⟨EQUAL|TY⟩

Efficient QUantum ALgorithms for IndusTrY

Funded by the European Union
under Grant Agreement 101080142

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OBJECTIVES

EQUALITY

- The EQUALITY project aims to develop cutting-edge quantum computer algorithms to solve strategic industrial problems.
- These are complex problems which have enormous computational requirements, forcing either the use of simplistic models or the reliance on expensive build-and-test cycles.
- Quantum computers provide an opportunity to tackle such questions, giving a competitive edge to the Europe and unlocking billions of euros for the industry over the coming decades.

AERODYNAMICS SIMULATION AND OPTIMISATION

SPACE MISSION OPTIMISATION AND DATA ANALYSIS

ENERGY STORAGE MATERIALS AND SYSTEMS

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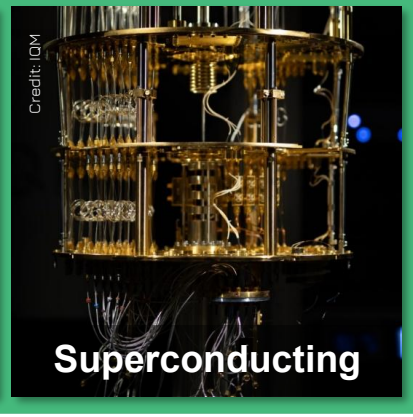
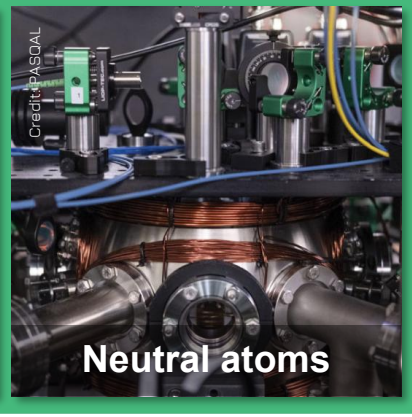
APPROACH

EQUALITY

› **EQUALITY will to develop quantum algorithms for real industrial problems running on real quantum hardware.**

QUANTUM COMPUTERS





HARDWARE EXPLOITATION

Divide-and conquer strategies

Optimal qubit routing algorithms

Exploitation of analogue mode simulations

Efficient trap-based noise characterisation

Logic- and ML-based methods for circuit optimization

CORE ALGORITHMS

Differential equation solvers

Stochastic differential equation solvers

Quantum generative models

Quantum chemistry simulators

Simulators for periodic materials

Quantum evolution kernel methods

Non-kernel quantum ML techniques

Gibbs state-based optimization

INDUSTRIAL PROBLEMS

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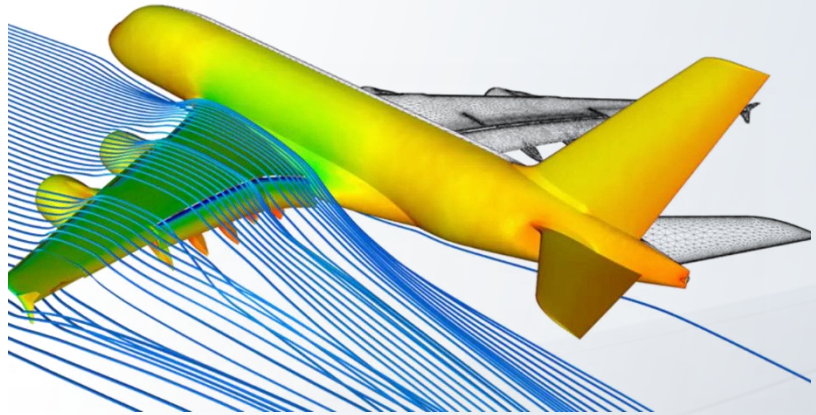
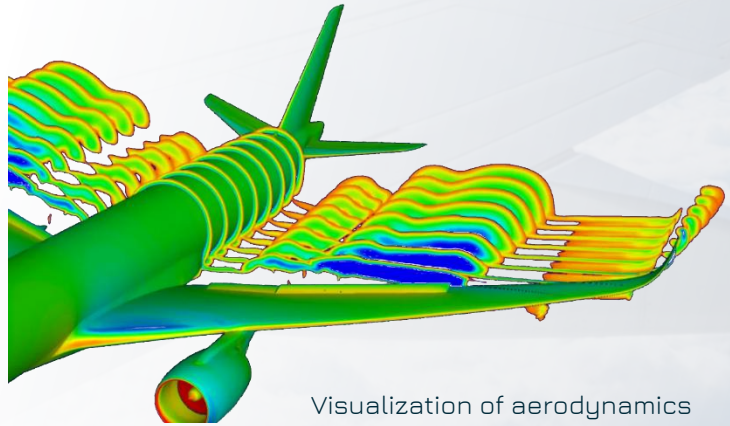
USE CASE:
AERODYNAMICS SIMULATION AND OPTIMISATION

- **More energy-efficient airplanes are one of the ways to propel the aviation industry towards lower emissions.**
- **Doing so involves detailed simulations of the air flow around the aircraft and the aerodynamic forces on its surfaces, while optimising for frame weight, integrity, and performance, which requires enormous computational resources.**
- **EQUALITY investigates how quantum computers could speed up the development and optimisation of critical aerospace problems.**





Visualization of aerodynamics simulation. Credit: Airbus

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USE CASE:
ENERGY STORAGE MATERIALS AND DESIGN

- New energy storage technologies, such as better batteries and fuel cells, are crucial to the green transition.
- Simulating these processes, consume huge computational resources, often beyond the capabilities of classical computers. Quantum computers offer a path forward for overcoming current trade-offs between precision and scale.
- EQUALITY investigates quantum algorithms to optimize the modelling of batteries and fuel cells, providing a multiscale picture of their dynamics.

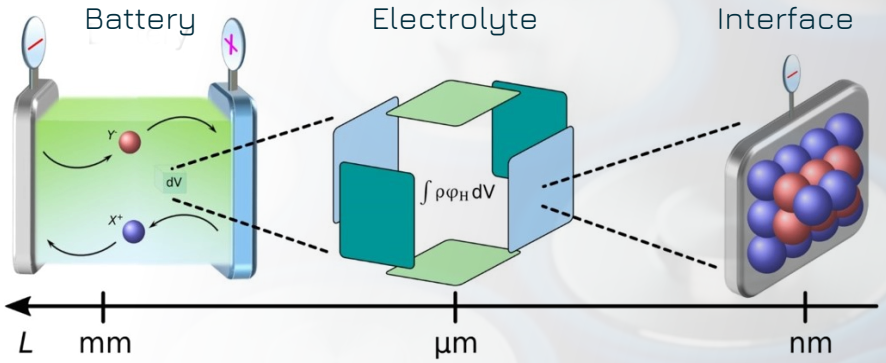
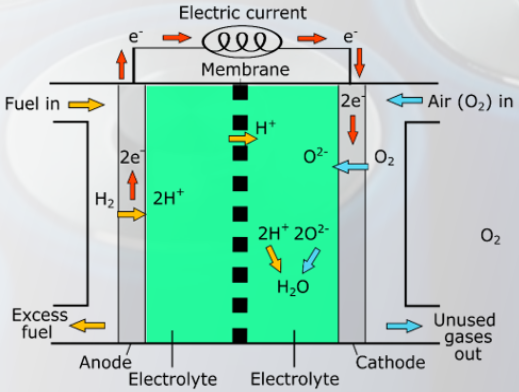


Illustration of the multi-scale approach for the example of a battery.



Left: state of the art planar solid-oxide fuel cell (SOFC) stack developed for stationary applications.
Right: basic set-up of a FC via the example of a SOFC.

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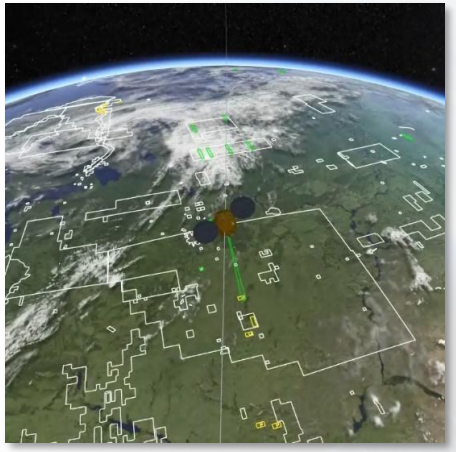
USE CASE:
SPACE MISSION OPTIMISATION

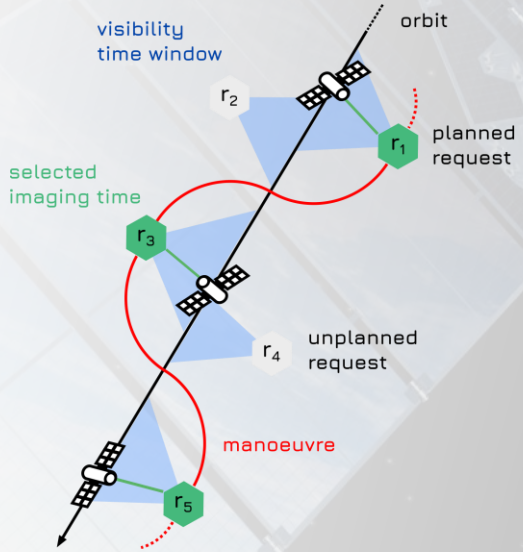
- **Space systems deliver critical solutions for enterprises and governments, such as telecommunication satellites, Earth observation instruments, deep space missions, etc.**

- **However, mission optimisation involves solving enormously complex mathematical problems which are extremely hard to tackle using classical computing methods.**

- **EQUALITY investigates quantum optimisation methods for faster and more efficient planning of space missions**



Visualisation of mission plan depicting acquisition requests (white), planned acquisitions (yellow) and acquired observations (green).



Scheme of an Earth observation satellite mission. Each request is accessible during a limited portion of the orbit. Some requests cannot be fulfilled because of manoeuvre time constraints.

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USE CASE:
SPACE DATA ANALYSIS

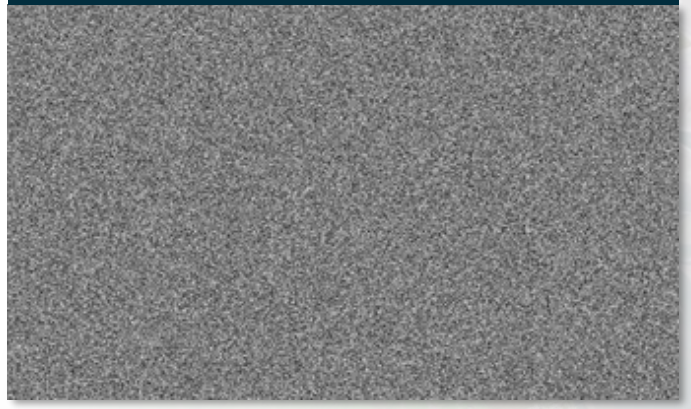
- **Earth-observation satellites provide information that are essential, for example, to evaluate the impact of climate change.**

- **Current trends, such as the use of satellite constellations and lower-cost imagery datasets are often subject to missing reference data, irregular sampling, and pseudo-periodic phenomena. As such, they demand more powerful post-processing techniques.**

- **EQUALITY investigates quantum machine learning techniques to alleviate the computational bottlenecks in space data analysis.**

Space data processing:
Synthetic-Aperture Radar (SAR)

RAW DATA



PROCESSED DATA

Credit: European Union, Copernicus Sentinel-2 imagery

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CONSORTIUM

⟨EQUAL|TY⟩

› **EQUALITY brings together leading research groups, SMEs, and prominent industrial players.**

AIRBUS

Capgemini

DA VINCI LABS

Fraunhofer ENAS

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

Inria

Universiteit Leiden The Netherlands

› **The consortium has been awarded in the highly competitive Horizon Europe funding programme, and the partners will receive a cumulative €6M grant from the European Commission from 2022 to 2025.**

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ALgorithms for IndusTrY

Join our community!

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