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# Manufacturing Industry



# Mathematical Optimization

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# Chapter 1

## Current State of the Manufacturing Industry

In recent years, rapid changes in consumer demand and the social environment have increasingly required manufacturers to produce a wide variety of products in small lots with short lead times. In order to respond quickly to these changes, there is also an increasing number of cases where companies can improve their market competitiveness by being able to build new production lines, factories, and logistics networks as needed. In response, companies are actively promoting digital transformation (DX) initiatives based on AI and IoT technologies to appropriately assess situations and consider strategies.



## 1.1. Challenges Facing the Manufacturing Industry

The impact of COVID-19 and geopolitical risks has brought major changes to the supply chains surrounding the manufacturing industry in recent years, including changes in consumer demand and purchasing trends, surging raw material prices, and logistics crises. As the social environment is expected to continue changing, the manufacturing industry will need to swiftly and accurately grasp the current social landscape and continuously optimize management decisions and on-site operations as necessary.

Furthermore, the decline in the working population is also becoming a major issue in manufacturing sites. There are many tasks in manufacturing sites that must rely on the experience and know-how of skilled workers, and there is a need to document the know-how of skilled workers and to establish training and standardized procedures to enable less experienced and younger workers to perform the tasks.

## 1.2. Existing Technologies for Problem Solving

In recent years, DX has been accelerating in the manufacturing industry. In particular, it has become possible to capture on-site conditions in real time by introducing various sensors and IoT devices. Furthermore, the use of AI technology has enabled analysis of data obtained and predictions (e.g., predicting when equipment will fail and predicting increases in order volume).

However, existing technologies have the following issues and have not yet succeeded in solving the previously mentioned “challenges faced by the manufacturing industry”:

- ✓ AI requires large volumes of data for utilization, but companies do not have sufficient data accumulated internally
- ✓ AI can perform “prediction,” but it is difficult to translate those predictions into “judgments” or “decision-making”

## Chapter 2

# Future of “Manufacturing Industry x Mathematical Optimization”

To solve the challenges faced by the manufacturing industry, NTT DATA is developing and conducting business validation of “mathematical optimization” technologies. Mathematical optimization is a method for determining optimal options using computers in order to minimize or maximize quantitative indicators such as costs and profits, and in recent years, advances in computing infrastructure such as GPUs and quantum computers have accelerated its application in business. By leveraging mathematical optimization technology, optimal decisions based on data can be made without relying on experience or intuition.

## 2.1. About Mathematical Optimization Technology That Solves Challenges in the Manufacturing Industry

As mentioned earlier, while AI technology is capable of making “predictions,” it is difficult to make decisions based on data, and the introduction of AI technology by itself will not enable swift management decisions or optimization of on-site operations. In response, NTT DATA is focusing on “mathematical optimization” technology that can determine the “optimal choice” based on predicted results.

Mathematical optimization technology is a technology that uses computers to determine the best options in order to minimize or maximize quantitative indicators such as costs and profits. For example, if the indicators to be improved are “the number of workers required at night” or “the number of machine changeovers,” mathematical optimization technology can be used to create a production plan that minimizes those indicator values.

Mathematical optimization technology itself has long been researched in the fields of mathematics and information engineering, and within NTT DATA as well, its group company NTT DATA Mathematical Systems Inc., has been developing various technologies and solutions, including the Nuorium Optimizer.

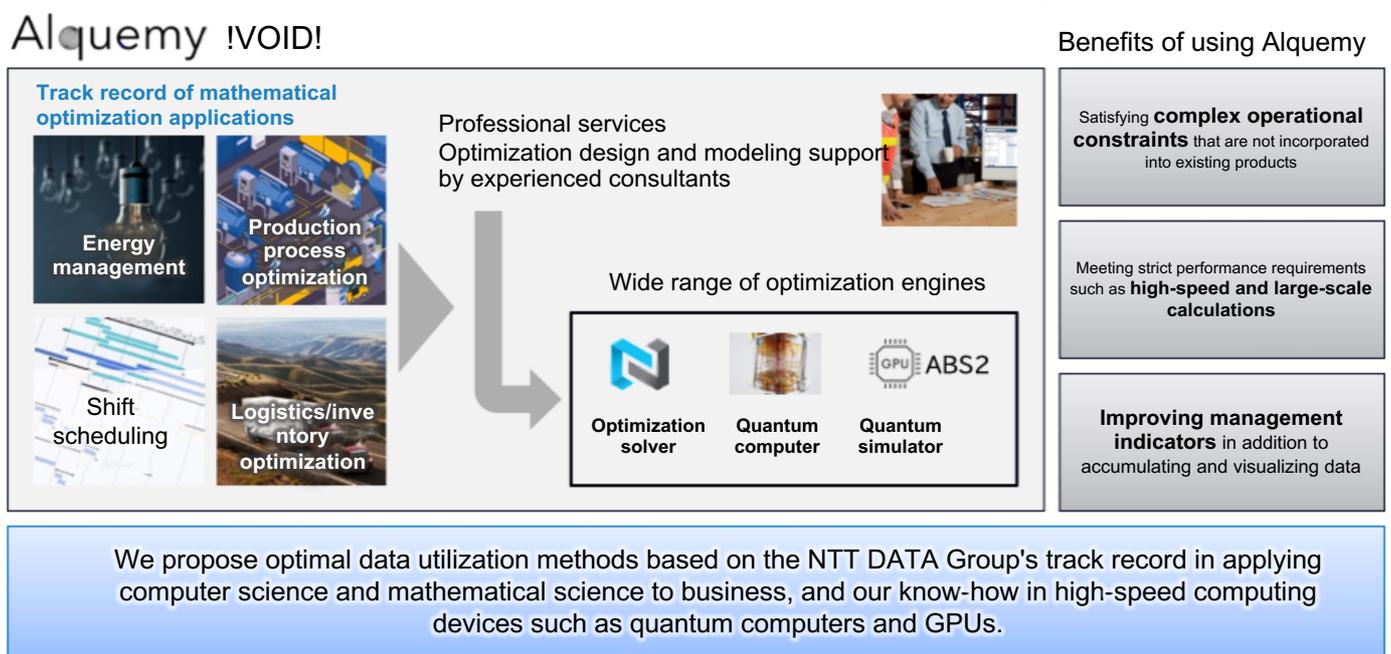
Mathematical optimization technology enables optimal decision-making based on data, but there are many challenges when applying it to businesses that are complex:

- ✓ Unless the optimal solver (software used for mathematical optimization) and algorithm are selected according to the type and amount of data and the business logic, the optimal solution cannot be obtained
- ✓ There are many operational constraints and rules in manufacturing sites, and it is difficult to incorporate those business logics into mathematical optimization formulas
- ✓ When applied to large amounts of data and complex business logic, the amount of calculation required becomes enormous, resulting in significant time needed to output results

## 2.2. Anticipated Use Cases for Mathematical Optimization Technology Aimed for by NTT DATA

To address the challenges of the aforementioned mathematical optimization technology, NTT DATA is developing an asset called “Alquemy” that enables the selection of the optimal technology tailored to each customer’s data and business logic. For example, in cases where results must be produced within a few seconds, cutting-edge computing platforms such as quantum computers can also be used. In addition, with the design and modeling support provided by consultants who possess expertise in mathematical optimization technology, complex business logic can also be incorporated across various computing platforms.

### NTT DATA's mathematical optimization platform/consulting services



As cases where Alquemy can be utilized, NTT DATA anticipates the following use cases in the manufacturing industry:

- ✓ Production process optimization
- ✓ Inventory volume optimization
- ✓ Facility layout design with flow line optimization
- ✓ Supply chain optimization
- ✓ Scheduling of facility inspections

Furthermore, the knowledge gained in the manufacturing industry can be applied to other industries, and NTT DATA anticipates the following use cases outside of the manufacturing industry:

- ✓ Energy management
- ✓ Inspection and design of various infrastructure
- ✓ Calculation of optimal pricing
- ✓ Logistics/inventory optimization
- ✓ Shift scheduling
- ✓ Optimization of product inventory and shelf allocation in stores

# Chapter 3

## Examples of NTT DATA's Initiatives

Finally, we will introduce two representative examples of initiatives with NTT DATA's customers who have utilized Alquemy. Going forward, in addition to the manufacturing industry, we will continue to conduct technology validation of new computing platforms and advance the development of technologies to incorporate industry-specific business logic, in order to solve challenges faced by customers across various sectors.



### 3.1. Shinko Co., Ltd. – Improving Production Efficiency in Printed Circuit Board Processing

NTT DATA, in collaboration with Hiroshima University and Shinko Co., Ltd. (hereinafter “Shinko”), has developed a unique algorithm to improve the manufacturing efficiency of printed circuit boards, which are essential base materials for electronic devices.

In printed circuit board manufacturing, the sequence in which the drill moves to predetermined coordinates on the board to make holes is crucial from the standpoint of efficiency. There is a need to shorten the time it takes to drill to all coordinates, but existing software has the issue of being unable to quickly calculate a highly efficient visiting sequence that shortens the drill’s travel distance. Furthermore, it was necessary to take into consideration the unique constraints (operational constraints and constraints on equipment behavior) that stemmed from Shinko’s production line.

By applying the proprietary algorithm developed to the work processes of processing equipment used in the manufacture of printed circuit boards, we were able to eliminate unnecessary traffic flow during operation, successfully reducing the time required for movement by approximately 9.6% and the total processing time by approximately 3.9%. Since April 2023, the algorithm has been applied to the production line at Shinko, and mass production of printed circuit boards has begun.

<https://www.nttdata.com/global/ja/news/topics/2023/080100/>

### 3.2. Komi Hakko Corp. – Smell Reconstruction

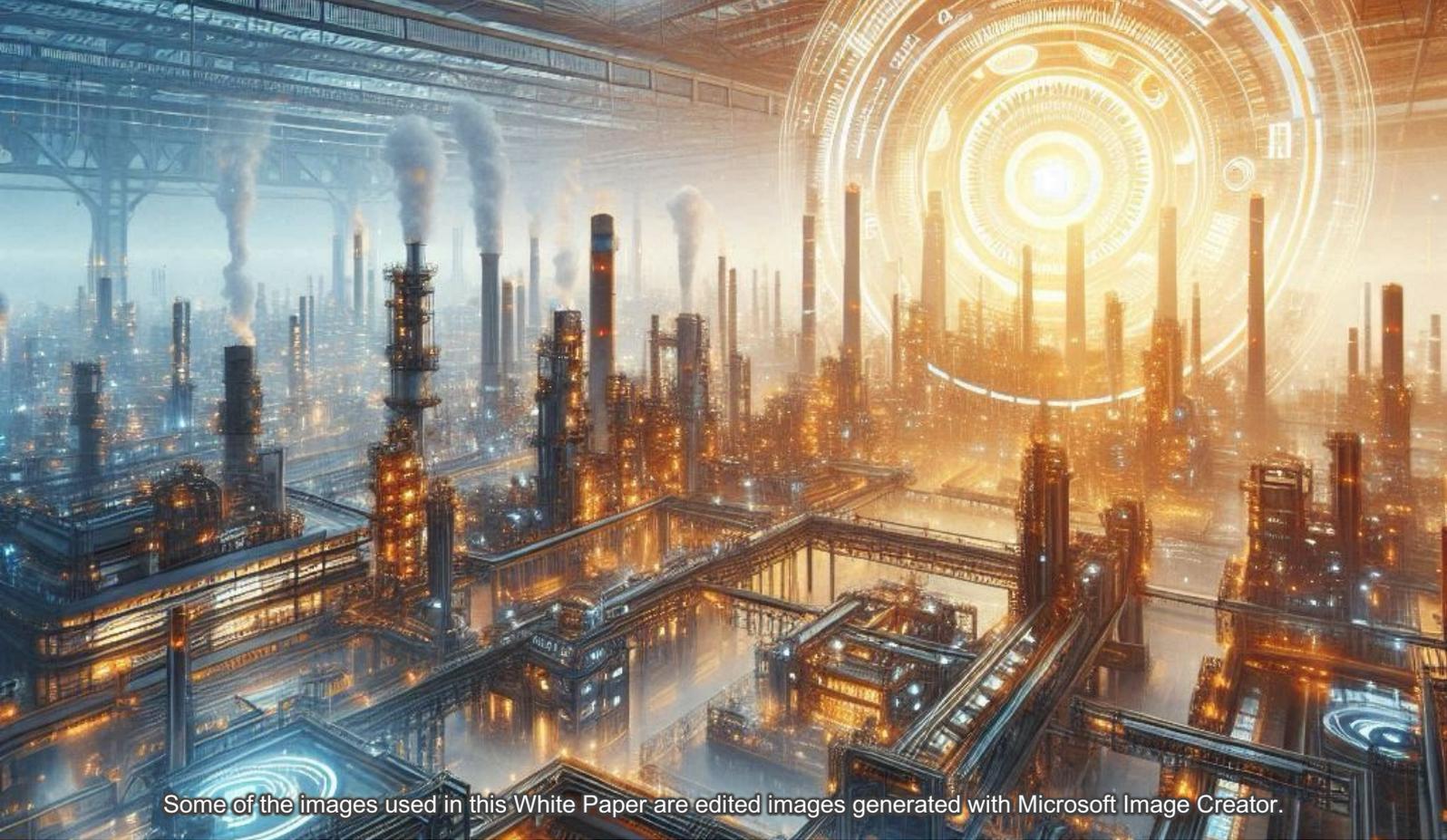
NTT DATA has been partnering with Komi Hakko Corp. (hereinafter referred to as Komi Hakko), the world’s first company to successfully quantify smell, since 2023.

Komi Hakko possesses the technology to quantitatively measure various smells and a database that compiles the measurement results of these smells, and operates a business that reconstructs desired smells by combining a small number of smell molecules. However, finding the right combination from thousands of different smell molecules requires large-scale calculations, and conventional methods have not been able to accurately calculate the more than 1,000 combinations. However, it is said that more than 8,000 different combinations of smell molecules are required to successfully implement the smell reconstruction business.

By utilizing NTT DATA’s combinatorial optimization technology, we were able to successfully calculate over 8,000 different combinations. Furthermore, as one of the outcomes of joint experiments conducted under a partnership agreement, the company is also working on developing a new deodorant formulation process that reduces the manufacturing period of deodorants by 95% compared to conventional methods.

<https://www.nttdata.com/global/ja/news/release/2023/032700/>

<https://www.nttdata.com/global/ja/news/topics/2024/083001/>



Some of the images used in this White Paper are edited images generated with Microsoft Image Creator.

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