discoverLOGISTICS

Magazine of the Fraunhofer Institute for Material Flow and Logistics IML Dortmund #23

Coverstory:

SIMULATION-BASED AI

How the virtual and real worlds connect to form a continuum

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. Currently 377 scientists as well as 250 doctoral candidates and students work at the institute founded in 1981.

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 30,000 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
Fraunhofer IML

Julian Jakubiak
Press Officer
Fraunhofer IML

The digitalization and networking of every aspect of our lives and the use of artificial intelligence are in full swing. These developments are supported by a new generation of autonomous mobile robots (AMR), which we have created at Fraunhofer IML. Vehicles learn in virtual reality and their avatars operate as cyberphysical twins on the real shop floor – creating the digital continuum, a self-optimizing control loop of artificial intelligence.

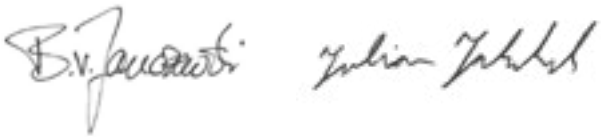
What sounds like science fiction has long been a reality and has become tangible. The high-speed swarm vehicle LoadRunner, the dynamically stable robot evoBOT and the outdoor robot O³dyn have already impressed visitors at various trade shows and events. We owe this new generation of robots to a new development process: simulation-based artificial intelligence. You can discover what this process is all about, what benefits it offers and why it will revolutionize the world of logistics in the cover story in this issue (from p. 6), where our institute director Prof. Michael ten Hompel also answers questions about this new field of research in an interview (p. 12).

The importance of artificial intelligence in logistics is also underlined by the consolidation of the Competence Center Machine Learning Rhine-Ruhr (ML2R), which has been operating as the Lamarr Institute for Machine Learning and Artificial Intelligence since July 2022, where we will take AI research to a new level together with our partners from Fraunhofer IAIS and the universities of Dortmund and Bonn (p. 16).

From now on, we would like to dedicate a separate section to another research success story: the Fraunhofer Enterprise Labs. The Enterprise Labs format was created at Fraunhofer IML in 2013 as a new type of long-term collaboration between business, research and development. Since 2016, collaborative partnerships have been able to make use of a specially established Enterprise Lab Center at our institute, where prototypes can be built, and even small-scale production is possible. In 2022, SSI Schäfer became the 13th company to opt for this innovative form of joint research. You can read about the topics we are researching together in this lab from page 20 onward. We also take a look at the current collaboration status with lab partners that have been with us for some time, starting with DACHSER and SICK (from p. 24).

In addition, this issue brings you interesting topics from the research that is taking place at Fraunhofer IML. These range from the latest developments in our large-scale Silicon Economy research projects (p. 40) to prospects for the future of the supply chain (p. 38) and a livable and sustainable cityscape of the future (p. 42).

We hope you enjoy reading this issue.

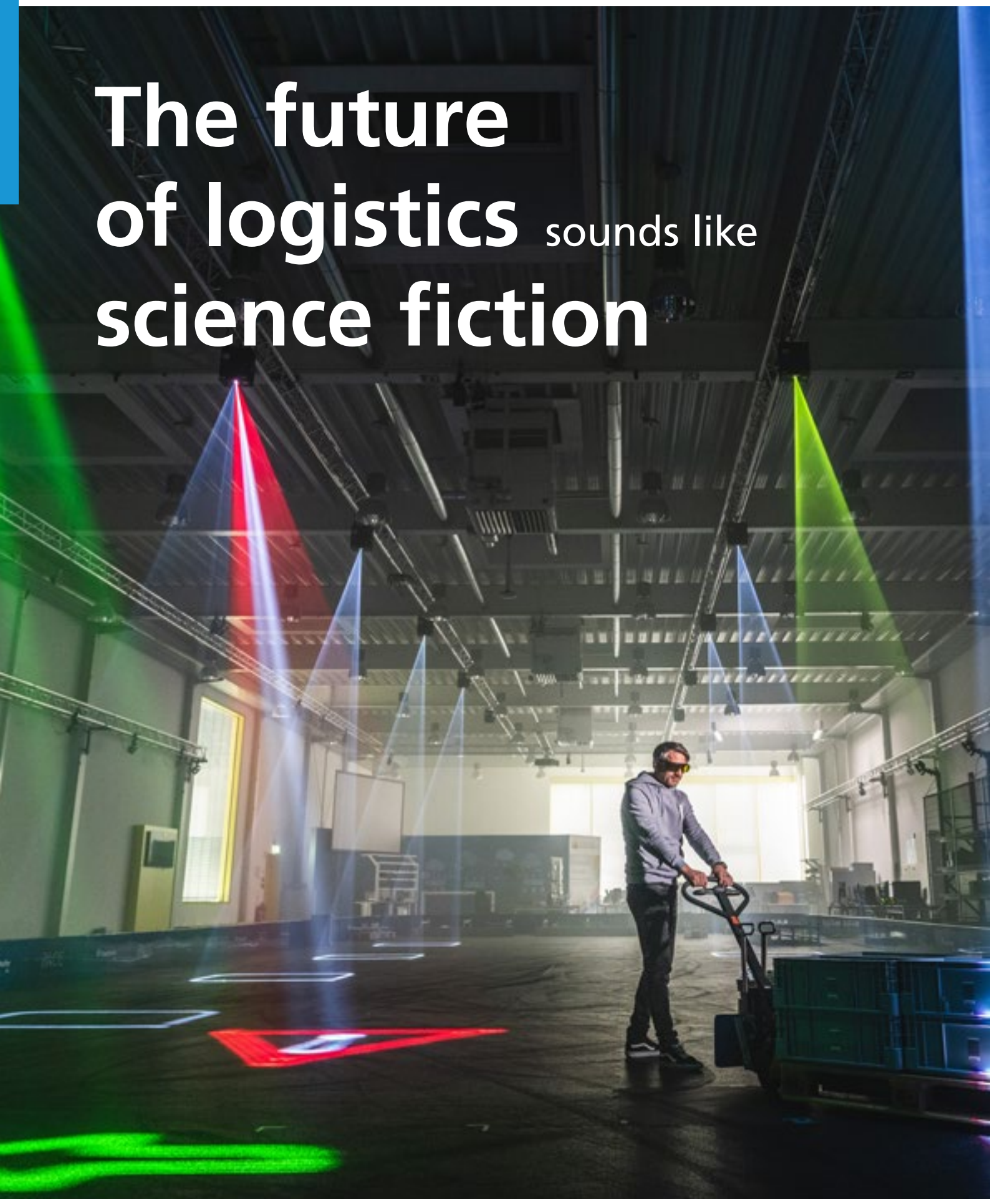


The “discover Logistics” editorial team

Content

discover Logistics #23

The future of logistics sounds like science fiction



Artificial Intelligence (AI) is crucial when it comes to turning the vision of highly flexible logistics into reality. In light of this, researchers of Fraunhofer IML have demonstrated with mobile autonomous transport systems, such as the LoadRunner, evoBOT and O³dyn, not only which technological resources are available today to raise logistical processes to a new level, but also how development processes can be accelerated and development costs reduced. The buzzwords are "simulation-based artificial intelligence" and "digital continuum".

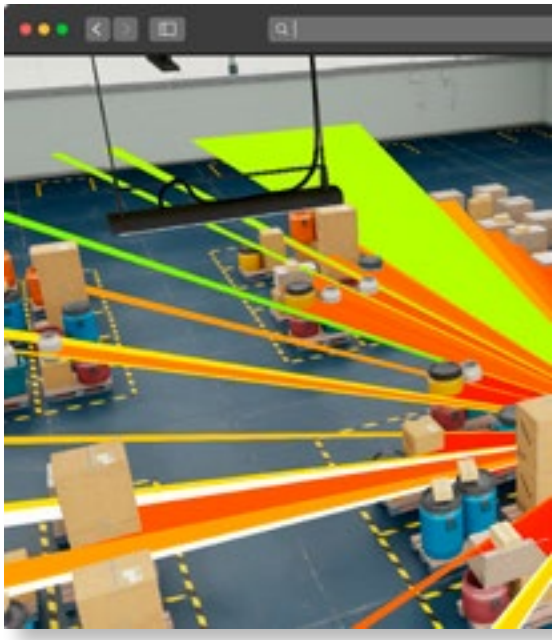
The dream of AI dates back even further than the computer itself. Science fiction in particular enables robots or machines to think and act independently with the help of AI – just think of the android data from Star Trek or C3PO from the blockbuster movie Star Wars. Away from science fiction, the scientific community has been working on artificial intelligence since the middle of the last century. AI can now be used to take efficiency, quality and productivity to a whole new level in a wide variety of industries and processes. The reason for this is that AI is able to analyze and combine huge amounts of data, recognize correlations and anomalies in order to draw conclusions and make its own decisions – and it can do this much more extensively and quickly than the human brain would ever be able to. AI allows processes to be continuously improved and problems to be anticipated and avoided. Therefore, AI offers logistics incredible potential in terms of optimizing processes in the warehouse and on internal and external transport routes. Thanks to AI, the required level of autonomy in decision-making can be achieved, while self-organization of the material flow can be put into practice. The wish for logistics systems that defy even extreme market dynamics with resilience and sustainability could become reality with the help of AI.

PACE Lab as platform for high-tech applications

In the PACE Lab (PACE stands for Positioning Accuracy Communication Evaluation), the Fraunhofer IML has implemented a high-tech test field for real-time data acquisition and created the only environment of its kind in the world for developing highly dynamic autonomous transport systems using AI. There are two test halls, with one where basic research is being conducted in the field of position detection, while specific applications are being investigated in the other. The PACE Lab operates as a 5G test field where the communication of autonomous systems with a base station, a device simulator and a host of measuring devices is tracked. The team at the Dortmund-based organization also uses an innovative laser system that is mounted on the hall ceiling and projects data onto the floor in real time during development – they can then experience augmented reality without wearing glasses.

LoadRunner flagship project implemented in live prototyping

The PACE Lab is also used to evaluate algorithms that then simultaneously undergo live prototyping thanks to the real-time capability of the system and the low latency of two milliseconds. The motion capture system makes this possible. Thanks to this system, the researchers were able to develop the "simulation-based artificial intelligence" method, which was deployed for the first time in the LoadRunner project. Although there was only one prototype, researchers managed to develop swarm behavior completely virtually – in other words, without the need for the corresponding hardware. For the simulation, researchers used a game engine that enabled them to create a dynamic representation of the system's behavior in real time. This fact alone was not a groundbreaking achievement. Using the motion capture system, however, they were able to model the dynamics of the LoadRunner so precisely that it was identical to the real prototype. This meant that they could test risky, complex maneuvers in the swarm system without any danger. To help determine the performance of larger swarms, the environment could even be scaled up. The simulation showed that amazing results can be achieved with a LoadRunner swarm. "Decoupling the development strands of a high-tech swarm and developing the mechanics, control technology and sensors in parallel within just three months was made possible by the unique infrastructure at the PACE Lab and simulation-based AI," says Dr. Sören Kerner, Head of Department AI and Autonomous Systems at Fraunhofer IML.



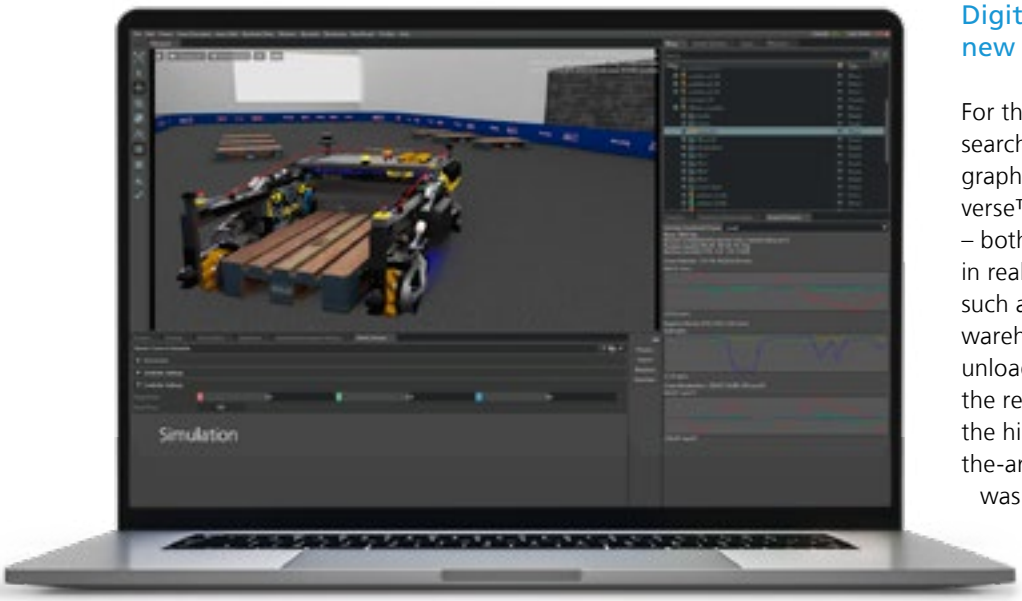
Next level autonomy thanks to **simulation-based AI**

With the purely virtual development of the swarm controller in the LoadRunner, Fraunhofer IML has established a global milestone in swarm robotics and emerged as a pioneer of the revolution from AGVs to mobile autonomous robots. Using simulation-based AI has also enabled the Dortmund-based scientists to open up a completely new field of research that forms the basis for many other projects, such as the AI Arena, the Datenfabrik.NRW and the open dynamic platforms of the Silicon Economy. The LoadRunner has since been followed by other outstanding projects, such as the "evoBOT" and "O³dyn" transport robots.

Cutting development times and saving costs

The more complex logistics becomes, the more important decentralization and self-organization are, in order to ensure that its effectiveness is not compromised. "A transport robot is a highly complex system, involving the interaction of mechanics, sensors and control technology," explains Dr. Sören Kerner. "The implementation of fully autonomous transport and robot systems is therefore associated with high costs and several years of resource-intensive development work. By deploying key technologies and tools, such as AI and simulation, we can reduce costs and cut development times." According to the researcher, if combined, they would offer the prospect of a digital reality – a holistic, AI-based, quasi-perfect simulation that enables the virtualized development of innovative autonomous systems – without any adaptation work being done to the real robot. This gives rise to the concept of simulation-based AI in a digital reality.

"By 'digital reality' we mean the fusion of simulation and reality, creating a digital continuum for robots. This makes it possible to develop algorithms digitally without having to adapt them to reality," according to Dr. Kerner. "In other words, when it comes to developing future transport systems or transport robots, we can make the simulation so realistic that it becomes reality for the robot. The algorithm can no longer distinguish whether it is being executed in a simulation or in the real robot."



Digital image of reality with a new class of algorithms

For the development of Odyn, the researchers are using new state-of-the-art graphics cards from NVIDIA, the Omniverse™ platform and the Isaac simulation – both also from NVIDIA – to simulate in real time highly complex processes, such as autonomous decisions on the warehouse floor and when loading or unloading, and then to transmit them to the real-life transport robot. Thanks to the highly parallel processing of state-of-the-art graphics cards, Fraunhofer IML was able to generate a new class of algorithms. Based on this, the simulation of highly complex

logistical processes can be performed holistically – and also physically – in real time. This is done by comparing the behavior of the simulated robot and transport systems with that of the real robot and transport systems in the test environment and optimizing the simulation model. "Using the highly accurate motion capture system," says Kerner, "allows you to capture several hundred objects in 3D in real time, with a frequency of up to 400 hertz, and create a perfect digital image of reality." In live prototyping, the prototype is created and then transferred 1:1 to reality, in other words, to the physical model, using the motion capture system. If the gap between the model and reality is reduced, the simulation becomes a digital reality for AI. This means that the robot becomes the simulation's CPS twin (CPS stands for cyberphysical system). "In this context, it is also said that the sim-to-real-gap – in other words, the difference between simulation and reality – becomes almost zero. Even the real robot perceives its environment only with digital sensors. For the robot, the simulation and the real world blur into a digital continuum (robot continuum)," says Kerner. "If this is the case, we are developing prototypes using simulation which can then operate directly on the real shop floor."

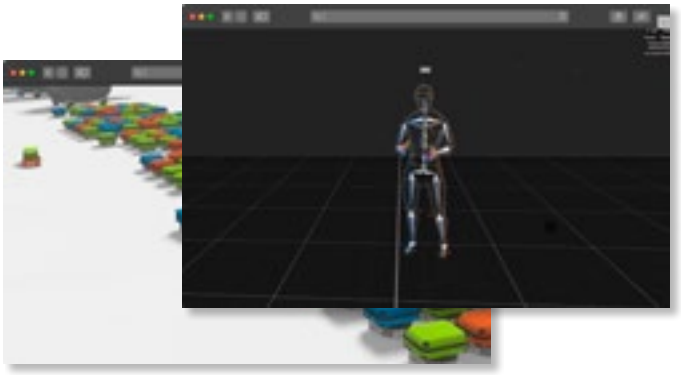
Simultaneous comparison between simulation and reality

The CPS digital twin has embedded software and electronics that are networked with the outside world, the physical twin, via sensors and actuators, and communicates with it in this way. Using the sensors, the CPS twin processes data from the physical (natural) world and makes it available for digital services. They, in turn, can act directly on processes in the physical world via the robot's actuators. The CPS twin is, as it were, the medium for transferring all information from the simulation – the virtual world – to the real world or to the physical model. The CPS twin is aware of every decision and every possible scenario in the simulation and physical model. This means that the benefit of using simulation-based AI for development is that you can react to changing conditions continuously and without expending substantial resources during the development of the transport robot by integrating the adjustments and modifications into the simulation. This creates a digital logistics continuum between development and application. Prototypes can be tested in digital reality before they are even built. This significantly reduces development time and costs. Whereas hardware and software development for highly dynamic systems previously had to take place consecutively, now the processes can run in parallel.

The logistics universe is large – the possibilities in the digital continuum are endless

The new AI-based generations of vehicles have enabled Fraunhofer IML to produce a kind of blueprint for the logistics industry as it moves toward a vertical and real-time networked digital platform economy. In the blueprint, shorter development times, on the one hand, and greater flexibility and resilience, on the other hand, are what differentiate autonomous logistics systems to ensure that they are geared up for the challenges presented by the markets of the future.

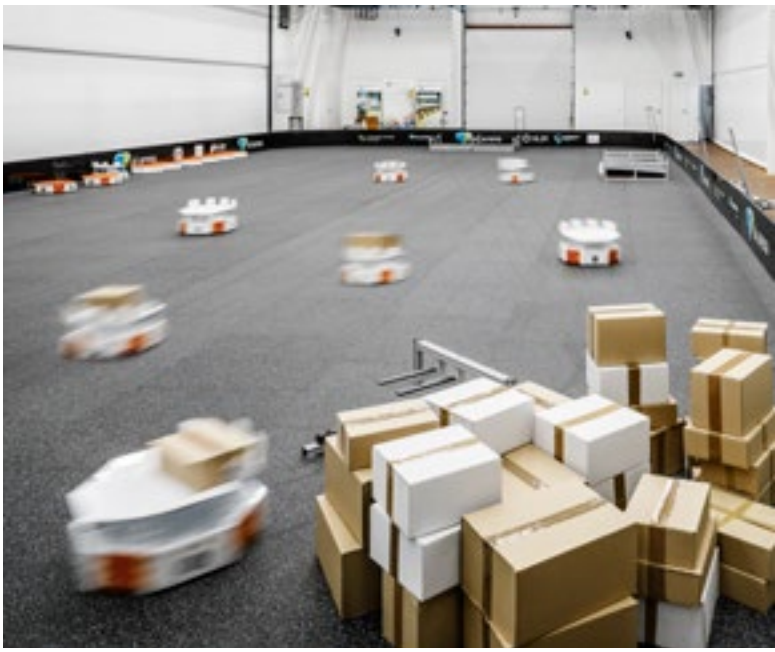
For Dortmund-based researcher Dr. Sören Kerner, one thing is certain: "Projects like LoadRunner, evoBOT and Odyn only scratch the surface of autonomous operation. Research into logistics is still in its infancy. At the same time, a greater focus on people will further increase autonomy in human/machine interaction and ensure that driverless transport systems and transport robots, including those operating in the last mile to the front door, become key players in the supply chain." Artificial intelligence is



evolving from the subject of hype into a standard application. Logistics features a wide range of applications for AI – resulting not only in the development of mobile autonomous transport robots, but also in a significant increase in the efficiency and quality of the entire supply chain, even to the extent of reducing the CO_2 footprint. "In the future, it will be possible to play out complex scenarios," says Dr. Kerner, "such as what happens if a ship is stuck crossways blocking the Panama Canal? What impact will this have on international shipping? How will my logistics systems become more resilient in the future? But simulation-based AI could also be helpful in warehouse planning." So, the digital continuum has only just begun. We are undergoing a continuous transformation process. While transformations were always completed in the world before digitalization, transformation in the digital age is a continuum – the new normal is an ongoing process of change.

Presenting **three transport robots** from the **“robot continuum”** of the Dortmund think tank

Using simulation-based AI on the basis of digital reality, researchers of Fraunhofer IML have successfully developed a future-shaping generation of autonomous, highly dynamic transport robots, which are groundbreaking in terms of future transport solutions.



LoadRunner sorts goods at lightning speed

With the development of the LoadRunner, Fraunhofer IML has introduced a new class of highly dynamic, autonomous swarm vehicles for sorting goods. The LoadRunner project is based on the future vision of logistics operating with a reduced infrastructure – a vision where the ideal logistical space is an empty one. After all, it is only possible to respond to the highly dynamic nature of today’s logistical environments with a high degree of flexibility and scalability. The focus in the development of the automated guided vehicle was not only on a high level of flexibility, but also on ensuring the faster entry and exit of goods. The LoadRunner can organize itself independently in the swarm and can offer impressive sorting performance. As a result, LoadRunner swarms can be considered for areas previously reserved for high-performance sorting and conveying technology. Unlike conventional sorting systems, it requires a much smaller amount of permanently installed infrastructure and offers significantly faster commissioning, dynamic performance adjustment and greater scalability. The vehicle has been fitted with an omnidirectional chassis which allows it to navigate freely. To prevent collisions, its trajectory control makes adjustments to both the path of travel and the speed. This prevents the vehicles from colliding with each other despite traveling at high speeds. The transfer of goods at the storage stations takes place according to the inertia-based transfer principle – without additional actuators. Fraunhofer IML has found in the KION Group a prestigious industrial partner that is licensing and jointly developing the LoadRunner technology in the joint Enterprise Lab for use in its group of companies.

To the video

evoBOT gives human colleagues a helping hand

The evoBOT is the first prototype in a new class of two-wheeled autonomous mobile transport robots. It can push, pull, turn and pass items, while always retaining its balance. This is a result of the inverse pendulum principle, which does not require a counterweight. Thanks to the pendulum movement, the robot can pick up objects, such as boxes and packages, directly from the ground as far away as its arms allow, and lift them off the conveyor and put them back at different heights. It can do this at a speed of up to 10 m/s. It can navigate ramps and edges, and even cope with bumpy paved surfaces in outdoor areas with ease. evoBOT can be used to handle many intralogistics tasks that have required different types of robots in the past. This is because the robot, which is based on a platform, can be equipped with a wide variety of gripper solutions for holding, positioning and moving goods. As a result, it can be used in a range of logistics applications and in an industrial context. With its arms and the penetrating gaze of its camera eyes, it points to the humanoid future of robotics – and not only in logistics. With its bio-inspired design and skills, it has the potential to become a real colleague.

To the video

Highly dynamic transport robot O³dyn revolutionizes pallet transport

The highly dynamic autonomous transport robot O³dyn is intended to bring about a significant transformation in external and internal pallet handling. Unlike most automated guided transport systems, Odyn offers a high level of dynamic performance and flexibility, and is also suitable for hybrid operation. It can transport large loads on pallets omnidirectionally. It can also leave the protected and defined environment of the warehouse and operate outside on factory sites. It transports materials over longer distances from one building to the next and moves seamlessly from indoor to outdoor areas. In addition, the vehicle has an omnidirectional chassis with Mecanum wheels and air suspension. This enables Odyn not only to maneuver in the tightest of spaces, but also to position its load accurately. The air suspension adjusts to uneven surfaces in outdoor areas and also allows the vehicle to be loaded. As an autonomous transport robot, Odyn is one of the first inhabitants of the "robot continuum," which merges simulation and machine learning with reality.

To the video

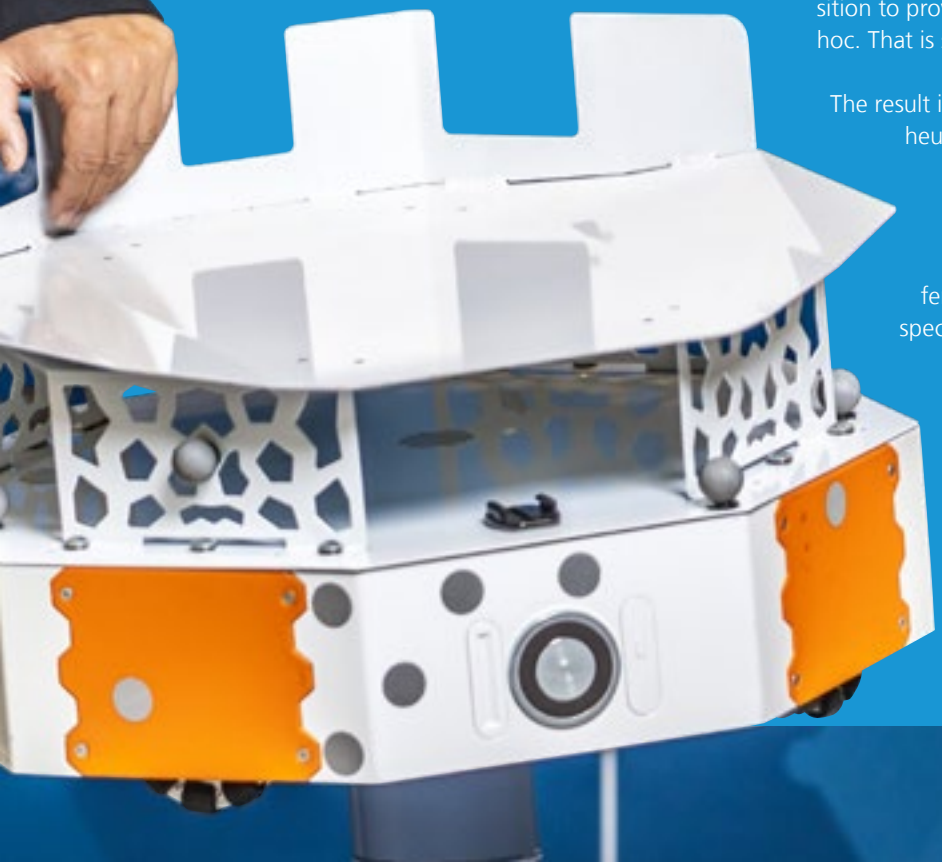
Contact
Dr.-Ing. Sören Kerner | +49 231 9743-170 |
soeren.kerner@iml.fraunhofer.de

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

Interview with Prof. ten Hompel

Simulation-based artificial intelligence offers completely new opportunities for the development of logistics solutions. What effects will this have on the logistical processes of the future?

Logistical processes are much more complex than they appear at first glance. The volumes of data are large and conflicting objectives need to be reconciled in many different places at the same time in order for logistics to work well. The result is that the scope of what needs to be considered "explodes" on a regular basis. In other words, the difficulty of solving logistical problems algorithmically is often so great that conventional computers cannot work them out in a reasonable time frame.



That's also one of the reasons why logistical problems are among the top issues that come up in connection with quantum computing. A quantum computer could capture millions of system states simultaneously and use superposition to provide solutions to specific problems virtually ad hoc. That is some way off, however.

The result is that we often work with simplifications and heuristics that seem logical to us in the moment, but may lead to a solution that is far from ideal – often we simply don't know any better. That is why we have started to simulate logistical systems so we can at least compare some different options. These simulations incorporate the specialist knowledge and intuition of highly experienced professionals.

With simulation-based AI, we go a step further: First we create an overall simulation environment (virtual reality), which might for example map a warehouse physically right down to the last detail. We then place a digital twin that has also been modeled in detail inside this virtual environment. The twin could be an algorithm, but

also an individual vehicle such as the O³dyn or a swarm of our new evoBOTs. The virtual reality, which we create with partners such as NVIDIA, is so perfect that the digital twins' sensors can't "detect" that they are in a simulation. You could call it a robot deep fake.

The next step is to automatically generate the models of the digital twins and train them using machine learning – first in the virtual world and then for their whole lives in the physical world. Many thousands of versions of a system can be simulated in this way and behaviors can be learned on a scale that would simply be impossible in reality. For example, a neural network could be thoroughly trained in the simulation before being transferred to an autonomous vehicle. This makes the robot into a cyber-physical twin, or an "avatar of virtual reality," the counterpart of the digital twin.

The move toward this simulation-based AI is not a revolution, but an evolution. Developments have been going in this direction for decades. What's new is that the simulated reality has been perfected and computer power has become able to map even complex systems in real time.

"The move toward this simulation-based AI is not a revolution, but an evolution. Developments have been going in this direction for decades. What's new is that the simulated reality has been perfected and computer power has become able to map even complex systems in real time."

Prof. Michael ten Hompel

As the circle of digital twin, virtual reality and cyberphysical twin closes, it gives rise to what we call the "digital continuum": a continuously self-optimizing control loop of artificial intelligence.

What potential can be unlocked with simulation-based AI?

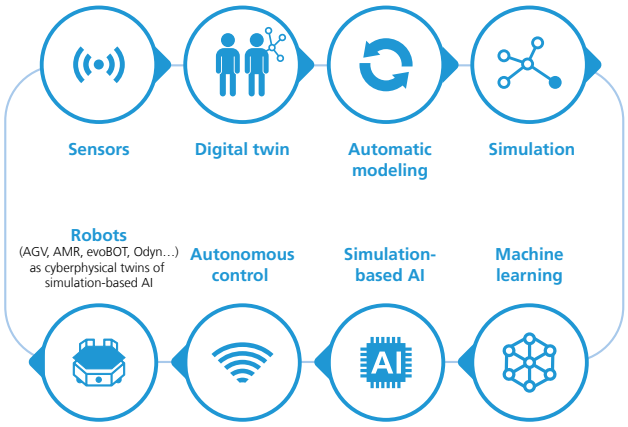
The potential is fundamental in nature and relates to the control, planning and scheduling of logistics as a whole. Since we're talking about artificial intelligence though, let's ask the GPT-3 transformer network (which generates human-like texts using deep learning). It replies: "Simulation-based AI is an AI technology that uses a computer program to create as realistic an environment as possible, in which one or more AI agents can act. The purpose of this technology is to train the agents so that they can function as well as possible in the real world. […] Simulation-based artificial intelligence will be able to improve logistical processes in many ways in the future. On the one hand, it will be able to improve the efficiency of the supply chain by connecting the different components of the supply chain together. On the other hand, it will be able to automate logistical processes and thus reduce costs."

Not a bad answer, I think.

What do you mean exactly by the digital continuum?

A continuum is an uninterrupted sequence. In physics, we are familiar with the space-time continuum, the unbroken frame of our existence. However, a closed circle can also be seen as an uninterrupted sequence. With the platform economy, and against the background of the silicon economy, autonomous process and value chains are now being closed. Planning, tendering, scheduling, operation etc. are being linked together on AI platforms and giving rise to learning, self-reinforcing and self-accelerating processes. We call this the supply chain continuum. This continuum requires transparency, data sovereignty, virtualization and near-real-time networking – in other words, the silicon economy. The silicon economy is the ecosystem of the supply chain continuum.

That's one side of the digital continuum. We've already talked about the other side – simulation-based AI closes the circle of:



This gives rise to the "robotic continuum," which makes robot swarms possible, for example. Until now, they have been too complex to map using conventional control systems. Today we have the LoadRunner, which we, together with KION, have developed into a completely new class of vehicle: an autonomous robot that is agile and intelligent enough to act as an avatar of the virtual world and thus to make the robotic continuum into a reality.

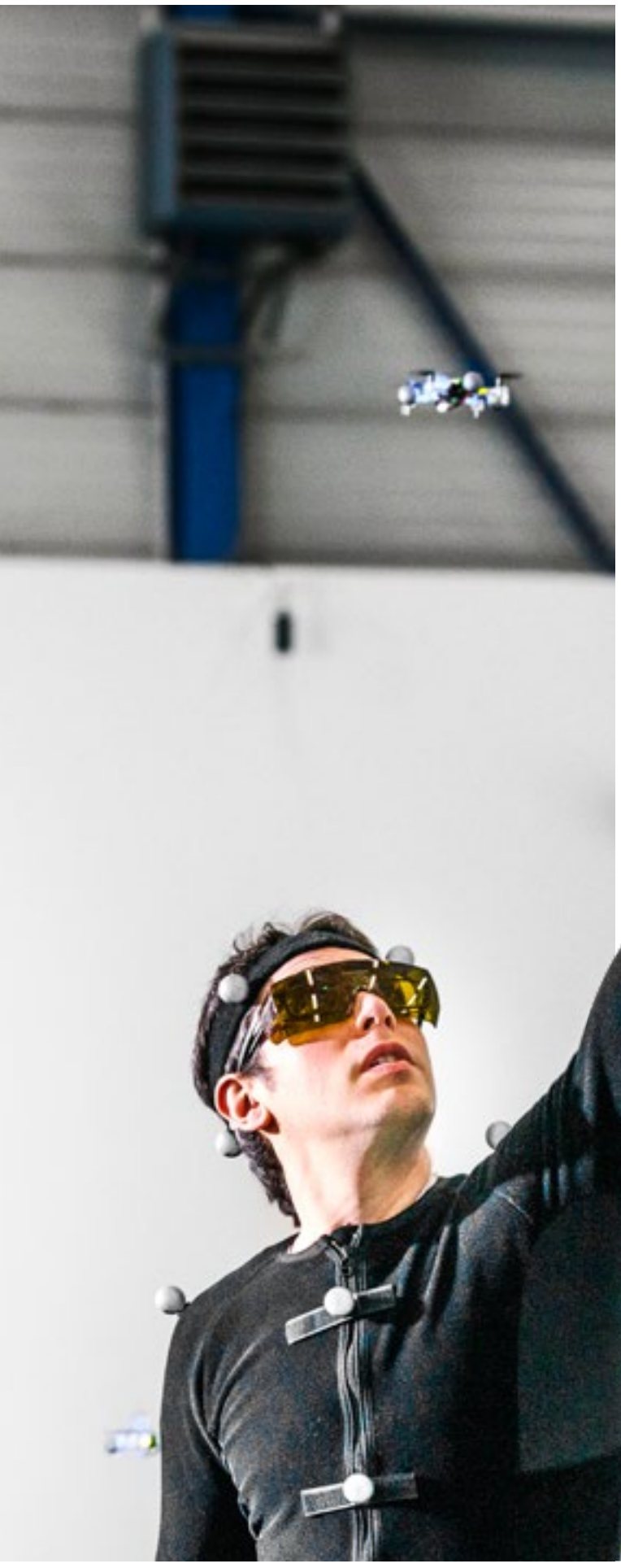
However, with all this technology, it's important not to lose sight of what it is for. In the end, its purpose is to create a sustainable, resilient, changeable and transparent future. I am certain that the digital continuum will be a crucial tool for achieving this.

Robot systems are becoming more and more complex and intelligent: How can you make sure that AI doesn't reach the point where it becomes independent?

It is in the nature of AI to become independent. We want to work with AI to reach new solutions, so we can't program it not to become independent. The question is when, to what extent and, above all, according to what standards this should happen. That takes us to the question of "machine responsibility," a topic we first brought to the table a number of years ago. This deals with setting out the values and standards that machines have to follow so that "machine responsibility" becomes an inherent part of AI. Attempts to force AI to be programmed in such a way that humans can understand its decisions and place their trust in AI are, in my view, a waste of time. Trust comes from experience. We already use AI-based assistance systems for driving and we trust them even though we can't understand the details of the rules given to the AI by the automobile manufacturer.

In addition, most major AI developments are happening in international open source communities like OpenAI . Monitoring these is simply not feasible – but bringing in a joint "machine responsibility" code certainly is. Here too, it is time for us all to work together!

Into the second round with a triangular paradigm



The four German Competence Centers for Machine Learning (ML) have fulfilled the high expectations set for them by the German Federal Ministry of Education and Research (BMBF). As a result, the ministry is now providing long-term institutional funding for a second round of top-level research. The Competence Center ML2R is becoming the Lamarr Institute for Machine Learning and Artificial Intelligence. Fraunhofer IML remains part of the team.

Logistics and artificial intelligence (AI) are made for each other. Logistical problems are often complex mathematical optimization problems – classic AI problems. "Logistics is an important area for the application of AI processes. Conversely, logistics benefits enormously from AI, which can help to make many processes even more efficient," says Dr. Sören Kerner, Head of Department AI and Autonomous Systems at Fraunhofer IML.

Extended

However, the "new" institute partners have already been conducting joint research in this area for a few years. The Lamarr Institute is the continuation of the Competence Center Machine Learning Rhine-Ruhr (ML2R), which TU Dortmund University, the University of Bonn, Fraunhofer IAIS and Fraunhofer IML joined in 2019 when the German Federal Ministry of Education and Research (BMBF) wanted to intensify AI research in Germany with competence centers for machine learning. The ML2R's style of research was to create ML applica-

tions that humans can understand and that do not require a lot of computing resources. Following an evaluation of the ML2R and the other competence centers by an independent panel of experts, the German federal government and the relevant state governments approved its continuation.

Reliable

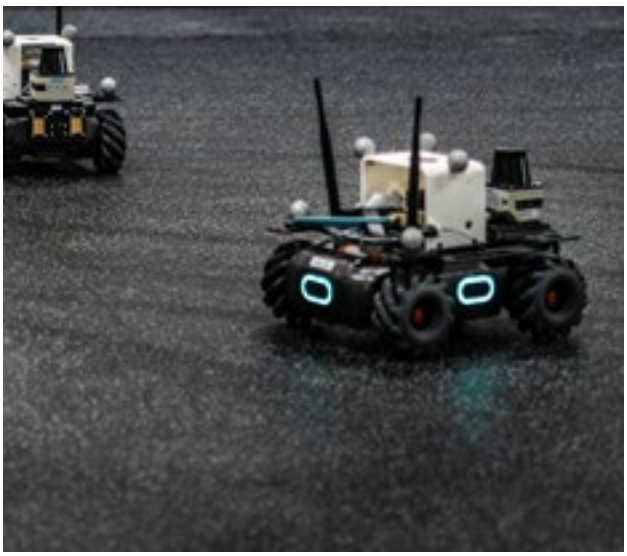
The researchers are sticking to the same research focus of reliable AI technologies. This requires machine learning processes to be transparent and the functioning and results of the applications to be interpretable, which makes it possible to trace back any (incorrect) decisions made by the AI. Reliability also means complying with ethical and data protection standards. The AI needs to make decisions that would be considered "fair." Another aspect is AI assurance, ensuring that AI is functionally secure, which is particularly important in interactions between autonomous robots and humans.

Embodied

The efficient use of resources also remains a focal point, but another dimension is being added: A robot with artificial intelligence embodies, in the truest sense of the word, the research field "embodied artificial intelligence." The researchers at the Lamarr Institute will be focusing

SPONSORED BY THE
Federal Ministry of Education and Research

Funded by
Ministry of Culture and Science of the State of North Rhine-Westphalia



more closely on embodied AI. The term can be understood with the help of the image of the robot. Embodied AI describes how AI learns in a physical environment: through perception and interaction, and from mistakes through reinforcement learning, not just from a large statistical data set. After all, the physical agents in the form of robots, the embodied AI, are designed to interact with the real world.

Intricate

"AI in a robot is extremely costly due to the complexity of the system," says Kerner – particularly when it comes to perceiving the environment. This requires a number of sensors to supply data, which the system has to evaluate and interpret. The physical agent also needs to be able to get enough "practice," because, like humans, it learns by making mistakes. In the real world, this is "expensive" – especially when it comes to industrial uses in logistics. Because of this, the researchers at the Lamarr Institute are using simulations; as the virtual counterparts of the agents, simulated environments significantly accelerate their development and make training safer. The basis of each simulation, however, is to create a model that is an abstraction of a complex reality – and therefore wrong, explains Kerner. This creates what is called the "sim-to-real gap."

Researchers at the former ML2R first conducted research into this sim-to-real gap with the LoadRunner, a swarm of highly dynamic systems. At the time, it was not possible for the researchers to develop the coordinating algorithms on the real system in the time available. As a result, in parallel with the hardware development, they also created a simulation model as a digital twin. With the help of motion capturing, the model could be aligned so closely with the first prototype of the LoadRunner that the sim-to-real gap was no longer relevant. The simulation became a digital reality for the algorithm, which was no longer able to tell whether it was being run on the real system or the simulated one. This meant that the AI for the swarm could be developed virtually without the sim-to-real gap being an issue.

Understanding

For the AI concept pursued by the Lamarr Institute, the researchers are deliberately taking usage into account in the development process. "Classic" AI focuses on algorithms and data input, while the Lamarr Institute works with "triangular AI." According to Lamarr Institute Co-Director Katharina Morik, this is "a new and more powerful generation of artificial intelligence, which is not only trained on data, but also uses additional knowledge and contextual information." Kerner also calls this approach "integrated AI."

Applications of AI technologies are also emerging in cooperation with businesses. The Lamarr Institute is supporting the transfer of its research findings to the economy and society. Twelve newly created professorships offer a new generation of developers and scientists the opportunity to train in close proximity to cutting-edge research into machine learning and artificial intelligence.

Contact
Dr.-Ing. Sören Kerner | +49 231 9743-170 |
soeren.kerner@iml.fraunhofer.de

"Enterprise Lab research is part of our global innovation and technology initiative"

There is no denying that automated guided vehicles (AGVs) are in the fast lane. Presumably, they will one day take over from conventional industrial trucks in warehouse logistics. Where the "new generation" is already successfully doing its job, some precautions had to be taken in advance to keep them on track. For example, one of the things usually required by automated guided vehicles (AGVs) is permanently installed route guidance. Therefore, by definition, this is not an autonomous driving mode.

Given the flexibility now required in material flows, the number of autonomous mobile transport robots (AMRs) entering the market is steadily growing. Vehicles of this nature largely navigate independently and, depending on the software used, are sometimes also able to operate collaboratively in a network. But there is a lack of dynamic input, which results in limited performance. And what does "autonomy" actually mean? Is there possibly even more to be achieved?

Open digital ecosystem for the New Logistics Economy

By way of an answer to this question, Guido Follert, Head of Department Machines and Facilities at Fraunhofer IML, refers to the still untapped potential of platforms and artificial intelligence (AI). Steffen Bersch, CEO of the SSI Schäfer Group, also addressed this point in his lecture "The virtual warehouse of warehouses" at the German Logistics Congress 2021 in Berlin. Among other things, he underlined the importance of proven technologies that will unleash their full power in the future in conjunction with an end-to-end supply chain platform. Data silos should be dismantled and replaced by an open software architecture or platform that allows all supply chain partners to exchange information in real time and interact seamlessly. Simulations combined with artificial intelligence play a central role both in development and in the reality of life in the future.

Overcoming the challenges of today and tomorrow hand-in-hand

While this is already actually happening, to some extent, in a pilot project run by SSI Schäfer, the Enterprise Lab at Fraunhofer IML and the collaboration with scientists who have dedicated themselves to applied research are opening up new opportunities. This also includes the focus on AMRs. "We are pleased to have gained another partner in SSI Schäfer, one of the world's leading providers of intralogistics solutions, which views its involvement in the Enterprise Lab as part of its global technology initiative and wants to establish new guidelines for logistics," emphasizes Follert.

Guido Follert is a member of the steering committee at the SSI Schäfer Enterprise Lab, together with Harald Rackel, COO at SSI Schäfer, Martin Böhmer, Vice President Global Technology at SSI Schäfer, and Prof. Michael ten Hompel. On this point, the Institute Director of Fraunhofer IML emphasizes: "SSI Schäfer is another big player in the industry that has opted for an Enterprise Lab at Fraunhofer IML. This form of collaboration allows us to position ourselves at the forefront of research together with our partners and to leverage the disruption potential offered by the latest technological developments. By embarking on our collaboration with SSI Schäfer, we have now taken an important step toward jointly establishing an innovation location in Dortmund with a high global profile for artificial intelligence and Industry 4.0."

"By embarking on our collaboration with SSI Schäfer, we have now taken an important step toward jointly establishing an innovation location in Dortmund with a high global profile for artificial intelligence and Industry 4.0."

Prof. Michael ten Hompel

Steffen Bersch (l.) and Prof. Michael ten Hompel announcing the collaboration at LogiMAT 2022.

Focus on AMRs and other strategically relevant topics

SSI Schäfer's plan is based on a kind of trend barometer: "The logistics industry is facing numerous challenges. These include, for instance, urbanization and difficult delivery conditions in city centers. In addition to adopting proven approaches such as modularity, scalability and sustainability, these mega-projects require technologically innovative logistics solutions, which we will now also promote together with partners at Fraunhofer IML," says Harald Rackel, by way of summary.

"In this context, flexible intralogistics solutions are needed, a kind of learning logistics that adapts to changes and is scalable," adds Martin Böhmer. "This is based on standardized components that can be integrated into different ecosystems, such as fully automated or semi-automated warehouses as nodes of a supply chain. This is where collaboration efforts along with effective and reliable human-machine interaction are of crucial importance."

From the outset, DS Automotion, SSI Schäfer's Austrian subsidiary specializing in self-driving vehicles and mobile robots, has been driving forward the development work at the lab. But there are no limitations: "Ultimately, all business areas in SSI Schäfer should participate in order to be able to provide suitable solutions for the logistics of the future," says Rackel. While AMRs will be the main topic during the first year, a flexible approach will also be taken to other short- and long-term tasks. The short-term tasks are expected to last for about three months.

Interdisciplinary teams of scientists and practitioners

An annual meeting of the steering committee features on the lab agenda, where topics are defined that will be worked on during the next cycle. Separate teams are set up for each approved project, taking into account the relevant key expertise. They meet at Fraunhofer IML or other locations, such as one of SSI Schäfer's technology centers, but also collaborate virtually. In the case of the intralogistics company and its partners, more than ten people are currently working on operational lab projects. The involvement of Fraunhofer IML will vary between six and ten employees over the duration of the work in the lab, depending on the topic. The agile project methodology is deployed. This means that the teams work in "sprints" toward a predefined objective, share or bundle their knowledge with a results-oriented approach and report regularly to the steering committee. As part of the collaboration in the Enterprise Lab, they use the existing infrastructures, including co-working spaces, workshops, laboratories and test facilities, such as the high-tech test field PACE Lab, where the "social networked industry" is gradually becoming a reality.

Interaction, agility and efficiency as features of modern supply chains

"Due to the constant state of flux, adaptability is immensely important in intralogistics too," says Martin Böhmer. "In addition to standardization and scalability, the keys to achieving this are mainly the potential of machine learning and artificial intelligence in conjunction with end-to-end networking and interaction. This would bring us back to the topic of 'learning logistics.' In the future, it will mean that companies no longer have to respond reactively, but can adjust their logistics processes or supply chains to new challenges in real time and actively control them." This sounds like a paradigm shift, which indeed it would be.

Contact
Dipl.-Ing. Guido Follert | +49 231 9743-253 |
guido.follert@iml.fraunhofer.de

Enterprise Labs – a success-story:

After the KION Group, Keller & Kalmbach, Commerzbank, the European Pallet Association e.V. (EPAL), Deutsche Telekom, DACHSER SE, Rhenus SE & Co. KG, Boehringer Ingelheim, the BMW Group, DB Schenker AG, the Würth Group and SICK AG, SSI Schäfer is the 13th company to opt for this innovative form of joint research involving industry and science.

Interview

Harald Rackel
COO of the SSI Schäfer Group

Why did you decide to partner with the Enterprise Lab at Fraunhofer IML?

The world is in an unprecedented state of flux. Ever-growing numbers of people in the industrialized nations are moving into the big cities. The continuing boom in e-commerce also requires further logistical improvements to be made. One key aspect of this is how to shorten delivery routes and reduce the consumption of resources. This calls for sustainable, technologically innovative solutions, which we will be researching together with Fraunhofer IML at the SSI Schäfer Enterprise Lab. We firmly believe that this collaboration with the institute's experts will provide us with valuable insights and momentum for new developments.

What are the main priorities of your research work at the lab?

One of our main priorities in the Enterprise Lab is the development of autonomous mobile robots (AMRs). The idea of collaboration in research and product development plays a special role for us. Right from the start, we have been working in the lab together with our AGV expert DS Automotion, an Austrian manufacturer of self-driving vehicles, and we are collaborating with three partners in the field of AMR. However, we want to use the lab in general to support all the business areas at SSI Schäfer in tackling current challenges and anticipating trends.

What benefits do you expect from collaboration with Fraunhofer IML?

Intensive collaboration with Fraunhofer IML in interdisciplinary teams provides us with direct access to current research and allows us to actively shape developments. Not to mention the possibility of sharing information with the existing Enterprise Labs. This is an area where we see further added value.

How important is Enterprise Lab research in the context of your corporate strategy?

Enterprise Lab research is part of SSI Schäfer's global innovation and technology initiative, which aims to create an innovation ecosystem. With this in mind, SSI Schäfer is working intensively on networking with development partners, start-ups and research partners, such as Fraunhofer IML and various universities. Other important components include cooperation with customers on implementing collaborative innovation projects. Active employee involvement in shaping the future of the organization is an explicit objective at SSI Schäfer. A newly developed innovation guide for the group creates the framework for this. It conveys our understanding of innovation, offers employees guidance and encourages them to submit their ideas. The Enterprise Lab is one of the options for embracing and implementing these ideas.

This collaboration in the lab started in early June 2022. What are your first impressions?

Both sides are taking a very open and enthusiastic approach. I also get the impression that the path we want to take together and the objective of guiding intralogistics into the future with sustainable innovations were very clear from the outset. This is also down to the fact that there has been close contact with the institute for several years, especially with Prof. Michael ten Hompel, providing a foundation that we can now build on together.

Lab, lab, hooray!

5 YEARS

of DACHSER Enterprise Lab

The year is 1930. Thomas Dachser founds a one-person transportation company in Kempten. Of course, things were different in those days. Not only were the fashions different in the 1930s, but logistics systems were also very rudimentary compared to what we have today. Could Thomas Dachser have guessed that his company, DACHSER, would one day become a Fraunhofer IML Enterprise Lab partner? Probably not, but he would definitely have been happy if he'd known how successful the collaboration would be.

DACHSER has long since grown into more than just a one-person business – the logistics provider now employs more than 32,000 people. As a family business still based in Allgäu, it relies not only on its own expertise but also on extensive cooperation with experts in relevant fields, for example in universities and institutes and from among its customers. "When it comes to development, we always work in areas where things already exist. The huge benefit for us of collaborating with Fraunhofer IML is that we can set up development projects between 18 months and two years earlier. That would be impossible for us within the framework of the business, because we wouldn't have all the knowledge we needed," says Stefan Hohm, Chief Development Officer (CDO) and member of the Executive Board of DACHSER.

The expertise shared in the Enterprise Lab has provided DACHSER with in-depth access to the world of research for the last five years. The collaboration is a valuable and instructive one for Fraunhofer IML too. Though it may sometimes be indelicate to mention the subject, the money is a key part of it – after all, without money there is no research. Dr. Volker Lange, Head of Department at Fraunhofer IML, appreciates the inflow of funds, as the collaboration is opening up new possibilities for Fraunhofer IML too: "We are working together to research practical applications, which I have to say is a big step forward for us as well. Of course, we evolve with our customers, firstly in terms of expertise and secondly by expanding our portfolio," says Dr. Lange.

Projects then and now

In the first few years, the lab focused on the topics of connectivity and data science. The aim was to link together information from all along the supply chain so that it could be exchanged faster and better between those involved and the data could be used for better processes and services. This included recommendations for the strategic central IT planning at DACHSER and algorithms for better forecasting, for example for volume and capacity planning purposes. Another important use was image and text recognition for tracking, measurement and counting operations.

Support from the data cosmos

One application that has already found its way from the DACHSER Enterprise Lab to the everyday world of logistics is called PAnDA One. The acronym stands for Predictive (P) Analytics (An) DACHSER (DA) and "One" because it is the first machine learning (ML) project.

The PAnDA One model was designed specially to forecast the incoming volumes for a DACHSER Road Logistics branch. The aim is to provide the responsible employees in the branches with support for their seasonal capacity planning decisions. This allows the necessary cargo capacity to be secured on the market and the resources of shipment warehouses to be pre-planned. The PAnDA One forecas-

© M. Sienz / Dachser

ting model supplies the corresponding incoming volumes up to 25 weeks in advance.

Processes are extensively analyzed and criteria for reliable forecasts are identified for PAnDA One using shipment data that goes back to 2011. This data pool is supplemented with calendar data such as federal holidays and school vacations. This allows the model to identify the important seasonal patterns for overland transport. To better anticipate trends, the model also incorporates a number of economic indices.

Innovative tracking

Shipment tracking and transport management via the Internet of Things is the focus of another groundbreaking project that was supported by the DACHSER Enterprise Lab and has already been rolled out on a large scale.

For transport within Europe, DACHSER primarily uses swap bodies for palletized goods. These containers are robust, but not smart when it comes to communication. Tracking them and their varied contents cost-effectively and reliably across the general cargo network required several years of development in technology and telecommunications. Solutions based on traditional 2G/3G communication standards proved too energy-intensive and costly and were not sustainable.

When LPWAN technologies emerged, the DACHSER Enterprise Lab began to conduct intensive research into their potential for swap body networking. LPWAN stands for low-power wide-area network, and is a type of network that is being established worldwide together with the latest 5G mobile communication standards.

This research has been used as a basis for work done together with a tracking solution provider to develop innovative smart tracking devices (STDs) for use on swap bodies. These consist of energy modules that are highly energy-

© M. Sienz / Dachser

efficient supported by solar cells and of modern satellite tracking technology (GPS, Galileo) and wireless modules based on the new 5G/LPWAN networks.

Following successful pilot applications, over 8500 swap bodies and 5000 trailers in the DACHSER Road Logistics network have been equipped with these smart tracking devices. This makes it possible to efficiently amalgamate, filter and process data from thousands of transport operations so that employees can find all the information that is relevant to them.

The cargo handling of the future

One ongoing project that has been under constant development and that relates to the field of data science is @ ILO. @ILO stands for "Advanced Indoor Localization and Operations" and describes a digital map of all packages, assets and processes for general cargo logistics. This "digital twin" will supply real-time data, generated entirely automatically, to each palletized shipment in the European DACHSER transport network. @ILO is already in operation at two pilot plants, in Unterschleissheim near Munich and Öhringen near Stuttgart.

© S. Grenzing / Dachser


© S. Grenzing / Dachser

In technological terms, it is based on several hundred optical scanners fitted to the warehouse ceiling that scan the entire floor, as well as on data matrix codes that serve as identifiers and are attached to the top of each package. By scanning the standardized, two-dimensional codes using scanners in the ceiling, artificial intelligence-based algorithms make it possible to identify, localize and measure all the packages automatically in real time. The large number of measuring points and measurements in the two pilot plants leads to a very high measurement accuracy without any disruption to the transport processes in the shipment warehouse, or even any need to start up measuring stations.

The process benefits DACHSER employees themselves and will also benefit their partners and customers in the future: The transport management system records packaging items when they enter the @ILO terminal, while they are inside it and when they leave, allowing a fully automated inventory of all the packages to be kept already in real time in the two pilot branches. All the pallets are tracked in real time to within a meter's distance in the shipment warehouses, which are often as large as a soccer pitch. This leads to shorter search processes, which in turn means that loading processes are also shorter. Another advantage is the automatic "marriage" of the industrial trucks and the packages, which enables the system to automatically detect when a pallet is picked up by a vehicle. When a marriage takes place successfully, the information is shown in real time on a display, for example, which shortens process times and eliminates the need for manual scanning.

Fraunhofer IML and DACHSER are currently still working on making this system, which is arguably the only one of its kind on the market so far, into a viable reality. The volume data obtained is expected to help drivers and employees in the shipment warehouse to assist in loading and route planning and to further increase the effective capacity utilization of swap bodies, trailers and local transport vehicles. This will reduce transport mileage and avoid unnecessary CO_2 emissions. For Stefan Hohm, @ILO is already a success: "I am delighted that we are now able to go public with it. The @ILO project is a striking demonstration of what it is possible to achieve with research and what actual effects this can have on everyday working life."

Good working atmosphere

The year is 2022. The global logistics company is still family-owned. Perhaps it is this and the resulting good working atmosphere that allow Dr. Volker Lange of Fraunhofer IML to take a positive view of this collaboration over the past five years: "What is special about this collaboration is the collective spirit, which really involves everybody. Both sides want to work on these projects and this makes things a lot of fun. Of course we have some great research topics, but we also work together with incredible mutual respect. The corporate culture at DACHSER is characterized by openness and respect, which is amazing. For me, that is a key part of the success of this lab." DACHSER too is more than satisfied with the collaboration, which is why the logistics provider extended the joint Enterprise Lab by another three years in 2020. Stefan Hohm explains: "We have a very, very high level of trust in the collaboration and the quality of the results speaks for itself. That's why we're really looking forward to extending the collaboration, and might even do it again."

Contact
Dr. Volker Lange | +49 231 9743-264 |
volker.lange@iml.fraunhofer.de

Interview

Stefan Hohm, Chief Development Officer (CDO) and member of the Executive Board of DACHSER

What do you appreciate about the collaboration with Fraunhofer IML (other than our fantastic cheese and leek soup)?

The cheese and leek soup is amazing, of course! Professionally, it's also fantastic how quickly the individual research projects, with participants from both organizations, have grown into one team. With each new project, there's an absolute determination to create something new, always with added value for DACHSER. Everyone acts in concert, often blurring the boundaries between DACHSER and Fraunhofer staff members.

Companies that are thinking about founding an Enterprise Lab with us are probably wondering what effect the lab will have on their business. What impact did the DACHSER Enterprise Lab have on you?

The close, trust-based collaboration gives us a great insight into the latest logistics research. It allows us to find out what new developments will affect our business model at an early stage, so that we can investigate them in a joint research project to ensure that our business remains sustainable. At the same time, we can identify the direction in which potential new business models could take our research. We can then shape that research in the Enterprise Lab together with our partners.

What moment or moments from the Enterprise Lab do you particularly remember?

It's difficult for me to highlight individual moments. The time when our first joint project, the automated identification, localization and measurement of all packages in the shipment warehouse, made the leap to the first of our sites, though – that was something special. One or more ideas have given rise to a pilot system. That has allowed us to "experience" the innovations from the Enterprise Lab in our corporate world.

What topics would you like to address and implement in the Enterprise Lab in the future?

The digitalization of the world is moving forward as fast as ever, especially in the logistics industry, and we will need the right responses and strategies to address that. Some topics worth mentioning here are "the digital twin," "the metaverse" and "brain-machine interface." With all these emerging technologies, we expect to get significantly better results if we take into account the insights from research.

The pioneer

A robot for 3D object recognition, a smart container and software for automated guided vehicles, to name but a few: The list of joint developments is long and varied. For more than nine years, sensor manufacturer SICK and Fraunhofer IML have been collaborating on developing the logistics of the future in the joint Enterprise Lab. While the initial focus was on individual solutions for the Internet of Things, the partners are now involved in developing increasingly complex solutions. The spotlight here is on topics relating to artificial intelligence (AI) and robotics within logistics.

SICK was a pioneer in this area – not only in terms of developing high-tech sensors, but also in collaborating with Fraunhofer IML. In 2013, the company, located in Waldkirch in Germany's Black Forest region, was one of the first to opt for an Enterprise Lab in Dortmund and, as a result, for innovative collaboration between business and science. Since then, the partners have been working together on developing logistical innovations.

At the outset of this cooperation, the focus was on how to bring the Internet of Things into projects. The partners focused primarily on sensors for shuttle systems and automated guided vehicles (AGVs). Highlights included, for example, the development of automatic map updates for AGVs. This allows changes in the environment to be automatically recorded and stored in navigation systems. In addition, the lab partners developed a system that had features allowing it to detect and report faults on machines based on image acquisition. The "InBin" smart container is also a development from the Enterprise Lab. It can communicate with people and machines, make decisions independently, monitor environmental conditions and control logistical processes.

A dramatic change has taken place in the work carried out within the Enterprise Lab in the years since it was set up: "Sensor technology has significantly evolved," explains Sebastian Hoose, who works as a research fellow at Fraunhofer IML. "Ten years ago, artificial intelligence was still in its infancy – nowadays the problems are more complex, but we also have considerably more solutions and technical resources available."

New 3D sensor demonstrator

Currently, the processes used within warehouses are gradually being transformed into fully automated logistics systems. This is where sensors play an important role, as object recognition in the form of 3D sensor data is essential for many autonomous applications. However, the existing 3D object recognition solutions are inflexible, making it difficult to transfer them to different use cases. Added to this are the sometimes high development costs for new applications.

The partners of the Enterprise Lab wanted to join forces in tackling these challenges. With this aim in mind, they developed a 3D sensor demonstrator for the application of bin picking, in other words, reaching into a box. A robot performs 3D object recognition and grabs different articles from the retail and e-commerce sector out of a container. "At LogiMAT 2022, for example, there were shampoo bottles, bars and tools in the box. The robot's job was to recognize the bars and remove them from the container," explains Hoose.

The randomly arranged objects are detected by a 3D sensor supplied by SICK and the data is then evaluated using artificial intelligence (AI). Potential gripping positions on the objects can be calculated using the 3D data available. A lightweight robot with a suction pad then grabs the object out of the container and places it on a table next to it. AI performs not only object localization, but also object classification. The special feature of the robot is that the development of both the software for 3D object recognition and the gripping function included the use of open source components.

This enables developers to overcome two challenges. Thanks to the consistent use and further development of freely available open source software, the costs for new solutions are significantly lower. Furthermore, using standardized interfaces with the 3D sensor means that other sensors or robots can be integrated as required.

To the video

Now the project has been completed, the partners are defining the next tasks within the Enterprise Lab: "One idea is to improve the complex labeling process for AI applications," says Hoose. In doing this, they aim to tackle the challenge presented by the need to create and classify large amounts of images and objects before the AI solution can recognize them independently. Researchers are seek to develop an application that simplifies this process and can be transmitted to various 3D cameras.

Trustful communication

"One of SICK's key objectives is to keep up with the times and monitor current technical developments," says Sebastian Hoose. The company does this by regularly discussing with Fraunhofer IML how current challenges can be overcome with new applications in order to reinforce its expert status on the global market.

> **"One of SICK's key objectives is to keep up with the times and monitor current technical developments."**
>
> Sebastian Hoose M. Sc.

Even though the sites of Fraunhofer IML and the company, located in the Black Forest, are more than 500 kilometers apart, this collaboration has been working well for more than nine years. "We always communicate directly and honestly with the developers," says Hoose.

The Enterprise Lab venture is automatically renewed every year – and the collaboration goes even further. SICK is involved as an associate partner in other Fraunhofer IML research projects. These include, for example, the "5G-RemRob" project that aims to enable service robots in hospital logistics to drive autonomously to different locations and take over transport tasks there.

"Given that SICK is also taking part in other projects, our employees always know which areas of applied research we are currently involved in," explains Hoose. The institute also gets to benefit from this set-up: "The upshot for us is that we get to know where the industry is at, which gives us a better understanding of the areas that are currently important," he says.

Contact
Dr. Jana Jost | +49 231 9743-522 |
jana.jost@iml.fraunhofer.de

Interview


© SICK

Bernd von Rosenberger, Vice President, Global Industry Center Logistics Automation, SICK AG

SICK was one of the first companies to collaborate with Fraunhofer IML in an Enterprise Lab. What motivated you to initiate the collaboration at the time?

Like many industries, logistics is constantly changing and requires smart and adaptable overall solutions. One provider cannot handle this alone. Even back in 2013, we saw applied research coupled with rapid industrial implementation with other industrial partners as the key to success. This approach is still proving valuable today.

What are the stand-out aspects of the collaboration with Fraunhofer IML?

First of all, there is a significant overlap in the topics that Fraunhofer IML and the Enterprise Lab have on their agenda. Once we have jointly identified a topic, such as the autonomization of shuttle systems or a robotics application, we quickly get to work. Especially when it comes to digitalization – in other words, the targeted use of sensor data – we have a competent partner in Fraunhofer IML.

What priorities do you want to set within the Enterprise Lab in the future?

Our agenda includes smart sensor solutions for robotics, quality control, mobile platforms and also track-and-trace applications. In the context of the silicon economy, we want to show that the logistics of the future will be more robust and adaptive, while also becoming more integrated with the help of sensor data – this will enable us to overcome the challenges of the future together.

A nimble assistant

Whether on paving stones, warehouse floors or ramps: "evoBOT" keeps its balance in any situation and can perform logistics tasks that previously required multiple different robots. Its abilities are the result of the innovative design created by Fraunhofer researchers.

The gray-white angular robot seems to be concentrating as it picks up a basketball with a focused gaze. It raises its arms, takes the ball out of a staff member's hands and holds it firmly. It then rolls through the hall on its two legs. If it needs to go faster, the robot leans forward, allowing it to accelerate to up to 10 m/s. The abilities of "evoBOT" make it the first of a new generation of autonomous robots. Scientists from Fraunhofer IML presented their new development for the first time at the intralogistics trade fair LogiMAT 2022.

evoBOT in video

evoBOT is a prototype for an agile and dynamically stable two-wheeled robot. With its extreme acceleration and maximum speed of 10 m/s, it can also operate in high-performance situations. "This combination of abilities is the next step in the evolution of autonomous, mobile robots, which is what gave evoBOT its name," explains Mathias Rotgeri, research fellow at Fraunhofer IML. The name evoBOT is made up of the words evolution and robot.

A robot for a wide range of tasks

Unlike previous robots, evoBOT does not just push or pull items: It is also able to turn and hand over objects such as boxes and packages. In addition, it can navigate ramps and edges, and even cope with bumpy paved surfaces in outdoor areas with ease. It always keeps its balance thanks to the inverted pendulum principle. The pendulum motion allows the robot to lift objects directly from the floor or conveyor and put them down again at different heights.

"evoBOT can handle many intralogistics tasks that used to require different types of robots," says Mathias Rotgeri. "Its bio-inspired design also makes interactions between humans and the robot easier, allowing evoBOT to become a personal assistant."

Reduced development time thanks to simulations

The basis for the development of the robot is simulation-based artificial intelligence, a new branch of research. Modern graphics cards allow real-time simulations of highly complex processes to be created. The scientists at Fraunhofer IML record the robot's movements and compare its behavior in the simulation to that of the actual vehicle. This allows them to optimize the simulation model – the smaller the difference between the model and reality, the more the robot becomes the cyberphysical twin of the simulation.

This process makes it possible to reduce development times significantly: For example, the researchers can test prototypes of robots in digital reality before they are built. The process also allows hardware and software developments to be decoupled from each other. The "robotic continuum," a digital continuum of development, is emerging.

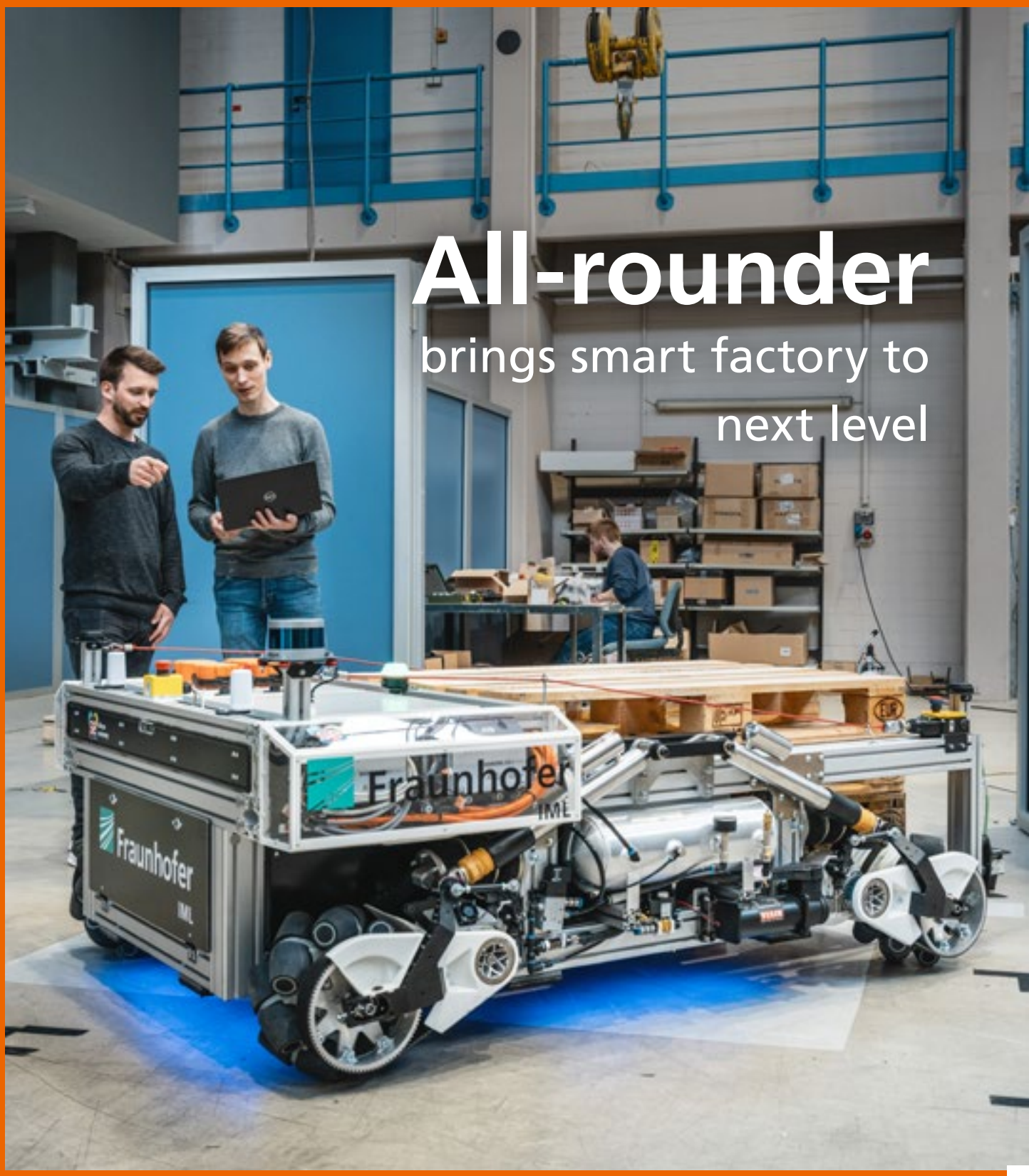
Like the O³dyn robot (see page 35), evoBOT is also a development platform: "On the one hand we use the vehicle to develop software and sensor components, and on the other hand we also plan to optimize evoBOT itself for specific use cases," explains Mathias Rotgeri.

Open source components available

The inverted pendulum function was used by the scientists in the "OpenDynamics" project, which is part of the Silicon Economy research program funded by the German Federal Ministry for Digital and Transport (BMDV). The construction plans for the first pendulum level of the chassis and components of the navigation and localization software are therefore available as open source software via the "Open Logistics Foundation" platform. The foundation was established in 2020 and aims to drive forward digitalization in logistics and in the supply chain management of businesses using open source applications.

Open Logistics Foundation

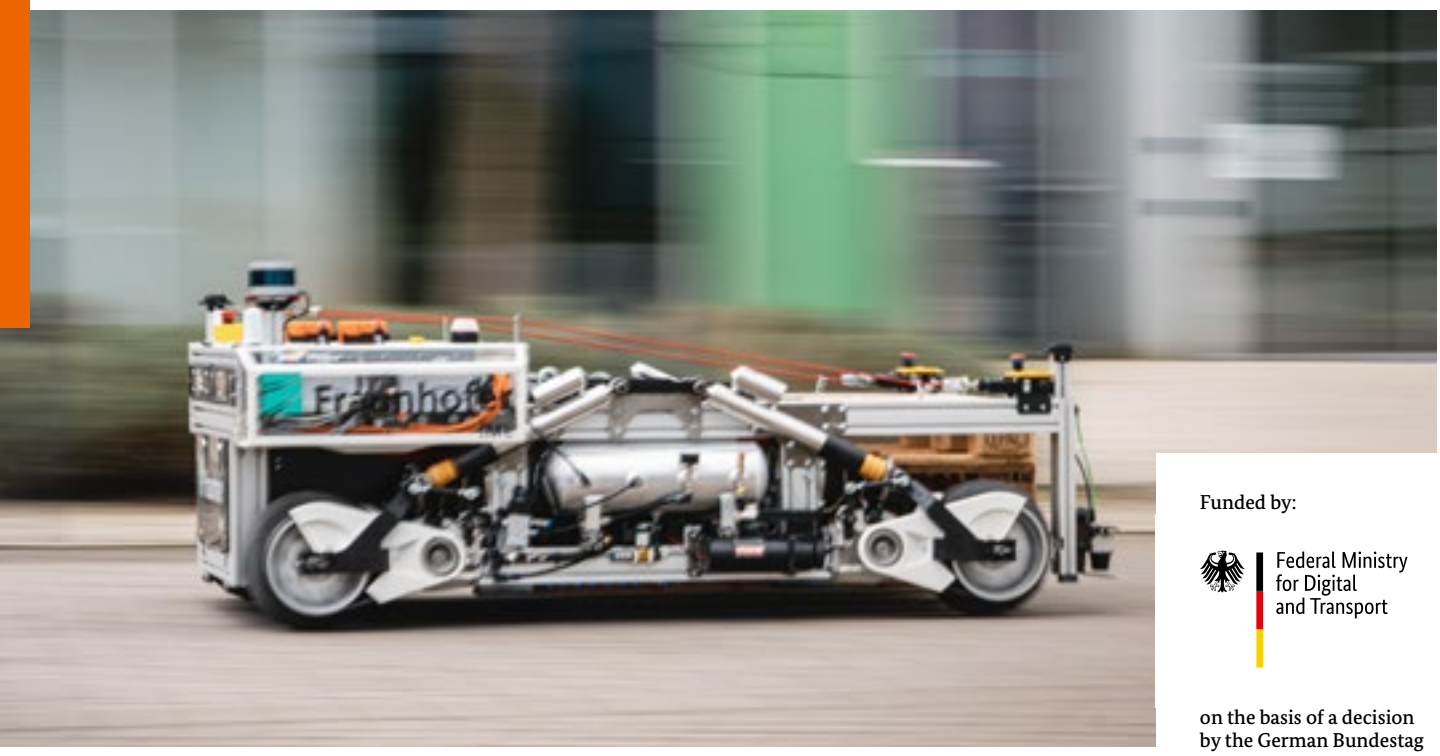
Contact
Mathias Rotgeri M. Sc. | +49 231 9743-335 |
mathias.rotgeri@iml.fraunhofer.de



All-rounder

brings smart factory to next level

With its reduced-infrastructure and automated logistics, the smart factory is no longer just a vision. It has long been a reality in the automotive industry and among its suppliers. Now, researchers at the Fraunhofer Institute for Material Flow and Logistics IML are demonstrating how simulation-based artificial intelligence can take the smart factory to the next level. With the highly dynamic autonomous transport robot "O³dyn," which debuted at LogiMAT in Stuttgart, the future of material flow has arrived.



Funded by:

Federal Ministry
for Digital
and Transport

on the basis of a decision
by the German Bundestag

As an autonomous transport robot, O³dyn is one of the first inhabitants of the "robotic continuum," which merges simulation and machine learning with reality. With the highly dynamic autonomous transport system, the Dortmund-based researchers intend to significantly transform external and internal pallet handling. "O³dyn" was developed as part of the major Silicon Economy research project. With this project, which received more than 25 million euros in funding over three years from the German Federal Ministry for Digital and Transport (BMDV), Fraunhofer IML aims to bring about a breakthrough in Germany and the rest of Europe with a decentralized, federal and open platform economy.

Greater security and efficiency in pallet handling

Unlike most driverless transport systems, which provide either high performance, dynamics or flexibility and are designed for either indoor or outdoor use, "O³dyn" combines all three properties in one. Not only is it highly dynamic and autonomous; it is also suitable for hybrid use. At speeds of up to 36 km/h, it can transport heavy loads in pallet format omnidirectionally. In doing so, it leaves the protected and defined environment of warehouses to operate dynamically on company premises. That is why the researchers call it "O³dyn" (pronounced "Odyn"), which stands for omnidirectional, outdoor and open source.

Odyn really comes into its own when materials need to be moved from one building to another over longer distances on large factory sites. It transports large pallets with ease and moves seamlessly from indoor to outdoor areas. Where forklifts or tugger trains are currently used for tasks of this kind, Odyn could increase resilience and flexibility in the future. Compared to conventional transportation vehicles, Odyn could, according to the researchers, reduce the risk of accidents and significantly improve efficiency. A tugger train, for example, always needs to be built first: Parts need to be buffered and put together, then spread along a production line in a milk run. A large amount of work is involved in coordinating this. Instead, individual, flexible and autonomously operating vehicles could travel directly to where they are needed. Odyn's payload is currently 350 kg. However, the vehicle can easily be set up for heavier payloads. "For industrial use, we could make the frame from steel instead of aluminum. The drive system and chassis are already designed for a weight of 1.3 metric tons," says Guido Follert, Head of Department Machinery and Systems at Fraunhofer IML.

Omnidirectional chassis for precise load handling

To allow Odyn to travel in indoor and outdoor areas easily, the researchers have combined the omnidirectional chassis with Mecanum wheels and air suspension. This means that the vehicle can not only operate in the smallest of spaces, thanks to traversing and sideways movement, but can also position the load with precision. The chassis adapts to uneven surfaces in outdoor areas. This is thanks to the special wheels and air suspension, which guarantee secure movement on unlevel ground regardless of the load being carried. This protects both the load and the vehicle.

The air suspension also allows the vehicle to be loaded by lowering it to pick up a pallet. The load is secured by catches that move in between the pallet blocks and hold them in place. This prevents the pallet from falling off while the vehicle is moving. The braking system consists of an electric service brake and an emergency brake, which operates using friction brake plates under the frame. If the emergency brake is triggered, the air valves on the chassis open. The vehicle lowers itself onto the brake plates and comes to a standstill immediately.

Smooth navigation between indoor and outdoor environments

Another obstacle that the Fraunhofer research team had to overcome when developing Odyn was to ensure that it could navigate smoothly between indoor and outdoor areas. They solved the problem with localization algorithms based on the environment and radio signals. The vehicle uses lidar scanners, 3D camera systems and a differential GPS/GNSS to establish its location. Another challenge that still remains to be solved is safe autonomous operation. "Like the automotive industry, we too need to find solutions to ensure safe autonomous driving in public spaces, with all the unpredictable factors involved, such as the sudden appearance of obstacles in the vehicle's path," explains Guido Follert. "There is still some work for us to do in this area."

The technical details at a glance:

- Drive system: 4 electric motors with lithium ion technology
- Battery output: 100.8 V rated voltage, 8.5 kWh
- Chassis: omnidirectional
- Vehicle weight: 450 kg
- Top speed: 36 km/h
- Payload: 350 kg
- Tracking system: 3D camera system, lidar scanner and differential GPS

Odyn in video

Into the "robotic continuum" with simulation-based artificial intelligence

Fraunhofer IML has developed this nimble transport robot with the help of a new branch of research: simulation-based artificial intelligence. Thanks to modern graphics cards, the Omniverse robotics platform from NVIDIA and the Isaac simulation software, also from NVIDIA, highly complex processes can be simulated in real time. With motion capturing, the scientists can align the behavior in the simulation with that of the real vehicles, allowing them to optimize the simulation model. "The smaller the difference between the model and reality, the more the robot becomes the cyberphysical twin of the simulation," says Dr. Sören Kerner, Head of Department AI and Autonomous Systems at Fraunhofer IML. "This approach enables us to reduce development times massively." In this way, prototypes can be tested in digital reality before they are even built. This allows hardware and software development to be decoupled from each other. A digital continuum of development ("robotic continuum") is emerging. Odyn's concept and design are being made available as open source applications at the Open Logistics Foundation . Fraunhofer IML has already made contact with the first project partners in the industry.

Contact
Dipl.-Ing. Guido Follert | +49 231 9743-253 |
guido.follert@iml.fraunhofer.de

7 suggestions for the supply chain management of the future

Current crises such as the coronavirus pandemic and the war in Ukraine highlight how vulnerable our global, wide-ranging supply chains are. As part of the Digital Day Talk 2022, Institute Director Prof. Michael Henke, together with Carina Culotta and Josef Kamphues from Fraunhofer IML, are therefore presenting seven key suggestions for sustainable supply chain management.

1. Resilience is currently more important than reducing costs.

In recent years, supply chain management has focused on keeping costs as low as possible. The effects of this have recently become increasingly apparent: "External shocks are enough to interrupt supply chains within a very short time," explains Henke. He therefore advocates more resilient supply chain management, which enables supply chains to get back up and running as quickly as possible after external events. Companies should, for example, analyze the vulnerable points within their value chains, as well as past events and their effects in order to be better prepared to face future challenges.

2. Diversification within the supply chain leads to greater resilience.

Diversification is an important aspect in relation to transparent supply chains. If, for example, one supplier is unable to deliver, there must be a second supplier in place who can take over the tasks. To ensure robust supply chain management, it is therefore useful for companies to build up a broad portfolio of suppliers and identify alternative transport routes.

3. Companies need a mix of global and regional value chains.

"In recent years, we have constantly optimized and globalized supply chains," says Henke. However, in the discussion about resilience, the recommendation now is to design supply chains exclusively on a regional basis. The institute director confirms that after crises companies can identify areas where regional production would be useful: "But German industry also benefits from globalization and networking," he emphasizes. Since many raw materials do not occur naturally in Europe, it makes most sense for companies to rely on a mix of global and regional supply chains.

4. Transparency is a prerequisite for resilient and diversified supply chains.

Transparency with regard to their own, wide-ranging supply chains is a basic requirement for companies. This means that supply chain managers can identify more quickly which section of the supply chain is affected by an external event. In addition, companies are then in a better position to provide information in accordance with the new German Supply Chain Act (see info box). According to Henke, the benefits of applications based on blockchain technology include providing greater transparency in the value chain.

5. Blockchain technology instills trust.

Blockchain technology can also be used to strengthen the role of individual companies within the supply chain: Data storage is distributed and tamper-proof; all participants are equal and trustworthy — this also applies to new partners that, for example, take over tasks within the supply chain in a crisis situation.

To the video with Prof. Henke

6. Use of open source software requires a new mindset.

Applications based on blockchain technology are still relatively new to the market and, therefore, not yet widely used by companies. Michael Henke sees an opportunity for open source software in this area. The use of these applications saves resources, has a low threshold and, therefore, is also suitable for small and medium-sized enterprises. However, companies must engage in collaboration, if necessary, also with competitors: "Both the use of open source software and the management of crisis situations only work together and in collaborative networks," emphasizes the institute director.

7. Platforms facilitate collaboration.

When operating on platforms, companies in the supply chain can confidently share data, exchange information and access the information provided by their partners. This type of collaboration helps organize the information within the value creation network and make it transparent. "In our contribution to the platform economy, the Silicon Economy, we combine blockchains with many other technologies," explains Henke. The researchers at Fraunhofer IML provide a basic framework comprising open source applications that companies of all sizes can use and connect to with their own software.

German Supply Chain Act

The German Act on Corporate Due Diligence Obligations in Supply Chains is intended to protect human rights within the supply chains of companies and, above all, to enforce a ban on child and forced labor. From 2023, it will apply to German companies with more than 3000 employees, and, in 2024, to companies with more than 1000 employees. German branches of foreign companies are also included if they have more than 3000 or 1000 employees in Germany. Some of the measures that companies must take include adopting a policy concerning respect for human rights, carrying out a risk assessment to identify and eliminate threats to human rights, establishing a grievance mechanism and introducing transparent public reporting.

More info

eCMR –

UPDATE... to the consignment note

Food, car parts and building materials are continuously crossing Germany and the rest of Europe by truck. Each journey involves administration and there are also papers to be signed at various points. At least, that is how it has been until now. The Silicon Economy digital consignment note is bringing these paper-based processes into the digital age and, thanks to its open-source approach, is creating the first uniform solution for the whole of Europe.

Within Europe, the consignment note is called a "CMR," short for the French "Convention relative au contrat de transport international de marchandises par route." Young people might describe its function by saying "the consignment note rules," which is fairly close to the mark when it comes to what the consignment note does: It sets out the rules for international road freight transport contracts. It has been doing this for quite a long time – since 1956, to be exact. That was when the CMR member states agreed on a protocol setting out what a consignment note needed to contain so that goods could be transported smoothly across national borders. For example, the CMR specifies what goods are being transported, who is sending them, who is providing the transport and who the end-recipient is – including transfer errors and a series of different formats.

With this in mind, researchers at Fraunhofer IML from the "Silicon Economy" development projects have developed a service to generate, store and transmit digital consignment notes in human-readable and machine-readable formats. "It was important to us to use established templates and international standards so that the user would know immediately how to fill out the consignment note, including the digital version," says Patrick Becker of Fraunhofer IML, product owner of the "eCMR" Silicon Economy project.

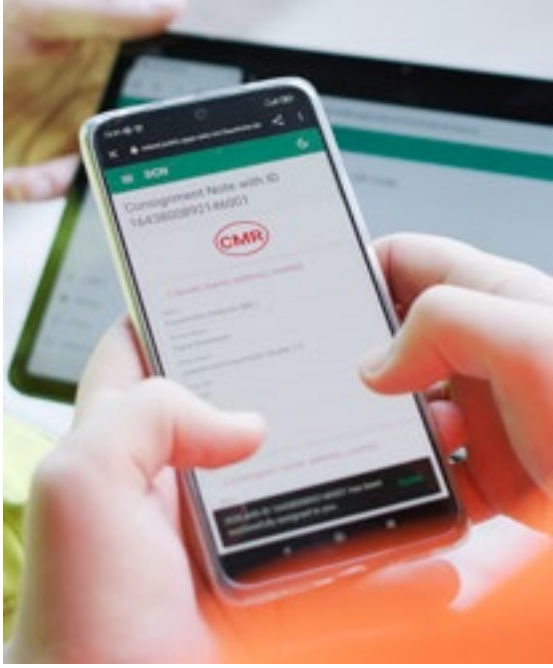
Blockchain and digital signature

Because the service is a web-based platform, it can be used on standard PCs and mobile smart devices such as smartphones. All that is needed is a browser and internet access. To make the process secure, the service uses the token manager from the project for the establishment of the European Blockchain Institute, via an interface. The electronic consignment note's unique ID and the "hash value" are stored on the blockchain. The hash value is like a document's individual fingerprint: If a user edits the document by just one character, the hash value or "fingerprint" will change. "As the recipient of the document, I can use the hash value to check whether the fingerprint on the blockchain matches the fingerprint of the digital consignment note. That allows me to see at any time whether the data has been modified or even manipulated on the way," explains Patrick Becker.

The digital signature also adds to the authenticity of the data. The "advanced signature" (defined by an EU regulation) links the digital signature to the active user account and the document's hash value. The digital signature and the subject of user management remain a challenge for the project team at the moment, as it is still unclear what requirements the relevant authorities might have with regard to the digital signature. For example, it is still uncertain whether any further authentication is required, such as an identity card, and how this would be verified.

Additional protocol for digital format

It has only recently become possible to use electronic consignment notes on German roads in the same way as their paper predecessors. Since 2008, there has been an additional protocol, similar to the original CMR protocol that all CMR member states have agreed to, but for the electronic version, which each individual country needs to agree to again. This additional protocol entered into force in Germany in April 2022, and forms the legal basis for using digital consignment notes in the country.
The sooner the individual member states agree to the additional protocol, the sooner they can use the electronic consignment notes. At the moment, there is a looming



Funded by:

Federal Ministry
for Digital
and Transport

on the basis of a decision
by the German Bundestag

danger of a "tariff jungle," where more and more service providers are offering their own solutions for electronic consignment notes. "The problem is that, when there are hundreds of these eCMR service providers and I have customers in the Netherlands, Spain and Portugal, for example, with each country having its own eCMR service provider, I need to work with all of them just to track the shipments," explains Patrick Becker. "That's why we're using an open source solution for the eCMR, which is very different from other e-consignment notes. Because we make all the source code completely public, any business can adapt it as needed while still communicating and exchanging data with the various bodies because they're all working on the same basis and using the same international standards," says Becker.

Significant interest in the eCMR

The practicability of the electronic consignment note was tested on a cross-border shipment for the first time by Fraunhofer IML together with an international logistics provider in August 2022, on a route between Germany and the Netherlands. The test demonstrated that the eCMR already functions effectively and is easy to use. The project team is now turning the results and the feedback into concrete specifications to develop the service for the logistics industry. There are plans to integrate additional functions and validate them in subsequent test phases.

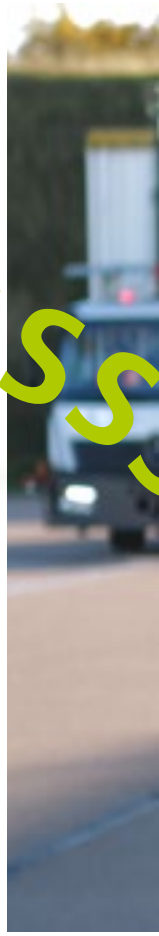
The eCMR's open source approach in particular has generated a lot of interest among logistics associations and organizations, but also among logistics companies. After all, every business that transports goods abroad must provide a consignment note. It also makes sense for five companies not to work with five different solutions. "The subject has now gained so much momentum that we are receiving a large number of inquiries from companies that want to test it with us. It's nice to see supposed competitors sitting around one table and working together on a European solution – because we need one," says Patrick Becker.

Contact
Patrick Becker M. Sc. | +49 231 9743-294 |
patrick.becker@iml.fraunhofer.de

Maximilian Schellert M. Sc. | +49 231 9743-378 |
maximilian.schellert@iml.fraunhofer.de

PSSSSSSSSSSSSSSSSSSS

We can't hear the noise anymore!



The best time for store deliveries is at night. Congested cities finally want to capitalize on the opportunity offered by night logistics, but there must be some way to indicate reliably whether delivery vehicles and handling equipment are quiet enough. Fraunhofer IML has published the "Quiet Logistics Guide," which forms the basis for finally getting night logistics rolling.

In the Netherlands, manufacturers of quiet vehicles can obtain certification under the "Piek" noise protection standard, and vehicles with a "Piek badge" are allowed to drive in city centers during the night. This also makes the badge the ticket to night logistics. Night logistics is a promising concept for German cities. But Germany does not have a certificate that identifies vehicles as suitable for this type of operation. Above all, there is a lack of straightforward options available for companies to provide the necessary evidence and obtain appropriate permits. The Urban Logistics and Electric Mobility team at Fraunhofer IML is currently working on resolving this situation using the "Quiet Logistics Guide." This work is part of a mobility study funded by the state of North Rhine-Westphalia.

Run times: As different as night and day

A delivery run at night takes around 25 percent less time than during the day, when cities are gridlocked by heavy commuter traffic and public transport. This is undoubtedly more efficient and also less stressful. It means that the traffic is staggered throughout the day and more runs can be completed overall with the same number of vehicles. Since night logistics must be quiet and this is primarily achieved using electric drives, it is also associated with reductions in CO_2 emissions. Between 2013 and 2017, Fraunhofer IML carried out an extensive investigation into the potential of "low-noise night logistics through the use of electromobility" in the GeNaLog project.

Research team tackles next hurdle

In the GeNaLog project, the researchers have actually shown that, technically, low-noise night logistics is possible, which complies with the decibel guideline values of the German Immission Control Act. However, they also stated: "There are still some hurdles to overcome, especially in terms of legislation and approval procedures," emphasizes Arnd Bernsmann, who is in charge of the "Quiet Logistics Guide" project at Fraunhofer IML. This is where the guide is intended to provide municipalities and companies with assistance. To ensure that the results can be used by the municipalities and integrated into the approval processes, the law firm BBG und Partner is holding workshops with representatives of the relevant authorities as part of the project.

Statutory guidelines for noise emissions exist primarily to protect the population from the harmful effects of noise pollution on health. In specific terms, the guideline values of the Technical Instructions on Noise Abatement (TA Lärm) apply to deliveries to retail outlets in Germany. For the night-time period from 10 p.m. to 6 a.m., these values are lower than for the day, and they are lower for residential districts than for industrial and commercial areas. The TA Lärm instructions give values for the weighted sound pressure level in dB(A) (which stands for "decibels, rated with frequency filter A"). The weighted sound pressure level is based on the "ordinary" sound pressure level in dB and is intended to be a measurement of human perception of the sound.

Cities take noise protection seriously

Night deliveries in the city may only exceed 45 dB(A) at selected times. If a company wanted to deliver at night, the relevant city office is therefore interested in whether it would comply with the 45 dB(A) level in the TA Lärm instructions. "We know how loud a commercial diesel vehicle is – too loud," says Daniela Kirsch, Team Leader Urban Logi-

stics and Electric Mobility, "but there are no reliable measurements for electric trucks." At this point, companies would

> **"We know how loud a commercial diesel vehicle is – too loud."**
>
> Dipl.-Logist. Daniela Kirsch

have to compile a noise report and convince the authorities – municipality by municipality. This is not an attractive proposition for businesses, as it takes time and costs money to obtain the necessary expert opinion, in addition to the already more expensive quiet equipment.

"Quiet logistics" seal of quality

The ticket to night logistics needs to be issued in a different way. Despite its exemplary nature, the Dutch Piek certification does not go any further than this, because it still "allows" operations up to 63 dB(A). But it is nevertheless a good idea. Certification specifically for quiet logistics would create a nationwide, standardized, meaningful form of proof to present to the authorities. Cities could reward "quiet" logistics service providers with specific user benefits. This would allow the providers to plan reliably for the future. Compared to the guide, a seal of approval for quiet logistics is the "bigger hit", as Bernsmann describes it, an objective that Fraunhofer IML is pursuing in the long term. The German Federal Ministry for Digital and Transport (BMDV) has also given this as a target in its Logistics 2030 Innovation Program.

But the introduction of a certificate for night logistics at federal level requires a lot of patience. The approach advocated by the Quiet Logistics Guide can help achieve the necessary progress in local approval processes beforehand. The project participants will design the guide in such a way that approval authorities can use it to determine the expected volume level during delivery. This is why noise emissions must be processed systematically. Typical delivery situations are simulated with vehicles of different sizes (7.5 t-40 t) and different drive types. In addition to the alternative drives powered by battery and electric motor, as well as compressed natural gas (CNG), the project team hopes to be able to include hydrogen-powered vehicles in the measurement program and is in contact with logistics service providers about this.

Listening to the entire delivery process

Working on this project means above all for the researchers: taking measurements themselves. First of all, they have defined the requirements for the measurement method, as well as logistical test cases. The Peutz Group is contributing its expertise in acoustics and noise protection to the measurement method. As an accredited measurement body for noise and vibrations, it supports the acoustic measurements.

There is far more to measure than the route traveled by selected trucks on the road. A night delivery does not end with the truck's arrival. The process of moving and loading the goods is also particularly noisy.

When vehicles are moving forward, the speed makes a difference to the noise emissions, and when they reverse, the acoustic reversing warning signal beeps. And how loud is it when the brakes are applied, the truck is idling and doors are slammed? Other relevant sources of noise on the truck are the refrigeration unit, tail lift and anti-roll protection. Not to mention the noises caused by loading equipment, such as roller containers or pallet trucks. "Basically, everything contributes to the noise," says Bernsmann and by that he also means the flooring and the fittings at the store. Therefore, both the individual sources and the overall process involving loading and unloading need to be measured. Once the series of measurements has been completed, the next project milestone is reached.

A solution for every noise source

Trucks powered by an electric drive may be quiet enough for night logistics. There are also "low-noise" solutions for cooling units and loading equipment. Roller containers can be fitted with quiet rollers, while pallets can be moved with quiet electric pallet trucks. For some refrigeration units, a simple and ingenious technology called "geofencing" can be used: the e-truck shuts down automatically as soon as it reaches the delivery location. Ideal conditions include sound-absorbing surfaces such as whispering asphalt and damping systems for gates. The specific requirements and options depend on the store, its location and its proximity to residential areas.

Sustainable urban logistics

While night logistics should, as far as possible, go unnoticed by residents, they may well become aware of another factor: the positive effects on the environment and air pollution emissions in the city. Since e-trucks are the primary solution for night logistics, increasing night-time deliveries is an incentive for logistics service providers to use e-trucks – including during the day. From the companies' point of view, if capacity utilization improves, it will make the use of e-trucks even more attractive. The Fraunhofer blueprint for low-noise night logistics using electric vehicles is therefore both more environmentally friendly and compatible with city life, which is why the German Federal Ministry for the Environment (BMUV) presented the GeNaLog project with its "Sustainable Urban Logistics" award in 2018.

Prof. Dr.-Ing.
Uwe Clausen

Contact
Dipl.-Ing. Arnd Bernsmann | +49 231 9743-352 |
arnd.bernsmann@iml.fraunhofer.de

Dipl.-Logist. Daniela Kirsch | +49 231 9743-345 |
daniela.kirsch@iml.fraunhofer.de

Interview with Prof. Clausen

One of the topics in focus at the Future Logistics Congress 2022 was "livable cities and regions." What can logistics do to help make cities more livable?

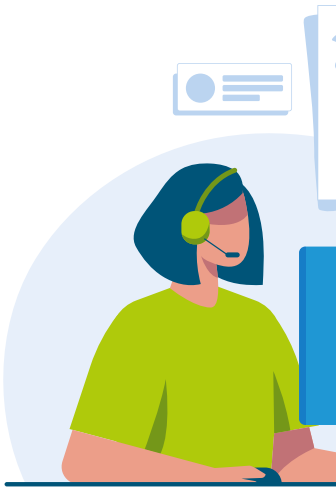
First of all, logistic systems are a basic requirement for supplying cities and regions with goods and removing waste. That recently became very clear during the COVID-19 pandemic and was acknowledged in the public discourse. Continuing urbanization means that competition for space in cities is high and logistical concerns are not always adequately addressed in municipal planning. Good planning considers all modes of transport and facilitates shipping and delivery traffic. Good logistics avoids wastefulness and ensures that goods are delivered and waste is removed. It minimizes detours and wait times, ensures that information flows quickly and enables sustainable transport solutions. We are developing comprehensive solutions along the entire transport chain to achieve the objective of quiet or low-noise logistics.

As well as quiet logistics, there are other concepts that are also helping to create the livable city of the future. What technological drivers and innovations will play a key role in achieving this over the coming years?

Right now, we see three main areas of potential: planning, digitalization and alternative drive systems. Electric mobility has begun to take off in recent years, so there are many more models of vehicle available now and delivery traffic is increasingly switching over to electric drive systems, especially in cities. Charging cycles are easier to integrate into the daily routine here than in long-distance transport with large trucks, for example. Acceptance of low-emission vehicles has increased and the demand for sustainable transport logistics solutions is high. As well as the expansion of the charging infrastructure, there is a need for better information on charging zones, delivery time windows, roadwork and disruptions in general. Digitalization offers many opportunities to use this information to manage delivery times or for traffic-dependent routing.

Against the background of climate change and global crises, the issues of sustainability and livable conditions are not just limited to individual cities and regions. In the coming years, we will need to make all our supply chains more resilient. In many ways, this primarily affects transportation logistics.

Yes, that much is clear, and as an institute we have been working systematically on methods of dealing with this challenge in recent years, from resilience indicators to design concepts. Logistics needs to be open to all modes of transport and to take into account multimodal systems and flexible routing at the structural optimization stage. In addition, storage and handling facilities must be designed to be robust, sensors need to be provided for operational use, IT security measures have to be taken and adequate preparedness is needed in terms of capacity and quality, including reliability and flexibility when purchasing services.



Delta Tango Test site for Alfa Air Charlie Digital Cargo

The air cargo industry needs to move into the 21st century. How about a digitalized transport chain, AI-supported resource planning and autonomous transportation at the airport? All of this is being developed in the Digital Test Site for Air Cargo before being made available to the industry on an open-source basis.

At night, the great tower at Frankfurt Airport lights up in blue. At the edge of the airport site, in the House of Logistics and Mobility, a team of researchers led by Dr. Harald Sieke and Lars Mehrtens of Fraunhofer IML is working on other "lighthouses" for air cargo: impressive demonstrators of standardized data exchange and other digital and intelligent solutions along the air cargo transport chain. The results will be useful for those working in every section of the air cargo logistics process, and they will likewise be made available to the entire industry as open-source solutions.

The "Digital Test Site for Air Cargo" research program is also an excellent example in terms of its execution, since project partners from all areas of air cargo logistics, including pre-carriage and follow-up, have joined up. This is the only way the air cargo industry can continue to develop without disregarding crucial stakeholder requirements.

In six subprojects, the DTAC consortium is taking on standardized data exchange, automation and AI optimization of the processes.

As well as the airports in Cologne, Düsseldorf, Stuttgart, Frankfurt, Leipzig and Munich, the consortium also includes the renowned logistics experts Lufthansa Cargo, DB Schenker, Sovereign Speed and CHI Deutschland Cargo Handling GmbH. LUG aircargo handling GmbH is the first associated partner to support the project. Fraunhofer IML is in charge of the overall scientific project management, with support from Frankfurt University of Applied Sciences for the management of individual subprojects. The research contract was awarded by the German Federal Ministry for Digital and Transport (BMDV), which provided seven million euros of funding for the project over a three-year period.

From accompanying document and barcode to a single label

When project manager Lars Mehrtens gives an update on the research a year after the digital test site was inaugurated, the project is progressing well. At the moment, he and his team are dealing with matters such as how to affix the relevant data and instructions for a shipment to the goods themselves – not as another accompanying document, but in a digitally readable and writable form. The idea is reminiscent of the barcodes commonly used in warehouse logistics. However, those barcodes are mainly only of use to the person who generated and printed them. When third parties try to read them, they often just get an indecipherable jumble of data, explains Mehrtens. As one of the key objectives is better networking between the parties involved in the transport chain, the solution being developed here needs to use a consistent standard that is free of charge.

Funded by:

Federal Ministry
for Digital
and Transport

on the basis of a decision
by the German Bundestag

Standardized yet variable

One suitable and relatively new standard is ONE Record, initiated by the International Air Transport Association (IATA) in pilot projects as recently as 2019. The researchers on the digital test site are now working on developing an open-source solution consisting of a ONE Record server application and a matching label that can be used by all involved parties, from the manufacturer sending the shipment to the shipping and handling agent to the recipient, to access information on the goods. The label will be based on web links – rather than remaining static, the data can be updated continuously so that all parties can access the most up-to-date information at all times, says Lars Mehrtens. However, not everybody has the same need to see all the information that is documented. For that reason, the "digital cargo pouch" – the data accompanying the shipment – will show data that is specific to the viewer's position in the transport chain.

The overarching concept for the smart pouch that is currently being outlined, which is intended to collate digitalized accompanying documents, is known as the digital hub. It is a key concept for the project, "which we will use to bring the world of data in air cargo out of hibernation," according to the team's playful vision. The hibernation metaphor in part reflects the fact that the air cargo system is "largely non-digital," as the BMDV identified at the start of the project. This is about more than digitalization for modern-day digitalization's sake, however. As well as exchanging data in real time between stakeholders, the data hub also serves as a basis for simulations and predictive analytics. Data that has been collected in the past serves as an input for machine learning processes that can be used to make predictions about future events and respond appropriately.

They could be used to predict peak times well in advance, for example. Those responsible would then be able to bring in more staff during these periods to prevent the system from being overloaded. Researchers are using simulations to analyze how profitable or potentially disastrous any variation in truck ramp availability could be when handling cargo. The associated subprojects are also particularly helpful in increasing the efficiency of the air cargo transport chain. Alongside improved networking, greater efficiency is a key objective of the digital test site.

Thinking outside the box

The fact that the researchers are using results from the ongoing large Fraunhofer Silicon Economy project, where appropriate, is another good example of efficiency and networking. For the subprojects on autonomous air cargo storage handling and autonomous outdoor transport, which have only recently started, Lars Mehrtens sees Fraunhofer IML development "O³dyn" as something the researchers at the digital test site can learn from.
He is certain that the Digital Test Site for Air Cargo project will result in robust, practicable demonstrators – not "ivory tower solutions" which are so fragile that they would not last a day in practice. They need to be accessible even for the smallest players in the industry – it is no coincidence that Fraunhofer IML was selected to provide a neutral project management framework for research relating specifically to air cargo. Finally, Mehrtens also hopes that the project will have a global impact and that the added value of the approaches that are chosen will be obvious.

Contact
Dr.-Ing. Harald Sieke | +49 69 668118-355 |
harald.sieke@iml.fraunhofer.de

Lars Mehrtens M. Sc. | +49 69 668118-353 |
lars.mehrtens@iml.fraunhofer.de

Two lives for one battery

In the newly founded "Innovationlab for Battery Logistics in Electromobility," Fraunhofer IML employees are conducting research into how to make batteries last as long as possible and be more environmentally friendly. They take the entire product cycle into account, from manufacture, transport and storage to reuse and recycling.

By the time a battery is installed in an electric vehicle and reaches the customer, it has already traveled a long way. First, raw materials like lithium, nickel and cobalt, which come from South America and the DR Congo, for example, are used to produce lithium ion battery cells. After additional assembly stages and performance tests, the batteries can eventually be fitted in the vehicle and used by the customer.

The problem is that if the battery's capacity has decreased to around 80 percent, this is no longer enough for use in an electric vehicle – the battery has reached the end of its life. The customer can return it to the car dealership – but then what happens? How can batteries be reused or the individual parts recycled? What needs to be taken into account to make storage and transportation as environmentally friendly as possible, against the background of the legal requirements?

These are the questions addressed by the "Innovationlab for Battery Logistics in Electromobility" (InnoLogBat for short) founded in early 2022. Researchers at Fraunhofer IML are working with project partners to investigate how batteries can be used in a more environmentally friendly way in a circular economy. These partners include Leipzig University, Remondis Industrie Service GmbH & Co. KG, Rhenus Automotive SE and Mercedes-Benz Energy GmbH. The project is receiving around 4.3 million euros in funding from the German Federal Ministry of Education and Research (BMBF).

"Recycling batteries is a highly complex process due to the raw materials they contain and the lack of standardization of battery types, and is therefore largely uneconomical for the businesses involved," explains Max Plotnikov, who is involved in the project as a research fellow at Fraunhofer IML. Inside the innovation lab, the issue is therefore seen from the perspective of the circular economy, with the individual parts of the battery being used for as long as possible with zero waste and zero emissions.

Reuse and recycling

A solution that is even more sustainable and cost-effective than recycling is using the batteries in areas that require less power. While they retain up to 50 percent of their power, they can still have a "second life." For example, old batteries can be used as home storage for solar power systems or in logistics robots to store electricity.

However, if the battery has less than 50 percent of its power left, it needs to be recycled so that the raw materials can be recovered. Employees working on the "InnoLogBat" project are focusing mainly on the logistical processes of recycling. This includes correct storage and transport while in or out of operation, including for batteries that have been damaged in an accident, for example.

The project partners initially carried out a risk analysis for the logistical processes after the electric vehicle has been sold: "The lost value of the battery when it is recycled is a potential risk that could affect demand and sales," explains Plotnikov. "There may be other risks when handling the battery, so there is a need to implement uniform safety measures or standards that may not yet have been codified, for example."

Next steps

"InnoLogBat" will continue until September 2024. As consortium leader of the project, the responsibilities of Fraunhofer IML include setting up and operating the innovation laboratory.

The next step planned by the researchers at the institute is to publish a white paper describing the battery's path from the procurement of the raw materials to the installation of the battery in an electric vehicle, as well as considering after-sales aspects such as second life uses and recycling.

The partners also aim to define the individual work packages within the project more precisely. This includes, for example, a detailed analysis of the legal situation for battery transport. With its expertise in the circular economy and the transport of hazardous goods, the scientists at Fraunhofer IML are also able to support industry partners with technological developments. "For example, blockchain technology could conceivably be used as a tracking system to monitor the transport of hazardous goods and prevent them from being tampered with – including with regard to compliance with the German Supply Chain Act," says Plotnikov.

"For example, blockchain technology could conceivably be used as a tracking system to monitor the transport of hazardous goods and prevent them from being tampered with – including with regard to compliance with the German Supply Chain Act."

Max Plotnikov M. Sc.

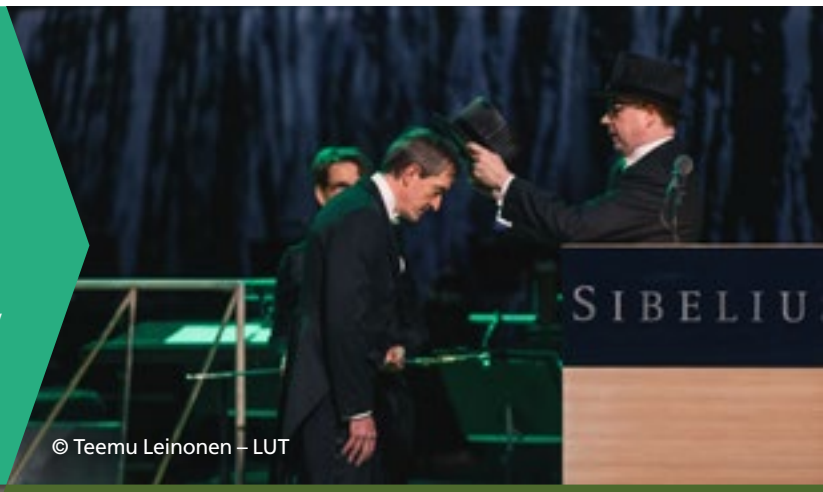
In addition, innovation laboratory employees are planning to develop new concepts for recyclable product designs and business models so that valuable batteries can be used for as long as possible.

Contact
Max Plotnikov M. Sc. |
max.plotnikov@iml.fraunhofer.de

Dr.-Ing. Arkadius Schier | +49 231 9743-481 |
arkadius.schier@iml.fraunhofer.de

Prof. Henke receives honorary doctorate

Lappeenranta-Lahti University of Technology (LUT) in Finland has awarded Prof. Michael Henke an honorary doctorate. The institute director of Fraunhofer IML and holder of the Chair of Enterprise Logistics at TU Dortmund University was honored on May 28, 2022, for his many years of cooperation and now has the title Univ.-Prof. Dr. habil. Dr. h. c. Michael Henke. He has been Adjunct Professor for Supply Chain Management in the School of Business and Management at LUT University for seven years.



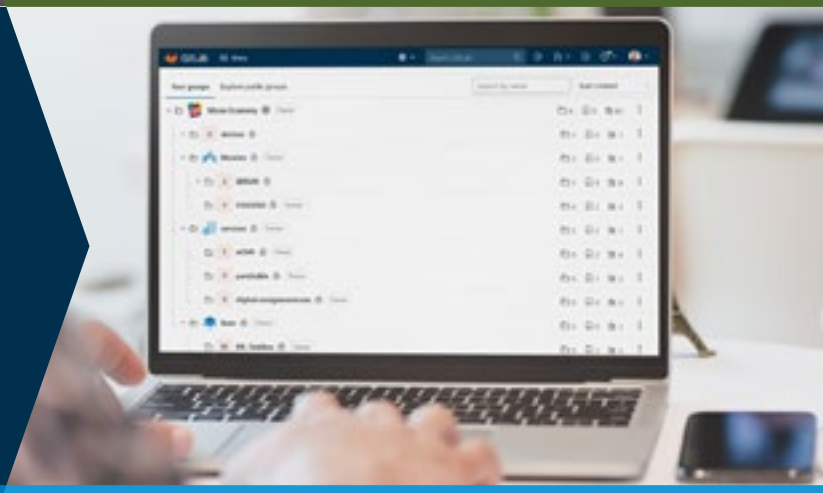
© Teemu Leinonen – LUT

FLIP at TEST CAMP Intralogistics

In March 2022, TEST CAMP Intralogistics took place in Dortmund's Westfalenhallen. Several manufacturers presented automated guided vehicles that demonstrated the new "VDA 5050" interface. This interface allows the different vehicle types to operate under one control system and carry out intralogistics tasks together. Fraunhofer IML participated with the slim vehicle FLIP and the VDA-5050 open source implementation: the "libVDA5050++."

First open source components released

On April 7, 2022, Fraunhofer IML published the first open source components from the "Silicon Economy" project. The results of the software and hardware developments from a total of five projects are now freely available in a digital library, the repository of the Open Logistics Foundation. The components include, for instance, a service for generating, storing and sharing digital consignment notes, solutions for integrating IoT devices and preparing data for use by other services.



Future Logistics Congress – 40th Dortmund Talks

"Toward the 'Silicon Economy Continuum' – The future of logistics is digital, open and sustainable" was the slogan at this year's Future Logistics Congress. From September 13 to 15, 2022, representatives from the worlds of science, business and politics exchanged views on the logistics of tomorrow. The focus was on the digital continuum that leads to new business models and technical innovations through the digitalization and networking of all processes.

Editorial Notes

discover LOGISTICS
English edition of the Magazine
Logistik entdecken No. 23

Publisher
Fraunhofer-Institut für
Materialfluss und Logistik IML
Joseph-von-Fraunhofer-Straße 2–4
44227 Dortmund (Germany)

Phone +49 231 9743-0

discoverlogistics@iml.fraunhofer.de
www.iml.fraunhofer.de

Editorial staff
Bettina von Janczewski, Julian Jakubiak, Sabine Barde, Sabine Vogel, Rolf Müller-Wondorf, Alia Khaddour, Rebecca Wolfer, Merle Janssen, Anna Appelbaum

Images
Sebastian Beierle, Michael Neuhaus
Fraunhofer IML, Dortmund
Adobe Stock, www.adobestock.com
see respective image reference

Design and Layout
Anna Tekath

Printing and processing
Druckhaus Dülmen Betz Vertriebs GmbH, Dülmen

Translation
Transline Deutschland GmbH

www.iml.fraunhofer.de