

Quantum Technologies Flagship kicks off with first 20 projects

What are quantum technologies, and what is the second quantum revolution?

Quantum technologies use the properties of quantum effects – the interactions of molecules, atoms, and even smaller particles, known as quantum objects – to create practical applications in many different fields. The so-called first quantum revolution, which saw the creation of the field of quantum physics, happened in the first half of the twentieth century and shaped the world we live in today. For instance it led to the development of lasers and transistors,, two foundational technologies for building computers, telecommunications, satellite navigation, smartphones and modern medical diagnostics.

The second quantum revolution is now underway and involved the detection and manipulation of single quantum objects such as atoms, photons and electrons. We can for example now rotate an electron clockwise and anticlockwise at the same time, and can connect particles invisibly across space and time. In many cases, the level of our control has reached a point that allows the use of quantum systems for real-world applications in sensing, secure communications and for computing and simulation. This is the field of quantum technologies.

What is the EU's standing in the area of quantum technologies? What are the EU's biggest assets, and how are industry and business making use of them?

Europe has well-acknowledged excellent scientific and technical expertise and a long history in financing research in quantum. Europe's strength relies on the excellence of its scientists, but also on the high degree of collaboration of the scientists across the Union, maximizing the benefits of cooperative science in this highly interdisciplinary field.

From the very beginning, European industry participated in EU research and innovation programmes. However, twenty years ago, industry participation was highly speculative and essentially limited to telecommunication, laser and computing companies. Nowadays those companies no longer see quantum technologies as a scientific curiosity but are increasingly integrating them in their products or are actively turning towards academia in search of quantum solutions. The unprecedented developments are bringing more and more industrial payers into the field of quantum technologies.

Why is the Quantum Flagship needed?

Europe has a strong tradition in quantum research, which began with the creation of quantum physics in the first decades of the twentieth century. A key strength is Europe's focus on a range of different fields in quantum technologies, a major factor in attracting overseas researchers.

The Quantum Flagship will address so far unsolvable research challenges such

as those of building a functioning quantum computer, developing ultra-secure communication systems or making major advances in quantum sensing technologies.

For some of these technologies, we are now at a turning point where science is ready to transfer to industry the knowledge and technologies required for delivering first products and services such as secure quantum communications, extremely accurate sensors, and very first quantum computers. Currently, there is a global race to create and conquer the market of these key technologies of the future. The U.S. is investing more than US\$1.2 billion in the period 2019 – 2028 and China is building a US\$10 billion National Laboratory for Quantum Information Sciences.

The Flagship aims to create a European ecosystem that will deliver knowledge, technologies and open research infrastructures to develop a world-leading knowledge-based industry in Europe. The big advantage of the Flagship is that it has established a research agenda that has been widely agreed by all the involved stakeholders and will be supported by the Member States and by the private sector in a well-coordinated manner.

What is the vision and what are the goals of the Quantum Technologies Flagship?

The long-term vision of the Flagship is to develop in Europe a so-called quantum web, where quantum computers, simulators and sensors are interconnected via quantum communication networks. There are three goals underlying this vision:

- To consolidate and expand European scientific leadership and excellence in quantum research, including education and training for developing the relevant know-how and skills;
- To kick-start a competitive European industry in quantum technologies in order to position Europe as a leader in the future global industrial landscape;
- To make Europe a dynamic and attractive region for innovative research, business and investments in quantum technologies, thus accelerating their development and take-up by the market.

How is the Quantum Technologies Flagship organised?

The Flagship will provide €1 billion of funding for quantum research over the next ten years. In its ramp-up phase (2018-2021), it funds [20 projects](#) from 21 countries under the Horizon 2020 research framework programme.

Negotiations are ongoing between the European Parliament, Council and Commission to ensure that quantum research and development will be funded in the EU's multi-annual financial framework for 2021-2028. Quantum technologies

will be supported by the proposed [Horizon Europe](#) programme for research and space applications, as well as the proposed [Digital Europe](#) programme, which will develop and reinforce Europe's strategic digital capacities, supporting the development of Europe's first quantum computers and their integration with classical [supercomputers](#), and of a pan-European quantum communication infrastructure.

The Flagship will ensure that there is close coordination between these projects and the ones funded by the Member States in their national quantum technologies programmes. The Flagship builds on the [QuantERA](#) initiative, co-funded by the Commission and funding agencies from 26 European countries. The Flagship also has a governance structure that will be set up in line with the [recommendations](#) provided by the Commission's High Level Steering Group on Quantum technologies.

The governance structure of the Flagship consists of:

- A Board of Funders, bringing together the Commission and the funding agencies of the Member States and Countries Associated to Horizon 2020, as a discussion forum to align national and European priorities and initiatives;
- A Strategic Advisory Board, a group of high level independent quantum experts. Their mandate will be to monitor the Flagship's progress and prepare, with the help of the research stakeholders, the next version of the Flagship's strategic research agenda that they will deliver, together with their recommendations, to the Board of Funders;
- A Science and Engineering Board, composed of the representatives of the Flagship's funded projects. Its mandate is that of coordinating the projects' common activities;
- A Coordination and Support Action, aiming to support the coordination of the different stakeholders who will be participating in the Flagship activities. One of such key players is the quantum community network, consisting of representatives of the national quantum communities.

What are the main research areas that the Flagship's projects address?

The [20 projects initially funded by the Flagship](#) cover research and technology development in the following five complementary and interdependent areas:

- **quantum computing**: using enormous computing power to solve otherwise insoluble problems, processing vast amounts of data faster than ever before to recognise patterns and train artificial intelligence systems, e.g. for digital assistants to help doctors to diagnose and treat

diseases or optimising traffic to reduce jams and emissions.

- **Quantum simulation:** understanding the functioning of complex systems, which will be key to the design of new chemicals like drugs and fertilisers, and of new materials, such as high-temperature superconductors for energy distribution without losses.
- **Quantum communication:** helping to protect data transmitted digitally, such as health records, financial transactions or other sensitive data sets by developing securest ways of communication, impossible to intercept without being perceived.
- **Quantum metrology and sensing:** providing highly accurate measurements increasing the performance of devices and consumer services, such as medical imaging sensors, high-precision navigation and the Internet of Things.
- **Fundamental quantum science:** complementing the projects in the four other areas and addressing related foundational scientific problems.

Who is participating in the Quantum Technologies Flagship?

In these first three years of the Flagship, the partners of the 20 funded projects come from EU Member States, associated countries to Horizon 2020, and Belarus (international partner).

What is the funding and duration of the Flagship's projects?

The duration of most of the projects funded by the Flagship is three years. Projects addressing quantum communication, quantum computing systems, quantum simulation, and quantum metrology and sensing will receive funding of up to €10 million, while projects in fundamental science are smaller and will receive funding of €2-3 million.

What advantages will future quantum technologies bring?

Within the next 10 years, the performance enhancements resulting from quantum technologies will yield unprecedented computing power, guarantee secure communications, and provide ultra-high precision measurements. Examples include the measurement of the tiniest variations of magnetic or electric fields for medical imaging below the cell level for less invasive diagnosis and treatments, or for searching raw materials (petroleum, minerals, etc.), ultra-precise atomic clocks in smart grids allowing energy savings, or yet quantum key distribution technologies to prevent eavesdropping in finance, banking and defence by establishing secure communication links, and supercomputers outperforming existing or future classical supercomputers and at a fraction of their energy consumption.

In the long term, quantum computing has the potential to solve computational problems that would take current supercomputers longer than the age of the universe. The scientific computing that this will enable could bring about breakthroughs in, for example, chemical process design, energy efficient materials, and energy harvesting, as well as machine learning and big data analysis.

What about quantum key distribution (QKD) – will the Flagship be able to provide ultra-secure data encryption for Europe?

The Flagship is currently funding, with a budget of about €34 million, four projects on quantum communication that include also research on faster and more secure quantum key distribution (QKD). The results of those projects will feed into the QKD pilot that will be funded by Horizon 2020 with €15 million, to test in real conditions the business cases for a telecommunication network with an additional layer of security provided by QKD. The expectation is that, after the Flagship's ramp up phase, this pilot will lead to an EU-wide deployment of a public QKD service. Such deployment is foreseen to be financed by the [Digital Europe](#) Programme in the period 2021 to 2028.

Will quantum computers replace current computers any time soon?

No. Initial prototypes of quantum computers are currently available in research labs, but they are only at a very early stage of development. They are built from up to a few dozen individual computing units (quantum bits of operation, or qubits), which are largely insufficient for resolving practical applications. In addition, the software and the algorithms that will exploit the computing capabilities of quantum computers are still in development. Larger quantum computers of up to 300 qubits are expected to be engineered by 2026-2027. Quantum computers with tens of thousands of individual computing units are expected to be operational only in 15-20 years.

For more information

[Press release](#)

[The first 20 projects](#)

[Official website of the Quantum Flagship](#)