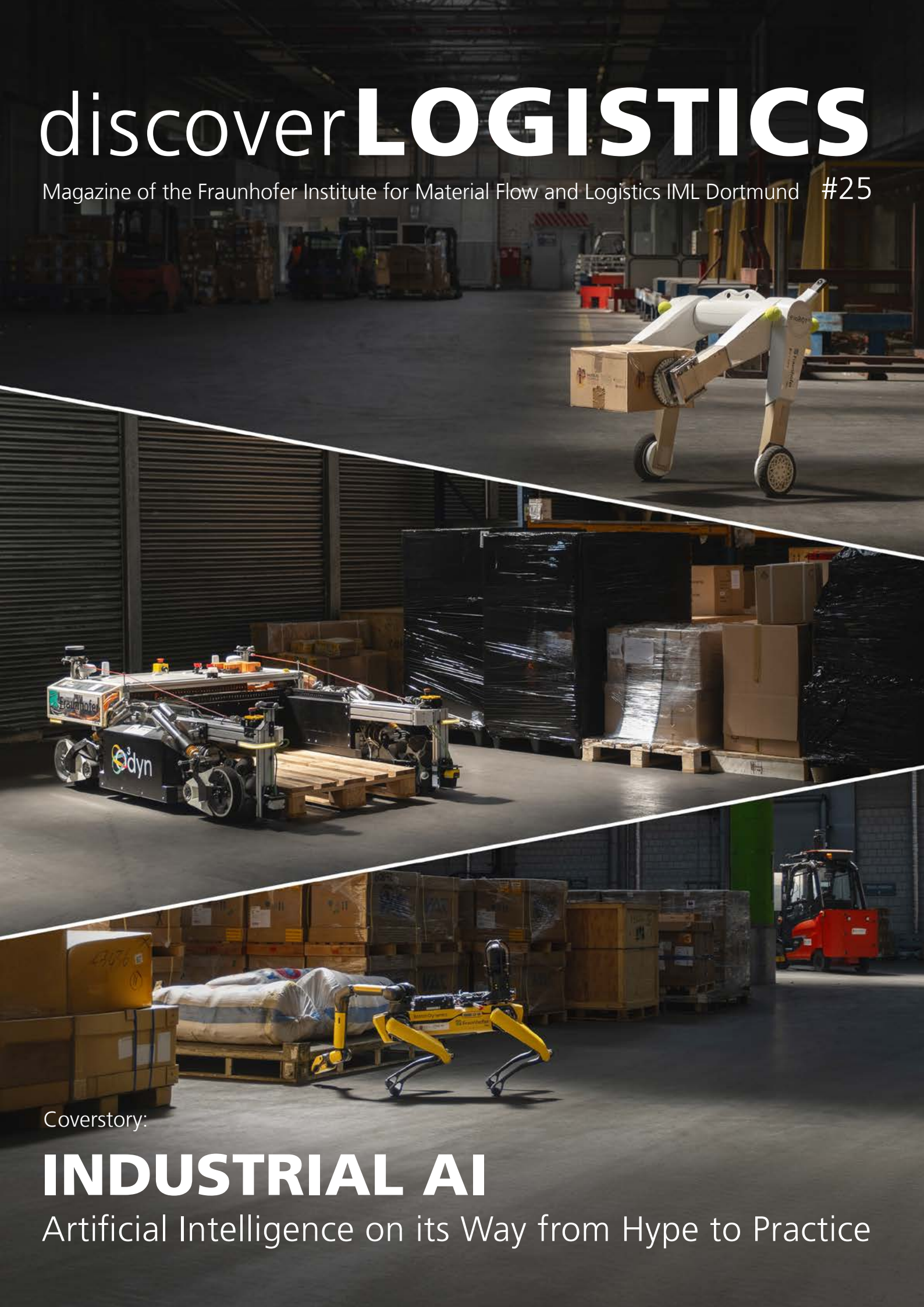
discoverLOGISTICS

Magazine of the Fraunhofer Institute for Material Flow and Logistics IML Dortmund #25



Coverstory:

INDUSTRIAL AI

Artificial Intelligence on its Way from Hype to Practice

About us

The Fraunhofer Institute for Material Flow and Logistics IML is the partner of choice for integrated logistics research. It works in all fields of internal and external logistics. In keeping with the concepts of the Fraunhofer-Gesellschaft, solutions to problems for immediate use in business are developed on the one hand, but initial research is also conducted on the other hand. Founded in 1981, the institute currently employs more than 700 people, including around 470 scientific staff.

Teams assembled according to project and customer requirements create cross-industry and customer-specific solutions, among other things in the field of materials handling, business process modelling, transportation systems and resource logistics. Artificial intelligence, smart finance and the Internet of Things are also among the current research focal points.

For interdisciplinary projects, the institute has access to a total of 30,800 employees in 76 facilities of the entire Fraunhofer-Gesellschaft.

Locations aside from Dortmund include Frankfurt/Main, Hamburg, Prien am Chiemsee and Beijing.

www.iml.fraunhofer.de

Dear friends of **logistics,**

Bettina von Janczewski
Team leader press and media
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Artificial intelligence (AI) is increasingly becoming part of our everyday lives – and at this point, it is almost impossible to imagine the logistics sector without it. Innovations that, for many years, had just been hypothetical ideas or visions of the future are now on the verge of being put into application in our industry – or have already been in use for some time. Fraunhofer IML is also involved in numerous developments in this area. That is why in this issue, we want to show you how artificial intelligence (including AI applications from Dortmund) is conquering the world of logistics – by contributing to developments in robotics, helping to form new business models and supporting optimization in transportation logistics.

Logistics is considered to be the discipline in which such new technologies are the first to break through. Our institute management team highlighted this fact in an extensive interview for this issue's coverstory (p. 6). It is time to move beyond the initial hype around technologies like large language models. Let us use AI, both, as the basis for developing more advanced business models along supply chains and also already for practical industry issues. In addition, our institute directors, Prof. Alice Kirchheim, Prof. Michael Henke and Prof. Uwe Clausen, will talk about the future of applied logistics research and how this field is developing – and also about the social dimension of artificial intelligence.

In this issue, we will also give you some insights into practical tests of AI-driven developments that are being conducted in locations ranging from airport runways (p. 46) to hospitals (p. 52). Another focus area for our institute's research is blockchain technology: The full, impressive potential of this technology, particularly when used in conjunction with AI, is only now being unveiled, and a number of promising new projects have been launched in recent months (explored on p. 36, p. 40 and in the interview with our institute management team). We also have new information to share with you on important, "slow-burn" topics in logistics – from ergonomics (p. 24) to innovations in packaging logistics (p. 26) to low-noise logistics (p. 50).

What's more, our award-winning Fraunhofer Enterprise Labs are breaking new ground: In recent times, these "Open Labs" have given multiple companies the opportunity to work on their future in collaboration with Fraunhofer IML (p. 16). This format enables small and medium-sized enterprises (SMEs) in particular to access our institute's research infrastructure. And there is always something new to report from our joint research with our long-standing Enterprise Lab partners – in this issue, we report on our success story with Rhenus SE & Co. KG, a company that has been working with us in Dortmund since 2017 (p. 18).

We hope you enjoy reading this issue.

The "discover Logistics" editorial team

Content

discover Logistics #25

f. l.: Prof. Uwe Clausen (Department of Logistics, Traffic and Environment), Prof. Alice Kirchheim (Department of Material Flow Systems) and Prof. Michael Henke (Department of Enterprise Logistics)

Interview

"No one will be able to overlook Dortmund when it comes to AI and blockchain, even outside the fields of logistics and supply chain management."

Since April 2024, a new institute management team has been setting the course for Fraunhofer IML. In an interview with the "discover LOGISTICS" magazine, Alice Kirchheim, Michael Henke and Uwe Clausen talk about developments in applied logistics research and the future of this field – as well as sharing their thoughts on how logistics and our society as a whole will benefit from widespread use of artificial intelligence.

Prof. Kirchheim, you have completed your first months as a new institute director now. What are your first impressions of Fraunhofer IML and the institute site in Dortmund?

Kirchheim: I feel very comfortable – overall, the phrase that comes to mind is that I'm "here to stay." When looking at it from the outside in the past, I always saw Fraunhofer IML as a vibrant organization with committed, enthusiastic employees. This impression has been confirmed – and it's exactly what I'd hoped for, because this is the kind of environment I love to work in. In recent decades, Fraunhofer IML has played a significant role in establishing Dortmund's position as a hub for logistics. An ecosystem of initiatives, projects, companies and start-ups has emerged here, many of them have offices in the same neighborhood as Fraunhofer IML. Of course, TU Dortmund is also a vital part of the site. Germany's first university course in logistics was set up at TU Dortmund over two decades ago, and multiple faculties are conducting research on logistics subjects there. In essence, it just doesn't get any better than this.

Personally, I'm still only just getting to know Dortmund and the whole Ruhr area – the city and the entire region offer lots of variety in terms of the culture and landscape. Moving here straight away was the right decision, and at the end of the day, it's only a short train journey from here to my hometown of Hamburg.

What attracted you to move from concentrating on basic research in a university setting to a Fraunhofer institute, where the focus is very much on applied research?

Kirchheim: Since completing my studies, I have worked at universities, universities of applied sciences, in industry and freelance, but always in the field of intralogistics. The way people interact and work together across all these contexts varies greatly. I felt comfortable everywhere I worked, but something was always missing. In combining my role at Fraunhofer IML with my chair at TU Dortmund, I have the best of both worlds. So I don't feel like I've switched from basic university research to applied research. But one thing is true of course: I was already looking for an application-oriented position as a research assistant in Bremen and found it...in logistics.

Prof. Henke and Prof. Clausen, while Prof. Kirchheim just joined the institute in 2024, you already have many years of experience at Fraunhofer IML. What's different today in comparison to when you started? How has logistics research changed since then?

Henke: In the last eleven years, since I began working in Dortmund, enormous strides have been made in logistics and supply chain management research – not only due to the occasionally disruptive changes in industry and society in recent years, but also because of the breakthrough of new technologies such as artificial intelligence (AI). That means the ecosystem in Dortmund's scientific hub has become even broader and more diverse than it already was in 2013.

Fortunately, two things have stayed the same: 1. We have and are quietly pursuing a strategic plan that will take us well into the future. 2. Logistics continues to be the field where new technologies always break through first. In the future, we want to focus stronger on developing new business models for these technologies along supply chains.

> **"Logistics continues to be the field where new technologies always break through first. In the future, we want to focus stronger on developing new business models for these technologies along supply chains"**
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> Univ.-Prof. Dr. habil. Dr. h. c. Michael Henke

Clausen: Much has changed in the more than 23 years that I have been a director of Fraunhofer IML. When I started, online retail was only just getting off the ground – today, it is a vital platform for (almost) all types of goods, and we are considering how we can manage cross-channel coordination of distribution processes in real time, i.e., take a "unified commerce" approach.

Back then, there was no talk of the internet of things; today, we're realizing how many aspects of that concept can work in actual logistics systems.

Back then, we said environmental assessments were important; today, we know much more about how we can actually implement them in practice – we helped to develop ISO 14083 and we are driving the transition to low-carbon logistics.

Back then, we had laid the foundations for DISMOD and had already implemented it in a number of industry and trade projects; today, this transportation logistics software is available as a web-based program, has been improved with multimodal features and has been used as the basis for 300 projects and five licensed applications, which means it is probably Fraunhofer IML's most successful software.

Although the scientific world was already talking about AI in my early days at Fraunhofer IML, we're only starting to be able to fully exploit its potential and put it into widespread application now. These days, we are also giving more im-

Prof. Dr.-Ing. Alice Kirchheim

portance to interdisciplinary collaboration and agile working methods, which are bringing us new opportunities.

One thing that will probably always stay the same is the need to provide the best logistics service while making the most cost-effective use of resources possible – but in the logistics sector, our confidence has (justifiably!) grown. Because the sector orchestrates the flow of goods and information, logistics is crucial to the success of companies and economies. This is true in general, but as an institute we have been able to contribute a great deal to this over the last two decades.

> **"The (justifiably!) self-confidence of logistics has increased. By orchestrating the flow of goods and information, logistics makes an important contribution to the success of companies and economies"**
>
> Prof. Dr.-Ing. Uwe Clausen

Prof. Kirchheim, you have taken over from Prof. Michael ten Hompel, who was one of the driving forces in the institute for over 20 years. Which topics will you be focusing on in your research, and are you planning to prioritize any new key areas at Fraunhofer IML and in the Chair of Materials Handling and Warehousing at TU Dortmund University?

Kirchheim: You're absolutely right – Prof. Michael ten Hompel has had a significant impact on intralogistics in the last few decades, and in his work here at Fraunhofer IML, along with his colleagues and all our employees, he has made a huge contribution to the ecosystem. With his visionary, holistic approach, he has driven progress around topics and concepts such as the internet of things, simulation-based AI and the digital continuum. So I personally feel I was very fortunate to take over the management of an institute that has developed so well and is running smoothly. However, this means I need to be the one to adapt, because I don't believe in changing a running system. In summary, after almost 100 days at Fraunhofer IML, I'd say we're moving forward in the right fields. And we will keep this progress going, particularly in mobile robotics and artificial intelligence. Deploying large language models in industry is a very topical field of research right now. But in this area, too, our employees are already bringing their first projects into implementation with our partners. Exactly the same applies to the Chair of Material Handling and Warehousing, where Dr. Moritz Roidl has been making significant contributions to the theoretical side of this field for many years. Maintaining the close connections between Fraunhofer IML and the Chair is important to me, because basic research gives rise to relevant topics for applied research, which can then be transferred to industry.

At the same time, we will be actively working on new topics and incorporating them into our research agenda.

What topics are going to shape your divisions – Material Flow Systems, Enterprise Logistics, and Logistics, Transport and Environment – and the research they carry out?

Kirchheim: Many high-performance intralogistic systems today contain kilometers of continuous handling equipment and, depending on the circumstances, large sorting machi-

nes. These are not flexible systems. It takes a long time to install them, they cost a lot to service and maintain, and you need to do a huge amount of work to adapt them to new conditions. Autonomous mobile robots, on the other hand, are flexible and don't come with any of these disadvantages. They are the future of intralogistic transportation. With the LoadRunner, evoBOT and O³dyn, we've made huge strides in the last few years in terms of researching and developing mobile robots for the logistics systems of the future. Now it's important that we stay on the ball. When we look to the future, humanoid robots are already on the horizon. In recent months, there have been some press releases from large corporations that have begun collaborations with companies or will be carrying out initial tests in the areas of production and logistics. And one thing is clear: Logistics will be a major field of application for humanoid robots. And artificial intelligence is at the heart of all these developments.

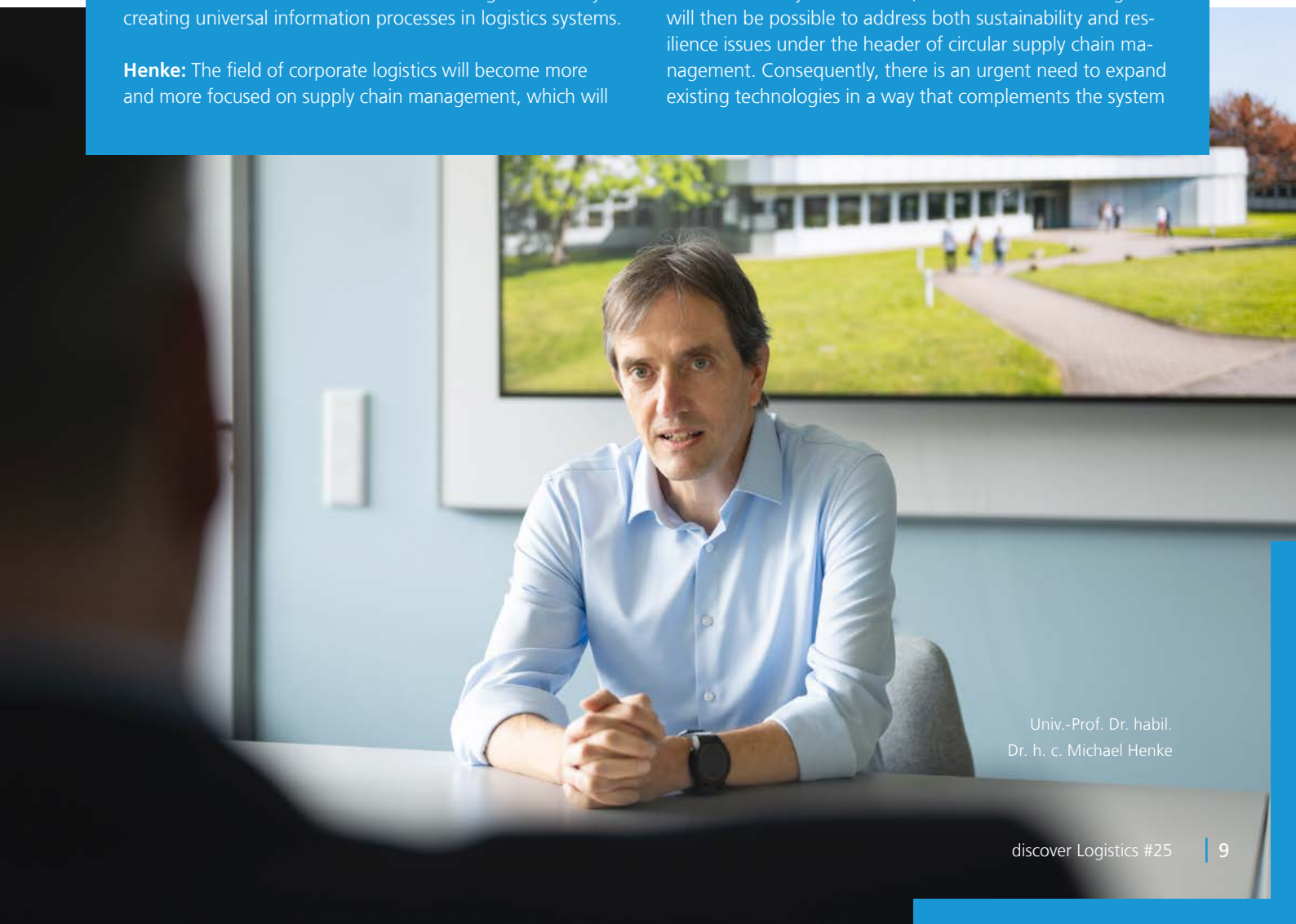
"Logistics will be a major field of application for humanoid robots"

Prof. Dr.-Ing. Alice Kirchheim

But I would like to add that here at Fraunhofer IML, we're not always just working on new trends and fields. We also have a lot of people working on exciting, slow-burn topics, including sustainable packaging, assistance systems for ergonomic workplaces and our warehouse logistics platform, not to mention our continued efforts to drive digitalization by creating universal information processes in logistics systems.

Henke: The field of corporate logistics will become more and more focused on supply chain management, which will actually encapsulate the flow of materials, information and finance. That's why we're working particularly hard in industrial research projects to lay the foundations for tools such as an AI system for digital twins that can address financial and environmental issues. In the future, this tool will allow us to carry out virtual simulations based on not only physical, but also financial data, meaning that the optimizations for every step of the chain, from raw material suppliers to end customers, will then be improved in real time. In doing so, we will also establish a basis for truly circular value creation, a key element of the fight against climate change and one that we must all unite across scientific disciplines to achieve.

With these developments, we are moving further and further into the digital continuum, which will be built on the ecosystem provided by the "Silicon Economy" initiative and for which we already have all the technologies we need. These technologies are being used more and more on companies' shop floors; however, on the top floors, they often have yet to be used as a basis for decision-making, e.g., in finance divisions. If we are to make the idea of circular value creation a reality in the future, this must and will change. It will then be possible to address both sustainability and resilience issues under the header of circular supply chain management. Consequently, there is an urgent need to expand existing technologies in a way that complements the system



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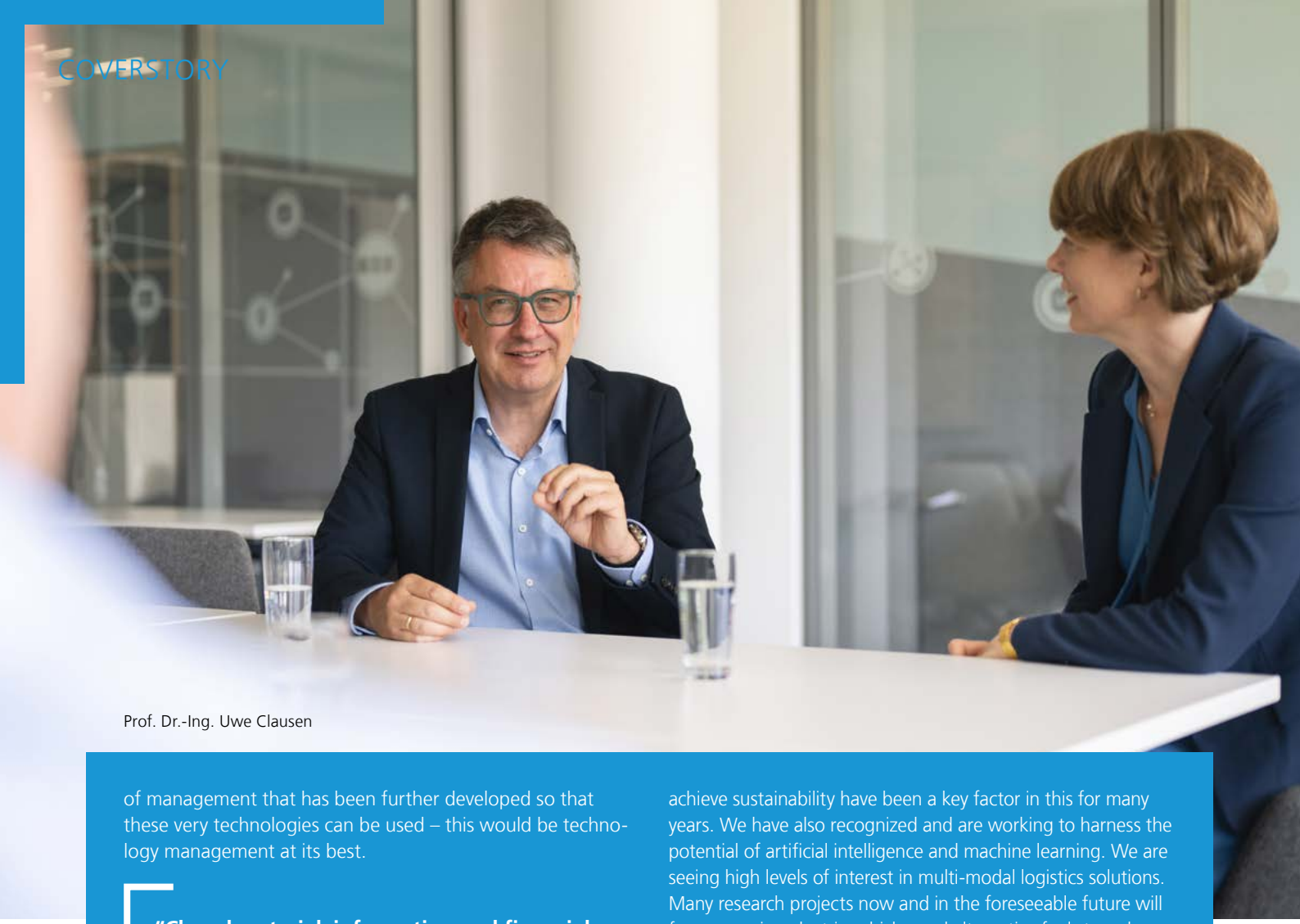


Prof. Dr.-Ing. Uwe Clausen

of management that has been further developed so that these very technologies can be used – this would be technology management at its best.

> **"Closed material, information and financial flows are the basis for true circular value creation, which we must all work on together and across disciplines to stop climate change"**
>
> Univ.-Prof. Dr. habil. Dr. h. c. Michael Henke

In our scientific hub in Dortmund, we are making advancements in technology management by integrating new technologies into supply chain management, resulting in increasing convergence of these technologies. As such, we are progressing beyond previous approaches to the digital transformation, because we are considering value creation networks in their entirety. The process of operationalizing cutting-edge technologies in business management is closely linked to considering and evaluating them from a commercial point of view.

All this only covers a small number of the topics that will shape research in the fields of company logistics and supply chain management in the years to come.

Clausen: Logistics is indeed more than just transportation, but it will never get by without freight transportation. We work in our projects and with our customers to develop innovative solutions so that we can continuously improve the efficiency, sustainability and adaptability of structures and processes within transportation logistics. Digitalization and efforts to achieve sustainability have been a key factor in this for many years. We have also recognized and are working to harness the potential of artificial intelligence and machine learning. We are seeing high levels of interest in multi-modal logistics solutions. Many research projects now and in the foreseeable future will focus on using electric vehicles and alternative fuels to reduce CO_2 emissions, in order to meet the industry goal of making logistics and transportation more sustainable. Other important issues include efficient solutions for last-mile deliveries – not only, but often in urban areas – and low-noise logistics. The role of humans in transportation logistics processes, a good understanding of human-system interactions and the adaptability of logistics systems will be highly significant in this context.

Everyone is talking about artificial intelligence right now. What influence will it have on your respective divisions in the coming years and how will it benefit us as a society?

Henke: AI is having a huge impact on logistics in general and on corporate logistics in particular. In the future, large language models and foundation models will also be used to a greater extent along supply chains, so they can be managed more effectively than ever before – these systems will be deployed in fields ranging from demand forecasting to risk management, so as, for example, to ensure that the beans for our morning cup of fresh coffee were actually produced sustainably.

Wherever AI is applied in the future, the most important thing will continue to be connecting technologies and developing new business models.

For example, "SKALA", a large project we have just launched with funding from the German Federal Ministry for

Digital and Transport (BMDV), will focus on developing scalable AI and blockchain solutions for automation and autonomization in value creation networks. Using these technologies in this context is extremely challenging because it involves a large number of financially independent partners that do not necessarily trust each other, but must exchange data, goods and values. Transparency and data sovereignty are essential prerequisites for exploiting the potential of AI, and these aims can be achieved through blockchain technology.

The SKALA project team is developing open source AI and blockchain components in the form of software modules, AI models, smart contracts and adapters for connecting with third-party systems. These components represent a unique opportunity for quickly and efficiently creating and disseminating de facto standards for technology convergence in a way that would not be possible for individual companies.

Clausen: AI has developed enormously in recent years and is becoming part of more and more areas of our everyday lives and the business world. It can help us automate repetitive tasks and is already increasing information volumes and leading to better information personalization, as well as helping improve route recommendations or device controls – for everything from logistics facilities to "smart home applications." AI also opens up entirely new possibilities when it comes to analyzing large data volumes and offers impressive potential in the creative field (text, image and video).

For example, efficient analysis of images and large data volumes could help improve operational processes and planning decisions in transportation logistics. In maritime logistics, we have successfully combined voice recognition and radiolocation at sea. Meanwhile, in the healthcare sector, AI could lead to quality improvements in diagnostics and, hopefully, greater efficiency in the very necessary process of documenting treatment and care. In all these areas, we at Fraunhofer IML work at the cutting edge and create value for our partners in industry, trade and service companies through innovation.

Kirchheim: In the last two years in particular, large language models have shone a spotlight on the ways in which artificial intelligence could be harnessed in our everyday lives, both professionally and personally. Now it is a matter of developing the initial hype into use cases that can be applied in industry. Automatically generated sustainability reports are an excellent example of the practical possibilities of this technology. We are developing a solution that will automatically generate and amalgamate data from an ERP system and carry out any calculations that are needed to translate this data into a sustainability report that complies with the applicable regulations. I don't know anyone that enjoys doing that kind of task manually, and it's also very error-prone work. If activities like these are no longer necessary, skilled workers will be able to focus on doing the tasks that we humans are best at. If you follow this train of thought and start compiling a list of how many such tasks are involved in the average company, then it's clear that our entire society will benefit from AI.

> **"Large language models have catapulted the usability of artificial intelligence in everyday professional and private life to the center of attention. The task now is to develop applications for industry from the initial hype"**
>
> Prof. Dr.-Ing. Alice Kirchheim

Prof. Clausen, you are the chairman of the Fraunhofer Transport Alliance, which has 20 years of experience in successfully pooling the numerous Fraunhofer institutes' transportation expertise. What role can a strong scientific alliance play in German politics (in the context of the transportation transition in particular)?

Clausen: We are in constant demand in our capacity as a neutral scientific interface between business and politics. As an institution, we cannot and do not want to be a political party or a lobby organization, even if we may naturally like to support certain goals at a personal level; however, this can in turn motivate us to use our research to help create better solutions for business and mobility in our society. Even at Fraunhofer, we do not always hold the same opinions when it comes to questions of which goals are more important and which solutions are better or even necessary, and I am emphatically in favor of allowing this. However, what is important for any Fraunhofer institute or for all of us collectively in the Transport Alliance is the replicability of our results and the quality of the scientific work with which we derive them.

Prof. Henke, let's venture a look into the future: Where do you see Fraunhofer IML and the domain of logistics research in ten years' time?

Henke: Even today, we are already "the place to be" for applied research in logistics and supply chain management, in Germany, in Europe and around the world. We want to maintain and expand this position by increasingly presenting logistics not only as a first use case for new technologies, but also by means of a further step where we demonstrate that the technologies and business models originally developed in the logistics sector can also be deployed effectively in other functional areas and industries. As to where we will be in ten years' time, I cannot make any legitimate predictions in times as wild as these. However, I do have goals: for example, my aim with regard to our project, SKALA, is that within two to three years, no one will be able to overlook Dortmund when it comes to combining AI and blockchain in general, even outside the fields of logistics and supply chain management.

Prof. Kirchheim, Prof. Henke and Prof. Clausen, thank you for talking to us today!

Artificial Intelligence Becomes a Student for Reality

Artificial intelligence (AI) will determine the future of logistics – that much is certain. At the same time, however, we also know that using statistical models and databases in warehouses around the world is not enough. We also need intelligent agents that can help us in the real world – embodied artificial intelligence. Methods for transferring AI from the digital world to reality is one of the last challenges to overcome on our path to the digital continuum. The Lamarr Institute for Machine Learning and Artificial Intelligence is leading the way here.

When you're in a foreign country where nobody speaks your language, you're essentially helpless. After countless failed attempts, you might eventually manage to communicate – but it is still a long, difficult journey. An artificial intelligence system would be similarly lost if we released it into the real world. In order to transfer the physical activities of an AI into the real world, we need a robot that can embody it. This is known as embodied artificial intelligence. However, creating this robot through countless hours of painstaking work and then allowing it to learn in the real world through trial and error the way we humans do, would be a rather expensive process. For this reason, the AI first learns how to behave in the real world through a simulation.

Back to school

The simulation in question is a sort of school for autonomous robots. In a protected environment, researchers can present robots with problems that they may encounter in the real world. The most challenging thing about the real world is that it is not always possible to make predictions and statistical calculations of what's going to happen. This is why the researchers make the AI react to as many situations as possible, by simulating variable physical properties, such as images or friction values for the floor, that can be picked up by the sensors. They also use varied structure and load scenarios in the simulation models to ensure the robots are as well prepared as possible for the various logistics processes they will encounter in reality and to make sure the robots can be used in the physical system without issue. In order to keep the modeling complexity at a low level, a process is being developed that can automatically and randomly generate these models. If the AI does its job well, its behavior will be given a positive evaluation and it will react similarly to this situation when it next encounters it. This way of teaching an AI is also known as deep reinforcement learning. Scientists at the Lamarr Institute for Machine Learning and Artificial Intelligence in Dortmund have proven that this method works. The Lamarr Institute focuses on researching and developing powerful, trustworthy, resource-efficient AI applications. As one of the Lamarr Institute's four scientific partners, Fraunhofer IML is helping to research the optimal design for embodied AI and how it can be used in logistics.

Leading by example

The evoBOT, an agile, high-speed robot, is a model student in the school of embodied AI. The evoBOT belongs to a new generation of autonomous robot systems and is able to assist warehouse employees in all kinds of situations – by handing things to them, for example. Its inverted pendulum design allows it to be used for a wide range of applications; the down side, however, is that it must constantly balance itself when in motion. One aspect of the evoBot that researchers are focusing on at the Lamarr Institute is the way it learns to take its first steps through deep reinforcement learning in a simulation.

Collisions in the classroom

In addition to investigating individual embodied robots, the Lamarr Institute team is also researching robot swarms – because in the warehouses of the future, there won't just be a single robot moving through the halls. While many existing systems control swarms of robots from a central control point, the approach used in Dortmund is different. The control system for the robots is decentralized, which has

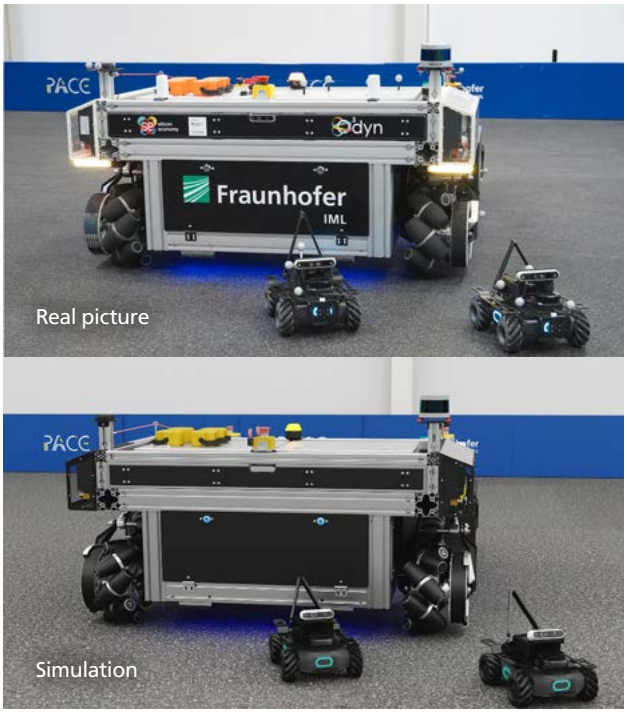
some huge advantages, especially in terms of flexibility and vulnerability to breakdowns. In the future, the researchers also want to make it possible for the robots to communicate with each other, because these systems also learn through deep reinforcement learning.

Each individual robot must continuously analyze its environment in order to operate efficiently and avoid collisions. However, realistically modeling the sensors that carry out this constant analysis in the simulation is an incredibly expensive, time-consuming process. Instead of using a 3D model, researchers at Fraunhofer IML have therefore created a simpler 2D model so that the robot can more quickly learn how to avoid collisions. This has worked well for some scenarios, but it will need further refining in the future, because, as these two projects have clearly shown, the researchers are also facing another, very different problem.

Mind the gap!

After countless hours in the AI school, the simulated reality, the time has finally come – soon, the embodied AI will "graduate" and take its first steps in real life. However, it cannot simply be let loose into the world. Before that, the robot must overcome the sim-to-real gap, i.e., the discrepancy between simulations and reality. Only then can the robots act and interact independently in the physical world. The preparation for bridging this gap begins back in the simulation, because having an optimal simulated learning environment is key to the robot's success in the real world. To create this environment, researchers must use complex physical models and a huge number of variants. In order for the behaviors that the robot learns through the simulation to become as ingrained as possible, thereby enabling it to apply them in the real world, the AI must be presented with unexpected situations and put through a lot of training. Creating a simulated world that is as close as possible to the real world is one of the last challenges we face on the path to the digital continuum.

The researchers at Fraunhofer IML have already tackled this challenge with their mobile robot, O³dyn. As this robot transports pallets at high speeds, it needed to be trained in the most accurate simulation possible, so it could learn to handle any potential hazardous situations. The results have been amazing: The researchers can send the same movement commands to the real robot and the simulated robot and they will move in exactly the same way. One particular challenge in developing O³dyn was its air suspension, which was initially very stiff and quite unrealistic. It also took some time to create a realistic representation of the omni-directional chassis with its mecanum wheels. Today, by using modern simulation tools and movement data from the actual robot, the researchers have created an advanced simulation that can also depict the robot's speed. Interfaces and sensors, such as camera and LiDAR data, are also simulated. This means the simulation model is perfect for developing hardware and software in parallel or for testing different application scenarios.



A double act

In order to overcome the sim-to-real gap, we need digital twins, i.e., one-to-one simulation models of hardware. Fraunhofer IML is currently researching this using robots like evoBOT and O³dyn. Simulations need to serve as a digital reality for the artificial intelligence here. It is becoming increasingly difficult for AI to tell whether it is being run on the real system or on the simulated system. This enables researchers to develop AI virtually and gradually reduce the effects of the sim-to-real gap.

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Deus ex machina

– The Logical Conclusions of AI

A guest commentary by Prof. Dr. Dr. h. c. Michael ten Hompel, Director of the Lamarr Institute for Machine Learning and Artificial Intelligence and former Director of Fraunhofer IML as well as initiator of AI24 – The Lamarr Conference.

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"Digitalizing everything and artificial intelligence in everything will change everything for all of us." We said it in 2019; now, it has become a reality. In the summer of 2023, the large language model ChatGPT passed the Turing test and is therefore "officially" considered to be artificial intelligence. But what has surprised everyone is that as they have grown in size, these "transformers" have developed fundamentally new, creative abilities that were not programmed into them and are difficult to explain. Large neural networks have clearly developed their own "view of the world": to see how this looks, we need go no further than the website for "Sora" (OpenAI), for example. You can now see more than just flat, still images there. If you enter a few lines of text (a prompt), Sora generates fascinating, high-resolution videos. AI seems to have developed an understanding of the relationships between objects. Reflections on the windows of a moving train, waves on a beach, a snowstorm or the human person itself: they are all modeled correctly and obviously haven't just been copied into the scene, but rather have been rendered in accordance with the laws of nature and cause and effect. Generative AI, which has been trained on tens of trillions of tokens, is living up to its name: It not only interprets, but also generates new versions of the reality that it has learned. Naturally, even the latest AI systems make mistakes, and if you look closely, you will spot hallucinations over and over again – but then again, this is happening much less than with previous versions.

For curious observer, one thing is becoming increasingly clear: Artificial general intelligence (AGI) no longer seems so far away. In fact, it may only be a question of having enough computing power to achieve further, exponential growth in AI capabilities. Apparently, that is how Mark Zuckerberg sees things – he has declared that he intends to build the largest AI cluster of all time with 350,000 H100 GPUs from Nvidia, in order to create the first AGI by the end of the year (but "responsibly").

Prof. Dr. Dr. h. c. Michael ten Hompel

Deus ex machina

It will probably take a little longer than that, but one thing is for sure: Mark Zuckerberg will not be the only one with plans for creating an AGI system, and Elon Musk and his X empire will soon strike back. We are experiencing a "deus ex machina" moment – a trope from Greek tragedies where a problem is suddenly and unexpectedly solved by a supernatural power. If we design and train generative AI in the right way, it will not only produce attractive images and write texts, but also solve major underlying problems and create new processes and machines.

The logical conclusion

It is quite possible that subsequent generations of artificial intelligence will become a partner, an active element in processes, and logistics will play a crucial role as a driving force in this transformation. A social networked industry will emerge, in which people and AI make plans together and collaborate as partners. However, humanoid robots – connected to a general remote AI – will learn skills that will surpass our capabilities. The latest videos of Tesla's "Optimus" robot give an idea of the road we are on. Research on AI and humanoid robotics is being conducted all over the world. At the end of last year, China announced that it would start mass producing humanoid robots in 2025, and that its artificial workers will be integrated into the industrial workforce by 2027.

Autonomous robots in intralogistics will take many shapes, but they will certainly need arms and eyes... and it is no coincidence that this brings Fraunhofer IML's own evoBOT to mind. Reflecting on the logical conclusions for AI brings us right back to the beginning: "Digitalizing everything and artificial intelligence in everything will change everything for all of us." Artificial general intelligence is going to become part of our digital reality much more quickly than most people think.

Open Lab  Open Source = Added Value for Everyone

It's a simple equation, but it will allow Fraunhofer IML to tackle the major problems of our time. Working together is the only way we can drive standardization to guarantee that interfaces are fit for application and based on a common language. Fraunhofer IML's Open Labs have assembled partners from related fields and areas of application to work together on future-oriented open source solutions.

There's a new offshoot springing from the tried-and-tested Fraunhofer Enterprise Labs research format. Since the Open Labs launched in 2024, researchers there have been breaking down the major trends of our time into a common language. Megatrends like artificial intelligence and decentralized systems can be overwhelming for individual players. However, Fraunhofer IML's Open Labs offer a solution by fostering collaboration across company boundaries so that standardized interfaces are created in a common language – and this language goes by the name of open source.

"Since 2013, the Fraunhofer Enterprise Labs have developed into a real success story. Winning the German Logistics Prize (Deutscher Logistik-Preis) in 2023 with our partner Dachser was a major accolade for this collaboration format. That's why we are now consciously setting ourselves the goal of enabling multiple companies to become part of our cutting-edge research and development with comparatively low monetary investment. We want to encourage the industry to view logistics as a team sport," said Prof. Michael ten Hompel, the former executive director of Fraunhofer IML, during his presentation on the format at LogiMAT 2024. A number of collaborative initiatives have now been established with at least three SMEs per focus area, primarily with the aim of developing or adapting solutions to fulfill certain basic functions. These initiatives are primarily focusing on developments that are needed across the entire industry, but that are not competitive differentiators. Instead, the resulting developments are intended to act as a freely available foundation for individual business models. Fraunhofer IML is directing and supporting the process in the individual focus areas, and at the end, the solutions will be made available in an open source format.

The structure of the individual labs is always characterized by a certain level of flexibility and based on open, reciprocal discussions of results. The governance structure of each Open Lab is divided into three areas: First comes the steering committee, which is responsible for monitoring the strategic objectives and regularly evaluating the product vision and the milestone plan. Next, there is the working group, which develops the overall product vision and is responsible for publicly disseminating the solution. Lastly, the development team breaks down the specifications into individual development tasks and is responsible for actually developing the individual services, and publishing and maintaining them.

At first glance, this may look like a lot of work for the stakeholders. However, in reality, it is a definite win for all involved, especially the SMEs, because they do not have to contribute their own development resources in any way, but rather act as drivers at a strategic and technical level. Fraunhofer IML provides the development team with know-how in the areas of open source solutions, development infrastructure and agile project management. Companies participating in the Open Labs have the opportunity not only to help shape the latest trends of our time, but also to get first call on using and adapting the results. In addition, the Open Source community is constantly changing. SMEs benefit not only from the expertise that the Open Labs have built up, but also from an entire community's worth of support and advances.

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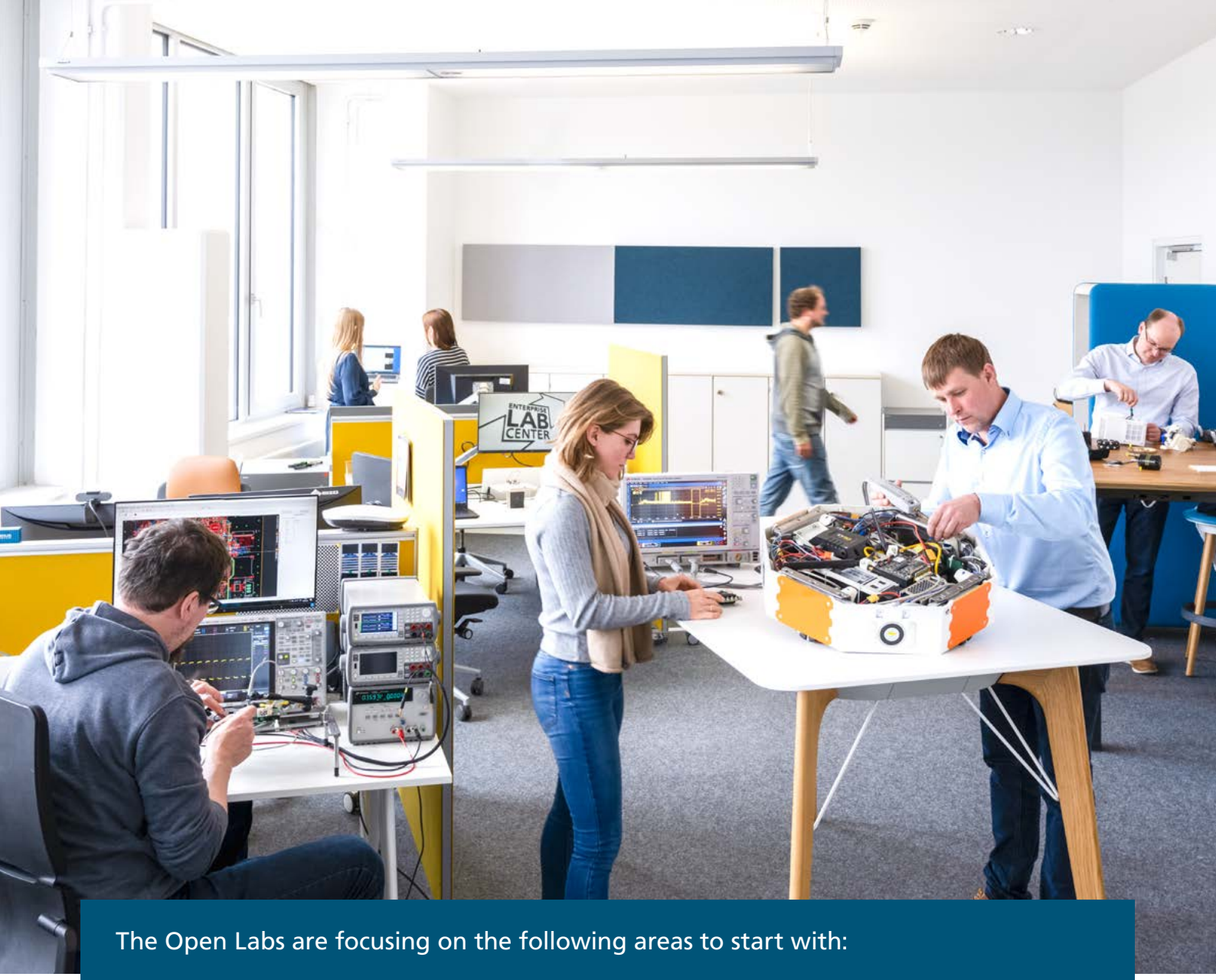

The Open Labs are focusing on the following areas to start with:

Digital product passport

Known in German as the "digitale Produktpass" or DPP, the digital product passport is valid for the product's entire lifetime, unlike a real passport. It contains everything stakeholders along the value chain need to know, from the materials used, the carbon footprint and the product and repair information, to disposal/recycling instructions. This consistently structured dataset can be used by government authorities as well as service providers and consumers. In fact, from 2030 onward, the digital product passport will become mandatory throughout the EU, but companies can start using it right now to increase transparency along their product life cycle and contribute to the circular economy transformation.

LogOS

In the LogOS project, Fraunhofer IML is working on an operating system for intralogistics: this self-organizing solution uses automated guided vehicles and autonomous mobile robots for in-house transportation. The day of self-organizing systems is nearly upon us, meaning that systems using overhead wires will soon be a thing of the past. The need for this kind of operating system arises from the variety of system landscapes at work in the logistics sector – from different WMS or ERP systems to different types of mobile robots that are supposed to interact with each other. As such, the industry needs an open, modular operating system that has the flexibility to adapt to the requirements of the given application field and supports (de facto) standards.

EfficientCargo

The aim of the EfficientCargo project is to increase utilization of cargo bay capacity (e.g., in trucks, aircraft and ships) in a cost- and resource-efficient manner, thus reducing transportation costs and CO_2 emissions. Other goals include dynamic adaptation of transportation capacity and monitoring of cargo space and package dimensions.

more information

Next Stop: **The Future**

Almost exactly eight years ago, at the 35th Zukunftskongress Logistik event in Dortmund, the Rhenus Group and Fraunhofer IML broke the news: they were going to collaborate in an Enterprise Lab. Since then, they have racked up a number of successes as partners in the Rhenus Enterprise Lab – and in the coming years, they aim to shape the future of logistics together.

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In 2017, Fraunhofer IML announced its collaboration with Rhenus in a dedicated Enterprise Lab by sharing an image of two puzzle pieces being pushed toward each other – it was the start of a genuine success story. In its 112 years of company history, Rhenus has developed extensive know-how in numerous areas: The experts at this global logistics service provider know how to further develop and optimize logistics processes along their customers' supply chains. From innovative solutions for all stages of the supply chain right through to warehousing and conventional transportation, Rhenus offers its customers almost everything in the logistics field.

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Meanwhile, Fraunhofer IML's expertise extends to many different areas of logistics research: it was with the aim of giving companies access to this expertise and the latest technologies and findings in logistics research that the concept of Enterprise Labs was devised at the institute in 2013. The Enterprise Lab Center in Dortmund allows partner companies to position themselves at the forefront of cutting-edge, agile, interdisciplinary research. The prototype center has a number of state-of-the-art laboratories where components and prototypes can be manufactured as needed and tested out. The Enterprise Labs also have integrated coworking spaces so project partners can collaborate directly on site. The establishment of a dedicated Enterprise Lab gave Rhenus new ways of accessing this infrastructure, allowing the group's employees to delve deeply into the research world and find optimal tailored solutions.

Half full or half empty? Rhenus employees and customers have both been mulling over this famous question for many years, but in a rather specific context: It relates to containers for files and data carriers that have to be kept locked to maintain security. However, if a service provider employee cannot look inside of the container, then they will not be able to tell whether it is half full or half empty. To take a German example: For many years, it was common for some secure containers to be emptied when they were only half full, while elsewhere, early emptying had to be manually requested for full containers.

This was the first project that the researchers at the Rhenus Enterprise Lab tackled together, and it was a roaring success: Rhenus customers are already using large numbers of these smart secure containers and the figures just keep on climbing. So what does the smart container look like? Quite normal actually: It looks just like the thousands of other document bins in office buildings around Germany. However, it has one small, but important difference: the "Rhenus ITC^{PRO} level sensor." The sensor, which is no larger than a cigarette packet, can automatically determine how full its respective bin is. It transfers this data to the waste disposal company's ERP system, which triggers automatic and timely bin collection and ensures customers no longer have to worry about secure containers for files and data carriers overflowing. What's more, this also prevents empty collection runs, as the containers are emptied at exactly the right time – which results in huge CO_2 footprint improvements for Rhenus customers, as Dr. Stephan Peters, Member of the Management Board of the Rhenus Group, emphasized when the ITC^{PRO} components were released as open source code in January 2024: "The ITC^{PRO} level sensor minimizes the number of empty collection runs and increases efficiency in collection planning, resulting in a significant overall reduction in collection runs – as innovation developers, we are delighted to give other companies access to this valuable method of reducing their CO_2 footprint."

When it was developed, this solution represented an important step toward establishing the internet of things (IoT) at Rhenus – allowing the group to establish its position as a pioneer in this field. The sensor also offers other major advantages, such as its long service life and its independence from local infrastructure, which was achieved by using the narrow-band IoT mobile communications standard and makes the sensor particularly energy efficient. The idea of using this mobile communications standard was developed in collaboration with another Enterprise Lab partner: Deutsche Telekom.

"Discover Logistics" spoke to André Remy and Michael Novoselsky from Rhenus about the partners' plans for the future (p. 20).

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Six questions

to André Remy and Michael Novoselsky

In the future, Rhenus and Fraunhofer IML aim to continue to build on the innovations they have developed together in the Enterprise Lab – and to keep on setting new standards in applied research for the logistics field. In an interview with "Discover Logistics," André Remy, Head of Global Group Customer Solutions and Innovation and Michael Novoselsky, Senior Innovation Manager at Rhenus, discussed the Lab's future direction and shared some insights into this collaboration between science and industry.

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André, what moment in your collaboration with Fraunhofer IML stands out to you to this day as THE milestone?

Of all the projects we have carried out with the Enterprise Lab so far, the most successful one is definitely our smart secure container and the related ecosystem. This project showed that we can develop specific, marketable products together – not only developing a prototype, but also developing and working out all the related processes that are needed to deliver tangible added value for customers.

What impact has the Enterprise Lab research had on Rhenus and your corporate strategy so far?

Innovation is the engine that drives our actions and ultimately, it is the reason that we have been able to offer our customers tailor-made solutions for the demanding challenges they face in the decades gone by. Last year, we gave this area an even more central role in our organization by creating the Customer Solution and Innovation team. This team works on the strategic focus of our innovation activities and ensures that they are aligned with our corporate strategy and trends in the areas of technology, society and the environment.

In the future, you want all your business units to be able to access the Lab. How can we imagine?

The Enterprise Lab gives us access to the very latest technologies and research findings. This is vital for all our products, so it is only logical if we consistently give all our units the opportunity to develop their products further with the Enterprise Lab. As a team that spans the entire group, we are interested in seeing all units succeed, so we want everyone to benefit from the know-how that is shared in the Enterprise Lab. That is why we have defined selection criteria for prioritizing projects correctly, which we coordinate internally. This selection process allows us to ensure the projects that go to the Lab deliver the greatest possible added value for our units. In order to increase this added value even further, findings from our projects are shared internally at an international level, so that everyone benefits from them.

Michael, as you are involved in the current projects, can you tell us what the development priorities are at present?

Right now, the Enterprise Lab is helping us optimize our autonomous transportation systems – a complex topic that requires not only expertise in robotics, but also a great deal of logistical process know-how. The strengths of Fraunhofer IML really come to the fore in cases like this, where expertise in a range of different fields is required.

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Michael Novoselsky, Senior Innovation Manager at Rhenus (left)

André Remy Head of Global Group Customer Solutions and Innovation (right)

We are also working together to identify the innovation topics that we will focus on in the coming years. For us, playing our part in driving change and bringing our colleagues with us on this journey is an important aspect of innovation. That is why we are working on an information tool to help familiarize people with these topics and also to show which people within the company are involved in them and what added value each technology provides for individuals.

What direction do you want to take the Enterprise Lab in over the coming years?

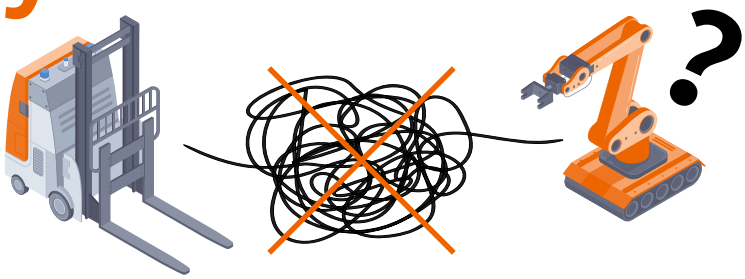
The motto "strengthening strengths" sums it up quite well. At Rhenus, we believe that our units know their business best, and we want to take this into account. That is why we are getting the units more involved in the selection of topics, and it's also why we believe that, in the coming years, we will be able to make the innovative power of this partnership more visible, both at an internal level and among our customers.

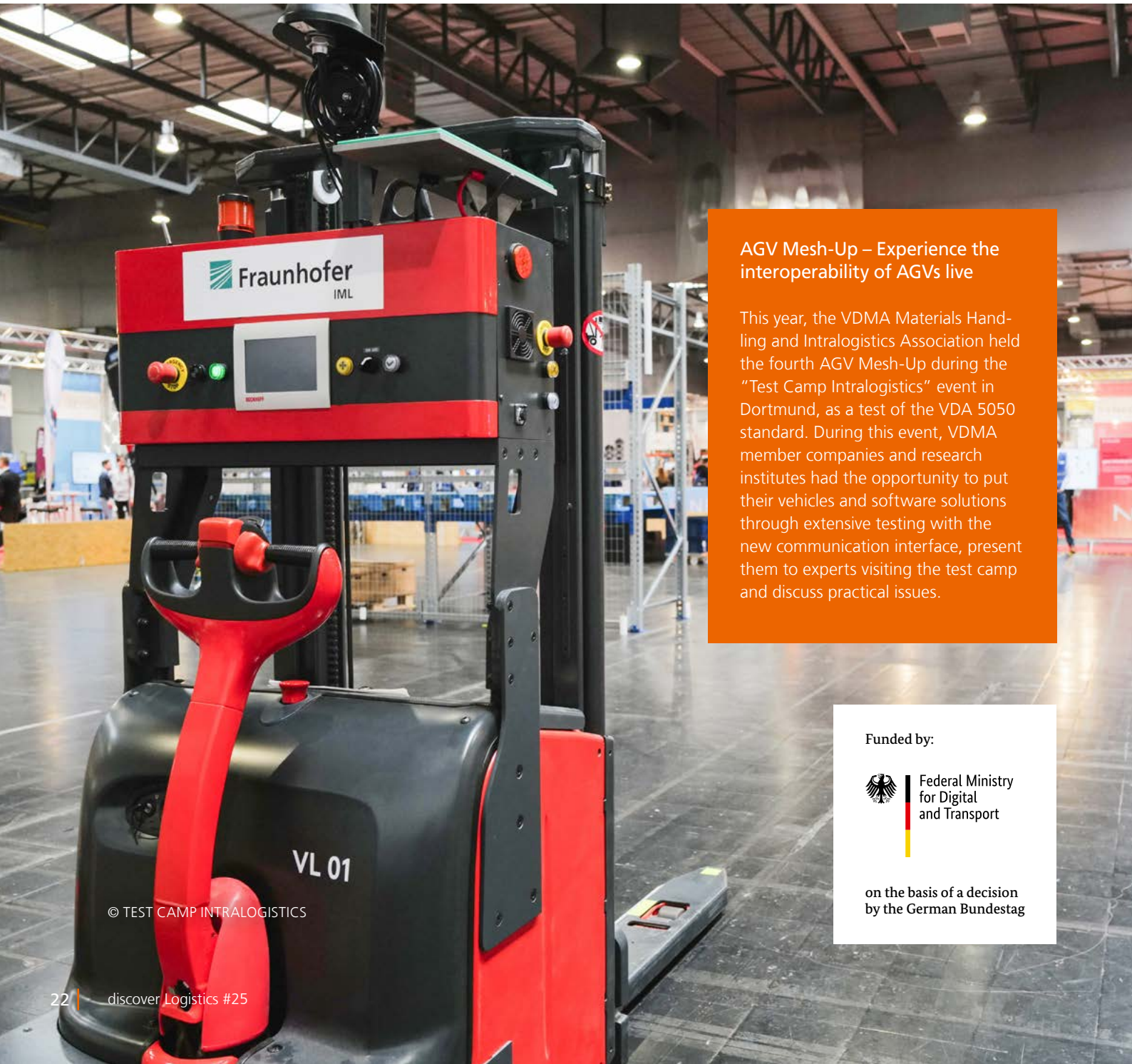
In more specific terms, we are harnessing applications from the fields of artificial intelligence and alternative fuels, because even today, we are already seeing disruptions to conventional business models in these areas. Related technologies, such as remote operation, automated guided vehicle systems and AI-driven data processing, are also highly relevant for us.

And our last question for André: what is the overall goal for Rhenus in working with the Enterprise Lab?

We want to be a competent partner that our customers can rely on when it comes to solving complex logistical challenges. Our collaboration with Fraunhofer IML complements this goal perfectly, because it allows us to evaluate technological innovations at an early stage and put them into practice.

Saying **Goodbye** to Communication Problems





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AGV Mesh-Up – Experience the interoperability of AGVs live

This year, the VDMA Materials Handling and Intralogistics Association held the fourth AGV Mesh-Up during the "Test Camp Intralogistics" event in Dortmund, as a test of the VDA 5050 standard. During this event, VDMA member companies and research institutes had the opportunity to put their vehicles and software solutions through extensive testing with the new communication interface, present them to experts visiting the test camp and discuss practical issues.

Funded by:

Federal Ministry for Digital and Transport

on the basis of a decision by the German Bundestag

In the past, it was considered almost impossible to get automated guided vehicles (AGVs) from different manufacturers to "fall into line" with each other at a plant. They speak different languages by default, after all. Now, however, the VDA 5050 is set to provide a solution. Researchers at Fraunhofer IML are helping to develop and implement this communication standard.

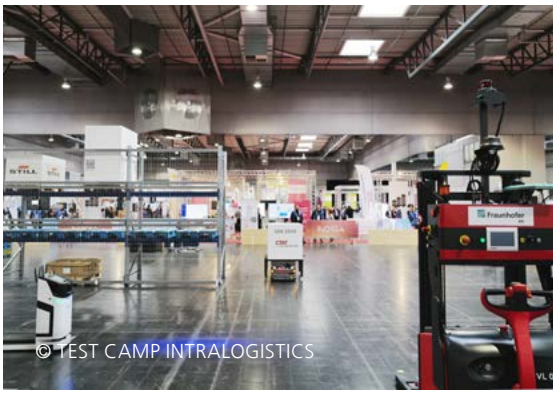
It is April 10, 2024. At the "Test Camp Intralogistics" event at the Westfalenhallen indoor arena in Dortmund, eight mobile robots from different manufacturers are moving precisely and purposefully around a 500 square meter test field. Equipped with state-of-the-art sensor technology and artificial intelligence, they effortlessly navigate the course and transport various goods from one point to another – without human intervention. The robots are communicating with the master control system via the VDA 5050 protocol. This helps the robots avoid collisions and calculate the most efficient routes. The robots' movements are synchronized and optimized, ensuring a smooth, continuous flow of goods. The entire scenario seen by participants and visitors at this year's AGV Mesh-Up in Dortmund gives the impression of a well-oiled machine, working tirelessly to perfect logistics processes. At the edge of the test field, Thomas Albrecht is observing the scene very closely. "A few years ago, you couldn't have run this process like that," says the AGV specialist from Fraunhofer IML. He goes on to explain: "Today's automated guided vehicle systems are actually always standalone solutions with a proprietary control system, i.e., one that is specific to the manufacturer. This has meant that – up until now – mobile robots manufactured by different suppliers could not be controlled by a common master control system from one manufacturer." Users have long been dissatisfied with this situation, especially in the automotive industry, where they tend to deploy many AGVs from different manufacturers.

VDA 5050: a game-changer

The solution has come in the form of the VDA 5050 standard, an open source interface project initiated by the VDMA Materials Handling and Intralogistics Association and the German Association of the Automotive Industry, which is being implemented with various partners. With this communication interface, users can manage a fleet of heterogeneous mobile robots from different manufacturers via a single control system. Fraunhofer IML researchers have been involved in developing the interface for some time. The Dortmund-based research institute has put two in-house developments through practical testing this year: A pallet AGV with the innovative STUART chassis design, and the open source software libVDA5050++.

STUART solves the issue of static over-determination seen in conventional four-wheel chassis without any need for expensive, high-maintenance springs, dampers or actuators. Thanks to its simple design, the STUART chassis can be scaled for any size and load capacity and is suitable for almost any application. It has one support wheel at the front and one at the rear, as well as two drive wheels positioned at the center of the longitudinal sides, which form a central differential drive axis. All the wheels are connected by simple levers and joints, forming two linked support triangles. As a result, all four wheels maintain contact with the ground at all times, even when the ground is very uneven. This structure ensures the chassis is stable and prevents it from wobbling, which typically happens when machines like this start up and brake. This means that in many cases, there is no need to refurbish the flooring, a step that is often required prior to utilizing AGVs, in order to create floors that are "AGV compliant" (meaning flat and free of holes).

As it is used in combination with a new kind of load transfer station for pallets, this AGV does not even need an active lifting mechanism for picking pallets up or putting them into storage. The load transfer station consists of two supports fitted with roller tracks. At the front, 50 cm of the roller tracks are tilted slightly downward, so the pallet is pushed onto the robot as it drives into the station. Then, as the AGV moves forward, the cargo pallet is lifted off the vehicle and transferred to the station. Depending on the type of station, the AVG can drive on through or reverse back out after it has delivered the load. To pick up a cargo pallet, the AVG drives into the station the other way around and collects the load using a simple loading mechanism.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Fraunhofer IML has also developed an open source implementation of the VDA 5050 standard, libVDA5050++. This has been designed to be middleware-neutral and can be adapted to the individual needs of manufacturers and AGV users with little difficulty. libVDA5050++ encapsulates the entire control logic of the VDA 5050 standard so that it can easily be connected to an existing vehicle control system via a lean interface. In addition, libVDA5050++ reduces inconsistencies in implementation, meaning that it can act as a standard in the future.

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Like Superpowers, But **Better**

With just one click, you can have the latest Harlan Coben thriller, a new pair of shoes or even fresh food delivered overnight, directly to your front door. However, the convenience that has such a huge influence on our daily lives in this modern age still presents many obstacles for the workers that make it happen. We often forget the physically demanding work that this industry is built on. So what we need is a way to reduce the physical and mental stress on logistics personnel (a frequently neglected factor) – something like superpowers, but better.

The way we live our daily lives these days simply would not be possible without the transportation or storage of goods. In spite of this, the workforce in this sector tends to receive fairly shabby treatment. "The research projects that have been carried out in this area clearly show that companies do not give sufficient attention to the recording and assessment of physical and mental hazards. This is exactly where Fraunhofer IML's Ergonomics Quick Check comes in: It addresses two key issues in the operational logistics sector, the shortage of skilled workers and high levels of sick leave, by contributing to the prevention and avoidance of physical and mental risks," explains Semhar Kinne, a research associate at Fraunhofer IML. Using a wide range of methods, including objective and subjective assessments of mental and physical demands, this service analyzes and evaluates occupational health issues and then provides individual measures for the companies.

The analysis is conducted on a step-by-step basis in order to identify as many different areas of optimization potential as possible and to enable the development of ergonomics measures that take a holistic view of the workplace. The first step involves quantifying the physical ergonomics situation by using a motion capture system to conduct a systematic stress analysis. The motion capture technology records body postures, movement sequences and physical stresses for one representative employee per workstation.

Subsequently, a workshop withresponsible process managers is conducted to determine the relevant Key Indicator Methods (KIMs).

The next step involves quantifying the cognitive ergonomics situation: A representative group of employees is asked to complete an anonymous survey on their subjective perception of the physical and mental work demands and any health complaints they may have. This includes all work-related conditions on the one hand, such as the work content, tasks, organization, social relationships and working environment, and health and well-being circumstances on the other, such as current state of health, musculoskeletal complaints and workload.

The initial results are drawn from these two primary avenues of analysis. The Ergonomics Quick Check finishes by providing an overview of the health hazards and risk factors, along with some initial recommendations for designing ergonomic workplace and processes. This should ensure compliance with physiological stress limits and help prevent occupational hazards across the board.

This basic version of the Ergonomics Quick Check can be expanded to include other elements, such as an analysis of workplace and working environment conditions. In this analysis, the workstation dimensions are compared with the current German regulations on working height, grip space, arrangement of displays and controls, movement space, light intensity and sound levels.

Another optional extra involves testing out exoskeletons. In this case, employees and managers receive in-depth training, and professional exoskeleton experts provide support for the entire process. Once they are introduced to the technology, volunteers can put it on and adjust it to their needs. The initial tests on the relevant workflows are then conducted again, but with the exoskeletons. A survey is also used to evaluate this process in order to gain an accurate representation of the benefit added by the technology and to collect feedback from employees.

This combination of measures makes it possible to improve working conditions at an individual workstation level and, ultimately, to counteract large-scale problems that affect the entire industry, from workload stress and health conditions, to skilled worker shortages in companies. The only way to make physically demanding professions both more attractive and more future-oriented is to introduce occupational health and safety measures that target work and health conditions; taking these steps into account will also ensure that logistics workers can keep pulling off the small acts of heroism that make all of our everyday lives easier.

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Packaging Laboratory 2.0

– Breaking New Ground

Admittedly, in the context of artificial intelligence (AI) and digitalization, test laboratories from 1986 do not sound particularly innovative or "mind-blowing" – at best, they seem traditional or even outdated. However, the Packaging Laboratory at Fraunhofer IML proves that "old" does not necessarily mean "decrepit," and that "tried-and-tested" and "cutting-edge" are not mutually exclusive qualities. AI is now also finding its way into the laboratory.

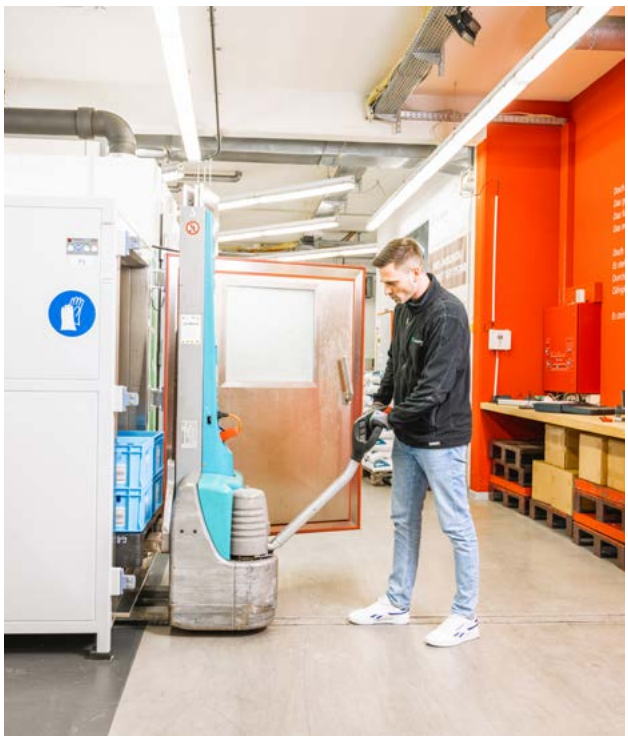
For every child (and for a lot of grown-ups!) with an appetite for destruction, this would be a dream job: getting to expose objects to heat and humidity, hit them, drop them and subject them to brute force until they break. This sounds like fun at best, but far from useful. However, it makes perfect sense when it comes to packaging logistics. After all, the primary purpose of any packaging is to protect products from damage. During daily use, packaging is stacked, rolled and pulled as it is moved around warehouses, transported on trucks or stocked in supermarkets; it gets dropped, shoved and vibrated during transportation and can be exposed to extreme temperatures and humidity, depending on its destination. In order to find out how much is really "too much" and how packaging must be designed in order to withstand these challenges, the "packagers" – as they call themselves – create realistic simulations of the stresses that result from this treatment in the laboratory using special testing machines.

Markus Menting, a research scientist at the Packaging Laboratory, is one of these "packagers" (packaging logistics specialists): "At the lab, we can analyze and evaluate weak points, potential cost savings and the performance of different types of transportation packaging, such as cardboard boxes and load carriers like Euro-pallets, but also complete unit loads," says Menting. The tests are carried out in accordance with German and international standards such as DIN (German Institute for Standardization), ISTA (International Safe Transit Association) and ASTM (American Society for Testing and Materials).

Going to extremes

DIN, ISTA and ASTM sound more like they would involve precise measurements and the occasional complex test report; however, they also include those stress tests that can be so much fun – not just for children. For example, in the tensile and compression testing machine, the researchers test pallets, pallet cages, containers and unit loads (e.g., a pallet packed with stacked cardboard boxes) for anti-slip properties and load capacity/deflection in high-bay and floor storage. Or, to put it more simply, boxes, containers and unit loads are placed between two metal plates and then crushed. The blocks and feet that containers and pallets stand on undergo the same procedure. Pallets made from a wide variety of materials are also bent until they break. In addition, the lab has a precision drop machine and a drop hook that researchers can use to drop test objects from heights of up to 4 meters, in order to assess how the robustness of a pallet or cardboard box is affected if it falls on its corner, for example.

Researchers in the lab can also make use of four climate chambers of up to 12 square meters in size to imitate different temperature and humidity conditions as well as constant stresses. In these chambers, the test objects can be exposed to temperatures ranging between 45 °C and +140 °C and to relative humidities of 10 to 95 percent, depending on the researchers' needs, before going through additional tests. Other lab equipment includes two vibrating tables for simulating the vibrations and dynamic vibration stress that affect packaged goods or unit loads when they are transported by road, rail or air. "The tests not only ensure that the packaging and load carriers are robust and reliable, but also help avoid expensive plant shutdowns, customer complaints and the use of oversized, expensive load carriers," explains Menting.



A sticky situation in the lab

At the heart of the Packaging Laboratory is the Horizontal Impact Test System (HITS). The only testing machine of this exact kind worldwide, the HITS was developed and manufactured in the USA especially for the Packaging Laboratory and has been in operation since 2012. Test objects weighing up to 1,500 kg can be subjected to actual transportation stresses on its 17 meter test track. The HITS provides a very precise simulation of horizontal stresses, such as those that occur when trucks drive around corners, during emergency braking or when coupling railcars. This allows the researchers to come up with ways of saving material and costs when putting unit loads together, and of improving safety during transportation. "We conduct tests on packaging from every kind of industry here – there was one unfortunate incident where we tried to simulate acceleration stress on sugar and ginger ale on the HITS, and everything tipped over right at the very start. There was sticky stuff all over the rails and in every crack, so there's definitely been a build-up in there over the years," says Menting. The machine probably still tastes sweet to this day.

A lab full of possibilities

The Packaging Laboratory's portfolio of tried-and-tested equipment also includes forklift trucks, pallet trucks and roller conveyors, which can be used to carry out driving and handling tests, like driving over bumps, braking and handling cargo roughly, under realistic conditions. The roller conveyor track can be used to establish how constant stresses – from abrasion to cracks and breaks – affect load carriers and unit loads. The wetting agent bath tests how load carriers for the hygiene sector (e.g., H1 hygienic pallets) behave after being dipped in hot soapy water. The results are recorded using cutting-edge precision measurement tools and camera technology, such as digital cameras that take slow-motion videos, electronic distance measuring devices and data loggers for recording temperature, humidity and acceleration.

Generations of packagers

Ralf Wunderlich, technical director of the Packaging Laboratory and a real "old hand" in his field, brings over 30 years of experience to the lab, along with very extensive know-

ledge. Every day, he passes on the fruits of his experience to young packagers and supports them as they carry out a wide range of tests and routine lab work. He has already trained many students and current employees in this way, but Wunderlich himself also feels the benefits of this collaboration. When it comes to research and sensor technology, the younger generation is one step ahead, so the team members complement each other perfectly. This means the Packaging Laboratory, which underwent extensive modernization and restructuring in 2012, is constantly adapting to the latest technological developments. As such, it values tradition and innovation to an equal degree.

"We have yet to completely exploit the lab's full potential – in fact, we are only really discovering what it can do now, for example, by triggering the same collision 100 times on a roller track so that an AI system can be trained on the motion or acceleration data," reports Lukas Lehmann, the packagers' team lead. He is referring to Pal2Rec, a research project that focuses on sensor-based logistical activity recognition for (Euro-)pallets and aims to detect logistical events (shocks, stops, etc.) based on movement data. But one thing at a time – what's the background to this project?

The Pal2Rec research project

These days, packaging has to do more than ever before. It must not only protect its contents, but also be environmentally friendly, cost-effective and user-friendly. "Smart packaging" has integrated sensors that make it possible to capture and evaluate data on the location, condition and availability of goods in real time. In recent years, it has also become increasingly common to equip pallets with codes and sensors, in order to unlock the hidden potential that these technologies hold for increasing transparency and efficiency in the supply chain. That's the theory, at least. But as Julian Brandt, project manager of Pal2Rec, points out: "Researching smart pallets is nothing new – the trick is to make something out of that data."

Pallets are the unsung heroes of logistics. These simple wooden frames transport untold quantities of goods from A to B and they have been indispensable for decades. But what if these pallets could do more than just carry cargo? This is exactly the question that the Pal2Rec research project, which was launched in February 2024, aims to answer.

Pallets equipped with sensors can record not only their own movements, but also falls, shocks, tilting movements and information on how they are accelerating. This allows for detailed insights into common transportation processes. When a pallet is put into or removed from storage, for example, the sensors record these events and provide valuable data for analysis.

From data collection to process optimization

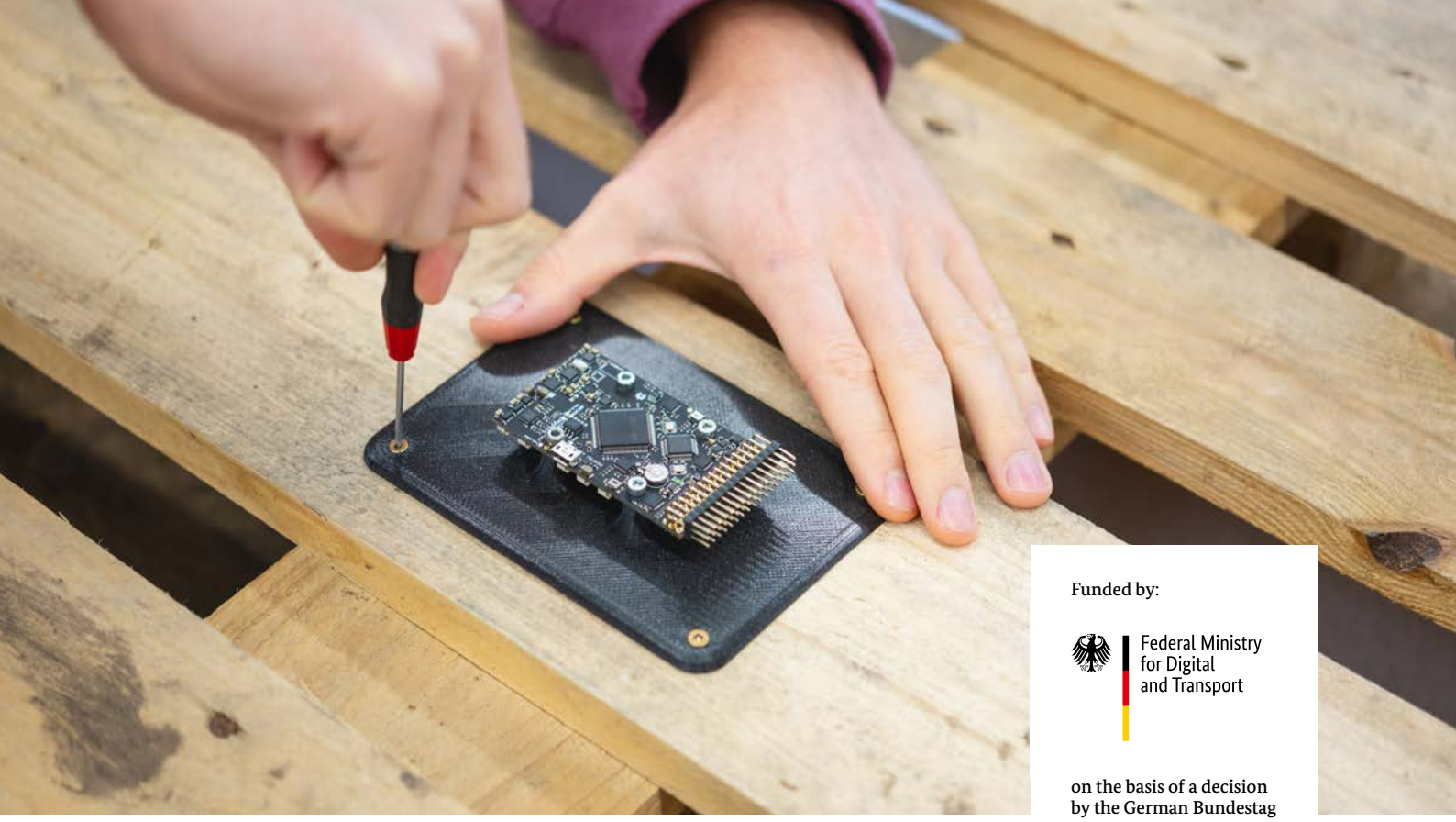
The researchers are hard at work in their lab: carrying out tests, comparing various sensors, recording videos and evaluating data. Pallets with integrated sensors travel around specially designed courses, and the resulting measurements are then matched with the video recordings and evaluated. The videos are later used to train an AI system to automatically recognize and classify the movement patterns. What is unique here is that the pallets do not require an external source of information. They are self-sufficient and collect their data themselves. All you need then is a suitable program to process the data and turn it into something usable.

The data collected by the pallets is invaluable to the logistics industry. "It not only allows us to track transportation processes, but also helps to detect anomalies and damage. This means we can intervene at an early stage if something goes wrong," explains Brandt. Currently, intralogistic materials handling is an absolute black box: Pallets go in intact, loaded with goods, and eventually emerge at the other end of the handling process and reach the customer – damaged, battered, broken. Pal2Rec is giving us a look inside this black box for the first time.

The mobile revolution

Ruined runners, bashed blocks, broken boards: Many companies are familiar with the issue of the pallets entering the handling process undamaged and coming out again after 10 kilometers looking like they have aged ten years. Since the Pal2Rec solution can also help here, the packagers have created a prototype for this problem in parallel to the research project. This prototype can be fed directly into the handling process at the customer site as a mobile test unit; the data it collects can be used to analyze possible abnormalities.

Here's how it works: A battery-powered pallet equipped with measuring technology runs through a company's normal cycle (production, storage, transportation) and records movement and acceleration data, including the shocks it is exposed to during the process. At the same time, a 360° camera takes pictures to capture the detail of these critical moments. Synchronized time stamps allow the recorded shocks to be matched precisely with the camera images, so that critical points throughout the handling process can be located accurately. Based on this, the specific problem areas can be analyzed and gradually optimized to reduce – or, in a best-case scenario, avoid – damage to the pallets effectively.



Funded by:

Federal Ministry
for Digital
and Transport

on the basis of a decision
by the German Bundestag

A glimpse into the future

The scenario described above only utilizes a small part of Pal2Rec's potential – but it still represents a very practical use case where the technology could already be applied. Once the current feasibility study is completed in October 2024, there are plans to bring the solution into broader application in collaboration with various logistics companies and industry players, so the system can undergo more extensive practical testing. The project team's main aim is to improve sensor technology and extend data collection to all areas of intralogistics, in order to enable identification of logistics activities.

The German Federal Ministry for Digital and Transport (BMDV) is providing 200,000 euros in funding for the project as part of its mFUND innovation initiative. The project partners, Fraunhofer IML and the Chair of Materials Handling and Warehousing at TU Dortmund, are currently applying for follow-up funding.

A new level in packaging testing

The measuring systems used in Pal2Rec are also being used outside of the research project and perfectly complement the lab's existing, tried-and-tested equipment. This opens up new potential uses and possible areas of application: Previously, the lab's research focused more on whether packaging gave goods adequate protection. Now, this measuring technology will make it possible to measure the effects on the goods themselves as well. In other words, the sensors can not only be attached to the outside of the packaging or on the load carrier to measure the forces acting there, but also directly inside the box, on the actual goods.

Alternatively, a 3D-printed replica can be placed inside the box instead of the goods. "We used to look at the packaging system. Has the pallet held up, has the box held up, has the carton held up, has the unit load held up – yes/no, and then we'd look inside: Is the product damaged/is the product undamaged. Now we can draw conclusions as to why it is no longer intact," explains Lukas Lehmann.

This is particularly important for goods or liquids that are at risk of breaking, but also for delicate objects such as medical devices or sensitive measuring equipment, which can be damaged by even the smallest vibrations.

The team at the Packaging Lab always know which vibrations affect the packaging systems during the tests, because they adjust the intensity themselves and take regular measurements to see whether the vibrations they set off have reached the packaging and unit loads. "In the past, however, we did not know exactly what was happening inside the actual packaging, because there was often a cardboard box, a layer of padding, perhaps another box and the product packaging in the way. We didn't know whether the packaging system was really absorbing the vibrations or shocks the way it is supposed to, and ultimately, it's all about protecting the goods," says Lehmann. With their state-of-the-art measuring system, the packagers finally know for sure.

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A Touch of Dolce Vita

How can people and robots interact safely in the workplace? To answer this question, Fraunhofer IML researchers and their European partners are working on a research project that investigates how humans and robots collaborate in the context of production. It seems that machine learning technology could be a key part of the solution.

What do you associate with the word "Felice"? For most people, this pretty Italian name brings to mind a child's smile, the first hint of sunlight after a long winter or a gentle breeze sweeping across the plains of Tuscany on a warm summer's day. For researchers, however, this melodic name has taken on a more functional purpose – they use it to refer to the EU research project "Flexible Assembly Manufacturing with Human-Robot Collaboration and Digital Twin Models" (FELICE). In this project, Fraunhofer IML is working with partners to study human–robot collaboration in production. The aim is to increase agility and productivity in manual assembly production systems, while also ensuring safety and improving factory workers' well-being. To do this, the researchers are looking for technologies that combine human cognitive abilities with robotic accuracy and endurance, and working to develop them further.

One area of the researchers' focus is the physical ergonomics that employees experience. Through a combination of various data sources such as wearables, BCIs and camera systems, the team is working to create a "digital twin" of the entire working environment. Using machine learning (ML) and artificial intelligence (AI) methods, the researchers adapt the robots' behavior to the people interacting with them. The planned project outcomes include adaptive workstations and a robot with a gripper arm used specifically to work together with the people on the assembly lines, whenever and wherever it can best support the production process. The goal is to use AI to gradually hand over tasks that require cognition to the robots.

Putting humans and robots to work in a real process

FELICE is being implemented in the Centro Ricerche Fiat (CRF) in Melfi, Italy, at a test facility for assembling and disassembling car doors that is operated by Fiat's research subsidiary. Here, researchers are exploring ways of meeting current production demand and developing the next generation of assembly processes. According to Oliver Urbann from the AI and Autonomous Systems department at Fraunhofer IML, the fact that FELICE works very closely with real robots, people and workflows in the industry offers a huge advantage – "something rare that represents a valuable opportunity." One very complex area of research that his team wants to forge ahead with under the optimal conditions at this test facility is "robotic gripping of objects," as despite considerable efforts, this still has not reached optimal functionality. However, this is also a highly complex process involving a large number of factors that must be taken into account – such as ensuring the correct level of force when gripping or the optimal position for the robot or tool. "After all, it's not until several years after we are born that we humans learn to grasp a screwdriver properly – even though we far outstrip robots intellectually," says Oliver Urbann, explaining the complexity of this stage of the workflow.

Machine learning optimizes gripping processes

Machine learning could be the game-changer here. "Simply put, in this specific case, we are simulating a large number of robots in parallel, and each one is in a slightly different environment," says Urbann. For example, a screwdriver may be in a different position or the robot may be in another place. This allows the whole system to "learn" how it should react to very different situations. The Fraunhofer IML researchers have now reached a point where if a screwdriver is taken away from the robot and put elsewhere, the robot can correct this "error" autonomously. "I am sure that in the future, machine learning

algorithms will unlock significant potential for robotics – particularly in terms of improving cognitive abilities," says Oliver Urbann. "The breakthrough is just around the corner and we are working full steam ahead on this challenge."

> **"I am sure that in the future, machine learning algorithms will unlock significant potential for robotics – particularly in terms of improving cognitive abilities"**
>
> Dr.-Ing. Oliver Urbann

"La dolce vita" is in the air

However, each journey to the FELICE headquarters in Melfi in southern Italy also presents something of a challenge for the Fraunhofer IML team members. This community with a population of 20,000 is situated far from the hectic streets and the noise of big cities – it's "in the middle of nowhere," surrounded by picturesque landscapes with rolling hills. This tranquil location really suits FELICE well. It gives the project a touch of "la dolce vita."

FELICE – Flexible Assembly Manufacturing with Human-Robot Collaboration and Digital

Financing:
H2020-EU.2.1.1. (EU Grant ID number: 101017151)

Budget:
6,342,975 euros

Project length:
01/01/2021–06/30/2024

Project coordination:
Institute of Communication and Computer Systems, Greece

Partners:
Profactor GmbH, Austria
Centro Ricerche FIAT SCPA, Italy
FH OÖ Forschungs & Entwicklungs GmbH, Austria
AEGIS IT Research GmbH, Germany
Forschungsgesellschaft für Arbeitsphysiologie und Arbeitsschutz e. V., Germany
IDRYMA Technologias Kai Erevnas, Greece
CAL-TEK SRL, ITALY
The Technical University of Darmstadt, Germany
The University of Salerno, Italy
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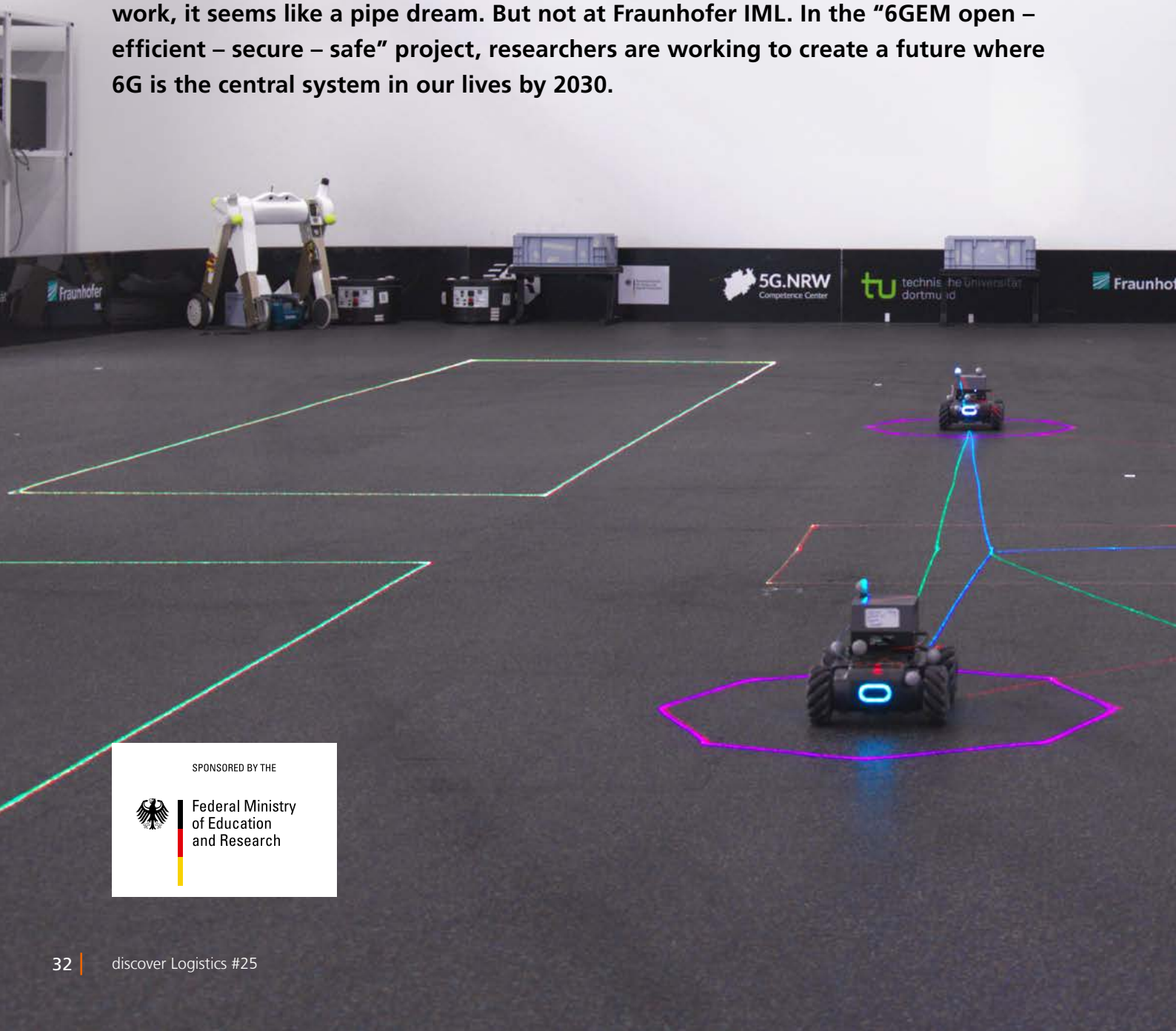
European Commission | Horizon 2020
European Union funding for Research & Innovation

The Network Of Our **Dreams**

Sometimes, it's hard to believe: It's 2024, and yet it feels like our mobile network is still lagging two decades behind – so when people talk about the 6G mobile network, it seems like a pipe dream. But not at Fraunhofer IML. In the "6GEM open – efficient – secure – safe" project, researchers are working to create a future where 6G is the central system in our lives by 2030.



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The "6G" part of the name stands for this future mobile network, while the "EM" part refers to the unique consortium involved the project, a combination of scientific excellence and mobile communications expertise made up of representatives from across the materials, networks, components, microchips and modules sectors in North Rhine-Westphalia. In addition to Fraunhofer IML, the Technical University of Dortmund (TU Dortmund), RWTH Aachen University, Ruhr University Bochum, the University of Duisburg-Essen and four other non-university research institutions are also participating in the project, which is funded by the German Federal Ministry of Education and Research (BMBF). The consortium has been working on this research project together since August 2021.

The goals of the initiative are to create a leading position for Germany in the technology provider market and to underline the importance of having a well-developed mobile network. To facilitate these aims, the project has been divided into a total of seven main topics:

- Digital operating theater
- Smart hospital
- German Rescue Robotics Center
- Highly automated production environment
- High-speed intralogistics
- Port logistics
- Road traffic scenarios, from inner cities to highways

The 3D automated intralogistics environment operated by Fraunhofer IML and the Chair of Materials Handling and Warehousing (FLW) at TU Dortmund consists of two research halls that can be used for demonstrations, simulations and testing, offering researchers reproducible validation options for testing and measuring 6G technology. Either real or even more critical measurements can be taken by adjusting the parameters of the mobile communication system. Obstacles that cause reflection and attenuation can be put in place to simulate shadowing effects and different signal strengths.

An initial prototype was set up last year, in which a cable-driven parallel robot that can move in three directions is used to bridge any gaps in the network connection. Meanwhile, a digital network twin (DNT) provides a real-time simulation of the test field, including the robot platforms, the obstacles and the mobile communications. The researchers are also using a laser system to visualize network communications and environmental information and display processes and results effectively, which helps the researchers get a deeper understanding of the network. This system was presented at the annual 6GEM General Assembly 2024.

Ideally, real-time decisions should be made at the point in the system where the conditions are most favorable and the best availability of technical equipment is to be found. An edge cloud continuum makes it possible for high-level capabilities such as AI and analytics to be distributed. The decision-making instances switch smoothly between cloud, edge and on-device, depending on the situation. The aim is to build OpenRAN-compatible software that allows decisions to be made, stores information on situational and fluid states and can change the execution location on this basis. In order to calculate these factors in the areas where the network is at its strongest and the best resources are available, multi-agent and cluster system approaches are used in the new 5G campus network that is currently being set up.

This prototype will be presented at the 6GEM General Assembly 2025, which will take place on the campus of Fraunhofer IML and the Chair of FLW at TU Dortmund. Apart from the innovative research dimension, one particular highlight of this project is actually this meeting of the consortium, where all the participants can share the current status of their research and make new contacts. In addition to the German project partners, international guests who are interested in the consortium's innovative research will also be in attendance.

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Breaking Down Barriers

to Implement AI

Artificial Intelligence (AI) has made enormous progress in recent years and its potential applications now extend to numerous areas, including logistics. Although there are a number of reasons that AI is not yet being fully utilized, there are fewer obstacles to overcome when implementing digitalization and AI solutions than you might think.

According to Josef Kamphues, there are a few main reasons why small and medium-sized enterprises (SMEs) do not value AI as much as this technology – with all its advantages – really deserves. Companies have concerns about data security and the complexity of the technology, and they lack AI expertise within their organization and are concerned about supposedly high costs. "These challenges must be addressed if we are to exploit the full potential of AI in industry," says the head of the Supply Chain Development & Strategy department at Fraunhofer IML.

Talking through the issues

One major obstacle is the shortage of skilled workers, i.e., a lack of specialist knowledge. Many companies cannot find qualified employees, or their existing staff are unable to acquire the necessary knowledge. As a result, the companies' AI projects frequently fail or never even get off the ground. Another obstacle is the lack of high quality data to use for training. Many AI applications require operational data that is often not available in sufficient quantities. The increased cost of financing AI technologies and a lack of financial resources are also significant obstacles. Other issues holding companies back include a lack of awareness on the part of the management, a lack of legal security, a lack of use cases that would add value, and regulatory obstacles. "As a matter of fact, when we enter into discussions with interested companies, we discover that we can quickly overcome the vast majority of these objections. This technology is still quite new, so there are many myths surrounding it – and they need to be corrected," says Helena Piastowski, head of the Production Logistics department at Fraunhofer IML. "Of course, AI is not an end in itself – it always needs a use case." "That's why we help companies – through the SME Digital Centre Ruhr-OWL, for example – to discover potential fields of application," adds Josef Kamphues.

An impressive example of an AI-driven solution

Martin Friedrich, an AI trainer at the SME Digital Centre Ruhr-OWL, describes one positive example: the implementation of AI-driven solutions in the field of container management at Mühlhoff Umformtechnik GmbH. By using advanced technologies to optimize their logistics processes, not only did the automotive supplier company from Uedem am Niederrhein increase efficiency, they also improved transparency and traceability throughout the entire production process. Container management at Mühlhoff encompasses a wide range of processes – from storage and transportation to tracking and managing containers. In the past, this has typically been a labor-intensive and error-prone field. "With the introduction of artificial intelligence (AI), this has fundamentally changed. AI-driven systems analyze large quantities of data in real time and provide accurate predictions regarding the demand for and availability of containers. Machine learning algorithms can detect patterns and anomalies that human eyes often miss," says Martin Friedrich. This enables proactive planning and reduces bottlenecks and overstocking. The

> **"Machine learning algorithms can detect patterns and anomalies that human eyes often miss"**
>
> Dipl.-Wirt.-Math. Martin Friedrich

implementation of AI technology at Mühlhoff has already yielded some remarkable results. The efficiency of its

container logistics has increased significantly, resulting in cost savings and greater customer satisfaction. In addition, by optimizing transportation routes and reducing the number of empty runs, the company has minimized its environmental impact. "Overall, Mühlhoff Umformtechnik GmbH is an impressive example of how AI-driven solutions can revolutionize container management," Friedrich adds. "By combining innovative technology and well-founded industry knowledge, the company is setting new standards in industrial logistics."

> **"By combining innovative technology and well-founded industry knowledge, the company is setting new standards in industrial logistics"**
>
> Dipl.-Wirt.-Math. Martin Friedrich

AI-optimized delivery time forecasts

The haulage and logistics company ECS GmbH is also on the road to implementing a digitalized arrival time forecast system. As part of a transfer project with the SME Digital Centre Ruhr-OWL, the medium-sized company implemented an AI-driven ETA service for calculating transportation routes and forecasting the expected arrival and departure times. "We've been working closely with the company managers throughout the entire project," says Martin Friedrich. The researchers recorded and analyzed the processes at the Kreuztal-based transportation company. The goal was to optimize delivery time forecasts using AI-driven software, simplify workflows and improve customer service. In order to achieve this, the SME Digital Centre Ruhr-OWL used the findings from an ETA service developed in Fraunhofer IML's Silicon Economy initiative. "Here we are developing an open source infrastructure for the platform economy of the future," explains Helena Piastowski. "The ETA service is a wonderful example of how basic AI-driven functions can be made easy to access and use in a financially viable way thanks to open source systems," she adds.

Leveraging expertise in AI implementation

Josef Kamphues believes that two factors are essential for successfully applying AI: "First of all, when considering AI applications, we need to start with the use case and work backwards. That's why it's so important to begin by thoroughly analyzing the specific application options at each company. And secondly, companies should not be afraid to draw on the experience of other companies and leverage the expertise of research institutions and innovative start-ups. This kind of dialogue and collaboration is precisely what we need to avoid some stumbling blocks and thus achieve the desired results from the project in question more quickly."

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Blockchain for Deforestation-free Supply Chains

International trade in raw materials and products plays an essential role in the global deforestation crisis. That is why, as part of the EU regulation on deforestation-free supply chains, which came into force at the end of June 2023, the European Union is obliging companies to meet due diligence requirements for reducing global deforestation. With project ForestGuard, Fraunhofer IML is supporting the affected companies in complying with the requirements of the European Union's Deforestation Regulation (EUDR).

Forests merit special protection for a wide variety of reasons: They not only act as CO_2 sinks and biodiversity hotspots, but also regulate temperature and water cycles, and serve as medicine cabinets, living gene banks and, last but not least, the foundation for many people's lives and identities. Nevertheless, the world has lost about 420 million hectares of forest (as of 2022) in the last 30 years, according to the Food and Agriculture Organization of the United Nations (FAO) – that's almost equivalent to the surface area of the European Union. Deforestation and forest degradation are among the main causes of the two greatest environmental challenges of our time: the climate crisis and biodiversity loss.

The EU is shouldering the responsibility

The main cause of global deforestation and forest degradation processes is the use of ever greater swathes of agricultural land to produce raw materials such as soybeans, beef, palm oil, wood, cocoa, rubber and coffee. As one of the biggest economies and consumers of these raw materials, the EU is a major contributor to global deforestation and forest degradation – in fact, it is the second largest exporter and importer of goods in the world. Its awareness of this responsibility has led it to adopt the EU Deforestation Regulation (EUDR) on deforestation-free agricultural supply chains, which entered into force on June 29, 2023. The regulation obliges companies to comply with due diligence requirements for reducing global deforestation. The "tree cover status" of agricultural production land as of the reference


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date of December 31, 2020 is the crucial factor here. To be able to import, export or distribute relevant raw materials and products made from them, companies must provide a full disclosure of the extent to which they are affected by the EUDR in terms of their products and in what capacity (i.e., as a distributor or retailer). The purpose of the EUDR is to ensure that raw materials that have been identified as critical and certain products that are manufactured thereof (such as leather, chocolate and furniture) and sold on EU markets do not contribute to deforestation or forest degradation, either in the EU or anywhere else in the world. From now on, the EU intends to only manufacture and consume "deforestation-free" raw materials and products.

Collecting and controlling data

Implementing the deforestation regulation is a complex process, requiring transparent recording and processing of large data volumes across the entire supply chain for all goods, including intermediate products. This process poses enormous challenges for companies. At many stages along the affected supply chains, this information currently is either not available at all or is not available in sufficient quantities or with adequate levels of quality, reliability, tamper resistance or manageability. If a company is impacted by risks associated with certain countries or if their products fall within the controlled categories mentioned above, they will be subject to individual inspections of all their suppliers and production spaces. The EUDR also calls for an individual risk analysis and the introduction of risk mitigation measures. As such, new technical concepts and solution methodologies will be needed before the regulation takes effect on December 30, 2024, in order to support the affected companies in their efforts to meet the EUDR requirements.

This is the starting point for Fraunhofer IML and its partners in the pilot project ForestGuard. The highly practical solution proposal provides companies with a way of feeding all the data results from previous analyses into one place and merge them across multiple supply chain stages while maintaining full tamper resistance and ensuring traceability. To do this, ForestGuard incorporates data from different actors, stakeholders and sources along the supply chains. This data will be consolidated in a structured way in order to ensure the transparency necessary for fulfilling the EUDR due diligence requirements, while still respecting data sovereignty. The research project is funded by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), as part of the Export Initiative Environmental Protection (EXI). The project started on November 1, 2023 and will run for 15 months.

Seamless, secure traceability

ForestGuard is a blockchain-based open-source solution for submitting (uploading) and managing (tracing across multiple stages) proof that products are deforestation free. The relevant data can be provided by users, traced across multiple supply chain stages, even in the case of mixed batches, and made available to third parties (both for display and download). Relevant data includes a proof of ownership, proof of freedom from deforestation, geodata, a description of the goods (e.g., quantity or degree of processing of the product in question) and – if available – certificates (Fairtrade, Fair Globe, etc.). To this end, the research team is combining blockchain with other technologies, such as the internet of things or data from geographical information systems.

Implementing blockchain technology creates a Single Point of Truth (SPoT) and ensures unchanging data integrity, while access control enables targeted insights for companies and government agencies. Opting for an open-source solution also increases the system's scalability. Fraunhofer IML is

using a generic research approach so that the supply chains for all the affected raw materials and goods can be mapped, while also including adjustments for the individual circumstances. "With ForestGuard, we want to create a model for other supply chains and regulatory requirements, such as the German Supply Chain Act (Lieferkettensorgfaltspflichtengesetz, LkSG)," explains Roman Koller, research associate at Fraunhofer IML and project manager of ForestGuard. "The project is also laying important groundwork for supply chain financing and investment financing for sustainability projects – especially in producer countries at the starting point of supply chains."

A real-world example: the coffee supply chain

As the researchers needed to develop ForestGuard under real-world conditions, they chose a coffee supply chain starting in Peru as an example for the project. By incorporating data from every stage of the chain – from plantation to retail – the project team aims to ensure transparency and traceability of EUDR-relevant information along the coffee supply chain. The functions of ForestGuard include merging and splitting batches, verification management, process tracking, accounting for harvests and producer management.

An implementation proposal with the corresponding functionalities is being developed in collaboration with major industry partners, including the REWE Group and Schirmer Kaffee. "Our project partners are all directly or indirectly affected by the EUDR. As such, they are under significant pressure to take action, but they are also highly motivated to play their part in developing new solutions," says Roman Koller. "They are giving us the opportunity to work very closely with the process – literally, from the field to the supermarket shelf – which means we can ensure the applicability of our development and its subsequent transfer into practice."

The support provided by the BMUV and this close collaboration with experienced industry partners highlight ForestGuard's relevance in the context of global environmental changes and the great pressure the EUDR is placing on companies to drive greater sustainability and transparency in supply chains. "Transparent supply chains are the foundation of our fight against climate change and deforestation," says Dr. Klaus Wirbel, member of the Sustainable Finance Advisory Committee of the German Federal Government and Head of Finance and Group Treasury at the REWE Group. "In this pilot project, we are gathering important insights into how we can manage the resulting data volumes and flows efficiently and transparently. We will then be able to pass on these findings – and that would be major progress."

From planning to the pilot phase

The first phase of the project focused on analysis and conceptualization. During this stage, the researchers set out the domain-specific, technical and regulatory requirements for a blockchain-based approach to implementing the EUDR from the perspective of the stakeholders concerned and developed a proposal for the program flow chart, software architecture and data model, and a description of the interfaces. Next came the second project phase, which started in May 2024 and includes the implementation of the design, a pilot project and validation with the project partners.

The research team is currently developing and implementing an initial functional prototype to demonstrate the effectiveness of the solution proposal. This will be followed by a pilot project, whereby the MVP will be applied in the coffee supply chain example – a mission that will take the researchers to a coffee cooperative in Peru. They want to get an idea

of the situation of local farmers, observe the harvest and logistics processes there and find out how data is collected and managed on site. Once the team has completed the pilot phase and evaluated the results, they will investigate the extent to which ForestGuard can be transferred to other supply chains. They are planning to make the open-source solution available to all companies affected by the EUDR by the end of the year.

Remaining obstacles

Until the tool is ready, not only the Dortmund-based researchers, but also all manufacturers, affected companies and the EU itself, will have to take on a number of challenges and work at high speed and with immense effort to launch EUDR-compliant solutions within this tight timeframe. The EU information system where companies are supposed to enter their data will not commence operations until the end of 2024 – i.e., at the same time that the regulation will enter into effect. The EUDR itself has yet to be finalized. For example, the specifications of the interface for the EU information system where due diligence declarations are to be submitted were not published until May 2024. The EU's controversial assessment of country risks is also set to follow later. However, companies cannot assess risks in their supply chain and take measures (such as new contracts/suppliers) to meet the EUDR requirements without this vital information. In addition, data availability and digitalization levels differ widely across the various countries of origin. In many of the-

se countries, recording of field and land ownership has yet to be completed. It remains exciting.

An open-source software solution for providing proof of deforestation freedom for (coffee) supply chains, taking into account regulatory and financial requirements

Funding recipients:
Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V.

Collaboration partners:
Schirmer Kaffee GmbH & REWE Group

Duration:
November 1, 2023 to January 31, 2025

Topics:
Interdisciplinary technologies

Key funding areas:
Feasibility study, Pilot and model projects

Target countries:
Peru

For more information, see:

Fraunhofer IML Project page

Export Initiative

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

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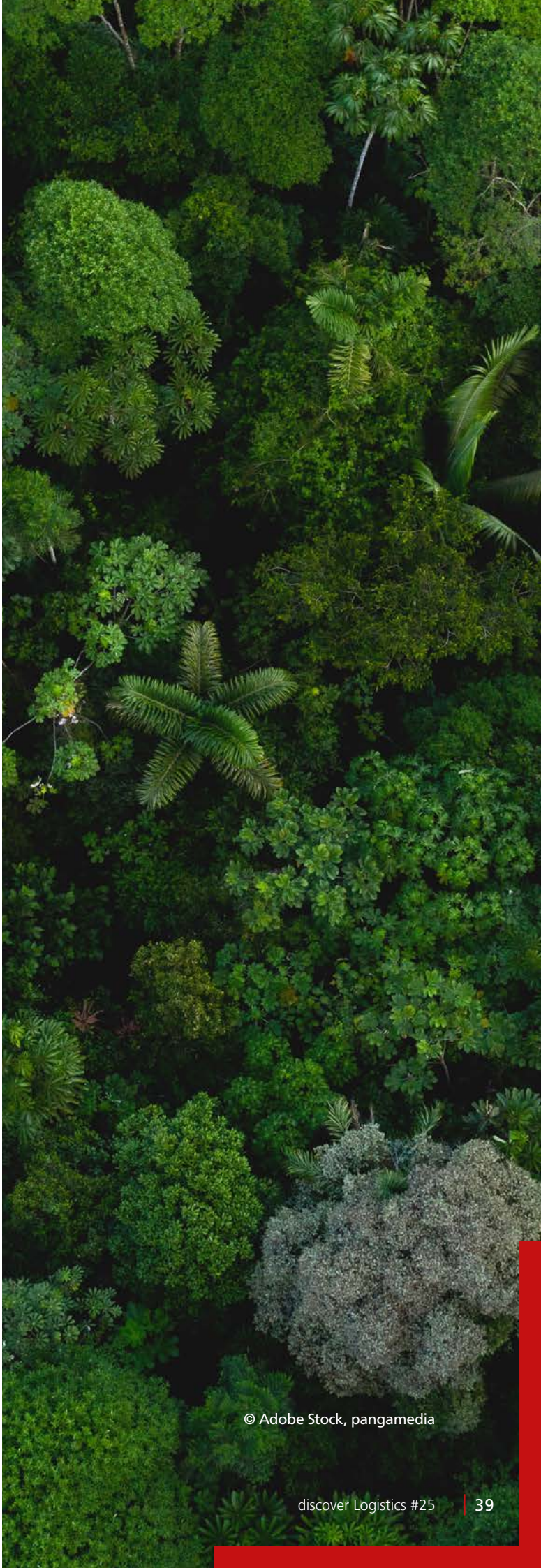

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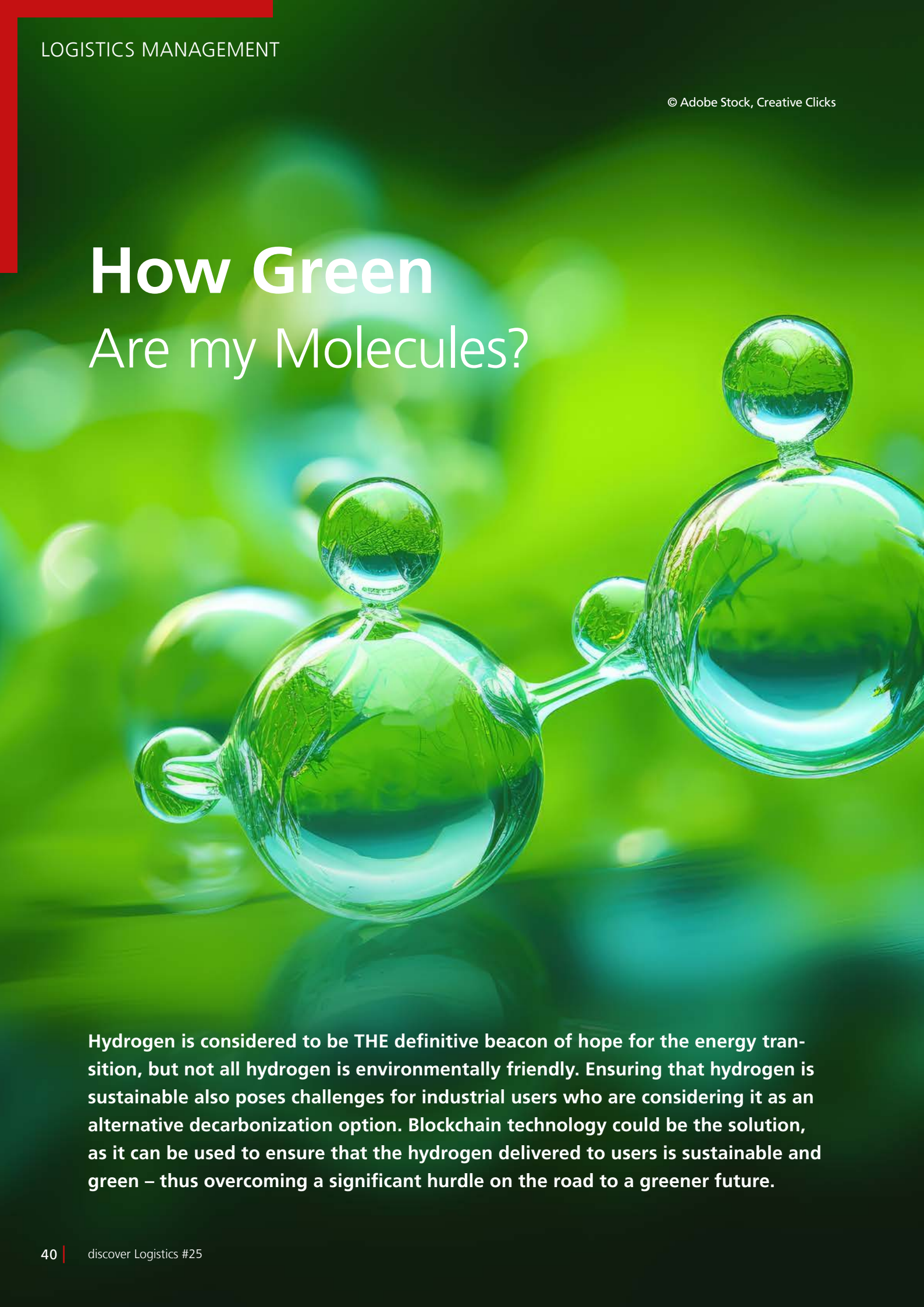
How Green
Are my Molecules?



Hydrogen is considered to be THE definitive beacon of hope for the energy transition, but not all hydrogen is environmentally friendly. Ensuring that hydrogen is sustainable also poses challenges for industrial users who are considering it as an alternative decarbonization option. Blockchain technology could be the solution, as it can be used to ensure that the hydrogen delivered to users is sustainable and green – thus overcoming a significant hurdle on the road to a greener future.

As the energy carrier of the future, hydrogen will be used as a fuel for vehicles and in industry to decarbonize energy-intensive processes that currently still rely on fossil fuels. Implementing hydrogen is no longer just a dream – it's getting closer day by day. Alexander Grünewald, a research scientist in the Supply Chain Development & Strategy department at Fraunhofer IML, also stresses our society's high hopes for hydrogen: "Sustainable hydrogen is a key part of the energy transition – but without a trustworthy hydrogen network, it could be impossible to create a climate-neutral production sector." In order for this to work, we need a way to prove that hydrogen is green.

> **"Sustainable hydrogen is a key part of the energy transition – but without a trustworthy hydrogen network, it could be impossible to create a climate-neutral production sector"**
>
> Alexander Grünewald

One molecule – many colors

Green, pink or blue hydrogen – it comes in a whole rainbow of colors. But that doesn't mean the H2 molecules are turning pink all of a sudden. The terms are used to indicate the different ways in which the hydrogen is produced. Currently, the various processes used to produce hydrogen require a great deal of energy. The color is determined by the type of energy and the production process that was used – for example, in pink H_2, the energy comes from nuclear power. However, the holy grail is green hydrogen, which is produced using renewable energy sources. This makes it particularly climate-friendly in the long term; however, only 0.03 percent of the hydrogen produced worldwide is green.

So to drive progress in the energy transition, we urgently need to produce more green H_2. One of the biggest challenges here is proving that the hydrogen produced is really green. This is because the idea of clearly separating hydrogen types by color codes does not match up with the complex reality. Numerous steps come between the hydrogen production and utilization phases, and these involve mixing H_2 of different colors. It is not always easy for companies along the supply chain to prove that the end product is still green.

Trust is good – proof of origin is better

The problem is that several different methods are currently used to assess whether hydrogen is green. However, legislation is now in place that will require proof of origin for hydrogen in the future, which shows the increasing importance of the topic. Companies can now use blockchain technology to comply with the new regulation: A blockchain network allows its users to store all their data transparently and securely. The companies in a blockchain network can view product properties and emissions at any time. This technology offers far more benefits than just certifying green hydrogen: Blockchain-based documentation can also be used for digital product passports and to comply with recycling regulations, which will become mandatory in the future.

Innovations for all!

It's a well-known fact that people work better in a team than alone, and the same goes for the hydrogen ecosystem – because using blockchain-based records to prove that hydrogen is green all by ourselves is never going to succeed. Every company in the hydrogen ecosystem needs to work together to make the idea of green hydrogen a reality. Because blockchain technology functions most effectively when everyone participates.

Innovations such as blockchain are not a one-way street, nor are they a privilege that's just reserved for large corporations. Small and medium-sized enterprises (SMEs) can also benefit from this technology. That is why the Fraunhofer Institute for Material Flow and Logistics IML and the Technical University of Dortmund are supporting companies with using blockchain technology as part of project DUH-IT, an initiative for blockchain in logistics that is focusing on innovation transfer for the Dortmund-Unna-Hamm model region.

Building up basic expertise in the field of blockchain is the first big step in this project. The companies will then be supported as they select and design their ideal blockchain technology – and what's more, they can also get their own ideas for potential areas of application by visiting labs and seeing demonstrations. This is about more than just using this technology in the hydrogen sector.

Due to its long mining history, the Dortmund-Unna-Hamm region is being particularly affected by the phasing-out of coal and the structural change that has come along with this transition. Developing and strengthening other industrial sectors through blockchain could strengthen the region's overall economy, making it a role model for other areas – including for other regions in Germany.

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What Do Humans and Machines Have **in Common?** That's Right, **Empathy!**

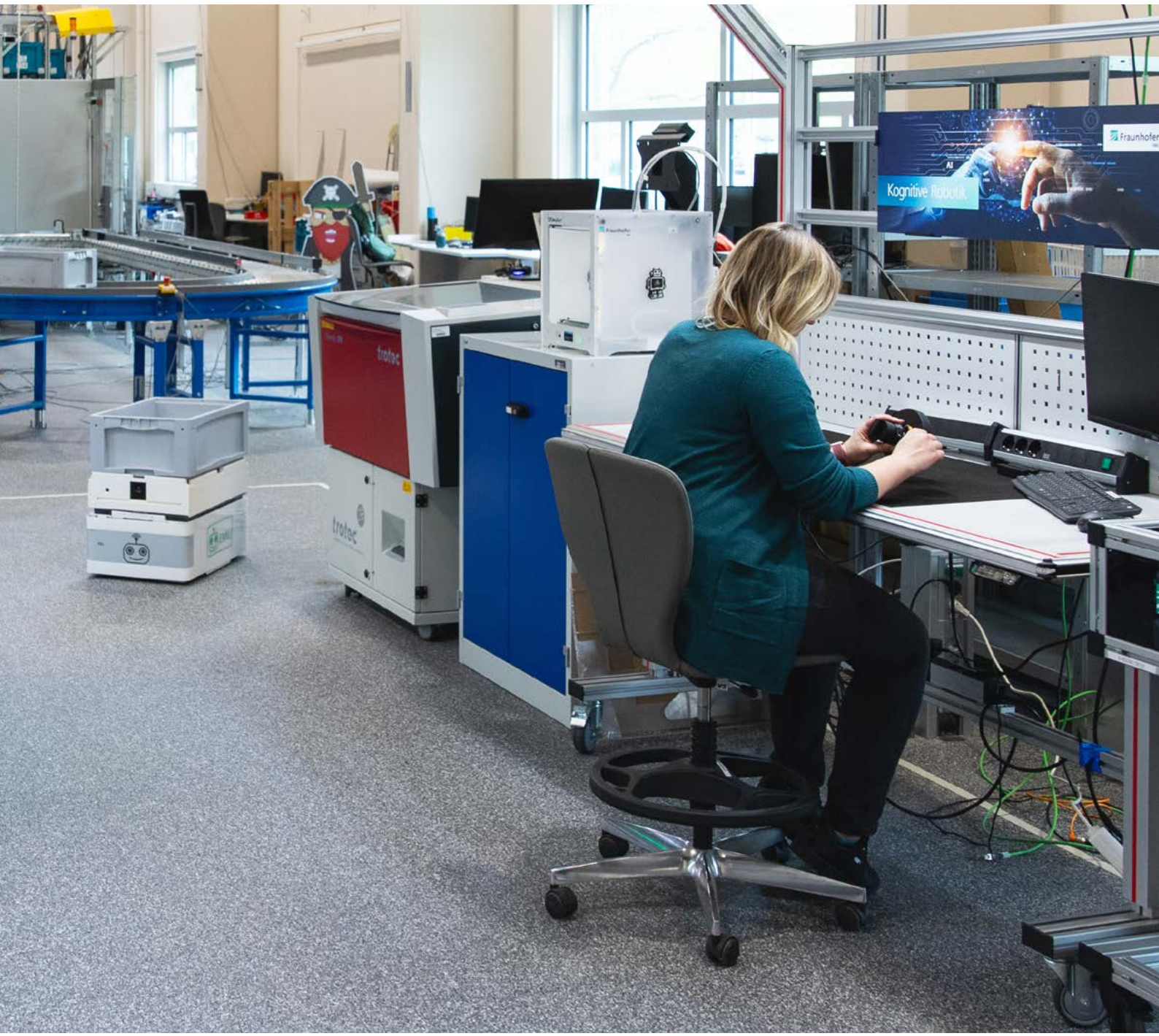
The special thing about interpersonal relationships is empathy, i.e. the ability to recognize and respond to the feelings and motives of others. What if cooperation between humans and machines were also characterized by these qualities? If the machine recognizes that the human is stressed and the human in turn knows the state of the machine at all times. Seven Fraunhofer Institutes are researching this synergetic collaboration in the "EMOTION" lighthouse project.

The Fraunhofer flagship project "EMOTION" aims to introduce a new concept into production: "empathic systems". In resilient production systems that are capable of reacting, learning and adapting, humans and intelligent machines must work hand in hand rather than side by side. However, this collaboration requires a completely new understanding of each other's abilities, goals and constitution, making empathy the decisive ability to make production systems more resilient and therefore future-proof.

The seven participating Fraunhofer Institutes see empathy as the necessary core competence, in contrast to conventional cognitive systems. Empathic technical systems have the system network to independently incorporate and process information. Empathic systems are therefore an extension of conventional cognitive systems. In concrete terms, this should mean greater transparency in production, faster detection of deviations, better predictive and adaptive capabilities and, ultimately, cooperative learning.

The aim of the project is to develop a reference model for emphatic production systems, taking into account the interoperability and individuality of the players, and to implement this technically by combining hardware and software solutions. In concrete terms, this means that the added value of human-technology solutions in terms of the responsiveness, learning and adaptability of production systems will be demonstrated and demonstrated through industry-oriented testing in the fields of assistance systems, maintenance and production planning and control. The target group includes users in plant, machine and vehicle construction as well as system manufacturers and system integrators in the digital economy.

A core task lies in the design of a decentralized system architecture that ultimately leads to the sovereignty of the players. To achieve this, an infrastructure for digital factory management must first be created, with edge computing solutions and the necessary data protection training. A digital twin is then placed on top of this, which maps all the information of the stakeholders and production. The ultimate goal is to transfer the emphatic cooperation between two people to cooperation with and between machines, so



that machines are informed of the other machine's status and goals and can then resolve a conflict independently.

Such a socio-technical system can react much more flexibly to everyday logistical problems, such as machine malfunctions, product variant diversity, fluctuating demand and delivery bottlenecks. Digital networking, collective learning and cooperative decision-making mechanisms create individual cooperation between humans and assistance systems and machine-machine systems, which increases resilience enormously. Additional components and new sensors are currently being added to the system to make human-machine interaction even smoother and to obtain further data, such as on necessary maintenance tasks. All of this continues to serve the goal of allowing people and technology to react to each other in an agile manner, thereby strengthening the overall system.

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AI Speeds Up Transportation Logistics

In today's fast-moving world, transportation logistics plays a crucial role in the efficient movement of goods and people. The implementation of generative artificial intelligence (AI) and digital twins in this area is set to bring fundamental changes to the way logistics companies and transportation service providers work.

Generative AI refers to algorithms and models that are capable of generating new data or content with similar properties to existing data. These models can produce many forms of data, ranging from text to images and music, and they can be used in various fields, from the creative industry to data augmentation and simulations. "This technology is often used in areas such as image and text generation; however, it is also seeing increasing use in transportation logistics," says Martin Friedrich. A senior scientist in the Transportation Logistics department at Fraunhofer IML, he sees route planning and optimization, fleet management, warehouse management and demand prediction as possible areas of application for GenAI. "Applying the new technologies in these areas will create significant benefits for logistics professionals – for example, efficiency gains, cost savings, increased sustainability and customer satisfaction," says the IML researcher.

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>
> Dipl.-Wirt.-Math. Martin Friedrich

Identifying potential optimization areas with sensor data

As an example, Friedrich cites a gas supplier that has equipped its gas containers with sensors that monitor how full they are. The system uses this sensor technology to check the current status continuously and calculate when the customer will need a new delivery. "With this information, the AI can predict demand very accurately and can tailor warehouse and fleet management decisions to these predictions," says the scientist. He's describing the current state of play, because generating predictions based on internal and external data and using them as a basis for making new decisions is already standard technology. "Now, we're coming to the language model level. For this, we have to combine massive quantities of information with operator communications and process them in such a way that the content is easier to understand and access. We're hoping to present a prototype of this technology at Fraunhofer IML for the Zukunftskongress conference. This will mainly focus on knowledge management and representation in the logistics context."

On the double

Another tool that is set to trigger a mini-revolution in transportation logistics is the digital twin, a virtual reproduction of a physical object or system that collects and analyzes data in real time. "It's important to note that a digital twin is more than just a 3D model. It is a dynamic, digital representation of a physical object or system that receives continuous updates from sensors and other data sources. For example, in transportation logistics, a digital twin could map a vehicle, a fleet, a logistics site or an entire logistics process," says Achim Klukas, a team leader in the Transportation Logistics department at Fraunhofer IML.

Project CRISTAL

Fraunhofer IML researchers are currently involved in a number of projects that aim to implement digital twins in the field of transportation logistics. For example, project CRISTAL (Climate Resilient and Environmentally Sustainable Transport Infrastructure) is focusing on increasing the share of freight transportation on inland waterways (IWT) by at least 20 percent and demonstrating strategies for impro-

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Dipl.-Logist. Achim Klukas

ving reliability by 80 percent at its three pilot sites (in Italy, Poland and France). "The project will help ensure that IWT capacity can be used to a greater extent than before, even during extreme weather events," explains Klukas.

To facilitate this, the CRISTAL project team have equipped buoys with sensors so that they can monitor water depth, which will then be used by infrastructure managers in conjunction with their DSS-RIS layer to determine the water level under a ship's keel. The results the researchers are hoping to attain include ready-to-use guidelines for establishing a synchromodal transportation corridor management system, covering regulation, administration, business models and management. They are also planning to set up a comprehensive real-time monitoring system for water levels and hydrological conditions, including RIS. "The solutions developed in project CRISTAL will strengthen the logistics processes in inland waterway transportation, enabling us to exploit previously untapped potential," concludes Achim Klukas.

A digital twin optimizes logistics in inland ports

Meanwhile, the TOLKIEN project team aims to increase process transparency at inland ports and to provide recommendations for process optimization. "One key focus in the project is developing a comprehensive, validated database and conducting standardized digital mapping of processes and emissions in the port area," explains Klukas. Other focus areas include using artificial intelligence to fine-tune recommended measures for selected business cases. The recommendations will concentrate on emission reduction and traffic flow control and will be incorporated into the digital map via machine learning methods. Fine-tuning of these business cases will be conducted in an agile manner, in line with the current project conditions: "The aim of the project is to identify and amalgamate individual data sources at an inland port and to build a uniform, structured database. This will allow us to create a consistent representation of the processes and thus increase visibility of emissions and traffic flows. To achieve this, we aim to create a digital map and model – also known as a digital twin – of the port's business processes."

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Digital Testbed Air Cargo:

Next-Level Air Cargo Handling

The significant increase in global goods flows demands efficient air cargo operations, incorporating automated and digitalized processes. Since 2021, researchers at Fraunhofer IML have been addressing this challenge through the „Digital Testbed Air Cargo" project.

Imagine a "robot dog" that autonomously patrols warehouses to locate empty storage spaces, a highly dynamic transportation robot that automatically moves pallets to designated storage areas, and a "Segway robot" with versatile functionalities for shifting cargo from Euro-pallets to a conveyor belt. This might sound like science fiction, but these innovations are now a reality. In April and May 2024, researchers from Fraunhofer IML demonstrated these technologies at Munich Airport, showcasing the first tangible results of the „Digital Testbed Air Cargo" (DTAC) project. Partnering with Frankfurt University of Applied Sciences, KRAVAG Versicherung, and industry stakeholders from Munich Airport (Cargogate, CHI, Sovereign Speed, and DB Schenker), the team aims to enhance efficiency and performance in the air cargo transport chain through better process integration and increased digitalization. The Fraunhofer IML scientists successfully displayed how four autonomous and automated devices could either take over labor-intensive, repetitive tasks or support employees in physically demanding roles.

A Pioneering Collaboration

"This compelling demonstration shows we are well-prepared to meet current and future challenges, especially in the air cargo sector. This sector must balance labor shortages with the need for high throughput rates. We can only overcome this challenge by leveraging all available technological advancements to optimize processes," emphasized Christian Bernreiter, Bavarian State Minister for Housing, Construction, and Transport. Dr. Jan Henrik Andersson, Chief Commercial Officer and Chief Security Officer at Flughafen München GmbH, also expressed optimism about the research outcomes: "The collaboration between Fraunhofer IML and Munich Airport is pioneering. With increasing air cargo volumes and staffing challenges, digitalization and robotics will be crucial in making cargo and baggage handling more efficient and attractive."

A Key Role for Robots

During the Munich Airport presentation, four very different robots demonstrated key roles. The "robot dog," Spot, from Boston Dynamics, equipped with a scanner and 4K camera, autonomously patrolled the warehouse, identifying large storage pallets ready for storage and locating suitable areas for them. An autonomous forklift managed the transfer of goods from transportation vehicles to an automated high-bay warehouse. Fraunhofer IML's omni-directional, high-speed robot, O³dyn, transported Euro-pallets to a neighboring warehouse. Meanwhile, evoBOT, another Fraunhofer IML development, transferred packages from a Euro-pallet to an X-ray machine conveyor belt and back again. EvoBOT, a dynamically stable system with two gripping arms, operates on the principle of an inverted pendulum without an external counterweight. Its processes were controlled by Fraunhofer's „openTCS" software, a user-friendly tool for coordinating automated guided vehicles (AGVs). In summer 2024, another test field

was also run at Stuttgart Airport to illuminate transportation on the apron.

Project Extension and Increased Funding

Initially scheduled to conclude in September 2024, the DTAC project received approximately 6.9 million euros from the German Federal Ministry for Digital and Transport. Recently, the ministry increased the funding by an additional 6.8 million euros, extending the project's duration until August 2026. This brings the total project funding to 18 million euros. "We need artificial intelligence in aviation to remain internationally competitive," asserted Oliver Luksic, Parliamentary State Secretary to the German federal minister for Digital and Transport. "This is the only way we can deploy our increasingly scarce workforce effectively and make optimum use of limited infrastructure to reduce costs long-term. The workforce shortage is particularly severe in logistics. Digital technologies will be essential in meeting these challenges and ensuring the quick, reliable, and efficient air transport of goods in the future. With the 'Digital Testbed' project, we are investing in our country's future viability." Dr. Harald Sieke, head of the Aviation Logistics department at Fraunhofer IML and overall project manager for DTAC, added: "This additional funding for the Digital Testbed Air Cargo project allows us to maintain and advance our leading position in technology and knowledge within the air cargo sector, positioning Germany as an attractive, future-oriented hub for digitalizing air cargo processes."

AI Provides Crucial Tools

While not all processes during the Munich Airport demonstration were fully automated, the Fraunhofer IML researchers anticipate a rapid and significant increase in automation in air cargo handling, especially given the available research funding. "We have made significant strides on the hardware front. Artificial intelligence will help us coordinate and control vehicles, providing the tools and algorithms needed to predict the paths of autonomous robots and avoid collisions. As a result, we will soon have fully autonomous systems to make the air cargo industry future-ready," says Prof. Michael Henke, executive director of Fraunhofer IML. In the extension phase of the project, work will continue on particularly relevant strands of research: These include robot development specifically for air cargo transportation units, end-to-end process considerations at the airport and control station applications for monitoring and controlling the robots.

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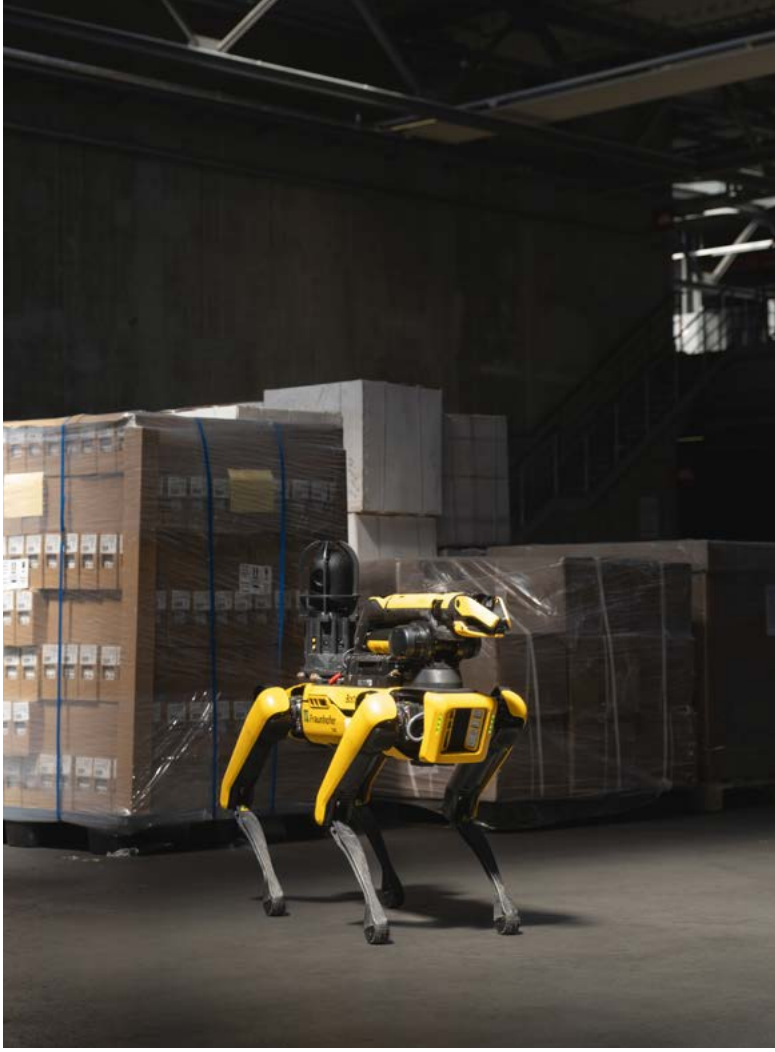

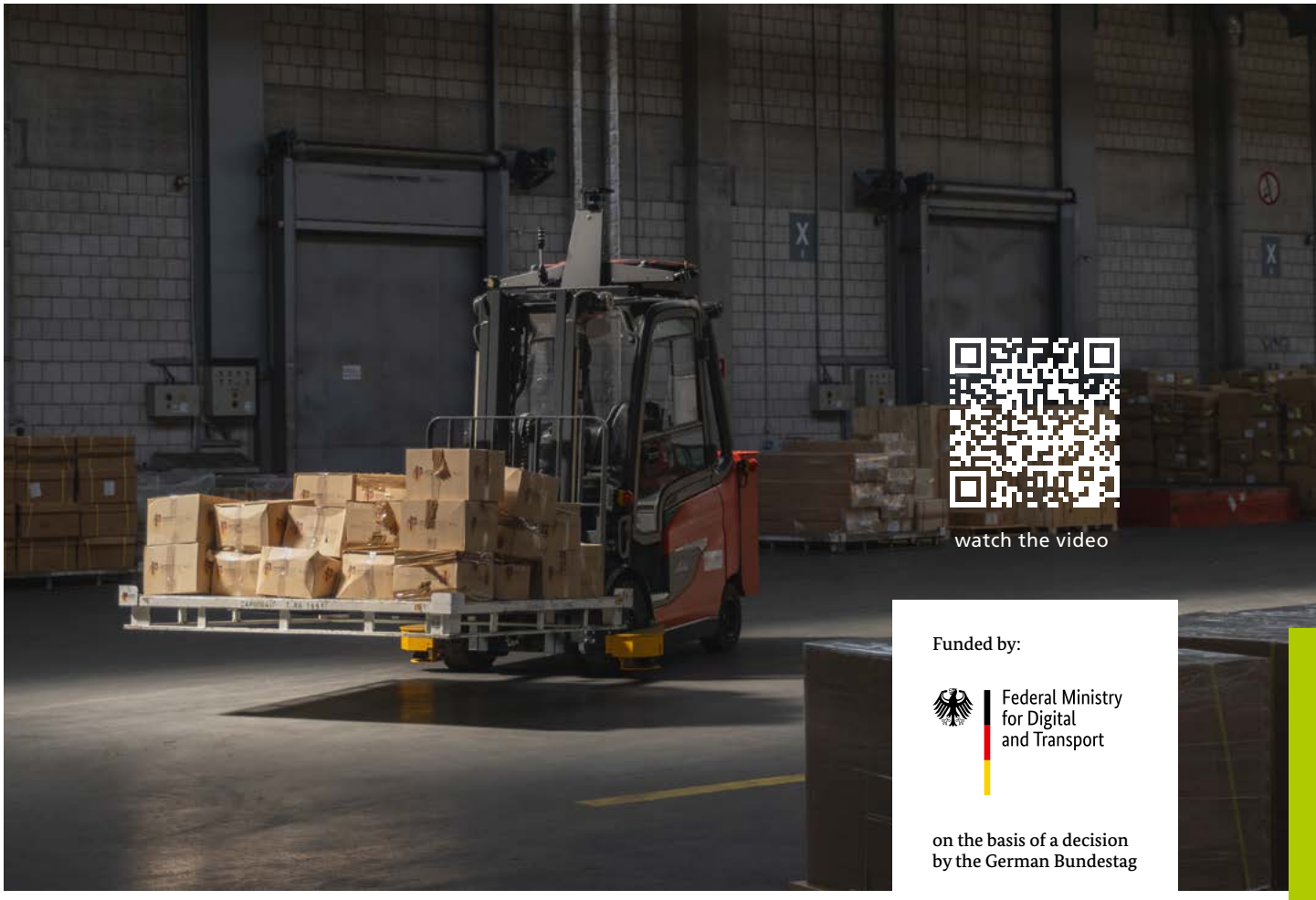

watch the video

Funded by:

Federal Ministry
for Digital
and Transport

on the basis of a decision
by the German Bundestag

Avoiding Urban Traffic Jams with Low-noise

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The increase in delivery traffic in city centers is pushing urban transport infrastructures to the limits of their capacity – especially during morning rush hours, when delivery drivers and commuters take to the roads at the same time. Straightening out the traffic situation while simultaneously ensuring punctual deliveries in the retail sector is quite a challenge, but Fraunhofer IML is already on the case. Since 2013, IML scientists have worked on a series of research projects that focus on developing solutions for "low-noise logistics" and shifting delivery traffic to off-peak hours or night time. This would make it possible to improve traffic flow during peak times, reduce congestion and bottlenecks and increase quality of life for city dwellers by using battery-powered trucks with lower noise and pollutant emissions.

In their first project, GeNaLog, the Dortmund researchers set out to find solutions that could supply city retail outlets while contributing as little as possible to noise or congestion levels – a common issue these days, as residential and commercial road usage are increasingly coming into conflict. Measures for making the retail stores themselves quieter, like noise-insulating walls, quieter paving on ground surfaces or a sound-absorbent "superstructure" to go around the loading docks, would be a good start. However, the GeNaLog team found that it is not possible to comply with legal requirements around noise levels if diesel trucks and loud equipment continue to be used for deliveries. They concluded that one possible solution may be "low-noise logistics," i.e., logistics with alternative fuel trucks and low-noise handling equipment. This would make it possible to move logistics processes to off-peak hours and night time, which could in turn increase tour efficiency and reduce pollutant and noise emissions. "We wanted to demonstrate that electric trucks can meet the current legal noise limits and to make it possible to supply goods to supermarkets, for example, at night or during off-peak hours," says Arnd Bernsmann, a project manager in the Transportation Logistics department at Fraunhofer IML. "During a test phase, we were able to proof that." The problem, however, was that the city permit authorities require each individual company site to provide proof that it is meeting threshold values for noise limits. Currently, Germany has not set any noise emission values for alternative fuel trucks, so local governments have no point of reference for them, and as a consequence, it is difficult to obtain permits for deliveries during the off-peak hours or at night.

Reference values for permit authorities

To remove the barriers to authorizing off-peak deliveries, permit authorities in municipalities need reliable noise emission threshold values for alternative fuel trucks. This is why the researchers have launched a mobility study on noise-free logistics (Mobilitätsstudie geräuscharme Logistik), as part of another funding project by the Ministry of the Environment, Nature Conservation and Transport of the State of North Rhine-Westphalia (MUNV). In this study, which is set to be published in September 2024, the researchers aim to provide the first reliable data on noise emissions for commercial alternative fuel vehicles. "With this study, we want to contribute to the development of consistent regulations for Germany and make it easier for municipalities and local authorities to assess noise emissions from alternative fuel trucks," says Daniela Kirsch, a team leader at Fraunhofer IML. The data in question was collected over the last two years. In collaboration with Peutz Consult, a consultation firm specializing in sound and noise, the researchers visited manufacturers and logistics service providers all over Germany to measure typical driving conditions for trucks during delivery in urban areas. They included a variety of alternative fuel vehicles in their tests, such as electric, hydrogen- and gas-powered trucks, and covered the entire range of vehicle weights, from 7.5 ton trucks to 40 ton semis. To mark the publication of the manual, Fraunhofer IML and the MUNV in North-Rhine Westphalia are planning an informative event for municipalities, logistics service providers, retail companies, sound consultant firms and other interested parties on September 25, 2024. The event will present lectures and information around the area of "low-noise logistics."

Quiet trucks are not enough: loading also needs to quiet down

The noise level measurements conducted for the low-noise logistics manual (Handbuch Geräuscharme Logistik) have shown that the alternative fuel vehicles are not especially loud. But there is still the noise that is generated during loading and unloading to consider: refrigeration units, closing loading flaps, warning sounds when vehicles reverse, moving trolleys over loading ramps and the employees themselves. Low-noise solutions for technical equipment are always a possibility. The trolleys can be fitted with quieter wheels, and the tail lifts can be covered with sound-absorbing coatings so that the trolleys can move on them even more quietly. But how can you keep the people quiet? "The employees are the make-or-break factor," explains Arnd Bernsmann. "Because no amount of rubber seals can stop people from turning their radios way up, having loud phone calls or slamming the tail lift down."

A best practice example from the Netherlands

"Our European neighbors have provided a positive example of how to overcome this challenge," says Daniela Kirsch. The PIEK certificate has been in use in the Netherlands since 2004. PIEK-certified trucks are approved for delivery during off-peak hours. In the Netherlands, trucks and transportation equipment must undergo an acoustic test to be certified for arrangements such as night deliveries, for example. To pass the test, the vehicles and equipment must not exceed the set decibel limits of less than 60 dB(A) at a distance of 7.5 meters. The PIEK certification is a standard for quiet delivery vehicles and other quiet technologies that is awarded by the PIEK quality seal foundation. Once you have a certified low-noise vehicle with the corresponding markings, you can start making supply deliveries in city centers at off-peak times. "As part of the PIEK certification, the trucker drivers also receive training on how to unload vehicles quietly," explains Kirsch. However, as the Dutch PIEK certification cannot be transferred to Germany on a one-to-one basis, the research team has plans to initiate a similar certification for Germany.

Follow-up project: loading and unloading processes

This is the point at which the currently ongoing project in this series has picked up. The follow-up project has received around 565,000 euros in funding from the Ministry of the Environment, Nature Conservation and Transport of the State of North Rhine-Westphalia via its mobility and mobility management funding program (FÖRI-MM). Between now and the end of the project in March 2026, the researchers primarily plan to study employee behavior during loading and unloading processes, along with the handling equipment used at the retail stores. They are looking for a sensor service provider to collaborate with on this, so they can measure employee behavior in the area of noise emissions. "We want to use the sensors to detect the sources of the noises produced by employees during loading and unloading and to measure and reduce the sound levels they produce," says Arnd Bernsmann. "To do this, we will attach a sensor system to the employee's shoulder, belt and wrist, and, in addition to measuring motion sequences, we will also measure the noise level produced by each work process with a microphone to determine how loud the process in question was." The research team is measuring both the current, actual acoustic conditions and the noise levels produced if equipment such as quieter rollers is used. "Employees will then receive training to raise their awareness of this topic so they can change their loading and unloading behavior accordingly. That's why training is so important," says Bernsmann.

A win-win situation for all involved

One conclusion that can be drawn from the research conducted so far is that transferring commercial transportation to off-peak times would ease the traffic situation in cities during rush hours and improve traffic safety and efficiency. However, for this to happen, every stage of the entire goods transportation and handling process – from driving through the city to loading and unloading – must be as quiet as possible. When it comes to noise emissions, employee behavior and handling equipment require particularly close attention. "We definitely do not want people in their homes to be startled out of bed," says Bernsmann. "Everyone should get an undisturbed night's sleep. That's why we're doing everything we can to make delivery traffic and the related logistics processes quieter."

With a reliable permit system that allows low-noise trucks to make deliveries during off-peak hours and night time, this aspiration could become a reality. This outcome would be a win-win situation for residents, the environment, road users and retail companies, who could deploy their vehicles more efficiently, while the extra costs incurred in the process could be offset by the extended operating times. The researchers are hopeful that they will soon be able to put their findings and the data they have collected to the test in a lighthouse project, and they are looking for an innovative city and interested companies to act as partners in this. Because with the continuation of this research project, North Rhine-Westphalia is maintaining its position as a trailblazer in the field of "low-noise logistics." Germany has yet to see any comparable research projects, where technical innovations and behavioral instructions for logistics personnel are developed under real-world conditions with the aim of complying with applicable threshold values and significantly reducing noise emissions for citizens and the environment.

Ministry of the Environment,
Nature and Transport
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A GAME-Changer For Hospital Logistics

Like so many industrial and commercial establishments, hospitals are bemoaning the shortage of skilled workers. The care sector is particularly affected by this. One solution to ease the burden on nursing staff and make the profession more attractive could lie in reconfiguring logistical processes with robots. Autonomous mobile robots (AMRs) have been used to transport high-volume loads such as food, laundry and dumpsters for several years. However, their sphere of activity is limited to areas where there is no foot traffic. But now, with the introduction of the smart transportation robot "RemRob" from Fraunhofer IML, this is set to change. Like R2-D2 from the popular Star Wars saga, the robot is designed to trundle through hospital corridors autonomously and supply the wards with medical materials.

As part of the research project "5G-Remote Assistance for Robotics" (5G-RemRob), the Fraunhofer Institute for Material Flow and Logistics IML and its industry partners, FACT GmbH, Sick GmbH and the St. Franziskus-Hospital in Münster, are aiming to use artificial intelligence to make existing autonomous transportation robots fit for more widespread use in hospitals, while also ensuring that they are easy to implement. The goal is to gradually enable transportation robots to drive autonomously around different areas of the hospital in order to deliver small amounts of materials, such as defective medical devices, pharmaceuticals or laboratory samples – tasks that are currently carried out by nurses. If robots were to take over these tasks in the future, not only would it help counteract the shortage of nurses, but workflows could also be designed more efficiently and resources could be utilized in a more targeted way, which would ultimately lead to better patient care.

Breathing intelligence into robots

The particular challenge in the 5G-RemRob project was developing a system that could successfully carry out transportation tasks in a chaotic, partially public environment where it would encounter many different groups of untrained people. The technology that the project team used was designed to enable the transportation robot to find independent solutions to specific problems, such as avoiding obstacles or interacting with people. The two-year project, which was funded as part of the 5G.NRW funding competition run by the Ministry of Economic Affairs, Industry, Climate Action and Energy of the State of North Rhine-Westphalia, ended in November 2023 with a pilot phase at the St. Franziskus Hospital in Münster.

The research project is based on three developments that each build on each other; however, at the core of them all is the Remote AI Box – the sensor box the robot uses to communicate and transmit and receive data. The AI box combines the sensors and computing hardware the robot needs to navigate through complex environments.

Hello, operator! Real-time communication between humans and machines

The researchers have developed a remote assistant functionality for cases where the transportation robot cannot independently solve a problem such as an obstacle along its route. This is used to send an error report to a control station overseen by an external operator. The operator can then take control of the robot using XR smart glasses that provide both technical system information and image data from the robot's surroundings. In addition, the XR technology's 3D imaging allows the operator to visualize the environment easily, immerse themselves in the robot's immediate surroundings and help the robot to navigate past the obstacle, so it can then continue with its transportation task autonomously. Fraunhofer IML uses the 5G communication standard to control the robot remotely. This ensures a stable, low-latency wireless network connection and fast, secure, real-time data transfers between different system components. The use of 5G presents another advantage in hospital contexts. If the robot were to use the hospital's Wi-Fi network, it would be in danger of violating regulations on protecting patient data.

Continuously learning from experience

The robot is not only connected to a remote user – thanks to neural networks, this person can also train it. The data generated during communication with the operator is processed and stored by an AI algorithm, so the robot learns to deal with different problems over time. In the long term, this will increase the robot's autonomy during operation, meaning it will require less and less help from its human colleague. The information that individual robots learn can also be transferred to other robots, thanks to the concept of lifelong AI training. With this learning method, the robots can become increasingly autonomous, even in new environments and difficult locations. "The AI Box's special features include modularity and advanced, integrated AI algorithms for tasks such as image recognition. This means a robot system can not only pinpoint where it is in the environment, but also recognize what is happening there," says Sebastian Hoose of the Robotics and Cognitive Systems department at Fraunhofer IML. "So the robot doesn't just see a wheelchair at the hospital exit as an obstacle, but also recognizes the obstacle as a wheelchair and knows that it needs to avoid it."

A cost-effective, compatible, flexible robot system

With the "RemRob" service robot, hospitals not only receive hardworking helpers for transporting medical materials, but are also given a great degree of flexibility when it comes to choosing the model of their robots. The modular design ensures the Remote AI Box is compatible with robot platforms from different manufacturers. In addition, the number of robots in the fleet can be adapted flexibly,

because all the training that a robot has built up at a given point in time can easily be transferred to other robots. Autonomizing logistics transportation processes in hospitals using robots could ease the strain on nursing, logistics and medical technology personnel and allow them to redirect their focus toward their high-value core tasks.

Everyday hospital work: a litmus test for robots

In order to evaluate and demonstrate the actual performance of the 5G-RemRob service robot, Fraunhofer IML and the FACT Group conducted a pilot phase at the St. Franziskus-Hospital in Münster. The aim was to conduct a practical test to demonstrate the technical feasibility of the autonomous transportation solution at the hospital and identify potential challenges. Nursing staff, logistics specialists, medical technicians and building operations managers all brought their expertise to bear in identifying suitable areas of application for the robot. "During the tests, the service robot was given the task of transporting small devices, such as infusion pumps, blood pressure monitors and ECG apparatus, from the wards to the medical technology department for repairs, and vice versa. It also transported boxes of drugs and medications and carried items between wards, such as nightgowns for patients, medications and files, particularly during the night," says Marcus Hintze, a research scientist in the Health Care Logistics department and head of the 5G-RemRob project. Throughout the tests, the robot transported the goods in locked boxes to prevent theft.

Challenges in existing hospital infrastructure

During the test phase, the robot undertook its first successful journeys in a hospital ward selected for this purpose. One of the challenges was the existing infrastructure at the St. Franziskus-Hospital. This hospital is a good example of an existing building complex that has been expanded several times over the years. "When using robots in existing buildings, one particular challenge is adapting to the infrastructure," explains Jan Rasmus, managing director of the FACT Group. "How can the robot handle elevators, roller gates, doors or paved paths? The robot must also be able to solve certain types of problems independently while transporting materials, such as avoiding obstacles or interacting with people. This is important because at some stage, the robots will ultimately need to be integrated into the normal everyday work on the hospital corridors, which often have very heavy foot traffic and may be cluttered with beds or equipment." The "lifelong training algorithm" is crucial here, because it means that, with the help of AI, the robot can gradually increase its autonomy and capabilities, and so become more adept at navigating within its environment over time.

In addition, service robots will need to be able to communicate with motion detectors or automatic doors at the hospital. Smart devices could act as the connecting link here, allowing for wireless communication and interaction. Fire protection requirements constitute a further hurdle. The robot charging station must be located in a separate room with fire alarms, fire-resistant walls and a T30 door.

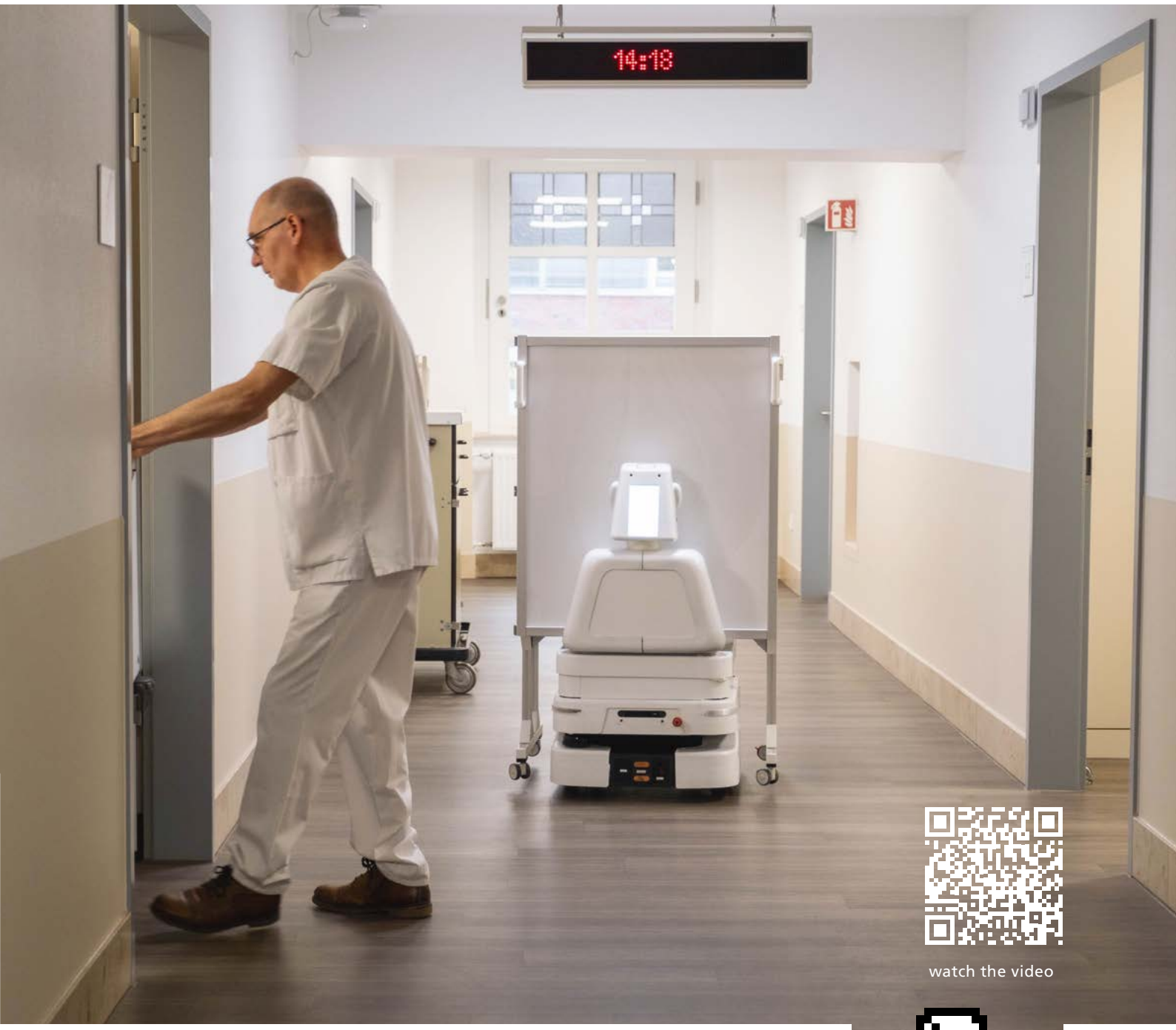
How economical are the robots?

The "5G-RemRob" research team also investigated the financial viability of using robots in the St. Franziskus-Hospital. They developed a tool that calculates financial viability once the relevant parameters are entered. This tool will support hospitals in making investment decisions. The calculation compared the manual transportation processes by people with the processes that could potentially be carried out by robots and showed that using robots to transport materials within hospitals can have financial advantages in comparison to transporting the materials manually. Because different hospitals have different building infrastructure, each one has its own very individual requirements for using robots. This means the financial viability must be calculated individually for each hospital.

Research on 5G-RemRob continues

After completion of the pilot phase at the St. Franziskus-Hospital in Münster, discussions with the FACT Group suggested that the capabilities of the sensor box should be expanded in order to make it a more attractive option for other possible areas of application in the service sector beyond medicine. In addition to transportation, the robot could also take on other tasks, e.g., in the area of monitoring and building security, as it passes by the points that need to be checked every day. Among other things, these tasks include fire extinguisher checks (e.g., making sure they are where they should be and have not passed their expiry dates), checking escape routes are clear and checking escape plans, etc.

The sensor box does not need any additional hardware components to perform these tasks. Only the software and algorithm would have to be adapted accordingly. The researchers have applied for 250,000 euros of funding from DATIpilot, a German Federal Ministry of Education and Research (BMBF) funding program. The project is due to be launched in September 2024 and will run for a year and a half. "With our support, commercial companies could then take over to develop the concept further and bring it to market maturity and commercialization," says Marcus Hintze, who is looking forward to discussing this with interested robotics manufacturers. "We believe that hospitals are increasingly going to depend on robots for help. This means robotics will keep on developing to meet these needs and will continue perfecting human-technology interactions in the process," says Hintze. "As a health care logistics specialist, we believe that care and medical diagnostics should still be a human task, but all non-care services can be automated with robots so that nurses can focus on the patients – a solution that patients are sure to welcome."



watch the video

Remote AI Box: specifications

- Six time-synchronized cameras for a 360° all-round view
- AI image recognition for detecting obstacles
- Microphones, speakers and touch panels for human-technology interaction
- 5G connectivity
- Control unit for remote sensor evaluation and control via augmented reality (AR) glasses
- Powerful CPU and GPU
- Ethernet and 12–36 volt connection for integration into existing AGVs

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Fraunhofer IML receives the Dortmund Dialog Prize 2024

In February 2024, Fraunhofer IML and the former director of the institute, Prof. Michael ten Hompel, were awarded the Dortmund Dialog Prize 2024 in recognition of their long-standing contributions to the city's structural transformation and innovative drive. The institute plays a vital role in shaping developments and setting trends in Dortmund's technological landscape, such as in the field of artificial intelligence (AI), for example.

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A Technology Transfer Award for the "LoadRunner"

The agile LoadRunner robot received this international accolade at the European Robotics Forum 2024. This award, which honors special synergies between science and industry in terms of transferring robotics technologies, is yet another demonstration of how the collaboration between Fraunhofer IML and the industry partners involved in the unique Enterprise Labs initiative is enriching for all involved.

Working out the roster with a pen and paper?

One in three companies in Italy is still organizing its warehouse staff rosters manually. This was shown in a recent survey of Italian companies regarding the workplace rostering systems used in their warehouses. Although in the modern world, warehouse logistics faces challenges such as fluctuations in the size and structure of incoming orders, automated processes are not yet part of everyday operations. Researchers at Fraunhofer IML are currently investigating whether these results also apply to Germany and other European countries.

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Preparations in full swing for the implementation of digital automatic coupling

In April 2024, DB Cargo launched the "DACFIT" consortium with Fraunhofer IML and five other European partners. A total of 500,000 freight cars across Europe need to be retrofitted, but without impacting operations. The project consortium is responsible for planning and organizing this endeavor, and is receiving financial support from Europe's Rail Joint Undertaking (EU-Rail).

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Battery logistics moves up a gear

Although electromobility is a key future technology, there are still many unanswered questions regarding lithium-ion batteries. Now, however, Fraunhofer IML's "Innovation Laboratory for Battery Logistics in E-Mobility" is providing companies with very practical help in bridging the remaining gaps in the field of battery logistics. The lab has chosen five projects that will serve as examples, including an open source solution for an EU battery passport, the production of electric semi-trailers for trucks, a 3D X-ray test for quality assessments and a project that aims to reuse or recycle sealed battery housing.

Better management for environmental projects

Fraunhofer IML has launched the research project GreenCraft together with multiple partners from science and industry. Funded by the ministry of the environment in North Rhine-Westphalia, with co-funding from the EU, this project aims to develop an AI-supported platform to help with initiating and managing environmental projects – such as initiatives for insulating houses and installing PV systems and heat pumps.

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Literature tips

Glossary on Reuse for the circular economy

The "Mehrweg-Glossar"/"Glossary on Reuse," which is published in German and English, provides short definitions to answer any and all questions on the sometimes indistinct terminology used in the context of the circular economy. On behalf of the Stiftung Initiative Mehrweg organization, Fraunhofer UMSICHT and Fraunhofer IML have compiled an overview to clear up uncertainties and ambiguities in the field of reuse and recycling. These terms and their definitions are going to become increasingly important in light of the adoption of the proposed EU Packaging and Packaging Waste Regulation (PPWR).

to the glossary

to the whitepaper

Comparison of shelving systems

In the dynamic and constantly evolving world of intralogistics, it is of great importance to make well-informed decisions when selecting technologies for a specific application. The publication series "Future Challenges in Logistics and Supply Chain Management" of the Fraunhofer Institute IML examines two rack systems for high-density storage: the Pallet Flow System and the semi-automatic Pallet Shuttle System. Both solutions cover a similar range of applications and offer different advantages and disadvantages through their functions and mechanisms.

Publishing Notes

discover LOGISTICS
English edition of the Magazine
Logistik entdecken No. 25

Publisher
Fraunhofer-Institut für
Materialfluss und Logistik IML
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Michael Neuhaus
Fraunhofer IML, Dortmund
Adobe Stock, www.adobestock.com
see respective image reference

Design and Layout
Anna Tekath,
Vinzenz Neugebauer

Printing and processing
Druckhaus Dülmen Betz Vertriebs
GmbH, Dülmen

Translation
Transline Deutschland GmbH

Fraunhofer
IML

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