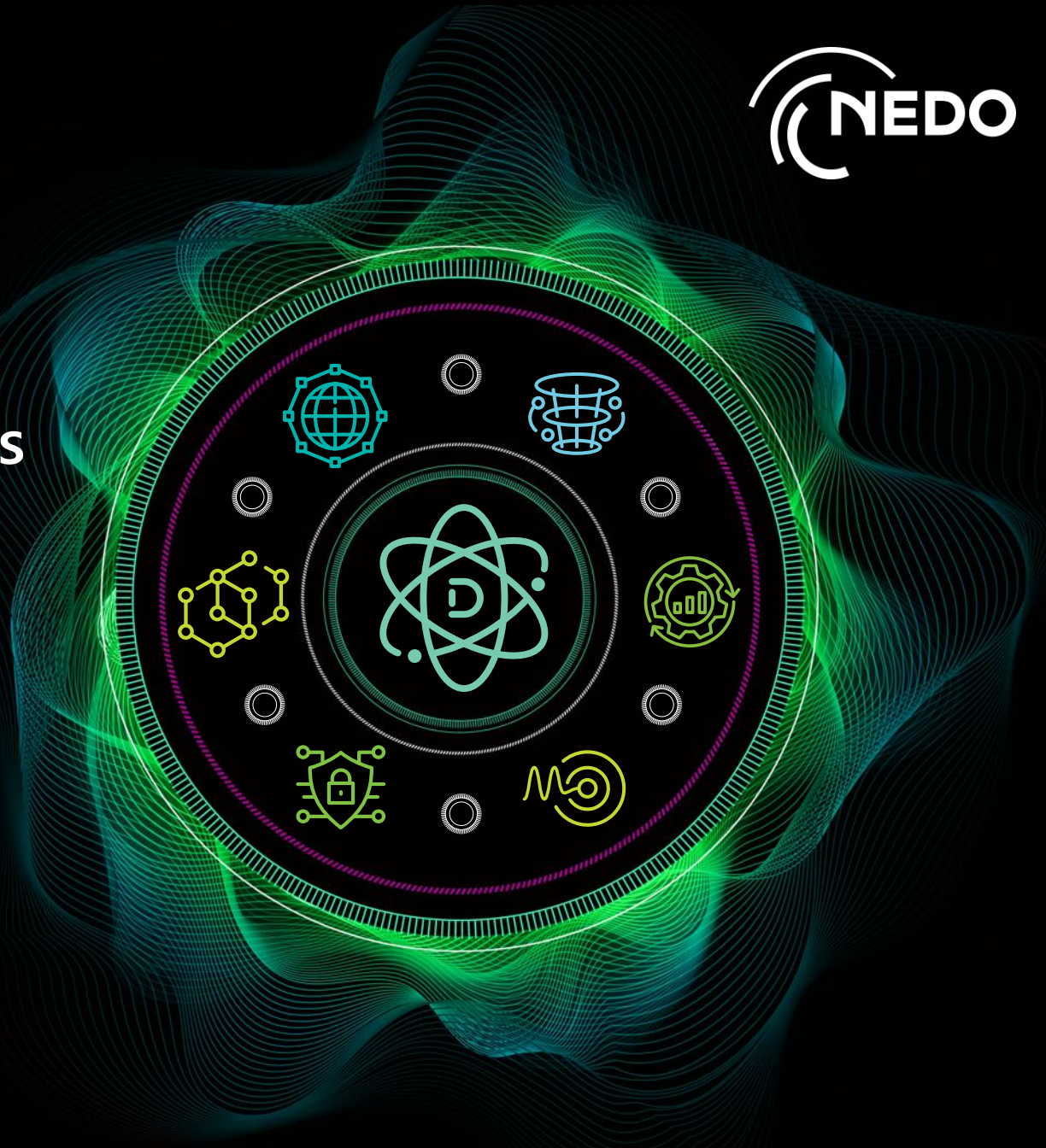
Quantum Computing Use Cases

Quantum-Classical Hybrid Analysis for Aerodynamic Simulation of Vehicle Shapes

Quemix × Nissan Motor



New Energy and Industrial Technology Development Organization (NEDO)

Quemix × Nissan Motor : Quantum-Classical Hybrid Analysis for Aerodynamic Simulation of Vehicle Shapes [2026/6] 1/3

Validation

Industry	Discrete Manufacturing
Process	Production
Method	Simulation
Category	Gate*

Background

- To achieve carbon neutrality, **improving aerodynamic performance has become an important challenge in automotive development**, and it is **necessary to understand the airflow around vehicles with high accuracy in order to improve fuel and power efficiency and extend driving range**
- Currently, the lattice Boltzmann method (LBM) is widely used as a mainstream simulation method, but **there were technical challenges specific to applying quantum computers to this field**
- In this context, Quemix and Nissan Motor launched a joint research project aimed at developing next-generation aerodynamic analysis software using quantum computers, and worked on quantum–classical hybrid analysis assuming execution on Early-FTQC

Issues and motivation to be solved

- When applying quantum computers to aerodynamic simulation, a **major challenge was how to handle complex geometries and boundary conditions such as those of vehicles**
  - ✓ Many conventional quantum fluid algorithms **assumed closed spaces within simple cubes or regular lattices**
- As a result, it was difficult to directly incorporate complex curved geometries such as those of actual vehicles into the computation, and in particular, it was **difficult to incorporate object boundaries and non-zero boundary conditions into the quantum computing process**
- In particular, when accurately representing complex object geometries or dealing with non-zero inhomogeneous boundary conditions, quantum circuits become extremely large and complex, making it **difficult for current and near-term quantum devices to maintain both computational feasibility and accuracy**

Reference: [Press Release] Quemix and Nissan Begin Joint Research and Development of Software for Aerodynamic Simulation Using Quantum Computers（https://www.quemix.com/post/20260601-nissan）
*Gate（gate-based）: A computing approach in which operations are applied sequentially to qubits to perform calculations. Similar in concept to logic circuits in classical computers, it can address a wide range of problems.

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Problem setting as a quantum computer

- Aerodynamic simulation capable of handling complex vehicle geometries was formulated **as a quantum–classical hybrid problem in which tasks are divided between a quantum computer and a classical computer**
- Specifically, **a hybrid algorithm for Early-FTQC was developed in which the classical computer handles calculations arising from non-homogeneous terms, such as inflow, outflow, and object motion, while the quantum side handles the main part of the fluid calculation, including boundary processing for stationary objects**
- **The algorithm was then implemented on a quantum simulator for aerodynamic simulation assuming complex vehicle geometries, and it was confirmed that the results could reproduce those of conventional classical computation with high accuracy**

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Expected business benefits

- Quantum-computer-based aerodynamic simulation was shown to be feasible, and it **was confirmed on a quantum simulator that the results of conventional classical computational analysis could be reproduced with high accuracy**
- As a result, this work has potential as a foundational technology for practical fluid analysis using quantum computers
- Moreover, its applications **are not limited to automobiles and may extend to fields of fluid analysis involving complex geometries, such as aviation, shipping, and architecture**
- Looking ahead, **practical implementation of aerodynamic simulation software on quantum computers and its application to actual vehicle development processes are envisioned**

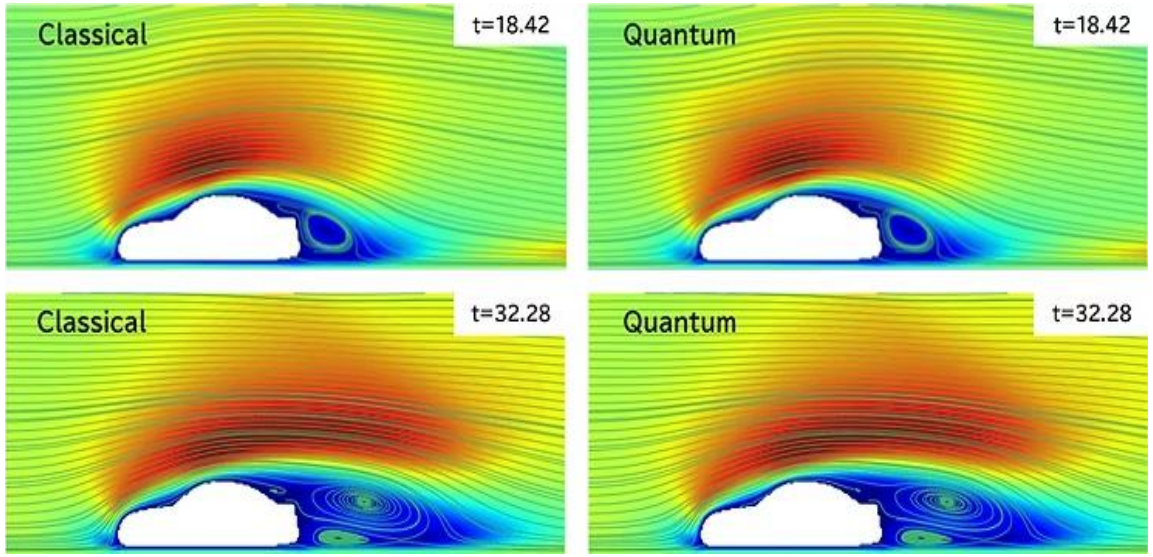


Figure: Comparison of aerodynamic analysis results (streamline plots) for a vehicle model
Left: Analysis result obtained using a classical computer
Right: Calculation result obtained using this algorithm, with accuracy at a level comparable to the classical result

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More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)

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