The European Commission's Vision for Quantum Engineering:
Challenges and Opportunities in EU-Funded Projects

Oscar Diez

HoS Quantum Technologies

Quantum Technologies Unit

European Commission

QUANTUM FLAGSHIP

European Commission

A quantum Continent

Birthplace of Quantum Science:

- Quantum theory emerged from European physicists such as Max Planck (Germany), Albert Einstein (Germany/Switzerland), Erwin Schrödinger (Austria), and Werner Heisenberg (Germany).

Scientific Excellence:

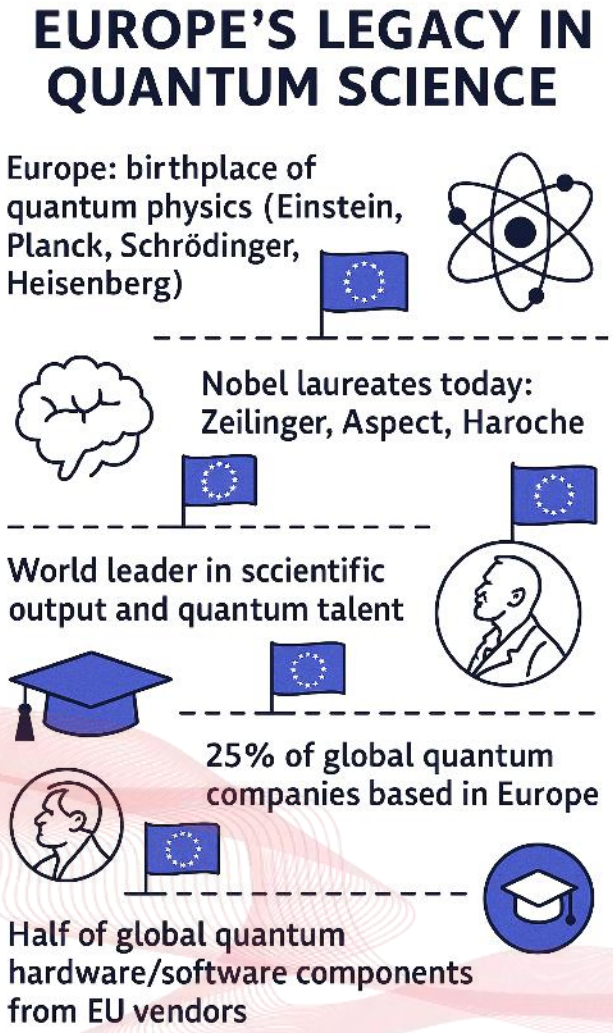
- Europe leads the world in quantum publications (over 30% of global output)
- Recent Nobel laureates: Zeilinger (AT), Aspect (FR), Haroche (FR)

Ecosystem Snapshot:

- ~25% of all global quantum start-ups are in the EU
- EU vendors produce ~50% of global quantum computing components

Human Capital:

- Over 110,000 graduates annually in physics, engineering, and ICT
- More than 40 specialized Master's programmes in quantum across the EU



Europe Strengths and weaknesses

Strengths – Assets

€8B+ total public investment (EU + MS combined):

- ~€2B from EU-level programmes (Horizon Europe, Digital Europe, EuroHPC JU, Quantum Flagship)
- ~€6B from Member State strategies (e.g., France, Germany, the Netherlands, Austria)

Academic Excellence:

- EU leads in quantum-related scientific publications (~30% of global share)
- Over 110,000 STEM graduates/year across EU
- 40+ specialised quantum Master's programmes

Start-up Ecosystem:

- 25% of global quantum companies are based in Europe
- Fast growth of deep-tech spin-offs (e.g. Pasqal, IQM, Terra Quantum)
- Public support structures like EIC, EuroHPC, and national incubators

Challenges – Gaps

Fragmentation:

- Multiple overlapping strategies and funding programmes
- Lack of shared roadmaps and alignment between EU and MS initiatives

Patent Gap:

- EU ranks 3rd in global quantum patents behind US and China
- Less translation of research into industrial IP

Private Investment Weakness:

- Europe captures <30% of global private quantum funding
- Strong in seed-stage, but lacking Series B and later
- Risk of acquisition by non-EU actors due to capital scarcity

Missing Lead Users:

- EU lacks industrial "anchor adopters" using quantum in production
- Slower pull-through of innovation into high-impact sectors (e.g., pharma, energy, finance)

Global Quantum Inflection Point

Quantum enters the market:

- Quantum sensing is already being used in gravimetry and medical imaging (e.g., Q-MRI).
- Early quantum computers are running hybrid simulations in logistics, energy, and pharma.
- Secure quantum communications are being piloted via EuroQCI and IRIS^2.

Strategic global investments:

- **China:** ~€15 billion in estimated total government investment.
- **United States:** >€5 billion through national initiatives and DOE/NIST/NASA projects.
- **European Union + Member States:** ~€8+ billion (EU + national combined), with €2 billion from the EU directly (Quantum Flagship, Horizon Europe, Digital Europe, EuroHPC).

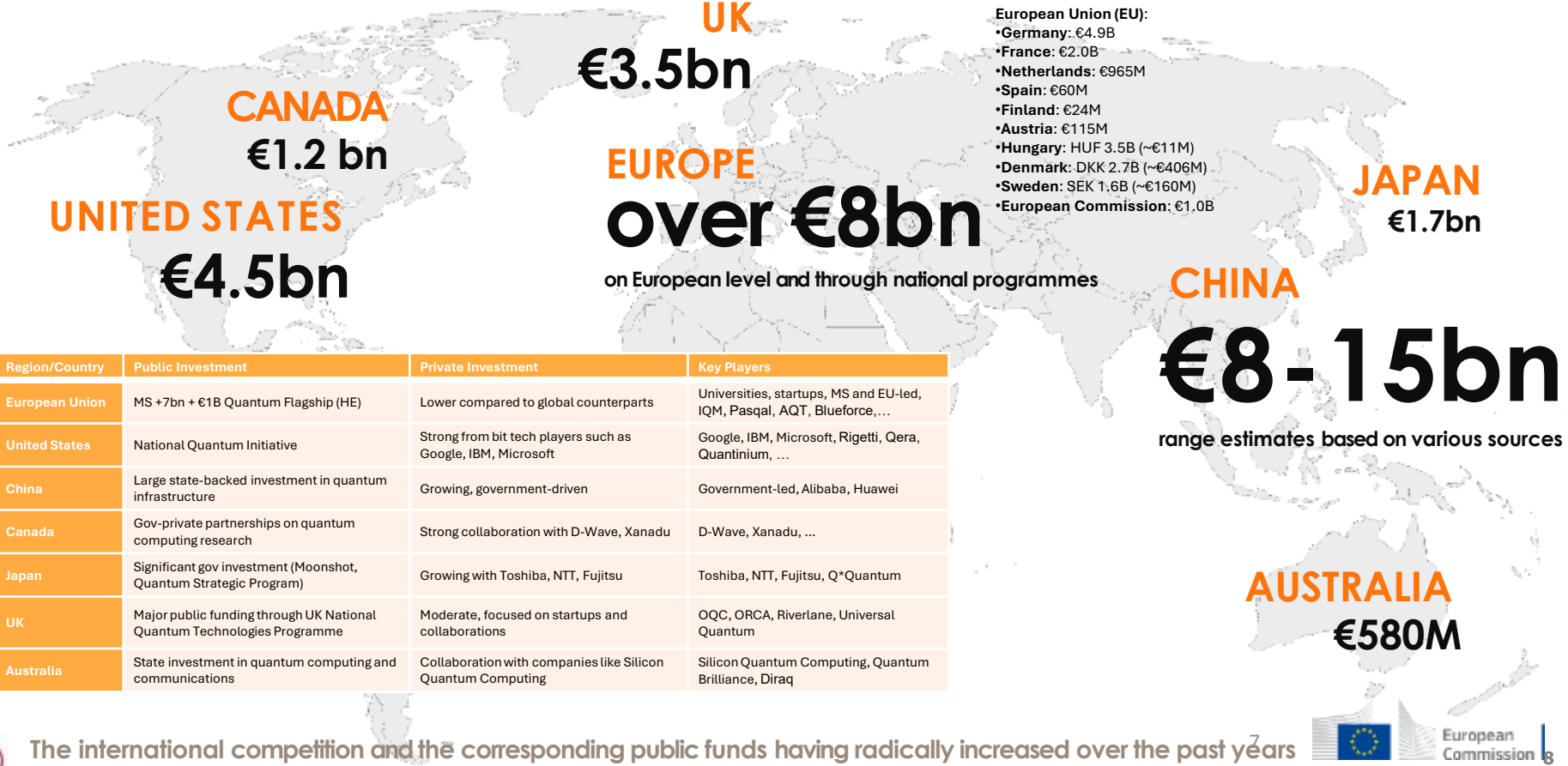
Dual-use examples:

- **Defence:** GPS-independent navigation, encrypted battlefield communication, threat detection.
- **Climate:** Gravimetric analysis for groundwater, volcanic activity, glacier loss.
- **Health:** Quantum-enhanced imaging and personalised diagnostics.
- **AI:** Faster training of models using quantum-accelerated subroutines.

Urgency for Europe:

- Europe ranks 1st in publications but only 3rd in patents.
- Fragmented markets and limited late-stage funding weaken scalability.
- Risk of losing startups and IP to foreign investors.

OUTLOOK: GLOBAL PUBLIC FUNDING



UK
€3.5bn

CANADA
€1.2 bn

UNITED STATES
€4.5bn

EUROPE
over €8bn
on European level and through national programmes

European Union (EU):
- **Germany:** €4.9B
- **France:** €2.0B
- **Netherlands:** €965M
- **Spain:** €60M
- **Finland:** €24M
- **Austria:** €115M
- **Hungary:** HUF 3.5B (~€11M)
- **Denmark:** DKK 2.7B (~€406M)
- **Sweden:** SEK 1.6B (~€160M)
- **European Commission:** €1.0B

JAPAN
€1.7bn

CHINA
€8-15bn
range estimates based on various sources

AUSTRALIA
€580M

Region/Country	Public Investment	Private Investment	Key Players
European Union	MS +7bn + €1B Quantum Flagship (HE)	Lower compared to global counterparts	Universities, startups, MS and EU-led, IQM, Pasqal, AQT, Blueforce,…
United States	National Quantum Initiative	Strong from bit tech players such as Google, IBM, Microsoft	Google, IBM, Microsoft, Rigetti, Qera, Quantinium, …
China	Large state-backed investment in quantum infrastructure	Growing, government-driven	Government-led, Alibaba, Huawei
Canada	Gov-private partnerships on quantum computing research	Strong collaboration with D-Wave, Xanadu	D-Wave, Xanadu, …
Japan	Significant gov investment (Moonshot, Quantum Strategic Program)	Growing with Toshiba, NTT, Fujitsu	Toshiba, NTT, Fujitsu, Q*Quantum
UK	Major public funding through UK National Quantum Technologies Programme	Moderate, focused on startups and collaborations	OQC, ORCA, Riverlane, Universal Quantum
Australia	State investment in quantum computing and communications	Collaboration with companies like Silicon Quantum Computing	Silicon Quantum Computing, Quantum Brilliance, Diraq

The international competition and the corresponding public funds having radically increased over the past years

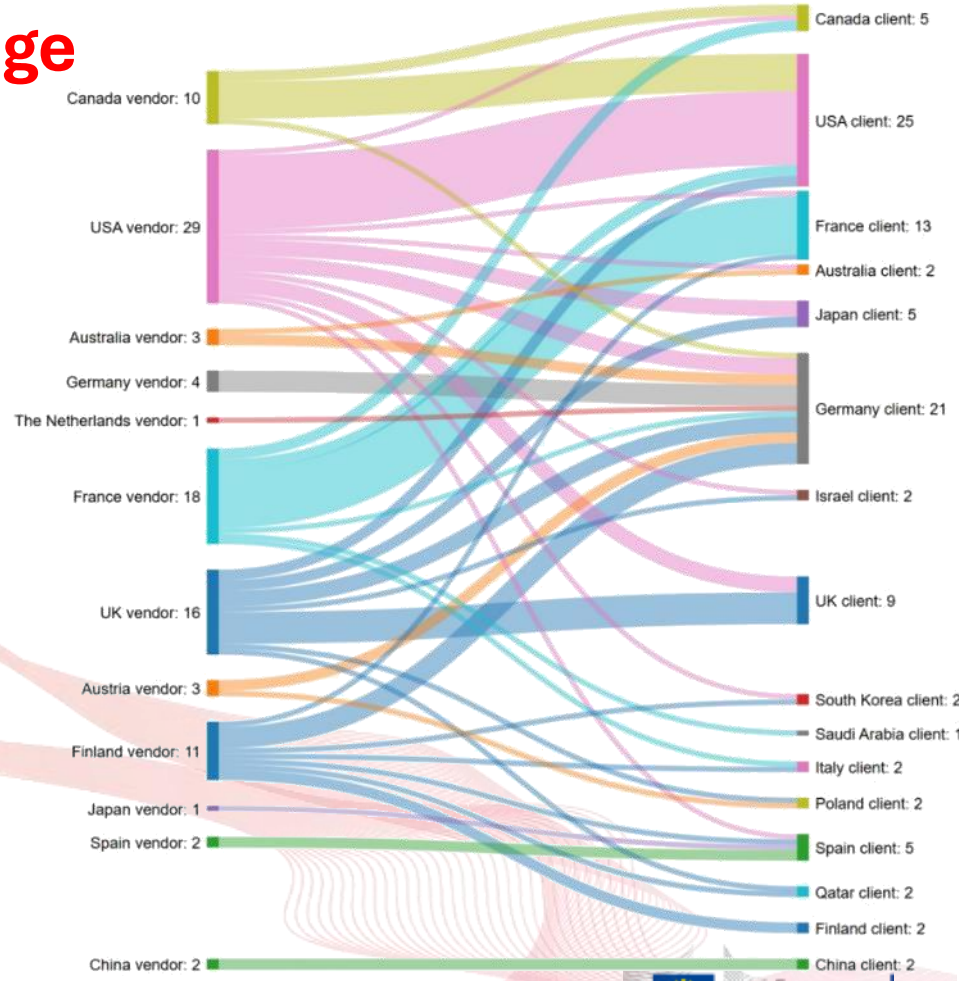
Source: qt.eu, McKinsey, Qureca

European Commission

The Fragmentation Challenge

Europe can lead at scale

- 100+ deployable quantum computers globally by 2025
- Europe hosts the **largest QPU zone (~40 systems)**—but distributed across 20+ vendors
- **Lack of consolidation limits scalability and market leadership**
- U.S. shows self-sufficiency (IBM, IonQ); Canada and Finland are strong exporters
- Germany remains a key user but depends on imported hardware
- *"The question is not whether Europe can lead. It's whether it can organize to lead at scale."* – Neil Abroug, Head of Quantum at Inria



Neil Abroug and Olivier Ezratty

European Commission

Europe’s Unified Response

Strategic framework and commitments

European Declaration on Quantum Technologies

A Common Commitment for Europe's Quantum Leadership

- Signed by 27 EU Member States to make Europe the *Quantum Continent*.
- **Aligns EU and national efforts** across quantum computing, communication, sensing & metrology.
- Commits to coordination in:
  - R&D programmes and infrastructure investments.
  - Supply chain and innovation scale-up.
  - Skills development and quantum competence clusters.
- Aims to ensure **technological sovereignty, economic security, and standard-setting**.
- Framework for action: from research to commercial applications and international cooperation.

[European Declaration on Quantum Technologies | Shaping Europe's digital future]

European Commission

Quantum Europe Strategy

A Unified Vision for Leadership

- Establishes **Europe's first unified quantum strategy** to ensure global leadership and avoid fragmentation across Member States and funding schemes.
- Builds on **€8B+ in EU and national public investment** to turn research into industrial and strategic capabilities.
- Structures efforts across five areas: **research, infrastructures, dual-use, ecosystem growth, and skills,** to align stakeholders under one roadmap.
- Aims to bring quantum technologies **from lab to market faster**, supporting scale-up, pilot lines, and industrial use cases.
- Addresses Europe's **late-stage funding gap and startup scale-up barriers** to avoid IP loss and reinforce technological sovereignty.
- Strengthens European **supply chains, testing facilities, and standards** to secure autonomy and reduce foreign dependencies.
- Prepares for the **2026 Quantum Act**, which will establish long-term governance, legal tools, and investment continuity.

European Commission

Quantum Strategy Call for Evidence

Have you say: 8 May – 3 June

- **Open Stakeholder Consultation** to collect input on the EU Quantum Strategy ahead of the 2026 Quantum Act.
- Focused on strengthening Europe's technological **sovereignty** and **economic security** in quantum.
- Seeks feedback on:
  - Research-commercialisation gaps
  - Industrial scaling and private investment
  - Skills shortages and supply chain risks
- Builds on:
  - The **European Declaration on Quantum Technologies (2023)**
  - The **Competitiveness Compass** and **Draghi Report**
- Input will guide policy, infrastructure, and funding priorities for quantum computing, communication, and sensing.
- Run by **DG CNECT, Unit C2 – Quantum Technologies**
- Accessible at: have-your-say

CALL FOR EVIDENCE

Shaping the EU Quantum Strategy

Open stakeholder consultation to collect input on the EU Quantum Strategy ahead of the 2026 Quantum Act.

Focused on strengthening Europe's technological sovereignty and economic security in quantum.

Seeks feedback on:
- Research-commercialisation gaps
- Industrial scaling and private investment
- Skills shortages and supply chain risks

Builds on: The European Declaration on Quantum Technologies (2023)
- The Competitiveness Compass arnd Draghi Report

Input will guide policy, infrastructure, and funding priorities for quantum computing, communication, and sensing.

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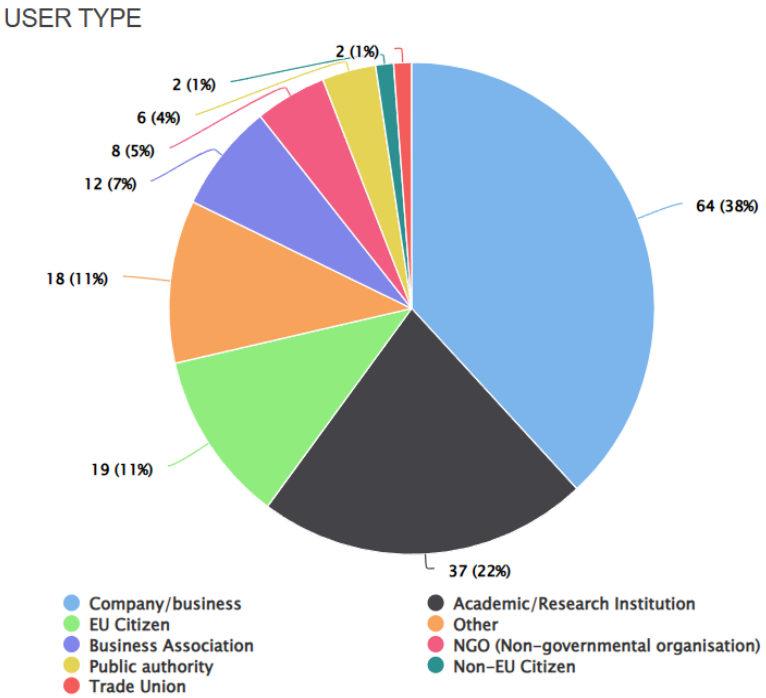
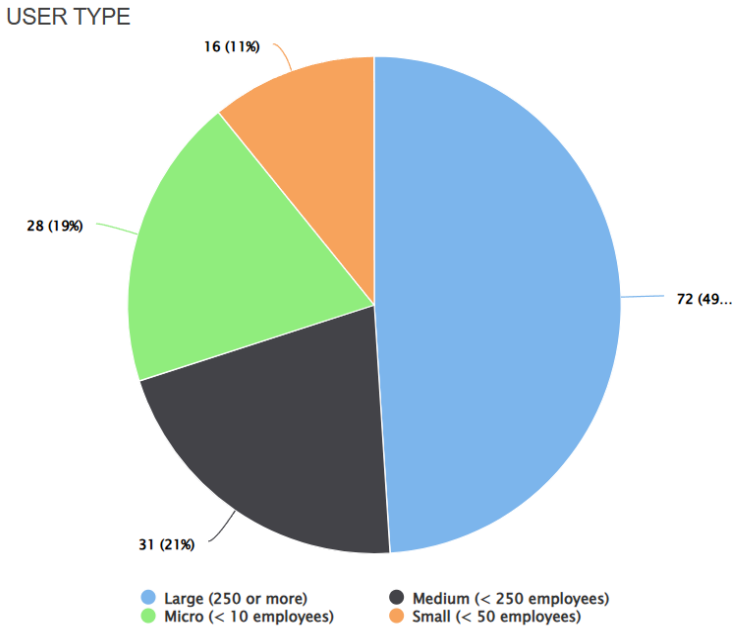
Accessible at:
have-your-say

https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14675-Quantum-Strategy-of-the-EU_en

Who Responded? 168 replies

Country	Count
Germany	25
France	20
Italy	18
Spain	15
Belgium	12
Netherlands	10
Austria	9
Denmark	8
Sweden	7
Poland	6
Finland	5
Ireland	5
Czechia	5
Romania	4
Portugal	4
Slovenia	4
Estonia	3
Hungary	3
Slovakia	2
Luxembourg	2
Lithuania	2
Latvia	1
Croatia	1
Bulgaria	1
Greece	1
Romania	4
Non-EU (US, UK, CH, etc.)	15





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The Quantum Act

From Strategy to Law

Provides the legal and financial backbone for implementing the Quantum Europe Strategy
- Establishes a legislative basis for sustained multi-annual EU and MS investment
- Empowers programme continuity beyond political cycles

Defines governance, IP, and infrastructure access frameworks
- Clarifies roles for the European Commission, EuroHPC, Chips JU, and Member States
- Supports sovereign, standards-compliant EU infrastructure (compute, sensing, comms)
- Protects European-developed intellectual property from strategic leakage

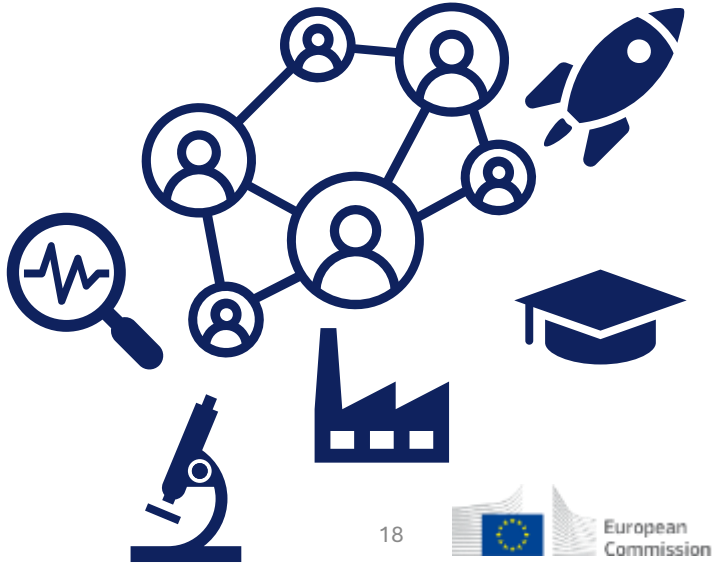
Aligns EU, Member States, and industry under a shared operational vision
- Facilitates vertical coordination from research to deployment
- Streamlines regulatory and procurement procedures across actors

Enables coordination, monitoring, and life-cycle support mechanisms
- Introduces Key Performance Indicators (KPIs), progress benchmarking, and oversight
- Supports dynamic reallocation of resources across technology readiness levels

Supports transition from project funding to strategic industrial policy
- Ensures legal stability for industrialisation, certification, and standardisation
- Positions the EU to lead in global quantum governance and competitiveness

Main Areas of Quantum Activities

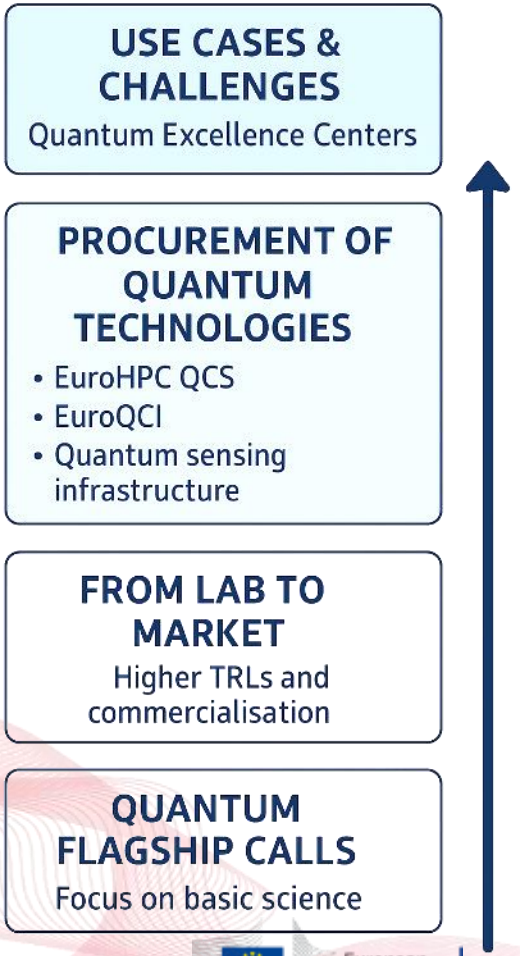
Strategic framework and commitments



Advancing Quantum in Europe

From Science to Commercialization

- **Strategic evolution of EU quantum policy** over the past decade
- **Started with Quantum Flagship calls** (Horizon Europe) focused on fundamental science
- Shifted **from lab to market**: higher TRLs, pilot lines, and industrial testing facilities
- Launched large-scale **procurement of quantum systems**:
  - EuroHPC QCS – quantum computing integration
  - EuroQCI – secure quantum communications
  - Quantum sensing platforms (gravimeters, Q-MRI)
- Now focusing on **real-world use cases**, Grand Challenges & **Quantum Excellence Centres** to connect users and industry
- Fully aligned with the **Strategic Research & Industry Agenda**, **Digital Europe**, and the **Chips Act** initiatives



Strategic Pillars of the EU Quantum Ecosystems

RESEARCH BASED

HORIZON EUROPE

2021-2027

INFRASTRUCTURES

DIGITAL EUROPE

Flagship

Bring quantum **technologies** from the **lab** to the **market** and consolidate European scientific **leadership** in quantum research

Fundamental R&D

Technology Supply

European Chips Act

Bolster Europe's competitiveness & resilience in semiconductors & **quantum chips** including production facilities & Quantum Fund

From Lab to Market

Pilot Lines & Testing Facilities

Advanced Digital Skills

Develop short term **training courses** and **Master's programmes** in key capacity areas

Q Sensing Deployment

Build and **deploy** Quantum sensing devices

Quantum Gravimeters

Quantum MRIs

EuroQCI

Build and **deploy** in the next decade a certified secure pan-European end-to-end QCI for **cybersecurity services**

QKD Infrastructure

EuroHPC-QCS

Build and **deploy** an infrastructure for high performance computing and **quantum computing**

HPC with Accelerators

Stand-alone Q Computers

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Quantum Flagship

Research and Development. From Lab to Market

European Commission

Quantum Flagship WP25

Calls HE WP 2025

Continuation of the Quantum Flagship (CSA)

- €4.5M CSA to act as **global quantum observatory**, coordinate EU–MS strategies, and support the Quantum Flagship's visibility, governance, and outreach.
- Updates the **Strategic Research and Innovation Agenda (SRIA)** and organizes EU-wide events like EQTC.

Technology-Agnostic Quantum Software Stack (RIA)

- €10M RIA for open, interoperable **quantum software ecosystems**
- Targets TRL 3–6; aligns with EuroHPC quantum platforms and hybrid workflows.
- Emphasizes **open-source**, **standard interfaces**, and developer training.

EU–South Korea Digital Partnership in Quantum (RIA)

- €8M to support **joint R&D in quantum computing, sensing, and communication**.
- Includes **mobility**, **roadmap alignment**, and co-design of devices and software.
- Enhances EU–Asia strategic quantum ties and access to infrastructure.

Quantum Internet – SGA2 (FPA)

- €47.5M for a **quantum internet prototype** with repeaters and 500+ km entanglement range.
- Demonstrates real-world **network applications**, software stacks, and **integration with classical internet**.

[wp-7-digital-industry-and-space_horizon-2025_en.pdf](#) [EU Funding & Tenders Portal](#)

European Commission

QUANTUM

Quantum Software calls

Calls to be launched 2025

DRAFT

Feature	Technology-Agnostic Quantum Software Stack	HPC/Quantum Computing Middleware Technologies
Purpose	Develop a universal, hardware-agnostic quantum software stack.	Create middleware technologies for efficient HPC-Quantum computing integration.
Key Objectives	- Advance software architectures, compilers, and simulators. - Ensure portability across quantum platforms. - Demonstrate quantum-classical workflows.	- Develop technology-agnostic middleware interfaces. - Integrate scheduling, execution, and monitoring of quantum-HPC workflows. - Foster seamless HPC-QC application development.
Focus Area	Supporting diverse quantum hardware platforms while promoting interoperability.	Enabling seamless integration of quantum computing with HPC infrastructure.
Expected Outcomes	- Universal quantum software ecosystem. - Open-source development. - Practical quantum use cases combining quantum and classical computing.	- Reference middleware stack with standardized interfaces. - Improved hybrid quantum-classical workflow efficiency.
Technologies Supported	Quantum software architecture, algorithms, and error correction mechanisms.	Middleware for quantum-classical scheduling, system management, and workflow integration.
Collaboration Requirements	Collaboration with other European quantum hardware/software projects and EuroHPC JU.	Build on HPCQS efforts and ensure alignment with European standards.
Principles	- Open access and FAIR data principles. - Promote EU digital sovereignty and minimize dependencies on non-EU sources.	- Encourage dialogue between QC developers, HPC operators, and software architects. - Adhere to interoperability and open standards.
Application Examples	- Basic quantum algorithm libraries. - Quantum software for hybrid computing workflows.	- Scheduling of QC tasks within HPC systems. - User and system management tools for hybrid workflows.
Strategic Importance	Establishing a strong, universal quantum software foundation for Europe.	Enhancing Europe's capability to lead hybrid HPC-Quantum computing advancements.

QUANTUM FLAGSHIP

EuroHPC Joint Undertaking

European Commission

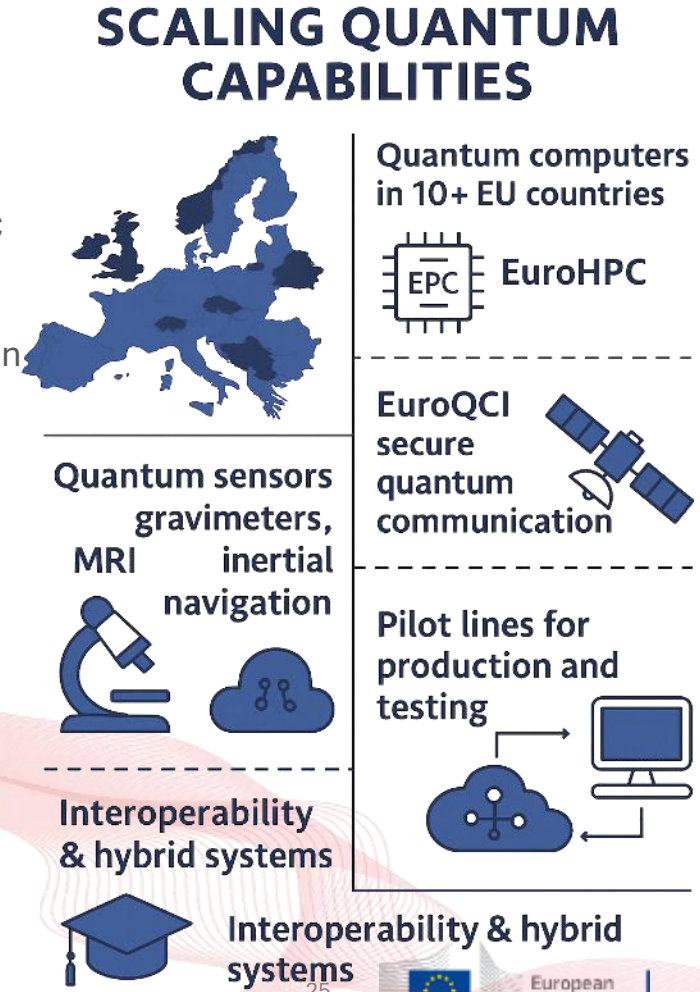
Quantum Infrastructures

Deploying EuroHPC QCS, EuroQCI & Sensing Infrastructures

Quantum Infrastructures

Scaling Quantum Capabilities

- Quantum computers deployed in **10+ EU countries** via EuroHPC JU
- **EuroQCI** rollout: secure, pan-European quantum communication network
- Development of quantum sensing systems: **gravimetry, Q-MRI, inertial navigation**
- Launch of **pilot lines** for quantum chip production and testing
- Early **hybrid quantum–classical systems** integrated into HPC workflows
- Infrastructure coordinated across EU to ensure **interoperability and access**



QCS Quantum Infrastructures

Quantum Computing and Simulation - EuroHPC

Do you want to know more about our quantum computers?

2 Quantum Simulators (100+ Qubits)

- Jülich: *JUWELS – PASQAL QS** (*Germany*)
- GENCI: *Joliot-Curie – PASQAL QS* (*France*)

➢ Both systems will be fully operational in **April 2025**

6 Selected Hosting "Entities" (Consortia of 30 participating countries) (1st CFEI)

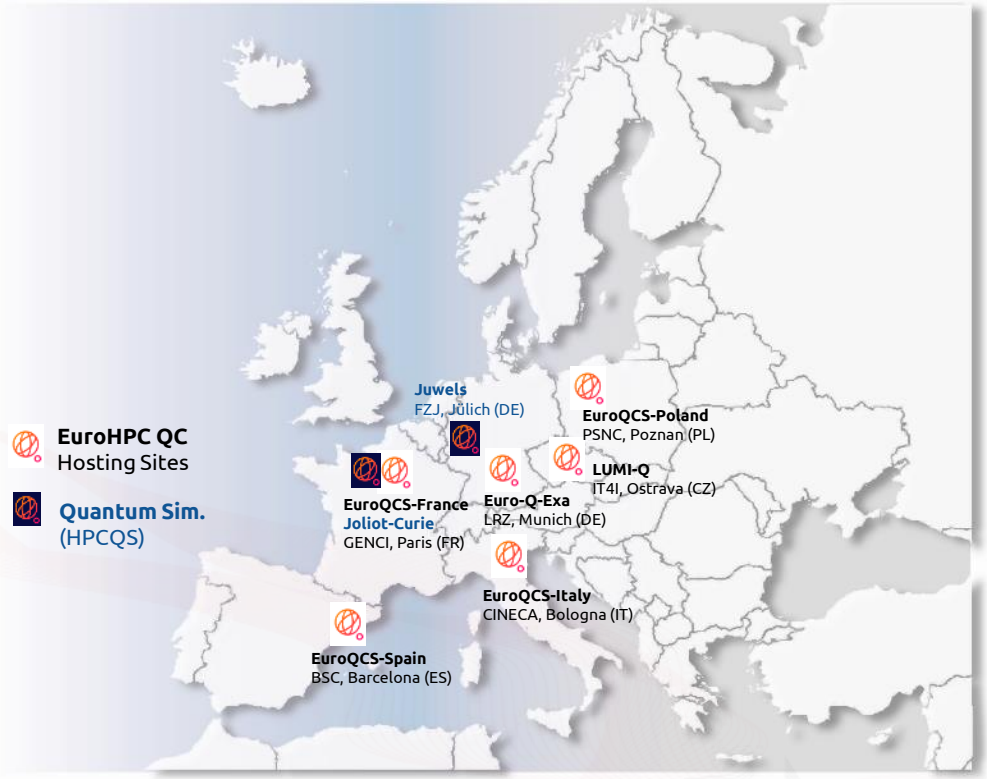
- Euro-Q-Exa, *superconducting Qubits* (DE)
- LUMI-Q, *superconducting Qubits* (CZ)
- EuroQCS-Spain, *superconducting Qubits* (ES)†
- EuroQCS-Italy, *neutral atom Qubits* (IT)
- EuroQCS-Poland, *trapped ion Qubits* (PL)
- EuroQCS-France, *photonic Qubits* (FR)

➢ All system expected to be operational in **Q2/Q3 2025**

2 Additional Hosting "Entities" (2nd CFEI)

- EuroSSQ-HPC, semiconductor *spin-Qubits (NL)*
- *MeluXina-Q, semiconductor spin-Qubits (LU)*

➢ First system expected to be operational in **Q2 2026**



*) Analogue Quantum Simulator †) Analogue Quantum Annealer

Total hardware investment: ~145 Mio. EUR

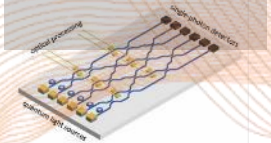
Quantum Computing and simulation Infrastructure

Quantum Diversity in Technology

EuroQCS-France [GENCI]

QUANDELA

Photonic Qubits (digital)

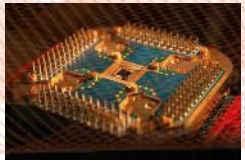


Joliot-Curie

Euro-Q-Exa (Germany) [LRZ]

IQM

Superconducting Qubits (digital)

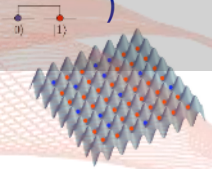


SuperMUC-NG

EuroQCS-Italy [CINECA]

Pasqal

Neutral atom Qubits (analogue/digital)



Leonardo

Lumi-Q (Czechia) [IT4I]

IQM

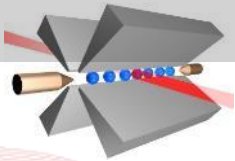
Superconducting Qubits with a star-shaped topology (digital)

Karolina

EuroQCS-Poland [PSNC]

AQT

Trapped ion Qubits (digital)

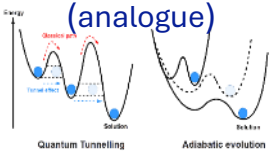


Altair

EuroQCS-Spain [BSC]

MILMANJARO
We do quantum computing

Superconducting Flux Qubits – Annealer Mode (analogue)



Mare Nostrum-5

Quantum Excellence Centers

From Research to Real-World Applications

- **European Quantum Excellence Centres (QECs)** advance quantum-enhanced applications in science & industry
- Deliver a platform-neutral application ecosystem (libraries, compilers, benchmarking tools, APIs)
- Supports key sectors: **finance, cryptography, materials science, pharmaceuticals, and AI**
- Provides **training, user support, and infrastructure access** to accelerate real-world adoption
- Fosters EU industrial leadership by **bridging research and market deployment**

Benchmarking

Quantum Computing & Simulation Benchmarking in EC & EuroHPC

Why Benchmarking Matters

For EuroHPC, EC and the Quantum Ecosystem

Capturing a Rapidly Evolving Quantum Landscape

- Multiple hardware modalities (superconducting, trapped-ion, photonic, neutral-atom…)
- Continuous architecture advances demand up-to-date performance tracking

Ensuring Objective, Transparent Metrics

- Cut through marketing hype with reproducible data
- Enable fair “apples-to-apples” comparisons across vendors

Informing Investment & Procurement

- Data-driven allocation of EU R&D and infrastructure budgets
- Mitigate vendor lock-in and reduce procurement risk

Driving Hardware–Software Co-Design

- Pinpoint bottlenecks in qubit control, error rates, compilation overhead
- Guide optimization of compilers, control electronics, and error-correction schemes

Fostering Standardisation & Collaboration

- Unite academia, industry and national labs around shared methodologies
- Accelerate consensus on definitions, toolsets and reporting formats

Strengthening Europe’s Strategic Autonomy

- Consolidate EU leadership in quantum technologies
- Ensure interoperability and mutual validation across EuroHPC centres

Measuring Sustainability & Operational Efficiency

- Benchmark energy consumption per quantum workload
- Promote greener, cost-effective quantum computing infrastructures

Systematic Benchmarking QC

Paper arXiv:2503.04905 [quant-ph], 2025

Five-Layer Architecture. Defines benchmarks at:
Component (gate-level), System, Software/Compiler, HPC/Cloud integration, Application/Workflow - ensuring end-to-end coverage from qubits to full workloads.

SDK-Agnostic Specifications + Reference Implementations

Every protocol ships with:

• Human-readable spec, • ≥1 open reference implementation

• Statistically-sound evaluation scripts & sample datasets

to guarantee reproducibility via CI/CD.

FTQC-Ready & Volumetric Metrics

Introduces next-gen yardsticks:

• Error-Per-Layered-Gate (EPLG), Λ (logical-error scaling)

• Clifford-Volume, GHZ-fidelity (single-shot)

• Volumetric compiler benchmark ("max qubits × layers in < T s")

Multi-Criteria Decision-Aiding (MCDA)

Aggregates heterogeneous KPIs (fidelity, throughput, energy, cost) using AHP, TOPSIS, PROMETHEE, etc., for transparent, customizable ranking.

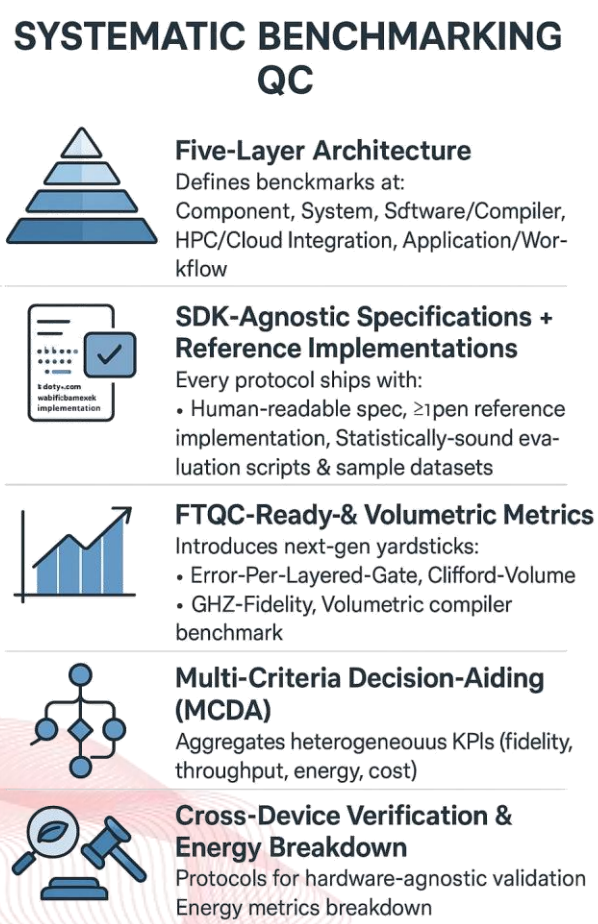
Cross-Device Verification & Energy Breakdown

• Protocols for hardware-agnostic result validation when classical simulation fails

• Energy metrics split into quantum core, cryogenics, control electronics & classical compute

Governance & Standardisation Alignment

Recommends liaison with IEEE P7130/P7131, CEN-CENELEC JTC 22/WG 3, IEC/ISO JTC 3 and establishment of a sustained steering body.



European Commission

Jeanette M. Lorenz, Thomas Monz, Jens Eisert, Daniel Reitzner, Félicien Schopfer, Frédéric Barbaresco, Krzysztof Kurowski, Ward van der Schoot, Thomas Strohm, Jean Senellart, Cécile M. Perrault, Martin Knufinke, Ziyad Amodjee & Mattia Giardini, **"Systematic benchmarking of quantum computers: status and recommendations,"** arXiv:2503.04905 [quant-ph], 2025

QC Benchmarking Stakeholder Matrix

Roles, Responsibilities & Key Deliverables for the EuroHPC Quantum Benchmark Framework

Role	Responsibilities	Key Activities	Deliverables / Info
QC Hardware Vendors	Provide access to devices; expose low-level metrics	– Share gate-fidelity & coherence data – Support SPAM-error characterization	– Device performance reports – Calibration & error-rate logs
QC Software & Middleware Teams	Implement compilers, emulators & control stacks	– Integrate benchmarks into software pipelines – Instrument compilation overheads	– Transpiler runtime metrics – Simulator vs. hardware correlation reports
Benchmark Framework Developers	Design, build & maintain the QC benchmark suite	– Define hybrid workflow benchmarks – Normalize against reference systems	– Specification, design & validation documents – Reference implementation
Standardisation Bodies	Harmonize metrics & reporting formats (ISO/IEC, IEEE P7130, QED-C, JTC 22)	– Convene metric-definition working groups – Publish benchmark standards	– Metric glossaries & reporting templates – Interoperability guidelines
Supercomputing Centres & NRENs	Host pilot deployments; orchestrate hybrid HPC–QC workflows	– Schedule and run QC benchmarks under real scheduler conditions – Report energy & queue delays	– Pilot benchmarking results – Site-specific integration guides
End-User Communities	Define use-case requirements & validate relevance	– Participate in co-design workshops – Provide feedback on real workloads	– Use-case descriptions – Performance & usability feedback reports
EuroHPC JU & EC	Fund, oversee & coordinate the call; ensure alignment with EU strategy	– Evaluate proposals – Facilitate standardisation liaison and dissemination	– Call text & budget allocation – Roadmap & governance model

EuroHPC – Identified Use Cases and Applications

Target Domains, Platforms & Quantum Algorithms for EuroHPC Benchmarking Pilots

Domain	Sector	Platform	Method
Fluid Dynamics (FDTD/ FEM)	Industry	Hybrid HPC-QC	Quantum Approximate Optimization Algorithm (QAOA)
Drug Discovery	Chemistry	Hybrid HPC-QC	Variational Quantum Eigensolver (VQE) Fault-Tolerant Quantum computing (FTQC)
Risk Analysis	Finance	QC	Variational Partial Differential Equation (VPDE) Quantum Monte Carlo (Q-MC)
Portfolio Optimisation	Finance	QC	Quantum Approximate Optimization Algorithm (QAOA) Genetic Quantum Annealing Algorithm (GA)
Scheduling Problems	Logistics	QC	Quantum Approximate Optimization Algorithm (QAOA) Quantum Adiabatic Algorithm (QAA)
Kernel based QML	Nat. Lang. Proc.	QC-AI	Quantum Machine Learning (QML) Quantum Generative Adversarial Network (QGAN)
Satellite Image Analysis	Earth Observation	QC-AI	Quantum Neural Networks (QNN)
Condensed Matter Physics	Science	QC-AI	Quantum Machine Learning (QML)
Medical Image Classification	Medicine	QC-AI	Quantum Machine Learning (QML)

QC Benchmarks in Procurements

Benchmarking quantum platforms from hardware fidelity through application performance.

EuroHPC Joint Undertaking

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Technology	Simple hardware metrics	Hardware efficiency metrics	Application / Performance metrics
Trapped-ion	- Native gate fidelities (Rx, Ry, Rz, Toffoli) **- Greenberger–Horne–Zeilinger (GHZ) states**		- Grover's algorithm - Quantum Fourier transform (QFT) **- Variational Quantum Eigensolver (VQE)** - Quantum Approximate Optimization Algorithm (QAOA) - Quantum Support Vector Machine (QSVM)
Superconducting	- Native gate fidelities (T, CNOT, Toffoli) **- Greenberger–Horne–Zeilinger (GHZ) states**		- Quantum Volume (QV) - Circuit Layer Operations per Second (CLOPS) **- Variational Quantum Eigensolver (VQE)** - Quantum Approximate Optimization Algorithm (QAOA) - Deutsch–Josza Algorithm - 1D-Heisenberg chains - Monte Carlo sampling - Quantum Phase Estimation (QPE) - Q-Score (Max-cut)
Photonic	- Native gate fidelities (T, CNOT, Toffoli) **- Greenberger–Horne–Zeilinger (GHZ) states**	- Photon source - Quantum circuit loss - Photon loss - Photodetector	- Quantum LINPACK - Q-Score (Max-cut application) **- Variational Quantum Eigensolver (VQE)**
Neutral Atoms			- Ising antiferromagnet in 1D and 2D arrays - Quantum Approximate Optimization Algorithm (QAOA) - Quantum Adiabatic Algorithm (QAA)
Semiconducting	- Single-qubit randomized benchmark - Two-qubit randomized benchmark - T_2-echo experiment **- Greenberger–Horne–Zeilinger (GHZ) states**		- Q-Score (Max-cut application) **- Variational Quantum Eigensolver (VQE)** - Quantum Approximate Optimization Algorithm (QAOA) - Bernstein–Vazirani algorithm

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Quantum-centric Benchmark Framework

Establishing a unified benchmarking foundation for next-generation EuroHPC infrastructures with integrated quantum acceleration

EuroHPC Joint Undertaking

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Purpose of the Call

- Develop a modular benchmark suite focused on quantum and hybrid HPC–QC workflows
- Enable performance assessment across NISQ devices, quantum simulators, and co-located HPC–QC systems

Quantum-First Vision

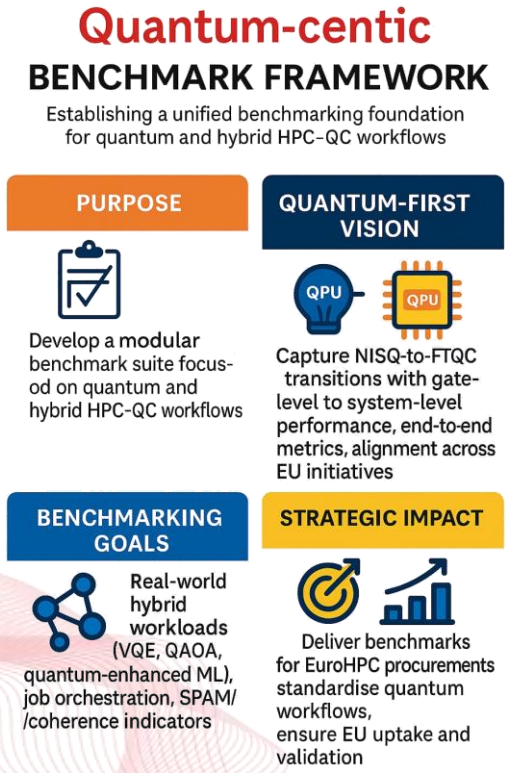
- Define benchmarks for NISQ-to-FTQC transitions, capturing gate-level to system-level performance
- Integrate end-to-end metrics: queue-to-solution time, energy per quantum operation, resource-normalised throughput
- Align with EuroQCS, Bench-QC, and European standardisation tracks (JTC 22, IEEE P7130)

Benchmarking Goals

- Capture real-world hybrid workloads: VQE, QAOA, quantum-enhanced ML
- Reflect job orchestration under live HPC schedulers (e.g. SLURM, PBS, ParTec MCP)
- Include quantum-specific indicators: SPAM errors, logical qubit throughput, coherence-time penalties

Strategic Impact

- Deliver transparent, reproducible benchmarks for EuroHPC procurements
- Anchor EU leadership in hybrid computing metrics and standardisation of quantum workflows
- Accelerate industrial and academic uptake through open-source governance (EUPL) and public validation events



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Key Requirements & Deliverables

A Quantum-centric Benchmark Framework (RIA)

DRAFT PROPOSAL

Framework & Suite: Define, implement and validate an extensible benchmarking framework covering:

- **Quantum computing** (NISQ & FTQC) and hybrid HPC–QC workflows
- **Micro-level** (gate fidelity, SPAM/coherence), **application/workflow** (VQE, QAOA, QML), and **system-level** under production schedulers (SLURM, PBS, ParTec MCP…)
- **Mandatory support** for ≥ 2 EU-hosted emulators

Per-Benchmark Deliverables:

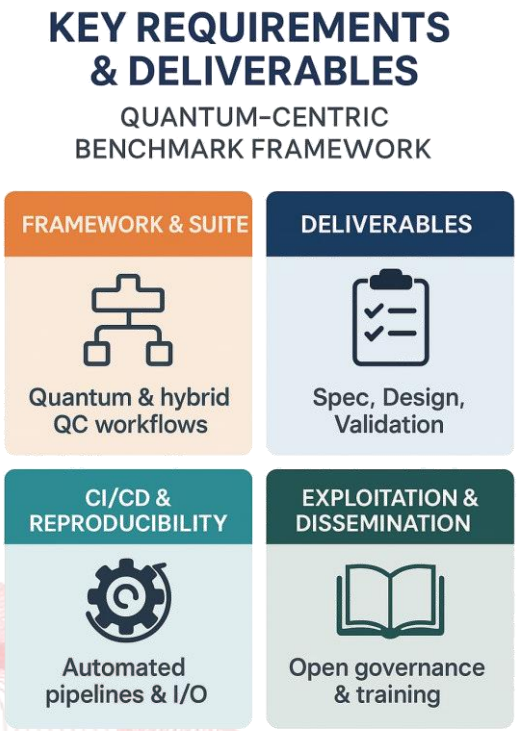
- **Specification**: functional & operational requirements (performance, energy-per-op, coherence metrics)
- **Design & Implementation**: reference code, portability layers, scheduler integration
- **Verification & Validation**: QA plan, reproducibility tests, cross-platform consistency, baseline & variability analysis

CI/CD & Reproducibility:

- Automated pipelines for code, benchmarks, baselines and regression testing
- Standardised I/O formats, version-controlled repository under EUPL
- Cross-system validation guidelines and energy/sustainability reporting

Open Governance & Training:

- Open-source governance: community-driven steering board, periodic roadmap updates
- Alignment with JTC 22, IEEE P7130, EuroQCS and Bench-QC standardisation tracks
- Training materials, documentation, public “results-day” events and EuroHPC centre engagement



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Practical Info and next steps

A European HPC-centric Benchmark Framework (RIA)

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Standardisation Efforts (Q2 2026 – Q4 2026)

- Establish working groups for metric definitions
- Liaise with ISO/IEC & IEEE quantum standards bodies

Integration into Procurement Guidelines (Q1 2027)

- Publish benchmark templates for EuroHPC JU calls
- Define reporting mechanisms for EuroHPC centres

Pilot Roll-Out & Iteration (2027 – 2028)

- Pilot deployments on LUMI, Leonardo, MareNostrum, etc.
- Bi-annual feedback loops & iterative refinements

Long-Term Sustainability & Governance (post-2028)

- Community-driven steering board (HPC/QC experts)
- Open-source governance model under EUPL license

Timeline:

- Publication: September 2025
- Submission Deadline: January 2026
- Grant Agreement & Kick-off: Q2 2026

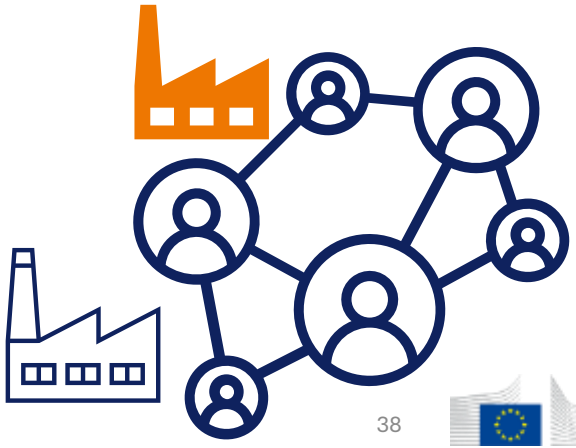
Duration: up to 3 years

Eligible Participants:

- National HPC centres, research & academic institutions
- Standardisation bodies
- Public/non-profit HPC users (no conflict of interest with for-profit vendors)

Ecosystem & Industrialisation

Focus on scaling companies, pilot lines, standards, supply chain



Ecosystem & Industrialisation

Growing Europe's Quantum Economy

- **6 industrial pilot lines** launching under the **Chips Joint Undertaking** in 2026
- Launch of the **EU Quantum Design Facility** and cloud-based design platforms
- **Public procurement** to drive market demand for EU-based quantum solutions
- Scale-up funding via **EIC Fund**, **InvestEU**, and the **TechEU Scale-Up** initiative
- **QU-TEST facility** to provide EU-wide quantum device benchmarking and certification
- Robust **IP strategy** and secure, diversified **quantum supply chains** under development

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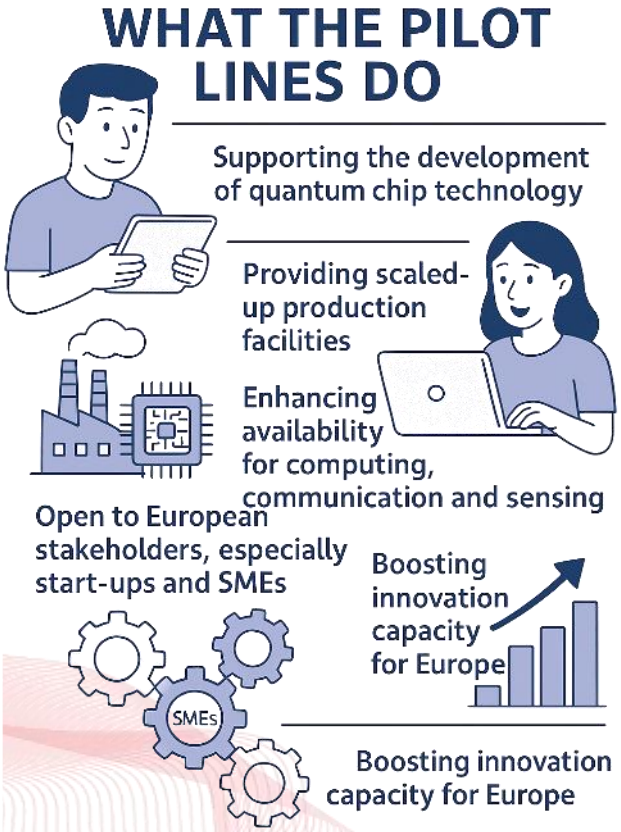
Quantum Stability Pilot lines

Growing Europe's Quantum Economy

Quantum Tech	Technical Focus	Strategic Objective
Superconducting	Integrated microwave control, scalable fabrication, coherence preservation	Industrial-scale yield of superconducting QPUs
Photonic	Quantum Photonic Integrated Circuits (QPICs), monolithic integration, photon sources	Enable photonic QPUs & QComm chips with CMOS-compatible fabrication
Semiconducting	Silicon spin qubits, CMOS-compatible fabrication, 2D/3D stacking	Transfer spin-based QPUs from labs to fabs, scalable readout & packaging
Diamond-based	NV and SiV centers in diamond, sensing and computing integration	Advance EU self-sufficiency in quantum sensors and QPUs based on diamond
Neutral Atoms	Atom arrays, optical tweezers, laser beam integration	Create pilot-level capability for neutral-atom-based digital/analog QPUs
Trapped Ions	Micro-fabricated ion traps, vacuum packaging, integrated laser systems	Establish EU trapped-ion foundry with sustainable chip-level production



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Skills and Talent

How we build the workforce

Competence_Framework_for_QT_v3.0_2025_official-version.pdf

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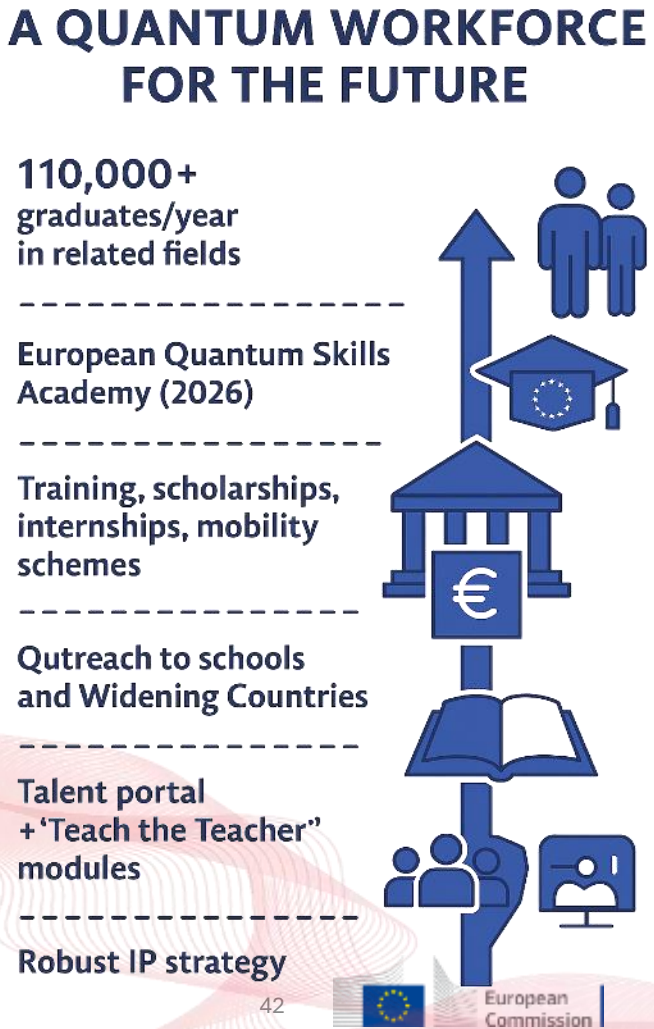
Skills & Talent

A Quantum Workforce for the Future

- **110,000+ graduates/year** in quantum-relevant fields (STEM, ICT, physics)
- Over **40 Master's programmes** and several doctoral tracks in quantum technologies across EU universities
- **European Quantum Skills Academy** to launch in **2026**, coordinating training and certifications across Member States
- Includes **internships, scholarships, fellowships**, and **talent mobility** within and beyond the EU
- Special focus on outreach to **Widening Countries**, **young students**, **women**, and **people with disabilities**
- Development of **"Teach the Teacher" modules**, a central **Quantum Talent Portal**, and school-level educational materials
- Linked to the **Union of Skills initiative** and aligned with the **Digital Skills and Jobs Platform**



Quantum Skills Digital Academy

EU Call for Proposals (DIGITAL-2025-SKILLS-08)

Establish a central EU-level academy to deliver specialised training in quantum technologies, targeting various education levels and professional profiles.

Scope of Activities:

- Master's/Doctoral programmes (ISCED 7 & 8)
- Self-standing training modules for professionals
- Hands-on quantum lab experiences, internships, summer schools
- Teacher training (Teach-the-Teacher), including visits to quantum labs
- Outreach to underrepresented groups, including women and less-developed regions

Ecosystem Building:

- Strong partnerships with academia, industry, and research centres
- Promotion of industry-linked education and quantum career paths
- Integration with EU initiatives like the Quantum Flagship and Deep Tech Talent Initiative

Measuring Impact:

- KPIs include number of trained individuals, industry uptake, satisfaction, and inclusivity
- Progress monitoring aligned with the Digital Decade & EU Skills Framework

Funding:

- Lump Sum Grant with a 50% funding rate
- Includes support for infrastructure, mobility, and third-party training initiatives

Launch Date:

- 2025, under the Digital Europe Programme

More Info: Visit Digital Skills & Jobs Platform https://digital-skills-jobs.europa.eu/en

Open: 15 April 2025 Submission deadline 2 September 2025 (17:00 CET)

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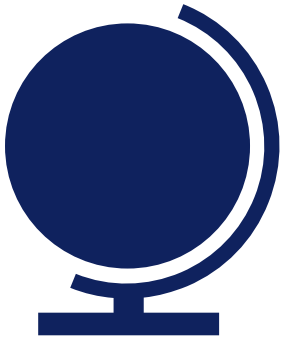
International Cooperation

Show Europe’s global partnerships



Global Partnerships

EU Cooperation on Quantum Technologies

Japan – Quantum Computing & HPC integration

- Collaboration through **EuroHPC JU on quantum computing** integration.
- Joint efforts under the **EU–Japan Digital Partnership** and **Quantum Dialogue**.
- Shared focus on **hybrid quantum-HPC infrastructure** and **post-quantum cryptography**.

South Korea – all Quantum Pillars

- Bilateral focus on **quantum computing, sensing, and communications**.
- Engagement in **technology co-development** and **mobility of researchers**.

Canada - all Quantum Pillars

- Strategic cooperation in **quantum software, secure communications, and sensing**.
- Joint roadmap discussions through science & technology platforms.
- Links to **NORAD modernization** via quantum sensing and computing

JAPAN
Strategic Tech Diplomacy

- Collaboration through EuroHPC JU on quantum computing integration
- Quantum Dialogue on hybrid quantum-HPC, post-quantum cryptography

SOUTH KOREA
Advanced Joint R&D

- Focus on quantum computing, sensing, and communications
- Technology co-development and mobility of researchers

CANADA
Trusted Quantum Ally

- Cooperation in quantum software, secure

Now Is Europe's Quantum Moment

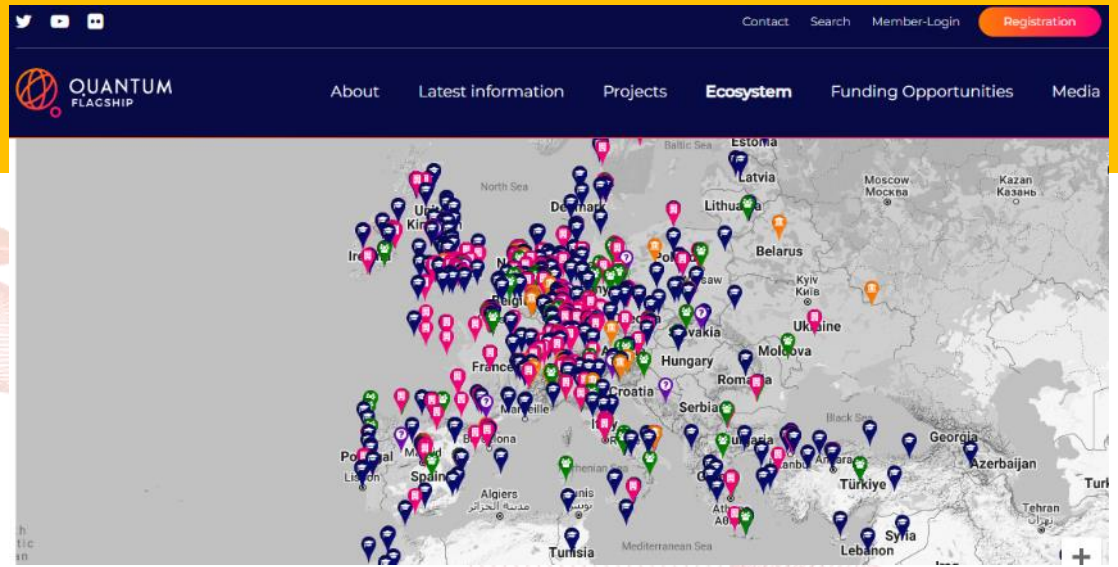
We lead in science – let's lead in technology
- Turn academic excellence into industrial capability
- Scale European quantum startups into global champions

Strategic autonomy is a necessity
- Reduce dependency on non-EU suppliers
- Secure critical quantum infrastructure under EU control

A united EU quantum ecosystem is essential
- Coordinate research, deployment, and skills across Member States
- Integrate start-ups, industry, and public stakeholders

Together, we build Europe's digital and industrial future
- Quantum is key to Europe's technological sovereignty
- Foundation for trusted AI, secure communications, and deep tech leadership

Thank you
more info in qt.eu



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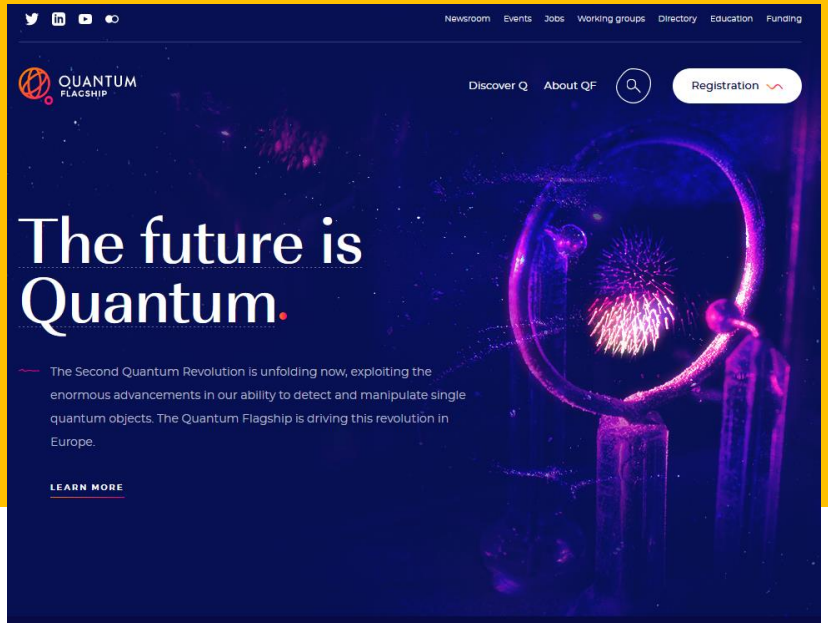
Back up slides



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Breakdown of EU funding per type of instrument

The most used instrument is the Grant, with a highest share of ERC Grants to individual scientists and scholars.