

⟨EQUALITY⟩

Efficient QUantum
ALgorithms for IndusTrY

Funded by the European Union
under Grant Agreement 101080142



Funded by
the European Union

OBJECTIVES

› 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



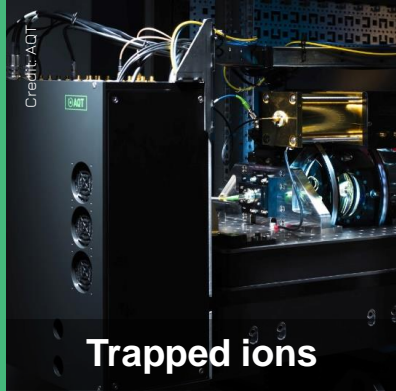
SPACE MISSION
OPTIMISATION
AND DATA
ANALYSIS



ENERGY STORAGE
MATERIALS AND
SYSTEMS

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

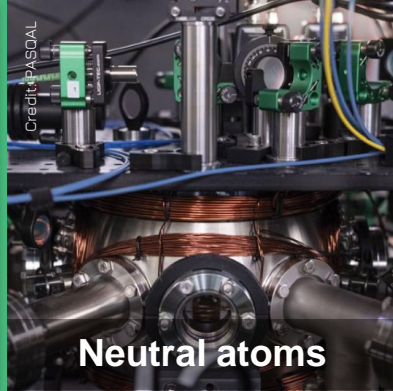
QUANTUM COMPUTERS



Trapped ions



Superconducting



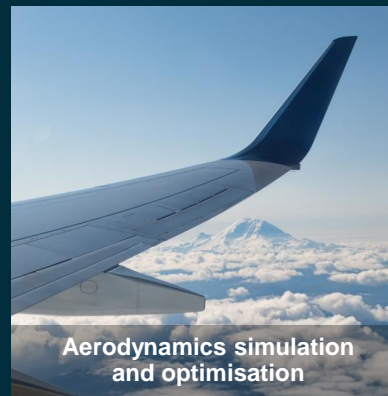
Neutral atoms

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

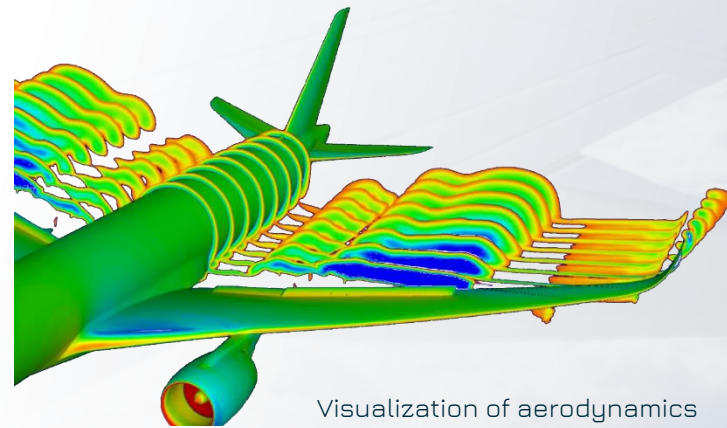
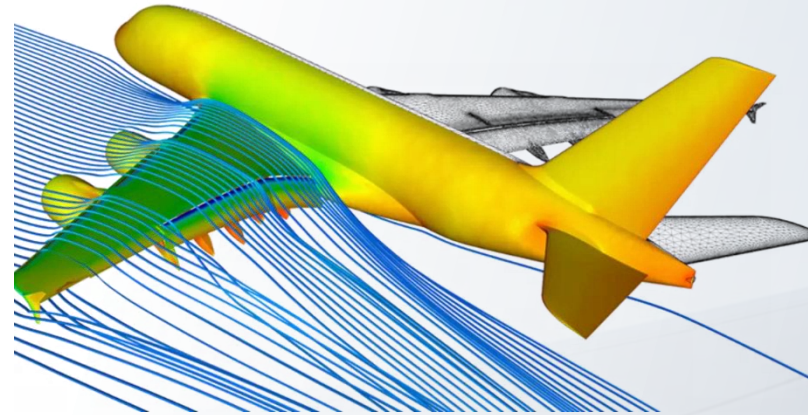
- Differential equation solvers
- Stochastic differential equation solvers
- Quantum generative models
- Quantum chemistry simulators
- Simulators for periodic materials
- Quantum evolution kernel methods
- Non-kernel quantum ML techniques
- Gibbs state-based optimization



INDUSTRIAL PROBLEMS

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

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.

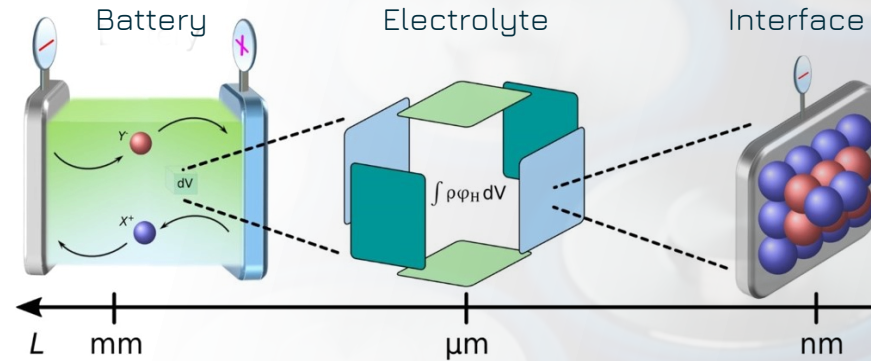
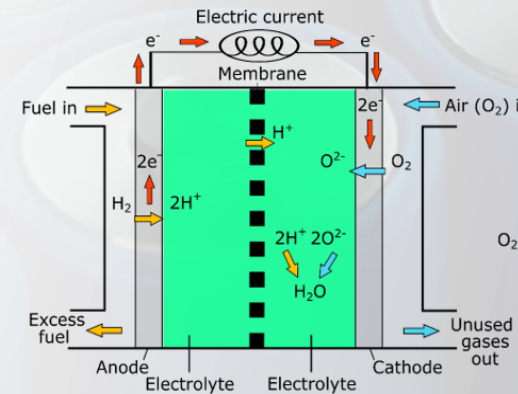


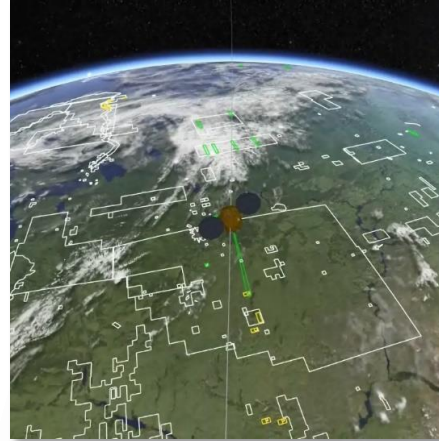
Illustration of the multi-scale approach for the example of a battery.



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.

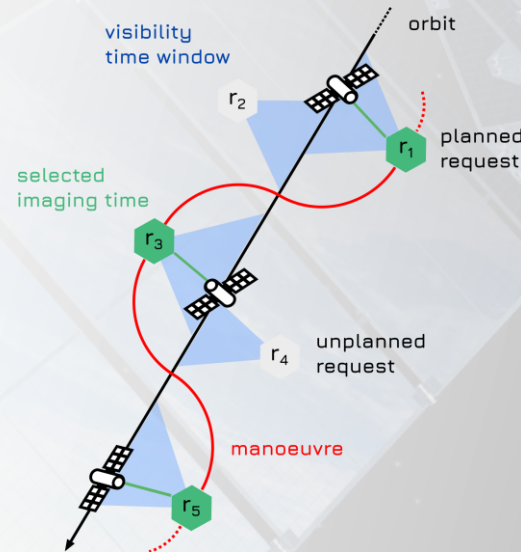
USE CASE: SPACE MISSION OPTIMISATION

- › 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).

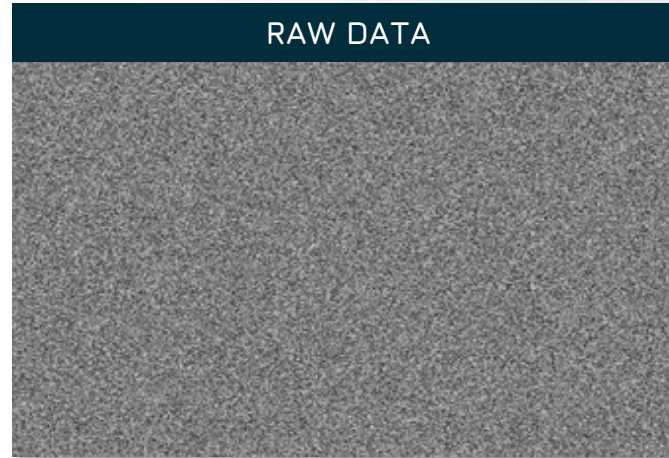
Scheme of an Earth observation satellite mission. Each request is accessible during a limited portion of the orbit. Some requests cannot be fulfilled because of manoeuvre time constraints.



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)



⟨EQUALITY⟩

- › 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

 **PASQAL**

- › 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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