QUANTUM FLAGSHIP

European Commission

Oscar Diez

Head of Quantum Computing

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European Commission

EUROPEAN QUANTUM TECHNOLOGIES
FUNDING OPPORTUNITIES

RESEARCH BASED

HORIZON EUROPE

INFRASTRUCTURES

DIGITAL EUROPE

HORIZON EUROPE
2021-2027

QUANTUM FLAGSHIP

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

- **FUNDAMENTAL R&D**
- **TECHNOLOGY SUPPLY**

Work Programme 2021-22
DESTINATION

DIGITAL AND EMERGING TECHNOLOGIES FOR COMPETITIVENESS AND FIT FOR THE GREEN DEAL

From Lab to Market -FPAs

- **Pilot Lines & Testing Facilities**
- **3x Quantum Computing**
- **Quantum Simulation**
- **2x Quantum Communication**
- **Sensing Market uptake**

ADVANCED DIGITAL SKILLS

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

European Chips Act

Bolster Europe's competitiveness and resilience in Semiconductors & **Quantum chips** including **Production Facilities & Quantum Fund**

DIGITAL EUROPE
DIGITAL SKILLS, CYBERSECURITY, SUPERCOMPUTING

QUANTUM COMMUNICATION INFRASTRUCTURE (EuroQCI)

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

- **QKD INFRASTRUCTURE**
- **TESTING OF CROSS-BORDER QCI LINKS**

QUANTUM COMPUTING INFRASTRUCTURE (EuroHPC)

Build and **deploy** an infrastructure for big data, artificial intelligence, high performance computing, among others

- **QT/HPC HYBRID**
- **QUANTUM SIMULATION/ COMPUTATION**

QUANTUM

qt.eu

leading-the-digital-decade.eu

Standards for quantum

- ✓ Essentials to develop pan-EU infrastructures with interoperable EU (certified) QT
- ✓ Provide trust to customers, e.g., National Security Agencies entering pan-EU QT infrastructures
- ❖ Few standardized design/manufacturing processes for QT, rather proprietary designs and hand made
- ❖ Few standards on application side, e.g., communication protocols, software stacks for quantum- and hybrid classical/quantum- computing

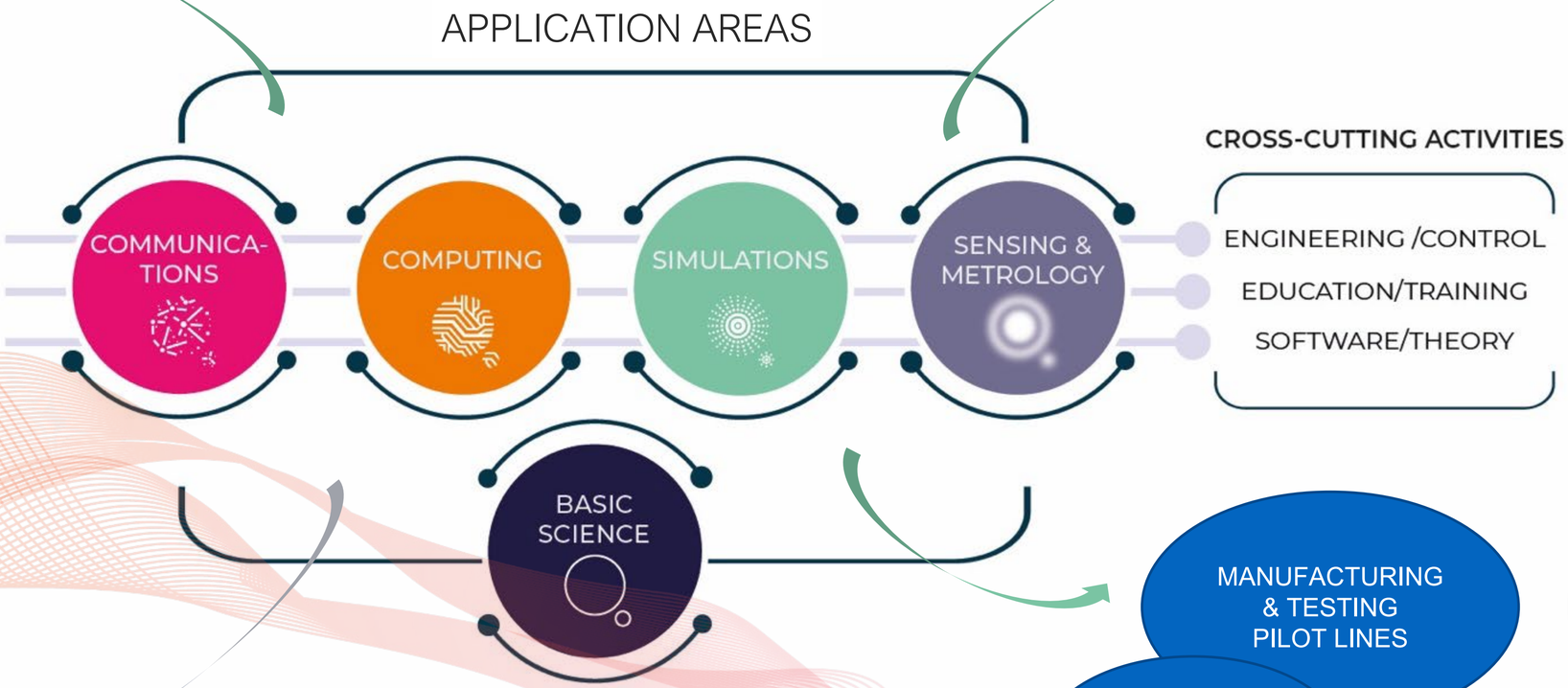
→ Standardization landscape, gap analysis, and roadmap
→ Assess the effect of quantum computing/communication technology in cybersecurity
→ EU standards for supply chains for modular quantum computers/communication architectures

The Quantum Ecosystem – strategic approach

HORIZON EUROPE - Quantum technologies for space gravimetry

EuroQCI

Quantum Flagship



MANUFACTURING & TESTING PILOT LINES

EQUITY SUPPORT TO START-UPS

Chips Act

EuroHPC Joint Undertaking

QUANTUM

Quantum Communication Infrastructure

Integrate quantum cryptography into critical communication systems

Combine terrestrial and satellite components for wide coverage

Protection of data networks, clock synchronization, e-voting,...

Backbone infrastructure for the quantum internet

Quantum Computation & Simulation Infrastructure

EuroHPC Joint Undertaking

Classical quantum simulation hardware in HPC

Quantum testbed facilities for hardware developers

Quantum computation and simulation hardware (ion traps, super-/semi-conducting qubits, spin qubits, phtonic circuits, neutral atoms)

Quantum application database (verification/validation, algorithms, apps)

European Commission

EU QUANTUM TECHNOLOGY ROADMAP

RESEARCH & INNOVATION

H2020

Horizon Europe

Flagship Ramp up Phase
24 Projects

Tech Demonstration Phase

Tech Implementation Phase

International Collaboration

QUANTERA

EU National Coordination

DEPLOYMENT

1st Entanglement
Quantum Network

QKD Infrastructure
Testing of Cross-Border QCI Links

Satellite integration
Full terrestrial deployment

Quantum Communications Infrastructure (EuroQCI)

EuroQCI 1st Phase

EuroQCI Operational Deployment

Quantum Computing Infrastructure (EuroHPC)

QT Simulator Pilot

1st Gen HPC/Q Computer/Sim

2nd Gen HPC/Q Computer/Sim Integration

EuroHPC HPC -
Quantum Simulator hybrid

QT/HPC Hybrid
Simulation/Computation

Digital Europe Programme

MANUFACTURING & PRODUCTION

ADVANCED DIGITAL SKILLS
Competence Framework

Pilot lines - Open testing & experimentation

Production capabilities

FPAs > Chips Act

Creation of QuIC
Industry Consortium

Quantum Sensing
& Metrology toolbox

BUSINESS CREATION

QT Fund

QT Fund - to support quantum startups in their development

QUANTUM ECOSYSTEM
The European Union is at the cutting edge of quantum capabilities

QUANTUM FLAGSHIP

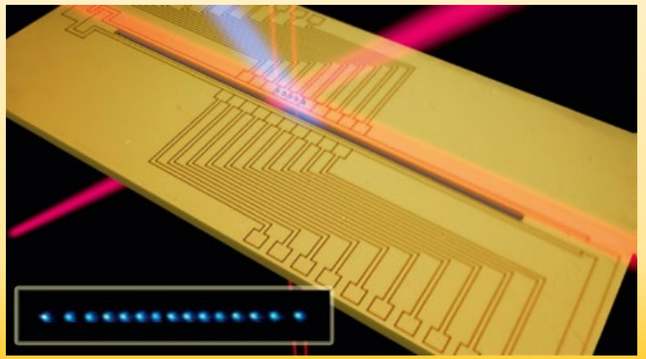
European Commission

Quantum in the Chips Act for Europe

How to achieve mass-manufacturable and large-scale uptake of quantum chips:

- ❑ Develop standardised processes
- ❑ Miniaturisation of the quantum chips
- ❑ Increase integration density
- ❑ Integrating quantum device with control electronics / integration as chiplets in semiconductor microchips

The Chips Act for Europe



- ❑ Innovative design libraries for quantum chips
- ❑ Quantum Pilot Lines
- ❑ Testing and experimentation facilities
- ❑ Participate in Semiconductor Competence Centres
- ❑ Semiconductor fund, including financing of QT start-ups and scale-ups

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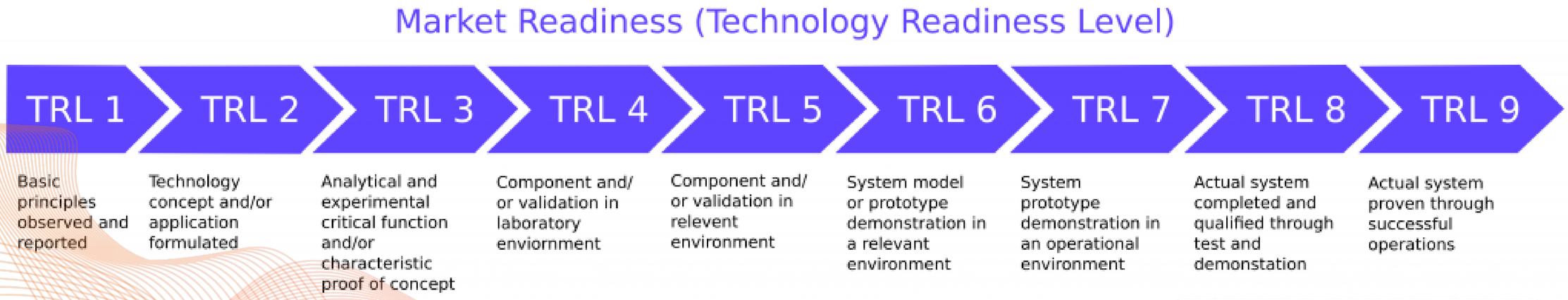
European Commission

Quantum standardization in the Flagship QuCATS CSA

- Work Package 3 on Standardization lead by QuIC (150+ industry members)
- Dr. Oskar van Deventer coordinating all Standardisation actions
- Organisational leadership
  - Continue chairmanship CEN-CENELEC FGQT
  - Use CEN-CENELEC as basis to coordinate with ITU, ISO, ETSI, …
- Technical leadership
  - Quantum computing hardware stack
  - Quantum computing software stack
- Industry involvement
  - Generating early engagement on the standardisation of critical aspects of quantum technologies for Europe
  - Capture standardisation needs from the European quantum industry + R&I community

https://qt.eu/about-quantum-flagship/projects/qucats/

European QUCATS standardization ambitions



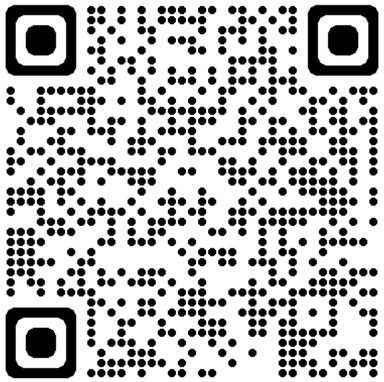
Standards for science (customer = scientist)
- Terminology
- Test set-up modularity
- Measurement methods
- ...

Standards for components (customer = system integrator)
- Physical interfaces
- Functionality
- Quality metrics
- ...

Standards for systems (customer = service provider)
- Protocols
- Data models
- Programming interfaces
- Control
- Management
- ...

Towards European Standards for Quantum Technologies

- Example: submitted article to EPJ Quantum special issue
  - 25 authors, 39 pages
  - https://arxiv.org/ftp/arxiv/papers/2203/2203.01622.pdf



Towards European Standards for Quantum Technologies

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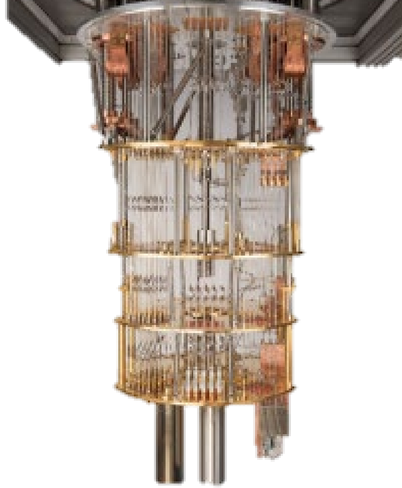
Standardisation Support for Research & Innovation Projects

https://hsbooster.eu/



Thank you

more info in **qt.eu**

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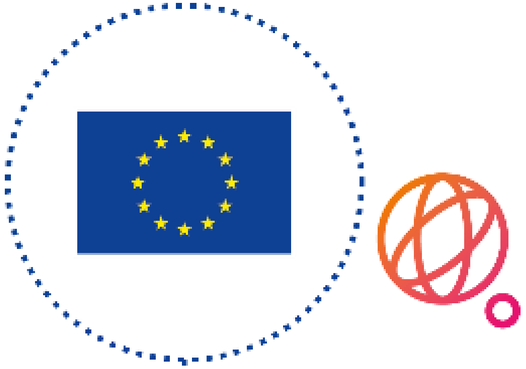
FROM VISION TO REALITY – THE EU'S COMMITMENT



Built with the support of the Commission's proposed Horizon Europe and Digital Europe programmes

HORIZON EUROPE

QUANTERA

QUANTERA

Give **funding support** to **international research projects** in the field of Quantum Technologies

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

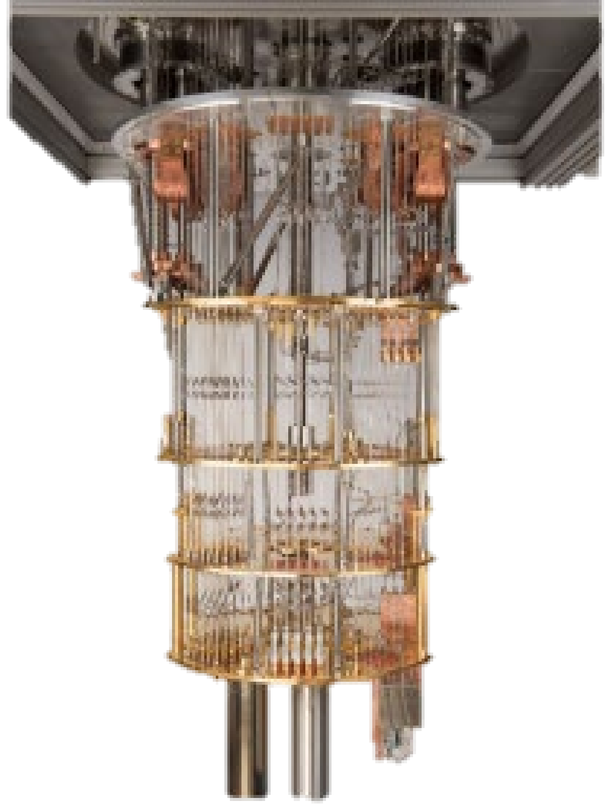
DIGITAL EUROPE

QUANTUM COMMUNICATION INFRASTRUCTURE (QCI)

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

QUANTUM COMPUTING INFRASTRUCTURE

Build and **deploy** an infrastructure for big data, artificial intelligence, high performance computing, among others



Backup Slides

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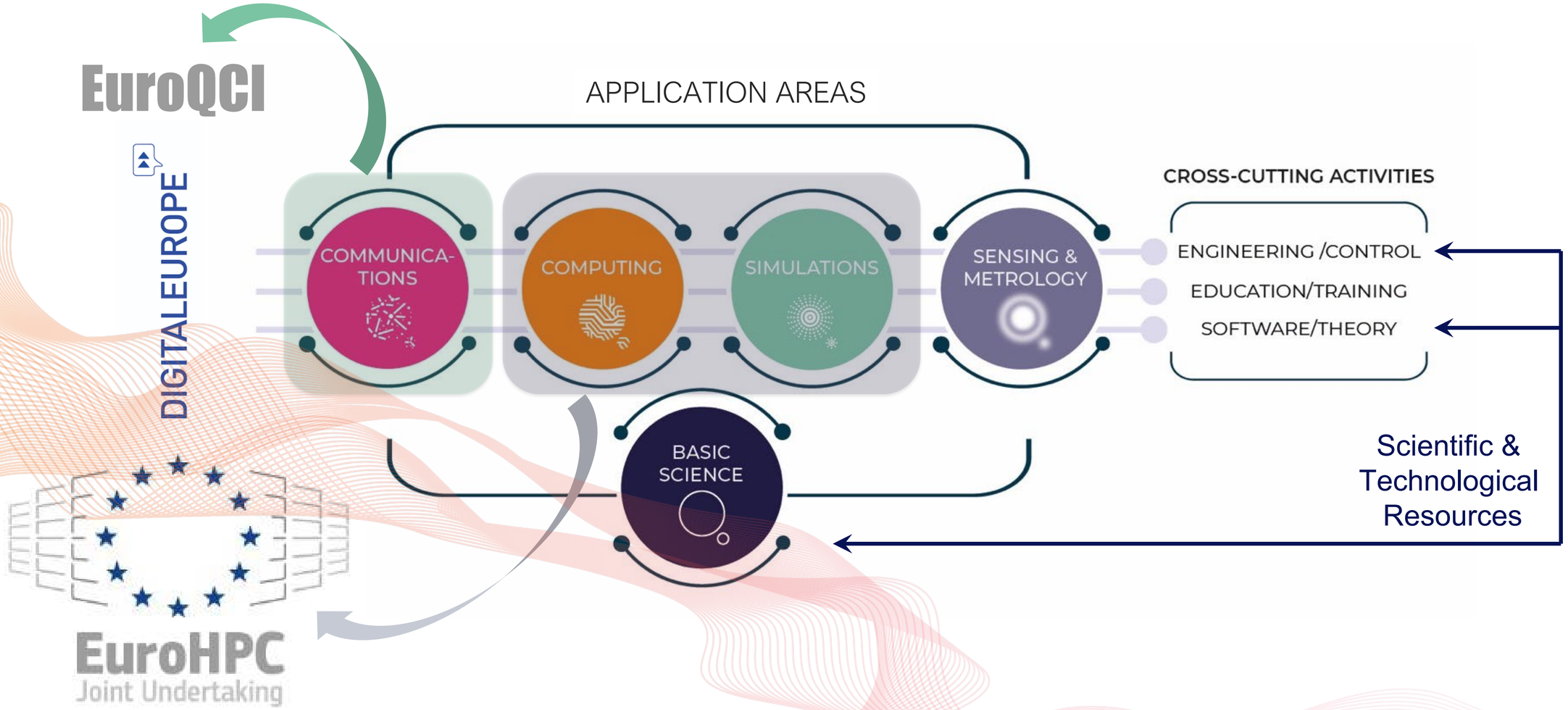
The Quantum Flagship
Structuring activities & efforts

https://qrgo.page.link/45fPy



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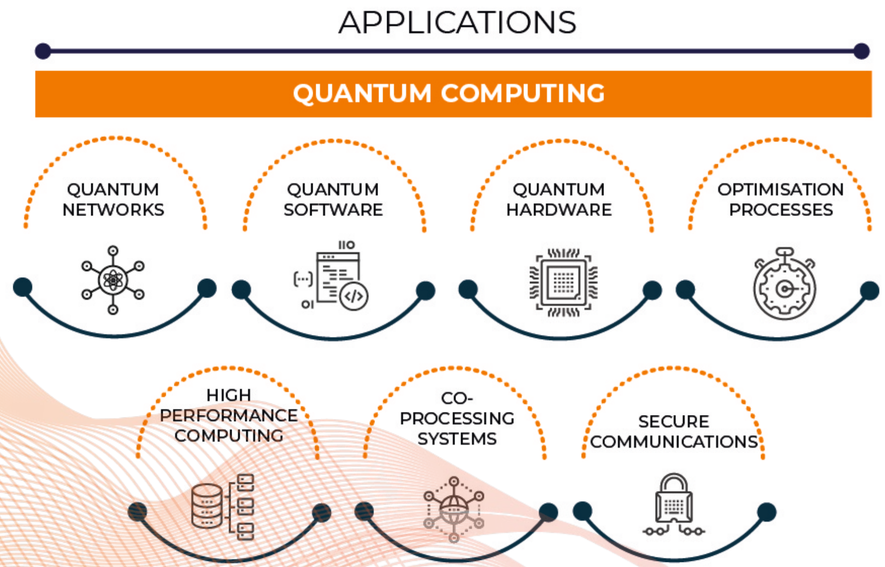
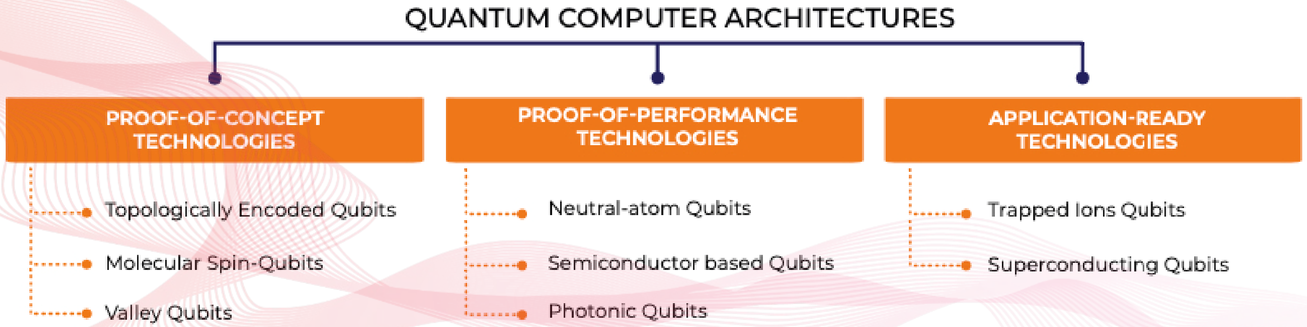
Quantum Computing



6-10 year vision

- Quantum processors fitted with error corrections
- Quantum algorithms with quantum advantage
- Establish/support foundries (integrated photnics, cryo and superconducting electronics), new instrument builders and software companies
- Research corrdination
- Expanded suite of algorithms, compilers, libraries
- Automated system control/tune-up
- Integrated tool-chain and module libraries for integrated optics, cryo- and superconducting electronics
- Coordination of EU-wide joint efforts with other fields (material science, engineering, mathematics, computer science)
- Standardization
- Integration of industry/foundries
- Engage with EU infrastructure, large labs programs, RTOs

Quantum computers have the potential to solve tasks that we don't even dare dream of today and that classical computers can never solve. Completely new solutions for drug development, material design or areas such as financial services and transport will be possible.



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EuroQCS: Quantum Computing & Simulation Infrastructure

Secure and performant sustainable digital infrastructures

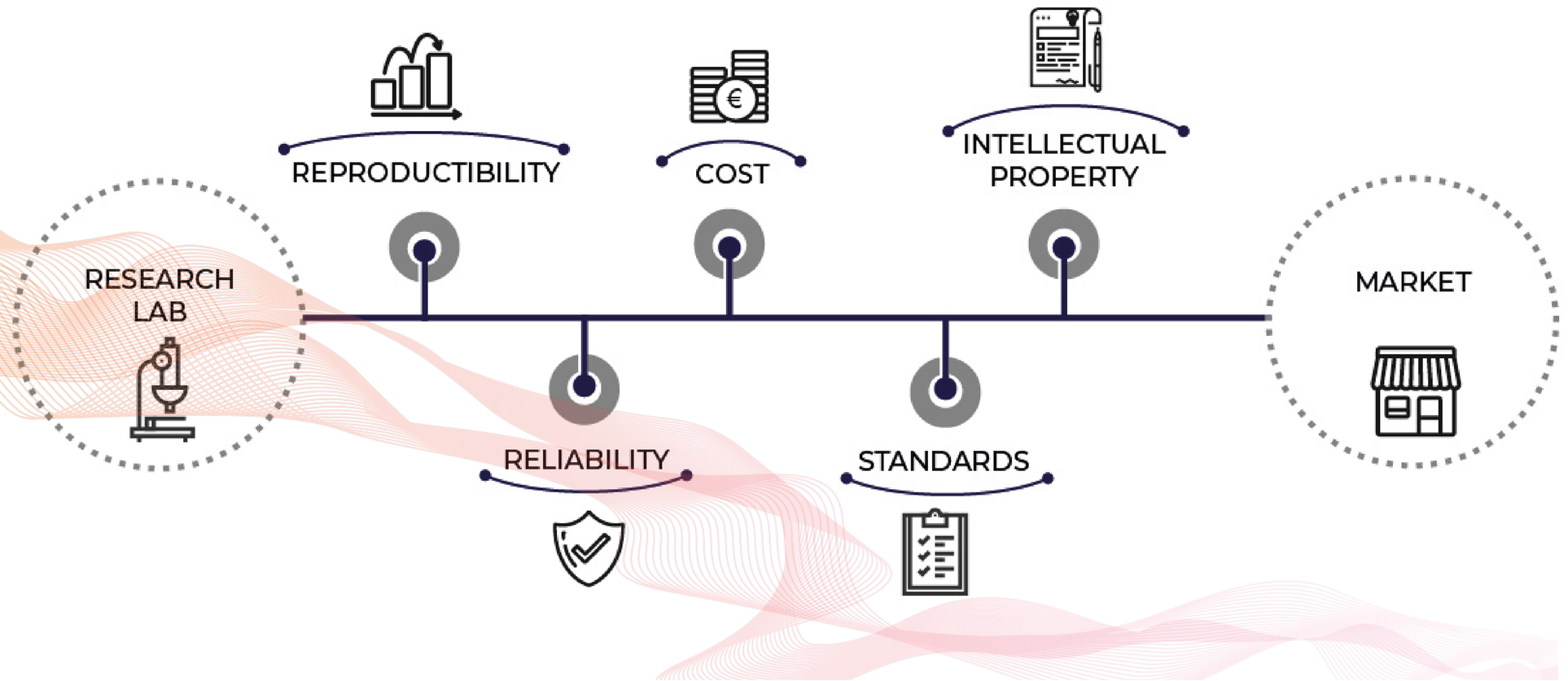
- "… By 2025, Europe will have its first computer with **quantum acceleration** paving
- the way for Europe to be at the cutting edge of quantum capabilities by 2030 …"

- Acquiring supercomputers and **quantum computers (stand alone or accelerator)**, connected with the EuroHPC extreme-bandwidth communication network
- Investing and cooperating in large-scale application platforms (e.g. for health, disaster prediction), as well as in HPC national competence centres and HPC.

	2019 & 2020	2021	2022	2023	2024	2025	2026	2027
HPC Infrastructure	pre-exascale + petascale HPC systems	Several petascale, pre-exascale systems and exascale HPC systems				exascale and post-exascale HPC systems		
Quantum Infrastructure	**quantum simulators** interfacing with HPC systems	1st generation of **quantum computers** + **quantum simulators** interfacing with HPC systems				2nd generation of **quantum computers + quantum simulators**		

Innovation & Infrastructures

Addressing the challenges of scaling up from lab to products and services, raising awareness and bringing key stakeholders together, are all essential to develop the dynamic innovation ecosystem that will put Europe at the forefront of the emerging quantum technologies industry.



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