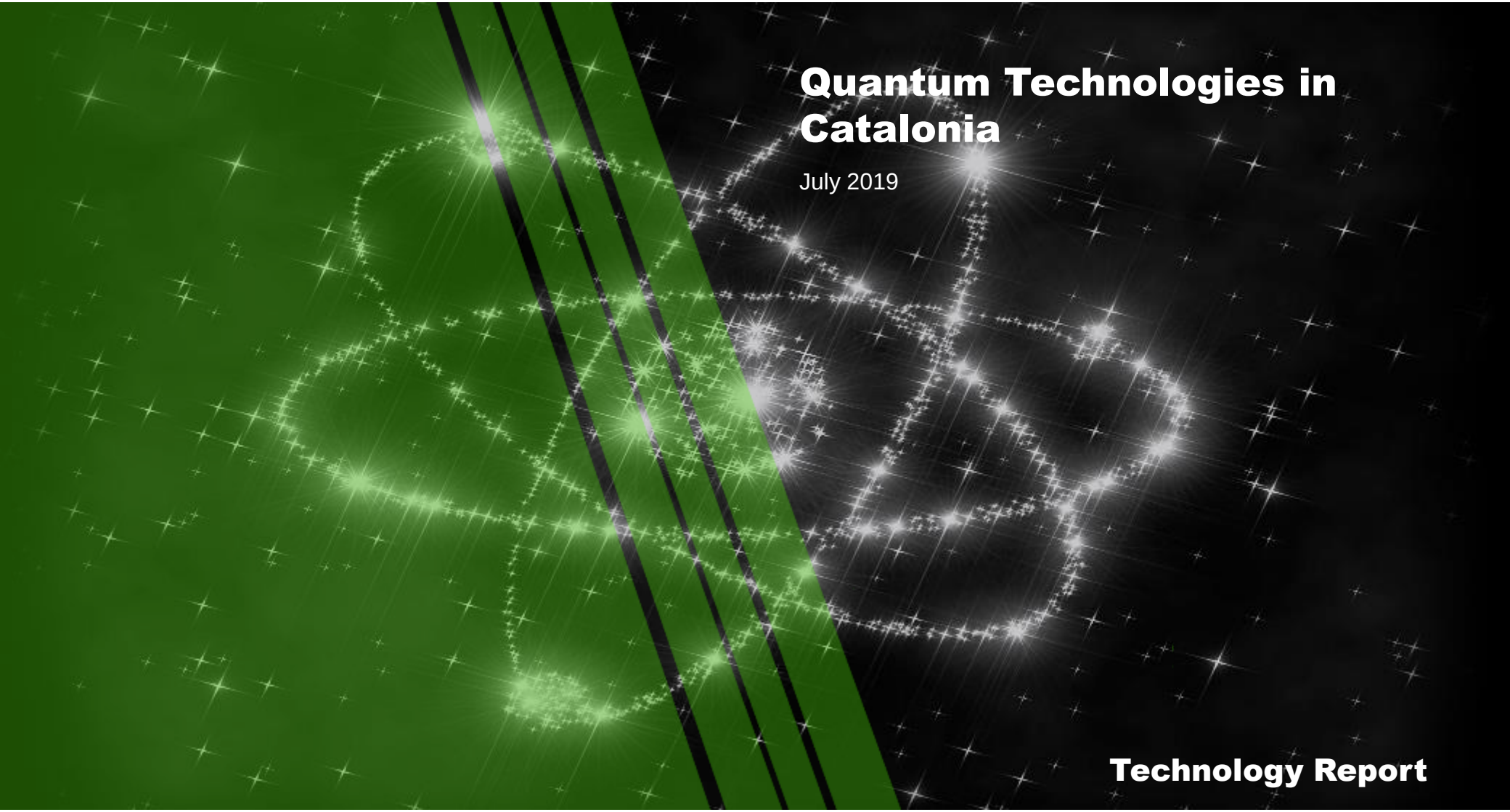

# Quantum Technologies in Catalonia

July 2019

## Technology Report

Catalonia Trade & Investment

Generalitat de Catalunya
Government of Catalonia

# Quantum Technologies in Catalonia: Technology Report

**ACCIÓ**
**Government of Catalonia**



**Prepared by**
ACCIÓ's Strategy and Competitive Intelligence Unit and
ICFO

Barcelona, July 2019

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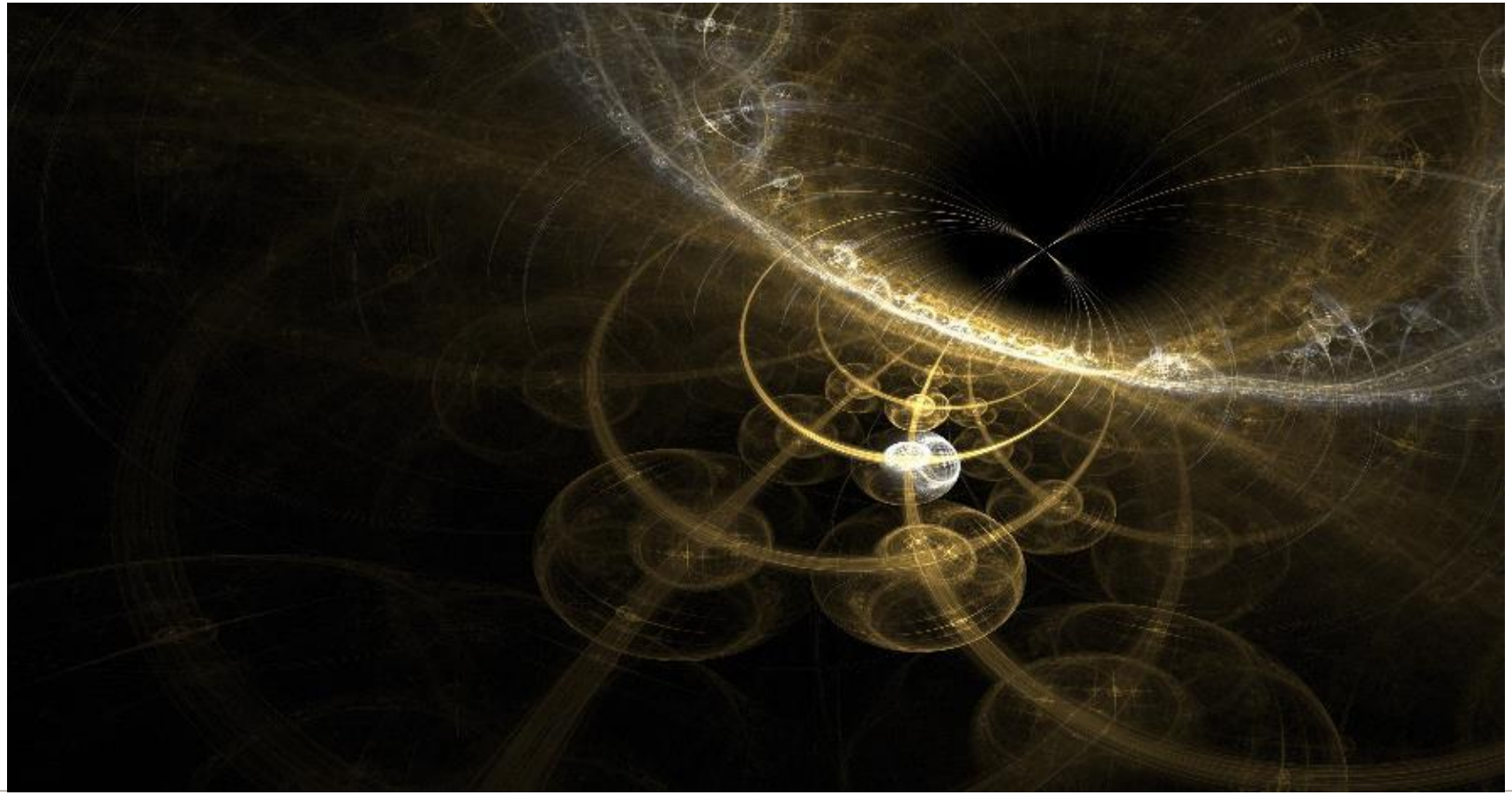
# 1. Definition of Quantum Technologies and Their Importance for Industry



# 1. Definition of Quantum Technologies (QTs)

- We are **currently** in the midst of a second quantum revolution, which is based on technologies that create, manipulate and measure the quantum states of matter, often by means of the quantum effects of superposition and interlacing.
- **Quantum mechanics** explains the behaviour of matter and light and their interactions at the scale of atoms and photons.
- **Quantum technologies (QTs)** use methods and tools based on quantum properties such as quantum superposition and interlacing.
- A **qubit** is the basic unit of quantum information. A **qubit** is a two-state quantum system. Examples include the electron's spin (spin-up and spin-down states) and the polarization of an individual photon (vertical and horizontal polarization states).

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 1.2. Fields of Application for QTs:

## Quantum communication

Communication | Computing | Simulation | Sensors/Metrology

- **Objective**: to code information in quantum states of light with a view to transmitting information and enabling disruptive applications in cryptography. Quantum properties can guarantee authenticity, integrity and non-repudiation.
- **Main applications**: secure communications, long-term storage, cloud computing and other cryptography-related tasks.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 1.2. Fields of Application for QTs:

## Quantum computing

Communication | **Computing** | Simulation | Sensors/Metrology

- **Objective**: to solve computational problems more quickly through the use of quantum phenomena, such as superposition and interlacing, to execute operations.
- **Main applications**: solution of factoring problems, machine learning and many other applications.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 1.2. Fields of Application for QTs:

## Quantum simulation

Communication | Computing | **Simulation** | Sensors/Metrology

- **Objective**: to solve major quantum problems by mapping them onto controlled quantum systems, either analogically or digitally.
- **Main applications**: solution of optimization problems such as those relating to logistics, complex financial models, risk management, material design and machine learning.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 1.2. Fields of Application for QTs:

## Quantum sensors

Communication

Computing

Simulation

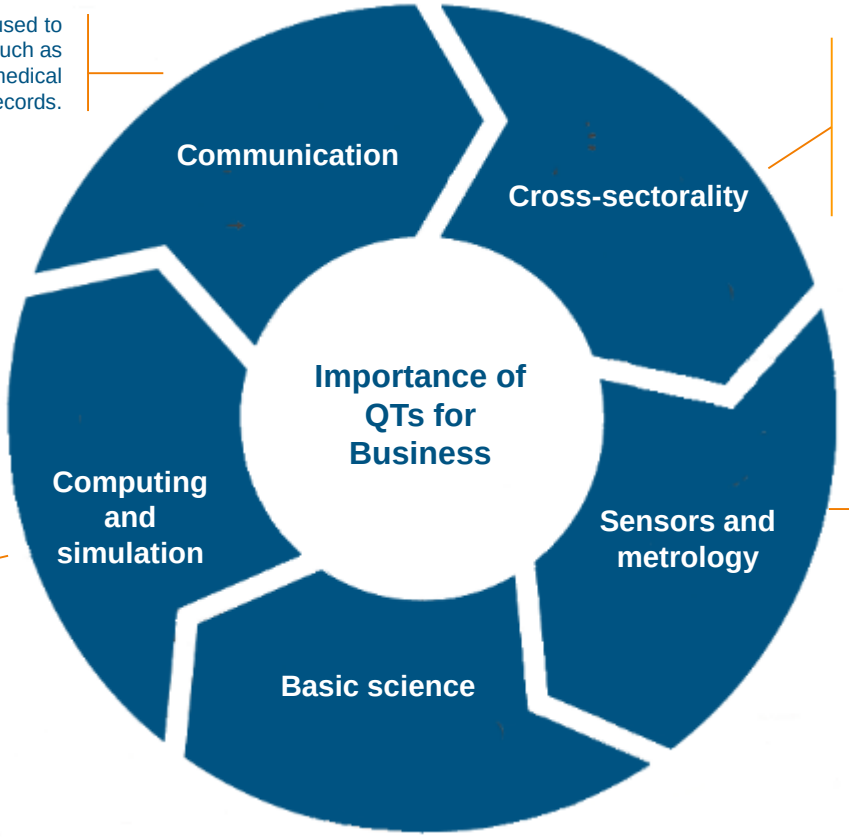
**Sensors/Metrology**

- **Objective:** to push the limits of classical detection and modern sensors through the use of quantum states.
- **Main applications**: improvements in existing sensor technologies and generation of new applications in medical diagnosis, material analysis, navigation, civil engineering, network synchronization, faster Internet and metrology standards.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 1. The Importance of QTs for Business

Quantum communication can be used to digitally **protect shared data**, such as financial transactions and medical records.




Quantum technologies represent a new field of engineering that can translate the effects of quantum physics into practical applications with disruptive potential in a wide range of fields, such as computing, telecommunications, satellite navigation, smart phones and medical diagnosis.

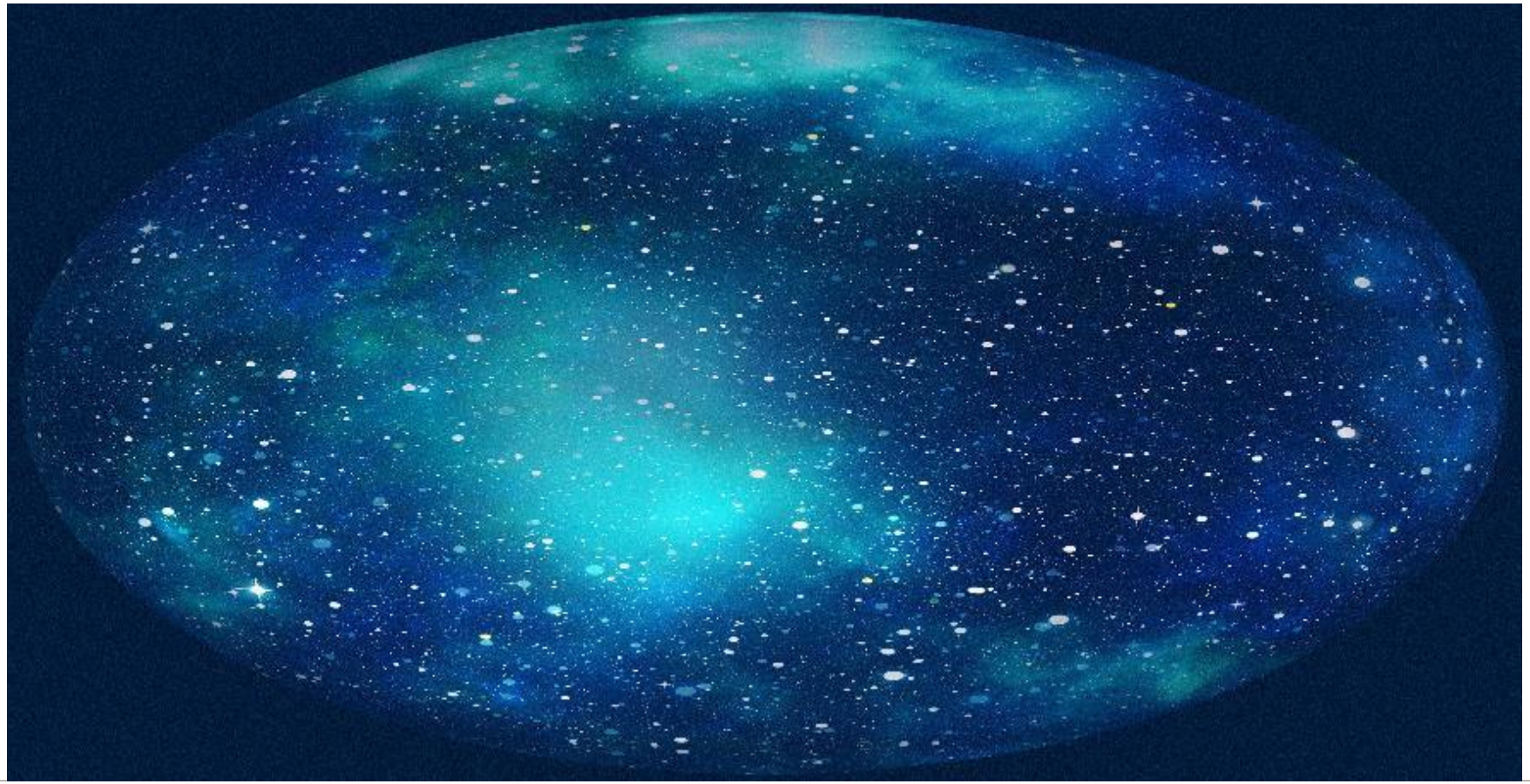
Quantum computers make it possible to solve currently unsolvable computational problems. Quantum computing has the potential to impact many fields, including **big data** and **artificial intelligence**. Quantum simulation **will be key in the design of new materials and drugs**, and will make it possible to optimize processes in areas such as logistics.

**Quantum sensors** provide extremely precise measurements that **improve the performance of devices** in sectors such as medical diagnosis, high-precision navigation and civil engineering.

Basic science encompasses research on and development of the theories and components required to drive quantum technologies.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 2. Key Global Dimensions



# 2.1. The Global QT Market

- **Many quantum technologies are currently in the development phase and have therefore not yet penetrated the main markets**. Not until the early 2020s are QTs expected to be developed enough to have a strong presence in any of the markets of the application fields. However, in areas such as quantum communication and quantum sensors, products are already on the market. In addition, major investments have been made in recent years in both the public and private sectors.

- **Global revenues from QTs are expected to amount to $13.3 billion** by 2023.

  **Communications and quantum cryptography**: the market is expected to grow from $285.7 million in 2017 to $943.7 million in 2022 (CAGR of 27%).

  **Computing and simulation**: the market is expected to grow to around $2.46 billion by 2022, at a CAGR of around 24% between 2016 and 2022.

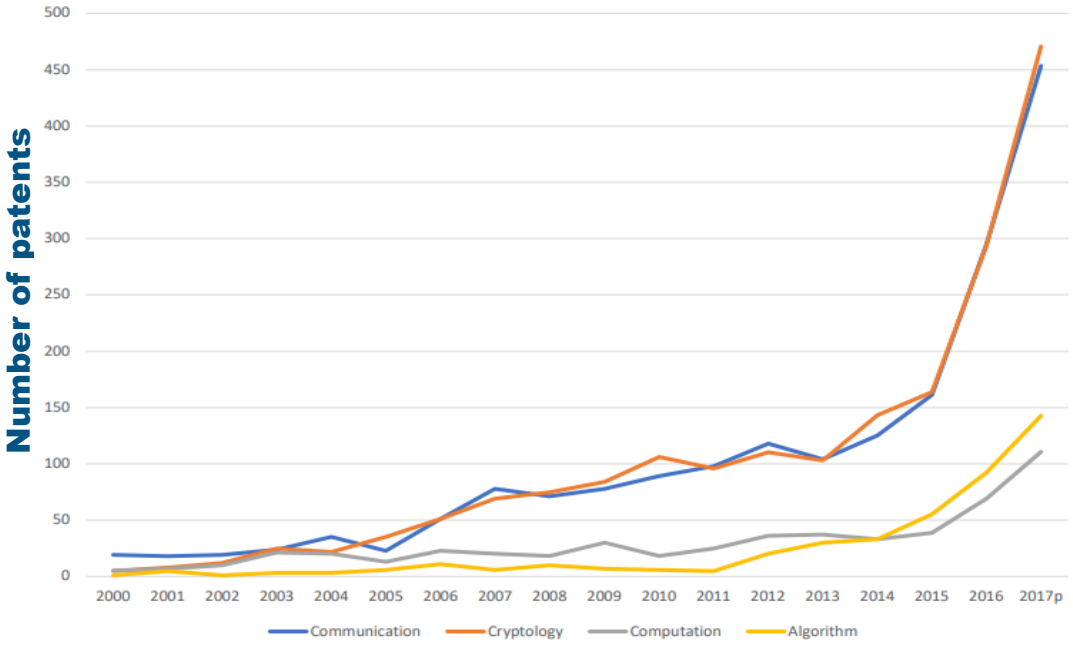
  **Quantum sensors**: the market is expected to exceed $300 million by the year 2023.

**Source**: EIC (DGI-ACCIÓ), based on data from ICFO and Business Wire, Market Research Future.

# 2.1. The Global QT Market

- Patents relating to quantum communication, cryptology, algorithms and computing have increased by more than 350% since 2017.
- There is a very strong correlation between quantum communication and cryptography, since many quantum communication methods involve encryption. As the graph shows, there was a marked evolution in these two quantum technologies from 2014 onwards; the same occurred in quantum computing and algorithms from 2015 onwards.
- The main actors are: United States, China, Japan, Europe, Canada, South Korea, Australia, Taiwan, Malaysia and Singapore. China has the largest number of communications patents (Qasky, Shenzhou, Alibaba and Huawei), while the United States leads the way in computing and sensors (Raytheon, IBM, Google, Microsoft and D-Wave). Europe is a major actor, but it is not a leader in any field in terms of the number of patents.
- Goldman Sachs has estimated that the quantum computing industry could be worth $29 billion by 2021; it is current valued at under $2 billion.
- **Main fields of application: defence, space and security.**

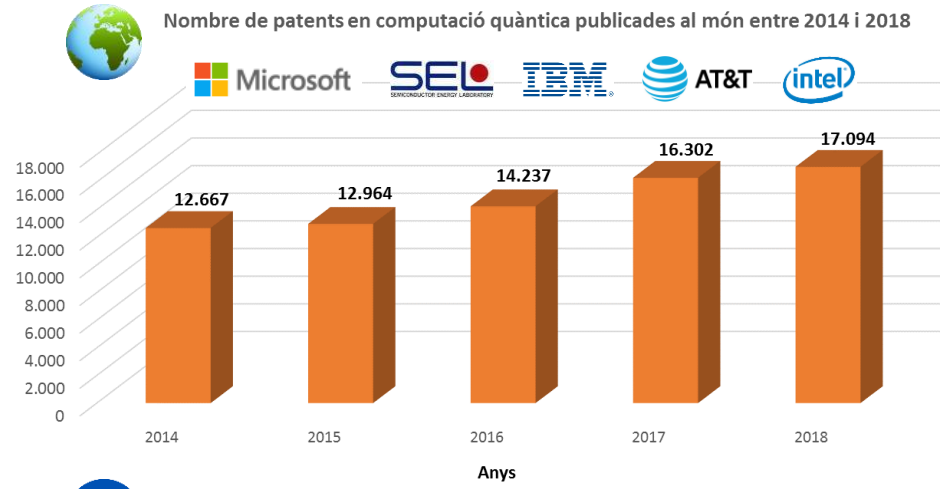
**Evolution of patents relating to quantum communication, cryptology, algorithms and computing at global level in the last few years**

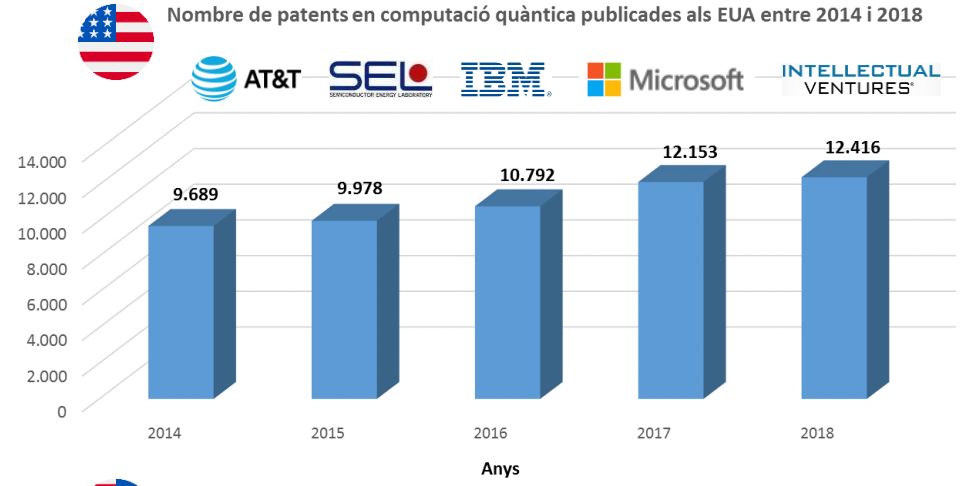


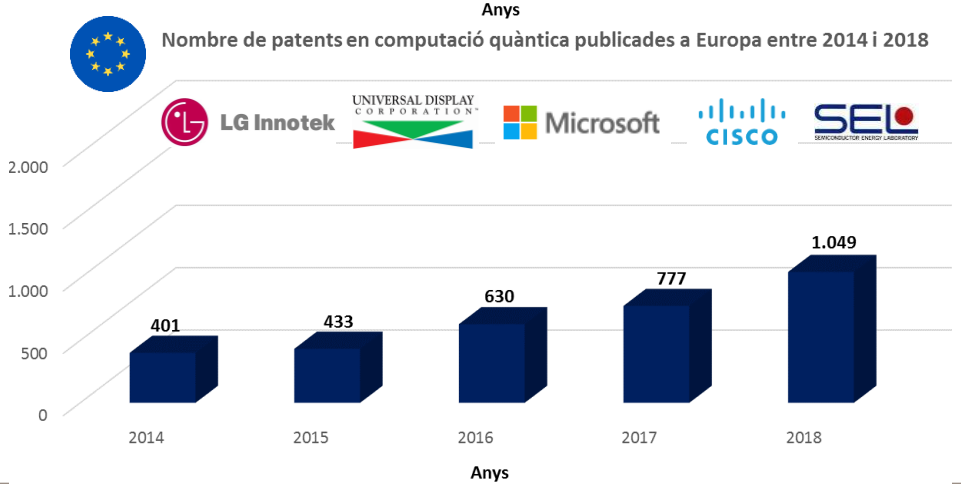

**Source**: EIC (DGI-ACCIÓ), based on data from Patinformatics, LLC, the Quantum Applications Patent Landscape Report and Goldman Sachs.

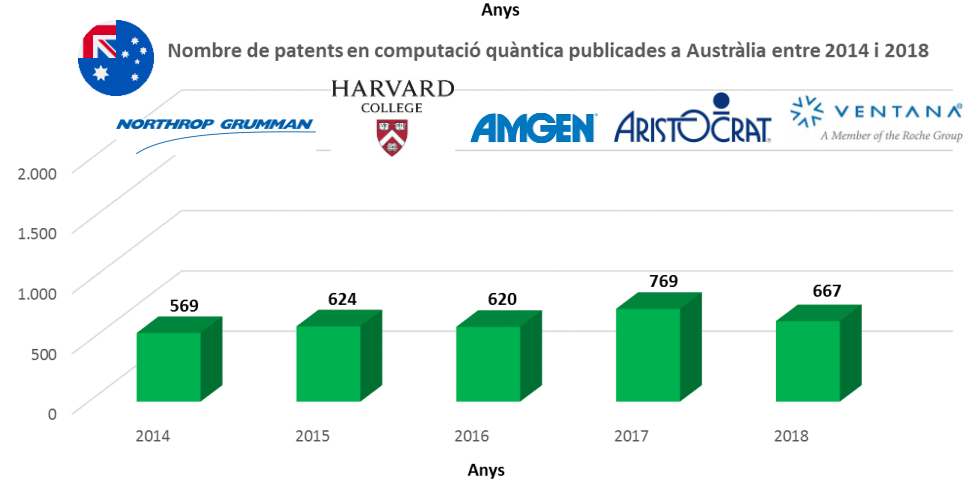
# 2.1. The Global QT Market

With regard to quantum computing, a total of 73,246 patents* were published worldwide between 2014 and 2018. The leading countries or regions were the **United States**, **Europe** and **Australia**. The companies that published most patents during the same period were **Microsoft** (1,797), **SEL** (1,785), **IBM** (1,553), **AT&T** (1,523) and **Intel** (924).



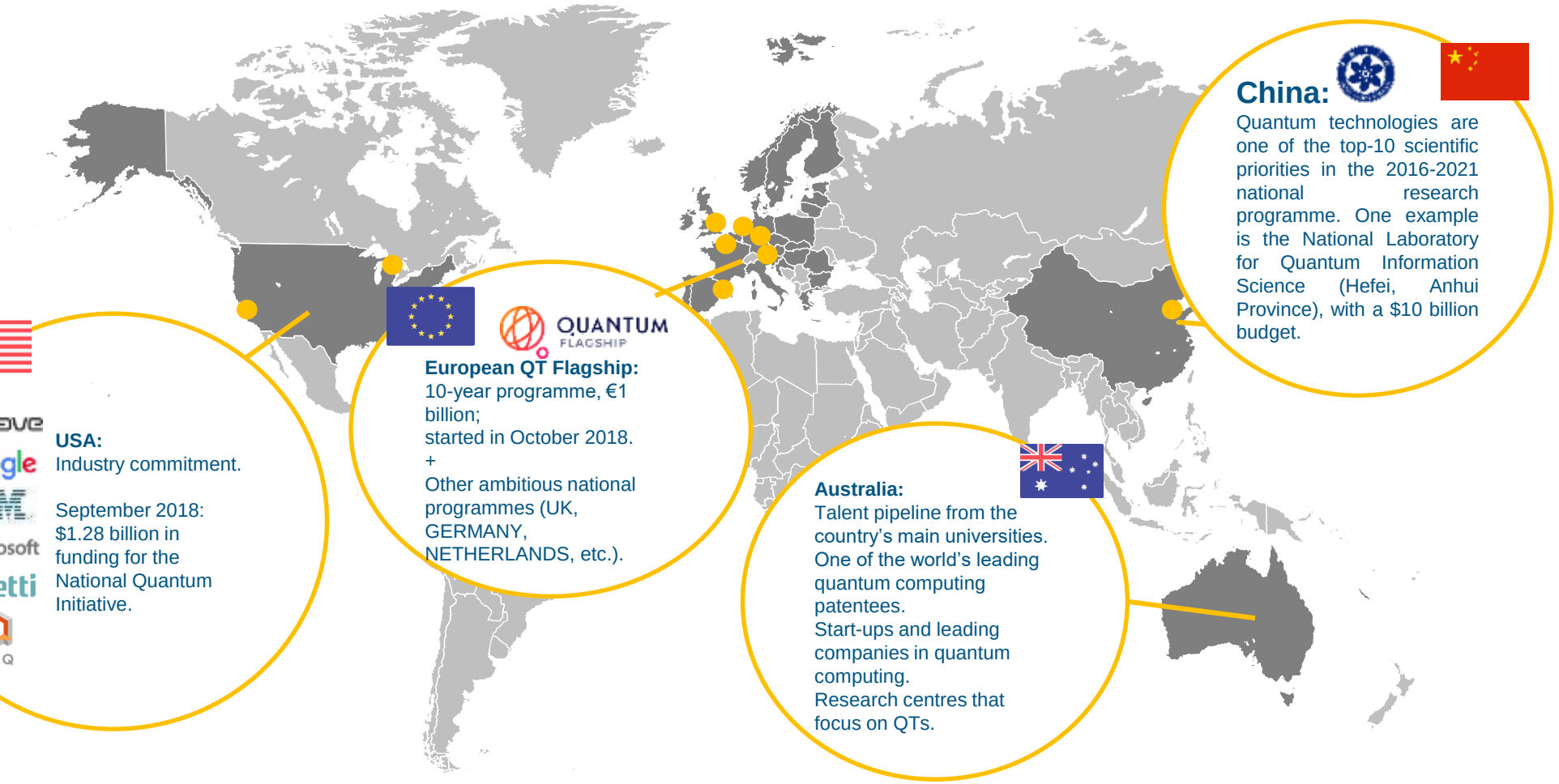




**Source:** EIC (DGI-ACCIÓ), based on data from Lens.org.

***Note:** the figure relating to patents registered in 2018 is provisional, since this information has not yet been consolidated.

# 2.2. Major Regions and Hubs



**USA:**
Industry commitment.

September 2018: $1.28 billion in funding for the National Quantum Initiative.

**European QT Flagship:**
10-year programme, €1 billion;
started in October 2018.
+
Other ambitious national programmes (UK, GERMANY, NETHERLANDS, etc.).

**Australia:**
Talent pipeline from the country's main universities.
One of the world's leading quantum computing patentees.
Start-ups and leading companies in quantum computing.
Research centres that focus on QTs.

**China:**
Quantum technologies are one of the top-10 scientific priorities in the 2016-2021 national research programme. One example is the National Laboratory for Quantum Information Science (Hefei, Anhui Province), with a $10 billion budget.

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**Source**: EIC (DGI-ACCIÓ), based on data from ICFO, CB Insights and Lens.org.

# 2.2. Major Regions and Hubs

## North America: Computing Leader

Both the United States and Canada are home to major companies that are investing heavily in quantum computing and simulation. In recent years, companies such as Google, Microsoft and IBM have invested in this sector by stepping up internal efforts and funding technology centres in this field in North America, Europe and other regions. The efforts of pioneering companies such as D-Wave and Rigetti are also worth noting. Finally, mention should be made of the new National Quantum Initiative in the United States, which has a budget of $1.28 billion.

## Europe: Horizon 2020 Initiatives

Europe has a solid track record in the research and development of quantum technologies. The European Commission's new initiative, the FET Quantum Technologies Flagship, is designed to consolidate European leadership and promote the development of technologies with a view to boosting the European economy. Many European countries, such as Germany, the Netherlands and the United Kingdom, are investing in similar national programmes. However, despite European companies' commitment to quantum technologies, there is a shortage of private equity investment compared to the situation in North America.

## Asia Pacific: Public and Private Investments

In Asia, China has made major public and private investments (e.g. Alibaba, Baidu) in different areas of QT. Quantum technologies represents one of the top-10 priorities in China's 2016-2021 national research programme and there are plans to construct a national quantum information centre. Furthermore, China has been a pioneering force in several quantum communication pilot tests. Other countries, such as South Korea and Australia, have been active in both the public and private sectors.



**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 2.3. Top Global QT Developers


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**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 2.4. Top Global Investors




**Source**: EIC (DGI-ACCIÓ), based on data from ICFO and ec.europa.eu.

# 2.4. Key Global Investors

IBM is currently developing superconducting circuits for quantum computing. In 2016, these were made available to users who wanted the IBM Q Experience, which can now be operated on the cloud and has around 20 qubits. In addition, IBM has developed a 50-qubit processor.

Google has invested heavily in quantum computing and collaborates strategically with research groups worldwide. In 2018, it unveiled the Bristlecone, a 72-qubit quantum processor.

In 2018, SK Telecom bought half the Swiss quantum communications company ID Quantique for $65 million.

Since 2017, Volkswagen has been working on traffic optimization studies with D-Wave, a Canadian company that already has a quantum annealer on the market.

In 2018, Baidu announced the launch of a quantum computing research centre, the Institute for Quantum Computing, in a number of locations around China.

Alibaba has invested $15 billion in R&D projects in the field of quantum computing. In 2018, it launched an online quantum computing platform with 11 qubits, the superconducting quantum computing cloud, and made it available to the public.



**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 3. Quantum Technologies and the SDGs

# 3. Quantum Technologies and the SUSTAINABLE DEVELOPMENT GOALS

The **Sustainable Development Goals (SDGs) are the blueprint to achieve a sustainable future for all**. They interconnect and address the global challenges we face every day, such as poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The SDGs are part of the United Nations 2030 Agenda for Sustainable Development, which aims to improve the quality of life and social well-being of everyone living on the planet by guaranteeing economic progress and growth in a sustainable way that respects the environment. **As disruptive technologies with a wide range of applications, QTs will help achieve these goals**.


**Source:** EIC (DGI-ACCIÓ), based on data from the United Nations.

# 3. Quantum Technologies and the SUSTAINABLE DEVELOPMENT GOALS

**Health**
Quantum neural sensors.
Ultra-accurate medical devices.
Development of new drugs.
Optimization of diagnostics and therapeutic methods through QTs.

**Climate Action**
Improved study of the behaviour of electrons and photosynthetic processes to obtain renewable and sustainable energy sources. Reduction in pollution through optimization of production processes and energy expenditure.




**Quality Education**
Optimization of calculations and improvements to computers with more capacity and power.

**Responsible Consumption and Production**
QTs applied to production processes to optimize resource expenditure. Reduction in production costs and more sustainable production thanks to new materials obtained from the study of electrons.



**Affordable and Clean Energy**
Optimization of energy consumption. Highly efficient and more effective solar panels.

**Sustainable Cities and Communities**
Optimization of energy expenditure in buildings and infrastructure. Ultrasensitive devices to collect big data in the IoT. Use of quantum computers to help create super smart societies*.



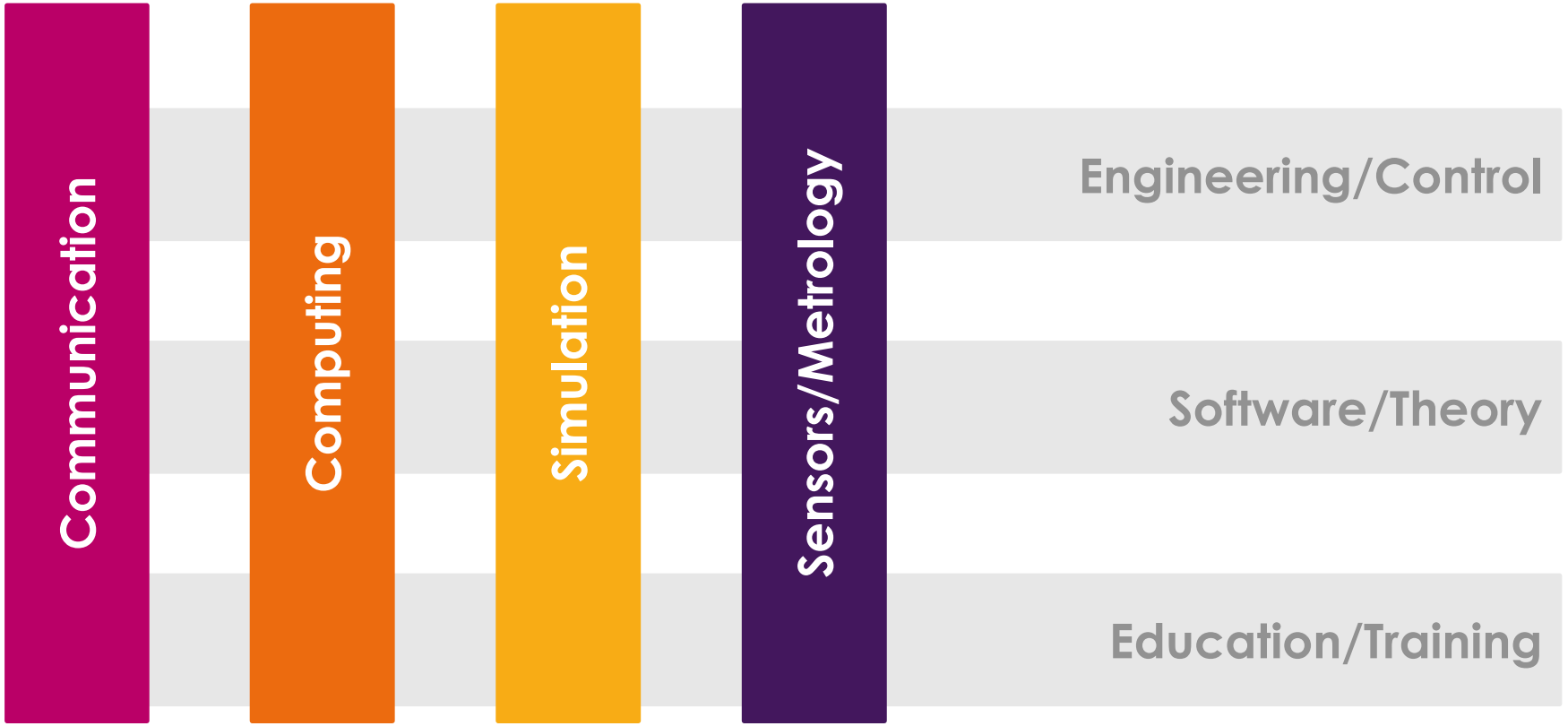
**Industry, Innovation and Infrastructure**
Optimization of industrial and logistics processes through QTs. Improvement and automation of production processes. Improvements in the capacity of AI and machine learning.

**Source**: EIC (DGI-ACCIÓ), based on data from the Tokyo Institute of Technology and medium.com.

***Note:** the term "super smart societies" (or "Society 5.0") refers to the concept of human-centred societies capable of achieving economic growth and solving social challenges through the implementation of quantum computers and AI in a system in which cyberspace (information) and physical space (the real world) are fully merged thanks to the communications network.

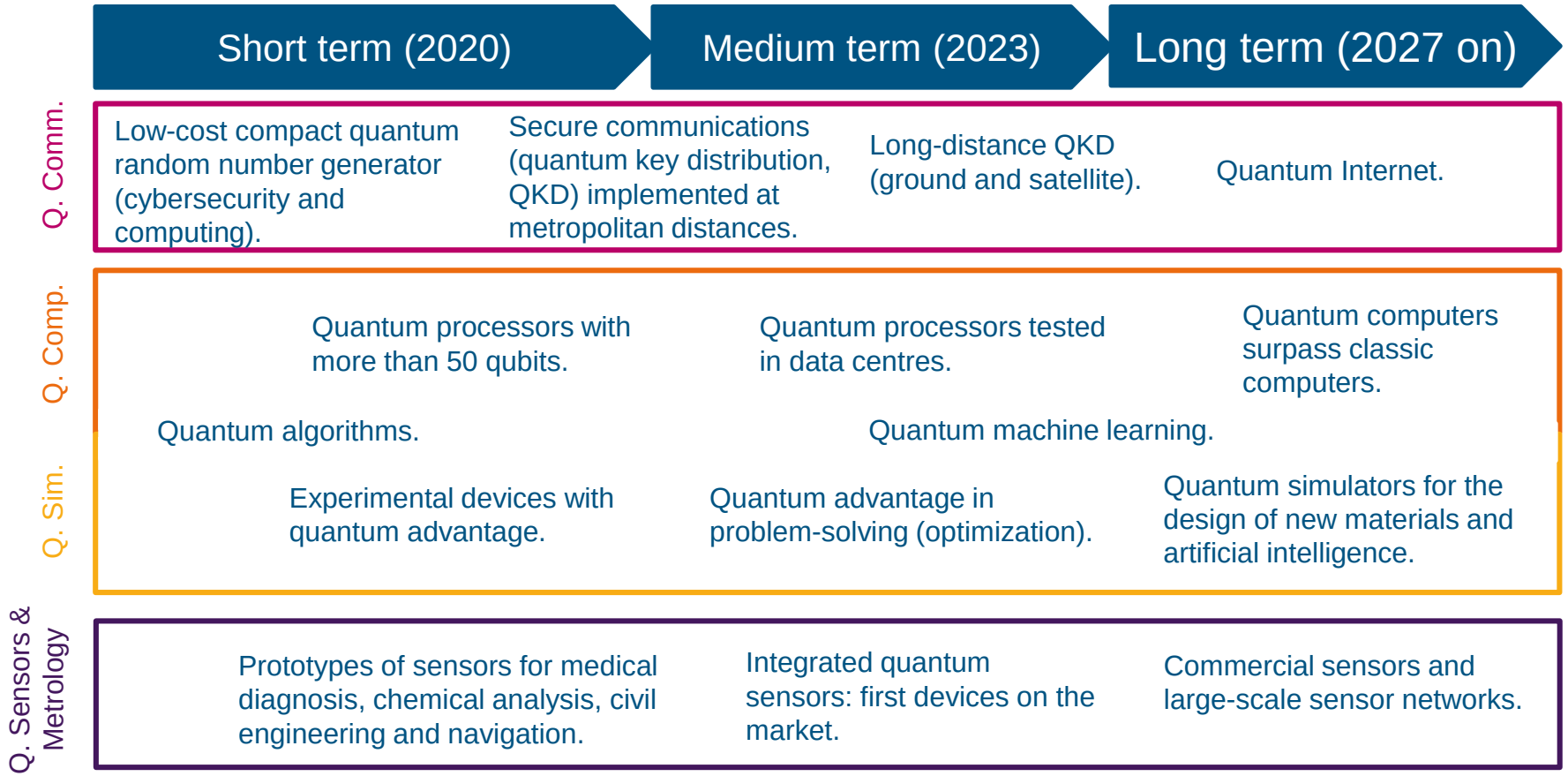
# 4. Key Applications by Demand Sector

# 4. Key Fields of Application




**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 4. Current and Potential Applications by Field of Application




**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 4. Potential Applications of Quantum Technologies

Q. Comm.

1. IoT

2. Critical infrastructure

3. Secure communications

Q. Comp.

4. Machine learning

5. Quantum chemistry

Q. Sim.

6. Logistics

7. Design of drugs and materials

8. Financial services

Q. Sensors & Metrology

9. Healthcare and diagnostics

10. Civil engineering and navigation

11. Aerospace industry

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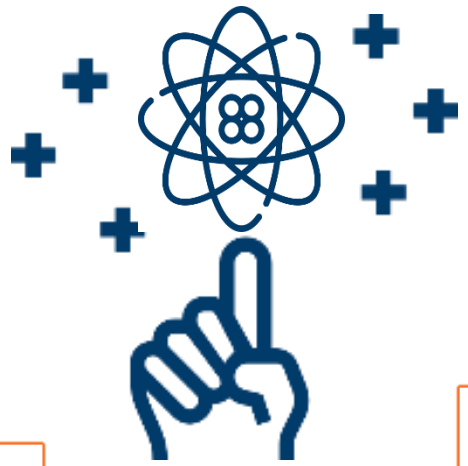
**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5. Quantum Technologies in Catalonia

# 5.1. Main Mapping Conclusions

## QTs in Catalonia



**Although QTs are still under development, Catalonia currently has a major presence in the ecosystem, especially in the public sector, through the QT Flagship.**

**Given that QTs are still in the development phase, no business figures or data relating to employees working in the field are available.**

**The ecosystem is made up primarily of research centres, major companies in related sectors such as telecommunications and ICTs, and start-ups.**

**Many companies in a range of sectors are beginning to show an interest and collaborate with technology centres with a view to launching business lines in the field of quantum technology.**



**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5.2. Ecosystem Companies and Agents

Partial list

## TECNIO, research and technology centres

ICFO, BSC, CNM Centre Nacional de Microelectrònica IMB, i2cat, IFAE, ICN2

## Universities

UAB Universitat Autònoma de Barcelona, Universitat de Barcelona, Universitat Politècnica de Catalunya BarcelonaTech

## Companies

| Entanglement Partners_ >, IBM, KEYSIGHT TECHNOLOGIES, The Quantum Revolution Fund, Metempsy, Microsoft, Signadyne, Telefónica, quantum business, QUSIDE, ZapataComputing

## Fairs and conferences

GSMA MOBILE WORLD CONGRESS

## Public agencies and administrations

European Commission, Generalitat de Catalunya, Ajuntament de Barcelona, cesicat

## Other entities

Quantum Flagship, bqb, Quantum World Association

## Applications

1. IoT
2. Critical infrastructure
3. Secure communications
4. Machine learning
5. Quantum chemistry
6. Logistics
7. Design of drugs and materials
8. Financial services
9. Healthcare and diagnostics
10. Civil engineering and navigation
11. Aerospace industry



**Source**: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5.3. Research and Technology Centres Working in the Field of QTs in Catalonia

Barcelona Supercomputing Centre (BSC) is Spain's national supercomputing centre. It specializes in high-performance computing (HPC) and hosts MareNostrum, one of Europe's most powerful supercomputers, located in the Torre Girona Chapel. It was recently selected to host MareNostrum 5, one of three supercomputers in the European Union. It conducts research in quantum computing and is developing a quantum computer.

The IMB-CNM is a research institute under the Spanish National Research Council (CSIC). Its main activity is research and development applied to the fields of micro- and nanotechnologies, and silicon-based devices and systems. It is currently collaborating with the BSC to develop a quantum chip.

The i2CAT Foundation is a non-profit research and innovation centre that promotes R&D&I activities in the field of advanced Internet architectures, applications and services. The centre advocates a new open-innovation framework and fosters collaboration between companies, public administrations, the academic sector and end users. It is part of the Quantum Internet Alliance and is involved in several quantum communication projects.

Source: EIC (DGI-ACCIÓ), based on data from ICFO and Tecnio.

# 5.3. Research and Technology Centres Working in the Field of QTs in Catalonia

The Institute of Photonic Sciences is a research centre located in a 14,000 m2 building in the Mediterranean Technology Park, in the Barcelona metropolitan area. At present, it has more than 300 researchers, including team leaders, postdoctoral researchers, doctoral students, engineers and staff, organized into 27 research groups. It has a research unit that focuses on quantum science. It is currently leading several projects within the European Quantum Flagship, where it focuses primarily on quantum communication.

The Catalan Institute of Nanoscience and Nanotechnology (ICN2) is a non-profit foundation that forms part of the CERCA Institution. Its mission is to achieve scientific and technological excellence in the fields of nanoscience and nanotechnology by developing ideas and basic knowledge in the area of nanoscience and promoting the adoption and integration of nanotechnologies in society and industry. With respect to quantum technologies, it is currently working on the development of 3D qubits and 2D semiconductors.

The Institute for High Energy Physics (IFAE) is a research centre that is affiliated with the UAB and forms part of the CERCA Institution. Its mission is to promote and conduct pioneering research in fundamental physics, i.e. particle physics, astrophysics and cosmology. The centre is divided into two divisions: experimental and theoretical research. It has a quantum technology research group and collaborates with the BSC on the development of quantum computing in Catalonia.

Source: EIC (DGI-ACCIÓ), based on data from ICFO and Cerca centres.

# 5.3. Research and Technology Centres Working in the Field of QTs in Catalonia

The Universitat Autònoma de Barcelona (UAB) is one of Spain's top public universities. It currently offers 88 undergraduate degrees, which cover a wide range of fields such as the arts and humanities, social sciences, health sciences, technology and physical sciences.

The Universitat de Barcelona is Catalonia's main public university. It has a large student body and the widest and most complete range of learning programmes. Moreover, it houses Spain's leading university research centre, which is also one of the best in Europe, both in terms of the number of research programmes and the excellence it achieves in this field.

The Universitat Politècnica de Catalunya is a public university that focuses on research and higher education in the fields of architecture, engineering, science and technology. It works closely with the production sector and represents an agent and driving force for economic and social change by attaching great importance to research and transferring knowledge and technology to society.



Source: EIC (DGI-ACCIÓ), based on data from ICFO and Cerca centres.

# 5.4. QT Training Cases in Catalonia

A range of educational programmes that focus on quantum technologies is available in Catalonia through its top-level research centres and universities, as well as public-private partnerships in the sector:

- **GSMA Chair at ICFO: quantum technologies at the 2019 MWC BCN**

The GSMA Chair aims to promote scientific and technological research and seek commercial applications.

- **AXA Chair in Quantum Information Science at ICFO:**

The world's first AXA Research Fund Chair in quantum information.

Encryption systems based on quantum devices with the aim of achieving 100% secure data communications.



Source: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5.5. QTs in Catalonia: The QuantumCAT Initiative

- Catalan quantum technology community.
- Technology transfer activities in collaboration with entities.
- Coordinated by ICFO.
- Projected official launch: 2019.
- Objectives:
  - To boost the impact of quantum technologies on industry in Catalonia.
  - To consolidate Catalonia's knowledge and excellence in the area of QTs.



Source: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5.5. QTs in Catalonia: SmartCatalonia Strategy

- **SmartCatalonia** is a strategy promoted by the Catalan government that, in line with the European Commission's Europe 2020 strategy, seeks to extend the smart city concept to Catalonia with a view to undertaking a programme that includes and coordinates local and supra-local initiatives, supports businesses and implements smart initiatives throughout the region. The objective of SmartCatalonia is to turn Catalonia into a world-class smart region that exploits technology and digital information to innovate in public services, boost economic growth and promote a more intelligent, sustainable and inclusive society.

- This strategy includes an advanced digital technologies (TDA) programme that aims to promote and coordinate the different research and innovation agents in the ICT sector to turn Catalonia into a European and global digital technology hub that can transform the economy and society. The challenges defined in the TDA programme include one relating to **Quantum Cryptography in Critical Communications.**

- Thus, quantum technologies play a key role in the Catalan government's digital strategy.

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SmartCatalonia


Source: EIC (DGI-ACCIÓ), based on data from ICFO and SmartCatalonia.

# 5.5. QTs in Catalonia: Quantum Encryption Demonstrator

- The Catalan government is digitalizing its processes and services. This digitalization process involves ensuring that its networks and security systems are up to the required standard, given the disruptive change in the field of security since the appearance of quantum encryption. **On 6 July 2017, the Catalan government tested the first videoconference call in Catalonia encrypted with commercial quantum technology products**.

- The results of the experience were satisfactory on a functional level, but the cost associated with adopting the technology and having to modify the network equipment led the government to rule it out as an option. Nevertheless, it is still interested in enhancing the security of its communications network.

- The government's objective is to have a quantum communication channel independent of the physical mode of transport, the distance between points and the communications operator, with a view to:

  - Generating random keys instead of current pseudo-random keys.
  - Protecting the distribution of QKD keys against eavesdropping.
  - Using standard market components to reduce costs by 75% with respect to current proprietary technology. The technology to be developed must be integrated with the existing fibre optic network in Catalonia and, on a logical and physical level, must present maximum compatibility to support a low-cost and easily deployed solution.

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IDQ ICFO i2cat CESICAT




Source: EIC (DGI-ACCIÓ), based on data from ICFO, *El País* and gencat.cat.

# 5.5. QTs in Catalonia: Quantum Communications Hub

- At the European Commission's Digital Assembly in June 2019, the creation was announced of **EuroQCI, a pan-European quantum communication infrastructure** and a framework for cooperation involving a number of EU member states. The objective of this collaboration is to develop and implement certified point-to-point quantum communication infrastructure in the next 10 years. This infrastructure is to include both terrestrial and space solutions and will allow data and information to be transmitted and stored in a secure way. The infrastructure is expected to connect critical public assets within the European Union.

- Catalonia will play an active role in this framework by implementing a test bed for terrestrial connections (optical fibre), free-space connections and satellite-based connections, led by ICFO, thereby making the region a key hub within the pan-European network.

- The OpenQKD project, which is currently in the process of being signed with the European Commission, is the pilot phase of EuroQCI and will involve the participation of ICFO.

# 5.5. QTs in Catalonia: Catalonia's Participation in Quantum Flagship

- The **European Quantum Technologies Flagship** aims to position Europe at the forefront of the second quantum revolution. In 2016, the European Commission announced this flagship, which will receive funding to the tune of €1 billion. It will be developed within the framework of the **Future and Emerging Technologies (FET) programme**. The funding will come from the **H2020** and other sources in the European Union and member states. The project seeks to involve public and private stakeholders with a view to establishing an EU-wide network for the transfer of quantum technology-based knowledge and research.

QUANTUM FLAGSHIP

**€1 B**

**Started in October 2018**

**Knowledge-based industry**

**Impact on society**

**Research and innovation**

**Academia and industry**



Source: EIC (DGI-ACCIÓ), based on data from ICFO and ec.europa.eu.

# 5.5. QTs in Catalonia: Catalonia's Participation in Quantum Flagship

Catalonia plays a key role in the EU's **Quantum Flagship** programme:

- Strong Catalan leadership in the QT Flagship through ICFO.
- Participation in seven projects.
- Coordination of two projects (ICFO).
- Strong presence in the quantum communications pillar through participation in three out of four projects.
- ICFO is responsible for the communication and dissemination tasks of this European initiative.




Source: EIC (DGI-ACCIÓ), based on data from ICFO.

# 5.6. QT Business Cases in Catalonia: Metempsy

- Metempsy is a company founded in 2014 by former Intel architects that offers consulting services in the fields of computer architecture, application optimization and silicon design.

- It has more than 15 years' experience in computer architecture and related fields, having worked for the Alpha Development Team (Digital Equipment Corporation and Compaq) on the EV8 and EV9 microprocessors and for the company Intel.

- Metempsy was central to Microsoft's decision to set up an office in Barcelona. Since 2015, this small company has worked for Microsoft on the design of the computer that will operate its first quantum computer. The CEO of Metempsy is Toni Juan, a computer architect who was responsible for designing the Intel processor that was the most powerful in the world for three years. Intel employed as many as 70 people in Barcelona, but in 2014, it decided to concentrate its resources in the United States and close the Barcelona laboratory. Toni Juan went on to create Metempsy, which now employs 12 people. This collaboration between Microsoft and Metempsy is expected to generate around 60 jobs.



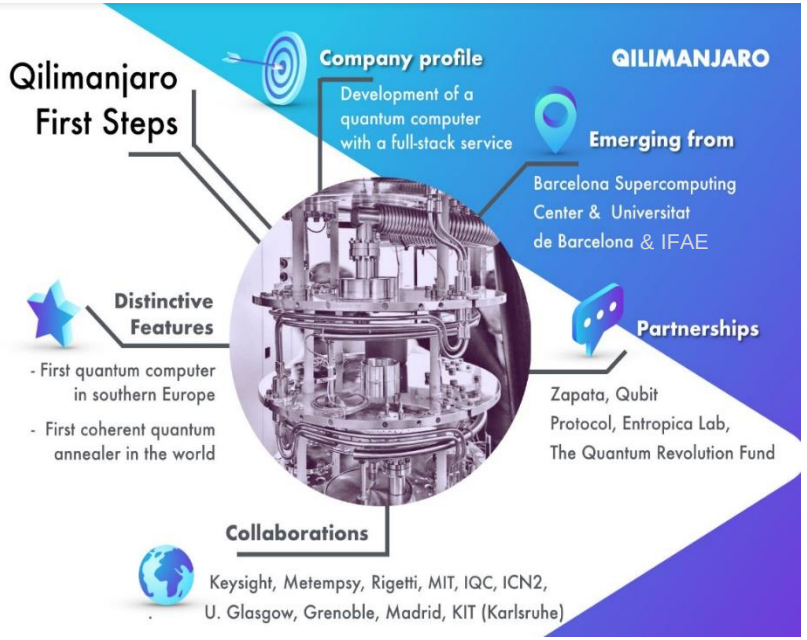
Source: EIC (DGI-ACCIÓ), based on data from ICFO, Metempsy and *La Vanguardia*.

# 5.6. QT Business Cases in Catalonia: Qilimanjaro

Qilimanjaro

- Qilimanjaro is a spin-off between the BSC, the UB and the IFAE. This platform provides consulting services and easy access to quantum computing for individuals and companies. Qilimanjaro scientists have carried out pioneering quantum information research for over 15 years and have made constant progress both in the development of quantum algorithms and the construction of quantum devices. Qilimanjaro's main function is to offer quantum computing as software-as-a-service (SaaS) or infrastructure-as-a-service (IaaS). However, the company revealed its true potential with Qibo, a high-level open-source API (application programming interface) for running applications on any existing quantum machine (e.g. IBM, Rigetti), in addition to Qilimanjaro's own quantum computer and quantum simulators in classical supercomputers such as MareNostrum. It promotes a collaborative community for mutual development in the world of quantum computing.

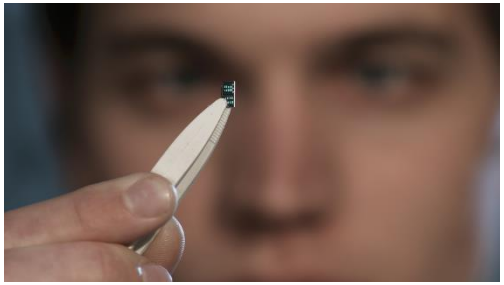
- The Qilimanjaro project is currently negotiating its first contracts and seeking potential investors. The quantum computer will be based on coherent annealing, which will be accessible through a cloud platform. This quantum computer will be the first in Southern Europe and will allow users to explore the possibilities of applying quantum algorithms to real-life problems. In addition, Qilimanjaro will provide a consulting service to adapt common problems to quantum algorithms.




Source: EIC (DGI-ACCIÓ), based on data from Qilimanjaro, Icoholder and Medium.com.

# 5.6. QT Business Cases in Catalonia: Quside

- Quside was founded in 2017 as a spin-off from ICFO. It develops quantum components for the fields of cybersecurity and supercomputing.
- Quside's products offer unprecedented security and performance in the information age, thanks to the unique properties of photonics. The products of this Barcelona start-up are based on quantum encryption and the random generation of security keys.
- With respect to the generation of cryptographic keys, quantum mechanics allows entirely unpredictable random numbers to be created, which was not possible with classical physical processes or computers. Quside is currently working on the development of a small microchip that exploits the quantum properties of light to equip any electronic device with the best possible random numbers.





Source: EIC (DGI-ACCIÓ), based on data from ICFO, Quside and Tecnonews.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