DIMENSIONS

THE RHEINMETALL MAGAZINE

ISSUE 2/2023

HYDROGEN

THE WORLD NEEDS A CRISIS-PROOF AND CLIMATE-FRIENDLY ENERGY SUPPLY.

RHEINMETALL

IN THE BEGINNING THERE WAS HYDROGEN

Just one millionth of a second after the Big Bang, vast quantities of hydrogen came into existence in space. It may be the lightest of all the chemical elements, but it still accounts for around three quarters of the mass of the entire universe. This image, which was taken by a NASA space telescope, shows the rich blaze of color that is the Orion Nebula, an enormous cloud of hydrogen gas some 1,450 light years away. And what about here on Earth? Here, hydrogen – as you can see in our cover image – usually occurs in molecular form. At first glance, a hydrogen (H) atom is quite unremarkable, comprising as it does just one proton and one electron. Yet this simplicity masks incredible diversity. Hydrogen atoms can be found in almost all the most vital organic and inorganic compounds – from water through to proteins, carbohydrates and human DNA. But what's behind all the current hype about hydrogen? Well, it can store a lot of energy – for months, if need be. Plus, on combustion, it produces very little in the way of emissions. These two properties make it the perfect energy source of the future.

DEAR READERS,

The feedback on the first issue of DIMENSIONS, our company magazine, has been incredible. Most of the printed copies were snapped up within the space of just a few weeks. We had to direct many of those inquiring to the digital version of the magazine, every edition of which is available to view and download online. The editorial team's goal for the coming months is to continue expanding the digital offering for DIMENSIONS. All feedback – whether positive or negative – spurs us on and encourages us to keep bringing you fascinating insights from the world of Rheinmetall.

This issue is devoted to a set of topics that are extremely topical for business, military forces and governments alike: hydrogen and green energy. Rheinmetall is pursuing ambitious targets in this regard. We have both the desire and the capability to deploy innovative technology that plays a valuable role in protecting the climate and ensuring global energy security. Our cover story shines a light on activities within the Group and showcases some major players and pioneers in the highly promising hydrogen economy.

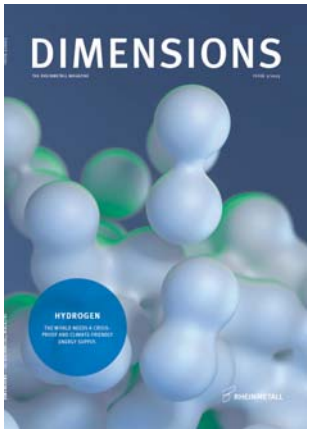
DIMENSIONS will also take you on a tour of Germany. The reports from our locations in Unterluess, Aschau and Schneizlreuth provide persuasive proof that those sites are home to not only technological expertise but also a wealth of entrepreneurial spirit.

We remain unwavering in our commitment to doing our utmost to support Ukraine in its fight to defend itself against Russian aggression. In these times of dramatic change, Rheinmetall is taking responsibility – an attitude that unites our management and workforce alike. That being the case, the fact that some of you are giving up your free time to help the people of Ukraine through your own aid projects is not surprising, but it is certainly worthy of being reported on in this issue.

I hope you enjoy reading the magazine and that it sparks some lively debates.

Sincerely,

Philipp von Brandenstein
Head of Corporate Communications
Rheinmetall AG



ABOUT THE TITLE PAGE

Abstract nanomolecular structure: hydrogen, the first element in the periodic table, is a colorless, odorless diatomic gas. Its diatomic molecules are visualized here as 3D spheres.

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Climate front
Refueling is faster than recharging. Synthetic e-fuels produced with green electricity are to replace fossil fuels in combat vehicles over the medium term.

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In conversation
Professor Claudia Kemfert is a renowned energy economist and political advisor. In DIMENSIONS, she tells us how a successful hydrogen economy could work.

DIMENSIONS is also available online: **www.dimensions-magazin.de/en**

HYDROGEN

Industry and the military are on a quest for a carbon-neutral and self-sufficient energy supply. What role will hydrogen play in a newly energy-independent future?
Pages 10 and 14

Help for Ukraine
The Gepard anti-aircraft vehicle is proving highly efficient in the defence of Ukraine. Rheinmetall is playing its part by supplying this urgently needed ammunition.

Volunteer work
The situation for the people in Ukraine is desperate. Beat Imhof from Nitrochemie in Wimmis is doing his bit to help out.

VERY BRITISH …

Everyone associates black cabs with the United Kingdom – and especially London, its capital city. But taxi companies the world over have realized the benefits of the spacious and, thanks to an extendable ramp feature, even wheelchair-accessible cabs. One such example is Taxi Ruf Düsseldorf. The version of the London "hackney carriage" used in Düsseldorf is, in keeping with modern times, equipped with a plug-in hybrid drive system and range extender allowing it to travel around 100 kilometers on electric power alone. The vehicle, which features state-of-the-art components from the Rheinmetall Group in the form of two electric coolant pumps and an electric water recirculation pump, is manufactured by London EV Company Ltd in Coventry, now a subsidiary of Geely Automobile, a Chinese corporation. The need to develop this cutting-edge version named TX4 cab, which is even available as a left-hand-drive model, was prompted by rules imposed in 2010 by Boris Johnson, who was the mayor of London at the time. These stipulated that starting in 2018, new taxis would be licensed for use in London only if they were capable of zero-emission driving at least some of the time. So with more than 5,000 vehicles, the TX4 already accounted for around a third of London's entire fleet of taxis in 2022. Thanks to its turning radius of just 8.54 meters (28 feet), which makes it the ideal vehicle for use in inner cities, it can now also be seen on the streets of such places as Bahrain, Bangkok, Berlin, Johannesburg, Singapore and Sydney.


TAXI
CITY
D EN 996E

The new charging technology makes room for essentials: an inconspicuous, space-saving, sustainable charging solution for street parking, customer and employee parking spaces, apartment houses and park & ride facilities.

→ More information about the innovative curbstone charging system can be found at the Rheinmetall website under www.rheinmetall.com/en/products/curbstone-chargers/curbstone-chargers

CURBSTONE CHARGING SET TO REVOLUTIONIZE URBAN MOBILITY

Soon it will be possible to charge hybrid and electric vehicles easily and conveniently at two locations in Cologne. A new type of charging infrastructure from Rheinmetall makes this possible. Integrating the charging electronics into a curbstone effectively turns it into a charge pole, but without the attendant limitations. Especially in urban settings, available open space is often lacking for the urgently needed expansion of public charging points. Rheinmetall's charging curbstone offers a space-saving solution that is both scalable and robust. The pilot project, in which the Group is cooperating with the City of Cologne and TankE GmbH, starts in summer 2023. The aim is to test public acceptance of this innovative technology as well as validating its urbanistic and design advantages.

OVER 100 AUSTRALIAN BOXERS FOR THE GERMAN ARMY

Germany and Australia plan to cooperate in the Bundeswehr's "Heavy Weapon Carrier, Infantry" project. The defence ministries of both nations signed a declaration of cooperation to this effect in May of this year in Canberra. The declaration paves the way for finalizing the contract with Rheinmetall. Once the legal and financial negotiations are complete, the Boxers earmarked for the Bundeswehr will be built at Rheinmetall's state-of-the-art MILVEHCOE centre of excellence in Redbank southeast of Queensland. Taking advantage of existing production capacity, they will be produced alongside the Combat Reconnaissance Vehicle, or CRV, a Boxer variant ordered by the Australian Defence Force. Delivery of the 100+ armoured fighting vehicles Germany plans to procure is scheduled to start in 2025.

The Boxer Combat Reconnaissance Vehicle is an advanced, hard-hitting wheeled armoured system with a two-man Lance turret and 30mm automatic cannon.

Lightweight components for e-vehicles

Rheinmetall's Materials and Trade division has won three new orders in rapid succession for structural parts for e-vehicles. Besides a well-known international automaker, China's Geely automotive group and Jidu Auto, a start-up specializing in autonomous electric driving, have placed their trust in Rheinmetall's expertise in light-weight engineering. Production of the shock absorber mountings and longitudinal girders is set to start in 2024. Each worth a figure in the two-digit million-euro range, the orders underscore Rheinmetall's successful pivot to future-oriented, environmentally sustainable drive technologies for the automotive industry.

SKYRANGER POISED FOR MARKET BREAKTHROUGH

A multitalented virtuoso armed with automatic cannon and a guided missile launcher, the Skyranger is highly effective against targets at close quarters and at ranges of up to 8 kilometres.

Denmark plans to procure around 15 high-mobility Skyranger 30 air defence systems installed on the Piranha 5 wheeled armoured vehicle. In Ukraine, the aging Gepard antiaircraft tank has shown how important an air defence capability is in modern warfare (see also p. 26). Rheinmetall's state-of-the-art Skyranger is a worthy successor to the tried-and-true Gepard. In Germany, the path ahead for Skyranger is already coming into view. The Bundeswehr intends to re-establish the Army's air defence capability. Serious consideration is being given to procuring around twenty Skyranger 30 systems, to be mounted on the Boxer 8x8 wheeled armoured vehicle. Hungary has also declared its willingness to procure the Skyranger 30, installed in this case on a new tracked armoured fighting vehicle, the Lynx. The Skyranger thus has the potential to be another major Rheinmetall success story: a modular air defence system that can be mounted on a wide variety of platforms in line with customer requirements.

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INFANTRY FIGHTING VEHICLES

Rheinmetall and KNDS have been awarded a joint contract to build another fifty Puma infantry fighting vehicles. The order is worth approximately EUR 1.1 billion in total, of which around EUR 500 million will go to Rheinmetall. Delivery is to commence in December 2025 and be complete by the beginning of 2027. In February 2023, Germany's Federal Office for Bundeswehr Equipment, Information Technology and In-Service Support had already issued an order for the comprehensive upgrade of 143 Puma infantry fighting vehicles belonging to the German Army. In both cases, the contractor is PSM GmbH, a joint venture of Rheinmetall and KNDS. Just a few months earlier, the Bundeswehr signed a framework contract with Rheinmetall for over 600,000 rounds of medium-caliber ammunition for the Puma, one of its principal weapons systems. Under this agreement, whose aggregate value exceeds EUR 576 million, Rheinmetall already delivered the first 25,000 rounds in 2022.

→ You can find all the latest news, information and background stories on the DIMENSIONS website: **www.dimensions-magazin.de/en.**

Nothing signifies the hope for a climate-friendly future more than hydrogen. When it reacts with oxygen, water is formed. And since this is an exothermic reaction, energy is released, too, as a by-product – in the form of heat on combustion or electrical energy inside a fuel cell. But the problem is that although it is most commonly present in nature in compound form, generating green hydrogen is still a relatively expensive process. It cannot yet be produced competitively on a gigawatt scale. And storing and transporting hydrogen pose additional challenges. So is it worth investing in the necessary technology? How economical is hydrogen? How can we put in place the necessary structures?

PRODUCTION

To ensure carbon-neutral water electrolysis, green hydrogen can be best produced wherever sufficient renewable energy is available – so places like southern and western Africa and Australia, for example. In Germany, the federal government is looking to establish an electrolysis capacity of at least ten gigawatts by 2030. Experts anticipate that hydrogen prices will fall. Compared with today, the cost of generating green hydrogen is expected to fall by between one third and one half by the end of the decade.

TRANSPORTATION

Whether pressurized, liquefied or bound, by truck, pipeline or ship, hydrogen can be transported in lots of different ways – depending on the quantity and distance. We still don't know which methods will be deployed in the future.

APPLICATION

The primary applications for green hydrogen will be those where there are no alternatives – that is, where hydrogen is needed in vast quantities and therefore where it's relatively easy to transport, so in the steel and chemical industries and in the form of e-fuels for long-distance and heavy-duty transportation.

The driving force

1

Without green hydrogen, it will be impossible for industry and the military to achieve carbon neutrality. The processes involved in producing, storing and transporting this prized gas are still not viable on a mass scale. Rheinmetall wants to change that.

Although the forecast figures for global hydrogen demand sometimes vary, market experts can all agree on one thing: the curve is on a steep upward trend. The World Hydrogen Council, for example, estimates that 660 million metric tons of hydrogen will be needed globally by 2050. That's more than seven times the figure in 2020. And no wonder, because hydrogen is ideal for myriad applications – whether as a raw material in industry, as a synthetic energy source or as a sustainable fuel for fuel cells.

NO ALTERNATIVES IN THE PROCESS AND CHEMICAL INDUSTRIES

Demand is biggest where there are no alternatives – such as in the process and chemical industries, where it is still obtained from natural gas, a fossil fuel, primarily by means of steam reforming. The associated greenhouse gas emissions are enormous. A much more environmentally friendly way of producing the gas involves the use of electrolyzers, which split water into its constituent parts: oxygen and hydrogen. If the electricity required for this originates from solar power stations or wind farms, the process yields what is commonly referred to as "green hydrogen."

The production processes needed for this are still highly complex and therefore expensive. But one thing's for sure: The more cheaply renewable energy can be produced and the more progress is made in further optimizing the water electrolysis process, the more affordable green hydrogen will become. Until these preconditions are in place, however, the currently scarce resource that is green hydrogen will be used where it is the only viable proposition from an environmental point of view, including in the production of "e-fuels" for civilian and military aircraft, heavy-duty transportation and shipping. But it will also play a vital role in the decarbonization of the aforementioned industries.

THE UNSOLVED QUESTION OF TRANSPORTATION

Some of the industries in question – and the steel industry above all – are already working hard to ensure that they will be capable in the

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future of producing green hydrogen in the immediate vicinities of their production plants. And with good reason, because both the transportation and storage of this volatile and sometimes highly explosive gas are not without their inherent problems and so pose a range of significant challenges.

Transportation over short distances has always generally taken place by road. While the expansion of pipeline systems requires huge investment, specially equipped and modified trucks are a quick and cost-effective option. When it comes to safety, however, they are subject to extremely stringent requirements regarding the tanks and pressurized vessels that contain the hydrogen. Other options involve methanation, for example, which allows chemically bound hydrogen to be transported across the sea in tankers. We still don't know which methods will prove to be most viable. One thing is clear, however, and that is that without the right logistics, a hydrogen economy is impossible. This will require never-before-seen storage methods and vessels and, in some cases, whole new transportation technology.

MASS PRODUCTION FOR A MASS-MARKET ROLLOUT

The market for hydrogen technology is set to witness tremendous growth over the coming years. Shena Britzen, Head of the Hydrogen Programme at Rheinmetall, is certain of this. This is why the technology group is already collaborating with research institutes and customers to develop a new hydrogen ecosystem. "Our aim is to develop market-ready solutions and components for the cost-effective production, storage and transportation of hydrogen," says Britzen, explaining the company's strategy. The DAX-listed Group sees itself as a "shovel manufacturer," as supplier companies for booming industries like to be called in stock market circles. As a technological pioneer, Rheinmetall possesses many years of expertise in the mass production of fuel cell components. The company is an industrial partner in the research and development consortium of the Center for Fuel Cell Technology (ZBT) in Duisburg and a member of the Hydrogen and Fuel Cell Initiative, which receives financial support from the federal government and state of North Rhine-Westphalia. "We want to make a decisive contribution to the hydrogen economy over the coming years and decades," says Britzen. The company is investing worldwide to support this mission.

1, 2 and **3** How can we ensure an independent, climate-friendly energy supply? One answer to this comes from Rheinmetall, which has developed a mobile, turnkey, modular solution for generating, storing, transporting and processing carbon-free hydrogen. It consists simply of solar panels, an electrolyzer, pressure tanks and, where necessary, a shipping container for synthetic fuel generation – nothing else!

A NEW GENERATION OF ELECTROLYSIS

Its latest innovation project, which it is implementing in collaboration with two technology partners, involves optimizing the tried-and-tested alkaline electrolysis process. Due to their low power density, conventional plants are capable of producing only a comparatively small amount of hydrogen for every square centimeter of surface area. Their material usage and space requirements are correspondingly demanding. The plan is to make next-generation alkaline electrolysis plants much more efficient and offer much higher power density. This will be achieved thanks to highly advanced, affordable and industrially scalable electrode and membrane components, which will be integrated to form an electrolysis stack and comprehensively tested by the partners working in close collaboration. Thanks to this powerful, low-cost electrode package, "E2ngel," as this joint project is called, aims to make the process of obtaining hydrogen more cost-efficient than it is today and so make a decisive contribution to the global energy transformation.

TURNING UP THE PRESSURE: TANK SYSTEMS

But electrolysis is not the only area in which Rheinmetall is contributing its development expertise to advance the cause of hydrogen, as Shena Britzen explains. "In our view, the storage and transportation of hydrogen offer huge market potential. In partnership with the Institute for Textile Technology at RWTH Aachen University, we have developed a technology for manufacturing innovative pressure tanks. Our mission now is to get this technology to the point of being ready for production." The project, which is called H2LORICA, is currently in the prototype development and validation phase. Rheinmetall is designing the machinery for enabling mass production in close collaboration with a plant manufacturer. Compared with now, this new manufacturing technology will reduce the winding time by as much as 80% – and with less carbon and more storage capacity, too. A new built-in fire detection system will also enhance the overall safety of the composite pressure tanks.

4 As part of the European Green Deal, Rheinmetall is taking part in the INDY (Energy Independent and Efficient Deployable Military Camps) project. The aim of the project team, which comprises members from 13 European countries, is to develop new technological concepts for the climate-friendly, independent supply of energy to military camps.

5 and **6** In the rainbow nation where energy is scarce, learning under the glow of gas lamps is part and parcel of everyday life for children in South Africa. To ensure that the lights don't go out for good, the country's energy company has for years been forced to turn off the electricity for several hours a day. The people and the economy are suffering, and jobs are in danger.

7 In sunny South Africa, solar energy for producing hydrogen is available in abundance.

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MORE SUPPLY SECURITY FOR SOUTH AFRICA

Around 9,500 kilometers further south, in Cape Town, the company is already one step ahead. Here in this port city on the southwestern coast of South Africa, subsidiary Rheinmetall Denel Munition (RDM) recently launched a turnkey modular solution enabling the production, storage and transportation of green hydrogen. The development of these shipping containers, which can be deployed as mobile or fixed installations, did not just happen by chance, as the CEO of Rheinmetall Denel Munition, Jan-Patrick Helmsen, explains. "The network infrastructure behind the public power supply in this country is old and, in many places, on the verge of collapse. The amount of energy generated is not enough to supply the numerous consumers in the country. To avoid total blackouts, the state-run energy company turns off the power for several hours a day." And this "load shedding" is not a problem limited only to private homes, says Helmsen. "The economy in particular has been suffering for years as a result of these forced shutdowns."

ELECTRICITY FOR REMOTE COMMUNITIES

Out of necessity, many companies and communities turn to alternative sources of power. When the lights go out yet again, all the generators roar into life. Instead of polluting diesel generators, self-sufficient, carbon-neutral energy solutions such as those developed by Rheinmetall Denel Munition will ensure the urgently needed supply security in future years. In sunny South Africa, solar energy for producing hydrogen is available in abundance. The production quantity can be tailored to individual requirements.

Rheinmetall also expects sales to be particularly strong in remote communities that are not connected to the public grid. "A shipping container solution equipped with solar panels, an electrolyzer and storage system can supply 30 to 40 homes with electricity around the clock," says Helmsen. "Our system can be deployed wherever

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an independent and reliable supply of energy is needed, such as in townships, industrial facilities and military camps." He and his team are already in talks with interested companies with a view to scaling the technology of the green energy solution provider and making it available for a range of different applications.

BLUEPRINT FOR DOWN UNDER

In a similar way, remote communities in Australia can benefit from this brand-new energy generated from shipping containers, too. Around 29% of the Australian population lives in remote rural areas. "We plan to manufacture this modular solution for the Australian market at the Rheinmetall Defence Australia plant in Brisbane," says Shena Britzen. "Development of the necessary production facilities is already in the planning stage." The site also wants to start manufacturing electrolysis containers.

THE ARMED FORCES OF THE FUTURE: ON THE ROAD TO ENERGY AUTONOMY WITH HYDROGEN

A secure energy supply guarantees stability. This is true as much for industry and society as it is for the world's armed forces, whose energy requirements are immense – especially in combat situations. According to experts, NATO's European combat forces consume more than 262 million liters of fuel per day during the course of operations. So it's all the more surprising that the military sector barely merits a mention in the public discourse surrounding issues vital to climate policy. Throughout history, new technologies have often been deployed initially for military purposes. Will decarbonization be the exception?

FUTURE INVESTMENT IN SOUTH AFRICA

In addition to producing medium- and large-caliber ammunition, Rheinmetall Denel Munition (Pty) Ltd is increasingly serving as a green energy solution provider in South Africa. Since the start of its joint venture with Denel in 2008, Rheinmetall in South Africa has invested more than EUR 200 million.

EUR 100 million in infrastructure

EUR 75 million in technology and product development

EUR 15 million in training, education & scholarships

EUR 12 million in renewable energies

POWER-TO-X

This term covers all the methods for converting excess green energy to gaseous or liquid energy sources. The "X" stands for either the energy form (gas, liquid, heat) or its application (fuel, chemicals, ammonia).

When Russia invaded Ukraine in February 2022, it became all the more clear that the freedom, economy and security of the western world depend on the availability of energy in sufficient quantities. So it's more important than ever that we ensure our energy and defence sovereignty and diversify the supply of energy in the military sector over the long term.

7 In combat situations, NATO troops depend on a quick and reliable fuel supply. E-fuels represent an eco-friendly alternative to fossil fuels.

7

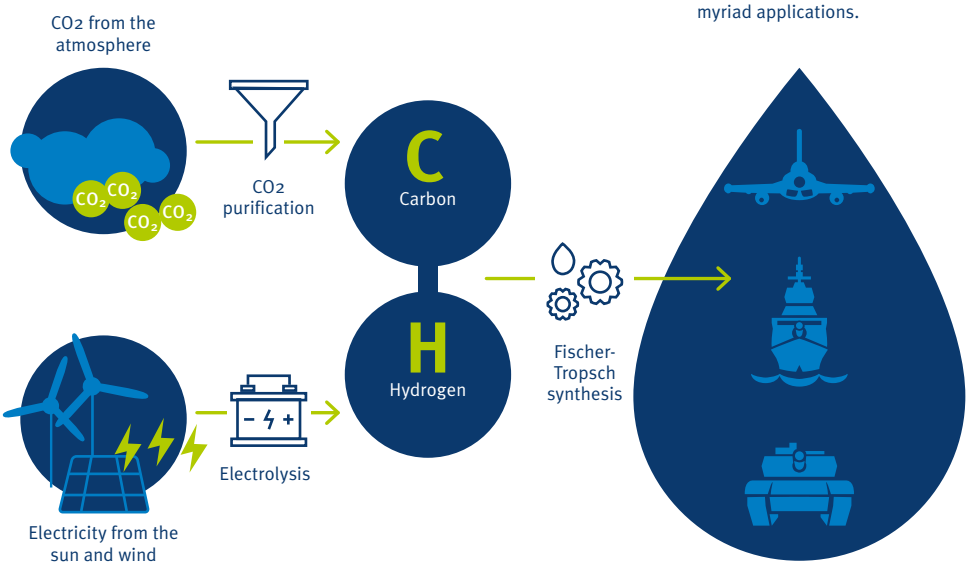
E-FUELS: A MATTER FOR THE STATE

While the war over the drive system of the future seems to be over in the civilian sector, the above figures make it readily apparent that electric transportation has no future on the battlefield. "Nobody is going to build a charging infrastructure for the armed forces on the front line," explains Britzen. In any case, because of their small power density, rechargeable batteries would never be capable of covering the high energy requirements of heavy-duty military vehicles. Another decisive factor is time – after all, refueling is faster than recharging, regardless of whether you're in combat. "We have to think in terms of logistics," says Britzen. Otherwise, that misses the point.

The alternatives are e-fuels, which can be produced in a carbon-neutral manner using green hydrogen and, in conjunction with combustion-engined vehicles, still provide armed forces with the necessary fuel quality and reliability. Power-to-liquid (PtL) is the method that makes this possible. This technology also offers a viable way of ensuring a self-sufficient and, in turn, crisis-proof supply of energy for NATO's European troops. "Given recent geopolitical developments, ensuring that our armed forces are self-sufficient in the supply of synthetic fuels must be declared a matter for the state. We need to stop treating fuel as a commodity," says Britzen, who is a reserve officer (Major) in the German armed forces. "Energy is a critical military capability."

MIRACLE CURE FOR CLIMATE CHANGE

The production of e-fuels involves binding atmospheric CO2 by means of green hydrogen to create synthetic fuel and other combustible material. What sounds like a miracle cure for climate change in fact dates back to 1925, when an early form of this process was developed by German chemist Franz Fischer and his assistant Hans Tropsch. Fischer–Tropsch synthesis first gained economic significance during the Second World War because it allowed large quantities of the necessary liquid fuel to be produced from locally mined coal. In the years of Germany's economic "Miracle on the Rhine," the idea of coal liquefaction quickly became financially unprofitable due to the low price of oil. But it enjoyed a renaissance just two decades later as the oil crisis took hold.



In the military, synthetic fuel has myriad applications.

PUSH FOR THE HYDROGEN ECONOMY

Sustainably produced synthetic fuels are not yet manufactured industrially. There is still too little hydrogen on the market for this. That is why Britzen does not expect that we will be likely to find e-fuels at gas stations any time soon. But the situation in the military sector couldn't be any more different. Action is urgently needed in this regard. While existing logistics chains for distributing e-fuels such as NATO's Central European Pipeline System (CEPS) can remain in use, the Ministry of Defence would have to invest between EUR 5 billion and EUR 10 billion in the expansion of PV and PtL plants, according to Rheinmetall. In war, support comes in the form of mobile shipping container solutions. "With just a few more trucks, brigade commanders could produce their own fuel reserves at a decentralized plant," says Britzen. "One electrolyzer, one compressor and one shipping container for synthetic fuel generation and another for the refining process – that's all it takes." Since the plants are used over many years, this is an investment that truly pays off – and not just in TCO terms. "If the armed forces start leading the way as pioneers of carbon-neutral fuel production, this would be a massive boost for the hydrogen economy," says Britzen. A push for the market on this scale would never be possible through state subsidies. ● *Pb*

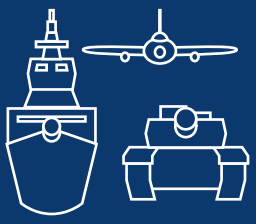
→ Find out more about this at
www.rheinmetall.com/en/products/hydrogen/hydrogen

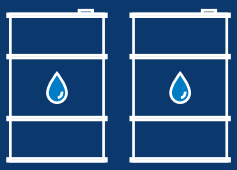
CLIMATE FRONT: DECARBONIZING THE GERMAN ARMED FORCES

NATO forces in Europe are facing the twin challenges of reducing their carbon footprint and becoming independent of fossil fuel imports. Synthetic e-fuels produced from wind and solar power are a viable proposition in this respect. The production plants required for this could supply NATO's 5,200-kilometer Central European Pipeline System (CEPS) with climate-friendly fuel. If the green PtX technology is recognized as an important contributor to NATO's combat readiness, this will significantly accelerate its expansion.

In keeping their land, air and sea transportation running in 2020, the German armed forces emitted a total of

630,000
metric tons of CO_2.





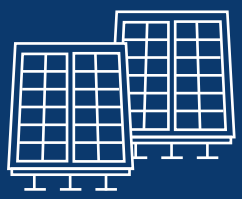
This is equivalent to around

238,000,000
liters of fuel
(Single Fuel Policy) per year.

60 percent of the green energy utilized can be stored as energy in the fuel. A PV system delivers 0.1 kW of electrical energy per square meter.

23,000
km² of PV surface area

Generating this quantity of energy from sunlight in Germany (1,650 hours of sunlight per year) would require around 23,000 square kilometers of PV surface area.



EUR 5–10 billion

With the technology available today and with scaling effects factored in, estimated total investment in PV and PtX systems would amount to EUR 5–10 billion.

Source: Federal Academy for Security Policy/own calculations

“Enormous opportunities”

Green hydrogen is still a rare and hence expensive commodity. Can it replace fossil fuels, and if so, in which areas? DIMENSIONS discussed these questions with Professor Claudia Kemfert. In an interview, the renowned energy economist set forth her views on the promise and limitations of this climate-friendly gas.

Professor Kemfert, will climate-friendly hydrogen be our most important energy source in future?
The energy system of the future will be fossil-free, and therefore largely emissions-free, efficient and economical. For two reasons, green hydrogen produced with green electricity will be one of the most important sources of energy. First, green hydrogen will be produced at times when there’s a surplus of green electricity and will thus be an important means of storage. As a long-term storage system, it can be used at times when green electricity is in short supply. Second, you need green hydrogen in places where direct electrification isn’t possible. Direct electrification is basically always the most efficient solution, but it’s not feasible everywhere.

Which sectors do you see as having potential for green hydrogen?
In industry, mostly, but also in heavy transport, shipping and aviation; the last will use e-fuels that depend on the methanization of hydrogen. You’ve always got to remember one thing: producing hydrogen is a complicated business, meaning that the degree of effectiveness declines with each additional transformation. Of the initial energy, 50 to 80 percent is lost in the transformation and application process. This makes green hydrogen precious, something that should only be used in special situations – it’s basically the champagne of energy sources. This means that the direct use of green electricity for electromobility, for example, or heat pumps, will always be the cheapest, most efficient approach.

Presuming that demand for green hydrogen rises sharply in the next few years, what would you want to see governments do?
Demand for green hydrogen will have to increase or we won’t be able to achieve our climate goals. I’d like to see governments back this growing market with comprehensive support. First of all, we’re going to need to generate a lot more green electricity, because without it we can’t produce green hydrogen. We have to pick up the pace significantly to expand green electricity capacity all over Germany. Moreover, electrolysis plants shouldn’t be subject to unnecessary fees and restrictions: they should be subsidized instead. And the parameters need to be adjusted to make sure they can grow. Especially in places where there’s surplus green electricity, it should be used and not capped. In Germany we need less red tape and to encourage digitalization. When it comes to permits, Germany needs to be leaner and more innovative.

… and what about industry?
Industry has finally got its act together and is investing massively in the green economy. Companies have

PROFESSOR CLAUDIA KEMFERT

Born in 1968, she has headed the energy, transport and environment department of the German Institute for Economic Research (DIW) in Berlin since 2004 and is professor of energy economics and energy policy at Leuphana University in Lüneburg. The recipient of multiple awards, Professor Kemfert also serves as an external expert and political consultant on various sustainability advisory boards and commissions. Her new book, *Shockwave*, has just been published.

abandoned their former hesitation and sometimes even their intentional obstruction of the process of transformation to truly emission-free ways of running their businesses. This process is now in full swing. Investing in a fossil-free, emission-free economy creates added value and jobs with a secure future. This strengthens resilience and immunizes us from global geopolitical crises. It doesn’t get more win-win-win than that.

Germany has set itself the goal of playing a leading role in hydrogen technology in Europe and the world. Do we have a chance of achieving this goal?
Yes, we do – but only if we generate more green electricity. Lots more. We’re competing with countries in sunny parts of the world that can produce green hydrogen at much lower cost. However, Germany enjoys competitive advantages in three areas: 1) Technology and expertise; 2) it still has a robust industrial base, with plenty of innovative medium-sized companies; and 3) political stability thanks to being a proper democracy. In a time of global instability, the last of these three shouldn’t be underestimated. If we make effective use of all of these, we have a good chance of taking the lead in hydrogen technology.

Basically speaking, what do you think we need to do to create the infrastructure and parameters for transport and storage, for instance?
In future, Germany is going to have to import a large share of the green hydrogen it needs. This means having to have adequate infrastructure in the form of terminals and pipelines. Building this infrastructure will require well-targeted financial inducements and the right parameters for industry.

Can we learn from other countries when it comes to hydrogen strategy? What countries are ahead of us?
Decades ago, voices could be heard in many industrialized countries calling for a “hydrogen society”, but nothing really came of this. Japan pinned its hopes on hydrogen very early on, creating infrastructure and enabling a wide range of applications. Of course, Japan has plenty of nuclear energy, providing it with large amounts of electricity necessary for producing hydrogen. Carmakers were quick off the mark, too, turning to hydrogen for fuel cell vehicles. Since electric vehicles have established themselves as a more efficient alternative, they’re steering toward hydrogen there too, at least in the passenger car segment. Hydrogen production is starting all over the world, in Holland, for example, but also in Asia and the Arab world. But as far as I’m concerned, there isn’t a clear, comprehensive hydrogen strategy anywhere, at least not on the scale that would be necessary. Here and there you see the occasional project or plan.

Is Germany too late to seize this opportunity?
In fact, the best time to have started would have been twenty years ago. If – and for no good reason – we hadn’t hit the brakes on the Energy Revolution and throttled the expansion of renewable energies and let important industries and know-how slip away, we’d have enough green electricity and could produce plenty of hydrogen with surplus green electricity, making us the number-one nation for environmental protection. Unfortunately, we squandered this opportunity. Now we’ve got to play catch-up and do better. The Energy Revolution offers enormous technological and economic opportunities. ● *Pb*

→ You can read the entire interview at **www.dimensions-magazin.de/en/**

1 From Unterlüss to Ukraine: Rheinmetall dispatched the first freshly overhauled Marder infantry fighting vehicles by rail on 21 March 2023.

We can deliver!

Countries can count on Rheinmetall – for quality and punctuality alike. All projects in support of Ukraine are running according to plan or even ahead of schedule.

Authors: ***David Ginster and Jan-Phillipp Weisswange***

On 21 March 2023 twenty freshly overhauled Marder infantry fighting vehicles rolled off the grounds of Rheinmetall's Unterlüss plant. It was an impressive sight. Rather than driving on their own tracks, these armoured fighting vehicles were loaded onto a train consisting of dozens of specially designed flatbed freight cars.

For the company official in charge of the project in Unterlüss – we'll call him Martin V. here – it was a special moment: "It was a truly remarkable moment, watching the vehicles roll out of the yard. I'm extremely proud of everyone involved in the project for their terrific commitment." The shipment of armour formed part of Germany's military support for Ukraine in the face of Russian aggression.

WHAT RHEINMETALL IS DOING TO HELP

The twenty Marder IFVs earmarked for Ukraine, which will soon be joined by another twenty more from the Bundeswehr inventory, were not the first to be overhauled by Rheinmetall in recent months. The war in Ukraine has been raging for well over a year. If at first there was no clear line among EU and NATO member states on possible support, that page has since turned. The Russian invasion of Ukraine has revived the sense of cohesion and urgency among EU and NATO nations. Several donor conferences have taken place in the meantime, aimed at furnishing Ukraine with the military wherewithal it needs to defend itself. Rheinmetall is making important contributions to this military aid.

The "Ringtausch" multilateral equipment exchange programme, developed by the German government shortly after the start of the war, offers a good example. Here, NATO member states transfer their Cold War-era, Warsaw Pact-made heavy equipment to Ukraine. In exchange, they receive Western-made replacement systems. This has the advantage of providing the Ukrainians with military hardware they're already familiar with. As part of these exchanges, Rheinmetall is currently supplying Marder IFVs, Leopard 2 main battle tanks and HX trucks.

Under the programme, Greece is receiving a total of forty Marder vehicles, 25 of which have already been delivered. The remaining 15 are due to ship this summer.

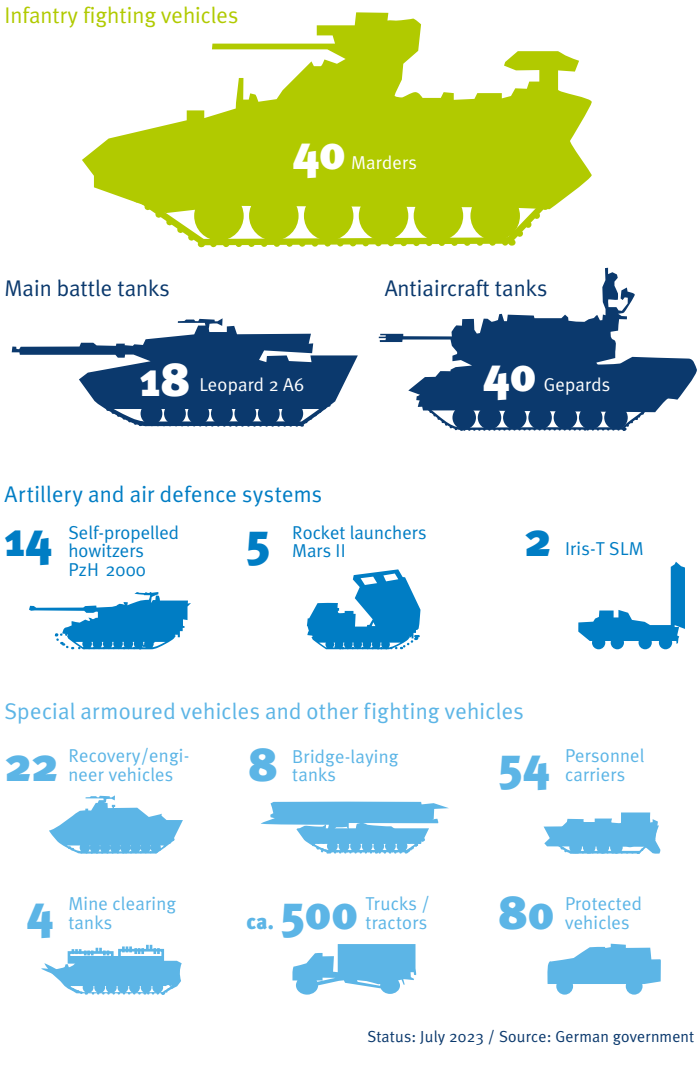
A total of 29 Leopard 2 tanks are due to go to the Czech Republic and Slovakia. Work here is proceeding apace. The first deliveries already took place at the end of 2022, and this year it looks like Rheinmetall will be able to deliver

even sooner than contractually agreed. Ever since April 2023, three vehicles a month have been transferred to the new owners. And back in December 2022, Rheinmetall supplied the Slovenian armed forces with forty HX 8x8 swap body systems. In exchange for these state-of-the-art logistic vehicles, Slovenia transferred 28 Soviet-era tanks to Ukraine.

As things stand, in addition to those already under contract, Rheinmetall has sufficient capacity to overhaul and upgrade scores of additional Marder and Leopard 1 systems, and several dozen Leopard 2 tanks.

GERMAN MILITARY AID FOR UKRAINE

Germany is supporting Ukraine with weapons and equipment. Some of these were drawn from Bundeswehr reserves, others from corporate inventories, financed by the German government. The following provides a partial overview.



Status: July 2023 / Source: German government

DEDICATION AND DRIVE

By themselves, these figures barely hint at the dedication and drive of the Rheinmetall staff. “The Marder dates back to the '70s. You can imagine what the demand for spare parts is like,” says Martin V. Fortunately, and at its own expense, Rheinmetall already started restocking its warehouses the previous year, which saved a lot of time.

Working tirelessly in a two-shift system, Group employees assigned to the project set about overhauling the Marders in Unterlüss and Kassel: “We’ve managed to achieve all this only because of the way every employee and every department – from top to bottom – has pulled together to get the job done,” declares the project manager. “I can’t say it often enough: I’m unbelievably grateful for the terrific support we’ve received.” In so doing, Rheinmetall has honoured its contractual commitments to customers at home and abroad, preparing itself for unforeseen scenarios: “Always expect the unexpected!”

COMPREHENSIVE SUPPORT

This principle also applies to other forms of support that Rheinmetall is providing for Ukraine, partly based on contracts directly awarded by Kyiv, as well as others issued by Germany and other countries. For example, at the behest of the German government, Rheinmetall has supplied 26 brand-new HX swap body systems; more than a hundred Rheinmetall trucks are currently operating in Ukraine.

Furthermore, in 2022 Ukraine took delivery of five Surveil-SPIRE airspace surveillance systems, with another five on order. Rheinmetall is cooperating in this project with an Estonian partner company. In 2023, Ukraine will receive two Skynex air defence systems and a field hospital, to be followed by another in 2024.

Ammunition – a core competency of Rheinmetall AG ever since its foundation – is the most urgently needed form of materiel.

Rheinmetall is the only contractor capable of supplying new 155mm, 120mm, 105mm, 35mm and 20mm ammunition on a large scale, which Ukraine needs for its artillery systems, Leopard 1 and Leopard 2 main battle tanks, the Gepard antiaircraft tank, and Marder infantry fighting vehicles. A new production unit is currently being commissioned in Unterlüss for producing 35mm ammunition (see p. 26ff). A first lot of which will be shipped to Ukraine this summer, earmarked for the Gepard.

THE MARDER

Starting in the 1970s, at times the Bundeswehr had over 2,000 Marder infantry fighting vehicles in its inventory, when it was the prime weapons system of Germany's mechanized infantry formations. Its successor, the Puma infantry fighting vehicle, first entered service in the German Army in 2015.

While expanding its capacity, Rheinmetall continued to provide Ukraine with shipments of urgently needed ammunition for its combat units.

In addition to the current high level of support, in the long run, Ukraine will need assistance in strengthening its own defence capacities and reorienting its production to Western standards. Rheinmetall is currently in talks with the Ukrainian government and examining possibilities for closer cooperation. The President of Ukraine, Volodymyr Zelenskyy, has even received Rheinmetall CEO Armin Papperger (see box). Ukraine has made clear its interest in creating an in-country capacity for producing Rheinmetall's Fuchs/Fox armoured transport vehicle and, in the long term, its state-of-the-art Panther main battle tank or Lynx infantry fighting vehicle. The objective is to rebuild Ukraine's once powerful arms industry and to safeguard the nation's strategic autonomy.

While this may still be a long way off, the first defence aid is already rolling in. On 30 March 2023 Ukraine's minister of defence, Oleksij Resnikow, inspected Marder IFVs that had recently arrived from Unterlüss. He thanked the Federal Republic of Germany for its steadfast support for Ukrainian independence. Following a formal ceremony, the Ukrainian military is now deploying these tried-and-tested infantry fighting vehicles at the front. Projects like this one contribute to Ukraine's national struggle for self-determination. For this reason, Rheinmetall has every reason to be proud of the claim: "We can deliver!" ●

→ The video of the rail transport of the Marder infantry fighting vehicles can be found at: **www.dimensions-magazin.de/en**

2 At Rheinmetall's Kassel plant, work on overhauling additional Marder IFVs is still in full swing. Scores of others could still be made serviceable.

CONSULTATIONS IN KYIV

On 30 March 2023 President Volodymyr Zelenskyy of Ukraine met with a small Rheinmetall delegation at the Presidential Palace in Kyiv.

"In my capacity as CEO of Rheinmetall, over the years I've met with numerous senior politicians and high-ranking military officials. None of these encounters made such a deep impression on me as my meeting with the head of state of a nation that had been fighting for over a year to defend its freedom and national existence", recalls Rheinmetall CEO Armin Papperger. "I'm very grateful for this fruitful and confidence-inspiring meeting with President Zelenskyy. At Rheinmetall, supporting our Ukrainian friends in their fight for freedom and democracy is a matter of central importance, which means supplying them as quickly as possible with urgently needed equipment."

Best known for its expertise in armoured fighting vehicles, ammunition, air defence systems and logistic vehicles, Rheinmetall is perfectly positioned to serve Ukraine as a valuable and effective partner, capable of meeting the country's short- and long-term security needs. Furthermore, the discussion partners in Kyiv looked at how Rheinmetall could contribute to Ukraine's future strength and stability by setting up local production facilities. Rheinmetall is also in constant contact with the German government to ensure that help reaches Ukraine as quickly and efficiently as possible.

→ You can find more on Rheinmetall CEO Armin Papperger's meeting with Ukrainian President Volodymyr Zelenskyy in the digital version of Dimensions at: **www.dimensions-magazin.de/en/talk-in-kyiv-support-for-ukraine**

1

Concentrated power for Ukraine

In Ukraine's fight to defend itself, the Gepard antiaircraft tank has proved to be an extremely effective defensive weapon. Consumption of ammunition has been correspondingly high. To address this acute supply bottleneck, Rheinmetall embarked on a multinational effort to set up a new production line at its Unterlüss plant, completing it in a matter of months.

Author: ***Oliver Hoffmann***

The freshly applied layer of antistatic floor coating in the empty production hall shines like a sheet of ice. Everything is ready for the new assembly line, which will soon be arriving from Italy. “The infrastructure is in place, now it’s time to get rolling. In Ukraine, they’re desperately awaiting the arrival of our product”, says Manfred M., 62, head of production at the Weapon and Ammunition business unit in Unterlüss.

The expectations on M. and his team could hardly be higher: in just a few weeks, the 35mm ammunition for the Gepard antiaircraft tank, which has proved so valuable in Ukraine’s defensive struggle, should start rolling off the assembly line in the new production facility. Several million euros have been invested in the facility. The time pressure is immense, for Rheinmetall has given the customer its word – and the customer is the German government. After only a few weeks in office, Germany’s new defence minister, Boris Pistorius, visited Rheinmetall’s Unterlüss plant to see for himself the current state of play. M. and his people are literally fighting against the clock – but they have the backing of an extensive network of Rheinmetall colleagues from all over the Group both at home and abroad.

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HAVING PRODUCTION CAPACITY IN GERMANY IS INDISPENSABLE

Flashback to Brussels on 14 February 2023: “We will resume without delay our own production of Gepard ammunition at Rheinmetall”, announced Boris Pistorius at a meeting of the Ukraine Defence Contact Group. He emphasized the crucial importance of ammunition in the drive to support Ukraine. Only a few days earlier, Pistorius had signed a contract with Rheinmetall for the speedy delivery of 300,000 rounds of ammunition for the Gepard antiaircraft tank.

In its quest to find a fresh supply of ammunition, the German government left no stone unturned, including internationally – all to no avail. Bundeswehr stocks had fallen to zero following the German military’s decision to permanently disband its Army air defence component in 2012, by which time the Gepard systems had all been taken out of service. As it turns out, the Gepards proved to be especially effective in combatting attack drones in Ukraine.

Brazil declined to make existing stocks of ammunition available for political reasons. Switzerland considered itself unable to help on account of its constitution. Moreover, because it was originally produced in Switzerland, other nations were also prohibited from transferring their ammunition to Ukraine. To get around the Swiss constitutional ban, it would be necessary to create an independent production capacity in Germany. Rheinmetall soon presented the Bundeswehr’s procurement agency with a possible solution – resulting in a firm order a short time later.

A MASSIVE AMOUNT OF MOTIVATION AND PRAGMATISM

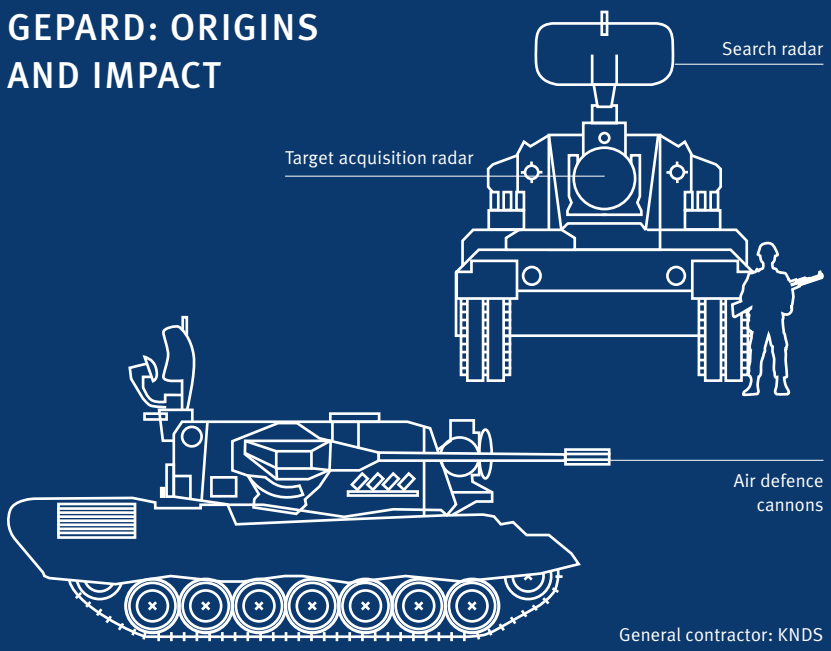
At Unterlüss, Constantin Sch., 44, is aware of the responsibility: “The men and women who work here know they’re doing the right thing. The motivation is tremendous. Responsible for operational business at Rheinmetall’s Weapon and Ammunition business unit, Sch. is happy to see the project proceeding at a rapid clip: “The pace of the project surprised us too. There was no time to go through all the usual steps involved in a programme like this. Speed was of the essence here, together with assuring adequate functionality and adherence to safety standards. This only worked because we operate in a very cooperative, interdisciplinary way – with

1 Every drone that’s shot down can save lives. Up to 40,000 rounds of ammunition for the Gepard antiaircraft tank are slated for delivery in 2023.

2 February 2023: During his visit to Unterlüss, German defence minister Boris Pistorius also witnessed first hand the modernization of combat vehicles being supplied to the Czech Republic and Slovakia under the multilateral equipment exchange programme.

3 Rheinmetall CEO Armin Papperger briefs his high-ranking visitor on processing sequences in the welding facility at Rheinmetall Landsysteme GmbH in Unterlüss.

GEPARD: ORIGINS AND IMPACT



General contractor: KNDS

An armoured mobile air defence system, the Gepard unites sensor and weapon systems on a single platform. With its two 35mm x 228 KDA automatic cannon and well-endowed magazine, it guarantees high shoot-down performance and operational effectiveness. In all three phases of air defence – monitoring, tracking and engagement – the Gepard operates autonomously. The trick here is achieving the right balance of system errors and optimization of the transition between phases – it's either that or settle for rare coincidental hits. The Gepard succeeds brilliantly here. Outstanding system engineering, ingenious layout of the components and high redundancy enable a combination of operating modes. Thus, despite external interference factors or partial failures, it retains maximum operational effectiveness. For example, as early as 1970, it featured a main and auxiliary computer as well as three possibilities for measuring the distance and angle of the target. A carefully designed operator interface for the vehicle commander and gunner in the turret are among the system's forward-looking technical features. Besides high mobility and a long operating range, the Gepard can operate around the clock without logistical support and keep up with fast-moving frontline formations. In military use, however, it proved to be expensive and tedious to maintain. Many spare parts are no longer even available today.

1,100
rounds per minute
(550 rounds per barrel)

caliber
35MM x 228
Types: Conventional high explosive incendiary-tracer (HEI-T) ammunition for engaging aerial targets; subcaliber ammunition for ground targets

1,440
m/s projectile velocity for subcaliber ammunition and 1,050 m/s projectile velocity for high explosive incendiary ammunition

A brief history of the Gepard
More than fifty years after its initial development and introduction, the Gepard anticraft tank's first combat mission took place – in Ukraine. The fact that it is so successful today is no coincidence. During the system's design, development and test phases in the 1960s and '70s, no effort was spared.

1960
In the mid-1960s, Contraves AG and Werkzeugmaschinenfabrik Oerlikon-Bührle AG (both of which now form part of Rheinmetall Air Defence) joined forces with Siemens-Albis AG to develop an air defence system at their own risk.

1968
Based on experience with the 35mm x 228 field air defence (Twin Gun) paired with Superfledermaus fire control units (forerunner of the Skyguard) and earlier studies for mobile antiaircraft systems (the four-gun 20mm tank antiaircraft quad), a first prototype of the Gepard was presented by 1968.

1970
Although a parallel project to develop an antiaircraft tank with a 30mm Hispano Suiza HS-831 cannon (Matador 30) was already underway in West Germany, the 35mm solution from the Oerlikon-Bührle group ultimately won the day.

1974
After successful conclusion of system development led by Contraves, preparations for series production were followed by manufacture of a pre-series of 17 vehicles, which were delivered starting in 1974.

1980
Krauss-Maffei AG, now KNDS, served as the general contractor for series production. By the early 1980s, over 550 of the vehicles in different variants were produced for the armed forces of West Germany, the Netherlands and Belgium.

Text: ***Dr. Moritz Vischer***

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EFFICIENT AIR DEFENCE

The experts agree: the Gepard with its 35mm twin cannons is a decisive factor in Ukraine's fight to defend itself. The German government has supplied the country with around forty of these anti-aircraft tanks. "Air defence rather than fighter planes saved Ukraine", confirms British military expert Justin Bronk. In its struggle for national survival in the face of numerically superior Russian forces, Ukraine's air defence assets let it keep control of its air space. In effect, Russia can barely use its air force in areas where the Gepard is likely to be present. The Gepard antiaircraft tank has also proved to be a very efficient means of countering Iranian-made Shahed-136 kamikaze drones. But because they are almost permanently in action, the consumption of ammunition is correspondingly high: the two Oerlikon KDA automatic cannons can spit out up to twenty rounds in a single burst of fire. With ammunition still in short supply, the Ukrainians generally confine themselves to five-round salvos. *(Ho)*

4 In action: the Gepard during a Bundeswehr live fire exercise. Photo: Ralf Schober

5 Boris Pistorius with Ukrainian soldiers in front of a German Gepard antiaircraft tank: two weeks after taking office, the new German defence minister travelled to Kyiv in February 2023. Supplying weapons to Ukraine was the central topic of the political talks.

Rheinmetall's civil and military wings pitching in and colleagues from Italy and Switzerland working with us here in Germany."

Over to a clearly impressed Peter S., 63, managing director of RWM Schweiz AG in Zurich: "It's unbelievable. We've accomplished in weeks what would once have taken months or even years. Basically, it's the craziest project I've ever seen – but also one of the most important." This only worked because of streamlined decision-making and plenty of pragmatism, coupled with maximum determination, motivation and stamina. "We're making ammunition in Germany for a war in Europe. I never could have imagined that we'd have to do this again after the end of the Cold War", says S., who served as a tank battalion commander in the Bundeswehr in Kosovo.

MODERN AMMUNITION TECHNOLOGY FOR A VINTAGE SYSTEM

"As I see it, nobody could have solved this problem as fast as Rheinmetall. For one thing, we're familiar with Gepard's Oerlikon-made main armament. On top of that, we have the necessary expertise to make the medium-caliber ammunition it fires", declares S. Moreover, ever since its takeover of the former Oerlikon Contraves AG of Zurich, the Group has been at the technological forefront of gun-based air defence solutions.

The challenge: "The Gepard is so old that nobody today knows the fire control unit of the antiaircraft tank in detail", reports Christian F., 44, in overall charge of the Gepard ammunition project. "There's hardly any documentation left, and we only have a rough idea of what actually goes on inside the fire control unit." Yet this electronic component explains the still impressive accuracy of the 35mm twin cannon system.

Delving into the details of this unique project, F. notes that "Replicating the old ammunition was out of the question, especially since the old tools were lacking. Due to the time constraints, we opted for a mix of reverse engineering and reconfiguration that's probably never been attempted before. In short, we took existing 35mm ammunition used in the main armament of an infantry fighting vehicle and adapted it for use in the Gepard." A special challenge here: "The fire control unit in the Gepard has to be able to reliably recognize the ammunition. To achieve this, the team first had to decipher and understand the Gepard's blackbox electronics so that they could adapt the ammunition to it. Accord-

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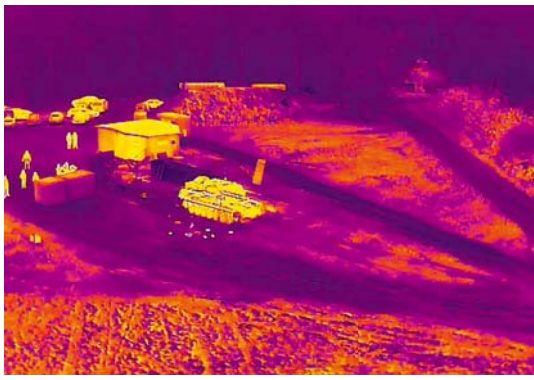

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ing to F., being able to draw on the knowledge of colleagues at Rheinmetall Air Defence was a huge help: "They immediately assured us of their full cooperation, furnishing us with active and pragmatic support.

A BROAD TECHNOLOGICAL KNOWLEDGE BASE IS AN UNBEATABLE STRENGTH

Manfred M. in Unterlüss shares this view. "That's our unbeatable strength at Rheinmetall – we're a system house with a very broad knowledge base in the Group." During comprehensive live-fire trials at the Unterlüss proving ground, the status of the system's functionality has been repeatedly tested. The final step: successful conclusion of the verification programme with ammunition fired from the Gepard antiaircraft tank in May 2023.

As Peter S. makes clear, "Our people are totally committed to this project, knowing full well that Ukraine urgently needs this ammunition – and the sooner, the better." In a technical tour de force, Rheinmetall engineers and technicians have succeeded in wedding a venerable weapon system with modern ammunition. "I marvel at the ambition and the way they've poured their knowledge into this project. Where others failed, we at Rheinmetall succeeded in the space of three months, bringing the process of reconfiguration to a successful conclusion", sums up S.

PLANT ENGINEERING EXPERTISE ON FILE

It wasn't just in the development domain that Rheinmetall had to find pragmatic ways of speeding the first deliveries of ammunition to Ukraine. The expansion of production capacity also required special ingenuity. As Manfred M. in Unterlüss explains, "The concept for the production facility comes from our colleagues at Pierburg, that is, from the civilian side of Rheinmetall. They have the necessary plant engineering knowledge, with blueprints for the production facility we needed practically stored in a drawer." In the words of Constantin Sch., "Our Pierburg colleagues have done a truly incredible job!"

Next, over to Holger D., 54, Director Equipment Building at Pierburg in Neuss: "Thanks to our experience, we're able to produce solutions very quickly. We've already built similar facilities in Camden, Arkansas for American Rheinmetall Munitions and in Varpalota, Hungary. In Neuss,

For reasons of corporate security, all names have been made unrecognizable.

6 Rank and file: Here, the practice version of the Gepard's 35mm ammunition, ready to fire. Each round weighs about 1.5 kilos.

7 and **8** Test firing at the Group's proving ground in Unterlüss: Rheinmetall experts testing the functionality of the newly developed Gepard ammunition. Meticulous harmonization of the complete system – encompassing the ammunition, weapon and fire control unit – is the only way to guarantee the Gepard's superior firepower.

9 Drone images are used during test firing for monitoring and documenting the target area and the fire position, including this infrared image.

we came up with the concept for the LAP line in Unterlüss that our colleagues at Pierburg Pump Technology in Italy built in Lanciano. From there, it was transported to Unterlüss and put into operation. We work hand in hand, reaching across borders." LAP stands for loading, assembly and packing, the process in which the casings are filled with propellant and the various components are assembled to form the cartridge, and then packaged. The powder for the propelling charge comes from Nitrochemie, another member of the Group.

FLAWLESS COOPERATION

Peter S. leaves no room for doubt here: "It was the perfect interplay of everyone involved in the project that made it possible to complete it in so short a time." Indeed, close cooperation runs like a red thread throughout the entire production process. "By expanding the supply chain, we were able to reduce the Swiss share of value added as far as possible, shifting it to Germany."

As his colleague Christian F. explains, "Ukraine will be getting 150,000 rounds each of two types of ammunition." The first is a subcaliber munition with heavy metal penetrators designed for engaging hardened targets. In parallel, preparations are underway to produce conventional high-explosive incendiary tracer (HEI-T) rounds, which are designed for an air defence role, i.e., for use against aerial targets like aircraft and guided missiles. Manufacturing the latter is a more complex process, however, requiring sufficient amounts of explosives and fuses. Therefore, the high-explosive incendiary tracer ammunition will be delivered in a second stage.

But that's no problem, insists Peter S.: "In the scenarios Ukraine finds itself operating in, the type of ammunition is practically a secondary concern – the main thing is having any ammunition at all. Even practice rounds can bring down dangerous Shahed drones."

WHEN EVERY DAY COUNTS

Meanwhile, Manfred M. and his team in the Südheide are gearing up for the start of production. "We're training our personnel to perform new tasks. Once the new plant and equipment are delivered and commissioned, we'll carry out a small production run to test how it functions before ramping up to full-scale production. The first shipments should go out this summer." Together with Constantin Sch., he looks forward to the day when the first truckload of Gepard ammunition leaves the factory in Unterlüss. "We're certainly going to celebrate", says M. "Supporting the people of Ukraine means a lot to the folks who work here." In all, 40,000 cartridges are due to be shipped before the end of 2023.

For F., the project manager, the Gepard project has been especially important. "We're used to working on our projects under extreme time pressure and with tremendous responsibility. It's our lifeblood, our passion – tight schedules are part of it. But this time it's different: time really is of the essence here. Our products can save people's lives in Ukraine. Every day counts. Knowing this gives us a huge energy boost."

The symbolic significance is impossible to miss: The only way to thwart Russian aggression is for the West to work together with Ukraine in a major combined effort. Once the first shipment of Gepard ammunition is on its way to Ukraine, it will be a success shared by many: a success for Rheinmetall colleagues in Zurich, Studen and Altdorf in Switzerland; in Neuss and Unterlüss in Germany; and in Lanciano in Italy – and a vital contribution to the defence of Ukraine. ●

European teamwork: The Rheinmetall locations at home and abroad that took part in the project, contributing their special expertise in development, plant engineering and production.

Security joins the DAX

1 The delegation from Rheinmetall AG celebrates the defence and technology company's promotion to the DAX in the trading room of the Frankfurt Stock Exchange.

Rheinmetall has begun a new chapter in its history now that, after 27 years on the MDAX, the Düsseldorf-based technology group has advanced to the DAX, Germany's benchmark index. This historic step forward is a testament to the dramatic change in Rheinmetall's role since the turning point represented by the Ukraine war.

Author: ***Till Kerkhoff***

On March 20, 2023, Rheinmetall finally officially joined the benchmark index of the German stock exchange. The founding member of the MDAX replaced dialysis specialist Fresenius Medical Care via the fast entry process. The group made a good start to its first day as a DAX-listed company, with the Rheinmetall share price up 5.4% at almost EUR 250 at the close of trading. "We're absolutely thrilled to have joined the DAX today," said CEO Armin Papperger at the opening bell ceremony at the Frankfurt Stock Exchange. "We regard this step up to the top tier as recognition for our development as a company over 130 years and of the services that we are providing in the present day. This accomplishment would not have been possible without the confidence of our investors and the outstanding performance of our employees. We owe them our thanks."

FORECAST CALLS FOR GROWTH

The impressive performance of the share price is evidence of exciting prospects for Rheinmetall. Given the change in the security policy situation, analysts consider the group to be in a good position to play an important role in the imminent increase in defence capabilities in Germany and partner countries. These expectations are underpinned by the 2% target for NATO member states and the special fund set up by the German government for re-equipping the Bundeswehr. For the 2025 fiscal year, the group is targeting a sales volume of EUR 11 billion to EUR 12 billion based on its strong growth prospects.

2 The Executive Board of Rheinmetall AG signs the guestbook at the Frankfurt Stock Exchange. Foreground: CEO Armin Papperger; immediately behind him: CFO Dagmar Steinert and Peter Sebastian Krause, Executive Board member for Human Resources.

3 Armin Papperger opens the first day of trading with Rheinmetall as a member of the DAX with the time-honored tradition of ringing the bell.

A lot is happening at Rheinmetall right now. With a new ammunition factory in Hungary and its strategic acquisition of Expal Systems, Spain's biggest ammunition manufacturer, the company is increasing its in-house production capacity significantly as it makes its debut on the DAX. Rheinmetall is also pulling out all the stops to set up a military maintenance and logistics center in Romania, a NATO partner country. This service hub is to be used to inspect and provide logistical services for western combat systems used in Ukraine to make sure that they are ready for operational deployment.

A RECORD YEAR IN 2022

Rheinmetall posted record figures last year as well. The technology group presented its report for the 2022 fiscal year on March 16, 2023, boasting sales of EUR 6.41 billion and an operating result (EBIT before special items) of EUR 754 million. The group's operating margin rose to 11.8%, up from 10.5% the previous year. Rheinmetall's order backlog also hit a new high, amounting to EUR 26.6 billion at the close of the fiscal year.

A dividend of EUR 4.30 per share was paid out to shareholders for the 2022 fiscal year.

A TURNING POINT FOR RHEINMETALL

Rheinmetall has been receiving a lot of public attention away from the financial markets as well. Perceptions and opinions of the security industry across society are currently undergoing a dramatic transformation in a manner that is symptomatic of the changing geopolitical situation. Aspects of military hardware are becoming topics of conversation for a concerned public again for the first time in a very long while. Arms exports to Ukraine are not only tolerated but actively demanded. As a result of this, the defence industry is being acknowledged by broad sections of the population as a vital instrument in ensuring that Europe is secure and capable of defending itself.

In CEO Armin Papperger's opinion, Rheinmetall AG has already been in that position for some time. "With our activities in the military sector, we regard ourselves as part of the German and European security apparatus. As a company, we are more conscious than ever of our special responsibility to society to make our contribution. Our skills and expertise allow us to play a role in protecting the people and defending the liberal democratic order. We intend to live up to that responsibility by continuing to be a capable and dependable partner to the Bundeswehr and the armed forces of our allies." ●

→ To watch the video of the opening bell ceremony, visit the digital version of our magazine at : **www.dimensions-magazin.de/en**

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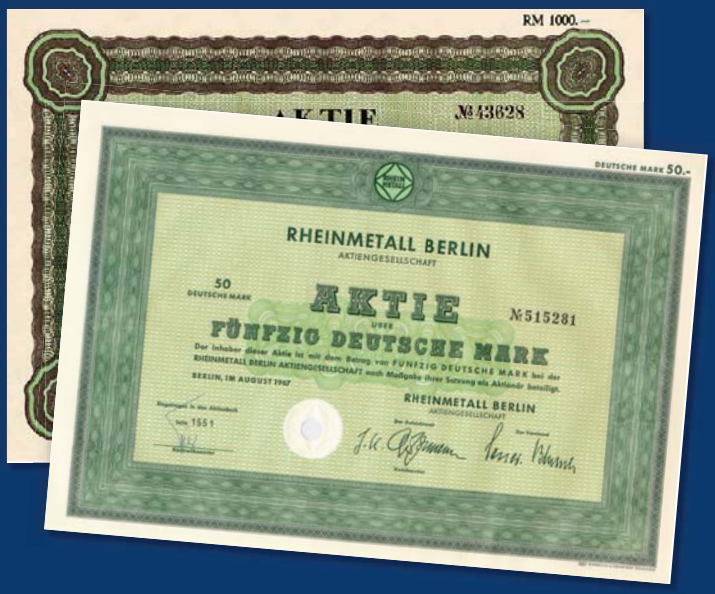
OPENING BELL EVENT

To mark special occasions, listed companies can ring the stock exchange bell to open trading. The ceremony takes place in the trading room of the Frankfurt Stock Exchange. Rheinmetall celebrated its accession to Germany's top share index at an opening bell ceremony on March 20, 2023.

THE OLDEST LISTED STOCK ON THE CURRENT DAX



1889 On April 13, 1889, Rheinische Metallwaaren- und Maschinenfabrik Aktiengesellschaft was founded by Hoerder Bergwerks- und Hüttenverein, a mining and steel company. The original capital was 700,000 marks.

1890 The first Rheinmetall annual general meeting took place in Düsseldorf on November 11, 1890. The company has held regular AGMs ever since, interrupted only by the Second World War and the post-war period. They have been held in Berlin since 1938, with a virtual meeting introduced in 2020.

1894 Rheinmetall common stock was first listed on the stock exchange on November 14, 1894, making it the oldest listed stock among current DAX members.

1903 Preferred stock was approved for official trading in Berlin for the first time on March 31, 1903. The first official share price was 78.1% of par value. By the end of the year, the price had risen to 91%.

1909 Fried. Krupp AG became the largest shareholder of Rheinmetall, holding 40% of capital stock in 1909.

1925 The German Reich became the majority shareholder with a stake of approximately 52%. Krupp gradually reduced its holding in Rheinmetall over subsequent years.

1936 On January 1, 1936, Rheinische Metallwaaren- und Maschinenfabrik Aktiengesellschaft became Rheinmetall-Borsig AG.

1951 The first post-war annual general meeting resulted in a decision to convert the capital from 75 million Reichsmarks to 15 million Deutsche Marks.

1955 The new Rheinmetall-Borsig AG stock, listed in German marks, was approved for trading and listing on the stock exchanges in Berlin, Düsseldorf and Frankfurt am Main on September 29, 1955.

1956 On June 23, 1956, the Röchling family acquired the majority stake in Rheinmetall-Borsig AG that had previously been held by Bank der Deutschen Luftfahrt AG i. L. for a price of DM 17,685,850. On November 20, the company changed its name to Rheinmetall Berlin AG (Rheinmetall AG since 1996).

1960 On April 7, 1960, the annual general meeting approved an increase in capital to DM 25 million. The Rheinmetall share price reached an all-time high of 510% of par value. New share certificates bearing the name Rheinmetall Berlin AG were issued for the first time. Previously, Rheinmetall-Borsig certificates had simply been stamped with the new name. Rheinmetall also paid a dividend again for the first time since 1944, at 6%.

1966 On August 4, 1966, the annual general meeting approved the payment of a 12% dividend for the first time, with the figure rising to 14% in 1969.

1984 Another capital increase, this time to DM 135 million, took place in September 1984. Rheinmetall Group staff had the chance to purchase employee shares in Rheinmetall Berlin AG for the first time.

1996 The MDAX share index was launched on January 19, 1996. Rheinmetall Berlin AG common stock was listed from day one. Rheinmetall remained the only stock to be listed on the index without interruption from then until March 19, 2023.

1998/99 Rheinmetall Group shares were traded in Deutsche Marks for the last time on December 30, 1998. Rheinmetall AG common stock closed at DM 43.00 and preferred stock at DM 31.30. From January 4, 1999, onward, the shares were listed in euros. The common stock opened at EUR 21.45 and preferred stock at EUR 17.00.

2000 On June 26, 2000, the common and preferred stock were converted from par-value shares to no-par-value shares and from Deutsche Marks to euros. Rheinmetall set up a dedicated Investor Relations department for the first time on August 1, 2000.

2003 On February 13, 2003, the share price of the preferred stock fell to a low of EUR 9.65.

2004 On November 23, 2004, the Röchling family of shareholders announced that they would be divesting themselves of their Rheinmetall stock. The day before, Rheinmetall preferred stock had reached a new all-time high of EUR 39.99.

2005 On May 10, 2005, it was decided at the annual general meeting to merge the common and preferred stocks. This involved the 18 million no-par-value shares without voting rights being converted to common stock (previously also amounting to 18 million). The preferred stock was traded for the final time on June 24, 2005.

2008 Starting on April 3, 2008, Rheinmetall issued employee shares for the third time in its history. The “Mein Stück Rheinmetall” [“My piece of Rheinmetall”] campaign allowed the 10,000 or so employees across the 31 sites in Germany to purchase large quantities of shares on favorable terms.

2022 Following Russia’s invasion of Ukraine, the Rheinmetall share price surpassed the EUR 200 mark for the first time in its history on March 28, 2022.

2023 On March 20, 2023, Rheinmetall stock was promoted to the DAX, the top German share index. Currently, 43,558,850 shares of Rheinmetall AG have been issued and the market capitalization is EUR 10.97 billion (July 14, 2023).

How Brisbane learns from Schneizlreuth

1 Australia's ANZAC-class frigate, like the one shown here during an exercise in the Pacific Ocean, are to be equipped with decoy technology from Rheinmetall.

The navies of 16 nations now place their trust in Rheinmetall's MASS ship protection technology. Australia is the latest customer. The inventors of this naval countermeasures system are based in Schneizlreuth, an idyllic little town in Bavaria: a transglobal transfer of knowledge.

An enemy cruise missile is flying toward a frigate on the high seas. If it reaches its target, it is certain to cost many sailors their lives. Yet right before impact, something strange happens: the frigate vanishes behind a curtain of smoke and flashing lights – almost like fireworks.

By the time the fog has lifted, the ship has disappeared, and the missile has fallen harmlessly into the sea. These spectacular scenes, which recall a magic trick by David Copperfield, are from a demonstration video for MASS, short for Multi Ammunition Softkill System, a highly effective naval countermeasures system. In the meantime, 16 nations use the decoy munition to protect their surface combatants. Australia is the latest member of the global MASS community.

MADE IN SCHNEIZLREUTH-FRONAU

Of course, MASS has very little to do with magic, and everything to do with expert knowledge and precision – and unsurpassed stamina. Nobody knows this better than Martin Fegg, the system's spiritual father. A physicist by background, he has been working on MASS for thirty years, initially on behalf of Buck Fronau, a company Rheinmetall took over in 1998. The plant, in the picturesque little town of Schneizlreuth-Fronau near Berchtesgaden in the Bavarian Alps, is one of the Group's smallest locations, with around 70 employees. Small but highly successful: MASS is the world market leader. "The Fronau Spirit is famous throughout the Group", laughs Fegg.

Most countries that use Rheinmetall's softkill system import the munitions and launchers from Germany. Australia is taking a different tact: the latest order will go hand in hand with a technology transfer. Headquartered in Redbank near Brisbane, Rheinmetall Defence Australia will produce MASS under licence, supplying

the Royal Australian Navy on location with the decoy systems. “The order is Rheinmetall’s first naval contract of this kind in Australia and marks an important milestone in the expansion of the Group’s industrial presence here,” notes Nathan Poyner, managing director of Rheinmetall Defence Australia.

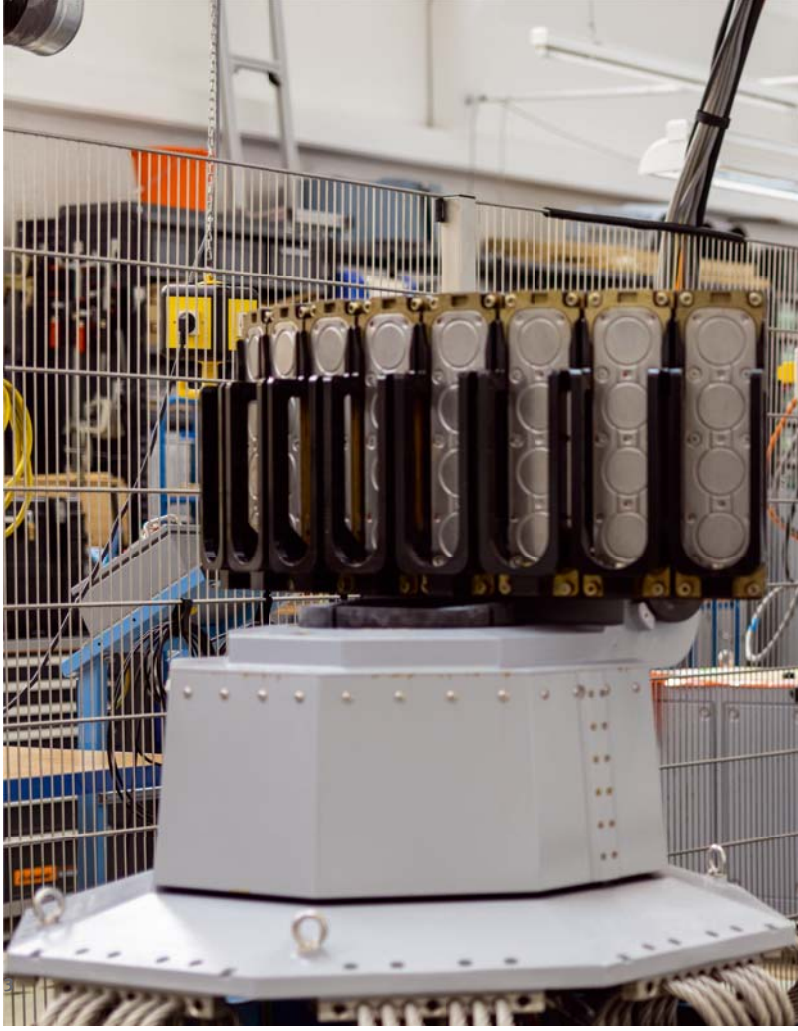
STEP BY STEP

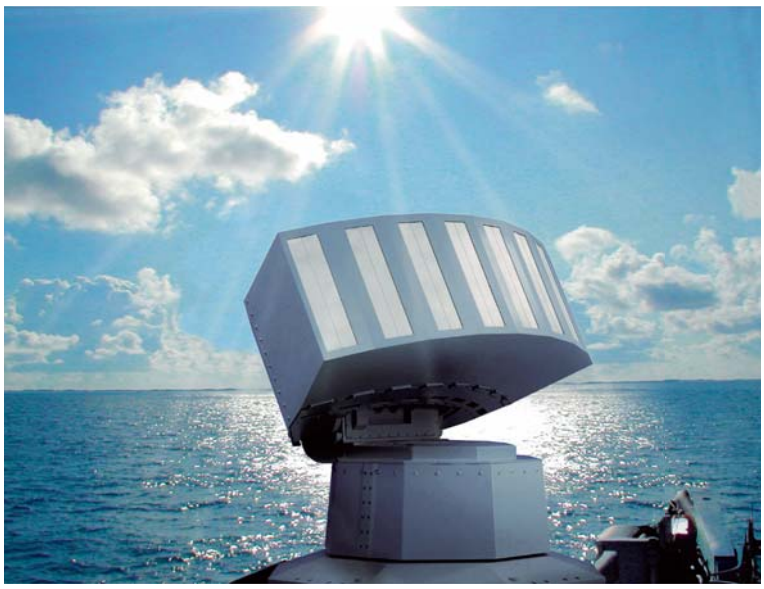
“The technology transfer is a gradual, step-by-step process”, says Martin Fegg. The first MASS systems earmarked for Down Under will be produced in Schneizlreuth. “Our Australian colleagues come here for training in our factory. Of course, we’re also busy preparing documentation for Australia. Next, we’ll be setting up a production line in Brisbane, once again with staff from Germany taking part in the commissioning process,” explains Fegg. “But even during this phase, the components for the launchers and munitions kit will come from Germany.” Once production is going smoothly, local Australian subcontractors will come into play.

Australia isn’t the first country to opt for local production. Canada and South Korea also produce MASS under licence. But Australia is the Rheinmetall Softkill Protection Systems unit’s biggest single order to date, with volume potentially totalling a billion Australian dollars, roughly EUR 610 million. MASS will initially be installed on the Royal Australian Navy’s Hobart-class destroyers and ANZAC-class frigates, with an option for equipping the entire fleet.

AN IMPRESSIVE DEMONSTRATION

Before the Australian ministry of defence opted for MASS, the system was put to the test on location – in the middle of the coronavirus pandemic, no less. For Martin Fegg and his team, this meant a two-week “bonus” stay in a quarantine hotel at the other end on the world before the tests could get underway.



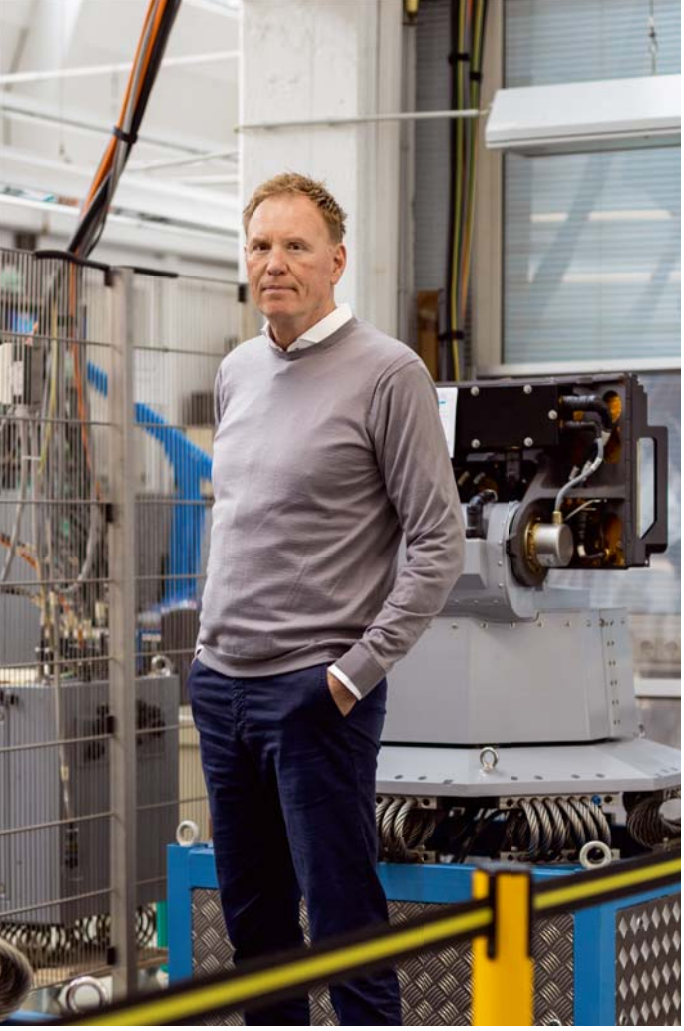


2 MASS is the world market leader in maritime decoy systems. No fewer than 16 nations protect their surface combatants with decoy munitions from Rheinmetall.

To demonstrate the effectiveness of the system, the New Zealand Navy made an ANZAC-class frigate available that was already equipped with MASS. As a result, the test campaign took place under real world conditions, enabling the decoy system to display its full effectiveness in the finest David Copperfield tradition. MASS passed every test with flying colours: the procurement order was soon a done deal.

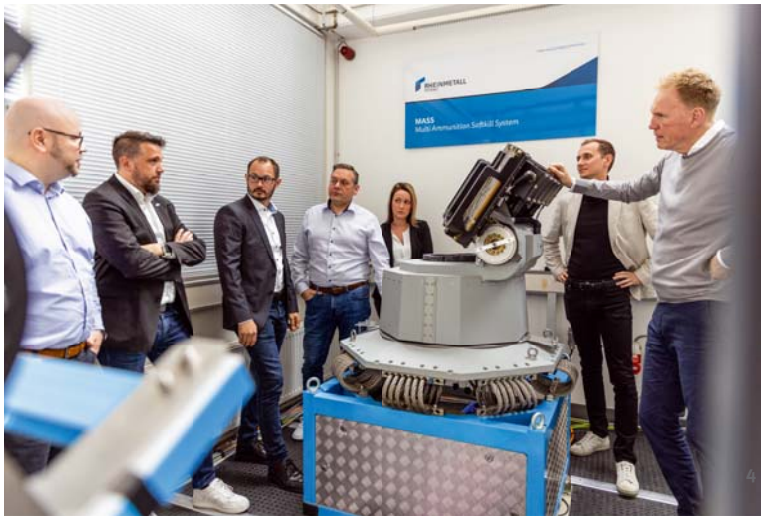
THE LAST LINE OF DEFENCE

Test campaigns like the one in Australia help to explain why MASS is the world market leader in maritime decoy systems. “We continuously put MASS to the test”, says Martin Fegg. Primarily with the German Navy but also with those of other user nations, regular attack simulations are conducted under realistic operating conditions. After all, advances in missile technology are relentless. “Every missile has its own signature that MASS has to be able to recognize,” adds Fegg. “We’ve been carrying out tests ever since 1995. As you can imagine, we’ve accumulated quite a lot of expertise.”



MARTIN FEGG

Born in 1962, Martin Fegg heads Rheinmetall Waffe Munition's Softkill product unit. A Berchtesgaden native, he left school with a standard school leaver's certificate before spending several year's working as a shoe salesman. Taking advantage of Germany's "second chance" provision, he returned to school, did his college-prep Abitur and went on to study Physics. In 1991 Fegg went to work at Buck Fronau, which Rheinmetall Waffe Munition took over in late 1998. Development of the MASS ship protection system began in 1993.



3 Martin Fegg in the training centre at Schneizlreuth next to his invention. A trained physicist, he has been working on MASS for 30 years.

4 Rheinmetall Waffe Munition won this major order from the Royal Australian Navy thanks to the excellent work of the entire team in Schneizlreuth.

The final stage of the technology transfer with Australia is slated to be complete in 2027. That this or that problem is likely to arise in the meantime "is due to the nature and complexity of the project", says Fegg. Yet he remains optimistic that everything will function properly in the end, noting that the teams on both sides of the globe are highly motivated and eager to overcome whatever obstacles they encounter along the way. "One thing we never forget in our work is that MASS is the last line of defence", insists Martin Fegg. "We're responsible for people's lives, and that's how we operate." ● *Pb*

ABOUT MASS

- The MASS ship protection system protects ships and boats from a wide array of threats from anti-ship missiles and laser-guided missiles.
- The system consists of three main components: the decoy munitions, the lightweight carbon fibre launcher, and the tactical operations software.
- The munitions contain millions of extremely thin glass fibers, their most important feature, which act in the air as antennae. They must be carefully arrayed in the cartridge to ensure subsequent equal distribution in the air. The glass fibers pick up a missile's radar echo and trick it with ship-like signals.
- MASS cartridges also contain built-in heat plates. When these ignite, they produce more heat than the ship, helping to deflect the missile. Smoke/obscurant adds to the confusion by interrupting the laser beam.
- Depending on the type of approaching projectile, the system generates a specific pattern. A "decoy curtain" for an infrared-guided missile, for example, looks different than one for a radar-guided missile. Even when a missile realizes it has failed to hit its target and takes aim at the ship again, MASS's tactical software takes account of this and reacts immediately.
- MASS can be installed on ships of all sizes. It can be readily integrated into existing command and weapon engagement systems or operate as a standalone system. In the standard version, MASS consists of one to six trainable launchers, each of which can fire 32 "Omni Trap" decoy munitions.
- In addition to MASS, Rheinmetall also makes the ROSY multifunctional self-defence system for armoured vehicles, and BIRDIE, a self-defence and false target system for aircraft.
- In total, 379 MASS launchers (including Australia) are now in operation on 42 different classes of ship.

In the powder workshop

PROFILE
NITROCHEMIE ASCHAU – PROPULSION SYSTEMS

Europe needs ammunition. It is required not only for Ukraine, but also for member states' own military forces. At its factory in Aschau, Nitrochemie – a subsidiary of Rheinmetall – works around the clock to make the urgently needed propellant powders and systems for tank ammunition and artillery shells.

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I need ammunition, not a ride." That was what Ukrainian president Volodymyr Zelenskyy said shortly after the Russian attack on his country began. His words are no less timely even in the second year of the war – quite the opposite, in fact. The EU, NATO and of course Ukraine itself urgently need artillery shells above all. Procuring them is a top priority for the highest levels of government.

Let us switch from the global stage to the small town of Aschau am Inn. It is home to the German operation of Rheinmetall subsidiary Nitrochemie, which has a second location in Wimmis, Switzerland. Since October 2022, the production division for propulsion systems has been operating across four shifts, 24 hours a day, seven days a week. The facility in Aschau makes propellant powders and nitrocellulose casings for large-caliber weapons systems – essential for the production of ammunition. A shell essentially consists of a casing, fuze, explosive and propellant, or a separate propellant system. The latter create the pressure required to catapult the projectile out of the barrel of a gun.

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PRECISION AND SAFETY

To the outside observer, it may not be immediately apparent that this is a high-pressure working environment. The administrative offices and several dozen smaller buildings are distributed across a sprawling 95-hectare site, with no giant factory building in sight. The compartmentalized layout is a matter of safety, because the workforce is almost literally sitting on a powder keg. It is essential to ensure that if an incident involving high explosive were to occur, any risk of a chain reaction would be ruled out. Safety first is also the motto of Georg Lingg, who has been the CEO of Nitrochemie since 2014. "Safety is always number one. Then comes product quality, and then quantity. Always in that order."

Lingg, a trained mechanical engineer, heads up the operations at both Aschau and Wimmis. "In Switzerland, we make the key raw materials that are needed in Aschau to manufacture the propellant powders, which means mainly what we call the raw mixtures of nitrocellulose and nitroglycerin." These are transported to Aschau by good old-fashioned rail. This may sound distinctly dangerous, but it is actually "not a problem at all," says Oliver Becker. Becker, a process engineer with a doctorate in technical chemistry, is responsible for powder manufacture in Aschau in his capacity as production manager. "Twenty-five percent of the raw mixture is replaced with water. You couldn't ignite it even with a lighter."

Once it reaches Aschau, the raw mixture is blended with various substances. These include stabilizers, flash suppressants and other sources of energy that can be used to alter the burn rate. After all, the powder does not detonate, but burns in a controlled manner – albeit at immense speed.

The enriched "paste" is then ready for the roller. The pressure exerted by the roller expels the water from the raw mixture entirely mechanically, without the use of chemicals. Becker is visibly proud of this: "Not everyone can do that." The process creates a sheet two millimeters thick, rather like a carpet, which is then rolled up.

1 Producing propellant powder to the highest standards of quality is the stated mission of Nitrochemie in Aschau. Demand for propulsion systems is immense, but that is all the more reason to keep a cool head in production. Precision, not mass production, is the order of the day.

2 Georg Lingg has been CEO of Rheinmetall subsidiary Nitrochemie's sites at Wimmis, Switzerland, and Aschau, Germany, since 2014. Born in Leimen in 1964, he originally trained as a mechanical engineer.

THE "POWDER" IS A PELLET

The next stop is the press. The key part of this is the die, which varies depending on the product being made. The press produces a kind of cable that is then cut into little cylindrical pellets – the propellant powder. Tiny holes in the cable are among the features that determine the burn rate. The more holes there are, the more gradual the burn, ranging from 1 to 19. Propellants for artillery shells generally have more holes.

Nitrocellulose is a byproduct of cotton, hence its common name of "guncotton." Consequently, the place of origin and weather conditions can result in variations in the properties of the material. The end product, however, must meet identical standards of precision at all times. This means that the batches of powder need to undergo further homogenization.

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3, and **4** The raw mixture made from nitrocellulose comes from the Swiss site in Wimmis. In Aschau, it is first stored in a dedicated building to allow it to settle before undergoing further processing.

LESS INDUSTRIAL PLANT, MORE SMALL-SCALE FACTORY

Aschau is a round-the-clock operation. Yet the way in which these highly sensitive materials are processed is anything but mass production, no matter how urgently they are needed. Every step is carried out by hand – every box, roll and powder container is transported separately to the various production stages in stand-alone buildings for further processing. The principle of "safety first" extends to even the tiniest details of manufacturing. For example, forklift trucks in sensitive areas of production are equipped with explosion protection to ensure that powder dust cannot ignite if it should come into contact with a hot surface.

The one place that appears a little more spacious is the filling facility. There, the powder is poured into a nitrocellulose casing that has previously been fitted with an ignition amplifier, also made in house. Some of the powder pellets need to be weighed out by hand to ensure the high level of precision necessary for the charge weight. The Nitrochemie factory makes products including the modular charge systems for the now-famous Panzerhaubitze 2000 armored howitzer. The powder used to be loaded into artillery pieces inside fabric bags. Depending on the calculated range and trajectory, only some of the bag's contents were used and the rest of the powder was discarded. With the modular charge system, the charge can be measured out precisely without any wastage. Becker likes to compare the system to ink cartridges for fountain pens.

The finished charge modules are packed in special plastic or metal containers, depending on customer preference, which are then loaded onto

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5 The powder is rolled to expel the water from it. This involves pushing the mixture through a wafer-thin roller gap. Entry to the roller room is prohibited during the process, so technical project manager Andreas Hofmann supervises proceedings on a monitor.

6, 7, 8, and **9** The product of the rolling process: a "carpet" of nitrocellulose about 2 mm thick. This sheet is rolled by hand into a roll weighing over 20 kg, which is then taken to the press for further processing. The employee needs to wear a respirator mask due to the fumes produced.

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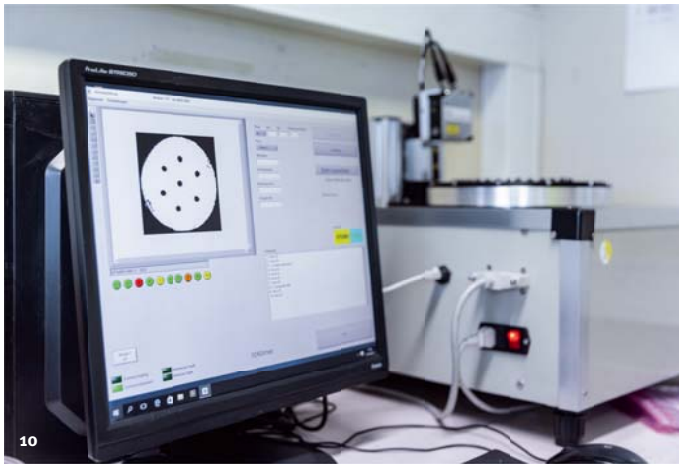
10, 11, and **12** Internal process monitoring involves regularly checking powder samples. This involves more than just making sure the dimensions are correct. Cotton, the raw material from which nitrocellulose is manufactured, is a natural product and so subject to variations. The powder is therefore homogenized to ensure consistent quality at all times.



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“We really do have a diverse array of assignments to deal with. There are technical challenges requiring broad knowledge – but that’s exactly what makes my job so exciting.”

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pallets. It goes without saying that the widely used EUR pallet is not an option in this case because of the enormously demanding transportation safety requirements. The pallets and the cartridge packaging need to be capable of coping with temperatures as high as 71°C and as low as –51°C, withstanding the kinds of vibrations that might be experienced in vehicles such as helicopters and surviving the impact of falling from a height of 36 meters (from a container ship into the sea, for example).

RECRUITMENT DRIVE

In late February 2022, soon after war broke out in Ukraine, Nitrochemie began to expand its powder capacity in Aschau. The biggest challenge was finding staff in the local area, which is largely rural. “The labor market in the Aschau region is virtually non-existent,” says Lingg. The management, though, had a few ideas up their sleeves. “We launched a full-scale recruitment drive, with commercials in movie theaters, flyers, out-of-home advertising and a career day in cooperation with the employment office. This allowed us to begin operating 24/7 in powder manufacturing from October 1 onward, increasing our production volume by around 40%.”

13 Oliver Becker has been in charge of production at the Aschau site since 2018 in his capacity as Senior Vice-President of Operations. Born in Munich, he is a process engineer with a doctorate in technical chemistry.

14 The casings for the propellant charges are also manufactured in Aschau. The casings for the tank shells shown here are made from nitrocellulose. After a process known as “felting,” Nitrochemie employee Peter Baal places them in a kind of press that extracts the remaining water. They then proceed to a lathe for the final machining step.

At the start of 2022, Nitrochemie had 440 employees. By the end of 2023, there will be 510 people working in Aschau. “That’s a big number, especially considering the fact that the growth is happening exclusively in the propulsion systems division and not in chemicals,” says Becker. “In addition, with so many new personnel, the entire company infrastructure is growing, with additional facilities such as showers, locker rooms and break rooms.”

BIODIVERSITY IN ASCHAU

Any modern company needs to ensure that its operations are sustainable wherever possible. Naturally derived ingredients are used in propulsion systems at Nitrochemie, as Lingg explains: “Our basic raw materials are made from a special cotton fiber. The nitroglycerin comes from glycerol. In other words, our products are already inherently pretty sustainable. That may sound strange, but it’s true.” – “Incidentally, the production of the rolled powder in Aschau is sustainable in itself, because it does not require any solvents,” adds Becker.

The site houses its own wastewater treatment plant, where biological methods are employed. The premises are surrounded by forest, with no hunting and very little noise or traffic, and Becker enjoys seeing examples of biodiversity on a daily basis. “We have deer wandering through, badgers, lots of different species of birds, and there’s a beaver lodge down at the river. The assorted flora and fauna seem to like it here!”

HARD WORK AND DEDICATION

Propellant powders are going to continue to be very much in demand. This represents a major undertaking for manufacturers, especially considering the fact that almost every step of the

process needs to be carried out by hand and an enormous amount of work needs to be devoted to safety. “We really do have a diverse array of assignments to deal with. There are technical challenges requiring broad knowledge,” says Becker – but that, he adds, is exactly what makes his job so exciting. One of the most important aspects is maintaining team spirit among employees, “especially those working in different units.”

Lingg is also passionate about his job. “Apart from all the people that my work gives me the opportunity to meet, one thing that really has an impact on me is the fact that we are making a product that is essential for supporting Ukraine and safeguarding Europe’s defence capabilities,” he says, “and I’ve noticed that there has been a massive upswing in appreciation for the defence industry lately. I think that is a very positive development.” ● *Pb*

→ You can read more on this subject at: **www.rheinmetall.com/en/company/subsidiaries/nitrochemie**

14

NITROCHEMIE GROUP

A Swiss-German company, Nitrochemie Group is based in Wimmis in the Swiss canton of Bern and in Aschau am Inn in the German state of Bavaria.

BUSINESS AREAS
Propulsion systems (propellant powders) and chemical intermediates (including the production of silicone binders used in commercially available silicone cartridges).

EMPLOYEES

HISTORY
Both sites have long histories. Powder has been manufactured in Wimmis since the end of the First World War. The Aschau site has been producing powder since 1953, initially under the name WNC Nitrochemie before being acquired by Rheinmetall in 1994.

The Powder & Charges division of SM Schweizerische Munitionsunternehmung AG in Wimmis merged with WNC Nitrochemie in 1998 to form Nitrochemie AG. The Aschau site has traded as Nitrochemie Aschau GmbH ever since, and the Swiss location as Nitrochemie Wimmis AG.

And the winner is …

Glass fibers are used for more than just fast internet. These materials are also playing an increasingly important role in chassis-building. The Rheinmetall Group, for example, has developed an innovative technology for car chassis springs in its Materials and Trade division. Users can now enjoy the benefits of lasting improvements to weight and handling as well as many other things besides.

Author: ***Folke Heyer***

As the world moves toward electric vehicles, much attention is being focused on lightweight engineering – and that applies to chassis as well. Special leaf springs made from lightweight materials are already in use in certain vehicles as a result of this development. But because many modern passenger car chassis use steel springs for reasons of space, Rheinmetall has devised an innovative solution that is based on fiber-reinforced plastic and features a space-saving design not seen anywhere else in the world.

It is no wonder, then, that the new glass-fiber springs rapidly began to attract interest from famous carmakers before they had even left the development stage. Having initially been installed in a lightweight technology demonstrator from a prestigious German manufacturer of premium automobiles, they have delivered such positive results that they could well find their way into the brand's production of electric vehicles. Preparations for advanced field tests with the new springs are also being made among a number of other high-profile car manufacturers both in Germany and elsewhere.

CHALLENGES FACING DEVELOPERS

Before the springs could be used for the first time, the designers in Neckarsulm had to overcome some significant hurdles in development. No sooner had these obstacles been cleared, though, the new fiber-reinforced plastic springs were awarded the plastic industry's equivalent of an Oscar. And with good reason, because the design – now patented – reduces the critical tension that occurs in the springs during operation and can be fitted even to vehicles that offer only very limited installation space. It was an approach that won over the panel of expert judges.

Marcus Gerlach, head of the Materials and Trade division and managing director of Rheinmetall Invent GmbH, where the springs were developed, explains what makes them so special: "Our innovative glass-fiber springs offer a wide range of benefits, and not just for carmakers. This gives them the potential to replace conventional steel springs in the chassis of all manner of vehicles while also helping to cut CO_2 emissions."

SIGNIFICANT WEIGHT SAVINGS

Not only are the glass-fiber springs up to 75% lighter than conventional steel springs, but they also offer a host of other advantages. First, they can be shaped in more or less any way. They also significantly improve reverberation properties thanks to the self-damping characteristics of the material. Then there is their resistance to corrosion and their gradual breakage characteristics. This can improve the way they behave in emergencies and makes it possible to continue driving even with a damaged spring. Thanks to their good NVH (noise/vibration/harshness) characteristics, they also produce less noise and do not transfer as much vibration into the vehicle interior.

Manufacturing the springs is not without its complications and calls for wide-ranging process expertise. "We set up a dedicated technical center at our Neckarsulm site to work on that aspect," says Ingo Goutier, the head of the unit in question, "where we can develop all processes in exactly the way that they will later be used in series production, coordinate them with each other and gradually increase the amount of automation involved."

A WIDE RANGE OF POTENTIAL APPLICATIONS

In addition to equipping prototypes and test fleets, the team in Neckarsulm can even serve the first production lines from the technical center, which offers the option of being expanded at any time. They could also potentially meet conceptual and design requirements for applications outside the automotive industry.

That way, they would be accommodating general interest from other sectors in rapidly verifying alternative lightweight designs, adapting the necessary processes and advancing the new technology to a stage of readiness for series production. So it may not be the last time we've heard the words "And the winner is: the Rheinmetall glass-fiber spring!" – and perhaps for the benefit of lots of other, different industries too! ●

THE OSCAR OF THE PLASTICS INDUSTRY

In 2022, Rheinmetall's glass-fiber springs won the prestigious SPE Automotive Award presented by the Society of Plastics Engineers Inc. in the Grand Innovation Award category, taking the top spot ahead of fierce competition in a vote by a 27-strong panel of expert judges.

1 YouTuber and *Car Maniac* editor Chris Karatsonyi was also impressed by the innovative spring.

A step ahead

Alternative fuels, hybridization, batteries or fuel cells: figuring out which path mobility will take in future is extremely difficult, even with current EU guidelines for cars and trucks. What's hard for consumers is even more difficult for manufacturers.

Author: ***Folke Heyer***

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Forced to make fundamental decisions far in advance that will have a decisive impact on their own product portfolios, auto parts makers and their development departments face the same conundrum. Jobs depend on this, and often the success or failure of entire companies. This is why being open to new technologies at an early stage is such a boon, as well as having pursued various drive concepts as a development partner for many years.

Rheinmetall is benefitting now from the conjunction of these two factors. After over two decades of research and development, Rheinmetall's Sensors and Actuators division is thoroughly at home in hydrogen technology as well. Based on this experience, products have emerged that now play a central role in fuel cells.

If the hydrogen used here is not only a very volatile commodity, it is above all a rare and valuable one. Despite this, it is sure to find its place in future applications (see interview with Professor Claudia Kempfert, p. 19-20). Ronny Marzog, head of the department responsible for the product, is convinced of this: "With long-distance trucks that have to cover over 500 kilometres in a day, there will be no getting around the fuel cell. We're talking here about fuel cell stacks with an output in the 100-150 kW range."

This is borne out by orders worth nearly half a billion euros in the meantime – and for just one product, the hydrogen recirculation blower, or HRB, which has now won over customers both at home and abroad. Nor are these customers limited to the truck and bus domain. Maritime applications, including ferries and container ships, for example, form part of the picture,

2

1 When producing recirculation blowers, meticulous quality control is an indispensable part of the process.

2 Rheinmetall has been developing hydrogen technology products for over two decades.

as do uses in stationary applications such as emergency generators. The critical factor in all these procurement decisions was the quality and reliability of the components, currently the highest on the market.

A SINGLE SOURCE

Producing the blowers requires teamwork in the truest sense of the word. A new production line is currently being built at Rheinmetall's Hartha plant in Saxony. Vendor parts come from the Group's Niederrhein plant (castings) and Abadiano in the Basque Country (electronics). Marzog expects the first qualification components to be ready for inspection by the third quarter of 2023, followed by standard serial products, "Made in Saxony".

WHAT DO HYDROGEN RECIRCULATION BLOWERS DO?

The blower performs a key function in fuel cell systems. Its task is to return hydrogen unused during the reaction to the stack in the cell. This enhances the fuel cell's efficiency and extends its service life. Furthermore, it enables even distribution of hydrogen, which improves a the system's starting behaviour.

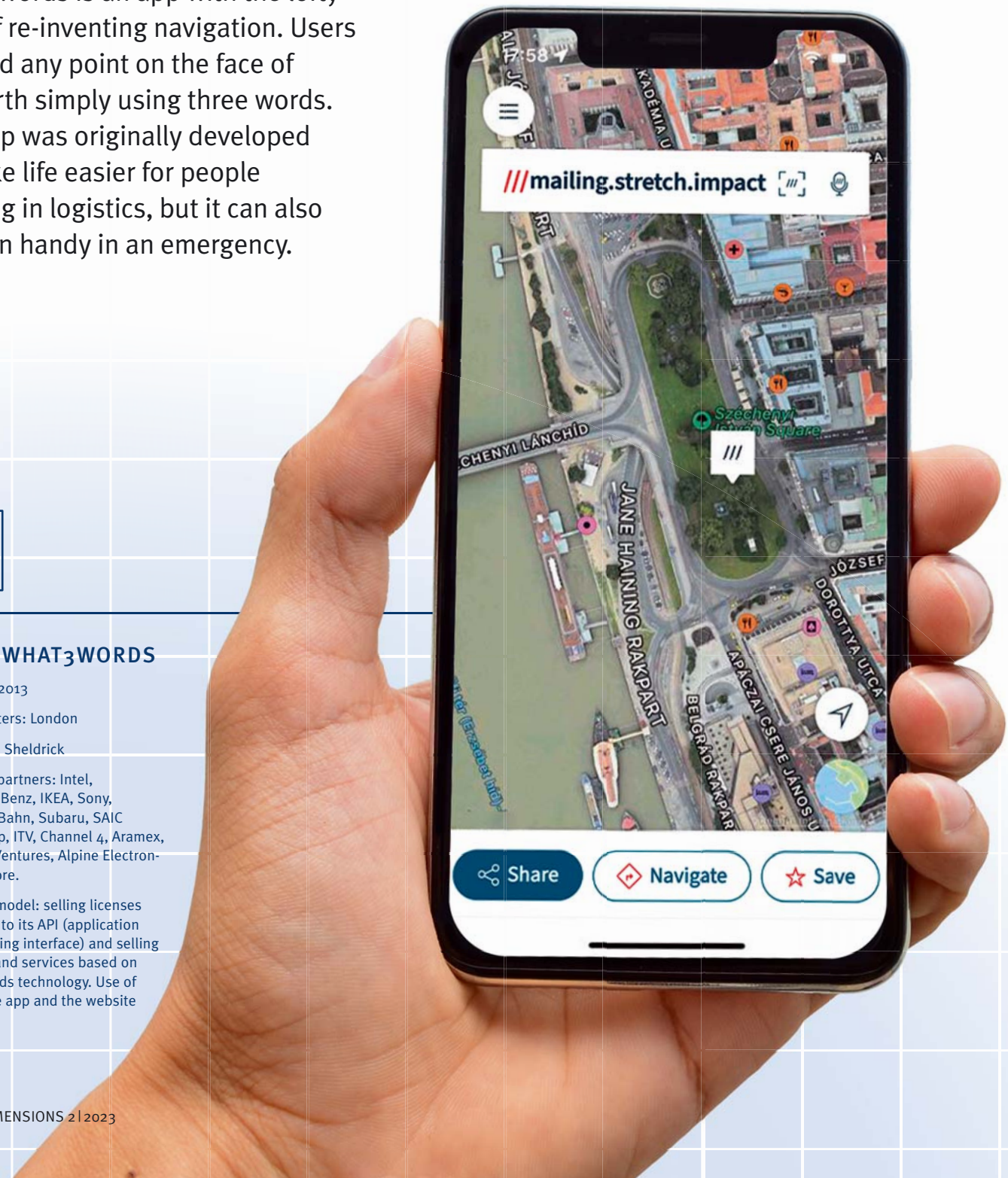
THE ROAD AHEAD

Marzog and his team are already developing units for even more powerful blowers. Some truck customers are now calling for a power intake of 2.5 kW. First and foremost, the developers are interested in achieving the required high-voltage stability in the components, while maintaining the same extremely high quality and density as well as the lifecycle target of 25,000 operating hours: a recirculation blower needs to reflect the operating lifetime of a modern long-distance truck.

In addition, the company is working on hydrogen recirculation blowers for stack outputs of 20-40 Watts, for cars and small stationary applications, for example, which have now reached an advanced stage of development. Owing to the most recent successes and the expected dynamic growth of the market, the company is expanding its development efforts in this area. Moreover, an array of other innovative components is now emerging that will progressively augment the company's portfolio. Behind all this is also a strategic decision by the company: Rheinmetall intends to play an enduring role in helping industry move toward more environmentally sustainable, advanced drive technologies for mobile and stationary applications alike and again is a step ahead. ●

Around the world in three words

What3words is an app with the lofty goal of re-inventing navigation. Users can find any point on the face of the Earth simply using three words. The app was originally developed to make life easier for people working in logistics, but it can also come in handy in an emergency.



ABOUT WHAT3WORDS

- Founded: 2013
- Headquarters: London
- CEO: Chris Sheldrick
- Company partners: Intel, Mercedes-Benz, IKEA, Sony, Deutsche Bahn, Subaru, SAIC Motor Corp, ITV, Channel 4, Aramex, Horizons Ventures, Alpine Electronics and more.
- Business model: selling licenses for access to its API (application programming interface) and selling products and services based on What3words technology. Use of the mobile app and the website is free.

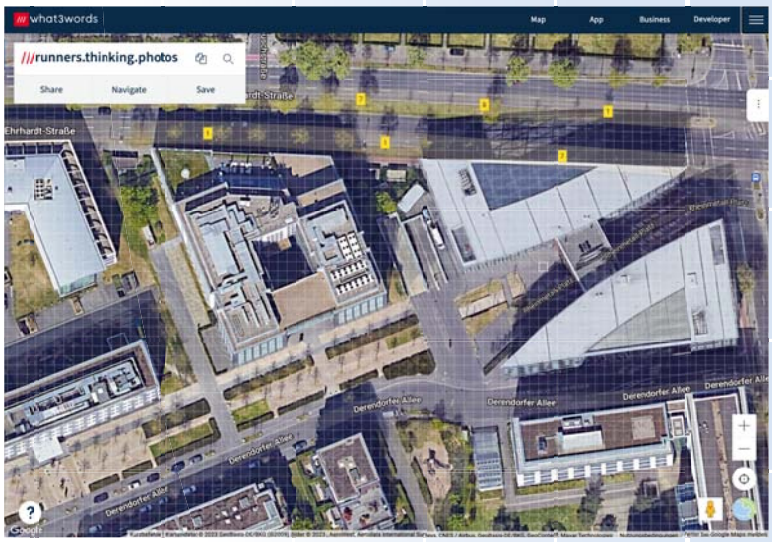
Parkstrasse in Berlin. Without knowing a single one of the residents personally, it is fair to say that most of them will have dozens of stories to tell about missing packages, lost visitors or pizzas delivered to the wrong addresses. That is because there are nine different roads called “Parkstrasse” in Berlin. They are bound to get mixed up from time to time.

The case of the Parkstrasses in Berlin is just one of many such examples. Logistics service providers, taxi companies and private individuals can all tell tales of incorrect or even just imprecise addresses, even in an age of cell phones and GPS navigation. The creators of What3words have made it their mission to bring an end to this misery with a geolocation-based system that divides the world into approximately 57 billion 3x3-meter squares. Each square is assigned a unique combination of three words. Using the website at www.what-3words.com or the app for mobile devices, it is possible to localize places all over the world accurately, and to do so in a simple and user-friendly way even without entering a specific address.

MEASURING THE WORLD

We’re going to stay in Berlin. Let us assume that a truck driver needs to deliver goods to an exhibitor at the Messe Berlin exhibition center on short notice. A Google search gives the address as Messedamm 22. This could conceivably be unsuitable for finding the right unloading point on the vast site comprising 26 different exhibition halls. This is where What3words comes in. The customer uses the app to localize exactly the right delivery point at Hall 6. The word combination is “twins.renews.rift”. That is easy to remember, even over the phone or radio. The app or, if it is compatible, the driver’s navigation system will then find its way to the destination by voice command.

Anyone who has ever been to Budapest and tried to find Széchenyi István tér, a much-visited square near the famous Chain Bridge, by using voice commands in Google Maps will know how useful What3words can be. The app will find the location easily if you use the words “mailing.stretch.impact”. The application is currently available in 54 languages. Word combinations are not translated directly but instead assigned entirely separately for each language. For example, German-speaking users will find Széchenyi István tér by entering “regelt.lenkte.gezielt”. Whether you speak German, English or Swahili, the app will automatically detect your language and adjust the search accordingly.



1

1 Rheinmetall corporate headquarters in Düsseldorf can be found using the following three words: “runners.thinking.photos”.

The app offers further benefits in places where a GPS signal and cell phone reception are hard to come by. That doesn’t just mean remote regions of Alaska or Lapland – even a walk in the woods can sometimes be enough to lose service. A GPS navigation system is useless without a signal. The world of What3words, with its 57 billion squares, is completely measured out. It works offline and anywhere in the world, whether you’re in the urban jungle or on the high seas.

THE IDEA BEHIND THE APP

In 2013, Chris Sheldrick, a 42-year-old from the UK, was fed up of constantly being led astray by his navigation system. As a manager in the music industry, he needed to make sure that his artists were in the right places at the right times. Sheldrick was finding this to be a real challenge, and this was what sparked the idea for What-3words. Companies such as Deutsche Bahn Digital Ventures and Mercedes-Benz AG have since invested in the London-based firm. New vehicles from Mercedes, Lotus and Mitsubishi are capable of navigating to a three-word address by voice command.

The address system is optimized for voice input, which can even save lives in an emergency. This is because emergency services tend to have their deployment locations sent through by radio. What3words makes that process quicker and more accurate, which is vital when every second counts.

THE SYSTEM HAS ITS LIMITS

It’s a great application, but the app has not triggered any great revolution in navigation. If you get lost and want to know where you are, What3words can’t help you. And it has of course long been possible to share the most accurate possible location coordinates using GPS. Yet the idea of the three-word combinations is smart and easy to remember – and comes with an entertainment value that should not be underestimated. The next time you want to visit Rheinmetall headquarters in Düsseldorf, give it a try using “runners.thinking.photos”. ● *Pb*

1 The top international class: Kevin Bryant in action at the D.SPORTS 3x3 Prime International. Visit the digital version of our magazine at dimensionsmagazin.de/en to see all team members of LFDY Düsseldorf and the Düsseldorf ZOOS.

A win-win situation

Community engagement in the local region has been an integral part of the corporate philosophy at Rheinmetall since it was founded. In Düsseldorf, for example, the modern 3x3 version of basketball is benefiting from the company's support – and the increasingly popular sport is a good fit for Rheinmetall, too.

Defence! Defence!– a cry that rings out from basketball fans all around the world as they cheer on their teams. So really, what better partner could a basketball team have on its side than a security and technology company? Since October 2022, Rheinmetall has been supporting two professional 3x3 basketball teams from the state capital of North Rhine-Westphalia – men's team LFDY Düsseldorf and women's team the Düsseldorf ZOOS – as part of an agreement with D.SPORTS/Sportstadt Düsseldorf. Both teams play basketball at the highest level and compete in international tournaments.

10

minutes – the maximum length of a game

2022

– the year the Düsseldorf ZOOS were founded

12

seconds – the time a team has to score a basket

DÜSSELDORF IS A HUB FOR 3X3

That apposite rallying cry was of course not the main reason for Rheinmetall to support this special variation on the popular ball game. Philipp von Brandenstein, head of Corporate Communications at Rheinmetall AG, makes that perfectly clear: "We're delighted that Rheinmetall can make a contribution to the evolution of this sport, which is still relatively new. It's an excellent addition to our existing sponsorship commitments in traditional sports such as handball and table tennis." The fact that Rheinmetall is based in Düsseldorf is also a factor. With its two top teams, the city on the Lower Rhine is becoming one of the most vital hubs for the dynamic game of 3x3 basketball, which is experiencing a surge in popularity across Germany.

WHAT IS 3X3 BASKETBALL?

The sport of 3x3 basketball can trace its roots back to "streetball," which has been played in major US cities such as New York and Los Angeles since the 1980s and 1990s. It differs from conventional basketball in that three people play on each team instead of five. In addition, both teams shoot for the same basket. Unlike streetball, however, the game has clearly defined rules. Each game lasts a maximum of ten minutes, but a team can win before then by reaching a score of 21 points. The teams alternate between attacking and defending, with the roles switching when a team loses possession or scores a basket, for example. The ticking clock adds to the tension because the team currently on the offensive is given just twelve seconds to take a shot at the basket. Incidentally, 3x3 basketball has been an Olympic sport since 2020.

GOOD FOR THE SPORT, GOOD FOR THE COMPANY

Ties almost never happen in basketball – with very few exceptions, one side or the other always wins. In this case, though, there are actually two winners. The players, for a start, are thrilled to have such high-profile sponsorship, as team manager Emre Atsür explains: "What we've set up in Düsseldorf is absolutely amazing. That applies both to the professional side, where we've achieved success on the international stage, and in the youth game, where we've inspired a whole host of kids to get involved in our emerging Olympic sport. Achieving that across the different levels would not have been possible without the support of Rheinmetall." In return for its role as an official "premium" partner, Rheinmetall gets to display its logo on the LFDY Düsseldorf website, on banners at home games and on the team photos for both the professional lineups. Posts by LDFY and the ZOOS also occasionally link to the company's social media channels. This gives Rheinmetall a presence among a young target group that might otherwise never have heard of the company. ● *Pb*

→ For more information about community engagement at Rheinmetall, visit: **www.rheinmetall.com/en/responsibility/society/society-overview**

A glimmer of light in dark times

Beat Imhof knows Eastern Europe like the back of his hand. An employee of Nitrochemie in Wimmis, Imhof takes time out of his vacations to volunteer for an organization called Licht im Osten, delivering aid to the poorest regions of the continent. Since war broke out in Ukraine, every trip has become a challenge, but stopping has never been an option for him.

On the morning of February 24, 2022, one single topic dominated headlines all over the world: the Russian invasion of Ukraine. The realization that war had returned to European soil was a painful one for many. Beat Imhof was among them. The 50-year-old works in plant services at Nitrochemie Wimmis AG, a company in the Rheinmetall Group's Propulsion Systems business unit. For years now, the former truck driver has been spending his free time traversing the furthest corners of Eastern Europe on behalf of Licht im Osten, an aid organization.

"On that day, my first thought was for the people in Ukraine," recalls Imhof. "Even before the war began, many of them had very little to live on. I fervently hoped that it would still be possible to operate our aid shipments." After the initial shock had subsided, he and his colleagues at the aid organization acted quickly. Tools, personal hygiene products, blankets, winter clothing, household goods and many other essential supplies were dispatched to the beleaguered country on an almost weekly basis.

Now, a truck heads to western Ukraine roughly every three weeks, according to Imhof. Each truck's cargo consists primarily of personal hygiene products and cleaning supplies. The 1,300 km route wends its way from Switzerland via Munich, Austria and Hungary. The last time Imhof himself got behind the wheel was March 2023. "We may not be going anywhere near the front lines, but the signs of conflict were in evidence all around just a couple of dozen kilometers beyond the border. Streets are no longer maintained, workshops have closed and young men have almost entirely vanished from the towns and cities." At the destination in the region of Mukachevo, the trailer containing the aid was transferred to a different tractor unit before being taken in the direction of Kyiv.

The most strenuous part of the trip, which took around a week, was the return journey from Ukraine. "The controls at the Hungarian border are very strict. First the army checked us, then the Ukrainian customs officials and then Ukrainian soldiers again. Some trucks have to wait a full week before they can cross." There is a serious reason for all the complexity, which is that all men in Ukraine aged between 18 and 60 are required to enlist for military service, but some of them would rather not play their part in defending their country and seek to dodge the draft by fleeing abroad. To prevent this, the Ukrainian border troops carry out very rigorous checks on people leaving the country.

Imhof sometimes has his doubts, especially during these long periods of waiting. He is sacrificing his vacation time, after all. "You sometimes think, 'Why am I doing this?' But when the people there weep tears of joy when the goods are being handed out, all his concerns melt away. Being able to help people gives me motivation. And it makes you realize how good we have it in Switzerland and Germany."

We finish by asking him what his hopes are. After a brief pause, he answers by saying, "The best thing for Ukraine would be if this war were to end tomorrow." But it will be some time yet before the Russian aggressors are driven out of the country. Imhof knows that. "That being the case, I hope that the conditions remain in place to enable us to keep doing good work with our aid shipments." Millions of people are still suffering the consequences of the war and are reliant on humanitarian assistance. Imhof is planning to get back behind the wheel in early 2024. ● *Pb*

BEAT IMHOF,

born in Thun in 1972. Trained as a truck driver. Born in Switzerland, he has worked in plant services at Nitrochemie Wimmis AG since January 2013. He and his two colleagues are responsible for the upkeep of the entire site, which covers around 500,000 square meters, including roughly 35 hectares of forest. Before joining the Rheinmetall subsidiary, he spent 20 years working as a truck driver in Switzerland.

IMPRINT

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