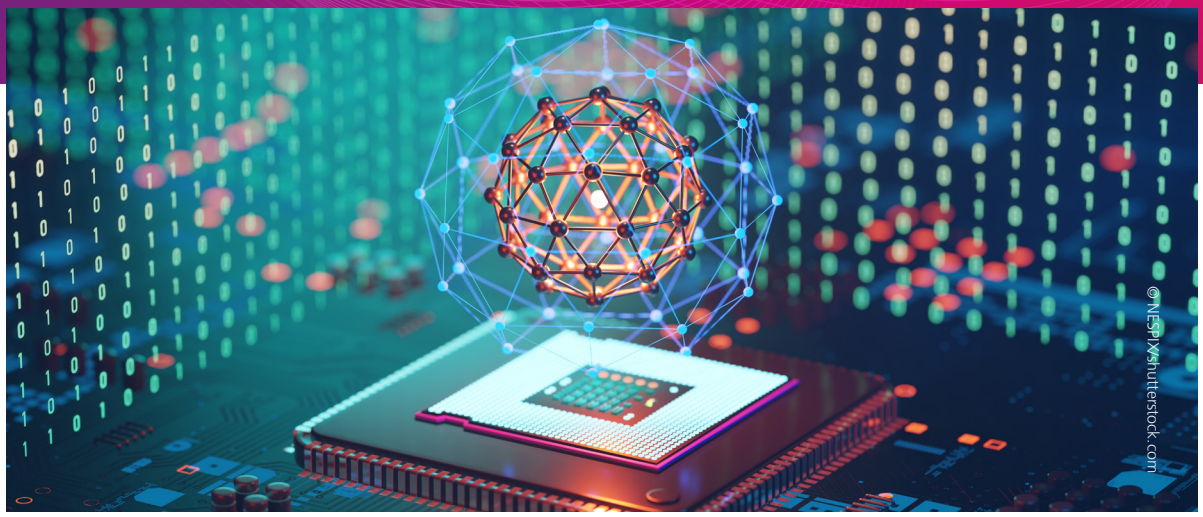
Fraunhofer CML

Newsletter QC26



Dear readers,

Over the past year, quantum computing in maritime logistics has evolved from a niche topic to a relevant research subject with many applications at Fraunhofer CML. This has been achieved thanks to kickstart financing from the City of Hamburg for the Quantum Computing for Shipping and Maritime Logistics in Hamburg (QSH) project. Even though quantum computing is still a promise for the future, we already identify industrial use cases that can benefit from this novel paradigm and lay the the foundations for a rapid transition to innovative technologies.

In this newsletter, we present several ongoing and upcoming projects that are intended for use in industry and business.

I hope you find it an inspiring read!

Kind regards, **Dr. Ole John, MBA**
Head of Department Ship and Information Management
Fraunhofer CML

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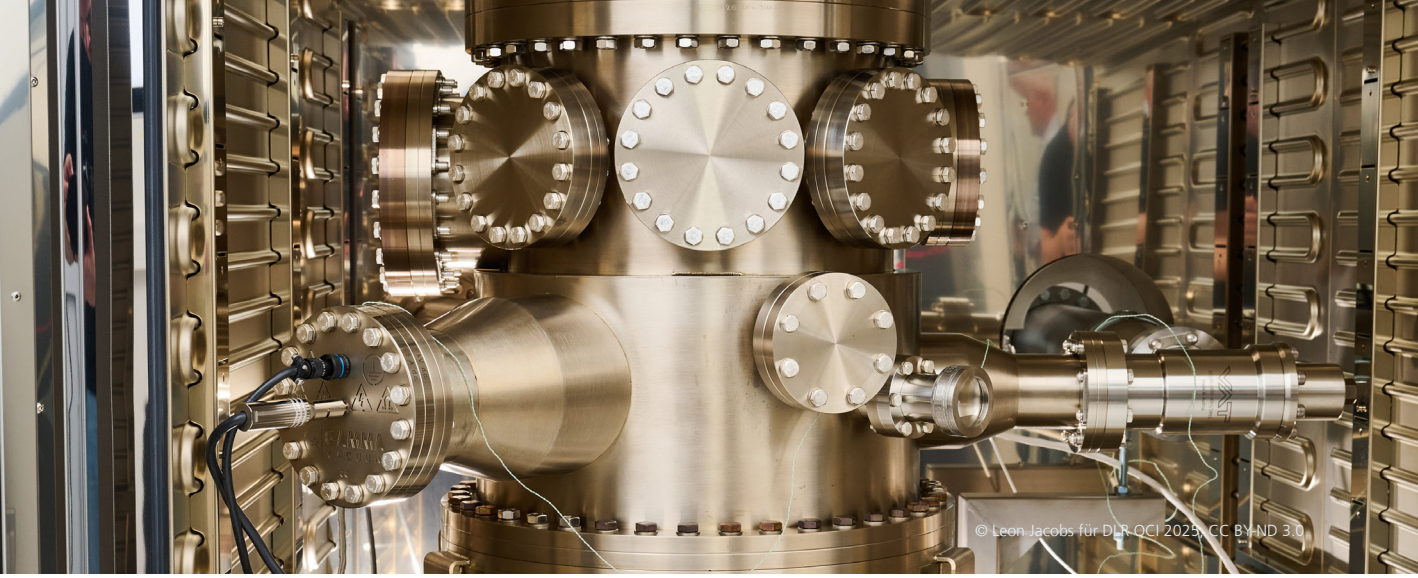

Ion trap quantum computers in the DLR QCI project Legato.

Fraunhofer CML: Part of the DLR Quantum Computing Initiative of the German Aerospace Center (DLR)

To achieve a leading international position in quantum computing, we need a strong ecosystem that accelerates technology transfer between industry and research. Fraunhofer CML is part of the solution within the framework of the DLR Quantum Computing Initiative (DLR QCI) of the German Aerospace Center. In several DLR QCI projects, we contribute tasks such as route optimization in tramp shipping, lock optimization, and challenges from intermodal transport and traffic light control. We are defining, modeling and solving the use cases with novel quantum algorithms.

In its projects, Fraunhofer CML will test a direct solution on quantum computers and a quantum-inspired method with quantum tensor networks and compare them with each other.

Background

Although industrial applications are still in the development phase, theoretical advances point to an imminent paradigm shift in which quantum computers could become key tools for optimization problems. Technically, problems are often formulated as quadratic unconstrained binary optimization problems (QUBO).

Many problems in logistics can be described as QUBOs, and the direct use of so-called quantum annealers is already possible today. Significantly larger instances can be tackled using quantum-inspired tensor networks. These networks are a clever solution for huge search spaces.

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Ion trap chip production in the DLR QCI cleanroom.

Overview for the DLR Quantum Computing Initiative Germany

In order to bring quantum computers into use more quickly, the DLR Quantum Computing Initiative (DLR QCI) works with industry, start-ups, and research institutions to develop quantum computers and suitable applications, with funding from the German Ministry of Education and Research (BMFTR). Fraunhofer CML is involved in the DLR QCI through several projects in the field of optimization with applications in logistics and, as a contractor, contributes its expertise to four projects with different focuses.

QCMobility | Maritime transport

As a typical optimization problem with a major impact, the project investigates whether lock management on inland waterways can be optimized with the help of quantum computers. Specific use case: the optimization of lock operations on the Wesel-Datteln Canal—Germany's second busiest waterway after the Rhine.

QCMobility | Intermodal transport

The aim of the project is to optimize the complex planning and control processes along intermodal supply chains and to support the shift of transport from road to the more environmentally friendly rail.

QuTeNet | Tensor Networks

The QuTeNet project aims to implement highly efficient quantum-inspired tensor network methods, test them on a real-world application problem in maritime logistics, compare them with conventional methods, and explore further use cases that are predestined for this method.

QI-TraSiCo

The aim of the project is to develop a quantum-inspired control system for traffic lights. Although optimization approaches for network-wide control of traffic lights are known, they have not yet been executable in real time with sufficient quality, as conventional traffic computers have limited computing power.

Hamburg aims to qualify for the quantum age.

QSH: Quantum computing for shipping and maritime logistics in Hamburg

In the QSH project, Fraunhofer CML is supporting the city of Hamburg in preparing industry for the coming quantum age. The potential of quantum computing will be assessed, particularly in the areas of shipping and maritime logistics, so that the insights gained can be put to profitable use.

To this end, optimization problems (such as berth allocation, cargo routing, and maritime inventory routing) from operational and strategic operations are being identified, formalized, and examined with regard to the sensible use of quantum computing.

We have worked closely with our industry partner Harren Group, particularly on the topic of cargo routing. In modeling these use cases, it has become clear that current quantum computing hardware is too low-performing to solve the problems directly. We therefore develop methods that break down the modeled problem into smaller, structured sub-problems. Decomposition reduces the size of the problem, allowing the computationally intensive part of the program to be solved on quantum computers, while classical computers solve the other part. Optimization problems that have a special structure and are easy to decouple are well suited for this approach.

Background

In our examples, we examine Benders decomposition, which divides the optimization problem into an integer master problem and continuous subproblems. This division allows the master problem to be cleverly converted into a quadratic unconstrained binary optimization problem (QUBO), which is suitable for porting to quantum computers. Initial results show that we have successfully reduced the problem size using this method.

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Data-driven planning and optimized scheduling in the Quantum Tug Scheduling project (symbolic image).

Quantum Tug Scheduling – the importance of real data

The Quantum Tug Scheduling project, funded by the Hamburg Investment and Development Bank (IFB Hamburg), was launched in the summer of 2025 and addresses tugboat scheduling in the Port of Hamburg. A hybrid optimization process that uses both classical and quantum computing solution methods is intended to enable faster and more accurate scheduling.

The first steps included requirements analysis and the recording of relevant parameters and objectives. Most of the available data reflects the situation after successful dispatching, but does not provide any insight into the short-term changes that are made on a daily basis during dispatching to ensure safe and efficient operations. With the help of our partner FAIRPLAY, the researchers were able to talk directly to the dispatchers, observe the deployment of tugboats, and look over the shoulders of the experts in the operations control center.

The scientists at Fraunhofer CML analyze all these observations in order to model the problem optimally, develop suitable algorithms, and thus arrive at a viable solution for our industry partners FAIRPLAY and soft-park.

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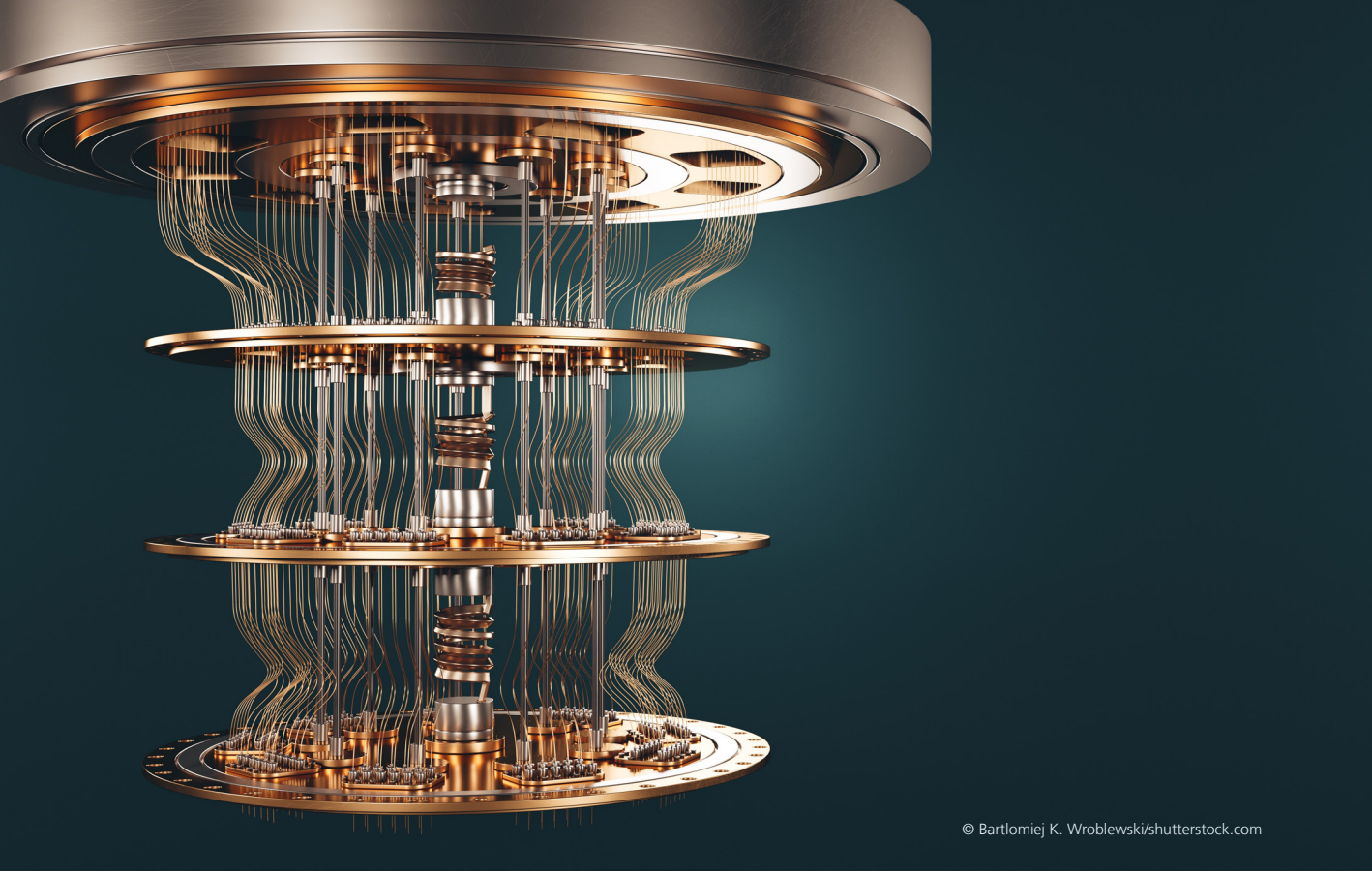

In 2025, the Europe-wide establishment of the QEC4QEA Center of Excellence started (symbolic image).

Quantencomputing@CML goes Europe: Outlook for our Quantum Excellence Center

December 2025 saw the launch of the European project QEC4QEA, which establishes a center of excellence for quantum computing applications in Europe. The project aims to close various infrastructure gaps in quantum computing (QC), such as the increased need for standard tools, specialized training, and far-reaching industry collaborations. To this end, a unified platform is being set up to accelerate the development and integration of quantum-based applications in various scientific and industrial fields. In addition, application libraries for different industrial sectors are being developed. Fraunhofer CML will model and implement real industrial use cases from maritime logistics using QC methods. Three problems are at the center of attention: the berth allocation problem, the maritime inventory routing problem, and the vehicle job routing problem.

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Spotlight on our publications

Comparison of approaches to solve the maritime inventory routing problem

The maritime inventory routing problem is an optimization task that aims to increase the efficiency of bulk cargo distribution by sea. It combines route planning for a fleet of heterogeneous ships between capacity-constrained ports with inventory management at the facilities involved. In this paper, we demonstrate the capabilities and limitations of current quantum computers using this problem and compare the computing power of a quantum-classical hybrid solver based on our model with the results obtained using a classical solution method.

A quantum-inspired approach to route planning for bulk carriers with time windows

In this conference contribution, we examine the routing problem for bulk carriers, where fuel consumption depends nonlinearly on ship speed and routing must adhere to strict time windows. The primary goal is to show how such problems from maritime practice can be modeled and addressed using quantum technology, both to demonstrate the path to practical application and to explore the current potential.

Efficient data encoding for simulations on quantum computers

Together with international partners, we work on making quantum computers usable for realistic simulations. It is important to store information in such a way that as little computing power as possible is required. One approach is to exploit the natural symmetries of the simulated systems. In our article, we use random-based linear coding, which allows the most important properties of a system to be mapped to a quantum computer with fewer qubits. This makes simulations more efficient. Our results show that such realistic simulations are fundamentally possible.

Summer school on quantum machine learning

Together with the institutes of the German Research Center for Artificial Intelligence in Kaiserslautern and Bremen, Fraunhofer CML conducts a summer school from August 16 to 21, 2026, in Bad Honnef, which is sponsored by the German Physical Society (DPG). Registration is possible via this link: Quantum Machine Learning — DPG

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