



# European ambitions on Quantum research and innovation

## QuantERA Funded Projects ´ Mid-term strategic conference

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High Performance Computing and Quantum Technologies

DG CNECT, European Commission

# The Origins

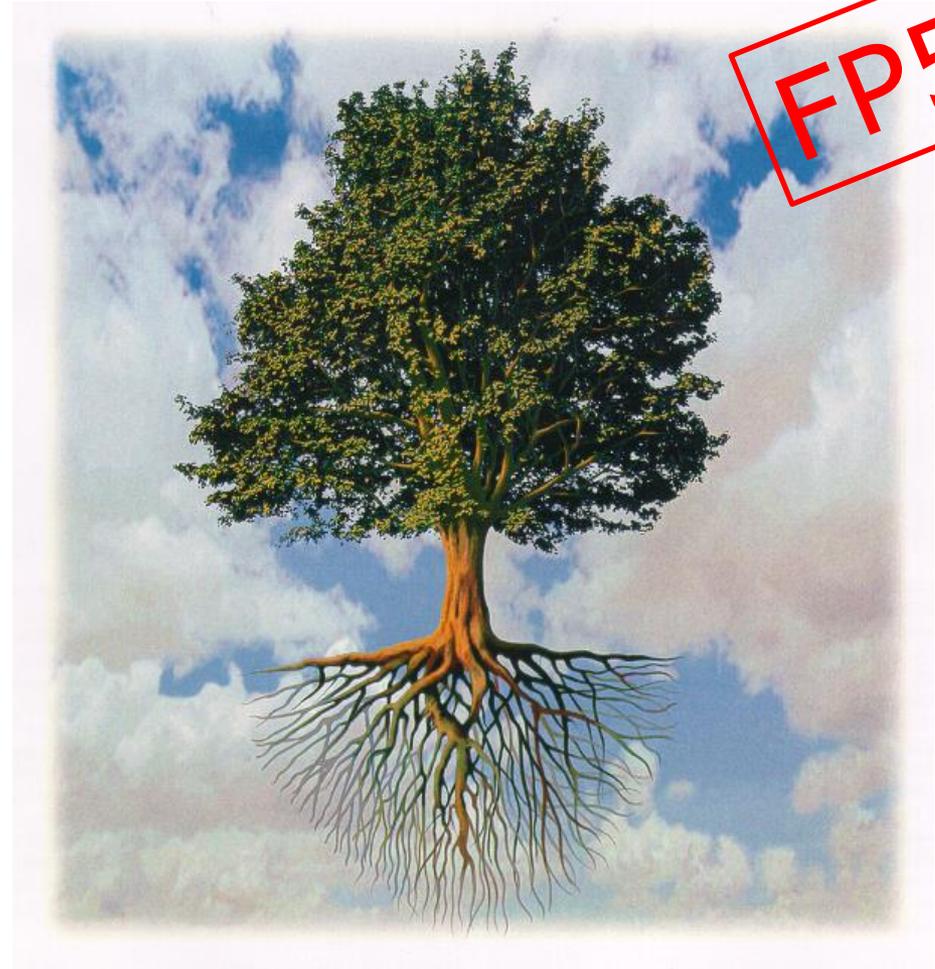


**Future and  
Emerging  
Technologies**

**Quantum  
Information  
Processing and  
Communication**

**Kick-off meeting**

**Brussels 22-23  
September 1999**



**2016:** Pioneer transnational initiative on QT !  
Coordination of national funding agencies = valuable  
communication channel

→ **QuantERA is a privileged partner of QT Flagship**

**26 countries**, 32 funding agencies  
**36M€ call** for transnational projects

- *Quantum communication*
- *Quantum simulation*
- *Quantum computation*
- *Quantum information sciences*
- *Quantum metrology sensing and imaging*
- *Novel ideas and applications in quantum science and technologies*

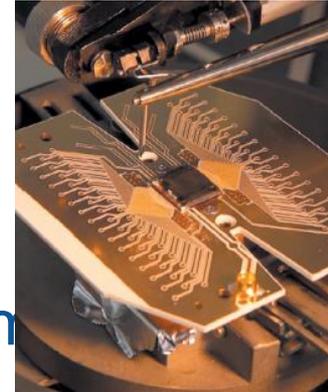
**Very successful response**  
**221 pre-proposals submitted**  
**2<sup>nd</sup> Call without EU top up (20M€)**



**QUANTERA**  
<http://www.quantera.eu>



## **2018: FET Flagship rationale**



- Maturing field – no longer "proof-of-principle "
- 550 M€ investment in 20 years – return on investment
- **FET Flagship → €1 billion over 10 years**
- First QT commercial products & companies emerge – growing steadily
- Accrued industrial interest
  - Big IT companies
  - Non-traditional users
- Other regions invest massively
- No dominant player yet → **build an European industry**

# The political mandate

"... unlock the full potential of quantum technologies, accelerate their development and *bring commercial products to public and private users ...*"  
(ECI 19/4/2016)

"... unlock the full potential of quantum technologies and *accelerate their development and take-up in commercial products ...*" (COMPET 26/5/2016)



# What is a FET Flagship?

***"A research and innovation initiative pursuing grand scientific and technological challenges"***

- ambitious
  - highly-risky
  - long term
  - large scale
  - Interdisciplinary
- 
- Coordination of national & EU efforts
  - Requires close cooperation between Member States & Commission.
  - Requires large & long term research investments that cannot be carried out alone by the Commission or any single Member State
  - Includes an **appropriate governance structure**
    - Member States are fully involved in the governance of the Flagships through the Board of Funders

# QT Flagship Governance



*Intelligence gathering*

*Decision making*

*Implementation*

*Advice*

**Stakeholders  
(QT community)**

**QUANTUM  
COMMUNITY  
NETWORK  
(QCN)**

**BOARD OF  
FUNDERS  
(EC + MS/AC)**

**EUROPEAN  
COMMISSION**

**SCIENCE AND  
ENGINEERING  
BOARD**

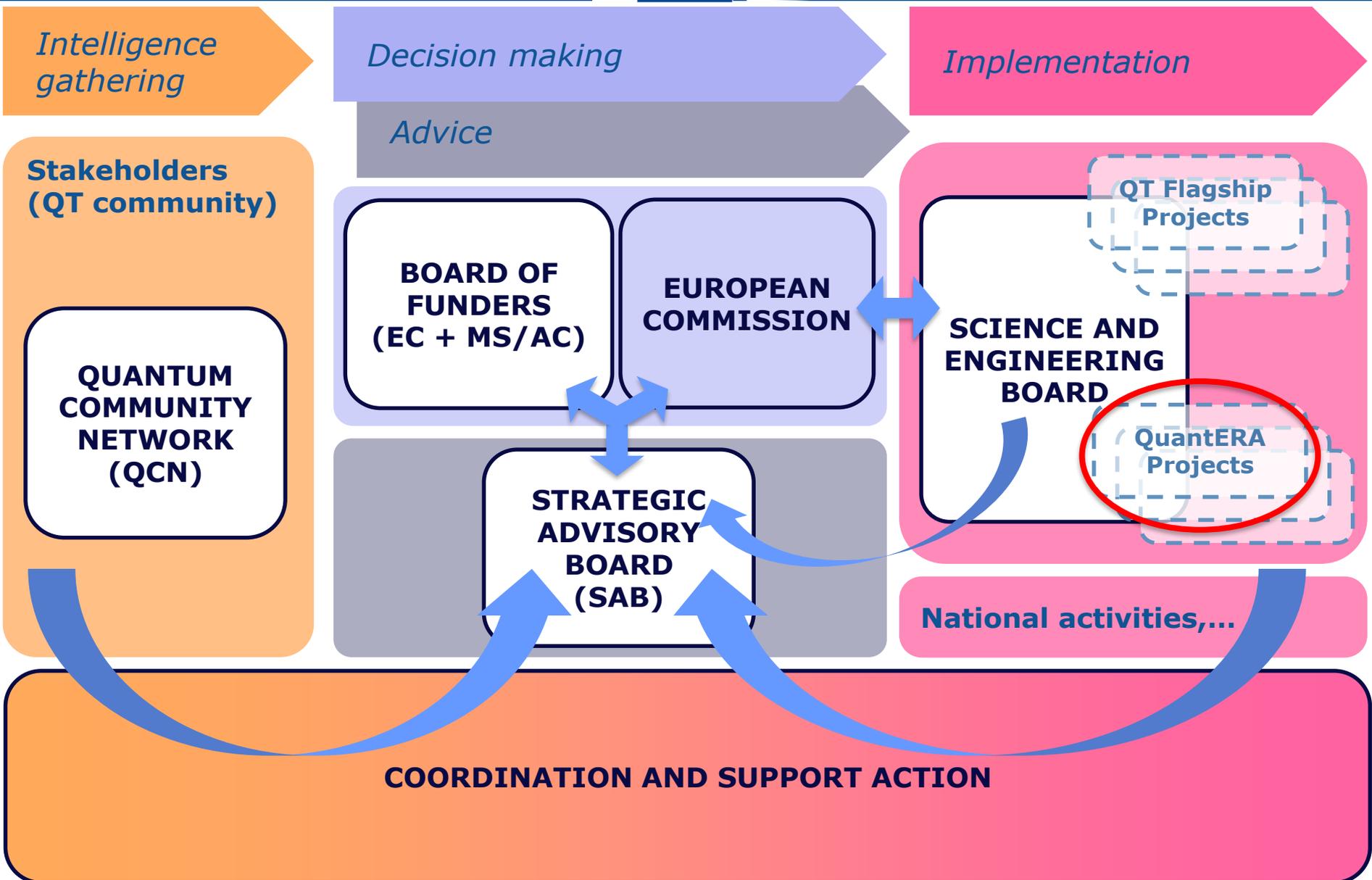
QT Flagship  
Projects

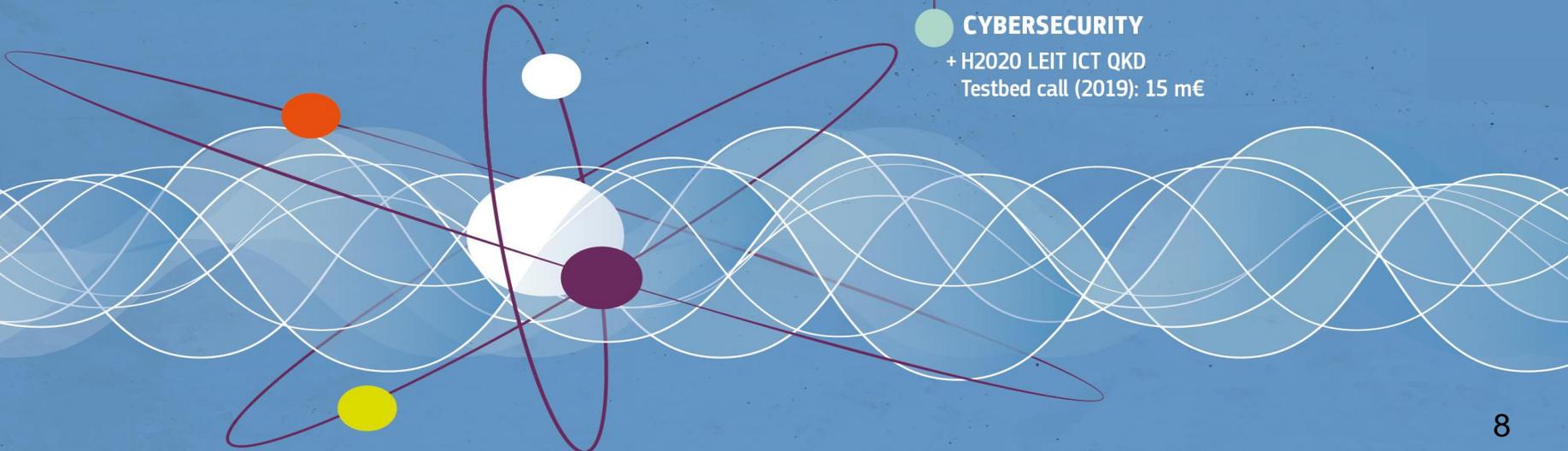
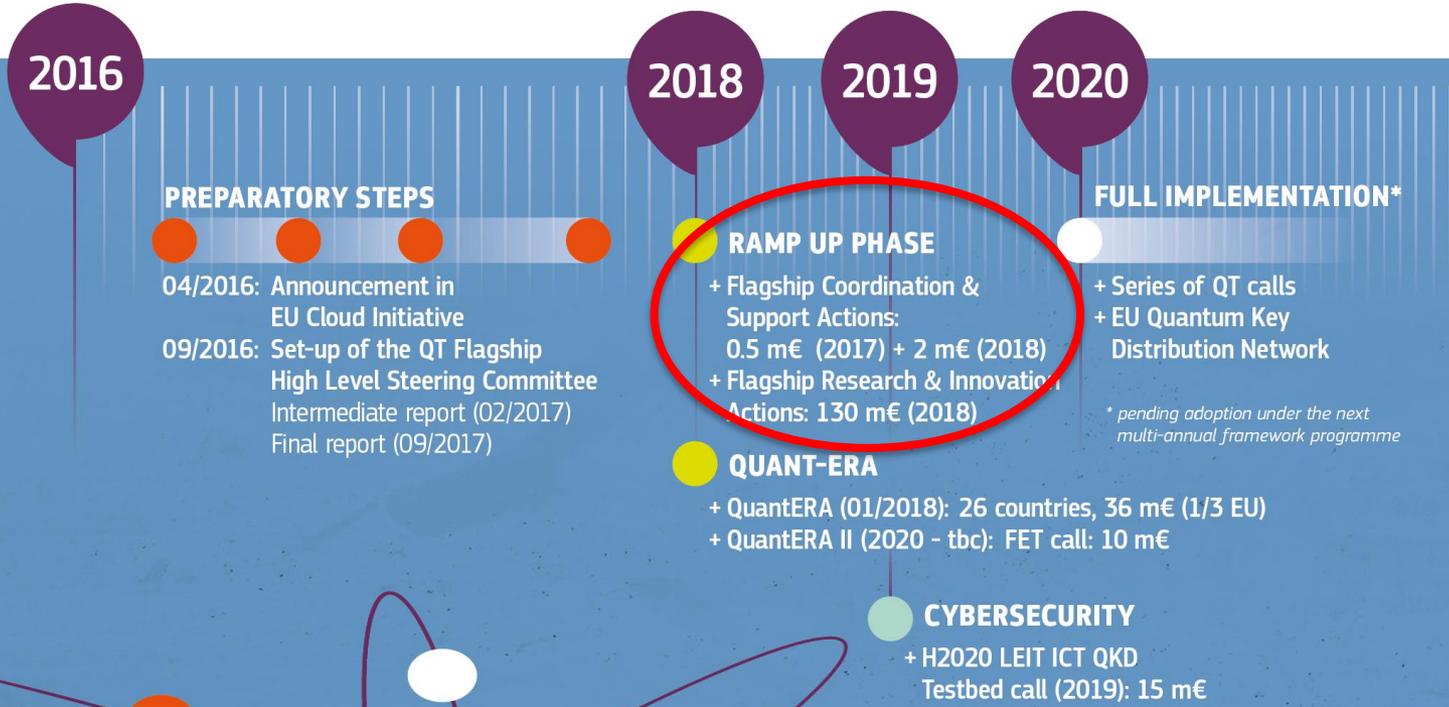
QuantERA  
Projects

**STRATEGIC  
ADVISORY  
BOARD  
(SAB)**

**National activities,...**

**COORDINATION AND SUPPORT ACTION**

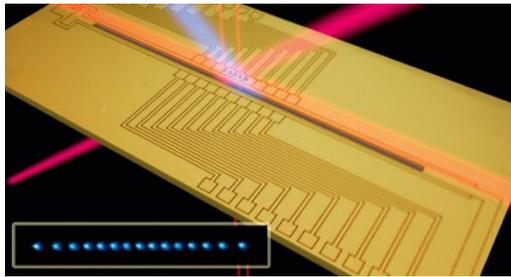




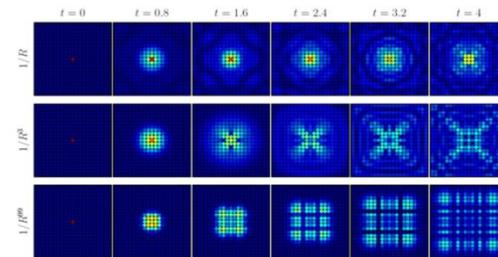
# Quantum Technologies FET Flagship: Coverage

~ 110 M Euro

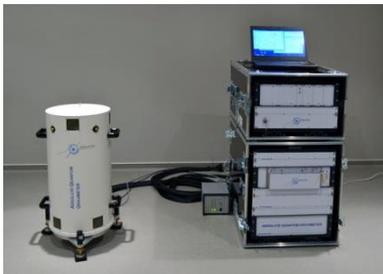
## Computing



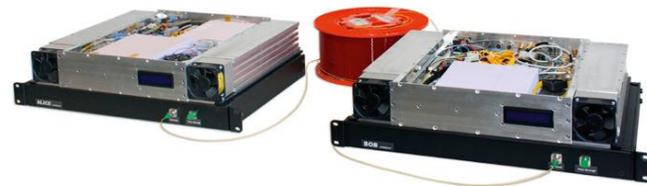
## Simulation



## Metrology & sensing

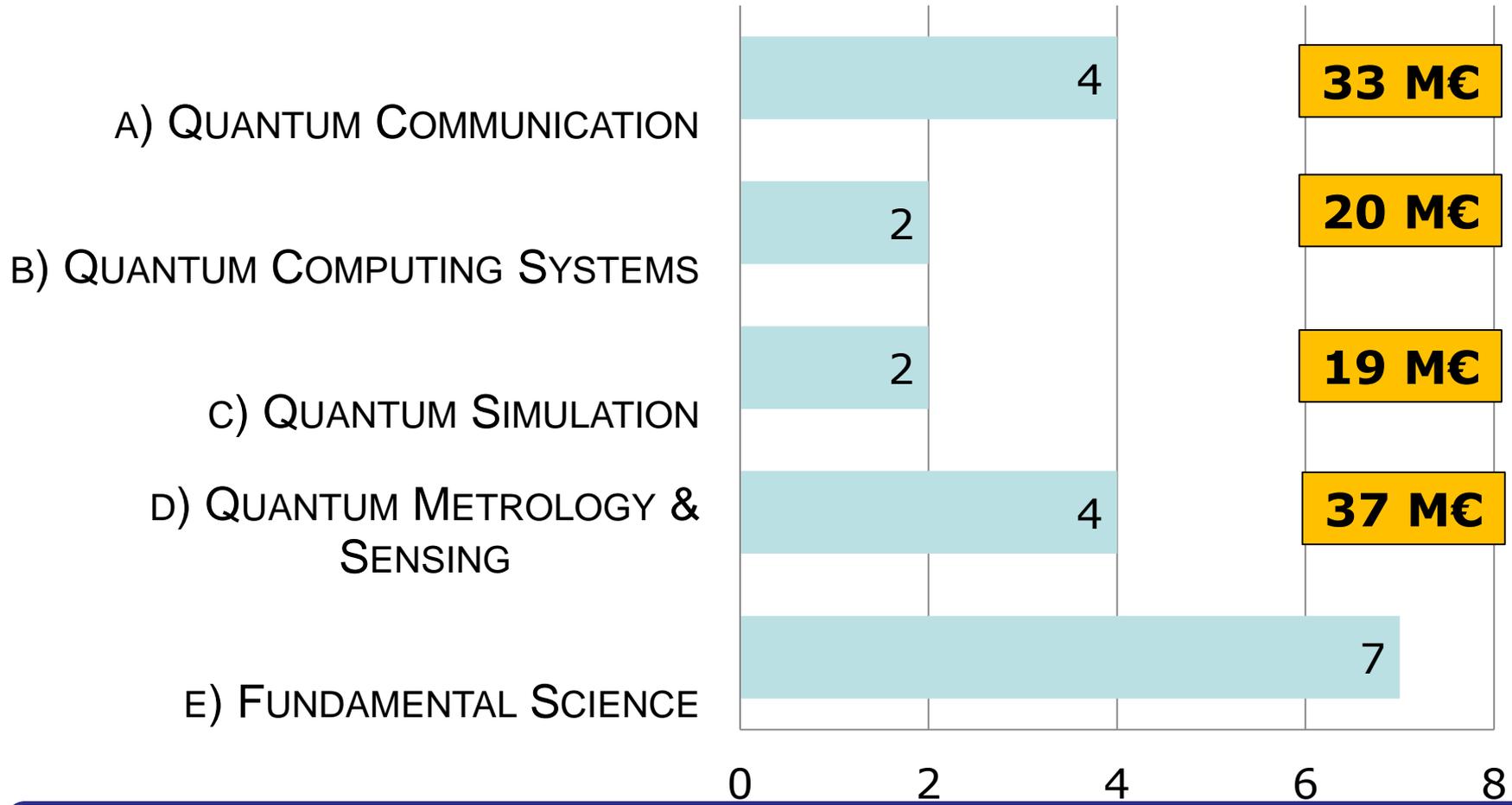


## Communications

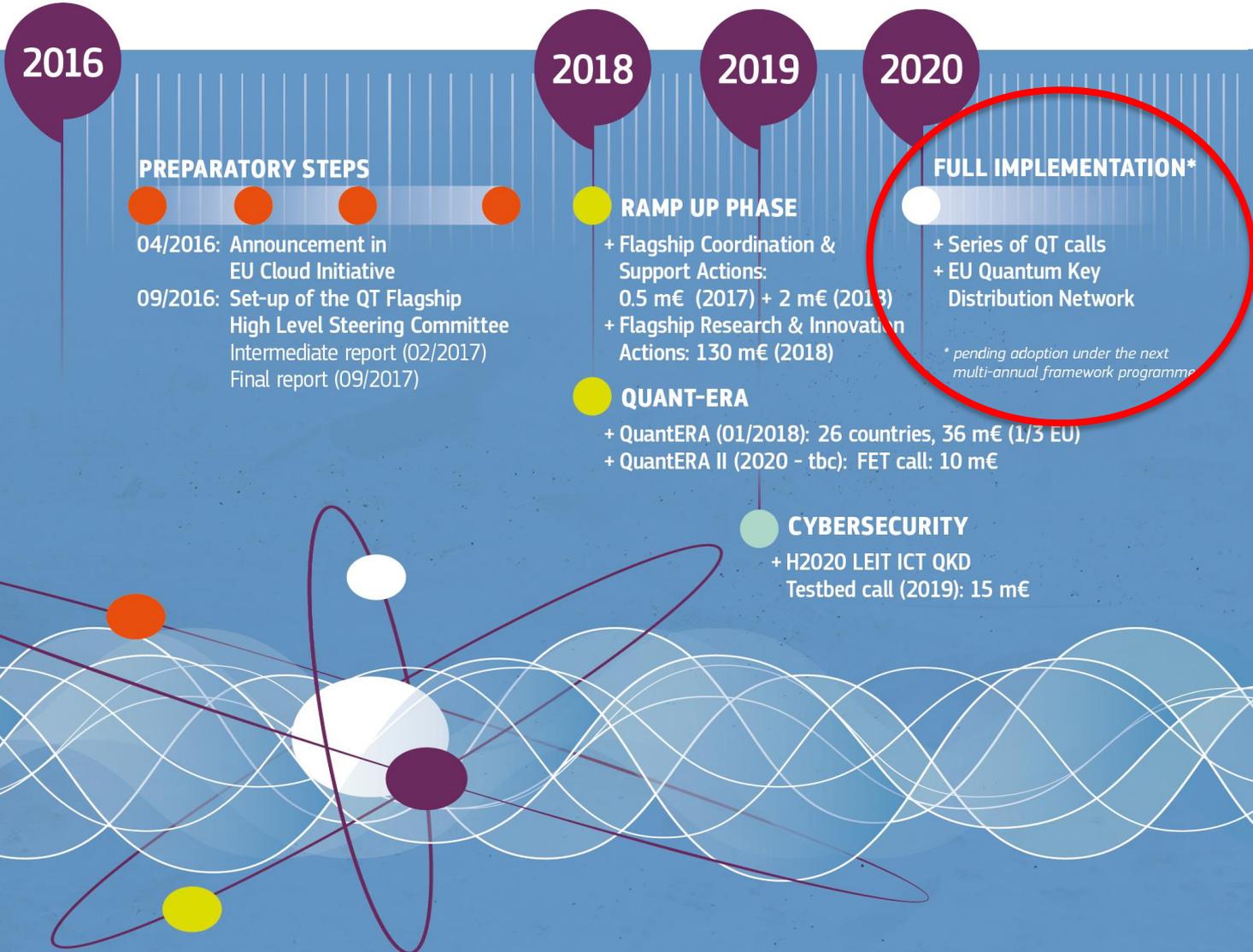


~ 20 M Euro

Fundamental Science



**Additional call on Quantum Computing (semicon) in 2020**

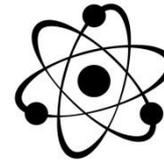


Under  
Negotiation



# Next Multi-annual Financial Framework

2021 - 2027



## Digital Europe Program €2.7 billion

- Supercomputing, quantum-computing infrastructure
- QT/HPC hybrid

## Horizon Europe QT FLAGSHIP €1 billion

- Technology supply
- Fundamental R&D



## Digital Europe Program €2 billion

- Cybersecurity, QCI

# The future: A comprehensive quantum strategy

- Four key pillars
  - Reinforce our R&D effort:
    - The quantum flagship: a renewed agenda, support from HE
    - + Quantum as key technology in Digital, industry & space cluster
    - + quantum applications in other clusters, e.g. cybersecurity
  - Build/strengthen the quantum capacities and infrastructures
    - Quantum computing, in EuroHPC,...
    - Quantum Communication Infrastructure
    - Digital Europe programme
  - Wide spread the use of Quantum
    - Quantum in Digital Innovations Hubs,
    - Set up testing and experimentation facilities
  - International cooperation



# Quantum Communication Infrastructure: EuroQCI

- Europe as a first mover in deploying quantum technologies
  - To secure and shield our assets, our economy and society
  - To stimulate business development
- A coordinated effort with ESA
  - A terrestrial and a satellite based QKD
- A collective effort: EU and MSs
  - 10 Mss already working together, more to come
- Co investment EU-MSs (DEP mainly)
- A pilot project on QKD already up and running

- Building on the two platforms already supported in the Flagship projects
  - Possible third platform
- Scale up, test and deploy
  - Budgets for testing and deployments in DEP
  - Involve industry upfront
- Make the infrastructure available EU wide
  - Build the ecosystem for programming, etc..
  - Support skills development
- Build first applications
  - In Health, cyber, etc...

# Quantum Technologies in HE. (In addition to Pillar 1 & 3)

Clusters	Areas of intervention	
Health 	<ul style="list-style-type: none"> <li>* Health throughout the life course</li> <li>* Non-communicable and rare diseases</li> <li>* <b>Tools, technologies and digital solutions for health and care</b></li> </ul>	<ul style="list-style-type: none"> <li>* Environmental and social health</li> <li>* Infectious diseases</li> <li>* Health care systems</li> </ul>
Inclusive (1) Secure (2) Societies 	<ul style="list-style-type: none"> <li>• Democracy, transformations                             <ul style="list-style-type: none"> <li>* Creativity</li> <li>* Cultural heritage</li> </ul> </li> <li>• .....</li> </ul>	<ul style="list-style-type: none"> <li>* Disaster-resilient societies</li> <li>* Protection and Security</li> <li>* <b>Cybersecurity</b></li> </ul>
Digital and Industry 	<ul style="list-style-type: none"> <li>* Manufacturing technologies</li> <li>* Advanced materials</li> <li>* Space</li> <li>* Circular industries</li> </ul>	<ul style="list-style-type: none"> <li>* <b>Key digital technologies</b></li> <li>* <b>AI &amp; Robotics</b></li> <li>* <b>Advanced computing, BD</b></li> <li>* <b>Next generation internet</b></li> </ul>
Climate, Energy and Mobility 	<ul style="list-style-type: none"> <li>* Climate science and solutions</li> <li>* Energy systems and grids in energy</li> <li>* Communities and cities</li> <li>* Industrial competitiveness in transport</li> <li>* Smart mobility</li> </ul>	<ul style="list-style-type: none"> <li>* Energy supply</li> <li>* Buildings and industrial facilities transition</li> <li>* Clean transport and mobility</li> <li>* Energy storage</li> </ul>
Food and Natural Resources 	<ul style="list-style-type: none"> <li>* Environmental observation</li> <li>* Agriculture, forestry and rural areas</li> <li>* Food systems</li> <li>* Circular systems</li> </ul>	<ul style="list-style-type: none"> <li>* Biodiversity and natural capital</li> <li>* Sea and oceans</li> <li>* Bio-based innovation systems</li> </ul>

Flagship

Under  
Negotiation

# Quantum Communication Infrastructure (QCI)

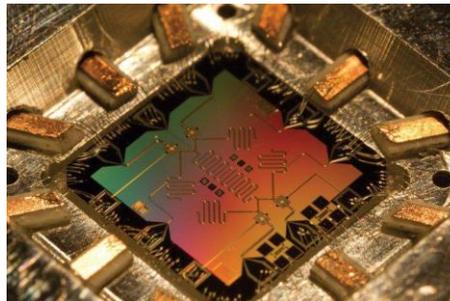
By the end of the next decade develop and deploy an end-to-end QCI comprising a series of quantum communication networks, linking institutional users and their critical infrastructures, and sensitive communication and data sites in Europe

Quantum Key Distribution (QKD) will be the first service of the QCI



# Motivation / Rationale

- Cybersecurity concerns: Prepare Europe to the emerging threat of QC for our infrastructures (→ quantum safe encryption)
- Excellence of research in QT in Europe
- Develop EU digital autonomy
- Boost innovation and industrial capacity



## Crypto Apocalypse

## National Security

In the News State of the Union School closings John McCain Pete Seeger Super Bowl

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Obama calls for year of action

Full text of Obama's speech

Tox mil

### NSA seeks to build quantum computer that could crack most types of encryption

By Steven Rich and Barton Gellman, Published: January 2 [E-mail the writers](#)

In room-size metal boxes secure against electromagnetic leaks, the National Security Agency is racing to build a computer that could break nearly every kind of encryption used to protect banking, medical, business and government records around the world.

According to documents provided by former NSA contractor Edward Snowden, the effort to build "a cryptologically useful quantum computer" — a machine exponentially faster than classical computers — is part of a \$79.7 million research program titled "Penetrating Hard Targets." Much of the work is hosted under classified contracts at a [laboratory](#) in College Park, Md.



# International activities

## Outside Europe:

- China currently the undisputed leader: continental-scale quantum backbone and satellite named Micius (QUESS)
- Japan and US showed their capacities with different architectures



### QUANTUM OPTICS

## Satellite-based entanglement distribution over 1200 kilometers

Juan Yin,<sup>1,2</sup> Yuan Cao,<sup>1,2</sup> Yu-Huai Li,<sup>1,2</sup> Sheng-Kai Liao,<sup>1,2</sup> Liang Zhang,<sup>2,3</sup> Ji-Gang Ren,<sup>1,2</sup> Wen-Qi Cai,<sup>1,2</sup> Wei-Yue Liu,<sup>1,2</sup> Bo Li,<sup>1,2</sup> Hui Dai,<sup>1,2</sup> Guang-Bing Li,<sup>1,2</sup> Qi-Ming Lu,<sup>1,2</sup> Yun-Hong Gong,<sup>1,2</sup> Yu Xu,<sup>1,2</sup> Shuang-Lin Li,<sup>1,2</sup> Feng-Zhi Li,<sup>1,2</sup> Ya-Yun Yin,<sup>1,2</sup> Zi-Qing Jiang,<sup>3</sup> Ming Li,<sup>3</sup> Jian-Jun Jia,<sup>4</sup> Ge Ren,<sup>4</sup> Dong He,<sup>4</sup> Yi-Lin Zhou,<sup>5</sup> Xiao-Xiang Zhang,<sup>6</sup> Na Wang,<sup>7</sup> Xiang Chang,<sup>8</sup> Zhen-Cai Zhu,<sup>5</sup> Nai-Le Liu,<sup>1,2</sup> Yu-Ao Chen,<sup>1,2</sup> Chao-Yang Lu,<sup>1,2</sup> Rong Shu,<sup>2,3</sup> Cheng-Zhi Peng,<sup>1,2\*</sup> Jian-Yu Wang,<sup>2,2\*</sup> Jian-Wei Pan<sup>1,2\*</sup>

Long-distance entanglement distribution is essential for both foundational tests of quantum physics and scalable quantum networks. Owing to channel loss, however, the previously achieved distance was limited to ~100 kilometers. Here we demonstrate satellite-based distribution of entangled photon pairs to two locations separated by 1203 kilometers on Earth, through two satellite-to-ground downlinks with a summed length varying from 1600 to 2400 kilometers. We observed a survival of two-photon entanglement and a violation of Bell inequality by  $2.37 \pm 0.09$  under strict Einstein locality conditions. The obtained effective link efficiency is orders of magnitude higher than that of the direct bidirectional transmission of the two photons through telecommunication fibers.



In Europe: several countries have started to develop their own (limited) quantum communication infrastructures e.g.,:

- In Netherlands between Amsterdam, Delft and The Hague (Quantum Internet),
- In Italy between Matera and Frejus (Quantum Time/Frequency distribution),
- In Spain, Madrid (Telefonica) quantum/classical testbed,
- In UK (UKQNetel), Austria (SECOQC) and Switzerland (SwissQuantum)



Under  
Negotiation

## QCI: A Terrestrial segment ...

- Cross-border connection of EU capitals
- Modular and upgradable towards a much broader range of applications, beyond QKD
- Starting point: an experimental testbed for validating the feasibility of QCI based on QKD and for testing the interoperability of different quantum components

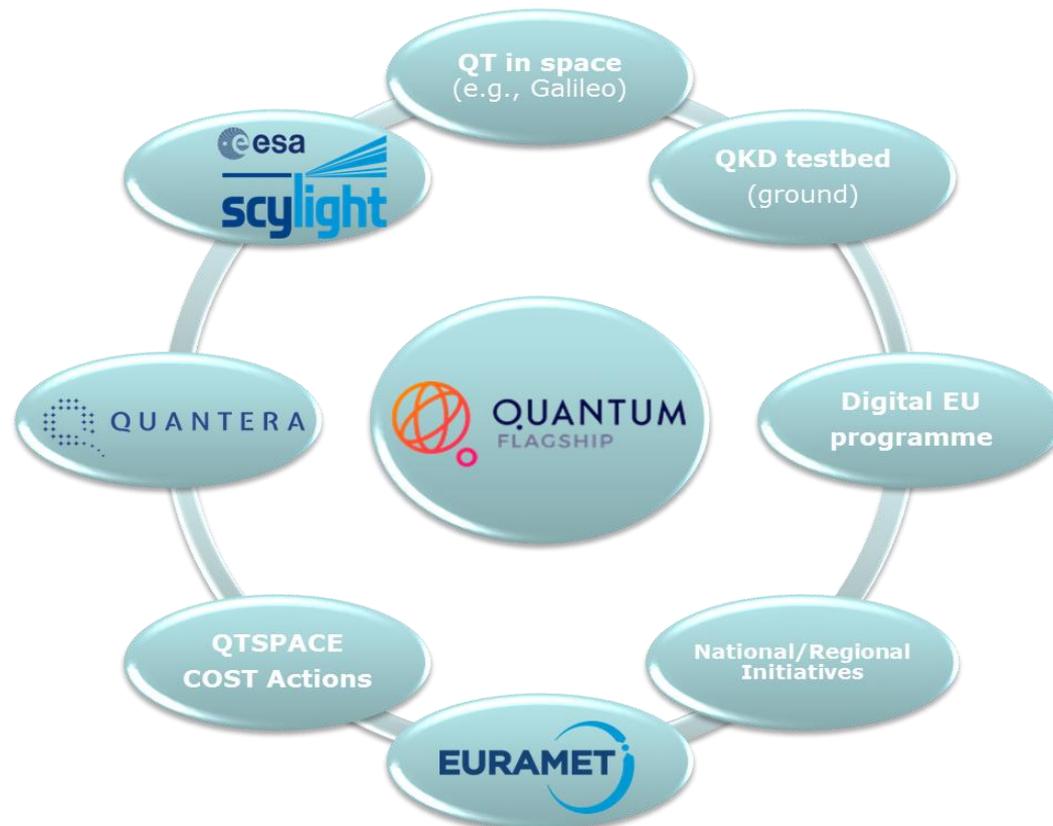
15 M€, H2020 – 1<sup>st</sup> September 2019





# Towards a EU QT-ecosystem

Several initiatives are already preparing the development of the technology components needed for the deployment of quantum communications in Europe.



# QuantERA: Strategic importance



## Pioneer successful transnational initiative on QT !

QT Flagship needs help

- **QF Flagship is not the only actor → Need better national coordination for defining and implementing QT**
- **QuantERA within the Flagship:**
  - **Where is complementarity?**
    - QT applications ↔ QT science ?
    - QT infrastructures ↔ QT R&D ?
- **QuantERA help on the implementation of the QT Flagship**
- **Help on define subject of future calls (technology mapping, public policy mapping, etc.)**

# Thank you for your attention

## Questions

