

The CN should provide technology SMEs with decisive support on their journey to elevate the Technology Readiness Level (TRL) of their solution based on HPC, Big Data, and/or Quantum Computing. Thus, SMEs, that are the lifeblood of innovation and economic growth, will be empowered with the tools, knowledge, and resources required to achieve technological excellence.

Therefore, the IAB envisages the following benefits for SMEs resulting from the engagement with the CN (most the benefits hold for large businesses as well):

- Empowering technological advancements: the CN should offer support in research and development, thus enabling these enterprises to enhance their existing solutions and explore new horizons in HPC, Big Data, and Quantum Computing.
- Market Viability: as the market viability of SMEs' solutions is essential for their growth, the CN could provide guidance and resources to ensure that their offerings are not only technologically robust but also strategically positioned for success in the marketplace.
- TRL Elevation: the CN should develop (and apply) a systematic approach to enhancing the readiness of solutions based on HPC, Big Data, and Quantum Computing technologies for practical implementation, scaling, and commercialization.
- Access to Expertise: the CN should provide access to domain experts and technical mentors who offer invaluable insights and guidance.
- Collaboration and partnership: the integration of SMEs into the larger technological ecosystem will foster collaborations and partnerships with research institutions, industry leaders, and fellow SMEs.
- Ethical Innovation: the CN should support SMEs in enhancing their technologies, while ensuring that their solutions align with ethical principles and societal values.
- Global Reach: the CN should assist SMEs in expanding their technological footprint on a global scale, by providing guidance on international market penetration and global competitiveness.

One of the expected goals of the CN should be to stimulate a transformation in the Public Administration and Government sectors by significantly enhancing the adoption of HPC, Big Data, and Quantum Computing technologies, by fostering the introduction of these technologies and their seamlessly integration into the very fabric of governance processes. The expected innovation will include and involve the modernization of public services, enhanced decision-making and policy, resilience and security, transparency and accountability, efficiency and cost saving.

Finally, the CN should empower and energize the creation of spin-off ventures that harness and fully exploit the potential of groundbreaking technologies, such as HPC, Big Data, and Quantum Computing. Therefore, the CN should be committed to fostering an environment where entrepreneurial endeavors can thrive and flourish. The CN should encourage the transformation of novel concepts and ideas into viable businesses that can leverage HPC, Big Data, and Quantum Computing and provide access to mentors, subject matter experts, and advisors who offer invaluable guidance to budding entrepreneurs. Then the CN should assist in the transition from research and development to market-ready solutions, enabling spin-offs to effectively bring their products and services to the market. The CN should facilitate access to resources (including funding, research facilities, and infrastructure) and promote collaboration, partnerships, and networking opportunities with research institutions, industry leaders, and fellow start-ups.

How to achieve the strategic goals

This section outlines the recommended initiatives and tasks that the CN should undertake throughout the PNRR project, with the aim of actively supporting the realization of the strategic objectives and the execution of the overarching vision, as detailed in the preceding sections. These initiatives and tasks are systematically structured into cohesive categories, which are developed in the subsequent sections.

Research

In order to foster industry-oriented innovation, solve practical challenges, and empower industries and businesses on HPC, Big Data and Quantum Computing, the IAB recommends the following activities and actions related to research activities under development in the PNRR project:

- **Engage and collaborate with** industry partners of the CN to tailor research activities and solutions to their needs.
- Organize **workshops** that bring together researchers, industry experts, and businesses. These events can serve as platforms for knowledge sharing, problem-solving, and networking.
- Request for **technical, technological, and business advisory** (technology selection, implementation strategies, best practices, business value, etc.) from industries seeking to adopt HPC, Big Data, and Quantum Computing.
- **Conduct cutting-edge research** that advances the state of knowledge on HPC, Big Data, and Quantum Computing and translate it into (or make it exploitable in) practical solutions for industry. This includes awareness and analysis of cutting-edge hardware advancements and base software ecosystem evolution, in order to leverage the scientific and technological research on HPC, Big Data, and Quantum Computing on solid and state of the art software and hardware foundations.
- Complement and integrate technology research with the **investigation of multi-faced disciplines or aspects** that turn scientific research into applied and exploitable research, leading to a comprehensive, realistic and effective application of HPC, Big Data, and Quantum Computing in real scenarios and use cases. Such facets and discipline involve social science, humanities, ethics, responsible innovation, human rights, security, safety, explainability, accountability, etc.
- Initiate **proof of concept** projects to demonstrate the practical viability of HPC, Big Data, and Quantum Computing solutions in real-world industrial applications while adopting by-design approaches to optimise performance, to support scalability and flexibility, to integrate security measures, and to ensure dependability.
- Conduct technology **demonstrations and showcases** to illustrate the practical application and benefits of HPC, Big Data, and Quantum Computing in real-world scenarios, use cases and applications.
- Conduct **multi-faced impact assessment** on research results, considering scientific, technological, societal, ethical, and security analysis.

- Regularly publish and **communicate** research findings, case studies, and best practices to **disseminate** knowledge and insights within the CN.
- Identify and analyse **emerging trends**, potential growth areas, and untapped **opportunities** in HPC, Big Data, and Quantum Computing for different industries.

These activities, when strategically implemented, can empower industries and businesses to harness the full potential of HPC, Big Data, and Quantum Computing, fostering innovation and addressing practical challenges in a wide range of sectors.

Services

In order to prepare the full operation of the CN, the PNRR project is expected to design, develop and deliver a coordinated set of **digital services** to augment the value proposition of the CN. These services are intended to facilitate access to and exploit the potential of the supercomputing infrastructure, the innovation network, and all additional resources within the broader innovation ecosystem connected to the CN.

Setting up and operationalizing a cloud-based supercomputing infrastructure is a complex and ongoing process that requires careful planning, management, and continuous improvement to meet the evolving needs of researchers and organizations. To this aim the IAB recommends the following activities and actions to be undertaken during the PNRR project:

- **Plan and design the supercomputing infrastructure** according to the specific objectives of CN and use cases (not only the project), computational and storage requirements based on the intended applications and workloads, including proper security measures, leveraging on state-of-the-art network infrastructure as well as hardware and software stack. Plan for future growth and scalability by designing the infrastructure to accommodate additional hardware and needs. Implement a strategy for expanding the supercomputing cluster as needed.
- Establish **security** policies and protocols to protect the supercomputing infrastructure from threats; implement access controls, firewalls, intrusion detection systems, and encryption (when appropriate).
- Create comprehensive **documentation** for system administrators, users, and developers.
- Provide **training and support** to users to ensure they can effectively utilize the supercomputing resources.
- **Test** the supercomputing infrastructure: conduct thorough testing to ensure the infrastructure performs as expected and meets performance, security, and usability requirements. Validate security measures and data integrity.
- Ensure that the supercomputing infrastructure **complies** with industry standards, regulations, and governance requirements.
- Implement **disaster recovery plans** and redundancy measures to minimize downtime and data loss in case of system failures.
- Regularly **benchmark and report** on the performance of the supercomputing infrastructure.

On top of the infrastructure (IaaS), a set of coordinated **platform capabilities (offered as-a-Service, i.e. PaaS)** should be planned, designed, implemented, integrated, deployed and delivered by the PNRR project to operationalise the CN and boost industry-driven innovation on HPC, Big Data, AI, and Quantum Computing. The IAB recommends the following activities and actions to be undertaken during the PNRR project to provide a robust and user-friendly environment for developers and data scientists:

- Determine the specific objectives and use cases for the PaaS platform. Identify the requirements and demands of users within the CN, including data scientists, AI researchers, and quantum computing developers.
- Select the PaaS components and tools required for Big Data, AI, and Quantum Computing, such as data processing frameworks, AI libraries, and quantum development environments.
- Implement data ingestion mechanisms to bring in large datasets for research and prototyping.
- Configure data storage solutions, including distributed file systems or data lakes.
- Deploy and provide data processing frameworks (e.g., Hadoop, Spark) for Big Data analytics.
- Deploy and provide AI frameworks and tools for machine learning and deep learning tasks. Integrate popular AI libraries and frameworks (e.g., TensorFlow, PyTorch) for machine learning and AI tasks.

- Design and provide a system for service orchestration to automate the deployment and scaling of Big Data, AI, and quantum applications.
- Support DevOps, DataOps, and MLOps practices, and AI/ML training dataset management.
- Design and set-up a Data Hub, as a distributed repository and data spaces, facilitating efficient data management and accessibility for a wide spectrum of applications.
- Set up a quantum computing development environment with access to quantum hardware and simulators. Configure quantum programming languages and libraries.
- Establish robust security measures to protect data, resources, and algorithms. Implement access controls, encryption, and identity management.
- Create user accounts and manage access permissions for developers, data scientists, and researchers.
- Develop and provide user-friendly interfaces for managing and deploying applications.
- Set up monitoring tools to track resource utilization, performance, and user activity. Configure logging for auditing and troubleshooting.
- Create comprehensive documentation for users and developers, including guides and tutorials. Provide training and support to users to ensure they can effectively utilize the PaaS platform.
- Ensure that the PaaS platform complies with relevant data privacy regulations and industry standards.
- Implement data backup and disaster recovery measures to safeguard data and applications against unexpected failures.
- Provide tools for collaboration and resource sharing among users and teams, fostering a collaborative environment.
- Continuously assess user feedback and emerging technologies to improve and expand the PaaS platform.

As stated above, the IAB envisages the creation of a dynamic environment where multidisciplinary experts converge to share knowledge, leverage resources, and collectively engage in joint research and innovation activities. To this aim, the IAB recommends that the PNRR project **sets up and operationalises a knowledge hub** on industry driven HPC, Big Data, AI, and Quantum Computing research and innovation. This involves a range of activities to centralize, manage, and disseminate valuable information and expertise, support knowledge sharing, foster collaboration, and facilitate research and innovation:

- Design the scope of the services offered by the knowledge hub tools.
- Develop content co-creation guidelines and quality control processes.
- Integrate collaboration tools like forums, discussion boards, and chat features to facilitate interaction and knowledge sharing among users.
- Implement user registration and authentication mechanisms to control access to the knowledge hub. Define user roles and permissions for different levels of access.
- Curate a wide range of content, including research papers, reports, case studies, articles, and relevant news related to HPC, Big Data, AI, and Quantum Computing. Organize content into categories and tags to simplify content discovery and browsing. Implement a taxonomy that aligns with the areas of HPC, Big Data, AI, and Quantum Computing.
- Provide a robust search function and user-friendly navigation to help users find relevant content efficiently.
- Define and implement engagement mechanisms, including guidelines and incentives.
- Regularly update the knowledge hub with the latest research, reports, and publications.
- Create a publication schedule to ensure a steady flow of new content.
- Implement AI-driven recommendation engines to suggest relevant content to users based on their interests and preferences.
- Incorporate data analytics tools to gather insights into user behaviour and content usage.
- Develop and nurture a community of users and contributors through engagement initiatives like webinars, virtual conferences, and discussion forums.
- Implement feedback mechanisms to collect input and suggestions from users to continuously improve the knowledge hub.
- Monitor platform usage and user engagement through analytics and reporting tools.
- Regularly assess the impact and value of the knowledge hub.

- Maintain content quality through peer review processes and content validation.
- Ensure that the information remains accurate and up-to-date.
- Implement privacy and data security measures to protect user information and sensitive content.
- Promote the knowledge hub through marketing and outreach efforts to attract users and contributors
- Promote responsible and ethical use of information and technology, addressing ethical considerations related to AI and Quantum Computing.

In addition to the digital services, the CN is expected to offer a range of **support services**, which will be formulated, established, and provided as part of the PNRR project. Consequently, the AIB suggests the following activities and measures throughout the project's duration:

- Design, plan, organise, and execute a **technology observatory** aimed at tracking of technological advancements, market trends and conditions, industrial needs, and emerging challenges.
- Proactively **analyse, anticipate, and forecast** future developments to position the CN at the forefront of technological progress. This will enable the CN and its members to lead and shape the trajectory of advancements in HPC, AI, Big Data and Quantum Computing, staying ahead of the curve and driving innovation.
- Provide **mentorship and recommendations** to ensure well-informed decision-making in the adoption of HPC, AI, Big Data and Quantum Computing. These recommendations are rooted in empirical knowledge, offering valuable insights and guidance based on sound data and analysis. They serve as a crucial resource for academic and industry stakeholders, assisting them in making informed and effective decisions within their respective domains.
- Provide **knowledge transfer** and **support in research and development**, thus enabling enterprises to enhance their existing solutions and explore new horizons in HPC, Big Data, and Quantum Computing.
- Offer market exposure, strategic direction, and resources to ensure that SMEs not only possess technologically robust solutions but are also strategically positioned for success in the market.
- Develop (and apply) a systematic approach to **evaluate the technological readiness and maturity** of solutions based on HPC, Big Data, and Quantum Computing technologies for practical implementation, scaling, and commercialization.
- Provide access to **domain experts and technical mentors** who offer invaluable insights and guidance.
- Develop **training** programs and immersive workshops dedicated to HPC, Big Data, and Quantum Computing technologies and their practical application in real-world use cases. Training programs will facilitate the transfer of such cutting-edge technologies from research to industry.

Recommendations

The IAB advises the CN to strategize, structure, and execute mechanisms and processes for providing strategic and policy recommendations. The AIB foresees a significant role for the CN in both national and European scientific, technological, and policy endeavours. Consequently, the AIB expects that the CN, first through the PNRR project and subsequently during its operational phase, consistently generates and shares:

- Public whitepapers
- Policy recommendations
- Strategic insights

These contributions will play a pivotal role in influencing and advancing the directions of advanced computing technologies and methodologies at both the national and EU levels.

Liaison with relevant EU Initiatives and Programs

The IAB recommends the PNRR project and its member to liaise at least with the following initiatives and projects:

- EuroHPC JU
- Quantum Flagship initiative

- European AI Alliance
- The European AI Research Initiative
- European Data Space Alliance (EDSA)
- Data, AI and Robotics (DAIRO) Association
- GAIA-X
- 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

Responsible, ethical, and sustainable innovation

To implement responsible innovation research on HPC, Big Data, and Quantum Computing while ensuring alignment with the values of integrity, inclusivity, and sustainability, and contributing to a landscape of innovation, competitiveness, and responsible growth in the business world, the IAB recommends that the following activities are undertaken:

- Develop a comprehensive ethical framework that guides research and innovation activities of the CN in HPC, Big Data, and Quantum Computing. This framework should encompass principles of integrity, inclusivity, and sustainability and serve as a reference point for decision-making.
- Incorporate social, ethical, and environmental impact assessments into the research and development process. Regularly evaluate the potential consequences and effects of new technologies and solutions on various stakeholders, the environment, and society as a whole.
- Promote inclusivity in research teams and projects. Encourage diversity in terms of gender, race, background, and expertise to ensure a broad spectrum of ideas and perspectives are considered in the innovation process.
- Establish protocols for responsible data collection, storage, and utilization. Ensure data privacy, security, and transparency, and consider the ethical implications of data usage.
- Make sustainability a core element of research and innovation. Assess the environmental impact of technology developments and strive for sustainable solutions, including energy-efficient computing and eco-friendly data practices.
- Foster a culture of responsible innovation by involving the public in the research process. Organize public consultations, awareness campaigns, and educational programs to ensure that innovation is aligned with societal values and needs.
- Stay up-to-date with relevant regulations and standards related to HPC, Big Data, and Quantum Computing. Ensure that research activities comply with legal and ethical requirements.
- Provide training and education on responsible innovation principles to researchers, developers, and business stakeholders. Raise awareness about the importance of ethical and responsible practices in innovation.

By integrating these activities into the research and innovation process for HPC, Big Data, and Quantum Computing, businesses and research organizations within the CN can ensure that their advancements align with values of integrity, inclusivity, and sustainability, contributing to responsible growth and competitiveness.

Sustainability and Governance

An essential determinant of the enduring, impactful presence of the CN lies in its capacity to sustain its operations beyond the conclusion of the PNRR project, thriving as a vibrant and indispensable centre for advanced computing, innovation, and research in the coming years.

The IAB suggests that the CN initiates the formulation of a strategy and an accompanying plan for the ongoing sustainability of the Centre, even after the conclusion of PNRR funding. This endeavour essentially involves future-proofing the Centre and encompasses at least the following activities:

- Define and delineate a robust and forward-looking strategic vision, starting from this document. This vision will encompass the long-term objectives, goals, and aspirations of the Centre,

positioning it as a pivotal player in the domain of advanced computing, technological innovation, and research.

- Analyse needs and define a plan for the allocation of financial, infrastructure, and human resources, required to sustain the Centre's operations over time.
- Define and document a detailed operational framework that defines how the Centre will function in the years to come. This includes organizational structures, governance mechanisms, and operational procedures that underpin its activities.
- Identify and analyse evolutionary strategies that allow the Centre to keep pace with technological advancements and changing market dynamics.
- Define engagement and collaboration strategies and plans, with the aim of fostering partnerships and collaborations with academia, industry, and research institutions.
- Define the financial and economic models of the CN, to sustain the Centre's financial, including revenue streams, funding sources, and investment strategies that support the CN'soperations and future growth.
- Ensure compliance with relevant policies and regulations (e.g. GDPR, AI Acts), by delineating a roadmap for navigating the regulatory landscape and maintaining compliance with evolving standards.