

CONNECTED

WINTER 2023

MAGAZINE

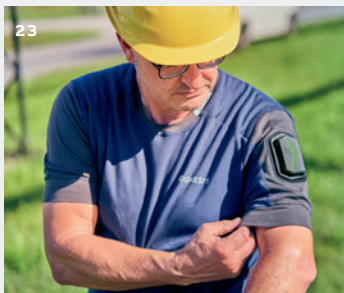
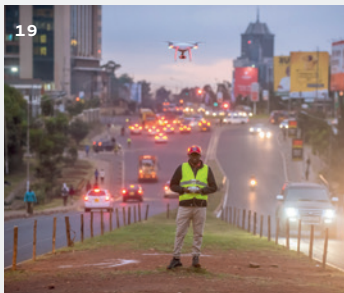
HYDROGEN CARS
ON THE STARTING LINE

DRONES TO FOSTER
SUSTAINABLE DEVELOPMENT

INTELLIGENT T-SHIRT:
AN ANGEL IN DISGUISE



IN THIS MAGAZINE



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EDITORIAL BOARD

Alexandre Pesci, Judit Hollos Spoerli,
Nicolas Huber, Tom Larkins, Peter Dent,
Cédric Savioz

WRITER

Nicolas Huber

TRANSLATOR

Judit Hollos Spoerli

GRAPHIC DESIGN

Thierry Winzenried

Caroline Ray

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WE ARE ANCHORED IN UK INNOVATION

A DECADE OF INNOVATION AND PASSION FOR YOU

Welcome to the 20th edition of our CONNECTED magazine which will soon celebrate its 10th anniversary.

A decade full of major developments, including a number of pressing challenges – the accelerating impacts of climate change, the pandemic, the war in Ukraine and the Middle-East... Rather than discouraging us, these challenges have strengthened our faith in science and technology. What drives them is the relentless quest to find solutions to problems. Contributing to their exponential quest and helping them to push their boundaries is the *raison d'être* of the LEMO Group.

And this is what has driven us to create this magazine for you. Every single issue has been promoting innovation, be it major or minor, through an impressive variety of applications. This

20th issue is no different: we present hydrogen mobility projects, a T-shirt that saves lives, drones serving sustainable development and many more. All of them dazzling highlights of human ingenuity, offering many good reasons to believe in the future.

CONNECTED exists also to thank you, dear customers and partners. Thank you for being there, for driving innovation, for striving to achieve excellence. We wanted to give you something nice and personal. We are pleased to extend this quest to the internet, where our new website promotes such applications better than ever.

We hope you will enjoy our journey and look forward to continuing it with you.

Alexandre Pesci
CEO LEMO

TECH-BITS FROM AROUND

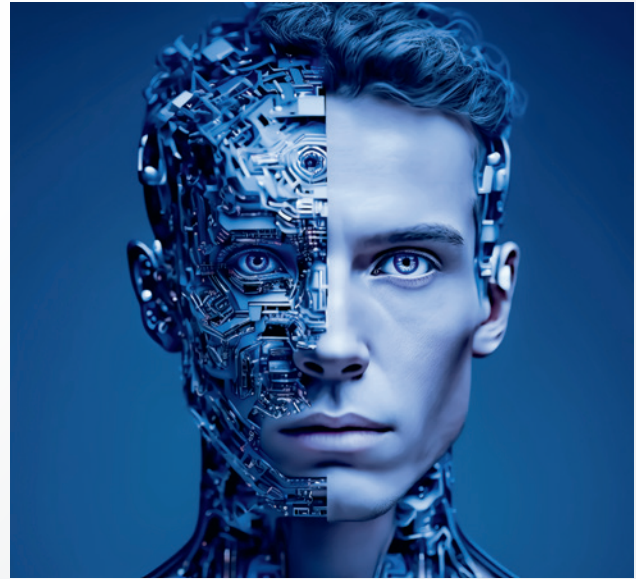


© Nasa

N°1

A long time ago in our galaxy far, far away...

Water, carbon, sulphide, magnetite and iron oxides are the components necessary to catalyse bioprocesses and initiate life on Earth. This is the composition of the sample – the largest piece ever collected from an asteroid in space – delivered by the Osiris-Rex spacecraft. The first analysis results, presented by NASA in October, seem to confirm that the “building blocks of life” may have been brought by asteroids colliding with our planet about 4 billion years ago. One of the challenges was to keep the sample completely isolated from contamination by earthly components. Launched in 2016, the Osiris-Rex mission travelled some 150 million kilometres to join asteroid Bennu, collect some sample material, then return to release its precious cargo into the Utah desert. The dust and rocks from Bennu will be studied for another two years by 200 scientists from around the world.

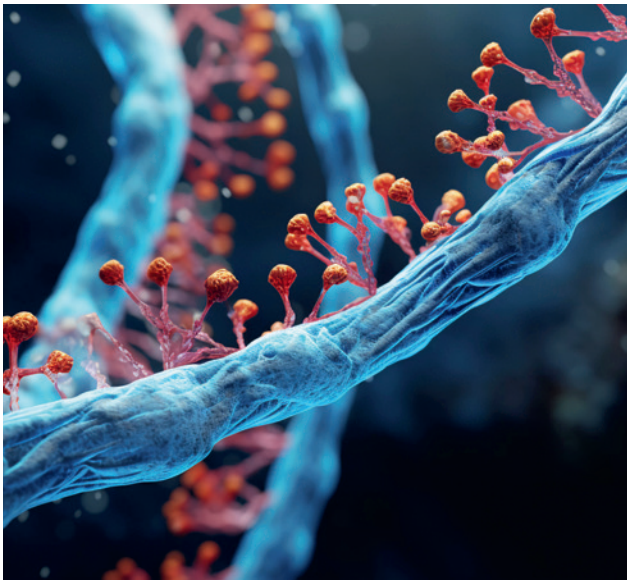


N°2

Back from the dead with AI?

Tamagotchi, those small virtual companions launched in the late nineties, were only the start of a strange relationship between humankind and artificial companions. Today, conversations with electronic friends are much more realistic thanks to AI and LLM (Large Language Models). Tens of millions of people have, sometimes rather intimate, dialogues with AI companions offered by services such as Replika and Soulmate Family. The blur between what is real and not involves emotional risks (in early 2023, a Belgian father followed a suggestion made by his chatbot and committed suicide to “join her”. What’s next? A trained chatbot with personal data (posts on social networks, chats...), that can simulate a “virtual copy”. Microsoft has filed such a patent but has refused to turn it into a product. However, others are already planning to give such chatbots the voice and appearance of an existing or deceased person.

THE WORLD



N°3

Nobel Prize-winning messenger

Messenger RNA (mRNA) vaccines can be developed much faster than classical vaccines. So, following the success of the first ones launched against the SARS-CoV-2 at the end of 2020, dozens of others are already being clinically tested to combat influenza, Zika, dengue, malaria, and HIV, raising enormous hopes. The lightning-speed development of Pfizer-BioNTech and Moderna during COVID, made conspiracy theorists anxious. However, it was, in fact, based on many years of research. In the early 2000s, biochemist Katalin Karikó and immunologist Drew Weissmann managed to lay the foundations of a new type of vaccine – synthetic messenger RNA that is not rejected by the body. With this mRNA, an instruction is transmitted to the cells to produce a virus protein. The body then detects the protein and is ready to combat the virus. Katalin Karikó and Drew Weissmann have recently been awarded the Nobel prize in medicine for their pioneering role.

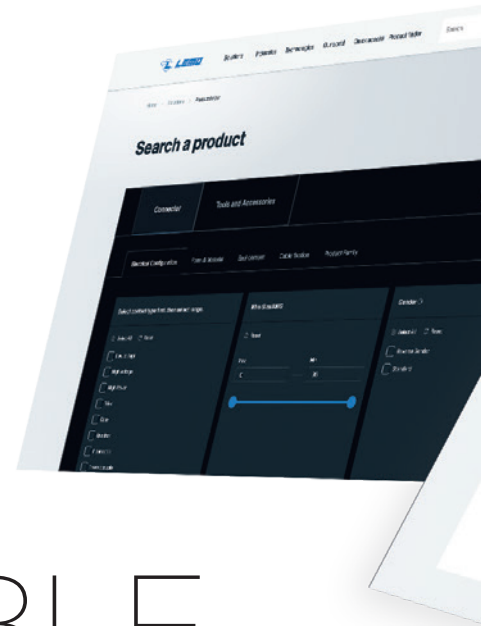


N°4

50% motorcycle, 50% android, 100% Motoroid

Back in 2017, Yamaha Motors turned heads when they unveiled the experimental concept: an autonomous motorcycle supported by artificial intelligence. The second version, presented by the Japanese manufacturer during the Japan Mobility Show this autumn, had a similar impact. Motoroid2 recognises its rider's face and approaches them. With its enhanced AMCES (Active Mass Centre Control System), the prototype "senses" the biker's movements during a ride and adjusts its centre of gravity – thanks to articulated parts – so that the rider doesn't need to shift their own weight. Additionally, its tyres tilt when going around a bend. At the end of a journey, Motoroid2 parks itself and deploys its stand. Its movements and autonomy are reminiscent of a pet animal and its design is worthy of the best science fiction Mangas.

© Yamaha Motors



THE NEW FACE OF A VENERABLE INDUSTRY LEADER

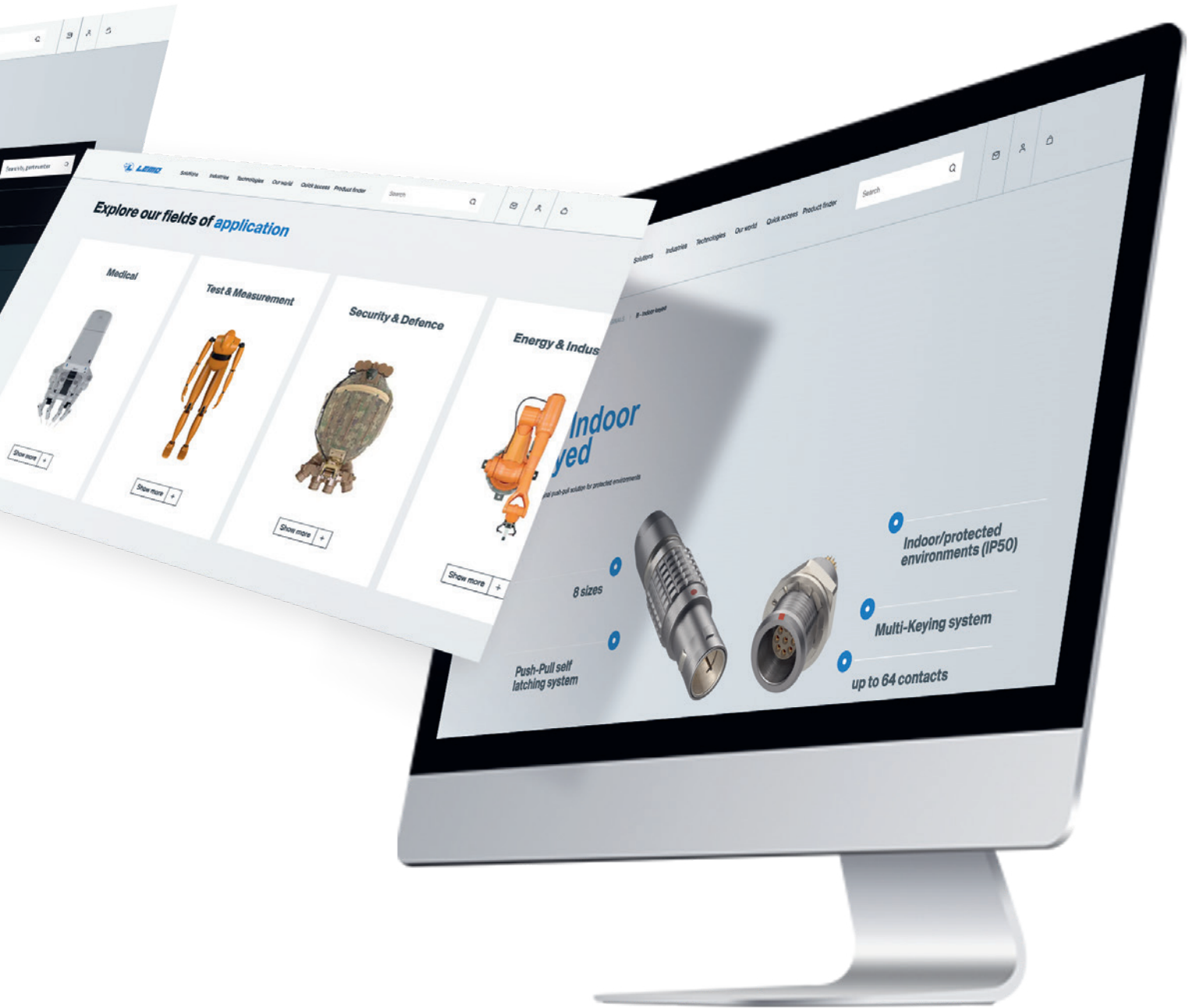
The redesigned LEMO website is a testament to innovation. It offers a smarter, richer, and more practical gateway to cutting-edge interconnect solutions for our valued customers as well as electronic and design engineers worldwide.

As a global benchmark, LEMO is dedicated to delivering services that match the quality of our solutions. Our newly launched website, with its 'mobile first' responsive design, ensures seamless access across all digital platforms. Its streamlined Swiss design underscores our commitment to excellence and innovation. Intuitive navigation mirrors the ease of use inherent in our Push-Pull system, originally invented by our founder.

Beyond its impressive design, the website places the customer at its core, introducing innovative features. The multi-criteria 'product finder' efficiently pinpoints the perfect solution, complemented by enriched product descriptions tailored to intricate requirements. A user-friendly comparator enables swift distinctions between solutions, empowering users to make informed decisions.

Customers can create accounts, save their discoveries, request quotes, and monitor their order status, enhancing their journey through our extensive product catalogue. Live chat is readily available on product pages for 'real-time' support, and contacting our subsidiary companies and distributors is easy through an online form. The 'Quick access' menu provides essential contact information, ensuring efficiency and ease.

Our content has been enriched with detailed information about the LEMO Group, its subsidiaries, history, sponsorship programs, and company culture rooted in family values.



LEMO's mission is to provide interconnect solutions that foster innovation across various industries, making lemo.com a valuable resource for electronic and design engineers worldwide. For example, the website indexes all the articles from the magazine you are currently reading, making them readily available for discovery and sharing.

Launched in late 2023, our website will continually evolve with new features and content, delivering an intuitive streamlined experience that helps our customers reach their goals. Our journey is just beginning. ■

FUELING THE FUTURE OF MOBILITY

Can the simplest element of the universe really solve the most complex challenge of our planet? Colourless and odourless, hydrogen has never attracted as much attention as now. In pursuit of “zero emission”, governments have been investing billions in hydrogen. Our special feature is dedicated to one of its promising applications: mobility.

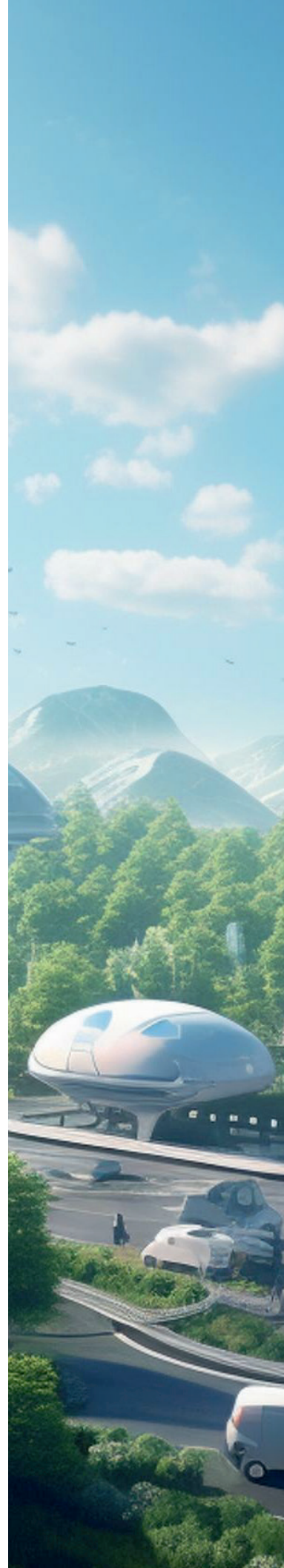
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PAGE 13 GREEN NAVIGATION: NO MORE SMOKE ON THE WATER

PAGE 14 FORZE RACING DRIVING AT 300 KMPH WITH NO POLLUTION







Dirty streets, dangerous traffic, polluted air, exhausting noise, rampant infections: transport caused a growing urban pollution problem in the... early 20th century. In fact, 120 years ago, New York, London and Paris were plagued by hundreds of thousands of working horses. Traffic was dense, the noise of metal wheels unbearable, and dust and horse manure caused growing health issues. When “carriages without horses” started to appear, it was welcomed as a revolution, a magic solution!

For a while, steam, electric and combustion engines were in competition. The latter came to the fore, multiplied exponentially... and now we are paying for the consequences of their nuisances that are much more insidious and dangerous than horse manure: threatening health, and a serious threat to humanity. Electric vehicles are back on centre stage.

Today, however, no one believes in a magic solution. Electric vehicles don't emit CO₂, but their design presents some issues, and their carbon footprint isn't neutral. Are there any better solutions? Here comes hydrogen, labelled “the energy of the future” for decades.

Hydrogen vehicles have experienced a strong growth these last few years. Some sources have even mentioned an 80 to 100% increase in H₂ vehicles since 2020. Have you seen them running in the streets? Not really? It is normal, as the relative figures show the reality of a solution which is still in its infancy.

In fact, there are allegedly only about 60,000 hydrogen vehicles running around the world. It seems like peanuts compared to the 10 million electric vehicles and 67 million vehicles (all categories) sold in 2022. Nine out of ten are running in only four countries (South Korea, USA, China and Japan). Volume production series are limited to two models only: the Hyundai Nexo and the Toyota Mirai represent 98% of sales (Honda abandoned the H₂ version of its Clarity in 2021).

Yet, hydrogen vehicles have multiple advantages. Firstly, compared to traditional cars: their fuel cells emit only a little water into the atmosphere, which is great for combatting climate change (and for the health of our lungs). Hydrogen cars also present major assets compared to electric cars: their tank is refilled much faster (a few minutes) and offers twice as much autonomy.

So, what's holding back demand? The usual reluctance to embrace such a major innovation. The lack of infrastructure (only a few hundred recharging stations around the world!) The high purchase price (around 60,000 dollars, twice as much as some electric cars) is pushed up by high production costs. Hydrogen has made better progress in heavy commercial vehicles (vans, trucks, buses) where the lack of autonomy and the lengthy recharging of electric batteries are critical issues.

For the user, the picture is also mixed upstream. As explained by our interviewee (see page 10), current hydrogen production – largely fossil-based – is a problem. And green hydrogen production (by electrolyzers) is far from being scalable. For instance, there are a dozen projects of producing hydrogen from wind energy in Europe (H₂Mare by Siemens Energy, SEM-REV by Lhyfe...), but they are still “proof of concept”.

This could rapidly change. Governments that have set ambitious goals for CO₂ reduction cannot go ahead without considering hydrogen. It enables the storage of electricity produced by renewable energies, replaces part of our heating, which is an enormous source of pollution. Additionally, it can power part of our transport system, currently using 20% of the energy produced worldwide. So, the benefits for the environment are potentially massive. Billions of dollars have been invested, boosting the market. From hydrogen production to fuel cells, safer, more compact and environmentally friendly storage, everything is being studied, rethought and optimised.



TOWARDS CARBON-FREE MOBILITY

In mobility for example, the energy demand of an aerial H₂ long-distance transport network is being evaluated (as presented in a study this summer by MIT). Hydrogen engines are being tested on boats (by technical schools, see page 13) and on heavy duty land vehicles (tractors in China, Daimler and Volvo trucks).

Cars are not left out either: big brands should soon join Hyundai and Toyota. Honda has announced its comeback on the market with an hydrogen version of its highly popular CR-V for 2024. BMW has been testing a small series of H₂ iX5 and plans its launch between 2025 and 2030. The VW Group has set up a dedicated team at Audi. Kia is planning to adopt fuel cells in the coming years.

Experts are expecting a continuous double-digit growth for hydrogen vehicles. The car market could leap to an estimated 29 billion (1 billion in 2020).

So, yes, we will end up seeing H₂ cars on our streets. For sure, they will be designed and sold as objects of desire. However, we should foremost consider them as our war horses in the Armageddon of climate change. ■

Upstream: hydrogen production

The most abundant element in the universe, hydrogen is rarely present on Earth in a pure state. So, it must be extracted, which requires a lot of energy unfortunately. Extracting hydrogen from hydrocarbons (petrol, natural gases) is the most polluting, the cheapest and the most common (we talk about grey hydrogen). On the other hand, obtaining it by water hydrolyse using renewable energy (green hydrogen) is the least polluting but the most expensive. As a pillar of energy transition, the latter decarbonated production, requiring mass production of electrolysers is widely supported.

Storage: hydrogen as a vector

Hydrogen can be stored in liquid (at -250°C) or gas (at 700 bars) form and transported. It complements renewable energies making it possible to store the electricity that they produce. Solutions still must be found to reduce the environmental footprint of storage and transport, which are both energy-consuming.

In action: producing electricity

For an equal mass, hydrogen contains three times more energy than petrol. To recover this energy, it can be burnt. It can also be used in various fuel cells, that produce electricity by chemical action. Proton exchange membrane fuel cells (PEM) have established themselves in vehicles thanks to three decisive advantages: efficiency, functions with air, at ambient temperature. In a PEM, hydrogen supplied to the anode splits up into protons and electrons. Protons pass through the (solid) polymer membrane towards the cathode and electrons follow in an external circuit, creating electric current.

Downstream: clean mobility

At the PEM cathode, protons and electrons combine with oxygen, forming water, the only byproduct of the reaction. This is how fuel cells generate electricity without emitting CO₂ nor other polluting or greenhouse gas, which makes them a potentially fantastic tool to combat climate change. ■

HYDROGEN, FUEL OF THE FUTURE?

AN INTERVIEW WITH PROFESSOR JAN VAN HERLE



© EPFL/Alain Herzog

Electric cars have been highly successful, and they don't emit CO₂. So, what's the use of exploring an alternative solution? This was the naive question addressed to Jan Van Herle, an expert in electrolyses and fuel cells, researcher, and professor at the École polytechnique fédérale de Lausanne (Swiss Federal Institute of Technology Lausanne).

Professor Van Herle, aren't electric cars sufficient for clean mobility?

Jan Van Herle: Current electric batteries are not the perfect solution. Their repeated charging and discharging cycles negatively impact their durability. Besides, recharging takes too long, which is not practical for the users. Their weight increases proportionately with the required autonomy and so you quickly reach a limit: it is hardly efficient to embark battery weighing several hundreds of kilos, part of which will never be used. Moreover, lithium resources are limited and will end up lacking. The use of hydrogen would mitigate some of these problems.

How?

By doing exactly what is already being done in hydrogen cars: replacing part of the heavy electric battery – storing electricity – with a fuel cell and a hydrogen tank – that will produce electricity. The cell is the main source of energy, the battery provides power – acceleration, and driving dynamics. A combination of the two provides a lighter solution with twice or three times as much autonomy, depending on the case. It also increases the battery's lifespan since the fuel cell keeps it in a reasonable charge status – avoiding deep discharge. It's a win-win solution.

What is the fuel cell/battery proportion?

Manufacturers adapt the proportion according to their intentions. Typically, it is fifty-fifty. A Hyundai Nexo is an almost purely hydrogen car: it has a battery, but it is the 5 kg of H₂ on board that drives it over 500 km.

The solution is still in its early days, is it performing enough?

Over the last few years, research and strong investment in the car industry have contributed to greatly enhancing their performance. We can see the progress for example in their power density – the kilowatts produced in relation to the cell volume. In the beginning, it was around 0.5 kW/l. Then it reached 1 kW/l. Today, in mass production, the Toyota Mirai 2 is at 5 kW/l. Some companies have designed cells that provide 8 kW/l. So, cells have become highly compact, and their performance is rather impressive.

How about the price? A hydrogen car is much more expensive than an electric car...

This is probably the main obstacle to their widespread adoption by the public. Some of the materials used in fuel cells are costly. Platinum, used as a catalyser is expensive, but it is used in smaller and smaller quantities. The polymer of the membrane is not cheap either. Bipolar plates are made of graphite, coated steel, or Titan. The latter is expensive. Moreover, it needs to be protected against corrosion in an acid environment. However, all these costs depend on production volumes. Thermal engines, composed of thousands of components, are also costly to start with. But, since they are mass-produced in 70 million copies a year, the price goes down to 50 euros per kW. If the same tendency applies to PEM fuel cells, their price will also drop.

There is a strong increase in hydrogen vehicles. However, when we compare their numbers with all car categories, they are paltry: 60,000 on the road, 1,000 filling stations planned in Europe by 2030...

Clearly, we are only at the very beginning. Manufacturers invest with prudence, evaluate the demand, and move forward step by step. Infrastructure also needs to be developed.

... especially that it is not possible to charge one's car "at home" like an electric car.

In theory, it should be possible. Nicolas Hayek, late CEO of the Swatch Group (and initiator of the Smart micro-car) imagined that houses could have an electrolyser powered by solar panels. It is technically possible, but too expensive and complicated from a safety point of view.

So, filling stations should be multiplied...

... which is also expensive. But again, unit prices will drop with increasing quantities. Note that the number of stations is not necessarily a limiting factor: there is no need to have that many to guarantee the rise of hydrogen cars. Once it starts, progress may be rapid.

Further upstream, there is the problem of the origin of the hydrogen used. Currently, 95% of its production comes from fossil energy, which ruins the very idea of "clean vehicles"...

For mobility, green hydrogen is a must, otherwise, it makes no sense. The proportion you mention can be explained by the current dominant use of hydrogen: heavy industry. It is used to produce ammonia (an essential component of fertilisers), to produce methanol, to remove sulphur from oil and to create value-added petroleum products. These are large-scale uses, and the hydrogen is derived from fossil fuels because they are the cheapest. By extracting it from natural gas, coal or, in the case of the petrol industry, from petrol itself, it costs 1–2 euros a kilo.

So how can green hydrogen be produced?

By electrolysis of water using energy from renewable sources – photovoltaic, wind, hydro...

Is this feasible on a large scale?

The world, and Europe in particular, is engaging huge resources in energy transition, of which solar and wind power are the pillars. Hydrogen is part of this effort because it offers a solution to the problem of storing renewable energy.

For example?

We can't "store" the excess electricity produced by a 2 MW wind turbine in the electricity grid, but we can put an electrolyser at the foot of the wind turbine, which will use electricity to produce hydrogen, which can then be stored and used later. We still need to improve the various solutions for storing and transporting H₂, which represents a heavy weight in the overall energy balance of this solution. However, scientists and politicians are pushing for large electrolysis capacities. Gigafactories of electrolysers are being considered to capture green energy and transform it into hydrogen...

(Continued on page 13)



(Continued from page 11)

... which vehicles can then use.

Exactly. The development of (large) hydrogen-powered vehicles is part of the energy transition. They are benefiting from its progress and are being driven by it.

What is required to boost this development even further?

Technological innovation or policy?

Both. A transition of this kind can't happen without strong political will. Technologically speaking, nothing is ever finished: the combustion engine has been around for 150 years, and billions are still injected every year to improve it... For fuel cells, we need to find ways of reducing the use of platinum. Because it's expensive, limited, polluting to extract and fragile to source (90% in South Africa, with Russia in the second place...).

In conclusion, what is your vision of the future of hydrogen-powered vehicles? Will they become dominant?

No, they won't. They will coexist with various complementary solutions. Electric batteries seem to be the best solution for light vehicles - bicycles, motorbikes, cars, etc. Fuel cells for heavier vehicles - commercial vehicles, lorries, boats, trains, etc. For very heavy vehicles and for covering large distances (crossing an ocean, etc.), fuel cells pose a storage problem, so liquid fuels will be used because their energy density is better. Ammonia and methanol are being considered, and we need hydrogen to produce them! Green mobility will need all these technologies. ■

NO MORE SMOKE ON THE WATER

Lightweight boats can also be powered in a clean way by fuel cells. The LEMO Group sponsors two engineering student teams who, after years of solar projects, are now exploring the full potential of this technology, pushing back the boundaries of innovation. The two teams know each other since they have both been participating in the most important meeting dedicated to clean navigation: the Monaco Solar and Energy Boat Challenge. The annual competition brings together about fifty teams from 25 countries.

Técnico Solar Boat, hailing from Instituto Superior Técnico (Portugal), started creating and developing a hydrogen boat as well as its own electrolyser in 2019. In 2021, they completed their first catamaran prototype (equipped with a 5 kW fuel cell). Their hydrogen system won two Innovation Prizes (in 2020 and 2023) at the Monaco Challenge.

Swiss Solar Boat team began testing a fuel cell on their asymmetrical "Dahu" (as featured in CONNECTED 17) just this year. The objective of the Swiss team is to enter the race with a hybrid hydrogen-solar boat in 2025.

There is a lot of hydrogen in water. Soon there will also be more hydrogen on the water. ■



© Técnico Solar Boat

HYDROGEN SUPERCAR BUILT BY DUTCH STUDENT TEAM

Hydrogen-fuelled cars do exist, but can they compete with high-performance cars, such as the supercars running in official races? Yes, they can, answers Dutch team Forze Hydrogen Racing. The proof is their spectacular Forze IX, designed to become the fastest hydrogen car in the world.

With its 5 m by 2 m dimensions, aggressive features, painted sky blue and white, the Forze IX has the looks of a supercar. Its performance - dashing from 0 to 100 kmph in less than 3 seconds, reaching a maximum speed of 300 kmph - is also that of a supercar. However, its engine is unique: a dual proton exchange membrane fuel cell, powered by four hydrogen tanks compressed to 700 bars, producing the electricity to move the four drive wheels.

Forze Hydrogen Racing has been preparing this car in view of participating in the Supercar Challenge, a series run on circuits in the Netherlands (Zandvoort, Assen), in Belgium (Spa, Francorchamps) and Austria (Red Bull Ring). "We want to compete in GT category, the fastest of all, alongside Porsche, Ferrari, Bentley, BMW..." explains team leader Abel Van Beest. To face them as equals but emitting only a little water vapour in the atmosphere.

Created in 2007 within Delft Technical University, Forze Hydrogen Racing developed, within a few months, a first model from scratch. Forze I, a 266-kg kart that accelerated from 0 to 90 kmph in less than 5.5 seconds was then considered as the first hydrogen race car in the world. It took ten more years of passionate work for another Forze - the VII - to become the first one to enter a professional competition (a Supercar Challenge race).

The journey is all the more remarkable considering that it is the work of a continuous succession of students. The first team, back in 2007, involved about 40 part-time contributors. Presently, there are around sixty team members, half of them enjoying a gap year to be fully dedicated to the project (if 80 hours a week is simply considered "full-time"). The team is renewed every year, which means an enormous challenge as far as knowledge transfer is concerned (shortly after his interview, Van Beest has actually handed over the lead to his successor). Luckily, more than one of the "oldies" stay active, adds Van Beest: "a hundred or so alumni continue to help us!"

Forze Hydrogen Racing has progressively distanced itself from TU Delft and finally set up a non-profit association in 2020. 90% of its staff are still from the Dutch university, but it has also opened up to outside talent.

Three years have been dedicated to the Forze IX, which resulted in exceptional performance.

"Fuel cells are very good in delivering constant power", explains the team leader. "But to stand up to petrol-fuelled cars, we had to boost power. We have designed an additional battery system which added an extra 360 kW, which is altogether 600 kW, twice that of Forze VIII!"

This increase entailed providing much more hydrogen to the fuel cell as well as other adaptations requiring extra space. "So, we had to completely reconsider a number of components – recirculation pump, ejector system, gear box... to make them more compact."

The fuel cell is supplied by a German company EKPO, but all the surrounding systems have been designed by Forze Hydrogen Racing, says proud Van Beest. "We have developed solid know-how in efficiently conveying hydrogen and oxygen to the cell. And, more generally, in integrating all these technologies in a race car."

Forze Hydrogen Racing would not have succeeded without convincing an impressive list of small and large partners (currently more than a hundred). "Some give us money; many more provide technological support". This is the case with LEMO, supplying robust F Series connectors. "Some partners help us in other fields, such as marketing or communication."

Forze IX was presented with much pomp and circumstance in February 2022. Since then, the team has been working on validating the design and, most of all, producing multiple components.

© Forze Hydrogen Racing

"We create and produce as much as possible in-house. This is one of the challenges of the project, but also a substantial part of the students' training. It involves a lot of testing and repeat visits to the drawing board."

The first road tests have been run this year. In particular, those of the drivetrain and the hydrogen system. Participating in the Supercar Challenge races is planned for 2024. A first one in April, then, depending on the driving characteristics and reliability of the car, some others. Ideally, ALL the others. On the longer term, the team plans to pass endurance tests and is dreaming about the iconic 24 Hours of Le Mans.

However, the races are but a minor part of the mission, concludes Abel Van Beest.

"Forze Hydrogen Racing has chosen motor sport, because it is extremely demanding in terms of engineering. And because it is very "sexy" – useful to attract students, partners, the media, the public... But we are using this application to tell a story on a larger scale: hydrogen will play a crucial role in the energy transition that our planet needs. It is important to tell this story and to train young engineers who will make it a reality." ■

▼
The 24 Hours of Le Mans run with a hydrogen engine?
Forze Hydrogen Racing wants to make that dream a reality.



SUPER MAGNETIC INSPECTOR

Bike, a small magnetic robot is capable of exploring large oil and gas facilities. Its uniqueness lies in a combination of agility and 3D localisation. A “Made in Switzerland” solution within the portfolio of US company Baker Hughes.

It is pitch dark, with only some distant metallic echoes to be heard. We are inside a pipeline of a gas power station, a labyrinth of criss-crossing pipes. Suddenly, there is a flash of light coming through a circular opening, followed by its source: a twenty-cubic-centimetre robot crawling down a chimney. It manoeuvres to enter the horizontal pipeline headfirst and moves forward whilst inspecting the site.

This amiable solitary robot isn't called Wall-E, but Bike. Unlike Wall-E, it is a perfectly real solution proposed by Waygate Technologies, a leading business in industrial inspection and non-destructive testing (NDT) as well as a subsidiary of energy equipment giant Baker Hughes.

Bike was designed for hard-to-reach inspections that are inaccessible to humans, due to size constraints, verticality, or efficiency. Whenever human intervention would require emptying and cleaning up, scaffolding or alerting rescue teams, Bike can indeed save a lot of time and energy. All you need to do is carry it (1.0 to 1.5 kg depending on the configuration), place it at the end of a pipe, grab the remote control and start the inspection.

Bike takes contact measurements (impossible for drones), and its use is lighter than a “serpent” type inspection robot (a long-articulated arm requiring massive counterweight).

Such simplicity has convinced more than one: Waygate Technologies has sold about a hundred Bike robots since its first launch a few years ago. Its customers are energy and chemicals companies that wish to integrate it into their processes, inspection companies and site operators. Bike crawls through power plants, hydroelectric plants, and oil and gas facilities around the globe. It inspects gas turbines, pipes, pressure vessels, heat exchangers and even vessel hulls.



© Waygate Technologies

Thanks to its highly articulated locomotion system, Bike is capable of negotiating concave and convex angles.

The robot's impressive agility is based on its locomotion system, at the core of the concept initiated in 2009. The Swiss Federal Institute of Technology in Zurich and partners at that time worked together to create a magnetic inspection robot capable of negotiating inner and outer right-angled bends. It was an exciting technological challenge: how do you change directions at a right angle when super magnets "stick" the robot to the wall?

The first iteration included only two wheels, one behind the other (the name "Bike" is a reference to this initial choice). The extremely compact design made it possible for the robot to slip into very small-diameter pipes. It was useful for inspecting narrow pipes, but too unstable and weak for transporting the payload required for many missions. So, they moved on to a four-wheel version with a larger platform that still crawls ahead easily in 30 cm-diameter pipes (40 cm if it needs to manoeuvre).

Negotiating concave and convex angles requires a highly articulated locomotion system which Bike is fitted with. The two gears are independent, each can turn 90 degrees to the right or the left, with 30 degrees of gimbal (required for moving with agility over the pipes' curved surface). And each wheel has its own ultraprecise engine, for separate speed control and appropriate allocation of steering forces.

The development process took several years and resulted in several patents. Bike was ready in 2016 and test-run by the first customers before being launched on the market in 2018. The project is just as sinuous as the robot's paths. With mergers and acquisitions, the lead went to Baker Hughes, who consolidated their industrial inspection activities in 2020 under a new entity, Waygate Technologies. However, development and production have continued to be "Made in Switzerland".

The robotic platform was one thing, but it still had to be equipped for inspection missions.

Bike is laden with cameras. Those for navigation, in the front and back, equipped with fish-eye lenses and lighting, enable the operator to guide the robot. And the inspection camera, thanks to its hinged support, can film in all directions, poke in a pipe or capture super close-ups. The robot also comprises a borescope – a long low-friction tube (10 m, even 30 m) that can be slid into the most confined spaces to film with a micro camera the hard-to-reach points (joints and welds, bends, nozzles).

Engineers have also developed an ultrasonic transducer. Placed between the front wheels of Bike, it measures and verifies pipe or pressure vessel wall thickness. It detects possible corrosion. Since ultrasound waves pass poorly through the air, the contact between the sensor and the wall is ensured by water from a neat outside pump.

Collected data is valuable, but even more so when geo-tagged with great precision. However, this poses another technical challenge, as Bike's environment makes GPS usage impossible. Waygate Technologies had to design a unique localisation system, using a lidar that automatically retraces the robot's path in a 3D environment. The operator always knows where it is. Every image captured, and every ultrasound thickness reading is precisely located, which makes subsequent intervention possible. Moreover, it makes it possible to repeat the same inspection, and so to measure the evolution of the situation.

Cameras, ultrasonic transducers, and a navigation system have become Bike's standard equipment. Many customers are happy to use it for their inspections. Others purchase the naked platform and add their own components. Some others choose the optional modules offered by Waygate Technologies.

Among these, there are additional attachments for cameras and borescopes. Rubber-coated wheels to avoid scratching delicate walls (painted or coated). Additional magnetic wheels for carrying heavier payload. Longer umbilical cables for deeper inspection (the use of optical fibres, for very special applications only, enables the robot to venture up to 200 m).

If further customisation is required (a remote arm, other sensors, etc...). The business develops tailor-made solutions and provides engineering support to its customers.

Bike uses several LEMO solutions for power and signal transfer. Various versions of the robust K Series, designed for outdoor applications, connect for instance the umbilical cord, the control, and numerous external modules including the ultrasonic sensor, and the lidar. They were selected thanks to their renowned reliability and ease of use.

Some functionalities are way too specific to be part of Bike's standard package (for instance, Waygate has created a version capable of descending 10 m underwater). However, the company strives to integrate what's most useful for its customers. So, its robot keeps evolving and increasing its capabilities.

Currently, Waygate Technologies is in the process of working on a revolutionary functionality which will raise Bike to a higher level. Which one? – you may ask. Bike has just disappeared into a lateral pipeline and darkness is back again. We won't learn anything more today. ■

Working upside down? No problem for this robot!



© Waygate Technologies

SUSTAINABLE DEVELOPMENT PROPELLED FORWARD

Initiated by four enthusiasts, the Flying Labs network counts on local competencies to boost the use of drones in emerging countries. A couple of hundred projects later, the impact of this small ecosystem keeps growing.

A snake bite in the middle of the Amazonian Forest: a drone flies over the canopy to deliver a dose of serum. In Cameroon, forest wardens monitor national parks for poachers from above. In Tanzania, farmers control the health of their crops and deduce their potential income. Following a landslide in Nepal, an algorithm analyses aerial views to organise reconstruction.

These applications, like several others, share one thing in common: they have been ensured by Flying Labs. This UAV professional network carries out local missions in emerging countries, consistent with the United Nations sustainable development objectives.

The concept's origins go back to 2015 when members of two associations met to promote the use of drones for good. On the one hand, Patrick Meier and Andrew Schroeder from the US association UAviators; on the other, Sonja Betschart and Adam Klaptocz from the Swiss Drone Adventures (that became Drone for Earth). Two of them work in the technological (development & hardware), the other two in the humanitarian field and all of them fly drones. They are all convinced that UAVs are excellent vectors for development.

▼
Powerful data collection tools, drones are also excellent for promoting technology to youth.

© WeRobotics





© WeRobotics

"Training and controlling are simple" explains Sonja Betschart. "Preparation and data analysis - with existing software, algorithms and machine learning modules - don't require complex training for the engineers either. These tools are a natural part of their activities, it doesn't require a revolution where everything needs to be relearnt."

The specialist readily compares drones with mobile phones, which have become omnipresent in emerging countries at incredible speed, thanks to a combination of usefulness and simplicity.

With UAVs, the south opens access to geospatial data, like never before (nine applications out of ten are for data collection, and the rest are for transport). Accessing this data is infinitely easier and more cost-effective than obtaining it through satellites, planes, or helicopters. The areas covered are smaller, *"but there is often sufficient data for analysing a local or regional situation and for making a decision."* Last but not least, adds Sonja Betschart, data acquisition is much more independent, *"local players produce their own data."*

Why isn't the UAV potential better used in emerging countries, despite the existence of local professionals?

"We realised that what was missing above all was access to opportunities," said Sonja Betschart. *"Local competencies are still dispersed, barely visible and the assumption that "Foreign experts*

are better" still predominant. Not only do these experts lack deep knowledge of the place and its players, but they also leave with their technology and competencies once their mission is accomplished. Calling on them is not a sustainable approach." So, there was a need to develop local UAV competencies *"and we took up the challenge."*

The four specialists partnered to create WeRobotics, a non-profit association that would take care of the networking. Then they selected the Flying Labs that would be members of the network. *"We started off with a two-year proof of concept in Nepal, Perou and Tanzania. It resulted in the social franchise model that we implemented in 2018."*

The model has caught on straightaway through its "bottom-up" approach chosen by WeRobotics. Unlike development NGOs, there is no centralised unit that goes on to open local satellites. *"It is the local companies that contact us to join the network. It is also the companies themselves - and not WeRobotics - that propose pilot projects."* By the way, the Labs are managed and financed locally.

WeRobotics - comprising only a dozen people - acts mostly as a facilitator. It brings stakeholders together, creates support material, internal programmes to assist Flying Labs in developing, better managing projects, and measuring their impact. If required, it provides technical support.

Representing all its members, the organisation has more impact when it comes to finding global partners for niche applications and local markets. It has successfully convinced an impressive number of them, including donors such as the Rockefeller Foundation, the Bill & Melinda Gates Foundation, the Hewlett Foundation, the Autodesk Foundation; major drone manufacturers, such as DJI, Skydio, Parrot; and software designers, such as Pix4D, Esri, Autodesk, who supply technologies and training; bringing them together with the demand (the World Bank, UN agencies, NGOs, universities...), international players who are usually inaccessible for local UAV service suppliers.

There are of course internal partners as well. Openness to cooperation, and willingness to help the other members of the network are part of the admission conditions. *"The Labs must share their experience via in-person or online meetings, document their projects and contribute to work groups"*. WeRobotics keeps an eye on things, and recontacts those who are too focused on their everyday activities and forget to share. It develops and continuously improves the tools fostering exchange. There are obvious benefits. Whenever a Flying Labs gets a request that is out of its scope (for instance landslide mapping), it can contact another member who has such experience (the Nepalese Lab in this case).

With its bottom-up approach, the Flying Labs network is perfect for developing local expertise.

"There is direct access to experts and data. The Labs can rely on existing material – processes, flight plans, data processing... – and avoid repeating the errors of others. They adapt their projects and then they in turn share their experience." Together, external partners and network members feed a particularly productive "UAV ecosystem". There are plenty of opportunities and the Labs are better prepared to meet the demand. First of all, the demand for local solutions: "80% of requests come from local research centres, local NGOs, local communities and authorities" explains Sonja Bertschart.

WeRobotics' "bottom-up" approach and the advantages of the network have convinced an increasing number of UAV players in emerging countries. The number of Flying Labs has been regularly increasing, even if some of them don't survive, because they fail to ensure the long-term sustainability of their projects. Currently, there are about forty, half of them in Africa, 30% in South America and 20% in Asia."

Since 2019, Flying Labs have ensured 400 applications in the form of local projects and training, contributing to public health, environmental protection, humanitarian actions, education, the economy...

In addition to the above examples, they have transported COVID tests; reported on illegal mines; spread "healthy" mosquitoes to replace those infected by Zika or dengue fever; measured air quality above waste dumps; evaluated reconstruction after floods; censused birds and sharks on their breeding sites; analysed urban development; livestock management; mapped soil erosion and deforestation. Another example: in Kenya, WeRobotics partnered with the EPFL, Swiss Federal Institute of Technology Lausanne, for a project using a swarm of drones to analyse and smooth traffic flows in Nairobi, one of the world's most congested cities.

Even if incomplete, this list illustrates the impressive diversity of what drones have to offer to the natural and human environment.

The impact of each project is remarkable. WeRobotics is also keen on promoting the global impact of its network in emerging countries. Sonja Bertschart mentions the 400 people committed to Flying Labs, a quarter of them women (which is twice as many as the average in the area). She quotes the over 250 local partners assembled by the network and the 4,000 professionals who got training to integrate drones in sustainable development. Last but not least, the 35,000 people (from local authorities, companies and institutions) who have been involved in the hundreds of discussions, conferences and workshops.

(Continued on the lower half of the next page)



© WeRobotics



LEMO & DRONES, THE SKY IS NO LIMIT

Flying Labs are using both mainstream and commercial drones. LEMO focuses on the latter, with already two decades of experience in professional UAVs.

LEMO solutions, renowned for their ruggedness and resistance to harsh environments (resistance to vibrations, extreme temperatures, dust, water, etc.) as well as their high reliability and compact design, seemed to be the perfect match for the exacting requirements of drones. They equipped the very first "all-weather" certified commercial drone launched in 2015 (see CONNECTED 3).

LEMO has taken off all the more naturally in the drone business, since it has been long-established in the demanding applications where drones are now commonly used. In test and measurement, for example, with data acquisition technologies (lidars, scanners, cameras, gyroscopes, infrared sensors). In aviation (navigation, flight control), power supply (propulsion system, power management, battery control and recharge), and communication (with the ground stations).

Several LEMO connector series can be embarked on UAVs and their equipment. Recently, professional drones have even become the main market of the legendary M Series, originally developed for motorsport, and a benchmark for extreme environment connectors. The journey has just begun, since LEMO considers drones as a privileged market. It develops new solutions to better meet UAV requirements (compact design, lightweight, high-speed data transfer, high power for engine connection).

Additionally, the Swiss brand also equips leading companies, in Europe and in the USA, for eVTOL "giant drones" (electric vertical take-off and landing). These flying taxis are not mere science-fiction: some will even be used during the Paris Olympic Games in July 2024. ■

© WeRobotics



The "drone ecosystem" does not attract adults only. With their futuristic looks, fluid flight and easy control, drones are excellent technology ambassadors for young people. WeRobotics counts a lot on this: three-quarters of Flying Labs organise STEM programmes, encouraging thousands of girls and boys to learn about

◀ *Even if not yet widespread, freight transport is one of the applications explored by Flying Labs.*

drones and, by extension, robotics and data as well as technical and scientific professions in general. Another way of contributing to development.

How about the future of WeRobotics? Further network expansion of course, but not only. *"We also want to enhance quality. We are working on the creation of centres of expertise – involving Flying Labs and its partners – that should be recognized both in the south and the north."* Areas of expertise abound, whether directly linked with the use of UAVs (for example the Labs support authorities in developing rules and regulations), or stemming from field projects, *"for example from natural disaster management, urban development..."*

Actively involved with operations, for Sonja Betschart hardly a day goes by without a videoconference with one or two Flying Labs around the world. What she likes in these discussions is *"The enthusiasm, the competence and all the possible applications – I think we have just scratched the surface! The development of UAVs, their sensors or data processing will further increase their impact."*

Are the seeds of sustainable development planted by drones? It seems that the sky is no limit. ■

THE ANGEL WEARS T-SHIRTS

In the event of a severe electric shock, reaction speed is vital. So, the Austrian company Adresys has come up with a solution that is both high-tech and discreet to detect accidents and raise the alarm: a smart T-shirt.

Electricity has two faces. It is this beneficial energy running through our body and the modern world. However, it is also the dangerous invisible monster that we warn our children about.

It is a fact that the power used by our equipment and installations has nothing to do with the power animating our nervous and muscular system. It only takes a fraction of a second for beneficial energy to transform into a dangerous monster with a violent bite: shock, tetanisation, various first- and third-degree burns, cardiac arrest and death.

The severity of the accident depends on multiple factors – voltage type, current strength, contact surface, the path followed by electricity through the body, the duration... It also depends on what happens after the electric shock – unconsciousness and falls also have their consequences. The danger is not only immediate: an electrocuted heart may stop after a few hours following the accident. An ECG is conducted on the patient to determine the risks.

►
Only tight-fitting sleeves and the Genius give away the T-shirt's "intelligence".



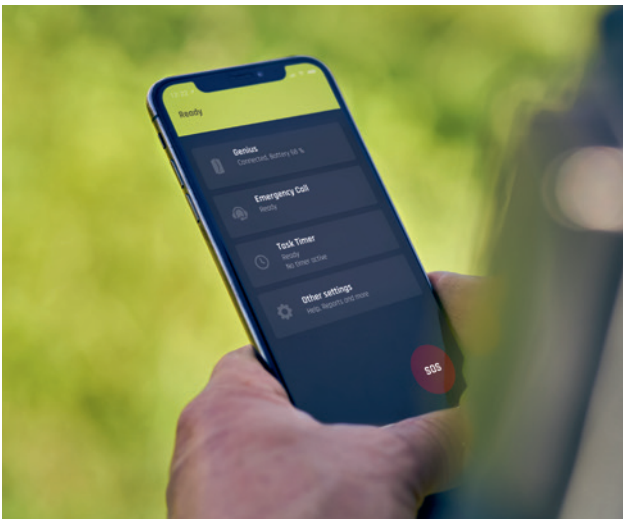
© Adresys



The Genius fitted on the worker's shoulder and an app on the smartphone.



© Adresys



© Adresys

The problem is that accidents happen inevitably. This is the unfortunate statistical reality of a world connecting millions of people to millions of electrical devices. There are fewer cases in the sector (electricians and professionals staffing power plants and construction sites) who are trained and equipped. On the other hand, since they work with much higher voltages, their accidents are much more serious.

The issue is particularly relevant to the Austrian company Omicron Electronics, a leader in testing, diagnostic and monitoring solutions for the power industry. Its technicians and customers are among people exposed. Omicron Electronics has assigned one of its entities, Adresys to find the best way to react in case of electrical accidents.

Adresys started by doing market research but couldn't find any solutions. No problem for Omicron's R&D centre (since its acquisition in 2012), it decided to develop its own. The prerequisites were simple: detect accidents, raise the alarm and notify the emergency contacts as quickly as possible.

In late 2021, after four years of arduous work, Adresys launched its product on the German-speaking market. Its terrific innovation is – drum roll please – a... T-shirt?

Yes, a T-shirt. And much more: Angel React Shirt System is a complete high-tech solution, built around an "intelligent clothing" concept.

The simple appearance was intentional. The solution was to be adopted naturally by the users, so what more ordinary than a T-shirt?

Companies are happy with it, as it is available in several colours and their logo can be integrated. The smart shirt is sweat- and wash-resistant.

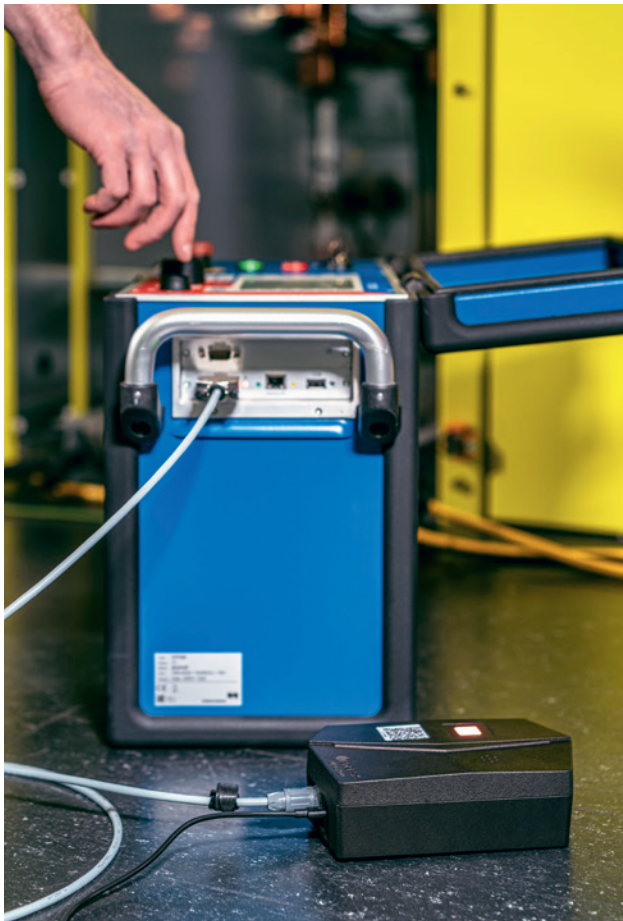
Its technology is integrated into the fabric (organic-certified cotton). There are electrodes in the sleeves, maintained in contact with the skin by spandex cuffs (the biceps of future users will need to be carefully measured to guarantee proper functioning). There is a textile cable – invisible and unperceivable – that goes along the back to carry data collected by the electrodes to the left shoulder.

The left shoulder is where the Shirt Genius "the brain" of the Angel React system is located. A small device that needs to be placed in its cradle – where it is held in place by magnets – to be activated. Genius' processor applies Ohm's law: it deduces the current running through the victim based on the voltage measured by the electrodes and the body's resistance. In addition, Genius uses sensors enabling its algorithms to detect falls and immobility. It is also equipped with a loudspeaker and its ringtone alerts other people nearby. Electricians and technicians often work alone, so Adresys did not stop there.

The main alert goes through Angel React's third component: a dedicated application on the user's smartphone. Genius is connected to it by Bluetooth (it will beep if the user moves away and risks losing the connection). The application shows live data and reaches out to as many as three designated emergency contacts. By a voice call, a text message and an (optional) e-mail, to maximise the chances of reaching the contacts.

These messages indicate who the victim is, its location (via the smartphone's GPS) as well as the type of accident (electrical, fall or immobility). The interface also enables the casualty, if conscious, to text these people without having to switch to another application. A link to Google Maps helps the contact persons to join the victim. Everything, absolutely everything has been considered to facilitate a reaction.

The application also allows to programme the scheduled duration of risky interventions. If the worker doesn't confirm the end of his/her mission, an alarm is raised, with the last registered GPS position.



© Adresys

The recorded data is transmitted only in case of an alarm. Adresys collects this autonomously to enhance the algorithms of its application. Only for that: the solution has been designed with "privacy first". Impossible for an employer to use it to trace employees.

T-Shirt, Genius and the dedicated application make up the Angel React Shirt system. Adresys proposes an additional option to further improve the victims' chances: Watchdog. This accurately named device (equipped with REDEL SP connectors) connects to the source of the power supply, be it a test device or a laboratory power supply. If an Angel React T-shirt detects an accident, the Watchdog switches off the voltage source immediately, within a few milliseconds, which is much faster than a colleague dashing to push a big red button.

Reaction speed is literally vital in case of an electrical accident. On the one hand, the harm and consequences of an electric shock depend largely on its duration. On the other, muscle cramp, caused by an electric shock can sometimes prevent the victim from releasing the electrocuting device. By cutting off the current flow (even in cases of a fall or immobility), the Watchdog also contributes to securing the area for those who, not always conscious of the danger, rush to help the victim.

Launched two years ago on a limited market, the Angel React System is only in the early stages of its story. Among its 200 customers, there are also some pilot companies testing the solution and giving precious feedback. One of them being ABB eMobility, who build electric car charging infrastructure.

Adresys, whose first own branded product is Angel React, will extend its market in 2024. It will sell its smart T-shirt in Scandinavia, in the UK and in southern Europe. The company, with its staff of 30 people in Salzburg, has also been working on the integration of new functionalities.

It will enable them to react even better and faster. And to save even more lives. ■



In case the Angel React T-shirt detects an electric shock, Watchdog (fitted with REDEL SP) cuts off the current immediately.

WE ARE ANCHORED IN UK INNOVATION

LEMO has recently celebrated its 50th anniversary in the United Kingdom. Launched as a modest sales office, the British subsidiary has since contributed to many iconic solutions and never stopped evolving, cementing its position as a market leader in the UK. Peter Dent, its managing director for almost a decade, answers our questions.

How's life in Worthing, where LEMO opened its first office in 1973?

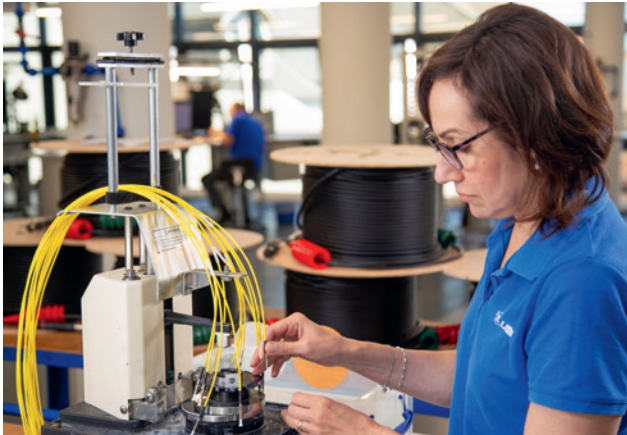
Peter Dent: That simple office is long gone. We are already in our fourth building, a purpose-built 4,000-m² plant inaugurated in 2010. We have been continuously developing our local services and, more importantly, our capabilities to complement the group's core connector range, especially in cable assembly. Over the years, we have expanded our local manufacturing services, including the addition of more automation and new processes, such as overmoulding, which had typically been outsourced in the past. To ensure the highest quality, we have adopted a vertical integration approach to local manufacturing, mirroring the long-standing practice of the LEMO group from its early days.

Your R&D has been involved in solutions which have become a benchmark in Formula One (F Series, M Series) and HDTV broadcast (3K.93C Series). Does it still play a central role?

Indeed, it holds a central role, not only resulting in innovative solutions, but also significantly influencing the way we support our customers. In recent years, our sales team has developed comprehensive expertise in various aspects, including products, markets, limitations, and requirements. This knowledge empowers them to serve as consultants rather than mere product suppliers. Our key customers see us as integral to their R&D, actively involved with their projects from



the early stages. They entrust us with the development of their solutions, ensuring optimisation from the initial design phase to the final product. As a result, we are deeply intertwined with their innovation.



▲
From R&D to cable assembly, the UK LEMO subsidiary offers a comprehensive range of services.

What common applications do you serve in this capacity?

The foremost ones that come in mind are defence and security, which have gained prominence in the current international context. We are partners with several companies developing high-end communication, monitoring, and surveillance equipment. These technologies are advancing rapidly, and, thanks to our expertise, we can assist these companies in anticipating demands for higher frequency, enhanced mobility, wireless solutions, smaller and lighter devices, cables with minimal loss and noise, and more.

Medical applications have also been the focus of attention...

... and they also serve as a good example, since they require special expertise which we can provide in the face of the increasingly stringent and costly qualification and approval processes. Many of our customers do not have this competence in-house, so we become their advisors. In addition to developing complete and medically approved solutions in collaboration with them (our cable assembly solutions are ISO 13485 certified), we serve as partners from inception to completion, minimizing the time and cost involved in that process. LEMO is now one of the leading companies able to provide high-end, full-service solutions.

What about test & measurement applications, where LEMO has a strong track record?

UK companies are at the forefront of non-destructive test equipment, and we are one of the leading companies supporting that market space. There is a rapidly growing demand for robust and reliable complete solutions for applications in remote locations. LEMO's historical leadership in harsh environments and our enhanced capabilities in high-quality cable assembly are a perfect match for this demand.

What about the evolution of the broadcast industry?

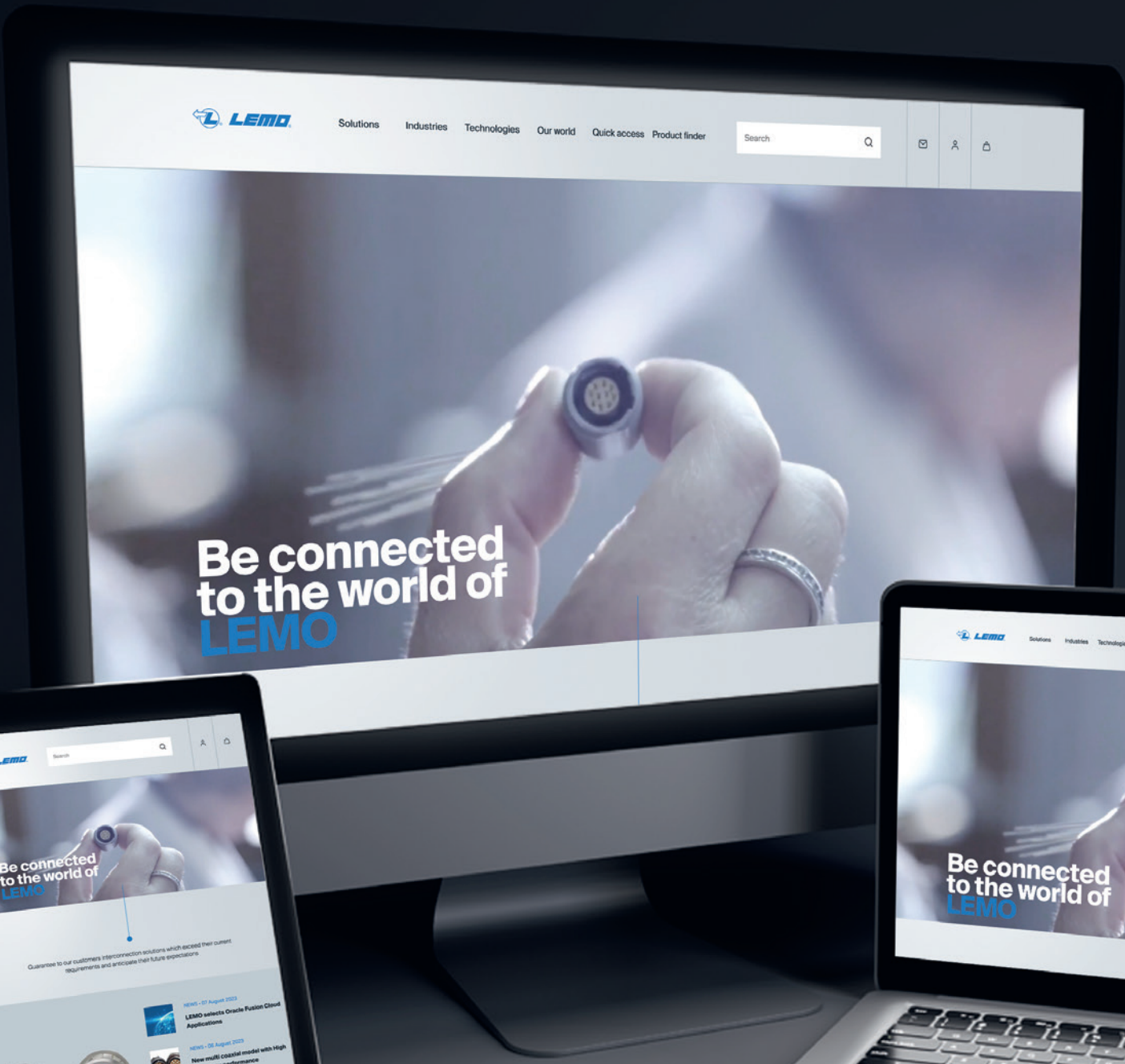
What we've seen in the broadcast market is the continual evolution of live events. So, we need to be able to develop solutions that are both custom and very quickly available – which is a challenge. We manage to create, thanks to the modular design of LEMO solutions, something which is tailored to the specific application, but uses standard components and materials within it. We have also expanded our reach within this industry, from the historical broadcast base to become stronger in the film and stage industry, as technology is adopted for applications like special effects. (Discover in CONNECTED 19 how LEMO contributes to the London show of *The Lion King*).

Your examples have shown that you focus on niche markets...

Indeed. A large percentage of UK manufacturing base is not involved in mass production, it's excellence shines in niche markets. There's a multitude of small and medium-sized companies that have risen to become global leaders in highly specialised applications. I could also mention Hi-Fi: many UK companies are renowned in the field. They strive to push the boundaries of what is achievable, and thus, they are receptive to LEMO's pursuit of excellence. This is how we often find ourselves supplying many Hi-Fi companies.

Such positioning aligns perfectly with LEMO and even the "Swiss Made" label...

The LEMO brand is ever-present in the UK high-end world where it has an excellent reputation. It has always been the case, but we have tried to further strengthen it by attending five or six specialised shows every year. The idea has been the same: to remain as close as possible to local expertise in assisting them in entering the same high-performance segment in which we operate. We accompany their development, and, in return, these customers also influence our progress. It is for their benefit that we continuously upgrade our production capacities, expertise, and service approach. ■

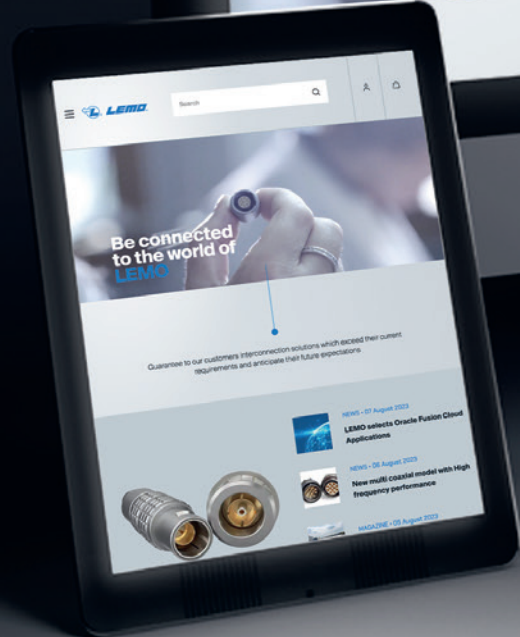


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LEMO SA
Tel: +41 21 695 16 00
info@lemo.com

SUBSIDIARIES

AUSTRIA
LEMO ELEKTRONIK GESMBH
Tel: +43 1 914 23 20 0
salesAT@lemo.com

BRAZIL
LEMO LATIN AMERICA LTDA
Tel: +55 11 94242 4293
info-la@lemo.com

CANADA
LEMO CANADA INC
Tel: +1 905 889 56 78
info-canada@lemo.com

CHINA / HONG KONG
LEMO ELECTRONICS
(SHANGHAI) CO., LTD
Tel: +86 21 5899 7721
cn.sales@lemo.com

DENMARK
LEMO DENMARK A/S
Tel: +45 45 20 44 00
info-dk@lemo.com

FRANCE
LEMO FRANCE SÀRL
Tel: +33 1 60 94 60 94
info-fr@lemo.com

GERMANY
LEMO ELEKTRONIK GMBH
Tel: +49 89 42 77 03
infoDE@lemo.com

HUNGARY
REDEL ELEKTRONIKA KFT
Tel: +36 1 421 47 10
info-hu@lemo.com

ITALY
LEMO ITALIA SRL
Tel: +39 02 66 71 10 46
sales.it@lemo.com

JAPAN
LEMO JAPAN LTD
Tel: +81 3 54 46 55 10
info-jp@lemo.com

NETHERLANDS / BELGIUM
LEMO CONNECTORS NEDERLAND B.V.
Tel: +31 23 206 07 01
info-nl@lemo.com

NORWAY / ICELAND
LEMO NORWAY A/S
Tel: +47 22 91 70 40
info-no@lemo.com

SINGAPORE
LEMO ASIA PTE LTD
Tel: +65 6476 0672
sg.sales@lemo.com

SPAIN / PORTUGAL
IBERLEMO SAU
Tel: +34 93 860 44 20
info-es@lemo.com

SWEDEN / FINLAND
LEMO NORDIC AB
Tel: +46 8 635 60 60
info-se@lemo.com

SWITZERLAND
LEMO VERKAUF AG
Tel: +41 41 790 49 40
ch.sales@lemo.com

UNITED ARAB EMIRATES
LEMO MIDDLE EAST
CONNECTORS LLC
Tel: +971 55 222 3677
info-me@lemo.com

UNITED KINGDOM
LEMO UK LTD
Tel: +44 1903 23 45 43
lemouk@lemo.com

USA
LEMO USA INC
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USA
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Tel: +1 715 294 21 21
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contactenos@microlink.com.co

CZECH REPUBLIC
MECHATRONIC SPOL. S.R.O.
Tel: +420 2 679 13973
mechatronic@volny.cz

GREECE
CALPRO
Tel: +30 210 7248 144
technical@calavitis.gr

INDIA
PT INSTRUMENTS PVT. LTD
Tel: +91 22 2925 13 53
ptinst@vsnl.com

ISRAEL
AVDOR TECHNOLOGY LTD
Tel: +972 3 952 02 22
sales@avdor.com

NEW ZEALAND
INGRAM
Tel: +64 9 580 28 00
sales@connectorsystems.co.nz

POLAND
SEMICON
Tel: +48 22 615 64 31
info@semicon.com.pl

SOUTH AFRICA
JAYCOR INTERNATIONAL (PTY) LTD
Tel: +27 11 444 1039
jeff@jaycor.co.za

SOUTH KOREA
SUNG SHIN I&C CO., LTD
Tel: +82 70 4015-8350
mail@sungshin.co.kr

TURKEY
MAK SAVUNMA LTD STI
Tel: +90 312 256 16 06
sales@maksavunma.com

UKRAINE
U.B.I.
Tel: +380 44 568 5765
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