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Ministero dell'Università e della Ricerca

Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

ICSC
Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

The Italian Research Center on High-Performance Computing, Big Data and Quantum Computing

Davide Salomoni (davide@supercomputing-icsc.it)
Ibergrid 2023, 26/9/2023

Contents of this talk

- The project and its organization
- Some of the current activities
- Trends and and perspectives

The project and its organization

PNRR – The Italian National Recovery and Resilience Plan

Piano Nazionale
di Ripresa e Resilienza

6 Missions

ICSC
Centro Nazionale di Ricerca in HPC,
Big Data and Quantum Computing

From Research to Business:

ICSC is one of the 5 «Champions» on Key Technologies funded by the Italian National Recovery & Resilience Plan ("PNRR")

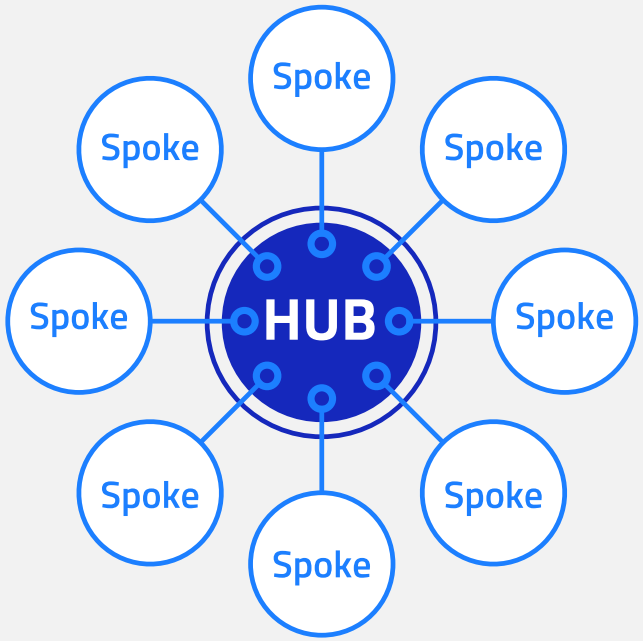
5 National Centres

1. **ICSC: HPC, Big Data and Quantum Computing**
2. **Agricultural Technology (Agritech)**
3. **Sustainable mobility**
4. **Drugs development with RNA technology and gene therapy**
5. **Bio-diversity**

1,6 B€ from PNRR

(approx. **320M€** for ICSC)

ICSC Working model



Networks of universities, research institutions, public and private entities aggregated in consortia in a «HUB&SPOKE» model

Started: 1/9/2022

Hub & Spoke model

- Governance structure: Hub and Spokes
- Hub purpose: management and coordination
- Spoke purpose: execution of CN activities (research, development, infrastructures and research material hosting, etc.).
- Spoke Leaders/Co-Leaders coordinate the scientific activities of each Spoke. The initial set of Spoke Leader e Co-leader will remain in charge for 4 years. Each person could be nominated again only once

The ICSC aims and objectives

Create the **national digital infrastructure** for research and innovation, starting from the existing HPC, HTC and Big Data infrastructures ...

... evolving towards a cloud datalake model accessible by the scientific and industrial communities through flexible and uniform cloud web interfaces, relying on a high-level support team ...

... form a sustainable, globally attractive ecosystem based on strategic public-private partnerships to fully exploit top level digital infrastructure for scientific and technical computing and promote the development of new computing technologies.

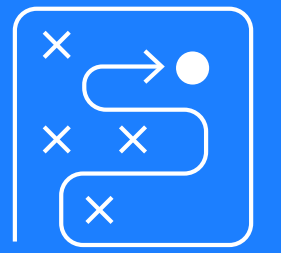
The Scenario

Why a National research Center on HPC, BD & QC?

With the current Data explosion...

- An unprecedented amount of data is going to be produced
- The real competitiveness challenge is extracting value from data
- Supercomputing, simulation, AI, high-performance data analytics and Big Data are essential for innovation and growth in a data-driven society

... need for an ambitious Italian strategy ...



- Europe has a clear strategy (e.g. EuroHPC, EOSC, EPI, Chip Act, Quantum Flagship) - European Data Strategy
- People, businesses and organisations should be empowered to make better decisions based on insights from data

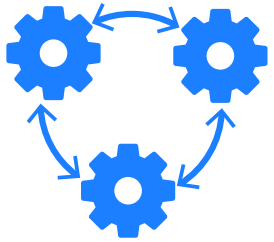
... to "close the gap" with best in class

- First actions: the Bologna Technopole, ECMWF Data Centre, Leonardo pre-exascale supercomputer
- A step forward based on **5 pillars**

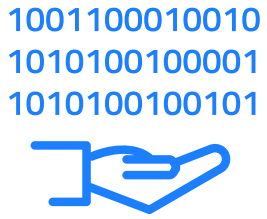
The 5 pillars of the ICSC action plan

- Build a **world-class supercomputing cloud infrastructure** to store, manage and process all the produced data

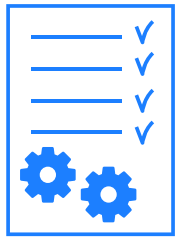
- Set **up centers of excellence** with teams of high-level experts to develop domain applications



- Set up strong **links** between **Academia, Industry** and **Public Administration**

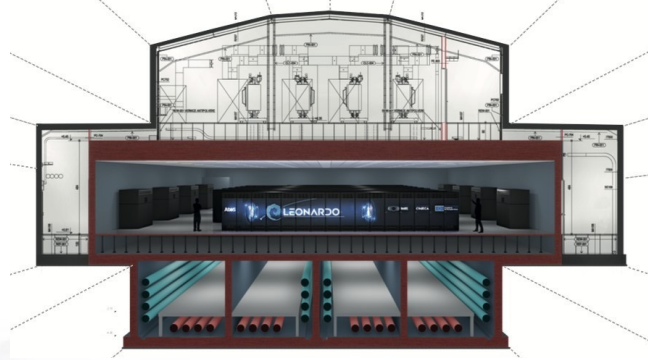


- **Train** the next generation of data scientists and managers to become **experts** in the digital transition



- Implement **structural measures for innovation** and for **dissemination**

The Big Data Technopole, Bologna



ECMWF Data Center

CINECA & INFN Exascale Supercomputer Center

Big Data Association and Foundation

Civic Protection and agency for development and innovation

ICSC

Conference and Educational Center

Meteo National Agency

Innovation Center

IFAB - International foundation Big data

Competence Center Industry 4.0

University Center

Biobank and Life Science

ENEA Center

Co-funded by the European Union

The Big Data Technopole, Bologna

Finalization of the civil works for the preparation of the buildings and of the infrastructures for the CINECA & INFN computing centers will be finished by the end of 2023.

- Fall 2023: installation of the INFN center
- End of 2024: installation of the Leonardo upgrades
- End of 2024: installation of the Quantum Computing Machine

The ICSC Headquarters are expected to move to the technopole area by 2025. They are temporarily hosted at the CINECA premises, close to Bologna.

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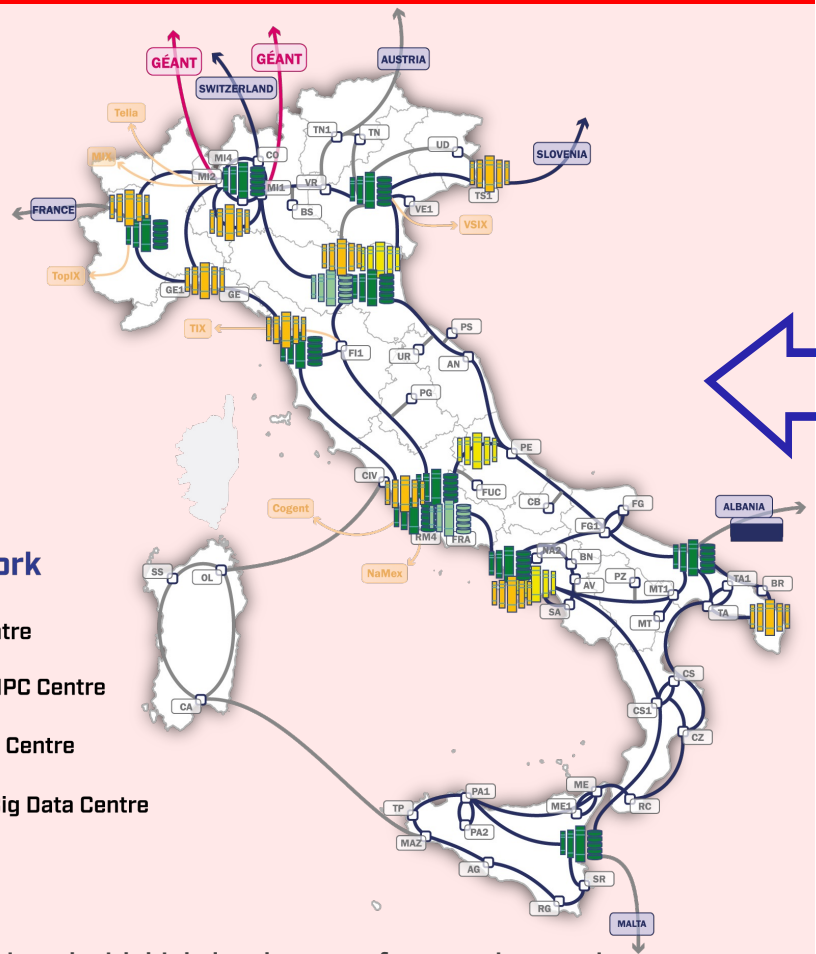
The Big Data Technopole, Bologna

ICSC is composed of
10 Thematic Spokes and **1 Infrastructure Spoke**

0 SUPERCOMPUTING CLOUD INFRASTRUCTURE



equipped with high-level teams of experts integrating
the Spokes working groups (mixed cross-sectional teams)

EDUCATION & TRAINING, ENTREPRENEURSHIP, KNOWLEDGE TRANSFER, POLICY, OUTREACH

1 FUTURE HPC & BIG DATA

2 FUNDAMENTAL RESEARCH & SPACE ECONOMY

3 ASTROPHYSICS & COSMOS OBSERVATIONS

4 EARTH & CLIMATE

5 ENVIRONMENT & NATURAL DISASTERS

6 MULTISCALE MODELING & ENGINEERING APPLICATIONS

7 MATERIALS & MOLECULAR SCIENCES

8 IN-SILICO MEDICINE & OMICS DATA

9 DIGITAL SOCIETY & SMART CITIES

10 QUANTUM COMPUTING

ICSC Founding Members: a public private partnership

Public Research Institutions Founding members:

a widespread initiative throughout Italy

National Institutes

INFN Istituto Nazionale di Fisica Nucleare

CINECA

ENEA

Consiglio Nazionale delle Ricerche

INAF Istituto Nazionale di Astrofisica

Istituto Nazionale di Geofisica e Vulcanologia

Consortium GARR

HUBs

UNIMORE Università degli Studi di Modena e Reggio Emilia

Università di Parma

OGS

Annual Members Budget Contribution:

6.325 M€

Private companies Founding members: **strategic players for digital transformation**

Highly-qualified group of large leading companies covering most of the strategic industrial sectors involved by digital transformation in Italy

fondazione innovazione urbana

Strategic partner to implement and develop the digital twin pilot case of an urban complex system

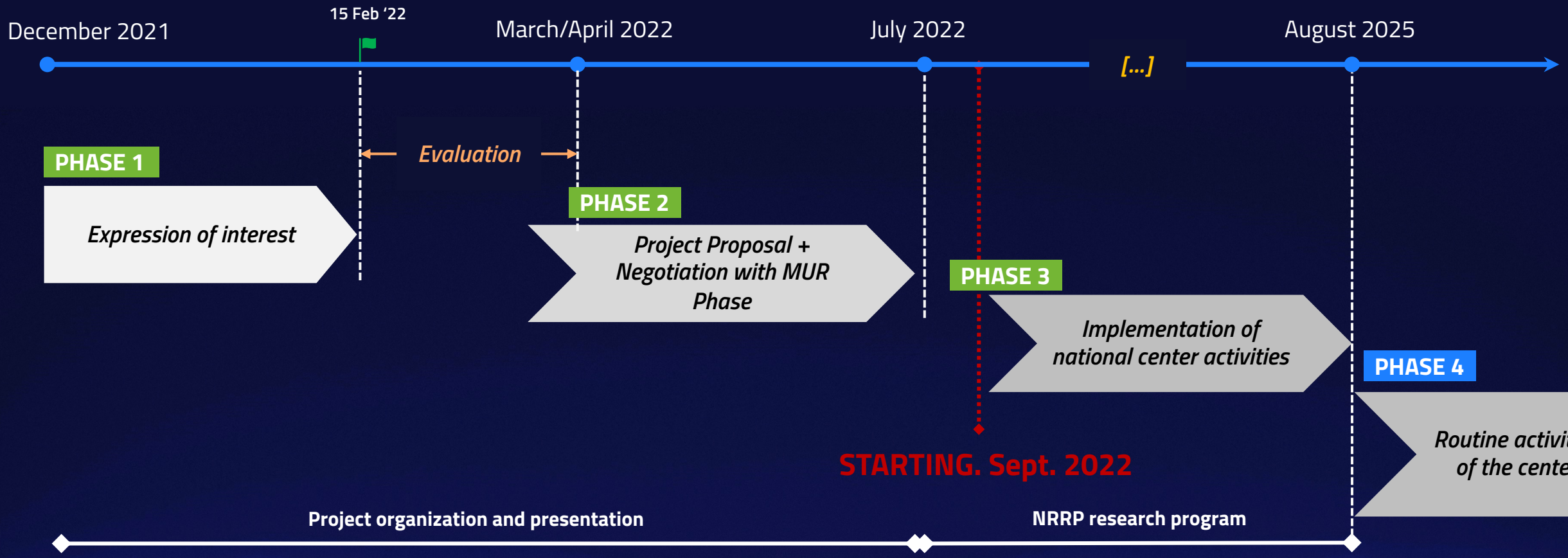
iFAB INTERNATIONAL FOUNDATION BIG DATA & ARTIFICIAL INTELLIGENCE FOR HUMAN DEVELOPMENTE

Industry-driven not-for-profit international organization aimed at: (1) aggregating companies, including SMEs, to engage with ICSC through a structured partnership, (2) funding research and innovation projects, (3) promoting the Big Data Technopole

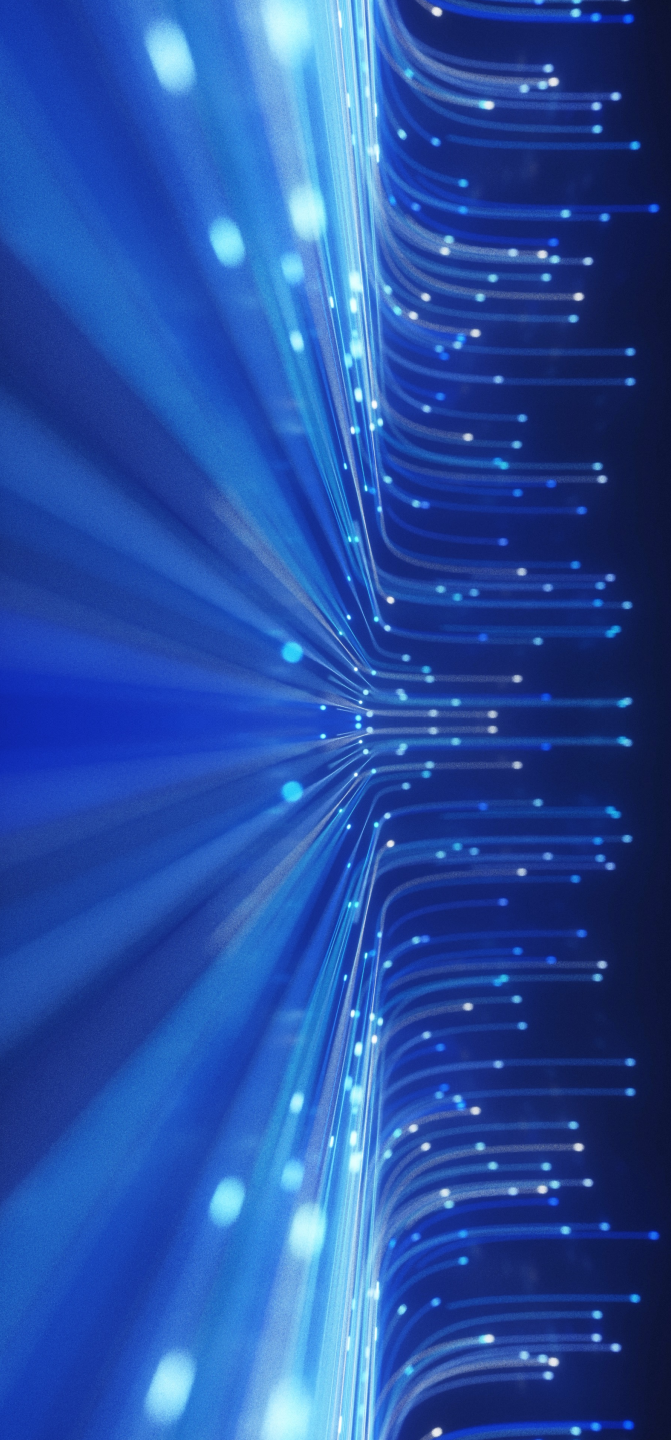
Contacts with new industrial partners

CANO, ERG, etc.

The three phases of the project

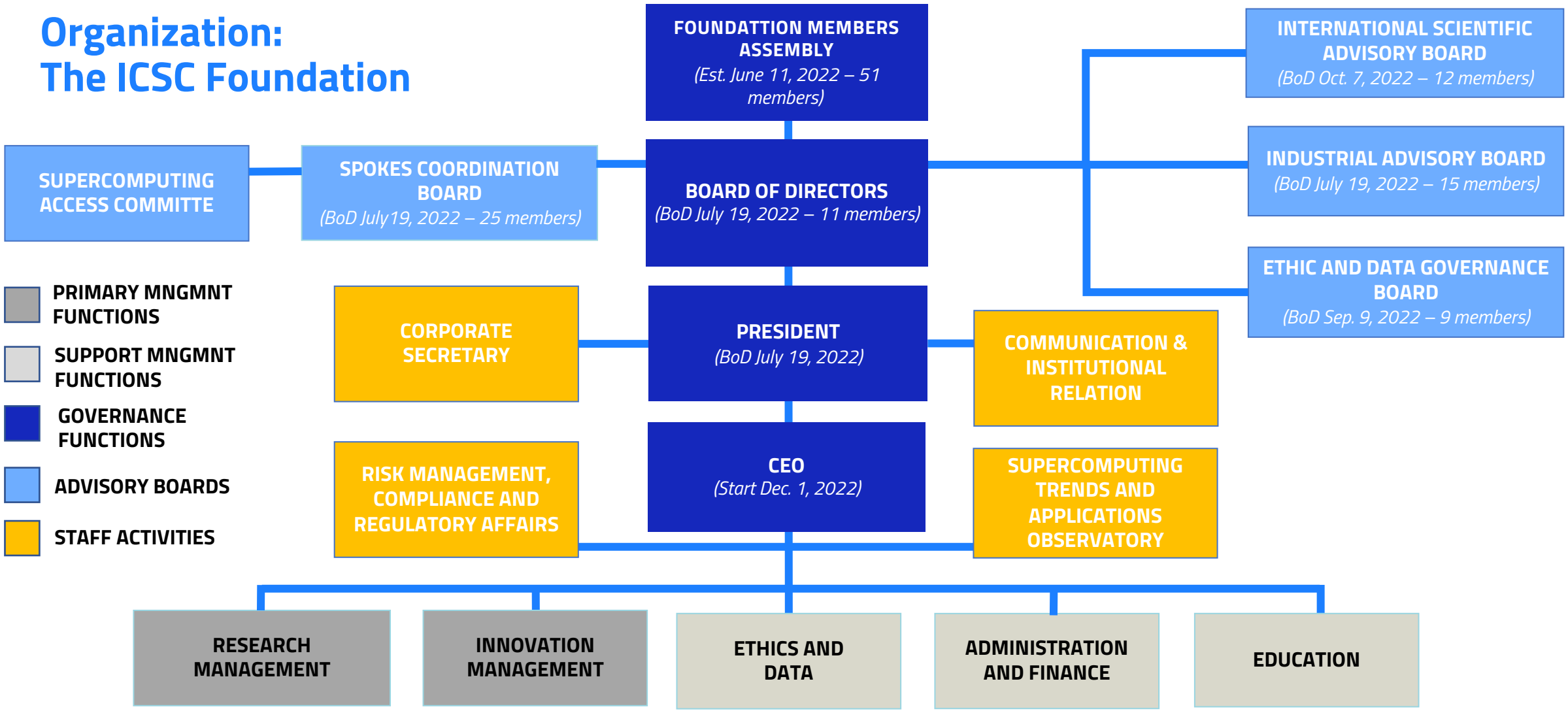


Kick-off Meeting Centro Nazionale – Bologna, 25/11/22

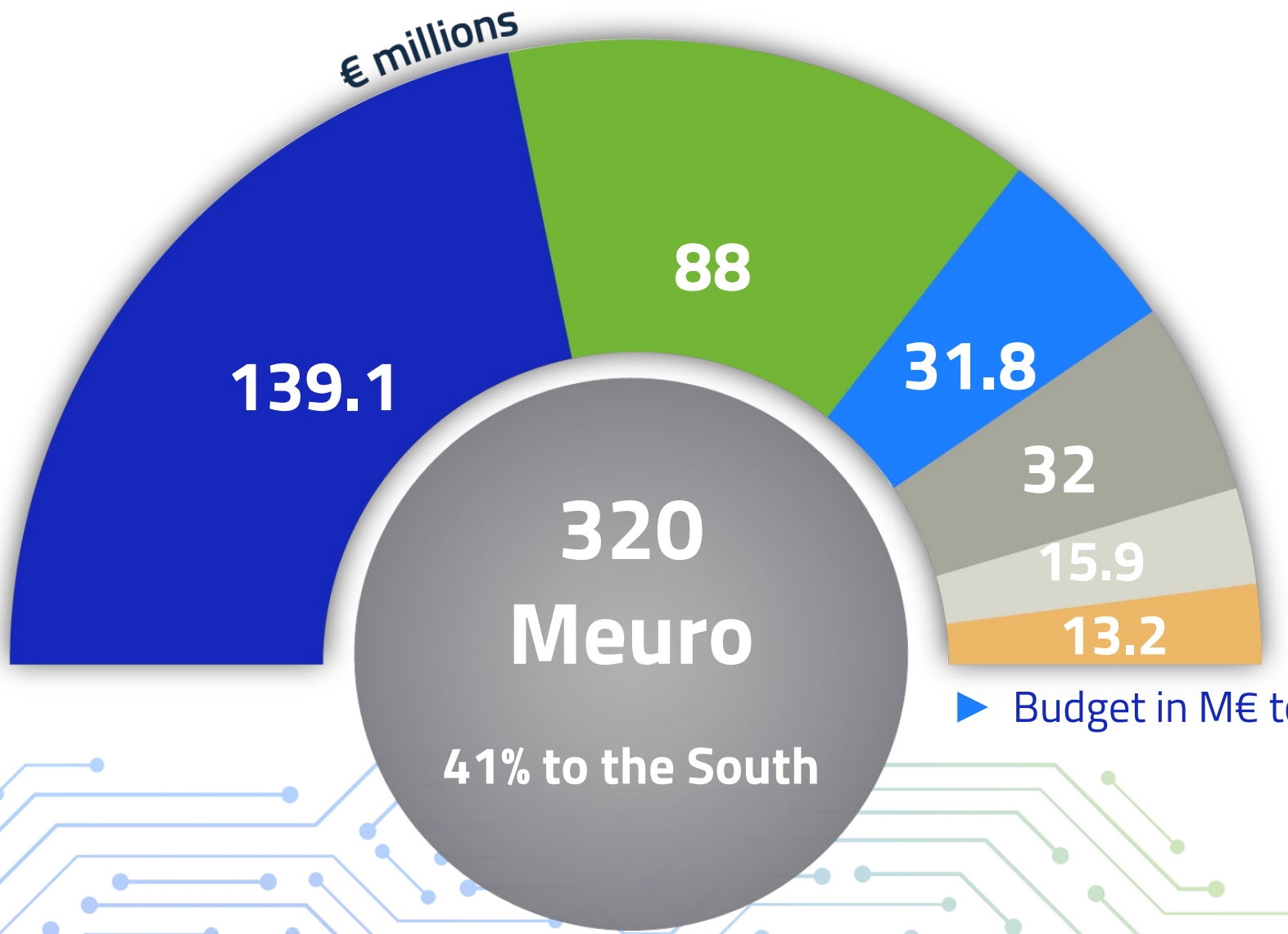


Some of the current activities

Organization: The ICSC Foundation



ICSC Budget



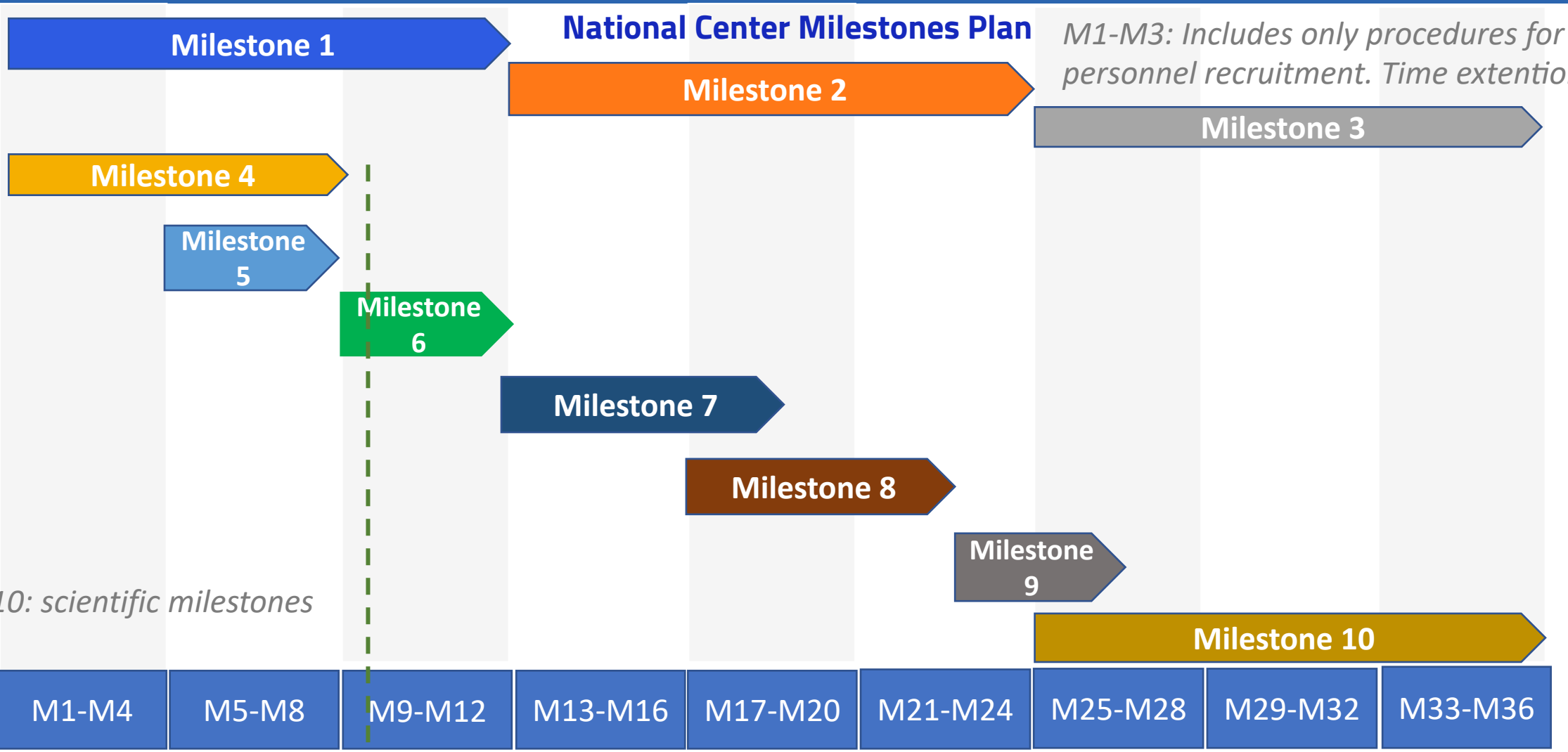
- INFRASTRUCTURES
- STAFF
- OTHER
- OPEN CALLS
- PHD
- INDIRECT COSTS

- Budget in M€ to be spent in the period **2022-25**

ICSC: resources to bring **Research results to Business**

National Center Milestones Plan

M1-M3: Includes only procedures for personnel recruitment. Time extention.



M4-M10: scientific milestones

M1: Sep. 2022

M9: May. 2023

M36:Aug. 2025

Spoke 0 – Supercomputing Cloud Infrastructures (139M€) - Main Targets

CINECA:

- Leonardo upgrade with digital components (Lisa)
- Leonardo upgrade with quantum components
- Upgrade of CNR and INAF resources (Tier-1) at Tecnopolo
- The CINECA – CNR Tier-1 in Naples (facilities and resources)

INFN:

- Upgrade of the Big Data distributed infrastructure
- Upgrade of the Cloud services infrastructure
- New Data Centre for Disaster Resilience (Gran Sasso) and Space economy (Frascati)

GARR:

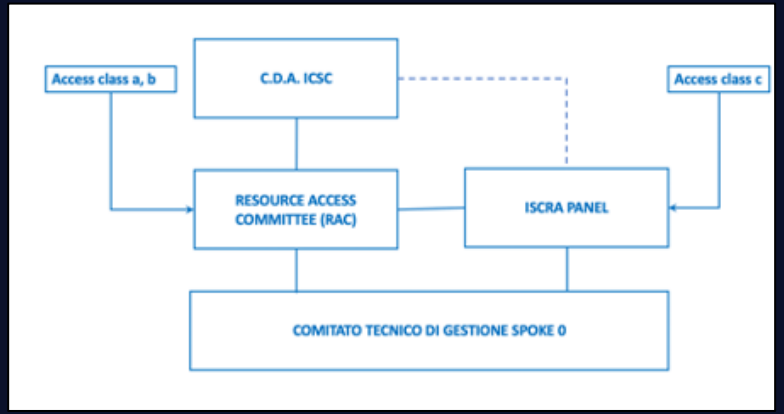
- Upgrade of the national research network infrastructure in selected regions, for interconnecting the national data centres and data repositories to the European system through GÉANT and its global international connectivity

Leader: Sanzio Bassini (CINECA), Co-leader: Claudio Grandi (INFN)

The ICSC Resource Allocation Board

- We defined a "Policy for the Allocation of ICSC Resource". We also defined 3 main types of initiatives that allow participants to request resources to ICSC:
  - "Type A" projects, reserved to affiliates. These includes all the ICSC flagship projects, innovation funds projects (more later), strategic or collaborative research projects.
  - "Type B" projects, or co-development projects. These include research contracts, living labs and joint research labs.
  - "Type C" projects, reserved to external entities. These include for instance the ICSC cascade funds, as well as the ISCRA open calls.

- We created a "**Resource Allocation Board**", composed by 9 experts, whose task is to dynamically handle resource requests for type A/B projects, based on the available resources.



Current resources @ CINECA for ICSC

Slide courtesy
Massimiliano Guarrasi
(CINECA)

Resources available for ICSC on current CINECA infrastructure:

- **Compute/HPC:**
  - **Leonardo:**
    - **Booster** module **already available:**
      - 3456 nodes, each equipped with:
        - 1 x CPU Intel Xeon 8358 32 cores, 2,6 GHz;
        - 512 GB RAM DDR4 3200 MHz;
        - 4 x NVidia custom Ampere GPU 64GB HBM2;
        - 2 x NVidia HDR 2×100 Gb/s cards;
      - 10% of the resources available for Italy, i.e.:
        - **up to 470'000 GPU hours per month**;
        - **up to 1 PB Work and 1 PB archive** (no quota on scratch);
    - **DC-GP** module **TBD**
      - **Available by the end of the year;**
- **Cloud:**
  - **ADA Cloud @ CINECA:**
    - 71 interactive OpenStack nodes each 2 x CPU Intel CascadeLake 8260, with 24 cores each, 2,4 GHz, 768GB RAM and 2TB SSD storage ➔ 6600 vCPUs available on the system;
    - Resources **available starting from 01/01/2024 ➔ 1000 vCPUs**.

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CINECA: Future ICSC infrastructure

Slide courtesy
Massimiliano Guarrasi
(CINECA)

Systems	Funding body (**)	Expected start of operations (*)	Type	Expected Minimum Performance
Leonardo upgrade (Lisa)	ICSC	Q4 2024	HPC (CPU + GPU)	90 Pflops (Rmax)
Quantum Computer	ICSC	Q4 2024	neutral atoms qubit technology	100/200/500 qubits
Tier-1 Tecnopolo	ICSC+Partner	2024 (TBD)	HPC (CPU + GPU)	15 Pflops
Tier-1 Napoli	ICSC+Partner	Q2 2025	hybrid HPC+Cloud	TBD
Tier-1 Casalecchio	PNRR	Q4 2024	Cloud (CPU + GPU) + Data Lake	100.000 vCPUs

(*) Estimation

(**) Partial or total contribution (CAPEX e OPEX)

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Current resources @ INFN for ICSC

Slide courtesy Daniele Cesini (INFN)

Resources available for ICSC on current INFN infrastructure:

- **Compute/HPC:**
  - 1500 vCPU; (Hyper Threading ON)
  - 200 TB net disk space;
  - A marginal number of GPUs (NVIDIA V100 and A100
  - Depending on the use case, it is also possible to grant user access to distributed Grid services (CPU and Storage)

INFN Resources made available during H1 2024 – procured via ICSC tenders

Resources available for ICSC on current INFN infrastructure:

- **Compute/HPC:**
  - 40k core on the distributed infrastructure
- **Storage:**
  - 14PB DISK on the distributed infrastructure
  - 6PB DISK on the CNAF Tier1 Datacenter
  - tape library access for long term archival on the CNAF Tier1 Datacenter200 TB net disk space.

Part of the resources will be accessible via Cloud interfaces, part via Grid systems

INFN: The TeRABIT HPC Bubbles

tender in the evaluation phase – not yet decided which fraction of the TeRABIT resources will be made available to ICSC

CPU Nodes	Min 112 cores (max 192) RAM > 8GB/core DDR5 IB NDR 400G 20TBL + OS disks
GPU Nodes	As CPU node + 4x NVIDIA H100 SXM5 - min 80GB and HBM2
FPGA Nodes	Min 32core RAM > 512GB DDR4 o DDR5 IB NDR 440G 4 x XILINX U55C o 4 x TerasicP0701
Storage Nodes (CEPH Bricks)	Min 48cores RAM >512GB DDR4 o DDR5 >360 TBL HDD + 12TBL SSD
Extras	Switch IB, Switch ETH Cables IB, Cables ETH Transceivers

Slide courtesy Daniele Cesini (INFN)

Depending on how the tenders go, it is expected that the HPC Bubbles will provide a *minimum* of about 13k vCPU, about 8 PFLOPS by GPUs, about 3PB of HDD space + about 100 TB of SSD space

ICSC: From Research to Innovation
Innovation Funds - Internal Financing Instrument

SCOPES

A) Fostering technology scale-up and transfer

B) Supporting new start-ups and spin-offs

C) Addressing skill gaps

D) Creating ISCS community and promoting entrepreneurial culture

MODALITIES

- Exploitation plans
- Call for ideas and business plans
- Contests and challenges
- Innovation grants

ACTIVITIES

- Deployment of demonstrators
- Scale-up grants
- Proof fo concepts
- Pilot applications
- Pre-seed funds
- Life long learning
- Training
- Industrial PhD projects

First Innovation fund assignments: July 2023

Innovation Funds: first feedbacks

- Both Innovation Funds and Open Calls (see later) are **strategic instruments for ICSC sustainability**, post-PNRR.
- Innovation funds are **reserved to ICSC affiliates**. All proposals must have **industrial leadership**, with topics related to the ICSC research program. Proposals are linked to one or more Spokes.
- In the July call of the Innovation Funds, we approved **43 proposals**. All were evaluated by both the Spoke Board (focusing on scientific merit) and the Industrial Board (focusing on impact). We expect another round of Innovation Fund calls around November 2023.

Innovation Funds: evaluations

I progetti presentati saranno valutati secondo i seguenti criteri:

Criterion 1 Relevance — Score

Alignment with the objectives and activities as described in the Work Program and in the call Document, as part of the Spoke objectives

Participation among affiliates of ICSC and inter-spokes (is the project proposed by an affiliate in co-ownership with an affiliate of the same or another spoke, more importance should be given to partnerships between private affiliates and public affiliates – ie. universities)

Contribution to long-term policy objectives, relevant policies and strategies, and synergies with activities at European and national level

Criterion 2 Implementation — Score

Capacity of the applicants, and when applicable the consortium as a whole, to carry out the proposed work (greater relevance for projects proposed by private and public affiliates in partnerships)

Maturity of the proposed action (es. follow-up projects that are presented as an evolution of previous ones)

Soundness of the implementation plan and efficient use of resources.

Milestones: Is there a clear implementation plan with defined milestones, work packages and deliverables, together with realistic resources and timings?

Criterion 3 Impact — Score

Timing: Is the timing right for this innovation in terms of market, user, societal or scientific of technological trends and developments?

Extent to which the proposal will achieve the **expected outcomes** and, when relevant, the **plans to disseminate and communicate project achievements**

Extent to which the proposal will **strengthen competitiveness, reduce risks and bring important benefits for society**

Extent to which the proposal addresses **environmental sustainability and the European Green Deal goals,** in terms of direct effects and/or in awareness of environmental effects

ICSC Italian Research Center on High-Performance Computing, Big Data and Quantum Computing — Missione 4 • Istruzione e Ricerca

In the referee opinion, both tasks are very interesting and with a valuable impact for Italian and European society. The federation of a data centre owned by a private company to the ICSC data lake is an added value for the project.

The proposed computational methodologies are at the state of the art for the corresponding field of study.

The proposed workplan and the manpower estimation appear to be reasonable.

The project partners came from industry, universities and computing centres.

As a minor issue, the technical referee would like to note that there is no detailed estimations of the computing and storage resources to be used for the project. Appear to be evident that large part of the needed computing resources will be given in the new machine that will be installed by the applicants in the ENI Date centre. However, a limited number of resources could be also given by ICSC (if requested) in the framework of the forthcoming allocation initiatives. Clearly having these data at our disposal could strongly help us to better evaluate the reliability of the proposal.

In any case, the project seems very interesting both from the scientific and technical point of view and we propose it for approval.

The project is well written and exhibits a well-thought and balanced approach. It aligns with the PNRR guidelines by addressing the key enabling technology of "Advanced Techno Agriculture and the Food Industry." Moreover, it supports the scientific and technol objectives of Spoke 7 of the CN HPC, Big Data, and Quantum Computing, benefiti expertise of various affiliates. However, a minor drawback is that none of the flagsh developed within the spoke will be used.

Overall, the budget, target TRL, and Southern-Italy quota appear appropriate.

Allocazione dei revisori per le proposte Innovation Grant

ID	Titolo	Aziende	Spoke primario	Revisore 1	Revisore 2	Relevance		Implementation		Impact		Bonus points		Total score	Media
16	HaMMon (Hazard Mapping and vulnerability Monitoring)	UNIPOLSAI, SOGEI	3			5	4	5	4.5	4	5	3	3	33.5	17
33	GNSS-SDR precision positioning for smart cities and safe mobility	SOGEI	9			4	5	5	4	4	5	3	4	34	17
2	Weather 4 Energy & Infrastructure	ILLUMIA (IFAB), ENI, Terna, Autostrade, Engineering	0			4.5	5	4.5	4	4	5	3	3	33	16.5
17	Serial Code Porting on HPC & Quantum Computing	SOGEI	3			4	4.5	5	4	4	4	3	4	32.5	16.5
42	Quantum Algorithms for the solution of differential equations	LEONARDO, TASI, ENI, IFAB	10			5	4.5	5	5	4	3	3	3	32.5	16.5
28	Atomistic simulations of damage, adhesion and drag reduction of graphene-based coatings	LEONARDO	7			5	13.5	5		5		3		31.5	16

ICSC Open Calls

Instrument addressed to external entities

SCOPES

A) Promoting access to computing resources of Academia, Industry and Public Administration

B) Stimulating the research potential of Academia

C) Stimulating the innovation potential of Industry, including SMEs, innovative start-ups and Public Administration

MODALITIES

- Stimulate investments in Research and Innovation to facilitate the **creation of new technologies, new products and processes**, in strategic sectors for the growth of the country
- With grants **(«cascade funding»)** or without grants
- Boundary conditions: **50% in the South, 51% to Industry**

ACTIVITIES

A) Access to advanced computing facilities

B) Optimization, scaling and testing

C) Use-cases

D) Research and software development

E) Attracting and engaging top-class international scientists

Italian Observatory on Supercomputing Trends and Applications

(In the starting phase)

SCOPES

- ✓ Providing evidence on the latest innovative trends and the related potential socio-economic impact
- ✓ Identifying the dynamics of good practices, focussing on SMEs
- ✓ Proposing policy tools to overcome the barriers to innovation
- ✓ Pursue 'win-win' relationships between entrepreneurs, policy makers, innovation facilitators and researchers
- ✓ Enhancing awareness of the latest innovation trends and success stories, through case studies, trend reports and workshops/conferences
- ✓ Distributing the ICSC/Spokes findings via the website and social media tools
- ✓ Supporting policy makers

On trends and perspectives

Sustainability: long-term profiles

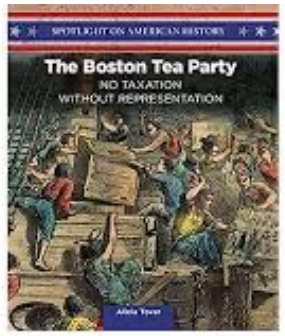
To define **ICSC sustainability**, we have been working on a **cost vs. revenue profile** at steady state, i.e., beyond 2026, when the NRRP funding ends. Our current analysis puts this profile at about 60 M€/year.

- This includes for example revenues and costs coming from items such as partners contributions, EU and national projects, living labs, training, industrial projects, exploitation of the Observatory outcomes, Foundation costs.
- This is just a “raw number”, that carries many considerations behind it and that should therefore be the constantly re-evaluated based on changing market conditions, opportunities and feedbacks.

But well before coming to “the number”, one needs to be clear on *targets and vision*.

One of our main targets is that **we want ICSC to be a national aggregator of key digital requirements and assets**. This *multi-faceted goal* will drive many of our future initiatives. It will certainly require tight collaborations with other PNRR initiatives and with related national and international projects.

Vision: the underlying motto



- The motto of the action of Ministry of University and Research that funded ICSC is "**From Research to Industry**". How to keep on implementing this is <u>what mainly drives our reflections on sustainability</u>. For instance:
  - The current hub and spoke *model*, together with various project constraints, were mandated by the PNRR action. However, neither the current set up, nor the current ICSC composition (for example) should be considered a dogma.
  - "No taxation without representation": a *future governance structure* must take into proper account inputs from both academia and industry.
  - How do you tackle the point of "bringing the *TRL* of <something> to a suitably high value?" What about the idea of "*productization* of the ICSC outcomes"? How do you define this concept? What about *IPR*? How do you reconcile them with *Open Science*?

Dalla RICERCA all'IMPRESA PNRR MUR

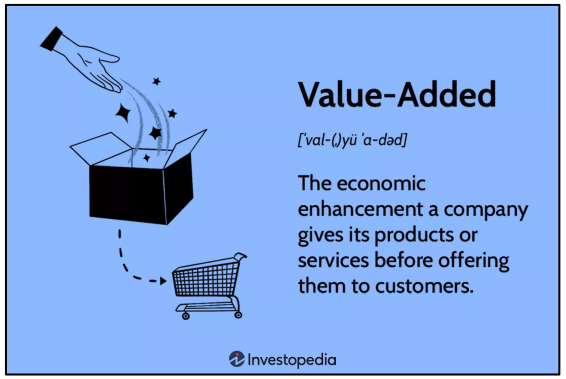
Missione 4 COMPONENTE 2

*"... strengthening of **basic and industrial research activities**, to encourage both open and multidisciplinary research... and **research aimed at addressing strategic challenges** for the country's development.*

*Particular attention is paid to **investing in young researchers and to the creation of public/private partnerships** of national importance or with a territorial vocation.*

*Furthermore, through reforms and investments in research doctorates, we want to encourage the **opening of research infrastructures to the productive world**. In this way, it is possible to **develop specific skills that meet the needs of businesses**, in particular those linked to green and digital issues."*

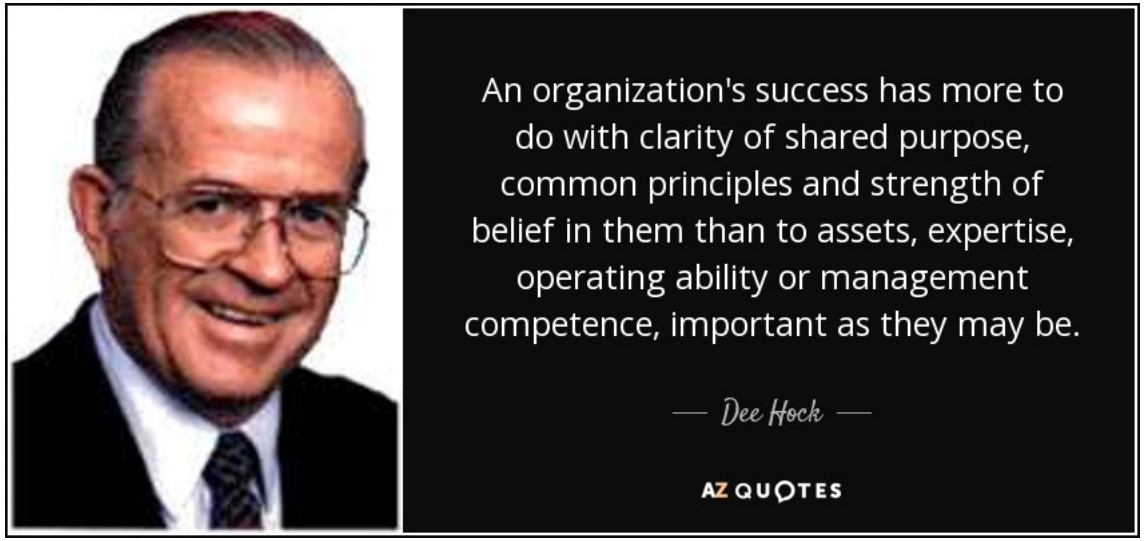
Vision: the implementation



- What is <u>the added value that ICSC brings to academia, industry and society</u>? This is *the* fundamental *raison d'être* of any initiative, the one principle that must be continuously verified, reconsidered and expanded.
  - For example, let's start from *uniqueness*: what is it that makes ourselves "unique" in a value proposition? We certainly do not want to pretend to be "another AWS". And what are the *core, durable needs* of our customers? Who are these *current and perspective customers*, in the first place?

> Center innovation on durable needs
>
> Focusing on the durable needs your customers have—not just the ones they have today but will continue to have into the future—enables long-term, sustainable innovation around the things that matter most to your customers.

From "The Imperatives of Customer-Centric Innovation", AWS



- And, of course, what will be <u>the role of the ICSC Foundation</u>? We shall be considering its evolution, for instance, in terms of its relation to stakeholders, competence, assets, services, toward Italy and beyond. But see also what Dee Heck said here on the left.

Thank you

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