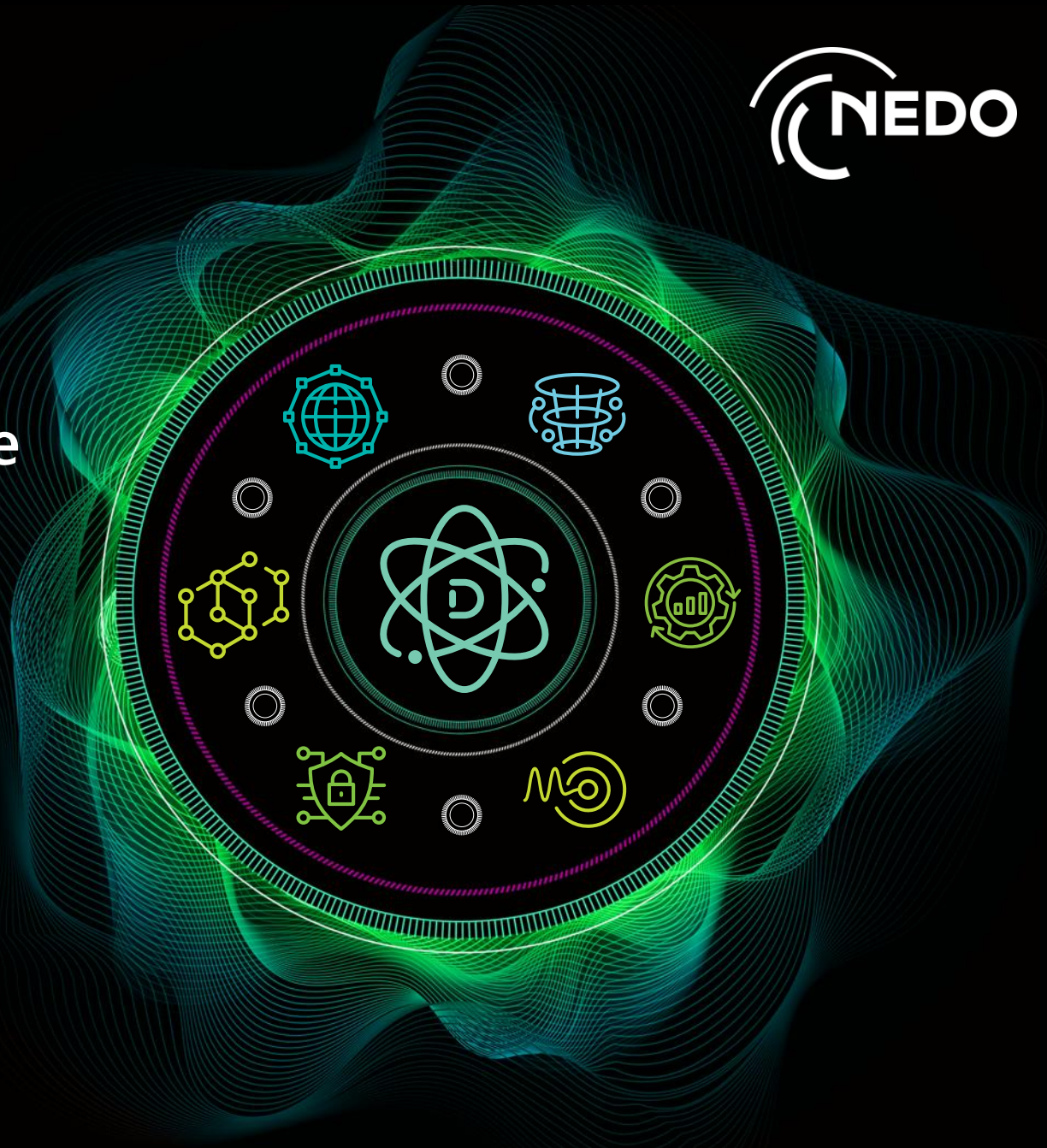
Quantum Computing Use Cases

Improving Jet Engine Performance

Rolls-Royce



New Energy and Industrial Technology Development Organization (NEDO)

Rolls-Royce: Improving Jet Engine Performance [2023/05] 1/2

Validation

Industry	Discrete Manufacturing
Process	R & D and product design
Method	Simulation
Category	Gate*

Background

- **We need to build state-of-the-art, high-efficiency jet engines** to achieve sustainable aircraft, but **jet engines are so complex that they are expensive to design and computationally expensive.**
- Rolls-Royce **plans to model jet engines in simulations that combine both classical and quantum computing** in jet engine design
- **Quantum computing research around the world is now powered by NVIDIA GPUs, and much of the world's quantum computing software now supports GPU acceleration using the NVIDIA quantum platform.**

Expected business benefits

- **10 million layers with 39 qubits *1 Design and simulation of the world's largest measurable quantum computer circuit for CFD**
- With GPUs, **we're preparing for a future with powerful quantum computers.**

*1: Current quantum computers can only handle a few layers (as of 2023/05), but run 10 million layers of circuits in a simulation

Issues and motivation to be solved

- **Ensure a system to enjoy the benefits of quantum advantage when the era of quantum computers arrives**
- advance **the implementation of hardware-independent algorithms optimized for quantum computers of the future (faster than classical computers),** as well as today's quantum computers



Example of a jet engine

Reference: NVIDIA"NVIDIA, Rolls-Royce and Classiq announce quantum computing breakthroughs for computational fluid dynamics in jet engines" (https://www.nvidia.com/ja-jp/about-nvidia/press-releases/2023/nvidia-rolls-royce-and-classiq-announce-quantum-computing-breakthrough-for-computational-fluid-dynamics-in-jet-engines/), PRTIMES"Rolls-Royce and Classiq team up to design quantum algorithms for fluid dynamics" (https://prtimes.jp/main/html/rd/p/000000007.000101286.html)
*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

- Implementation of **New Analysis Algorithms for Fluid Flow Analysis (CFD)** *1)
- Regarding the HHL algorithm *2 for solving linear equations, the nonlinear part is solved by a classical computer, and the linear part is solved by a quantum computer
- **Leverage Classiq's proprietary platform to** develop **state-of-the-art quantum circuits optimized for HHL algorithms**
- For the circuit synthesized above, **Simulate the circuit using the NVIDIA A100 Tensor Core GPU.**



Classiq's Quantum Software Development Support Platform

*1: CFD is a numerical analysis and simulation method that observes the flow by solving equations related to the motion of a fluid (Euler equations, Navier-Stokes equations, or their derivatives) on a computer using the numerical solution of partial differential equations, etc.

*2: Harrow-Hassidim-Lloyd (HHL) algorithm is a fast algorithm for solving simultaneous equations. Simultaneous linear equations are used in all kinds of scientific and technical calculations such as electromagnetic and thermohydrodynamic analysis and machine learning.

Reference: Classiq"Quantum software platform enabling design, optimization, analysis and execution of quantum algorithms"(https://ja.classiq.io/, https://prtimes.jp/main/html/rd/p/000000007.000101286.html)
*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.

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

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