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QUANTUM TECHNOLOGIES FOR SPACE

DEVELOPING NEW TECHNOLOGIES AND SERVICES FOR A CUTTING-EDGE EU SPACE PROGRAMME

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The quantum revolution
and its relevance for space

As the 19th century drew to a close, paradigm-changing scientific experiments on the physical properties of materials and radiation put into questions the certainties of classical mechanics. In 1927, the world's most notable physicists met to discuss the newly formulated quantum theory at the famous Solvay Conference. Quantum theory is the basis of modern physics that **explains the nature and behaviour of matter and energy on the atomic and subatomic levels**.

Quantum physics has fascinating properties, which reveal a world very different from ordinary human perception. For example, the behaviour of a particle can be described as a wave. In fact, the quantum state of a particle can even be described by the superposition of multiple waves. Their peaks and troughs can overlap or cancel out, depending on the forces and accelerations the atom is subject to. This "atom interferometry" can be used to make **highly sensitive gravity detectors, accelerometers and gyroscopes**.

Since the first quantum revolution in the early twentieth century, a whole range of applications in the field of scientific research, but also in our daily life, has emerged. Such **applications include laser, electronics, satellite-based positioning and medical imagery**. The second quantum revolution is now underway. The EU Space Programme and the EU satellite-based services must seize this opportunity and make the best and most strategic use of quantum technologies to improve the daily life and security of EU citizens.

The objectives for space quantum are to:

- Support the **EU space policy** and the **EU Space Programme**
- Reinforce **EU non-dependence** for the development of EuroQCI (the European Quantum Communication Infrastructure)
- Leverage **In Orbit Demonstration/In Orbit Validation (IOD/IOV) missions** dedicated to testing quantum technology in space
- Build a **dynamic and innovative industrial ecosystem** in Europe

> *Europe should invest massively in quantum technologies. This is a matter of technological sovereignty. Quantum could have important applications in the space domain like in encryption or in the mapping from space of the underground landscape.*
>
> *Commissioner T. Breton, 22 January 2020*

Evolving European space

Leveraging the fascinating properties of quantum physics, which reveal a world very different from ordinary human perception

Creating scientific capabilities

Boosting European know-how and skills in critical key areas such as cybersecurity and quantum technologies

Achieving technology leadership

Ensuring European non-dependency in an enabling technology of the future

Applications of the quantum revolution:

Quantum Space Gravimetry

The use of quantum technologies for enhanced space-based climate data and environmental processes modelling can be a game-changer to **monitor the Earth's resources, assess and predict adverse climate change and future disasters**. The satellite gravity missions provide unique observations which are not made available by other Earth Observation missions. The study of global mass transport phenomena via gravity field monitoring from satellite gravimetry offers essential insights and crucial information to understand and monitor, for example, underground water reservoirs.

This is why the European Commission is preparing for a future **EU Earth observation mission using quantum gravimetry, as part of the evolution of Copernicus**. The Commission is first setting the ground for a pathfinder mission with the support of Horizon Europe, starting with the development of the EU technologies and components for a space quantum gravimeter or gradiometer. In the Horizon Europe-funded project CARIOQA the engineering model of the **atomic accelerometer** for a subsequent space mission will be developed.

Quantum Key Distribution

In addition, the European Commission is developing a Quantum Communication Infrastructure (EuroQCI) with a terrestrial segment and a space segment. **This Quantum initiative "EuroQCI"** intends to mature the new technologies and perform the qualification for space and ground.

The **terrestrial segment of EuroQCI will rely on fibre communications networks** linking strategic sites at national and cross-border levels and the **space segment of EuroQCI will be based on satellites** to overcome the limitations of ground-based segments. It will connect national quantum communication networks across the EU, including its overseas territories. It will also **improve Europe's cybersecurity, digital sovereignty and industrial competitiveness**.

In this context, the European Commission will test the viability of quantum communication technologies in orbit and demonstrate the feasibility of operating the Quantum Key Distribution service with the **Eagle-1 mission**. The launch of Eagle-1 is scheduled for late 2025 / early 2026. This mission is co-funded by Horizon Europe under the **IOD/IOV component** and is a precursor of the **EuroQCI initiative**, which will later be integrated into the EU's Infrastructure for Resilience, Interconnectivity, and Security by Satellite (IRIS²)

Be part of the EU-funded space R&I

Horizon Europe is the EU's key funding programme for research and innovation, with a budget of around €95 billion over 2021-2027, of which close to €1.6 billion is dedicated to space research. The space R&I is managed by the Health and Digital Executive Agency (HaDEA), the EU Agency for the Space Programme (EUSPA), the European Space Agency (ESA) and the European Commission itself. Most calls are also published on the EC Funding and Tenders participant portal.