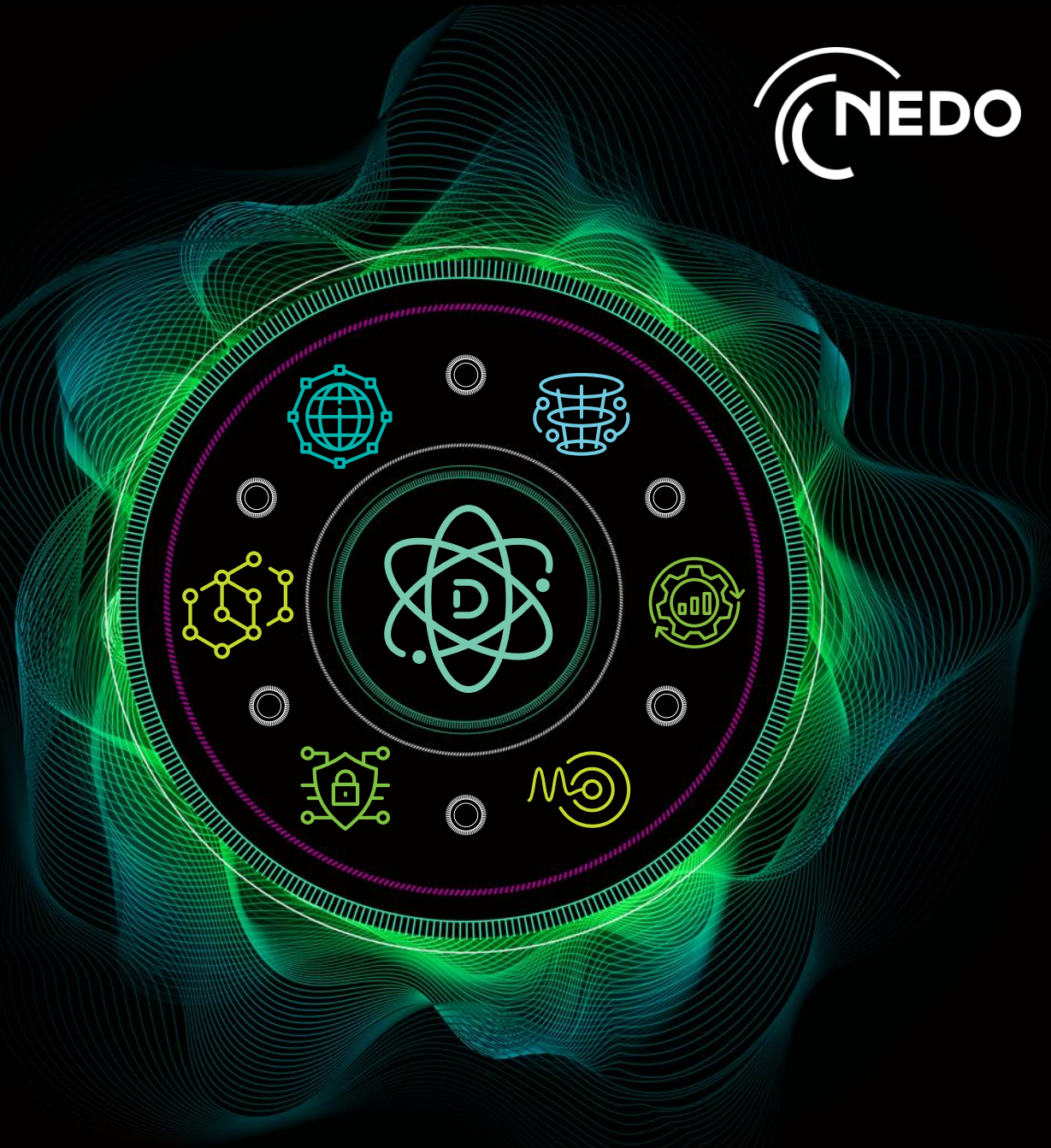
Quantum Computing Use Cases

Vehicle design optimization using black box optimization

Mazda



New Energy and Industrial Technology Development Organization (NEDO)

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Validation

Industry	Discrete Manufacturing
Process	R & D and product design
Method	combinatorial optimization
Category	Ising*

Background

- Since 2006, Mazda has been working to **share the optimal structure across models and grades** based on its Common Architecture strategy
- **Black box optimization using quantum annealing Ising machine was utilized for the design of optimum structure exceeding car models (optimization of thickness of steel plate).**
  - ✓ From 2014 to 2015, Mazda, in collaboration with JAXA and the Tokyo University of Science, tried an approach to optimizing the thickness of steel plates using a supercomputer based on evolutionary calculations. However, it took tens of thousands of trials and several months to obtain a reasonable Pareto solution with conventional techniques, and it became clear that further efforts were needed for practical application.

Issues and motivation to be solved

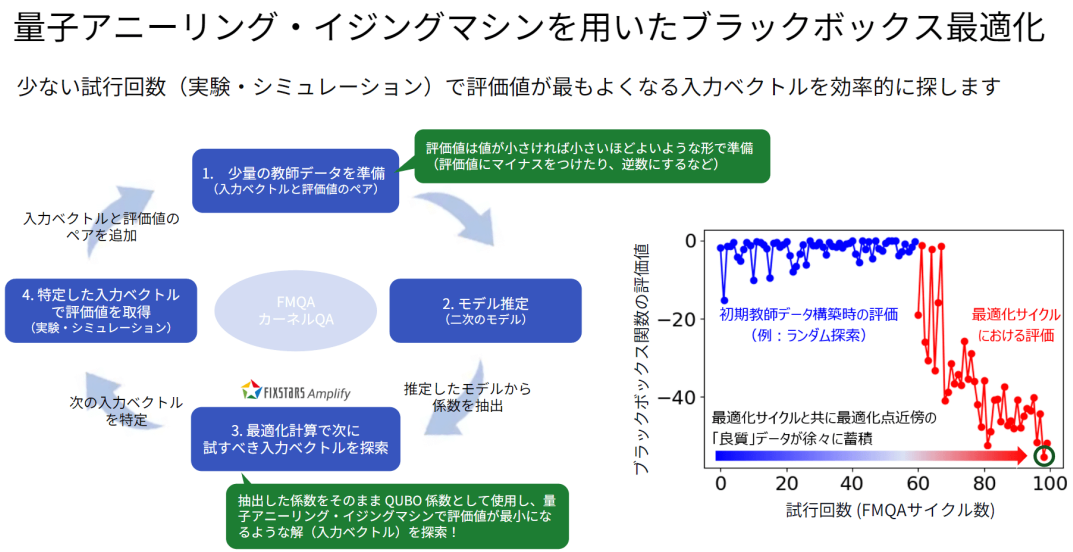
- Mazda addressed the simultaneous optimization problem of body structure design by Bayesian optimization, but **the problem remains that it becomes extremely difficult to find a solution that satisfies the constraints, especially as the size of the problem increases.**
- Regarding the above issues, we implemented initiatives with the aim of achieving FMQA *1, **black box optimization by**, *2 and **solution by**.

*1: Black-box optimization method combining machine learning and quantum annealing

*2: Optimize (minimize/maximize) the result for a given input in a situation where only the output result can be obtained and no other information is given.

Problem setting as a quantum computer

- As a simultaneous optimization problem of body structure design for 3 models, the **problem of determining which thickness of steel plate is best allocated** was addressed to 74 parts per model (222 parts in total for 3 models). After satisfying the constraints on quality characteristics such as ride comfort and collision performance required for each model, the **multi-objective optimization problem of realizing vehicle weight reduction and maximizing the number of parts common to multiple models** was tackled.



Optimization by FMQA

Reference: Fixstars Amplify "Mazda Motor Corporation Black Box Optimization for Vehicle Design " (https://amplify.fixstars.com/ja/customers/interview/vehicle-co-optimization)

*Ising: A computing approach, mainly associated with quantum annealers and simulators specialized for the Ising model, in which a problem is first formulated as an Ising model and then solved computationally. It is particularly well suited to problems that involve finding the optimal combination from a vast number of possibilities.

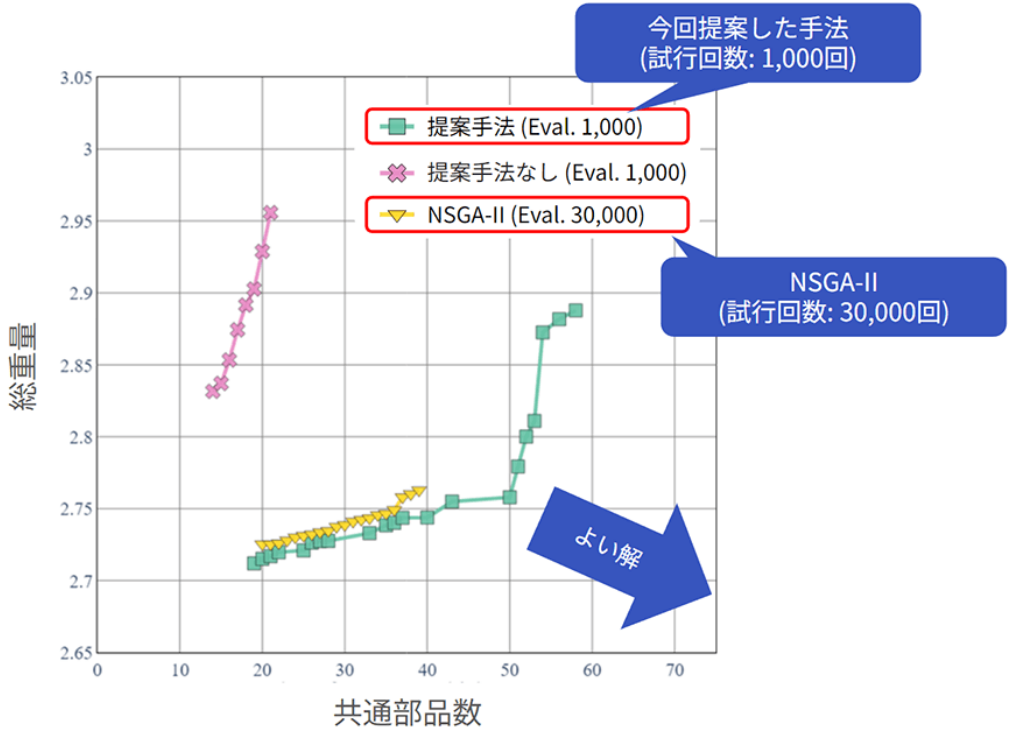
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Expected business benefits

- Optimization using a black box using a quantum annealing ising machine **succeeded in obtaining a solution superior to that obtained by NSGA-II after 30,000 trials in 1,000 trials**, which is one of evolutionary calculations and a representative method of multi-objective optimization
- At present, it is in the research stage, and the main focus was on how quickly a good solution could be found. However, **it is necessary to be able to stably obtain a moderate solution in a small number of trials, even if it is not the best solution for daily use in the field of actual design.**
- In addition, it is necessary to make systems and parameterless systems that are easy to use by any designer.



superiority of the proposed method
(Weight reduction in complex conditions with many parts)

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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

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