

# discover **LOGISTICS**

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

#22



COVERSTORY:

# **OPEN INNOVATION** IN THE SILICON ECONOMY



## 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 334 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 29,000 employees in 75 facilities of the entire Fraunhofer-Gesellschaft.

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

[www.iml.fraunhofer.de](http://www.iml.fraunhofer.de)

# DEAR FRIENDS OF LOGISTICS,

On September 15, 2020, the scientists of Fraunhofer IML set out in their own small way to change the world of logistics. With funding of around 25 million euros from the German Federal Ministry of Transport and Digital Infrastructure (BMVI) announced at the Future Logistics Congress by Federal Minister Andreas Scheuer, the assignment of the "Silicon Economy" research project was to facilitate a breakthrough for a decentralized, open platform economy in Germany and Europe.

Time now to look at what has been achieved so far: What developments resulting from the project have been presented to the public? What milestones have been achieved so far? And the most important question: How is the project being received in the business community?

To answer these questions as thoroughly and transparently as possible, our lead article devotes a full 14 pages to the Silicon Economy and an initial interim conclusion (p. 6). In it, you will learn how it all started and took shape, why open source is so important for the platform economy of the future — and, above all, what leading representatives of the industry think about the project. You will also find out what new development projects are starting this year to keep our scientists busy over the coming months.

In the Silicon Economy, it all started with the LoadRunner, first presented to the public at the 2019 Digital Summit and with prominent reports in the evening news on German television. Since then, we have gained a real heavyweight as an industry partner for this groundbreaking swarm technology: In a joint Enterprise Lab, the KION Group and Fraunhofer IML now plan to further develop and industrialize this autonomous vehicle swarm equipped with distributed artificial intelligence. We look back once again at the history of its development and take a look at the collaboration with our new partner (p. 22).

In addition to our lead article, you can find out what's going on in existing Silicon Economy development projects in the other articles in this edition — learn about a dynamic break management system (p. 26), AI-controlled ETA (estimated time of arrival) forecasts (p. 36) and the first startup to emerge from this project (p. 20).

Another technology that plays a central part in making the Silicon Economy a reality is the blockchain. We therefore present a series of articles on blockchain technology (starting on p. 28), offering you an insight into the work of the European Blockchain Institute at Fraunhofer IML. But in the current edition of "Discover Logistics", we also present exciting questions and topics that our researchers are currently working on away from the Silicon Economy.

We hope you enjoy reading it.



**Julian Jakubiak**  
Press Officer  
Fraunhofer Institute for Material Flow and Logistics IML





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# silicon economy

## HALF TIME


### IN THE CONTEST FOR THE FUTURE OF LOGISTICS





“ The Silicon Economy is the best idea in decades. Once you understand what it’s about, it’s amazingly simple: We can sink millions of euros into the digitalization of commodities, or we can save millions of euros by working together on development and making the results available to everyone. ”

Jochen Thewes, CEO, DB Schenker



open platforms and data spaces are the only way for all businesses to take part without giving away their business models or data.

Michael ten Hompel is the inventor of the Silicon Economy, a concept intended as an alternative to the monopolistic structures of Silicon Valley that is developing an open source infrastructure to allow logistical and industrial B2B platforms to work together side by side. The research project of the same name is the largest project at Fraunhofer IML in ten years. In September, a half-time review was drawn up.

### Promoting digitalization is easy, but implementing it changes everything. Time for a half-time review of the Silicon Economy.

Soccer and digitalization have a lot in common. Playing in a youth team is all about having fun, but once you get to the professional leagues, everything is at stake. There are some 80 million experts who think they know what the best strategy is. And sometimes all you need to win a match is a top-class striker, but only the best team wins the whole tournament.

In the world of logistics too, everything is at stake, although most people are unaware of it. “Digitalization will usher in a new age in logistics and change everything for everyone,” says Prof. Michael ten Hompel, Executive Director of the Fraunhofer Institute for Material Flow and Logistics IML. In the business-to-consumer (B2C) sector, Amazon, Uber and Alibaba have long dominated the world of logistics. Dominance of the logistics market for B2B platforms, on the other hand, is still up for grabs, and now is the crucial moment in determining who will control the logistical world of the future. Fraunhofer researcher Michael ten Hompel is convinced that

### I am a Silicon Economist

More than 150 IML researchers have worked together with businesses to program dozens of software tools and algorithms. Innovative modular IoT devices have been created and are now the eyes and ears of the Silicon Economy. They collect data that is used to form parallel innovative business models. Even the way in which research is conducted has changed. “Research is more agile than ever before. For the first time, we no longer have to specify what the end result will be before we start. We can change direction if we find ourselves hot on the heels of innovation,” says Dr. Michael Schmidt, Chief Scientist at Fraunhofer IML and Strategy Developer for the Silicon Economy. When it comes to innovation, businesses have a remarkable tendency to behave like package holidaymakers. They want to know exactly where they are going, what there is to eat and what day trips are on the itinerary.

But a review of the first-half highlights rarely starts by talking about the devices or IT tools. “The spirit of logistics has changed,” says ten Hompel. The industry’s commitment shows how seriously it takes the subject. For the first time in the history of logistics, a

broad coalition of businesses, politicians and unions is forming with the aim of creating an open source software and hardware environment for autonomous logistics driven by artificial intelligence. This environment will allow businesses to offer and use services and data securely across different companies and platforms.

The realization has not come a moment too soon, as experts expect large portions of the logistics sector to be fully digitalized using artificial intelligence in the next three years. Business models will change radically. Money will no longer be earned through assets, but through platforms, data and an edge in acquiring expertise.

"It is no longer about whether we digitalize logistics, but about how and how quickly," highlights Andreas Scheuer, German Federal Minister for Transport and Digital Infrastructure. His establishment is also promoting the Silicon Economy, in particular to make it as easy and cost-effective as possible for small and medium-sized logistics companies to introduce artificial intelligence so that they can benefit from platform business models.

At the moment, the process of building a platform or a data-based business model is not only expensive, but immensely resource-intensive and legally insecure. It requires easy-to-use IT components and open standards for specific tasks — from order placement to transport to billing. "Networking is the goal, and open source is the key," says ten Hompel.



# WHAT'S NEXT?

## THE IMPORTANT FIELDS OF RESEARCH IN THE SECOND HALF OF THE SILICON ECONOMY CONTEST.

The second half is crucial, including when playing for the future of logistics. There are seven research projects on the agenda.

### **Perishable Import: digitalization of import processes in air freight fresh food logistics**

At present, the import process for perishable goods transported by air freight depends heavily on physical paper documents. Processing them for approval is a costly exercise that is prone to errors and lacks transparency. This makes it difficult to plan and leads to a loss of efficiency. The "Perishable Import" development project is laying the foundation for the standardization and complete digitalization of central import processes.

**Target group:** air freight — carriers, importers, airports

### **DoKlass: an AI-based service to digitally record and process documents**

Many of the documents used in the logistics sector, such as invoices and delivery notes, are not available in digital form and need to be processed manually, which can be time-consuming. The "DoKlass" development project is an AI-based service that automatically records paper documents and converts them into a standardized digital data model. This makes it possible to automate a number of different processes, such as the initiation of payments.

**Target group:** IT service providers for integration into in-house applications

### **Modular Open Source IoT Devices**

Developing custom (with regard to sensors) IoT devices is costly and resource-intensive, and for many companies it is simply not feasible. The development project is creating a modular building block system that makes it possible to configure custom IoT devices easily. Demonstrators based on individual business models are also being developed to showcase the specific advantages and usage scenarios.

**Target group:** logistics companies with in-house software development, IT service providers

### **IoT OS: an IoT operating system and communication protocol**

The "IoT OS" development project is the software counterpart to "Modular Open Source IoT Devices." The project adapts firmware, drivers and operating systems to work with the hardware components - and makes them available on an open source basis

**Target group:** logistics companies with in-house software development, IT service providers





© Frank Reinhold

After the presentation by the Open Logistics Foundation, it quickly became clear to the Port of Duisburg that we wanted to get involved. The pooling of resources is a particular focus for us, as we can only drive the digitalization of logistics forward together. This requires the right market players to be brought together and the right topics to be pooled. Only then is it possible to work together to develop common standards instead of producing more monoliths.

The overall aims of our commitment are industry-wide communication, the identification of challenges facing the sector as a whole and the development of industry-wide standards to simplify location-independent collaboration through technology.

Taking part in developing these standards allows us to create the conditions internally at an early stage to be “at the cutting edge” and to put forward our own key topics so we can

a) examine what is needed with other partners and b) achieve implementation with shared resources.

**Markus Bangen**  
CEO, Duisburger Hafen AG



#### **OpenDynamic AGV — Odyn: Autonomous transportation on company premises**

At present, automated guided vehicles (AGVs) are typically used in halls and warehouses. The goal of “OpenDynamic” is to expand the scope of use of autonomous shuttles to include outdoor areas, enabling hybrid operations. The main challenge is in making a seamless transition from indoor to outdoor, as different communication and navigation technologies are usually needed.

**Target group:** vehicle manufacturers, logistics companies

#### **e-consignment note: digital consignment note**

Consignment notes, i.e. accompanying documents for goods shipped by national and international freight, are often still created and enclosed with shipments manually and in analog form. The aim of this development project is to implement a digital service that allows digital consignment notes (“e-consignment note”) for both national and cross-border shipping to be generated, stored and processed in digital folder form. The implementation is intended to serve as a reference that is easy for businesses to adapt and use.

**Target group:** logistics companies and IT service providers for integration into in-house applications



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Logistical processes are becoming increasingly interlinked. This increases transparency in international supply chains, enabled by the use of numerous IT tools and platforms. Until now, market players have acted independently to develop their own instruments. The Silicon Economy is promoting a paradigm shift in the industry, with market players collaborating on logistics systems.

At BLG LOGISTICS we are already using open source tools. The experience has been extremely positive, both for us and for our customers. The solutions we have developed with our innovation team are too good to keep to ourselves. That's why I'm convinced that developing common standards is exactly the way to bring the digitalization and networking of the logistics sector in Germany to the next level.

### Frank Dreeke

Chair of the Executive Board  
BLG LOGISTICS GROUP AG & Co. KG

#### Open source and the business sector's auto-immune system

Dachser CDO Stefan Hohm is convinced that open source is becoming an important competitive factor. He believes that, "When developing a standard application, programming each individual line of code in-house makes little financial sense and provides no real competitive advantage."

For BLG in Bremen, the use of open source tools is not a new thing. BLG Chairman Frank Dreeke has not only had good experiences with them; he is even ready to share his own. "The solutions we have developed are too good to keep to ourselves." Dreeke is

the exception rather than the rule; when it comes to open source, the business sector's auto-immune system tends to kick in rapidly. Open source means that the source code for a piece of software is freely available at no cost. In real life, however, purchasers can struggle just as much when the purchase price is zero as when it is in the millions. IT officers see it as a threat to security and fear the company will go under. According to Gartner, over 95 percent of IT firms worldwide are already using open source software for their business-critical IT functions, whether they know it or not. We all use services that are produced on an open source basis every day, not least the internet. Web browsers like Firefox and Chrome and most programming languages are open source. So is



## MILESTONES OF THE SILICON ECONOMY

SEPTEMBER 4, 2019

**"Whoever controls the world's logistics chains controls the world's economy":** Professor ten Hompel presents his vision of AI-controlled supply chains at the BMVI.

MARCH 2018

**How it all started:** Professor Michael ten Hompel develops the original big picture for the Silicon Economy and presents it to the public for the first time at LogiMAT in Stuttgart. On the afternoon of Sunday, November 25, 2018, he secures the domain [www.silicon-economy.com](http://www.silicon-economy.com).



The brains behind Silicon Economy and the European Blockchain Institute: Fraunhofer IML Institute directors Prof. Michael ten Hompel and Prof. Michael Henke.

Linux, which is the world's most commonly used operating system and runs on all Android smartphones, countless servers around the world, internet routers and even many smart light bulbs.

The Silicon Economy aims to be the Linux of logistics - a logistical operating system that meets the highest data protection standards and that any business can use for free. The project extends far beyond the self-perception of the logistics sector and the limits of traditional thinking in the world of transportation. The main focus is not on vehicle and drive technology, assets or infrastructure expansion, but on the technologies that will be used to shape the digitalization of the industry. What the Silicon Economy is building will be nothing short of a public IT infrastructure, in the form of open source software components that allow businesses to fully automate the processing of their operations.



© BMVI



The comprehensive digitalization of our society is taking place at high speed. In the future, logistics will be increasingly characterized by artificial intelligence and automation. Through cooperation and transparent networking, we can successfully ensure that the industry remains sustainably competitive. That is why the BMVI has awarded around 25 million euros of funding to the Silicon Economy project.

The transformation of the logistics sector is taking place in the digital space: Containers that automatically report their location and the status of their contents, automated contract negotiations, route planning and the choice of mode of transportation, digital accompanying documents and much more will soon be part of the standard.

As an entrepreneur, you know best how to implement digital applications in your own business. The Silicon Economy project provides you with the ideal tools to do this, on an open source basis. Get involved!



**Steffen Bilger**

Parliamentary State Secretary at the Federal Ministry of Transport and Digital Infrastructure





**Swarm intelligence takes off:** Through highly distributed artificial intelligence and 5G, 20 drones communicate with each other with no central control system as part of the first bio-intelligent drone swarm.

OCTOBER 28, 2019



**Breakthrough into swarm robotics and forerunner of the Silicon Economy:** The "LoadRunner," a new generation of autonomous high-speed DTV, celebrates its world premiere at the Digital Summit in Dortmund.

OCTOBER 28, 2019

The Silicon Economy is the big picture of a fully digitalized logistics sector. In the Rhenus Lab at Fraunhofer IML, we have made the smart container mass-marketable thanks to the hardware and software instruments of the Silicon Economy, thereby implementing our individual big picture within the internet of things. For a few weeks now, containers have been sending hundreds of fill level reports and sending localization and status data. Smart Contract and digital invoicing are not only closing the circle of digitalization, but are also an example of how we can apply blockchain technology in a specific way.

Digitalization is not an end in itself. It bridges interfaces and contributes to the achievement of overarching goals like transparency, efficiency and sustainability. Above all, however, it needs to translate into euros and cents and be successful on the market. At half time, the Silicon Economy has already shown it can meet these goals. Going 100 percent digital is not a vision - in an increasing number of use cases, it is our common future.



© RHENUS

**Dr. Stephan Peters**

Member of the Executive Board, Rhenus SE & Co. KG



© Dachser

A powerful IT system gives us a clear competitive advantage, which is why we are investing in intensive in-house system development as well as in research and innovation in the field of digitalization. In addition to our collaboration with various technology partners, crucial support in this area is also provided by the DACHSER Enterprise Lab at Fraunhofer IML.

At the same time, however, we are also seeing a rise in the prevalence of co-opetition approaches in logistics. When developing a standard application, programming each individual line of code in-house makes little financial sense and provides no real competitive advantage. Focusing too heavily on individuality can also be an impediment to interaction with other system partners, particularly in a world that increasingly relies on cloud and platform solutions.

For that reason, it would benefit all those involved in the supply chain if selected software components at the low code level were available as open source elements in future. Open source is becoming an important competitive factor, which is why we have been supporters of the Open Logistics Foundation since the very beginning.

**Stefan Hohm**

Chief Development Officer (CDO), DACHSER SE



**Politicians discover the Silicon Economy:** Professor Michael ten Hompel and Chancellor Angela Merkel discuss the potential of the forthcoming industrial platform economy at the Digital Summit.

**OCTOBER 29, 2019**

### Sink millions or save millions

In the world of logistics, in-house IT development was more or less the holy grail of competitive advantages for a long time, but the willingness to share is growing. This is not because sharing is in at the moment, because the success of their own business models is at stake. The sector has long recognized that it will not get far with AI-based platforms if supply chain partners are still using Excel or even carbon copy paper. The new generation of business leaders also know very well that in-house services, however smart their programming is, are no longer profitable for them. They are no good as a unique selling point or as a business model, because no customer would want to pay even an extra cent for tracking and tracing. The logistics sector is swarming with valuable commodities - everyone uses the same consignment note, everyone plans trips, calculates ETAs or offers tracking and tracing.

DB Schenker CEO Jochen Thewes sums it up in a nutshell: "The Silicon Economy is the best idea in decades. Once you understand what it's about, it's amazingly simple: We can sink millions of euros into the digitalization of commodities, or we can save millions of euros by working together on development and making the results available to everyone."

**MILESTONES  
OF THE SILICON ECONOMY**

### Blockchain, not bureaucracy

"The business models that are successful in the next few years will come from the Silicon Economy," says Prof. Michael Henke, Institute Director at Fraunhofer IML, with absolute certainty. It rarely makes sense, however, to introduce a smart container or e-consignment note on its own. The full business model from sensor to platform is crucial. The winners will be digital platforms that combine existing technologies into end-to-end solutions, because "whenever we design technology and processes together, we are right at the cutting edge."

The blockchain plays a key part in this. As with the internet, everybody uses it but few people could explain how it works. "Without blockchain technology there would be no big picture for the Silicon Economy. It is the missing link for ensuring tamper-proof data exchange. It automatically and autonomously allows the collected data to be exchanged in a legally secure way. Without it, smart contracts and pay-per-use models wouldn't even be a possibility," says Henke, who is also heading up the development of the European Blockchain Institute. Martin Jauss, Managing Director

of Würth Industrie Service and development partner of the Silicon Economy, sees the technology as "a prerequisite for success that makes the difference between aspiration and reality." This view is well founded, as the efficiency gains for optimization seem limitless. At first glance, the use cases of customs and hazardous goods management or the e-freight folder may not seem like the sexiest topics in logistics, but practitioners are not the only ones who have an idea of the hidden potential of making millions of accompanying documents usable and moving them to the blockchain. "Blockchain, not bureaucracy," as Henke says.

One of the big pictures for the Silicon Economy, and a specific example of how blockchain technology can be implemented, is already becoming a reality at Rhenus. For a few weeks now, containers have been sending hundreds of fill level reports and sending localization and status data. The revolutionary aspect is not that a container has been equipped with an ultra-low-power tracker that reports its fill level via a 5G connection to headquarters, where a dispatcher then arranges for it to be emptied. The revolutionary aspect is that the emptying process is arranged by the container itself. It orders a truck to collect it and pays the transportation bill as soon as it has been picked up. This all takes place through the blockchain. This example is representative of complex logistics processes in which swarms of autonomous drones or AGVs organize themselves, in which artificial intelligence negotiates, plans, supports planning decisions, optimizes inventory, simulates flows of goods and traffic, calculates routes and analyzes, checks and tracks goods by camera, to name just a few examples.

Agility is the art of steering a business through an increasingly complex environment - particularly in logistics. The potential to deploy new technologies rapidly is becoming a competitive factor. It is important for us to quickly demonstrate the benefits of research and technology to our customers, from the fascinating show case and attractive use case to the robust business case. In the Silicon Economy project, we are taking part in a partnership of exchange with other businesses and in research to promote this agility and support us on the path to developing value-generating solutions for our customers. This is the only way to deliver on our promise of agility.

We see our half-time result as an acknowledgment and a vision at the same time: When it comes to artificial intelligence, corporate networking and the platform economy, the Silicon Economy is an inevitability. It's our once-in-a-century opportunity for a self-sufficient B2B platform economy. It can and will be the beginning of our future if we manage to prove the business cases with hard facts and win over the right people. This is the best way for us to establish the Silicon Economy.



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**Bernd von Rosenberger**

Senior Vice President,  
Global Industry Center Logistics Automation, SICK AG



© DB Schenker

The Silicon Economy is the best idea in decades. Once you understand what it's about, it's amazingly simple: Businesses can all sink millions of euros into the individual digitalization of commodities, or we can save millions of euros by developing our IT standards together in the logistics sector across the boundaries of different companies, and making the results available to everyone.

My appeal to the logistics sector is that, if we want to successfully digitalize the sector, it is hugely important that we bridge silo structures. The open source software that is currently being developed in the Silicon Economy, with a holistic approach and on a large scale, can and will play an important part in this. What is unique to the Silicon Economy is that this open source development is being linked directly to applications. There are no technical gimmicks or lofty visions for the future, just specific solutions contributing toward one major goal: providing the logistics sector as a whole with infrastructure for the platform economy of tomorrow and allowing platforms to work together side by side. That will benefit every business.

This cross-company, interdisciplinary form of collaboration has already proved its worth for DB Schenker thanks to the Enterprise Lab for Logistics and Digitalization, which has been in place since 2015 with Fraunhofer IML and Fraunhofer ISST.

**Jochen Thewes**  
CEO, DB Schenker

"The Silicon Economy is an inevitability. It's our once-in-a-century opportunity for a self-sufficient B2B platform economy. It can and will be the beginning of our future if we manage to prove the business cases with hard facts," says Bernd von Rosenberger, Senior Vice President of Sick. What he is referring to is something that will be important for everybody in the second half of the match: demonstrating the benefits of research and technology in robust business cases. "Supply chain execution — automated goods receipt" is one such case. It enables the exchange of data collected by sensors between companies while maintaining data security and data sovereignty via a neutral

entity. When a company ships goods that have been ordered, the program can trigger a payment process itself. The Sick parent factory in Waldkirch is currently conducting a live test. For Schmidt, as a strategy developer for the Silicon Economy, this multi-company project, in which Würth, Schenker and Commerzbank are also collaborating, is right at the top of the list of first-half highlights.

**MAY 5, 2020**

**The blockchain picks up speed as a key technology of the Silicon Economy:** The development of a European Blockchain Institute begins at Fraunhofer IML. The Minister of Economic Affairs and Digitalization of North Rhine-Westphalia, Dr. Andreas Pinkwart, reveals that 7.7 million euros of funding will be provided.



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## SILICON ECONOMY

// Aspiration or reality: What would it be like to have a fully transparent overview of self-organizing supply chains available live at any time? For Würth Industrie Service, data is one of the most important resources for achieving this ambitious goal: from suppliers and technology partners to our own value chains and logistics, right through to our customers. Making data usable is the foundation of innovation and the basis of new AI-based business models in the platform economy of the future. No business can manage that alone. At this stage, it is important to join forces, work together on development, and make technology available on an open source basis. It is also important to ensure responsible handling of data.

That is why we are taking the path towards the Silicon Economy together with Fraunhofer IML and other top players, which will enable an open source infrastructure to be created along the entire supply chain. We see the continued development of blockchain technology in particular as a prerequisite for success. It is what makes it possible to exchange data in a secure way, and what ultimately makes the difference between aspiration and reality.



© Würth

### Martin Jauss

Managing Director, Würth Industrie Service



9 mm high, plug-in, 5G-compatible communication, high-resolution display (1440 x 1072 pixels), sensors for temperature, acceleration, position. Battery life: up to 2 years

### OCTOBER 26, 2020

#### No device, no business model:

The blockchain device heralds a new chapter in the history of logistics. The prototype for monitoring temperature-sensitive goods along global supply chains is the first device developed by the European Blockchain Institute.

### SEPTEMBER 15, 2020

#### Formula 1 on the hall floor:

The autonomous LoadRunner swarm shows what it can do: 60 vehicles process 13,000 shipments an hour, equaling the performance of conventional sorting systems for the first time.

### SEPTEMBER 15, 2020

#### Heralding the start of a new age for logistics:

At the Future Logistics Congress, Transport Minister Andreas Scheuer reveals by video message that 25 million euros of funding will be provided for the "Silicon Economy Logistics Ecosystem".

### AUTUMN 2020

**I'm a Silicon Economist:** For the first time in the history of logistics, a broad coalition is forming with the aim of making an open source infrastructure for the platform economy of tomorrow available to the sector as a whole. The community is emerging.



### OCTOBER 1, 2020

**Kick-off for the "Linux of logistics":** Silicon Valley was yesterday; today is when research on the Silicon Economy begins. As many as 150 researchers are working with businesses on solutions to specific logistical problems and making their basic components available in hardware and software form to be used freely via an open source platform.



## OCTOBER 2021

**Open source mission:** The non-profit Open Logistics Foundation is in the starting blocks. In future, it is to act as a neutral body to monitor the open source tools of the Silicon Economy.

## MARCH 11, 2021

**Blockchain, not bureaucracy:** A research partnership between the European Blockchain Institute and the Windesheim University of Applied Sciences in the Netherlands is focusing on the tamper-proof design of customs or hazardous goods processes using blockchain technology that can be used free of charge by anybody.

## JANUARY 5, 2021

### Open source gets it done faster:

Logistikbude is the first company to make use of silicon open source components. The "e-pallet note" saves the founders months of development work in building up their app-controlled platform for AI-controlled carrier management.



# NEVER WALK ALONE.

### Next steps — never walk alone

Back to soccer: Having gotten off to a strong start, in the second half the Silicon Economy needs to make its effects felt quickly. "Scaling beyond Germany's borders is on the agenda," says Schmidt. New businesses and business models will emerge, blockchain technology needs to be made suitable for mass deployment and there are seven more open source projects on the research agenda (see box). However, to win the tournament, "it is important for the logistics sector to reposition itself, join forces and make use of the technologies of the Silicon Economy," says ten Hompel.

The IT tools that have emerged are not yet open source. That will change as soon as the Open Logistics Foundation is launched. This non-profit foundation is likely to be the most important milestone, and certainly the most forward-looking one, on the road to a successful platform economy. It was created on the initiative of the logistics sector itself and, in future, it will act as a neutral guardian for further development of open source technology. One of those who wasted no time in getting involved is duisport CEO Markus Bangen, because "the digitalization of logistics can only be advanced by working together."

### Never walk alone.

# DIGITAL INFRASTRUCTURE IS JUST AS IMPORTANT AS TRANSPORTATION INFRASTRUCTURE

Digital platforms are crucial for Germany's competitiveness in the logistics sector. The Silicon Economy is expected to help the platform economy achieve a breakthrough. Why is it important to start with developments that are made in Germany? The Editorial Team spoke with Andreas Scheuer, Federal Minister of Transport and Digital Infrastructure, about who will benefit hugely from the Silicon Economy and whether the logistics sector is even ready for AI & Co.

**The Federal Ministry of Transport and Digital Infrastructure (BMVI) is providing the "Silicon Economy" with around 25 million euros of funding. Do you still remember the moment that convinced you of the value of the Silicon Economy project?**

The Silicon Economy was presented to me at the BMVI. Then, in 2019, Fraunhofer IML premiered a swarm of autonomous high-speed logistics vehicles to the world for the first time at the German federal government's Digital Summit in Dortmund - with funding from the BMVI. The Chancellor was very impressed. The message was clear: Where dispatchers still need to take care of transport coordination today, tomorrow there will be an increasing number of smart pallets and autonomous vehicles that will be able to do it for themselves. As fascinated as I was by the technology, I quickly realized that the use of artificial intelligence would require powerful digital platforms. Operating those requires an equally powerful digital infrastructure. That was when the "Silicon Economy" project was born: the concept of an open platform ecosystem that would allow platforms to work in parallel. For me, it's important that we start with our own products made in Germany and do not leave this field exclusively to others. We also don't want any monopolies, which disadvantage small and medium-sized enterprises. Last but not least, we need digital infrastructure that guarantees security and data sovereignty. That's why, with the Silicon Economy, we're creating an infrastructure for platforms — like a transportation network — that is open to all businesses and that any business can use. This digital infrastructure is as important as our railways, roads, bridges, tunnels, broadband networks or cell phone towers.

**At the Future Logistics Congress a year ago, you made a digital announcement that Fraunhofer IML had been granted funding for this major project. What is your conclusion so far - have your expectations been met?**

The speed and momentum with which the projects are going ahead is astounding. After just one year, concrete Silicon Economy services are already available. One thing that stood out for me was something called a sensing puck, which looks like a hockey puck. The sensor uses very little energy, but it measures the goods' temperature, ambient humidity and more along the entire transportation chain, and transfers the data via GPS to shippers and carriers. That makes it much easier to monitor shipments permanently and comprehensively.

**The proof that the Silicon Economy is doing something right is the response from businesses and associations...**

...Germany's logistics companies have identified the huge benefits of a shared digital infrastructure and the uniform components to platforms and services. And what's more, some have joined together under the Silicon Economy project to develop both funded and in-house projects to develop more modules. With this com-



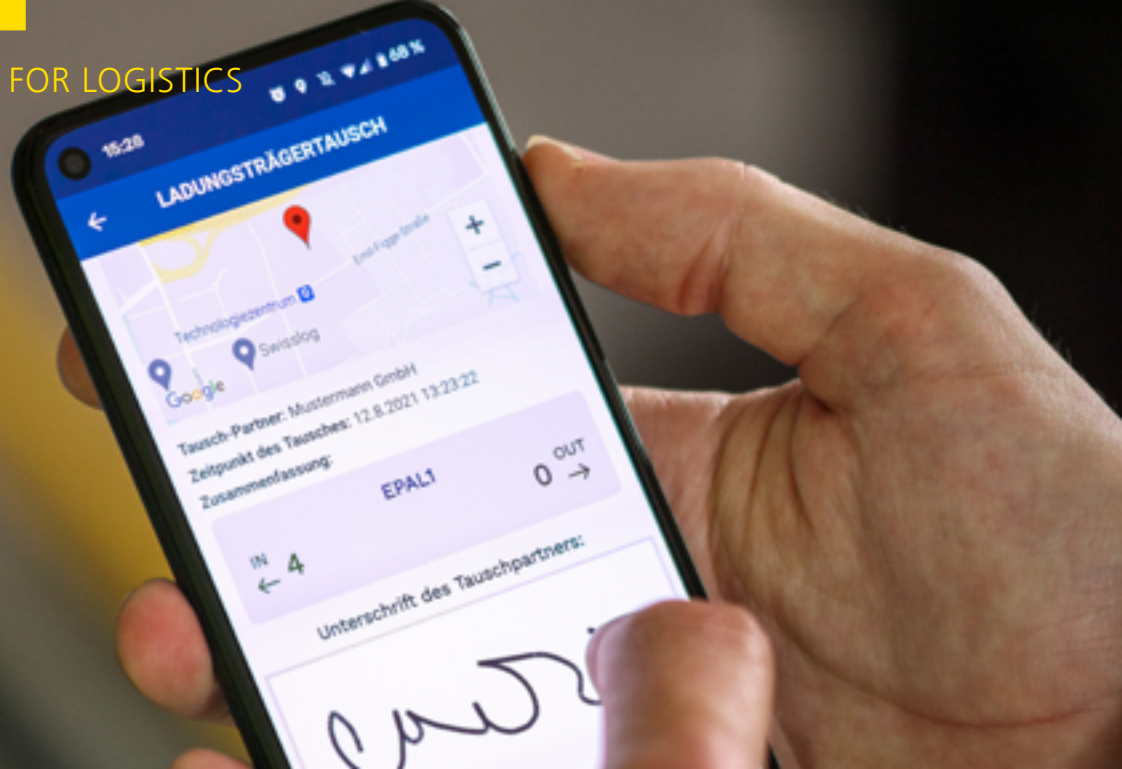
mitment, we are establishing the conditions for the full digitalization of logistical processes and making logistics as a whole more flexible and transparent. This helps us to organize flows of goods better and achieve our sustainability goals.

**Is the logistics sector ready for the “Silicon Economy” yet, with everything that entails: artificial intelligence, autonomous systems, blockchain, platform economy and data sharing?**

The logistics sector is absolutely ready for the Silicon Economy, judging from the interest and commitment that have been shown by logistics companies toward the project. It is no longer about whether we digitalize logistics, but about how and how quickly. The Silicon Economy guarantees that all those involved, particularly the many small and medium-sized enterprises and their employees, can benefit. That is a major advantage. Through the Silicon Economy, the logistics sector is becoming what is possibly the most comprehensive use case for secure data spaces and the cloud infrastructure that is currently being developed as part of the GAIA-X project.

**What advice do you have for medium-sized enterprises that want to digitalize their logistics processes?**

I like Professor ten Hompel’s guiding principle: “Never walk alone.” Transportation and logistics are characterized by value chains that involve multiple companies. I can only digitalize them by working with others. However sophisticated the software used by a transportation company might be, it’s of little use if the shippers and recipients of the goods don’t have it too. The big players are often the ones who take the lead, because they have the resources. In the Silicon Economy, even competitors can sit around the same table to drive new solutions. The real innovation is that they make these solutions available as open source software. So that means: Any company can take the source code developed in the project, integrate it into its IT and use it for its own solutions. This is a huge opportunity, particularly for medium-sized enterprises, whether they are logistics service providers or logistics software companies.



# THE TALE OF THE LOGISTIKBUDE AND THE LOAD CARRIERS

**A long, long time ago**, there was a distant land called Logistica. The soil in Logistica was very fertile and the citizens were all diligent and hardworking. The farmer worked the fields and harvested the grain, the miller ground the grain into flour and the baker baked the most delicious bread from the flour. Given the fact that it was impossible to carry each grain to the miller individually, loose flour would have been blown away by the wind, and the many loaves of bread would have been too heavy to carry to market all at once, the citizens used load carriers. The bags, containers, baskets, bottles and much more were, of course, used by all the other citizens living in the country.

Many years passed and the ancient land of Logistica became a modern country. Baskets became boxes, loose boards became pallets, and carriages became trucks. In time, there came to be more than one billion of these load carriers on the continent.

One day, however, the citizens of Logistica realized that they often did not know where their load carriers were and what condition they were in. Moreover, the pallets, containers and transport racks regularly came back damaged, but no one knew at which point in the process the damage had occurred. What's more, they often went missing altogether and had to be replaced. The second issue that bothered citizens was the regular confusion about how many load carriers they owed each other and the time and financial losses associated with this. Paper-based documentation, account management, and account reconciliation was standard practice, and this was labor-intensive and time-consuming. The situation was no different in the surrounding countries.

The citizens of Logistica were eager to improve the logistical processes in their country, but most of them had precious little knowledge of this topic. So they thought about organizing a competition that all of the country's citizens could take part in. And that's exactly what happened.

All over Logistica, people were mulling over how to solve the issues, because they all knew how cumbersome the existing processes were. Four young, bright men came together to form a team and started to conduct research together. Their names were Philipp, Michael, Jan and Patrik. In order to look more closely at the matter, they entered into a cooperation with EPAL – a manufacturer of load carriers and operator of the largest open pallet pool.

The four young, bright men first set about determining the current state of play. They found that the tracking, booking and inventory management operations for the load carriers were mainly carried out manually or by means of special technical systems. The latter first had to be painstakingly integrated into the respective IT landscape of the individual companies.

A few months passed, during which time the four young, bright men worked on a pioneering concept. They had envisioned solving the problems with easy-to-use software. However, this would not only factor in load carrier management of open pools, but would equally offer companies the option of linking their own load carriers. To achieve this, they developed algorithms and used cloud computing, artificial intelligence and machine learning. Once they were satisfied with what they had developed, they presented it to the citizens of Logistica.



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The four young, bright men told the citizens about their web-based platform and accompanying app, which made it possible to completely eliminate previously essential process steps in the load carrier management system. From that point onwards it was possible to digitally record all exchange processes and make them accessible to the parties concerned using the app. Even the accounts of individual citizens were reconciled in a fully automatic manner. Since the citizens could keep track of all progress on the website and correct individual bookings as needed, the time and effort required for companies to complete processes was reduced. It was no longer necessary to look at each booking with each company individually and exchange countless emails and PDFs. The algorithm even automatically detected whether and where advantageous swaps with other app users were possible, thus preventing unladen journeys, for example. When the citizens heard this, they were very happy. Finally, there was an easy-to-use solution that did not require any installation effort or training.

The four young men reported without hesitation that the platform also worked for load carriers that were not part of an open pool but belonged to a single company. To take advantage of this, companies simply had to follow the step-by-step instructions on the platform in future to assign a unique label to the selected load carriers. This bar code label could be printed straight away and affixed to the load carriers. From then on, no one was wondering where exactly the load carriers had ended up, what condition they were in, and what had happened to them along the way. It was even possible to connect partner companies.

#### This might sound like a fairytale, but it's real:

The "Logistikbude" is a spin-off company of Fraunhofer IML, which emerged from the joint Enterprise Lab with the European Pallet Association e.V. (EPAL). Philipp Wrycza, Michael Koscharynj, Patrik Elfert and Jan Möller are the four bright men behind the Logistikbude.

The platform was created in the EPAL Lab and elsewhere, and features open source components from the "Silicon Economy." Digital load carrier management is suitable for large industrial companies and freight forwarders as well as for small and medium-sized enterprises. The platform is now ready for the market, and the project is currently in the pilot phase with different customers.

The German Federal Ministry for Economic Affairs and Energy is supporting the team with an EXIST research transfer. The four members officially founded the company in September 2021.

Tracking, exchanging, photo documentation, examination and marriage of goods – all of this was now possible through the platform and the app. All functions and stakeholders were finally under one roof.

The citizens liked the solution so much that they organized a big party in honor of the four young, bright men, and all the citizens of Logistica were invited. Knowing that the four young, bright men were eager to continue tackling logistical challenges, the citizens built them their own house to say thank you. The four young, bright men were very happy, because they had finally found a place where they could give free rein to their thoughts and ideas.

They called the house **"the Logistikbude"**.



# ONLY FLYING IS FASTER

The year is 2021. In the “Silicon Economy”, the digital platform economy of the future, vehicle swarms organize themselves and communicate with human beings, other swarms and platforms to complete their mission. What sounds like science fiction has already become a reality in Dortmund. With the “LoadRunner”, the Fraunhofer Institute for Material Flow and Logistics IML has set a global benchmark in swarm robotics: a new generation of automated guided vehicles that use artificial intelligence and 5G communication to organize themselves independently in a swarm at high speeds, putting in an incredible sorting performance.

The LoadRunner for the digital platform economy celebrated its world premiere at the 2019 Digital Summit in Dortmund as part of a project funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI). On that occasion, a high-speed swarm of eight small vehicles whizzed across the hall floor before the eyes of leading politicians and major television broadcasters, organizing themselves with the aid of distributed, intelligent vehicle coordination. They picked up parcels completely autonomously and put them back in the right place without colliding with each other. Since then, the scientists have been working on the further development and scaling of the system.

## The ideal logistical space is an empty one

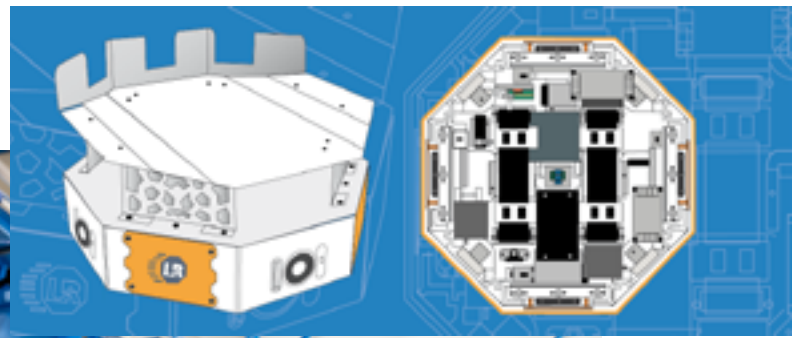
The LoadRunner project builds on the future vision of infrastructure-reduced logistics – a vision in which the ideal logistical space is an empty one. After all, the highly dynamic nature of today’s logistical environments can only be counteracted with a high degree of flexibility and scalability. It must be possible to commission logistics facilities and dismantle technical facilities quickly and at optimal cost. With the LoadRunner, the scientists from Dortmund have come a step closer to realizing this vision. The LoadRunner is a logical next step in the development of existing concepts that do not need to be permanently installed in the building infrastructure and can be used universally.

## Parcel sorting needs to happen more quickly

Looking at parcel sorting in today's parcel distribution centers, while there is a noticeable trend towards smaller AGVs (automated guided vehicles) and vehicle-based sorting, most AGV sorting solutions operate in a grid. This means that the travel routes are perpendicular to each other and collision avoidance is relatively simple. The disadvantage, however, is that vehicles may have to cover longer distances or sit and wait if routes are blocked. The Fraunhofer scientists have therefore focused their AGV development activities not only on high flexibility, but also on high throughput, in part by ensuring quicker inward and outward transfer of goods.

The LoadRunner has been fitted with a completely new hardware platform and control system. For this purpose, the vehicle has been equipped with an omni-directional chassis consisting of four 3.6 kW motors, allowing the LoadRunner to navigate the space in a completely unrestricted manner. Unlike conventional collision avoidance methods, the trajectory control of the LoadRunner makes adjustments to both the travel route and the speed. This prevents the vehicles from colliding with each other despite traveling at high speeds. This is an enormous achievement, as the LoadRunner can reach a theoretical speed of 25 m/s. Therefore,

in theory, a swarm of high-speed vehicles can whiz through a warehouse at about 90 km/h without any collisions occurring. An interdisciplinary team of scientists has developed many other new features for the LoadRunner – for example, cameras that record up to 400 images per second, allowing vehicles to determine their own location despite their high speed. Optimizing the transfer of goods at the storage stations was also a key priority for the researchers. In this case, the inertia-based transfer principle was applied: The load is transferred solely by means of inertia when the vehicle brakes – i.e. without additional actuators.



### The technical data of the LoadRunner®-prototype at a glance:

- Omni-directional chassis
- 4 direct drives with a total power rating of 14.4 kW, no transmission
- Max. speed 10 m/s (theoretical maximum speed: 25 m/s)
- Acceleration up to 5 m/s<sup>2</sup>
- Payload: approx. 30 kg
- Camera for location detection (400 images per second)
- Load protection through highly dynamic alignment based on the acceleration vector



## Real-time simulation confirms impressive sorting performance

During the process of developing the LoadRunner and improving its sorting performance, the scientists from Fraunhofer IML also built a simulation model for performance evaluation. The simulation environment was based on the real-time 3D development platform Unity – a gaming engine. In addition to being used for simulation purposes, Unity also provides a dynamic representation of the system’s behavior in real time. This allowed the researchers to test out risky and complex maneuvers within the swarm system in a risk-free manner. The environment can also be scaled in order to determine the performance of large systems. The very first version of the simulation showed that a LoadRunner sorting swarm was capable of astonishing performance levels.

A study conducted back in September 2020 on the use of the LoadRunner for parcel sorting delivered promising initial results: With just 60 vehicles, it is theoretically possible to sort well over 10,000 consignments every hour. The researchers modeled a sorting operation using different numbers of LoadRunners and different acceleration values. In addition, they looked at factors such as vehicle tracking and collision avoidance. The result: The performance levels of conventional sorting systems can be reached with as few as 60 LoadRunners. “With more vehicles and a slightly higher degree of acceleration, we could improve performance levels significantly,” explains Moritz Roidl, Chief Engineer at the Chair of Materials Handling and Warehousing at the TU Dortmund University, who was involved in the project. What’s more, the LoadRunner is far less reliant on permanently installed infrastructure than conventional sorting systems. It paves the way for dynamic performance adjustment, greater scalability and significantly faster commissioning processes.

## Flexible deployment

At present, a LoadRunner can move at up to 10 m/s in a swarm in a highly dynamic manner. If required, multiple vehicles and up to four passive trailers can link up magnetically to transport large and bulky pieces. A single LoadRunner can transport and sort loads weighing up to about 30 kg on its own. This means that it can also be used, for example, for transporting and sorting luggage at airports.

“With the LoadRunner, we have developed a key piece of the jigsaw for tomorrow’s logistics sector and set an international benchmark in terms of autonomous transportation systems and artificial intelligence. These vehicles can accelerate like a sports car and are entering a whole new performance dimension. LoadRunner swarms can be considered for applications previously reserved for high-performance sorting and conveying technology. WiFi 6 and 5G-based communication, autonomous handling and booking of orders via the blockchain, and on-board artificial intelligence make the LoadRunner the forerunner of a new AI-based generation of vehicles and the blueprint for the logistics industry as it moves towards a vertical and real-time-networked digital platform economy,” emphasizes Prof. Michael ten Hompel, Executive Director of Fraunhofer IML.

And Jan Behling adds: “The way in which the LoadRunner was developed is a typical example of how we work at Fraunhofer IML. An interdisciplinary team implements an innovative idea as a prototype with great enthusiasm for the desired outcome and a clear focus on the subsequent application. Despite the high degree of complexity, the development work for the LoadRunner was very successful. We have had an extremely positive response from the field and are now looking forward to developing the LoadRunner into a marketable system together with a capable industry partner.”

## LoadRunner technology on the verge of a breakthrough

In the KION Group, Fraunhofer IML has found a well-known industry partner who would like to license the LoadRunner technology for use in their group of companies. At a joint enterprise lab at Fraunhofer IML in Dortmund, the partners now want to further develop and industrialize the artificial intelligence-equipped autonomous vehicle swarm. At the enterprise lab, eight employees from both partners will work together on the further development of the LoadRunner technology. The Lab has started its operation in September 2021 and is set up to run for at least three years. The common goal is to industrialize and optimize the AI-based swarm technology, from the sensors right through to the higher-level platform.

“The launch of the joint enterprise lab with the KION Group clearly demonstrates the disruptive potential of this technology. In KION, we have secured an intralogistics think tank as a partner, which, with the LoadRunner, will open up markets the world over,” emphasizes Prof. Michael ten Hompel, Executive Director of Fraunhofer IML. And Gordon Riske, CEO of KION GROUP AG, had the following to say when the partnership was announced: “Artificial intelligence is revolutionizing the industry, and we are playing an active role in this. Expanding the use of artificial intelligence in our products and software solutions is an important part of our ‘KION 2027’ strategy. The innovative LoadRunner technology and the partnership with Fraunhofer IML will help us to make the processes in our customers’ warehouses even simpler, faster and more efficient – this will lessen the burden on the on-site logistics teams significantly and also have a considerable impact on profitability.”

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## INTERVIEW

**Tobias Zierhut**

Senior Vice President at  
KION Mobile Automation



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

KION Group AG and Fraunhofer IML have been exchanging ideas for many years, and have also worked very successfully together in the past, for example in the Dematic Multishuttle project. We have followed the research and development of the LoadRunner with great interest throughout. We see this as the right time to join the project and take part in its further development through to the industrialization stage. By investing in partnerships and the development of autonomous mobile robots (AMRs), the KION Group has already taken significant steps to expand its solution portfolio in recent years. We view the LoadRunner as a disruptive development towards AMR 2.0 that will take goods transportation in logistics and e-commerce to a whole new level.

### **What are the main priorities of your research at the lab?**

Our research will focus on aspects of our customers' sorting processes, by which I mean the distribution and allocation of goods in the logistics process. The scope of relevant applications is highly diverse, ranging from parcel logistics to luggage logistics at airports. We also see the LoadRunner potentially contributing to future solutions in goods transportation by helping to realign and streamline use cases that currently make use of conveyor belts – particularly for "just-in-time" deliveries in industrial manufacturing processes.

### **What benefits do you think the Enterprise Lab research offers?**

The Enterprise Lab research enables KION to ensure a close collaboration between theoretical research and practical implementation, including further development to get the product ready for market. The collaboration gives us the opportunity to contribute

specific aspects from the KION side so that we can help to set the course for the progress of technology, including by adapting the solutions to specific focus areas. To achieve this, employees of the Fraunhofer Institute will work closely with KION colleagues from the fields of Mobile Automation, Technology and Innovation as well as from the KION subsidiary Dematic at the Dortmund site. They will receive extensive support from specialists at the KION Energy Systems and KION Manufacturing & Engineering divisions.

### **How important is the Enterprise Lab research in your overall strategy?**

Because of the broad spectrum covered by the KION Group, we naturally deal with a wide range of different developments. However, we see a very high disruptive potential in LoadRunner for the future as a crucial solution to help provide greater flexibility and time savings in the applications of our customers.

### **How has the cooperation with Fraunhofer been going so far, can you say anything about it at this stage?**

The cooperation with the individual team members at Fraunhofer IML has been and continues to be invigorating, solution-oriented and constructive. The entire KION team is looking forward to working together with them in the future.

# TIME FOR A DYNAMIC

A sensor wristband that provides personal break recommendations: The “Dynamic Break” project aims to adapt industrial engineering and work organization at companies not only to logistical requirements, but also to the needs of employees.

An employee has been busy in the warehouse for several hours when he or she receives a message from their smartphone: It uses a wristband to indicate that they should take a break.

With the aid of sensors, the wristband records various vital signs such as one’s pulse, skin conductivity, intensity of movement, and skin temperature throughout the entire working period. If the values deviate too greatly from the employee’s natural state and stress is detected, then the device recommends that they take a short break to recover. The employee can then decide for themselves whether they wish to follow the recommendation.

The “**Dynamic Break**” project was launched at Fraunhofer IML in 2019. The aim is to adapt industrial engineering and work organization at companies not only to the company’s internal processes and logistical requirements, but also to the needs of the employees. “We first examined what data would be required in order to measure personal stress levels. To this end, we exchanged ideas with experts from the fields of medicine and stress and break research, among others,” explains Dr. Veronika Kretschmer. She coordinates the project together with her colleague Benedikt Mättig.

The researchers then determined how the collected data would be analyzed. The sensor wristband uses a web-based service and machine learning methods for this purpose. The scientists worked with sample data at first in order to train a neural network. For this reason, they recorded the vital data of people under conditions of stress and recovery and used questionnaires to determine their subjective feelings. The data were used to train a neural network that can recognize whether an employee is about to reach a critical stress level based on the various signs. The wristband informs the employee about this before the critical stress level is reached.

## Benefits for companies and employees

Die Daten werden dabei anonymisiert behandelt. The data are handled anonymously throughout the process. The employer only sees that breaks are being taken and is able to manage and plan staff resources accordingly. The employee’s data-based break recommendations and personalized break requests are managed in another web-based service and linked to the respective resource management software at the company. According to Veronika Kretschmer, the project has benefits for both companies and employees: “The individual recommendations are intended to make the process of organizing breaks at a company more flexible and dynamic, thereby optimizing that process. In the long run, dynamic breaks help to maintain health, performance and safety of warehouse workers,” she says.

The next step will see the researchers at Fraunhofer IML collect real data from industry partners and use them to further adapt the machine learning model. To this end, they are still looking for additional industry partners to conduct pilot tests of the “Dynamic Break.” The more diverse the data, the better able the scientists are to train the neural network. Since break and warehouse management differs from company to company, the sensor wristband is only intended to supplement the company’s internal regulations, not replace them.

## Importance of people persists in Silicon Economy

The development work for the “Dynamic Break” project began in the “Hybrid Services in Logistics Innovation Lab” at Fraunhofer IML. Now it is part of the major “Silicon Economy” project: In the platform economy, machines, vehicles and employees communicate with each other; everything is interlinked.

“Our project puts people at the heart of the Silicon Economy,” explains Benedikt Mättig. Especially in



# BREAK



work areas with manual activity requirements, workers remain a valuable resource and an economic success factor regarding to their speed, flexibility and wealth of knowledge and experience. "The employee must not become overwhelmed by all the technical developments and needs to be integrated into the system. In this context, digital ergonomics offers the opportunity to optimize working procedures with the help of artificial intelligence and to support employees."

However, the wristband not only detects when an employee is stressed and needs a break, but also when the break can end: Once the employee's heart rate and other stress indicators have returned to normal, it recommends that the employee resume work. At present, the researchers are working on their own sensor wristband for data collection, which will take care of the entire process of interacting with the employee and replace the current smartphone app.

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## BLOCKCHAIN

# Booster for optimized, end-to-end digital dangerous goods management

Dangerous goods handling and the blockchain – how does all that come together? In the “Blockchain Europe” project, scientists are proving that this combination actually works wonderfully well – using a blockchain-compatible assistance system with integrated sensor devices to organize the exchange of information in a legally secure and tamper-proof manner. At the same time, digitalization and automation via smart contracts ensure improved coordination as well as simplified and expedited processes in the transportation of explosive substances and goods.

Fraunhofer IML started writing a new chapter in logistics in late October 2020 with its first prototype of the “**blockchain device**”. However, the device for monitoring temperature-sensitive goods is just the beginning of a series of blockchain-compatible IoT devices for real-time supply chain management, including legally compliant negotiations, transactions and bookings.

### Cutting-edge technology for current and future challenges

There are those who claim that there are still issues with the implementation of specific applications. The scientists involved in the “Blockchain Europe” project do not consider this statement to be absurd, but they do take a strong stand against it. For example, the development of two blockchain-compatible devices is currently on the agenda, which could significantly improve the handling of dangerous goods if they are used interactively. “First of all, it is important to know that the transportation of dangerous goods is a logistical process that is heavily influenced by law. This serves to protect people and the environment,” says Philipp Klink from Fraunhofer IML. “What’s more, numerous stakeholders are involved, from the consignor and forwarder to the carrier, the consignee and other control bodies. The documentation requirement for compliance with legal and regulatory requirements is similarly comprehensive. “These framework requirements restrict flexibility to a considerable extent and at the same time call for time-consuming advance planning. This is precisely where blockchain technology comes in.



### Keeping a keen eye on the resilient use case

The Blockchain Europe team is pursuing two work streams in this project: On the one hand, there is a focus on the digital exchange of information between the parties involved in the process.

Among other things, this is the aim of the prototype development of a blockchain-based electronic dangerous goods transport document, in which the interaction is documented in a seamless, tamper-proof and constantly updated manner with the aid of the blockchain. Simultaneously, the objective is to produce a blockchain device for the operational handling of dangerous goods.

This will be used to retrieve relevant accompanying documents from the blockchain, continuously track events, and trigger smart contracts that can be used to automate recurring processes in dangerous goods handling. This will save an enormous amount of time in the future and minimize manual, human errors. At the same time, the implementation process becomes considerably more flexible, as accompanying documents, including the history, are always available in digital form and continuously updated, and instructions for action can be derived from the information directly.

### Seamless documentation of procedural progress

The researchers have already aptly named the two components to be implemented as part of this development project: “dangerous” (**D**igitalisierung und **A**utomatisierung von **G**efahrgut – **R**echtskonform und **S**icher, meaning Digitalization and automation of dangerous goods – legally compliant and safe) and “dragon” (**D**evice for **r**eliable **d**angerous **g**oods **t**ransport). But how does the interplay work? “On the dangerous user portal, the stakeholders provide all relevant information for dangerous goods shipping digitally, which is now exclusively available to business partners who are authorized in this regard,” explains Product Owner Sebastian Brüning. The dangerous goods to be transported are recorded and corresponding shipping labels are generated at the same time.

“The dragonDevice is then used during the process of loading the dangerous goods onto the transportation unit,” the blockchain expert continues. This can be used to scan a QR code found on the shipping label generated previously to assist in checking the condition of the dangerous goods. The transfer of risk is completed once an integrated handover mechanism is triggered, and this

is written to the blockchain as a transaction. In addition, a notice regarding the labeling obligation is issued before transportation begins. The vehicle driver uses the dragonDevice to record both the beginning and the end of the dangerous goods transportation.

The device can then also be used to couple dragonPucks (modular IoT devices for capturing status information) with the shipping unit. This enables tracking and tracing of dangerous goods transports. Stakeholders with the appropriate authorization can therefore view the entire dangerous goods handling process on the dragonDevice or on the dangerous dashboard. In addition, continuous checks are carried out to ensure that the sensor data recorded is within a predefined tolerance range, allowing potential hazards associated with the dangerous goods being transported to be identified at an early stage.

### Sustainably secured, simplified processes

“The decisive advantage of automated order communication in the context of dangerous goods handling is that implementation is expedited, transparency can be established throughout the process, and the planning process is effectively collaborative,” says Philipp Klink, in summary. In addition to providing information on the current temperature and humidity, the sensor technology in the devices is also reliable in providing information on the current location in the medium term. “Converting legal requirements and regulations into smart contracts that can be executed in an automated manner has a significant impact on compliance with those requirements and regulations. It also immediately simplifies the process of handling dangerous goods for all stakeholders. As such, the blockchain definitely has the potential to revolutionize dangerous goods handling.” The development results of the development project, which will run until 2023, are to be made available as open source components and thus also made accessible to smaller and medium-sized companies that want to press on with their digital transformation with the aid of the blockchain and minimize the associated implementation work.

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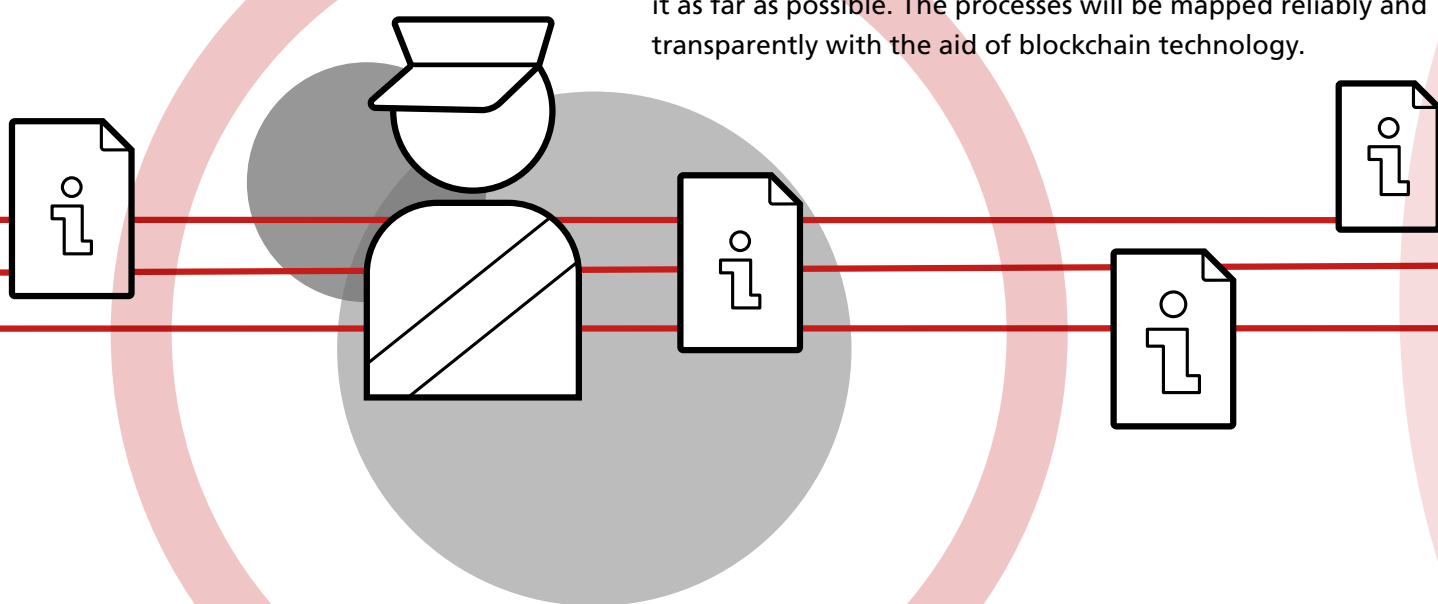
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# BORDER CONTROL

## BLOCKCHAIN DRIVES DIGITALIZATION OF CUSTOMS PROCESSING

In the “Blockchain Europe” project to establish the European Blockchain Institute in North-Rhine Westphalia (NRW), Fraunhofer IML, software provider AEB SE and automotive supplier Adient plc are working on digitizing customs processing and automating it as far as possible. The processes will be mapped reliably and transparently with the aid of blockchain technology.



At present, customs processes are often handled in analog rather than digital form: In a typical export process for example, the customs authority sends a document to the exporter to confirm that an export is permitted. The exporter prints out this export accompanying document and encloses it with the shipment. On the far side of the border, the consignee must re enter the goods information in a digital system in order to lodge the import declaration. “This process is very time-consuming for everyone involved,” explains Roman Koller, Product Owner (Customs) for Blockchain Europe at Fraunhofer IML. “That is why we want to digitize the entire customs process in collaboration with our partners AEB, Adient and other members of the Blockchain Europe Community.”

In the project “**BORDER**” (“Blockchain-based organization of relevant documents in external trade with regulatory compliance”), which was launched in February 2021, customs documents are made available digitally. The export accompanying document is the first stage for the scientists. “This document is the bridge between the exporting country and the third country, i.e. a non-EU country,” explains Roman Koller. “We plan to digitize the content of the document and map it in the blockchain.”

Currently, there is often an asymmetry of information between the various parties involved, says Roman Koller. In this context, some stakeholders such as customs authorities have more information at their disposal than others.

Blockchain technology, combined with smart contracts, is used to facilitate storing and updating digital processes and documents for all parties involved in a decentralized and tamper-proof manner. This would make documents, delivery routes and other content traceable at all times, for example for exporters, importers, software and transportation companies or customs brokers. The solution, which will be made available open source, also reduces paper consumption and the amount of effort involved.

documents and information to be structured and merged as required. Changes and additions can be viewed in the transaction history. Additional basic components are used to provide supplementary functions. For example, the basic component "Authorization Module" can be used to assign access rights in order to control which parties are allowed to read or edit information in the blockchain and to what extent. In the case of the BORDER project, documents are to be stored securely in this way and goods movements are to be reflected in the blockchain.

### Brexit, the digitalization catalyst?

The scientists want to digitize an initial prototype customs process using an agile Scrum process. After the export accompanying document has been addressed, they plan to make other customs documents available in digital form as well. These will include, for example, what is known as proof of origin, which indicates the country from which the goods originate.

As of this year, this proof must be provided in order to engage in trade with the United Kingdom: The country's exit from the EU creates new bureaucratic challenges, such as essential export and import declarations. According to a survey by the German Association of Chambers of Commerce and Industry (DIHK), this results in up to 10 million additional customs declarations per year – on the German side alone.

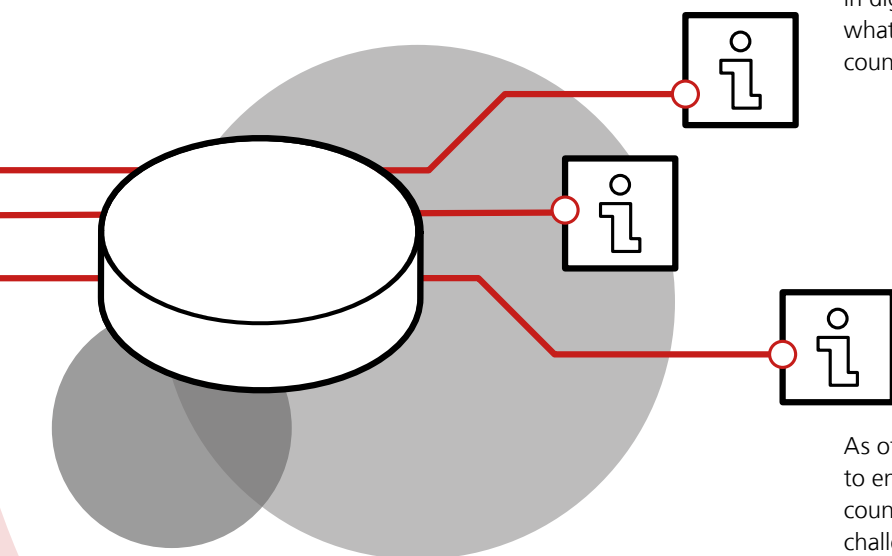
This makes the UK particularly interesting for the scientists on the BORDER project. In general, they are still looking for companies that would like to participate in the ongoing the project – even if they are not affected by Brexit.

"Companies can collaborate with Blockchain Europe in order to contribute to end-to-end digital customs processing. In addition, as validation partners, they are invited to test the planned prototypical processes in practice. In this way, Brexit as an additional impulse for digitization in the customs world may have something good after all," says Roman Koller.

### Use of basic components

Customs authorities are to be included in the project over the long term. "When it comes to engaging with the authorities, digital and analog processes will continue to exist alongside each other at first, or will be digitized to varying degrees. That is why we make sure that our developments are always compliant with existing regulations and procedural instructions," explains Roman Koller. Authorities would also benefit from greater supply chain transparency: The fact that the entries stored in the blockchain are immutable means that they can also serve as a basis for audits by customs authorities later on.

The scientists are making use of various basic components developed at Blockchain Europe to implement the project. The "Token Manager" is one of these: It maps information and values in the blockchain using so called tokens. The Token Manager allows the stored



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# DIGITIZING PORTS

Ports play an important role in logistical processes. For this reason, scientists at Fraunhofer IML are currently involved in various research projects in an effort to digitize processes and make them more efficient with the aid of technology.



Globalization is turning inland ports and seaports into important logistics hubs for the economy. The digitization of processes poses challenges for many operators – but this is the only way that ports can continue to structure processes efficiently and remain competitive in the future. Inland ports in particular, which are often located in densely populated areas, stand to benefit from reductions in CO<sub>2</sub> and noise emissions. Against this backdrop, scientists at Fraunhofer IML are currently conducting research in three projects with a view to digitizing ports using IoT applications, augmented reality, or automated transshipment terminals.

## Internet of Things: “I<sup>2</sup>PANEMA”

In the research project “I<sup>2</sup>PANEMA” (“Intelligent IoT-based Port Artifacts Communication, Administration & Maintenance”), processes at inland ports and seaports are to be digitized using new IT strategies such as the Internet of Things (IoT). To this end, researchers are developing demonstrators at various ports to show how IoT concepts can be applied to on-site processes.

One area is the transfer of road freight transportation to railways and waterways by means of process improvements and the use of IoT solutions. Congestion and lack of parking could become an issue at the respective terminals. This problem arises, for example, in the port of Dortmund, which is located downtown.

As part of the “I<sup>2</sup>PANEMA” project, trucks traveling to the terminals are tracked in an application. Using IoT devices and camera recognition, the traffic, parking lot and factory gate circumstances are evaluated so that vehicles arrive on time.

Other application scenarios for “I<sup>2</sup>PANEMA” include automatic noise detection and reduction when loading and unloading containers, the use of sensors to reduce emissions through intelligent control of processes, and screens at ferry terminals that show in real time when ships are leaving.

The researchers also designed reference architecture for the project in order to integrate IoT devices at seaports and inland ports. It supports the implementation of IoT-based programs at ports.

Digitization results in information gains for everyone involved in the project and thus in new optimization potential: “In addition to improving the efficiency of processes, we are also aiming to make ports sustainable, characterized by low emissions and a cooperative coexistence with the local population,” says Achim Klukas, Research Associate at Fraunhofer IML.

**Locations:** The ports of Dortmund, Nuremberg, Wesel, Gijón, Hamburg, Assan, Safi

**Project duration:** June 2019 to the end of 2021

**Project partners:** 17 companies from Germany, Spain and Turkey

**Funded by:** Turkish Institute for Scientific and Technological Research (Turkey), Federal Ministry of Education and Research (Germany), Center for the Development of Industrial Technology (Spain) in the framework of the ITEA.

»I<sup>2</sup>PANEMA«



Fraunhofer IML; Elisabeth Drache



Fraunhofer IML; Elisabeth Drache

## Augmented reality: “InnoPortAR”

Digitization offers new ways of making work processes at seaports and inland ports more digital. More of the information that needs to be processed by employees can be made available. At the same time, this information continues to be missing from other work steps that can be made more efficient through digitization. Scientists at Fraunhofer IML want to rectify this issue with the “InnoPortAR” project. To do this, they are using augmented reality (AR) technology, which sees additional information displayed virtually on a pair of glasses or a screen. For example, during maintenance work, the next steps are displayed in the field of view. This supports and optimizes the work procedures at the ports.

To this end, the scientists are testing the AR glasses and tablets in four application scenarios: maintenance and servicing of a gantry crane, crane operator support during ship unloading procedures, cargo securing, and interface control during container handling procedures at the trimodal terminal.

These are connected to both the rail and road transportation means or to the ship. “The use cases highlight the number of possible applications for this technology at the port,” says Achim Klukas. “The project is also expected to help improve the economic efficiency and competitiveness of trimodal terminals at inland ports and seaports.”

**Location:** Ports of Duisburg and Dortmund

**Duration:** October 2019 – September 2021

**Project partners:** Port of Duisburg, Materna, Materna TMT

**Associated partners:** Container Terminal Dortmund, Haeger&Schmidt, Eurogate

**Funded by:** the German Federal Ministry of Transport and Digital Infrastructure (BMVI)

## Automation: “AutoModal”

Combined transportation is considered a more environmentally friendly alternative to road transportation. The idea is to transport cargo by rail and inland waterway instead of by truck. This changeover takes place at the ports at what is known as the transshipment terminal. “These processes are often carried out manually, which can lead to delays or inefficient use of resources,” explains Achim Klukas. To improve the reliability and efficiency of combined transportation, researchers at Fraunhofer IML are investigating how end-to-end automation of the transshipment terminal could be carried out.

The scientists are automating a gantry crane: For this purpose, they have developed suitable control software and integrated hardware components such as cameras and sensors. The automated operation will then enter prototypical testing for about six months. The researchers are also drawing up a road map that details possible end-to-end automation of the transshipment terminal.

**Location:** Port of Wörth

**Project duration:** March 2019 – February 2022

**Project partners:** Contargo, synyx

Funded by the German Federal Ministry of Transport and Digital Infrastructure (BMVI)

Further projects on digital twins at inland ports, networking of stakeholders through platforms, and noise reduction are in the preparation stage

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# PORT -RELATED INNOVATIONS

**At present, Fraunhofer IML is involved in three major projects at ports. To what extent can the results act as innovation drivers for logistics in general?**

The projects share the common background of digitalization and the objective of sustainable and enhanced logistics. By implementing IoT concepts along the transportation chain, the data that are transferred between processes or process participants become easier to exchange and interpret. On the one hand, we need standards for the interfaces. On the other hand, it must be possible to adapt the solutions flexibly to the requirements. The insights we gain from this can also be of great benefit to other areas of logistics.

**Which IoT applications (from the I2PANEMA project) could be adopted at many ports?**

In many areas of logistics, but especially for ports and general combined transportation facilities, improved up-to-date forecasts for transportation and handling times are an important element in terms of improved efficiency and reliability in dealings with customers. Another application that I expect to attract significant interest, and this goes for other areas as well, is "smart devices." That is because of their recording and documentation capabilities, which efficiently facilitate compliance with safety and environmental regulations on board.



**Prof. Uwe Clausen**

Director at Fraunhofer IML

**What needs to happen to ensure that a greater amount of cargo is transported using this more environmentally friendly combined mode of transportation?**

Combined transportation has grown in importance in recent decades, but there is a lot of untapped potential. There are infrastructural prerequisites as well as operational and IT requirements in this regard. Scheduled construction projects, for example in the rail network, must be implemented in a "capacity-saving" manner. What's more, to make terminal operations more efficient and to make swift decisions on which mode of transportation to use, it is important to have up-to-date data. Reliable transportation and transshipment times as well as enhanced logistics capability on account of data provided prior to and during transportation are also among the success factors for combined transportation.



# A smart approach to calculating **ARRIVAL TIMES**



## In future, researchers at Fraunhofer IML want to be able to calculate the arrival times of shipments with the aid of artificial intelligence. Importantly, the components and software used will be open source.

The KI-ETA program is straightforward to use: First of all, companies enter the starting point and destination of the route that a vehicle such as a truck is to take on a map. Using artificial intelligence, the program then works out what time the vehicle will arrive at its destination. During the analysis process, KI-ETA (short for artificial intelligence – estimated time of arrival) takes into account factors such as the weather and any traffic jams and accident data. This enables companies to provide their customers with more reliable arrival times and improve the efficiency of their own planning.

The project has been running since the fall of 2020 as part of the major “Silicon Economy” project. The scientists had to take a step-by-step approach to implementation: The first component developed was a freely available online map service. They used OpenStreetMap as a basis, which collects freely accessible geodata and structures it in a database.

The second component is called a geo-coding service: “If I enter a starting point and a destination, we can generate geocoordinates from that, which are then displayed on the map,” explains Alex Rotgang, Product Owner of the “AI-based ETA service” at Fraunhofer IML. Ultimately, the route is depicted by the third component, the route service. To calculate the arrival time as accurately as possible, the software divides the route into its smallest components.

The Mobility Data Marketplace (MDM) is integrated in order to provide a more accurate forecast of the arrival time. Today, more than 500 providers from the public and private sectors are posting mobility data from Germany on this publicly accessible platform. This enables scientists to see what speeds are like at certain times and in certain locations. “We already have the data for North Rhine-Westphalia and are integrating it into the service,” explains Alex Rotgang.

Another basic component that has been developed is the weather service. The researchers incorporate this into the ETA calculation. It displays historical and current data as well as future weather forecasts. “We then present all these data to the AI. It learns from the data and can then forecast accurate arrival times,” says Alex Rotgang. “The data sources are already available to everyone. What’s special about it is that we make it useful by incorporating various basic components.”

### Vision: Multimodal

The scientists are currently working on mapping multimodal shipments as well. This refers to shipments that make use of different modes of transportation (by sea, rail, road or air). For this purpose, they integrate terminals where combined transportation takes place. In addition, the typical durations of handling activities are factored in.

The scientists are also looking for additional industrial partners who would like to get involved as pilot customers: “We would love for companies to collaborate with us and test the program,” Rotgang explains.

Small and medium-sized companies in particular benefit from the fact that they can integrate the service within their own software and no in-house developments are required. But there are also benefits for larger companies: With KI-ETA, all of the mobility and location data remain with the company, which thus retains data sovereignty.

This is made possible by software developed as part of the “International Data Spaces” initiative, one of the network partners of the Silicon Economy. Using what is known as the “IDS Connector,” companies can decide for themselves which data they want to share and with whom. Alternatively, companies can also integrate the entire program code of KI-ETA into their own transportation management system.

“The service aims to provide complete transparency on the transportation services offered by the different modes of transportation on the market. That is far from being a foregone conclusion at the present time,” says Alex Rotgang. This transparency is made possible by the Silicon Economy. “What’s special about the Silicon Economy is that the projects are open source and anything can be linked to anything,” he explains. For example, other projects within the large-scale project have already incorporated components such as the map or the weather service into their own projects.

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## DB Schenker extends research partnership

DB Schenker was one of the first companies to found an Enterprise Lab with Fraunhofer IML in 2015 to develop forward-looking projects and technologies together. Now the partners have extended their research partnership through to the end of 2023. In the next few years they intend to focus on the issue of open source, which will involve continuing to digitalize the logistics processes in use at DB Schenker.



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## 6G research hub approved

Working together on 6G mobile communications technology: A call for tenders by the Federal Ministry of Education and Research was won by a proposal from RWTH Aachen University, Ruhr University Bochum, the Technical University of Dortmund, the University of Duisburg-Essen and Fraunhofer IML. The partners are working together to research new communications technologies with the goal of enabling Germany to become a leading supplier of technology in the future.

# 6GEM

6G Forschungshub für offene, effiziente und sichere Mobilfunksysteme

## New Digital Center for small and medium-sized enterprises

Fraunhofer IML is one of the project partners of the "Mittelstand-Digital Zentrum Ruhr-OWL" (Ruhr-OWL Digital Center for Small and Medium-sized Enterprises), which has been supporting small and medium-sized enterprises (SMEs) since 2021 with the digitalization of products and processes and the development of digital business models. The center gives SMEs the opportunity to benefit from scientific findings and practical experience free of charge in order to boost their competitiveness. The Digital Center for Small and Medium-sized Enterprises is receiving funding of 5.9 million euros from the Federal Ministry for Economic Affairs and Energy up to June 2024.



Mittelstand-Digital  
Zentrum  
Ruhr-OWL

## Study on quiet urban logistics

Quiet logistics aims to make freight transport in inner cities more sustainable and city-friendly. This is why researchers at Fraunhofer IML are conducting a study into how to improve traffic flows and measure noise emissions – including by using alternative drive systems for trucks such as electric, gas or hybrid engines. In September 2021, Transport Minister Hendrik Wüst presented the Transport Ministry's grant decision to provide the study with 506,700 euros in funding.



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