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Fraunhofer Center for Maritime
Logistics and Services CML

15 Years

Innovating the Maritime Sector.

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Fraunhofer Center for Maritime Logistics
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Blohmstr. 32 ▪ 21079 Hamburg
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Phone: +49 40 2716461-1260
E-mail: info@cml.fraunhofer.de

Project managers Fraunhofer CML:
Prof. Dr.-Ing. Carlos Jahn
Dipl.-Ing. Claudia Bosse
Etta Weiner, M. A.
Dipl.-Des. Benedikt Beck, M. A.

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»The challenges facing the maritime sector call for innovative approaches«

In this interview, Prof. Carlos Jahn, Director of Fraunhofer CML, talks about innovations, collaborations with industry, and his vision for the future.

Professor Jahn, Fraunhofer CML has been active in maritime research for 15 years. Which moments from this long period would you like to highlight – either for the development of Fraunhofer CML or from a personal perspective? Do you see any early developments that were groundbreaking for today's Fraunhofer CML? What were the most important milestones?

Fraunhofer CML has undergone an impressive development over the past 15 years. There have been numerous moments that were of great significance both for the development of the research institution and for me personally. Its founding in 2010 was a decisive step toward strengthening maritime research in Germany. The first projects we initiated at that time laid the foundation for our current expertise in the areas of digitalization, automation, and sustainability in maritime logistics. The goal behind this was to build a highly qualified, interdisciplinary, and industry-oriented team. The collaboration between engineers, computer scientists, logistics experts, economists, and nautical experts has enabled us to develop innovative solutions for the maritime sector. Originally based at the Hamburg University of Technology (TUHH), we have now been working at our new research location in Harburg's inland port for around three years, which offers us optimal conditions thanks to its direct location on the water. The construction and move to our modern research building in 2022 was a very special milestone. It provides us with the infrastructure to continue our research at the highest level and develop new technologies.

For me personally, it has been particularly fulfilling to see how Fraunhofer CML has grown from an idea into an internationally recognized research center. Working with talented colleagues and having the opportunity to actively shape innovations for the maritime sector are the biggest highlights for me.

Research sounds like science and university – how do companies in the maritime sector find you?

There are several ways. On the one hand, many companies approach us directly – for example, because they have become aware of us through publications, conference contributions, or specific projects. Our long-standing presence in the industry has created a strong network that constantly opens up new contacts.

Another important avenue is cooperation within the framework of funding projects – for example,

through EU programs such as Horizon Europe or initiatives by federal ministries and the state of Hamburg. In such projects, we work closely with companies to jointly develop innovative solutions.

Thirdly, we use events such as workshops, seminars, specialist conferences, and trade fair appearances to actively engage in dialogues with the industry. These formats are not only important for presenting research results, but also for initiating new partnerships.

Finally, there is also the completely individual approach: companies approach us with specific questions or challenges, often of a technological or strategic nature. We then develop tailor-made, scientifically sound solutions that are designed to their specific needs.

The maritime future is exciting – we are shaping it with innovation, sustainability, and team spirit.

How is cooperation with the industry structured?

Our collaboration with the industry is practice-oriented and focused on developing concrete solutions. This takes place, for example, in the context of contract research, where we work specifically on problems in areas such as ports, shipping, and logistics. Together with companies, we develop new technologies directly in practice to test their suitability for everyday use.

In addition, we offer technical expertise and training to help companies adapt to new technological and regulatory requirements. The collaboration is therefore very diverse – ranging from research to concrete implementation in the workplace.

And what about scientific cooperation?

Cooperation with other research institutions is very important to us. It enables us to address interdisciplinary issues and combine the strengths of different partners. For example, we collaborate on joint research projects with universities, institutes, and international partners to solve complex challenges in maritime logistics.

In addition, we foster scientific exchange through publications, conferences, and specialist networks. Innovation networks such as the Maritime Cluster Northern Germany and the quantum computing network of the Fraunhofer institutions in Hamburg are also particularly important to us—they bring business and science together and promote targeted technology transfer.

What is your recipe for solving today's problems with the means of the future?

Our recipe is based on a combination of scientific excellence, technological innovation, sustainability, and practical implementation. By tackling today's challenges with the tools of tomorrow, we create solutions that not only transform the maritime industry but also make a positive contribution to society and the environment.

What do you see as the biggest challenges for maritime shipping in the coming years – and which developments do you consider particularly groundbreaking?

Technological innovations, environmental requirements, and new geopolitical conditions are bringing about noticeable changes in the industry. The digitalization of the maritime sector is advancing rapidly. It is fundamentally changing the maritime transport chain—from automated processes on board to data-driven decisions in real time. This offers great opportunities, but also requires significant adjustments to existing structures. I also see climate protection—specifically decarboniza-

tion—as a key challenge. Reducing greenhouse gas emissions is not only a regulatory requirement, but also ecologically, socially, and economically essential. Another issue is the resilience of global supply chains. Events such as the COVID-19 pandemic and geopolitical tensions have shown how vulnerable the system is. Maritime supply chains must become more robust, flexible, and digitally connected in order to better cushion future disruptions.

Last but not least, the shortage of skilled workers is a growing problem—both at sea and on land. The industry must position itself much more attractively for young talents and invest in training and further education in order to be able to cope with technological change in terms of personnel.

And which developments do you consider particularly important for the coming years?

I see three key developments: first, alternative propulsion systems and fuels, which play a key role in decarbonization. Second, the use of autonomous and connected ships—they will significantly increase efficiency and safety. And third, the digitalization of ports. Only if ports also get on board can maritime logistics be made holistically sustainable.

Your final thoughts?

The maritime sector is facing profound change driven by demands for sustainability, digitalization, and resilience. The next few years will be crucial in overcoming these challenges and making the industry fit for the future. Innovation, collaboration, and a clear strategic direction will be the keys to success.

I am convinced that the coming years will be at least as exciting and groundbreaking as the past 15. With our technological infrastructures and focus on innovation, sustainability, and collaboration, we are ideally positioned to continue successfully mastering the challenges of the maritime sector. ▪

15 years of Fraunhofer CML

Fraunhofer CML looks back on 15 years of innovative strength and successful collaborations, shaping the future of the maritime sector.

For 15 years now, the Fraunhofer Center for Maritime Logistics and Services (CML) in Hamburg has been shaping the maritime sector with innovative solutions, practical research, and a strong network of science and industry. Founded in 2010 at the Hamburg University of Technology (TUHH), Fraunhofer CML was the first Fraunhofer institution in the Hanseatic city. From the outset, the research institution pursued the goal of bringing research and practice in the fields of maritime logistics, ports, and shipping closer together. After the initial phase on the TUHH premises, the institution moved to a new building in Harburg Harbor, a central maritime location in Hamburg, in 2022. Today, the building offers state-of-the-art laboratories and research infrastructure and enables intensive cooperation with industry partners directly at the heart of the maritime economy.

Numerous projects demonstrate the close cooperation with partners from business and industry – from the automation of logistics processes and intelligent prediction models to specific technologies for ports and shipping companies. These projects are examples of Fraunhofer CML's application-oriented research, which focuses on feasibility and market potential. The topics range from sustainable ship operation and alternative fuels to new technologies such as hydrogen and quantum computing. With the establishment of a hydrogen test center and the development of future refueling solutions in the Port of Hamburg, Fraunhofer CML is clearly committed to the ecological responsibility of the industry.

Hamburg benefits twice over: as the location of an internationally recognized research institution and as a hub for knowledge transfer to the regional economy. Exchange with universities, authorities, and companies not only ensures innovative strength, but also the qualification of future skilled workers. In this way, Fraunhofer CML makes a significant contribution to the competitiveness and sustainability of the maritime industry—today and in the years to come. On the following pages, you will find a timeline of important events and projects that have significantly shaped the path over the past 15 years. ▸

2010
Founding of Fraunhofer CML at TUHH

With a focus on applied research in maritime logistics, the Fraunhofer Center for Maritime Logistics and Services is being founded at the Technical University of Hamburg to develop innovative solutions for ports, shipping, and logistics and to strengthen the competitiveness of the maritime sector.

2011
Design of a Green Container Terminal

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In 2011, Fraunhofer CML develops a design for a Green Container Terminal that integrates sustainable technologies and processes to reduce energy consumption and emissions as part of the EU-funded Green EFFORTS research project. The focus is on environmentally friendly infrastructure, efficient logistics, and innovative energy management systems for green port management.

2012
Launch of MUNIN

In 2012, the MUNIN research project – short for "Maritime Unmanned Navigation through Intelligence in Networks" – launches with the aim of designing a concept for an autonomously operating ship. Funded by the EU, the project lays the foundation at Fraunhofer CML for the development of technical solutions for autonomous maritime navigation.

2014
Optimized personnel planning with SCEDAS®

Evgeny Shulin/shutterstock.com

SCEDAS® is a software solution developed at Fraunhofer CML that helps ship managers calculate detailed work schedules for all seafarers – mathematically optimized with powerful algorithms, ready for use on land and on board. Legal requirements for personnel deployment are automatically taken into account and documented by this comprehensive solution.

2015
Establishment of EMSN

The European Maritime Simulator Network EMSN consists of around 40 ship bridges at more than ten European locations. Developed as part of an EU-funded research program, the network is used for joint training in complex and realistic maneuvers in a simulator environment. The EMSN and its test runs are coordinated at Fraunhofer CML, where the participants' experiences are evaluated for the next development steps – and the network continues to operate successfully to this day.

2015
Perpetuation as an institution of the Fraunhofer-Gesellschaft

After a successful five-year start-up phase, Fraunhofer CML is officially established as a permanent institution of the Fraunhofer-Gesellschaft. This secures its role as a leading research institution for maritime logistics and innovative port solutions in the long term and creates the basis for applied maritime research.

2016
Study on cooperation between North German seaports

iStock.com/chuyu

How can northern German seaports work together cooperatively to make optimal use of their locational advantages, balance the burden on infrastructure, and standardize processes for the benefit of their customers? In 2016, Fraunhofer CML is investigating the interrelationships in a study and developing innovative proposals for strengthening the individual locations.

2017
Remote-controlled harbor tugboats

Starting in September 2017, Fraunhofer CML plays a key role in the FernSAMS project ("Use of Remote-Controlled Tugs during Berthing Maneuvers of Large Ships"), which is funded by the German Federal Ministry for Economic Affairs and Energy. The aim is to develop safe and efficient RoboTugs that are controlled from land. A key contribution from Fraunhofer CML: augmented reality visualization that expands the tugboat's field of vision with virtual displays – this creates realistic situational awareness and supports safe control from land.

2018
Emissions reduction, digitalization of the transport chain

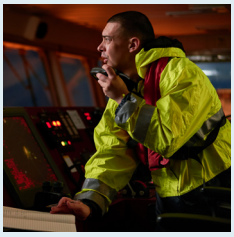
Fahroni/shutterstock.com

Fraunhofer CML actively promotes emission reduction and smart digital logistics: With the EmissionSEA project, funded by the Federal Ministry of Transport, a software prototype for CO_2 calculation using AIS, weather, and ship data will be developed starting in 2018. The information from this software will enable shipping companies to obtain reference values for the mandatory reports on CO_2 emissions in European waters.

2019
Laying of the foundation stone for the new building in Harburg's inland port

The ceremonial laying of the foundation stone in June 2019 marks an important milestone for Fraunhofer CML in Harburg's inland port. The new building heralds the dawn of a pioneering era of research in the field of maritime logistics. State-of-the-art infrastructure creates ideal conditions for applied science and close cooperation with industry and business. The new building symbolizes not only growth, but also a clear commitment to Hamburg as a location. It is creating a place where innovative ideas take shape – an important source of inspiration for the future of maritime logistics and services.

2019
Transcription of maritime radio communications



Denys Yelmanov/shutterstock.com

Starting in 2019, Fraunhofer CML uses marFM® to develop AI-supported systems for the automatic transcription of maritime VHF radio messages, including radio location, to improve communication and documentation. With the help of marFM®, information can be reliably exchanged among rescue services, especially in maritime emergencies where acoustic and linguistic impairments interfere with vital radio transmission.

2020

Use of autonomous research platforms in the SeaClear1.0 project

In the EU-funded SeaClear project, Fraunhofer CML is developing autonomous robots that efficiently detect, classify, and collect marine debris. The project uses unmanned underwater, surface, and aerial vehicles that work together in a network. In the follow-up project SeaClear2.0, the system is being further developed and scaled to make seabed cleaning even more effective. Fraunhofer CML's research platforms are important components of this innovative solution.

2021

Maritime hydrogen transport and handling

Logistics chains for transporting green hydrogen by truck, freight train, and inland waterway vessel are being modeled and simulated by Fraunhofer CML in collaboration with Fraunhofer IGP as part of the H2 Logistics project funded by the German Federation of Industrial Research and University-Related Research Associations (AiF). In a study on Hamburg's role as a future hydrogen hub, Fraunhofer CML assesses the maritime import and production potential, including port infrastructure, and shows that Hamburg can play a central role in meeting a significant proportion of Germany's total hydrogen demand in the context of the energy transition.

2022

Computer vision on the terminal

In 2022, Fraunhofer CML begins intensive research into the application of computer vision in maritime logistics. The COOKIE project, funded by the German Federal Ministry of Transport, is developing an AI-based system for automated damage detection on containers. The aim is to make this container management task safer, more efficient, and largely digital.

2023

Quantum computing & founding of Fraunhofer IQHH

In 2023, the four Fraunhofer institutions in Hamburg – CML, IAP, IAPT, ITMP – jointly establish the Fraunhofer IQHH virtual application center for quantum computing in order to efficiently implement industrial applications in the fields of maritime logistics, additive manufacturing, materials development, and drug research.

2023
AI in truck handling

Projects such as KIK-Lee and FLEXIKING, both funded by the Federal Ministry of Transport, use AI to predict arrival times, dynamically adjust time slots, and reduce waiting times. This optimizes truck handling at logistics hubs, improves transport processes, and helps reduce emissions in the transport sector.

2024
Mobile robotics at the terminal

In the Pin-Handling-mR project, funded by the German Federal Ministry of Transport, Fraunhofer CML is demonstrating the potential of mobile robotics for optimizing workflows and increasing efficiency in port environments: In collaboration with Hamburger Hafen und Logistik AG (HHLA), a mobile robot is being developed to automate the manual insertion of folding pins into container wagons. This increases work safety and boosts efficiency in terminal operations.

2025
Christening of research vessel Vektor

On February 20, the research vessel Vektor is ceremoniously christened by Senator Dr. Melanie Leonhard. In addition to autonomous navigation, the former police boat serves as a platform for above-water and underwater drones as well as for data collection.

2025
15 years of Fraunhofer CML

Fraunhofer CML celebrates 15 years of innovation in maritime research. With groundbreaking projects, it is actively shaping the future of digital and sustainable shipping and port logistics. Building on this strong foundation, Fraunhofer CML looks ahead to the coming decades with energy and vision – ready to make maritime technologies even smarter, more efficient, and greener.

Dr. Gaby Bornheim

As managing director, Dr. Gaby Bornheim has been jointly responsible for the management of Peter Döhle Schiffahrts-KG, one of Germany's largest shipping companies, for many years. She is the first woman to hold the office of president in the 114-year history of the German Shipowners' Association (VDR).

» For 15 years, the Fraunhofer Center for Maritime Logistics and Services (CML) has stood for innovation, practical relevance, and future orientation in the maritime industry. With its research into digital solutions, automation, sustainability, and efficient logistics chains, Fraunhofer CML, led by Professor Jahn and its highly motivated staff, is making a decisive contribution to keeping ports, maritime logistics, shipping companies, and shipbuilding competitive.

As a connector between science and industry, it develops practical concepts and provides impetus for maritime transformation. This anniversary underscores not only the successes of recent years, but also the growing importance of Fraunhofer CML as a partner for sustainable and efficient maritime logistics of the future. Vivat! Crescat! Floreat! «

Prof. Dr. Axel Müller-Groeling

Prof. Dr. Axel Müller-Groeling is a physicist who has worked in Kiel, Bonn, and Heidelberg. After working in science and industry, he has held management positions at Fraunhofer Institutes since 2016. Since 2022, he has been a member of the Executive Board of the Fraunhofer-Gesellschaft, responsible for research infrastructures and digitalization.

» Over the past 15 years, Fraunhofer CML has established itself as an indispensable source of inspiration for the maritime industry. With its strong links between applied research and practice, Fraunhofer CML designs innovative solutions for sustainable, efficient, and future-proof maritime infrastructure.

Its expertise in areas such as autonomous systems, AI, and hydrogen technologies makes the institution a beacon of maritime research in Europe.

We are proud that CML, as part of the Fraunhofer-Gesellschaft, is strengthening the competitiveness of the maritime industry and driving innovation – for the benefit of the economy, the environment, and society. Congratulations on your anniversary! «

Ports and Transport Markets: Partner for innovation and future-proofing

Strategic investments and modern infrastructure projects require reliable information and innovative technologies.

The Port and Terminal Development Group provides support in the development of forward-looking strategies, the evaluation of technologies and innovations, and the implementation of digitalization projects.

Based on many years of experience in maritime projects, the group provides in-depth analyses, targeted data, and innovative solutions in the areas of strategic consulting, technology, and digitalization. Micro and macro traffic simulation models can also be used to visualize, analyze, and optimize traffic in ports and terminals. For example, the potential impact of autonomous trucks on operations in a container terminal was investigated.

Given limited financial resources, it is crucial that investments in transport infrastructure are targeted at locations with proven high demand. Sustainable and demand-oriented infrastructure planning is only possible with sound demand forecasts and justifications. Our studies and forecasts on transport demand make a significant contribution to determining whether new projects or maintenance measures are economically viable and socially necessary.

Our data-driven studies enable resources to be used efficiently and misguided investments to be avoided. Infrastructure maintenance is by far the largest cost factor for seaports and inland ports. We are researching innovative methods, e.g., to better predict corrosion of sheet pile walls, in order to target scarce resources effectively.

The WaCaBa project—short for Water Cargo Barge—funded by the Hamburg Ministry of Economic Affairs, Labor, and Innovation, aimed to strengthen water transport and cargo handling on Hamburg's inner-city waterways.

The operation of barges is intended to relieve inner-city roads and help reduce pollutant emissions from delivery traffic through modern propulsion systems. It would also contribute to the achievement of environmental goals. With its multitude of waterways and canals, which provide access to large parts of the city, Hamburg offers considerable potential for this. An important prerequisite for the use of barges is the navigability of the waterways. Since many of them in Hamburg have been partially unused for years, their condition sets strict requirements for navigation and transshipment.

Whether short-term adjustments or long-term developments for the construction of new port and terminal infrastructure in the port and hinterland – an information advantage regarding trade volumes and their distribution across transport corridors and modes of transport creates certainty and flexibility. ▪

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EyeCaptain: Maritime Situation Awareness reimagined

EyeCaptain combines state-of-the-art sensor technology with intelligent software – an innovative assistance system that significantly increases safety and visibility on board.

With the EyeCaptain project, Fraunhofer CML has teamed up with shipping company Bernhard Schulte to develop a camera-based system that supports the bridge team during navigation, combining real-world shipping requirements with the latest research findings. The aim was to significantly improve situation awareness (SA) on board. The system was designed to provide support, particularly in complex sailing situations, in narrow fairways, or in poor visibility. The system developed as part of EyeCaptain impressively demonstrates how findings from applied research can be utilized for operational ship management.

EyeCaptain combines visual data from 360° panoramic cameras and thermal imaging cameras with real-time data from AIS (Automatic Identification System), GPS (Global Positioning System), radar, and electronic nautical charts. The real-time data is collected and interpreted using modular software components and displayed on a touchscreen on the bridge via an intuitive user interface. The system not only supports visual orientation, but also automatically detects dangerous situations, including by calculating the closest point of approach (CPA) and the time to CPA (TCPA). The calculations enable the system to actively warn the user of collisions, groundings, or risky encounters. Relevant events are automatically recorded and can be analyzed later on land.

The development of the system began in 2021 and underwent several pilot phases on selected ships in the Schulte fleet. The very positive response from the nautical crew led to the decision

to implement EyeCaptain in various stages across the entire fleet. The initial core system (360° panorama, thermal cameras, software) was upgraded to the full version with additional cameras on the bridge cams for maneuvers in narrow ports.

The utilization of previous research projects in EyeCaptain is particularly noteworthy. Key components were adopted from the B ZERO project funded by the Federal Ministry for Economic Affairs and Energy (BMWE). The automated evaluation of the traffic situation, taking into account the Collision Regulations (COLREGs), and the sensor fusion of radar, AIS, and position data represented particularly valuable enhancements to the existing system architecture. These capabilities were further developed specifically for use in a production-ready system. The FernSAMS project, also funded by the BMWE, in which Fraunhofer CML developed a visual support interface for the remote control of tugboats, also provided important impetus for the design of the camera view and user interaction in EyeCaptain. The result is a highly mature system that is capable of increasing both safety and efficiency in ship operations. At the same time, it opens up new perspectives for the data-based analysis of ship maneuvers afterwards, for example for training or for optimizing internal safety procedures.

The integration of EyeCaptain into regular operations is a prime example of how Fraunhofer CML, through continuous research and collaborative development, creates practical innovations that go beyond the status of a demonstrator and offer real added value in everyday shipping operations. ▪

Fraunhofer CML impresses with its blend of science and business relevance, bringing new perspectives to the collaboration.

Lennart Swoboda
Head of Autonomy,
Bernhard Schulte GmbH & Co. KG

Senator Dr. Melanie Leonhard

Dr. Melanie Leonhard is Senator for the Hamburg Ministry of Economic Affairs, Labor, and Innovation. Since 2011, the historian, who holds a doctorate, has been a member of the Hamburg Parliament and, since 2018, has been the state chairwoman of the SPD Hamburg.

» For 15 years, Fraunhofer CML has been a beacon of maritime innovation and technological excellence in Harburg, combining innovation, research, and business.

In the heart of Harburg's inland port and Hamburg's strong innovation ecosystem, solutions are being developed for the challenges facing tomorrow's maritime industry. With a focus on digitalization, artificial intelligence, and sustainability, Fraunhofer CML is actively shaping the transition to climate-neutral, efficient shipping. Fifteen years of excellent research at Fraunhofer CML have made a significant contribution to shaping the maritime issues of the future.

Working together from Hamburg, a hub of innovation, to promote the maritime industry in a sustainable manner – that is my wish for Fraunhofer CML and all its partners in the years to come! «

Dr. Wibke Mellwig

Dr. Wibke Mellwig is Head of the Waterways and Shipping Department at the Federal Ministry of Transport. Prior to this, the doctor of law was Head of Office at the Hamburg Tax Authority and also worked for the Hamburg Economic Authority and the Federal Ministry for the Environment.

» Over the past 15 years, Fraunhofer CML has developed into an excellent research partner in the field of innovative technologies for the port industry.

The applied research conducted by Fraunhofer CML makes a significant contribution to the study and optimization of modern ports. With innovative solutions such as the development of digital twins, automation technologies, and AI-supported analyses, Fraunhofer CML improves the efficiency and sustainability of port processes. Close cooperation with port operators, shipping companies, and global partners ensures that the results of Fraunhofer CML's research are implemented in a practical manner and strengthen Germany's role as a center of innovation in the maritime industry. «


Innok
Robotics

Mobile Robotics in ports

With smart robotics solutions, Fraunhofer CML is bringing fresh momentum to port logistics – making processes more efficient, safer, and ready for the challenges of tomorrow.

Port operations face specific risks and demanding requirements. Dynamic markets, geopolitical influences, and growing ship sizes make planning difficult and increase pressure on infrastructure and superstructure. High safety standards, stricter environmental regulations, and competition for market share, technologies, and skilled workers are driving the optimization of processes and costs. Automation is increasingly emerging as a technology for overcoming these challenges. From an occupational safety perspective, automated or remote-controlled processes, in which terminal employees are not directly on site where the related activity is being carried out or in the cab of the respective handling or transport vehicle, are safer than manual processes. But it is also about reducing operating costs, increasing process reliability, and responding to the shortage of skilled workers.

The challenges and trends in ports with regard to automation encompass three main areas of application for the promising use of mobile robots: transport, inspection, and manipulation. Fraunhofer CML has application-oriented examples for each of these main areas of application.

Collaborative general cargo transport

Approaches to automated transport in port logistics include conveyor belts for bulk cargo and driverless transport systems (e.g., automated guided vehicles = AGV) for containers. AGV operate in defined areas, use transponders for localization, and have a lower degree of autonomy than mobile robots. In addition to cargo transport, special transports, such as the on-demand transport of spare parts, tools, or rigging gears, are necessary. These are currently carried out with terminal-owned vehicles or forklifts equipped with flashing lights. The use of mobile robots with a suitable payload for such tasks offers advantages: Terminal employees can take on more skilled tasks, and automated transport increases safety and reduces disruptions in terminal operations. In our specific case, we consider general cargo terminals, where the material flow is manual and labor-intensive.

Our automation approach focuses on the horizontal transport of cargo between the quay crane and the warehouse – using one, two, or even several transport units, depending on the cargo-related requirements. Collaborative transport of general cargo was designed on a laboratory scale, and the core functions were developed and tested. The robots have been equipped with sensor systems that enable localization and obstacles detection. The current tests show that our approach can be transferred from the laboratory demonstration to a real working environment.

Regular inspections of the infrastructure (roadways, railway, or crane rail tracks), the superstructure (transport and handling equipment), and the cargo are crucial for safe port operations. These inspections are mainly carried out by terminal employees who walk through the relevant areas. They usually check the objects to be inspected visually for any abnormalities. Any anomalies found are documented and either rectified immediately

or documented so that the necessary measures can be taken. Our application combines the innovative technologies of virtual reality and augmented reality with the capabilities of mobile robots to make inspection and repair tasks more efficient. The central idea is that the inspection is carried out by the robot, while the terminal employee initiates and monitors the inspection process from the office and intervenes only if necessary. This was demonstrated using a fictitious inspection in our new building. By combining the quadruped robot with immersive technologies, users can explore the inspection site virtually without being physically present. This approach is particularly advantageous in hazardous working environments. It also promotes digitalization, as the documentation of the inventory is not created after the inspection, but in real time. In the long term, the mobile robot should operate more independently and be able to detect anomalies on its own.

Automated manipulation of container pins on transport wagons

Most container terminals have a rail area that connects the port and to the hinterland. Container trains are firstly unloaded, and then loaded with import containers. Railway waggons are equip-

ped with folding pins which serve the purpose of fixing containers and preventing slipping. Depending on the loading plan, pins are manually folded up or down before loading. Two employees set the pins along the approximately 800-meter-long train using printed plans. This repetitive task carried out in a working zone of potential risk for terminal staff has potential for automation. In the Pin-Handling-mR project, a mobile robot for automated pin handling was developed and successfully tested. After laboratory tests, the application was piloted in a real working environment. The mobile robot reliably navigates to the correct lane between trains, moves to given pin positions, moves to the pin positions, detects the pins, and flips them according to the target status using a robot arm with a magnetic gripper. Tests conducted over several months prove the robustness of the system at temperatures ranging from -10°C to +30°C, in changing weather and under varying lighting conditions.

The integration of complex functions such as order management, navigation, object recognition, and manipulation make this application to a highly innovative project. After the successful validation, the application is supposed to be made more robust, and extended to further pin types. ▪

SeaDragon brings future technologies from the laboratory to the port – practical, autonomous, and AI-supported.

Prof. Carlos Jahn
Head of Fraunhofer CML


SELVA
SeaML-Tender
HH-AF 141

Voices from Fraunhofer CML

Around 100 people from more than 20 countries work at Fraunhofer CML – below, some of them talk about what makes their work special.

Dr. rer. nat. Valeria Bartsch
Research Associate
Maritime Scientific Computing and Optimization

» It is exciting to be able to apply my passion for quantum computing in the field of maritime logistics. «

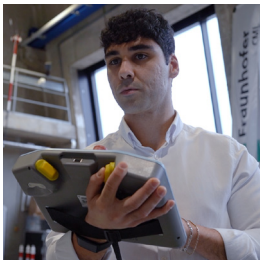
Lennart Grambow, M. Sc.
Research Associate
Maritime Technologies and Biomimetics

» Technology meets ocean: Innovation does not arise solely from theory; practical application is the key to progress. «

Dipl.-Kfm. Kai Lehnert
Head of Department
Administration

» My job is to create organizational frameworks that keep research optimally on track for innovation. «

Can Ongun, M. Sc.
Research Associate
Port Technologies



» I am proud to be developing innovative robotics solutions for the maritime future at Fraunhofer CML with creativity and team spirit. «

Dipl.-Wi.-Ing. Johann Bergmann
Team Leader
Port Technologies

» The proximity to industrial practice and technology neutrality make working in the field of port technologies particularly attractive. «

Dipl.-Ing. Ralf Fiedler
Group Leader
Ports and Transport Markets

» Future-proof ports and terminals: We support investment decisions with innovative strategies and precise analyses. «

Dr. Ole John, MBA
Head of Department
Ship and Information Management

» Research means mapping the unknown and using technologies in such a way that they create real added value. «

Etta Weiner, M. A.
PR Officer
Corporate Communications

»In public relations, we transform scientific work into exciting messages for a broad audience. «

Chhandosee Bhattacharya, M. Sc.
Research Associate
Maritime Operations Management

» My AI research at Fraunhofer CML is exciting and innovative, with the freedom to explore new ideas and technologies and collaborate with partners. «

Dipl.-Wirtsch.-Ing. Univ.
Hans-Christoph Burmeister
Head of Department
Sea Traffic and Nautical Solutions

» My task: to make tomorrow's maritime technologies tangible and implementable – and to put out a few fires in the project business. «

Sven Becker
Workshop management
Sea Traffic and Nautical Solutions

» With technical expertise on board, we support maritime research and thus make scientific findings visible. «

Dr.-Ing. Anisa Rizvanolli
Team Leader
Maritime Scientific Computing and Optimization

» From the start in research to strategic development – I am grateful for a strong team, trust, and many ideas for the future.. «


Fraunhofer
CML

Digital innovation and cyber risks in maritime shipping

The Ship and Information Management department focuses on the digitalization of the maritime transport chain, ship operations, and safety equipment at sea.

The digitalization of the maritime transport chain is an ideal environment for the use of artificial intelligence and quantum computing solutions. The complex transport chain offers great potential for optimizing logistics processes with the aim of increasing efficiency through digitalization for the seamless and simultaneous exchange of all transport-related information. This affects all elements of the chain: from the optimized utilization of a transport container to the optimized flow of trains and trucks to and from ports, to the sequence of handling at the terminal gate and the inspection of containers in the empty container depot for damage and contamination.

Artificial intelligence for efficient and safe ship operations

Fraunhofer CML develops applications for ship operations that optimize personnel deployment and route planning. Highly complex problems can be mapped and optimized with the help of machine learning or other artificial intelligence applications. This improves personnel availability on board and thus enhances maritime safety. Optimized route planning, which can also respond flexibly to schedule changes, leads to optimized fleet utilization and greater process efficiency, also associated with lower emissions.

Research for safe shipping: Cyber resilience with Fraunhofer CML

However, digitalization can also have its downsides. On the one hand, digital systems and data transmission channels can be hacked by third parties, compromising or blocking IT systems. On the other hand, false information can be fed into the system, which in the worst case can result in an accident at sea or in port. This is because disrupted or falsified AIS signals mean that ships can no longer reliably identify their own position or that of other ships on the electronic nautical chart. Furthermore, this poses a threat to commercial shipping and leads to a general deterioration in safety in the North Sea and Baltic Sea. The Cybersecurity Laboratory at Fraunhofer CML investigates the effects of cyberattacks on navigation and communication systems and components. Commercially available devices are connected in this laboratory and tested for their resilience against hacker attacks for our clients. In addition, the researchers detect falsified AIS signals, thus enabling decisions based on false information to be avoided.

In recent months, there has been an increase in the use of merchant ships as platforms for transmitting falsified AIS information. These ships can be identified by tracking their transmissions – the

first prerequisite for initiating protective measures. Fraunhofer CML can contribute to this by setting up mobile sensor networks. Three mobile antenna platforms are used in conjunction with our research vessel Vektor. The antenna platforms are placed at different coastal locations and use various sensors to pick up signals from the surveillance area. Additional data can be recorded by the Vektor at sea and, with the help of AI modules, together they generate a meaningful and up-to-date maritime situation picture. ▪

Prof. Dr.-Ing. Andreas Timm-Giel

Prof. Dr.-Ing. Andreas Timm-Giel has been a professor at Hamburg University of Technology (TUHH) since 2009 and he is its president since 2020. As an expert in communication networks, he is shaping the digital future – from smart mobility to maritime research.

» The Technical University of Hamburg and the Fraunhofer Center for Maritime Logistics and Services have enjoyed a close partnership for many years – strengthened by their proximity in Harburg's inland port and strong networking in the Hamburg metropolitan region. Under the scientific direction of Prof. Carlos Jahn, Fraunhofer CML has developed into a key partner of TU Hamburg in research and innovation. Together, we are implementing our guiding principle of "Engineering to Face Climate Change" – particularly in the research fields of aviation and maritime systems, as well as logistics, mobility, and infrastructure.

Fraunhofer CML stands for excellent, research that makes a decisive contribution to greener logistics and shipping. Congratulations on your 15th anniversary – and here's to many more successful years of collaboration! «

The founding of Fraunhofer CML 15 years ago provided a significant boost to maritime research in Germany. From the first projects to its state-of-the-art research facility on the waterfront, Fraunhofer CML combines interdisciplinary expertise with innovation to drive forward digitalization, automation, and sustainability.

This brochure outlines the development of the institution and selected research projects that address current challenges facing the industry—from autonomous ships and smart port solutions to environmentally friendly technologies. This paints an impressive picture of a research center that is helping to shape the maritime world of tomorrow.